Diamond Jubilee Souvenir

राष्ट्रीय धातुकर्म प्रयोगशाला
NATIONAL METALLURGICAL LABORATORY
1950 - 2010
60 Glorious Years
वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्
COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

राष्ट्रीय धातुकर्म प्रयोगशाला

National Metallurgical Laboratory

(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्)

(Council of Scientific & Industrial Research)

जमशेदपुर / Jamshedpur-831 007, INDIA

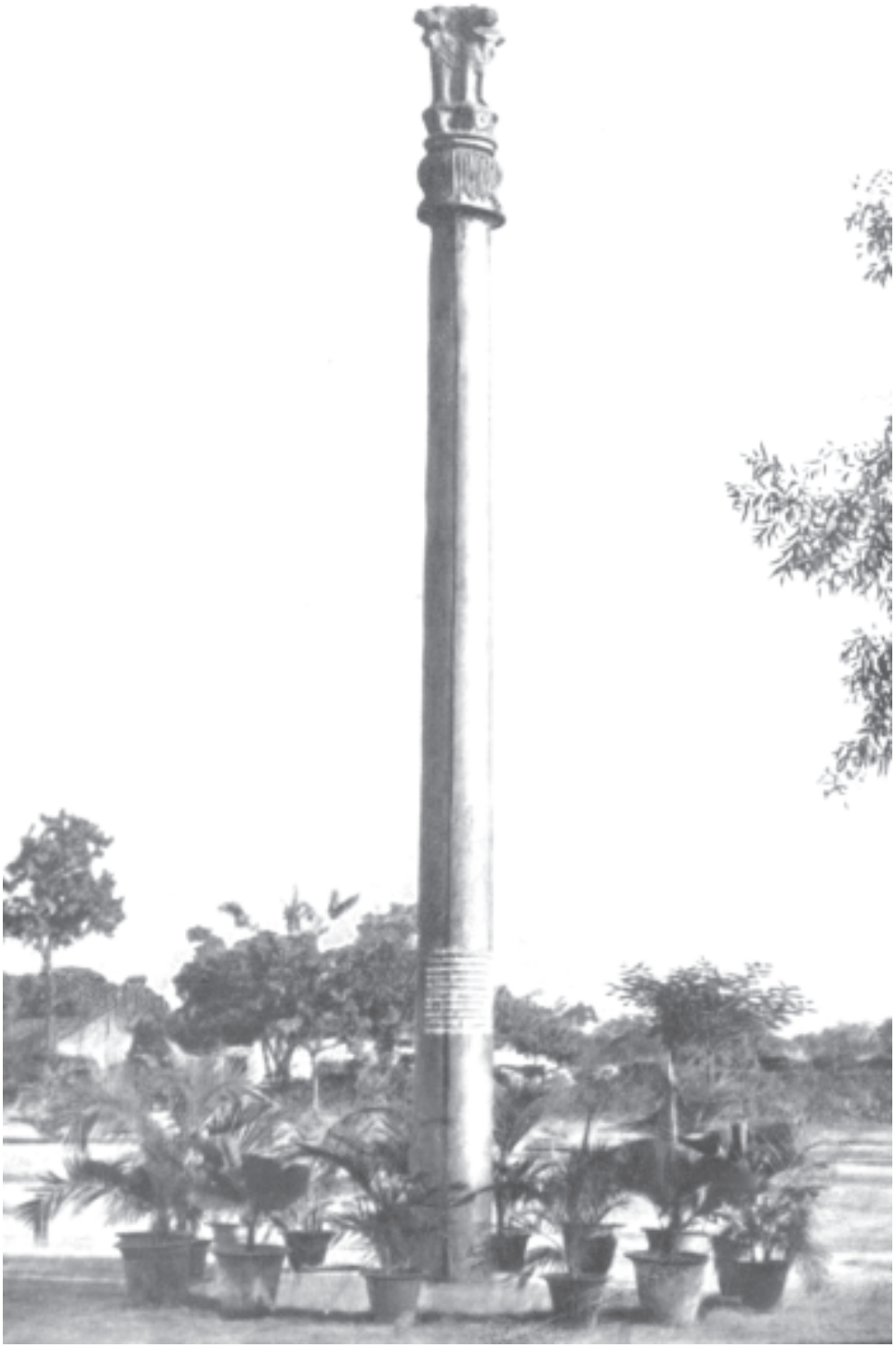
Souvenir

Glorious Years

National Metallurgical Laboratory

Council of Scientific & Industrial Research

Jamshedpur - 831 007, India



"The Replica of the Ashoka Pillar was installed at the National Metallurgical Laboratory on the 26th November 1950, on the opening of the Laboratory, by Shri Jawaharlal Nehru, Prime Minister, as a Symbol of the Science and Industry of India in the past, a token of the present, and as an inspiration for the future."

1946
1950
1955

1958-
1960-
1981
2000
2004

H M Nerurkar
Managing Director

From Chairman, Research Council

2010 is a momentous year for the National Metallurgical Laboratory as it celebrates its Diamond Jubilee in this month of November. Such occasions come only once in a lifetime. They provide an ideal opportunity to look back, turn the pages of history to make an assessment of what has been achieved, and at the same time, chalk-out a road map for what can be done in the coming years. As the Chairman of the current Research Council of this prestigious institution, it is my privilege to felicitate all of you in NML on this historic occasion and extend my heartfelt greetings.

I understand that when Pandit Jawaharlal Nehru inaugurated the National Metallurgical Laboratory on 26th November 1950, he had said : *"..... coming to Jamshedpur and opening this great Laboratory, I think of the combination of this Laboratory with the great Steel Works in this city (referring to the then Tata Iron and Steel Company Limited, now Tata Steel Limited), of the* ***marriage of science with industry****. Now, neither this Laboratory nor any other is by itself progress. It is the (only) tool out of which progress can come out, and it depends on those who use these tools as to how far progress can come. So, this marriage of science and industry is important because this means that we utilise science for the immediate advantage of the betterment of our people. That is typified by this Metallurgical Laboratory being situated in this city of Jamshedpur".*

The remarkable visionary that India's first Prime Minister was, how appropriate that 60 years ago, he foresaw the importance of a strong marriage (bonding) between science and industry! It is remarkable that JRD Tata speaking as the Chairman of Tata Steel had once similarly remarked : *"The strength to defend India's freedom could come only from widespread industrialisation and the* ***infusion of modern science and technology in the country's economic life"****.* In the years that have followed, this has been successfully accomplished. The co-existence of Tata Steel and NML in the Steel Town of Jamshedpur for the last 60 years is the ultimate proof of a happy marriage between technology and industry, from which both the organisations have gained tremendously. As the Managing Director of Tata Steel, I acknowledge with a deep sense of gratitude, the role played by NML in ensuring that Tata Steel has successfully ridden the crests and troughs of the steel business. There is little doubt in my mind that a part of Tata Steel's success over the last more than hundred years is ascribable to the fact that R&D and technology have been embedded into the very fabric of Tata Steel's business - in this endeavour NML has played a stellar role.

India was indeed very fortunate to have a leader like Nehru at the helm of affairs after independence. He recognized the importance of science and scientists in nation-building and enshrined the Scientific Policy Resolution as early as March 1958. In fact, even as early as 1945, Nehru had declared that *"I firmly believe that of all the big problems that face India today, nothing is more important than the development of scientific research, both pure and applied"*. Inaugurating the 34"' Indian Science Congress at New Delhi, he reiterated his views: *"Surely science is not merely an individual's search for truth. We should like to tap all the latent scientific talent in the country and to give it opportunities for growth and service to the community. The first objective, it seems to me, from any point of view*

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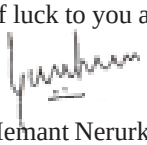
and more especially from the point of view of ***science is to help in the building of a free and self-reliant India ".*** Like many other statements that Nehru made during his tenure as India's first Prime Minister, these words have turned out to be profoundly prophetic. Perhaps, that is what true leaders are made of.

On the occasion of the Diamond Jubilee of NML, one can only stand back and admire the foresight of the makers of modern India, - admire that those who were the prime architects of the resplendent India that we have today could think, so many years back, that cooperation between science and industry had to be as strong and as enduring as marriage - so solemn an event in Indian society. Having been fortunate enough to have had the path of progress chalked out by visionaries like Pandit Nehru, JRD Tata and many other doyens, the fruition of their dreams was made possible by pristine organisations like the CSIR Laboratories and the Atomic Energy establishment that Nehru and JRD help set-up. India as a whole and Jamshedpur in particular has certainly gained enormously from the presence of the National Metallurgical Laboratory - **perhaps the brightest jewel in the CSIR crown.** NML shares more than a common boundary wall with Tata Steel. I wonder if there is any better example anywhere else in the world of this type of literal "coming together" of science and industry! Many books have been written and seminars conducted on the subject of industry-research laboratory collaboration. In Jamshedpur, it has been taken for granted for the last 60 years! This is yet another example of Jamshedpur being the harbinger of many path-breaking innovations that have become icons of independent India.

As one looks back at the history of NML, one can only marvel at the achievements that make us all Indians proud, particularly those like me who are citizens of Jamshedpur. The magnitude of NML's multifarious achievements is truly phenomenal - from iron ore up-gradation and coal beneficiation, to extraction of iron and steel, to the characterisation of metals and materials, to the casting of foundrygrade iron, to processing non-ferrous metals like magnesium, nickel and copper - the saga of NML's success goes on and on. As a student of metallurgy in Pune, I read about NML and often wondered if it was all true. Over the last 35 years, first from the other side of the boundary wall and more recently from close quarters, I have personally had the privilege to watch the success story of NML unfold in front of my own eyes. The achievements over the last 60 years are indeed real truly remarkable. There is little doubt in my mind that NML has not only lived-up to the mandate given at the time of its inception, but has gone far ahead by leaving its indelible footprints on Indian society as a whole. During my stay in Jamshedpur, I have had many opportunities to interact with NML. I can state from personal experience that the past and present Directors of NML have each been metallurgical stalwarts, whom I have not only admired as scientists and leaders, but I have learnt lessons from them that have benefitted me in my professional career. Interactions with all the Scientists of NML have enlightened me on many occasions. The International Conferences organised by NML over the years have been milestones in terms of their technical content, from which each one of us, including myself, have gathered tremendous knowledge. How can I forget how much I have learnt from the books and journals in NML's Library? During my tenure in Tata Steel in R&D, Quality Control, Operations and even during my short stint in Usha Alloys, I have used the NML Library extensively. The plethora of books and journals available here is the envy of many. This is another aspect of NML's yeoman service to Indian industry that is often lost sight of. Industry-Research interaction is not necessarily confined to investigations and scientific exchange of knowledge, but can go down to the very grass roots of knowledge management.

On the occasion of the Diamond Jubilee, I extend my good wishes to Dr. S Srikanth and the entire NML team. You are the leaders of metallurgical research, not only in India, but you can hold your own on the global platform. We are all proud of you.

I am sure greater success awaits this National Institution in the years to come. If I, as the current Chairman of your Research Council, can in anyway contribute towards NML's greater glory, I would consider it as my privilege. Best of luck to you all in NML on this historic occasion.



Hemant Nerurkar
Chairman, Research Council of NML

Jamshedpur
5th November, 2010

From the Director's Desk...

As National Metallurgical Laboratory is celebrating its Diamond Jubilee Anniversary, my thoughts race back to 2 September 1990, the day I joined NML. I can never forget this day of my life. As I walked into NML through the main gate, the majestic sight of the main building of NML, the lush green gardens with the water sprinklers and the beautiful flowers adoring the perimeter of these lawns all caught my fascination. I was on my way to the Director's office, when to my complete surprise and embarrassment, Prof. Shilowbhadra Banerjee rushed out of his chamber to the corridor and with a broad smile had these words of adoration "Welcome to NML Dr. Srikanth. It is a privilege to have you". I was so overwhelmed that I didn't have any words to respond. I was just a fresh Ph.D. out of IISc Bangalore and here, the Director of one of the reputed National Laboratories comes out to welcome and greet you. This single incident created a lasting impression of NML on me and I never looked back with any regret. I know that several of my colleagues who joined NML during this period were given the same gorgeous welcome and carried a similar first impression. The warmth and affection with which we were taken into NML defined our entry into NML and ensured our commitment and deep belonging to NML for the rest of our lives. Thus started my journey at NML.

Twenty years later as I reflect back, there is a sense of happiness and satisfaction, not because I could accomplish anything great, but merely because the twenty years that I have spent here has been a joy working. The ambience, culture and the sense of belonging among everyone at NML is something that you should experience to believe. There is also a tinge of disappointment that over these two decades I could have done a lot more. There were indeed several hurdles and obstacles, there were several moments of frustration, but they were ours and we were determined to overcome them. It is during these twenty years that I learnt the heritage and legacy of NML, the vision and foresight of its founders and past directors, the lasting impressions that she had created in the industry and the respect with which the metallurgical fraternity of the world had beholden her. It also to me brought home the honest realization that for whatever reason (changes in government policy, moving from self reliance and import substitution to market driven R&D, from pilot plants as an asset to them becoming a burden, from technology development as a mandate to research excellence as driving force, constantly changing parameters of performance etc.) the NML of our era possibly has not lived up to its full potential as the NML of the yester years (purely my personal assessment).

Research at NML up to the mid-80's was driven by self-reliance, conservation of foreign exchange, indigenous technology and use of indigenous resources. The era of the fifties at NML belonged to steel. Steel, by oxygen blowing, was made for the first time in India on a pilot scale, in the L.D. oxygen converter at the National Metallurgical Laboratory. The development of nickel free austenitic stainless steel based on indigenously available Iron-Chromium-Nitrogen-Manganese-Copper at tonnage scale was another landmark development.

The 1960's at NML belonged to pilot scale development of an iron making process from lean grade iron ores and non-coking coal in a low-shaft furnace and the establishment of an Integrated Mineral Beneficiation Pilot Plant. Inaugurating the low shaft furnace pilot plant in 1959, Sardar Swaran Singh, the then Union Minister for Steel and Mines had stressed "For a country like India where there is a shortage of metallurgical coal and considerable deposits of lignite and other non-metallurgical coals exist, methods are to be developed for using these non-metallurgical fuels for the production of pig

iron". Words of prophecy which over the next two decades, NML helped realize. Similarly the mineral beneficiation pilot plant not only catered to almost all the mineral processing requirements of the country but also to several international clients. Almost all the iron ores and limestone used from the various mines by Tata Iron and Steel Company and all the constituent steel plants of Hindustan Steel Ltd. (presently SAIL) up to the 1970's, the copper ores at Ghatsila and Mallanjkhand and the fluorspar and phosphate deposits all over the country were evaluated at NML. The plant was rated to be one of the best internationally. Sir Charles Goodeve, Director, British Iron & Steel Research Association had these words to say "I had the opportunity of studying quite a number of pilot plants in my life but I had not yet seen any that can stand above the pilot plants in operation at the NML… the British Iron & Steel Research Association who were planning to extend their mineral beneficiation pilot plant facilities had not even gone half the pace in comparison with the National Metallurgical Laboratory during the last five years… I am seriously thinking of sending some of our own problems which could be worked out at the National Metallurgical Laboratory where the facilities in many respects exceed greatly our own in Britain". The strong tradition of pilot scale research in mineral processing continues till today.

The 70's saw NML take leadership in the country not only in the development of indigenous processes utilizing indigenous resources such as the country's first pilot scale sponge iron process, Asia's first pilot scale ferroalloys smelting facility, development of substitute aluminium conductors to replace copper but also assist the strategic sectors. NML's effort in the 70's on sponge iron making at pilot scale in a rotary kiln is pioneering. India's first commercial sponge iron plant with a capacity of 30,000 tonnes per year based on NML's technology was commissioned in 1975 at the plant site of M/s Andhra Cement Company at Vijayawada and inaugurated by the Minister of Steel and Mines, T.A. Pai. The 70's was also an era of ferroalloys at NML. The 500 kVA submerged arc furnace established in 1962, served as a national facility for the making all types of ferroalloys and smelting of a variety of ores not only from India but also from a large number of neighbouring countries, such as Nepal, Bhutan and Egypt. The 500 KVA Submerged Arc furnace installed then is in operation even today.

The war of 1965 accelerated the development of the magnesium extraction process. A 250 tonnes/ year sponge magnesium plant based on the Pidgeon process was commissioned and dedicated to the country by Sri Mohan Kumaramangalam, Union Minister for Steel and Mines, in November 1972. This was later transferred to M/S Southern Magnesium for commercial production.

With the initiation of the Fast Breeder Reactor Programme by the Department of Atomic Energy in 1970's, NML had a major role to play in the materials evaluation and qualification program especially the creep properties of the proposed materials for these reactors. In February 1972, Asia's largest 'Central Creep Testing facility', having 150 test points was commissioned in a separate building at the National Metallurgical Laboratory with assistance from the United Nations Development Program. This facility is recognized as one of the best creep laboratories in Asia even today.

Focus on industrial research was not at the expense of long-term fundamental research. Citing the words of Sir Shanti Swarup Bhatnagar 'In the field of metallurgy particularly, fundamental and applied research tend to be complementary instead of existing as two distinct or different types. A proper recognition of the roles of fundamentals and applied research are essential in the planning of any research laboratory, that is intended not merely to aid a particular industry out of the knowledge that is already available but also to the furtherance of such knowledge'. Basic innovative research in relevant areas remained the cornerstone of NML's long term research strategy. Some of the most innovative basic studies pertained to transformation characteristics of hydrogen-stabilized austenite, study of liquid structures and corrosion behaviour of ancient Indian iron and steel which were published in the leading international scientific journals such as "NATURE" and Acta Metallurgica.

The 1980's was a tumultuous period at NML; Pandit Nehru's prophecy was coming true "…One I always fear is that when any good work is done and good processes developed in our laboratories, these get stuck up and it becomes rather difficult to derive proper benefits out of them. A long time is elapsed and industrial exploitation of such processes is postponed and we feel that we have attained the goal or with that our responsibility ends. This is not right. When outstanding processes are developed, we should make use of them at the earliest and not wait to find out as to who should make use of them. As these are useful, Government itself should use and benefit from these processes…"

Further, there was a change in leadership; this decade also witnessed technology denial to India in the strategic sectors. Consequently, the focus shifted to developing technologies for strategic materials. In 1983, with assistance from the Department of Ocean Development, NML launched the poly-metallic sea nodule programme for the extraction of nickel, cobalt and copper. Over the next two decades, NML developed a pilot scale process for the metals extraction from the sea nodules following the "Reduction roast - Ammonia Leaching - Solvent extraction - Electro winning" route. Preservation of the environment also became an issue in the 80's. In the early 1980's NML designed, developed and installed scrubbers for sulphur dioxide scrubbing in some of the foundries of the Taj trapezium. This was followed by the development of a less capital intensive and dry gas cleaning system for cupolas that range from 2 to 25 t/h capacity.

The 1990's saw the economic liberalisation and the consequent shift in research policy from self reliance and strategic research to market driven research; from a protected domestic environment to being internationally competitive. The Abid Hussain Committee report on the functioning and performance of CSIR laboratories was also scathing in its remarks on being completely divorced from the user. It recommended that at least thirty percent of the budget of each CSIR laboratory be generated from industrial funding.

To fulfil the mandate of partial budget from industrial sources, NML began associating the industries directly in its research programmes. In the late 1980's NML in collaboration with Tata steel, developed inhibitors in hydrochloric and sulphuric acid media and used them In Tata Steel as well as Tinplate Company of India Limited, Jamshedpur and Rourkela Steel Plant of Steel Authority of India Limited. In the early 90's, NML also launched the Component Integrity Evaluation Program with World Bank loan and partnership with a consortia of industries. This program went on to provide yeoman service to the power plants, petrochemical industries, nuclear plants and steel plants in the evaluation of structural integrity of plant components and their remaining life assessment. Another landmark development in the mid-nineties was the development of coke-less cupola technology based on the use of low sulphur gaseous or liquid fuel (1 and 2 t/h capacities) and its demonstration in some of the foundries in the Taj trapezium. The signing of the WTO protocol by the Govt. Of India also ushered in intellectual property protection in a big way, which was given a high priority in defining the Vision for 2001 by CSIR. NML responded with the filing of an unprecedented number of national and international patents between 1995 and 2005.

The late 90's and the early years of the new millennium also saw high priority accorded to international accreditation processes to enable standardization of experimentation and reporting of results across the world. In April 1999, NML received ISO-9001 certification.

It is said that "Failures are Stepping Stones for Success". NML has been lending scientific and research credence to this statement since the first Symposium on "Industrial Failure Analysis of Engineering Metals & Alloys" was organized by NML in February, 1953. Over the years, NML has provided failure analysis and damage assessment for railways, thermal and hydel power plants, petrochemicals and various other industries. Today, Center for Military Airworthiness and Certification has recognized NML as a pioneering laboratory in failure analysis and life estimation of aircraft, helicopters and engine components. NML has offered expert opinions for several military aircraft accidents over the past decade. The decade of the new millennium also saw NML consolidate its activities on Technologies for Engineering Critical Assessment. In collaboration with Bhabha Atomic Research Centre, Mumbai NML successfully developed a Portable Automated Ball Indentation system for on-site evaluation of structural integrity and damage of components. The new millennium also saw NML dominate in mineral processing research in terms of flow sheet development at pilot scale for a large number of iron ores and non-ferrous minerals as well as the development of the column flotation technology. Research on column flotation was initiated at NML Madras Centre during mid-1980s as an alternative to conventional flotation technology, to treat finely disseminated low grade ores. The 2000's saw the large scale commercialization of this technology. Presently, there are three commercial column installations of 150 tonnes per day capacity in operation Indian Rare Earths Limited, Chatrapur, and Chavara for sillimanite beneficiation and Calpro Mineral Technologies India Private Ltd., Salem for limestone beneficiation.

Several new programmes on materials development (advanced high strength steels, light metal alloys, nano-materials, magnetic materials and biomaterials), non-destructive evaluation, blast furnace modelling have been initiated at the dawn of the new millennium.

Before I conclude, I ponder at these words of Shri Ashok Mehta, Deputy Chairman of Planning Commission expressed during his visit to NML "What is liked by this particular laboratory is that it has succeeded in assembling together a group of men and women, young scientists, young engineers who have confidence, ability, ingenuity and improvisation. These are essential qualities that are needed today and in the next few years. Nothing must be allowed to intimidate. There will be difficulties and if difficulties are going to intimidate us, then this one-seventh of the world's humanity will remain always a load, a burden for the rest of the world to carry". Words that are relevant possibly even today.

Lastly, I take this opportunity to thank all those (more than hundred of the leading metallurgists, industrialists, government functionaries, past research council chairmen and members and retired employees) who have responded magnanimously to our invitation to write-up for the Diamond Jubilee Souvenir. I have read through them and I find their reminiscences nostalgic and thought provoking. I am sure that all of you who read through this Souvenir will find these messages very interesting and touching a chord. We have also tried to provide all information on NML since its inception in 1950 (publications, patents, research reports, manpower, budget, extra budgetary resources and so on) in the Souvenir to give the readers an idea of how NML has moved through times.

I hope you will cherish reading through the Souvenir and possessing it.

DIRECTOR

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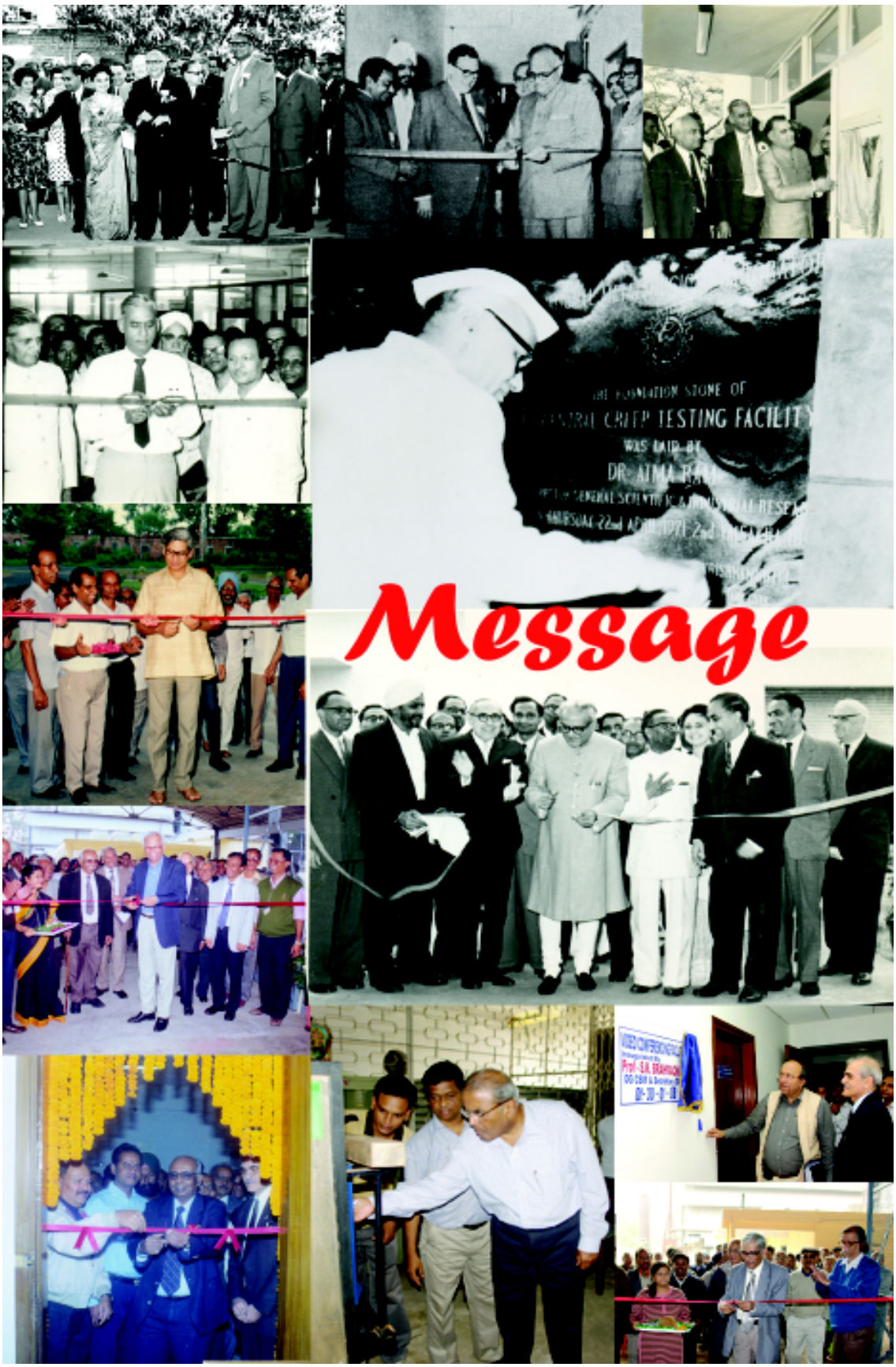
Message

अर्चना दत्ता (मुखोपाध्याय)
राष्ट्रपति के विशेष कार्याधिकारी (जन सम्पर्क)
Archana Datta
(Mukhopadhyay)
OSD (PR) to the President

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President's Secretariat,
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MESSAGE

The President of India, Smt. Pratibha Devisingh Patil, is happy to know that the National Metallurgical Laboratory, Jamshedpur is celebrating its Diamond Jubilee Year and bringing out a Souvenir highlighting the history and achievements of the NML.

The President extends her warm greetings and felicitations to all those associated with the Laboratory and wishes the Diamond Jubilee Celebrations all success.

A. Datta

Officer on Special Duty (PR)

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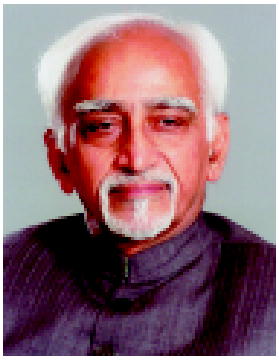

MESSAGE

Hon'ble Vice President of India is happy to know that the National Metallurgical Laboratory, Council of Scientific & Industrial Research, Jamshedpur is celebrating its Diamond Jubilee Year. National Metallurgical Laboratory throughout its existence has played a vital role in the quest of the country towards scientific and technological leadership and in providing solutions to the industries in the areas of minerals, metals and materials.

Vice President of India extends his greetings and good wishes to the organizers and the participants and wishes the Diamond Jubilee Celebrations all success.

(P. HARISH)

New Delhi
29th September, 2010

प्रधान मंत्री

Prime Minister

MESSAGE

I am happy to learn that National Metallurgical Laboratory, Jamshedpur is celebrating its Diamond Jubilee this year. The National Metallurgical Laboratory is one of the first research laboratories set up by the Council of Scientific and Industrial Research. Having established itself as a premier R&D institution in the country in the field of minerals, metals and materials, the National Metallurgical Laboratory today possesses a unique knowledge base in areas such as mineral processing, iron and steel making, ferroalloys and extraction of non-ferrous metals.

The sixtieth year is a significant milestone in the life span of any institution. On the happy occasion of the Diamond Jubilee celebrations, I extend my greetings and felicitations to the scientists of NML, students and staff of the Laboratory and to all others who have been associated with this premier institution and wish them all success in their future endeavours.

(Manmohan Singh)

New Delhi
22 September, 2010

Dr. APJ Abdul Kalam
Former President of India

August 20, 2010

MESSAGE

I am very happy to know that National Metallurgical Laboratory, Jamshedpur is celebrating its Diamond Jubilee this year and celebrating its Foundation Day on 26 Nov 2010. It is pertinent to note that NML played a significant role in the industrial revolution of India starting from 1950 especially in the areas of mineral processing, iron and steel making, ferroalloys and extraction of non-ferrous metals, notably magnesium. NML has the unique distinction of having second largest creep testing lab in Asia and plays a vital role in the quest of the country towards scientific and technological leadership and providing scientific solutions to the industries in the areas of minerals, metals and materials.

India is the fifth largest producer of steel in the world. Government targets to increase the production capacity from 56 million tons annually to 124 MT in the first phase which will come to an end by 2011 - 12. Currently with a production of 56 million tons India accounts for over 7% of the total steel produced globally, while it accounts to about 5% of global steel consumption. The higher the steel consumption within our own country, the higher the growth in the 3 sectors of the economy, certainly the domestic consumption is set to grow in the years to come. About 50% of the steel produced in India is exported. India's export of steel during April - December 2008 was 64.4 MT as against 9.7 MT in December 2007. In February 2009, steel export increased by 17% to 12.6 MT from 10.8 MT in the same month last year. More than 50% of steel from India is exported to China. The Govemment's decision to reduce export duty on iron ore lumps from 15% to 5% has given a major boost to the export of steel.

Certainly, India has to concentrate more on improving the mineral processing technology to the state of the art level. We need to overcome the hurdles such as Power Shortage, outdated processes, raw material deficiency. Our focus should to be diverted to increase the productivity of our labour which is today 144 tons per worker per year against 600 tons in Western Europe as per the estimates and improve the inadequate transport and shipment capacity to the adequate and requisite level to meet the global requirements. As per Investment Commission of India more than 30 billion USD are in the pipeline for investment over the next five years which will certainly enrich the capacity of india in metals, minerals and materials production, process and its export as well as help increasing the domestic consumption capacity.

NML has a major role to play in enriching the minerals processing and production capacity of India. My greetings to the members, staff and management of NML for success in their mission while you are celebrating the Diamond Jubilee in 2010.

A.P.J. Abdul Kalam

APJ Abdul Kalam

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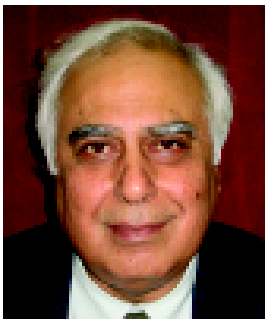

Message

I am truly happy to learn that The National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee this year. NML owes its origin to the visionary foresight of Pandit Nehru and Dr Shanti Swarup Bhatnagar and the munificence of Tatas. At the formal inauguration, 60 years ago, Panditji had set the vision for NML in his remarks that "the combination of this laboratory with the steel works in the city, of the marriage of science with industry(is) for the progress of both". The laboratory gained national prominence during the tenure of its first Indian Director Dr. Balraj Nijhawan, in the fifties and early sixties when it developed several flow sheets and processes for the then nascent metals and ore processing industries. Since then it has to its credit development of several other technologies notable amongst these being for aluminium alloys for electrical conductors and alloys for coins. Its creep testing facilities have served the nation with distinction for several decades.

I congratulate the NML community, the new Director and the leadership at CSIR, both present and past who have so assiduously over the last six decades built a robust national research facility. My best wishes to the NML in their endeavour of developing minerals, metals and materials technologies of significance to the nation.

(Kapil Sibal)

Prithviraj Chavan
Ministry of State (IC) for Science & Technology and Earth Science;
Ministry of State in the Prime Minister's Office;
Personnel, Public Grievances and Pensions
and Parliamentary Affairs
Government of India, New Delhi

पृथ्वीराज चव्हाण
राज्यमंत्री (स्वतंत्र प्रभार) एवं प्रौद्योगिकी मंत्रालय;
राज्यमंत्री (स्वतंत्र प्रभार) पृथ्वी विज्ञान मंत्रालय;
राज्यमंत्री, प्रधान मंत्री कार्यालय तथा
कार्मिक, लोक शिकायत एवं पेंशन मंत्रालय तथा संसदीय कार्य मंत्रालय
भारत सरकार, नई दिल्ली

MESSAGE

The National Metallurgical Laboratory (CSIR), Jamshedpur, which is celebrating its Diamond Jubilee this year, has contributed significantly towards the growth and development of metallurgical industries in our country. Over the last sixty years, NML has established itself as a provider of innovative and sustainable R&D solutions to the various complex problems related to mineral processing, ferrous and non-ferrous extraction of metals, ferroalloys, alloy development, structural integrity and remaining life assessment as well as environment related issues in metal extraction and processing. Many of the technologies developed at NML have either been successfully transferred to various industries or have led to significant societal benefits. NML is now a comprehensive and unique repository of knowledge in all the areas related to minerals, metals and materials.

I understand that NML is now focusing on increased collaboration with industry as well as other stakeholders so that its expertise and knowledge base can be effectively applied to arrive at compatible solutions to our industrial, environmental, societal and related problems. On this memorable occasion of NML, I wish all Scientists and Staff Members of the laboratory, both past and present, as well as all others who were associated with this renowned institution, all the success in future.

Date : 30th September, 2010

(PRITHVIRAJ CHAVAN)

JAWAHARLAL NEHRU CENTRE FOR ADVANCED SCIENTIFIC RESEARCH
(A Deemed University)

JAKKUR CAMPUS, JAKKUR P.O.
BANGALORE - 560 064, INDIA

Professor C.N.R. RAO, F.R.S
National Research Professor
and
Honorary President

16 July 2010

Message

It gives me immense pleasure to note that the National Metallurgical Laboratory (NML), Jamshedpur is celebrating its Diamond Jubilee celebrations. On this occasion, I extend my good wishes to all the staff members of the laboratory.

I congratulate NML on this occasion which has promoted scientific research and development as one of the best advanced laboratories today. It has contributed substantially to the Jamshedpur economy and business. The laboratory equipped with modern and high-tech gadgets has facilitated research on the fundamentals of science as well as on applied projects related to minerals, refractories as well as ferrous and non ferrous metals, and industrial alloys. The collaboration work with leading research institutes and international agencies which are pioneers in research and development has been impressive.

I extend my best wishes to NML, Jamshedpur, for success and glory in all its endeavours.

C.N.R.Rao
National Research Professor
&
Linus Pualing Research Professor

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अर्जुन मुण्डा

मुख्यमंत्री
झारखण्ड

संदेश

यह जानकार अतीव प्रसन्नता हुई कि 'राष्ट्रीय धातुकर्म प्रयोगशाला' (वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्), जमशेदपुर अपनी स्थापना का 'हीरक जयन्ती समारोह' का आयोजन कर रहा है। इस अवसर पर स्मारिका का प्रकाशन स्वागतयोग्य है।

झारखण्ड राज्य की हृदयस्थली एवं भारतीय खनिज सम्पदा के आँगन कोल्हान में इस 'राष्ट्रीय धातुकर्म प्रयोगशाला' की स्थापना हमारे प्रथम प्रधानमंत्री पंडित जवाहर लाल नेहरु की दूरदृष्टि का परिचायक था। इसके लिए उनके प्रति जितना भी कृतज्ञता ज्ञापित की जाए वह कम होगी। यह प्रयोगशाला 'क्रीप टेस्टिंग लैब' के रूप में एशिया में द्वितीय स्थान पर है। यह भी इस राज्य के लिए गौरव का विषय है।

मैं, 'राष्ट्रीय धातुकर्म प्रयोगशाला' (वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्), जमशेदपुर के 'हीरक जयन्ती समारोह' के आयोजन एवं स्मारिका के प्रकाशन की सफलता के लिए अपनी अनन्त मंगलकामनाएँ अर्पित करता हूँ।

(अर्जुन मुण्डा)

Dr. V. S. Arunachalam
Chairman
Center for Study of Science, Technology & Policy (CSTEP)
Bengaluru

MESSAGE

I am happy to see National Metallurgical Laboratory, more familiarly known as NML, is sixty years young. It is one of the earliest science laboratories to come into being in independent India, very soon after NPL and NCL were created. Our first Prime Minister saw how important materials are in building the nation's economy and society's wellbeing. No wonder he chose to call the laboratories as temples of modern India. NML didn't disappoint. The scientists there chose challenging and nationally relevant problems to address. Dr. P. I.A Narayanan's work in ore beneficiation, Dr. Bhatnagar's work on nickel-free steel and Dr. Chaterjee's work in novel methods of iron and steel making are not just yesterday's problems but are current as well. If more laboratory equipment and industrial scale facilities were available then, these researches could have made greater impact in the country. Investments in research facilities were hard to come by in those years. These programmes were followed by projects in magnetic materials, creep measurements and fundamental research on liquid metals. Production of magnesium metal in industrial sale was also established. The credit for all these should go to the scientists and directors who worked hard to build the institution.

Sixty years is not a long time in the life of a laboratory, but long enough to re-engineer itself for the tasks ahead. The new challenges are going to be different: minimizing the greenhouse gas emissions in industrial processes, recycling and reducing the lifetime costs of engineering materials and practicing the mandate for sustainability. More than addressing the new challenges, the laboratory must also build the nation’s human talent reservoir for materials research and development. Only then will the country be able to sustain its impressive economic growth the nation is now witnessing.

I have had the privilege of visiting NML on a number of occasions. I carry happy memories of these visits that were educative, and also enabled renewing of friendships and building new ones. I also enjoyed the occasional talks I was invited to give at the laboratory. On the happy occasion of the laboratory's sixtieth foundation day, I send my best wishes and greetings. The road ahead for the next sixty years' journey looks at once challenging and enticing. The laboratory is well endowed and inspired for embarking on this journey.

प्रो. समीर के. ब्रह्मचारी
महानिदेशक, वै.औ.अ.प.
एवं सचिव, भारत सरकार
वैज्ञानिक और औद्योगिक अनुसंधान विभाग
Prof. Samir K. Brahmachari
Director General, CSIR
& Secretary, Government of India
Department of Scientific & Industrial Research

वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्
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COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
Anusandhan Bhawan, 2, Rafi Marg, New Delhi-110001

MESSAGE

I am delighted to learn that the CSIR-National Metallurgical Laboratory (NML), Jamshedpur, is bringing out a Souvenir to be published on the occasion of its Diamond Jubilee Celebrations.

CSIR-NML was one of the first of the chain of national laboratories that was established soon after Independence, because the growth of the mineral and metallurgical sector is one of the pillars of foundation for any modern nation. CSIR-NML's motivation and commitment have remained unchanged through the years illuminating every substantial and significant contribution to the national cause over six long and challenging decades.

Its contributions towards the development and growth of mineral processing, iron and steel making, development of substitute steels and Al-base alloys and extraction of non-ferrous metals, especially magnesium deserved praise. In addition, it has also made phenomenal contributions towards generation of knowledge and enhanced understanding on many important basic issues related to the science of metallurgical processing and related environmental implications. It has also contributed significantly towards the strategic sector through materials qualification for the fast breeder reactor, failure analysis of military aircrafts and the Component Integrity Evaluation Programme (CIEP).

CSIR-NML's societal contributions in the areas of preserving traditional knowledge of iron-making & artisanship and development of water treatment technologies are also praiseworthy.

It is a matter of pride that CSIR-NML has made major contributions in all three major areas of R&D, namely : Industrial, Strategic and Societal.

I am confident that in the coming years too, CSIR-NML will play a major role in providing scientific leadership and technological excellence in niche areas. I am confident that it will shape the next generation of metallurgical researchers and professionals through the Academy of Scientific & Innovative Research (AcSIR).

On this momentous occasion of NML's Diamond Jubilee Anniversary, I congratulate all the Scientists and Staff Members, both past and present, for the laurels earned and wish them success in their future endeavours.

(Samir K. Brahmachari)

Dated : 15-11-2010
New Delhi

Ratan N Tata
Chairman

July 8, 2010

Dear Professor Brahmachari,

Thank you for your letter of June 29th.

I am pleased to know that the **National Metallurgical Laboratory (NML)**, Jamshedpur, will be celebrating its Diamond Jubilee this year and would like to thank you for inviting me to be the Guest of Honour at the Diamond Jubilee Foundation Day function on November 26th.

Unfortunately, I will not be able to be in Jamshedpur on that day due to prior commitments which require me to be in Mumbai. Nevertheless, on this proud and significant occasion let me take this opportunity to wish you and all at NML the very best in the years ahead.

With regards,

Yours sincerely,

Ratan N Tata

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C. BALAKRISHNAN
सचिव
Secretary

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भारत सरकार
कोयला मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF COAL
शास्त्री भवन / **SHASTRI BHAWAN**
नई दिल्ली, दिनांक
New Delhi, Dated

No. 8453/Secy(coal)/10

13th August, 2010

MESSAGE

It is indeed a pleasure to learn that the National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee this year and a Souvenir is being brought out to mark this occasion.

NML's contribution during all these years in raising the bar and setting new benchmarks of performance in the areas of mineral processing, iron & steel making, ferroalloys and extraction of non-ferrous metals is truly commendable. I am sure that with the strong and committed staff covering a wide spectrum of expertise and equipped with modern facilities, NML would continue to play a critical role in meeting the challenges in the user sectors and reach even greater heights.

I wish the event all success.

(C. Balakrishnan)

अतुल चतुर्वेदी
Atul Chaturvedi

सचिव
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भारत सरकार
उद्योग भवन, नई दिल्ली
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24th August, 2010

MESSAGE

I am extremely happy to note that National Metallurgical Laboratory (NML), Jamshedpur, is celebrating its Diamond Jubilee this year. NML has great heritage and legacy and I congratulate the scientists, engineers and all other employees of NML on this Diamond Jubilee Year.

I am happy to note that NML has been playing a significant role in the industrial revolution of India especially in mineral processing, iron & steel making and development of other metals and materials. It is also satisfying to note that NML has the state-of-the-art materials evaluation and characterization facilities including the largest creep testing facility in India, which has helped in advanced materials development over the years.

The Indian Steel Industry has come a long way. Today, we are the 5th largest steel producer and we expect to become the 2nd largest steel producer in the world, very soon. Naturally, the challenges are many. Utilization of low grade iron ore is one of the key issues which have to be addressed on priority. NML and other research laboratories have to find out optimum beneficiation circuits ensuring maximum yield to make these low grade ore usable. There are several gaps on technological fronts which are responsible for lower productivity and higher energy consumption leading to higher cost and make Indian steel industry uncompetitive. We have to find out ways and means to remove these bottlenecks. Development of ultra high strength steel with optimum formability and nano-structured advanced materials are yet other challenges before the industry. I am happy to note that NML is already addressing most of these issues through their CSIR networked projects.

Ministry of Steel through its R&D programmes has been pursuing several research projects to find techno-economic solutions to some of the problems confronting the steel industry in India. I have noted with pleasure that NML has a very close relation with Ministry of Steel and they have been extending full support in pursuing the R&D programme by the Ministry.

I wish NML all the best. I expect that in years to come, NML will develop still greater linkage with the industry and jointly resolve the problems being faced by them in a partnership mode.

(Atul Chaturvedi)

सचिव
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सत्यमेव जयते

डॉ. शैलेश नायक
DR. SHAILESH NAYAK

SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF EARTH SCIENCES
'MAHASAGAR BHAVAN' BLOCK-12, C.G.O. COMPLEX,
LODHI ROAD, NEW DELHI-110 003

MESSAGE

National Metallurgical Laboratory (NML) has been the premier organisation of repute in the field of metals, minerals and materials. Aptly located in the mineral rich belt of India, NML has contributed significantly to the developments in mineral processing, iron and steel making, ferroalloys and extraction of magnesium. The creep facility established in early 1970s at NML is still the second largest testing facility in Asia. The NML has been associated with the Ministry of Earth Sciences for more than two decades and has actively participated in the National R&D endeavours for extraction of copper, nickel and cobalt from polymetallic nodules found at seabed from water depth of 4 km to 6km.

With the emergence of new materials, coupled with nanotechnology, the basket of applications is likely to be expanded manifold leading to a very different perception and outlook. While the major processes for metallurgical industries is likely to be continued using the conventional technologies for some time, advanced efficient process routes would become important. The scientific and technological leadership, that NML offers, I am certain, would pave way for meeting some of these challenges of the future.

I am happy to note that NML is celebrating the Diamond Jubilee this year and I consider this as an unique opportunity to rededicate ourselves in contributing to new emerging and path-breaking trend delving into the possibility of yet another industrial revolution.

I wish NML great success.

(Shailesh Nayak)

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डॉ. श्रीकुमार बैनर्जी
Dr. Srikumar Banerjee

भारत सरकार
Government of India

अध्यक्ष, परमाणु ऊर्जा आयोग
व
सचिव, परमाणु ऊर्जा विभाग
Chairman, Atomic Energy Commission
&
Secretary, Department of Atomic Energy

August 19, 2010.

Message

I am very glad to note that the National Metallurgical Laboratory, Jamshedpur is celebrating its Diamond Jubilee this year. Coming up soon after India's independence, the laboratory was symbolic of the country's quest for self-reliance in every sphere, including research and development. Excelling in all the branches of metallurgy, it is national in its spirit and international in its class. All the achievements of NML Jamshedpur truly belong to its dedicated staff and management. Being located in the steel city and the metal country, it is a guiding institution to many metallurgical industries. Today it offers consultancy in key areas to the metallurgical industry, and sets an example for a publicly funded laboratory which more than fulfills its mandate.

We at the Department of Atomic Energy were also the beneficiaries of its consultancy, be it the creep characterization of Prototype Fast Breeder Reactor structural steels, or the mechanical behaviour of Pressurized Heavy Water Reactor piping materials, or the uranium ore processing.

I wish to convey my hearty congratulations and best wishes to all the employees of NML, Jamshedpur on its Diamond Jubilee. I wish that the institution will continue to excel and achieve new heights in its march towards its Centenary and beyond.

Srikumar Banerjee

(S. Banerjee)

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Prof. U R Rao
Chairman, PRL Council, ISRO-DOS
Member, Central Board of Directors, Reserve Bank of India
Chancellor, Babasaheb Bhimrao Ambedkar University, Lucknow
Chairman, Karnataka Science & Technology Academy
(Former Chairman, Space Commission & Secretary, Department of Space)

ISRO/URR/I.19 July 16, 2010

MESSAGE

I am extremely happy to note that National Metallurgical Laboratory is celebrating its Diamond Jubilee this year. NML has greatly contributed to the development of material sciences in this country which also helped our atomic energy and space programs. I wish NML continues to provide leadership in the country in this vital area of development, which is essential to enable India to compete in global industrial economy.

I congratulate NML and its scientists for their excellent work in the past and hope for even better performance in the future.

(U.R. Rao)

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Dr. K. Radhakrishnan
Chairman

MESSAGE

I am indeed pleased to note that the National Metallurgical Laboratory (NML), Jamshedpur is organizing its Diamond Jubilee Celebrations on the Foundation day of NML on 26th November 2010.

National Metallurgical Laboratory, one of the premier laboratories of CSIR family has gone a long way in taking forward the development of Science and Technology in India. Having served as a backbone to the Indian Industries successfully since its inception, I sincerely hope that NML would continue to have its scientific and technological leadership and provide solutions to future challenges in the areas of minerals, metals and materials.

I take this opportunity to congratulate everyone at NML and the CSIR family as a whole for their commendable achievements in the area of Science and Technology. I extend my best wishes for the Diamond Jubilee celebrations and wish NML scales to greater heights of glory in the future.

(K Radhakrishnan)
23rd September 2010

Jamshed J Irani
Director

August 12, 2010

Dear Dr. Srikanth,

Congratulations on the National Metallurgical Laboratory reaching its 60th birthday. It is a fine institution, and you are privileged to be at the helm on the occasion of its Diamond anniversary.

My association with the NML started in the year 1968 when I joined the R&D Division of Tata Steel, which was just across the wall from the NML.

I soon found out that this 'brick and mortar' wall was a formidable divide between the two institutions, not only physically but also, more importantly, in their mental approach. There was hardly any dialogue or cooperation between the scientists on either side. I made it my mission to breach this wall, as it was my conviction - later proved to be right - that cooperation and coordination would benefit both the organisations.

In the next decade, I found an able ally in Dr S Banerjee, the then Director of NML. who invited me to become the chairman of the Research Council (RC). This cooperation was further enhanced by the next Director who was none other than the late Dr P Ramachandra Rao.

With the active support of both these directors, Tata Steel and NML built up a series of collaborations which extended from Iron and Steel technology, through refractory to physical metallurgy. Several joint teams were formed, and I was delighted to see that both sides benefited enormously from the exchange of knowledge without, in any way, stepping on each others shoes.

After all, that is what science is all about: to share knowledge and to synergise for the common good of all the participants.

On this 60th Anniversary, I wish NML all successes in future, and I am sure it will continue to grow to be a jewel in the CSIR.

With best wishes and regards,

Yours sincerely,

Jamshed J Irani

(Jamshed J Irani)

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डॉ. बलदेव राज
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एफएएससी, एफएनएएससी
प्रतिष्ठित वैज्ञानिक एवं निदेशक

भारत सरकार
परमाणु ऊर्जा विभाग
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Dr. BALDEV RAJ, FTWAS, FNAE, FNA, FASc., FNASc.
Hon. Member, International Committee on NDT
Member, German Academy of Science &
Academia NDT International
Distinguished Scientist & DIRECTOR

GOVERNMENT OF INDIA
DEPARTMENT OF ATOMIC ENERGY
INDIRA GANDHI CENTRE FOR ATOMIC RESEARCH
KALPAKKAM 603 102, TAMIL NADU, INDIA

MESSAGE

The diamond jubilee year of one of the premier scientific organizations of our country, the National Metallurgical Laboratory (NML), Jamshedpur, is a significant milestone in the progress of metallurgy and materials science and technology in India. On this momentous occasion, it gives me immense joy to pen my associations with NML in the souvenir, which is a tribute to the past and beckoning of the talents nurtured so far, to meet the challenges of the future.

The National Metallurgical Laboratory occupies a pivotal position in the national network of strong collaborations and valuable cooperation that has been constantly broadened and deepened in various fields. IGCAR has had strong interactions, ever expanding with successive leaderships of NML. The genesis of such interactions dates back to my younger days, when creep testing, structural integrity and advanced non destructive testing (NDT) techniques were essential, to establish a successful fast reactor technology in our country. I firmly believe that many ambitious projects like developing state of the art NDT techniques and materials testing could be successfully completed over these years, with admirable deliverables. This could be achieved only through the joint efforts of NML and IGCAR, through collective sharing of experiences and facilities and worthy collaborations.

I am closely associated with NML for a long time, and in recent years, as the Chairman of Research Council (RC). The periodic meetings of the RC enabled me to appreciate the excellent work being done and guide the future plans. These plans could be implemented successfully to meet the objectives and targets, sometimes even surpassing them, with in-depth scientific understanding and meeting the demanding applications.

I also draw satisfaction from my association with NML as a leading member in formulating a comprehensive proposal to DST for establishing a non destructive evaluation (NDE) Centre for Infrastructure Asset Management and also successfully participating in the discussions with DST that enabled DST to approve the proposal. The new centre is proposed based on the realization that, in the eastern region of India, there is no NDE centre dedicated to research and development, while challenging demands exist from the industry in the area of NDE science and technology. The

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Centre has established strong collaborations with the NDE Centre at IIT Madras and IGCAR. I am most happy that the NDE Centre at NML has blossomed into a well recognized Centre with many developments in NDE sensors, instrumentation and software. The centre is recognized as centre of excellence with credible contributions in research and applications, with a large network of collaborations with eminent national and international institutions of high merit and relevance.

A few of the focused research based activities successfully taken up by the NDE Centre at NML include: (i) Study on crack growth behaviour of steel by acoustic emission testing, (ii) Damage assessment of in-service components by non-linear ultrasonic, (iii) Ultrasonic technique for damage assessment, (iv) NDE signal and image processing, (v) Development of electromagnetic techniques for materials characterization and (vi) Materials development for magnetic sensor application. The Centre has made significant contributions in meeting the NDE requirements of Indian Air Force, Indian Oil Industry and Indian Railways.

During the 1980s, the National Metallurgical Laboratory, Jamshedpur decided to take up an important programme named "Component Integrity Evaluation Programme (CIEP). At that point of time, there was a worldwide concern to meet the challenge of managing huge investments needed for the establishment of new "Green field" plants in the core sectors, in order to cope up with the ever increasing expansion of industrial activities. An alternative approach was to extend the availability of the machines and plants which were still operating. In order to make this approach viable and effective, it was necessary to generate extensive data base on the materials degradations if the plant components were allowed to work beyond their design lives, and to take important decisions as to whether rejuvenations were possible at less cost or whether the components would need replacement. All these objectives were to be achieved with enhanced demands on safety requirements.

While carrying out the details of the planning of the CIEP, it was found that in India, even at the early phase of the life cycle of a component, there was dearth of knowledge-base on the behaviour of critical components under challenging service conditions. NML initiated a courageous and vital step forward to have a wide-encompassing programme to address issues related to the integrity of industrial components at various stages of the life cycle of a component and going beyond their design lives. This programme was supported by many organizations : The Department of Atomic Energy was one of them, with others being Indian Oil Corporation Limited, Bharat Petroleum Corporation Limited, Tata Steel and Steel Authority of India Limited. The interactions also led to the initiation of projects related to the behaviour of high temperature materials in the creep and creep-fatigue regime and development of advanced NDE techniques such as acoustic emission, micromagnetic and ultrasonic NDE with relevance to structural integrity assessment. Infrastructural and expertise base developed at NML are continuously being utilized for the IGCAR programmes, particularly for creep testing of fast reactor structural materials. IGCAR has also hosted one of the review meetings of the CIEP, with overwhelming participation from industry, academic and research centres.

IGCAR has participated in one of the X plan CSIR TECA projects on structural integrity of engineering components, coordinated by NML. As part of the programme, IGCAR has extended the facilities and expertise towards development and characterization of micro magnetic sensors, NDE procedures for creep damage assessment and sensors for structural health monitoring, with active involvement from CGCRI, Kolkata. IGCAR has actively participated in all the review meetings and contributed for the success of the project. We have also enjoyed conducting focused workshops and conferences together, which have strengthened our mutual interactions.

I am fortunate to have worked with eminent and wonderful professional leaders, like Dr. Balraj Nijhawan, Former Director of NML, Prof. S.Banerjee, Former Director of NML, Prof. O.N.Mohanty, Former Deputy Director, NML, Prof. S.P.Mehrotra, Former Director, NML and presently professor in the department of Metallurgy and Materials, IIT, Kanpur, Dr. D.K.Bhattacharya, my former colleague and Deputy Director, NML Prof. R.N. Ghosh, Former Deputy Director, NML, and presently professor at IIT, Kharagpur, the young and dynamic current Director Dr. S. Srikanth and too many to mention individually.

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I had the fulfilling period in shaping and enhancing NML architecture of research and development, with Dr. S.P.Mehrotra, the dynamic inspiring Director, who was always interested to enhance and support the programmes and his colleagues. I would be failing in my duty if I do not make special mention of late Prof. P. Ramachandra Rao, former Director of NML. Prof. P. Ramachandra Rao, one of the most respected members of Indian scientific community, has provided outstanding leadership with deep commitment to NML. Many of us are inspired by his lifetime achievements. I have had the fortune of close collaborations with him and had always respected him for being an excellent human being, ever willing to enhance the capabilities of scientists and enable them to realize their best potential.

The leaders of the past have made outstanding contributions to fulfill the vision of Prof. Shanthi Swarup Bhatnagar at the time of inception of NML and take the institution further, with ever enhancing contributions and earning eminence. I feel privileged to have fond memories of such associations as the prized possessions of my life.

The sterling achievements of NML, need to be guarded and triumphs need to be celebrated. But we are living in a world of rapid evolution. This imposes a greater responsibility on current and future generation, with new opportunities in NML. It is necessary to continue to embrace the rapid advances in science and technology to usher into a new era of challenges and opportunities. I can say confidently that NML is poised to take up mega challenges and deliver frontline research and development.

On this memorable occasion of NML commemorating the diamond jubilee celebrations, it is a great pleasure for me to congratulate all those giants of the past who have contributed to grand success. I wish NML all the best for leaping into greater heights of fame in future, providing the much anticipated support to the science and technology of India.

(Baldev Raj)

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भारत सरकार
GOVERNMENT OF INDIA
भाभा परमाणु अनुसंधान केंद्र
BHABHA ATOMIC RESEARCH CENTRE

विशिष्ट वैज्ञानिक एवं निदेशक,
स्वास्थ्य, संरक्षा एवं पर्यावरण वर्ग
Distingushed Scientist & Director
Health, Safety & Environment Group

एच. एस. कुशवाहा
H. S. KUSHWAHA

At first I wish to congratulate NML fraternity on the occasion of the Diamond Jubilee celebration of their Institution. NML is one of the leading research laboratories in India involved in the area of materials and metallurgical engineering. As a member of the assessment committee for the CSIR networking project, I came to know about the quality of work being carried out at NML, which is at par with the worldwide research. BARC's association with NML started with component integrity evaluation program in 1994 with an objective to demonstrate the safety of the critical components in the existing operational plants. Engineers worldwide had started applying the principle of leak-before-break as part of the philosophy of fail-safe design criteria. We were in the process of demonstrating the leak-before-break design criteria for the primary heat transport system piping of Indian Nuclear Power plants. Therefore, there was a need to generate database of the fatigue and fracture properties of the materials used in the Nuclear power plants. NML was the right place to carry out this work because of their expertise in the area of experimental fracture mechanics. NML Scientists agreed to work in collaboration with us. Fracture toughness test results indicated that initiation fracture toughness (J_{IC}) cannot be evaluated as per the conditions given in the ASTM standard. This issue was addressed after understanding the physical significance of the initiation fracture toughness that the initiation of crack starts after blunting in the material ahead of the crack tip saturates. The features of blunting and tearing can be differentiated on the fracture surface of the tested specimens and the stretched zone width can be measured. This SZW parameter does not depend on the thickness and size of the specimens. Finally initiation fracture toughness based on SZW was established.

To understand the behavior of materials under seismic loading conditions, there was need to evaluate the fracture toughness of the material under cyclic loading and there was no standard available. NML scientists in collaboration with BARC developed the procedure for the evaluation of fracture toughness of the material under cyclic and dynamic loading. This helped in carrying out the analysis of the components under seismic loading conditions and the safety margins were established. Embrittlement of the material due to the Dynamic strain ageing (DSA) effects was also quantified.

Residual life estimation and extension calls for the evaluation of material properties of the ageing components and this is possible if the technique is developed to measure these properties in-situ or using miniature specimens. Again NML scientists took up this challenge of establishing techniques to evaluate the material properties. This was established by carrying out the large number of tests using ball indentation tests and the miniature disk bend specimens on tabletop machine customized to carry out the tests. These results were compared well with conventional tests as per the ASTM standard for large number of materials such as

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ferrous, non-ferrous, heat-treated materials and the welds. After establishing the ABI technique, there was a need to develop a portable ball indentation system so that properties can be evaluated in-situ. Again NML scientists along with BARC conceptualized, designed and fabricated the portable ball indentation system with the help of M/s DUCOM, Bangalore. This system was validated by carrying out the tests on various types of materials and the system is functioning satisfactorily.

BARC is in the process of demonstrating the life of the PHT system piping (austenitic stainless steel) of the proposed Advanced Heavy Water Reactor (AHWR). Low temperature sensitization is the one of the life limiting degradation mechanisms which needs to be addressed. This requires accelerated ageing (7 years at 350°C) and testing of the materials for susceptibility to sensitisation. This issue has been addressed by NML and further investigation on effect of strain on the low temperature sensitization is being investigated.

Apart from this, large numbers of tests have been carried out for low cycle fatigue and fatigue crack growth on pipe and pipe weld materials to understand the fatigue behavior of the materials at operating temperatures. Fatigue ratcheting behavior of the materials has also been investigated. Recently NML scientists along with BARC have successfully established testing procedure for carrying out tests on tubular specimens to address the issue of multiaxial loading on the fatigue behaviour of the materials.

Damage mechanics modeling of the materials requires the metallurgical parameters such as void fractions etc at the various levels of loading conditions. The measurements were carried out under SEM by NML, which helped BARC in predicting the fracture behavior of the material numerically.

We have found NML scientists to be enthusiastic, willing to take up work in new areas with keenness. They were more than willing to listen to the other side of argument, and implemented the corrective measures, wherever required. Due to this, BARC's association with NML has been very fruitful and has helped in resolving the several issues. We are indeed proud to be associated with NML and wish to continue this relation for years to come.

My best wishes for further growth and success !

(H.S. Kushwaha)
Director, HS&E Group

Mumbai
July 27, 2010

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INDIAN NATIONAL SCIENCE ACADEMY
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Prof. M. Vijayan
President

I am delighted to learn that the National Metallurgical Laboratory (NML), Jamshedpur is celebrating its Diamond Jubilee in 2010. The dawn of independence witnessed the founding of a series of national research institutions in India with the support of the visionary Prime Minister Jawaharlal Nehru. NML is among the prominent of them. Over the years, the Laboratory has done India proud. We are living through exciting times when India is beginning to be recognized as a major economic player in the comity of nations. In this phase also, I am sure that NML would continue to serve the country with distinction.

M. Vijayan

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DR. P.S. GOEL
President

Dr. Vikram Sarabhai Distinguished Professor (Hon), ISRO Hqrs., Bangalore
Formerly Secretary, Ministry of Earth Sciences; Chairman, Earth Commission and Member, Space Commission & Director, ISRO Satellite Centre, Bangalore

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Ref: INAE/406

October 4th, 2010

MESSAGE

I am happy to note that National Metallurgical Laboratory (NML), Jamshedpur is celebrating its Diamond Jubilee Year during 2010. The scientists at NML have made significant research contributions towards the advancement of state-of-the-art engineering and technology in the crucial area of metals, minerals and materials. In particular, NML has made an impact in the fields of Advanced Materials Development, Magnetic Materials, Rapidly Solidified Alloys, Surface Coatings, Metallic Foams and many others. Its materials evaluation and characterization facilities are at par with the best in the world. NML's foray in the sector of Energy and Environment with emphasis on Waste Utilization, Metals Recycling, Green Metallurgical Technologies and Pollution Mitigation addresses the need of achieving sustainable development.

I wish the Diamond Jubilee Celebrations on the Foundation Day of NML on 26th November 2010 all the success. NML has evolved into a premier institution in the country in the area of metals, minerals and materials and I have no doubt that it shall continue to soar to greater heights of excellence.

(Dr. PS Goel)
President INAE

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Prof. Asis Datta
Ph.D., D.Sc., FNA, FASc., FNA Sc., FTWAS
Professor of Eminence
Formerly :
Founder Director, National Institute of Plant Genome Research and
Vice Chancellor, Jawaharlal Nehru University

Message

I am happy to note that the National Metallurgical Laboratory (NML) of (CSIR), Jamshedpur, having successfully completed its 60 years, is celebrating its Diamond Jubilee in the year 2010. Certainly, over the years, NML has established itself as one of the oldest national laboratories of CSIR. In the world of scientific & technological advancements the contributions of NML in gearing the industrial revolution of India, are worth praising.

This Laboratory has great heritage and legacy; as its foundation stone was laid by Hon'ble Sri Chakravarti Rajagopalachari and the first Prime Minister of India, Pt. Jawaharlal Nehru formally inaugurated this Laboratory. Since then, NML played a significant role in the industrial revolution of India especially in the area of mineral processing, iron and steel making, ferro-alloys, extraction of non-ferrous metals, notably magnesium and qualification of materials of India's atomic energy programme.

It is good that NML is proposing to publish a commemorative volume having the chronological details of the developments associated with the its glorious genesis. It is time to celebrate.

With all my good wishes for a successful organization of the Diamond Jubilee Celebration's Programmes.

(Asis Datta)
President, NASI

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सर्व शिक्षा अभियान
सब पढ़ें सब बढ़ें

FROM THE PRESIDENT

MESSAGE

The National Metallurgical Laboratory of CSIR is one of the pillars of India's remarkable heritage in metallurgy. As one of CSIR's first national laboratories, and indeed as India's first national laboratory in metallurgy, NML has played a path breaking role in the country's metallurgical flowering, in iron and steel making, in the extraction of non ferrous metals, in its high temperature testing facilities, and in many other fields. It has been my privilege to be personally associated with many of NML's scientists and leaders over the last few decades. NML has been an integral part of the growth of the Indian Institute of Metals through the many faceted contributions of its leaders such as Prof Nijhawan, Prof Altekar and Prof Ramachandra Rao who also presided over the IIM. I am honoured, on behalf of the Indian Institute of Metals, to greet the NML family on the momentous occasion of the laboratory's diamond jubilee year. While we rejoice with the laboratory on their celebration of 60 years of glorious achievement, we are also sure that the best that the laboratory has to offer the nation is yet to come. We wish the NML family all success in their endeavours.

DIPANKAR BANERJEE

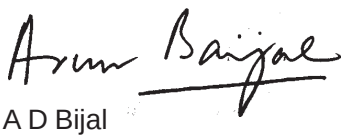
MESSAGE

It is a matter of great pride and pleasure for me to be a part of the occasion when National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee.The National Metallurgical Laboratory(NML) was the first of its kind when it was established to serve the minerals and the metal industry in India. The Laboratory has made significant contributions through very important and challenging projects over several decades.

It is very gratifying experience for me personally to be associated with NML as a Senior Industry Executive as well as National President-Indian Institute of Mineral Engineers.

I am quite sure that the Laboratory will continue to serve the industry and the nation through innovative solutions and close participation with the industry through new developments with modern technologies.The Industry is looking forward to cost effective and environmental friendly processes to maximize utilization of natural resources for sustainable development of high quality products and services.

I wish the Jubilee Celebrations a grand success.



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Subject : RE : Diamond Jubilee Year of NML
From : “Ramesh Mashelkar” <ram@ncl.res.in>
Date : Wed, July 7, 2010 12:18 pm
To : director@nmlindia.org

My dear Srikanth,

My heartiest congratulations on the Diamond Jubilee.

I think very highly of NML's contribution. It has also had some exceptional leaders over the years.

I am unable to comply with your request to write an article.

The whole of July is busy with foreign travel and board meetings.

I wish NML all the very best in its journey from the diamond to platinum jubilee.

Warm personal regards,

R.A. Mashelkar

Dr. Bal Raj Nijhawan
Former Director
National Metallurgical Laboratory

Sukh Villa
Kokomo, Indiana. USA.
October 1st, 2010

Message

I have been privileged and honored to have lived long enough to be a small part of the history of India, and to have been one of the members of this leading and prestigious international institution. To say that I am proud of my association is an understatement. But in order to fully appreciate and honor the National Metallurgical Laboratory (NML), it is important to pay homage to its real founders and its history, on this special occasion of its Diamond Jubilee to be celebrated on November 26th, 2010.

At the time when the foundation stone of what was to become NML was laid on November 21st, 1946 India was still a colony of Britain, and I was just a young metallurgist. Following Independence, the Laboratory was formally inaugurated on November 26th, 1950 by Pandit Jawaharlal Nehru who inspired our young India with a vision of hope and an enduring faith in our future. Pandit Nehru spoke to our hearts at the time and challenged us to come and work with a zeal that would have great consequence. I can recall that while the vision of India's founding fathers focused on self-sufficiency, practical science, and establishing a foundational growth for the future, it would be dependant upon the scientists, engineers, and the people of India to grasp this fundamental truth in order to make it a reality. I have many memories of early colleagues who not only worked hard, but who sustained this vision so that Pandit Nehru's words would come true " … service to science is real service to India - no, even to the whole world - science has no frontiers." Self-sacrifice and commitment to grow a Nation required the following basic characteristics : never give up attitude; to lead by example; commit to excellence; focus on action and urgency; and to find common ground for the interests of the Nation, above self-interests. I am proud to say and humbly acknowledge that all the great men and women of the early years of NML exhibited these characteristics - something that I can see has continued to this very day, 60 years later.

Sir Shanti Swarup Bhatnagar visualized in 1940 a network of research institutes that would be required to take the country forward in science and technology. It is critical to recognize and give homage to the core strength of what NML is today - a leading research and development metallurgical institute that is contributing significant value to India's industry and to research efforts globally. This is a sign of respect for Sir Shanti Swarup Bhatnagar's research orientation and fundamental approach to establishing and growing what became the Council of Scientific and Industrial Research (CSIR) in post-independence India. Sir Bhatnagar's vision, Pandit

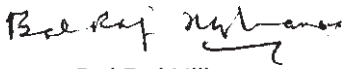
Nehru's inspiration, and the commitment of the early pioneers of NML was just the right mixture for NML, and what has now become a globally recognized Institution.

In the foundational years of the NML, there was a close cooperation between the Laboratory and industry. The establishment of the Laboratory was generously supported by Tata Industries Ltd., Sir Ratan Tata Trust and Sardar Bahadur Sir Indra Singh of Indian Steel and Wire Products. With these seed investments, the Laboratory set the pace for rapid growth in the initial planning years through the establishment of pilot plants and research programs. International symposiums created the forums for knowledge and research exchange of know-how and global initiatives. Following my tenure at NML, and while I was in the United Nations Industrial Development Organization (UNIDO), there were several UNIDO seminars and symposiums that clearly established the leading role that NML has had to play. The success that NML has enjoyed these past 60 years is in no small measure due to the significant leadership that the Directors and the scientists of the Laboratory have provided. You are blessed to have had impactful leaders so far, and I am confident that under Dr. Srikanth this example will continue in the future.

I am humbled to have had the opportunity as a young man to have experienced the joy and inspiration of the founding fathers of India, and the founding visionaries of the Laboratory. NML has been my life and joy. It was said of Sir Shanti Swarup Bhatnagar that " Action was the breath of his life and he could not live without work." Now, 60 years later I am humbled and respectful of the many colleagues, friends, and visitors from all over the world whom I have come to know and love, through my association with the NML. The names are many and it has been my privilege to have known you and worked with you.

When I rest, I am reminded of Pandit Nehru's words : " … But when I come to Jamshedpur it is not the past of India that comes up before me but some vision of the future comes before my eyes." My mission is almost done, but yours is still growing. I know that when I am gone, my heart will still live in the hallowed halls of the National Metallurgical Laboratory in Jamshedpur.

With my heartfelt congratulations to each of you and to the fine institution of NML, on this occasion of its Diamond Jubilee. May your spirit live long and your visions be fulfilled.



Bal Raj Nijhawan

R. Gupta
Chairman & Managing Director

URANIUM CORPORATION OF INDIA LTD.
(A Govt. of India Enterprise)

MESSAGE

I am glad to learn that National Metallurgical Laboratory (NML) is completing its 60 years of glorious service to the nation. Located at the centre of country's rich mineral belt, equipped with many state-of-art facilities and with a strong dedicated workforce, NML has been contributing immensely towards the cause of the mineral industry of the country.

Uranium Corporation of India Ltd (UCIL) with all its production centers in Singhbhum East district has a long association with NML. Over the years, the uranium processing technology adopted by UCIL has been enriched with the precise analytical support from NML leading to fine-tuning of process parameters and improved recovery of uranium and by-products. NML's special contribution towards recovery of copper-nickel concentrate and molybdenum from Jaduguda plant is well illustrated. The on-going research on recovery of uranium from low grade uranium ore of Singhbhum by bio-leaching holds the promise for improved uranium production from Singhbhum region.

I am sure, the proposed Souvenir planned during the celebration of the Diamond Jubilee functions shall detail many glorious achievements of NML. I take this opportunity to thank the organizers for such an inspired effort and wish the event a grand success.

(R. Gupta)

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अशोक कुमार सिंह
अध्यक्ष–सह–प्रबन्ध निदेशक

सेन्ट्रल माईन प्लानिंग एण्ड डिजाइन इन्सटीच्यूट लिमिटेड
(कोल इण्डिया लिमिटेड की अनुषंगी कम्पनी / भारत सरकार का एक लोक उपक्रम)
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A. K. Singh
Chairman-cum-Managing Director

Central Mine Planning & Design Institute Limited
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Gondwana Place, Kanke Road, Ranchi - 834 031, Jharkhand (INDIA)

No. CMPDI/TS/2010/C-S/1301 Dated 18 Aug. 2010

MESSAGE

It gives me immense pleasure to note that National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee this year (1950-2010) and a number of distinct events including **International Seminar on "Mineral Processing Technology (MPT - 2010)"** have been planned as part of the Diamond Jubilee celebration.

CMPDI value the contribution made by NML for the Metal & Mineral Sector and expect that our long standing association will continue in future with more vigour.

I wish the Seminar and Celebration of Diamond Jubilee a grand success.

18/8/10

(A.K. Singh)

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नालको NALCO

ए. के. श्रीवास्तव
अध्यक्ष-सह-प्रबन्ध-निदेशक
A. K. Srivastava
Chairman-cum-Managing Director

Bhubaneswar
Dated 24th August,2010

Message

Dear Dr. Srikanth,

It gives me immense pleasure to know that National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee this year. To commemorate the celebration, besides various activities, NML is also planning to organize the prestigious International Seminar on " Mineral Processing Technology- MPT-2010" during 15-17 Dec.2010.

I am happy to know the long standing Association of NALCO and NML in undertaking various collaborative research projects. The findings of some of the projects have given a new direction to NALCO in forwarding its R&D programmes. NML has always proved itself to be a pioneer National Research Laboratory of our country and the work delivered in the field of metallurgy & material science has been commendable. I am confident that the Institute with your leadership would further excel in the field of Science & Technology and contribute to the nation.

I, on my behalf and on behalf of NALCO wish a grand success to all the scientific fraternity of NML in celebrating the Diamond Jubilee function and its various associated activities taken up by NML during the year.

(A.K. Srivastava)

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राष्ट्रीय इस्पात निगम लिमिटेड
Rashtriya Ispat Nigam Limited

P.K. BISHNOI
Chairman-cum-Managing Director

MESSAGE

It is really heartening to note that **National Metallurgical Laboratory (NML)** is celebrating its **Diamond Jubilee Celebrations** on its Foundation Day on 26th November, 2010. NML has grown from strength to strength over years and it is inspiring to note that it has expanded its canvas of activities to a host of research areas from mineral processing to modeling. The infrastructure facilities available at NML are worth admiration and have greatly contributed to the development of the metallurgical industry in the country.

I compliment the NML collective for their glorious activities and **wish the Diamond Jubilee Celebrations a great success.**

01.09.2010 **(P K Bishnoi)**

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V. S. Gadhavi, I.A.S.
Managing Director

MESSAGE

I am indeed glad to know that National Metallurgical Laboratory (NML) is celebrating its diamond jubilee this year (1950 - 2010). The Mineral Industries is not only directly essential for all elements of civilization but also critically important for conservation of other resources of the mother earth. It is high time to maintain high ratio between raw-material cost to value added products. To achieve this, beneficiation and upgradation of low grade / sub grade mineral for their optimum use for value addition is essential. The role of NML in sustainable developments of our mineral resources is considerable and R & D efforts towards developing innovative and eco-friendly technologies for exploitation of minerals with the improved efficiency low energy investment and high profitability.

GMDC is having a great pride that we initiated setting up of important Fluorspar Beneficiation Plant long back in 1970 through National Metallurgical Laboratory. I am sure that Diamond Jubilee Celebration of NML will provide a unique opportunity for meaningful interaction and create awareness towards maximum value addition of the mineral resources.

I wish the Organising Committee and National Metallurgical Laboratory a great success to this event.

V. S. Gadhavi

GUJARAT MINERAL DEVELOPMENT CORPORATION LTD.

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UNIVERSITÉ LAVAL

Faculty of Science and Engineering
Department of Mining, Metallurgical, and Materials Engineering
Quebec City, Canada G1K 7P4

Fathi Habashi, Dr. techn., Dr. Sci.h.c.
Professor Emeritus of Extractive Metallurgy

Quebec City July 28, 2010

Dr. S. Srikanth, Director
National Metallurgical Laboratory
Jamshedpur-831007
India

Subject : National Metallurgical Laboratory Diamond Anniversary

Dear Dr. Srikanth

Scientia potentia est is a Latin maxim quoted after the Persian philosopher Ferdowsi (940-1020), which in modern times is paraphrased as "knowledge is power". The same phrase is also attributed to the English philosopher Sir Francis Bacon (1561-1626). With knowledge one's potential or abilities in life will certainly increase. Research is the means to gain knowledge and the vision of the Governor General of independent India who in 1946 laid the foundation of your laboratory is certainly well placed.

I have been associated directly or indirectly with your Laboratory for the past thirty years but it was only in 2008 that I had the unique chance to visit Jamshedpur and meet my old friends when I was on my way to Bhubaneswar to attend a conference. I was impressed by the equipment available, the enthusiasm of the young as well as the senior researchers, and the many processes that were developed there. I wish you a successful celebration and continued progress. After all educated people are the most important wealth of a country. Unfortunately I will be unable to attend the celebrations because of a previous commitment.

Sincerely,

F. Habashi

Tel: (418) 656-7269 (Office)
(418) 656-2160 (Secretary)
(418) 651-5774 (Residence)

e-mail: Fathi.Habashi@arul.ulaval.ca
Fax: (418) 656-5343

Subject : Diamond Jubilee
From : "H.D.D.H. Bhadeshia" <hkdb@cam.ac.uk>
Date : Wed, June 30, 2010 6:51 am
To : director@nmlindia.org

Dear Dr. Srikanth,

To have systematically contributed to the scientific well-being of India over a period of sixty years is laudable. But to have done this with such poise and dedication in a field so utterly important to the national interests of India warrants the highest praise.

I have nothing but admiration for the National Metallurgical Laboratory, where I have personally experienced an infectious enthusiasm for the creation of knowledge and a yearning to apply it for the good of humanity.

But sixty years is a short period. As they say in cricket, I look forward to the century. My best wishes to you all on the occasion of your Diamond Jubilee.

With best wishes, Harry

Harry Bhadeshia, FREng, FRS
Tata Steel Professor of Metallurgy
Director, SKF Steel Technology Centre

University of Cambridge
Department of Materials Science and Metallurgy
Pembroke Street, Cambridge CB2 3QZ, U.K.

Brajendra Mishra
The George S. Ansell Department of Metallurgical & Materials Engineering
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July 6, 2010

Dr. S. Srikanth, FNAE
Director
National Metallurgical Laboratory
Council of Scientific & Industrial Research
Jamshedpur, Jharkhand 831007, India

Dear Dr. Srikanth:

I am immensely pleased to learn that the National Metallurgical Laboratory - the premier research facility for metals and materials in India - is celebrating its Diamond Jubilee this year. The contribution of NML to the industrialization and growth of India and to her fast-paced economic progress cannot be overemphasized. NML should be proud of its role in advancing the metallurgical & materials industry over the past sixty years. On this occasion, I am filled with a sense of pride as a research collaborator with NML over the past several years. As an employee of your neighbor in the city, Tata Steel, I had many opportunities to work alongside scientists from NML. I fondly reminisce the long hours spent with Drs. Dash & Singh from NML to successfully develop the process for pure iron production from sponge iron fines. In recent years, I have been associated with your scientists on nanomaterial advances in surface engineering - an interaction where I am particularly impressed by the professionals at NML.

NML's long tradition of providing distinguished scientific support to nation's progress will continue with the same vigor well into the future, no doubt. I congratulate NML on reaching this coveted milestone and wish the very best in its future endeavors.

Kind regards,

B. Mishra

Brajendra Mishra, FASM
Honorary Member, Indian Institute of Metals
2006 President, The Minerals, Metals & Materials Society
2011 President, American Institute for Mining, Metallurgical & Petroleum Engineers

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October 27, 2010

Dr. S. Srikanth
Director, National Metallurgical Laboratory
Jamshedpur 831007 India

Dear Dr. Srikanth,

Thank you for your letter for expressing my experience with the NML. First of all, I congratulate you and your staff for celebrating Diamond Jubilee of the prestigious National Metallurgical Laboratory, Jamshedpur. I have had the pleasure of long-term, continuing research collaborations with the NML. Initially, Dr. Amitava Mitra of the Magnetics Materials Group at NML visited my laboratory at Iowa State University as an Exchange Visitor in the early 1990s and we worked together on various aspects on amorphous metals and the effects of stress on magnetic properties of materials. This was an exciting time and we published about 10 papers together between 1995 and 1997. Some of these publications were in leading journals such as *IEEE-Transaction in Magnetics and Philosophical Magazine.*

Subsequently, we had a joint research grant between the United States and India on "Magnetic evaluation of fatigue damage and deformation." This was funded from the United States National Science Foundation and the Department of Science and Technology of the Government of India. This allowed me to make several visits to NML in the first few years after 2000, and for NML scientists from the Magnetic Materials Group to visit our research group at the Ames Laboratory, USA. We actually made exciting progress on the development of Barkhausen effect for nondestructive evaluation and a further four joint papers were published between 2004 and 2006. We continued this work after I took up the position of Director of the Wolfson Centre for Magnetics at Cardiff University in the United Kingdom between 2005 and 2010.

I was pleased to have the opportunity to make so many fruitful visits to NML. The works conducted by both sides during our collaboration were published at conferences and in leading journals. I was impressed by the excellent facilities at NML particularly in the Magnetic Materials Group laboratory, which contains state-of the-art equipment, in some cases constructed by NML staff, such as the hysteresisgraph and Barkhausen spectrometer, and of course their outstanding scientific staff who have always been a pleasure with whom to work. Besides the magnetic group, I had strong interaction with the mechanical metallurgy group and was very much impressed by the facilities that NML has on the creep and deformation behaviour of materials and also with the scientists working on corrosion. In addition to my collaborations with your scientific staff, I had opportunities for social interactions with families and other members of NML. I found that the community within the NML is very strong and welcoming and certainly reflects well on your laboratory.

Now that I am back in the United States, I look forward to further collaborations with NML and future visits to India.

Sincerely,

David C. Jiles
Anson Marston Distinguished Professor
Palmer Endowed Departmental Chair
Department of Electrical and Computer Engineering

TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG

Institut für NE-Metallurgie und Reinststoffe

Congratulations to 60 years of excellent research !

First of all let me send my warm and heartily congratulations for the Diamond Jubilee of the National Metallurgical Laboratory in 2010. 60 years of research on minerals, mineral processing and metallurgy of steel and nonferrous metals is a long history and has lead to an impressing organisation that plays an outstanding role in the scientific globalised world.

For more than 25 years I could observe the impressing and sometimes even path breaking research activities of NML, especially focussed on the field of nonferrous metals. This includes the whole range of metals from Aluminium over copper to zinc, and even the whole range of projects on steel making. At any time the quality of the published work was on the highest standards in the world, and a large amount of ideas and technical innovations was spread from the members of NML all over the world.

In 2001 I had the great luck and honour to improve my knowledge on NML by an invitation of the Central Electrochemical Research Institute in Karaikudi, that lead me for more than 4 weeks over Karaikudi, Madras Center of NML to Jamshedpur. I was deep impressed on the research that was done in India, but even more I was impressed on the warm and friendly hospitality from my colleagues all over India. It was the beginning of deep friendship to some colleagues of NML, and in the following years we altogether had the possibility to initiate scientific visits of Indian colleagues to Germany, on the other hand I could join the MPT 2006 in Chennai.

At this moments let me pronounce that I am honoured by NML to be one member of international advisory board for the MPT 2010, and I want to thank all of my friends in India for the confidence and outstanding hospitality I could come to know.

For now more than half a century NML is a model for success. It is a motor for the technical development in India and even in the whole world. The economic growth in India would not have been possible without an organization like NML.

But please let me focus this a little bit more: This large and beneficial impact of NML is borne by the people of NML. Scientists, technicians, people of the administration and all the others, that helped NML to become a worldwide known and highly accepted research organisation made this success possible. And from my personal point of view this success will continue over the next years, as long as the employees of NML are so highly motivated as now, and additionally feel as members of a large community precisely as members of NML.

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In this context it is really difficult to single out a special person, but nevertheless let me try to do so. For the time being in India and also for the time having my friends from NML here in Germany Dr. Rakesh Kumar and Dr. Srinivasan Srikanth have been the most impressing persons to me. Their personally warm and friendly hospitality and support and just as well their impressing scientific competence made them to personal friends and partners in the way of scientific cooperation.

To sum up, I'd like to wish NML decades more of success, having the right people and the best ideas for a sustainable development in India and even worldwide.

Prof. Dr.-Ing. Michael Stelter
Director of the Institute for Nonferrous Metallurgy and Purest Materials
TU Bergakademie Freiberg

KOREA INSTITUTE OF GEOSCIENCE & MINERAL RESOURCES (KIGAM)
92, Gwahang-no, Yuseong-gu, Daejeon 305-350, Korea

July 30, 2010

Diamond Jubilee Greetings to NML, Jamshedpur

We, the researchers and the staff members of Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon, Korea, are pleased to offer our warmest greetings to the National Metallurgical Laboratory (NML), CSIR, Jamshedpur, India on the occasion of its Diamond Jubilee Celebration for achieving significant milestones in the preceding 60 years. In particular we would like to remind to the scientists and staffs of this institution – NML that because of the persistent plan and policy, elaborate tactics to foster the growth of science and engineering of metallurgy, long term strategy, and perseverance, it has been possible for them to be outstanding for such a long time. The globalization has further provided unique opportunities to the researchers of this laboratory to be a trendsetter in the broader arena of metallurgy and material science in the coming years at the national and international level.

Both the institutions, the KIGAM, Korea and the NML, India have cherished similar area of research interests such as mineral processing, extractive metallurgy and materials processing, and have made very fruitful joint research collaborations while facilitating closer interaction through individual and group exchange visits of scientists and researchers, to achieve the mutually agreed objectives.

We are indeed honored to be a partner with the scientists and technologists of NML in its research endeavors. In particular our joint research in the area of metal recycling from E-waste is poised to establishing the sustainable future society in both countries. We hope that further collaboration to solve the prevalent and projected mineral resources crisis will be continued under the dynamic leadership of the new Director of NML - Dr. S.Srikanth.

“Our heartiest Congratulations for the excellence achieved and the best wishes for the future endeavors”.

On behalf of Mineral Resources Research Division, KIGAM

Dr. Jae-chun Lee,
Principal Researcher / Adjunctive Professor
Mineral Resources Research Division, KIGAM
University of Science and Technology

Subject: Congratulations
From: "David Gaskell" <gaskell@materials.ecn.purdue.edu>
Date: Fri, July 30, 2010 12:33 am
To: ssrikanth@nmlindia.org

Dear Dr. Srikanth,

I wish to offer my sincere congratulations on the occasion of the National Metallurgical Laboratory celebrating its Diamond Jubilee this year. I have fond memories of the many interactions that I have had with metallurgists at NML over the 43 years that I have been a member of the faculty of a university. I also recall the one memorable visit that I made to NML after a joint US-SAIL conference on steelmaking at Ranchi. I recall that a group of schoolboys waiting at the entrance to NML mistook me for a member of the visiting German national soccer team which was playing matches with various Indian teams at that time.

Best wishes for a successful and enjoyable celebration.

Your sincerely,

David R. Gaskell
Professor, Purdue University
USA

MPA **MPA STUTTGART**
Otto-Graf-Institut
Materialprufüngsanstalt Universität Stuttgart

Stuttgart, July 14th, 2010

The National Metallurgical Laboratory (NML) Jamshedpur, India, is one of the leading institutes in materials research and testing in the field of mechanical as well as civil engineering. NML has achieved this outstanding position during the 60 years of its existence through not only well-founded scientific but also application-oriented excellent research.

During the last decade within the Indo-German collaboration programme the cooperation between NML and MPA Universitat Stuttgart has been intensified. Within this we had the great pleasure of visiting NML several times, especially on the occasion of International Seminars, e.g. Workshop on Fatigue, Fracture and Integrity Assessment (FFIA-2002). Also an exchange of scientists from NML and MPA University Stuttgart could be realised (e.g. Dr. Narasaiah from NML at MPA Stuttgart in 2006 and Mr. Fesich from MPA at NML in 2010).

It is always a great pleasure to see the competence and the expertise of the NML staff and the high quality of the results obtained. From our point of view this applies especially to the fields of cooperation between our institutes which are :

- fracture mechanics material characteristics under consideration of the stretch zone width development to quantify crack initiation reliably for the evaluation of fracture mechanics characteristics for the safety analysis of components
- multiaxial fatigue behaviour of materials, experiments have been carried out on tubular austenitic stainless steel and ferritic steel specimens under tension, torsion, and combined tension-torsion loading with and without phase shifts, thus focusing on the problems related to non-proportional multiaxial stress conditions and enabling the verification of multiaxial fatigue life prediction models which is an important basis for light weight design
- the microstructural investigations on materials damage evolution which is very important for materials development, and optimisation

On this basis a very fruitful and extensive scientific knowledge transfer has been established in the past through both formal and more informal means.

We look forward to a further good cooperation with NML in the future. We wish NML all the best.

Prof. Dr-Ing. Eberhard Roos

Dr S. Srikanth
National Metallurgical Laboratory
(Council of Scientific & Industrial Research)
Jamshedpur - 831 007
INDIA

Univ. Prof. Dr.-Ing. Wolfgang Bleck
Institut für Eisenhuttenkunde
Intzesir.1
52072 Aachen

Deutschland

Aachen, 12 July 2010

Good memories of Jamshedpur

Dear Dr Srikanth,

In 2008 I was awarded the Humboldt Reciprocity Research Award by The Indian Council of Scientific and Industrial Research. I chose The National Metallurgical Laboratory in Jamshedpur as the host institution for my stay.

The National Metallurgical Laboratory embodies an tensely cultivated tradition that is also persued in Germany: making a contribution to solving industrial problems applying scientific methods. For two weeks I had the opportunity to get an idea of how this tradition is translated into action in India. In an excellently equipped working environment and - what is far more important - with excellently trained scientists topics are explored in close agreement with industrial partners, topics that the academic as well as the industrial steel community is concerned with world-wide.

Apart from the inspiring discussions I have experienced a thorough introduction into the Indian culture, daily life and current political life. I gained a deeper insight into the country through those talks and my stay in Jamshedpur. It has been a great experience professionally and personally that I would not miss.

Let me congratulate you on the Diamond Jubilee The National Metallurgical Laboratory is celebrating this year. May this cosmopolitan place be a centre of attraction for scientists and engineers from all over the world in years to come. This place engages people's sympathy for India, its employees and its technical and scientific accomplishments.

Yours sincerely,

Prof. Dr.-Ing. W. Bleck

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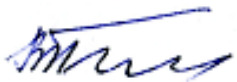
म.उंपसरू तववज/वसपकण्देबण्तनए ीजजचरूछ्ण्वेवसपकण्देबण्तन

Message

National Metallurgical Laboratory (NML), a constituent laboratory of the Council of Scientific and Industrial Research (CSIR), has evolved into a premier Indian organization in the areas of studying minerals, metals and materials. The directions of research and developments at NML include mechanochemical activation. The outstanding results achieved by the NML in the field of mechanochemistry have been recognized by the world scientific community. The NML was an organizer of the 6th International Conference on Mechanochemistry and Mechanical Alloying (INCOME) in 2008. It took up the baton from the Institute of Solid State Chemistry and Mechanochemistry (Novosibirsk, Russia) which organized the 5th INCOME. The ISSChM has already a tradition in the collaboration with the NML. Mechanochemistry has made great progress in the last few years incorporating elements of materials science, nanotechnology, chemical and mechanical engineering and all aspects of metallurgy. This has led to an almost explosive increase in the way that mechanochemistry finds practical applications. Nevertheless, mechanochemistry requires fundamental approaches and new ideas. The objective of the common project between NML and ISSChM is to develop a basic understanding of the mechanisms of mechanical activation and/or mechanochemical synthesis with emphases on interaction of phases in multicomponent systems. The project was supported by Russian Foundation for Basic Research and Department of Science and Technology of Indian Ministry of Science and Technology. The Russian group associated with the project is considered as a pioneer in the field of mechanochemistry. NML has gained significant expertise in the mechanical activation of oxide/oxyhydroxide phases and their mixtures. The synergy between the two groups under the project will result in achieving a new knowledge pertaining to mechanical activation of multi-phase materials, the role of fluid phase etc, which will have potential in the development of new materials / processes. Due to the fact that the NML's materials evaluation and characterization facilities are at the highest world level, there is no doubt that the project will be successful. The future projects are prepared.

On occasion of the Diamond Jubilee of NML, we wish all the people working in NML good health, good luck, and success in their work.



Prof. Vladimir V. Boldyrev, Academician of the Russian Academy of Sciences

Prof. Elena V. Boldyreva

Dr. Tatyana P. Shakhtshneider

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K. Hanumantha Rao, Ph.D.
Professor of Mineral Processing

Dr. S. Srikanth
Director National Metallurgical Laboratory
Jamshedpur- 831 007
India

Luleå, 5 November 2010

Dear Dr. Srikanth

It is heartening to note that the National Metallurgical Laboratory (NML) established in 1950 and inaugurated by the beloved first Prime Minister, Pt. Jawaharlal Nehru, completed five decades of research and leadership in metallurgy now celebrating Diamond Jubilee on 27 November, 2010. As India registering quantitative growth and progressing to become truly developed nation, NML's significant role in innovative research of creating new knowledge and new technology in effective utilization of mineral resources while arresting waste and environmental degradation is indispensable.

I am glad to note of my association with NML for the last two decades where I visited the laboratories in Chennai and Jamshedpur on numerous occasions and exchanged research efforts in fundamental and applied problems in mineral processing. It was a sense of satisfaction to collaborate with NML scientists when they worked at my division in 1990, 1996 and 2000 as visiting scientists on the research problems of mutual interest in the context of Swedish and Indian ore processing industry. I am equally pleased to learn that the students graduated with PhD degree and worked as post-doc in Sweden have joined NML as scientists.

India and Sweden endowed their share of mineral resources in the world; particularly both countries are rich in iron ore. As the socio-economic development of India continues to grow, the per-capita consumption of steel increases and there is a significant opportunity of research co-operation between Lulea University of Technology (LTU) and NML for developing the scientific base of minerals industry and metal extractive industries. I strongly believe that the existing co-operation between LTU and NML will strengthen further in the years to come under the umbrella of the Centre for Advanced Mining and Metallurgy (CAMM) which has been recently initiated at our university by the Swedish government under Swedish Strategic Research Initiative programme.

I, on behalf of the staff of the Department of Chemical Engineering and Geosciences, LTU, Sweden, heartily extend our best wishes for the grand success of Diamond Jubilee celebration while complimenting NML's role in balanced sustainable development of raw material industries.

K. Hanumantha Rao

(K. Hanumantha Rao)

Institutionen for Kemi oeh Metallurgi/Department of Chemical and Metallurgical Engineering
Avdelning for Mineralteknik/Division of Mineral Processing

MESSAGE

July 8, 2010

It brings a lot of good memories while I was working at NML as senior research Fellow. I was a fresh graduate in the field of Metallurgical Engineering from Regional Institute of Technology (RIT), Jamshedpur, now known as National Institute of Technology since December 27,2002. When I look back, it is hard to imagine that I joined NML in 1966 under the leadership of Dr. Balraj Nijhawan, the first Director of the laboratory, who has made notable contributions in iron and steel making. During my tenure, I learned how to address galvanizing among other areas such as modeling of porosity during casting under the guidance of Mr. Kapoor and Mr. Gupta. When I recall the facilities at NML, it was unique in many ways including the availability of working transmission electron microscope. I wanted to continue my career at NML but did not find suitable position. I left in 1968 when Dr. Banerjee became director of the laboratory. I landed at Carnegie Mellon University where I got my M.S. in Materials Science and later Doctor of Science from George Washington University.

During late eighties, I was part of a group that initiated nearly 50 projects in India under PL-480 program that brought cooperation between most of the leading institutions in India and the United States. National Metallurgical Laboratory was part of this program. This gave me the opportunity to visit NML during nineties and early two thousand including other institutions. At NML, we coordinated with R. N. Ghosh, O. N. Mohanty, D. D. N. Singh, S. Tarafdar and others on project titled "Fundamental investigation in Advanced Ferrous Alloys". I visited the unique creep testing facility at NML and followed the work. We published two proceedings under the heading of "Indo-US Collaboration in Natural Sciences", one in 1997 and the other in 2004, where we described the outcome of the projects including the work at NML. I follow the work of NML with pleasure. NML continues to play a vital role in providing scientific solutions to the industries in the areas of minerals, metals and materials. It is, indeed, a great pleasure for me to share my association and feelings for NML during the celebration of Diamond Jubilee of National Metallurgical Laboratory, November 26, 2010. I wish the best for future.

M. Ashraf Imam, D.Sc., FASM
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Dr S Srikanth
Director
National Metallurgical Laboratory
Jamshedpur,
India

6 September 2010

Dear Dr Srikanth

I am absolutely delighted to know that NML will be celebrating its Diamond Jubilee this year. Congratulations to you and all staff members of NML for celebrating this momentous occasion. I may not be able to attend this event due to my current teaching commitments. However, on a personal note, I do share the joy and pride for my affiliation to NML. My association with NML began in late nineties when I was invited by Dr. Amitava Bandopadhyay to present a paper at EWM-1998. I was an academic staff at University of Malaya that time. Although EWM was primarily a national conference, the sessions had some excellent papers. This event encouraged me to attend the subsequent event, EWM-2000. It had a more intense international flavour and I was privileged to attend the conference as a TOKTEN-UNDP fellow, supported by NML. In the year 2004, I led a consortium of EU and Indian researchers to set up world's first chemical free arsenic removal plant based on bioremediation in India. NML was the lead Indian agency in that consortium that successfully commissioned a trial plant for this purpose near Kolkata.

Reflecting on the events of the past ten years, I must admit that I am humbled by the support extended to me by fellow researcher Dr. Amitava Bandopadhyay and other colleagues of NML. It may be worth mentioning that our work has received international recognitions such as St Andrews Prize for the Environment in 2010. I would like to congratulate you and fellow staff members again for your achievements and thank you all for your unfailing support to me over the years.

Yours sincerely

Bhaskar Sen Gupta
Senior Lecturer in Environmental Engineering
School of Planning, Architecture and Civil Engineering
Queen's University Belfast; BT9 5AG UK

Niraj Bajaj
Chairman & Managing Director

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Message

It gives me immense pleasure to note that one of our Premier Institutes in the Country, National Metallurgical Laboratory, Jamshedpur, set up by Pandit Jawaharlal Nehru just after independence, is going to celebrate its Diamond Jubilee on its Foundation Day on 26th November, 2010.

Mukand's association with NML goes back to quite a few decades, when the Country didn't have many metaliurgical research/testing facilities and Mukand had to call upon NML's expertise and facilities for its steel related developments. Being a quality conscious organization and having an enviable track record for technical professionalism, Mukand always had a bias towards quality improvement and innovative technologies. And in that pursuit, who else but the IITs and NML had to be approached for collaboration. Thus the R&D of Mukand (serving its Foundry as well as Steel Divisions) often had close interactions with NML for exclusive property evaluation activities, for its rolled steels and castings.

This momentous occasion of Diamond Jubilee celebrations, therefore, invokes special emotional sentiments for us in Mukand. I am sure NML will continue to uplift the glorious values of ***Quality Research*** in the Metals, Materials and Minerals, in the Country.

My heartiest compliments to all of you !!

Niraj Bajaj

MUKAND
Infinite resolve

MESSAGE

It gives me great pleasure to greet the National Metallurgical Laboratory (NML) on the occasion of its Diamond Jubilee Celebrations. It has had a glorious 60 years of growth and accomplishments and I salute it.

I learnt about NML during my undergraduate studies in Metallurgy in the mid 1960' s, at the Indian Institute of Science at Bangalore. Then between 1973 and now, I have had many contacts with NML in various capacities. I have greatly enjoyed this association. I fondly remember my interactions with many of the Directors, namely, Prof. V.A . Altekar, Prof. P. Ramachandra Rao and Prof. S.P. Mehrotra. I had the pleasure of delivering a CSIR Diamond Jubilee Lecture at NML in September 2003 on the topic "Some Thoughts on Leadership and Knowledge".

Also, during my year as the President of Indian Institute of Metals (2009-10), I noted the continued passion of NML scientists in the broad spectra of Metals, Metallurgy and Materials Engineering.

I wish NML a very successful future.

With best wishes,

Dr. Sanak Mishra
Vice President of ArcelorMittal

Chief Executive Officer
Greenfield Projects India

ArcelorMittal India Ltd.
Plaza M-6, 6th Floor,
Jasola District Centre,
New Delhi - 110025 India

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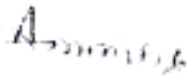
Message

I am glad to note that NML is celebrating year 2010 as its Diamond Jubilee year.

Tata Sponge recognizes excellent testing and analysis facilities that NML has.

The Company has been extensively using the services of NML for testing of coal, iron ore and char. In addition, NML has done exhaustive study for Tata Sponge on utilization of waste product such as fly ash. I am pleased to mention that now Vidya Shakti Niyas, a charitable trust managed by ladies of Tata Sponge township, is successfully making fly ash bricks and marketing the same. Full income from the fly ash bricks is used for social and charitable activities by Vidya Shakti Niyas.

I look forward to a long and fruitful association between NML and Tata Sponge. I wish NML all the success in its celebration.



A.M. Misra
Chairman
Tata Sponge Iron ltd.

TATA Sponge Iron Limited
PO Joda Dist Keonjhar Orissa 758014 India
Tel 91 6767 278178 Fax 278129 Email : info@tatasponge.com

K. J. SINGH
Chairman-cum-Managing Director

MOIL LIMITED
(Formerly Manganese Ore (India) Limited)
(A Government Undertaking)

MOIL Bhavan, 1A Katol Road, Nagpur - 440 013
Tel. : 0712 - 2592070, 2592071
Fax : 0712 - 2592073
E-mail : cmd@moil.nic.in
Website : www.moil.nic.in

16th September 2010

MESSAGE

I am happy to know that National Metallurgical Laboratory is celebrating Diamond Jubilee this year. NML has a glorious history and MOIL has a long standing association with NML. The contribution made by NML to the Indian metallurgical and mineral industries is par excellence. I understand that NML had done a number of research works for production of Electrolytic Manganese Dioxide and Manganese Ore beneficiation. These works have helped MOIL to establish EMD and Beneficiation Plants at our mines. I am also happy to note that NML is organizing an International Seminar on Mineral Processing Technology (MPT-2010). I am sure the pioneer work done on the field of Mineral Processing Technology by NML shall be a boon for the industry and the participants shall be greatly benefited through mutual interaction.

I would like to convey my best wishes to all in NML and wish the institution will continue its good work in future as well.

K.J. SINGH
Chairman-cum-Managing Director

NARENDRAKUMAR A BALDOTA
Chairman & Managing Director,
MSPL Limited, Hospet.

Message

It gives me immense pleasure in congratulating National Metallurgical Laboratory (NML) for its Diamond Jubilee year celebration with tireless contribution in research and development of science and technology.

Indian Mineral Industries are required to adopt Advanced Technology and Scientific Methods, as this is paramount ingredient for continued sustainability of Mineral Sector. NML is contributing its technology development and value addition processes to the economic growth of the nation.

MSPL is happy to be associated with NML for various process development activities towards zero waste management.

At this present situation, a line of thinking towards maximum utilization of natural resources available is significant for sustainability and future demand of raw- material. The development of the society and economy of the country depends upon right usage of the available natural resources including human resource. The NML is giving its best for the development of mineral industries and the Nation by providing advanced processing technology.

I wish the Diamond Jubilee Celebration a grand success.

With best regards,

NARENDRAKUMAR A BALDOTA

Basant Lall Shaw
CHAIRMAN

JAYASWAL NECO INDUSTRIES LIMITED
F-8, MIDC INDUSTRIAL AREA, HINGNA ROAD, NAGPUR - 16 (INDIA)
PH. : (O) 91-7104-236251, 236742, 237471 FAX : 91-7104-237583, 236255
PH. : (R) 91-712-2540711, 2551678 E-MAIL : contact@necoindia.com

August 28, 2010

Shri S Srikanth,
Director,
National Metallurgical Laboratory,
Jamshedpur 831007

Subject : Diamond Jubilee Celebration of National Metallurgical Laboratory

Dear Mr. Srikanth,

I acknowledge with thanks the receipt of your letter dated 28th July 2010 on the above.

I have great pleasure in extending our best wishes to National Metallurgical Laboratory for the Diamond Jubilee Celebrations. Jayaswal Neco Group Companies have long association with your esteemed organisation for technical inputs / collaborations towards upgrading the products / processes of Minerals and Metals.

NML is well known for its achievements towards developing indigenous metallurgical industries in terms of state of art technologies available world over with indigenous raw materials / inputs. NML with its scientific and engineering knowledge pool, in terms of trained manpower and infrastructure, is well placed to serve Indian Industries.

I wish them all the best in reaching to pinnacle of industrial research and development horizon wherein they are comparable with the world's best similar institutions.

With regards,

(Basant Lall Shaw)

GALADA
POWER AND TELECOMMUNICATION LTD.
(An ISO 9001 : 2000 Company)
Admin. Office : 201, Galada Towers, Begumpet, Hyderabad - 500 016.
Phone : 91-40-27766224 / 5, Fax : 91-40-27766226 Email : galada_dc@sify.com
Regd. Office & Factory : P 2/6, IDA, Block III, Uppal, Hyderabad - 500 039. A.P.

GPTL/265 26.08.2010

Dear Dr. Srikanth and one and all at **NML**,

I am thoroughly convinced that **NML** has played a remarkable role in building the metallurgic leadership position of country in the comity of nations. On looking back at the years passed by, my heart swells with joy, that NML has fully utilized the opportunity accorded to it. Institutions like **NML** have definitely played a prominent role in making India a leading scientific Nation. Congratulations on diamond Jubilee celebrations.

Our collaborative experience with **NML** has been most rewarding due to the unstinted support of Prof. Altekar, Dr. Rajendra Kumar and Dr. Manjeet Singh along with their wonderful **NML** team. **GALADA** team along with them worked for years to develop different applications of ***"NML-PM2 Aluminum Alloy"***. I confidently say that this alloy is far Superior as ***Transformer winding wires and strips, Enameled wires, Telecommunication cables, Solid-sector cables, Overhead transmission conductors, House wiring cables, Welding cables*** etc.

GALADA, with **NML** support, mastered the technology of alloy rod rolling, wire drawing and getting above end products tested. Had these products been approved by BIS and widely used by the Central and State Utilities, the Nation would have saved a few thousand Crore Rupees by now. Developmental products, in my opinion should become **National Products of Excellence** and **NML** should further its efforts.

with kind regards

D. C. Galada

Managing Director
Galada Power and Telecommunication Ltd.
301, Galada Towers, Begumpet
Hyderabad - 500016
Andhra Pradesh

SAVING ENERGY THROUGH PIONEERING TECHNOLOGY

आदित्य स्वरूप माथुर
कार्यपालक निदेशक प्रभारी
A. S. Mathur
Executive Director Incharge

स्टील अथॉरिटी ऑफ इण्डिया लिमिटेड
STEEL AUTHORITY OF INDIA LIMITED
आर एण्ड डी सेन्टर फॉर आयरन एण्ड स्टील
R & D CENTRE FOR IRON AND STEEL

MESSAGE

It gives me a great pleasure to note that National Metallurgical Laboratory, Jamshedpur is celebrating its Diamond Jubilee Anniversary this year. Our heartiest Congratulations.

Mineral resources of a country are vital for its economic development. India has seen a rapid development in the field of iron ore production during the last few decades. These non-renewable assets are fast getting depleted. It is necessary to develop appropriate beneficiation technologies for leaner and difficult-to-treat ores & minerals.

NML has rightly chosen this topical theme for its International Seminar on "Mineral Processing Technology (MPT-2010) during December 15-17, 2010 at NML, Jamshedpur. I am sure that the deliberations in this seminar would enrich our knowledge-base to evolve a roadmap for beneficiation of mineral resources in India and other countries.

RDCIS, SAIL, Ranchi have been having more than three decade's association with NML in various research activities in general and Mineral Engineering, in particular. We look forward to foster this relationship further.

I wish the seminar MPT-2010 a grand success.

A. S. Mathur

(A S Mathur)

इस्पात भवन, डोरण्डा, राँची–834002, झारखण्ड, भारत, दूरभाष: (का.) 0651–2411124, 2411126, (आ.) 0651–2410245, 2410061, फैक्स : 0651–2411103, 2411090
Ispat Bhawan, Doranda, Ranchi-834002, Jharkhand, India, Phone: (O) 0651-2411124, 2411126, (R) 0651-2410245, 2410061, Fax : 0651-2411103, 2411090
E-mail:asmathur@sail-rdcis.com ; adityaswarup@rediffmail.com ; Website : www.sail.co.in

DR. S. K. GUPTA
Director, JSW Steel Ltd.
Director, Jindal Saw Ltd.
Director, IVRCL Infrastructures & Projects Ltd.
Director, Sobha Developers Ltd.
Director, Jindal South West Holdings Ltd.
Director, Surana Industries Ltd.
Chairman, Vesuvius India Ltd.
Chairman, BMM Ispat Ltd.

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M : 0982113727 I 098459 17415
E : saibalkgupta@gmail.com

June 21, 2010

Dear Dr. Srikanth,

Very happy to learn that National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee this year (1950-2010). I congratulate you and all the Scientists of NML in this unique occasion. I also remember many stalwarts over the years who had made yeomen services.

We are proud of the contributions of NML in movement of frontiers of knowledge and applications thereof in the vast discipline of Metallurgy in this eventful 60 years post-Independence. I had many occasions to be involved in the activities of NML over the years.

Even recently, I happened to have incited NML to take a leading role in providing key pioneering R&D inputs and services to Indian steel industry in two critical areas. I am observing the developments.

Thank you for remembering me in the occasion, although I will not be in a position to write a memoir in your souvenir, partly because of my pre-occupations and rest due to laziness.

I once more wish that NML continue to provide more path-breaking services in the evolution of India's deserved destiny.

With warm regards,

Yours sincerely

S. K. GUPTA

Bharatiya Vidya Bhavan

BHAVAN'S CENTRE FOR COMMUNICATION & MANAGEMENT

DR. S. K. TAMOTIA
B.E. (Hons), ME (Soil), D.Engg. (Hon)
FIE, FISTD, FAIMA, FIIM, MICWA, MIPM, MIChE, MIME, MICA
Director General
Former Director, Vedanta Resources Plc, London
Former: President & Chief Executive Officer, INDAL
President, Aditya Aluminium, HINDALCO
Chairman-cum-Managing Director, NALCO

Bharatiya Vidya Bhavan, Bhubaneswar Kandra
9, Kharavela Nagar, Bhubaneswar - 751 001
Tel/Fax : 0674 - 2530428, Tel. : 0674 - 2535727 (O)
Tel. : 0674 - 2552888 (R), 9937011356 (M)
E-mail : bvb.mba.bbsr@gmail.com
Web : www.bvbbhubaneswar.org

Date: 09.08.2010

Dear Dr. Srikanth

Congratulations on your taking over as Director, NML.

It gives me immense pleasure to know that the National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee this year. On this occasion I recall my association with NML as a member of 'Research Council' from 2005-2008 and even subsequently as a special invitee.

Contribution of NML specially in the area of conservation of natural resources has been a milestone. Mineral resources are finite and non-renewable. The growth of mineral industries reflect the economic powers of the country. India has a growing mineral sector which contributes approximately 4% of the Gross Domestic Product (GDP) which was only about 0.5% in fifties & sixties. Thus the exploitation and optimal utilisation of these non-renewable natural resources need to be judicious to obtain better value, beside conservation and wholesome utilisation with zero waste.

Cooperation between industry and the institute was another milestone, which helped in proper commercialisation of the results of the research. Normally managers in industry resort to short cuts to obtain fast result but scientists celebrate the severity of science uncompromisingly with peer review process. Willingness of NML Scientists to be part of the Industry has yielded rich dividends.

May this continue in future for the growth of NML.

With best regards,

Yours sincerely,

(Dr. S. K. Tamotia)

M. N. DASTUR & COMPANY (P) LTD
CONSULTING ENGINEERS
P-17, MISSION ROW EXTENSION
KOLKATA - 700013, INDIA

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FAX : (+91-33) 2225-1422 & 2225-7101
E-MAIL : Bhaskar.R@dasturco.in

26th October 2010
1036 - 4969A

MESSAGE

It is a matter of great pride and satisfaction that National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee this year.

NML has been a pioneer in the field of scientific research work and technology development relating to minerals, metals and materials. The scientists and technologists at NML have been rendering invaluable service in the nation's progress towards attaining greater industrialization and technological self reliance. There can be no doubt that NML will achieve even greater success and progress in the years to come.

Dasturco has had the privilege of associating with NML on a number of projects in the past, and we would like to continue this association in the coming years.

I would like to wish the Diamond Jubilee celebrations all success.

Bhaskar Roy
Director
M. N. Dastur & Company (P) Ltd
Consulting Engineers
Kolkata

Subject : Diamond Jubilee Celebration
From : “Dr. MD. Mathew” <mathew@igcars.gov.in>
Date : Fri, August 6, 2010. 12:10 pm
To : director@nmlindia.org

Message

Dear Dr. Srikanth,

Thank you very much for your letter dated 21.07.10 regarding the diamond jubilee celebrations of NML. I am extremely glad that you have taken over the reins of NML at this important point in the history of NML. I have always admired your scientific and managerial capabilities and technical knowledge during our interactions in Chennai.

My interactions with NML date back to the late seventies when we started the creep testing programme at NML on 316 SS which was the structural material for FBTR. Dr. Raghubir Singh was associated with the creep activities at that time from NML. We have been assisted by NML in several of our long term creep studies on 316 SS, 316N SS weld metal and Mod. 9Cr-1Mo steel steam generator tubes, the latter programme was completed only recently. The longest test creep rupture test in the history of IGCAR's creep research was conducted at NML with a rupture time of 140,000 hours. This is a historical test even for creep research in India. There is no doubt in my mind that it was a very significant and important collaboration between IGCAR and NML.

As regards the proposed souvenir, I do not have any photographs that can be retated to the collaboration referred to above. I understand that IGCAR has already contributed an article for the proposed souvenir which discusses the collaborations between the two institutes in details. At that time, we were also looking at some photographs.

I wish NML a brighter future and the celebrations a grand success.

With best wishes and warm personal regards,

Yours sincerely,

Dr. M.D. Mathew
Head
Mechanical Metallurgy Division
Indira Gandhi Centre for Atomic Research
Kalpakam, P.O., TN 603102

भारत हेवी इलेक्ट्रिकल्स लिमिटेड
कारपोरेट अनुसंधान और विकास, विकासनगर, हैदराबाद - 500 093
Bharat Heavy Electricals Limited
Corporate Research & Development, Vikasnagar, Hyderabad - 500 093., INDIA

Kulvir Singh, Ph.D.
Addl. Gen. Manager/ Metallurgy

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निवास / Res 040-27751524
टेलेक्स / Telex 0425-8033
फेक्स / Fax 040-23776320
ईमेल / E-mail kulvir@bhelrnd.co.in

06.08.2010

Sub : Diamond Jubilee Celebration of National Metallurgical Laboratory

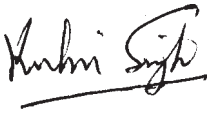
Thank you very much for your letter dated 26th July, 2010 on the above subject. It was my privilege and great pleasure to be associated with NML in many ways.

During late seventies and early eighties, when BHEL R&D was in infancy stage and was establishing its facilities, NML's help was sought in developing and indigenizing many creep resistant steel grades such as T22, T11, T1 and carbon steel grades. The help in extensive creep testing and expertise in analyzing the test results was readily extended by NML. I can recall names of many senior scientists and staff members such as Dr Rajendra Kumar, Director/ Creep and Material Characterization groups, Mr K M Chowdary, Dr Raghubir Singh, Dr R N Ghosh, Shri Kanhaiya Prasad, Shri S C Bose, Shri Y N Tiwary and Shri Arjun Dev to name a few.

In 1980, Shri K M Chowdary and Shri S C Bose joined BHEL R&D and established the second biggest Creep Laboratory after NML at BHEL R&D with 122 Creep Test Points. Extensive help was also sought from Dr R N Ghosh in the area of Creep modelling. We are still collaborating with him being at IIT, Kharagpur.

Looking forward to many more fruitful collaborations with NML in future.

Yours sincerely



(KULVIR SINGH)

G. P. KUNDARGI
Director (Production & Planning)

MOIL LIMITED
(Formerly Manganese Ore (India) Limited)
(A Government Undertaking)

MOIL Bhavan, 1A Katol Road, Nagpur - 440 013
Phone No. : Off. : 0712-2590775, Fax : 2592073
Website : www.moil.nic.in, E-mail : gpk@moil.nic.in

16th September 2010

MESSAGE

It gives me immense pleasure to know that NML has completed 60 glorious years of dedicated service to the nation and celebrating Diamond Jubilee this year. I am proud to say that I have a pretty long association with NML spanning over more than three decades. The studies done by NML on MOIL's manganese ore for production of Electrolytic Manganese Dioxide has helped the Company to establish an EMD Plant at its Dongri Buzurg Mine which is operating successfully. During the Pilot Plant studies for manufacture of Electrolytic Manganese Dioxide conducted during 1987-88 on MOIL's ore at NML, I had involved in the entire study period of three months along with representatives of MECON. I had an opportunity to work with dedicated team of scientists at NML. I recollect the wonderful co-operation and inputs received from all the concerned scientists at NML to complete the studies successfully. Likewise, the beneficiation studies done by NML on manganese ore of our Balaghat Mine has led to establishment of jigging process for up-gradation of manganese ore. I have no hesitation to say that I have always received full co-operation from the scientists and everyone in NML during my long association. It is also heartening to note that NML is organizing MPT 2010 which will benefit the industry a great deal.

I would like to convey my best wishes to all in NML and wish the institution will continue its good work in future as well.

G.P. KUNDARGI
Director (Production & Planning)

Somu Organo-Chem (P) Ltd.
Regd. & Admn. Office : Somu Centre, # 20, MRIEHBC Society, 29th Main, 2nd Stage, 1st Phase, BTM Layout
Bangalore - 560 076. India. ☎ : 6783586, 6783696, 6783728, 6784291 ※ Fax : + 91-80-6783729.

Dr. Uma Raman
Jt. Managing Director

29th Sept 2010

To
Dr. S. Srikanth
Director,
National Metallurgical Laboratory
Jamshedpur

Dear Dr. Srikanth,

It is with great pleasure and an equal quantum of humility, I dare to write this note on my association with NML. Though a look at the NML golden jubilee site where in I notice views of eminent Metallurgists of the Nation discourages me from venturing to record my views, it is the memory of my fruitful and pleasant interactions, I had with the Madras group of NML scientists that gives me the courage to do so.

My interaction with NML is rather short compared to the long existence of this great organization. Nevertheless, it is an example of how a private limited company can interact with a National Laboratory for the benefit of the Nation, however small level it may be. As a technocrat, I entered the manufacturing of reagents for mineral beneficiation a decade back. We had limited success in manufacturing and supplying flotation reagents to Kudiremukh Iron ore Co. Ltd. displacing a multinational organization. However, we could not take our success further to higher levels due to our limited R&D resources. It is at this time, we approached Dr. S. Prabhakar and Dr. G. Bhaskar Raju at the Madras NML complex seeking help in the evaluation of our reagents. It was the warmth with which the entire group at Chennai, led by you that engulfed us leading to the development a host of reagents for mineral beneficiation that includes a single reagent for reducing the ash content in coal to a level less than 10%. It is a pleasant partnership that continues and hope will take us to several significant land marks. As a technocrat from a small scale industry, I would not have dreamt of having such a friendly and fruitful interaction with eminent scientists in your team at the Chennai laboratory. It is this interaction that has introduced me a host of other mineral processing scientists of the Nation through various International Seminars on Mineral Processing Technology.

I wish to record my appreciation to the entire organization (NML) and encourage a host of other industries to partner with NML for mutual benefit thus contributing to the national development like the contribution of a squirrel in the construction of 'Ramasetu'.

With warm regards

Uma Raman

(Uma Raman)

ASHAPURA
MINECHEM LIMITED

August 23rd, 2010

Dr. S. Srikanth, FNAE
Director
National Metallurgical Laboratory
Jamshedpur-831 007
India

Sub: Diamond Jubilee Celebration of National Metallurgical Laboratory

Ref: NML/DJ/DJ-163/2010 dated: July 28th, 2010

Dear Sir,

I understand National Metallurgical Laboratory, one of the most prestigious research institute of India, has been actively involved in the knowledge creation in the area of Minerals, Metals and Advanced Materials. NML' s efforts have been well recognized due to its outstanding contributions made towards Scientific and Industrial growth of our nation.

Ashapura Minechem through its Innovation & Knowledge Centre has long association with NML and has been one our main source of scientific knowledge. We are also one among the other beneficiaries of the state-of-the-art Mineral Processing facilities at NML.

India as marching to become a world power, our Research Organizations has very crucial role to play in terms of Science, Technology and Industrial development. Industries, a downstream beneficiary of research outcome should also come forward to have close interaction with Research organizations to reap the benefit of high level research activities.

When world demands ecological balance and eco friendly environment, means NML have to play a vital role to achieve such expectations through their knowledge and experience.

On the occasion of Diamond Jubilee celebration of NML, I wish NML would continue its efforts as in the past and will always be recognized as an important contributor to the advancement of lndia's Science and Technology.

Wish you all the success.

Sincerely,

Chetan Shah

Jeevan Udyog Building, 3rd Floor, 278, D. N. Road, Fort, Mumbai - 400 001. India
Tel.:+91-22 66651700 • Fax:+91-22 2207 9395 / 2207 4452 • E-mail: ashapura@vsnl.com • Website: www.ashapura.com

Calpro Mineral Technologies
India Private Limited

Date : 08-09-2010

Dear Sir,

At the outset we wish to congratulate NML for celebrating its Diamond Jubilee in dedicated service to our country in developing technologies, processes and supporting the metals and mineral industries.

We are one of the leading mine owners in the business of limestone in Salem, Tamilnadu for over five decades. Over the years the grade of the limestone has depleted which affected our market potential. To increase our business prospects we have decided to beneficiate the low grade limestone to a value added product and find new applications.

We approached NML Madras Centre in the year 2000 for a solution. Lab scale studies conducted by NML were encouraging which prompted us to test the results on a pilot scale. The pilot scale column was erected in a short time at our works and the results were demonstrated for our satisfaction. Based on the confidence on the technology and NML expertise, in 2007, we have decided to invest in establishing an integrated beneficiation plant of 150 tons per day including a commercial scale flotation column near our mines in Sangagiri. The column flotation system with 1.25 metre dia was designed, erected and commissioned in six months time with continuousupport from NML team. We are grateful to the NML team for their dedication and commitment in developing a viable technology for producing a value added product from a low grade ore. We are able to find market for the high grade limestone in the production of white cement and as a chicken feed supplement. Thanks to NML, we are now established as supplier of high quality limestone at a competitive price in the region.

To our knowledge this is first commercial plant in our country beneficiating low-grade limestone utilizing column flotation technology.

We being a small scale entrepreneur are grateful to NML for extending full co-operation in technical issues and consideration in financial matters.

We wish NML a glorious future in its sustained efforts in promoting world class R&D in our country for developing the metals, materials and mineral industry.

Thanking you.

Yours faithfully,

(J Mohan Kumar)
Director

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Adm. Offi : 1.60 PS Garden, Bhavani Main Road, Sankari - 637 301
Email : mohan kumar_jk@yahoo.co.in, Calprotec@yahoo.co.in
Mobile : 99447 72409, 94432 46490 Fax : 04283 - 243022

Arun M. Kumar, PhD
Lab Group Manager
Materials Characterisation and Modelling
India Science Lab
General Motors R&D

21 November 2010
Bangalore

MESSAGE

It's a matter of great pride for all of us to observe the diamond jubilee celebrations at the National Metallurgical Laboratory at Jamshedpur. The Laboratory has enjoyed a rich and vibrant past ever since it was inaugurated and dedicated to the Nation by Pandit Jawaharlal Nehru. It has since then been nurtured, moulded and led by a host of luminaries into a vibrant, modern Institution with state of the art facilities and talented people that it has become known for today. The mission of CSIR to provide scientific and industrial research and development that maximises economic, environmental and societal benefits for the people is well reflected in the activities and in the context of metallurgical science and technology development efforts in the Laboratory. It is a privilege and an honour to be associated with the prestigious National Metallurgical Laboratory as an industry representative from the automotive sector.

Today, India is one of the top automotive growth regions in the world registering double digit growth rate figures. It's not a surprise that global auto OEMs have set up manufacturing facilities in India to cater to the rising demand. Historically, the automotive industry has always had a very critical and dominant influence on the development and application of advanced materials including steels, aluminium, magnesium, polymer composites, etc. This influence is seen both in terms of production volume and product sophistication across these materials. Thus, the automotive sector plays a critical role in the development of new materials, processes, manufacturing methods and new products across primary and secondary material manufacturers, thus strongly impacting the overall development activity, in general. For instance, different classes of advanced high strength flat steel products with novel properties have been developed and commercialised primarily to address critical automotive performance requirements, eventually to the benefit of the end consumer. It is, therefore, very critical for India to evolve a robust strategy on automotive materials against the backdrop of the robust automotive growth in the country in order to affirm its growing influence at the world stage. The National Metallurgical Laboratory is today well placed to take on the challenge and establish a leadership position in this aspect. It can strategically lead and connect both current and future scientific efforts in the country with the automotive requirements and needs, thus creating conditions for new process and product innovations as well as technology development across various classes of advanced ferrous and non-ferrous materials.

Hearty congratulations on the special occasion of the diamond jubilee celebrations and best wishes to the National Metallurgical Laboratory for its continued success in the future.

Arun M. Kumar

From: "Tiruvannamalai Ramachandran" <trramachandran@yahoo.com>
Date: Wed, November 3, 2010 1:03 am
To: "Srinivasan Srikanth" <ssrikanth@nmlindia.org>

MESSAGE

Dear Dr. Srikanth :

Thank you for your message informing me about the Diamond Jubilee Anniversary of NML; I am glad to note that the Jubilee function is scheduled for Nov 27th. As you are already aware, I am presently in the USA and in all probability I would be back in Hyderabad in the first week of December. Consequently I have to deprive myself of the pleasure of participating in the function and meeting with all of you.

As I write this message my thoughts go back to the early 1960s; my first visit to the NML was in Jan 1964. As a young scientist I found it exciting to go round the various facilities in the laboratory. I was particularly impressed by the Pilot plant based on the Pidgeon Process for the production of Magnesium. I have followed with great interest the work in NML on melt treatment of aluminium and development of aluminium cables. I also had the opportunity of interacting with the scientists interested in electron microscopy. In every visit I made to NML, I found something new being developed/talked about and that is an ample reflection of the vibrancy of the organization. All these have happened because of the dynamic leadership provided by a galaxy of metallurgical luminaries heading the laboratory from its inception to the present time. I send my greetings to you and to all your colleagues on this happy occasion and wish the function well.

Wishing you the very best and with regards

Dr. TR Ramachandran

Dr. S. K. Bhattacharyya
B. E. Met (Cal). Sc. D. (MIT. USA). FNAE
Steel Chair Professor

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Department of Metallurgy & Materials Engineering
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Message on the occasion of Diamond Jubilee celebration of NML

I am indeed happy to know that National Metallurgical Laboratory is celebrating its Diamond jubilee this year.

My association with NML dates back to early sixties when I visited the laboratory as a college student. The splendid facilities, particularly the experimental low shaft furnace was quiet inspiring and motivated one to pursue research in metallurgy. .

While trying to develop creep resistant steel indigenously in mid seventies, I was involved from Alloy Steels Plant, Durgapur, SAIL in the creep testing program at NML. The newly procured battery of creep testing machines along with the expertise available at NML paved the way for success of the national mission.

Later on my interaction with NML increased manifold when I was at RDCIS, SAIL. We had a number of fruitful collaboration on projects of national interest with the active support of ministry of steel. With the ambitious plan of producing 200MT of steel by 2020 the steel industry would look forward to lots of technological support from NML.

I wish NML will play the vital role of leading metallurgical research in the country with focus on industrial applications and at the same time provide world class laboratory facilities. I am sure they would be able to fulfill the demands successfully with their excellent pool of scientists, technologists and the leadership.

Dr. S .K.Bhattacharyya

Director : ***Tayo Rolls Ltd., NFL, Beekay Steel Industries Ltd.;*** **Chairman:** ***Steel Expert Group, Govt. of W.B.***
Former Managing Director : ***Durgapur Steel Plant, SAIL; Past President : The Indian Institllte of Metals***
Residence : **34/2, Mahim Halder Street, Kolkata- 700 026**

Message

It is with a sense of pride and nostalgia that I recall my association with the National Metallurgical Laboratory, Jamshedpur, as a member of the Research Council for 3 terms from 1988 to 1998. It was during this period that I came to have a clear picture of the significant contributions being made by NML to the country's metallurgical industry. It was heartening to talk to the bright and dedicated scientists and engineers working against all odds in the then prevailing atmosphere of lack of appreciation for Indian technology. Many facilities had been developed in-house. Several facilities like the mineral beneficiation pilot plant were unique and of great national importance.

I first visited NML in 1958 as a student at BHU. Although we were all highly impressed with what we saw, we had no idea of its actual significance at that time. It was only much later that many of us realized the importance of the organization to the nation's growing metallurgical industry. Incidentally, I also presented my first technical paper in the conference hall of NML in 1967 at the ATM of the Indian Institute of Metals. It was indeed a long and happy association.

On the occasion of the Diamond Jubilee I wish NML continued and even greater successes in the years and decades ahead. I am sure it will grow to be one of the topmost R & D organizations of the world.

P. Krishna Rao
Professor Emeritus , IIT Bombay

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To

Dr. S. Srikanth
Director
National Metallurgical Laboratory (CSIR),
Jamshedpur - 831 007

Dear Dr. Srikanth,

I am writing this letter to you to record our appreciation for the contributions made by the National Metallurgical Laboratory (CSIR), Jamshedpur in connection with the European Commission TiPOT Project on arsenic removal from groundwater through in-situ treatment technology [Also known as Subterranean Arsenic Removal (SAR) technology]. As a lead technology partner from India, NML has implemented the in-situ treatment technology at Kashimpur in the North 24 parganas district of West Bengal in a branch of Ramakrishna Vivekananda Mission (RKVM) during 2005-06. The application of the technology has brought down the arsenic level from ~ 40 parts per billion (ppb) to ~ 3 ppb against the WHO norm of 10 ppb arsenic in drinking water. NMLhas also successfully carried out the process integration and optimization work at Kashimpur in collaboration with Dr. Bhaskar Sengupta, Team Leader, EC TiPOT Project from the Queen's University, Belfast, UK. This EC project was the basis for replication of the SAR technology to six locations in West Bengal in the districts of North 24-parganas and Nadia through a *"Global Development Marketplace, 2006" grant from the World Bank.*

I am very happy to inform you that all the six plants are currently operating successfully and have brought down arsenic level from very high values such as above 200 ppb to less than 5 ppb. Each of these plants is supplying safe arsenic free drinking water to more than 500 people in each locality.

I take this opportunity to thank the National Metallurgical Laboratory (CSIR), Jamshedpur, in particular, Dr. Amitava Bandopadhyay for his invaluable contributions and unfailing commitment to the project and helping to bring in SAR technology in India and for further development of this green, clean and chemical free as well as sludge free technology for arsenic remediation of groundwater. The fruitful application of the technology had a major societal impact and people in the localities where we have worked have realized the health benefits.

On the year of the Diamond Jubilee Celebrations of the National Metallurgical Laboratory, I wish them great success in future.

With kind regards,

Yours sincerely,

Soumyadeep Mukhopadhyay

(Soumyadeep Mukhopadhyay)
Team Leader, World Bank Development Marketplace Project DM-06 880
RKVM-IAS, Kolkata

Also received ..... Goodwill messages ....

From :

Dr A R Upadhya, Director
National Aerospace Laboratories
Bangalore

"Please accept hearty congratulations and good wishes from CSIR-NAL and CSIR-CMMACS and me personally on this historic occasion. We also wish the function all the success."

From :

Dr. Chandra Shekhar, Director
Central Electronics Engineering Research Institute
Pilani, Rajasthan

"We wish NML even greater success during the diamond jubilee year and beyond under your inspiring and visionary guidance."

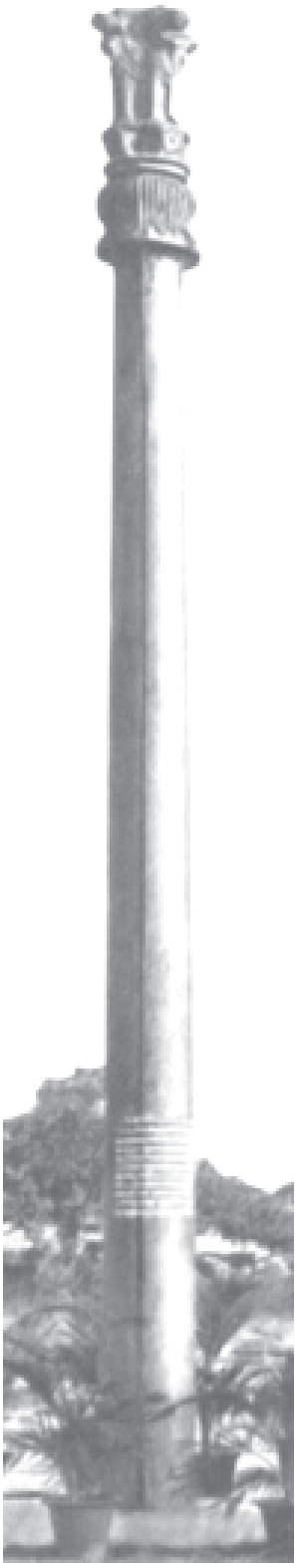
From :

Dr. Satish R. Wate, Director
National Environmental Engineering Research Institute
Nagpur

Dear Dr. Srikanth,

"NML under your leadership will scale greater heights and will continue to enhance the glorious image of NML built over last 60 years.

Reminiscence



Recollections of my association with NML

P. RAMA RAO
International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI)
Hyderabad

My first exposure to the National Metallurgical Laboratory (NML) was during the late 1960s when I was a young faculty member at the Department of Metallurgical Engineering, Banaras Hindu University (BHU). It was an awe-inspiring experience. NML was then led by Dr. B.R. Nijhawan, an internationally renowned stalwart. I noticed that chemistry based metal extraction processes for eventual industrial production was a major theme of the laboratory. The mineral dressing laboratory, equipped with some of the best facilities and led by Dr. Narayanan, a distinguished and well-known expert in the field, made a deep impression on me.

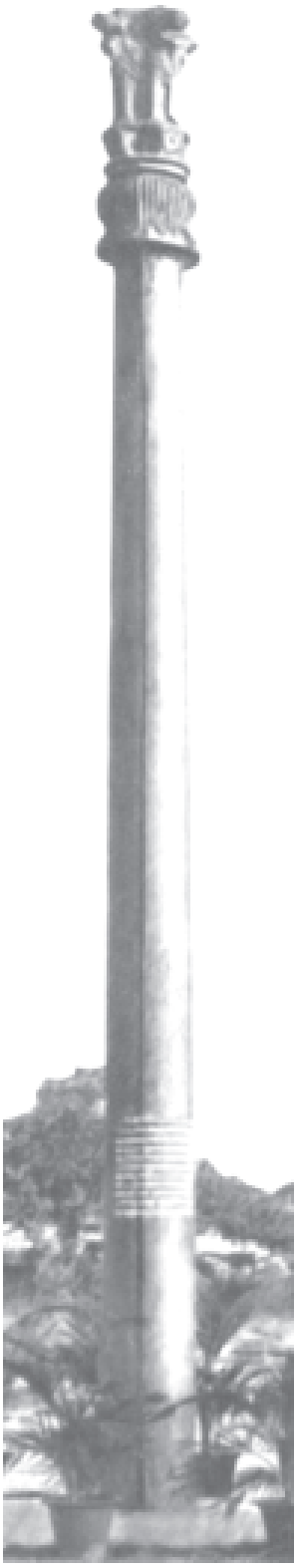
During that period, NML justifiably prided itself on the development of the nickel-free stainless steel which the laboratory had christened 'Thackeron Steel'. We, at BHU, were struggling to develop research programmes. One of the bottlenecks was non-availability of materials of emerging importance for advanced studies. Dr. Kutumba Rao, who had done his M.Tech. in our Department at BHU, opted to carry out his Ph.D. research with me as his supervisor. We chose creep fracture as the problem and I sought the help of NML for supply of Thackeron steel for these studies. Thereby hangs a tale !

I became closely associated with NML during 1984-91. I was initially a member of the NML's Research Council under the chairmanship of Dr. V.S. Arunachalam and later its Chairman. This period, when there was a change of guard, marked a watershed in the history of the laboratory. Prof. V.A. Altekar relinquished directorship after nearly 15 years and Prof. S. Banerjee, who was then a Professor at the Indian Institute of Technology, Bombay, took over the leadership of the laboratory.

The new leader faced several challenges. Some of the pilot plants at NML had become redundant. Similarly, several items of equipment had become obsolete. The average age of the staff was unacceptably high. The ratio of scientific to technical and administrative staff was alarmingly low. Prof. Banerjee was quick to grasp the problems confronting NML. He began to act. The situation showed signs of improvement quickly. The magnesium pilot plant was sold to Southern Magnesium Ltd. Prof. Banerjee initiated steps to restructure the entire R&D programme. Greater thrust was laid on thrust area and sponsored research projects. A majority of the R&D programmes was directed towards four nationally important thrust area projects dealing with beneficiation of low grade tungsten ores, extraction of Ni, Co and Cu from polymetallic sea nodules, production of low S&P pig iron using vertical retort direct reduction and submerged arc furnace route and component integrity and evaluation of industrial components. The Defence Metallurgical Research Laboratory had undertaken a massive project to produce, on an industrial scale, anti-tank ammunition based on tungsten. The NML programme of beneficiation on tungsten ores provided enormously significant support to this defence programme. It is a pleasure to acknowledge this support in this write-up.

Dr. Banerjee's dedicated efforts in locating and inducting new talent began to show results. The flow of funds steadily increased. Particular mention must be made of the World Bank grant / loan of Rs. 350 lakhs to build facilities under the Component Integrity and Evaluation Programme (CIEP). The programme was also supported by a number of Indian science agencies and industrial laboratories.

The Research Council that I was asked to chair had awesome membership : Dr. J.J. Irani, Dr. M.N. Dastur, Dr. S.K. Gupta, Dr. R.K. Iyengar, Dr. L.K. Singhal, Professors HS Ray, PK Rao and PN Chakravorty, Shri CV Sundaram and Dr. Amit Chatterjee who came in as special invitees made the RC even richer. At this time, NML faced a new challenge. Abid Hussain Review Committee mandated CSIR laboratories to earn 30% of their budget through externally sponsored research. Despite severe constraints, NML rose to the challenge and successfully adopted the path of change from mostly state-funded to at least partially industrially funded R&D laboratory. A few industrially relevant projects taken up deserve mention: development of weldable rail steel with higher wear and fatigue resistance, development of wrought magnesium alloy products, process for production of high purity iron powder

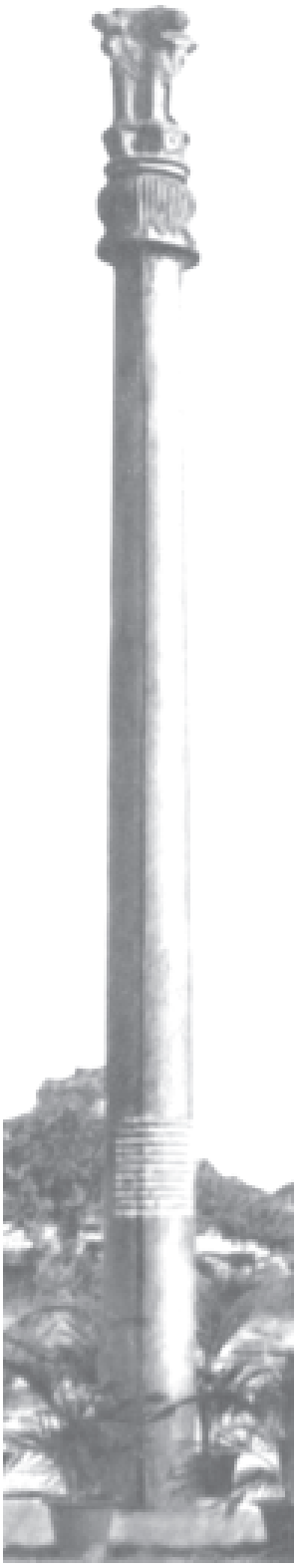


from sponge iron fines, development of ferro alloys (CaSi & FeSi), process for de-ashing of coal, flowsheets for iron ore washing/beneficiation, process for dry beneficiation of limestone and development of new inhibitors (e.g. GALVASAVE, METASAVE).

At the Director's insistence, NML brought out several status reports which not only provided information about, but also direction for the R&D programmes of the laboratory. The Research Council meetings were thrown open to all laboratory scientists and thereby became interactive. With RC laying special emphasis on nurturing younger scientists, not a meeting went without exclusive time being allotted to the presentation of new ideas and interesting research results by the young scientists.

Although my tenure as RC Chairman ended and I became involved in other activities, I made it a point to maintain my contact with this premier laboratory. Prof. Ramachandra Rao and Prof. Mehrothra graciously welcomed my periodical interactions with them and their laboratory. I watched with considerable pleasure the progress NML registered from time to time.

NML has been a pillar of metallurgical research in this country. It enjoys a rich heritage which, I must record, the laboratory has carefully preserved and built upon. The credit should go to the outstanding persons who as Directors have rendered yeoman service to the laboratory. On this historic occasion of NML's Diamond Jubilee, it is a privilege to greet and congratulate the scientists and staff of NML. I wish them every success in their future endeavours.



My Association with the National Metallurgical Laboratory

B MUTHURAMAN
Vice President
Tata Steel Limited, Mumbai

On the historic occasion of the Diamond Jubilee of the National Metallurgical Laboratory (NML) to be observed on 26th November 2010, I would like to chronicle various incidents that I can recall about my long association with this Laboratory - an Institution that is not only a top-class research laboratory in India, but has, over the years. become a global benchmark for other research institutions to emulate. I am sure this will be the most fitting way for me to pay my personal tribute to this. glorious establishment.

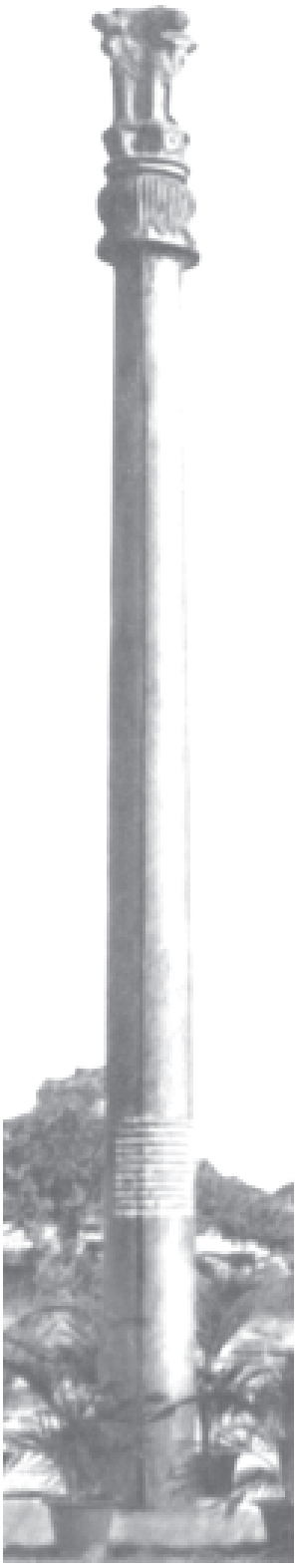
Both Tata Steel and NML are neighbours in Jamshedpur - literally sharing a common boundary wall. To this extent, cooperation between NML and Tata SteeI was perhaps pre-ordained. What has transpired has been a part of destiny! Looking back over the last 60 years, it is clear that the bonding between NML and Tata Steel has been extremely strong. Both the organisations have individually and jointly been actively engaged in furthering metallurgical progress of India, As a result, right from NML's inception, Tata Steel and NML have been partners in several endeavours that have "shaped" India - not many institutions in this country can justifiably make such a claim.

My long association with Tata Steel, beginning with my Graduate Trainee days in 1966 till I left the Company as its Managing Director in September 2009 is well known. What is perhaps not so equally known to many, is that my personal association with NML (and Jamshedpur) began even before I joined Tata Steel. My first visit to Jamshedpur was in 1965, when I was a Metallurgy student in lIT, Madras. In fact, I mentioned this when I was the Chief Guest in the Diamond Jubilee Celebration of CSIR. held at NML in Sept. 2002. I wonder how many persons who were present in the NML Auditorium that morning are still around today, but I am proud that I was personally present in NML, when CSIR observed its Diamond Jubilee and here I have the opportunity to pen some of my thoughts for NML's Diamond Jubilee.

My first visit to Jamshedpur was when along with my lIT Madras classmates, I came for observation training to steel plants, so that we could relate our textbook knowledge to what actually takes place in a steel plant. We were naturally brought to Jamshedpur the place where the steel (and in many ways, metallurgy) story of India began. The then Director of IIT, Madras, Dr. Vibhutibhushan Sen Gupta came along with us. He took us to the residence of a friend ofhis; we landed up in Dr. A.B. Chatterjea's house. Dr. Chatterjea was, I believe, then the Assistant Director of NML. Little did I realise then that Jamshedpur would later become my home, and IwouJd become associated with Dr. A.B. Chatterjea's son, Dr. Amit Chatterjee in my professional Career. The next day, we visited NML's Low Shaft Blast Furnace Pilot Plant facilities. As a student of metallurgy, the visit to a blast furnace, small though it may have been, left a deep impression on my young mind. In a way, therefore,I got to know NML even before I became a metallurgist certainly before many of the NML employees of today were introduced to NML!

In subsequent years, I learnt that the National Metallurgical Laboratory was the third in the Council of Scientific and Industrial Research (CSIR) family of 38 laboratories. The foundation stone of NML was laid on 21st November, 1946 by the first Governor General of independent India, Shri C. Rajagopalachari. The Laboratory was formally inaugurated and dedicated to the nation on the 26th of November, 1950 by Pandit Jawaharlal Nehru "in a spirit of hope and I faith in the future". The Laboratory formed part of a great plan, which Sir Shanti Swarup Bhatnagar visualised in 1940,in order to provide India with a network of research institutes capable of taking the country forward in science and technology. The establishment of the Laboratory was generously supported by the Tata Industries Ltd. and the Sir Ratan Tata Trust, besides others.

The research programmes initially undertaken by NML were in line with the Five Years Plans of the young Republic of India. Over the years. NML grew in size and prestige; I am particularly happy that,



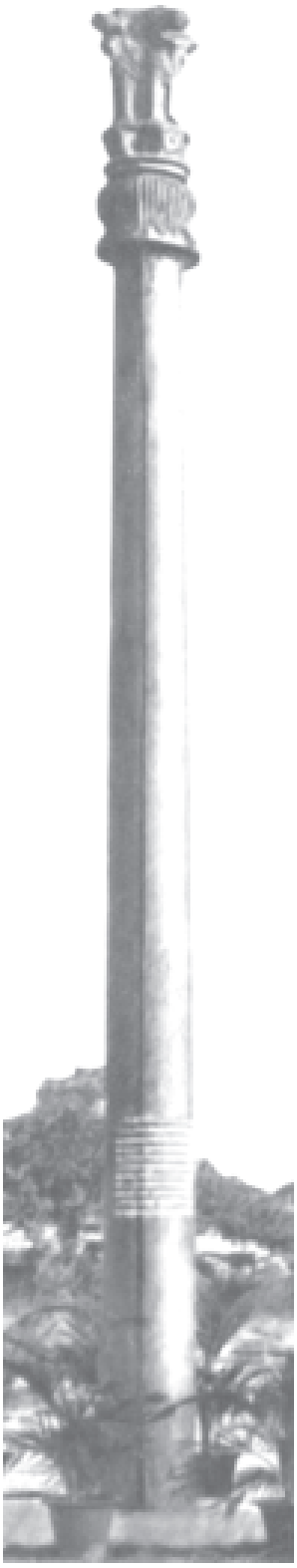
much later, NML diversified its facilities as far as Chennai, which is my home town, by opening a Centre there. I understand that the present Director, Dr. S Srikanth started his research in the Chennai Centre of NML another reason for my “nostalgic" feelings about NML

NML played a significant role in the industrial revolution of India, starting from 1950, especially in the areas of mineral processing, iron and steelmaking, ferroalloys production as welI as extraction of non-ferrous metals, notably magnesium. Asia's largest creep testing facility was also set up at NML in the early 1970's in front of my own eyes. Even today, it ranks as the second largest creep testing facility in Asia. NML has continued to play a vital role in India's quest for scientific and technological leadership by providing ingenious solutions to industries like Tata Steel, in the areas of minerals, metals and materials. Since its inception NML has undertaken wide ranging research in extractive metallurgy, alloy development and import substitution, refractory material development, corrosion studies, mathematical and physical modelling of metallurgical processes, advanced materials, integrity evaluation of critical industrial components (in which again Tata Steel was involved and cleaner and sustainable metals production. To me what is equally important is that NML has also made sustained efforts to create awareness among the common masses on issues relating to health, environment, rural technology and sustainable development by suggesting methods for improving the quality of drinking water in terms of arsenic reduction, etc.

With a strong and committed staff having a wide spectrum of expertise and with the state-of-the-art facilities now available in NML, I have no doubt that this Laboratory will continue to meet the challenges of India becoming a part of the global economy and reaching greater heights in the years to come. I may not be around to join in NML’s Platinum Jubilee, but I am confident that this unique Institution will be the harbinger of greater glory for India in future.

My confidence arises from the personal association I have had with many of the Directors of NML beginning with Dr. Balraj Nijhawan - the first Indian Director of the Laboratory, who set the pace for its rapid growth by encouraging the establishment of a number of pilot plants facilities. NML initially began to make a mark on the research map of lndia during his tenure. I remember that he continued to visit Jamshedpur (and NML) for many international symposiums, even after he joined the United Nations. He was followed by Prof. V A Altekar, Prof. P. Ramchandra Rao and later, by Prof. S. Banerjee. who sat along with me on the Boards ofTata Companies, Of course, I had personal close touch with Prof. S P Mehrotra. As a matter of fact. I had the good fortune of meeting Prof. Mehrotra prior to his stint in NML; when he was in lIT Kanpur where my son studied. As the Managing Director of Tata Steel, I was the Chairman of the Research Council (RC) of NML from January 1, 2004 to December 31, 2006. As the RC Chairman, I interacted on a regular basis with Prof. Mehrotra. I could see for myself that he was one of the pioneers in this country in the area of mathematical modelling and simulation of minerals and metallurgical processes. During this period, I also had the privilege of interacting with luminaries in the scientific community like Dr. Baldev Raj of IGCAR, Dr. P Pradip of TRDDC, and many others. Collectively, we tried to impress upon the NML scientists that the role of the RC Members should not be limited to merely reviewing the progress of ongoing activities of' the Laboratory, but, it was for the scientists to have the necessary passion and creative spirit to challenge the RC Members to provide the focus required lor break through research at NML. I am happy to note that this spirit has now permeated into the very fabric of NML, which augurs welI for India.

Another worthwhile activity embarked upon by NML in this period was to undertake a SWOT analysis, on the basis of which, an attempt was made to prepare a Vision Statement. The Vision Statement was circulated to a number of experts and as per the feedback received from them, the R&D plan of NML was formulated. Purely by coincidence,this happened in the 50th RC Meeting held on March 2005 - another milestone in NML's long journey. when I happened to be the RC Chairman. The Vision document, I understand, still serves as a guide for the R&D activities that are taken up by this Laboratory. Another particular incident that I can recall was that NML was requested to organise a meeting of all the metallurgical oriented industrial units in the Eastern region along with all the academic institutions and the R&D organisations involved in material science so as to identify the infrastructural facilities availilble in each of the organisations, So that duplication of hardware could be avoided. Another initiative taken was to encourage NML to pursue interaction with the student community so that they



could be enticed to join hardcore metallurgical organisations and not get swayed by the "glamour" of IT jobs, I am happy to note that this has happened, and today. top-class professionals are joining this prestigious Laboratory by choice to take research to unprecedented heights of excellence.

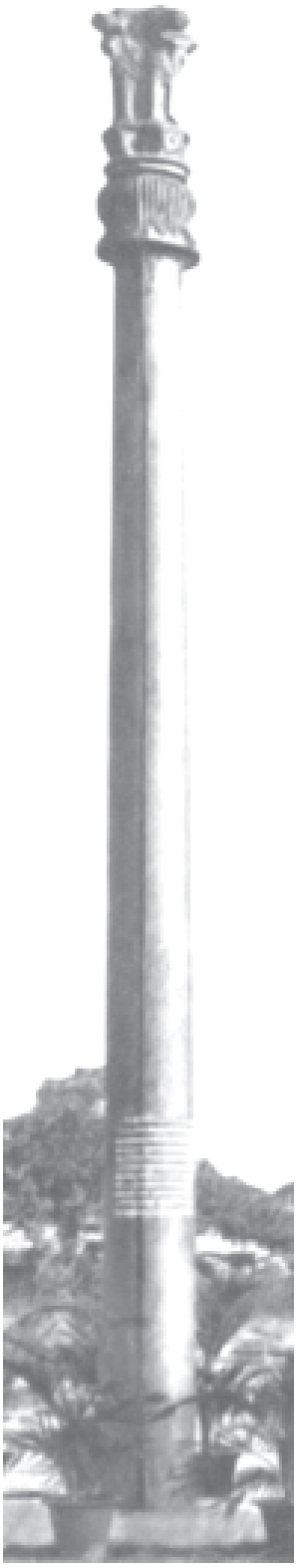
Some of the important projects that were initiated and completed during the period that I chaired NML's RC were :

- Maximising blast furnace production with Indian iron ores
- Extraction of magnesium from indigenous raw materials
- Improvement in the energy efficiency and resource conservation in industries like cement
- Column flotation studies for mineral beneficiation
- Processing of poly-metallic sea-nodules from the Antarctic Ocean for recovery of copper, nickel, and cobalt
- Development of a suitable methodology for engineering critical assessment

Before I conclude, let me reiterate that Tata Steel has had a wonderful relationship with NML that has stood the test of the last 60 years. Besides the fact that both the institutions are situated side-by-side, both have been responsible for having left an indelible foot-print in the evolution of India after independence. Although several examples have already been cited earlier, I will now recall how Tata Steel has greatly benefited from the expertise available in NML. Several of the early mineral beneficiation studies on the captive raw materials of Tata Steel like iron ore from Noamundi and Joda were undertaken at NML Even later, when Tata Steel decided to exploit the Khondbond iron ore reserves in Orissa,help was taken from NML to design the iron ore washing facilities. India's first coal washery at Jamadoba was installed by Tata Steel based on the flow-sheet developed by NML.

NML and Tata Steel together have embarked upon another new initiative of jointly expertise available at IIT Kharagpur to frame tri-partite projects. These three organisations are not only located close to each other, but are amongst the most outstanding organisations in the country in the fields of research, steel production and academia respectively. The coming together of three outstanding metallurgical institutions is certainly a step in the right direction. For example, it is obvious that steel companies of the future will only survive if they fundamentally change their way of thinking in terms of promoting their products, re - engineering their work methods, and encourging their employees to be far more innovative than what they have been in the past. For the steel industry in India to prosper in future so that India is second only to China in terms of steel production, this type of close interaction amongst top-class organisations is the only plausible solution. The enormous contribution that academic institutions can make in fulfilling this role is not always appreciated. I am confident that the National Metallurgical Laboratory, IIT Kharagpur and Tata Steel have sown the seed of success in the years to come.

I am extremely happy and honoured to have this opportunity to contribute to the Diamond Jubilee Celebrations of the National Metallurgical Laboratory, being organised under the leadership of Prof. S Srikanth. I have been personally extremely fortunate to have had close links with NML for more than 40 of these 60 years and I wish the Diamond Jubilee Celebrations responding success.



National Metallurgical Laboratory

Dr. S.K. JOSHI
Former Director General
Council of Scientific & Industrial Research, New Delhi

I am happy to recollect and write for the Diamond Jubilee souvenir of the National Metallurgical Laboratory (NML), Jamshedpur. NML has been close to my heart. I had visited NML a number of times while I was DG. All which I am writing about pertains to a two decades old period, and I am writing from memory. Memories get blurred and misty through the passage of time.

NML is one of the trio of the laboratories which the dynamic founder of CSIR Sir Shanti Swarup Bhatnagar planned along with the National Physical Laboratory, New Delhi and the National Chemical Laboratory, Pune. NML was located at Jamshedpur , so that it works in close coordination with the steel industry.

When I took over as DG, CSIR in February 1991 from Dr. A.P. Mitra FRS, Professor S. Banerjee was the Director of the NML at that time. Professor Banerjee was an articulate, determined, dynamic and persistent person. He had prepared a blue print of a transformation of NML. The Laboratory was ridden with problems and troublesome issues when Banerjee took over as the Director. He courageously implemented the changes, which were so crucial for the growth of NML in later years. I hope Banerjee will write an account for this souvenir about the transformation he brought about in NML and the difficulties he faced in the task.

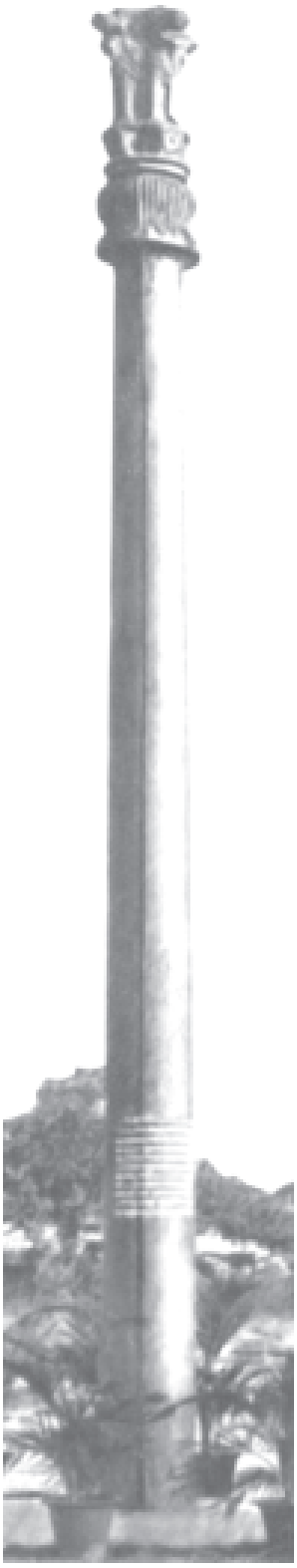
Dr. A.P. Mitra, the then DG, CSIR introduced the prestigious Bhatnagar Fellowship for freeing outstanding scientists from administrative chores and Professor Banerjee was one of the first to be offered this fellowship. If I am right he was the only one who accepted and joined the fellowship. By the time he joined the fellowship I had taken over as DG, CSIR. Banerjee's decision forced us to look for a new Director of NML. We were able to persuade Professor P. Ramachandra Rao to join NML as its Director after Professor Banerjee vacated the position.

In 1992 P. Ramachandra Rao joined NML as its Director. He already had established reputation and was internationally known for his work on rapid solidification done at BHU Varanasi. He provided enlightened leadership to the Laboratory for almost 10 years. The key role played by Ramachandra Rao to give high importance to basic research at NML is worth mentioning. I remember during my visits to NML during his tenure, I saw that he himself was doing high quality basic research and more than that he was encouraging others to pursue serious basic research along with the developmental work they were doing. He always paid attention to the positive qualities of scientists and staff. He was a friend and guide to them. Because of his leadership the quality of services provided by NML to its clients improved considerably.

When I discussed with Professor Ramachandra Rao the budget of NML for the Year 93-94, he got the allocation to NML enhanced through his persuasiveness and persistence. He argued strongly with all the necessary data and solid proposals that if the laboratory is to move forward it has to be provided with bare minimum resources. I could simply use the words of Samual Johnson to describe the traits of late Professor Ramachandra Rao

"A FRAME OF ADAMANT, A SOUL OF FIRE
NO DANGERS FRIGHT HIM, AND NO LABOURS TIRE"

This is also an occasion to pay our tribute to all those who worked hard to make NML known through their contributions. They laid a foundation on which we can build further and make NML a centre excellence in a field of metallurgical engineering chosen after due deliberations and discussions. We should aim to become world leaders in that field. Keep in mind that excellence demands hard work, discipline, tenacity of purpose and will to win.



We should initiate collaborative and cooperative programmes with academic institutions in the neighborhood like IIT Kharagpur.

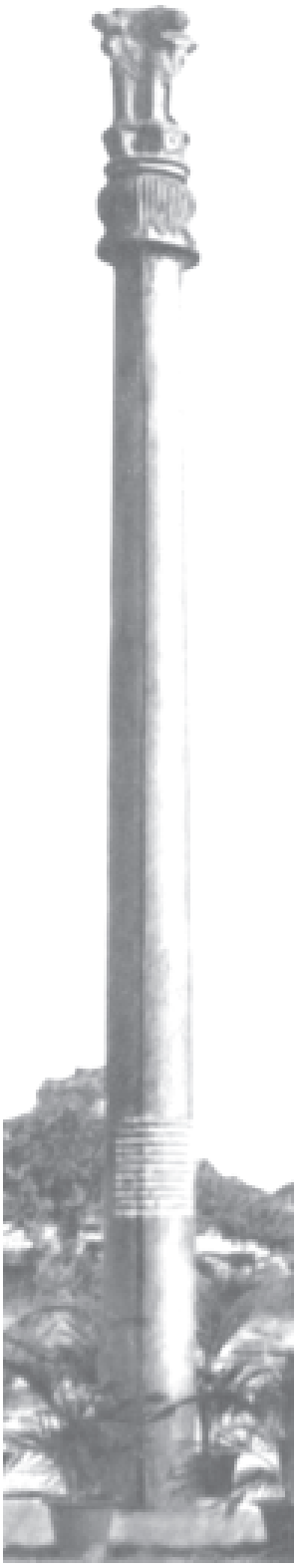
I have research interests in Physics of Materials, and much of the R&D work done at NML interests me. Earlier the laboratory had focussed on metals and minerals, but in recent past there has been reasonable emphasis on advanced materials and the component integrity evaluation. One notices that in many applications traditional metals and alloys are being replaced by composites which have higher strength to weight ratio compared to metals. Does it mean that composite materials will replace metals and NML programmes have to undergo a total transformation? The answer in my opinion is no because metals have much higher fracture toughness compared to other materials. Metals are used in places where we have highest requirements of reliability such as engines. bridge cables, vehicle body frame, body implants and nuclear reactors. In composites the fracture is often catastrophic ie the material fails all of a sudden. Metals are better electrical conductors. Metals have useful magnetic properties. Metal have best over all properties in the operating temperatures of chemical engineering plants and power houses. Metals will therefore always be in demand. What laboratories like NML need to do is to improve the properties of metals by using the results of basic research, so that in future we have better metals.

The journey of past sixty years of NML has been eventful sometimes tumultous and difficult, but ultimately NML has come out stronger. We look forward to the future of NML with high expectations from its scientists and staff.

Present Address :
National Physical Laboratory
Dr. KS Krishnan Marg
New Delhi - 110 012

National Metallurgical Laboratory - A glorious past, an uncertain present but a promising future ahead

PRADIP
Tata Research Development and Design Centre
A Division of Tata Consultancy Services Ltd., Pune, India



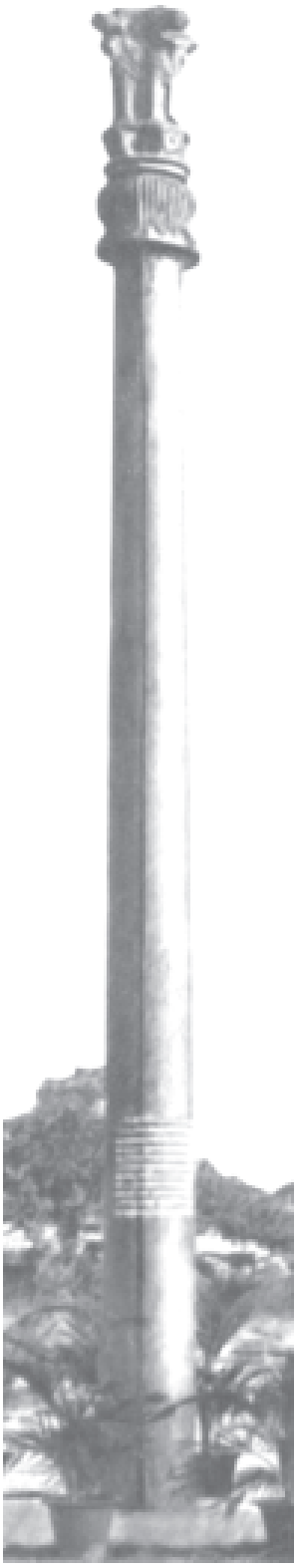
On the occasion of the diamond jubilee of this great institution, I salute the vision, the courage and the self- confidence of the founders of National Metallurgical Laboratory (NML), the people who created a world class institution with such an ambitious charter, at a time when the country was struggling to stand on its feet and was confronted with formidable challenges on all fronts. I recall with immense pride the great contributions of our professional peers, the past and present members of the NML family, to the cause of mineral processing and extractive metallurgy and for the benefit of our minerals and metals industry. Our heartiest congratulations to all the members of NML family on this joyous occasion!!

It is painful, to say the least, that a country which prides itself on a glorious heritage in minerals and metals as exemplified in the legendary Wootz steel from which Damascus swords were made, the Ashoka pillar which has defied corrosion for so many centuries, the ancient retorts of Rajasthan which were used to produce zinc and the exquisitely crafted bronze icons from south India made by the lost wax process, has almost stopped teaching mineral processing and extractive metallurgy to our next generation. It is to the credit of institutions like NML, that they have kept this field alive.

I was introduced to NML in my student days by Professor Biswas, my teacher at IIT Kanpur. Thanks to the inspiring lectures of my outstanding teachers, Professor AK Biswas and Professor PC Kapur in particular at IIT Kanpur, I became a mineral engineer and mineral processing and extractive metallurgy became a lifelong passion for me. It was only in early 80's when I got an opportunity of actually visiting NML for the first time. I was working in the Ore Dressing Section of BARC at that time and we needed some help from NML. I accompanied Dr. GP Mathur of NML and Mr. RN Khare of Hindustan Copper, two stalwarts in the field at that time and they introduced me to Professor VA Altekar, the then director of NML. It was my good fortune that I got an opportunity soon thereafter of working on a project at Tata Steel in Tata Steel R&D Laboratories, located next to NML. It was a great learning experience for me and I benefitted immensely from my interactions with several distinguished scientists of the Mineral Processing Division at NML. I also consider myself distinctly fortunate that I have had the privilege of interacting with successive directors of NML so closely, over the years - starting with Professor S. Banerjee in the eighties, Professor P Ramachandra Rao in the nineties, Professor SP Mehrotra in the first decade of the new century and Dr. S. Srikanth who is leading the institution today. Each one of them brought their own style of functioning and their own distinct vision of what NML should strive for and in retrospect, each one has contributed to the growth of NML as an institution of national importance and international stature in the field of minerals, metals and materials. Considering the proud legacy NML has and the exciting opportunities being offered to NML, I have no doubt in mind that NML will scale new heights of excellence in the years ahead.

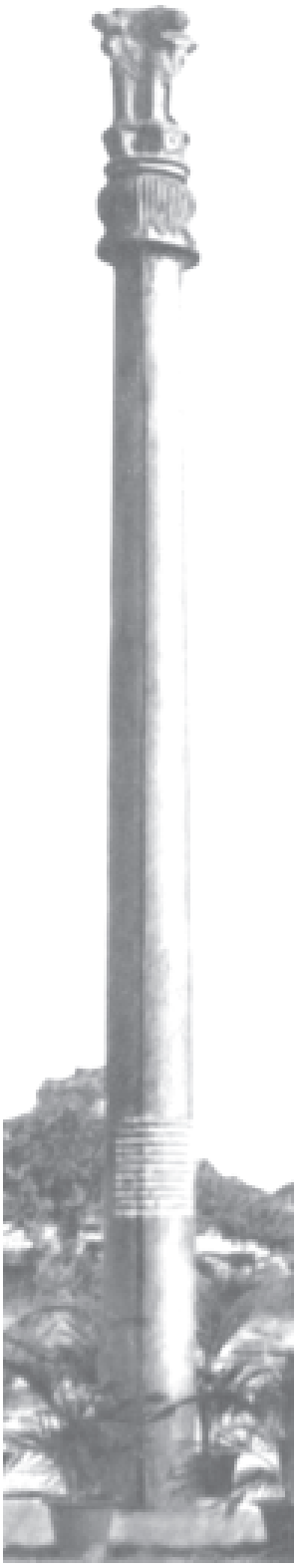
Having been such a frequent visitor to NML and having interacted so closely and with so many professionals at NML during the past thirty years of my career, I consider myself an integral part of NML family. It is no exaggeration when I say that I have grown with NML. Being a mineral engineer myself and having been closely associated with Indian Institute of Mineral Engineers (IIME), I am grateful to NML for providing a home to IIME for the past so many years. IIME is an institution which was founded by Dr. KK Majumdar, the then Head, ODS, BARC, Trombay and moved to NML in the eighties when Dr. Altekar was the director. Successive directors of NML have nurtured this important institution with great interest and care for the country.

India of 2011 is qualitatively different from India of fifties when NML came into being sixty years ago. Great institutions continue to reengineer themselves and NML is no exception. Listening to Dr. Srikanth,



the young, dynamic leader at the helm of affairs today, during the NML's first RC meeting after he took over as director, was indeed a revelation. I wish him all the very best in his laudable efforts to steer NML on to roads which are "less travelled". I believe we are living in interesting times, certainly challenging to all of us who have anything to do with minerals and metals industry. What we are witnessing today is unprecedented. Not many would have even dreamt this kind of future for India, a couple of decades back and that is the best part of it. We have to think afresh. Start all over again so to say since these times are as exciting and as challenging as the times our predecessors, the visionaries of fifties faced when NML was born. We will have to invent a new paradigm for laboratories like NML.

If one is audacious enough to assert and I believe that is the call of the times, that India has the will, the capacity and the wherewithal to lead the world in the world of minerals and metals, then NML has to play its part as a world class institution which can nurture the professional leaders who are amongst the very best anywhere in the world. Without going into reasons, which could be debatable but it is obvious to us all that India has suffered from a serious handicap and has paid a heavy price for that and that is, the dearth of professional integrators, professionals whose business is to bridge the gap between the dream world of ideas and the real world of hard core engineering to realize the value of those ideas in practice. It is that breed of professionals who can feel at home with the academic world, can understand and converse in the language of professors and through their solid, scientific rigour in whatever they do, earn the respect of the academic peers and yet at the same time also master the vocabulary of the industry, have the uncanny ability of engineering the best solution, possess the feel of the market, the pulse of what it takes to make things happen in the market place and thus know how to persuade and convince the investors to dare enter the unchartered territories. I am sure my esteemed colleagues in NML today understand and appreciate it very well. They know what I am talking about since we all have travelled together on this road for the past so many decades. We know from our own experience that a bright idea alone is not enough; one has to invent new business models as well, create the kind of skills set within the organization so that one can pick out the winner early on, at least earlier than many others and convert a few of the many inventions into innovative products or a processes which succeed in the marketplace. I believe NML can be one of those institutions which will nurture these integrators. It can create the ambience, the environment, the ethos, the eco-system, where our young colleagues who have the audacity, the temperament and the passion to innovate on whichever front and on a sustained basis so that they flourish and make things happen. Nothing succeeds like success and I believe we are on the threshold of a revolution in how science and technology is done in India and NML can be part of that revolution.



National Metallurgical Laboratory and the Renaissance in Indian Metallurgy in the Twentieth Century

S RANGANATHAN
Indian Institute of Science, Bangalore

The Materials Heritage of India is a rich and celebrated one. Its decline from the fifteenth century and more so under the colonial rule is also recognized. The twentieth century saw a renaissance in Indian metallurgy. Modern steel industry came into being with the Tata Steel Company in 1907. Metallurgical education began in 1923 at the Banaras Hindu University and got strengthened at the Indian Institute of Science in 1945. In the forties the foundation for metallurgical research was laid in 1946 at Jamshedpur with the National Metallurgical Laboratory. The metallurgical component of the Department of Atomic Energy grew from 1957, when Prof Brahm Prakash joined the programme. It is of interest to note that all the programmes in industry, research and education had the founding fathers from abroad or trained abroad. The strong interrelationships among all these pioneering institutions, as individual scientists moved among them, is also of historical significance.

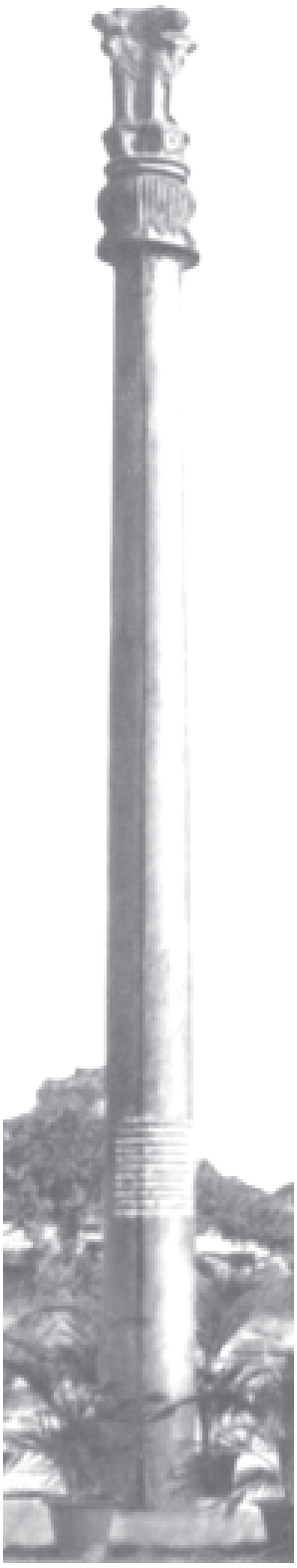
In the case of NML the first three directors- George Sachs, Charles Crussard and EH Bucknell - were from the USA, France and the UK. Dr Crussard was the Director, when Pandit Jawaharlal Nehru dedicated the laboratory to the nation on November 26, 1950. Even though Dr Crussard spent a short time, his influence can be traced to the mark on creep studies that NML has made. It may also be noted that he had supervised the doctoral thesis of Dr R V Tamhankar, who became the founding Director of the Defence Metallurgical Research Laboratory in Hyderabad.

While I did not have the privilege of personal knowledge of the first three directors, I had the opportunity to know all the subsequent Directors - Dr B R Nijhawan, Dr V A Altekar, Dr S Banerjee, Prof P Ramachandra Rao, Prof S P Mehrotra and Dr S Srikanth. As I look though the prism of time, the Directors became younger as I grew older! It is the good fortune of NML that the six Indian Directors could guide the destiny of NML over long spells. I was associated with NML in its Executive Committee and the Research Advisory Council for varying periods of time.

The gamut of research at NML runs all the way from mineral processing, through process metallurgy, physical and mechanical metallurgy to novel engineered materials. My own personal research interests made me admire the work on solidification including rapid solidification, the development of Thackeron steels, corrosion resistance of the Delhi Iron Pillar and experimental archaeology of tribal iron making.

The Diamond Jubilee is an occasion for celebration. NML has much to celebrate in laying a strong foundation for extracting the mineral wealth of India. Its contributions in magnesium production and manganese metal from sea nodules is well known. Its long term creep studies are of vital importance to electrical and nuclear industry.

The Jubilee is also a time for introspection. In 1950 NML was a pioneering institution. Today the Indian metallurgical landscape is noted for many R & D Institutions. NML faces challenges in this competitive environment. It must resolve to keep its premier position by a judicious choice of the research programmes. All of us wish NML the very best as it chart its journey to its centenary to come.

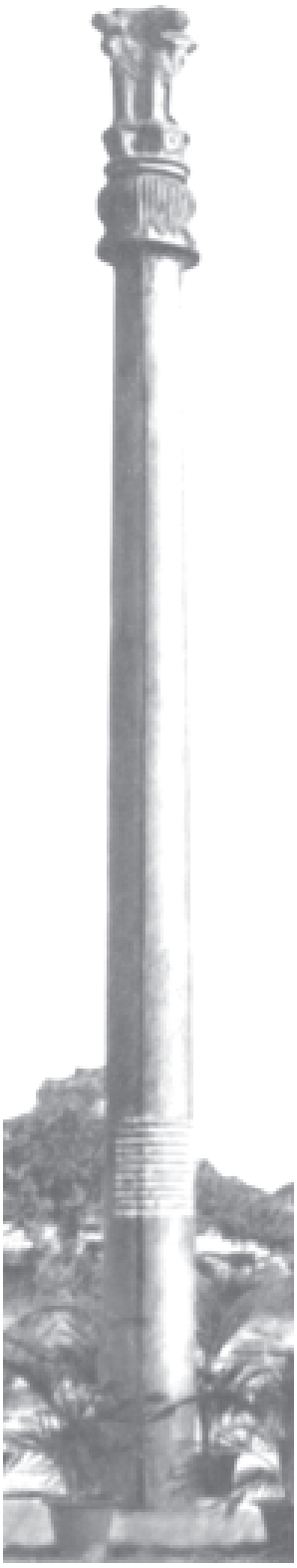


My Association with the National Metallurgical Laboratory : Random Recollections

K. A. PADMANABHAN
(Former Dean, Academic Research,
IIT Madras and former Director, IIT Kanpur)
School of Engineering Sciences & Technology, University of Hyderabad
Hyderabad 500 046

My earliest memory about the National Metallurgical Laboratory (NML) goes back to my student days (1963-68) at the Banaras Hindu University (BHU), Varanasi. Dr B R Nijawan was the Director at NML and we used to be told that he was the first Indian Director and that before him there was a "foreigner", Prof. E H Bucknall at the helm at NML. Those were the days when the integrated steel plants at Bhilai, Rourkela and Durgapur were in their infancy and the dream of many of my classmates was that they should join one of these steel plants. Prior to that, many of the graduates of the Department were seeking jobs at NML. In fact, many of the early employees of NML were graduates of the Department of Metallurgical Engineering at BHU. We were further told that on the advice of Pt. Nehru, who emphasized a lot on the role of S&T in national development, it was decided to locate NML in Jamshedpur, next door to Tata Steel, with the legendary Sir Jahangir Ghandy, the then MD of TISCO, being asked to play an important role in the shaping and development of NML so that a symbiotic relationship emerges between R&D and industry. We had Prof. G R Bashforth, a reputed British steelmaker, who was past his prime for the British Steel Industry, teaching us Iron and Steel Making. (The "Indianisation" of Prof Bashforth, who stayed at BHU for 6 years and wrote the 4 famous books on Iron and Steel Making along with Dr A K Biswas was so complete that the students used to refer to him fondly as "Ganga Ram (GR) Bashforth".) Being a man from the Industry, Prof Bashforth wanted us to have hands-on experience. Therefore, he started a unique pilot-plant activity at the Department of Metallurgical Engineering at BHU in which he taught the students how to construct a cupola, a sintering plant etc. He established the Fuels and Assay Lab. Direct Reduction Processes (of iron ores), which was a key area of research at NML at that time became a subject of intense discussion in our classes- productivity and efficiency of the Blast Furnace vs. better resource utilization approach involved in the direct reduction processes etc . There was constant comparison between the open-hearth (practiced at the time in Bhilai) and the then very new LD process (practiced in Rourkela). With the departure of Prof Bashforth, the pilot-plant activity died a natural death. Prof Bashforth used to say, "In India you have many Banerjee, Mukherjee and Chatterjee. But you people simply have no energy!" (Dr Amit Chatterjee, a very popular figure at Tata Steel and Jamshedpur in later days, who has always been a great sport, used to laugh the loudest at this joke.) This lack of emphasis on things practical/ applied, which seems to have spread throughout the country has made most of the Engineering Departments in India (in the words of Prof. L S Srinath, a former Director of IIT Madras) "second rate Physics and Chemistry Departments". NML, for example, is not able to recruit easily highly trained and motivated personnel in the area of mineral dressing or applied aspects of materials processing. This is not withstanding the fact that India has one of the largest deposits of iron and aluminium ores in the world. On this auspicious occasion of the Golden Jubilee of NML, we should resolve to take concrete steps to remedy this situation.

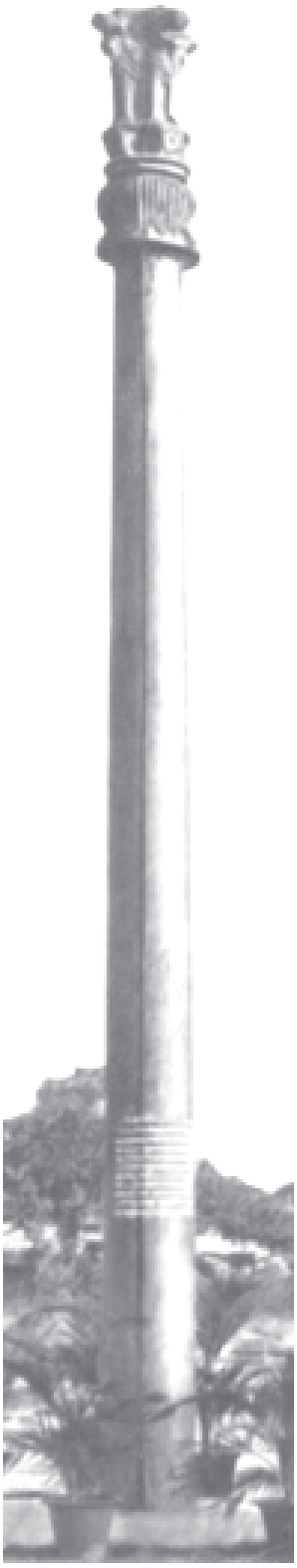
Dr Rajendra Kumar, the then Head of the Physical Metallurgy Group at NML, was a regular visitor to our Department at BHU as an examiner. NML developed a high-nitrogen containing stainless steel which was named Thackeron after Dr. M S Thacker, the then Director General of CSIR. In that process capping was necessary to dissolve nitrogen in the alloy which made the process somewhat difficult to implement. In our final years, Dr V A Altekar became the Director of NML. He, along with Dr S Viswanathan and Dr Pranjpe of TISCO used to be "regulars" for our practical/ comprehensive examinations. I was fond of Dr Altekar, who was an affectionate father figure and was a professor in Mumbai before joining NML. (It is interesting and coincidental that he was on the panel of experts which appointed me to a professorship at IIT Madras at an interview held in September 1979.)



On my return to India after my PhD abroad, I served my Alma Mater during April 1972 to December 1979. In that period my visits to NML were rare. I think that I gave a seminar talk there in early 1979 on the deformation behaviour of a very dilute aluminium alloy. But, frequent meetings with Prof Altekar and Dr Rajendra Kumar took place regardless, as they were regular visitors to our Department. From them I kept learning of the progress NML was making in those years.

After moving to IIT Madras (IITM) in January 1980, although I lost touch with NML till 1982, I had the privilege of working closely with Prof. E G Ramachandran (EGR), the first professor and founder Head of the Department of Metallurgical Engineering (now Metallurgical and Materials Engineering), IITM. Prof EGR was an Assistant Director at NML before joining IITM. My association with Prof EGR, who retired from IITM in 1985, was during his last 5 years of service. I was in my early 30s. Our residences were a few meters from each other. Therefore, I interacted with him closely and he fulfilled the role of a father figure in the Department. He had a puckish sense of humour and took his own claims as well as those of others with a big pinch of salt. Recently, the Director NML, Dr Srikanth, brought to my notice two papers published by Prof EGR in Nature on Hydrogen Stabilization of Austenite. Till then, I was not aware these two publications, even though Prof EGR and I had many personal and intimate conversations over the years and he had guided my former colleague, Prof KJL Iyer towards a PhD degree in the same area. Now I know why Dr C Dasarathy, who was an Assistant of Prof. EGR at the time the Nature papers were written, worships the latter. Prof EGR took very good care of those who were sincere/ loyal in their behaviour towards him.

In 1982 I became a Consultant to Telco (the present day Tata Motors) in their efforts to use the first generation micro-alloyed steel 49MnVS3 for the manufacture of crankshafts- a critical load-bearing component- for commercial vehicles. This consultancy assignment was spread over a few years. During my visits to Telco/ Tata Motors I also used to visit NML. Then, during the time Dr S Banerjee was the Director of NML and Dr O N Mohanty was the Deputy Director who looked after assessments and promotions, I became a regular visitor to NML and was one of its main Advisors for assessments and selections in the areas of physical and mechanical metallurgy. The rapport I developed with "Onkar" (Mohanty) has endured to this day. The association with NML became practically non-existent in the "post-Shilowbhadra Banerjee" days, only to be revived vigorously after the assumption of office by Prof S P Mehrotra (SPM) as the Director of NML. Prof. Mehrotra asked me to deliver one of the Foundation Day lectures and I spent a couple of days at NML. During that period I got to know a good bit about the type of work being done at NML in recent times and even drew up plans for joint work with some colleagues, which have remained to this day as- plans! Prof SPM asked me to help in organizing the severe plastic deformation segment of the international symposium on Mechanochemistry and Mechanical Alloying (INCOME 2008), which was very successfully organized with Dr Rakesh Kumar as the Organizing Secretary. It was during the organization of this conference that I came to know the present Director, Dr Srikanth, rather well, although I knew him somewhat superficially even before this event. When I left for Germany in January 2009 to join the University of Muenster for a year as the Mercator Professor- a national Chair offered to me by the German Research Foundation- I transferred my PhD student at Anna University Chennai to Dr Srikanth. This introduced an academic dimension to my association with NML and in more recent times, Dr Sandip Ghosh Chowdhury has been picking my brain on some topics of mutual interest. As NML celebrates its Golden Jubilee, I take delight in its many successes to date, its sincere efforts in tiding over many difficult phases and situations and wish the organization far greater glory and success in the years ahead.



Mineral Processing Research : Eary Reminiscences and Vision Ahead

ARUN KUMAR BISWAS
Formerly Professor, IIT, Kanpur, Jadavpur University
The Asiatic Society, Indian Institute of Advanced Studies, Shimla,
INSA Fellow, History of Science

My hearty congratulations and best wishes to the esteemed community of the National Metallurgical Laboratory (NML), which is celebrating its Diamond Jubilee (1950-2010) on the Foundation Day, 26 November 2010. In particular, I thank Dr S Srikanth, FNAE, Director NML for inviting me to participate in the joyous celebrations, to contribute an (this) article on reminiscence and vision related to the field of my experience, and also to deliver a Diamond Jubilee Lecture on this subject. The erstwhile Director, Late Prof. P.R.Rao had also persuaded me to contribute an article, which was indeed the first article in the NML Golden Jubilee Commemorative Volume (2001): 'Metallurgy in India-A Retrospective'.

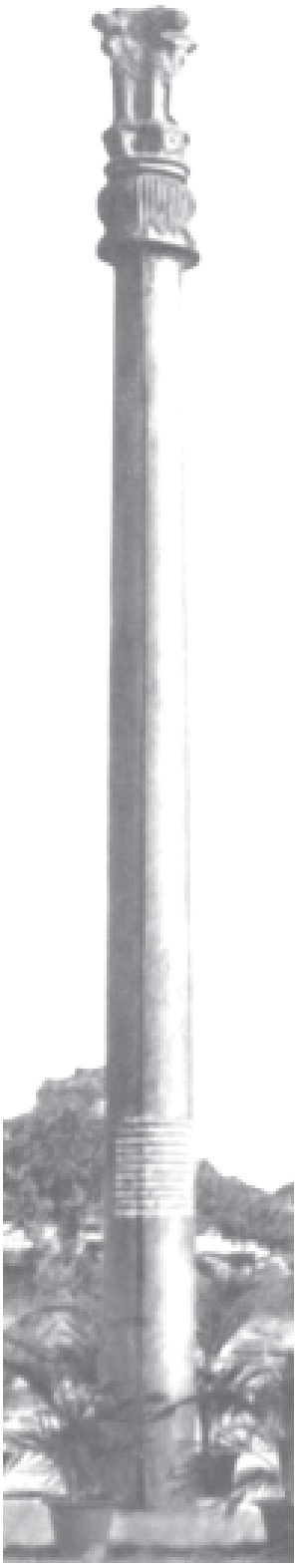
Sir Shanti Swarup Bhatnagar had visualized the chain of CSIR laboratories and Pandit Jawaharlal Nehru inaugurated NML on the 26th of November 1950. As a student in Kolkata, I had the privilege of listening to their lectures in 1952; we termed their grand effort as 'the Nehru-Bhatnagar Effect'! My first visit to NML was in 1954. The first Director, Dr Bal Raj Nijhawan was very particular about punctuality, and used to be at the gate quite often during the start of the day to welcome the late-comers! He was instrumental in initiating research programmes and pilot plant investigations in several fields including Mineral Engineering/Processing or Ore Dressing.

The Indian School of Mines (ISM) had been founded at Dhanbad in 1927, but there was very little advanced education or research on mineral dressing in India before 1940. Kamala Kanta Majumdar (born at Shillong in 1913) had worked directly under Professor J.C. Ghosh, Director of the Indian Institute of Science, Bangalore in 1940 on the beneficiation of graphite deposit from the Mysore State. Majumdar was probably the first to earn an Indian Ph.D. in mineral dressing (1949). Later he proceeded to work in the Columbia University under the renowned teacher Professor A.F. Taggart.

During the 1940's, a sizeable number of Indian young scientists studied at the Massachusetts Institute of Technology (MIT), U.S.A. and worked on mineral-based projects. M.N. Dastur worked with Professor Chipman and later founded his own consultation company on iron and steel earning international repute. Working with Prof. A.M. Gaudin, Dr. Brahm Prakash became an expert in atomic energy minerals and metals and then assisted Prof. H.J. Bhabha at the DAE (later BARC). Tuhin K.Roy worked at MIT on hydrometallurgical recovery of cobalt and nickel from their deposits. The present author received the blessings of all the aforementioned seniors before proceeding to MIT in 1960 to work under Professor A.M. Gaudin on Hysteresis of Contact Angles.

Central Fuel Research Institute at Jealgora (near Dhanbad) had organized an international symposium on 'Coal Washing in India' in 1953. Four years later, National Metallurgical Laboratory organized a grand symposium on 'Mineral Beneficiation & Extractive Metallurgical Techniques' (February 1957). Altogether 53 technical papers were presented, many of them by international experts. P.I.A Narayanan, who was heading the Ore Dressing Division at NML, talked about the manganese ore beneficiation plants in India designed to aid the ferro-manganese alloy programme. His juniors, such as G.P. Mathur, G.V. Subramanya, N.N. Subramanian presented the report on iron ore beneficiation and sintering work at NML. It was felt that microscopic studies must be supplemented by electron microscopic investigation of the sub-microscopic grains. Later, the present author proposed that there should be a comprehensive study of all important iron ores in India. IISc Bangalore organized an international seminar in 1959 in which surface chemistry in general, and froth flotation, selective flocculation in particular, were specially emphasized in several technical papers.

The present author completed his education at MIT during 1960-63 and on his relearn to India started his 32 years long career at the Indian Institute of Technology (IIT) Kanpur. Later he was joined in the



faculty by the respected colleagues Dr. T.C. Rao and Dr. P.C. Kapur who attained international stature in their profession. Later Prof. S. Ranganathan of I.I.Sc., Bangalore wrote in 2001 NML Golden Jubilee Volume: "During the seventies and early eighties IIT Kanpur was perhaps the best school in the Mineral Engineering field in India and easily one of the best in the world at that point in time". Prof. H.J. Bhabha visited IIT Kanpur in 1965, and we would refer to him again in this article.

When Professor V.A. Altekar joined the NML as the Director we developed intimate professional links. We attended the International Mineral Processing Conference (IMPC) at Prague, communist Czechoslovakia together . The present author worked at the NML laboratory for two months staying within the office campus with his wife. One evening while working late in the ore dressing laboratory I found myself locked in, alone!

At IIT Kanpur we organized a Short Course on 'Mineral Engineering Practice' during 27-28 February 1969. Dr. K.K. Majumdar came from the BARC laboratory and Prof. V.A. Altekar from NML to assist us. Professor A.M. Gaudin of MIT had accepted our invitation to come to Kanpur and teach the participants. Regrettably, his visit never took place on account of unavoidable circumstances. He expired in 1974.

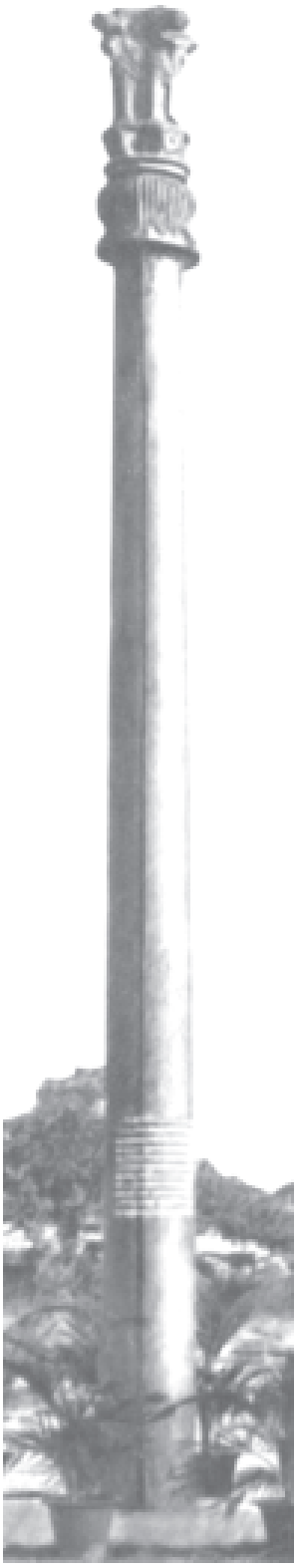
Dr. K.K. Majumdar founded the Indian Institute of Mineral Engineers (IIME) in 1968 and became the Founder President. On 02 January 1969 the Institute was inaugurated by Professor Nil Ratan Dhar, the famous physical chemist and soil scientist. Dr. Altekar assisted the President in drafting the Memorandum of the Institute. The present author had the privilege of becoming the first Life Member (LM1) of the Institute. The head quarters of the IIME used to be located in the DAE/BARC premises in the beginning. At present NML is kindly providing the infrastructural facilities.

In 1984 the Indian School of Mines started at Dhanbad a B.Tech programme in Mineral Engineering, the only one of its kind in India. Professor T.C. Rao was chosen to pilot this programme as Head of the Department of Fuel and Mineral Engineering. Rao and his associates undertook commendable work on computer modelling and improvement of the Coal Washery circuits related to crushing, grinding, heavy media cyclone, water only cyclone, froth flotation etc. The ISM also launched M.Tech and Ph.D. programmes in Mineral Engineering.

The present author proposed the creation of a National Mineral Engineering Research and Training Institute (NMERTI) which should (a) undertake active research programmes in advanced and frontier areas of mineral science and technology, not touched at present by other national laboratories, (b) train high quality personnel for manning different sectors in mineral engineering, (c) offer diplomas and degrees in collaboration with academic institutions, and (d) collaborate with all the relevant agencies and institutions like IIME. Whereas NMERTI was supposed to act as the super-structure or a kind of 'brain' in the mineral engineering profession, IIME was expected to serve as the co-ordinating 'heart' of the system. This proposal is yet to be implemented. The IIME should look into this matter, find ways and means to implement the various proposals, and critically review its own performance and achievements ever since its birth. The NML should also review its continuing surveillance over the Mineral Dressing Division, and stimulate the growth of this profession.

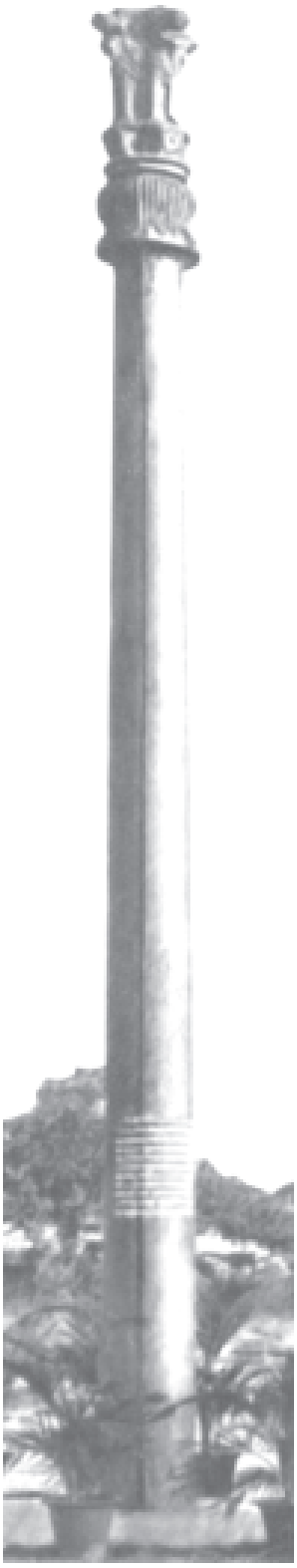
We mentioned Professor H.J. Bhabha's visit to IIT Kanpur in 1965; he discussed with us the problem of high intensity magnetic beneficiation of low grade hematitic ores. We found him very critical of the hurried expansion of the CSIR network at the cost of the universities and quality of scientific research. Meghnad Saha, Bhatnagar and Nehru had expired one after another, and Bhabha also died during the tragic air crash (1966) over Mont Blanc in Switzerland. His critical essay, delivered as a lecture on 07 January 1966 (merely 17 days before death), was published in Science and Culture , July 1966, pp. 333-342 and has been recently reprinted in The Scientist in Society, Thema, Calcutta, 2000, pp. 216-235.

Bhabha preferred his own DAE Model (over the CSIR Model), following which TIFR and BARC developed, cautiously and meticulously, excellent departments of international stature - and even mining, metallurgy, mineral processing and fabrication facilities, Zircalloy, Plutonium Plant, Thorium-based Breeder Reactors and so on. In-house educational facilities were also developed.



The present author observed, while working at the NML during the 1960s, that more attention was being paid on the feasibility studies in several pilot plants. The then Director, Prof. V.A. Altekar agreed with us that appropriate emphasis should be laid on basic research in the mineral processing systems as well.

Several decades have elapsed since then, and surely many developments and improvements have taken place. I am not fully aware of the ground realities. At IIT Kanpur the Mineral Engineering Division has dwindled to trivialities. The name of the department has been changed, in terms of association, from Metallurgy to Materials Science. The students are in general interested more in Computer Software and Management professions, and less in Hardware Mining and Metallurgy. I wish NML may try to restore the balance, adopt the Bhabha Model and strongly interact with the academic institutions and industries. Godspeed beyond the Diamond Jubilee Celebrations!



Reminiscences 1964-1967

Dr. U. K. CHATTERJEE
Former Professor, IIT Kharagpur

Six of us, six fresh graduates in metallurgical engineering from IIT Kharagpur, entered the portals of National Metallurgical Laboratory, Jamshedpur, as Senior Research Fellows in July 1964. This was the outcome of a meeting between the then Director of NML, Dr. B. R. Nijhawan, and the then Head of the Department of Metallurgical Engineering at IIT Kharagpur, Prof. P. R. Dhar. The former was eager to induct promising metallurgical graduates, who were normally allured to join industry, to the NML fold for building a career in research, not quite cultivated at those times; the latter was apparently indulgent to this idea with the added foresight of building a long-term research collaboration with NML for the eight-year old blooming department. Time has proved both of them right. The two-way interaction continued to grow with time culminating in an unshakable professional bond that persists till date.

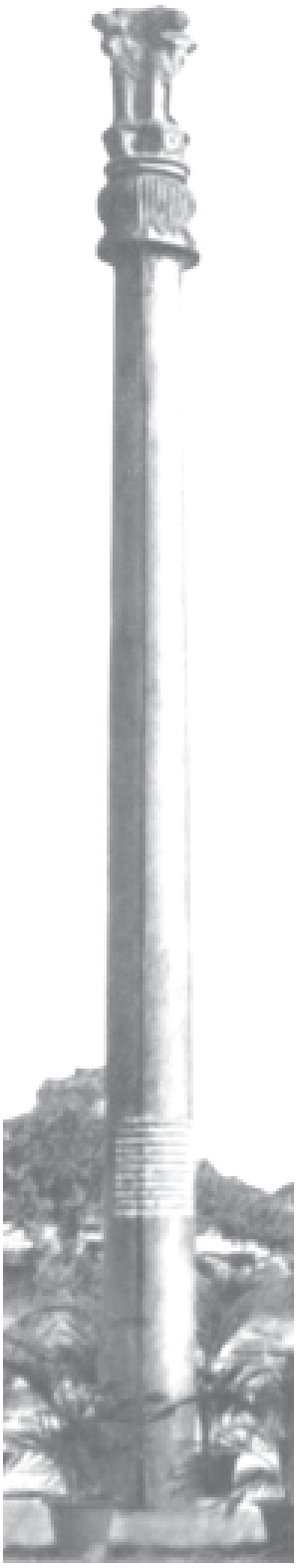
However, the start of our personal sojourn was a bit eventful. After about two months of joining NML, when were not yet (quite expectedly!) clear about the direction of our research work and doubtful about our future, four of us received appointment letters from Hindustan Steel Limited (SAIL, as it is called now).We thought it to be prudent to accept an assured job rather than spending three to four years of uncertainty. So, we tendered our resignation letter to the Director. Next day Dr. Nijhawan summoned us to his office and bluntly asked us: "What will you achieve by working in steel plants? Produce only steel and children?" He successfully persuaded us to retreat. Thereafter there was no looking back for us, at least for me. As a student of intermediate I had my first visit to NML and was thrilled to have observed the microstructure of cast iron right through a microscope, an incident that prompted me to opt for my studies in metallurgical engineering. Now I had to take my research work seriously to complete my commitment.

Those days seem to be wonderful as I look back. Initial problems notwithstanding, we got adjusted to the working place by picking up acquaintances with the Scientists (Scientific Officers, as they were called then), scientific and other staff members. A good number of "Pool Officers" were also there. They were home returnees on completion of studies at foreign universities and aspiring to seek positions in India. Quite a few of them got absorbed in NML in due course. It was a pleasant experience to get socially and professionally integrated with this wide spectrum. Personal research work apart, it was quite an experience to see the working of the Low Shaft Furnace Pilot Plant led by Dr. A. B. Chatterjee and the Mineral Beneficiation Pilot Plant (MBPP, fondly nicknamed 'Madrassi Budda Pagal Plant' after its zealous leader Sri P.I.A. Narayanan).

NML in those years was pioneer in organizing annual metallurgical conferences, which have become so common now-a-days. They contributed in no small measure to develop the culture of scientific interaction. I still remember the enthusiastic young researchers from BARC comprising Placid Rodriguez, C. K. Gupta, G. P. Tiwary and the like posing probing questions at the technical sessions of the conferences much to the discomfort of the not-so-well prepared presenters.

NML provided me (and many others like me) all the support to carry out research work. It was a pleasure to have received the guidance of Dr. A. K. Lahiri who is still active as a leading corrosion consultant in the country. During my entire professional career at IIT Kharagpur over four decades, my association with NML continued with participation in its various activities. I also received all the cooperation from NML whenever asked for. I never felt detatched.

I wish NML further glorious years beyond diamond jubilee.



Some Recollections

Dr. AHINDRA GHOSH
Formerly Professor, Department of Materials and Metallurgical Engg., IIT, Kanpur

I am happy to note that National Metallurgical Laboratory (NML) is celebrating its Diamond Jubilee, starting this year. My best wishes for success of the celebration, and for future prosperity of NML! The laboratory is one amongst the few National Laboratories set up by the Government of India within a few years of independence in order to promote indigenous research and development. This shows the awareness of the Government on the importance of the metals and minerals sector for the country. For quite some years, NML was the only research and development organization in India in the metallurgical field. The pioneering role played by it for R&D in this sector is well-known.

I had the opportunity to visit and interact with NML countless number of times over a period of about 50 years. It started in 1956/57, when as students of Metallurgical Engineering of the then Bengal Engineering College, we visited NML as part of our industrial tour program. We were impressed by the lectures delivered by Dr. T. Banerjee, Deputy Director of NML.

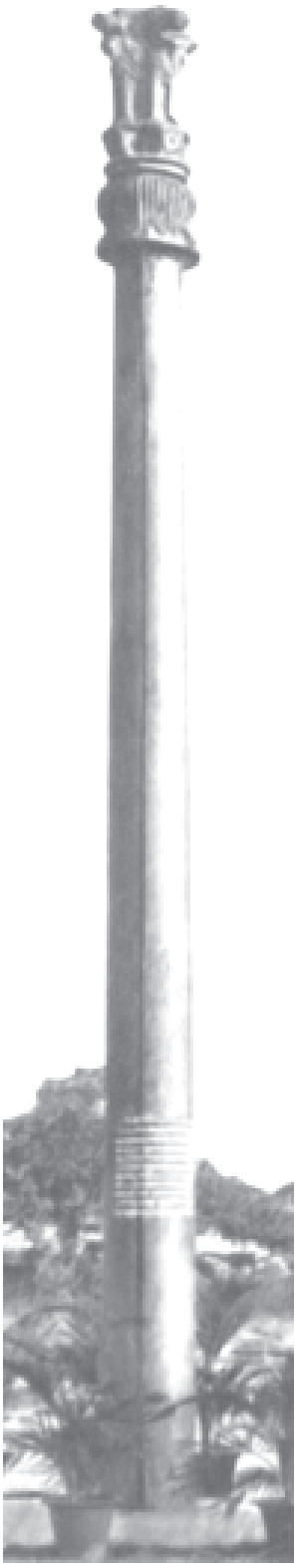
Upon return to India after post-graduation in the USA, I visited NML many times on various occasions and assignments, such as participation in Conferences, Seminars and Workshops, attending selection committee and other meetings,and visits at my own initiative. I would like to record a note of appreciation for cordial hospitality extended to me, as well as for enthusiastic discussions. I also tried to keep myself abreast of research work at NML, especially those on alternative ironmaking.

NML had (I believe it still has) excellent scientific services, with well-equipped laboratories and competent scientists. Several times, with kind permission of Director of NML, we availed of the same for our research. NML library was the best for collection of metallurgical journals, which also we occasionally availed of for our work.

It is neither possible, nor necessary, to recall so many details. Just for the sake of record, I am noting only my important interactions with NML below.

- Invited speaker, Symposium on Sponge Iron and its Conversion to Steel (1973)
- Member, NML Advisory Committee on Iron and Steel(1981 -)
- Session Chairman and Panel Member , Seminar on Continuous Casting of Steel (1987)
- Session Chairman and Panel Member, Workshop on Alternative Charge Materials for Electric and Induction furnaces (1994)
- Invited lecture on the occasion of Diamond Jubilee Celebration of the CSIR , published by NML in its compendium volume (2002 -2003).

I spent many years at IIT Kanpur as a member of faculty in the Department of Materials and Metallurgical Engineering. I am happy that our department has made its humble contributions to NML. Several of our ex-students joined NML as scientists. Some of them are still working there. One of our faculty colleagues served as Director, NML as well.



Non-equilibrium processes of metal growth - Remembrance on the collaboration with NML

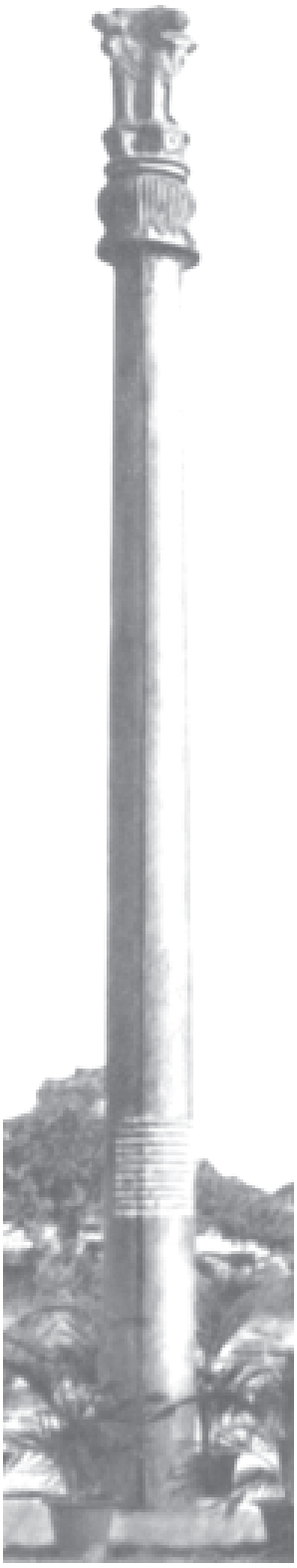
ZDENEK CHVOJ
Institute of Physics, v.v.i. AS CR, Prague, Czech Republic

My first visit of India materialized on the invitation of Madras University and CSIR in 1988. During this one month visit I had opportunity to acquaint with the leading Indian institutions in Science, with the organization of research and mainly with the high educated, creative and very charming colleagues in India. I visited Madras University, Bangalore, several institutions in Mumbai and in Calcutta. Besides interesting programs of these institutions I knew also beautiful nature and some of the rich history and culture of India, what I was interested long before about. When I returned back in Prague I sought to find chance for collaboration with colleagues in Indian institutions. At this time I was working in the thermodynamics and non-equilibrium statistical physics and application of theories in growth processes of solid phase from melts. At the end of 90's a chance appears to fill my hopes. The agreement was signed between CSIR and Academy of Science of the Czech Republic and my favorite topic Non-equilibrium Solidification was included in this program. The application of non-equilibrium thermodynamics and statistical physics was not standard and this branch and started to develop. I was responsible for this project. Since in NML in Jamshedpur similar projects were developed, naturally I established contact with Dr. S. Srikanth, present director, who was also interested to collaborate with our Institute, and I visited NML in 1997. NML was respected Institute which assumed reputation in application and also in basic research of growth processes. My stay in NML brought me many new knowledge about the work in Indian institutions and life within the researcher community. I had opportunity to know them from close range thanks to the hospitality of colleagues in NML, especially of Dr. Srikanth. It was fruitful also for my scientific activity. I remember how Prof. P. Ramachandrarao explained me mystery of cricket, the popular game which was completely unknown for me.

The cooperation was very effective, Dr. S. Srikanth visited Institute of Physics in Prague and during this stay we finished two papers, which were published in prestigious journals. Of course, that the topic of these publications was actual - nonequilibrium kinetics of nucleation and grows and thermodynamic limits under such conditions. With joy I shown to my friend Dr. Srikanth history and spirit of old Prague and I hope that he has fond memory on his stay in Czech Republic and work in Institute of Physics was benefit for his future successful career.

Even the common program finished, I often recall my stay in India and follow the turbulent development of all India, its society, economy and especially science. From my stay in NML this institution came through important changes and now National Laboratory is on the path to become top institute in the material science. Not only traditional disciplines of the metallurgy and macroscopic growth are developed. Dynamics, so important in growth processes, is inherent to advancement of NML, since it continuously develops nonequilibrium methods and extends activity also in the modern and promising nanotechnologies, which bring new materials with new unsuspected applications.

On occasion of the jubilee I wish National metallurgical institute many prosperous projects and filling of all dreams of present director and my excellent friend S. Srikanth.



My Association with NML

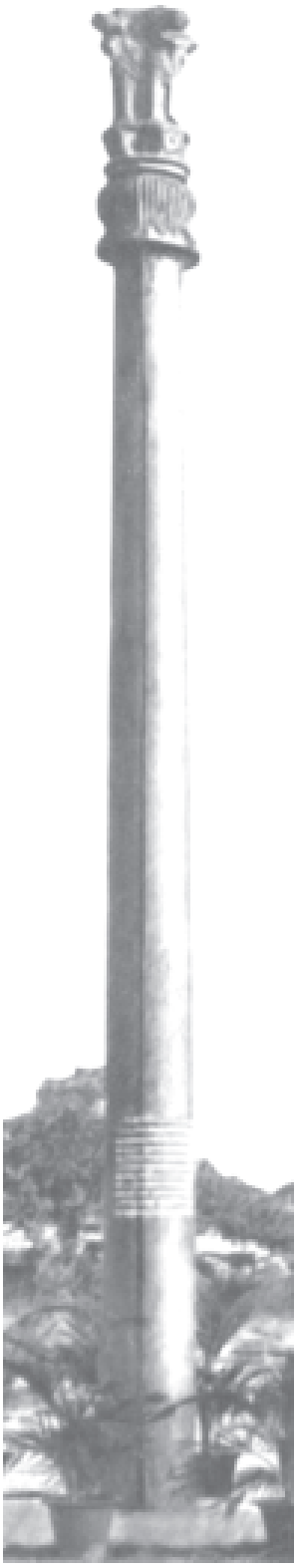
Dr. AMIT CHATTERJEE

Where do I begin? It is a difficult question to answer, since NML is in my DNA. So, perhaps the best thing to do is to begin at the very beginning. After all, an individual's DNA gets defined even before his/her birth! In my case, as the subsequent paragraphs will illustrate, NML was literally in my blood even before I was born!!

My father, Dr A B Chatterjea (who passed away at the age of 90, six years back), took up employment in Jamshedpur in 1942, as soon as he graduated in Metallurgy (the very first batch) from the Bengal Engineering College, Shibpur. He was initially employed in the Government Laboratory (now in the building opposite NML), which, as far as I can recall from what I heard from my late father, was then called Government Inspectorate. The name came from the fact that the primary task of this Laboratory was to certify products made by the Tata Iron and Steel Company (then TISCO and now Tata Steel Ltd.) so that Wheels and Tyres made in TISCO could be safely utilised by the Indian Railways. If my memory serves me right, my father had joined the Government Inspectorate sometime in 1942; he got married in 1943, and I was born in August 1944. I came to Jamshedpur as a two-month old baby from Calcutta; i.e., I was in Jamshedpur towards the end of 1944. Soon thereafter, my father took a "lien" in his service from the Government Inspectorate to join NML. I recall him mentioning this several times to my sister and myself as we grew up in Jamshedpur - he maintained all through his life that he was more comfortable with research than mere inspection to guarantee the quality of products. My father left NML as the senior-most Deputy Director, a couple of years after I returned to India in 1972 to join Tata Steel, having completed my Doctoral work in Imperial College and employment in British Steel (England) and Thyssen (Germany). Quitting NML was not easy for him; we as a family goaded him to take premature retirement. He always hoped that one day, I would become the Director of NML - one of his few wishes that I have not fulfilled.

For 30 years (1944 to 1974) whenever I was at home, all that I heard was NML, NML and more NML because my father's life revolved around NML. As a young boy growing up in Jamshedpur, I "experienced" the trials and tribulations of a Scientist in NML reflected in the multitude of emotions that were often palpable on my father's face. The state of his mind at the end of a long day in NML would sometimes result in the Chatterjee family getting an ice-cream treat at Soda Fountain (then, a Restaurant on the Main Road, Bistupur where now Yash Complex has come-up) or me getting a scolding (he never beat us) for mistakes I often made in arithmetic in Loyola School. NML was "family" for us; for my father it was his third child - he cared for it so much.

I can vaguely recollect the day when NML was inaugurated by Pandit Jawaharlal Nehru in 1950. Wearing short pants, I hid behind some tables as the main function proceeded on the Lawns (those were days when security was nowhere near as strict as it is today). I cannot remember what transpired during the function, but memories that it was a very important day with the Indian Prime Minister being present in Jamshedpur, still lingers in my mind. So does recollections of several home conversations between my father and mother, which invariably centered on NML. I can recall my father mentioning names like Prof. Coheur, Prof. Crussard, who I gathered later were some of the early foreign national Scientists (Directors) of NML. The first NML Director with whom I can relate quite vividly as having met him was Dr. Gustav Contractor, in whose name the Gustav Club was instituted in the "Tuiladungri" NML Colony, opposite the then RD Tata High School. I was present on the day the Club at the entrance of this Colony was inaugurated. I also have fond memories of visiting many of my father's friends in these NML quarters - Dr. B C Kar, Dr. S. S. Bhatnagar, Mr. G. P. Mathur, Mr. A N Kapoor (whose son Akhil studied with me in Loyola for a while), Mr. Srivastava and many other NML Scientists (all Uncles to me then). While we as children played, the NML "Club" of Scientists exchanged notes amongst themselves about research (obviously beyond me at that point of time). I asked my father why we were not living in this Colony; what his answer was I cannot remember. At that time, we lived in a rented private accommodation in Contractors Area, where now the Equinox Restaurant of the Sonnet Hotel

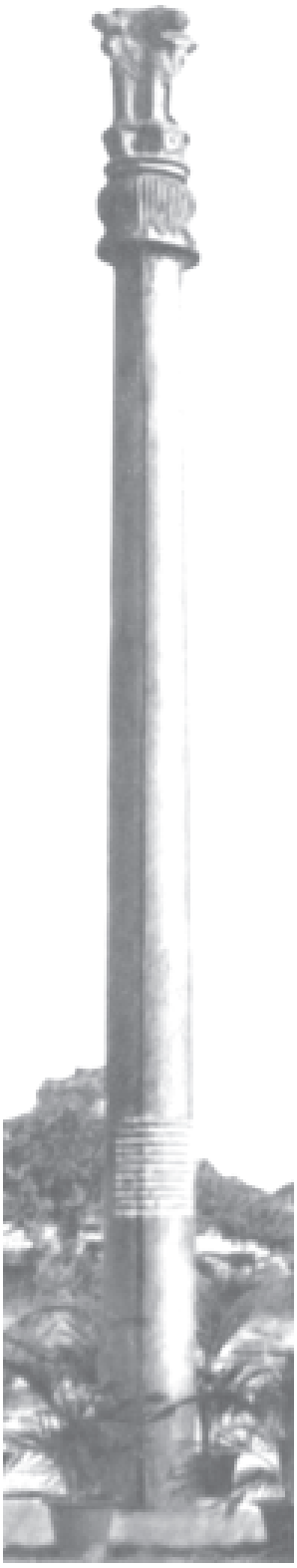


has come-up. Each time I dine in the Equinox, I can not help but think about my childhood days when I played cricket/marbles here, flew kites, cycled around aimlessly - all the usual things any young boy does. Playing would stop and studies would begin as soon as my father came back from NML late in the evening in his black Ford Prefect car. Only later, my father was allotted a NML Bungalow on Pipe Line Road, opposite the Rabindra Bhawan (which came-up much later) - first a "B" type Bungalow, and later a "C" type Bungalow (both red in colour) with lovely gardens (explains my fondness for gardening even today).

Talking about gardens brings back memories of NML's stately Old Building with a resplendent garden all around it. The New Building came much later (in front of my own eyes, since my father was involved in its design) to house the UN-aided Creep Testing facilities - one of the largest in the world. The facilities still exist, though I am not sure what creep testing is being carried out at present (used to be very active in the days of Dr. Rajendra Kumar, who joined NML much later from BHU). The New Building unfortunately came up at the cost of the wonderful garden area, but I cannot forget the gorgeous flowers in this garden - they had to be seen to be believed, particularly during winters. Each year, on the occasion of Independence Day and Republic Day, we always came to NML for Flag hoisting by the Director. All such occasions were followed by Sports for the Staff and their families. Alas, I never won a prize and missed out on opportunities to shake hands with the Director. However, I do have vivid memories of many speeches made on such occasions by Directors like Prof. E Bucknall, Dr. B R Nijhawan and Ag. Director Dr. T Banerjee (his son Dharmapada was my classmate in BHU). When I was 12 years old, and we were living in a private accommodation on Inner Circle Road (where the Equinox Restaurant is now located), I had my Sacred Thread Ceremony. A temporary pandal was erected outside our house. What fun we all had as the pandal was getting erected under my father's watchful eyes. In the evening function, I recall Prof. Bucknall and his wife coming and presenting me Rs. 121 (a large sum of money in 1956!). Later, I was curious and asked my father why his fair-looking British Director gave me the "peculiar" amount of Rs. 121. His answer had something to do with the fact that in the UK, it is customary to present a Guinea (21 Shillings in those days in UK currency) on ceremonial occasions. Helped me a lot in school later, when stupid sums were given to us dealing with conversion of Pounds, Shillings and Pence.

Prof. Bucknall was succeeded by Dr. B R Nijhawan - the first truly Indian Director of NML. Dr. BRN became an institution by himself as the years rolled by. My father's direct Boss with whom he authored many of his papers, later became one of my closest well-wishers. His two sons, Pradeep and Promod were a few years junior to me in Loyola School. I have met Pradeep on a few occasions in the US since then; but, I must frankly admit that I have got to know the father much better than the sons - could be bonding inherent in the metallurgical fraternity! Dr. Nijhawan was "famous" (infamous may be a better word) for detaining NML Scientists after working hours - my father would often have to wait till 7 PM or even 8 PM, just because Dr. Nijhawan wanted to have a five minute chat with him on some research issue. Sounded silly to me then; sounds ludicrous now! My mother would get extremely perturbed wondering as to why my father was not coming home. She would make us ring NML, which using the party-line system (there was a shortage of telephones lines in Jamshedpur those days and each telephone line had two parallel connections - A and B) was not easy. Getting through to NML was tough (sometimes impossible); only to be told that " Chatterjee Sahab is in the Director's Office" . Therefore, in my growing-up days, the Nijhawan name became somewhat of an "anathema". It changed completely when I grew up to become a metallurgist myself, and realised what a towering status Dr BRN enjoyed in the world of metallurgy. I met Dr. Nijhawan in many Seminars all over the world as well as in Jamshedpur. He became extremely fond of me - often called me: "The best metallurgist in the world" (made me feel so happy). On my part, I admired Dr Nijhawan's tenacity and perseverance in his pursuit of excellence, even in his advancing years. Dr. B R Nijhawan and NML are symptomatic even till today - he ably steered NML through difficult times, and made it an entity to be reckoned with, not only in India, but in the world at large. NML owes a lot to this Great Man. I understand he is not well just now as I write this piece - may God be with him and his family (my wife and I are extremely fond of Mrs. Pushpa Nijhawan).

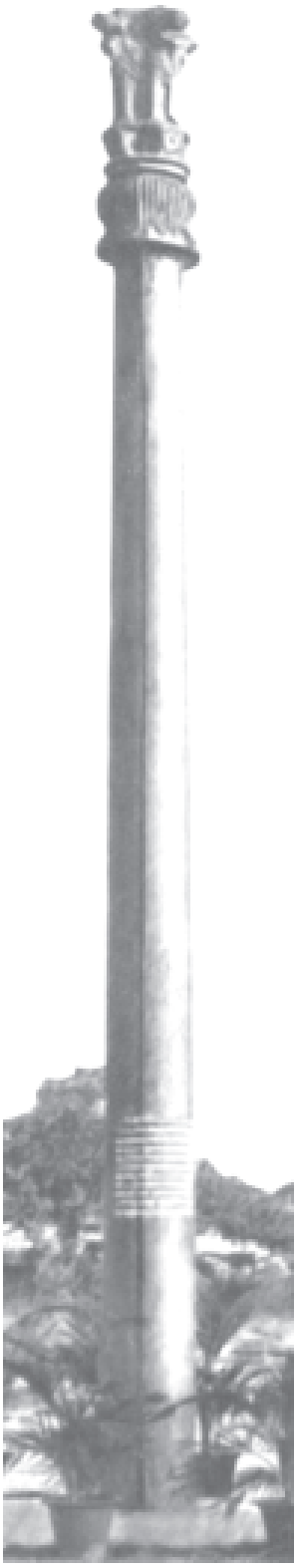
The Directors that followed - Dr. V A Altekar and Dr. S Banerjee - were also known to me, the former more socially than as a Scientist. I interacted with Dr. Shilbhadra Banerjee on many technical matters,



since during his tenure as NML's Director; I had become a regular Special Invitee to the NML Research Council Meetings. I did not always agree with Dr Banerjee's views, particularly on subjects dealing with extractive metallurgy, but I could see that his ceaseless pursuit of discipline at all costs was important to bring NML back to its pristine glory. This had unfortunately waned somewhat, post Dr Nijhawan. With the subsequent Directors - Prof. P Ramchandra Rao and Prof. S P Mehrotra - I had a totally different type of relationship. I knew Prof. Ramchabndra Rao (who unfortunately expired prematurely very recently) from my BHU days as a young Lecturer, who came to Banaras from IISc (along with a large retinue of others to join Prof. T.A. Ananatharaman), while I knew Prof. Mehrotra when he was in IIT, Kanpur because both of us had Prof. J Keith Brimacombe as a common friend. I knew Keith as a fellow Doctoral Researcher in Imperial College; he was known to Prof. Mehrotra during his stint at the University of British Columbia (Keith became a global authority on continuous casting at UBC, continuing the good work that he had begun at IC, where many of us got introduced to process metallurgy). I respected both Prof. Ramachandra Rao and Prof. Mehrotra for their professional acumen, which was of the highest order. They carried with them the legacy of NML Directors that were a force to reckon with, in the world of metallurgy.

Before I conclude my rambling on my childhood memories of NML (this can go on forever and ever), let me try and recollect right from its inception, which I was virtually a witness to, what NML has achieved. I cannot forget how my father was involved in installing the Low Shaft Furnace Pilot Plant (opposite Incab) and in the same complex, Mr. P I A Narayanan and Mr. G P Mathur added the Mineral Beneficiation Pilot Plant. Both these facilities were world-class; the stress on large-scale pilot plant experimental work was something NML began very early. The example was followed much later by international laboratories like Mefos, Swinden Technology Centre, etc. Must give due credit to the powers that be in NML for their foresight. When I was in my early teens, I must have been to the Low Shaft site more than 30-40 times accompanying my father, who was the prime mover of this work. I used to hear phrases like: "how is the furnace behaving", "increase the coke charge", "reduce the ore size", "the silicon content is too high - can you not adjust the hot blast temperature" and other such blast furnace ironmaking jargon every night before going to sleep, as my father would take the Furnace Report, before retiring for the day. These words still ring in my ears; fifty years later! Perhaps this, and the spectacular sight of the "Orange Sky" in Jamshedpur (which I later realised came from the Bessemer Converters) and the red-hot slag being poured on top of a small hillock near R D Tata School (where we would often ask my father to drive us in the evenings for an outing) were the reasons for my attraction towards the extraction of iron and steel right from my college days The romance still continues - old habits are difficult to get rid off.

As a metallurgist today, I can look back at the years of my association with NML to recount various developments that have (or at least should have) left an indelible mark on the metallurgical map of India. NML's work in the area of developing nickel-free stainless steel (named Thackeron, after the Director General of CSIR at that stage, Mr. Thacker) was a major break through pioneered by NML Scientists like Mr. P P Bhatnagar, Dr. S S Bhatnagar, Mr. P K Gupte and others. Although the immense possibilities of Thackeron steel were not fully exploited (for one reason or another, including perhaps the fact that it was developed before its time), this development is something that has certainly contributed towards the popularity of low-nickel stainless steel, in which India is the world leader today. Similarly, the work carried in what became known as NML PM 2 on the development of aluminum-based wires rather than copper wires for transmission on electricity was a major break through, for which Dr. Rajendra Kumar and his team deserve to be complimented. My father, Dr. A B Chatterjea's work in the Low Shaft Furnace Pilot Plant where pioneering research was carried out in using non-coking coal in the form of briquettes charged into ironmaking furnaces, injection of auxiliary fuels like naptha through the tuyeres of the furnace, etc. was certainly noteworthy. I cannot help but imagine what would have happened if this effort, instead of being categorised as the Low Shaft Furnace was made under the name of Mini Blast Furnace, since post-1980 (two decades after NML's work), India became the world centre of Mini Blast Furnaces. Today more than 300 MBFs are operating in India; yet, NML's contribution towards this technology does not get featured anywhere (Dr. BRN has himself confided in me that this was a major blunder made by NML in his era). In fact, after NML abandoned work in this area, the furnace was purchased by an entrepreneur who is operating the furnace as a small MBF. Similarly, another outstanding effort made by NML was in the area of coal-based direct

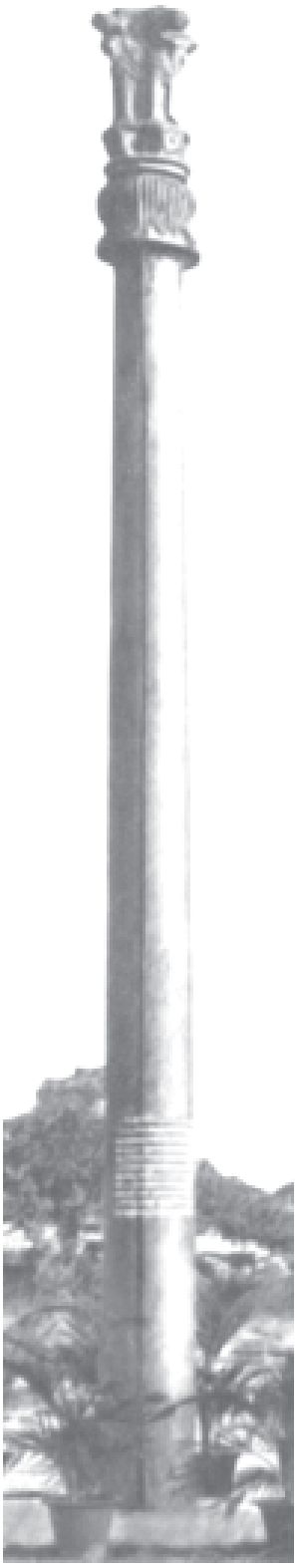


reduction. My father was again involved - without doubt, NML was the first agency in the country to have undertaken this type of investigation not only at a pilot plant level, but also extending it to the modification of a commercial cement kiln to produce sponge iron (the process know-how, design changes, etc. were all undertaken by NML!) Yet, when coal-based direct reduction became extremely popular in India, NML was not in the picture at all. What a pity - a golden opportunity missed if ever there was one! In fact, NML (Mr. K N Gupta, my father and a whole team of Scientists) also undertook research on vertical kilns for producing sponge iron using coal as the reductant. Pioneering activity was also undertaken in electrical arc / submerged arc furnace melting of sponge iron. Aluminising rather than zinc coating was another NML activity of yesteryears. High class corrosion testing facilities were put up in NML many years back. These are areas of current interest in the Indian steel industry; but NML has often been forgotten. Why? Certainly calls for introspection.

In the Mineral Beneficiation Pilot Plant, which fortunately exists even today, NML has right from the beginning undertaken outstanding research work to develop several flow sheets for the beneficiation of different minerals; for example, iron ore for Tata Steel Ltd., fluorspar for Gujarat Mineral Development Corporation, etc. The washing circuits at Joda, Noamundi and recently, Khondbond iron ore mines of Tata Steel are based on extensive studies conducted in this facility. Hats-off to NML for these efforts.

The Low Shaft Furnace Pilot Plant area also housed cupolas of various sizes, in which my father and his team, many years back, worked on developing alternative fuels to coke for cupola melting. This same facility was later used during the tenure of Prof. P Ramachandra Rao with which I was also involved) to undertake trials on using LPG/Natural Gas instead of coke, so that pollution around the Taj Mahal from the coke-fired cupolas in Agra could be abated. NML can also take credit in installing a Magnesium Pilot Plant, which was later supposed to be up-scaled in Adityapur (it never actually happened, though land was acquired). NML's work on magnesium extraction has not been very successful, despite sustained efforts (all research does not necessarily end in success, but, it is still a contribution). In later years after I joined Tata Steel, I found that NML has over the years developed world-class expertise in characterisation of materials like steel, use of submerged arc direct smelting of pre-reduced iron ore for producing steel, making standard samples for chemical analysis, and in many other areas that are regularly used by industry.

Looking back over the last 30-40 years, I can personally state with confidence, both as a metallurgist and as a NML family member that NML has undertaken pioneering research work in several fields, which India can be proud of. On the occasion of the Diamond Jubilee, it is customary to look back and take a walk down memory lane. I am sure many will do what is customary and pen down their thoughts. For me, this trip over the last 60 years is more than just recollection. It is personal involvement. I am as much a product of NML as I am of Jamshedpur, of Loyola School, of Banaras Hindu University, Imperial College and Tata Steel. I wish the Diamond Jubilee of the National Metallurgical Laboratory all success under the stewardship of the present Director, Dr S Srikanth, who again (strange coincidence) is close to me. You just cannot take NML out of my system; it is, and will be, in my DNA, till my dying day! How I wish my father was around today - he would have been even more nostalgic. For him NML was not in his DNA; it was his heart and soul!



NML Diamond Jubilee Celebrations

C. N. HARMAN
Director (Technical)
FACOR Alloys Limited, Shreeramnagar-535 101, Dist. Vizianagar, AP.

Ferro Alloys Corporation Limited, Shreeramnagar P.O., Garividi Mandal, Vizianagaram (Dist.) in Andhra Pradesh, popularly known as FACOR are the pioneers who first established large capacity Submerged Arc Electric Smelting furnaces for the production of High Carbon Ferro-Manganese in India during 1957.

Originally their associated company was exporting Manganese ores mined in Garividi and other locations in Vizianagaram Districts. It had also established a versatile mineral beneficiation plant for low grade manganese ores with crushers, ball mills, rod mill, jigging, tabling and flotation cells and other facilities and operated the same for about five years. However the production of the upgraded product proved uneconomical compared to the available lumpy ores. Moreover the desired objective for phosphorous removal from high phosphorous manganese ores could not be achieved to the required extent and the final fine concentrates needed further processing by agglomeration for usage in electric smelting furnaces which would add to the cost.

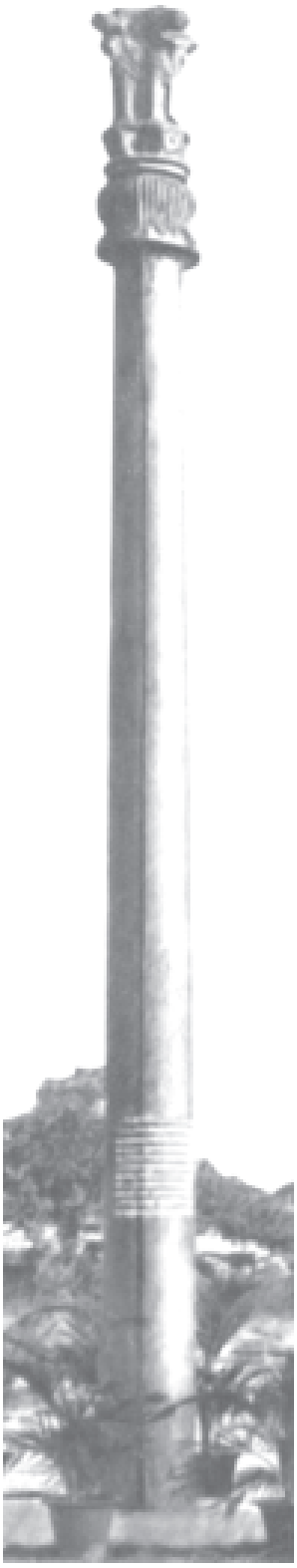
The Management of FACOR has been progressive and enterprising and had always a fascination and great interest for R & D Work for mineral beneficiation and to make use of our vast mineral resources like manganese and chrome ores. They always sponsored investigations to Research Institutions as and when needed.

In early 1960, FACOR was contemplating to set up electric smelting furnaces to cater to the requirement of High Carbon Ferro Chrome and Low Carbon Ferro Chrome by Integrated Steel plants and newly set up alloy Steel Plants producing various alloy steels and stainless steel, when H.C.Ferro Chrome and L.C.Ferro Chrome were largely imported. Hitherto the Government policy was very restrictive in granting industrial licenses for production of bulk ferro alloys. An Industrial license was obtained by FACOR in 1956 for 45000 TPA for all bulk ferro alloys like High Carbon Ferro Manganese & Ferro Chrome, Silico Manganese, Ferro Silicon and Low Carbon Ferro Chrome.

Mr. C.N.Harman, of FACOR, attended an International Seminar on Ferro Alloys Industry in India organized by National Metallurgical Laboratory, Jamshedpur in February 1962. He had the opportunity to see the pilot electric smelting furnace of 600 KVA capacity of BIRLEFCO make which was inaugurated by Prof. M.S.THACKER D.G. of CSIR during that Symposium. Dr. B.R.NIJHAWAN, DIRECTOR NML emphasized that this pilot furnace is very versatile to undertake smelting trials with different raw materials to produce ferro-alloys and other metallurgical products and therefore industries could take advantage of their facility. This prompted FACOR to sponsor a comprehensive investigation to prove and establish the feasibility of production of Standard grade H.C.Ferrochrome and silico-chrome with indigenous chrome ores and other Carbon Reductants, prior to commissioning their own large size furnaces. National Metallurgical Laboratory when approached for trial smelting in their pilot furnace readily came forward to undertake the investigations with raw materials supplied by FACOR. FACOR delivered the required quantities of sized chrome ore and Giridhi Coke (P<0.03%) plus required fluxes for the smelting trials.

High Carbon Ferro-chrome and Silico-chrome Production

The first two campaigns were during March/April 1966 for High Carbon Ferrochrome, and silico-chrome by two stage process. Smelting tests were done with a well planned programme to understand the effect of quantity of carbon reductant agents to be used, effect of different carbon reductants, effect of fluxes like quartzite, Dolomite and bauxite and furnace operating conditions for free flow of slag with clean slag/metal separation on tapping. The operation for H.C.Ferrochrome production was carried out for 14 days. Parameters were derived for the production of H.C.Ferro-chrome with various silicon contents that is max. 4.0% and max. 12.0% grades. The operation was very successful and



basic performance data were obtained for standard grades of H.C.Ferro-chrome with 60-65% Cr, 4% silicon and 6.0 to 8.0% carbon.

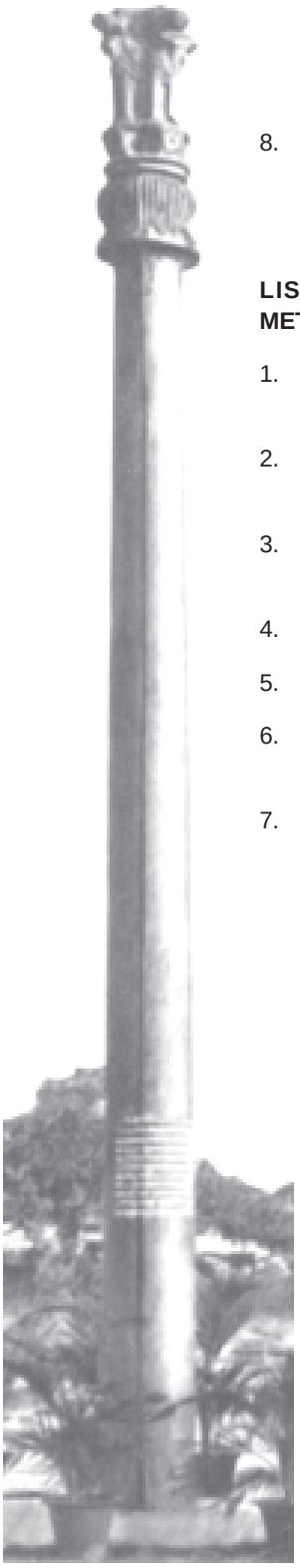
Then this campaign was immediately followed for the production of silico-chrome by two-stage process. In this process High Carbon Ferro-chrome containing 7 to 9% silicon obtained during the previous campaign was broken and crushed and screened to 50-60 mm size. It analysed 62.28% Cr, 7.98% Si and 6.08% C. This was smelted together with quartzite and other carbon reducing agents to produce silico-chrome. Very little slag is produced in this process as only the ash contents of carbon reductants, unreduced quartzite and flux addition contribute to the slag formation. The campaign was done continuously for six days and the effect of usage of different reducing agents like pearl coke, Giridhi coke and Charcoal and their quantum was observed. The tapping of silico-chrome metal was found to be easier as only a small quantity of slag was generated. The carbon content of the metal was also found very low. Silico-chrome containing 37-38% Cr, 40-44% Si and C <0.05% was produced with an average power consumption of 5160 KWhr per tonne of metal. An investigation report (1) incorporating all the data was received by FACOR.

The third campaign for the production of silico-chrome by single-stage process where smelting is done using both chrome ore and quartzite together with carbon reducing agents was carried out in June 1969 for a period of 13 days. As in the previous campaigns, the effect of various parameters were studied. Here more importance was given to the control of slag composition for an easy tapping. Silico-chrome containing 40.3-47.2% Si, 35%-40.7% Cr and 0.05% C maximum was produced. It was established that silico-chrome by single stage process could be successfully produced by keeping the SiO_2 between 45-52% with MgO/Al_20_3 ratio of 1.0 and basicity CaO + MgO/SiO_2 of 0.73 in the slag. An average power consumption of 7200 KWH/Tonne of silico-chrome was obtained. A notable feature was that the carbon content in silico-chrome could be brought down to less than 0.05% by holding the tapped metal in the ladle for a certain period and floating up the SiC particles as a SKUM and removing it out. The report (2) incorporating all the data was received by FACOR.

It must be mentioned that there was a very good rapport and mutual co-operation between FACOR's engineers and NML Scientists and Staff during the entire period of investigation lasting several days. The pilot smelting tests helped FACOR very much to gain experience with indigenous raw materials for their forthcoming establishment of a Ferro-chrome plant. FACOR established a 12 MVA furnace for High Carbon Ferro-chrome and Silico-chrome production and an 8 MVA slag furnace for L.C.Ferro-chrome during 1967.

Besides the successful pilot plant scale investigations on the production of High Carbon Ferro-chrome and silico-chrome, FACOR sponsored many other investigations to NML and obtained very valuable feed back.

1. Investigation on utilization of High Manganese Slag (Mn 30%) for the recovery of Manganese as Manganese Sulphate (3). The ground Ferro Manganese slag on leaching with sulphuric acid; a recovery of 75% Manganese was obtained. The consumption of Sulphuric acid was high and hence the techno-economic pilot plant study was not pursued. Also the Ferro-Manganese slag could be directly utilized in Silico-Manganese production.
2. Sintering studies on some Manganese ores were done at NML (4).
3. Beneficiation tests on two low grade chrome ore samples were sponsored (5).
4. L.C.Ferro-chrome slag (very fine powder) was given as sample for studies to use as hardner for Sodium Silicate bonded sand in foundries.
5. As a quality control measure on the production of Low Carbon Ferro-chrome, different samples were sent to them for investigation to know the type, size and shape inclusions. A report was obtained on their investigation with MACRO and MICRO photographs (6).
6. Average L.C.Fe-Cr sample from FACOR's production was analysed by NML for Nitrogen content.
7. In a reciprocal and collaborative spirit to test the process and products developed by NML, FACOR undertook investigation on the suitability of a special electrode carbon paste known



as Dense Carbon Aggregate paste by NML. This was developed to Substitute the electrically calcined Anthracite based soderberg Carbon electrode paste usually imported. NML developed this paste based on petroleum coke and coke-ovens tar pitch. Initially 10 Tonnes of this paste was tested by filling into an electrode column of 1050 mm dia in the production of Ferro Silicon in a 7.5 MVA furnace. While the other two electrodes were filled with regularly used carbon paste. The NML Dense Carbon Aggregate paste was found to perform well as that of other two electrodes filled with carbon paste normally used and FACOR gave a satisfactory performance TEST report to NML. Later another 30 Tonnes of Dense Carbon aggregate paste was supplied by NML which was used satisfactorily in the production of H.C.Ferro-manganese.

8. In another instance, FACOR utilized the magnesium metal flakes generated as waste during the production of Magnesium metal as crowns at the Magnesium Pilot Plant of NML. 10 Tonnes of Magnesium metal flakes (<10 mm size) were procured from NML and consumed in the regular production of Ferro-silicon Mangesium inoculant at FACOR successfully.

LIST OF SOME OF THE INVESTIGATIONS SPONSORED BY FACOR AT NATIONAL METALLURGICAL LABORATORY, JAMSHEDPUR

1. Production of High Carbon Ferro-chrome and silico-chrome from raw materials supplied by Ferro Alloys Corporation Ltd., Garividi, NML/I.R.No.377/66, July 1966.

2. Production of Silico-chrome by single stage process with the raw materials supplied by M/s.Ferro Alloys Corporation Ltd., Garividi, NML/I.R. No.531/69, July 1969.

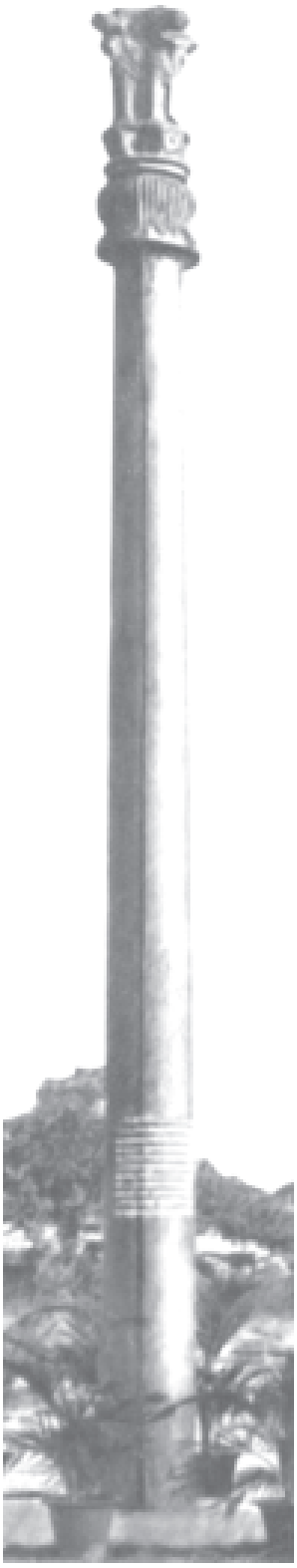
3. Utilization of Ferro-Manganese slag for production of Manganese Sulphate, No.NML/LRC/(7)-13/77-5, 23rd November 1977.

4. Manganese Ore Sinter Studies, SFM/19F(6)/141/76, dated 05.03.1978.

5. Beneficiation tests on two low grade chrome ore sample, SFM/176/83/78, dated 07.04.1978.

6. MACRO and MICRO-structure of Low Carbon Ferro-chrome samples, No. NML/RC(2)-5/71. dated 20.12.1971.

7. Use of Dense Carbon aggregate as a base material for Soderberg electrodes. Proceedings of the All India Seminar on Carbon Technology, 4-5 March, 1978 organised by BALCO and I.I.M at KORBA.



My Journey to the Mineral World

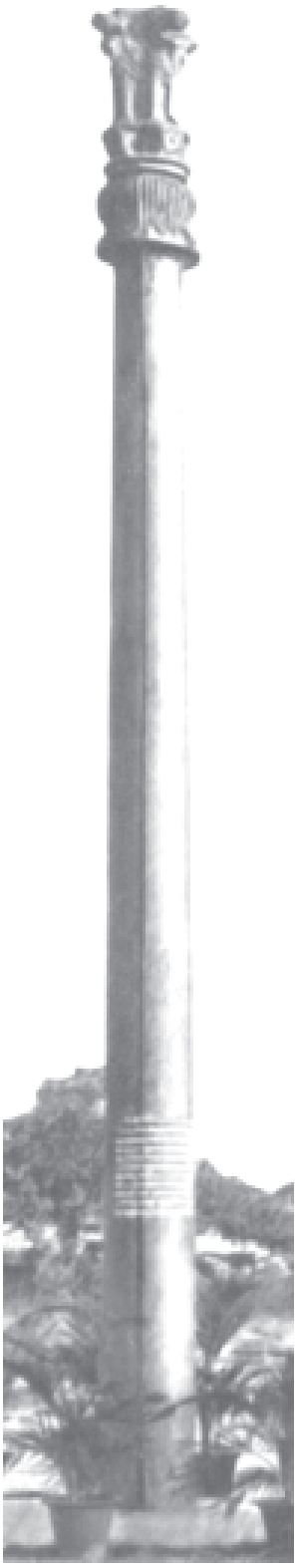
Dr. Ing. H.P. MISHRA
Former Chairman, IPICOL
222/1, Shastri Nagar, Bhubaneswar

In the twilight days of my life, I fondly remember the period during 1950 to 1970 when I had deep association with NML. In 1956, after completing my study in University of Aachen, West Germany, I started working for Rourkela Steel Plant. My first work was to determine a suitable coal blend for the blast furnace.For this I was in constant touch with NML and CFRI. During that time, I had opportunity to come in contact with metallurgist of repute in NML Dr. B.R. Nijhawan, Dr. A.B. Chatterjee and later on Prof. V.A. Altekar. I was like a family member of Dr. Chatterjee and many times, during my visit to Jamshedpur, I was privileged to stay with Dr. Chatterjee. My association continued even after the demise of Dr. Chatterjee. Dr. Amit Chatterjee,worthy son of of Dr. A.B. Chatterjee and a metallurgist of great repute working in TISCO is like my own brother and has immensely helped me in the 'Direct Reduction Technology' of producing sponge with solid fuel like non-metallurgical coal from Talcher and other sources of our country. This work started with Dr. A.B. Chatterjee in NML in association with my organisation in Orissa i.e. IDCOL and IPICOL. Before this, during my tenure as Chief Superintendent, Iron & Steel, in Bokaro Steel Plant from 1967 to 1969, I was a constant visitor to NML. For Bokaro Steel, the blast furnace burden preparation technological tests on our iron ore and coal were carried in NML.

Towards the end of 1969, I returned back to Orissa as Managing Director of Industrial Development Corporation. From 1970 to 1974, I took help of NML for our sponge iron and Ferro-vanadium project. Lot of work was conducted in pilot plant of NML with the assistance of Dr. A. B. Chatterjee's team for sponge iron project as well as extraction of Vanadium from vanadium bearing titaneferrous Magnetite ore of Mayurbhanj district. These work helped us to apprehend the Orissa sponge Iron & Tata Sponge Iron projects. During this time, Dr. Nijhawan helped us to secure NORAD assistance for conducting pilot scale test on our vanadiferrous ore in Elkam, Kristiansand. Myself along with my friend technologists stayed for three months in Kristisand for this test. This test was successful and a detailed feasibility report was prepared by Dastur Co. for realizing this project. I feel that, time matched for realizing the project as market price and demand were in most favourable conditions.

In 1974, when IPICOL was grounded, I joined as its Chairman and had interaction with NML for realising Ferro Nickel Project based on laterite Nickel ore and Chrome ore overburden from Sukinda area. Dr. Nijhawan, Former Director, NML was working in Viena for UNIDO and we got financial assistance for conducting tests in Elkam in Norway. Three thousand tons of laterite ore was trans-shipped to Norway for tests and the test provided great promise for ferro nickel project. MECON and Dastur Co. have prepared feasibility report and we were pursuing to realize the project in view of growing demand of Ferro-Nickel for stainless steel project. Beside these projects, NML contribution for realizing Ferro alloy projects specially charge chrome, ferro-manganese, ferro-silicon etc. are noteworthy.

National Metallurgical Laboratory is our premier laboratory conceived by our first Prime Minister Pt. Nehru. NML has played pioneering role in converting our mineral resources to national wealth. On the occasion of diamond jubilee celebration, I remember my pleasant and close interaction with NML. I wish all the past and present staff of NML healthy professional life.



My Reminiscences - with a few thoughts thrown in

P. PARVATHISEM
Consultant (Non Ferrous Metals), Hyderabad
(Former RC Chairman, NML)

At the outset I am grateful to NML for giving me an opportunity to share my pleasant memories and also express a few thoughts that have come to my mind regarding the future of NML as I see it.

My first romance (interaction may be a more appropriate word) started way back in 1974 when I had occasion to meet Shri M.J Shahani in connection with the technology developed and offered by NML for the production of Zinc Dust. Dr. Altekar was the Director of NML then. Zinc Dust is used in the manufacture of Zinc through the route of Hydro Metallurgy to cement out impurities like Copper, Cadmium, Cobalt and Nickel and produce a pure Zinc Sulphate solution to be subjected to Electrolysis for electro winning of Zinc. While the technology offered by NML was technically competitive, Nitrogen Gas used as an inert medium to prevent Zinc oxide formation is taken "once through" and not recycled. This in turn pushed the cost of conversion up and we from Hindustan Zinc had to resort to import technology which incorporated Nitrogen recycling.

Little did I realize in 1974 that 26 to 27 years later I would be chairing the Research Council of NML and that I would be succeeding a great personality like Dr. J.J Irani. The job was an onerous task and I had a professional satisfaction during my tenure. At this time, I must remember Late Professor P.Ramachandra Rao, who was the then Director of NML and later occupied a distinguished position as Vice-Chancellor of Banaras Hindu University. Prof. Ramachandra Rao was a knowledgeable person, simple in nature and was responsible for the name NML made during his long tenure there. It is unfortunate that he died recently when he could have contributed a great deal more to this country.

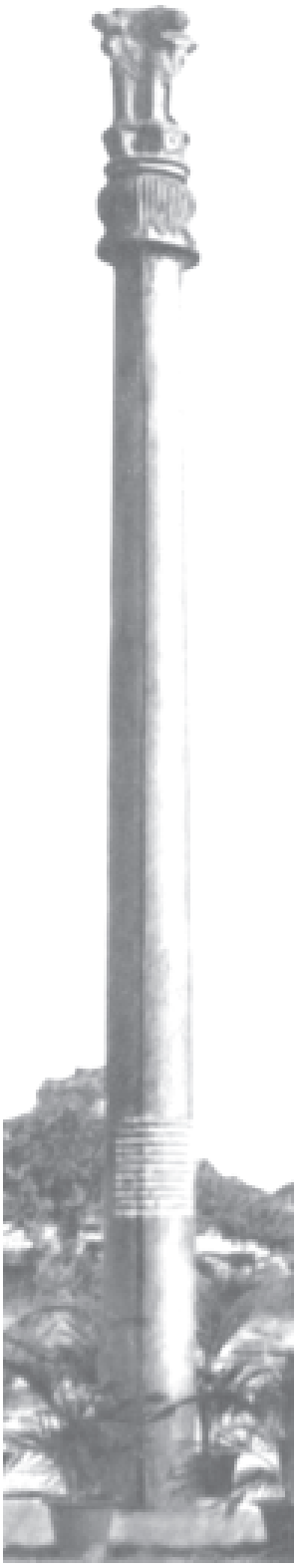
The next Director with whom I had my interaction was Prof. Mehrotra who is acknowledged as an expert in the field of Mineral Beneficiation. In fact I had spent a far longer time with Prof Mehrotra. Mineral beneficiation is an important pre-operation to smelting and by virtue of its enrichment of the metal constituents and separation of gangue materials reduces the load considerably on downstream smelting. It is only in the fitness of things that Indian Institute of Mineral Engineers is being associated in the organisation of an International Conference in the month of December along with NML and Tata Steel. A person of Prof Mehrotra's stature would add great value to this event.

I take this opportunity to put across a few thoughts of mine on NML. Based on a detailed analysis, NML could take a view on these :

- By virtue of its physical location, NML has always been perceived as a research Laboratory dedicated to the Iron and Steel Industry. With the exponential growth of non-ferrous metals like Zinc Copper and Aluminum in Public and Private Sectors, I wonder whether there is a need for NML to project itself as a complete laboratory dedicated to all metals in an equal measure.
- As person from the shop floor and industry, for the past 40 to 45 yrs, and continuing in the profession of metals, there is an obsession to look towards research as a tool to promote innovative technologies, away from the traditionally accepted practices and not in providing incremental improvements in beaten track technologies. However it goes without saying that such new technologies should be commercially viable.
- Today R&D and Industry are representing two ends of a spectrum. Both have to cover some distance to get to a meeting point. Besides publishing papers in journals of national and international repute, R&D may have to cover a little more distance to shake hands with Industry. A purposeful and determined R&D-Industry partnership will go a long way in creating a vibrant India.

In conclusion, under a young and dynamic Dr. Srikanth I am confident that NML will reach great heights in a short time.

I wish the Diamond Jubilee celebrations a great success.



Sillimanite beneficiation through Column Flotation Technology Spin off from NML to IREL, Chavara

P. F. JOSEPH
HEAD, Chavara Unit

Indian Rare Earths Ltd is a central public sector undertaking under Department of Atomic Energy, Government of India engaged in the production of valuable minerals from the beach placers and the Chavara unit is operating in western coast of Kerala in Kollam district. Its products are Ilmenite, Ruffle, Zircon and Sillimanite and this article discusses highlights of IREL's endeavor to increase the recovery and grade of Sillimanite through Column Flotation -a technology knowhow from NML Madras centre.

The content of Sillimanite in our raw material is 3.5 to 4.5 % and is upgraded to 55% through various process equipments like spirals, magnetic separators before introduction to six horizontally oriented mechanical floatation cells wherein the mechanism of mineral and air bubble attachment is effected by a rotating impeller that generates negative pressure for drawing compressed air. The recovery and grade achieved were 65-75% and 91-93% respectively.

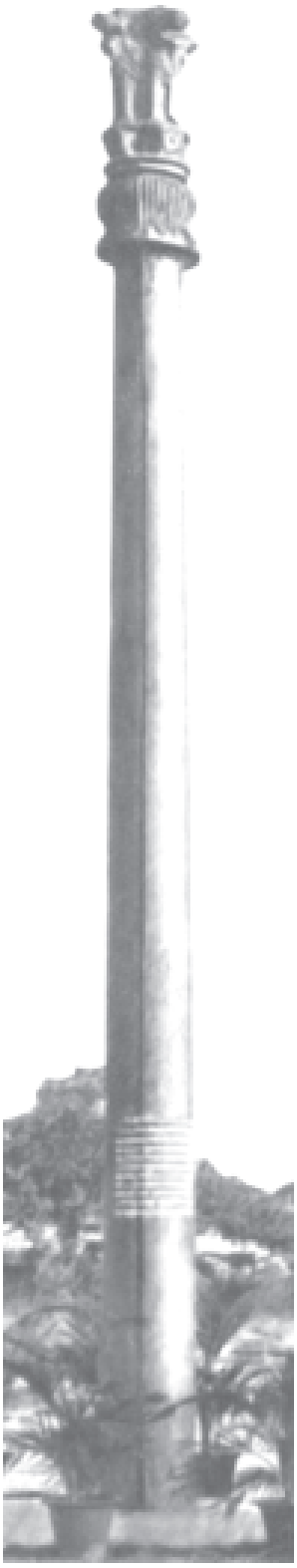
Subsequent to the success of Column flotation in the beneficiation of Sillimanite in IREL OSCOM unit in Orissa it was proposed to install the same at Chavara unit and in this regard sought the service of NML, Madras center for the design, supply, supervision of erection and commissioning of 1.2m dia Flotation Column.

NML as a goodwill gesture agreed to provide the services at a reduced cost as compared to the service cost for OSCOM column. The process details, engineering drawings, accessonesfinstrument specifications were swiftly provided by NML as per outlined project milestones and it was decided to fabricate the Flotation Column to NML's specification departmentally. Given the space constraint at the Chavara unit, the finalization and freezing of process and equipment layout was taken up in parallel with the active participation of Dr S.Prabhakar Scientist G - project in charge from NML.

During the fabrication and erection period, Dr Prabhakar visited the Chavara on more than one occasion to ensure that the progress is made as per specification down to the finest details. The column floatation system was commissioned on 24-07-2010 and NML deputed two scientists Mr Bhaskar Raju and Mr Vijaykumar for commissioning and process streamlining.

During commissioning it was observed that the grade could be achieved relatively quickly but the recovery was fluctuating, the column feed pump was getting bogged down frequently and the column could not be operated continuously. The causative factors for fluctuation in mineral recovery and frequent pump jamming were carefully analyzed by both NML and IREL and the following root causes were identified. Addition of make up water was diluting the pH value of the slurry and the air entrapment in the chemically treated feed slurry was causing loss of suction resulting in frequent jamming of the feed pump. As a corrective measure IREL redesigned the feed pumping system wherein entrapped air could be vented out and make up water requirement is being minimized with an added provision of instrument logic control for ensuring consistent feed rate and pulp density to the column. The above corrective actions resolved the operational bottleneck successfully.

Thereafter commissioning activities were recommenced and the stabilized process parameters and the reagent dosages were adjusted to scientists thoroughlytrained hthe engineers grade and 85% recovery. Senior NML and operators on the fundamentals of column flotation technique which profoundly helped to successfully overcome the inertial resistance to change. The system was formally inaugurated and inducted by our Chairman Managing Director Dr.R.N. Patra on 19th July 2010 and is being operated without any problem since then. We thank NML scientists Mr Prabhakar, Mr Bhaskar Raju, Mr Vijaykaumar, Mr S. Subba Rao who tirelessly put in their best to make this project successful.



My Association with NML

R. N. PARBAT*
Former Member of the Research Council of NML

In my 50 years of Metallurgical Career, I was associated with NML as a Member of the Research Council for two terms, most probably from 1995 to 2003 during the directorship of Late Prof. P Ramchandra Rao and Prof. S P Mehrotra.

As a Metallurgist, I always admired NML as the highest centre for Metallurgical Research in India. Many of my friends have made their career there and later elsewhere. Some individuals, I associate with some of the unique work done by them. Dr. B R Nijhawan is associated with his work on Mn-Stainless Steel, Dr. Chatterjee with his work on Mini Blast Furnace, Dr. Rajendra Kumar with his work on Ti-B Grain Refiner, Prof. S Banerjee with his untiring efforts to commercialize Mg-Pilot Plant, Prof Ramchandra Rao with his efforts to popularize Smokeless Cupola and Prof Mehrotra with his coordinating efforts to make the Project on Improving thermal and chemical performance of Indian Blast Furnaces by using special purpose sensors. If I am not mistaken, I was, most probably, also associated with Prof Ramchandra Rao in selection, promotion and transfer to Chennai Centre of the current Director of NML.

In the Diamond Jubilee Year, I wish NML a continued success in it's chosen fields of Research and also an eminent position in the International community of Metallurgical and Materials Research.

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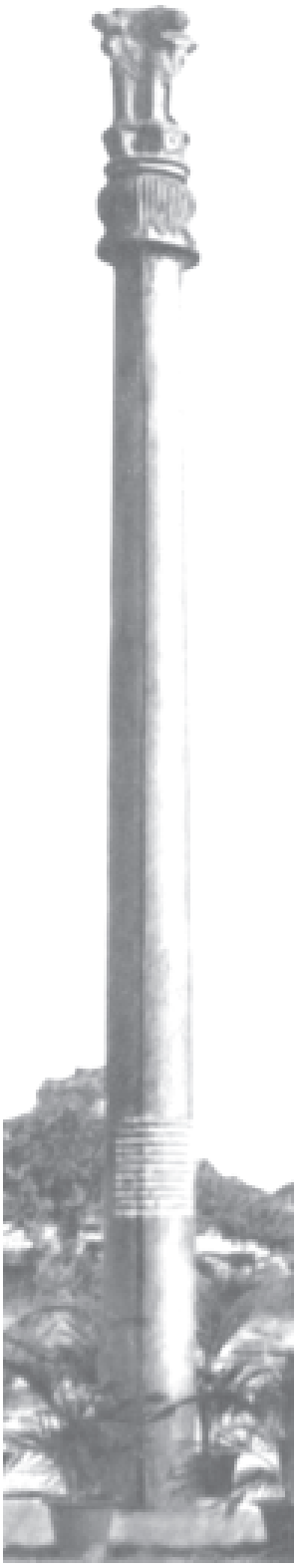


Creep Laboratory at NML

Dr. S.L.MANNAN
Consultant, Gas Turbine Research Establishment (GTRE),
C.V.Raman Nagar, Bangalore-93

I am glad to know that NML is celebrating its Diamond Jubilee year. On this occasion, it is a privilege for me to recall my association with the laboratory.

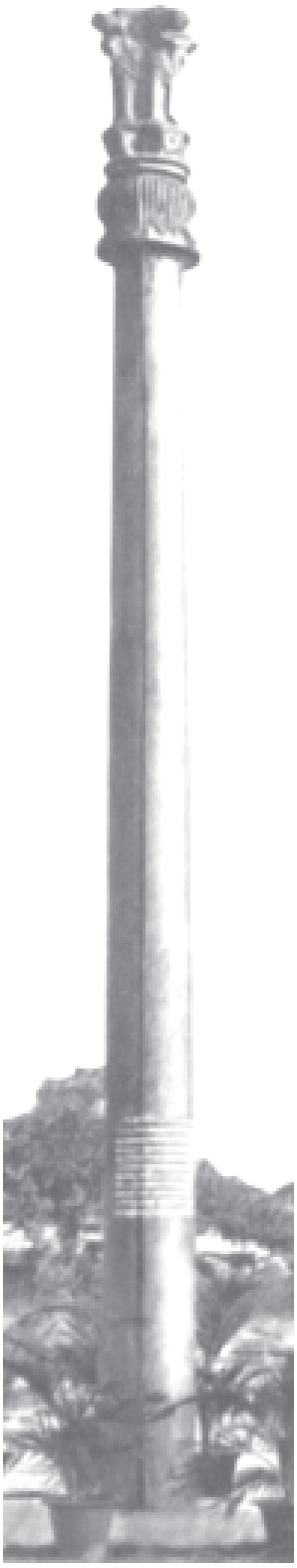
My association with NML goes back to the mid-seventies. We were in the process of setting up our creep laboratory at Kalpakkam and had also envisaged a major program in creep testing on Fast Breeder Reactor Materials. At that time, NML was probably the only creep laboratory of its kind in the country and we chalked out the programme for creep testing on Fast Breeder Reactor Materials in consultations with NML. The first major programme of our collaboration with NML was testing of various heats of AISI Type 316 stainless steel used in the construction of Fast Breeder Test Reactor at Kalpakkam. I remember some of our tests were really long term tests running for more than 10 to 15 years. Another important activity with regard to creep evaluation and testing was the setting up of the Creep Panel. This panel had its head quarters at NML and guided activities towards certification of indigenous creep resistant steels. Regular meetings of the creep panel were held to discuss and debate various issues related to development and testing of creep resistant steels. NML played a pivotal role in the activities of creep panel. Though some meetings of the panel were held in other member institutes, NML was the place where we met more often. I had numerous occasions to be at NML both for creep panel meetings and to review our on going collaboration on creep testing. I was quite impressed with the professional way the laboratory was functioning. All the finer details of each test were recorded meticulously and made available for analysis and evaluation.

Looking back, NML did play an important role in the indigenous development of creep resistant materials. While creep testing facilities have come up over the years in many organizations to meet their in-house demands, NML continues to cater to the requirements of creep testing for many strategic programmes in the country, being the only nodal agency of its kind. Considering the present and future demands for development and testing of high temperature materials in the country it would be necessary to refurbish and augment the creep testing facilities at NML. My interactions with NML continued as I moved to Gas Turbine Research Establishment (GTRE). GTRE has extensive programme on creep testing of materials for Kaveri engine and its Marine version. Some of these programmes are already underway in collaboration with NML.

Over the years, extensive facilities for microstructure evaluation have been set up at NML and mechanical properties - microstructure correlation has been receiving greater emphasis. This is vital for development of new materials as well as for understanding damage mechanisms in operating plants. *In-situ* assessment of creep damage in power plant components and assessment of remaining life is an important area being pursued at NML. I recall that structural integrity programme was initiated at the laboratory some years back and this is one area in which emphasis should be placed in the future.

There is strong need for creep and fatigue assessment in petrochemical equipments, aircraft engine, power plant components of both conventional and ultra super critical plants and nuclear reactors with the view to predicting remaining life of various plant components. Reliable material data is one aspect along with understanding of dominant mechanisms of failure. NML would play an important role both in generation of reliable data along with understanding of damage mechanism and contribute to the safe operation of the plants which is vital for the anticipated economic growth of the country. A related area that should receive emphasis is the development of small specimen testing methods that can be used for evaluation of service components.

I take the opportunity to convey my greetings and best wishes to all the members of National Metallurgical Laboratory on the occasion of Diamond Jubilee celebrations and hope that the laboratory would achieve even greater heights in the years to come.



My Tryst with National Metallurgical Laboratory (NML)

Dr. ANJAN K. CHATTERJEE
Managing Director, Conmat Technologies Pvt. Ltd.
CFR-318, Sector-I, Salt Lake Kolkata 700 064

It was in 1971 that I first visited the National Metallurgical Laboratory (NML) in Jamshedpur on my return from abroad to settle down in India - a decision many of my near and dear ones considered foolish then. My first serious day-long encounter with a national research establishment like NML, beginning with a not-so-brief session with Dr. Altekar in his chamber, convinced me more comprehensively that my decision to come back and settle down in India, despite the lures of the developed countries, was correct - a decision that I never regretted later. My tryst with NML started with this defining moment in my professional career.

For a variety of chance factors in my life and career I never took up a regular employment at NML but I had many occasions and opportunities of interaction with the scientists at NML over the next four decades. I could see the progressive transformation of NML with time - a laboratory that was founded in November 1946 by the first and only Governor General of India Shri C. Rajagopalachari and which was later inaugurated by the visionary Prime Minister of the country Shri Jawaharlal Nehru in November 1950. Dr. Balraj Nijhawan, the first Director of NML, became an icon in ore-dressing and metal research then in India and abroad.

I still remember in mid-eighties of the last century I was engaged in the ACC Ltd on developing a new white cement project using the beach sand near Dwarka in Gujrat. One of the basic requirements of this project was to bring down the iron oxide content in the sand, which was close to about 1.0 per cent, to below 0.20 per cent. When we were on the run to search out the right beneficiation technology of this level of precision at pilot scale level, only NML could provide the facility of high-intensity magnetic separation. The industry- - research cooperation thus started for us three decades back.

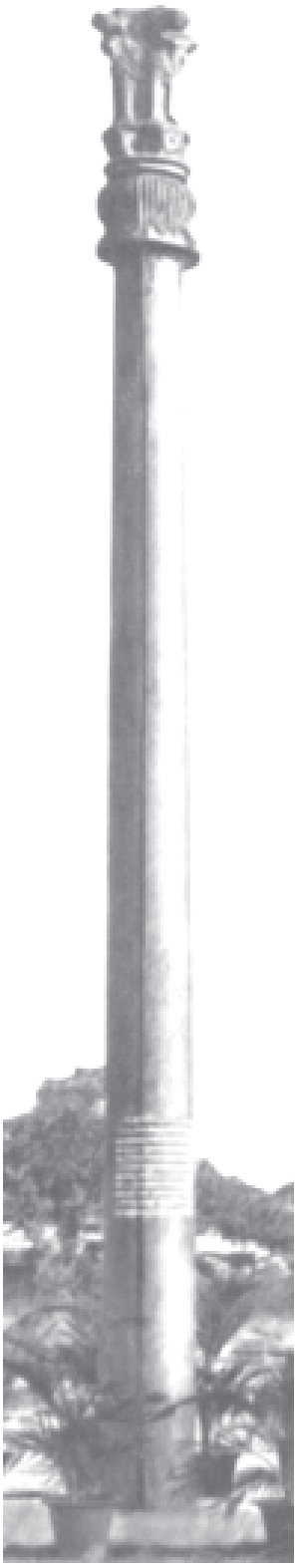
Quite in keeping with time, NML imperceptibly reoriented its capacity, expertise and expanse from the focus on ores and metals to the wider world of 3M's - Minerals, Metals and Materials. Under the leadership of Dr. S. Banerejee, Late Dr. P. Ramachandra Rao, and Dr. S.P. Mehrotra, with whom I had occasions to meet and exchange views, I could sense the dimensional transformations that had been taking place in NML. Quite a few times in the past I had been invited to the Research Council meetings of NML and I could feel the change dynamics in their research strategy, planning and execution.

In the mid-nineties running up to the early part of the new century, NML was a constituent member of a National Millennium Initiative of an altogether new technology development in cement making. The new comminution technologies were the focus of NML, while the other facets of manufacturing were taken care of by other constituent academia and research bodies. I happened to be a member of the Project Monitoring Committee at the national level. It was highly encouraging to see the innovative approach adopted by the concerned research team of NML, producing interesting results and unfolding newer opportunities. I am sure that NML must be pursuing to take the project from its "proving stage" to commercialization in association with industrial partners.

I understand that NML has now moved further into many new fields of materials research such as geopolymer cements, nano-structured advanced materials, etc. I am sure all these new research endeavours will lead to both innovations and inventions for substantial societal benefits.

NML has many claims of research success, technology transfer and knowledge dissemination in the wide area of its coverage. It has gathered immense inherent strength in the last six decades to take the R & D front of the nation to new dimensions not reached so far. Dr. S. Srikanth has taken charge of the Laboratory at the most interesting times, when unforeseen technologies and materials are being invented.

I congratulate NML at this anniversary and wish the scientists and staff members all success.



National Metallurgical Laboratory and - A Random Selection of Reminiscences

HEM SHANKER RAY

My first exposure to any R & D laboratory was at the National Metallurgical Laboratory (NML). It was fifty years ago and I was then an undergraduate student at the Indian Institute of Technology (IIT), Kharagpur. I do not remember the circumstances, perhaps I was there during an industrial tour of our batch or it could have been during a summer training at what was then known as TISCO. What I do remember, however, is that I as much impressed by the size of the main building as I was by the length of an office room at the end of which sat the venerable Dr. A. B. Chatterjee, the then Deputy Director and a champion of the low shaft furnace for ironmaking. I remember visiting the pilot plant that would be operated for years. I was then too small to even try talking to him. However, I have talked a lot with his illustrious son Dr. Amit Chatterjee who has become a close friend and collaborator.

After my graduate studies abroad I joined IIT-Kanpur in 1967 and immediately thought of visiting NML. I had started writing a book on Nonferrous Metals Production and I needed literature. I travelled to Jamshedpur to work for a while in NML library, reading the books there and copying diagrams using carbon paper. I must have received good co-operation because I do not remember facing any problem there. The book was eventually published some fifteen years later with Professor K. P. Abraham and Dr. R. Sridhar as co-authors. Needless to say that I had to bear the expenses of my travel and stay in a cheap lodge. May be there was a Guest House but, at that time, persons lower down in the pecking order never even dreamt of such priviledges.

I began to learn about NML's R & D activities on import substitution, creep and fatigue, corrosion etc. I encouraged my first M. Tech student (Gopal Bandyopadhyay) to join NML as a researcher but he did not continue. The laboratory at that time did some pioneering work in developing aluminum based electrical cables and nickel free stainless steels. The concept and emphasis on 'impart substitution', however, always seemed flawed to me. No wonder that idea was eventually abandoned everywhere. However, NML did some important fundamental research in the search for 'substitutes'.

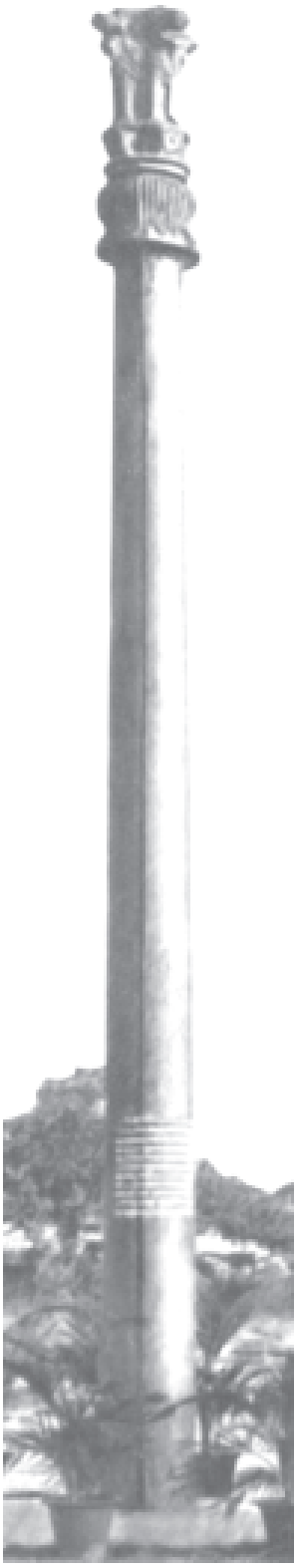
Gradually I came to know some of the scientists there including the Director Dr. Altekar. Earlier I had barely met Dr. Nijhawan during formal occasions. I read with interest whatever they published. I sensed that Dr. Altekar liked me for some reason unclear to me.

I joined IIT-Kharagpur in 1980. Within a year or so two of our best colleagues there Dr. Omkar Mohanty and Dr. R.N. Ghosh left to join NML. After Dr. Altekar retired, Dr. Rajendra Kumar took over as Officiating Director. Because of a variety of reasons, many institutions including IITs and our R&D Laboratories were passing through bad times then and NML was no exception. There was paucity of both funds and talent.

Something very interesting happened then, perhaps in the early 80s. There was an advertisement for the position of the Director, NML and for reasons best known to himself, Omkar sent me an application form to apply. As one who was then just settling down at IIT-Kharagpur I did not consider myself at all fit for this challenging task. But Omkar insisted and I sent the form. Fortunately, I did not have to worry about the interview because a few days later I received a letter inviting me to be a member of the Selection Committee ! I promptly withdrew my application saying that I would rather be with the more comfortable selection side.

There were several very well known persons who came for the interview, Professor S. Banerjee, Dr. C. K. Gupta and Dr. B. K. Sarkar (who would later be the Director, CGCRI) etc. Dr. R. Kumar also came.

After the interviews, when the time came for deliberations, the Chairman, Dr. Arunachalam turned towards me and asked. 'So, Professor Ray, who do you think is the best suited ?' Obviously, I had to



be the first. I did not answer that question and somewhat boldly put a counter question to the others, 'Normally we expect the Officiating Director to take over. If we should rather select a new man, then I would like to first know why ?'. Dr. Arunachalam was not offended at all and spoke for almost ten minutes to explain why the Laboratory needed a new person. He was forthright, forceful and very impressive. I had guessed that perhaps there was already some consensus about Professor Banerjee and I named him although I knew very little about him then. Then I named two others as well. I was happy that I had not erred.

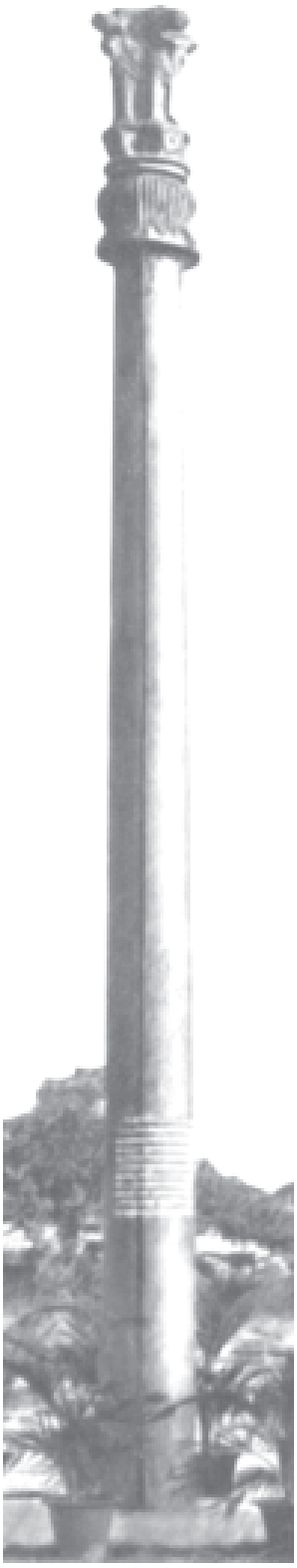
What a difference Professor Banerjee made ! In a few months time everything seemed to change and it all started with general order and discipline. A strict man with a soft core, he streamlined things and created a 'system'. He went beyond macro planning and emphasized micro-planning supervising the smallest details. He trained everybody to use proper slides and the viewgraphs when they came for assessment interviews. Even the peons learnt to use these so very well. At times, however, he went a little too far when he standardized the lettering sizes too ! I learnt many things from him. He insisted that the glass windows in the office doors be cleared up, no paper or wooden covers, because he said that they were there to ensure transparency. Years later when I joined the Regional Research Laboratory (RRL) at Bhubaneswar, I did the same thing and had all glass windows in the doors cleared up.

For many years, during Professor Banerjee's time, I was closely associated with NML as a frequent visitor and / or member of RAC. I chaired numerous Committee meetings for assessments and selections. Prior to every meeting I would routinely ask him if he had anything special to say about any candidate, anything positive or negative, that my Committee should keep in mind. His answer was always straight. 'Do as you and your Committee think fit'. Many scientists we selected then have since risen through the ranks and have proven themselves. It makes me happy that our Committees rarely made a wrong selection. There was perhaps a rare exception when a lady scientist we recruited did not do so well in the months to follow. He told me, jokingly, that perhaps my Committee's decision was influenced by her good looks. Yet, he admitted that there was nothing wrong with her credentials and her performance in the interview. I remember telling him that, unfortunately, there was nobody in the committee who could read the future and then in this case too we did agree on something.

NML gave me my first exposure to CSIR and big projects. Dr. Arunachalam, then Chairman RAC, arranged for some 2 crores for a project on extraction of tungsten from Degana deposits of Rajasthan. The metal was needed for armour plates of tanks being developed in his laboratory. Unfortunately, although NML did develop a successful process, it was not economically viable because the ore was very low grade. This work made me understand the importance of techno-economics of the R & D activities we undertake so very routinely.

In the initial years of Dr. Banerjee's time as Director, I was at IIT-Kharagpur and I had the opportunity to collaborate in several R & D activities. Dr. Swatantra Prakash then registered for his Ph. D under me with Mr. K. N. Gupta as co-guide. Prakash's work was very original and after he presented his work in some Conference abroad he received invitation from a prestigious journal for contribution of a paper. No other scholar of mine would receive such a recognition again. Two other senior scientists of this Laboratory, Dr. R. P. Bhagat and Dr. A. Bandyopadhyay had also done their Ph. D under me. But both of them initiated their work when they were in RDCIS, SAIL. They did very good work too.

I initiated an important project in NML based on the findings of one of my Ph.D scholars, S. Mookherjea who had shown that one could easily produce iron roads if a column of iron ore fines were heated surrounded by coal fines. The concept was nothing extraordinary but Mookherjea had systematically worked out the necessary process parameters and the theory. Professor Banerjee was initially skeptical when I urged him to try this out in a large scale. But then urged on by Mr. K. N. Gupta and me he agreed and soon some trials were initiated. Professor was excited when K. N. Gupta was routinely producing some 6'' dia 6' long rods. He arranged for electroslag remelting of these rods in an integrated system by designing and commissioning a rather sophisticated pilot plant. For a while this was a major activity of NML and several patents were also taken. There was, however, some inherent snags and I could have suggested some remedies. But then I found myself somewhat unwanted and of course, my name was not there in the patents either.



Professor Banerjee did two remarkable things I specially remember. First, he managed to sell off the Magnesium Plant which had been closed down years ago. There were so many people (80 ?) who simply came to sign the attendance register. I remember asking the Scientist-in-charge of the plant during an Assessment interview , What do we assess you for ? What do you have to say ?' His answer was, 'Sir, I have done nothing excepting keeping the premises clean ; I had no job. This sad life was my destiny'. Second, he started the Component Integrity Evaluation Programe (CIEP) , then a path breaking concept. Through this he managed to raise funds from the industry and through a World Bank loan. Laboratories then, unlike now, were severely short of funds and the CIEP rejuvenated NML and, subsequently, there have been many spin offs .

After I moved to RRL, Bhubaneswar, Professor Banerjee helped me in many ways, often acting as a mentor. He was also a member of the RC there. In fact, during some union problems when my laboratory was in turmoil he sent some emissaries to help restore order. Our association continued even after he joined RDCIS, Ranchi.

NML was fortunate to have Dr. Ramchandra Rao after Professor Banerjee . Professor Rao, an eminent academician came from the Banaras Hindu University to a Laboratory which was in good shape. His academic credentials were outstanding. He excelled in administration too and particularly in human relations. I know of a lady in CGCRI who once worked in his office at NML. She would, routinely, receive a call from him on her birthday even at CGCRI and she was not an exception . No wonder so many today mourn his loss.

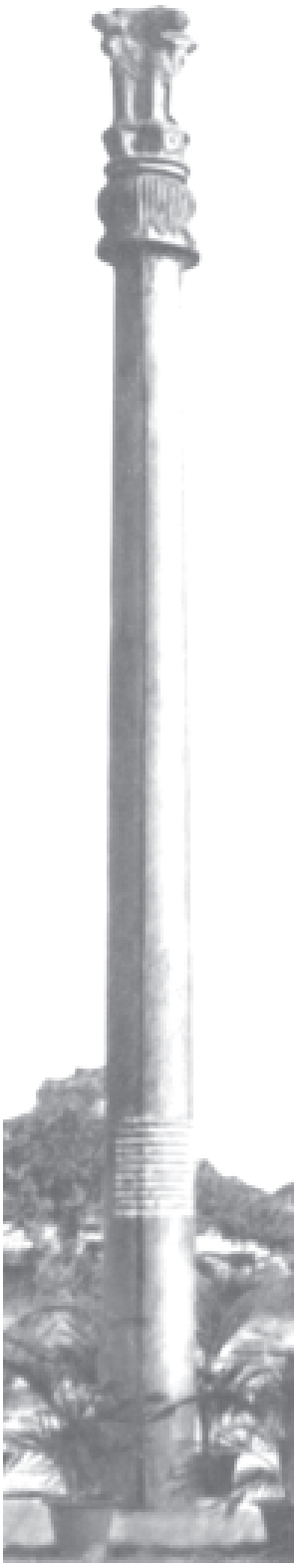
I came to know him only after he joined CSIR and soon we became very good friends. Passionate about academic matters, he once explained to me his work on quasi-crystals for nearly an hour. It was around one midnight in Science Centre in Delhi and only when I appeared to be very sleepy that we stopped talking. We met for the last time in November 2009 in Kolkata during the ATM. He talked about a book of Thermodynamics he was writing and he wanted me to have a look. I will not receive the manuscript now. I remember the occasion when we shared the stage at NML a few years ago and each of us talked on environmental issues. My lecture was more of a 'popular' kind but his paper was full of data and figures. He happily gave me his lecture material which I used in many of my lectures later. NML was fortunate to have as Director a man like him.

I was extremely happy when Dr. Rao was succeeded by Dr. S. P. Mehrotra who was in the first batch of undergraduate students I taught at IIT-Kanpur. I always thought very highly of him and much before he joined CSIR. I had asked him if the would be interested in a position in CSIR even though I was aware that he was doing well as a Professor. He was not interested in CSIR then. That he had a solid background in Process Metallurgy and Mineral Processing was a special input in NML. He was able to continue the good work of his predecessors.

I have an interesting connection with the new dynamic Director, Dr. Srikanth too. His Ph. D thesis was sent to me by his guide Professor Jacob whom I have known for many years. I went for his viva-voce too. I had been truly impressed by the long list of papers he had published already. Subsequently, perhaps, I was involved in his selection as a scientist at NML also.

I had from my first meeting with him had known that he was marked for higher things. By this we do not mean just a position that he has now. I truly believe that under his leadership NML will achieve great heights.

In this write up there is more focus on people than projects mainly because, now that I am no longer very young, people matter more than projects. And, therefore, I must recall here my association with some other scientists of NML. Dr. Omkar Mohanty and Professor R. N. Ghosh, still amongst my best of friends, remain in my mind amongst the best scientists NML ever had. Many other names come to my mind but I would rather not list them just in case I miss mentioning somebody. I do however, cherish interacting, at various times, with people of diverse interests - somebody effortlessly combining his SWA activities with yoga and laboratory projects, another passionate about rural development oriented projects and then still another always eager to challenge established concepts in thermodynamics and so on. I think of some who think more than they do and some others who do more than they think.



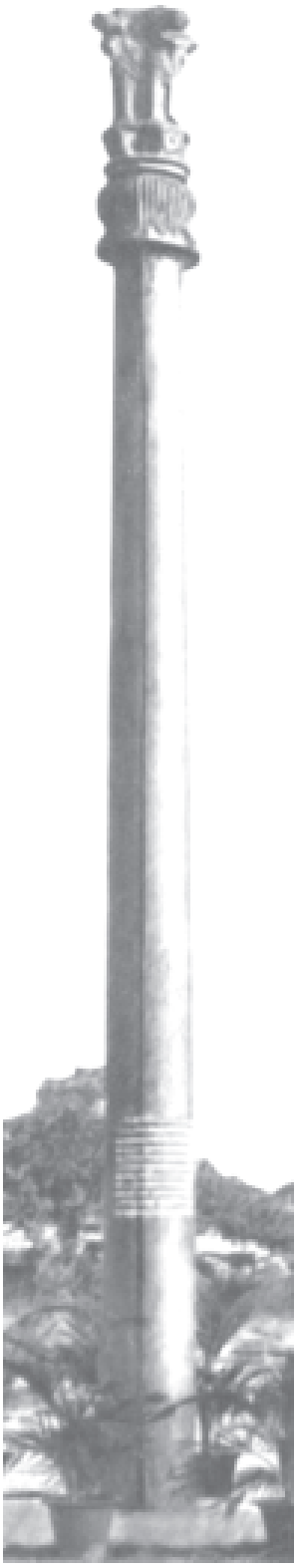
What is NML's future ? There was a time when any discussion on CSIR started with mention of NPL, NML, CFRI and CGCRI. It is not so any more and Engineering Sciences group of laboratories seemed to have been relegated to back benches. NML at one time was so well known that few cared to know the full name - the abbreviation was sufficient and the pronunciation of this had many variations. It could be Enamel, Enmail or Emenel. Dr. Rajendra Kumar once told me that once he actually received a letter addressed simply as Dr. R. Kumar, ANIMAL, Jamshedpur.

NML now needs to seriously face the question as to what kind of animal it must be in the present day jungle of R & D and academic institutions specially since CSIR is poised to assume an additional role of some kind of an Academy while engaged in R & D and CSIR 800. The I of CSIR may be changed from Industrial to Innovative but that alone cannot change anything. After all innovation is coupling of inventions with enterprise and this is there in Research and Development anyway. Yet, an emphasis on Innovation must be welcome because it may help change the mindset of scientists who must prove wrong all those who say, 'The more things change, the more they remain the same'.

A laboratory changes when both aptitude and attitude of scientists. Innovative research today necessarily needs awareness about diverse subjects - energy, environment, industrial metabolism, various regulations, quality related issues, technoeconomics, forecasting, intellectual property right, knowledge management, marketing and networking etc. and, above all, values and ethics. The bar is being raised all the time and the goal post is receding. Nobody can sit on past laurels, projects completed long ago and degrees earned in the past. It has been said that the past is history and the future is a mystery. But the present is a 'gift' and that is why it is called a 'present'.

Planning great things mean little, even deciding to do mean nothing unless there is execution of plans and implementation of decisions. This would need continuous brain storming, training, feed backs and monitoring. Above all scientists must learn to dream. You can do if only you can dream.

I hope that under the new leadership and with the combined efforts of all the scientists NML, will once again become a flag bearer of CSIR.



PERSONAL OBSERVATIONS
The National Metallurgical Laboratory

PRADEEP NIJHAWAN
Son of Dr. B. R. Nijhawan, Former Director, NML

On this auspicious occasion of the National Metallurgical Laboratory's (NML) Diamond Jubilee on November 26th, 2010, we acknowledge the special bonds that have existed between my father, Dr. Bal Raj Nijhawan, and the institution that he came to love and nurture during his early years in Jamshedpur. To put it succinctly, his journey has been personal and one of dedication and inspiration.

My earliest recollections are those of the staff - the scientists and persons - who came to the NML to answer the call of a young India. The call that caused them to put aside any regional differences and to commit to establishing an institution that reflected the very best of India's vision and the dreams of its founders. My father was one of them. He dedicated himself to the very hopes of Pandit Jawaharlal Nehru, and I would often hear him talk about Nehru, Baldev Singh, and Shanti Swarup Bhatnagar. I learned about them and other Directors of the Council of Scientific and Industrial Research (CSIR), and imagined the close relationships between them. Growing up in Jamshedpur also gave me strong insights into the Tata Iron & Steel Company, Indian Wire Products, and the Indian Tube Company. I often recognized names as Sir Jehangir Gandhy, Sardar Ajaib Singh, and J.G. Keswani, and they became part of the normal familial associations. My father believed in the future of India, and in the future of the NML. To him there was no doubt that in order for India to grow, it needed a strong foundation of institutions that were capable of providing the research and technology for its industries, especially metallurgical. He had no doubt that the vision prepared by India's founders needed personal conviction and self sacrifice. And he stepped up to this task. There was nothing that he expected from his staff that he would not do himself. Personal example and leading by inspiration became his personal trademarks.

As I grew older and through my adolescent years, I became very much aware of the numerous guests, scientists, foreign dignitaries and India's leaders - Prime Minister, Governors, Chief Ministers - who routinely came through Jamshedpur. For me, it was no longer when but "who" was coming. I have strong memories of all of these events, both official and social. My brother and I were often honored to meet with these dignitaries - we simply accepted this as a normal course of events. The importance and significance of the NML and its research was widely accepted not only in India, but across the world. I have personal memories of meeting the leading scientists from the USA, UK, and USSR. Among my most vivid recollections is that of garlanding Prime Minister Jawaharlal Nehru on his visit to the NML. And of course who can forget the pride of being able to garland Prince Philip of the UK, during his visit to the NML. Alongside my parents, I was able to shake hands with the leaders of India, including those who were to become Prime Ministers and Presidents of the Nation. In the center of all this was my father who orchestrated the numerous activities with his extremely capable staff and dedicated scientists, who had also chosen to become a key part of NML and the future of its legacy. Their dedication, commitment and sacrifice supported what the NML was becoming - a leading metallurgical institution that was pioneering advances in new materials, such as Thackeron Steel (nickel free stainless steel), and pilot plants that became the tools of an emerging industrial nation.

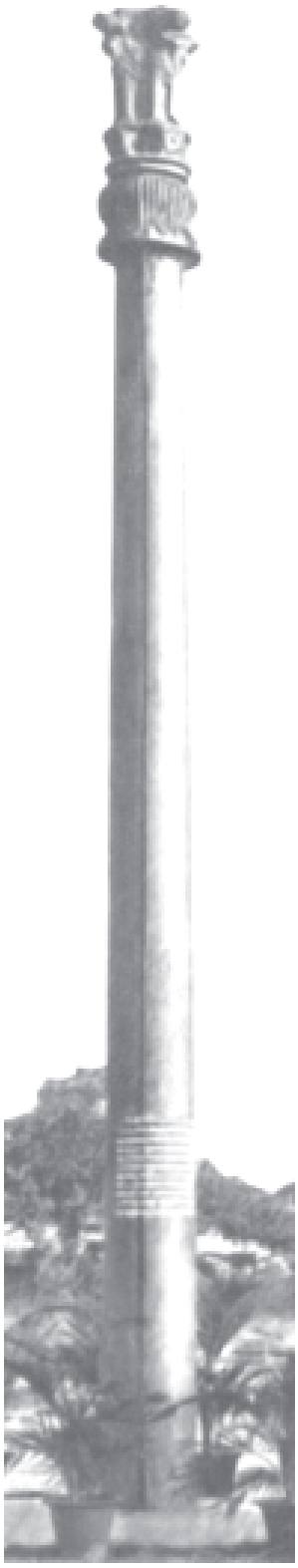
My father displayed a strong sense of "family" while at the NML. The NML became a family of sorts and it was common that these bonds formed as a part of the culture that nourished those who came to work at the NML, and who had strong family support systems. I have many personal memories of NML picnics, on the grounds of the institution, as well as in other sites such as Rivers Meet, Dimna Nala, and some that even involved train journeys. I think my father recognized that if he expected loyalty and dedication to the NML, it was necessary to ensure that the family had opportunities to come together and enjoy times that would strengthen all. I can recall that long 12 hour days were routine, and some times our family would also find themselves at the NML offices on a Saturday or Sunday afternoon. In my personal memory, I often compliment and thank Mr. R.M. Krishnan, Mr. Lakhbir Singh, and Mr. Seva Singh, who devoted themselves on a daily basis to respond to the many calls that my father needed. And of course, the devoted driver, Mr. Sadhu Singh who drove him

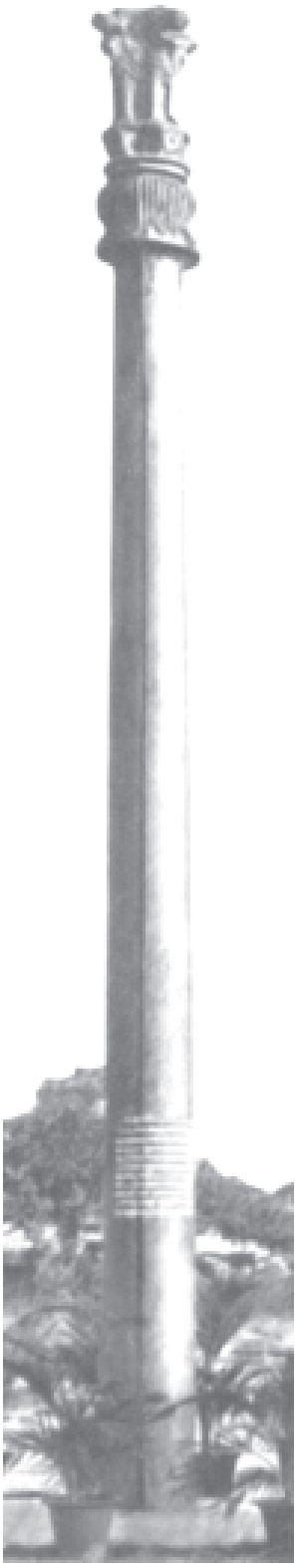
around to his many meetings and appointments. Another person who I simply recall as Goswami would come on a moments notice to repair literally anything that went wrong in our home - whether it was the air conditioner, electrical wiring or the like. Needless to say, I was able to learn a lot from these loyal NML staffers. The NML not only was an integral part of my father's daily life, it became a core part of our lives as well.

I would be remiss if I attempted to try to recall the many persons who became a part of my father's life. The persons, staff, guests, dignitaries are too many to name. But I know that if my father was able to, he would remember all of them, including the specific circumstance and occasion when he met them. Such was his memory and total recall. And even when he left the NML and joined the United Nations, and was a founding member of the United Nations Industrial Organization (UNIDO), he never lost sight of the NML. In his UN days, scientists from the NML were engaged with scientists in countries across the globe. These led to symposiums that were hosted at the NML, under the auspices of UNIDO. My father had a very rewarding career in the United Nations until his retirement in 1986, and it was remarkable how he was able to weave programs and projects within UNIDO, UNDP and the World Bank, with programs and initiatives with the NML - his first love. Professionally, I have traveled the world as an Industry consultant in the global steel and metals industry. I have had the privilege of personally meeting and working with many industrialists in the United States, Canada, Brazil, Mexico, in Europe and the Far East. It has given me pride when they take note of my father and his intimate knowledge of their industry and specific knowledge of the National Metallurgical Laboratory. The NML will always remain his legacy.

With its Diamond Jubilee on November 26th 2010, the NML will complete 60 years since its inauguration. I know that my father would have been honored and would have loved to be present. However, at his age of 95, he is not able to personally attend, and asked me to pen some thoughts for him. Aside from his family, I know that there is no other place he would rather be.

With kind regards, deep respect, and sincere congratulations on the National Metallurgical Laboratory's Diamond Jubilee from the family of Bal Raj Nijhawan.





Seven Years at NML

S. BANERJEE
Former Director, NML

Prologue

When I joined NML two and a half decades ago, I was 46 - a complete greenhorn in organizational and leadership issues. On the other hand, I was full of energy and enthusiasm to pursue exciting research.

I left NML after about 7 years to scale-up and commercialize a radically new technology, the developmental and pilot plant work on which I had started at NML.

I recall now, only one aspect of the story of these 7 years, which may be of interest to the current NML members - as a benchmark and a referral:

NML has always been charged to pursue excellent Research and Developmental work. But to pursue such work, it faced what appeared to me when I joined - an insurmountable barrier, which all of us at NML, joined together and overcame. Two questions become obvious. How did NML overcome the barrier? What difference did that produce in NML, as a result?

NML, before I joined, had a glorious record of achievement. I had used external experts to authentically assess only one aspect of the achievement - a quantified summary of which is reported towards the end here.

Notwithstanding that, NML inherited several long-standing problems due to decades of attention-deficit. Unfortunately, all these problems were interrelated, compounded and interdependent. Therefore, the problems required a persistent, comprehensive and simultaneous solution and progress. The problems existed in practically every front: Human Resource; Programmes; Finance; Facilities and Marketing. Indeed, the problems had piled up and became increasingly difficult and therefore remained unsolved.

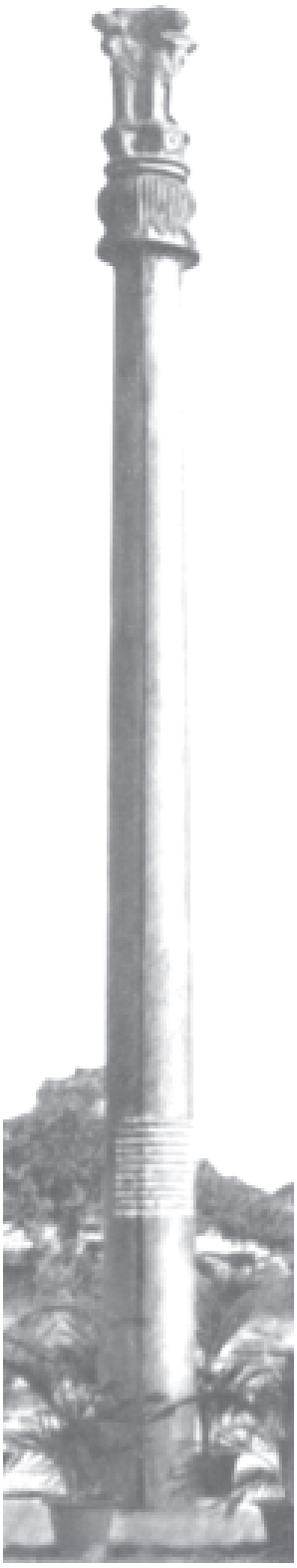
NML's reorganization and development to overcome the problems in all these fronts, fully occupied all its employees, particularly the Senior Scientists of NML, during my 7 years at NML. The quantified details of NML's development in all these fronts are documented in about ten reports that NML produced during my tenure. After 18 years, I can recall only a few significant developments which I now recount below.

But before I do so, I must state that I write this piece to pay tribute to all my NML colleagues of those days, who not only worked with outstanding dedication, commitment, diligence and enterprise, but without expecting any personal benefit. This inspired me. When I look back, I also sense that they indulged me while we pursued some challenging ideas and overcame what looked like unsurpassable hurdles in implementing these ideas.

The Story

NML's host of problems at that point included the following :

High average age of Scientists; Low Scientists to Non-Scientist Ratio; Low Morale of both the Scientists and the Non-Scientists; Indifferent Quality of Research Outputs; Inadequate Understanding of the Needs of the Users and Customers; Pervasive Time-Overrun of Projects; Persistently Nagging problems created by Lack of Funds; Obsolete and Worn Out Equipment and Pilot Plants; Ineffective R & D Programmes; Long-Standing Backlog of the Maintenance of Building and Facilities which often broke down; Poor and Inadequate Facilities for Scientists' Housing; Closure and Redeployment of 146 employees of the Magnesium Plant; 280 Casual Labours contending for regularization with no position at NML to accommodate them; and Confrontational and Splintered Unions which hardly focussed on employees' real problems.



The brain storming with all the employees and finally with the Senior Scientists on all these problems at the start of my tenure, produced a unanimous decision for action, that is: we all resolved to make drastic changes in all fronts at NML. Senior colleagues were highly enthusiastic and raring to go. They wanted to lead and do whatever is required to be done to overcome all the hurdles, to make these changes.

Indeed, NML needed a lot of changes not only in its people, their ideas, attitudes and procedures but in its basic wherewithal, that is: the organization structure and power devolution.

Accordingly, NML's objective and motto were defined. NML's Divisions and Groups which earlier were Scientist-centric, were restructured based on the 'scientific areas' which would survive obsolescence and continue to remain relevant and productive - during the ensuing decades. Unlike before, the Heads of Divisions and its scientists were empowered with full autonomy and authority to define and accomplish programmes and goals of the Division.

A 'Committee Structure' with the constitution, role, functions and procedure of each of the 13 committees was unambiguously defined and documented.

Most important, all the functional powers of the Director were decentralized and delegated to the Chairmen of these 13 Committees.

The entire structure and procedures of the Divisions and Committees, were documented for ready reference and compliance-check, if and when required.

Senior colleagues prepared written guidelines and mounted a massive annual effort to cope with the cumbersome government procedures so that NML could regularly recruit each year, several very bright and young scientists and capable supporting staff.

They prepared written guidelines to clear the decade old backlogs of assessment-promotions and the discipline and the grievance-redressal cases which were pending for more than a decade.

Amongst the changes attempted, the change in ideas, attitudes and perception of the people, was most difficult and slow to accomplish. But changes in these came from an unexpected source, as explained below.

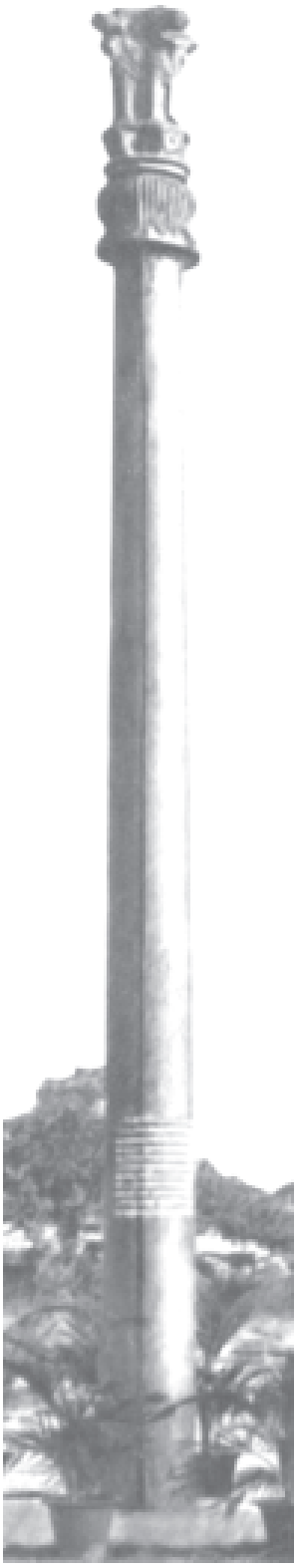
NML defined 5 different R & D Programmes, 70 % of which were User-oriented; and 30% were targeted to produce high-value publications. Three of these programmes are notable.

First: the Exploratory Projects which constituted the most prestigious of the programmes. The projects in this programme were undertaken to pursue excellent scientific work. The work was targeted to deliver new thoughts and produce high-value publications in prestigious high SCI professional journals. This stimulated in the scientists: originality, creativity, innovativeness on the one hand; and new capability, confidence, self-belief and pride on the other. This is one set of projects in which I enthusiastically participated as a Team Member whenever the Project Leader asked me.

Thrust Area Programmes which consisted of very large, long-duration, externally-funded projects. These projects were undertaken to: deliver what the User/Customer needed, garner significant external fund for setting up research and pilot scale test facilities, and obtain recognition from the users of the value that NML's Deliverables supplied to his business.

The third category of Programme consisted of the Interactive Projects, targeted to produce excellent interaction and interface with leading industries which, in turn, produced quantifiable monetary benefits to the industry. The industry shared the benefits with NML. But more important, these projects offered valuable opportunity to NML to directly learn, as to how an industry operates and performs.

Careful selection of the projects in these programmes, were based on objective criteria. These were meticulously planned. More important, during the project execution, the review focussed on the Outputs, Outcomes and Time Overruns. This changed the attitude, perception, confidence and commitment of both Scientists and Supporting Staff who worked on these projects. Consequently, NML's work culture changed, producing strong achievement-motivation.



Persistent lack of funds at NML, motivated one and all of NML's Senior Scientists to put in strong marketing effort to attract significant external funds whether through: Thrust Area; Interactive; or Sponsored R&D; Projects. This enabled NML to set up Mineral Processing Facility; Pilot Plant to process Polymetallic Sea Nodules; and Equipment and Instrumentations. The flow of external funds was attracted to beat the inflation, to provide for the rising expectation of the NML employees and to develop new facilities and equipment for future work.

Munificent supply of extra-budgetary resource from the DGCSIR (NML had to be ready to use it since it mostly materialized in March-end of every year!) enabled NML to: procure and install state of the art, sophisticated Equipment and Instrumentation and Computational Laboratory and Facilities; set Up a Multi-Purpose Unit Operation Facility; construct an expensive Perimeter Wall and develop the 15 Acres of Prime Land to protect it from its encroachment; and most important to complete the construction of 96 Scientists' Apartments.

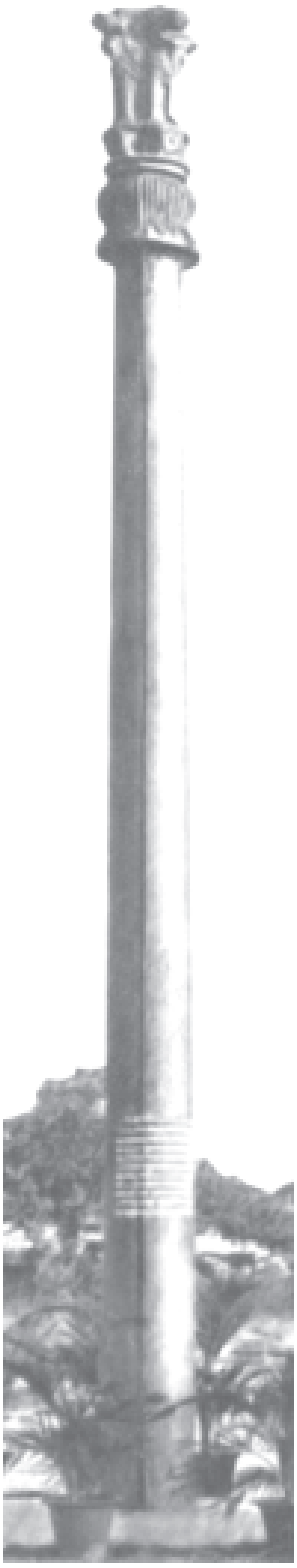
Extraordinary and very unusual procedures were used to obtain one-time large funds by liquidating NML's dead assets, to: overcome Backlogs of Large Maintenance Jobs, Renovation of Building and Laboratory; and Relocation of the laboratories of a division in the contiguous areas, to promote cohesion of the division and ready interaction within it.

Constant support and valuable help of Tata Steel in all fronts including the initiation of Interactive Projects (the donation and development of 15 Acres of prime land was a only a small part of it), often enabled NML to bridge that critical gap, whenever required.

Epilogue

A very legitimate question: all these stupendous efforts of my colleagues in sweeping-cleaning, digging, foundation, brickwork and plumbing - did it produce improved R & D Outcome? The answer is a resounding yes. Because, these efforts resulted in the following:

- Annual publications increased from rather poor to an impressive 70 per year, and about 25% of these were in high SCI journals;
- NML succeeded in focussing 65% of its organizational effort on 4 Thrust Area Projects, each of which were very large, externally funded; and were of long duration - to produce large scale and long range impact. CSIR considered this as a unique achievement by a laboratory. Also, these projects taught NML Scientists how to negotiate and attract large projects to build NML's Large Scale Test Facilities.
- NML Scientists proposed towards the end of my stay, about 50 Exploratory, Sponsored and Interactive Projects per year, a majority of which were highly innovative.
- NML's Scientists Filed 25 patents (most of them were sealed) and copyrights every year from a hitherto negligible level in the previous years.
- External Funds increased from a negligible amount each year, to an impressive 40% of NML's annual budget.
- Attitude and approach of the majority of its scientists and quality of their outputs changed; and they projected NML in the community of researchers - as a dynamic, assertive and confident organization, full of hope and aspiration for growth and development.
- The NML Collective discovered its identity, heritage, self-belief, self-esteem and fulfilment, when it found that the use of NML's technologies developed since its start in 1950's' had resulted in: an annual 'Savings Produced' of Rs 30 Crores; total 'Losses Avoided'of Rs 200 Crores; and a total Value Addition of ~ Rs 500 Crores. NML had commissioned external experts to generate these authentic numbers. This assessment had not been done before, since it is very painstaking and has to be rigorous. I, myself, felt proud of the achievement of my predecessors!



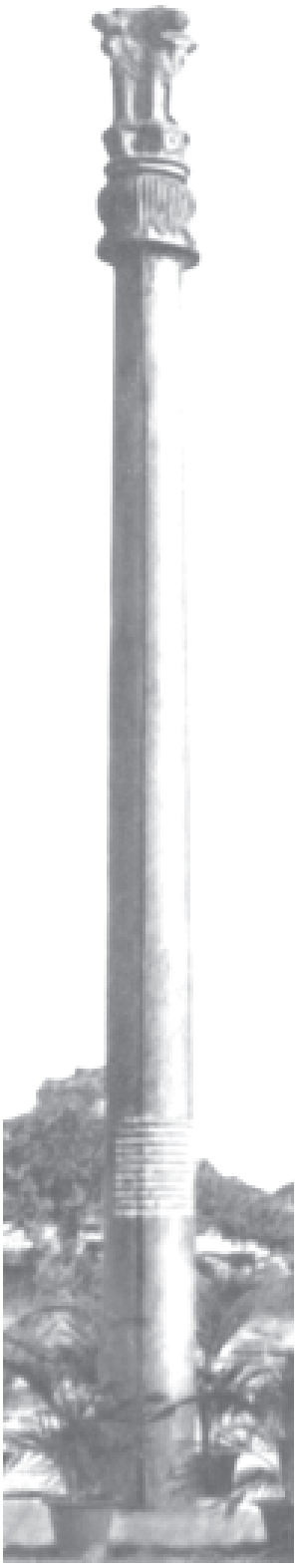
I cannot help but recall that I had personally convinced Dr S. Srikanth, Director of NML, to join us. But in addition, I had to travel that extra mile and intervene with the authorities, to facilitate his induction. I had done the same for other bright and young scientists, all of whom, like him, have matured today with excellent achievement record and quality of leadership.

I feel fulfilled that my efforts then paid rich dividend today. For, the manner in which Dr Srikanth has functioned within the short period ever since he took charge of NML, convinces me that NML will significantly contribute a new and experience a new peak of excellence under his capable, confident and astute leadership.

I wish and am sure that on its foundation day, the entire NML collective and each and every member of NML will resolve to 'think together, plan together and work together', and collectively and individually achieve great kudos and laurels for the laboratory.

Before I close, I reproduce what I had written in the preface of one of these ten reports, a few months before I left NML - which succinctly sums up my current sentiments after 18 years:

"At the end, I must record that I consider it a privilege to have been selected to shoulder the lofty assignment of heading this prestigious laboratory. Even though, in attempting to match the hard work and dedication of some of my NML colleagues, I have experienced some very strenuous and anxious times, I have enjoyed every bit of this assignment."



NML : My cherished experiences and fond memories

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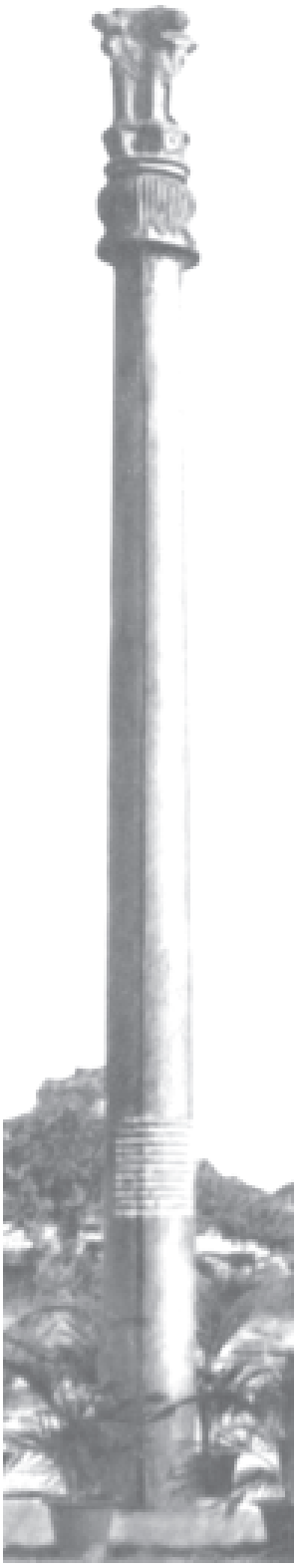
Former Director, NML, Jamshedpur

I was pleasantly confused when on March 22, 2002, morning I received a telephone call from the CSIR Head Quarters in New Delhi informing me of my appointment as Director, NML Jamshedpur. My affiliation with IIT Kanpur had been for almost 39 years and I was not contemplating to leave the Institute to join any other organization. Directorship of NML was never in my mind. It was a close friend of mine who sent my nomination in spite of my reservations. When I received an invitation to attend the interview in New Delhi on March 6, 2002, I was almost certain of not attending it. It was only a coincidence that I was also invited to be a member of a faculty Selection Committee on March 5 at IIT Roorkee. It was only when I accepted the Roorkee invitation that it occurred to me that in any case I would be in Delhi on March 6 morning, so why not attend the NML interview as well. Thus, just two days before the interview I decided to attend it. Although my interview went off very well, I was somehow convinced that I would not be facing a situation in which I would have to consider an option of leaving IITK.

That one telephone call on March 22 morning created a situation for which I was not mentally prepared. I had mixed feelings: the thought of being successful in the interview was flattering and pleasing, but the thought of leaving IITK was hurting and not easily acceptable. It took me a couple of days to realize that declining the offer just like that was neither proper nor ethical on my part, and that I had to explore the possible options more sincerely. I sought an appointment with Dr. R.A. Mashelkar, DG CSIR, for a meeting. I was invited to a breakfast meeting at the CSIR Science Centre, New Delhi, two days later. The meeting lasted for almost two hours and during this time he had very convincingly sold the NML and CSIR to me. I was impressed by his vision of CSIR, his dynamic leadership and his sensitivity of treating CSIR as a family. He convinced me that I was not only needed at NML as Director, I was very welcome as a member of the CSIR family.

After this meeting, for the first time I could not totally discard the possibility of leaving IITK to join NML. I was well aware of several strengths of NML: the kind of R&D activities it was involved with, and the kind of some very unique infrastructure that existed there. I was also fairly convinced that if I decided to go to NML, academically it would be very satisfying to me as I could see myself directly interacting with more than 70 percent of the ongoing activities because of my overlapping R&D interests. I was also aware of the fact that the former Directors of NML, Dr. B. R. Nijhawan, Dr. Altekar and my immediate predecessors, Prof. P. Ramchandra Rao and Prof. S. Banerjee, with whom I had directly interacted several times, were great leaders and had contributed immensely to give NML a stature and place amongst the elite R&D organizations in the country. All these points were very positive. My major concern, however, was now to assess the impact of our moving to Jamshedpur on the lives of my wife, Archana, and my 85 year old mother. Having lived in one of the best campuses in the country, that is IITK campus, for almost 30 years it was not easy to comprehend living in isolation. I was more concerned about the loneliness that my wife and my mother would have to face. In IITK we had lived a very active social life. Archana was also very actively involved with a children school in the campus which not only kept her busy but also made her a very popular figure in the campus. My mother, who was a handicraft wizard, was hardly ever without a company. I knew that NML did not have a consolidated campus of its own and that it was scattered in different locations in Jamshedpur. Although the NML Directors Bungalow is in the Circuit House Area, one of the most posh parts of the town, it is isolated from the other residential colonies of NML. How would Archana and my mother would keep themselves fruitfully busy was my worry. I had long discussions with my wife. After initial apprehensions she agreed to visit Jamshedpur with me and see the place for herself before taking the final decision.

We reached Jamshedpur on April 9 on a two day visit. These two very hectic days gave Archana a chance to interact with the families of some of my old friends, my several students of IITK who were now at NML or Tata Steel, and of course there were many others whom even I was meeting for the first time. She liked the Director's designated Bungalow. There was no doubt that the location was very

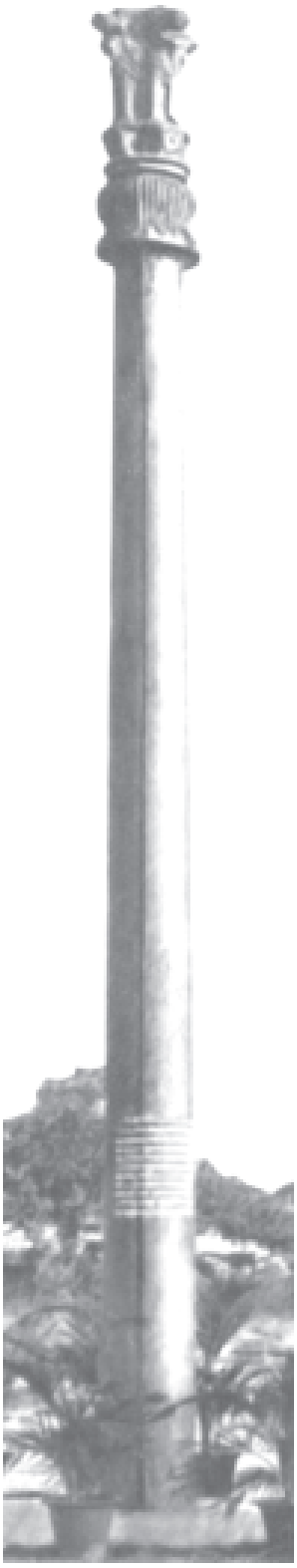


good. Gardening being one of her favourite hobbies, she would be busy with that. For compulsive walkers that two of us are, proximity to Jubilee Park was a big plus. The city of Jamshedpur was never an issue as it was far cleaner, greener and better planned city as compared to Kanpur. It has all the facilities of a big city without having their nuances. The welcome and the affection that we got in these two days could also not be ignored.

By the time we reached back Kanpur, the decision had almost been made. I sent my acceptance letter to DG two days later indicating June 2 as the joining date - June 1 being the Sunday. I took over charge from Dr. R. N. Ghosh, the Officiating Director of NML, on June 2 morning and addressed the NML staff on June 3 afternoon. In my address I said "I may be new to NML and to CSIR but being a fast learner I shall soon learn the great traditions and strengths of these organizations". I assured them that I would not only not tamper with these traditions but further strengthen them to the extent possible. I also promised not to try to impose the IITK culture on NML - IITK culture being so thoroughly ingrained in me, the latter would be a daunting task, I knew. I told them that I had no fixed agenda except for trying my best to ensure that NML acquires a higher position within the informal hierarchy of CSIR Labs at the end of my term than the position it was occupying at the time of my joining. I tried to convey to them that I believed in an open and transparent administration and that I would be accessible to them at the shortest possible notice. I had meant each and every word of what I said in my address. With that address my journey at NML had begun.

Just within a few days of my joining, I received a notification from the DG CSIR along with the list of 55 network projects which the Planning Commission had approved for funding during the 10th Five Year Plan. These were mega projects with funding ranging in tens of Crores. For each project one of the CSIR laboratories was identified as the nodal laboratory with several other Labs as the participating in the network mode. Thus, each major CSIR Laboratory was to lead at least one network project, while associated with several other projects. To my surprise NML was the only Lab which did not have even a single network project to lead. As soon as this list was released, as I had expected, there was a feeling of despair and frustration amongst the scientists. I knew that I had to do something urgently to ensure that the injustice done to NML was undone at the earliest possible. I had a long telephonic conversation with the DG the very next day. DG sensed our disappointment and frustration and agreed with me that NML, being a R&D leader in the area of minerals, metals and materials, could not be left out without a network project. He asked me to submit up to two project proposals to him at the earliest so that he could take up this matter with the Planning Commission. The ball was now in our court and the onus of coming up with two scientifically strong and technologically relevant proposals was with us. I called a meeting of all scientists and senior technical staff and assured them that we could still salvage the situation provided we all worked as a team with a purpose. After a few rounds of brain storming sessions in small and large groups, we converged on to two broad based topics: (i) Technology of engineering critical assessment (TECA), and (ii) Mathematical modelling of selected mineral and metallurgical processes. Two separate teams worked on each of the two proposals. Several open house discussions took place in which not only the NML scientists but also the potential project partners from other CSIR laboratories participated. By August end the two project proposals were submitted to DG who was genuinely impressed by their quality. He however asked me to prioritise them. Because of my own interest and expertise I was tempted to rank the second proposal as number one, and TECA as number two. But then knowing that TECA was closer to the NML's real strength, and much larger number of scientists would be able to participate in it, TECA was ranked as the first priority project. It is now history that TECA, with about Rs. 20.00 Crore budget, was approved by the Planning Commission in less than two months time after its submission, and it was rated, by an independent evaluating group, as one of the best delivered projects in engineering at the end of the 10th FYP.

One very important realization that I had from this exercise was that the scientific and technical staff at NML would work as a team if they were properly motivated and given well defined objectives. In terms of quality and competence, many of them were as good as one would find in some of the best R&D and academic institutions. This realization, in fact, was my strength during my entire tenure at NML as I could always count on my colleagues and make commitment on behalf of the Lab at all levels - they rarely failed me.



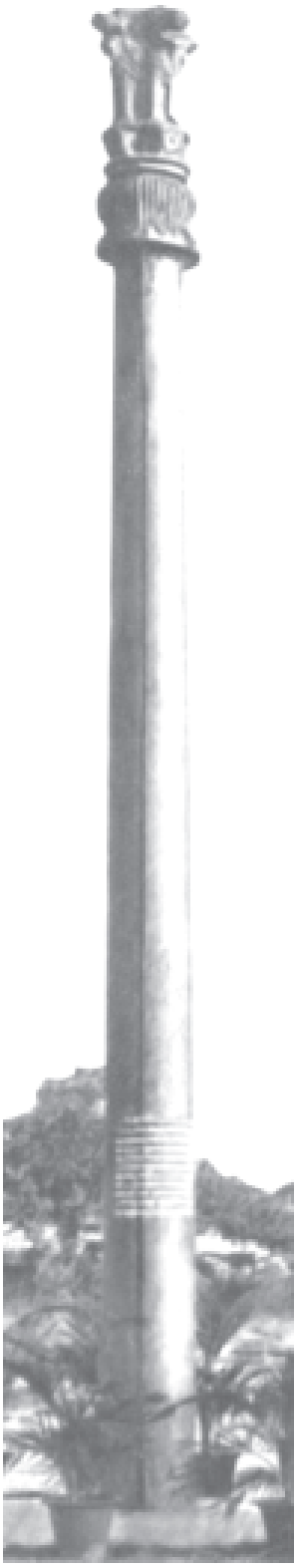
One other major issue that I had to face within the first few weeks of my joining was related to two prestigious mega projects: one, on Blast Furnace, funded by the Ministry of Steel, and the other on Demonstration of a New Technology for Magnesium Extraction on Pilot Plant Scale, funded by the Ministry of Mines. As these projects were not showing much progress, the funding agencies were getting edgy. There were even murmurs of their premature. I had to ensure that nothing of this sort ever happened, but then NML too had to honour its commitments of delivery in letter and spirit. Fortunately, both these projects were in the area in which I could directly contribute. Therefore, I decided to become an active member of the two project teams. I started reviewing the progress of the projects almost on weekly basis to ensure that we had a definite work plan to present before the monitoring committees of the projects which were to meet in July/August. The deliberations in the two monitoring committee meetings were very frank and positive. We honestly accepted the delays and lapses on our part but could also convince them that with our new work plan and approach we would achieve the projects objectives. We delivered whatever we had committed for. Here again it was the team effort that made it possible.

When I joined, NML had in all 14 Technical Divisions. I saw a general reluctance amongst the scientists to interact with the colleagues in other divisions. I felt, having so many divisions tended to create artificial boundaries between the scientists and went against the spirit of networking. To promote better interaction amongst the scientists by minimizing the boundaries of Divisions I started thinking in terms of restructuring the Lab and reduce the number of Divisions. As it was a sensitive matter, it had to be done by taking all my colleagues in confidence. I prepared the blue print of a restructured NML with only 6 Divisions and presented it to the scientists and technical staff in an open forum. I solicited their honest opinion and frank feedback. I assured them that I would implement the plan only if there was a consensus on it. After several rounds of discussions in open forums and in smaller groups we converged on to a plan for restructuring which was generally acceptable. This whole exercise took several months but it was worth it, I felt.

Restructuring of Divisions however created one problem - at least six senior colleagues, who were Heads of Divisions, lost their positions. I was very cautious of not hurting their feelings. I therefore decided to use their experience and expertise in assisting the Director in running the day to day Lab administration by creating three new positions of Advisors on experimental basis. Some of these positions really helped while some did not.

One practice at NML that bothered me was the Purchase Procedure of CSIR. To my horror I found out that the average time to procure major equipment was more than a year. In some cases it could even be two years or more. In IITK the average time was 3-4 months. In NML I came across, for the first time, the tendering system - a must in the whole of CSIR. I could never understand how is it that IITs which are also Government funded organizations can have very simple, transparent and convenient Purchase Procedures, but CSIR has such an elaborate, and at times, cumbersome procedures. I was determined to bring down the average procurement time to a reasonable level. I started raisings this issue at various CSIR forums. At the same time I also started convincing our purchase teams the need of expediting the procedures at our end as well. I think it worked because even with almost 10 fold increase in our annual equipment purchase, the procurement time could be brought down to 4-6 months. I must add that it could be done only because of the tremendous cooperation and support that we got from the successive Purchase officers/ Dy. Purchase officers and the entire their team.

During our initial days at Jamshedpur, both Archana and I often felt concerned about the lack of social and cultural activities at NML. Except for some very formal occasions, families rarely mingled with each other. Archana did try to activate the NML's Women club but with only very limited success. I also did not know what to do to encourage voluntary participation of our colleagues and their families in social and cultural activities. The opportunity to bring about a change came when NML was celebrating its Foundation day in 2003. I distinctly remember the evening of November 26, 2003 when I came back home after the formal function in the Lab and casually told Archana about it. Her spontaneous reaction was, in what way our Foundation Day was different from a normal working day. Just listening to a technical lecture by an eminent person cannot be termed the Foundation Day celebration because the technical lectures are anyway organised in NML throughout the year. Foundation Day, in her opinion, should have involved each and every member of the NML family. Her

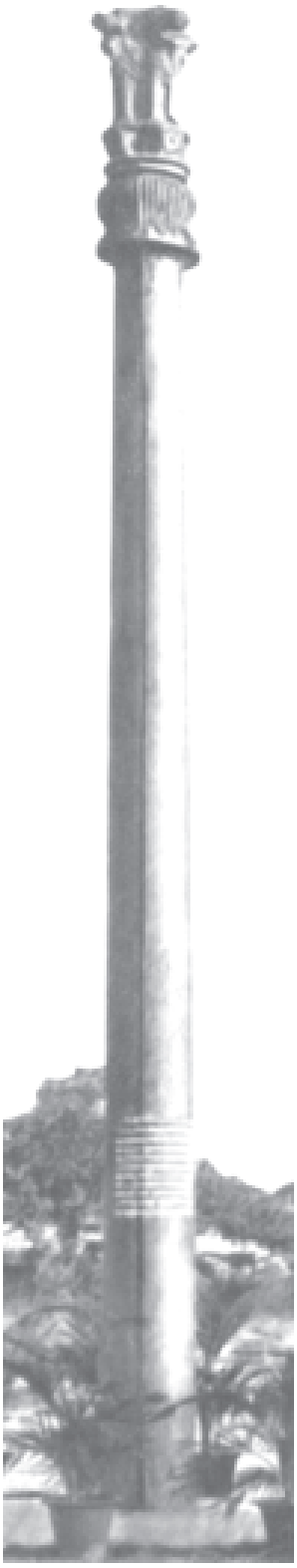


statement touched me and decided to do something about it. I informally started talking about it with my colleagues and soon realized that almost everyone felt a need for a better social and cultural ambience, but did not really know how to do it. We started activating the Staff and the Women Clubs by organizing activities like contributory dinners, fetes and activities for campus children. We got good and enthusiastic response to these activities. Encouraged by it, in June 2004 we decided to chalk out a detailed one week programme for our next Foundation Day in November 2004. The programme was to have, beside technical lectures and other academic activities, one Sports day for the entire NML family, a TV style Family Quiz, several programmes for children, and a Cultural Programme by the NML families. As the planning and rehearsals for the programmes picked up momentum in September/October, there was a lot of enthusiasm and excitement all around. People were curious to know what new was going to happen. The Sports' Day on November 21, 2004, in which more than 600 people participated, was a big success. In the beginning several people had inhibitions and hesitation in participating but when they saw me and Archana ready to participate in all sports events, their inhibition vanished, and they too participated enthusiastically. The event was so successful that even after it was over at about 6.00 P.M. many people were not willing to leave the ground. They stayed back until very late in the evening singing, dancing and having a bone-fire. The Cultural Evening which was the Grand-finale of the Foundation day celebrations was truly remarkable. The three hour programme by NML staff and their spouses only exposed for the first time the enormous talent that had been hitherto hidden. I believe, this Foundation day with one week long festivities turned out to be mile stone in the history of NML.

Foundation Day celebrations of that year changed the social and cultural fabric of NML. The amount of confidence and the interest that these events generated was tremendous and led to cultural events being organized by the Staff and Women clubs at almost regular intervals. One of the finest events which I shall never forget was the three hour long famous Hindi play "Ashad Ka Ek Din", based on the famous play of Maha Kavi Kali Das, which was staged by NML staff in our auditorium. It had a perfection of a Professional Troupe. The regular cultural and social activities on the campus, I believe, brought the NML families together and helped in generating the feeling of comradeship.

I have always wanted active community participation in matters of concern to the community. As a part of the Diamond Jubilee Celebrations of CSIR, each Lab was to receive substantial additional grant for improving the housing conditions in our colonies and face-lifting our campuses. I wanted to use this grant as per the needs and wishes of the residents and not that of the administration. We activated the Welfare committees of the colonies and insisted for a direct feedback on their needs from the residents, particularly the house wives. To break their inhibitions in articulating their requirements, I decided to take Archana's help. We had several meetings in our two colonies which both Archana and I attended. We encouraged the residents, particularly the house wives, to suggest things that they wanted to be done in their houses. After initial hesitation they came up with suggestions. The majority of people wanted modifications in their kitchens and bath rooms. These decisions became the part of NML plan and were implemented. We also started a tree plantation programmes in our colonies involving campus children.

Preparation of our Vision Document turned out to be another very pleasant experience. I was convinced that it would be implementable to guide the NML R&D programmes only if the scientists believed in it and owned it as their document. Their wholehearted participation in preparation of the document was, therefore, essential. We initiated discussion at the Divisions level and each scientist was asked to give his/ her own R&D Plan for next 3-5 years and then for next 10 years. And also in his/ her view what should be the vision of his/her Division and of NML as a whole. Division level discussions were to give a vision of the respective Division and of NML. Presentations were then made by each scientist and by Heads of Divisions in an open forum of all Scientists. We had presentations/ frank discussions spread over 5-6 weeks. A committee of Scientists which was coordinating these activities very meticulously gone through the inputs and feedbacks of the individual scientists as well as the groups of scientists and prepared the first draft of the Vision document. This again was discussed in open forums several times until we converged to. This was an exercise in which almost each and every scientist of NML had participated and contributed to. The draft document was sent to all our RC members and several other eminent persons in the country in our field and their comments and observations were incorporated in the final document.



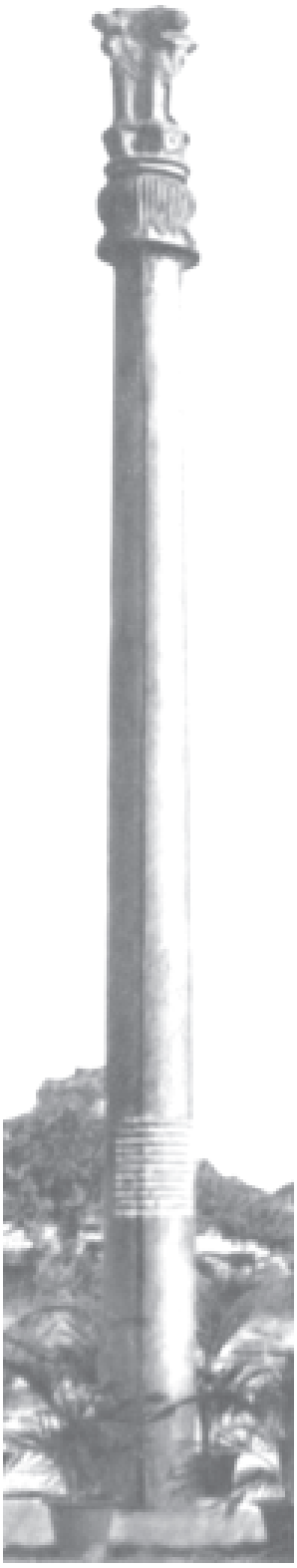
I have always believed that the R&D in cutting edge technology areas is facilitated by State of the Art Infrastructure as well as the exposure and interaction of our scientists with the leading international groups and the organizations. With the conviction that NML, being the premier R&D Lab of the country in Minerals, Metals and Materials, has to focus on cutting edge R&D, I gave high priority to: one, creating the State of the Art infrastructure at NML, and two, to encourage our scientists to go abroad for short and long term stays to participate in prestigious international conferences, training programmes, and avail scholarship / fellowships like Boyscast, Humboldt and other bilateral exchange schemes of Govt. of India. As a result, the number of NML scientists going abroad every year jumped from 4-5 to 25-30 or even more. This not only created awareness about the global R&D trends but also gave an impetus to our scientists to take up more challenging projects in newer areas. In terms of infrastructure, we not only upgraded our existing facilities but also added several new State of the Art facilities in the areas of Advance Materials Processing, Materials Characterization and Materials Testing, and NDE. Major resources for this activity came from mega sponsored projects of CSIR and other funding agencies.

One major strength area of NML, as I stated above also, has been its capacity to work as a team and in unison as and when it is needed. Although it was amply demonstrated on numerous occasions, I would mention three particular instances which really made me feel proud of my colleagues and NML as an organization. These events were: (i) Inter Laboratory CSIR Indoor Meet (2006), (ii) Mineral Processing Technology (MPT) - 2006 organized by NML Chennai Centre, and (iii) International Conference on Mechanochemistry (2008).

To organize a sports meet with about 400 participants from about 10 sister laboratories without our own infrastructure was a major challenge. But the manner in which the event was meticulously planned and organized was remarkable. Several participants who had been participating in earlier such meets had no hesitation in declaring it as one of the best meets that they ever participated in. MPT (2006) was another mega challenge. Having failed three times since the year 2000 in our bid to host the International Mineral Processing Congress in India for the first time, the Indian Institute of Minerals Engineers had decided to use MPT (2006) for showcasing Indian organizational skills and Technical competence in Mineral Processing. MPT (2006) was planned to have about 400 participants with about 100 of them from overseas. NML was entrusted with the responsibility of organizing it at Chennai with NML Chennai Centre as the Principal Coordinator. In retrospect I can say without any exaggeration that both from technical and organizational points of view it was one of the best International Conferences that I have participated in India or abroad. The similar sentiments were expressed by a large number of foreign delegates as well. The entire credit for the success of this conference goes to NML team, particularly our colleagues at Chennai Centre. It was the impact of MPT (2006) that during IMPC 2008 in Beijing, Indian bid of hosting IMPC-2012 in New Delhi got the overwhelming support of the IMPC Council.

International Conference on Mechanochemistry had a different story. It was the International Council of Mechanochemistry which wanted NML to organize this conference. It was for the first time that the conference was to be held in Asia. NML was chosen in recognition of its expertise in the field. Jamshedpur, in my view, is not an ideal venue for holding such an International event primarily because of its poor air/ train connectivity, and lack of infrastructural support that the city can offer. We decided to hold the conference in our main Lab, which incidentally needed a major face-lifting to be ready for this prestigious event. Meticulous planning and several sleeple ss nights on the part of a very large number of our colleagues, who had taken responsibility of different aspects of organization, be it pickup of guests and foreign delegates at Kolkata/ Ranchi, or Accommodation and Transport, or Technical and Cultural programmes, or Fund Raising, Preparation of Conference Halls, Or Exhibition, etc., made the event possible. The untiring effort of our Engineering Division and several other colleagues changed the entire look of the Lab in a short period of time and made it unbelievably beautiful. It was very satisfying to all of us that the conference went off very well in spite of the most terrible incidence of terrorists attack in Mumbai on November 26, just a few days before the conference. The entire organization of the conference was highly applauded .

The visits of national and international dignitaries to the Lab have always been cherished at NML. During my tenure also several very eminent persons visited our Lab. The visits of former NML Directors



and former First Ladies, Mrs. & Dr. B. R. Nijhawan, Mrs & (Late) Prof. P. Ramachandra Rao and Prof. S. Banerjee were very special and nostalgic. The most exciting moment for all of us, however, was when the then Hon'ble President of India, Dr. A. P. J. Abdul Kalam visited the Lab on February 13, 2004. A gist of major on-going R&D activities of the Lab was presented before him through a Posters display. He very inquisitively made enquiries about the projects and gave some very valuable suggestions. He then interacted with the entire NML staff through an almost one hour long question answer session in which people from the audience asked questions and he responded. This session gave us an insight to his Vision of India, which indeed was very inspiring. During this visit of Hon'ble President, we also had the honour of welcoming the Hon'ble Governors of Jharkhand and West Bengal and Hon'ble Chief Minister of Jharkhand.

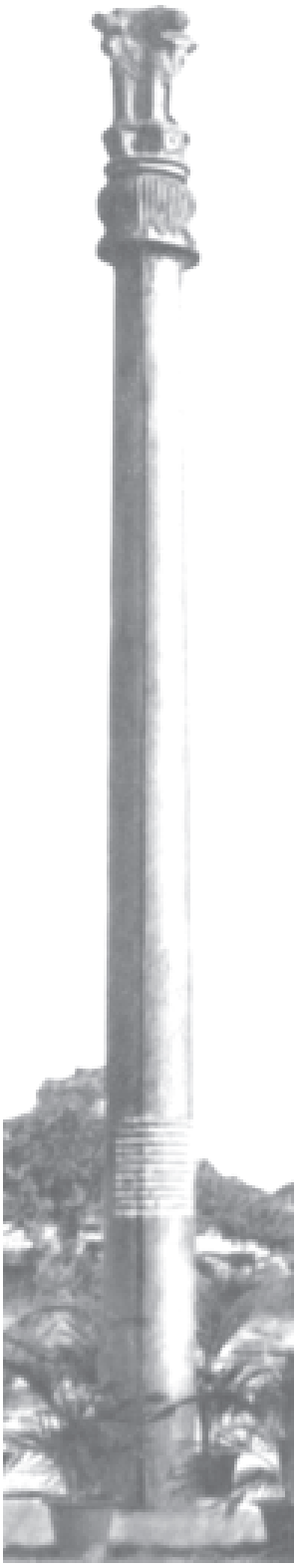
NML has had a very healthy tradition of holding its Research Council meetings in an open forum mode, which is different from the practice followed at most other CSIR Labs. In our open forum part of the RC meetings, invariably lasting 3-4 hours, scientists were encouraged to participate in the discussion, and the RC members also made their observations, which included both the appreciation as well as the constructive criticism of the work, directly to the scientists. Our RCs were always very supportive and constructive, and I was indeed lucky to have Chairmen like Shri Parvathisem, Shri Muthuraman and Dr. Baldev Raj whose guidance and advice was invaluable to me.

As I have always supported an honest and constructive periodic evaluation of all mega projects by experts groups, project monitoring committee meetings were taken seriously in the Lab. Quite often I insisted for a pre-presentations before an internal group where we would have an honest and frank appraisal of our efforts and achievements in the project. Most of the monitoring committee meetings, particularly the ones chaired by experts like (Late) Dr. P. Rodriguez, Dr. Baldev Raj, I found extremely useful and full of new ideas and approaches.

It was heartening to see that the concerted efforts of our colleagues resulted in several new mega projects under the 11th Five Year Plan. These included Planning Commission funded CSIR Network project TERMAC (major extension of TECA under 10th FYP); CSIR Supra Institutional Project on Speciality Steels: CSIR mega project on Nanostructured Advanced Materials; Ministry of Mines funded on Processing of Poly-metallic Sea Nodules; Ministry of Steel funded project on Development of Real Time Process Simulator For Bhilai Steel Plant Blast Furnaces; and Department of Informational Technology funded project on Processing of Electronic Waste. The latter was particularly pleasing to me because we conceived of this project at NML as a project of immense national relevance and importance and started working on it through our own internal resources 4-5 years ago. It was only after our initial success that DST and later DIT started funding it. We also started interacting with several international agencies/ organizations which substantially increased our international visibility and R & D collaboration.

There is at least one activity in CSIR where, I think, the Director is always at the receiving end. This is the exercise of Assessment Promotion of Scientists. I must have participated in more than a dozen such committees. While the assessment results of NML were always better than most of the other Labs, I too had my share of criticism no matter how sincerely and honestly I participated in it. I do not remember to have ever tried to stop the assessment promotion of any of my colleagues if the Assessment Committee was having a positive view of the candidate which was against my own assessment of him/her. There were several cases where I could change the initial negative opinion of the committee to a positive one through my positive feedback, but there were instances too where the committee did not agree with me and overruled my positive recommendations. But for many unsuccessful candidates, Director was the villain who came in their way.

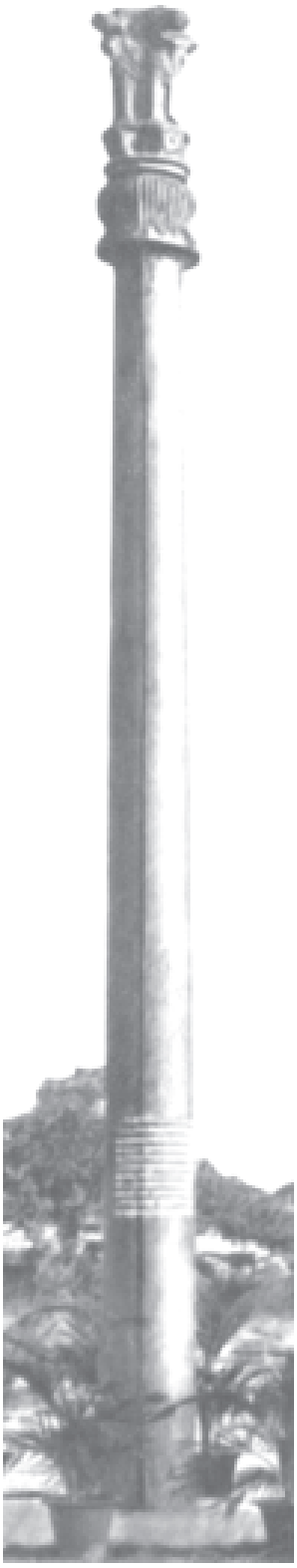
My stay at NML was full of events and activities and it is difficult to resist the temptation of talking about them. But realising the space limitation and the fact that too much narration would bore the readers, I have to constrain myself. But one point that I must make is that I have been lucky in many ways. My predecessors had established a very cordial relationship with most of the local industries, particularly Tata Steel, who always provided a helping hand as and when it was needed. It was for me to ensure that this relationship further grew, and, I think, we succeeded in this endeavour to a large extent.



As the President of "Raj Bhasha Karyanvaya Samity of Jamshedpur" I had the privilege of chairing the Quarterly and half yearly meetings of the Samity of which over fifty Government Offices, Public Corporate Units and Nationalized Banks of Jamshedpur and nearby towns were the members. This gave me an opportunity to establish a direct rapport with the top most functionaries of these organizations. Our Raj Bhasha Samiti, I believe, must have really worked well as it received several recognitions during my tenure, including the First Prize for being the most efficient Samiti in the whole of Eastern region of the country. I cannot forget the visit of the Parliamentary sub- committee, consisting of several senior members of both houses of the Parliament, to review the efforts being made by randomly chosen fifteen Government organizations of Jamshedpur to promote working in Hindi in their respective organizations - NML, of course, was one of them. As the President of the Jamshedpur Raj Bhasha Samiti I was to coordinate the visit. In Government circles this committee is one of the most feared committees because the committee members do not show any leniency towards defaulters and at times are brutally critical of any negligence on the part of the CEOs. In our preparatory meetings of the CEOs of these organizations, I could gaze this fear. Since our Samiti was really working hard to promote Hindi in our respective organizations, we decided to face the sub-committee frankly and honestly. The visit of the subcommittee and their review of our efforts turned out to be a very pleasant experience. The committee not only openly complimented our efforts, I, as the President of the Samiti, also received a letter from the Chairman of the Sub-Committee highly appreciating the working of Jamshedpur Raj Bhasha Karyanvaya Samiti, something that the sub-committee rarely does.

The kind of cooperation and support that I got from all my staff members in the Directorate, Administration, Accounts and Purchase was remarkable. All the COAS and AOs, FAOs and Purchase Officers who worked with me during my tenure at NML were extremely nice and I hardly ever had any problem with anyone of them. Unlike the most other offices where the officers in these positions are generally "rule minded" and have the habit of writing notes on files, my officers were always ready to suggest me ways of doing things expeditiously without violating the rules. Their constructive and positive outlook was a tremendous help to me and it created, I believe, a positive ambience in the Lab. The manner in which our colleagues in the Accounts Section prepared the salary statements of the entire NML staff as per the Sixth Pay Commission in just 3-4 days by working almost day and night and also on a Saturday/ Sunday was exemplary. NML was amongst the first CSIR Labs to implement the Sixth Pay Commission award.

My tenure at NML has given me the feeling of fulfilment and contentment which I genuinely relish. I do not know what did I give to NML, but NML, for sure, gave me a lot - I learnt a lot. It changed my total perception of teaching and its relevance. As a result, I never enjoyed teaching so much as I am doing now on return to IITK. The love and affection and the respect that we got from my colleagues during our entire stay at NML was overwhelming and it became our strength. The farewell function on April 30, 2009, turned out to be a very emotional event for both Archana and I. In my farewell address I revealed a truth. While leaving IITK for NML in May 2002, I had believed that my heart was fully occupied by IITK and that there was no place in it for any other organization. It was only at the end of my tenure at NML when I was going back to Kanpur that I realized how wrong my earlier conviction was. NML indeed had occupied a big part of my heart to remain there forever.



My years at the NML (1962-84) & Paradigms in R&D scenario in the context of socio-economic development of India

Dr. RAJENDRA KUMAR
Former Scientist (Director) NML

Politically free in August 1947, independent India faced the enormous task of ameliorating the abject poverty of a vast multitude of her population and to bring about their economic rehabilitation within a short framework of time. For this purpose, the politico-economists, chose the Western model of rampant and wide spectrum industrialization through the establishment of heavy, energy guzzling metallurgical, chemical and engineering industries, in preference to the Gandhian model of village level development - a theme which was central to the freedom movement. The highly motivated and committed leadership of those yester years involved the national intelligentsia through the Planning Commission and establishing for them a chain of national laboratories under the Council of Scientific & Industrial Research and the National Metallurgical Laboratory was amongst the first five of them - the last sixty years of its existence have almost coincided with sixty years of my own professional life, having graduated from the Banaras Hindu University in the year 1950. I had joined the NML in the year 1962 as Assistant Director and Head of Physical metallurgy Division at the persuasion of the then Director, Dr B R Nijhawan who also accepted the three Research Fellows who were working with me at the BHU on research schemes supported by the CSIR. I was with the NML until 1986 when I was transferred to the Regional Research Laboratory, Bhopal.

Whilst some joined the national laboratories to earn their living, some of us did so to work on problems which would have "great consequence", in the words of Pt. Jawaharlal Nehru, to the national industrial and economic scenario. Many of my generation of Indians who, after receiving higher education and specialized training abroad, returned to India, leaving behind lucrative jobs and career, to fulfill their inspired dream of bringing India within the comity of prosperous, developed and resurgent countries. It is very gratifying to see that we have largely succeeded. It was an honour for us to have been a keg in the giant wheel of socio-economic progress, spurted by metal based industrial growth, covering all major sectors - mineral beneficiation, primary metal industries, infra-structural development of thermal power industry, engineering industry. NML played a vital role in each of them.

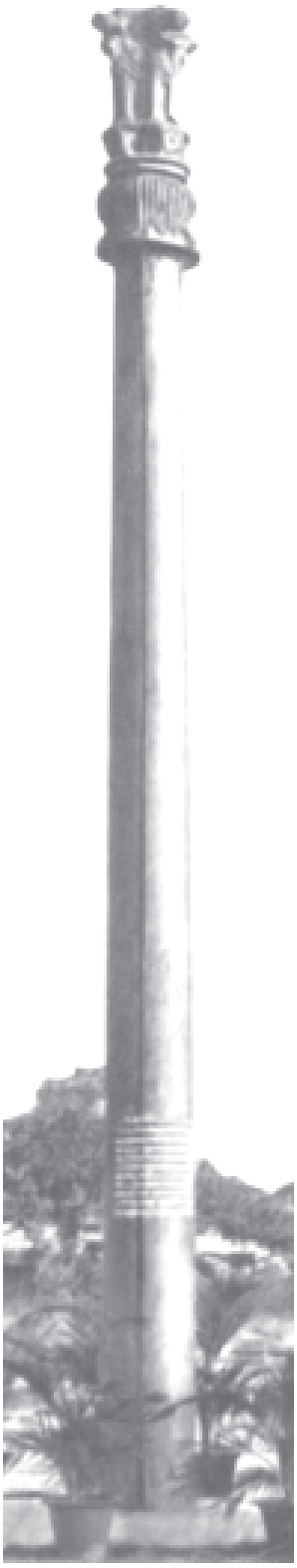
NML DEVELOPS ITS PERSONALITY

The concept of sponsored research was not yet born then. The existing, metallurgical industry and new iron and steel plants (in the public sector) were being established, almost always with foreign financial and technology collaboration. As the infra-structure for research, both in terms of facilities and personnel was being established at the national laboratories, research was in its nascent state and supported by government funding. It was left to the discretion of the Director and the scientists to work on areas that tickled their inventive bones. There, however, was an unwritten understanding that research programmes should largely be of applied nature and act as seeds for industrial growth within the dynamics of the industrially oriented socio-economic development scenario and should be directed so as to provide direction, pace and acceleration to it.

The Industrio-Economic Scenario: Post Independence Era:

The most widely used engineering metals and alloys were then, as are now, based steel (including common and special grades of stainless and low alloys steels), copper, aluminium, zinc and tin were mostly met through imports. The government protected the nascent Indian industry through levying import duty, wherever necessary. Free import was unthinkable in view of non-availability of foreign exchange and adverse balance of trade. The Government favoured indigenous development of associated technology.

Whilst extensive resources were available of iron ore and bauxite, those of coking coal and electrical energy were highly deficient. Similar was the position for the rest of industrial metals but not those of manganese. It was thought that manganese could be extensively used as alloying element in steel,



as a substitute of nickel. The concepts of the import of mineral concentrates, coking/steam raising coal or that of Indian companies owning captive mines abroad were not then born, largely on account of non-availability of funds. Import substitution was the clarion call of those times and provided the main thrust for the R & D programmes.

After initial floundering, it was only under the leadership of Dr B R Nijhawan that the NML really took off and acquired international recognition and respect. Massive scientific inputs were made in the following areas (to cite a few examples)

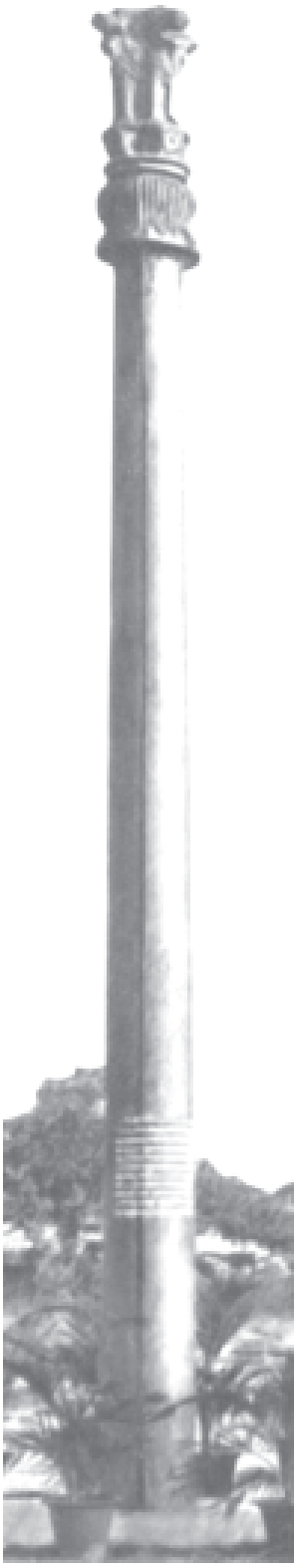
1. Low shaft furnace technology for the production of pig iron using inferior grades of coke.
2. Extensive mineral characterization work including technology for the beneficiation of different mineral minerals Mineral beneficiation plants are existing in different parts of the country that are based on the flow sheets developed at the NML. The raw materials, particularly iron ores for the different public sector plants was done at the NML
3. Technologies for the production of manganese metal and manganese dioxide were developed. That of the former in the hope that manganese could be groomed to be a substitute for nickel for the stainless steels. Most of the austenitic stainless steel was then being imported for the utensil industry. There was very little chemical industry then.
4. Thrust was given to the development of electric grade aluminium alloy (NML-PM2) to provide as versatile a conductor metal as copper. The alloy had made a nationwide impact and was mentioned favourably in a Report brought out by the Department of Science & Technology describing different facets of notable Indian R &D activities.
5. Anticipating widespread use of aluminium for engineering applications, cutting edge technology for treatment of alloy melts and melt filtration was developed.
6. Technology for the production of magnesium was developed and a pilot plant established using the silico-thermal reduction route.
7. NML was the pioneer in the development of sponge iron technology.
8. Anticipating huge growth of the thermal power industry, necessitating availability of several grades of high temperature creep resisting steels, a creep testing facility was established with assistance from the UNIDO. Activities at the Facility paved the way for the acceptance of indigenously produced steels to be used in high pressure boilers in accordance with the mandatory requirements of the Indian Boiler Regulations. Later the Facility developed techniques for remaining life prediction.

CREEP TESTING FACILITIES

Formation of Indian Creep Panel

Thermal power plants, being then imported from the then USSR, USA, UK, France etc, were using proven and tested creep resisting steels in accordance with their own Standards. As commercial production of such a large variety of steels for identical service conditions and their extensive testing for meeting the regulatory requirements of statutory bodies was a huge task, their rationalization into a few grades was a national priority. This gigantic task was spearheaded by the NML through the formation of Indian Creep Panel - a voluntary association of experts from users (largely BHEL), steel manufacturers, other R & D organizations and the Indian Boiler Board. Valuable guidance was also received from the UNIDO Expert posted at the Facility at the NML Alloy steel manufacturers then produced these steels and got their creep properties evaluated at the Central Creep Testing Facilities. It is a pleasure to record here that the Indian steel manufacturers had the competence to produce steels of international quality. The present author was inducted into the national programme at the behest of the UNIDO and with the approval of the CSIR. Later, the facility had to be substantially expanded to accomodate the very large number of samples that we had begun to receive for testing.

Later, in the early 1980s we developed our own methodology for the estimation of residual life of exposed power plant components. Our first client was the Neyvelli Lignite Corporation who .I understand,



continues to patronize the NML for this kind of work. It is also a pleasure to record that my successors at the helm of the Facility continued to work on the refinement of the technique. This technique is of great use now in the rehabilitation programmes of aged power plants.

POWER PLANT COMPONENT FAILURE ANALYSIS AT THE NML MAKES IMPACT ON NATIONAL R & D SCENARIO

The period 1960-1985 was witnessing a very rapid growth, not only of the installed generating capacity but also in the capacity of individual units. Whilst our thermal engineers showed remarkable resilience to errect, operate and maintain the modern marvels of engineering, there were a large number failures in the high temperature, high pressure components. The result was that the power plants were operating at vey low plant load factors. It was easy to put the blame on poor quality of the metals used in the construction, our investigations showed that the failures were largely influenced by the operational scenario. Our vociferous and sustained campaign to educate the thermal engineers soon began to show results. We were asked to organize continuing education courses on the metallurgical interface of boiler operation. Further, the present author had the distinction of being named as the Expert Coordinator, with the approval of the Director General CSIR, for a nation wide study of boiler tube failures under the auspices of the Central Board of Irrigation & Power, Government of India. Later, the project moved with the author to the Regional Research Laboratory, Bhopal where he was transferred by the CSIR in 1986.

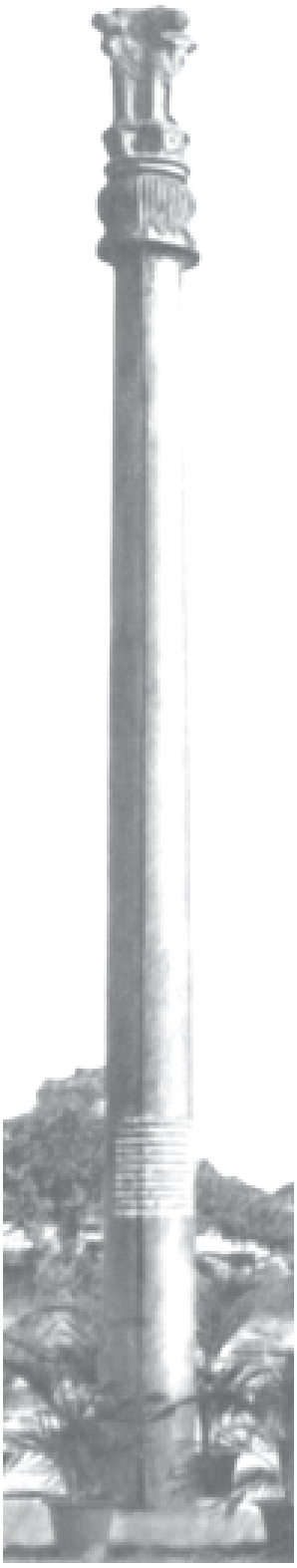
MEMORABLE EVENTS IN MY LIFE AT THE NML

NML had been my "karam bhumi" for the better part of my professional career in self chosen fields and my mind is full of several interesting anecdotes that occurred during the period of my association with the NML. I shall recount the two most pleasant ones:

1. The then Prime Minister of India, Smt Indira Gandhi had convened a Directors' Meet to discuss the contributions national laboratories could make to her twenty point programme that she was implementing on high priority. Unaided she conducted the meeting herself and gave everybody present opportunity to speak. Seeing my raised hand, she called out my name to speak. Complimenting her for according the energy sector highest priority in her developmental plans, I drew her attention to the then prevailing poor plant load factors on account of frequent failures in their high temperature pressure parts, I said that NML can help by carrying out the root cause analysis extensively (and we were already doing it) and thus help in improving the average plant load factors. Since this would only be a repetitive work and would not in any case bring the Scientists credit in the form of published papers, I requested her to have the promotion norms modified suitably. I felt deeply honoured to find the Prime Minister of India making notes. A few days later, I found myself nominated to the R & D Panel of power sector. The Panel recommended establishment of metallurgical centre to cater for the growing needs of the thermal power stations. I apprised the CSIR authorities about this and suggested that steps be taken to have the Centre with the Central Creep Testing Facilities at the NML. The Centre was established under the umbrella of the Central Power Research Institute and is located at Nagpur.

2. The Vice President CSIR, Prof Nurul Hasan had entrusted work related to the control of pollution emitted by the large number of foundries at Agra as they were damaging the world famous TajMahal. At a Directors' Meet, Prof Hasan abruptly presented me before the Prime Minster, Smt Indira Gandhi who asked me to elaborate on my metallurgical plans in this direction. Learning of my plans to design a scrubber to remove the oxides of sulphur and nitrogen from the emitting gases, her only question was about cost. On learning about the estimated cost, she asked her secretary to make a note and the amount was indeed sanctioned. We had put up two units at Agra, one of which was certainly working until recently and may still be in operation.

What was amazing in this episode that the Prime Minster had time to cut a joke even amidst the serious professional presentation! In retrospect it appears that in those days there was no barrier between the Prime Minister and people of India. The concept of "aam admi" was not born yet then.



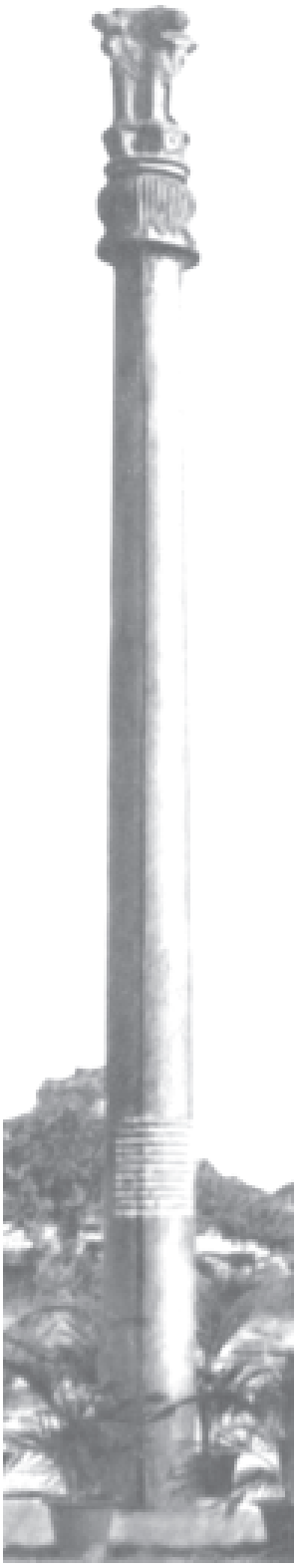
CONCLUSION: Personal Reminiscences

Visions of Divine Aura : No account of my NML days would be complete without mention of my psychic experiences - the foremost being the unique privilege of having the "darshan" of Shri Shri Maa Anadmayee who was visiting Jamshedpur in 1979. Not only was I got identified from amongst the thousands who had thronged for Her darshan and was asked to be presented before Her, She gave me the opportunity to witness the divine aura around Her. Her melodious voice and words of blessing continue to ring in my mind. She truly was Maa Durga incarnate.

On another occasion, my family and I were sitting before Bashir Baba (of Cuddapah ?) who had come to Jamshedpur. In 1969. Without any word from me, he ordered me to continue with the NML as it was my "karambhumi". I was then thinking of leaving the services of NML. He said "I will remove all roras (obstacles) from your path". And removed obstacles he did!

Finally, *would like to pay handsome tribute to my valuable colleagues and co-workers who were steadfastly devoted to their work and made me as proud of them as I was of the achievements of my team. They stood by me in moments of my distress. We made a major contribution to the revenues earned by the NML that on one occasion I requested the then Director General, Dr Nayudamma to have our earnings of five years invested in Government Bonds and I will manage my team within the generated interest. He remarked "Kumar, You are ahead of your times."*

I wish Dr. Srikanth and his colleagues continues success and hope that their work will bring new laurels to the NML.



The Mettle in the Metal

ANURADHA ALTEKAR*

A black and white photo of my father and mother, shot during the Steel '80's international symposium in Jamshedpur, occupies a place of pride in my living room: both all smiles-he, a picture of elegance; she picturesque, beaming with the radiance of a 1000-watt bulb.

Now that I write this piece, that photo brings back memories of another photograph.

As a teenager growing up in the 70's, I had put up posters of rock stars-the Junior Statesman carried them--in my room. One day, he took a cursory peek into my room. As his eyes took in the psychedelic assault, he walked over to a spot and brought down a photograph: it was a portrait of my illustrious grandfather the late historian Dr Anant Sadashiv Altekar. The answer to my unsaid question was quiet and pithy: "Bad company." I removed the posters promptly. That was his way--never to impose himself, but always ready to show the path should someone want to see. From that day on, I never lost sight of our heritage.

Vishwanath Altekar and Nalini Altekar. They were a fairy tale couple, Baba and Aai--meant for each other, and to live happily ever after. Today, two decades after he has passed away, and not more than a few months after her demise this year, I remember them in tandem.

The 'once upon a time' story of their lives together begins in the late 1940's when they met for the first time at my mother's maiden home in Baroda. Nalini was 18, the 7th of 8 children. Aai's father. Vishnu M Kathavate. was a specialist in agriculture and farming in the duty of the erstwhile Maharaja of the State of Baroda Sayajirao Gaekwad. Her mother, ever consumed with anxiety over their ability to find a match worthy of my mother's hand, whispered to her older daughter: "The boy is dark but quite smart." I suppose Aai liked what she saw because she shyly consented to the match, as did Baba. Baba had completed his B.Sc (Metallurgy) from BHU and had joined the University as Lecturer. His heart was set on going abroad for further studies at the Colorado School of Mines in the US--with Aai in tow! My grandfather would not hear of such an impropriety. The situation would have reached an impasse but for a kindly relative who intervened to work out a compromise: they would get engaged and be married after Baba returned. In the next 3 years that separated them, they wrote to each other frequently. Aai preserved his letters tied with a red satin ribbon in a small pastel pink plastic box with a floral print. We children were not allowed to read them but we have seen photos of his addressed 'My darling Nalu' and signed 'Your loving Vishwanath'! Baba, I am told, pined so much for Aai that he had a kept a portrait of her in his rooms in Denver. That was his devotion and loyalty to her, even well before they married.

After his return from the US in 1951, they married and settled in Benaras. Baba resumed his work in BHU. My late brother, Deepak (1952-1998), was their first child. I was born six years later in Aai's maiden home in Baroda. My brother and sister-she was born in 1966--were blessed with the best of their features and their brightness. I had to content myself with other power genes like my mother's tenacity and Baba's perseverance.

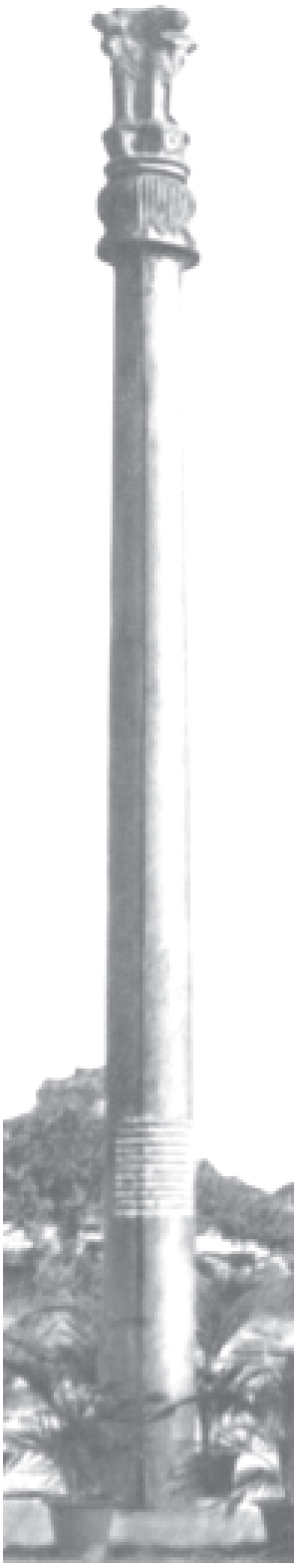
In 1957, Baba left Benaras to join UDCT (University Department of Chemical Technology), Mumbai, now known as the Institute of Chemical Technology, as Reader. In 1962, he became a Professor. His students SV Kamat and Prof VV Mahajani, retired Professor of Chemical Engineering at ICT, recall his teaching clearly, more than 50 years later.

Student reminiscences

"Prof Altekar taught us metallurgy in my third year of chemical engineering in 1969-70. We enjoyed his lectures. He was very down-to-earth and was able to spark our interest in the subject. I have very fond memories of him. I often refer him to my students--he's a bible for chemical abstracts."

-- Prof VV Mahajani, retired Prof of Chemical Engineering, ICT

*Daughter of Dr Altekar. She is a masters in economics from Fergusson College, Pune. She has many national awards for her work as a communications professional at Tata Steel, Dr Reddy's, and Lupin. She has her own company Ubiquus, offering 360-degree communications to corporates, and lives in Mumbai.



"Prof Altekar was an authority in physical metallurgy. He taught us in the third year of our B.Chem Engg course, in 1965-66 . His teaching was lucid and flowing, making it easy for us to grasp the subject. He had an impressive personality and gait. His eminence made students wary of approaching him. He appeared a bit reserved too, which made us keep our distance.

Prof Altekar used to wear a blazer. As soon as he entered the class, he would greet us and hang his coat. Quite frequently, he would start by saying he had just returned from such and such place. He was a very busy person and was on the visiting faculty of many institutions and consultant to a number of companies in the metallurgical industry."

--SV Kamat, B. Chem Engineering, UDCT

In 1969, Baba was selected by CSIR for the position of Director, National Metallurgical Laboratory, Jamshedpur. He was among a chosen few scientists who fanned out to head research institutes in India. At 11, all I knew was that I would be leaving my friends, school mates and my favourite pastimes behind. On the way to Jamshedpur, in the first class coupé of the Bombay Howrah Express that we had to ourselves, I extracted a promise from him to buy me a cycle as a deal. When we arrived in Jamshedpur, so overwhelmed was I by my new surroundings-new town, new people, the big Director's Bungalow at Circuit House Area with a sprawling garden and backyard, the Plymouth station wagon driven by Chauffeur Choudhry, and the imposing grandeur of the NML building that was to be Baba's new office-that I quite forgot to claim my bike. It was not until a few years later, when my sister got one, that I remembered his unkept promise to me in the train!

Baba, my light

Suchitra Mangesh Kolhatkar

One of my strongest memories of Baba was his belief in 'simple living and high thinking'. The command, respect and authority that he had earned in his field was solidly grounded in his upbringing. Aai always credited his mother for it. Baba was always well-dressed--even at home--woke up early, and never lazed around. On holidays, he would find himself a good book to read or disappear into his study-cum-office on the second floor of our home or help us with our studies. He was well-groomed; he had no bad habits at all, and no vices. He was generous but, at the same time, never spoilt us. Baba never demanded this, that, or the other from us. All he expected from us was that we study, play, and work hard. He asked from us only what he had lived by all his life, no more. Though it would have given him much joy if we had shined like him, I do not believe that he wanted anything extraordinary out of us; he would have been just as happy if I had been a homemaker, provided I was good at it!

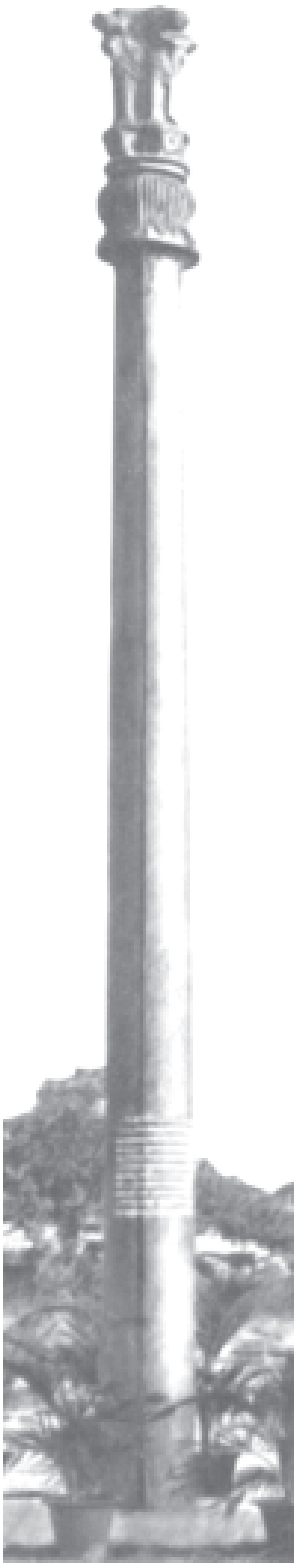
I don't remember him ever talking ill of anyone. We hardly got to hear much about his pressures and challenges at work, though I'm sure that there would have been many, given his responsibilities.

I never remember a time when we misused the office facilities. We went to school like other kids, in cycle rickshaws, or walked or biked. Nor was I spoiled with too many toys or dresses. We dressed well, lived well, and ate well, but considering the background that we grew up in, I would say our living was modest. The only time I really started splurging on myself was when I started to earn my own money.

Aai would have to go in a cycle rickshaw for grocery shopping, whenever he was traveling, which was really very often. I also remember him telling us kids to help Aai out at home with the dishes if the maid did not come in for the day.

We had our share of serious issues at home; on the personal or professional front, however, he kept his focus and cheer. His balanced outlook to life kept him and the family in good stead, especially in difficult times. The only time he would be upset with me was when I slipped at studies. At such times, I dreaded to show my report card to him. He made sure that he provided for all our needs-good schools, good colleges, special lessons, music classes-and never lacked for anything-movies, outings, or vacations to different places.

He was a practical man, not easily swayed by emotions, and that is what kept him on one purposeful, single-minded track--to devote himself to metallurgy and to raise a family with responsibility, and with



commitment. Today, this sense of duty comes home to be more strongly than ever, as I bring up two little kids of my own.

He always made it a point to visit and to build relations with Aai's side of the family too, with my aunts and uncles. My cousins looked forward to his visits for 'Kaka's day out'. Inevitably, he would take them all out on a jaunt or to eat out at their favourite place. He was genuinely warm with them, and they also extended the same respect to him.

Baba was well ahead of his time, and he always wanted Aai to go out and work, be her own person, as he wanted his daughters too to go out, and be their own women. When Aai took up B.Ed, she could do so because he was behind her. I suppose he would have learnt this early in life from his mother who gave all his siblings-3 brothers and 3 sisters-an equal opportunity to flower. No one was more disappointed than he when she had to abandon the course because of domestic pressures.

After he passed away, I met an uncle (I don't remember who it was) who said he offered him a blanket on the train even though there was only one between them. That was his way: putting others before self.

To this day, I often find myself wondering what Baba would have advised me to do in such and such situation. He is--and always will be--my guiding light.

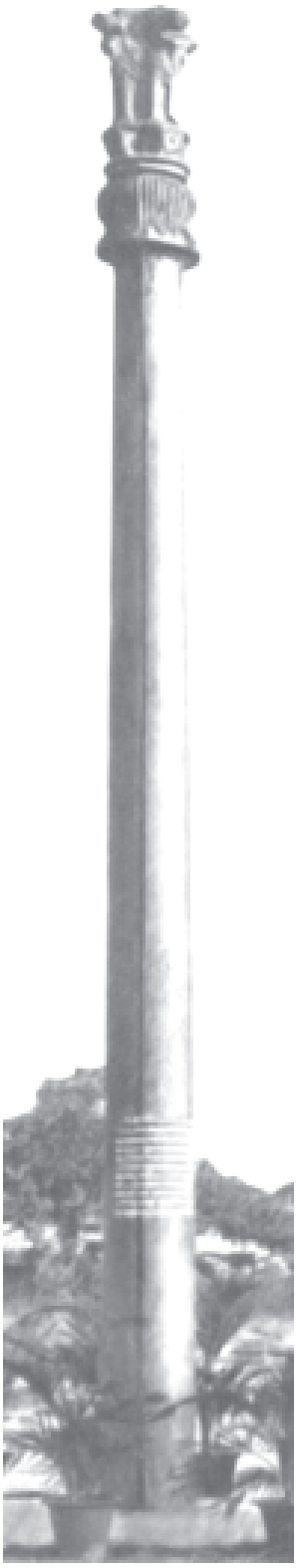
The author is the younger daughter of Dr Altekar. A B.Sc. In geology from Fergusson College, Pune, and MBA from IMDR, Pune, Suchitra has settled in Foster City, CA, USA, with her husband Mangesh, a telecom engineer and two children Kayhan ,5, and Lavanya, 4.

I remember that Krishnan uncle was very helpful in getting me an admission into Sacred Heart Convent School. Everyone in NML ensured that we were made comfortable in our new home. As we settled down to a new life, we made new friends. GP Mathur, PP Bhatnagar, Dr R Kumar, KN Gupta and KN Srivastava, were more than Baba's colleagues; they and their families came close. We had good times together at picnics and outings, and major NML functions. Our families were all well-matched. Member for member, none of us ever lacked for company or companionship. It was fun visiting some of the mines and the plants with our fathers as they made the rounds of Kiruburu, Digha, Barbil, Betla, Muri, Puri, and many more interesting spots. Baba teased Mathur uncle about wanting to carry his paan box with him on a trip to Vienna. We looked forward to Mathur aunty's mouthwatering mutton curry with parathas, Bhatnagar aunty's pakore ki kadhi, Gupta aunty's inimitable kachori and the delicious Sindhi treats that Shahani Aunty sent us with so much affection, without fail, every Diwali.

Baba began his day early. He would be up at 5 a.m well before the rest of us. He often made the first round of tea for the family at home and, sometimes, even in the afternoon on a Sunday. On a week day, he would have his bath with the radio tuned in to AIR playing Rabindrasangeet, followed by the morning news bulletin. He never trusted the news on foreign channels-to him BBC was 'sensationalist'. He would be ready to leave for work at 8.15 a.m. sharp. On the weekend, though the occasions became more infrequent as his travel increased and work pressures mounted, he would drive Aai to Bistupur bazaar for shopping. While she bought vegetables and groceries, he would saunter around the market munching on chana chur or chana. His mid-day meal in the office was ordered from the canteen. It comprised--to my mother's utter horror--one gulab jamun, a rosogulla or jalebi and a samosa. Despite her protests, he steadfastly stuck to this unwholesome diet till he retired in 1985. He adored fried foods and liked eating out. At home, he expected only simple meals, comprising a pumpkin or a gourd vegetable, which were his favourite. Even an extra bit of oil would evoke a frown from him. That aside, he never made any demands on my mother. Whatever she served was good enough for him. He cheered her through all her culinary experiments in quest of the perfect this or that specialty. His one peeve was that after she had achieved the desired state of perfection, it was the last he would see of the dish.

As children, we met a string of distinguished personalities who visited our home. Among them were the late Prof Nurul Hassan, the then Vice President of CSIR, the late Prof Y Nayudamma, the late S Mohan Kumarmangalam, the then Hon'ble Minister for Steel and Mines, Shivraj Patil, the then Hon'ble Minister for Science and Technology, and renowned metallurgist the late Dr Brahm Prakash.

We all loved Baba's hand-writing, which we copied with varying degrees of success. We were also proud of his complete mastery over Hindi and English. More than Marathi, Hindi was his first language,



as he was brought up in Benaras. It was natural for him to converse with his brothers and sisters in chaste Hindi. Once, I asked him what he would have been if he had not been a metallurgist. After a split-second pause, he replied "an English litterateur" which came as a complete surprise to me. I would never have thought that he would, for even once, seriously consider any other pursuit than that of science. He was a great speaker who could capture his audiences when he addressed Independence Day and Republic Day in NML. It was a joy to listen to him.

He never returned empty-handed from his travel. We watched with bated breath as he opened his baggage and brought out some curio or specialty from his visits to exotic destinations-silver filigree earrings from Cuttack or Hyderabad, a saree from Bangalore, a dress from Delhi, a papyrus roll and mementos of pharaohs and queens from Egypt, a cut glass vase from Czechoslovakia, piano concertos by Chopin and waltzes by Strauss from Vienna, a baking book and yes, even rock music, from the US.

When I finished school, it was time to discuss what I would do next. My classmate and close friend had opted for studying in Loreto College, Lucknow. I, too, stubbornly insisted on joining the same college. Baba, ever tactful, probably disapproved of the idea; eventually, we arrived at a compromise that I would study in Mumbai. Once we had decided, he moved like lightning. That very day, we got on to a train to Mumbai and spent the night roughing it out in a cramped, unreserved compartment. We got my admission in Sophia College for Women. Only after he was sure that I had settled and comfortable did he return to Jamshedpur. He would write frequently, sometimes rebuking me for this or that action but always loving, caring, concerned, and responsible. He was strict with us but not rigid. Most importantly, he was always behind us… at studies or work, egging us on, even provoking us to improve and better.

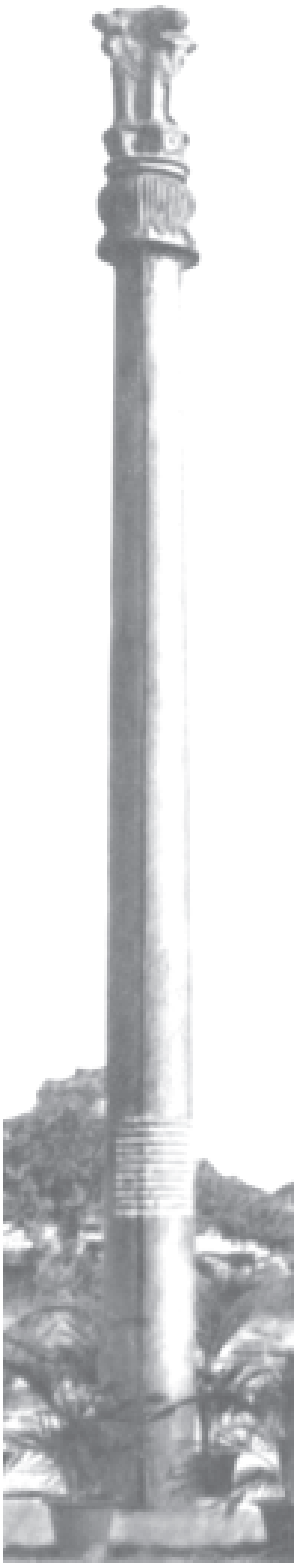
Few people would be aware of his mischievous, jocular side. With his wit and witticism, he could entertain or cut people to size without intending any malice, as the occasion demanded. Examples: "So, was I with a pretty girl?," in reply to a friend who told him he had seen him in his car, driving to NML, or "Hello, Devi da. How are you and how is your motivated Motif?", in greeting, to a journalist who worked in that magazine. He did not suffer fools gladly, as the expression goes. If any one got the better of him, it was my mother. She was the perfect foil for him; she saved us from his wrath if we went wayward or countered his witticism with her own special brand of repartee. He was a doting husband who yielded to her every whim and indulged her every quirk with mock horror. Aai detested travel and he would have to make at least one reservation change before she would ready for a journey. On such occasions, I could see his tolerance being tested to the limit but he responded with no more than mild exasperation. She had a penchant for collecting stainless steel kitchenware. An aunt recalls the day Baba found a suitcase loaded with a large stainless steel grain storage bin filled to brim with 25 smaller boxes, to his complete astonishment. He replied with his sang-froid "Well, if ever the Tatas face a shortage of steel, they won't need to import it. If she puts her entire collection together, Nalu can take the contract."

I'm not sure how many would have known that he once had a hot temper and was not afraid of a brawl. Aai would often recount an anecdote of him roughing up a tangawala for rash driving when the tanga (horse-led carriage) they were riding overturned and ejected Aai out into the road. Another senior relation remembers a train journey in his company when Baba knocked out a fellow passenger for usurping his seat and for threatening to assault him. His temper had mellowed considerably, however, by the time my sister arrived.

Scientist to the world, my everlasting memories of him are of a man with kindness, generosity, large-heartedness, compassion, a great sense of fair play at all times and detachment to caste, creed or religion. He never stood in judgement of people. He had a great regard for women who attempted to rise above the ordinary but also because he found in them contemporary role models for his daughters.

All I can say is that Baba was an icon for all that he held dear. In short, he rocked.

With grateful thanks to Sanjeevani Kathavate, Jay Kathavate, Sushama Cheema, Prof BM Udgaonkar, Padma Udgaonkar, and Dharnidhar Narayan Sinha for their valuable inputs and help.



एन.एम.एल. कुछ संस्मरण

श्रीमती सुधा राव*

किसी भी संस्थान की बुनियाद; उसका गौरव, नाम, प्रसिद्धि अपने आप नहीं आ जाती क्योंकि वह केवल ईंट, पत्थर की ईमारत मात्र है। संस्थान को यह यश, वहां पर विविध पदों पर आसीन कर्मचारियों के परिश्रम द्वारा प्राप्त होता है। उनकी लगन, परिश्रम, दूरदर्शिता, कार्यक्षमता, आपसी सहयोग आदि ही संस्थान को इस स्तुति का पात्र बनाते हैं, अतः राष्ट्रीय धातुकर्म प्रयोगशाला के सभी भूतपूर्व व वर्तमान कर्मचारी बधाई के पात्र हैं जिनकी लगन व परिश्रम आज रंग लाई हैं। हीरक जयंती समारोह के इस शुभ अवसर पर प्रयोगशाला के सभी पूर्व एवं वर्तमान कर्मचारियों को मेरी शुभ कामनाएं एवं हार्दिक बधाई।

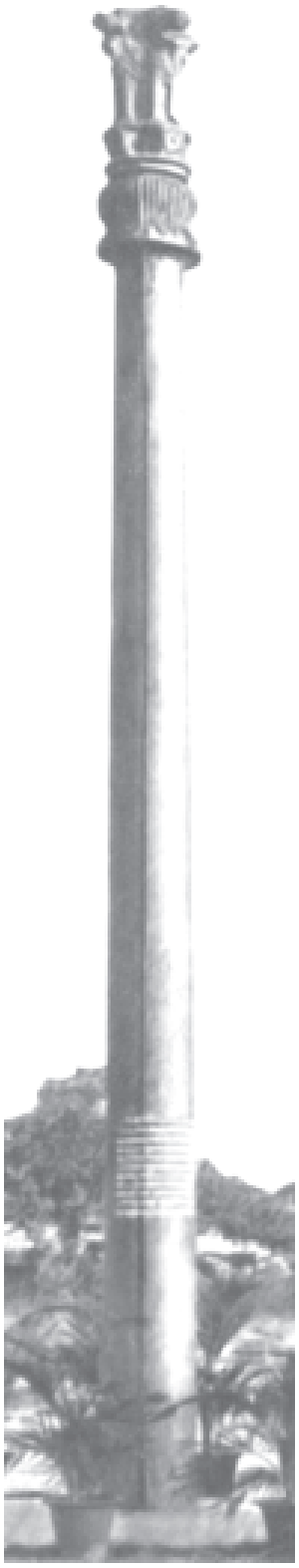
राष्ट्रीय धातुकर्म प्रयोगशाला के वर्तमान निदेशक डॉ. एस. श्रीकान्त ने मुझे प्रयोगशाला के बारे में लिखने के लिये कहा यह मेरे लिये गर्व की बात है। समस्या यह है कि क्या लिखूं कहां से प्रारंभ करूं क्योंकि प्रत्यक्षरूप से इससे मेरा कोई संबन्ध नहीं। मेरे पति प्रो. पी रामचन्द्र राव, सितंबर 1992 से फरवरी 2002 तक इस संस्थान के निदेशक थे अतः अप्रत्यक्ष रूप से मैं इससे अवश्य जुड़ गई। प्रो. राव ने संपूर्ण उत्साह व लगन से अपना पूरा समय व योगदान एन. एम.एल. के उत्थान में लगाया। मेरा योगदान सिर्फ इतना सा था कि मैने उनके किसी काम में दखल नहीं दिया तथा घर गृहस्थी की ओर से मुक्त रखा। यदि मुझे एन.एम.एल. के बारे में कुछ कहना है तो प्रो. राव के काम के बारे में बिना लिखे इस संस्थान के उत्कर्ष की कथा अधूरी ही रह जाएगी। उनके कार्य काल में इस संस्थान को एक दिशा मिली व कुछ ही वर्षों में उन्होंने इसे विमान की 'टेक आफ' स्थिति में ला खड़ा किया। यह अतिश्योक्ति नहीं है, उस समय के सभी कर्मचारी इसके साक्षी हैं। उनके कार्यों के कुछ अंश प्रस्तुत करने का प्रयत्न करूंगी।

सन् 1992 में जब प्रो. राव ने जब इस संस्थान का कार्यभार संभाला इसका यह रूप नहीं था जो आज हैं। झारखंड का बिहार से अलग होने का राजनीतिक माहौल गर्म था। इस ताप में गुंडे, बदमाश भी अपनी रोटी सेंक रहे थे। आये दिन कभी वाहनों की मांग कभी रुपयों पैसों की मांग, कभी उनके अपने कार्य के लिये स्थान की मांग, न मिलने पर कर्मचारियों या निदेशक को जान से मान डालने की धमकी। एन.एम.एल. का माहौल भी गर्म ही था 5–6 यूनियनें थीं। आये दिन एन.एम.एल. के मुख्य द्वार पर अलग–अलग मांगों को लेकर प्रदर्शन होते थे। इन सबका असर प्रत्यक्ष या परोक्ष रूप से संस्थान के काम पर पड़ता था। प्रो. राव न कभी इन गलत मांगों के आगे झुके न कभी उन्होंने इसका समर्थन किया। सन् 1992 अक्टूबर कि बात है शाम के समय संस्थान के सुरक्षा अधिकारी आये उन्होंने सूचित किया कि एन.एम.एल. के बस चालक को जो संस्थान के बच्चों को स्कूल से घर ले जा रहा था, धमकी दी गई है कि सुबह होते ही बस को उनके हवाले किया जाय अन्यथा ड्राइवर व उस पर सवार लोगों की जिन्दगी की खैर नहीं। यह सुझाव रखा गया कि बस चालक व बाकी सब को पुलिस संरक्षण दिया जाय। प्रो. राव ने कहा ''किन्तु कब तक ? यह कर्मचारियों के जीवन का प्रश्न है'' उन्होंने बिना कोई समय गंवाये पता किया किसने धमकी दी हैं, उनके मुखिया कौन है, कौन उनके करीबी मित्र हैं (क्षमा कीजियेगा मैं यहां किसी का नाम नहीं लेना चाहूंगी) किसकी वे सुनते हैं। शीघ्र ही उस मित्र से संपर्क किया गया। उन्हें सारी स्थिति से अवगत कराया गया और संयोग से वे करीबी परिचित निकले। उन्हें रातों रात उस गांव भेजा गया जहां मुखिया किसी की शादी में सम्मिलित होने गये थे। इस प्रयास का फल यह हुआ कि मुखिया जी ने कहा ''आज से एन.एम.एल. को कोई भी नहीं तंग करेगा''।

एक और मजेदार घटना घटी फोन पर मारने की धमकियों अक्सर आती थीं। उस दिन रविवार था फोन आया प्रो. राव ने ही उठाया दूसरी ओर से आवाज आई 'का हो बड़का डाइरेक्टर बनत हौ आपन जान की फिकर करा' प्रो. राव ने कहा ''का कहत हो मर्दुआ तनि सामने आवा'' बस उनके इतना कहते ही दूसरी ओर से हंसने की आवाज आई और फिर धमकी भरे फोन आने बंद हो गई। इस तरह की छोटी बड़ी घटनाएं होती रहीं।

प्रारंभ के एक दो वर्ष आंतरिक व बाह्य रूप से काफी संघर्ष पूर्ण थे। धीरे–धीरे जब लोगों ने उन्हें समझा, उन्हें जाना कि वे जो भी कर रहे हैं एन.एम.एल. की भलाई के लिये कर रहे हैं, प्रो. राव का कोई स्वार्थ नहीं है, इसमें उनकी (कर्मचारियों की) ही भलाई है। शनैः शनैः सबने अपना सहयोग देना प्रारंभ किया। आपसी मतभेद कम हुआ। काम करने का वातावरण बना, यहां तक कि सब यूनियन नेताओं ने यूनियन का विघटन किया। वे सब संस्थान की प्रगति

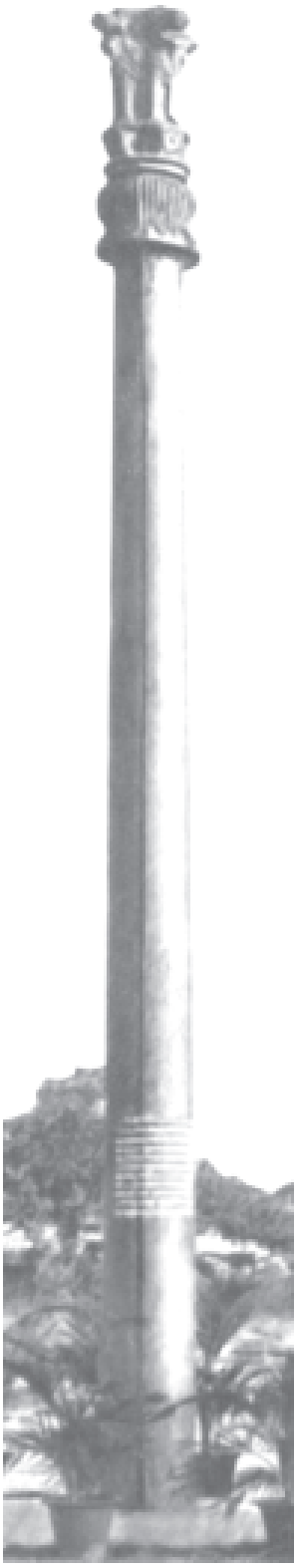
*स्व. प्रो. पी. रामचन्द्र राव की पत्नी



के लिये सामने आये। अपना संपूर्ण योगदान दिया। प्रो. राव सभी छोटे बड़े कर्मचारियों से समान भाव से मिलते थे। उनका मानना था आदमी बुरा नहीं होता, परिस्थितियां उसे ऐसा बना देतीं हैं। वे यह भी कहते थे कि हर कर्मचारी के चेहरे के पीछे परिवार के कई चेहरे छुपे होते हैं हमें उन्हें भी ध्यान में रखना चाहिये। यही कारण था शायद कई कर्मचारी उनसे अपनी व पारिवारिक समस्याएं बतलाते थे। उन्होंने स्वास्थ्य संबंधी कई सुधार किये। हर कर्मचारी का अनिवार्यतः स्वास्थ्य परीक्षण किया गया। फल स्वरूप कई लोग जिन्हें ज्ञात ही नहीं था कि वे रक्तचाप या मधुमेह के शिकार हैं उनका सही समय पर उनका उपचार हो सका। इतना ही नहीं बारहतल्ला व अन्य कर्मचारी आवास जिनकी हालात काफी खराब थी शायद कुछ दशक गुजर गये होंगे उनकी कोई मरम्मत नहीं हुई थी, उन सब आवासों की मरम्मत व रंग रोगन का काम भी हुआ। इस तरह कर्मचारियों की भलाई के साथ–साथ विज्ञान तथा अभियांत्रिकी के विकास में लिये उन्होंने कई काम किये। इस संस्थान को राष्ट्रीय स्तर पर खड़ाकर एक पहचान दी। एन.एम.एल. को एक सूत्र में पिरोने के लिये उन्होंने कुलगीत की सृष्टि की। सबको यह जानकर सुखद आश्चर्य होगा कि यह कुलगीत एन.एम.एल. के लोगों द्वारा ही रचित, संगीतबद्ध किया व गाया गया। प्रति कार्यक्रम में यह अति उत्साह एवं गर्व से गाया जाता था। सांस्कृतिक कार्यक्रम भी होते थे, जिसमें न केवल कर्मचारी बल्कि उनके परिवार के बच्चे व बड़े भी हिस्सा लेते थे। इस तरह एन.एम.एल. एक परिवार बना और हर सदस्य ने इसकी उन्नति में अपना योगदान दिया। आज राष्ट्रीय धातुकर्म प्रयोगशाला का जो स्वरूप है वह प्रो. राव के निर्देशन एवं समस्त कर्मचारियों के परिश्रम, लगन व सहयोग का परिणाम है।

एन.एम.एल. के प्रति स्नेह की एक घटना आज भी मेरे दिल को छूती हैं। कोलकाता में कुछ वर्षों पूर्व एन.एम.एल. की एक शाखा थी वहां एक टैक्सी चालक प्रो. राव को स्टेशन से उस शाखा तथा एयरपोर्ट ले जाया करता था। प्रो. राव के एन.एम.एल. छोड़ने के साल भर बाद, जब वे बी.एच.यू. के कुलपति थे, उसने अपने पैसे से वाराणसी फोन कर कहा ''साहब यहां बहुत गड़बड़ चल रहा है। ऑफिस से सब लोग सामान ले जा रहे हैं'' हुआ यह था कि वह शाखा बंद कर दी गई थी तथा वहां से सामान हटाया जा रहा था। यह वृतांत बाह्य रूपसे जुड़ें लोगों के प्रेम का साक्षी है।

एन.एम.एल. को छोड़े आज आठ वर्ष से ऊपर हो गये। आज प्रो. राव नहीं रहे फिर भी उनके प्रति जो मान, सम्मान व प्यार सबके दिल में है उसके लिये मैं हृदय पूर्वक आभारी हूं। मुझे आज भी आत्मीयता, सम्मान, प्यार इस संस्थान के लोगों से मिल रहा उसे जीवन पर्यंत हृदय से लगा कर रखूंगी।



Looking Back 50 years

Prof. E.G. RAMACHANDRAN

I joined the National Metallurgical Laboratory in October 1956, as Assistant Director in its Physical Metallurgy Division from the Indian Institute of Science, Bangalore. I served the NML for 5 years leaving it in October 1961, to join the Indian Institute of Technology Madras.

Although nearly 50 years have elapsed since I left the NML, I have the liveliest recollections of my association with this great centre of metallurgical research and development, which I served in its early formative years.

When I joined the NML in 1956, I was one of three Assistant Directors, working with Dr. B.R. Nijhawan, the Director when I left it in 1961, there were six or seven Assistant Directors - so much had the NML grown in five years !

I had a special rapport with Dr.Nijhawan, partly because we were both Ph.D's from the University of Sheffield. In fact, we were the only two Ph.D's in Metallurgy at the NML. He had complete faith and trust in me and supported me in my work in the area of Physical Metallurgy. I had some very valued colleagues - Dr. Ved Prakash, Dr. Maji and Dr. C. Dasarathy, among others, and we did a lot of research and development work in the areas of permanent and soft magnet material, X-ray diffraction and effects of hydrogen on the transformation characteristics of steel.

A notable feature of my tenure at the NML was the way the Director asked me to take round the entire laboratory many distinguished visitors. This was, I believe, due to the way I could speak about and explain in popular language the technical work carried out in various divisions. This gave me an opportunity to learn of the research and development work carried out in the various divisions of the NML. This enhanced my knowledge of the various branches of metallurgy - a very valuable asset in the planning and development of the courses and curricula at the metallurgy department of the Indian Institute of Technology, Madras.

Another notable feature of my stay at the NML was the seminars I gave on a regular basis on various topics in physical metallurgy and physics of metals. These were largely attended and I believe, proved very valuable to many of the younger staff at the NML.

Another feature was my association with the sports activities at the NML. I was a well- above average sportsman, excelling in tennis, badminton and volleyball. I was thus a natural choice for the captaincy and leadership of the team from the NML which took part in the annual S.S.Bhatnagar memorial tournaments organised by the Council of Scientific & Industrial Research. I am glad to recall that the NML did particularly well in tennis and badminton.

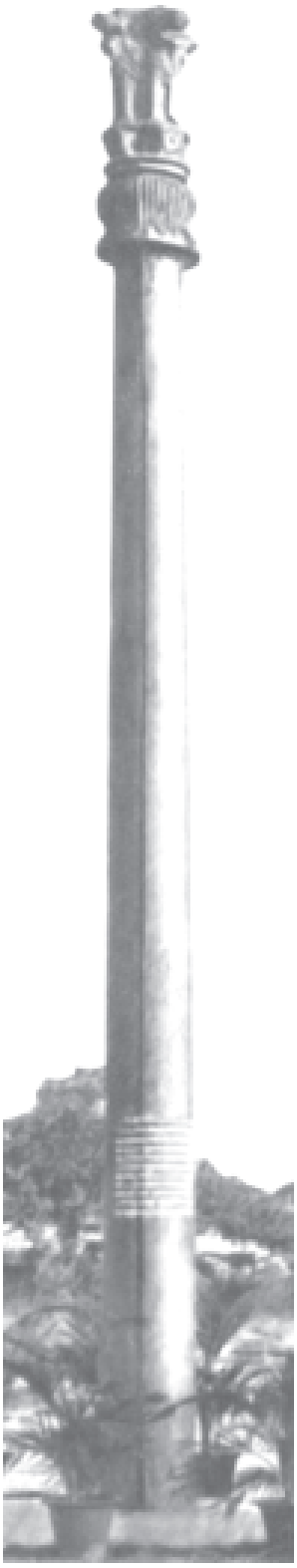
Dr. Nijhawan had a tight control over his colleagues, particularly in the area of their seeking jobs outside the NML. He was particularly nice and helpful to me, when I decided to join the IIT, Madras, at the end of my 5 year contract with the NML.

He was very particular about punctuality in attending the laboratory and would station himself at the main gate to monitor personally late comers and admonish them severely. He spared me from this indignity as he had other evidence and reason to be proud of my good work.

I retained close contacts with many colleagues at the NML after October 1961, particularly with Dr. Nijhawan, Sri R.D.Tandon, Dr. A.B. Chatterjea and Sri Jatinder Mohan. I had also a good rapport with Sri Naseeruddin Ahmed who was for a couple of years, the Administrative Officer at the NML.

All-in-all, the 5 years I spent at the NML were a very fruitful and valuable period of my career. I am always grateful to the NML for the opportunity it gave me to broaden my outlook and interests in metallurgy.

I am happy that it is completing sixty years of glorious life and pray that it will in turn complete a century of great achievement and contribution.



My Seventeen years in NML

Some Reminisces

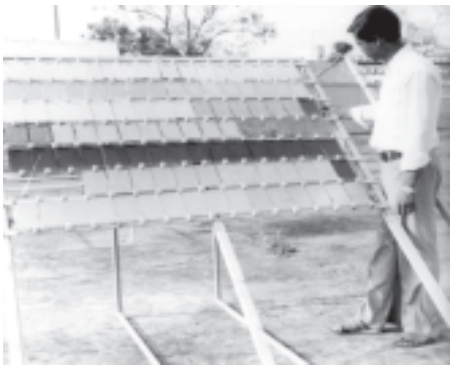
DR A. K. LAHIRI
Materials, Corrosion and Inspection Consultant, Bangalore
Lahiri04k@rediffmail.com

After graduation in metallurgical engineering from Banaras Hindu University in 1953, I started my working career as a CSIR research scholar in B.E. College, Sibpur. I joined NML in 1955 and my 17 years in the Laboratory had been of great help in developing my approach to dealing with technical problems. The importance of understanding multi disciplinary nature of work, working in harmonious groups, completion of work in a time bound program and finally dedication of people working have been my strength in planning my successful working career of 57 years which includes in addition my work in Engineers India Ltd, UNIDO assignments and working as consultant post retirement in 1989. Scientists should keep in mind that unless research and development work is done in a planned time bound manner the user is not going to wait indefinitely. Some of the major projects in NML which highlights this approach has been given.

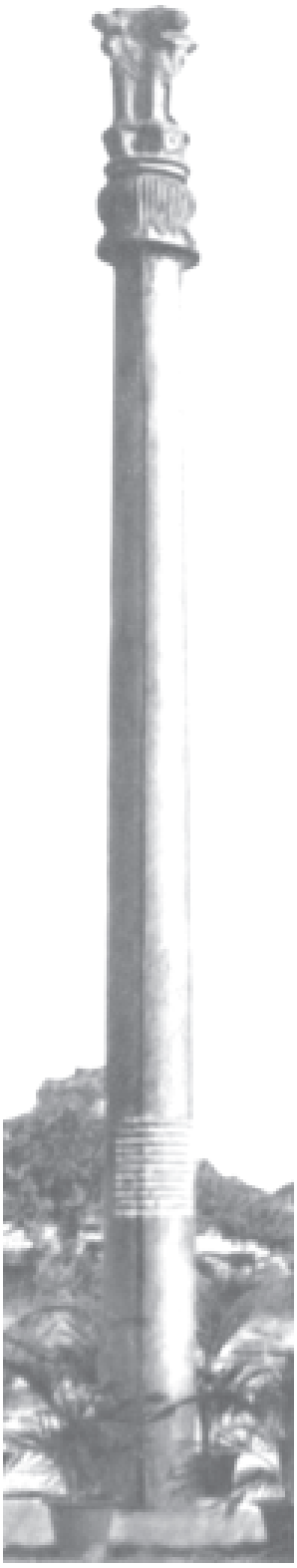
Today 70% of austenitic stainless steel produced in India conforms to Gr 200, Fe-Cr-Mn-N alloy, used primarily for production of utensils and other house hold items. It was in late 1950 that for the first time in India production low Ni / Ni free stainless steel was taken up at NML. The project starting from melting, working and establishing mechanical and corrosion resistant properties was completed, as far as I remember, within about six months. This involved planning and full involvement of different groups. We in the corrosion section conducted series of tests for some of which we had to stay in the laboratory overnight for more than a week.

One of the earliest corrosion project taken up in India by the CSIR and Defense Laboratories was atmospheric corrosion tests. Later Corrosion Advice Bureau (CAB) under Metals Research Committee of CSIR decided to prepare a Corrosion Map of India. As Officer-in Charge of CAB a detail plan was drawn up to conduct fresh tests at existing locations using standard samples of carbon steel and zinc. While TISCO supplied the steel plates and Exide Ltd (earlier Union Carbide) supplied the zinc plates. To increase number of test sites to cover larger area, as per the direction of Sir J.J Ghandy, Chairman Metals Committee, research fellowships were granted at Universities and Colleges which agreed to conduct these tests. It was a large collaborative project with corrosion section of NML being the nodal point. Samples were sent to different stations. Corrosion rate, climatic and pollution data collected at different sites were received and analysed in NML and finally Corrosion Map of India was published in 1975. Such a project would not have been possible without a joint cooperative effort.

Corrosion section was also involved in the development of Cu - Mn as alternate coinage alloy in collaboration with India Government Mint during which both laboratory and commercial scale trials at Mint were undertaken. In spite of alloys having desired white colour and possessing ring similar to silver coin, it could not be accepted because of its inadequate tarnish resistance. Though the Mn containing Cu alloys did not meet all the required properties of coinage alloy it became possible to study in detail hitherto unreported stress corrosion cracking and high temperature oxidation resistance properties of these alloys, which formed the topics of PhD of four scientists / research fellows in the corrosion section.



Experimental set-up for Atmospheric corrosion studies



Journey at NML during May'49 - July'86

K.N. SRIVASTAVA
Former Sr. Scientist, NML

My most memorable journey of life started at NML in May'49 with my selection in the first batch of NML officers under the Chairmanship of Dr.S.P.Mukherjee, when he remarked that why I need to leave TISCO my earlier employer, when the Govt. cannot pay that much salary, my reply was "my wish to join a National Lab, where the quality of work is different than a factory life of TATA's". Thus I was selected in the first batch of Senior Officer at NML, where I was made In charge if Liaison & Research Coordination. But soon I had to take care if Purchase of Capital Equipments from abroad as that required a very close chasing & follow-up.

This made me in close touch with Dr. S.S. Bhatnagar, whom I had to meet every fortnight for one reason to the other to request the Govt. officials to push my foreign equipments to be in time at JSP by year end. What a patronage I was given by Dr.SSB who used to go with me from one office to another and ensure that all the capital equipments are made to reach JSP by year end i.e., 49-50.

The day arrived when Dr. SSB came to NML in end Nov'50 to personally ensure that all the equipments are installed are put on operations. I just asked him my job, when he categorically told me that when on the night of 25th Nov, he takes PanditJee with all dignitaries like Bhabha, C V Raman, etc., the set up all the entire NML need be fully OK.

I was always given full support and encouragement by Dr. SSB when he took round PanditJee on 25th Nov, with all dignitaries gave me a big Pat saying that he is very very happy to see the Lab in full form.

Then came the real Red Day i.e., Golden Day, the memorable 26th Nov'50. When everyone present was almost wild with joy & happiness to see Pandit Jee open the NML and cut the tap. The dignitaries like Sir C V Raman, Bhabha, Tata etc., started giving speeches etc in praise of NML future to make the country self sufficient. The most eloquent and long one lasted nearly 1 hour by Sir CV Raman whom we all heard with rapt attention. He was so much excited that we all feared that it may not harm his own health.

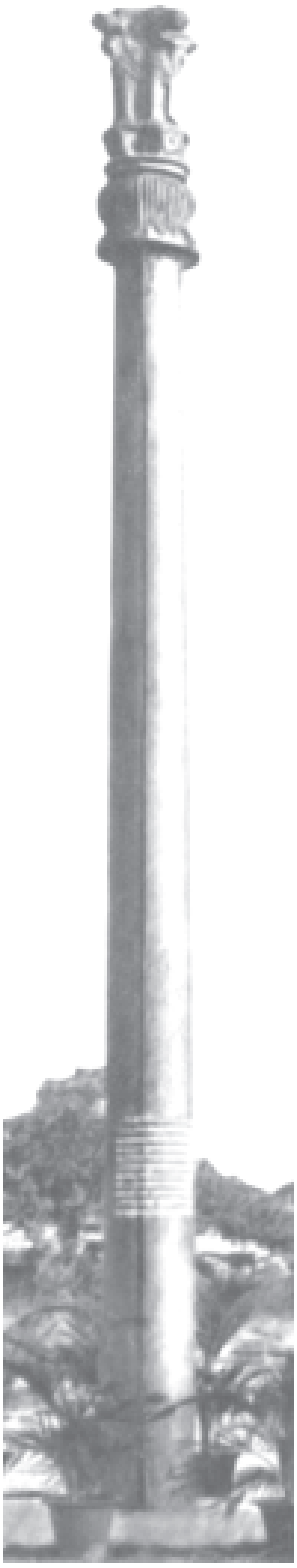
While everyone was overjoyed to watch the opening day function, I can only day that entire atmosphere was agog with pleasure to feel that NML alone can change the future with all our dreams of Modern India.

In 1952 I was selected to Study in W. Germany for an Alternative Process of making Pig Iron without coking coal. While on deputation to W. Germany in 1952-54, I had an occasion to meet Dr. SS Bhatnagar at Bonn, when he told me that I have to be on Transfer of Technology in India. This made me concentrate for a technique of only in Transfer of Technology and promoted me to organize successive Get Together's all are the country to identify meaningful projects based on Mineral Resource of all States and prepare NML to offer Turn Key Projects with the help of consulting Eng. firms, with warranty, penalty, etc., I could organize meaningful get together in Collaboration with Chamber of Commerce, in every State and identify meaningful projects to offer to Govt. etc. This exercise was very useful as could identify meaningful projects to offer Govt. on Turn Key basis with usual penalty etc., Thus NML organized nearly 18 Get Together all over the country and make the country self sufficient with vast mineral resources.

Next event was to prepare a film on NML for progress made in 25 yrs. This was done with the collaboration of Film Division and NML showing at least nearly a dozen places showing NML could project "Men Behind Metals" was made and passed by NMLs Division released on Silver Jubilee at JSP with Minister of Steel to see it at NML Silver Jubilee Function.

In short NML made its own rapport on Metallurgical maps of India, with several of its processes are being exported to make the country self sufficient based on vast mineral resources.

JAI HIND



Contribution of Pilot Plants in the Growth of NML

K.N. GUPTA
Ex Scientist `G`, NML

In the late fifties and early sixties in last century, there was a mushroom growth of pilot plants in several industrial research institutions in India including CSIR laboratories. The earlier understanding was to develop new and innovative processes and technologies on lab scale and transfer the technologies to industry. There was a lack of faith shown by the industries in absorbing the technologies. It was therefore, thought to install such scale of operation of the processes which convinces industries and the transfer become much easier. These units were called pilot plant operation of the processes. NML, in its own wisdom, set up number of pilot plants in several divisions. This gave almost an exponential growth of NML. New lands were acquired, new equipments ordered, new instrumentation were developed and this gave scientists totally new skills to design, install, operate, maintain and improve the processes for easy transfer to industries.

There is a long list of pilot plants, set up at NML but here it is restricted to the area of iron and steel making or in some way related to it.

10-15 tons / day Low Shaft Furnace : A 10-15 tons per day Low Shaft furnace was procured and installed at NML with a view to evaluate the suitability of low shaft furnaces for iron ores and coals of India. This was equipped with complete raw material charging unit, gas cleaning unit, slag disposal unit, hot blast arrangement and burning of cleaned gas to pre-heat the blast. Ore preparation unit, briquetting plant, slag granulation unit and other sundry units were also installed simultaneously. With this facility iron ores and coal and coke from various locations in India and abroad were tested to evaluate their suitability for the production of different grades of iron. The important among them were ores from Bihar, Orissa, Andhra Pradesh, Maharashtra, Bailadila, and several other states. Most of the pig iron so produced was sold in the open market.

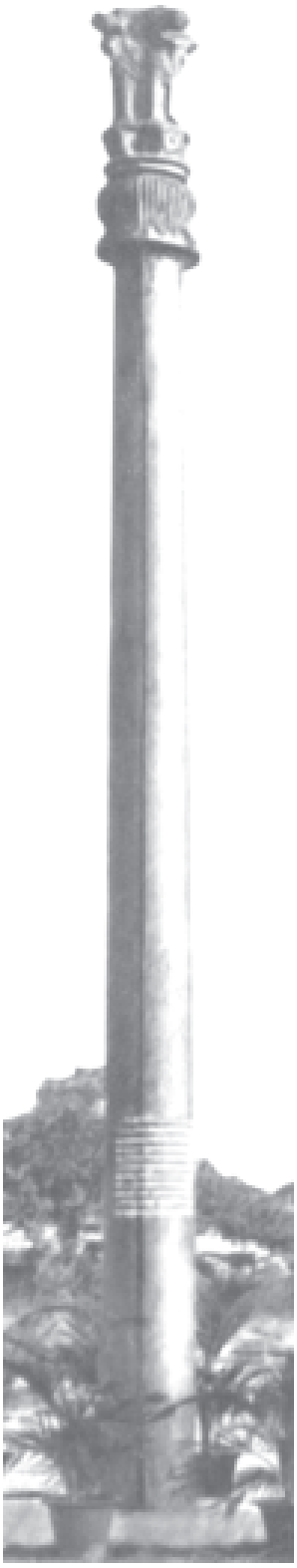
This plant had a different type of raw material charging equipment and to regulate the raw material pattern inside the furnace, so a half size cold model was designed and constructed to study the distribution pattern of raw material. The model study helped in properly regulating the charging of raw materials.

This pilot plant operation gave a big name of NML in the industry.

500 Kg Basic lined Side blown Converter : A 500 kg basic lined Side blown Converter was designed fabricated and installed near Low Shaft Furnace site with a view to convert the iron produced in LSF to different grades of steel. It was unique because it is basic lined and air is blown from the side instead of bottom. Several successful production trials were made and desired results were achieved. Desired levels of P, Si and S were achieved in the steel so produced. This was licensed to several parties in India.

This unit was revived by making it bottom blown and directly connected to powder injection equipment, capable of injecting 1-10 kg of any powder in molten metal. Trials were made to convert high carbon Fe-Cr to low carbon Fe-Cr and decreasing P in Fe-Mn.

Basic lined side blown converter



Small L-D converter : A small 100 kg L-D was designed and erected at the LSF site to blow oxygen through a consumable long pipe to convert pig iron to desired grades of steel.

Rotary kiln for production of sponge iron : A rotary kiln, 10m long and 0.9m in diameter, meant for the reduction roast of manganese ores, was modified and converted to produce sponge iron from iron ores with non coking coal. This could produce about 20 tons of sponge iron per day of different grades varying from 80 to 89 % metallization.

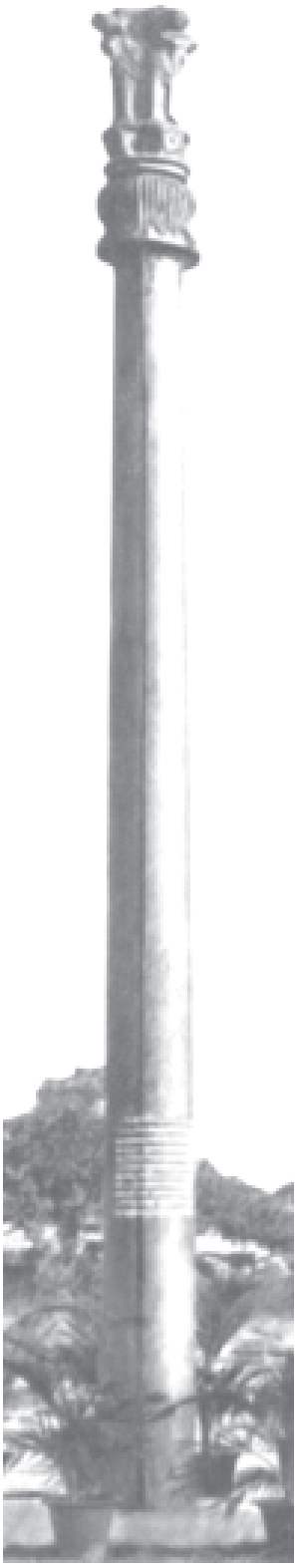
Based on the successful trials at NML, a cement kiln, 45 m long and 2 m indiameter, at M/s Andhra Cement Company, Vijayawada was modified and converted to produce sponge iron using non coking coal. Good grade sponge iron so produced was sold in the market for converting to steel. After couple of years of operation this was shut down due to market conditions. (If found in the records insert the photograph)

Vertical Retort Furnace for the production of sponge iron : After initial trials at laboratory scale operation, a unit was designed, fabricated in the pilot plant area for the production of sponge iron. This 1 tonne per day plant was suitable to develop the technology for indirectly heating, and reducing iron ores with coals in a shaft furnace. Various grades of sponge iron with metallisation above 90% were achieved. This had distinct advantage of higher productivity per unit area of the retort.

500 KVA direct arc electric arc furnace : A 500 KVA direct arc electric arc furnace was installed at NML to produce different types of Ferro alloys to be used in steel and other alloys production. This was later on used for smelting sponge iron and for the production iron and steel. It was also used to produce 75% grade Ferro-Silicon from Quartzite of Bhutan. A plant is operating in Bhutan. (Insert a photograph of 500 KVA furnaces here)

In addition to these units, giving a real growth to NML, several other units were also installed in other divisions. Some of them are Industrial scale powder Injection unit; Sintering plant, Pelletizing plant; Iron ores and mineral beneficiation plant, Magnesium plant; Carbon Refractories Pilot plant; Mechanical and Heat treatment plant; Nickel pilot plant etc. etc.

It is admitted here that several of these pilot plants at NML and other CSIR laboratories were closed down as a committee headed by Prof. Kane set up by Government of India, recommended against their continuation beyond certain number of years. Also, it is not in the charter of CSIR to produce materials and sale in the market to make them self sustaining. It is to develop, demonstrate and transfer the technologies to industries.



How NML grew on me

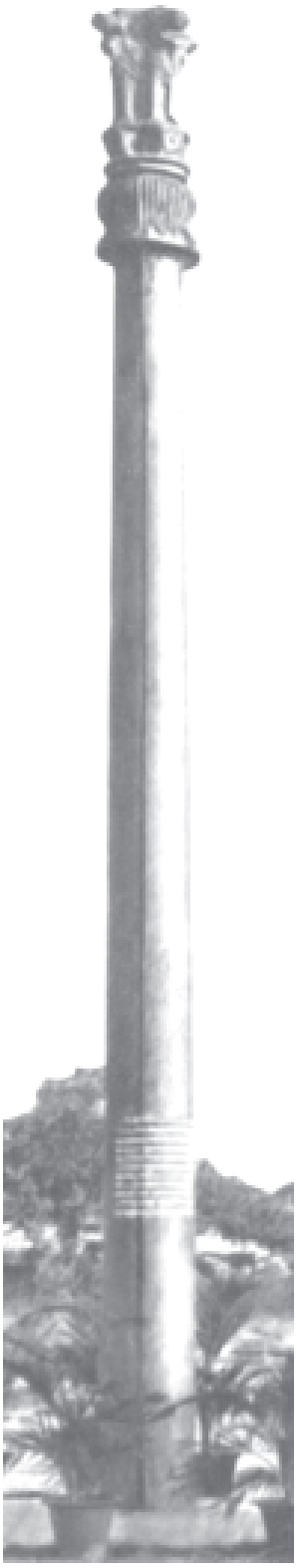
OMKAR NATH MOHANTY

Every time I would come to Jamshedpur from 'my sheltered home' in the IIT Kharagpur campus, I would suffer this strange, 'leave-as-early-as-possible' syndrome! The dust, the unending streams of cyclists heading for the plant, the rather 'unfriendly looking' strangers on the streets, the crowded market places of Sakchi and Bistupur, practically everything here was quite intimidating to me during the few times that I had visited this town. I knew only a few friends in Jamshedpur, the most important for me, Dr. Rabindra Nath Ghosh had already joined NML from IIT Khragpur and a few young faculty from the then RIT, including Dr. Mahindra Pratap Singh who was pursuing his Ph. D. programme at IIT Kharagpur. On the other hand, at IIT Kharagpur, me and my wife had become an integral part of the cultural life in the campus; our son, who grew out of the cradle in the campus had made his close friend-circle among the other children of his age, our daughter was just born and appeared to be doing well and most importantly, both my wife and me were professionally happy; I had reasons to draw satisfaction from the fact I was already a Professor and was setting up my own research group. Therefore, I had not the slightest intention of leaving the campus and obviously never nursed the idea of coming and settling in Jamshedpur. Perhaps the turning point came on a lazy train journey from Rourkela to Kharagpur !

Dr. Rajendra Kumar, then a Director-level Scientist at NML and I were travelling together, after completing a selection interview at the then REC (now NIT), Rourkela. On the way, among other items, Dr. Kumar suddenly broached this topic of an opening at NML at the level of Sct. 'F' and requested me to fill in the forms that he would send. The application forms reached and as promised to Dr. Kumar, I filled them in and dispatched them to the CSIR. after due formalities at IIT Kharagpur for the lien, in case the selection would go my way. I remember distinctly how my mind was revolting within me even to allow the thoughts of Jamshepur and I was looking for an alibi to wriggle myself out of the circuit, without suffering a loss of image in the eyes of my senior friend, Dr. Kumar. The interview for Scientist 'F' was to take place at the CSIR Hd. Qrs. in Delhi and I wrote to the then Director General of CSIR, Dr.Sidhu that it would not be possible to come to attend the interview unless the air-fare was provided in view of my commitments at Kharagpur (some how I was feeling confident that this request would not be acceded to and I would be staying back without any guilty conscience). However, a telegram reached me from the DG, CSIR's office informing that my air tickets would be reimbursed! I went through the interview at Delhi and Dr. Sidhu let me know that I would be selected in all probability and that he would need my 'report' on NML early. On my way back from the Annual Meeting of IIM at Varanasi in November 1983, I dropped by at NML , visited most sections of the laboratory and soon submitted a report to CSIR. My appointment letter arrived promptly and I found myself getting ready for NML. Joined NML in February 1984; a clear win for the destiny over my heart ! I shifted to Jamshedpur, put up at the NML Guest House in Sakchi (now converted into a quarters), in one of the rooms in the first floor. The caretaker Jagannathji started taking good care of me.

The NML building appeared to me very impressive. I was given a large, sprawling office-room (the previous occupant of the room was Mr. G.P.Mathur who was in-charge of the Mineral Processing group and had just retired) in the old, original block, which manifested every bit of its heritage; the imposing façade, the winding staircase, teak wood doors and so on. The newer block was where the Director's office was (and, still is) located; this part of the building came up with the UNIDO funds that came for setting up the Creep Facilities, the largest of its kind in the country. The plaque at the stair case was particularly impressive that announced the inauguration of the NML building by the then Prime Minister Jawaharlal Nehru and the function presided over by Mr. JRD Tata in the presence of the Industries Minister of India, Harekrushna Mahtab, Dr. S.S. Bhatnagar the CSIR Chief and other important personalities of the time. The date was 26th Of November, 1950 and what amused me was that it was a Sunday!

At the NML itself, things were to my liking. Prof. V.A.Altekar, the Director appeared to me as an instant father-figure and was I felt beholdened by his generous gestures. For the period when I was staying in the guest-house which was right behind the Director's Bugalows, I would return everyday with the



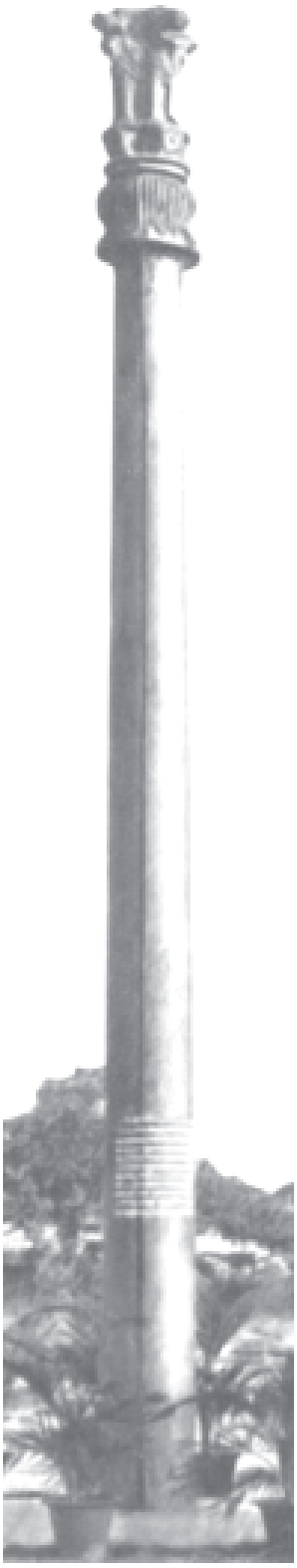
Director, Prof. Altekar in his car. Subsequently, every time I would come by NML car and pass by any traffic police, the driver disappointedly would narrate how in the city of Jamshedpur, the image of NML had gone down compared to the time of Dr. Nijhawan when every traffic police would salute the NML Director, passing by in the car !

On the work front, I was asked by the Director to take charge of some of the critical equipment of material characterization and order some others that would be urgently required. Thus, I looked at the existing TEM which was barely used and earnestly started building a group around the same. The first major piece of equipment I placed order for was an X-Ray diffractometer (the old diffractometers were getting frequently out of order), of the Siemens-make from Germany and thereafter, an SEM with EDAX attachment of JEOL-make , Japan. The immediate problem was where to install these new facilities; we were already crammed for space. At that time I found that the radio-isotope section of NML had only one scientist (Mrs. A. Bahadur who acquired her Ph.D subsequently), was spread over a large areas , had a good number of old facilities and were by and large unutilized. I could convince Prof. Altekar about the better utilization of that space by winding up the section as NML had had no plans for growing in the radio-isotope area. These rooms had to be totally re-done in order to house the diffractometer and the SEM (these facilities continue to be there today, with additions of newer models).

I remember the day that was the last day in office for Prof. Altekar; after the formal farewell, he went round the laboratory; in the process came to my room, we had a brief chat, he wished me well and left. Shortly afterwards, he moved out of Jamshedpur. I recall, he did come to NML again within a few months after his retirement, dropped into my office and we talked quite animatedly about technical issues, including the Damascus Sword, stainless steels (where NML had the distinction of being one of the leading centres in the world that had developed the technology for nitrogen-bearing stainless earlier, during Dr. Nijhawan's tenure) and so on. That was the last I had seen of him; a few months later, we received the sad news of his passing away. Deep within me, a sigh makes its way up even today when I think of Prof. Altekar! My experience at NML moved on. There was a period when Dr. Kumar had moved out of NML (he subsequently joined as Director, RRL Bhopal), and Prof. S.Banerjee from IIT Bombay, the Director-designate, had not joined; I had to shoulder the responsibility of the Scientist- in-Charge of the Lab. The flag-hoisting during the Independence Day of 1985 and the photographs that Mr. Blaggan, the Security officer handed down to me as souvenirs, are still with me somewhere…Subsequently, Prof. Banerjee joined the Lab. as the Director in December, 1985 and a new chapter began.

A strong fundamental-based technology development became our main goal. At the behest of Prof. Banerjee we, the Heads of various Groups started preparing Group documents indicating the goals, activity-plan; time-plan, requirement and utilization of resources (including man-power), major enablers etc. The interesting part was the interaction amongst the Group Heads everyday at the pre-noon time and getting the feed back from one another. In view of the changes in the technological climate, a necessity in re-grouping of activities was felt. I vividly recollect the train journey from Tata to Delhi during which Prof. Banerjee and some of us got into the serious activity of re-designing the Divisions of NML. That took shape soon after. As a result, we felt that there was a better synergy between groups.

On my own research front, this was a very busy period. My interest on the Damascus swords had started since my IIT Kharagpur days and I was particularly fascinated by the subject when I met Prof. Oleg Sherby at Stanford University in 1981 and discussed about the metallurgical aspects of Damascus sword. This was primarily a high carbon (> 1.5 %) ferrous material, displaying extra-ordinary toughness along with strength. We formed a team (J Bhattacharya, B N Ghosh, S K Choudhury, S P Chakraborty, P K De and myself) and started processing a 1.6 % C - 'steel' using the concepts of DET (Divorced Eutectic Transformation) and the DET WAD (with associated deformation), ensuring that one obtains < 10 micron ferrite grain size and < 2 micron size carbides. The material, in the first attempt showed 1155 % elongation, and subsequently, under more optimized processing conditions, over 2000 % elongation and displayed all characteristics of a super plastic material. We were truly excited and presented the data at the RC meeting (Prof. Rama Rao was the Chairman) - the overhead projector

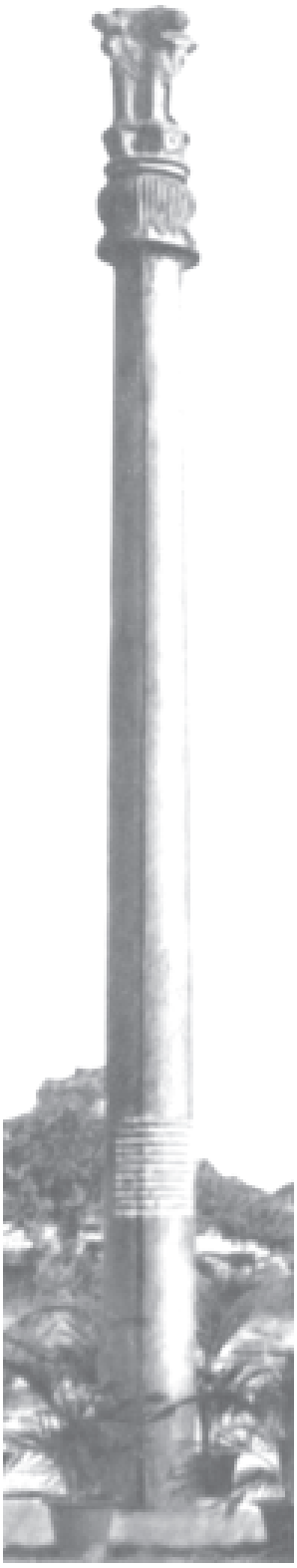


showed the size of the actual tensile sample before and after the warm tensile deformation (when it looked like a wire). We also applied for patents based on this work (a similar concept was also applied for drastically reducing the time for spheroidising annealing done for imparting machinability to steel). While a sense of euphoria grew in our minds for this work, one day my thoughts were transported to the ancient times over two thousand years back, when our ancestors manufactured the Damascus blades in India based on their empirical knowledge about the interplay between processing in a two-phase region and ultra fineness of grains, that in turn led to unusually high plasticity in the material ! Moreover, although we were able to introduce very high plasticity in this steel, we could not replicate the damascene patterns that one associates with typical Damascus swords (which for centuries had eluded even the top western materials scientists and was demystified by Prof. Verhoeven at the Iowa State University, in Ames only in the late 1990s by establishing that the presence of very small amount of strong carbide formers such as V or Mo would induce formation of clusters of carbides that led to the damascene patterns). Thus, we still fell short of what our metallurgical forefathers achieved; must confess, this brought in a sobering and humbling thought about one's achievement without in any way diminishing the confidence !

Another area of work that gave us some degree of satisfaction was the development of a strong non-destructive characterization (NDC) group at NML. Thus, residual stress measurement on engineering components using x-ray diffraction (which necessitated a 3-point calibration system for the diffractometer on lines of what we saw at the Fraunhofer Institut at Stuutgart), magnetic Barkhausen measurement etc. were the beginning of our activities. Acquiring a low-end 2-channel acoustic emission (AE) analyser (subsequently, NML procured some of the high-end multi-channel AE-units for field surveillance based on the initial confidence building activities in this area) was a fascinating experience as I had left behind my AE-gadget at IIT Kharagpur and missing it very much. I fondly recollect the joining of Dr. N. Parida from the then Czechoslovakia (now Czech republic) and got associated with acoustic emission. I also remember interacting with Dr. Prabhugaonkar of IIT Bombay at this time on his interesting work of using ultrasonic measurements for crack propagation studies. The study of electrical resistance and magnetic properties of steels being close to me since IIT days and we initiated studies on the correlation between micro-structural changes and its correlation with electrical resistance and magnetic properties as a means of characterization of material. The joining of Dr. Amitav Mitra from IIT Kharagpur meant that the fundamentals of magnetic property measurements and understanding would get deepened. Additionally, thermal conductivity measurement device and differential scanning calorimetric (DSC) studies started engaging our attention. The three Ph.D programmes of Dr. Sukomal Ghosh (Aluminium Cast Irons for High Temperature Wear Resistance); Dr. R.R.Dash (Iron Powder Production through Electrolytic Route from Sponge Fines) and Dr. B.V.Kumar (Modelling and Prediction of Properties in Heat Affected Zone in Welding of Steel Plates), all registered at and obtained from IIT Kharagpur, provided me with opportunities to learn about new areas. Similarly, through the work of Sri J. Bhattachrya and others I was exposed for the first time to brazing alloys and their structure-property correlation.

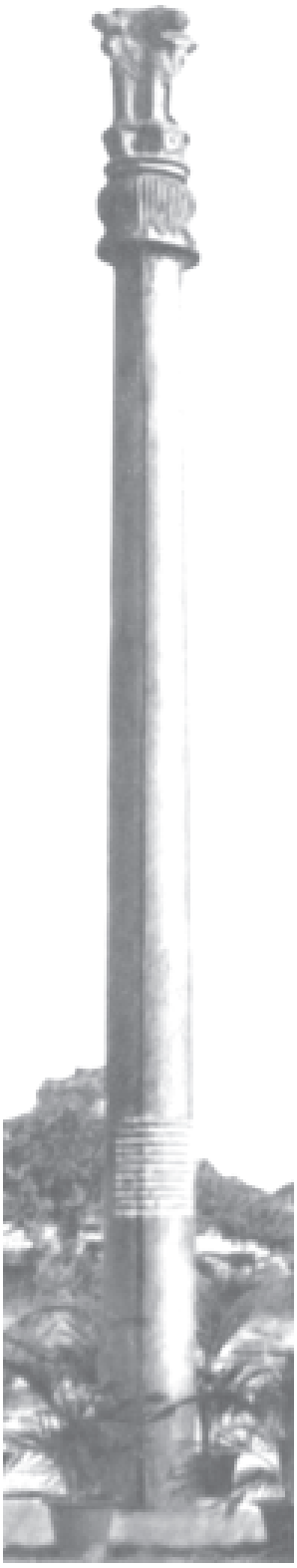
I also recall the two International Conferences that we held; one on Rapid Solidification and the other on the Advanced High Strength Ferrous Alloys. The former was held in Jamshedpur and the Proceedings published (1988) by Trans Tech. Publishers, Switzerland. I remember how our original Chief Guest for the inaugural function, Prof. Morris Cohen of MIT had to cancel his trip at the last moment (as his daughter became a casualty in an accident) and Dr. S.K.Das from Allied Signal Corporation, USA filled up that role admirably. The second conference on, Advanced High Strength Ferrous Alloys was a part of our Indo-US Joint project in which a number of Indian and US organizations were participating and Dr. BB Rath, the Associate Director of Research for Materials Science and Component Technology, Naval Res. Lab. of USA was the main coordinator from the US side (I was looking coordinating from the Indian side), was held in Delhi. The Proceedings of this conference was also published by the Trans Tech Publishers, Switzerland. I cannot forget the support given by late Dr. Sivaramakrishnan (the warmth of whose company is an unforgettable experience for me), and from my office, by Mr. Vijayan (whose unstinted support for me was a source of strength for me at NML).

By far, the most demanding and at the same time, exciting undertaken by us was the World Bank assisted project of, Componenet Integrity Evaluation Programme (CIEP). This was possibly the first



research project that was being supported financially by the World Bank in India. In addition to the six crores of rupees that were coming from World Bank, we were supposed to bring another three crores from Indian beneficiaries of the programme. Thus, we had to 'sell' the idea to Atomic Energy Commission, Tata Steel, SAIL, Indian Oil Corpn.; Bharat Petrolem and Hindusthan Petroleum; each one was requested to assist with rupees 0.5 crore and in return the Programme was to provide technical solutions to various live problems through a set of Generic Projects (results to be shared by all) and Specific Projects (for each supporting organization). Tata Steel and Atomic Enegy were the first organizations to confirm their participation. There were interesting moments while the CIEP was going through the formative stage. I recall one such when Prof. Banerjee and me were to go to Bharat Petroleum in Bombay and make a presentation to some of their very senior executives. I arrived in the building and the executives arrived too. However, Prof. Banerjee (who is known for his punctuality) was still not there; presently, I received a phone call from him and discovered that he was in a different building of Bharat Petroleum that was some twenty kms. away ! He gave me the green signal to proceed; he would join later. That happened; Prof. Banerjee came and participated during the most crucial period of the discussion. We thought the day was won. Bharat Petroleum soon confirmed their participation in CIEP. One of the most difficult clauses of the monetary support from World Bank was the one that required the CIEP to pay back the capital, albeit in easy installments over a long period. One was not sure, if in a country like India, a knowledge base programme would be able to earn money. Thanks to all our supporting organizations, in particular to Dr.P.K. Mukhopadhyay, then Director of R&D at Indian Oil (who subsequently became the Chairman of IOC), Dr.J.J. Irani of Tata Steel and Dr. P.K. Roy of BARC (who sadly passed away during the initial phases of CIEP), we could go through the hurdles, and ventured to ink our MOU with World Bank, although with some trepidation. We got the three crores from the Indian participants, World Bank accorded their approved and CIEP began in right earnest.

I wish to recall the special gesture shown and the affection that I received from Dr. Mukhopadhyay who was the first Director of the R&D set-up of IOC, at Faridabad and has been the only one from R&D to have become the Chairman of IOC (it is sad that Dr. Pranab Kumar Mukhopadhyay has passed away in March, 2009 and many would miss him as a fine human being apart being an excellent scientist); who was a constant supporter of the Programme. I cannot but recall a personal incident of this time. On the 20th. of August, 1991, we had scheduled an Apex Committeee meeting of the CIEP and many prominent members from across the country were to be there. On the previous night however I had received the saddest news of my life - my father (the noted novelist, Dr. Gopinath Mohanty) had passed away in San Jose, California. For a moment I thought I would not be able to participate in the meeting as the coordinator; thereafter I made up my mind that I would go through as planned. Prof. Banerjee arrived around 9 a.m. in the morning as usual, I got into his car and broke the news. He was visibly disturbed as he personally knew my father, and asked me to stay back. I told him my mind and we went through the entire meeting (the only thing that I had not counted in, was the fact that the National TV had announced the news and Mr. Vijayan, my office-in-Charge came to know about it; he kept sending small notes to inform me of the sad event. After a while, I came out and told him that I was aware of the fact !). This personal set-back notwithstanding, my association with the programme continued, and if anything, got more intense. The contribution from gifted scientists like Dr. R.N.Ghosh to the CIEP, it must be recorded, was invaluable. Several international collaborations started and flourished. In particular, with Prof. McLean from Imperial College, London in High temperature materials development area (with Dr. R.N.Ghosh) was a great satisfaction for us (I am aware, many other institutions have collaborated subsequently with NML). While there were many areas which CIEP could justifiably take pride in, I wish to recall only a few. The carburization of aged tubes in refineries carrying hydro-carbon products at low (< 300 o C) temperatures was practically unknown to the scientific community; this was studied, elucidated (diffusion of carbon in ferrite is easier than in austenite and all of the diffusing carbon result in carbide precipitation) and its correlation with the degradation of integrity of these tubes established; the method to inspect them for brittleness was recommended. The work was appreciated by IOC (the investigation was initially carried out at Mathura refineries). The plan to construct a Horton Sphere with the help of all the oil companies, in order to simulate the latitudinal and longitudinal welding lines and determining the presence of flaws on curved surfaces (with the help of synthetic flaws and presuurising the sphere) was an exciting work for the country. The fracture toughness work by Dr.S. Tarafder and Dr. V.R.Ranganath in general (subsequently,

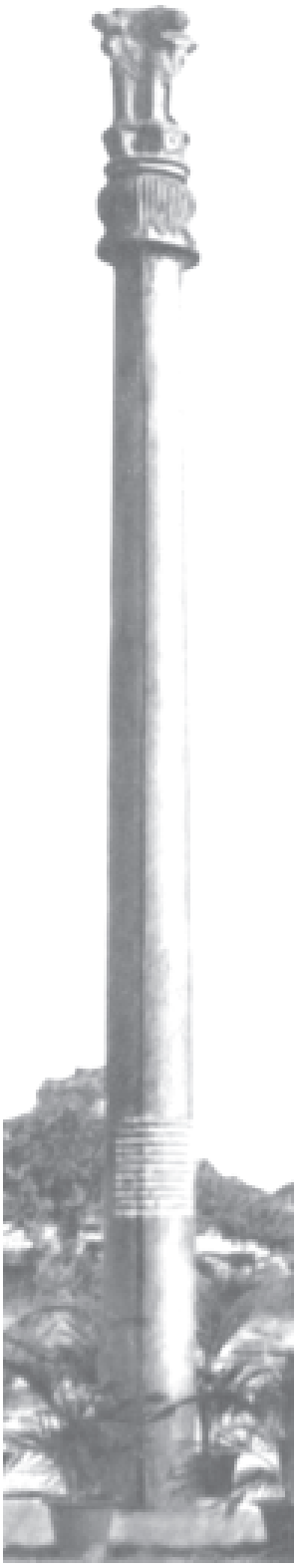


in pipes in particular) was already attracting the attention of the researchers in this area. The Remaining Life Assessment work of NML which was already well-known across the country for power plant components, now also got extended to other components (line pipes; off-shore structures, engineering components etc.) where the damage mechanisms were not just creep, but could be fatigue; fatige plus creep; fatigue plus creep and corrosion and so on. With Prof. Banerjee's vision and confidence, CIEP started taking great strides. I feel very happy and proud that it is today an internationally recognized research programme, thanks to the contributions of the bright group of scientists who have constantly served the cause of high science-based technology at NML.

One of the interesting features during Prof. Banerjee's tenure was the massive cleaning-up operation that he launched; literally tons of old papers and junk materials were removed. I remember discovering hundreds of pieces of spare cut-off wheels (that had long exhausted their shelf-life and would be too risky to be used in the cutting machines) stacked in racks / almirahs; they were all taken out. As a consequence of the clean-up exercise, the biggest retrieval was the gorgeous, teak-walled Conference Room in the old block (next practically to my room).This was one of the finest 'heritage' halls that was out of bounds for several years and colleagues were scared to enter that room, stacked with papers and many claimed having seen snakes in this hall !

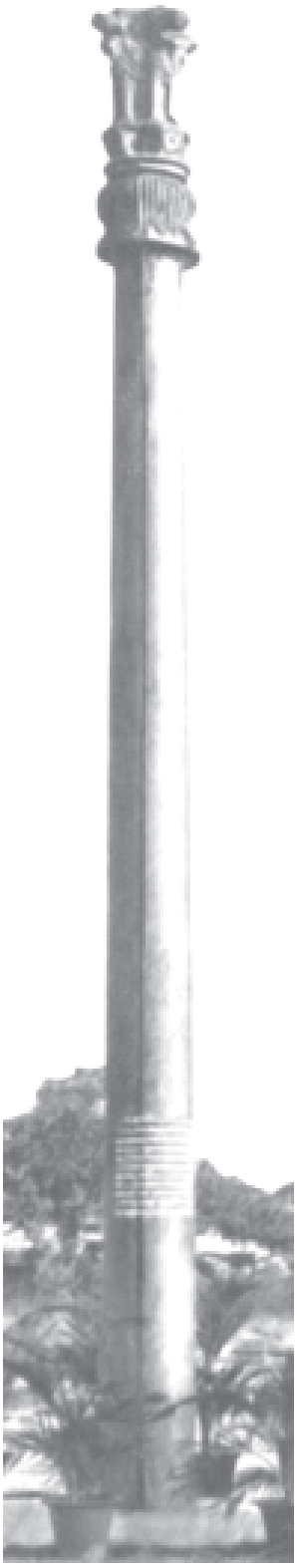
Another feature of this time was a joint platform created for collaborative activities with Tata Steel, primarily for use by Tata Steel. A Tata Steel - NML platform was created that was meeting almost every three months and alternately at NML and Tata Steel (chaired alternately by Dr. Irani and Prof. Banerjee). There would be presentation on project-proposals as well as on running projects for monitoring the progress. Money would be made available from Tata Steel for projects that were relevant and of a novel nature. The RESINESS process of iron production, initiated by Prof. Banerjee himself, was an innovative process and had caught the imagination of Tata Steel. One of the major projects that was implemented at Tata Steel was the superior passivating agent used during acid pickling of sheets, developed at NML (Dr.DDN Singh); the note-worthy feature of this project was the manner in which the benefits were quantified through actual measurements in the plant. Although I was not directly involved (was only coordinating from NML's side the Tata-NML collaboration) in this project, I was deeply impressed by the insightful manner in which Prof. Banerjee piloted the evaluation process of the NML developed material on the shop floors of Tata Steel. Another large project taken up in this programme was the use and optimisation of operational parameters of sub-merged arc furnace for the production of Fe-Si (Tata Steel wanted to produce this ferro-alloy at their Joda plant, reducing the production of Fe-Mn). Our Group's important project to have been supported by the Tata -NML programme was the production of iron powder from sponge-iron fines through electrolytic process (Dr. R.R.Dash). The process needed titanium plate electrodes and after some optimizing of the process parameters the product that came out was excellent, thanks to the work being done by Dr. R.R.Dash (subsequently, the process has been transferred for commercial production). I must record my gratitude to Dr. Dash for the SEM coloured photographs of the dendrites of iron powder, looking like lovely flowers (later on, the photographs adorned my office wall in Tata Steel and most people would not believe that they were not flowers !). I had always felt that India needed more such research-industry collaboration, patterned after the Tata-NML model. Indeed, another tri-partite interaction model, the Tata-NML-IIT Kharagpur forum was also created; unfortunately one could not speak of a similar degree of success as was derived from the Tata - NML bi-partite programme , the reasons were perhaps many; the most important pre-requisite however is the firm belief of the head of an institution in a programme.

A major national programme being undertaken at that time included the Sea Nodule Project for nickel production; another CSIR lab. (RRL Bhubaneswar) was also involved. The nodules occurring under the ocean floor, containing Mn and some Ni were the subject matter of research only in a few countries and India was one of them, primarily because of NML's work. Indeed, the international right to lift this mineral was granted to India in view of the research at NML. Our pilot plant activities were going on vigorously (under the leadership of Mr. Akerkar); we were quite proud of this work that was being supported by Govt. India. Most of the knowledge gained (both at RRL Bhubaneswar and at NML) were subsequently utilized in the Nickel Project (pilot plant set up later on at RRL) using the Chromite ore overburden from Sukinda mines (one of the prominent shares of these belonged to Tata Steel



then). Another area of work that gained national stature, involved the mineral processing group (under the leadership of Mr. N.Chakraborty). In the development of the Iron and Steel industry in India, the mineral processing group's contribution in developing flow-sheets were already recognised by the Govt. of India and large scale facilities had come up in the Pilot Plant premises. A prestigious project on tungsten was also being handled by the group (it is a matter of great joy for me that the pilot plant area is now full-fledged and is currently full of activitie, with facilities and knowledge second to none in the country). The Madras unit, which I had visited only a few times (Dr. Khangaonkar, Sct. F was the Head here when I joined in 1984); and was always impressed by the quality of work (e.g. the development and transfer of technology of column flotation). One of the major technology transfer activities that took place during Prof. Banerjee's tenure was the one for Magnesium Metal Production which was waiting at NML since a long time. I recall, the Chief of Industrial Development Corporation of the Andhra Pradesh visiting us and negotiating the transfer. The principles and the terms & conditions of technology transfer clearly were areas that needed expertise of a different kind and I was impressed by the way Prof. Banerjee was handling them so deftly, keeping NML's image and interest high.

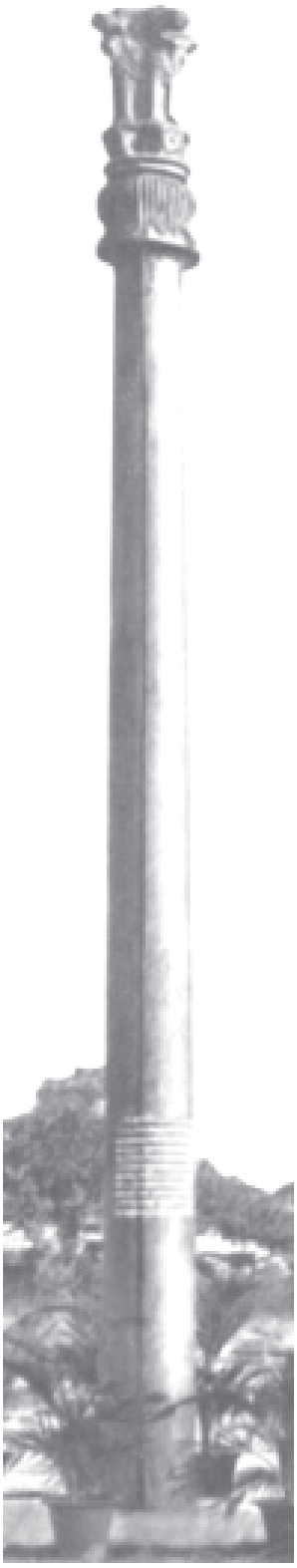
One of the finest experiences in my entire professional career of over forty three years, has been made at NML; this related to the planning and development of the human asset. At NML, until the end of 1985, the bulk of the scientific man-power (designated as "scientist") possessed degrees up to B.Sc. only. Many of them were good in terms of empirical understanding; however, when it came to a break-through product or process, based on a novel fundamental concept, most found themselves inadequate. It was therefore considered absolutely necessary to prepare a comprehensive plan for recruitment of young and bright people (preferably with Ph.D in Engineering) and provide them with the necessary equipment and computational facilities. Further, a very serious problem was that the career advancement was pending for many many years, resulting in accumulated cases that would be so difficult to judge (some were retired, sick in bed !). I was privileged that I was deeply associated with the man-power planning exercise that Prof. Banerjee conceptualized. Around this time, the Abid Hussain committee was appointed to look into the functioning of the various CSIR laboratories; Mr. Hussain, a well-known economist-turned bureaucrat visited NML as well. He spent about a day and declared the CSIR a 'lame duck' in the press. As luck would have it, I found myself in the same IA-flight (morning) from Kolkata to Delhi. I went up to him in the mid-air and asked for his views about NML. He chuckled in his inimitable manner and answered, " I have called CSIR a 'lame' duck, not a ' dead duck yet !' He explained to me that laboratories like NML that have undertaken a serious exercise in man-power creation, have a good chance to do well (his broad formula was to earn at least one-third of the Govt. support from external sources). We started clearing the back-log for the career advancement of internal candidates and planned for new recruitment Prof. Banerjee had attached great importance to the selection process and laid down a multi-directional strategy for the same : one, to put up advertisements in all national dailies, and two, contact good people and encourage them to apply. For the selection, a parameter-based, objective evaluation process for candidates was put into place. Further, wherever both husband and wife were found good, both were appointed (in some cases, couples formed after recruitment !). A few cases of recruitment I still remember. One was the case of Dr. Godiwalla, a mechanical engineer and a Ph.D. from IIT Kharagpur was employed with the then TELCO (now, Tata Motors), and had shown his inclination for a scientist's position; had however forgotten about the interview date. The morning session was over when it was discovered that he had not shown up; we rang him up (he was in the shop floor with soiled hands!) and requested him to attend the interview urgently. Dr. Godiwalla attended the interview, got selected , joined NML and continued. Another case was that of Mr. Samar Das, who was running TEM at IIT Kanpur and had shown great interest to work at NML. Three days prior to the interview it was found that Mr. Samar Das had not received his interview letter. Through our 'phone call to him at IIT Kanpur, informed him of the interview date etc. (and the fact that a call letter had gone to him that some how could not locate him). He finally landed (with great difficulty , without reservation), got selected and joined our Group; continued until he retired about two years back (while at NML, he also did his Ph.D). During this period of large-scale recruitment (1986 - '92), NML was lucky to have attracted many talented young men and women as scientists; most of them are leaders in the country today in their respective areas and have been recognized at the national level. It is a matter of pride for me personally that, Dr. S. Srikanth, a recruit of this time is today at the helm of affairs at NML as Director.



Prof. Banerjee's tenure came to a close on the 9th. of September, 1992. The farewell function was very touching, the laboratory surely had experienced a radical change on all fronts. Personally for me, I did learn quite a few things about managing science and technology. Prof. P. Ramachandra Rao took charge, probably on the 17th of September, 1992 (on Viswakarma Pooja day) and yet another glorious chapter in the life of NML began. We were aware of the high esteem with which Prof. Rao was held by the scientific and technological community in the country; personally I had interacted with him on several previous occasions and was impressed by his scholarship and touched by his simple manners. Within some weeks of his joining, we had been to BHU and Prof. Rao had booked our accommodation in the guest house. In the evening, he took us to a celebrated pan (betel)- shop and demonstrated to us how to stand on an acute angle and thereafter put the betel in the mouth and instantly come to an obtuse angle position - the right way to do justice to the uncommon betel ! At the laboratory, we started interacting on some exciting areas of research, including measurement and interpretation of residual stress in metals, formation of meta-stable delta ferrite in rapidly solidified cast-iron and so on. I left NML in the first half of the year 1993; our friendship however continued. I watched how he brought in newer, front-line areas of research into NMl (e.g. Bio-Mimetics), how he inculcated an intimate sense of belonging among the scientists by introducing the NML-anthem and getting it sung at every important event. I was present in the Seminar at Jamshedpur organized to bid him farewell, where many of his erstwhile students were present, one could feel the deep bond between him and his students. His sudden earthly disappearance has been an irreparablr loss to the materials technology community of India. Perhaps, the only thing I pray for, is that let his example inspire scientists of NML into great levels of achievement .

NML continued to engage my attention even after I left the Lab. in 1993, on many fronts and I used to attend several seminars and technical meetings of IIM; IIW and MRSI at NML, as I continued in the near-by laboratory, the R&D of Tata Steel. Even after leaving Jamshedpur in 2003, my association with NML continued. My interaction with the team of CIEP was always fascinating as I saw them establish themselves as a first rate research and application group on all areas, in particular, in developing the fundamental understanding of ultrasonics, acoustic emission, magnetic properties and so on. I saw how the indentation hardness (Dr. Goutam Das) that had started as a laboratory curiosity developed into a marketable product. Similarly, I was impressed by the growth of the nano-indentation area (Dr. Suman Mishra). Practically every section of NML gives me a great deal of joy whenever I visit the laboratory. I appreciate now even more, as to why Dr. Nijhawan, at a very old age still used to visit NML, every time he would be in India. Although my association with NML was only for under 10 years out of the 60 years of its existence and out of the 65 years of my life (NML was founded in 1946, one year after my birth), the Lab. has grown inseparably within me !

Let the lawns of NML be greener and continue to grow beautiful flowers, even metaphorically, for which they are known. I wish the Director and all others associated with this great institution an even more exciting time ahead !



Transformation of NML during the last 25 years

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Introduction

Diamond jubilee of an organization is a great occasion to celebrate. I am indeed fortunate to be closely associated with two well known institutions which came up almost simultaneously in independent India and are approaching diamond jubilee year of their establishment. I consider this to be a great honor to get an opportunity to reminiscence on one of the two where I spent the best part of my career. I had an opportunity to interact with seven of the nine former Directors of NML and the present Director happens to be one of my beloved colleagues. My interaction with Dr B R Nijhawan, the First Indian Director was only informal. He used to visit NML whenever he was in India. His visit in November 2007 during the NMD celebration was indeed memorable. He did come to my room at NML which incidentally happened to be the one used by him.

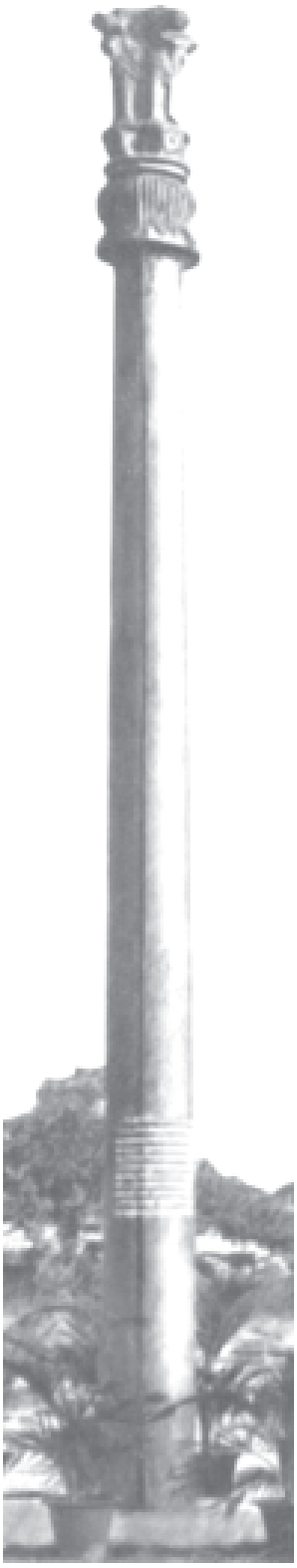
When I joined as the first year student of Metallurgical Engineering in 1964 Professor E H Bucknall was UNESCO Professor at IIT Kharagpur. He took a couple of our orientation classes. He introduced us to the book "Metals in the Service of Man" written by one of his friends. I still cherish reading this. I was a post graduate student in 1970 when Professor Altekar visited IIT Kharagpur. Professor P R Dhar the then head of Department while taking him on a tour of the facility introduced me to him and asked me to tell about my project work. I remember having shown him a demonstration of the small experimental set up I had assembled to measure MS temperature of 18NiSi steel.

In those days to a student of Metallurgical Engineering, NML had always occupied a special position. I had an opportunity to visit it as a delegate from IIT Kharagpur in November 1975 when National Metallurgist Day celebration & Annual Technical Meeting of Indian Institute of Metal was held. This also coincided with silver jubilee year of NML. A large stage was erected at the entrance of the old building, the seating arrangement for the audience extended beyond the road onto to the garden. It was also a special occasion for all of us at the then Metallurgical Engineering Department of IIT Kharagpur as one of our colleagues Professor S C Sircar was one of the recipients of the National Metallurgist Day award for that year. This was also an occasion; I got a chance to see the newly built Creep Testing Facility at NML. I was so impressed with the set up that when I got an opportunity I readily accepted the offer of joining the same.

My initial years at NML (NML during mid eighties)

When I came here as a scientist in December 1982 Prof Altekar the then Director was on the verge of his retirement. Most of the facility barring Creep Laboratory was in need of up gradation. Pilot plants which one time was the major attraction remained unused for lack of work / market demand. There were a large number of supporting staff whose services could not be put to effective use. There were around 1200 permanent employees, 5 field stations & 35 Divisions. There was no computer. Most of the employees were against setting up of computer in the lab because it would affect employment opportunity.

It was extremely difficult to get a quarter. It was so acute that many had to wait for 10-15 years. I too had to suffer. The situation might have been different if I would have asked for lien terms which allowed consideration of past service for allotment of quarter. I missed this opportunity as I followed the advice of Dr Rajendra Kumar, the then head of Material Science Division of which creep testing facility was a part; and resigned from a permanent position at IIT on the false belief that I may be allotted a quarter out of turn. This did not happen. I had to live in a rented house in Sonari with my



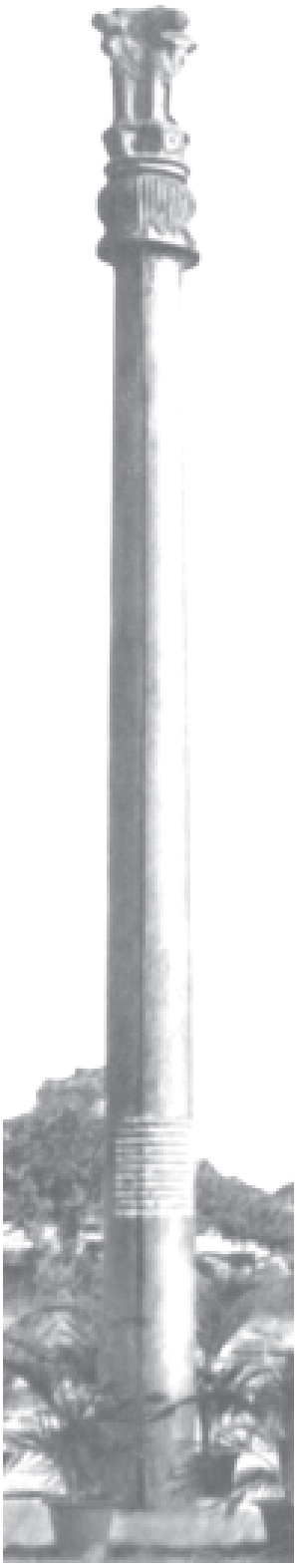
family for over six years. In those days getting a good private accommodation in Jamshedpur was very difficult. Nevertheless I learnt a lesson that apart from being a scientist one has to be more aware of rules & regulation. When I look back now I do not repent the decision I took. If I would not have done so I might have gone back to the peaceful & relaxed academic environment of IIT possibly within a year.

During early eighties amongst the scientists very few had PhD degree. Number of research scholars was very few. Average age of scientists was high. The lack of infrastructure was a major bottleneck to attract bright young scholars & scientist. When we compare this with what we have today there is a sea change. All this was possible because we were lucky to have three outstanding academician & scholar as our Director. I was fortunate to be closely associated with all of them. Each in their own characteristic style played important roles in restoring the image of the laboratory.

It may be worthwhile to look back and recollect some of the major achievements during this period. Professor S. Banerjee joined NML as the Director in December 1984. Before taking over this responsibility he did visit us on several occasions. I met him possibly in March 1983 when he came to NML on a short visit and delivered a couple of lectures on Application of Fracture Mechanics. He again came to NML during summer vacation for a little longer stay. During this period I did interact with him much more closely. We were able to initiate fatigue pre-crack in 3 point bend specimen using the then existing electro magnetic fatigue tester (Vibrophore). The pre-cracked specimen was finally tested on 25 ton screw driven Instron testing system in creep laboratory. As a consequence Professor Banerjee had a fairly good idea on the strength and weakness of this organization. He came with a clear vision & a broad outline of a plan to transform its work culture. This was also the time when it was extremely difficult to get enough plan grants to upgrade the basic infrastructure so crucial for the survival of aging laboratory. He was primarily responsible for major reorganization of the divisional structures, relocation of facility, introduction of documented procedures for project initiation, monitoring & closure. Some of the new concepts particularly those associated with project monitoring introduced in this laboratory are now being adopted at other places as well. Open door meeting involving all scientists, be it in-house committee or RC meeting originated from here.

During this restructuring I was inducted as one of the members in House Allotment Committee. Dr Dhanjayan was the Chairman. One of the targets set by us was to display the eligibility list for allotment of quarters by the first week of January 1986. Preparation of this list was the main bottleneck for quick allotment of vacant quarters. The criteria of allotment were also very complex. There was no alternative but to take help of computer. Only facility available then was two Merlin computers procured in 1984 March / April for word processing. These were placed in the room where BDM office is located. It had only two 8 inch disc drive having 128KB memory. Nevertheless we started entering the all the data for all the employees in floppy drive in word format. Most of these were done on weekends. The number of records and fields necessary to prepare the list were too large to be accommodated in one floppy. It had to be saved under different file names in several floppies. The final eligibility list was prepared by merging records from several files and running the sorting program. It was possible to display the list as per our target. The database was also used for allotment of individual identity number for all employees. This was done by sorting the data in an ascending order of the date of joining NML. This helped us in demonstrating how use of computer could help in administrative work as well and make it more fair and transparent.

Establishment of Computer Application Division : Here after there was no resistance in setting up computational facility in the laboratory. I was given the responsibility to set up new computational facility & to promote its use in scientific as well as administrative work. We got generous help from institutes & organizations having prior experience. The support we got from Professor D B Phatak of CSE Department IIT Bombay is worth mentioning. He helped us prepare the specs of a distributed computer net work with several terminals & accessories. We got overwhelming response from several suppliers of computers as soon as query was floated. A comparative statement was made by us. The concerned parties were invited for technical evaluation of their bids. Professor Phatak came to NML to help us. He reached our guest house sometime late night. As per his instruction the files were kept in GH so that he could go through it before the technical committee meeting. The following day the

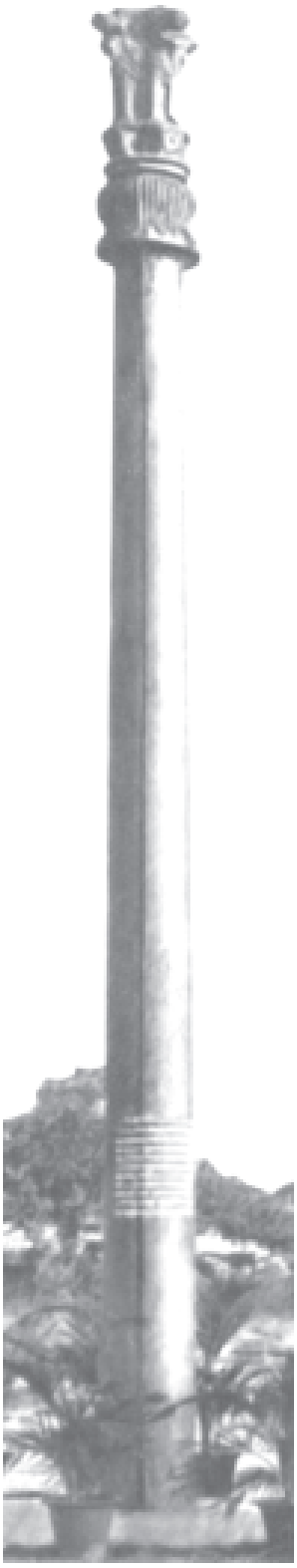


meeting started as scheduled. Possibly 8/10 vendors were present. After technical presentation a common minimum specs was drawn. All of them were asked to submit their final bid as per the given format by the same evening 6.00PM so that the evaluation is fair & transparent. The offers were opened in presence of the bidders. Comparative statement was prepared. Selection was based entirely on the price quoted. On the basis of the requirement two parties were selected one for data processing & the other for computer aided design & graphics. By the time the selection process was over it was almost time for Professor Phatak to board a late night train to Howrah to catch a flight to Bombay the following morning. Selection & securing administrative approval for setting up a distributed computer network with 13 terminals a few of these at remote locations and a graphic work station was just the beginning of a long journey.

A site (the present location of servers) was identified for setting up a new computer application division. It had to be thoroughly renovated to accommodate the proposed system. None of us had any formal training on running a computer network. We got co-operation from all. It took us nearly a year to refurbish the location & install the computer. I was fortunate to have a few dedicated colleagues (Dr KM Godiwalla & Dr Subroto Chattopadhyay) whose untiring efforts lead to the establishment of a new division. This was formally inaugurated in the month of November 1987 by Dr VS Arunachalam the then chairman of RC. Soon we realized how difficult it was to generate enough work to keep the system busy & in running order. It was extremely difficult to maintain & generate work which could be done by such a system. We were always on the lookout for a properly trained system administrator. It was extremely difficult to find one. Most of our time was spent in providing training & maintenance support. There were several eager learners from other division as well. Some of them help us develop software for payroll preparation. This was being used by our bill section until the new accounting package from CSIR was installed. Some used the drawing packages to prepare layout drawings of the entire laboratory. This proved useful for planning relocation of divisions and infrastructural facility. Soon after we realized that we have stepped into an area which has a very high rate of obsolescence. We were badly in need of additional funds to upgrade and also persons for technical support. Around 1990/91 it was possible to recruit a person having zeal & dedication to pick up operation & maintenance of computer system. With his untiring efforts and the generous support from major projects like Component Integrity Evaluation Program (CIEP), Steel Development Funded project on Blast Furnace & planned grants for modernization it was possible to upgrade the facility periodically with more modern & rugged system. It was possible to keep pace with the unprecedented growth in ICT during the subsequent decades. Ours were amongst the first few laboratories under CSIR to provide access to internet & email through WAN with terminals located at every desk of scientists and administrative staff. I feel introduction of computers the way the new systems were installed in 1987 was a major turning point in changing the face of NML.

Component Integrity Evaluation Program (CIEP) : Another major turning point was launching of Component Integrity Evaluation program, in August 1991. Initial plan started sometime around 1986/87. It was visualized as a multi sponsored project. In view of the then interactions with thermal power plants and activities connected with Indian Creep Panel it was identified as one of the promising areas where concerted efforts could be initiated to bring a large externally funded project. Initial proposal was prepared by Dr ON Mohanty around 1985/86. It was also the time when a few initiatives were taken to involve Petroleum Industries. This included investigations on the health of Haldia - Mourigram product pipeline segments having type III defects and cracking of Horton sphere of Gujrat refinery. Our proposal was sent to various funding agencies & potential customers like power plants & petrochemical industries. This was also the time World Bank showed interest to support R&D activities by providing low interest loans. Our proposal was one amongst those short listed by CSIR. We were invited by the WB team to present our case. It was possibly around June/July 1987.

Professor S Banerjee gave the responsibility to me to present our case. The meeting was arranged by Dr HR Bhojwani at CSIR head quarters. Our linkage with petroleum & power sector proved helpful. It was incidentally amongst the first few proposals accepted by World Bank for funding. It was going to be in the form of a long term interest free loan. The total project cost was worked out to be 6 crore. Detailed proposal in the format received from WB was subsequently prepared by Dr Amitav Roy who joined NML around May/June 1987. The idea of getting 50% of the total cost from the potential



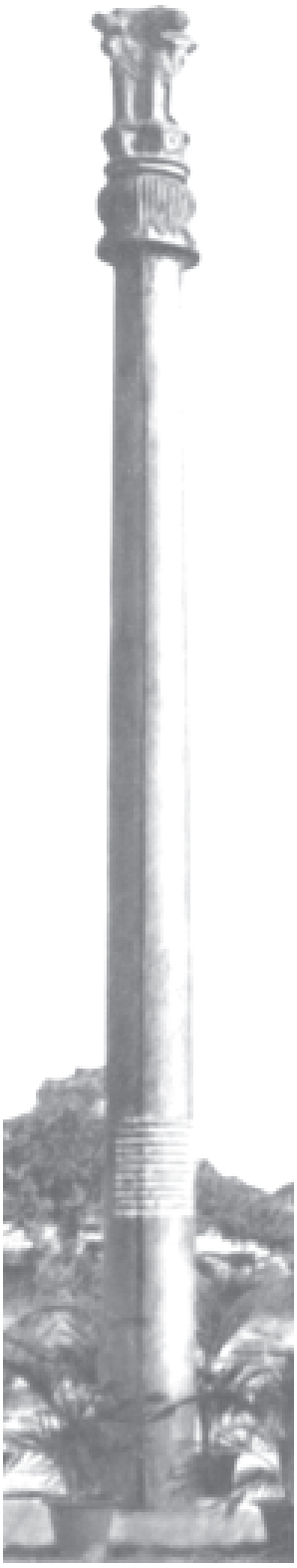
beneficiary was floated by us although WB could have given the full funding. The final proposal was presented before RC during 1988/89. Dr JJ Irani was present as RC member. There were several important dignitaries of Tata Steel were also present as invitees. In fact the first encouraging response came from Shri PN Roy. He said this could of considerable importance to steel plants. He cited as an example the importance of integrity of critical components like crane hooks used to carry molten steel ladle. As far as I recollect they were the first sponsor of this program. The first installment of payment (25 lakh 50% of the total commitment) was released soon after. With this initial encouragement it was possible to get 4 more sponsors namely Atomic Energy (AEC), Bharat Petroleum (BPCL), Indian Oil Corporation (IOCL) and Steel Authority of India (SAIL).

The project was unique in several respects. It not only focused on detailed plan of activities but also suggested a unique monitoring system. Program Management Board (PMB) was the apex body with members from each of the sponsor, WB representative and Director NML. Group leader of the project was the convener. The next level was Project Technical Committee (PTC) with GL as the Chairman & representatives from sponsors as members. The overall technical activities were divided into 5 broad areas: High temperature creep, Fatigue & Fracture, Corrosion Base assessment, Non-destructive evaluation and Modeling & Simulation. The broad R&D activities were decided based on the feedback & needs of the sponsor. Apart from this there was provision to take up one sponsor specific work from each. The first meeting was held on 18 August 1991. Dr ON Mohanty, the first Group Leader of the project & convener of the PMB ably conducted the meeting as scheduled even though the same morning his father passed away in USA. Many of us came to know about it after the meeting. This was also the time when we were able to recruit some of the best young scientists to take up the challenging problems identified for this activity. Two of them now happen to be the key persons who could take the laboratory to greater heights. In fact some of them preferred to join NML even though they had offers from Tata Steel & other well known R&D establishment of the country. The PMB used to meet once a year & PTC twice a year.

The program was so well planned & structured that when Professor P Ramachandra Rao took over as the Director of NML in September 1992 it continued as per schedule. When Professor ON Mohanty left NML to join Tata Steel I became the group leader. However by then steps for procurement of new equipments were already initiated. A separate account was opened at Canara Bank, Bistupur at the instance of ICICI, bank through which the World Bank fund was routed. The purchase procedure was also suggested by WB. A workshop was organized. This was attended by Dr Roy & me. It was indeed very helpful. We were able to insist payment terms even if it was a 100% LC and extended warranty clause. We also had to insure our equipment purchased through WB fund. All these proved extremely useful as we faced minimum problem in subsequent years in their upkeep and maintenance. Apart from fulfilling the commitments made to the sponsor, the facility was being increasing used for others to generate funds to pay back the loan. During the course of the program a number of site work related to remaining life assessment of power plants were also taken up. In spite of the difficulties in reimbursing actual expenses one experience during site work we did get voluntary support from a few young colleagues. In one particular year total earning form such work did exceed 1crore. Although there were immense possibility to increase ECF through such effort it could not be pursued because of the stringent TA/DA rules admissible for such work. In the light of the changes in TA/DA rules may be it is time to explore such possibilities. Nevertheless laboratory based investigation that we were able to attract under this umbrella project it was possible to refund the loan as scheduled from the external cash flow from this program. The last installment was paid in the year 2002.

A number of workshops were organized to disseminate the knowledge. Proceedings were also brought out. A few of these had excellent circulation. Professor P Ramachandra Rao also took a special initiative to bring out a special volume on Life & Integrity Assessment. This was brought out by Indian Academy of Science. This had several articles from well known experts from abroad with whom we were able to establish close contacts during these years.

With better infrastructure & expertise it was subsequently possible to attract many challenging jobs. NML was also indentified as one of laboratories where failure & life assessment of aircraft components could be taken up. Innumerable failure investigations thereafter have been carried out at NML. Many of these have been highly appreciated particularly by IAF. It was also possible to take up major



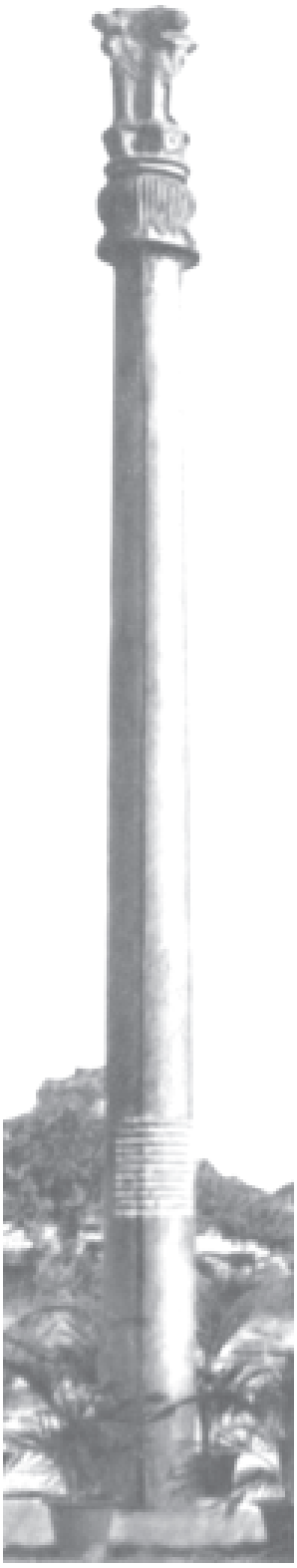
Network Projects during 10th / 11th five year plans. New state of the art testing & characterizing facility were established. On the whole CIEP was indeed a land mark. This did help us build close linkages with industries and focus our attention towards challenging problems the industries in managing their ageing infrastructure.

International Collaboration : During eighties opportunity to interact with foreign laboratories were very few. Since mid eighties there was concerted effort to initiate foreign collaboration in a few selected areas. I was fortunate to get one such opportunity to spend a year at National Physical Laboratory, Teddington, UK and interact with Malcolm McLean & his colleagues during 1988/89. I was lucky to get a challenging task to develop predictive models for creep of single crystal super-alloy SSR99. My experience in setting up computer facility at NML proved handy. Very soon I was able to develop a model which could predict orientation dependence of creep behavior of single crystal. The stay was so productive that the interaction with Malcolm McLean continued for over 15 fifteen years even though he moved to Imperial College in 1990. He as well as some of his colleagues (Brian Dyson) did visit NML on several occasions. We were also successful in getting EPSRC UK supported project on modeling & simulation of creep of steel and super-alloy. One of our colleagues got an opportunity to work at Imperial College for a couple of years. The collaboration culminated in organizing 2day workshop on Physically Base Constitutive Models for High Temperature Materials at National Aerospace Laboratory, Bangalore during January 2004 apart from Dr Sanjay Sondhi & me there were lectures by Prof McLean, Prof Brian Dyson, Dr Hector Basoalto & Professor David Hayhurst of UMIST, UK. It was attended by over 30 participants from various industries & academic institutions. Professor McLean was supposed to visit NML as well. However because of flight disruption due to fog it had to be cancelled. Unfortunately the following year Professor McLean passed away. My association with him was indeed a turning point of my career. Possibly it was also the beginning of several successful collaborations with laboratories & academic institute abroad.

Advanced materials : World over there has been great excitement at the possibility of discovery of host of new materials having attractive material properties mid eighties onwards. Synthesis of such materials using many unheard of techniques caught the attention of many scientists world over. It was possibly late eighties / early nineties Fullerene was discovered. These formed the foundation of the much talked about nano science & technology. It was also the time Professor P Ramachndra Rao joined NML. He being an excellent orator and a great teacher was able to motivate several young colleagues to venture in this field. The beginning was possibly made with the work on rapid solidification processing in mid eighties with installation of melt spinner and organization of an international seminar on rapid solidification. The activities in this area picked up very fast. Younger colleagues were encouraged to bid for external funding. This did result in sudden increase in technical publication & patents. Many of the areas the laboratory has excelled were started during nineties. Some have resulted in initiation of major externally funded projects large projects. Mechano activation has proved useful in allowing more fly ash to be used in cement making. Work on Bio-mimetic synthesis of hydroxyapatite was also started during this period. It was so attractive that it quickly found an entrepreneur. The technology was successfully transferred.

Archive : Establishment of an Archive was also a landmark (when?). It gives a glimpse of the evolution of the laboratory over the years. A visit would reveal how the areas of interest of the laboratory changed in its life time. The projects that were taken up in fifties were of considerable relevance to our mineral resources. Some of the technologies that were developed such as low shaft furnace, rotary kiln to explore alternative routes for production of iron & steel using none coking coal, Nickel substituted stainless steel, Technology for ferro alloy production etc were far ahead of the time. Some were transferred where as others were discontinued for lack of market demand. Later when these became economically viable & there were signs of its revival, the expertise were not available (as the concerned person had retired) & rejuvenation of the facility became very expensive. It also displays some of the products made in the laboratory over the years.

Future : An institution or an organization does age. A periodic assessment and planned renovation is vital for its survival. Here we need action & support of all the employees irrespective of their position. Life assessment & refurbishment of engineering component is one of the major activities of this laboratory. Over the years we have built up excellent facility & expertise. May be unknowingly we have developed similar expertise in transforming an aging organization into vibrant and active establishment.



However we should not be complacent. We need to think and change with time. May be if we compare our performance in the scale currently in vogue we are possibly doing very well. The scale also may change with time. Of late a sizable amount of tax payer money has been spent in setting up state of the art facility. There will be growing demand to show output commensurate with this investment.

One of the ways of survival of an organization is periodic assessment of its health. SWOT analysis was done some time ago. Selection of some the projects were based on this analysis. Possible it is time to do it again. An R&D organization has to keep pace with changing world scenario.

Preservation of environment is going to a major concern. The global warming & increase in CO_2 in atmosphere are intimately connected. There will be increasing pressure to shutdown industries emitting green house gases. It is going to have a major impact on metallurgical industries. There will be growing emphasis on development of more energy efficient processes. A major initiative could come from NML. There were some initiatives taken up during mid nineties to cut down SPM (solid particulate matter) in foundries in and around Howrah. Likewise installation of coke-less cupola in place of conventional ones in Agra to protect Tajmahal could fall under this category. However with growing awareness much more needs to be done. More emphasis needs to be given to develop expertise in Life Cycle Assessment (LCA): cradle to grave analysis of products & processes.

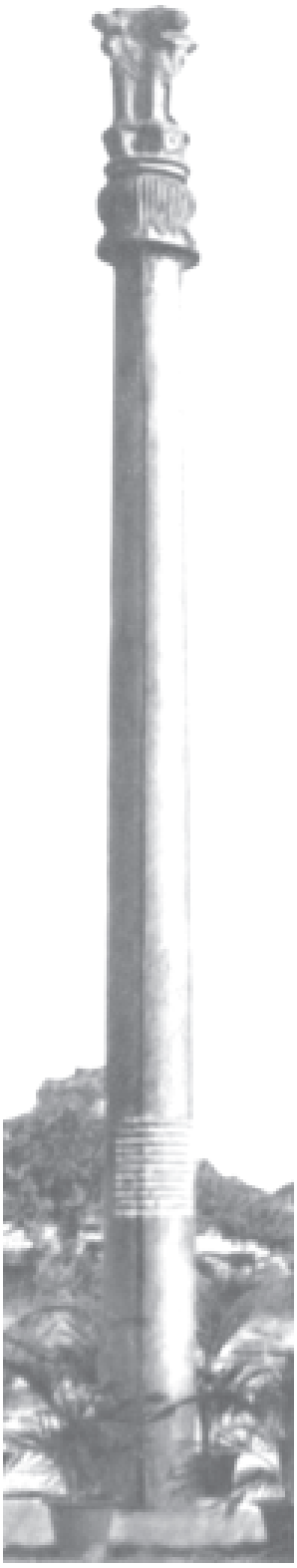
Carbon sequestration is a major issue for fossil fuel power generating station & metallurgical industries. Possibly nanotechnology has a solution. Development of nano material with large surface area with ability to absorb CO_2 is worth exploring. Expertise in mineral processing & mechano chemical activation may prove quite useful. However one also has to look at the impact of such materials on environment.

Development of ultra strength steel was taken up keep during 11th five year plan with this in mind. Whatever we deliver has to be in line with the technologies being adopted for casting & thermo mechanical processing. There are indications that thin slab/strip caster will soon be installed in major steel plants. Therefore current thermo mechanical processing route will not be able to meet the minimum specified strength requirement for several applications for example X70 steel for line pipes. Both the composition & rolling schedules need to be optimized. If new plants opt for such energy saving measures others manufacturing the same by current practice will find it very difficult to compete.

There has been too much emphasis on characterization & testing of materials. NML now can certainly boast of having one of the finest facility & expertise for such work anywhere in the world. It is time to think & look how long can this be sustained. We were fortunate to get generous funding during the last decade to establish it. Will funding situation be that liberal in coming decade? Are we in a position to maintain / upgrade these on our own? Are we able to deliver what was expected out of these? One has to face such queries in future. Can we not set target to develop a fixture or attachment which would enhance the power of the existing system? Can we make it so attractive that original equipment manufacturer with think of introducing this in their future model? In this direction development of Portable Mechanical Property Evaluation unit based on ball indentation technique is indeed a landmark. There is ample scope to take up similar steps to develop new generation of material health assessment tools. .

NML is located in an area far removed from the region which is known to the outside world as the hub of R&D activity in our country. In the light of this the achievements during the last 25 years is indeed remarkable. We do hope that this disparity will soon disappear. Possibly we do see some signs of these happening. This is the impression we got from the large number of International Participants who visited NML to attend INCOME during December 2008 and Nano Materials Meetings in March 2008.

The remarkable transformation that has taken place at NML would not have been possible without the support of employees at all levels whether permanent of temporary. It is they who have put in hard work. We do appreciate and recall their contribution. Hope the trend would continue. It is gratifying that Dr S Srikanth who joined this laboratory as scientist around 1988/89 is the chief of the same establishment now. This too is a recognition of the efforts put in by the scientists & employees of this great laboratory during this period. We sincerely hope under his leadership NML will reach greater heights where scientists from all over the globe would love to come & work.



On Diamond Jubilee ...

K K MISHRA
Retired Scientist (Sct. G) and Former Head, IRM Division

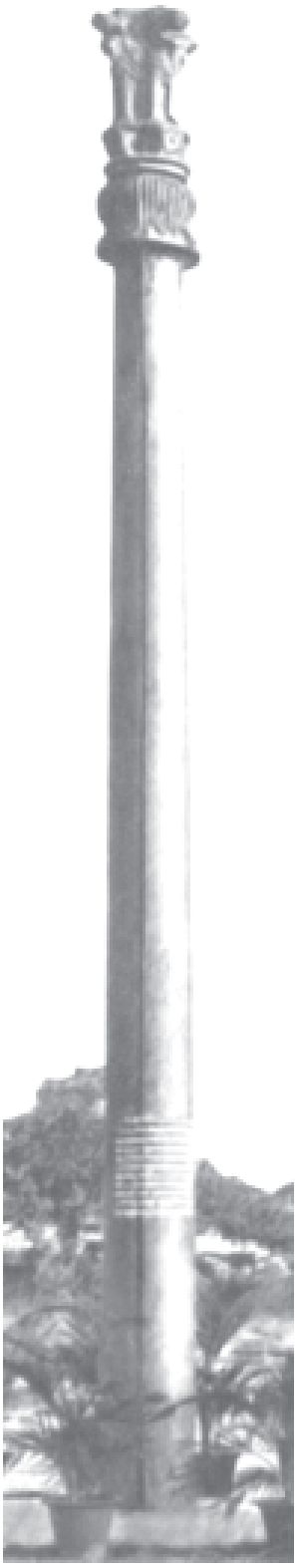
I started my carrier from the Foundry Forge Plant (FFP) of M/s Heavy Engineering Corporation (HEC) Ltd., Ranchi in the year 1962 where I served for 12 years and in June 1974 I shifted to M/s Tata Yodogawa (TAYO) Ltd (now Tata Rolls) at Jamshedpur. In October 1985 I changed to M/s Gontermann Peipers India (GPI) Ltd.at Kolkata as Works Manager. This plant belonged to ISPAT group of companies of L.N.Mittal's fame and finally in July 1990 (after 28 years in heavy industry) I joined NML as Head-IRM. In HEC the learning opportunities were enormous in association with the Czech, Russian, German and Indian engineers. It being a newly coming up plant there were all kinds of opportunities to expose oneself to construction, erection, operation of all kinds of equipment on one side and Grey Iron, Non-Ferrous, and Steel foundries as my major areas of work. The experience gathered there helped me throughout my professional carrier. The technology at TAYO was from Japan and I could contribute myself significantly in modifying the designs of various gadgets used in the processes and at many instances the process itself which resulted in steep rise in productivity and sharp fall in rejections. While in GPI (1985-1990) the process of liberalization introduced by Msrs. Narsimha Rao, Manmohan Singh and later Rajiv Gandhi had begun. It started yielding results in business and the organization was open to global access along with tough competition. Quality standards had to be raised at par with the best elsewhere and the delivery commitments had to be unfailing. ISO 9000 had come to stay. It needed great effort in a very short period to be on the World map of industries and players.

While in TAYO (1974-1985) I took two and a half years time out in January, 1983 for my Ph.D. from the University of Wisconsin, Milwaukee (USA). It was during this period that I was fascinated by the research. Right from melting the alloy in the melting furnace to casting into ingots, swaging, forging, extrusion, rolling etc. etc. had to be done by the researcher himself. The foreman or technicians at respective work centers used to guide once and then watched from their seat that one was not doing things wrong or in unsafe manner. I had plenty of occasions to independently work on SEM, TEM, XRD, and all instruments of inspection and testing .The job was fascinating because every operation and activity pertaining to research had to be done by self. Interest created there for research led me to join NML in 1990 even at much reduced financial and administrative privileges.

CSIR NML is very congenial place where one can pursue individual research as well as group research which are of basic or sponsored in nature. In 1995 DSIR invited NML to examine the proposal of one Sri Balraj Gill who wanted to import a Coke less Cupola from U.K. for which he had requested for necessary funds from DSIR. I was representing NML. In the course of meeting DSIR proposed if NML could develop such Cupola indigenously. I accepted to do so provided the funds were available for the same. As it turned out that one year later in 1996 Dr. S.Varadrajan (Ex.DG CSIR) proposed that NML can be entrusted to develop the Coke less Cupola to be installed in Agra foundries which were facing the threat of closure due to the Sulfur emissions from their Coke cupolas which could tarnish the white marble of the famous Taj Mahal. With the help and recommendations of Dr. Varadrajan NML got a soft loan from DST to bring Coke less Cupola to reality. This was achieved in one year's time and the technology was transferred to M/s Tata Korf Jamshedpur. Tata Korf installed one 2T/hr and one 3T/hr. Coke less Cupolas in Agra with active help from NML. Unfortunately due to Politico-Economic reasons the job did not proceed beyond two cupolas. The foundries shifted to Dholpur-a place 52 km. from Agra in Rajasthan.

Still the users are reserved on the use of the Coke less Cupola because even the UK based organization is still waiting to have a buyer in India. It seems we have to Waite for a proper moment.

Another remarkable instance has been the installation of pollution control units in the Iron Foundries using Coke Cupolas. A design based on multiple cyclone separators was developed and installed by Dr. A. Bandopadhyay of NML in Howrah Foundries in 1996 and it worked very well. Based on this work NML received an SOS from IISCO Burnpur to install similar units for their Heavy Molding Foundry (HMF which has 2x8T/hr coke Cupola), Spun Pipe Plant II (SPP II which has 2x15T/hr.Coke Cupolas), and Spun Pipe Plant III (SPP III which has 2x20T/hr. Coke Cupolas). These foundries exist in the Growth shop of IISCO at Kulti and these were facing closure orders from the honorable Supreme Court if the pollution control units did not become functional by December 1996. NML took the job on



9th July 1996 and handed over the units on 26th January 1997-a job that appeared impossible from any standards.

We have several such examples but I would like to mention two out of them. The events relate to 1997. A team had come from VSSC (Vikram Sarabhai Space research Centre). They wanted us to melt,alloy ,process and evaluate a highly alloyed Invar type sample. Their intention was to explain the job to NML scientists, go back to their head quarter and come back again when we intimate the compliance. To their surprise the NML group led by Late Dr.C.Sivramkrishnan started the work as they were explaining it and just like an online work completed the entire deliverables in one go consuming only a week. The VSSC team did not have to go back and come again. The team was not only happy but concerned over the dedication of the NML team. A similar feet was repeated by the same group a few months later with an ACME Iron sample from NCML (Naval Chemical and Metallurgical Laboratory, Mumbai). The end comment of both (VSSC and NCML) was that if it was administratively possible their job could be at a desirably faster rate with NML's help. There are memoirs of several such instances in my short tenure of 11 years in NML.

I wish to conclude with the following three commentaries:-

(1) Following is a verse from the great epic Mahabharat composed by Maharishi Ved Vyas :-

पठकः पाठकाः मूर्खः येश्चार्ये अर्थ चिन्तकाः
सर्वे व्यवसिनों मूर्खोः योक्रियावान् स पंड़ितः

I interpret it as there are those who study and teach or preach and there are many who think. They all are addicted fools but the one who studies, thinks and implements his ideas and findings for the good and benefit of the mankind is really a Pundit

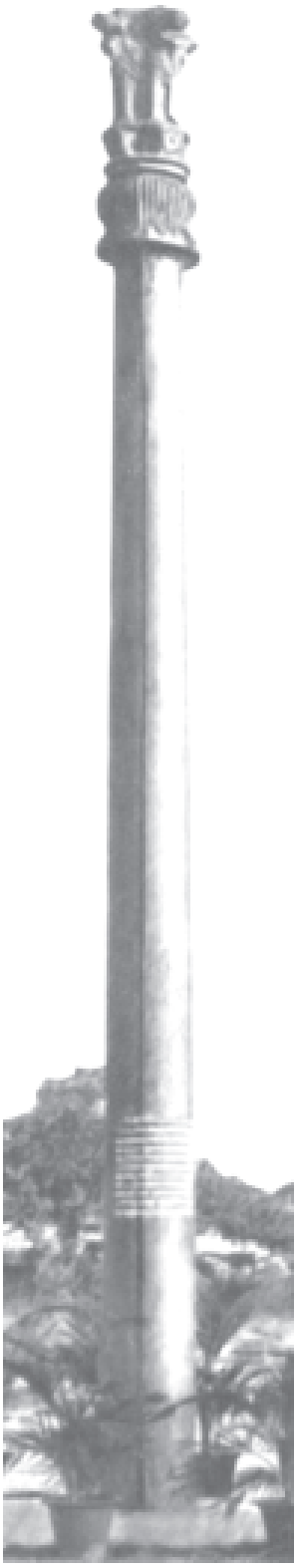
(2) This is a fable from our mythology and narrates on the quality of work:-

We know that God Vishnu resides in Ksheer Sagar on the bed provided by curled Shesh Nag having 1000 hoods and thereby 2000 eyes. Once for some reasons one of the eyes of the Shesh were paining very severely and as he shook his head in pain the Mother Earth was subjected to big tremors resulting in fear and shock everywhere. Lord Vishnu called twins Ashwini Kumars to relieve pain of Shesh. They smeared "Tridhat" which is the ultimate remedy for paining eyes. The pain got doubled. Narad came and suggested to the two brothers to go to Earth and see a vaidya giving his address. Ashwini Kumars disguised as Brahman approached the Vaidya and narrated to him their problem. Vaidya said very politely that Sir! You said that even the application of Tridhat did not ease the pain in the eyes of your patient then I have questions that Tridhat is patent of Ashwini Kumars and they only know about it. So tell me that you two are Ashwini Kumars to which they replied in affirmative with apology. The Vaidya continued that even Tridhat did not help so it must be the eye of Shesh Nag only which is paining. The two brothers were surprised at the knowledge and diagnosis of the earthly Vaidya. The Vaidya said that Tridhat is good but please go back and ask Shesh to close all his 2000 eyes and then open the eye which is paining and gently smear Tridhat into it. The two went back and did exactly as advised by the earthly Vaidya. Shesh was in complete comfort immediately.

The morale of the anecdote is that mere patenting is nothing unless the application and thereafter results are good and acceptable.

(3) It is about the privilege that we enjoy in our CSIR. I was attending Executive development programme meant for Scientists from F onwards at ASCI Hyderabad. On the very first day all were given 10 minutes to express there views on CSIR. Every one had a big list of inadequacies and dissatisfaction. I was a late entrant in the organization having tasted the outside world. In my turn I narrated an anecdote told to me by a Turkish friend of mine who was doing his Ph.D. with me in USA. It runs as follows:-

Once there was a seminar of Surgeons from all over the World in USA. In one session they were exchanging their experience of most complicated operation performed in their respective countries. Every body used his chance to speak but the Russian fellow newer got up. He was persuaded by all to come up and say some thing. He got up and murmured slowly that Tonsil is most difficult in my country to operate. The entire audience burst into laughter. When the noise of the laughter subsided a bit he further murmured that the surgeon has to operate without the patient opening his mouth. Every body was dumb at that. I had to comment that we in CSIR are fortunate that we can easily and any time open our mouth and are heard.



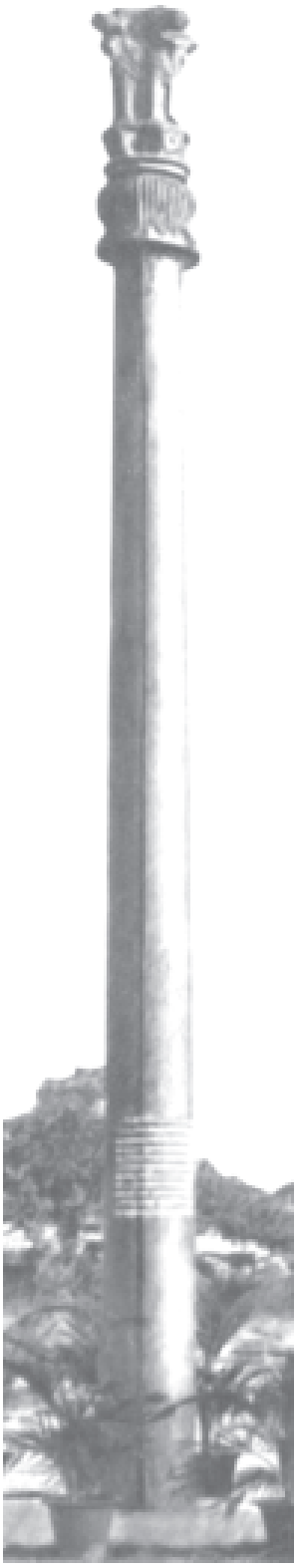
On Reminiscences…

I joined NML in July 1990. It was my fourth placement having served earlier in three organizations over 28 years in heavy industry. In the interview for selection I was asked to present before the selection board as to what all I have to offer. They gave me reasonable time to express myself and once my deliberations were over the board members questioned me for doubts and clarifications. Whether I would have been selected or not but I was fully satisfied for being given opportunity to present myself. This was unique in NML/CSIR. I had appeared for several interviews for the jobs earlier but invariably in most cases the appearances were farce show of fulfilling the formality.

I found the work culture here to be different from many other organizations. A scientist could propose or associate himself in relevant research work irrespective of his division or department. I was in an infrastructure division of Research Management (IRM) but I could lay my hands actively in projects pertaining to Ferrous, Non-Ferrous, material evaluation and infrastructural projects in individual capacity as group leader or a group member. It is a great feature of the working because it saves the scientist of the frustration of confinement to his division and makes it possible for the organization to use the capability of the person in full.

NML (CSIR) has typical approach that the projects do not suffer with the stigma of hierarchy. A scientist "B" can propose a project as group leader and the Director of the Laboratory can be a member in the team. It keeps the spirits going high and is a healthy work oriented tradition. A scientist has to use his information, tact, name, and fame to select a project and get a good sponsor with adequate financial grant. A meaningful work results in this way. There are several projects of Centralized nature like Young Scientist Award, Crazy Idea Fund etc. where the scientist has to toil hard and apply his mind competitively to get on to such projects. In the nut shell I found working during my 11 year tenure in NML (1990 to 2001) very fascinating and involving.

Administratively there were lots of things to learn from the three Directors with whom I had occasion to work with. In my opinion Directors are over worked because delegation is very difficult In CSIR set up. Prof. S. Bannerjee was there up to September 1991. He constituted 28 committees covering administrative requirements of the laboratory. Every committee had a Chairman. These committees served as delegation tool to the Director to ease his immediate worries. Prof. P.Ramachandra Rao (who had been Director from September 1991 to February 2002) got dispensed away with these committees and instead preferred Senior Scientists to be head of activities which the Director intended to delegate. Though it was handy to the Director but the involved Scientists had to devote most of their time in conducting their allied responsibility. I had been emeritus scientist during the directorship of Prof. Mehrotra and therefore was merely a fence sitter. However I could see and learn the improvements resulting from his reorganization of research divisions and vast improvement in the dwelling condition of employees. He was an excellent person to render good advice and cautions on things which may possibly go wrong at the end. We could watch the systematic annihilation of SWA and other Work inhibiting multitudes in CSIR. I feel the methodology of achieving such feet is not only worth praising but they are also worth copying by industry to get rid of unwanted road blocks to work.



Memories of My Days at NML

C. SANKARAN
Former Scientist-in-charge, NML Madras Centre

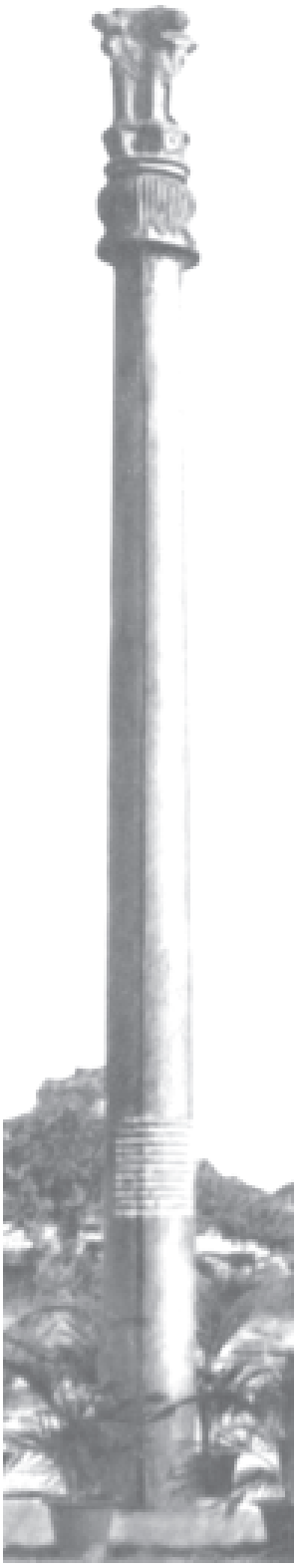
My career in NML Jamshedpur started with joining the extractive metallurgy division in early 60s. During my early days I worked with my seniors on some of the projects like smelting of low grade ferruginous manganese ores, reducibility of iron ores, digestibility of bauxites by Bayer's process, chlorination of Ilmenite and on the extraction of nickel and cobalt from nickeliferous laterites. I always enjoyed my work, as the field is vast and well diversified involving lot of chemistry besides metallurgy and offered ample of scope to invent and develop newer technologies.

NML had a Regional Foundry Field Station functioning since the late 60s. Later on, all its activities were shifted during 1974 to a newly established full-fledged NML Madras centre situated at CSIR Complex, Chennai Many scientists from NML Jamshedpur were transferred to NML Madras centre with the main objective to set up a modern mineral processing laboratory. I was assigned to look after the process metallurgy activities of the centre. I continued my R&D in process metallurgy completing successfully some of the projects viz., recovery of vanadium from vanadium-bearing titaniferrous magnetites etc.

Knowledge and expertise obtained by direct association with the former directors like Dr.V.A.Altekar (by free discussions and exchange of ideas), Prof S. Banerjee (communication skills, development of innovative ideas etc.) and Dr. P.Ramachandra Rao (freedom of expression, action and R&D management), shaped me to become the Scientist in Charge of NML Madras centre in1989.

During my tenure. I always enjoyed the cooperation of all the scientists and supporting staff and pursued innovative R&D technologies. The major innovative technology worth mentioning is COLUMN FLOTATION for the beneficiation of fluorspar, sillimenite, calcite, gold ores and extending the use of the technology (electro column flotation) for the treatment of industrial effluents from tanneries and municipal waste. The laboratory column developed by the centre is in good demand for carrying out basic work and the laboratory has already supplied multiple units. The Column flotation technology has already been transferred to a major Industrial (group on a proprietary basis. The flotation columns are presently in use in two major industries. The contribution and the expertise developed by the centre are recognized worldwide and many of the centre's publications have appeared in leading journals. Other notable projects include beneficiation of Sivaganga graphite ores (a commercial unit is in operation even today); pilot plant smelting of vanadium bearing titaniferrous ores at VISL, Badravati; development of emission standards for foundry and lime industries; design of pollution free lime kilns approved by CPCB, New Delhi etc. On the academic front, NML Madras centre had produced several Ph.Ds under the guidance of its experienced scientists. The centre also imparts training in R&D to many students from various colleges, universities. All the above achievements were made possible by a team of knowledge based scientists totally devoted to their profession.

NML with its ultramodern infrastructure and back up, of 60 years of R&D experience in metallurgy, materials science and allied fields has a bright horizon. It has a proper blend of basic research coupled with business oriented research. I am confident that with the good leadership, policy-strategy, experienced supporting staff, development of innovative - futuristic R&D programme, technologies through partnerships and resources, NML will achieve excellence and rise to greater heights in all its endeavors.



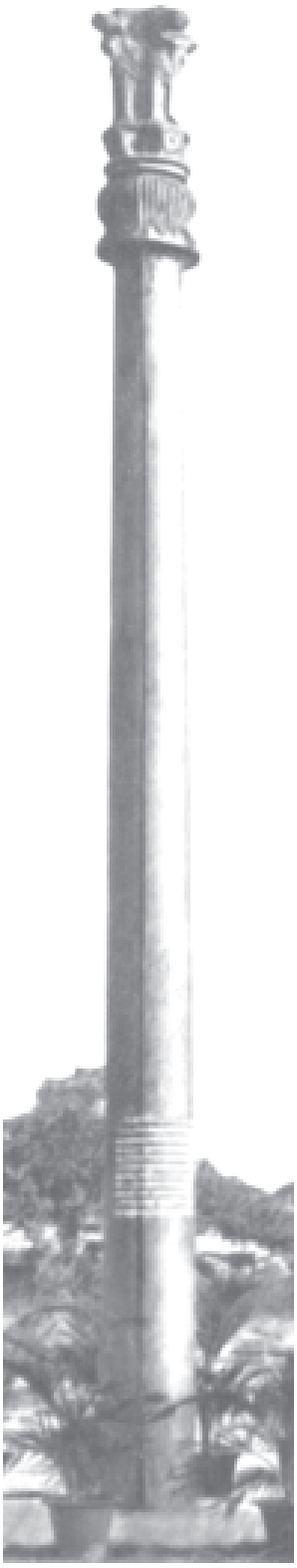
Work with joy at NML

S C MAULIK
Ex-Scientist, NML Jamshedpur

NML was established in 1950 with the broad objective of taking up fundamental and applied research in metallurgy and keeping with the perspective, activities related to characterisation and beneficiation & agglomeration of ores and minerals started from the very beginning. An integrated mineral beneficiation and agglomeration was subsequently installed in 1962. At the time of my joining the Ore Dressing Division (now Mineral Processing) in March 1970, I was greeted by a group of very enthusiastic and energetic people working in a complete harmony. Pilot plant activities particularly on iron ore gained the maximum momentum and since then almost all the iron ore deposits of the country have been studied in details. The unique facility of iron ore washing followed by treatment of different process products for enrichment and subsequently agglomeration(sintering and pelletisation) made a complete cycle. This formed the basis of many iron ore beneficiation plants in India. In the late seventies, under the guidance of (Late) Prof. V A Altekar, the then Director, NML, direct reduction of iron ore with coal to make sponge iron was first studied in the country in a pilot scale which primarily formed the basis of many working plants now. In iron ore sintering, continued studies till mid eighties made the efforts successful in addition of superfines in iron ore concentrate to a large extent. At the same time as a parallel study comprising physical beneficiation followed by chemical treatment produced super grade iron ore concentrate with extremely low silica and alumina which was then converted to ferrites to form electronic components. Over the years many sophisticated equipment for gravity and magnetic separation for fines treatment have been added and NML developed an expertise of beneficiation low grade ores from other countries as well viz., Syria, Egypt, Ukraine etc.

By late eighties. beneficiation of low grade ores and fines and to recover values from wastes became NML's forte and my involvement was with several significant studies on isolation of heavy minerals from beach sand, low and off grade magnesite samples, processing waste from barite plant and many other but the most important were recovery of phosphate from a soil sample from Uganda and development of process for production of tungsten from lean tungsten ore of Rajasthan.

Memory of my stay at NML till end 2005 was a very pleasant one. I had opportunity of working with stalwarts to know right from the basics of mineral processing to commissioning commercial plant. The spirit of team work and homogeneity & cohesion of the group was our asset to success. I wish the same continues to lead NML to a greater height.



Reminiscence

UPKAR SINGH
Retd. Scientist, NML

My role in National Metallurgical Laboratory, after I was assigned to the Engineering Division, was primarily that of a facilitator for the R&D work of scientists. This involved design of Metallurgical Processing and Testing equipment as well as its fabrication and installation with co-operation from other concerned divisions.

Quite a few projects in the fields of Steel Making, Non-ferrous Metals Recovery/Production, Metal Powders, Mineral Dressing, Waste Utilisation and Greenfield projects like recovery of Ni from sea nodules, RESINESS (Reduction, Sintering and Electro Slag Smelting), were undertaken. Their timely completion/progress was mainly due to the vision and foresight of one individual i.e. The Head, Design & Engineering. He foresaw requirements of raw materials, tools and tackles, various types of drives and other engineering inputs years ahead.

Other factors which contributed to the success of my work were:

i. Complete confidence reposed in the Design & Engineering Division by successive directors and divisional heads, particular those whose work needed engineering inputs, and

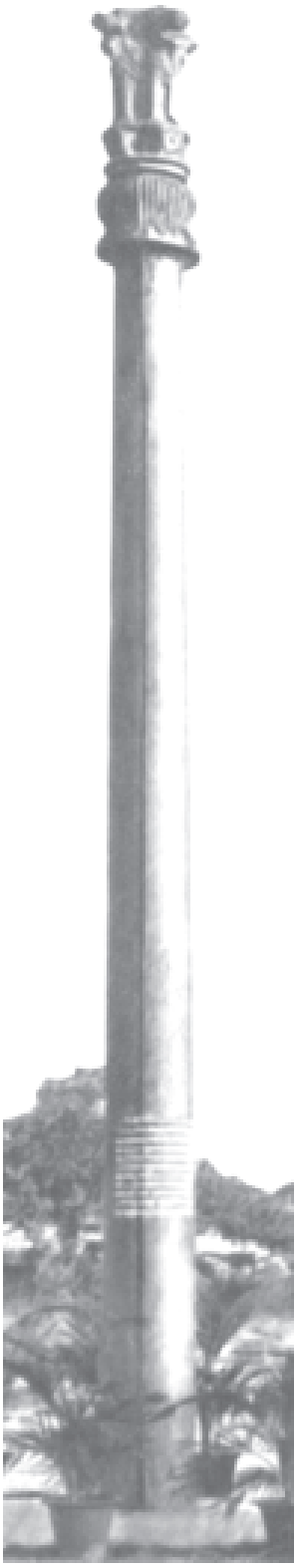
ii. The availability of a group of highly skilled and dedicated craftsmen in Fabrication, Fitting, Machining and Pattern making (Woodwork), who brooked nothing second best, even from themselves. All of them had very broad and deep knowledge about their craft, and many a scientist would come and seek their help/advice when in a fix.

As an example of their dedication, I would like to cite one example. The new auditorium (Creep Lab) was to be inaugurated, and some of the bought-out items were received only three to four days before d-day. The group constituted to complete the installation and commissioning the bought-out items, worked continuously for nearly forty hours without a break, and left only after all work had been satisfactorily completed and tested. In between, they would not leave even for their meals on the plea that they had meals everyday, but the opportunity to work like this came up rarely. When offered an off for the next day, everybody turned up on duty and on time.

A word about Dr. S.Banerjee, ex-director, NML. He stressed the primacy of science/scientist for the existence of the laboratory, and gradually by subtle means, started loosening the stranglehold, which the administration exercised over almost all aspects of the functioning of the laboratory.

In the end, I would like to express my deep gratitude and sincere thanks to my seniors, under whom I served, and whose support and encouragement allowed me to grow, both academically and professionally and achieve milestones, which often looked beyond my own limited abilities. My thanks, also to all those who worked with me, and assisted in the execution of various projects.

One regret is the failure to see the Magnethern unit in operation. Considerable effort had gone into its design, fabrication and installation. But unfortunately the scientist who had collaborated in the design, providing process inputs, resigned, and none could be found to replace him.



NML Madras Centre

Dr. G. BHASKAR RAJU
Scientist-in-chage

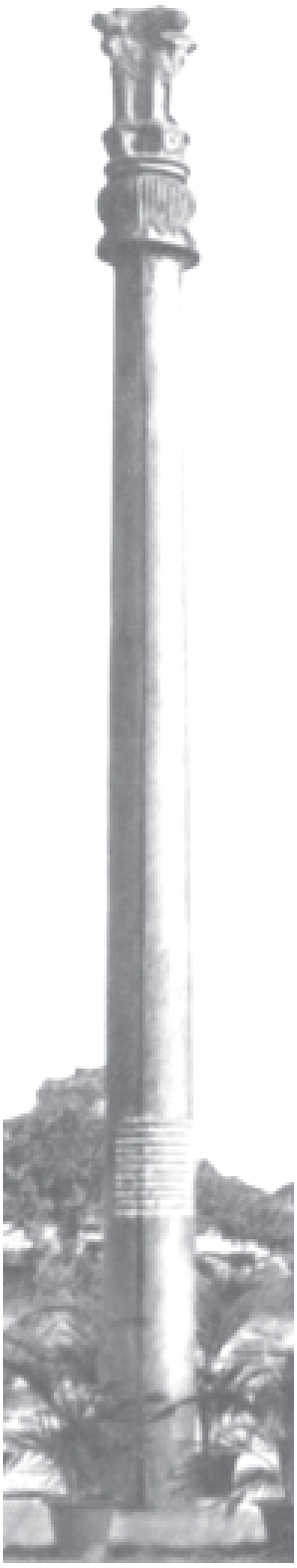
Exending the Outreach"Going south albeit with success

NML has initiated its regional activities at Chennai to cater to the metallurgical needs of the southern states. NML Foundry Station at Chennai was inaugurated on December 14, 1965 by the former President of India Shri.R.Venkatraman especially to help the foundries at Coimbatore. Later on, it became a full-fledged NML Madras Centre at CSIR Madras Complex.

Notable achievements of the NML Madras Centre include (i) flow sheet development for the beneficiation of Sivaganga Graphite Beneficiation Plant and (ii) Development of column flotation technology and electro-flotation technology. R&D efforts were initiated to utilize low-grade finely dessiminated ores. Industrial size flotation columns for the beneficiation of sillimenite were designed, installed and commissioned at OSCOM Chatrapur and IREL, Chavara. Also flotation column to produce high grade calcite was installed for M/s Calpro Mineral Technologies Pvt Ltd., Salem. Beneficiation of low-grade iron ores around Bellary-Hospet and Barite at Mangampet, Andhra Pradesh by a combination of reverse flotation process and flotation column was proposed. M/s Indian Barytes and Chemicals are presently setting up a plant at Mangampet under the guidance of NML Madras Centre. Electro flotation technology to separate low density colloidal particles from industrial effluents was developed and demonstrated especially for tannery and textile industries situated in Tamilnadu.

The Columns of Strength

Research on column flotation and electro-flotation was initiated at NML Madras Centre during mid-1980s as an alternative to conventional flotation technology, to treat finely disseminated low grade ores. An automated 3.0 inch dia laboratory column was developed first time in our country and extensively field tested in various mineral processing industries such as Hindustan Copper Ltd., Kudremukh Iron Ore Company Ltd., Hindustan Zinc Ltd., Gujarat Mineral Development Corporation Ltd., Bharath Gold Mines Ltd. Encouraged by the acceptance of the industry, a pilot scale column of 0.5m dia with necessary controls was developed and field tested in the on-stream conditions of various processing plants. This exercise has resulted in gaining the confidence of the flotation circuit operators as well as the management to establish columns for commercial operations. Presently, there are three columns in operation established by NML technology, namely, IREL, Chatrapur (150 tpd) and IREL, Chavara (150 tpd) for sillimanite beneficiation and Calpro Mineral Technologies India Private Ltd., Salem (150 tpd) for limestone beneficiation. For effective marketing and commercializing the technology, in the year 2008, NML has signed an MOU with M/s. McNally Bharat Engineering Co. Ltd., one of the leading engineering consultancy firms in our country. Under the agreement, a commercial flotation column (700 tpd) is being commissioned for M/s Indian Barytes and Chemicals Ltd., for beneficiation of low-grade barites at Mangampet, Cudappah, AP.



NML - as I see during last 28 years

Dr. ASHOK KUMAR VAISH
CSIR - Emeritus Scientist & Former Scientist 'G'
National Metallurgical Laboratory, Jamshedpur - 831 007

Joined the Extractive Metallurgy Division of National Metallurgical Laboratory, Jamshedpur on 31st December 1982 as Scientist 'C'. The National Metallurgical Laboratory, being the third in the Council of Scientific & Industrial Research (CSIR) family of laboratories, was one of the leading laboratories of Metallurgical Engineering in the world. Dr. Balraj Nijhawan, the first Indian Director of the laboratory, set the pace for the rapid growth of the laboratory through the establishment of a number of pilot plants and facilities and initiating research programmes which were in line with the Five Year Plans of the young Republic of India. NML had four field stations in different parts of our country namely at Ahmedabad, Digha, Batala and Madras. Each field station was carrying out specific R & D activities in Metallurgical Engineering required in that region and transfer the concerned technology to the entrepreneurs of that region accordingly.

During 1982 the strength of NML employees was more than 1200, with a large number of technical personnel supporting the then ongoing R & D activities and pilot scale investigations and testing of materials from different parts of our country as well as abroad. The pilot scale facilities included

(i) 500 KVA pilot scale Submerged Arc Furnace for developing the know - how of different types of high carbon ferro - alloys in India

(ii) Pilot - scale rotary kiln for the development of technology to produce sponge iron in our country

(iii) 400 KVA pilot - scale Electric Arc Furnace for the development of different grades of steel and steel alloys

(iv) VR DR furnace for producing 1 tonne/day sponge iron

(v) Pilot- scale coke-fired cupola furnace for melting pig iron

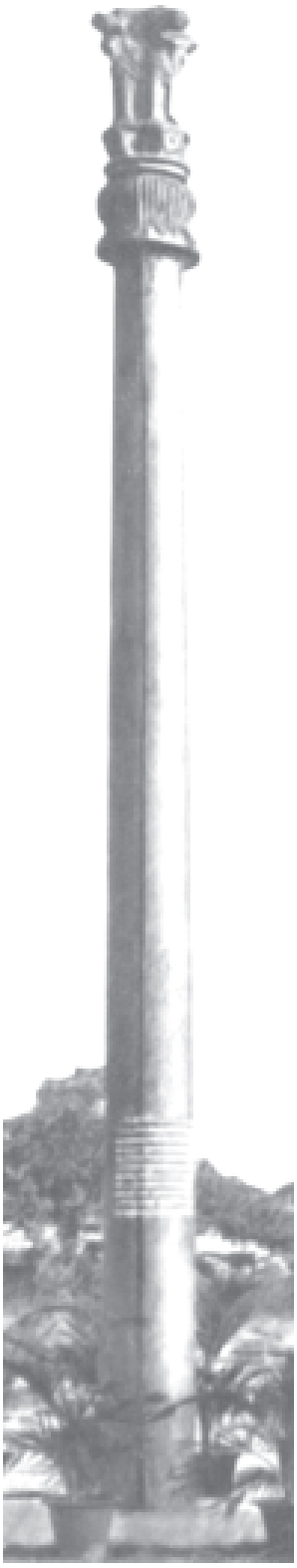
(vi) A complex of mineral processing pilot plants for the beneficiation of minerals and coals belonging to different parts of our country

(vii) Carbon plant for producing carbon paste and pilot scale facilities for the development and testing of new refractory materials

(viii) Sukhinda Nickel pilot - plant to develop flow sheet for the extraction of nickel metal from lean ores of nickel available in India

In those days NML was getting considerable number of sponsored investigations/testings of materials on regular basis and pilot plants were operated involving a large number of scientific and technical personnel from different divisions. Apart form these pilot plants, NML had semi-commercial plants for the production of magnesium metal required for defence applications and Low Shaft Furnace for testing the iron ores and reductants from different parts of our country. The know - how for specific high carbon ferro-alloys namely ferro-manganese, silico - manganese, ferro - chrome, ferro - silicon, calcium silicide, ferro - nickel etc. were developed in 500 KVA Submerged Arc Furnace at NML, optimizing their process parameters. The mineral beneficiation pilot plants of NML were unique in our country to process/beneficiate minerals from different geological backgrounds and produce concentrates from lean ores. The creep laboratory of NML has unique facility in Asia to determine fatigue, fracture and failure analysis of varieties of components belonging to power plants and heavy industries.

Apart from these pilot plants NML had excellent pilot scale facilities for forging, hot rolling, cold rolling and extrusion. It had a number of heat treatment furnaces and tensile testing and impact testing facilities. Its materials processing division had unique expertise to develop a number of critical alloys



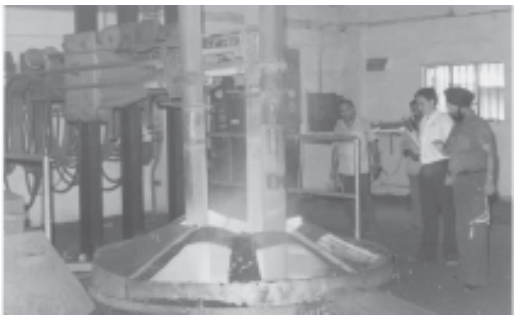
of different compositions for specific applications in railways, defence, nuclear engineering and aero space engineering. NML had specific equipments/instruments namely Scanning Electro Microscope (SEM), Transmission Electron Microscope (TEM), X - ray diffraction (XRD) facility etc. for characterizing the materials processed or product produced in the laboratory under different investigations.

In 1980s Prof. V. A. Altekar was leading NML as its Director and Dr. Rajendra Kumar, Director Grade Scientist, was directing extensive activities of physical metallurgy. At that point of time, the laboratory was known all over the world for the development of pilot scale processes for the extraction of ferrous and non - ferrous metals as well as development of specific alloys for critical applications. Among scientists, a majority of them were simple science graduates, some of them had technical background such as in diploma in engineering or equivalent. In those days only a few scientists had formal engineering qualification with and without post graduate degrees while others had masters degrees or PhD in basic sciences. Most of the divisional heads were Assistant Directors and others belonged to scientist 'B' and Scientist 'C' categories. During the course of time these scientists had acquired excellent expertise in the development of technologies in different emerging areas of metallurgy. Apart from this a large number of technical personnel were involved in the operation of pilot plants and related activities. All of them had acquired very good expertise in the maintenance and operation of pilot plants. Further a good number of casual labours were involved to assist in the operation of different pilot plants. In due course of time they had acquired very good expertise in the maintenance and operation of pilot plants. Many of them were gradually absorbed into permanent cadre with the changing rules and regulations of CSIR.

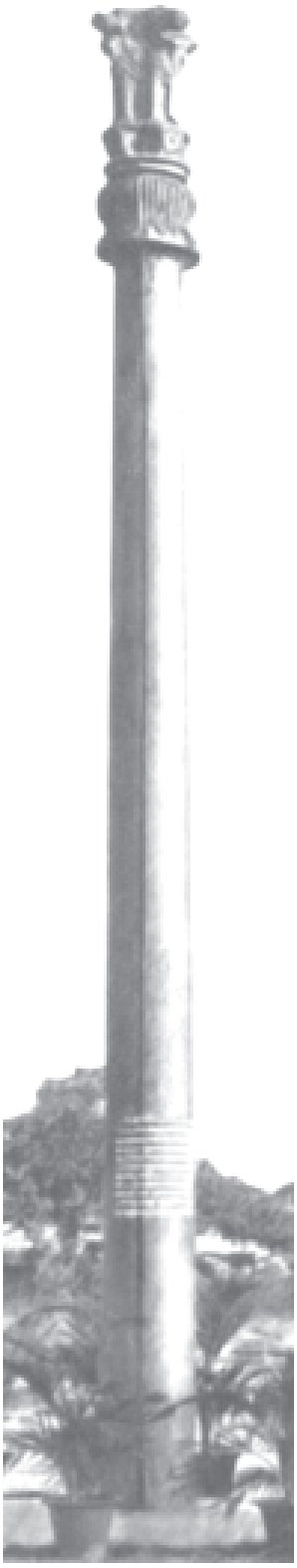
The employees of NML had two recognized organizations - NML Employees Association (EA) and Scientific Workers Association (SWA) to represent their general problems to the authorities of NML in a formal manner. On social front NML had its Staff Club which was conducting indoor and outdoor sports activities as well as organizing social and cultural functions from time - to - time throughout the year.

Prof. V.A. Altekar managed the activities of the laboratory smoothly for a long period from August 1969 to March 1985 with harmonious relation with all categories of staff of NML The long regime of Prof. V.A. Altekar as Director came to end in March 1985 and Dr. R. Kumar took over as Acting Director of Laboratory till the third week of December 1985. In the last week of December 1985 Prof. S. Banerjee from IIT Bombay took over the reign of NML as Director. He guided the destiny of NML from December 1985 to September 1992. Being an able administrator he tried to direct the R & D activities of the Laboratory to the best of his ability. He tried to provide full freedom to scientific community of NML in carrying out their R & D activities in emerging areas of metallurgy. He appointed a large number of scientists mostly with engineering background in different divisions of the laboratory. He also gave special priority for the construction of Scientist Apartments in Agrico Campus of NML with a view to provide great relief to many newly joined scientists of laboratory who were forced to live in the rented accommodation in different areas of Jamshedpur city without much safety and security due to the scarcity of available official accommodation. Prof. Banerjee tried to provide basic facility to all types of employees of NML. He used to strictly monitor three thrust area projects of NML namely (i) processing of Sea Nodules for the recovery of copper, nickel and cobalt (ii) VRDR - SAF for the production of low sulphur phosphorous liquid iron and (iii) beneficiation of Tungsten minerals on

VRDR furnace in operation at NML



500 KVA – Submerged Arc Furnace in operation at NML



monthly basis. The sea nodules project was initiated by Shri DD Akerkar, Head, Non - ferrous process division, the VRDR - SAF project by Shri K.N. Gupta, Head ferrous process division and Tungsten project by Shri S. Chakraborty, Head, Mineral Processing division.

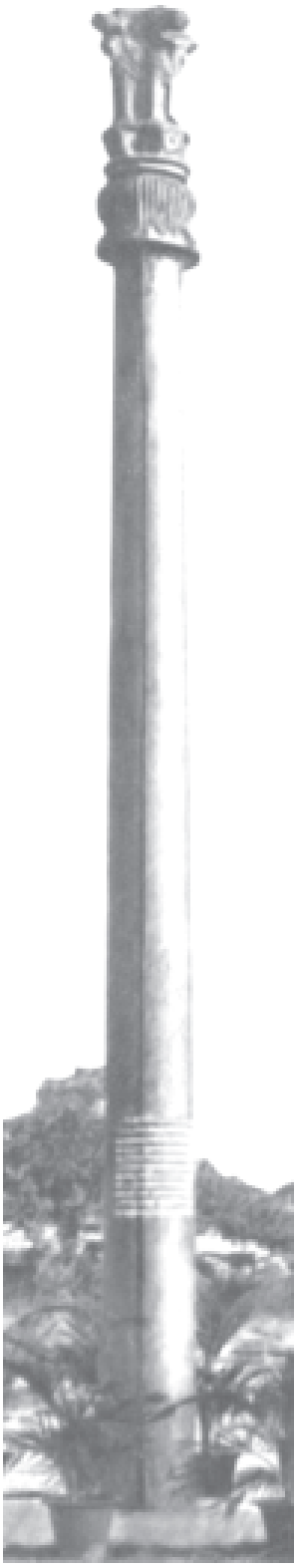
He gave full freedom to the scientific community with respect to purchase of equipments and materials for R & D projects and even relaxed the then existing purchase procedures. During his regime several scientists were also bestowed with different National Awards. Prof. Banerjee tried to formulate his own rules and regulations for the assessment of scientific community without bothering the rules and regulations of CSIR as mentioned in the document of MANAS. He designed his own performance indicators for the assessment of scientists of NML which however could not be implemented. He tried to develop pilot scale RESINESS process for producing direct steel from the fines of iron ore and the non - coking coal involving a good number of scientists and technical personnel of the laboratory. Inspite of his best efforts, the process could not succeed due to several inherent drawbacks. Prof. Banerjee successfully developed the pilot scale process for producing SG iron at one tonne scale making use of low sulphur phosphorous hot metal from pilot scale 500 KVA Submerged Arc Furnace by smelting sponge iron fines and using magnesium as inoculant. During 1980s a number of sponsored investigations namely (i) smelting of sponge iron fines in 500 KVA - SAF for producing foundry grade iron in 1987 and 1989 sponsored by M/s Sponge Iron India Ltd., Kothaguden (AP) (ii) smelting of DRI lumps/pellets of varying degrees of metallization in 500 KVA - SAF for producing low S & P liquid iron sponsored by RDCIS, Ranchi and (iii) production of calcium silicide sponsored by Tata Steel were carried out successfully under able leadership of Prof. S. Banerjee. "Meta save" was developed by NML scientists at NML and its technology was successfully transferred to Tata Steel under the able leadership of Prof. S. Banerjee. He could successfully project NML on national and international scenario by establishing Component Integrity Evaluation Centre at NML with the assistance of Prof. O. N. Monanty, the then senior Dy. Director of NML. He also encouraged rural technology project in Bankura District of West Bengal for casting "Lotas"

Prof. Banerjee could successfully manage from Tata Steel a large space near NML Agrico campus adjacent to oxygen colony for building NML school, guest house and sports grounds for cricket, football, tennis and volleyball as well as a community hall for social and cultural functions. He re-organized the divisions of NML and merged small divisions with big ones for better efficiency of R & D activities. He motivated his scientists in new areas of metallurgy and encouraged even younger scientists as project leaders. He permitted them to attend conferences and seminars on regular basis. He further recognized the scientists having higher qualification (M. Tech and PhD) by promoting them through advertised positions in open interview. Prof. Banerjee by his dynamic personality and simplicity tried to uplift the laboratory to the best of his ability. The regime of Prof. S. Banerjee came to end in the year 1992 and Mr. K. N. Gupta was the acting Director of the laboratory for some time.

On 17th September 1992 Prof. P. Ramachandra Rao, joined NML as its Director from Banaras Hindu University, Varanasi. During the regime of Prof. P. Ramachandara Rao NML made all round progress on all fronts of metallurgical engineering. With his materials science background Prof. Rao initiated several activities related to materials engineering and also recruited scientists with the background of material science/engineering. During 1990s a number of scientists from NML were bestowed Young Scientists Awards, NMD awards and several other awards from professional bodies.

Prof. P. Ramachandra Rao tried to give a new outlook and new direction to NML by initiating the following at the laboratory :

- Prof. Altekar award for best technology
- Dr. Nijhawan Award for best technical paper
- Best worker award
- Celebration of NML foundation day on 26th November each year
- Introduction of NML song to be recited on special occasions



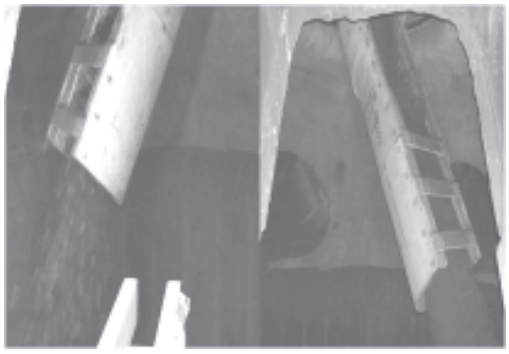
- NML Archives - a repository of all old technical reports and publications
- Business Development center - depicting the latest technologies developed at NML.
- Establishment of NML - Kerala public school at Agrico for NML employees and others.
- Formal farewell function at the end of the month for retiring employees of NML in that particular month.
- ISO certification of NML
- Pleaded for organizing seminars and workshops on emerging subjects for science dissemination.

Prof. Rao also initiated R & D projects and investigations with Defence organizations, Airforce, Railways etc. Under his dynamic leadership NML took a new initiative in the environmental pollution control projects related to industries. During the regime of Prof. Rao basic research was initiated in several emerging areas of metallurgy and materials engineering. Several investigations were carried out in pilot scale 500 KVA Submerged Arc Furnace, VRDR pilot plant, pilot scale coke- fired cupola and 40 Kg capacity vacuum induction furnace. A societal project "Documentation and development of iron making process used by tribals of India" sponsored by Ministry of Steel Govt. of India was also initiated under the able guidance of Prof. Rao. A process was developed during 1993 -94 to produce standard grade ferro - silicon replacing charcoal by low ash coke, non - coking coal and wood chips under an investigation sponsored by M/s Bhutan Ferro Alloys, Bhutan under the able leadership of Prof. Rao. Extra low carbon micro - alloyed steels were produced in a joint project of NML and IIT Kharagpur under extra mural research programme of CSIR. The pilot plant for the extraction of copper, nickel and cobalt by the processing of sea nodules was successfully established and process parameters for each unit of the plant were optimized. The development of commercial scale cokeless cupolas for Agra foundries, successful establishment of particulate capturing units/cyclone separators at Kulti foundries and Howrah foundries as well as development of pollution control device for lead particulates suitable for small scale battery scrap smelters are some of the achievements of NML in this direction. Prof. Rao could bring mega project related to the modelling of blast furnace from Ministry of Steel, Govt. of India with a view to increase its productivity considerably. He also brought mechnochemically activated cement making project with a view to save energy consumption.

Production of extra low carbon micro-alloyed steel at NML under extra mural research programme of CSIR

On social front he had extremely cordial relations with the office bearers of Scientific Worker Association and NML Employees Association to look after the grievances of Scientific community as well as employees belonging to technical cadre and administrative cadre. He was always very considerate to solve the legitimate problems of NML employees. The Golden Jubilee year of NML was successfully celebrated under the able leadership of Prof. P. Rao, with Dr. R. A. Mashelkar, DG CSIR as Chief Guest during the year 1999. The successful organization of SSBM tournament at NML for the first time was highly appreciated by one and all.

The regime of Prof. P. Ramachandra Rao ended during February 2002 when all of a sudden he left NML and joined as Vice Chancellor of BHU Varanasi. Dr. R. N. Ghosh was Acting Director of NML for a few months after the departure of Prof. Rao. Prof. S. P. Mehrotra, from IIT Kanpur joined as Director



Burden distribution measurements in Blast Furnace No. l, Bokaro Steel Plant, Bokaro

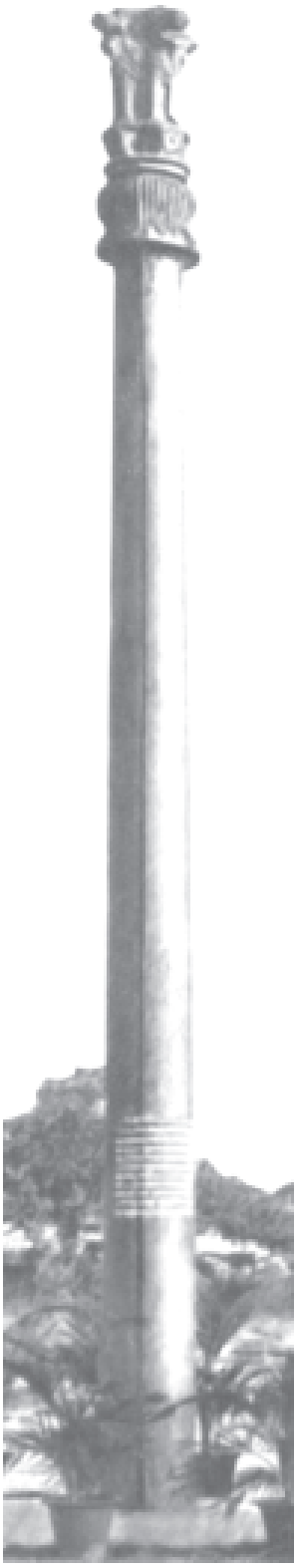
of NML in the first week of June 2002. Prof. Mehrotra tried to formulate his own rules and regulations for general working of NML and he reoriented the nomenclature of divisions after merging some of them for the smooth working of laboratory. Most of the mega projects such as blast furnace project, sea nodules project, cokeless cupola project, mechnochemically activated cement making project etc. were continued during his regime. Burden distribution measurements were successfully carried out in blast furnace No.1 of Bokaro Steel Plant, Bokaro. An automated ball indentation technique was developed for tensile testing and accordingly prototype model was developed and transferred. Biomimetic materials developed by a group of scientists were suitably marketed. The second phase of the societal project "Documentation and development of iron making process used by tribals of India" sponsored by Ministry of Steel Govt. of India was successfully completed at NML with the assistance of tribal artisans from Chattisgarh and demonstrated at two tribal sites in Jharkhand and Orissa.

Demonstration of scaled-up furnace of ancient iron making

Demonstration of 2 t/hr. capacity coke less cupola at Agra

Prof. Mehrotra gave special importance to societal project "water treatment" and it was demonstrated in several areas of Jharkhand state. He successfully organized an international conference "INCOME - 2008" - largely attended by Indian and foreign delegates. He shifted the entire activities of Mineral Processing Division to Pilot Plant area of NML for better implementation of sponsored and investigation projects.

Prof. Mehrotra paid more attention towards social, cultural and sports activities in NML campus and Mrs. Mehrotra also took keen interest in all these activities and actively participated in most of them. The visit of Dr. A. P. J. Kalam, President of India, to NML and his address at NML Auditorium was historical. The regime of Prof. Mehrotra ended on 31st March 2009 and Dr. Sukomal Ghosh became acting Director of NML for about one year from April 2009 - February 2010. Dr. S. Srikanth an young, energetic senior scientist of NML itself took over as directorship of NML in the first week of March 2010. He has taken revolutionary steps to streamline the R & D activities and bring more and more sponsored investigations from industries and R & D organizations in private sector of our country. He is celebrating the Diamond Jubilee of the laboratory in a befitting manner.



My Journey ... to NML

M R GURU MURTHY
Former Sr. Controller of Administration National Metullurgical Laboratory

It was the year 1996. 1 was empanelled for the post of Sr COA and eagerly expected posting somewhere in the South. I was jubilant but not hopeful. To my utter chagrin, CSIR posted me to NML, Jamshedpur. Though good in geography I was not sure where Jamshedpur was ! I asked my PA to check the map and find out where I was destined to head. She came back with a wry face to say that it is in Bihar. This was the state rich in natural resources with plenty of water for agriculture - yet, needed an honest and efficient political leadership to lead the state towards its economic growth. With the sole intension of not to lose my promotion, I decided to join NML.

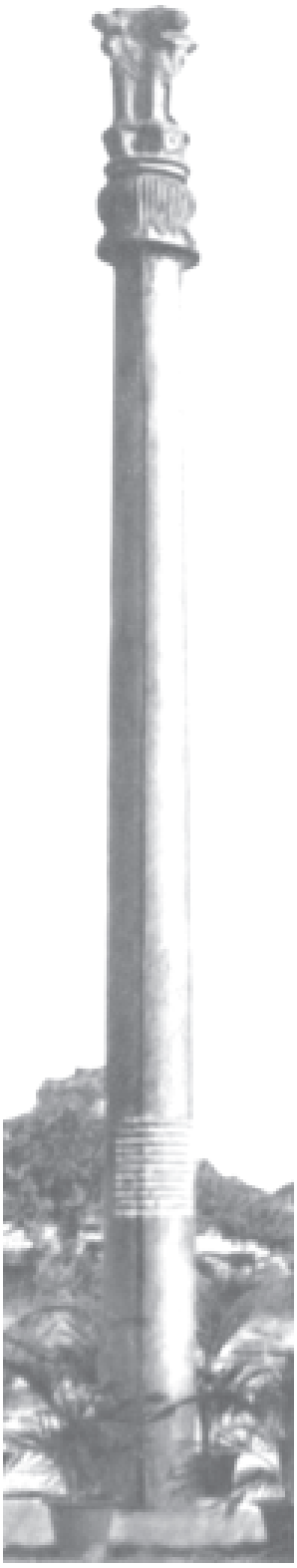
Thus began my journey to Jamshedpur !

As is my wont, after taking over as Sr.COA my first job was to know the activities and also the facilities available in the Lab. I was astonished, scientific and technical manpower was extraordinarily large and the facilities innumerable. Perhaps, this was one Lab which had everything that was talked about in Metallurgy. The scientists had innumerable projects and the cash flow from the projects and consultancy was fairly large and most of those engaged in these projects had to work within the time frame committed to their clients.

It was my feeling that my designation Sr.Controller of Administration was a misnomer as I was a facilitator to ensure that the activities of the organization are carried out without much hassles. I was fortunate; the staff & officers working with me were experienced; used to routine functions for many years in the same capacity were not hesitant to change their way of working - though with initial reluctance - according to the needs of the tab. Complacency being the inherent quality of most human beings, they were receptive to my way of working. My exposure to different types of pulls and pressures in several of my previous employments in both Public sector and also as a Sr.Executive in a Multinational had moulded me to withstand all sorts of professional pressures thus enabling me to stand up to the expectations of the organization wherever I worked. This was proved when the Fifth Central Pay Commission Recommendations were to be implemented in NML. Disproving the " Doubting Thomases ", we were able to complete the pay fixation and payment of arrears for the entire staff within seven days. My colleagues in all the branches of administration deserve credit for their wonderful performance.

I and my family enjoyed our stay in Jamshedpur. My father who was racing towards his ninetieth year was quite comfortable as he was fluent in as many as nine Indian languages. As part of my career progression, I moved to Gujrat in the year 1999 and my contact with NML slowly reduced.

It is heartening to note that NML is celebrating its Diamond Jubilee this November. When you look back, you can count the milestones erected along this long route. The change in global scenario has dismantled the national boundaries and different Nationals and MNCs are vying with each other in every sector thus making survival difficult. Diamond Jubilee year is not a mean achievement and NML deserves what it is today - a No. I slot in Metullurgy and related fields. I dream of a day when the world looks towards NML for Technology and Support. Scientific excellence achieved during the last six decades should form the core of its strength. This, I feel is not an impossible task considering that the mantle of managing and taking NML to greater heights is in the hands of younger leadership.



NML Diamond Jubilee Celebrations

RAMA MAHADEV
Sr. Controller of Administration
Nehru Aerospace Centre, Bangalore

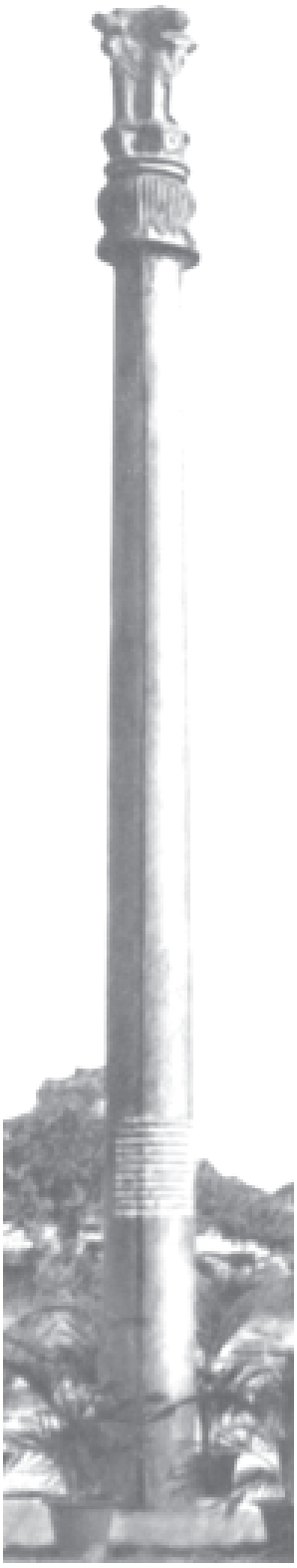
It is a matter of great pleasure and pride for me to reminisce my association with National Metallurgical Laboratory, as the Laboratory celebrates its Diamond Jubilee.

NML is my parent Laboratory in CSIR and my initial grooming in Administration was at NML under the able guidance of Shri S K Roy, AO (SG).

My fond remembrance of NML are the imposing architecture of the Main Building of the Laboratory, the plain speaking nature of the people who made the Laboratory, Cultural activities organized by the Ladies Club and the Staff Club on various occasions, the Ladies Lounge that was unique in CSIR, and the farewell function to all retirees on a uniform scale, at the same venue.

I recall with a great sense of satisfaction my association with the initial computerization of administrative functions undertaken at NML in the year 1987 along with Shri R Chakraborty, AO with assistance from Shri Maulik and Shri Patnaik, Scientists. I also wish to place on record that my initial experience gained in a Laboratory of the size and stature of NML has stood me in good stead in discharging higher responsibilities in other CSIR laboratories / institutes.

As I lay down office as Sr CoA at NAL, Bangalore in August, 2010, I send my greetings and good wishes to the Director, Staff members and their families for a glorious future for the laboratory and every one associated with the Laboratory.



My Forty Two Years in NML

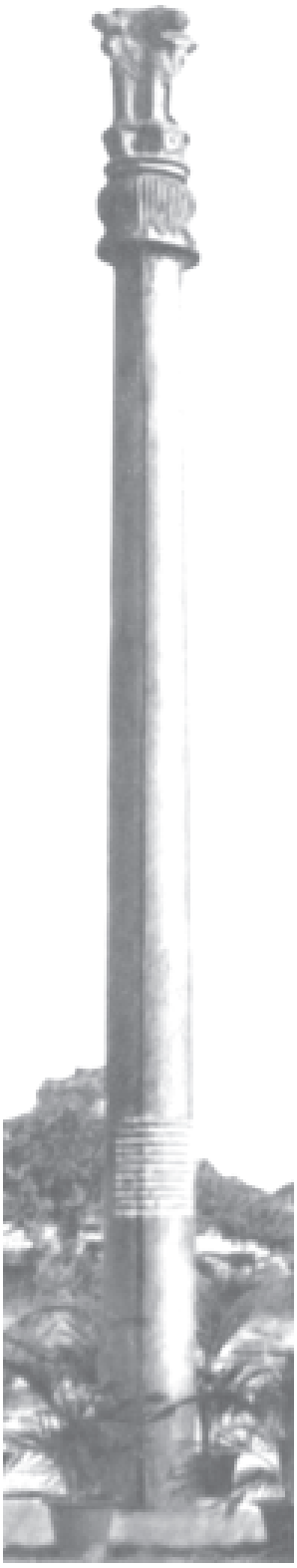
D. K. GOSWAMI
Ex-Technical Staff, NML Jamshedpur

Joined NML in January 1959 under the directorship of Dr. B.R. Nijhawan, first Indian Director of NML. Started my first assignment in Low Shaft Furnace Project (LSFP) division whose in - charge was Dr. A. B. Chatterjea. In those days for the first time in our country Low Shaft Furnace was established at NML and low shaft furnace project was inaugurated by Sardar Swarn Singh, Honorable Central Minister, Govt. of India for the production of pig iron. Subsequently Mineral Beneficiation Pilot Plant (MBPP) was established under the guidance of Dr. B. R. Nijhawan in the nearby campus. The low shaft furnace was operated using charcoal/nut coke as reductant and lime stone as flux making use of iron ores from different locations in India. During the initial stage of operation of low shaft furnace, some mishaps took place, as a result a few workers were injured and one permanent staff got burnt and lost his life. Accordingly necessary compensation was given to the affected persons by the NML authorities. Gradually, the operation of the furnace got established and briquettes were made using iron ore fines, charcoal fines, limestone/ dolomite fines and molasses as binder and successfully smelted for the production of pig iron improving the quality of metal and productivity of the furnace. Dr. A. B. Chatterjea always used to inspire the staff of low shaft furnace to contribute sincerely for the success of this prestigious project of our country. This furnace was in operation till 1969 testing a number of samples of iron ore and different reductants. Dr. B.R. Nijhawan gave entirely a new outlook to the laboratory by establishing 500 KVA Pilot Scale Submerged Arc Furnace in 1962 for the production of high carbon ferro - alloys and Semi - Commercial Scale Plant for the production of magnesium for defence applications.

Dr. B.R. Nijhawan was excellent human being and used to visit the laboratory during the operation of pilot plants even at midnight alongwith Mrs. Nijhawan. He used to visit even the hospitals to take care of the health of NML employees. NML employees association came into existence in late 1950s during the regime of Dr. B. R. Nijhawan and it used to have dialogue with him from time to time to discuss the grievances of different categories of employees. Dr. Nijhawan was quite considerate towards the legitimate problems of the workers. After the departure of Dr. B. Nijhawan, Dr. T. Banerjee, a prominent scientist of India, was the acting Director of NML for a few years and he contributed significantly for the development of the laboratory. During August 1969 Prof. V. A. Altekar from UDCT Bombay joined as Director of the laboratory and he initiated a number of laboratory scale and bench scale R & D activities at NML apart from the ongoing investigations/testings in the pilot plants. The credit of establishing the Creep laboratory for the first time in India for fatigue, fracture and failure analysis of critical components from heavy industries and power plants goes to Prof. V.A. Altekar. Even today it is considered as one of the best facility in Asia. Dr. R. Kumar, Director Grade scientist and expert of physical metallurgy was the In - charge of creep laboratory and he was acting Director of NML for some time after the departure of Prof. Altekar in March 1985. Almost all the Directors of NML tried their best to provide accommodation to NML staff. Dr. Nijhawan took keen interest in building the Golmuri residential campus while Prof. Altekar for building 12 storied flats and 5 storied flats in Agrico campus of NML. Further scientist apartments were built in Agrico campus by Prof. S. Banerjee, the then Director of the laboratory. As a result newly joined scientists during the regime of Prof. S. Banerjee could easily avail official accommodation.

The activities of NML Employees' Association (NML EA) were quite vigorous during the regime of Prof. S. Banerjee. NML EA initiated New Year's Celebration in January 1989 inviting the then Director Prof. S. Banerjee to address the employees. Subsequently NML SWA and NML administration also assisted in organizing this celebration each year. During the regime of Prof. P. Ramachandra Rao as Director, NML EA successfully organized an all India Seminar "Workers Participation in Project Management" followed by an all India get together in which workers representing almost all the laboratories of CSIR participated. This seminar was inaugurated by a Cabinet Minister, Govt. of Bihar at NML auditorium. Further NML EA succeeded in having a dialogue with Prof. Rao to distribute motivating allowance to each employee of NML before Durgapuja each year. Even today this allowance is being continued by NML authorities. Prof. Rao initiated NML foundation day on 26th November each year. He also introduced NML song being recited on special occasions as well as best worker award to inspire NML workers to dedicate themselves in their respective assignments. Prof. Rao was a kind hearted person and he always tried to do his best for the betterment of the workers and the laboratory at large.

I am very much glad that Dr. S. Srikanth, good sportsman, an energetic scientist and good leader has recently taken over the Directorship of NML. I am sure under his able leadership, NML will have many more achievements in the field of science and technology and it will be one of the best laboratories/ institutions of CSIR in future.



NML's Padyatra

NML desires that all divisional heads, sectional heads, AO, FAO, and PO be present at the conference hall at 4 pm to discuss progress about various projects. All concerned persons with their files, plans, progress charts etc. get ready to join this marathon session. This was in years up to 1966 (I have experienced from 1962). It starts exactly at four and each division and section discusses their progress, new plans, any time bound activities, delays and their remedial measures. Usually it used to be serious session but it was worth seeing the faces of most scientists full of tensions, searching for answers, ready for absorbing sarcastic remarks or appropriately answering them. Each one has to explain the reason for poor progress, delays, hurdles, poor performances etc. To save themselves the targets used to be purchase officer (strict GOI purchase procedures), Head of Electrical, Mechanical, Civil and Electronics. They also by virtue of experience counter attack the scientists for giving incomplete information or non cooperation. It used to be very interesting as everyone enjoys the fun over the embarrassment of others. This was never deprived of the moments of laughter particularly because of the remarks of D'NML. I am reminded of one when D'NML requested one senior officer (he was hard of hearing, but with hearing aid) to call an officer who was not present. God knows what he heard but he went and called a senior lady officer. When she came with a perplexed face, the whole hall was in laughter for few minutes. Such instances broke the monotony of serious discussion. This session used to continue till about 7-30 to 8 pm.

This will then be followed by 'PADYATRA'. It only means that D'NML will visit along with some Deputy Directors and Engineering divisional heads to go to all the divisions and sections and the scientists will have to explain the problems right affront and solutions are given there and then and no excuses are accepted. This will continue till 9-30 to 10pm. Sometimes the tea will be served. This caused lot of worries, tensions and grumbling by the wives and family members. Nevertheless this whole thing has positive and negative points. I will still call the positives surpasses negatives in a big ways.

K.N.GUPTA
Ex-Scientist, NML Jamshedpur

Do not Laugh

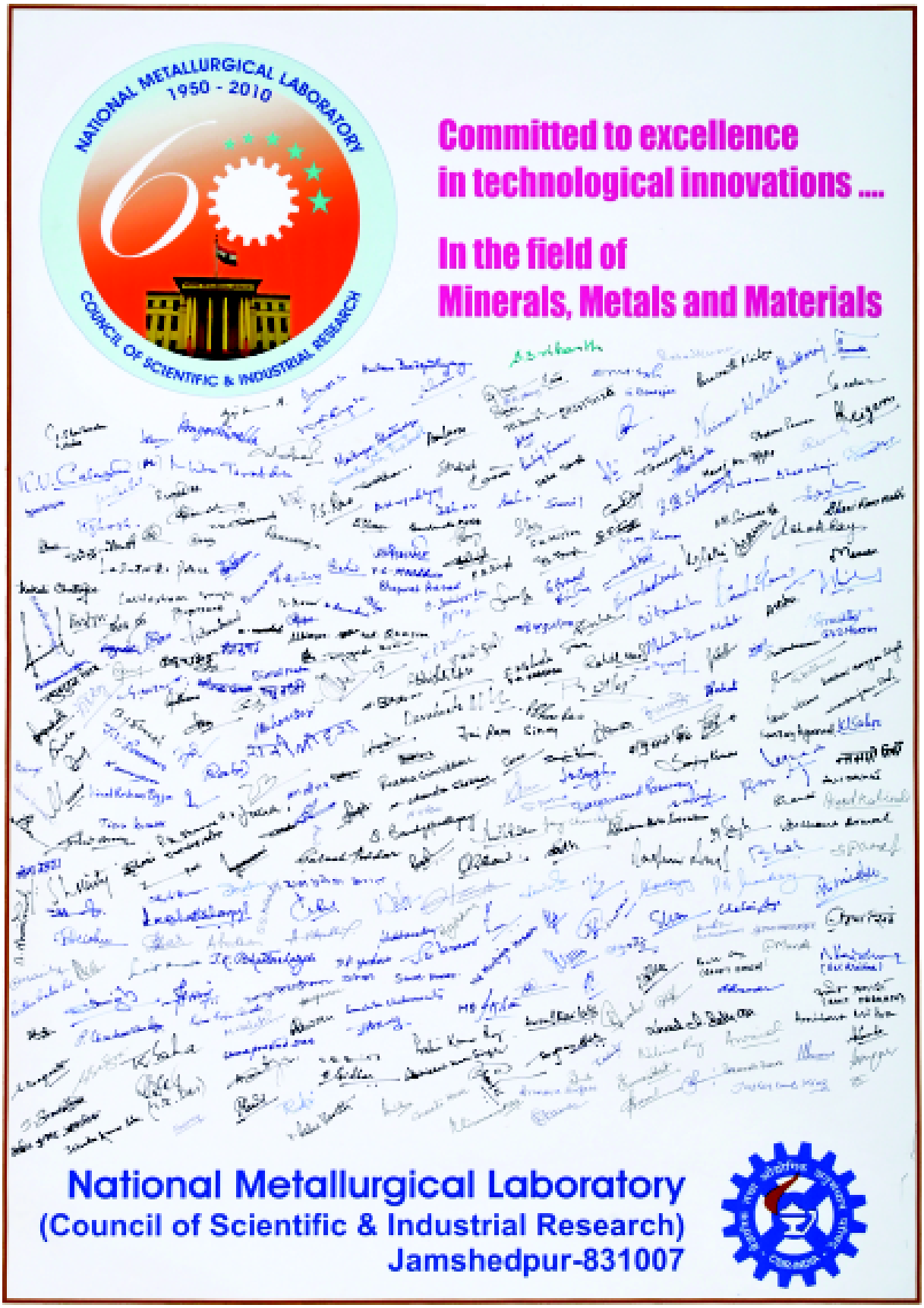
At the time of farewell of Mrs Nilima Chakraborty, our Library incharge, Prof. V.A. Altekar related that in one of the papers, she had asked him to "Sing here" and with his red pen, he had circled the words and remarked " Where do you want me to sing?" She had sent the papers for his signature and in place of "Sign", she had written "Sing".

At the time, Scientist C and above were to get their EL sanctioned from the director and I had applied for my earned leave for about 21 days and sent the same for sanctioning to Prof. V.A.Altekar, the then Director. But somebody had complained against me that I was taking too many leaves (usually I used to take half day CLs to finish my work and had applied for EL after a gap of two years). So Prof. Altekar accused about the same. When I told him that I have 60 days EL and taking the EL after a gap of two years, then he understood that he was given wrong information. Then he smiled his sweet smile and sanctioned my leave saying "So officially you are taking your leave after two years"

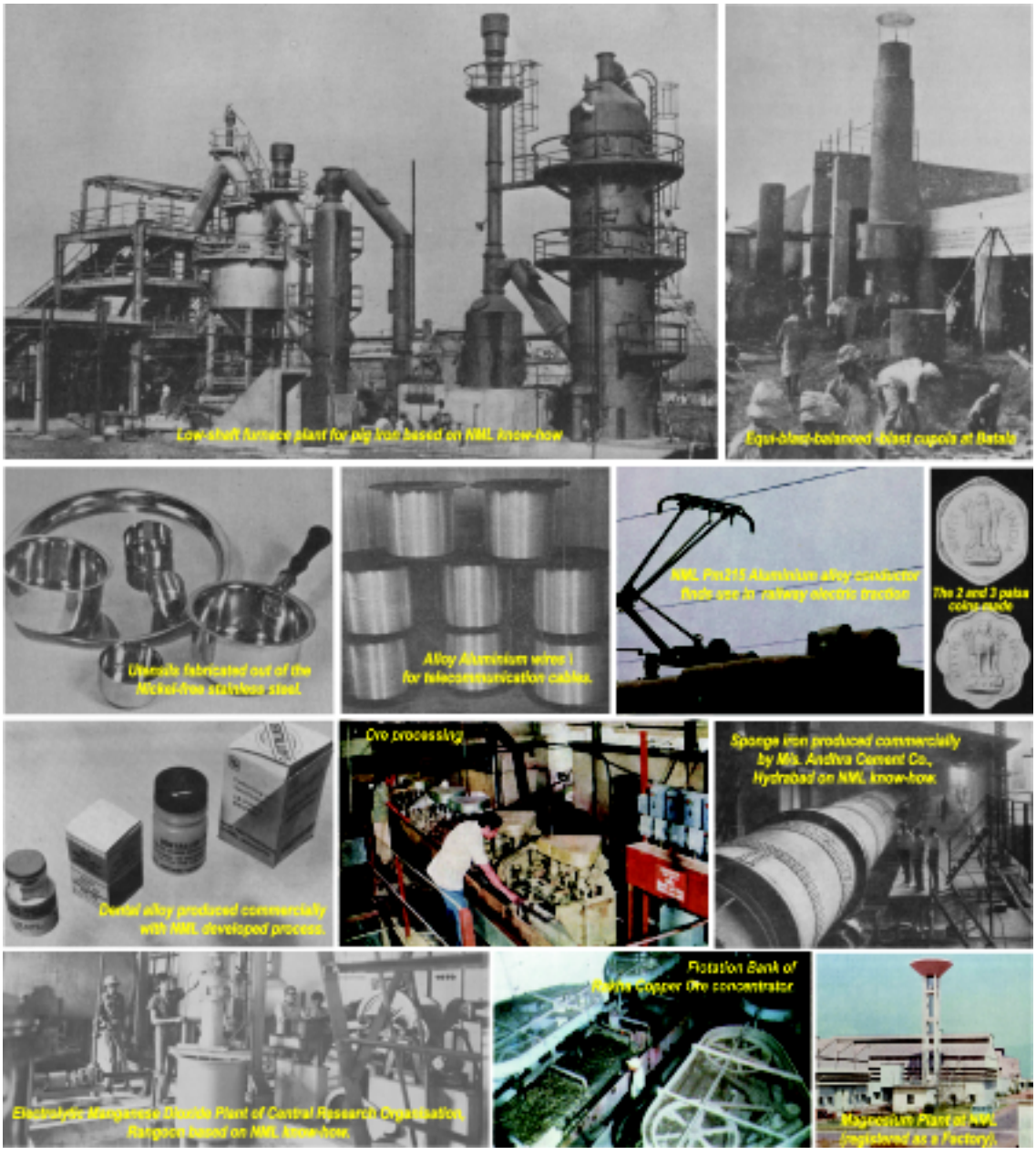
Prof. B.R. Nijhawan, the then Director, was standing near the main gate and checking the people who came late. Our Mistri, T. Banerjee, came late and when asked why he was late, explained that he got his cycle tube punctured and hence the delay. He asked somebody to go with him on a truck and get it confirmed. Banerjee immediately apologised and took resolve not to tell a lie in future and come late.

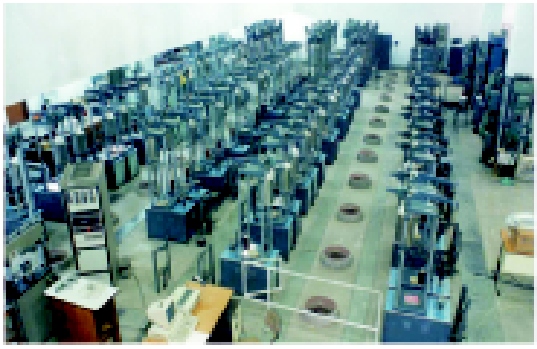
Dr. S.K. NARANG
Ex Scientist, NML Jamshedpur

Spectrum in Retrospect
ISO 9001-2000
Crashed SU-30MKI
GOLDEN JUBILEE
50
Years of
NML
IN SERVICE TO THE NATION
1950-2000


NATIONAL METALLURGICAL LABORATORY
1950 - 2010
COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
Committed to excellence
in technological innovations ....
In the field of
Minerals, Metals and Materials
National Metallurgical Laboratory
(Council of Scientific & Industrial Research)
Jamshedpur-831007

Over last 60 years NML grew from strength to strength and contributed significantly to the industrial development and economic growth of our country. NML's research, development and pilot studies were suitably oriented to meet the urgent requirements necessitated by the rapid expansion of mineral and metallurgical industries during the successive Five Year Plans.





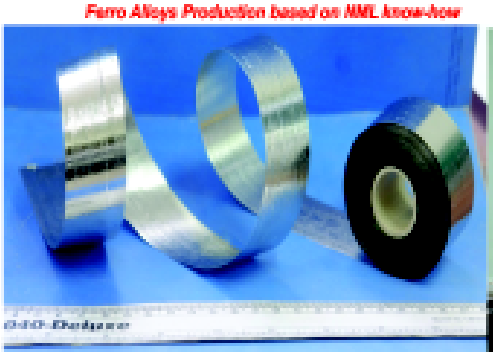
Creep Testing Bay

Gas based cokeless Cupola

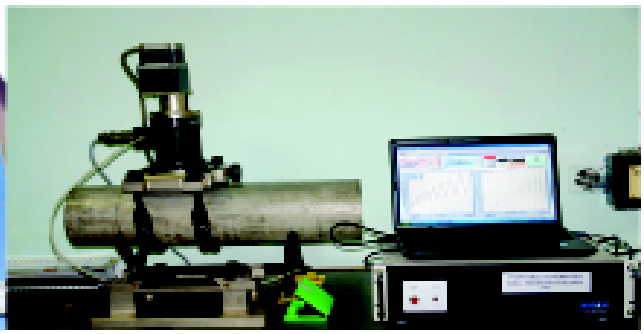
Metasave, Manufactured by Metall Corpn. based on NML knowhow - finds use at Pickling Plant of Tata Steel

Column flotation

Ferro Alloys Production based on NML know-how



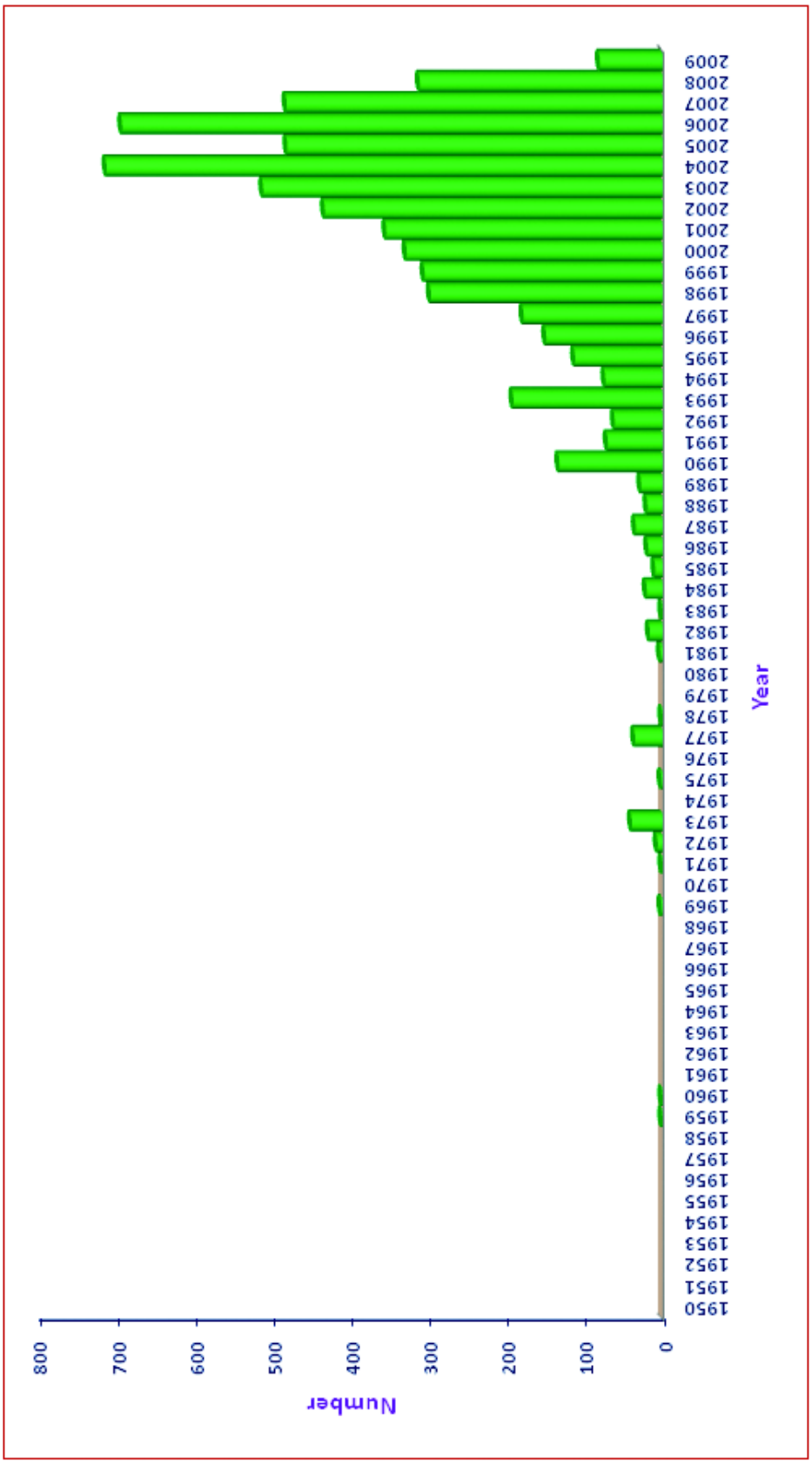
Metallic Glass Ribbon



Portable Automated Ball Indentation System

Research Publication

Citation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Papers / Reports Presented

Patent /Copyright

Manpower

Scientific
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Administrative
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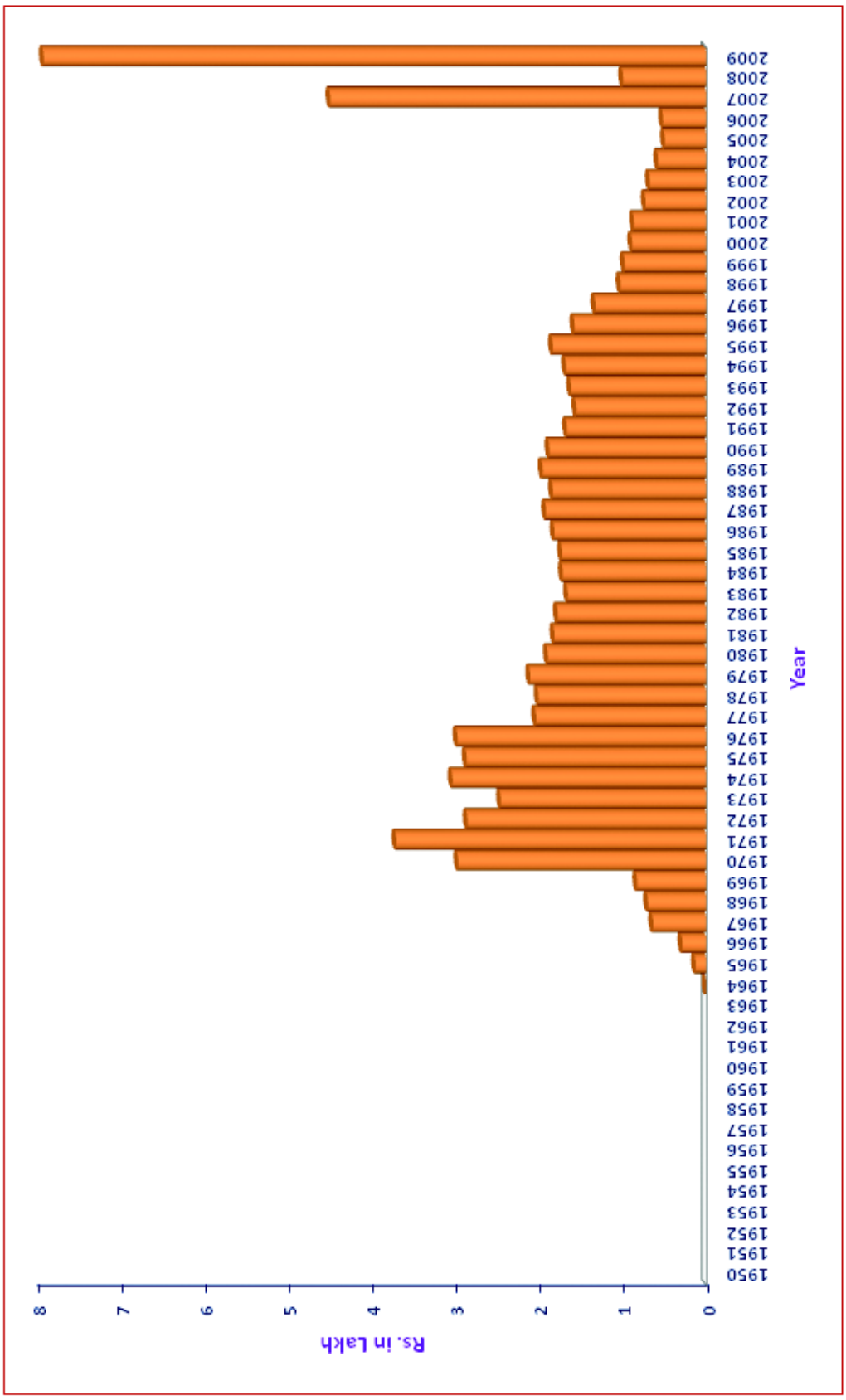
Technology Transferred

Royalty Received



Budget

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EBR Generated

NML
Symposium on Pilot Plants
Processing of Fines

Commercialisation of Technologies

Sl. No.	Process	Licensee	Year
1.	Carbon bonded graphite crucibles	Released to a local state based entrepreneur	1957
2.	Electroplating on aluminium	Released to several parties, non exclusive royalty free at lump sum terms to SSI Units	1958
3.	Chemical polishing on aluminium	Released to several parties, non exclusive royalty free at lump sum terms to SSI Units	1958
4.	Brass plating from non-cyanide bath	Released to several parties, non exclusive royalty free at lump sum terms to SSI Units	1958
5.	Metallization of non conductors	Released to several parties, non exclusive royalty free at lump sum terms to SSI Units	1958
6.	Improvement in or relating to mullite refractories from kyanite	Released to several parties, non exclusive royalty free at lump sum terms to SSI Units	1959
7.	Refractory composition comprising graphite and silicon carbide	Released to several parties, non exclusive royalty free at lump sum terms to SSI Units	1959
8.	Liquid Gold	Delhi based firm	1960
9.	Aluminium plating	SSI Units	1961
10.	Electrolytic Manganese Dioxide	M/s. T. K. Chemicals, Bombay	1961
11.	An improved process for electrolytic production of high-purity manganese dioxide	*	1962
12.	An improved method for the production of manganese salts from manganese ores, and its application for the regeneration of the spent electrolytic manganese sulphate baths	*	1962
13.	An improved process for the production of electrolytic manganese metal	*	1962
14.	Improvements in or relating to magnesium silicate refractories and use of the same	Released to several parties, non exclusive royalty free at lump sum terms to SSI Units	1962
15.	A process for making completely stabilized dolomite refractories	Released to several parties, non exclusive royalty free at lump sum terms to SSI Units	1962
16.	Brass plating from non-cyanide bath	*	1962
17.	Production of dense carbon aggregate suitable for being used as base materials for being used as base materials for cabon products in general and soderberg paste in particular	*	1962
18.	Production of electrical resistance alloys for heating elements	*	1962
19.	Technology of production of thermostatic bimetals	*	1962

20.	Production of alnico type permanent magnets	*	1962
21.	Production of chemically bonded metal-clad or unclad basic refractory	*	1962
22.	Production of iron powder for autogenous cutting	*	1962
23.	Production of carbon-free ferro alloys by alumino-thermic reactions	*	1962
24.	Hot Dip Aluminising of Ferrous Materials	M/s. K.S.M Lab. Glass Works 11 Mount Road (Little Mount), Saidapet, Chennai	1962
25.	Improved Carbon Bonded Graphite Crucibles	M/s. Maheshwary Graphite Udyog Pvt. Limited, Vijayawada	1963
26.	Improved Carbon Boned Graphite Crucibles	M/s. Patna State Graphite & Mining Co. Limited, Tililagarh, Orissa	1963
27.	Pectin and Aluminsing of Ferrous Materials	M/s. Pharma Trading Co. Pvt. Limited 2, Minto Park, Kolkata	1963
28.	Hot-dip aluminising of ferrous materials (Aluminised Wires).	M/s. Sri Venkata Durga Aluminising Works Ltd., Nandigama, AP	1963
29.	Thermostatic Bi-metals	M/s. Cable Works (India) Limited 47, Hide Road, Extension, Kolkata - 700 027	1964
30.	Zinc metal from zinc drosses and waste	M/s. Indian Tube Company	1964
31.	Improved clay-bonded graphite crucibles	M/s. J.D. Jones & Co. Limited 1, Hulang Road, Calcutta	1964
32.	Improved clay bonded graphite crucibles	M/s. Patna Sate Graphite & Mining Co. Limited, Titlagarh	1964
33.	Improved Clay Bonded Graphite Crucibles	M/s. Maheshwary Graphite Udyog Pvt. Limited, Vijayawada	1964
34.	Ceramic magnet from blue dust		1965
35.	Hot Dip Alumining of Ferrous Materials	M/s. Hind Steel Co., 431, G.I.R., Shahdra, Delhi	1965
36.	Carbon free ferro-alloys by alumino thermic process	M/s. R. Sen & Company 10/1, Culcutt	1966
37.	Ceramic Magnets	M/s. Ceramic Magnetsoh Product Moonlight Flat No. 12, 158 Oueens Roa, Mumbai	1966
38.	Hot Dip Aluminising of Ferrous Materials	M/s. Rainbour Industries, 78, Gandhi Park, Indore	1966
39.	Carbon-free ferro alloys	M/s. Bharat Pulverishing Mills Limited, Bombay	1967
40.	Carbon-free ferro alloys	M/s. T.K. Industries, Kurukhshetra	1967
41.	Improved Carbon Boned Graphite Crucibles	M/s. Mattapalli Satyam & Sons, Samalkot, Andhra Pradesh	1967
42.	Basic lined side blown converter	M/s. Mehra Ferro Alloys Ltd., Amritsar	1967
43.	Carbon free ferro-alloys	M/s. Stemet Alloys Ltd., New Delhi	1967

44.	Ceramic Magnets	M/s. Tapadia Engineers & Traders Pvt. Limited Post - Jugsalai, Tatanagar	1967
45.	Carbon-free ferro alloys	M/s. Industrial Minerals & Chemicals Co. Limited, Bombay	1968
46.	Carbon free ferro-alloys	M/s. Saindas Kishan Chand Mehra, Amritsar	1968
47.	Hot-dip Aluminising of ferrous materials	M/s. Sri Venkata Durga Aluminising Work, P.O. Nandigrama	1968
48.	Brightener Composition for bright nickel plating	M/s. Dunlop India Ltd., Calcutta - 16	1970
49.	Production of metal powders by atomization of molten metals	Shri A.K. Mishra B 37/111, Parvati Bhavan, Baijnath (Kamachao), Varanasi - 1	1970
50.	Production of metal powders by atomization of molten metals	M/s. Sinterfine Metals Powders, New Delhi	1970
51.	Fluxes for submerged arc welding	M/s. Tapadia Engineers & Traders Ltd., Raipur	1970
52.	Basic lined side blown convertor	M/s. Mehra Ferro Alloys Limited, Amritsar	1971
53.	Electric grade aluminium alloy	M/s. Aluminium Cables & Conductor Ltd., Calcutta	1972
54.	Carbon free ferro-alloys	M/s. Electric Control Gear Pvt. Ltd., Ahmedabad	1972
55.	Metal powders by atomization (i) of molten metals (Al & Zinc-60 to +200 mesh size)	M/s. Industrial Minerals & Chemicals Co., Bombay, 125, Narayan Dhuru Street, Nagadevi, Mumbai - 3	1972
56.	Electric grade aluminium alloy	M/s. Bharati Smelting & Refining Corporation, Worli, Bombay	1973
57.	Improved carbon bonded graphite crucibles	M/s. Silcarb Crucible Pvt. Limited, Vapi Industrial Estate, Gujarat	1973
58.	Production of Extra Fine zinc dust	M/s. Associated Pigments Limited, Calcutta	1974
59.	Aluminium Alloy PM-2 Conductor	M/s. Bharati Smielting & Refining Corporation Khanna Construction Hosue, 44A Gaffa, Mumbai	1974
60.	Aluminium Alloy PM-2 Conductor	M/s. Narbheram & Company Pvt. Limited Railway Station Tatanagar (SE Railway), Jamshedpur - 831 002	1974
61.	Hot Dip Aluminising of Ferrous Materials	M/s. Bharat Aluminising Corporation Maninager 4, Chotd, Ahmedabad - 8	1975
62.	Improved Graphite Crucibles (Carbon Bonded)	M/s. Circar Graphite Products 16-20, Gandhi Puram, Innispeta, Rajahmundry - 3	1975
63.	Aluminium Alloy PM-2 Conductor	M/s. Galada Continuous Casting Limited P-2.6, IDA Block - III, Uppal, Hyderabad	1975
64.	Basic lined side blown converter	M/s. Kartar Iron & Steel Co. Ltd., Jamshedpur	1975
65.	Basic lined side blown convertor	M/s. Pratap Steels Limited, Mahindra Groups, Amritsar	1975
66.	Production of Ferro-vanadium	M/s. Mysore Iron & Steel Works, Bhadravati	1975

67.	Bi-metallic powders by atomization	M/s. Paras Metal Powders, Nasik.	1975
68.	Hot Dip Aluminising of Ferrous Materials	M/s. Andhra Pradesh & Linine Corporation Limited, Nizansays Factory Limited, Hyderabad	1976
69.	Electrical Resistance Alloys for Heating Elements	M/s. Cable Works (India) Limited 47, Hide Road, Extension, Kolkata - 700 027	1976
70.	Hot Dip Aluminising of Ferrous Materials	M/s. K. Nivas, 309,C Defence Colom, New Delhi	1976
71.	Electrical Resistance Alloy for Heating Elements	M/s. Met Industries 166, Jessore Road, Kolkata - 700 055	1976
72.	Extra Fine Metal Powders	M/s. Metapow Industries 1216.12, Eersha, K.P. Kulkarni Marg, S. Poona	1976
73.	Insecticidal Coating Composition	M/s. Nalimal Servers & Wire Products Limited 51, Steplious 4, Dalhousre by East Colo, Kolkata	1976
74.	Dental Amalgam Alloys	M/s. Shakti Industries A-1.69, Gaighat, Varanasi	1976
75.	Liquid Gold	M/s. Universal Chemical Industries (Popular Watch) Co. Gharwas Rolhi, Chowk Masjid, Desk, Shahbad	1976
76.	Belencyler Acid	M/s. Aceto Chemicals (P) Limited 22, Barbousme Road, Kolkata	1977
77.	Galvaflux	M/s. Adityapur Dies, Jamshedpur	1977
78.	Submerged Arc Welding Fluxes	M/s. Alloy Specialties 73, 1st Crase 8th Block Jayanagar, Bangalore	1977
79.	Liquid Gold	M/s. Andeep (India) C-3.255, Janakpur, New Delhi - 110 058 M/s. Gujarat Bullion Refinery, Ahmedabad - 7	1977
80.	Production of sponge iron with solid reductant	M/s. Andhra Cement Co., Vijayawada	1977
81.	Dental Amalgam Alloy	M/s. Bharat Dental Jugsalai, Jamshedpur - 831 006 M/s. Dentifils (India) Ltd., Jamshedpur	1977
82.	Thermostatic bi-metals	Cable Works (I) Ltd., Calcutta 47, Hide Road, Extension, Kolkata - 700 027	1977
83.	Hot Dip Aluminising of Ferrous Materials	M/s. Electrical Mfg. Co. (P) Limited 2, Minto Park, Kolkata	1977
84.	Paint grade stainless steel powder	M/s. Euroflax Transmission (India) Pvt. Limited, Aydersad, Balanagar, Gandhinagar	1977
85.	Hot Dip Aluminising of Ferrous Materials	M/s. Golden Shaf Food Wire industrial 15, Gsand Trunk Road, Licuha	1977
86.	Setting up of a pilot plant for production of Electrolytic Manganese Dioxide (50 kg/day)	M/s. Central Research Organisation, Govt. of Burma Rangoon	1977
87.	Iron Power For Auto Generous Culling	M/s. Indian Oxygen Limited 48.1, Diamond Harvers Road, Kolkata - 700 001	1977

88.	Hot Dip Aluminising of Ferrous Materials	M/s. Macman (P) Limited M/s. Masuli Palam Road, Industries, State. P.O. Vijaywada	1977
89.	Basic lined side blown converter	M/s. Pratap Steels Ltd., Mahindra Garh, Amritsar	1977
90.	Thermostatic bi-metal	M/s. Precism Products & Metallic Alloys Co. K-69, howrah Industrial Estate, Howrah	1977
91.	AlNiCo Type Permanent Alloys	M/s. Precism Products & Metallic Alloys Co. K-69, Howrah Industrial Estate, Howrah	1977
92.	Thermostatic Bi-Metal	M/s. A.J. Electronics 39.55, Evndawana, 9.B Prabhat Road, Poona	1978
93.	Copper Clad Aluminum Sheets and Strips	M/s. Adarsh Engineers Post Box No. 165, 8 Circuit House Areas, Jamshedpur - 831 001	1978
94.	Production of extra fine zinc dust	M/s. Associated Pigments Ltd., Calcutta	1978
95.	Electrical Resistance Rods, Wires & Strips for Heating Elements	M/s. Beni Limited 117, B.T. Road, Kolkata - 700 058	1978
96.	Nickel Magnesium Alloys	M/s. Industrial Minerals and Metals 11.11, Shaktinagar, New Delhi - 110 007	1978
97.	Liquid Gold	M/s. Industrial Products (India) Attn. Sh. S.B.Singh, 3016, Sector 21-D, Chandigarh 160 022	1978
98.	Carbon Free From Alloys by Alumino Thermic Reactions	M/s. Sain Das Kishan Chand Mehra Kalsa Aluwalhian, Amritsar	1978
99.	Hot Dip Aluminising of Ferrous Materials	M/s. Shiva Wire & Slut. Prod. Limited 21, Jalinda Mohe Avenne, Kolkata	1978
100.	Hot Dip Aluminising of Ferrous Materials	M/s. Wens Alumizess 20, Firoj Gandhi Road, New Delhi	1978
101.	Nickel Magnesium Alloys	M/s. ABM & Metal Alloys D-1, Industrial Estate, Sagar Road, Shimoga - 577 016	1979
102.	Hot Dip Aluminising of Ferrous Materials	M/s. Aluminium Coatings & Castings F-47, Cannaught Place, New Delhi - 110 001	1979
103.	Aluminium Base Sacrificial Anode for Cathodic Protection	M/s. Aluminium Manufacturing Co. Limited 2, Jessoree Road, Kolkata - 700 028	1979
104.	Hot Dip Aluminising of Ferrous Materials	M/s. Assam Bengal Casehoord Co. Pvt. Limited Kolkata - 700 001	1979
105.	Reactive Filters for Aluminium and its Alloys	M/s. Bhaskar Stoneware Pipe Pvt. Limited Post : Ishwar Nagar, New Delhi - 110 065	1979
106.	Hot Dip Aluminising of Ferrous Materials	M/s. D.S.C. Roubey & Sons Private Limited 24, Strand Road, Kolkata	1979

107.	Hot Dip Aluminising of Ferrous Materials	M/s. East India Wire Industries 178, Mahatma Gandhi Road, Kolkata - 700 007	1979
108.	Copper Enamels	M/s. Electronic & Industrial Instruments Co. Pvt Ltd. B-17, Industrial Estate, Sanatnagar, Hyderabad - 560 018	1979
109.	Copper Enamels	M/s. Indian Copper Corporation, Gillanders House Netaji Subhas Road, Kolkata	1979
110.	Liquid Gold	Jitendra Jethala 7.9, Isarael Mohalla, Bachooali House, Mumbai - 400 009	1979
111.	Automatic Carbon Analyser	M/s. K.S.M. Lab. Glass Works	1979
112.	Hot Dip Aluminising of Ferrous Materials	M/s. Orissa Wire Products Pvt. Limited, Cuttack	1979
113.	Carbon Free Ferro Alloys by Alumino Thermic Process	M/s. P. Jalan Co. Wire Cond. Delhi Pvt. Limited, 14th Floor, 6, New Delhi - 110 019	1979
114.	Carbon Free Ferro Alloys by Alumino Thermic Process	M/s. Pratap Steel Rolling Mills (1935) Limited Pratap Estates, Chehharta - 143 105	1979
115.	Hot Dip Aluminising of Ferrous Materials	M/s. Prem Udyog (P) Limited, 211, New Cloth Market, Ahmedabad - 2	1979
116.	Hot Dip Aluminising of Ferrous Materials	M/s. Ramswrup Industrial Corporation, Kolkata	1979
117.	Carbon Free Ferro Alloys by Alumino Thermic Process	M/s. Rare Metals and Chemicals 80-A Burdwan Compound, Kali Mandir, Ranchi - 1	1979
118.	Submerged Arc Welding Fluxes	M/s. Southern Electrodes Limited Mould Ali Industrial Area, Hyderabad	1979
119.	Arc Welding Fluxes	M/s. Tapadia Engineers & Traders Pvt. Limited Post - Jugusalai, Tatanagar	1979
120.	Ceramic magnets; Ferrite magnets	M/s. Tapadia Engineers & Traders Pvt. Ltd., Raipur	1979
121.	Hot Dip Aluminising of Ferrous Materials	M/s. Tayahi Bucket Oippon Rond Factory, Mumbai	1979
122.	Aluminium Alloy (NML PM-2)	M/s. Universal Cables Limited Post Box No. 9, Satna - 485 001	1979
123.	Hot Dip Aluminising of Ferrous Materials	M/s. Asian Industry Sabun Godam, Bhagat Road, Meerut	1980
124.	Hot Dip Aluminising of Ferrous Materials	M/s. Banita India Limited 13-N, Cannaught Circus, New Delhi	1980
125.	Electrical Resistance Alloys for Heating Elements	M/s. Cable Works (India) Limited 47, Hide Road, Extension, Kolkata - 700 027	1980
126.	Ceramic Magnets	M/s. G.P. To Lemi Co. Citadelm, Nepean Road, Mumbai	1980
127.	Hot Dip Aluminising of Ferrous Materials	M/s. Gupta Aluminising Industries Mathura Prasad Sheo Prasad, Kuli Bazar, Kanpur	1980

128.	Electrical Resistance Alloys for Heating Elements	M/s. Heatwell (India) Pvt. Limited 18, Mayfair Road, Kolkata - 700 019	1980
129.	Hot Dip Aluminising of Ferrous Materials	M/s. Hindustan Construction Commercial Corporation 218-A, A Chittaranjan Avenue, Kolkata	1980
130.	Carbon Free Ferro Alloys by Alumino Thermic Reactions carbon	M/s. Jeypore Sugar Co., Limited, Rajagada, Dt. Koraput	1980
131.	Hot Dip Aluminising of Ferrous Materials	M/s. K.S. Chaudhri Indian Aliminising Com G-20, C.I.J. Bidg, Kolkata	1980
132.	Air & Nitrogen Automized Extra Fine Metal Powders	M/s. Maser Pvt. Limited 20, Sheila Mahal 1st Pasta lane Coloba, Mumbai - 5	1980
133.	Carbon Free Ferro Alloys by Alumino Thermic Process	M/s. Mysore Manganese Company Pvt. Limited 218, Upper Palace Orchards (Bellary Roa), Bangalore - 560 080	1980
134.	Hot Dip Aluminising of Ferrous Materials	M/s. Navsari Processing Industry Pvt. Limited Dhadake Bangalow, Lunskui, Navsari	1980
135.	Hot Dip Aluminising of Ferrous Materials	M/s. Paramount Iron & Steel Works (Pvt.) Limited 1667-A, Dewan Hall, Chandni chowk, New Delhi	1980
136.	Improvements in or Relating to Modifications of Aluminium Base Alloys	Prof. Dr. Ing. A. Wittmoser, University of Aachen 684, Hamperthein, Near Man him, Heperthein	1980
137.	Liquid Gold	M/s. Shree Ram Industries Phase - III, F-I(P), Industrial Area, Bokaro - 014	1980
138.	Hot Dip Aluminising of Ferrous Materials	M/s. Shri Ct. Alagappan 32, Haddours Road, Hungamba Kkam, Chennai	1980
139.	Improved Graphite Crucibiles (Carbon Bonded)	M/s. Coromandal Crucibiles, Industrial Estate, Samalkot	1981
140.	Semi Automatic Carbon Analyser	M/s. Equipment Sales & Service Corporation III L.D. Road, Little Mount Road, Chennai - 015	1981
141.	Extra Fine Metal Powders	M/s. Prosencentre Industrial & Business Co. 16, India Exchange Place, 3rd Floor, Kolkata-700 001	1981
142.	Extra Fine Metal Powder	M/s. The Fortwilliam Co. Limited 14, Netaji Subhas Road, Kolkata - 700 001	1981
143.	Refractory Cement (Fondu Type)	M/s. Devraj Anand Ceramics (P) Limited 16, Sourth Side Bulandshahar Road, Ghaziabad - 1	1982
144.	Aluminium Base Sacrificial Anode for Cathodic Protection	M/s. Dum-Dum Valves and Bearings (P) Limited Banik Mansion, 250, Lake Town, B Block, Kolkata - 700 055	1982
145.	Aluminium Base Sacrificial Anode	M/s. Electro Protection Services 161, Velachery Road, East Takbran, Chennai - 59	1982
146.	Electrical Resistance Alloys for Heating Elements	M/s. G.K. Enterprises N.S. 15B, 2nd Phase, Industrial Area, Adityapur, Jamshedpur - 831 001	1982

147.	Extra-fine non-ferrous metal powders by atomization	M/s. NALCO Metal Products Ltd., Madurai	1982
148.	Hot Dip Aluminising of Ferrous Materials	M/s. Technology Syndicate Main Road, Ranchi (Opp. Ranchi Club), Ranchi	1982
149.	Vanadium Enriched Slag from Vanadi Ferrous Iron Ore	M/s. Visvesvaraya Iron & Steel Limited, Bhadravati-1	1982
150.	Extra Fine Zinc Dust	M/s. Zinc Product & Co. Limited Road No. 6, Rajinder Nagar, Patna - 800 016	1982
151.	NML PM-6 Welding Wires / Rods	M/s. Bhoruka Aluminium Limited 1, K.R.S. Road, Metagally, Mysore - 570 016	1983
152.	Submerged Arc Welding Flux	M/s. Electro Flex Pvt. Limited 36, Mehdipatnam Flat No. 21, Golconda, Hyderabad - 500 028	1983
153.	Hot Dip Aluminising of Ferrous Materials	M/s. Emani Metal Industries, G-45, Nizam West, Delhi	1983
154.	Extra Fine Metal Powder	M/s. Jagnnath Pyrotechnic Pvt. Limited Gulmar, H. No. 3-6-15.2, Street No. 24, Nimay, Hyderabad - 500 029	1983
155.	Liquid Gold	M/s. Jyoti Refinery, 16B, Samhita Industrial Area off Andheri, Mumbai - 400 072	1983
156.	Liquid Gold	M/s. Shree Contacts Limited Mohata Niwas, Nelson Square, Nagpur - 440 013	1983
157.	Semi Automatic Carbon Analyser	M/s. Stul City Scientific Products Ramnagar, Post - Kagal Nagar, Jamshedpur - 11	1983
158.	Brightner Composition for Bright Nickel Plating	M/s. Dunlop India Limited Dunlop House, 57-B, Mirza Ghalili Street, Kolkata	1984
159.	Air & Nitrogen Automized Extra Fine Metal Powders	M/s. Extrusions Fe-Mets (India) Limited 6B Lower Circular Road, Kolkata - 700 017	1984
160.	Copper Clad Alumium Sheets and Strips	M/s. Industrial Minerals & Chemicals 125, Narayan Dhuru Street, Nagadevi, Mumbai - 400 003	1984
161.	Aluminium Alloy PM-2 Conductor	M/s. Rishi Alloys Pvt. Limited Naimivilla, 25.1, Rambagh Road, New Muzaffarnagar - 251 001	1984
162.	Metal Powder by Atomisation of Molten Metals	M/s. Sinterfine Metal Powders K-14, Birhal Marg, Jangpura Extn., New Delhi	1984
163.	Air & Nitrogen Atomised Extra Fine Nonferrous Metals Powder	M/s. Associated Traders 1, Nritya Gopal Ghoshal Road, Ariadaha, Kolkata - 700 001	1985
164.	Carbon-Free-Ferro Alloys and such other Metals and Master Alloys Produced By Aluminothermic Process	M/s. Bharat Pulverising Mills Private Limited Hexamer House, Sayani Road, Mumbai - 025	1985

165.	Air & Nitrogen Atomised Extra Fine Nonferrous Metals Powder	M/s. Bharat Pulverising Mills Private Limited Hexamer House, Sayani Road, Mumbai -025	1985
166.	Metal Powder by Atomisation of Molten Metals	M/s. Bharat Pulversing Mills Pvt. Limited Henamar House, Sayani Road, Mumbai - 400 025	1985
167.	Aluminium Alloy Conductor (NML PM-2)	M/s. Fort Gloster Industries Limited 31, Chowringhee Road, Post Box No. 912, Kolkata - 700 016	1985
168.	Aluminium Alloy PM-2 Conductor	M/s. Indian Aluminium Cables Limited Kanchenganga (7th Floor), 18, Barakham, New Delhi	1985
169.	Carbon Free Ferro Alloys	M/s. Kem India Products, 1015, Padyath Road, New Delhi - 110 060	1985
170.	Air & Nitrogen Automized Extra Fine Metal Powders	M/s. Murarka & Sons M - 17, Basanti Colony, Uditnagar, Rourkela - 12	1985
171.	Carbon Free Ferro Alloys By Aluminothermic Process	M/s. Niranjan Mohanty 765, Saheed Nagar, Bhubaneswar - 751 007	1985
172.	Carbon Free Ferro Alloys	M/s. Shemet Alloys (P) Limited 26, Rajinder Parle, New Delhi - 110 060	1985
173.	Manufacture of Carbon Free Ferro Alloys by Alumino Thermic Reaction	M/s. T.K. Industries, 90, Rudra Talkies, Kurukshetra	1985
174.	Inhibitor Suitable for Picking of Steels in HCL Solution	M/s. Chem Tech Enterprises B-12, Industrial Estate, Adityapur, Jamshedpur - 832 109	1986
175.	Carbon-Free-Ferro Alloys and such other Metals and Master Alloys Produced by Aluminothermic Process; production of Cr-Mn Alloys	M/s. Industrial Minerals & Chemical Company (P) Ltd, 125, Narahayana Dhuru Street Nagdevi, Mumbai - 400 003	1986
176.	Metal by Atomisation of Molten Metals	M/s. Industrial Minerals & Chemicals Co. (P) 125, Narayan Dhuru Street, Nagdevi, Mumbai	1986
177.	Hydrochloric Acid Pickling Inhibitor	M/s. Peddington Chemical Industries Wakefield, House Sproti Road, Ballard E, Mumbai - 400 001	1986
178.	Aluminium Based Galvanic Anodes for Cathodic Protection	M/s. Welcome Alloy Pvt. Limited Swarna, 70, Halls Road, Chennai - 600 010	1986
179.	Sacrificial aluminium anode	M/s. Welcome Alloys Pvt. Limited, Madras	1986
180.	Sulphuric acid inhibitor	M/s. Mikasu, Metreat, Jamshedpur	1986
181.	Air and nitrogen atomized extra-fine non-ferrous metal powder	M/s. Extrusion Fe-Mets (India) Limited, Calcutta	1986
182.	Steel in Basic Lined Lide Blown Converter	M/s. Ajay Foundry & Forge Pvt. Limited Partap Mansions, II-3-A, The Mall, Amritsar - 2	1987
183.	Manufacturer of Liquid Gold	M/s. Bharat Pulversing Mills Pvt. Limited Henamar House, Sayani Road, Mumbai - 025	1987

184.	Electrical Resistance Alloys for Heating Elements	M/s. Burgwal Electricals, Bahroi, Moradabad	1987
185.	Air & Nitrogen Atomised Extra Fine Nonferrous Metals Powder	M/s. Kerala State Industrial Corporation Limited Keston Road, Kauediar, Trivandrum - 695 003	1987
186.	Recovery of Vanadium Pentoxide from Sludge of Aluminium Industry	M/s. Rare Metals & Chemicals Burdwan Co., Ranchi	1987
187.	Improved Graphic Crucibles (Carbon Blended)	M/s. Silcarb Crucibles Pvt. Limited Plot no. 147, Gide, Industrial Estate, Vapi, Gujarat	1987
188.	Electrolytic Manganese Metal	M/s. India Manganese Metal B-29, Industrial Estate, Rourkela - 769 004	1988
189.	Air & Nitrogen Atomised Extra Fine Nonferrous Metals Powder	M/s. Maharashtra Metal Powder Pvt. Limited 221, Shrimohini, 345, Kingsway Nagar, Nagpur - 440 001	1988
190.	Aluminium Alloy PM-2 Conductor	M/s. Aluminium Cables and Conductors (U.P.) 2A Shakespear Sarni, Kolkata	1989
191.	Nonferrous Metals Powder	M/s. Amar Singh Gupta Saubhagya 1, S.M. Padmnabhpur, Durg - 001	1989
192.	Extra Fine Metal Powders	M/s. Associated Pigments Limited 14, Netaji Subhas Road, Kolkata - 700 001	1989
193.	Electrolytic Manganese Dioxide	M/s. Magno Mining Co. Limited 3-604, Divya Shakti Apartments Ameor, Hyderabad - 500 016	1989
194.	Electrolytic Manganese Dioxide (EMD)	M/s. Manganese Ore (India) Limited 3, Mount Road Extension, Nagpur - 440 001	1989
195.	Zinc Oxide from Zinc Waste Such as Zinc Ash / Zinc Hydroxide	M/s. Sulecto Drugs & Chemicals Pvt. Limited E-4.50, Arera Colony, Bhopal	1989
196.	Direct Reduced Iron (Sponge Iron) by VRDR process	M/s. Bastar Ispat Udyog Pvt. Limited Geedam Road, Jagdalpur, Bastar - 494 001	1990
197.	Welding electrode	M/s. National Aluminium House, Raipur	1990
198.	High temperature metal / alloy melting container - clay bounded graphite and carbon bonded graphite	M/s. Sambhavnath Crucibles Pvt. Limitied, Ahmedabad	1990
199.	Inhibitor Suitable for Pickling of Steels in Hydrochoric Acid Solutions at Room Temperature	M/s. Shree Ram Industries, Phase - III, F-I(P), Industrial Area, Bokaro - 827 014	1990
200.	Clay and byproduct values from cyclone under flow rejects of washing	M/s. English India Clay limited, Trivandrum	1991
201.	Stainless Steel Powder	M/s. Nitu Electronic Pvt. Limited 67B, Vakil Road, New Mandi, Muzaffarnag - 251 001	1991
202.	Zinc Oxide from Zinc Waste Such as Zinc Ash / Zinc Hydroxide	M/s. Panch Karma Chemicals Pvt. Limited Tonta Ki Bazaria Kampoo Brigede, Lash, Gwalior	1991

203.	Ferro-vanadium from alumina sludge	M/s. Balaji Vanadium Co. Pvt. Limited, Korba, MP	1992
204.	Zinc oxide from zinc ash and hydroxide	M/s. Zinc Smeltiers & Refiners 303, Arechandia, Nariman Point, Bombay	1992
205.	Recovery of Vanadium Pentoxide from Vanadium Sludge of Alumina Industry	M/s. Jaiswals Oxides & Pigments Co. (P) Limited 837, Block P, New Alipore, Kolkata - 700 053	1993
206.	Copper powder for electrical and electronic component	M/s. National Aluminium House, Raipur, MP	1993
207.	Nickel free exhaust steel valve	M/s. Star Wire (India) Limited, Ballabgarh, Haryana	1993
208.	Sintered alumina grains	M/s. Tata Refractories Limited, Belpahar	1993
209.	Flyash based wear resistance ceramic	M/s. Tatanagar Bricks Limited, Adityapur, Jamshedpur	1993
210.	Colorizing of steel pack cementation	M/s. Tube Products of India, Madras	1993
211.	NML Galvasave	M/s. Metoil Corporation, Jamshedpur	1994
212.	Pickling Inhibitor for Descaling Steel	M/s. Navdeep Chemicals Pvt. Ltd., Mumbai	1994
213.	HCL Inhibitor	M/s. Deepak Brother, Nagpur	1995
214.	Corrosion and scale inhibitor	M/s. Kesal Chemicals & Pigments India Pvt. Limited, Kolkata	1995
215.	Galvasalt	M/s. Ambica Industries, Hyderabad	1996
216.	Gas Cleaning System for foundries	M/s. Crawley & Ray Howrah	1996
217.	Air & Nitrogen Atomised Extra Fine Nonferrous Metals Powder (Aluminum Powder)	M/s. Eastern Engineering and Foundry Comp. 26, Purulai Highway Sakchi, Jamshedpur - 001	1996
218.	Stainless Steel Powder	M/s. G.D. Stainless Industry A-10, MIDC, Lohara, Yavatmal - 445 001	1996
219.	Recovery of copper from waste solution	M/s. Grishma Metal Technology, Mumbai	1996
220.	Long-life Radiator Fluid	M/s. P.G. Enterprises, Jamshedpur	1996
221.	Gas Cleaning System for foundries	M/s. Uma foundry Pvt. Limited, Liluah, Howrah	1996
222.	Ferro vanadium from alumina sludge	M/s. Gyan Ferro Metals Ltd., Jamshedpur	1997
223.	Grates for cokeless cupola	M/s. Adityapur Dies, Jamshedpur	1997
224.	Air atomized aluminium powder	M/s. Eastern Engineering & Foundry Co., Jamshedpur	1997
225.	Stainless Steel Powder	M/s. Euroflex Transmission India (P) Limited 3-203 Divya Shakti Complex Ameerpet, Hyderabad	1997
226.	Gas Cleaning System for foundries	M/s. IISCO Kulti, Bardwan	1997
227.	Copper powder for carbon bushes and welding	M/s. Jamshedpur Meta-Chem Industry, Jamashedpur	1997
228.	Production of High Purity Electrolytic Iron Powder from Sponge Iron Fines	M/s. National Engineering & Service Limited, Gamaria, Jamshedpur	1997
229.	Improvements in Surface finish of copper and copper based alloy	M/s. Alcobex Metals Limited, New Delhi	1998

230.	Electroless Nickel plating	M/s. Saptharishi Metals, Alloys & Product Limited, Jamshedpur	1998
231.	Extraction of Zinc and EMD from Zinc Sulphide	M/s. Nepal Metal Co. Limited, Nepal	1999
232.	Pig Iron by Low Shaft Furnace	M/s. Polybond Insulation Ltd., Bhilai	1999
233.	Grates for cokeless cupola	M/s. Adityapur Dies, Jamshedpur	2000
234.	Ceramic Balls	M/s. Adityapur Dies, Jamshedpur	2000
235.	RELIEF (Software)	M/s. BHEL, Tiruchirapalli	2000
236.	CLIP (Software)	M/s. BHEL, Tiruchirapalli	2000
237.	Vapour phase inhibitor	M/s. Flexi Trade Co., Jamshedpur	2000
238.	Electrolytic Manganese Dioxide	M/s. Golden Edifice Elements Pvt. Limited 37, S.D. Road, Secunderabad - 500 003	2000
239.	Pickling Inhibitor for Descaling Steel	M/s. Navdeep Chemicals Pvt. Ltd., Mumbai	2002
240.	Galvasalt - an improved technology of Galvaflux	M/s. Ambica Industries, Kolkata	2003
241.	CLIP (Software)	M/s. CMERI, Durgapur	2004
242.	Production of Nano-sized hydroxyapatite powder	M/s. Eucare Pharmaceuticals Pvt. Ltd., Chennai	2004
243.	Electrolytic Iron Powder from Sponge Iron Fines	M/s. Saraf Groups of Chemicals, Mumbai	2004
244.	Column flotation for the beneficiation of limestone	M/s. Calpro Mineral Technologies India Pvt. Limited, Salem	2005
245.	Designing, installation and commissioning of flotation column	M/s. Indian Rare Earth Limited, Kerala	2006
246.	Spargers for flotation column	M/s. Silcarb Heating Elements Pvt Ltd, Bangalore	2006
247.	Portable Stress Strain Measuring System Using Automated Ball Indentation Technique	M/s. Ducom Instruments Pvt. Ltd, Bangalore	2007
248.	Generation of process parameters to leach and cement lead from the residue	M/s. Chakradhar Chemicals Pvt. Limited	2008
249.	Biomimetic nano bio-ceramics for bone graft	M/s. Eucare Pharmaceuticals Pvt. Ltd. Chennai	2008
250.	Arsenic removal water purification process	M/s. Pacific Technical Services India (Pvt) Ltd, Chennai	2009
251.	Designing prototype for production of continuous metallic glass (amorphous) ribbon	M/s. Vacuum Techniques Pvt. Limited, Bangalore	2009
252.	Process for lead recovery from zinc plant residue	M/s. Chakradhar Chemicals, Muzaphar nagar	2009
253.	Recovery of Gold from Slag	M/s. Emerald Jewel Industry India Ltd, Coimbatore	2010
254.	Development of Process Flow Sheet for Atasu underground Mine, Kazakhstan	M/s. Orken LLP, Kazakhstan	2010

*Parties name could not be traced

Notable Awards

1958

Dr. KG Naik Gold Medal by University of Baroda
Dr. T Banerjee

First Ph.D., Working at NML Awarded by Punjab Univ.
Shri T.N. Trehan

Padmashri
Dr. B.R. Nijhawan

Certificate of Merit by IIM
Dr. B.R. Nijhawan and Mr. P.K. Gupte

1959

Captain N.N. Dutta Medal
Shri A. Ghosh

1960

Kamani Gold Medal of IIM
Shri S.M. Arora

1965

Shanti Swarup Bhatnagar Memorial Award
Dr. B.R. Nijhawan

President of IIM
Dr. B.R. Nijhawan

1966

National Metallurgist's Day Award
Dr. S.S. Bhatnagar & Dr. Rajendra Kumar

Honorary Secretary of the Inst. of Indian Foundrymen
Shri R.M. Krishnan

1968

Work performance Award
Shri P.P. Bhatnagar, Shri V.S. Sampath &
Shri G. Bysak

1970

National Metallurgist's Day Award
Prof. V.A. Altekar, Dr. Ved Prakash & Dr. A.K. Lahiri

1971

National Metallurgist's Day Award
Dr. M.R.K. Rao

Certificate of Merit of Institution of Engineers
Sri S.K. Ray

Binani Gold Medal
Dr. N. Dhanajayan

1972

National Mineral Awards
Shri G.P. Mathur

1973

Distinguished Alumnus Award
Prof. V.A. Altekar, Dr. Rajendra Kumar &
Shri R.M. Krishnan

1974

National Metallurgist's Day Award
Shri K.N. Gupta

1975

2nd Indranil Award
Dr. Rajendra Kumar

1976

19th National Award (2nd Prize)
NML Technical Journal Aug 1976 issue

1977

Indranil Award
Dr. P.R. Khangaonkar

1978

Distinguished Achievement medal of the Colorado School of Mines, USA
Prof. V.A. Altekar

1979

Dr. Rajendra Prasad Memorial Gold Medal
Dr. Rajendra Kumar

Indranil Award Gold medal for metallurgy
Shri G.P. Mathur

1981

Indranil Award for Metallurgy of the Year
Shri D.D. Akerkar

Certificate of Merit by Institution of Engineers
Shri H. Singh & Prof. V.A. Altekar

1988

FICCI Award
Dr. S. Banerjee

MASCOT Award
Dr. Inder Singh

1989

National Metallurgist's Day Award
Dr. O.N. Mohanty

CSIR Young Scientist Award
Dr. D.D.N. Singh

1990

Young Metallurgist Award
Dr. S. Srikanth

1992

CSIR Young Scientist Award
Dr. S. Chattopadhyay

1993

MRSI Medal
Dr. R.N. Ghosh

NMD/ATM Best Poster Presentation
Ms. M. Tarafder, Mr. A.S. Kumar, Dr. K.M. Godiwalla and Dr. R.N. Ghosh

Nijhawan Award for Best Paper
Dr. Raghubir Singh, Prof. S. Banerjee

Altekar Award for Best Technology
Shri Swapan K. Das, K.N. Gupta, K.C. Ray, B.K. Mitra

PL Thermal Science - ITAS Award
Dr. A. Bandopadhyay

1994

National Metallurgist's Day Award
Dr. R.N. Ghosh

NMD/ATM Grand Prize for Oral Presentation
Ms. M. Tarafder, S. Tarafder, V.R. Ranganthan and R.N. Ghosh

NMD /ATM Award - Area : Iron & Steel Technology (2nd Prize)
Dr. S. Prakash

NMD /ATM Award - Area : Metal Processing
Dr. O.N. Mohanty, S.K. Choudhury, B.N. Ghosh, S.P. Chakraborti, P.K. Dey & J. Bhattacharya

NMD / ATM Award - Area : Materials Science & Engineering
Dr. I. Chattoraj, A.K. Bhattamishra, S. Jena, S.K. Das & S.P. Chakraborti

Nijhawan Award for Best Paper
Dr. R. Kumar, S. Das, Dr. R.K. Ray & Dr. A. Biswas

Altekar Award for Best Technology
Dr. A.N. Mukherjee, T.L. Sharma & Dr. P. Prabhakaran

Nucor Group Award
Dr. D.K. Bhattacharya

Distinguished Service Award
Dr. N.G. Goswami

1995

Distinguished Alumnus Award
Prof. P. Ramachandra Rao

Distinguished Materials Scientist Award
Prof. P. Ramachandra Rao

CSIR Young Scientist Award
Dr. S. Srikanth

NMD / Binani Gold Medal
Dr. S. Prabhakar, Mr. C. Sankaran and Dr. G. Bhaskar Raju

NMD / Best Oral Presentation
Dr. A. Bandopadhyay, Dr. K.K. Mishra and Prof. P. Ramachandra Rao

NDE Award
Dr. A. Mitra and Prof. D.C. Jiles

Nijhawan Award for Best Paper
Sri Ratnakar Singh

Distinguished Service Award
Shri T.L. Rao & Shri M.L. Blaggan

1996

Nijhawan Award for Best Paper
Dr. Ashok Kumar Ray

Distinguished Service Award
Shri S.S. Khan

Distinguished Alumnus Award, BHU
Prof. P. Ramachandra Rao

RDCIS Award for Best Paper
Dr. D. Bandopadhyay

CSIR Award for Hindi
Dr. R.P. Bhagat

1997

CSIR Young Scientist Award
Dr. I Chattoraj

Altekar Award for Best Technology
Dr. K.K. Mishra & Team

Nijhawan Award for Best Paper
Dr. Sanjay Prasad, Dr. B.D. Pandey and Shri S.K. Palit

INSA Prize for Material Science
Prof. P. Ramachandra Rao

ARDB Award for Excellence in R&D
Dr. Ajoy Kr. Roy

Mascot National Award
Dr. A.N. Mukherjee

Indranil Award
Dr. A. Bandopadhyay

Refractory Technologist Award
Dr. K.K. Singh

NACE International Corrosion Awareness Award
Dr. D.D.N. Singh

NDT Award
Dr. A. Mitra

Ministry of Steel Award
Dr. R.P. Bhagat

ATM / IIM Award
Shri Ratnakar Singh, S.K. Das, S. Palit Sagar and M. Tarafder

Best Paper Award in IIF Journal
Dr. P.K. Biswas

Distinguished Service Award
Shri V.K. Sinha

1998

National Metallurgist's Day Award
Dr. Amitava Bandopadhyay

CSIR Young Scientist Award
Dr. Arvind Sinha

Distinguished Engineer Award
Prof. P. Ramachandra Rao

Altekar Award for Best Technology
Dr. R.R. Dash

Nijhawan Award for Best Paper
Dr. Amitava Mitra

Distinguished Service Award
Shri Ashok Chatterjee

IXth AGM of MRSI
Dr. L.C. Pathak, T.B. Singh, S.K. Das and Prof. P. Ramachandra Rao

NMD / IIM Award on Metallography
Dr. R.R. Dash and team

NMD / IIM Poster Presentation Award
Dr. A.K. Vaish and team (2nd Prize)

1999

CSIR Young Scientist Award
Dr. Suman Kumari Mishra

Nayudamma Award
Prof. P. Ramachandra Rao

Shri Om Prakash Bhasin Foundation Award
Prof. P. Ramachandra Rao

Nijhawan Award for Best Paper
Dr. S. Srikanth & Prof. P.R. Rao

NMD / IIM Best Paper Presentation
Dr. Suman Kumari Mishra, S. Das, S.K. Das, A. Roy and Prof. P. Ramachandra Rao

NMD / IIM Award on Metallography
Dr. Arvind Sinha, S.K. Das, V. Rao and Prof. P. Ramachandra Rao

KANO Award
Shri Ratnakar Singh

IIME Khare Award
- Dr. G. Bhaskar Raju, S. Pabhakar, S. Subba Rao and C. Sankaran
- Dr. T.S.N. Sankara Narayanan and team (2nd Prize)

Distinguished Service Award
Shri Baijnath Sharma

2000

CSIR Young Scientist Award
Dr. K.L. Sahoo

FICCI Award
Prof. P. Ramachandra Rao

VASVIK Award
Prof. P. Ramachandra Rao

Prof. B.C. Haldar Memorial Award
Shri T.V. Vijayakumar, S. Prabhakar and G.B. Raju

NACE Best Paper Award
Dr. T.S.N. Sankara Narayanan and team

Altekar Award for Best Technology
Dr. K.K Mishra and Team

Nijhawan Award for Best Paper
Dr. S. Ghosh Chowdhury

Distinguished Service Award
Shri S.K. Roy

2001

National Technology Day Award
Dr. K.K. Singh

IEEE Best Paper Award
Dr. N.V. Satyanarayana

IIM Poster Prize
Mr. Anil Kumar, S. Tarafder and I. Chattoraj (2nd prize)

THERMANS Best Paper
Sharva Shri A. Stepen, T.S.N. Sankara Narayanan, S. Gurukanthan and S. Selvakumar

Altekar Award for Best Technology
Dr. K.K Singh, Prof. P. Ramachandra Rao, Dr. K.K. Mishra, Dr. D.K. Biswas, Dr. S.D. Singh & Mr. B.K. Mitra

Nijhawan Award for Best Paper

Dr. K.L. Shaoo, Dr. C.S.S. Krishnan, Prof. A.K. Chakraborty

Distinguished Service Award
Shri D.K. Khan & Shri M. Vijayan

Peravadhanulu Award
Shri A. Chattopadhyay

2002

CSIR Young Scientist Award
Dr. K.K. Sahu

MRSI Young Scientist Award
Dr. Jui Chakraborty

SAIL Gold Medal
Prof. S.P. Mehrotra

Best Metallurgical and Materials Engineers Award
Prof. S.P. Mehrotra

IIME Mineral Beneficiation Award
Prof. S.P. Mehrotra

Deokaran Award for Glass
Shri S.K. Malaviya

Altekar Award for Best Technology
Dr. S. Prabhakar, Dr. G. Bhaskar Raju, Dr. S. Subba Rao & Shri T.V.K. Das

Nijhawan Award for Best Paper
Dr. L.C. Pathak, Dr. D. Bandyopadhyay, Dr. S. Srikanth, Dr. S.K. Das, & Prof. P.R. Rao

Distinguished Service Award
Shri S. K. Pramanick & Shri V.P. Singh

2003

MRSI Medal
Dr. Suman Kumari Mishra

Gold Medal of the Mining, Geological & Metallurgical Institute of India
Dr. R.K. Jana

19th IETE Bimal Bose Award
Dr. S.K. Mandal

IIM Best Paper Award in Oral Presentation
Shri A.K. Mandhyan

IIM Best Paper Award in Poster Presentation
Dr. A.K. Panda, M. Manimaran, S. Basu and A. Mitra

Best Paper Award of the Society of Geoscientists and Allied Technologists
Dr. B. Nayak

Science Congress Best Paper
Shri B.R.V. Narasimhan, T.S.N. Sankara Narayanan and Mrs. S. Usha

IIME Best Paper
Shri T.V. Vijayakumar, S. Prabhakar and G.B. Raju

Nijhawan Award for Best Paper
Dr. S. Sivaprasad, Dr. S. Tarafder, Dr. S. Ranganath & Prof. K.K. Ray

Distinguished Service Award
Shri H.C. Gope

2004

National Metallurgist's Day Award
Dr. S. Srikanth

CSIR Young Scientist Award
Dr. Bibhuranjan Nayak

Silver Medal of the Mining, Geological & Metallurgical Institute of India
Dr. A. Chattopadhyay

Nijhawan Award for Best Paper
Dr. A. Mitra, Dr. A.K. Panda, Dr. S.R. Singh & Prof. P. Ramachandra Rao

NML Best Project Award
- Dr. K.K. Sahu (PL), Dr. B.D. Pandey, Shri Premchand, Shri Z.H. Khan & Shri S.B. Mathur (1st Prize)

- Dr. S. Sivaprasad, Dr. S. Tarafder, Ms. M. Tarafder, Dr. J.K. Sahu, Dr. V.R. Ranganath & Dr. Swapan K. Das (2nd Prize)

Distinguished Service Award
Shri N. Pandey, Shri D. Kumar & Shri H.N. Singh

2005

NACE Award for 'Best Corrosion Research Laboratory of India Institutional Award'

Mascot Award
Dr. D.D.N. Singh

MRSI Medal
Dr. Arvind Sihna

Tamotia Award on Environment
Shri M. Murugananthan, Dr. G.Bhaskar Raju and Dr. S. Prabhakar

Misra Award for Best Technical Paper
Shri C. Sasikumar, Dr. D.S. Rao, Dr. S. Srikanth, Dr. B. Ravikumar, Dr. N.K. Mukhopadhyay and Prof. S.P. Mehrotra

Peravadhanulu Award
Dr. D.S. Rao, Dr. B.K. Mohapatra and Dr. B.D. Nayak

IIM Oral Presentation Award
Dr. (Ms.) Suman K. Mishra

IIME Best Paper Award
Dr. (Ms.) Jhumki Hait

National NDE Award
Dr. (Ms.) S. Palit Sagar

Distinguished Engineer's Award
Dr. P.N. Chaudhary

Wolfson Distinguished Award
Dr. A. Mitra

Nijhawan Award for Best Paper
Shri C. Sasikumar, Dr. D.S. Rao & Dr. S. Srikanth, Dr. B. Ravikumar, Dr. N.K. Mukhopadhyay & Prof. S.P. Mehrotra

Altekar Award jointly for Best Technology
- Dr. K.K. Sahu, Dr. (Ms.) A. Agrawal, Dr. B.D. Pandey, & Prof. S.P. Mehrotra
- Dr. A. Sinha and Dr. (Ms.) S. Nayar

Awards for excellence In-house Project

1) Ms. M. Tarafder, Shri B. Dash, Ms. S. Dey, Dr. S. Sivaprasad, Dr. S.K. Das, and Dr. S. Tarafder

2) Dr. (Ms.) S.K. Mishra, Dr. L.C. Pathak, Dr. S.K. Das and Dr. S. Das

3) Dr. G. Das, Ms. S. Ghosh, Mr. S. Das, Dr. S. Tarafder and Dr. S. Ranganath

CSIR Outstanding Service Award Category - I
Shri R. Prasad, M. Vijayan Nair, Kedar Singh, K.V. Laxman

CSIR Outstanding Service Award Category - II
Shri P.N. Swamy, Sudhir K. Bose, Rajeev K. Singh, K.S. Naidu

CSIR Outstanding Service Award Category - III
Shri S.K. Mahato, Joginder Singh, P.C. Dev, Jagnath Singh

2006

National Metallurgist's Day Award
Dr. Amitava Mitra & Dr. Rakesh Kumar

Misra Award by IIME
Dr. S. Srikanth

MRSI Medal
Dr. S. Srikanth

Nijhawan Award for Best Paper
Dr. Rakesh Kumar, Dr. Sanjay Kumar, Shri S. Badjena & Prof. S.P. Mehrotra

Altekar Award for Best Technology
Dr. S. Prabhakar, Dr. G. Bhaskar Raju, Dr. S. Subba Rao, Dr. D.S. Rao & Shri T.V. Vikayakumar

NMD / IIM Metallography Contest
Shri Arpan Das

NMD / IIM Poster Presentation
Under Process Category - Shri J. Pal, M.C. Goswami, D.P. Singh, Dr. A.K. Upadhyay and Dr. Sukomal Ghosh

Under Product Category - Dr. S.K. Mishra (1st Prize)

Under Product Category - Shri G.K. Mandal, S.K. Das and Prof. S.P. Mehrotra (3rd Prize)

NMD / IIM Oral Presentation
Ms. M. Tarafder, Ms. T. Das, Dr. S.K. Das and Dr. S. Tarafder (3rd Prize)

NDE Award for Oral Presentation
Ms. Mita Tarafder

TECHNICA Award for Poster Presentation & Quiz Competition
Shri Arpan Das

CSIR Outstanding Service Award Category - I
Shri S.K. Poddar, Shri D. Bhattacharya, Shri A. Gopalkrishnan & T.K. Mohanty

CSIR Outstanding Service Award Category - II
Shri K.P. Krishnan, Shri T.K. Bhattacharjee, Shri R.K. Saha & Shri D.P. Rao

CSIR Outstanding Service Award Category - III
Shri T.S. Das, Shri Shatrughan Singh, Shri H.P. Gope & Shri Ashok Chatterjee

Awards for excellence In-house Project
1. Shri J. Pal, Shri M.C. Goswami, Dr. S. Ghosh, Shri R.K. Minj, Shri D.P. Singh & Shri A.K. Upadhyay

2. Dr. S.K. Das, Dr. S. Tarafder, Shri P.K. De, Shri S. Das & Dr. S. Sivaprasad

3. Dr. (Ms.) S. Palit Sagar, Dr. N. Parida, Dr. S. Sivaprasad, Dr. D.K. Bhattacharya & Dr. R.N. Ghosh

2007

National Metallurgist's Day Award
Dr. D.D.N. Singh

MRSI Medal
Dr. L.C. Pathak

NMD Young Metallurgist Award
Dr. V.C. Srivastava

NMD Tata Gold Medal
Prof. S.P. Mehrotra

NMD / IIM - Poster Presentation
Metal Science Category - Dr. (Ms.) S. Palit Sagar and Dr. S. K. Das
Non-Ferrous Category - Dr. R.K. Jana

NMD / IIM - Oral Presentation
Metal Science Category - Dr. S. Ghosh Chowdhury and Mr. B. Mahato
Non-Ferrous Category - Dr. B.D. Pandey and Dr. Vinay Kumar

National Mineral Award Scheme of the Ministry of Mines Govt. of India
Dr. S. Prabhakar & Dr. G. Bhaskar Raju

Misra Award by IIME
- Shri S.C. Pal, Abhilash, K.D. Mehta, V. Kumar, B.D. pandey and T.R. Markhand

Distinguished Engineers' Award
Dr. A.K. Vaish

Young Chemist Award
Dr. T. Mishra

IIME Mineral Beneficiation Award
Dr. G. Bhaskar Raju and Dr. S. Prabhakar

IIME Best Paper Award
Characterisation Area - Dr. D.S. Rao, T.V. Vijayakumar, S. Prabhakar, G. Bhaskar Raju and T.K. Ghosh
Environmental Issues - Dr. Rakesh Kumar, Sanjay Kumar, S. Badjena and Prof. S.P. Mehrotra
Beneficiation - Dr. C. Guria, Mohan Verma, Santosh K. Gupta and Prof. S.P. Mehrotra

Nijhawan Award for Best Paper
- Dr. S.K. Sahu, Dr. K.K. Sahu and Dr. B.D. Pandey
- Dr. R.K. Sahu, Dr. A.K. Ray, Dr. S.K. Das, Dr. A.J. Kailath and Dr. L.C. Pathak

Altekar Award for Best Technology
Shri S.A. Akbar, Dr. Bandopadhyay, Dr. S.K. Das & Dr. R.P. Goel

Awards for excellence In-house Project
Dr. A.K. Panda, Dr. A. Mitra, Mr. P.K. De & Dr. S. Garai

ECM Best Presentation Award
Shri P. Lakhmipathirai, S. Prabhakar, S. Parvathy and G. Bhaskar Raju

Hindustan Platinum Best Poster Presentation Award
Dr. T. Mishra

M.S. Khan Memorial Trophy
Dr. A.K. Vaish

CSIR Innovation Suggestion Award
Dr. S. Prakash, Shri S.K. Pal and Ms. A. Madhukar

CSIR Outstanding Service Award Category - I
Shri Ajoy Kumar Acharya, Shri Tej Bahadur Singh, Shri Dharmendra Kumar & Shri Shridhar Khiste

CSIR Outstanding Service Award Category - II
Shri B. Mahato, Shri Ravinder Thakur, Shri R. Raju & Shri H.N. Singh

CSIR Outstanding Service Award Category - III
Shri S.K. Roy, Shri M. Mondal, Shri S.K. Saksena & Shri A.K. Sumbroi

2008

CSIR Young Scientist Award
Dr. R.K. Sahu

MRSI Medal
Dr. Ashok Kumar Ray

VAVSIK Award
Dr. (Ms.) Suman K. Mishra

Misra Award by IIME
Dr. S.K. Sahu, Dr. K.K. Sahu and B.D. Pandey

Khare Award for the best paper presentation
Sri T.C. Alex, Dr. Rakesh Kumar, Sri S.K. Roy and Prof. S.P. Mehrotra

National Award for Best Employee
Sri A.K. Mandhyan

Best Technical Paper (Ferrous) Award
Dr. Sukomal Ghosh

IIME Mineral Beneficiation Award
Dr. B.D. Pandey

IIME Best Paper Award
Bio-hydro-electro processing Area - Dr. S.K. Sahu, Dr. K.K. Sahu and Dr. B.D. Pandey

Characterization - Ms. Mamta Sharma, A.K. Singh, N.K. Shukla, S.K. Srivastava and K.K. Bhattacharyya

Beneficiation - Sr T.C. Alex, Rakesh Kumar, S.K. Ray and Prof. S.P. Mehrotra

Nijhawan Award for Best Paper
- Shri A. Metya, Dr. N. Parida, Dr. D.K. Bhattacharya, Dr. N.R. Bandyopadhyay & Dr. S. Palit Sagar,
- Dr. S.K. Mishra, Dr. S.K. Das & Dr. V. Sherbacov

Altekar Award for Best Technology
Dr. Goutam Das, Shri K.K. Paul, Dr. S. Tarafder, Dr. N.V. Satyanarayana, Dr. S. Prakash, Dr. Sabita Ghosh, Ms. Mousumi Das & Dr. R.N. Ghosh

Awards for excellence In-house Project
- Dr. Avimanyu Das, Dr. Shobhna Dey, Shri K.K. Bhattacharyya, Mr. S.C. Maulik and Dr. J. Konar

- Dr. Shrabanee Sen, Dr. S.K. Mishra, Dr. S. Palit Sagar, and Dr. S.K. Das

2009

National Metallurgist's Day Award
Dr. S. Tarafder

Khare Best Paper Award
Coal Preparation - Dr. A. Das, A. Vidyadhar and S.K. Dey

Beneficiation - Dr. R. Singh, R.K. Rath, D.S. Rao, K.K. Sahu and K.K. Bhattacharyya

Misra Award by IIME
Dr. S.K. Sahu, B.D. Pandey and Vinay Kumar

IIME Best Paper Award - Beneficiation
Dr. Biswajit Sarkar, Avimnayu Das and S.P. Mehrotra

Nijhawan Award for Best Paper
- Dr. R. Singh, Dr. S. Ghosh Chowdhury and Dr. I. Chattoraj

Altekar Award for Best Technology
Dr. A. Mitra, Mr. K.K. Paul, Mr. A.K. Mallik, Dr. A.K. Panda and Mr. Arvind Kumar

Awards for excellence In-house Project
- Dr. Sanjay Kumar, Dr. Rakesh Kumar, Dr. A. Bandopadhyay, Dr. Swapan K. Das, Dr. B. Ravikumar, Mr. B.K. Mitra and Prof. S.P. Mehrotra

- Mr. B. Sarkar, Dr. Avimanyu Das, Mr. K.K. Bhattacharyya and Mr. S. Chandrasekhar

2010

CSIR Technology Awards for "Business Development and Technology Marketing"

- Institutional Award

MRSI Medal
Dr. Amitava Mitra

Recently Served Clients

1. ACC, Chaibasa
2. Ador Welding Ltd, Chennai
3. Advait Enterprise, Mumbai
4. Aeronautical Development Agency
5. Agni Steels Pvt. Ltd, Ingur
6. Akshara Enterprises, Faridabad
7. Akshay Steel Works Pvt. Ltd, Jamshedpur
8. Almamet Reagents (India) Pvt. Ltd, Jamshedpur
9. Amba Rerolling Mills, Adityapur
10. AML Steel & Power Ltd, Chennai
11. AML Steel & Power Ltd, Jamshedpur
12. AML Steel and Poder Ltd, Kolabira
13. Anandeshwar Traders, Kanpur
14. Anubhav Chemical, Kanpur
15. AP Instruments, Jamshedpur
16. Apollo Instruments and Equipment, Kolkata
17. Arihant Corporation, Jamshedpur
18. Arush Metal Casing PL, Jamshedpur
19. ASL, Adityapur
20. Asstt Commissioner of Customs, Raxaul
21. Astha Ferrotech Pvt. Ltd, Jamshedpur
22. B.Chemical Works, Agarpara
23. Balco, Korba
24. Bhagatwali Mines, Rajasthan
25. Bhabha Atomic Research Centre, Mumbai
26. Bharat Dynamics Ltd
27. Bhilai Steel Plant, Bhilai
28. Bhushan Power Steel Ltd, Sambalpur
29. Bihar Sponge Iron Ltd, Chandil
30. Billion Traders Pvt. Ltd, E Singhbhum
31. BIS, Ropar
32. BOC India Ltd, Jamshedpur
33. Bokaro Power Supply Co(P) Ltd
34. Brahamani River Pellets Ltd, Bhubaneswar
35. BRNS, Mumbai
36. Bureau of Indian Standards, Mohali
37. Caleb Brett India Pvt. Ltd., Kakinada
38. Caleb Brett India Pvt. Ltd, Chennai
39. Carl B. Lub. Pvt. Ltd, Bangalore
40. Carl Bechem Lub.PL, Bangalore
41. Cement Corporation of India Ltd, Assam
42. Cement Corporation of India Ltd, Dimapur
43. Central Power Research Institure, Korba
44. Chattisgarh State Elec. Board, Raipur
45. Chem Equip, Jamshedpur
46. Chemical Centra, Howrah
47. Chemi-Equip, Jamshedpur
48. Control Equipments, Chennai
49. CPRI, Bangalore
50. CPRI, Koradi
51. Cunningham &Lindsey Int. Pvt Ltd, New Delhi
52. D&H Welding Electrodes (India) Ltd.,
53. D-di Engg. Corpn, Rajkot
54. Delhi Test House, Delhi
55. Dept. of Science & Technology, New Delhi
56. Dept of Atomic Energy, Mumbai
57. Dept. of Information Technology, New Delhi
58. DGQA, Min. of Defence, Ghaziabad
59. Dinesh Das & Sons Mines & Steel Ltd., Orissa
60. Directorate of Revenue Intelligence, Ahmadad
61. Domain Chen-Core, Raipur
62. DRDO, New Delhi
63. Drinking and Clean. Div., Adityapur
64. Energo, New Delhi

65. Ennore Foundries Ltd, Ennore
66. Essar Steel Orissa Ltd, Bhubaneswar
67. European Commission
68. Fine Chemical Products, Kolkata
69. Fluidteq Systems, Mumbai
70. Forge & Forge Ltd, Rajkot
71. Gala Precision Technology Private Ltd, Thane
72. Ganesh Fundation PL, Kolhapur
73. Geo-Chem Laboratory Pvt Ltd
74. Gharda Chemicals Ltd, Mumbai
75. Gimpex Ltd, Chennai
76. Gimpex Ltd, Kolkata
77. Golchha Enterprises, Jamshedpur
78. Good Earth chemicals Pvt. Ltd, Hospet
79. Harjit and Jagdish, Jamshedpur
80. Hindustan Copper Ltd, Ghatsila
81. Hindustan Copper Ltd, Jamshedpur
82. Hindustan Udyog Limited, Kolkata
83. Hindustan Zinc Ltd., Kolkata
84. Hyderabad Metallurgical Services Pvt. Ltd
85. Idcol Kalinga Iron Works Ltd, Barbil
86. Impression Enterprises, Sangli
87. Indian Air Force, Kanpur
88. India Foils Ltd, Kolkata
89. India Resources Ltd, Mosabani
90. India Scientific Company, Tirupati
91. Indian Air Force, Nagpur
92. Indian Air Force, Nasik
93. Indian Chain Pvt. Ltd, Kolkata
94. Indian Oil corporation, Barauni
95. Indo Farm Tractors & Motors Ltd, Chandigarh
96. Indo Gulf Fertiliser, Lucknow
97. Industrial & Research Suppl. Corpn, Kolkata
98. Industrial & Research Supplier, Mumbai
99. Industrial Scientific Instruments, Mumbai
100. Innova Enterprises Pvt. Ltd.
101. Inspectorate Griffith India Ltd, Chennai
102. Inspectorate Griffith India Ltd, Kolkata
103. Institute of Steel Development & Growth, Kolkata
104. International Business Consul.,Secunderabad
105. Intertek Caleb Brett, Mangalore
106. IRC Industrial Research & Consultancy PL
107. ISRO, Bangalore
108. ISTM Ltd, Pune
109. Jai Mangla Enterprises, Hazaribagh
110. Jai Mangla Enterprises, Hyderabad
111. Jamshedpur Engg & Machine Manufacturing Co
112. JEMCO, Jamshedpur
113. Jindal Stainless Ltd, Hissar
114. Jindal Steel and Power Ltd, Angul
115. Jindal Steel and Power Ltd, Raigarh
116. JKUAT, Kanya
117. JMT Auto, Jamshedpur
118. Johar Steel Enterprises P Ltd, Jamshedpur
119. Joda Mines, TISCO
120. K.M.Steel Traders, Jamshedpur
121. K.S.J. Lab Glassware & Chem, Chennai
122. K.Y.S.Manufacturers & Exp PL, Jamshedpur
123. K.Y.S.Sponge Iron PL, Jamshedpur
124. Kalyani Steels Ltd, Ginigera
125. Kamakhya Chemical Industries, Golaghat
126. Kailash Chemicals, M.Gobindpur
127. Karthikeyan Chemicals, Hospet
128. KIGAM, Korea
129. Kishore Scientific, Delhi
130. Kishore Scientific, Jamshedpur
131. Kohinoor Steel(P) Ltd, Jamshedpur
132. KSJ Lab Glass. & Chem, Chennai
133. Kundu House, Jamshedpur
134. L.R.Fero Alloys Pvt. Ltd, Ranchi

135. Lab & Engg Corpn, Mumbai
136. Lafarge India Pvt Ltd, Jamshedpur
137. Land Customs Station, Raxaul
138. Laxmi Enterprise, Durgapur
139. M.P. Laboratories, Goa
140. M/s A.K.Mishra, Barajamda
141. M/s A.K.Singh, Ranchi
142. M/s Mr.Khan, Jmashedpur
143. M/s Murmu, Jamshedpur
144. M/s T.K.Chakorborty, Jamshedpur
145. M/s T.N.Das
146. Madras Metallurgical Services Ltd, Chennai
147. Mailam India Limited, Pondicherry
148. Mainawati Steel Industries Pvt. Ltd, Nepal
149. MECON Limited, Ranchi
150. Meghalaya State Electricity Board
151. Mehta and Sons, Sangli
152. Metalite India Pvt. Ltd, Ranchi
153. MIA Test Lab and Res. Centre, Nagpur
154. Micro Engineering & Testing Laboratort, Deli
155. Ministry of Defence(DGQA), Ghaziabad
156. Mishra Dhatu Nigam Ltd, Hyderabad
157. MMTC, Barbil
158. Monnet Ispat & Energy Ltd, Raipur
159. Multi-Serve Rolls Ltd, Kolkata
160. NALCO, Angul
161. Naryan Mahavidyalaya, Goreakothi
162. National Aluminium Company Ltd.
163. Natwar Steel Pvt. Ltd, Mandi Gobingarh
164. NAV DURGA FUEL PVT lTD
165. Neepaz Tube Pvt. Ltd, Jamshedpur
166. NICCO Jublee Park Ltd, Kolkata
167. Ni-Chrome Alloys Casting(P) Ltd,Visakhapatam
168. Nidhi Pipes Ltd, Chandigarh
169. Nilachal Iron and Power Ltd, Jamshedpur
170. Niranjan Hi-Tech Ltd, Giridih
171. NIT, Durgapur
172. Nuchem Scientific and Engg, Keenjhar
173. Office of Comm. of Customs, Kolkata
174. Office of Sup. Engg of Central Excise, JSR
175. Omkar Foundries, Sangli
176. Orient Abrasives Ltd, Bhiwadi
177. Oswal Enginnering & Chemical Co, Jamshedpur
178. Pacific Refractories Ltd, Mumbai
179. Pharma Chem-de Drug, Howrah
180. Pharma-Chem-de-Drug, Jamshedpur
181. Philips Carbon Black Ltd, Kolkata
182. Orissa Cement Company Ltd.
183. Polycab Premiers Pvt. Ltd, Jamshedpur
184. Prathyusha, Visakhapatnam
185. Premier Industrial Corporation, Mumbai
186. Quality Evaluation Services, Visakhapatnam
187. Quality Services & Sol, Chennai
188. Raajratna Electrodes PL, Ahmedabad
189. Rama Ferro Alloys & Finance Pvt Ltd, Kolkata
190. Rashmi Cement Ltd, Kolkata
191. Rashtriya Chemicals & Fertiliser Ltd, Thal
192. Rashtriya Ispat Nigam Ltd, Visakhapatnam
193. Ratnesh Metal Industries Pvt. Ltd, Mehsana
194. Rakha Copper Concentrator for HCL
195. RDCIS, SAIL, Ranchi
196. Remi Metals Gujarat Ltd, Jhagadia
197. Rashtriya Ispat Nigam Ltd., Bailladila
198. S.B.Enterprises, Sambalpur
199. S.G.Multicast, Jamshedpur
200. S.G.S. India Pvt. Ltd, Jamshedpur
201. S.J.C. Enterprises, Hyderabad
202. Sadbhav Calibration Services, Manjaipur
203. Sai Enterprises, Gamharia
204. SAIL, Durgapur

205. SAIL, Jamshedpur
206. SAIL, Kolkata
207. SAIL, Rourkela
208. Samaj Vikas Kendra, Jamshedpur
209. Sandeep Industries, Jamshedpur
210. Sant Values Pvt. Ltd, Jalandhar
211. Santosi Maa Chemicals, Goa
212. Sasco Steel Pvt Ltd, Jamshedpur
213. Scan Steels Ltd, Rourkela
214. S-Di Engineering Corporation, Rajkot
215. Seth Electrodes Pvt. Ltd, Khurai
216. SGS India Pvt Ltd, Jamshedpur
217. Shambhu Traders
218. Sharada Ent, Jamshedpur
219. Shiva Rama Sponge Iron(P) Ltd, Jamshedpur
220. Shri Krishna Laxmi Steel Udyog PL,Jamshedpur
221. Shri Vasavi Industries, Kolkata
222. Shri Venkateswara S.P. Pvt. Ltd, Kolkata
223. Siddhi Chemicals, Kolkata
224. Simhagiri Foundry Works Pvt Ltd,Vizianagram
225. South Esatern Railways, Kharagpur
226. Southern Scientific Services, Chennai
227. Spinco Scientific Equip, Kolkata
228. Star Wire (I) Pvt. Ltd, Ballabgarh
229. Steel Authority of India Ltd, Bokaro
230. Steel Industries, Jamshedpur
231. Sterlite Industries
232. Strohlein Laboratory Services India, Chennai
233. Subh Steel Pvt. Ltd, Jamshedpur
234. Sudamdih Washery, BCCL, Dhanbad
235. Sunny Scientific Enterprises, Ahmedabad
236. Superintendence Company of India, Kolkata
237. Suresh Scientific Co, Tiruchirapalli
238. Swastika Steel & Allied Products, Kolkata
239. Tarapore & Co, Jamshedpur
240. Tata pigments Ltd, Jamshedpur
241. TATA STEEL, Jamshedpur
242. Tayo Rolls Ltd, Jamshedpur
243. TCRC, Mumbai
244. Team Ferro Alloys Pvt Ltd, Dadra
245. The Orissa Mining Corpn Ltd, Daitari
246. Thermax Babcock & Wilcox Ltd,Pune
247. UCIL, Jaduguda
248. Unistar Galvanisers&Fabricators PL,Jamshedpu
249. United Technical services, Udaipur
250. Usha Martin Ltd, Jamshedpur
251. Usha Martin, Ranchi
252. Uttam Foundries & Ispat Pvt. Ltd.
253. Vaneeta Chemical Lab Furnishers, Jalandhar
254. Veeresha Casting Pvt. Ltd, Sangli
255. Venus Testing & Research Lab, Sagar
256. Vijaya Steel Ltd, Bangalore
257. Vinay Iron Foundry, Agra
258. Vinita Enterprises, Dhanbad
259. VSSC, Thiruvanthapuram
260. Walchandnagar Industries Ltd, Pune

Eminent Visitors

1946

Visit of Shri C. Rajagopalachari, then Minister for Education and Arts; Dr. S.S. Bhatnagar, Secretary, Ministry of Natural Resources & Scientific Research and Director, Scientific & Industrial Research; Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO

1950

Visit of Prime Minister Pt. Jawaharlal Nehru; Dr. S.S. Bhatnagar, Secretary, Ministry of Natural Resources & Scientific Research and Director, Scientific & Industrial Research; Mr. J.R.D. Tata, Chairman, Tata Industries Ltd.; Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO; Hare Krushna Mahtab; Dr. G.P. Contrator; R.P. Bahadur.

1952

Dr. S. Hussian Zaheer, DG CSIR; Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO

1953

Mr. Fazal Ali, Governor of Orissa; Delegates from Jugoslav Goodwill Mission; Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO; Foreign delegates participated Symposium on 'Electroplating and Metal finishing' held at NML

1954

Sir Alfred Egerton; Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO; Foreign delegates participated Symposium on 'Non-Ferrous Metal Industry in India' and 'Industrial Failures of Engineering Metals & Alloys' held at NML

1955

Visit of Marshal Tito, President Yugoslavia; King of Nepal; Prof. M.S. Thacker, DG CSIR; Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO; Foreign delegates participated Symposium on 'recent trends on Refractories' held at NML

1956

Visit of Dalai Lama; Franz Blucher, German Dy. Prime Minister; Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO; Foreign delegates participated Symposium on 'Alloy Steels' and 'Mineral Dressing & Extraction Metallurgy' held at NML

1957-58

Pt. J.L. Nehru, PM of India (Mar. 2, 1958)

Dr. Zakir Hussain, Governor of Bihar

Shri Morarji Desai, and Sardar Swaran Singh, Cabinet Ministers, GOI,

Shri YN Sukhtankar, Governor of Orissa

Shri J.R.D. Tata, Chairman, Tata Industries Ltd.; Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO

H.R.H., the Duke of Edinburg

I.P. Bardin; VP, USSR Academy of Science; Dr. CD Deshmukh, Chairman UGC

Prof. M.S. Thacker, DG CSIR (Feb. 5-8, 1958)

1959-60

Prof. M.S. Thacker, DG CSIR opening the Bay housing the equipment received from Govt. of UK (Feb. 15, 1960)

His Excellency Mr. Tage Erlander, PM of Sweden alongwith 15 Nos. of Foreign delegates; Dr. AG White, UN Tech Programme; Sir E. Smith delegates from Royal Society, UK; Dr. HJ Bhabha; Mr. TN Singh, Member Planning Commission; Mr. K. Lalbhai, Chairman, NRDC; Gen. KS Thimayya, Chief of Army Staff, GOI.

1960-61

Prof. Humayun Kabir, Minister for Scientific research and Cultural affairs, GOI and Vice-Chairman, CSIR

Dr. B.V. Keskar, Minister for Information and Broadcasting, GOI

Shri K. Kamaraj Nadar, Chief Minister

Shri C. Subramaniam, Minister for Finance

Prof. M.S. Thacker, DG CSIR (Feb. 14, 1961)

1961-62

Prof. M.S. Thacker, DG CSIR inaugurated the symposium (12-15.02.1962)

Shri J.R.D. Tata, Chairman, Tata Industries Ltd.

Shri J.D. Choski, Vice-Chairman Tata Industries Ltd.

Mr. G.M. Holmes, Chief Chemist, London & Scandinavian Metallurgical Co. Ltd, UK

Dr. A.G. Wilson, Assistant Blast Furnace Manager, Appleby-Fordingham Steel Co., United Steel Companies Ltd., Lincolshire, UK; Mr. J.R. Borrie, Rolling Mill Manager, Workington Iron & Steel Co.,

Prof. G. Reginold Bashforth, UNESCO Expert; Mr. F.A. Lyttom, Export Sales Director

Mr. A.B. Fitz Joh-Asst. Chief Engineer of Jessopsarille Ltd., Sheffield, UK

Dr. H.H. Koppers, Director, Heinrich Koppers, GMBH, Essen, West Germany

Mr. J. Westly, Metallurgical Engineers, Elektrokemisk A/S, Norway

1962-63

Prof. Humayun Kabir, Minister for Sci. Res. and Cultural Affairs

Hon'ble Mr. C. Subramaniam, Union Minister and Chairman Executive Council of NML

Sir J.J. Ghandy, Director, TISCO

Mr. Maurice Fiennes, President of Iron and Steel Institute (UK)

1963-64

Sir J.J. Ghandy, Chairman, Executive Council of NML and Director, TISCO

Prof. Humayun Kabir, Minister for Petroleum and Chemicals

Sir Ramaswami Mudaliar, Chairman, Reviewing committee

Dr. Hussain Zaheer, Director-General, CSIR

1964-65

Prof. Humayun Kabir, Minister for Petroleum and Chemicals

Shri R. Venkataraman, Min. for Industries, Govt. of Madras

Shri Asoka Mehta, Dy. Chairman, Planning Commission

Mr. M.C. Chagla, Min. for Education, GOI

Sir J.J. Ghandy, Chairman Executive Council of NML and Director, TISCO (Photo)

1965-66

Prof. Humayun Kabir, Minister for Petroleum and Chemicals

Shri R. Venkataraman, Min. for Industries, Govt. of Madras

Shri T.N. Singh, Min. for Iron and Steel

Mr. M.C. Chagla, Min. for Education, GOI

Sir J.J. Ghandy, Chairman Executive Council of NML and Director, TISCO

Late Dr. H.J. Bhabha, F.R.S.

1966-67

Dr. Zahir Hussain, Vice-President of India

1968-69

Dr. Atma Ram, DG, CSIR

Sir J. J. Ghandy, Director, Tata Sons Ltd.

Shri Nityanandan Kanungo, Governor of Bihar

1969-70

Dr. G. Mikeldaze, USSR

Mr. J. Greehill, UK

Mr. K.T. Chandy, Chairman Hindustan Steel

Mr. R.P. Billimoria, Director Hindustan Steel

1970-71

Dr. R.S. Barnas, London

Mr. Charles B. Baker, Belgium

Mr.Pancier, NIFFT, Ranchi

Dr. Johari, USA

Dr. Martin; Dr. Byer; Dr. V.G. Pande, Ford Foundation

1971-72

Sri C. Subramaniam, Union Minister

Sri S. Mohan Kumarmangalam, Union Minister

Dr. Atma Ram, DG CSIR

Sr. H.C. Sarin, Secretary, Dept. of Steel

Sri S. Moolgaokar, Vice-Chairman, TISCO

1972-73

Sri S. Mohan Kumarmangalam, Union Minister

Shri Kedar Pandey, Chief Minister of Bihar

Dr. Y. Nayduamma, DG CSIR

1973-74

Mr. Wadud Khan, Chairman, SAIL

1974-75

Shri Chandrajit Yadav, Union Minister

Shri Chandra Sekhar Singh, Union Minister

Shri J.G. Keswani, GM and Director M/s Indian Tube Co.

Mr. Wadud Khan, Chairman, SAIL

Dr. Y. Nayduamma, DG CSIR

1975-76

Shri Chandrajit Yadav, Union Minister

Dr. Y. Nayduamma, DG CSIR

Shri A.N. Banerjee, CMD, Hindustan Zinc Ltd.

1976-77

Shri R.P. Billimoria, Chairman, SAIL

Brig. B.J. Shahney, DG, Technical Director, GOI

Shri Saran Singh, Secretary, Dept. of Steel, GOI

1977-78

Shri S.R. Valluri, Director, NAL

Shri K.N. Johry, Chief, International Scientific Collaboration, CSIR

Dr. H. Kaufman, UNDP

Dr. B.R. Nijhawan, Senior Industrial Adviser and Chairman, UNIDO

Dr. D. Blasezyn, UNIDO

1978-79

Prof. A. Ramachandran, DG-CSIR

Dr. V.S. Arunachalam, Director, DMRL

1979-80

Shri D.P. Kharia, Dy. MD, TISCO

1981-82

Dr. G.S. Sidhu, DG-CSIR

Shrimati Indira Gandhi, PM and President of CSIR

1982-83

Dr. J.J. Irani, Dy. MD, TISCO

Dr. H. Buhl, IAM, Lohman, West Germany

1983-84

Dr. J.J. Irani, Dy. MD, TISCO

Dr. H. Buhl, IAM, Lohman, West Germany

Hon'ble Minister Sri N.K. P. Salve

Shri R.H. Mody, Chairman, Tata Steel

Dr. M.N. Dastur, Chairman & Managing Director

1984-85

Shri Shiv Raj Patil, Minister for State for Science & Technology visited the Laboratory

Dr. B.R. Nijhawan, Senior Adviser, Inter Regional UNIDO Vienna.

1985-86

Dr. B.R. Nijhawan, Senior Adviser, Inter Regional UNIDO Vienna.

1991-92

Dr. A.P. Mitra, DG-CSIR

1993-94

Dr. S.K. Joshi, DG-CSIR

1994-95

Shri A. Parthasarthy, Addl. Secretary, DSIR

1995-96

Prof. T.R. Anantharaman

1996-97

Dr. B.R. Nijhawan, Former Director NML & Senior Industrial Adviser & Chairman, UNIDO

1997-98

Dr. R.A. Mashelkar, DG-CSIR & Secretary DSIR

1998-99

Prof. P. Rama Rao, Chairman, AERAB, Mumbai

1999-2000

Visit of Dr. R.A. Mashelkar, DG-CSIR & Secretary DSIR

Dr. B.R. Nijhawan, Former NML Director & Sr. Consultant UNIDO, USA

Dr. J.J. Irani, MD, Tata Steel

Shri P. Parvatisem, CMD, NALCO

2000-01

Dr. A.P.J. Kalam, Principal Scientific Advisor

Prof. V.S. Ramamurthy, Secretary, DST

Dr. J.J. Irani, MD, Tata Steel

2001-02

Prof. Malcom McLean, Imperial College, London

Dr. Kota Harinarayan, Distinguished Scientist & Light Combat Aircraft Programme Director, ADA Bangalore

Mr. P.N. Singh, Jharkhand State Industry Minister

Mr. Ravinder Rai, Minister of State for Mines

Mr. Arjun Munda, Minister of State for Welfare

2002-03

Dr. Azmi Hj Indris, Senior GM, SIRIM Berhad, Malaysia

Ms. Bachendri Pal

Shri B. Muthuraman, MD, Tata Steel

Dr. Placid Rodriguez, Chairman, RAB, DRDO

Prof. Dr.Ing E.Roos, University of Stuttgart, Germany

Dr. Ing. G. Dobmann, Germany

Dr. V. Kucera, Swedish Corrosion Inst., Stockholm

Prof. D.C. Jiles, Iowa State Univ., USA

2003-04

Dr. K. Kimura, NIMS, Japan

Dr. Sanak Mishra, MD, Rourkela Steel Plant

Prof. K.T. Jacob, IISc, Bangalore

Prof. H.J. Christ, Dean, Germany

Dr. Stan Terras, UK; Dr. A.K. Roy, R. Prabhakaran & V. Marthadam, Las Vegas

Prof. S. Dhande, Director, IIT Kanpur

Dr. D. Bhattacharya, Director, NIT, Jamshedpur

2004-05

His Excellency, President of India Dr. A.P.J. Abdul Kalam

Sri Murwah, Governor of Jharkhand

Sri Arjun Munda, Chief Minister, Jharkhand

Prof. R. Chidambaram, Principal Scientific Advisor, GOI

Shri B. Muthuraman, MD, Tata Steel

Dr. R.A. Mashelkar, DG-CSIR

Dr. P.C. Mandal, DG, Geological Survey of India (GSI)

Prof. D. Hector Cristain Basoalto, London

Dr. Herbett Wiggenhauser, Berlin, Germany

Dr. David Jenkins, CSIRO, Australia

Dr. Gero Vikash Sinha, Germany

Dr. Voker Uhlenwinkel, Germany

Dr. H.K. Park, KIGAM, South Korea

Prof. S. Banerjee, Former Director NML & RDCIS, SAIL

2005-06

Prof. John Banhart, Hahn-Meitner Institute, Germany

Prof. D.C. Jiles, Lowa State Univ., Ames, Lowa

Prof. Mohmoud I Nasr, CMRDI, Egypt

2006-07

Prof. Ivoka Dragieva, Sofia, Bulgaria

Prof. Varadarjan Seshadri, Brazil

2007-08

Visit of High Power Delegation from Mozambican Delegates

Visit of officials from CARIRI, Trinidad Tobago Staff

Visit of JKUAT Kenya Faculty and officials

Prof. K.A. Padmanabhan, Former Director, IIT Kanpur

2008-09

Prof. Damodar Acharya, Director IIT Kharagpur

Dr. T. Ramasami, Secretary, DST, GOI

Dr. Serena M. Best, Univ. of Cambridge, UK

Prof. Fathi Habashi, Canada

Dr. Dirk Prinz, Germany

Dr. Maksym Karpash, Ukraine

Prof. Nikola V. Stiochev, Sofia, Bulgaria

Dr. Martin Strangwood, Univ. of Birmingham, UK

2009-10

Prof. S. Brahmachari, DG-CSIR & Secretary DSIR

Prof. P. Ramachandra Rao, Former Vice-Chancellor, BHU Varanasi & DIAT, Pune and Director, NML

Prof. Jae-chun Lee Principal Researcher, KIGAM, South Korea

Prof. Sushant Datta Gupta, Director, IISER Kolkata

Prof. C. Ravindran, Canada; Dr. Andres Thissen, Germany

Prof. Dr.ing. Wolfgang Bleck, Germany

Dipl.-Ing. X. F. Schuler, Germany

Dr. Roger A. Brooks, Univ. of Cambridge

UK; Dr. Juergen Mattusch, Germany

Prof. Ing. Ivo Dlouhy, Czech Republic; Visit of Russian Delegates

Dr. T. Ramasami, Secretary, DST

Dr. Usha Dar, Director, Research & Consultancy, World Environment Foundation

Dr. K-H Park, Distinguished Principal Researcher, KIGAM, South Korea

Major Events

1957-58

Symposium on Recent Dev. In Foundry Technology (08.02.1958)

Exhibition, depicting the present stage of the progress, inaugurated by Prof. M.S. Thacker, DG CSIR

1959-60

Symposium on Pilot Plants in metallurgical research and development (15-18.02.1960)

Symposium on Iron and Steel industry in India (Feb, 1959)

1960-61

Symposium on Light metal industry in India (14-17.02.1961)

1961-62

Symposium on Ferro-alloy industry in India (12.02.1962)

Symposium on Light metal industry in India (Feb, 1961)

1962-63

International Symposium on Recent developments in Iron and Steelmaking with special reference to Indian conditions (4-8.02.1963)

1963-64

International symposium on utilization of metallurgical wastes (10-13.03.1964)

Directors' conference of National Laboratories held at NML (Oct, 1963)

14th German Industries exhibition, West Berlin and Frankfurt New York World Trade Fair

1964-65

Opening the NML Foundry Station at Madras (1964)

International symposium on Micro-metallurgy - the role of minute additions to ferrous and non-ferrous metals and alloys (Mar 29, April 1, 1965)

Opening of the new extension to the Main building of the NML (06.02.1965)

1965-66

Declared open the NML Foundry Station at Madras (14.12.1965)

Symposium on Metallurgy of substitute ferrous and non-ferrous alloys (Apr 27-30, 1966)

Opening of the new extension to the Main building of the NML (06.02.1965)

1966-67

33rd International Foundry Congress (4-9.12.1966)

1968-69

International symposium on Recent developments in Non-ferrous metals technology (4-7.12.1968)

Celebration of Silver Jubilee of CSIR

1969-70

Conference on Development and Testing of High Temperature Materials

1971-72

UNIDO workshop on Creation and transfer of metallurgical know-how (6-10.12.1971)

Seminar on Monolithic refractories (22-24.04.1971)

Convection of Indian Institute of Mineral Engineers (19-20.02.1972)

Seminar on Standardization in Foundries: Foundry convention and Seminar

1972-73

Symposium on Science and Technology of Sponge Iron and its conversion to steel (19-22.02.1973)

Seminar on Bacterial leaching (21-22.12.1972)

Asia Fair 1972 (Nov, 1972)

1974-75

Seminar on Aluminium conductors and cables (13-14.02.1975)

Seminar on Steels for High temperature service (26.11.1974)

1975-76

VII Annual Technical Convection of Indian Institute of Mineral Engineers (11-12.07.1975)

Seminar on Corrosion of Metals in Industries and their prevention techniques (18-19.09.1975)

Symposium on problems in transfer of technology from R&D Laboratory to Industries (14.11.1975)

29th ATM of IIM (15-16.11.1975)

Silver Jubilee Celebration of NML (14.11.1975)

CSIR technology exhibition (13-14.04.1975)

1976-77

CSIR-Industry-Government Get-together at Patna (14.04.1976)

Get-together at NML on Refractories, Glass and Ceramic Industries in Bihar (12.02.1977)

Seminar-cum exhibition on Transfer of Technology to Rural India, held at Delhi (27-03.08.1976)

Exhibition organised by Singhbhum Chamber of Commerce and Ind. (03-05.12.1976)

Exhibition on Survey, Conservation and Utilisation of Resources (Jan 1977)

1977-78

UNIDO Consultation meeting on adaptation of steel technology to the needs of the developing countries (Nov 28 - Dec 2, 1977)

Meeting of the Co-ordination Council for Engineering Group of Laboratories of CSIR (13.01.1977)

Get-together and Exhibitions (Apr, 1977)

NML-MECON Agreement

State level R&D Committee for Bihar

1978-79

Get-together on Mineral processing and Metallurgical Engineering (29.04.1978)

State level R&D Committee for Bihar (30-31.08.1978)

Exhibition on Science for Villages, held at Wardha

Indian National Exhibition in Moscow (Aug, 1978)

Exhibition on Advance in Chemical Metallurgy, organised at BARC, Bombay (Photo) (03-06.01.1979)

NML-MECON Agreement

1979-80

Get-together and Exhibition of National Labs held at Birla Industrial and Tech. Museum (April 1979)

State level R&D Committee for Bihar (15-16.10.1979)

Exhibition during 33rd ATM of IIM (14-17.11.1979)

India International Trade Fair (Nov 10-Dec 9, 1979)

National Industries Fair'80 (Jan 21-Feb 3, 1980)

1981-82

UNIDO workshop on regional project for the Co-operative Research among metallurgical research and development centres in Asia and the Pacific (7-11.12.1981)

1982-83

A National Seminar on "Co-operation in Information management (14-15.02.1983)

Two metallurgical orientation courses, and a short term course on 'Basic metallurgy' (1983)

Participation in India International Trade Fair 1982

Participation in Festival of India Exhibition 1982 held at London

23 Feb-1 Mar 1983 - CSIR Parliamentary Science Exhibition at Parliament House

1983-84

24-26 October - A Seminar on problems and prospects of ferro-alloy industry in India - 1983

14-27 November - Participation in India International Trade Fair 1983

1984-85

11-13 March - Seminar on Mineral processing and the Annual Technical convection of India Institute of Mineral Engineers (IIME) jointly organised by NML & IIME

8-9 February - Eleventh National Powder Metallurgy Conference

15-16 February - Symposium on Magnesium - its Status & progress in India

1985-86

11-13 March - Seminar on Mineral processing and the Annual Technical convection of India Institute of Mineral Engineers (IIME) jointly organized by NML & IIME

8-9 February - Eleventh National Powder Metallurgy Conference

15-16 February - Symposium on Magnesium - its Status & progress in India

1992-93

27-29 February - International seminar on refractories

25-28 March - International workshop in advances in Low carbon High strength ferrous alloys

14-15 April - National seminar on Research & Process Development in Mineral preparation

23-24 December - A Seminar on Corrosion & Protection in Hindi

1993-94

21-22 January - Workshop on Non-Destructive Evaluation of Materials

September - Workshop on use of non-coking coal in Metallurgical Industries

1994-95

12-14 January - National workshop on Modern methods of chemical analysis for minerals, metals & Pollutants

12-14 January - Refresher Course on Ferro Alloys

7-12 February - Refresher Course on Mineral Beneficiation

11-13 May - Workshop on Heat treatment and surface engineering of iron and steels (THIS-94), jointly organised by NML & IIM

12 September - Workshop on Utilisation of industrial waste (In Hindi)

23-24 September - Workshop on Tailoring of properties through mechanical processing - A practical approach

28-29 November - Workshop on Calcium carbide operations : Present and future

14-16 December - Workshop on Alternative charge materials for electric arc and induction furnaces

1995-96

16-17 February - Workshop on small scale foundries as a part of skill-cum-technology upgradation programme

11-12 April - National Workshop on Boiler Corrosion

4-8 December - Workshop on small scale foundries as a part of skill-cum-technology upgradation programme - "NML-STUP"

1996-97

15-16 February - National workshop on Modern methods of chemical analysis for minerals, metals, refractory materials and ferro-alloys

15-16 February - National workshop on Transport phenomena in metallurgical Processes

12-13 February - National workshop on Environmental and waste management in Metallurgical Industries

23-24 April - National Seminar on Automotive Materials (AUTOMAT-96) was organized

20-21 August - National workshop on Status of Ferro-alloy industry in the liberalized economy (FALECON-96)

16-20 September - National workshop on Component Integrity Evaluation and Life Assessment (CIELA-96)

10-11 December - National workshop on Computer Application in Materials and Metallurgical Engineering (CAMME-96)

12-13 December - National workshop on Mechanical testing and property evaluation of engineering (METPEM-96)

1997-98

6-7 January - National workshop on Hot Dip Galvanising (HODGA-97)

9-10 January - National Seminar on Processing of Fines (PROF-97)

27-28 January - National Workshop on Appraisal, Utilisation and Conservation of Medicinal plants of East Singhbhum

1998-99

22-24 September - Challenges and achievements in Mineral Industry & Workshop on Froth Flotation (CAMI-98)

9-11 December - National Workshop on Modern methods of chemical analysis for minerals, metals, refractory, materials and Ferro-alloys (MMCA-98)

22-23 December - National Workshop on Surface Engineering (NWSE-98)

1999-2000

19-20 January - National Workshop on Metallographic techniques for characterisation of industrial materials (METCIM-99)

26-27 February - National Seminar on Utilisation of Fly Ash for value added ceramic products (UFAVCP-99)

28-29 July - National Seminar on Environmental and Energy Audit in Metal Industries: Concepts for the New Millennium

7-8 December - Environment and Waste Management in Iron & Steel Industries

7-9 December - Indo-Russian Microsymposium on Non-ferrous Extractive metallurgy in the New Millennium (NEFNM-99)

26 November 1999 - Inaugural function of NML Golden Jubilee Celebration

1-3 December - XXXII Shanti Swarup Bhatnagar Memorial Tournament (Indoor Finals), for the first time

2000-01

18-19 January - Workshop on Aqueous Effluent treatment and recycling of metal wastes

9-11 February - International Seminar on Non-ferrous Metals and Materials in the Twenty First Century with a Satellite Symposium on Aluminium

2-3 November - International Symposium on Processing of Fines (PROF-2000)

14-15 September - WEB 2000 - 3rd Annual Meeting of the CSIR Laboratories on IT Matters

26 November - NML Foundation Day & Golden Jubilee Valedictory Function

2001-02

18-19 January - Workshop on Recent trends in structural integrity assessment

17 April - Seminar on Mineral based Industry for Jharkhand State

26-27 April - National Workshop on Advanced Materials processing

5-6 September - Workshop on Environmental Management for Industries using Eco-friendly technologies

19-21 September - Seminar on Metallurgy for Engineers

13-14 December - National Seminar on Corrosion and its prevention

18-19 December - National Seminar on Synergy of R&D and marketing

2002-03

22-23 January - International Seminar on Non-equilibrium phenomena in materials science and technology

24-25 January - National Seminar on Clean technologies for metallurgical industries (EWM-2002)

30-31 January - Workshop on Eco-friendly technologies for better environmental management

8 March - Workshop on Empowering women for Enriching society

12-13 March - Indo-Malaysian joint workshop on Advanced materials

27-28 August - Workshop on Environmental Management-Pollution Prevention Pays

28-29 November - Workshop on Fatigue, Fracture and Integrity Assessment

10-12 December - Workshop on Total Environmental Control based quality and productivity management

2003-04

8-9 January - Workshop on Remaining Life Assessment and extension of aged components of thermal power plant and petrochemical industries

21-23 January - Workshop on Continuing Education course on Metallurgy

30-31 January - National Seminar on Microalloyed Steel for Automotive Industries

4-6 February - Workshop on Promotion of Entrepreneurial Skills for Empowerment of Women

10-11 February - Workshop on Intellectual Property Assets in Business Development

5-9 March - Short Term Training programme on advances in mineral processing

15 October - Awareness-cum-implementation programme on ISO 9001:2000 QMS

4-5 December - National Seminar on Pollution in Urban Industrial Environment

2004-05

9 January - Seminar on Recent Developments in Metallurgy

18-19 April - National Seminar on Corrosion, Failures and Mitigation (CFM-04)

27 August - Seminar on Amorphous & Nanocrystalline Materials : Synthesis and characterisation

9-10 September - Seminar on Water : Conservation, Purification and Harvesting in Hindi

14-15 December - National Seminar on Prevention of Corrosion in steel structures (PCSS-04)

Workshop on Quantitative NDE in condition Monitoring (QNDE-04)

2005-06

11 March - IIM Seminar on Perspective of Metallurgy in Industrial Practices

5-9 December - Workshop on Metallurgy for Engineers

25 December - FUGIYA-2005

2006-07

15 September - 38th SSBM Zonal Indoor Tournament

10-11 January - Workshop on Electromagnetic NDE methods for Materials (ENDEM)

26-27 July - Seminar on Remaining Life Assessment (RLA-06)

2007-08

5-6 March - Workshop on Intellectual Property Rights for RTOs under EU-India Trade and Industrial Development Programme

22-23 March - Training Programme on Value added gift items for waste materials

26-27 March - National Seminar on Coal in Hindi

2 April - EMAT Technology

17-18 April - Seminar on Intermediate Teachers (LAPICT)

30 August - 1 September - National Seminar on Advance Gravity Separation (AGS-07)

7-27 September - Training imparted to CARIRI, Trinidad Tobago Staff

11-13 October - Training imparted to JKUAT Kenya Faculty and officials

10-14 December - Seminar on Metallurgy for Engineers

28 November - 1 December - National Seminar on Processing of Iron Ore (PIO-07)

5-7 December - Workshop on Industrial Corrosion Evaluation and Mitigation

2008-09

29 January - Workshop on Automated Ball Indentation Technique (BIT)

25-26 February - Workshop on Special Metal Casting and Forming Processes (CAFP-2008)

27-29 February - Workshop on Extraction of Non-ferrous Metals and their recycling (NFTP-2008)

27-29 March - CSIR-ISTAD Theme meeting on Nanostructured Advanced Materials

16-18 April - Workshop on Agglomeration and characterisation of iron bearing raw materials (ACIM-08)

18-20 September - Workshop on Advancements in Steels for Defence Applications

1-4 December - VI International Conference on Mechanochemistry and Mechanical Alloying (INCOME-2008)

2009-10

16 February - Seminar on Optical Emission Spectro & Gas Analyzer

9-13 November - Workshop for Indian Air Force Officials

14-16 December - Seminar of Metallurgy for Engineers

13 January - Inauguration of Pilot plant for Mine water reclamation

21-22 January - National Seminar on Electronic Waste

Advisory Members - Executive Council

1949-50

Chairman
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Member Secretary
Dr. George Sachs
Director
National Metallurgical Laboratory, Jamshedpur

1950-51

Chairman
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Member Secretary
Prof. Charles Crussard
Director
National Metallurgical Laboratory, Jamshedpur

1951-53

Chairman
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Member Secretary
Dr. G.P. Contractor
Acting Director
National Metallurgical Laboratory, Jamshedpur

1953-56

Chairman
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Member Secretary
Mr. E.H. Bucknall
Director
National Metallurgical Laboratory, Jamshedpur

1956-62

Chairman
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Member Secretary
Dr. B.R. Nijhawan
Director
National Metallurgical Laboratory, Jamshedpur

1962-63

Chairman
Shri C. Subramaniam
Union Minister for Steel & Heavy Industries
Govt. of India, New Delhi

Member Secretary
Dr. B.R. Nijhawan
Director
National Metallurgical Laboratory, Jamshedpur

1963-64

Chairman
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Member Secretary
Dr. B.R. Nijhawan
Director
National Metallurgical Laboratory, Jamshedpur

1966-69

Chairman
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Member Secretary
Dr. T. Banerjee
Acting Director
National Metallurgical Laboratory, Jamshedpur

1969-70

Chairman
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Member Secretary
Prof. V.A. Altekar
Director
National Metallurgical Laboratory, Jamshedpur

1970-71

Chairman
Sir A. Ramaswami Mudaliar
India Steamship House
21 Old Court House Street, Calcutta

Members :
Dr. D.P. Antia
Dy. Managing Director
Union Carbide (India) Limited, Calcutta

Dr. R.V. Tamhankar
Director
Defence Metallurgical Research Laboratory
Phisalbanda, Hyderabad

Dr. Brahm Prakash
Director, Metallurgy Group
Bhabha Atomic Research Centre
C.S.M. Marg, Bombay

Dr. P. Dayal
Industrial Adviser (Metals)
Director General of Technical Development
Internal Trade & Co. Affairs
Ministry of Industry, Udyog Bhavan, New Delhi

Prof. T.R. Anantharaman
Prof. & Head of the Dept. of Metallurgy
Benaras Hindu University, Varanasi

Shri F.A.A. Jasdanwalla
Technical Director
Indian Standard Metal Co. Limited
ISM Estate, Chinchpokli, Cross Lane, Bombay

Shri R.L. Khanna
Works Manager
Indian Copper Corporation Limited
Post - Ghatsila, Singhbhum

Shri K.C. Khanna
Asst. General Supdt. (I&S)
Hindustan Steel Limited
Durgapur Steel Plant, Durgapur

Prof. V.A. Altekar
Director
National Metallurgical Laboratory, Jamshedpur

Director General
Council of Scientific & Industrial Research
Anusandhan Bhavan, Rafi Marg, New Delhi

Finance Adviser
Council of Scientific & Industrial Research
Anusandhan Bhavan, Rafi Marg, New Delhi

1971-72

Chairman
Shri K.T. Chandy
Kerala State Industrial Development Corpn. Limited
Trivandrum - 1, Kerala

Members :
Sir J.J. Ghandy
Director
Tata Iron & Steel Co. Limited, Jamshedpur

Dr. D.P. Antia
Dy. Managing Director
Union Carbide (India) Limited, Calcutta

Dr. R.V. Tamhankar
Director
Defence Metallurgical Research Laboratory,
Phisalbanda, Hyderabad - 23

Dr. Brahm Prakash
Director, Metallurgy Group
Bhabha Atomic Research Centre
C.S.M. Marg, Bombay

Dr. P. Dayal
Sr. Industrial Adviser (Metals)
Dept. of Mines & Metals, Ministry of Steel & Mines
Government of India, New Delhi

Prof. T.R. Anantharaman
Prof. & Head of the Dept. of Metallurgy
Benaras Hindu University, Varanasi

Shri F.A.A. Jasdanwalla
Technical Director
Indian Standard Metal Co. Limited
ISM Estate, Chinchpokli, Cross Lane, Bombay

Shri R.L. Khanna
Works Manager
Indian Copper Corporation Limited
Ghatsila, Singhbhum

Shri Rup Rai
General Superintendent
Rourkela Steel Plant, H.S.L.
Rourkela, Orissa

Prof. V.A. Altekar
Director
National Metallurgical Laboratory, Jamshedpur

Director General
Council of Scientific & Industrial Research
Anusandhan Bhavan, Rafi Marg, New Delhi

Finance Adviser
Council of Scientific & Industrial Research
Anusandhan Bhavan, Rafi Marg, New Delhi

Dr. A.B. Chatterjea
Dy. Director
National Metallurgical Laboratory, Jamshedpur

1972-83

(Data not available)

1984-87

Chairman
Dr. V.S. Arunachalam
Scientific Adviser to the Minister of Defence
Ministry of Defence, South Block, New Delhi

Members :
Dr. S.R. Pramanik
Director (T)
Metallurgical & Engineering
Consultants (India) Limited, Ranchi

Dr. G. Mukherjee
Vice Chairman
Steel Authority of India Limited
Ispat Bhavan, Lodhi Road, New Delhi

Dr. S.K. Gupta
Director (R&D)
Research & Development Centre for Iron & Steel
Steel Authority of India Limited, Ranchi

Dr. V. Ramaswamy
Deputy General Manager
Research & Development Centre for Iron & Steel
Steel Authority of India Limited, Ranchi

Dr. M.K. Asundi
Head, Physical Metallurgy Division
Bhabha Atomic Research Centre
Trombay, Bombay

Dr. P. Rama Rao
Director
Defence Metallurgical Research Laboratory
P.O. Kanchanbagh, Hyderabad

Dr. H. Md. Roshan
Professor
Department of Metallurgical Engineering
Indian Institute of Technology, Adyar, Madras

Dr. H.S. Ray
Professor
Department of Metallurgical Engineering
Indian Institute of Technology, Kharagpur

Shri R.G. Mahendru
Chairman & Managing Director
Central Mines Planning & Design Institute, Ranchi

Dr. A.C. Wadhawan
Director
Smelting Operations
Hindustan Zinc Limited
6, New Fathpura, Udaipur, Rajasthan)

Dr. S. Ranganathan
Professor & Chairman
Department of Metallurgy
Indian Institute of Science, Bangalore

Dr. T. Mukherjee
Director of Scientific Services
Tata Iron & Steel Company Limited, Jamshedpur

Director General or his Nominee
Council of Scientific & Industrial Research
Anusandhan Bhavan, Rafi Marg, New Delhi

Prof. P.K. Rohatgi
Chairman, Co-Ord. Council Engineering Group of Laboratories
Library Building, University of Bhopal, Bhopal

Director
National Metallurgical Laboratory, Jamshedpur

1987-91

Chairman
Dr. P. Rama Rao
Director
Defence Metallurgical Laboratory, Hyderabad

Members :
Dr. S.K. Gupta
Director, RDCIS
Steel Authority of India Limited, Ranchi

Prof. H.S. Ray
Head, Metallurgical Engineering Department
Indian Institute of Technology, Powai, Bombay

Prof. P.C. Chakraborty
Director
National Institute of Foundry & Forge Technology
Ranchi

Dr. M.N. Dastur
Chairman & Managing Director
M.N. Dastur & Co. Pvt. Limited, Calcutta

Prof. P.K. Jena
Director
Regional Research Laboratory, Bhubaneswar

Dr. J.J. Irani
Joint Managing Director
Tata Iron & Steel Company Limited, Jamshedpur

Dr. L.K. Singhal
Director (Technology)
Metallurgical Engineering Consultants India Limited, Ranchi

Dr. R.K. Iyengar
Addl. Director General
Council of Scientific & Industrial Research
New Delhi

Prof. S. Banerjee
Director
National Metallurgical Laboratory, Jamshedpur

Dr. N. Dhananjayan
Head, Information Management Division
National Metallurgical Laboratory, Jamshedpur

1991-1994

Chairman
Dr. J.J. Irani
Managing Director
Tata Iron and Steel Co. Limited, Jamshedpur

Members :
Dr. S.K. Gupta
Chairman & Managing Director
MECON, Hinoo, Ranchi

Dr. H. Dalal
Jaihind Syachi
Bombay Pune Road, Chinchwad, Pune

Prof. P.K. Rao
Head, Metallurgical Dept.
Indian Institute of Technology. Powai, Bombay

Prof. B.K. Dhindaw
Head, Metallurgical Engg. Department
Indian Institute of Technology, Kharagpur

Prof. P.N. Chakraborty
Director
National Institute of Foundry & Forge Technology
Ranchi

Shri S.V. Venkatesh
Executive Director
Metallurgical Services Hindustan Copper Limited
8, Samce Street, Calcutta

Prof. H.S. Ray
Director
Regional Research Laboratory, Bhopal

Dr. T.C. Rao
Director
Regional Research Laboratory, Bhopal

Prof. P. Ramachandra Rao
Director
National Metallurgical Laboratory, Jamshedpur

1994-95

Chairman
Dr. J.J. Irani
Managing Director
Tata Iron and Steel Co. Limited, Jamshedpur

Members :
Dr. V. Ramaswamy
Director (Technical)
Special Steel Project, Jindal Poluster Limited
No.2-C, Vandhana Building, New Delhi

Shri R.N. Parbat
Vice President, Indian Alluminium Co. Limited
Calcutta

Prof. P. Krishna Rao
Head, Metallurgical Engg. Department
Indian Institute of Technology, Powai, Bombay

Professor B.K. Dhindaw
Head, Metallurgical Engg. Department
Indian Institute of Technology, Kharagpur

Shri C.S. Mohan
Chairman-cum-Managing Director
National Mineral Development Corp. Limited
Khanji Bhavan, 10-3-311-A, Castle Hills,
Mass Tank, Hyderabad

Shri M.M. Phadke
General Manger & Vice President (Fibre)
Balapur Industries Limited Thapar House,
New Delhi

Dr. T.C. Rao
Director
Regional Research Laboratory, Bhopal

Shri T.K. Maitra
General Manager
IDBI, Eastern Regional Office
44, Shakespeare Sarani, Kolkata

Dr. L.N. Acharyulu
Director
Defence Metallurgical Laboratory
P.O. Kanchanbag, Hyderabad

Dr. A.K. Guha
Scientist 'F'
CSIR Rafi Marg, New Delhi

Prof. P. Ramachandra Rao
Director
National Metallurgical Laboratory, Jamshedpur

1997-2000

Chairman
Dr. J.J. Irani
Managing Director
Tata Iron and Steel Co. Limited, Jamshedpur

Members :
Shri M.M. Phadke
Vice President (Fibre)
Balapur Industries Limited Thapar House, 124
Janpath, New Delhi

Shri R.N. Parbat
The RETREAT
P/16 Bank Gardens
Raynagar Bansdroni, Calcutta

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Prof. S. Ranganathan
Chairman
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Indian Institute of Science, Bangalore

Prof. S. Lele
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Kalpakkam

Prof. P. Ramachandra Rao
Director
National Metallurgical Laboratory, Jamshedpur

2000-2002

Chairman
Shri P. Parvathisam
Chairman & Managing Director
National Aluminium Co. Limited

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Intl. Advanced Res. Centre for Power Metallurgy &
New Materials
P.O. Balapur, Hyderabad

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Dean of Postgradute Studies & Professor of Met.
Engg.
Indian Institute of Technology, Kharagpur

Shri R.N. Parbat
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Raynagar Bansdroni, Calcutta

Prof. T. Sundarajan
Managing Director
Combution Engineering Lab.
Indian Institute of Technology, Chennai

Shri Firdose A Vandrevala
Vice President, Raw Materials Tata Centre
Tata Steels Limited, Chowringhee Road, Calcutta

Prof. D.D. Misra
Director
Regional Research Laboratory, Dhanbad

Dr. Vibhuti Mishra
Director
Regional Research Laboratory, Bhubansewar

M.B. Goswami
Council of Scientific and Industrial Research
Rafi Marg Anusandhan Bhavan, New Delhi

Dr. P. Ramachandra Rao
Director
National Metallurgical Laboratory, Jamshedpur

2001-2002

Chairman
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Managing Director
Spex Engineering Pvt. Limited, Secundrabad

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Intl. Advanced Res. Centre for Power Metallurgy &
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Indian Institute of Technology, Chennai

Prof. D.D. Misra
Director
Regional Research Laboratory, Dhanbad

Dr. Vibhuti Mishra
Director
Regional Research Laboratory, Bhubansewar

M.B. Goswami
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2003-2007

Chairman
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2007-2010

Chairman
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Prof. S.P. Mehrotra
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2010 -

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Dr. S. Srikanth
Director
NML, Jamshedpur-831007

Brief History

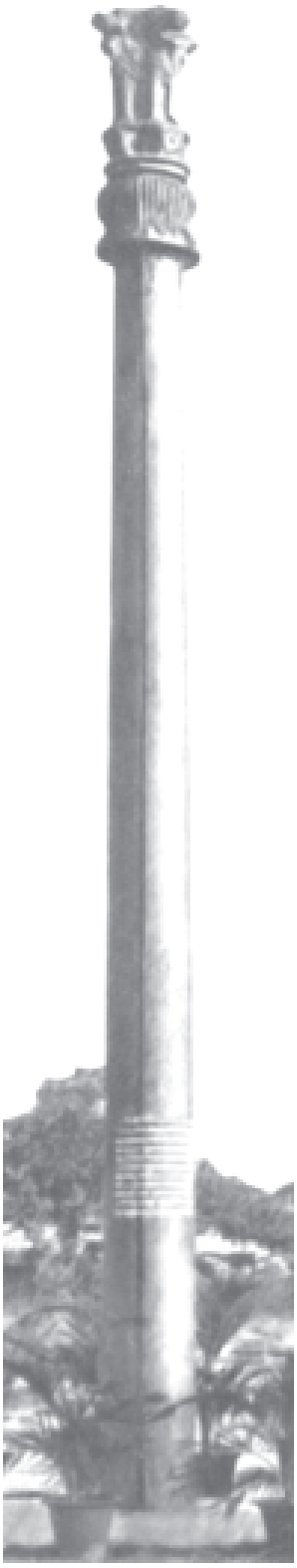
SOON after Dr. Bhatnagar assumed charge of Government-inspired research in India, as the Director of Scientific and Industrial. Research in 1940, he suggested to the Board of Scientific and Industrial Research the setting up of a Metals Research Committee in order to ensure the progress and expansion of India's metallurgical industries. At its first meeting held in December 1940 the Committee came to the considered decision that a central organisation in the form of a National Metallurgical Research Laboratory was essential. A Laboratory Planning Sub-committee of the Metals Committee was later constituted with Sir J. J. Ghandy as chairman to formulate a concrete scheme for submission to the Board of Scientific and Industrial Research. The preliminary report of the Committee was ready in May 1942. The layout and architectural plans were drawn up by Messrs Ballardie Thompson & Matthews in September 1942. The final report of the Committee, including approximate estimates of both capital and recurring expenditure, was submitted to the Board in November 1942. The Board accepted the Sub-committee's recommendations and in October 1944 the Board appointed the National Metallurgical Laboratory Planning Committee with Sir J. J. Ghandy as chairman and Dr. G. P. Contractor (Assistant Director) as secretary. Tentative proposals for the establishment of the National Metallurgical Laboratory were published in 1946.

Out of a total sum of Rs. 50.75 lakhs made available for the establishment of this Laboratory, the grant from the Government of India was about Rs. 38.0 lakhs, and the balance of about Rs. 13.0 lakhs was from donations, the most important of which were the magnificant contribution of Rs. 12.0 lakhs from the Sir Ratan Tata Trust, and Rs. 1.0 lakh from Sardar Bahadur Sir Indra Singh. The Council also received a donation of Rs. 10,000 from the Indian Metallurgical Association towards the establishment of this Laboratory.

The Tata Industries, Ltd., generously placed at the disposal of the Council a plot of land measuring about eight acres for the site of the Laboratory, together with about 18 acres of land for staff quarters.

The foundation-stone of the National Metallurgical Laboratory was laid by Shri Chakravarti Rajagopalachari, then Minister for Education and Arts in the Interim National Government, on November 21, 1946. The actual construction work was taken in hand in January 1948. In order to advise and plan the day-to-day constructional work, the Council of Scientific and Industrial Research constituted a Local Planning Committee under the chairmanship of Sir J. J. Ghandy, the other members being Sardar Ajaib Singh, Major W. H. Ames, Mr. B. R. Kagal and Mr. A. K. Aga. The Laboratory was opened by the Prime Minister, Shri Jawaharlal Nehru on 26th November 1950. A few excerpts from the speeches made on that occasion are reproduced below :

Shri JAWAHARLAL NEHRU - *"Opening this great Laboratory I think of the combination of this Laboratory with the great steel works in this city, of the marriage of science with industry for the progress of both."*



Professor CHARLES CRUSSARD - *"India is one of the few countries to build a National Metallurgical Laboratory. This Laboratory is exactly of the right size for a self-contained unit."*

Sir J. J. GHANDY - "If the Prime Minister has been the inspiration behind this string of laboratories, it has fallen to Dr. Bhatnagar, the great dean of scientific research, to give them concrete form. I am sure a better choice could not have been made, as Dr. Bhatnagar is not only a scientist of great repute, but is also an indefatigable worker and can be more than fitly compared to that beryllium-copper alloy commonly known as 'Tireless Alloy,' which does not fail or even show signs of fatigue under severe stresses."

Sir C. V. RAMAN in his speech compared democracies with metals and said *"She (democracy) stoops to conquer, she yields to conquer. The more she yields, the stronger she becomes and that is the true secret why metals have conquered the world-why the civilization from the very beginning of time has been built on metals."*

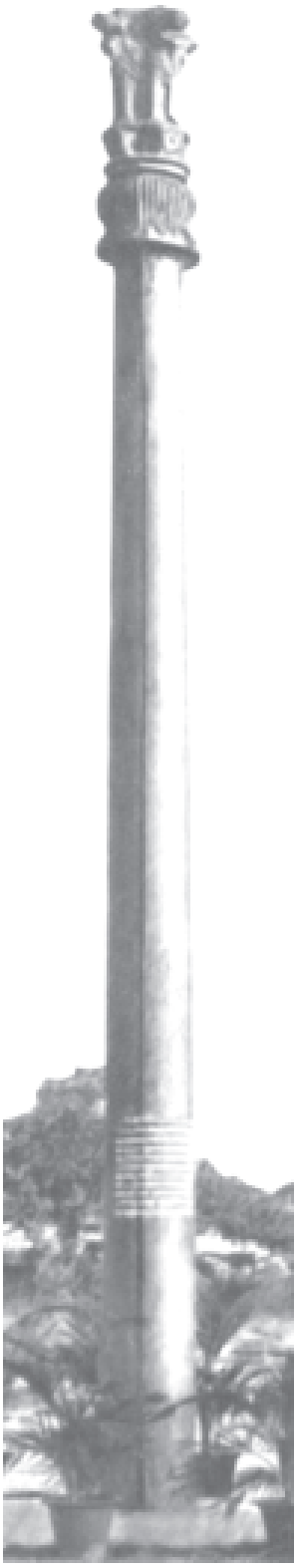
1957 - 58

I have great pleasure in presenting the Report of the Director, National Metallurgical Laboratory for the year 1957-58.

The National Metallurgical Laboratory has now completed its seventh year of existence. Its research programme has been streamlined and is directed towards the discovery of effective uses of indigenous raw materials and development of substitute alloys to replace those imported at considerable expenditure of foreign exchange. Efforts in these and allied fields have been stepped up *pari passu* with the development of Indian metal industries under the powerful stimulus of the Five Year Plans of the Government of India.

From the material contained in the Annual Report, it will be observed that the main emphasis has been on attacking problems of direct development interest to the industry. It will also be noticed that, concurrently with such attack, research work on certain aspects of fundamental and basic metallurgical research has been energetically pursued. At present the research and development work is being directed towards the production of nickel-free austenitic stainless steel based on chromium-nitrogen-manganese-copper compositions, carbon-bonded graphite crucibles, development of mullite refractories, beneficiation of low-grade manganese ores, development of nickel-free high manganese coinage alloys, production of chromium-manganese alloys for incorporation in the nickel free stainless steels, production of steel by the L.D. process utilizing indigenous dolomite and magnesite refractories. These activities have all a direct bearing on the development of mineral and metallurgical industries in the country. Significant results have already been reached in some of the industrial processes initiated at the National Metallurgical Laboratory on a laboratory scale, such as the production of electrolytic manganese metal, electrolytic manganese dioxide, concentration of low-grade manganese and other ores, production of special type of ferro-alloys, studies on soft and permanent magnet materials, beneficiation of low-grade manganese and chromite ores, production of refractories, which are now being translated to pilot plant scale. The process developed for the manufacture of carbon-bonded graphite crucibles has already been handed over to industries for commercial exploitation. The outcome of these projects, I am sure, will result in a sizable saving of foreign exchange and some of them may even earn foreign exchange for the country in the future. Due emphasis has also been laid on the studies of fundamental aspects of metallurgical problems, such as isothermal transformation characteristics of Indian steels, quench-ageing and strain-ageing embrittlement in steels, phase studies of electrodeposited alloys, preferred orientation in rolled sheets and studies of textures, structure of carbide in alloy steels, etc. etc. Collaborative investigations with the Indian Bureau of Mines, the Atomic Energy Establishment, the Metals Research Committee, the Railway Board, etc., have also been pursued.

In collaboration with the Metals Research Committee of the Council of Scientific & Industrial Research of which I have the privilege to be the Chairman, the National Metallurgical Laboratory is establishing one of the largest pilot plants anywhere and definitely the largest in India known, as the Low-shaft



Furnace Project, at a cost of Rs. 27 lakhs capital and Rs. 10 lakhs recurring, to produce primarily commercial grades of pig iron, utilizing non-metallurgical coal or carbonized lignite, plentiful supplies of which are available in the country. The results obtained from this pilot plant should produce data of great value to the future development of iron and steel industry in India and will no doubt be watched with great interest by metallurgists and industrialists not only in India, but the world over.

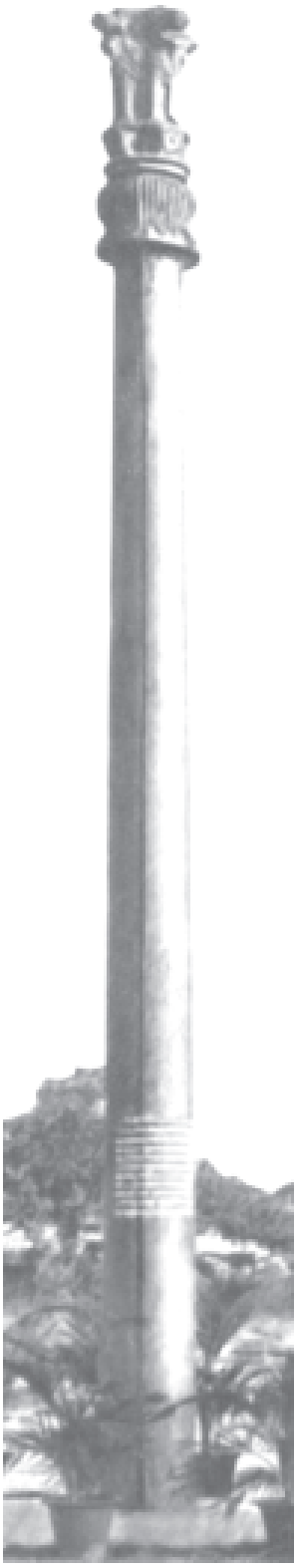
Another significant contribution which the Laboratory has made in the dissemination of scientific knowledge to the industries is the holding of the demonstration of the technical' know-how' of the four patented processes developed by the Laboratory, viz. electroplating on aluminium, chemical polishing on aluminium, brass plating from non-cyanide bath and metallization of non-conductors, which demonstration I had earlier the privilege of inaugurating before the representatives of small-scale industries. Even though the laboratory had received lump sum offers for the commercial exploitation of the above patented processes, I should commend the decision of the Laboratory to release the processes free of royalties, as the results of the investigations of this type find ready application in industry.

Early this year, this Laboratory arranged a successful symposium on "Recent Developments in Foundry Technology" and also an interesting exhibition, inaugurated by Prof. M. S. Thacker, Director-General, Scientific & Industrial Research. The National Metallurgical Laboratory has enjoyed at all times the support and goodwill of the Director-General of Council of Scientific & Industrial Research, Prof. M. S. Thacker, who has taken a keen personal interest in its affairs.

The National Metallurgical Laboratory is proceeding along right lines under the leadership of its Director Dr. B. R. Nijhawan and doing an extraordinarily good job of the different problems posed. There is tremendous work going on in the Laboratory having a direct bearing on the industry and related directly or indirectly to industrial growth during the Second Five Year Plan. I would like to take this opportunity to congratulate Dr. Nijhawan and his colleagues who are working hard in the pursuit of various research and development projects and have done commendable and excellent work. I feel sure that members of the Executive Council and others would like them to know that they deeply appreciate their painstaking endeavours as well as their sense of devotion to research.

J. J. GHANDY
Chairman
Executive Council of the
National Metallurgical Laboratory

Jamshedpur
8 December 1958



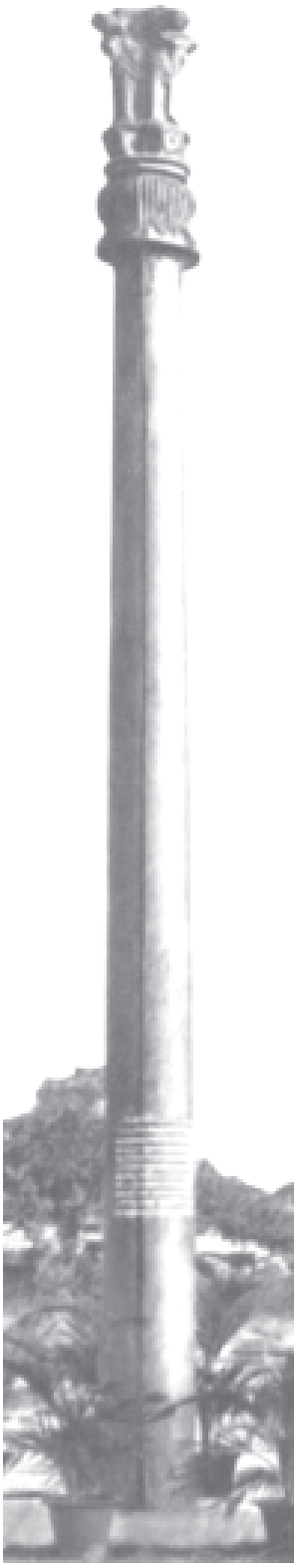
1958 - 59

I have great pleasure in presenting the Report of the Director, National Metallurgical Laboratory, for the year 1958-59. The National Metallurgical Laboratory has now entered its eighth year and is enlarging its activities in many directions closely allied with problems of direct interest to Indian mineral and metal industries.

The Laboratory's research, development and pilot plant programmes have been oriented to meet the requirements of general expansion of metallurgical industries during the successive Five Year Plans of the Government of India. It is heartening to note that more and more emphasis is being laid on the development of pilot plant projects. The Low-shaft Furnace Project which was mentioned in the last year's Report has made further progress. The Pilot Plant was inaugurated by the Hon'ble Sardar Swaran Singh, Union Minister for Steel, Mines and Fuel, early this year and is now in operation yielding valuable data on the use of non-metallurgical fuels for smelting iron ore. Other pilot or semi-pilot plant projects which have made further progress during the year relate to ore-dressing, thermal beneficiation of low-grade ores, production of steel by the L.D. process, aluminizing of steel wire and sheets, refractories and electrolytic manganese and manganese dioxide.

Research on fundamental metallurgical problems has continued during the year. Considerable fresh ground has been broken and consolidation of the work already in hand has been *pari passu* with the development of various pilot plant projects. An atlas for Indian steels is being prepared on the study of isothermal transformation characteristics. Quench-ageing and strain-ageing of some Indian steels, phase studies on eleetro-deposited alloy, structure of carbides in alloy steel, preferred orientation in rolled sheets, study of sigma phase in alloy steels are among the many fields on which work has been carried out. I would commend the creditable efforts put in by this Laboratory in having fabricated a number of laboratory scientific apparatus and pilot plant equipment which have saved valuable foreign exchange notable amongst which are the vacuum fusion gas analysis apparatus for the determination of gases in alloy and plain steels, apparatus for the micro determination of hydrogen in steels of the order of 0.000005 per cent hydrogen, equipment for studying the comparative life of electric resistance and heating alloys, special set-up for accelerated fatigue test, vertical gaseous reduction and horizontal rotary furnaces for upgrading low-grade ferruginous manganese ores and apparatus for hot stage microscopy for studying high temperature phase equilibria of refractories, glasses, slags and cements.

Further valuable development work on nickel-free austenitic stainless steel has been undertaken during the year and tonnage steel ingots and sheets have been produced. The sheets have shown deep drawing qualities and corrosion resistance against specific media. Likewise, work is being actively pursued on nickel-free coinage alloys, nickel-free electrical heating elements and nickel-free manganese brasses. I also find that useful work has been taken in hand on the development of clad metals and bi-metals, production of magnesium by electrolytic method from magnesium chloride and by vacuum distillation technique using dolomite.



During the year under review, the Laboratory has taken several patents and today it has a total of 36 patents to its credit. I would like to make a special mention that some of these processes were released free of royalty for the benefit of the industries and periodical demonstrations were held to provide technical 'know-how' of these patented processes.

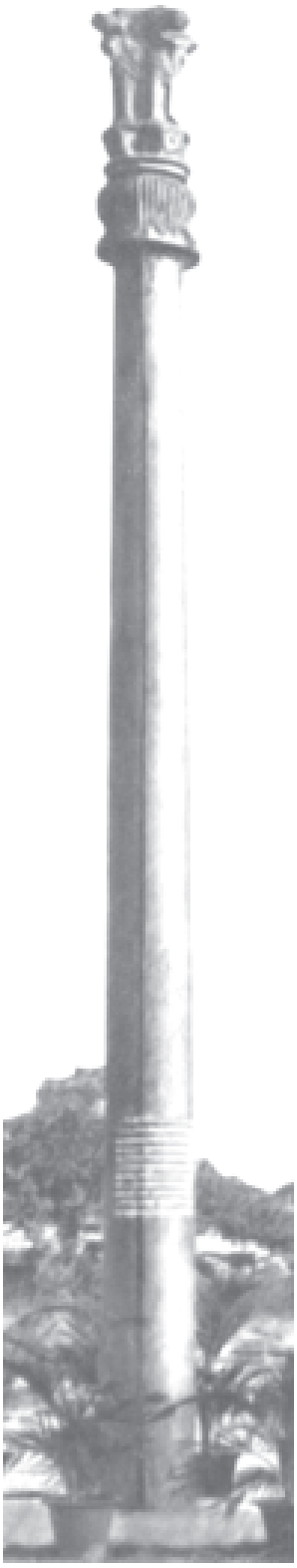
From the large number of enquiries attended by this Laboratory and short term investigations undertaken on behalf of the industries, it is apparent that considerable importance is being given to technical aid to small and medium scale industries as a means of solving their problems. The Liaison and Information service in general to industries and the government bodies have been enlarged both in scope and in actual service rendered. The Laboratory is to be congratulated for bringing out the N.M.L. Quarterly Technical journal which should provide a forum for disseminating scientific data from various investigations and projects undertaken in the Laboratory.

Early this year, as in previous years, the National Metallurgical Laboratory arranged a symposium on 'Iron and Steel Industry in India' which was inaugurated by Prof. M. S. Thacker, Director-General, Scientific and Industrial Research. The Laboratory has always enjoyed the support and goodwill of the Director-General, Prof. M. S. Thacker, who has taken a keen personal interest in its affairs.

In the ensuing years, the pilot plant projects should yield data of considerable value and many new schemes of importance would be undertaken. I am glad that the National Metallurgical Laboratory is occupying a prominent place today amongst the National Laboratories of the country which are making their usefulness felt in various spheres of national activity. Much of the credit goes to the hard work and organizational ability of its Director, Dr. B. R. Nijhawan, and his colleagues. I am sure the Members of the Executive Council and others would join me in placing on record our appreciation of their commendable and excellent work as well as their devotion to research.

J. J. GHANDY
Chairman
Executive Council of the
National Metallurgical Laboratory

Jamshedpur
August 13, 1959



1959 - 60

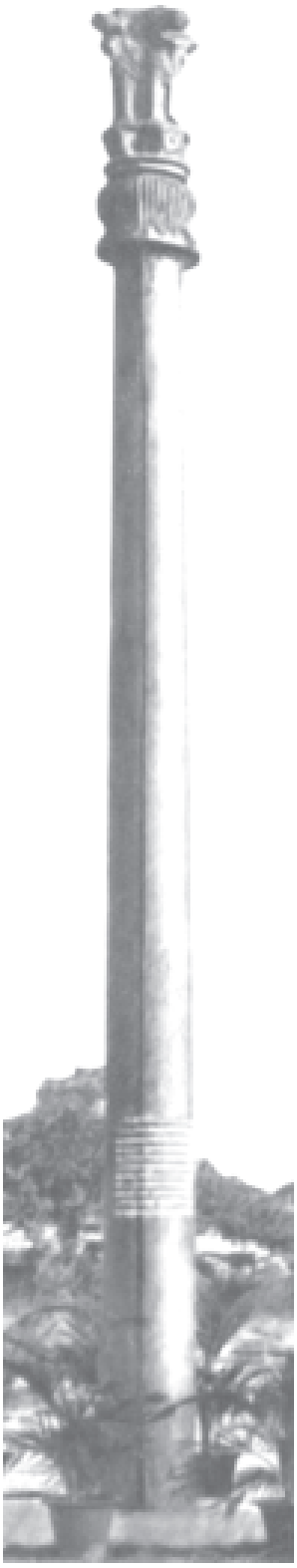
I have great pleasure in presenting this report on the working of the National Metallurgical Laboratory during the year 1959-60. The Laboratory, now in its ninth year, has well-nigh completed the expansion envisaged under the Second Five Year Plan and is preparing itself for shouldering larger responsibilities in the next Plan period. Its plans for expansion, completed or projected, are closely allied to problems of the rapidly expanding mineral and metal industries.

Greater emphasis is being progressively laid in the Laboratory's work on the industrial implementation of research through the agency of pilot plant trials and investigations. It is in this sphere of the Laboratory's activities that the greatest expansion has taken place during the Second Plan. This is a healthy development because pilot plants help to speed up the translation of the latest technological concepts and innovations into acceptable industrial practice. Significantly, therefore, the annual Symposium held in February 1960 was devoted to the discussion of the role " Pilot Plants in Metallurgical Research and Development". A new technological block, housing four new pilot plants, was inaugurated during the Symposium. Particularly gratifying is the fact that these new pilot plants were designed and fabricated in the Laboratory's Instrument and Machine Workshops, saving the country's considerable foreign exchange. Apart from pilot plants, these workshops have successfully fabricated many other items of costly scientific equipment.

The largest pilot plant, of course, is the 15-ton per day low-shaft furnace set up in January 1959. Apart from the usual teething troubles in operating a new plant of this size, several basic modifications had to be made by the Laboratory to the component units. Over a thousand tons of foundry grade pig iron of suitable quality have, however, been produced. The current programme of work relates to the smelting of iron ores from Bihar and Orissa with non-coking coals from the Raniganj and Dishergarh coalfields. This is to be followed up by smelting trials on iron ores from Chanda district and non-coking coals from Ballarpur, Kampti and Wardha valley in Maharashtra State. Later, Salem magnetite ores and Neyveli lignites will be used for experiments.

Another important line of research is the effort to develop a rationalized series of alloy steels based on indigenous elements. The Laboratory is also working on basic lined, side air-blown converters of varying capacities for making steel from medium phosphoric indigenous pig irons. Thus, this Laboratory is developing as a central institution for operational and development research in the iron and steel industry.

In respect of austenitic nickel-free stainless steel, research has been directed towards the problems of industrial scale production, particularly the rolling down of tonnage ingots into commercial gauges of hot-rolled and pickled sheets. These sheets were subjected to various tests, including the assessment of the deepdrawing properties, both in cold and hot-rolled conditions for utensils and other applications. It is a matter of satisfaction that all raw materials used in these tests were processed in the Laboratory right from the stage of ores.



Another approach of importance is the effort to substitute nickel by other indigenously available alloy elements for the production of heating elements and coinage alloys. At the request of the Defence Ministry, the Laboratory has been working on the production and supply of low-carbon ferro-chrome, in which considerable success has been achieved. Likewise, magnesium powder of high purity has been successfully made on a laboratory scale conforming to the rigid specifications of the Ministry. A Pilot Plant for the production of magnesium from dolomite is now being established.

Beneficiation of low-grade manganese ores is a subject which has been under continuous study. Ore samples from various States were investigated and the feasibility of upgrading established. The complexity of these investigations has been made public in a monograph entitled " Beneficiation of Low-grade Indian Manganese Ores ". Another monograph on " Foundry Moulding Sands of India " is under print.

During the year, the Laboratory took out several patents. Practical demonstrations were held to acquaint interested manufacturers and engineers with the know-how of four patented processes. These were released free of royalty-premia for the benefit of small-scale industries. This apart, it may be noted that some processes developed here are now being commercially exploited on payment of royalties. Shortly expected to be added to this list is the process for the electrolytic production of manganese and manganese dioxide. To extend the benefit of research and development work done in the Laboratory, the Liaison and Information Service has been enlarged and considerable importance is attached to providing technical aid to small and medium-scale industries.

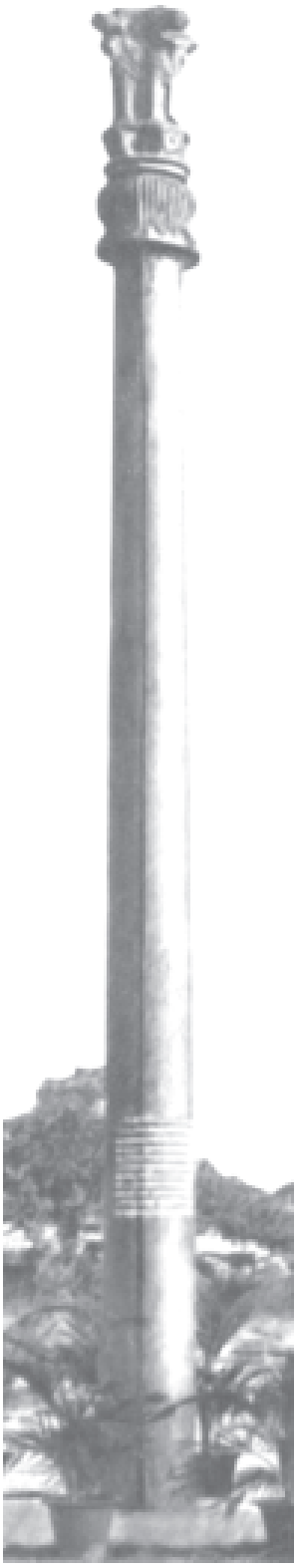
I take this opportunity to recall our gratitude to the U.K. Government for making a gift of equipment worth over a million rupees under the Colombo Plan. The formal presentation was made during the February Symposium by the U.K. Trade Commissioner to Prof. M. S. Thacker, Director-General, Scientific & Industrial Research.

In the present stage of the Laboratory's development, priority is naturally given to operational and development work, but fundamental research has not been ignored. Several important studies are in progress which are illustrated in the appropriate section of the report.

The Council of Scientific & Industrial Research are proving their usefulness in various fields of National Development and I am happy to note that the National Metallurgical Laboratory is holding a prominent place therein. I should like to express our deep appreciation of the hard work and devotion to duty of Dr. B. R. Nijhawan, Director of the Laboratory, and his colleagues. They have done commendable work in many fields and much of the success of the Laboratory's work is undoubtedly due to the organizational ability of Dr. Nijhawan.

J. J. GHANDY
Chairman
Executive Council of the
National Metallurgical Laboratory

Jamshedpur
May 1, 1960



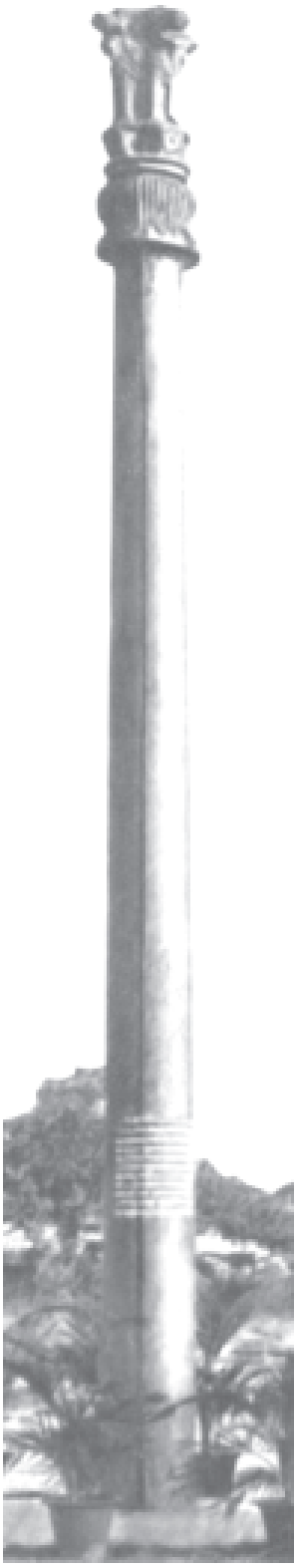
1960 - 61

I have great pleasure in presenting the Report of the Director, National Metallurgical Laboratory for the year 1960-61.

The National Metallurgical Laboratory has now entered the Third Five Year Plan period having nearly completed the expansion envisaged during the Second Five Year Plan and has prepared itself for shouldering heavy responsibilities during the Third Five Year Plan.

The Laboratory's research, development and pilot-plant work has been suitably oriented to meet the urgent requirements of general expansion of mineral and metallurgical industries during the successive Five Year Plans. The hard core of the Second Five Year Plan has been the expansion of the iron and steel industry; in this task, as in many others, the National Metallurgical Laboratory has geared itself to render all possible assistance both to the public and private sectors and acted as a king-pin in the solution of the multitudinous short and long term problems posed before it which were all investigated with thoroughness, speed and technical efficiency, which I am glad to say is the characteristic of the National Metallurgical Laboratory. Great emphasis is being continually laid on heavy pilot plant projects and investigations and prototype trials with the objective of industrial scale implementation of important research and pilot scale processes developed at the National Metallurgical Laboratory; it is in these spheres of the Laboratory's activities that further expansion far greater and broader in scope than in the Second Five Year Plan that has been projected for the Third Plan period. This is indeed a very welcome and healthy development because pilot plant operations speed up the translation of the latest technological concepts and innovations into acceptable industrial plant operations. With the fast expanding pattern of the industrialization of our country covering today a wide spectrum, the research and development projects of the National Metallurgical Laboratory are planned and executed to provide adequate yet at times most difficult answers through research and pilot plant investigations for the ever-increasing problems of the smallest metallurgical units to the giant integrated industrial complexes now emerging. These aspects of the work of National Metallurgical Laboratory have been related to both iron and steel and non-ferrous industries where heavy expansion has been planned during the Third Five Year Plan. Significant in this context was the Annual Symposium arranged by the National Metallurgical Laboratory in February 1961, which was devoted to different aspects of 'Light Metal Industry in India'. The Symposium was a great success and went a long way in focussing attention on our deficiencies and expansion plans for the projected growth of light metal industry during the Third Five Year Plan.

In my 'Foreword' to the last Annual Report I had referred to the important new Pilot Plant Technological Block, housing several important pilot plants which was inaugurated last year. These pilot plants, it is particularly gratifying to note, are now in operation with most of the pilot plant equipment designed and fabricated in the Laboratory's workshop, effecting considerable savings in foreign exchange.

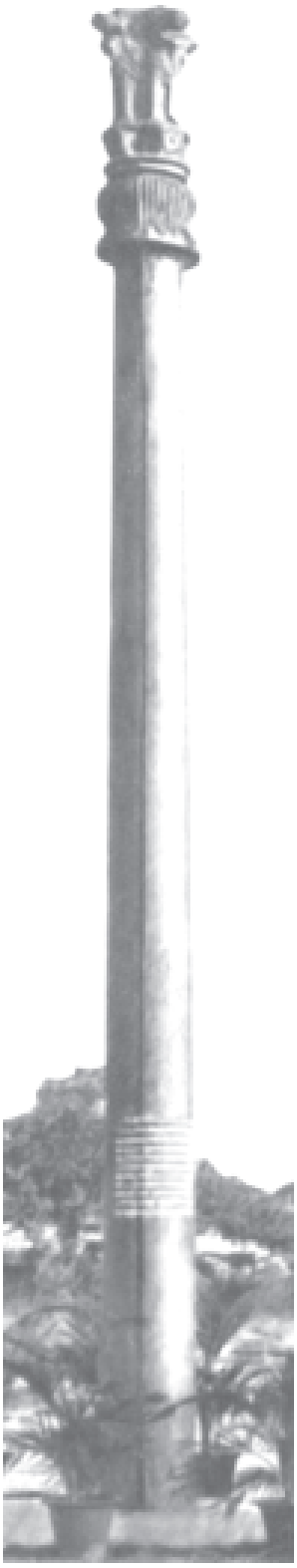


Keeping up the general theme of expansion, I am glad to state that the Laboratory is now adding to its Main Building two side and one central wings at a total cost of about Rs 1.5 million. These wings will contain the new radioactive isotope metallurgical research laboratory, new corrosion laboratories, X-ray fluorescence unit, heavy vacuum melting equipment and components for pressure leaching and hydro-metallurgical research activities of the National Metallurgical Laboratory. These extensions are expected to be completed within the next two years and will be valuable additions indeed. Concurrent with this expansion, the Governing Body of the Council of Scientific & Industrial Research has also sanctioned another heavy pilot plant to beneficiate and treat about 25 tons of low grade manganese ores a day involving a total capital and recurring expenditure of Rs. 5 million out of which Rs. 3 million will be the capital cost of heavy equipment to be imported from abroad under the U.S. Exim Bank Scheme. Land covering over 6 acres has been donated by the Tata Iron & Steel Co. Limited. This pilot plant will be located next to the Low-shaft Furnace Pilot Plant of the National Metallurgical Laboratory and will use the clean low-shaft furnace gas for reduction roast trials of the ferruginous low-grade Indian manganese ores during their beneficiation. This pilot plant is also expected to be completed during the next two years. We are sure that this pilot plant for the beneficiation of manganese ores of India will be of very considerable economic importance to this country. It is also most gratifying that the plans for the installation of a submerged electric arc ferro-alloy furnace at a total cost of Rs. 0.6 million have now been completed and the furnace is expected to go into production early next year. This pilot ferro-alloy furnace with a daily output capacity of over a ton of different ferro-alloys will be the first of its kind to be installed in India and perhaps in the whole of the East, and will be a valuable tool in research and production development work on ferro-alloys to be made from indigenous resources. This pilot plant will be inaugurated early next year and will be available to the general industry for pilot scale ferro-alloy production trials on 'Contract' basis. With these expansions to the Laboratories and different pilot plants, there is no doubt that the National Metallurgical Laboratory will be one of the largest of its kind anywhere in the world and we should feel proud of its stature and activities even as it justifiably does today, deriving its strength from the valuable research and development work completed during the Second Five Year Plan.

During the year under review, Professor Humayun Kabir, Minister for Scientific Research & Cultural Affairs, Government of India, visited the Laboratory and was greatly impressed with the equipment and facilities provided in the National Metallurgical Laboratory and spoke very highly of the excellent standard of research and development work in progress. I might say here that many of the scientists and engineers from overseas, who had visited the National Metallurgical Laboratory, had told me that there were perhaps very few places in the world, including the U.S.A., where such extensive research facilities and equipment had been provided under one roof for metallurgical research and pilot plant trials.

To me, it appears that there is hardly any necessity to send our problems, particularly on raw materials, to outside laboratories for investigations or evaluation. It is my pleasure to state that on an assignment given to National Metallurgical Laboratory by the Tata Iron & Steel Co. Ltd. for beneficiation of iron ore, particularly with regard to the treatment of fines and a balanced alumina-silica ratio, the systematic and comprehensive investigations carried out at the National Metallurgical Laboratory has proved most valuable. Research investigations at the National Metallurgical Laboratory have shown that by washing, screening and heavy media separation, the physical characteristics of the iron ore can be greatly improved which would render the iron-making operations much more smooth and metallurgically more efficient. It is also highly gratifying that similar work has now been undertaken for the steel plants of the Hindustan Steel Limited, Government of India, as also on systematic studies of metallurgical problems, such as quality assessment of the L.D. oxygen steel including its sub-zero physical characteristics, studies on the deadburning of the dolomites in vertical shaft kilns and their stabilization for use in L.D. oxygen steel-making.

In the present stage of the Laboratory's development work considered in the context of our successive Five Year Plans, priority is naturally given to operational and developmental research projects, but



researches on fundamental metallurgical problems have also made good headway and considerable fresh ground has been broken. Consolidation of the work in diverse fundamental fields already in hand has been undertaken *pari passu* with the development of different pilot plant projects.

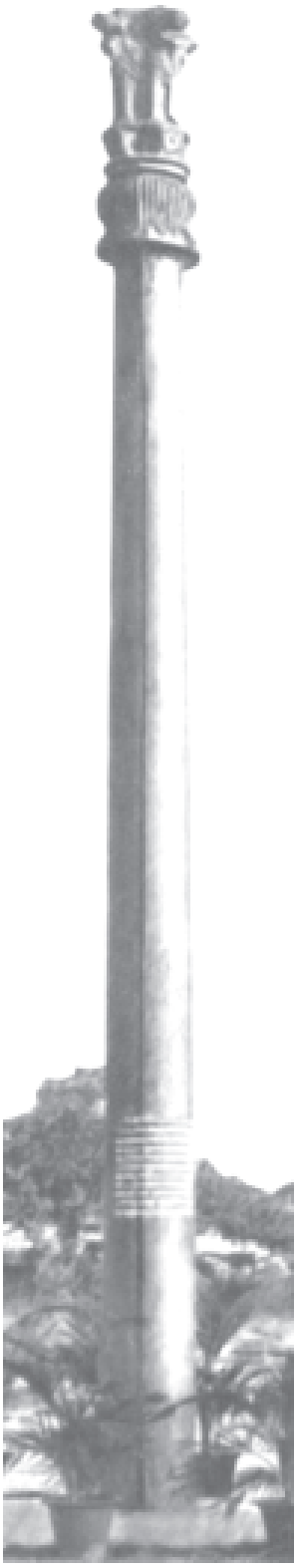
The Laboratory has now taken in seven Fellows working on fundamental fields of research for a period of three years with the object of obtaining higher degrees from Indian universities. This is a useful innovation and should prove exceedingly useful for getting trained personnel in diverse metallurgical research fields.

During the year, the Laboratory brought out two excellent publications; one relating to the Monograph on "Foundry Moulding Sands of India" and the other relating to the Proceedings of the Symposium on "Pilot Plants in Metallurgical Research and Development" held in February 1960, which have been very well reviewed and highly spoken of in India and abroad; the former publication contains the research results on India's foundry moulding sands and bonding materials obtained during the past several years of work at the National Metallurgical Laboratory which are proving valuable to the India's foundry industry fast expanding under the tempo of the Third Five Year Plan. The Symposium publication has been classified as one of the best of its kind brought out within just five months after a Symposium and is finding a place in the technical libraries the world over. The Symposium itself was termed as a 'metallurgical summit' in having drawn scientists and technologists, specialists in their fields, from different parts of the world and providing thereby an international forum for exchange of technical' know-how'.

During the year, the Laboratory has taken out several new patents. Practical demonstrations were arranged to acquaint interested manufacturers with the know-how of the National Metallurgical Laboratory's patented processes; some of which have been released on payment of heavy premia and production royalties - the process on the production of Electrolytic Manganese Metal and Electrolytic Manganese Dioxide will shortly go into full-scale industrial production by a leading firm in Bombay paying a lakh of rupees as the premium with $2^1/_2$ per cent production royalties. Likewise, several other processes relating to production of refractories from indigenous resources and other fields have been passed on to Indian industries through the National Research Development Corporation; these are healthy and highly encouraging developments.

Highly important work on the development of substitute alloys with partial or full substitution of these metals in which India is lacking has made further significant headway. Research and development work on the nickel-free totally austenitic chromium-manganese-nitrogen-copper stainless steel has made excellent progress; the process is now covered by National Metallurgical Laboratory patents taken in India and abroad. Highly valuable results in this project have been obtained towards its production on industrial scale for multitude applications; work in fundamental fields of this project has also yielded valuable results applying X-ray diffraction techniques to 'aged' stainless steels. Studies on cold working characteristics, high temperature oxidation and creep properties in their fundamental aspects of these steels have yielded highly interesting results. Its use for pressure cooker bodies and lids, the latter requiring rigid springy characteristics, has now been established. The development work on bi-metals and other substitute alloys, such as nickel-free heating elements, is now entering its final phase prior to industrial scale implementation. Two general-purpose bi-metals have heen developed: one for application up to 220°c and the other f or application up to 300°C . The nickel-free heating elements have given during industrial scale trials higher electrical resistivity than the conventional heating elements that are imported. Full use has been made in these projects of indigenous resources, such as aluminium, chromium, manganese and rare earth group of metals; it is the latter group that is now leading to the development and formulation of indigenous aluminium-based magnesium wrought light alloys containing optimum additions of rare earth metals at the National Metallurgical Laboratory.

Likewise, other interesting developments have been recorded during the year under review, such as the production of high purity iron powder from ‘Blue Dust’ pockets met with in Indian iron ore mines,



through an ingenious process of solid state reduction developed at the National Metallurgical Laboratory. This fine iron powder has immediate market needs in India considering that the entire demands thereof are met from imports. This process is now ready for passing on to the industry towards which due steps will be taken. Work on the production of nickel plating salts from indigenous resources has yielded good results and the National Metallurgical Laboratory's plating salts have been reported to be as good as, if not better than, those imported.

The Laboratory has continued to collaborate with different Ministries or the Government of India in their research and development programmes, such as the formulation of the production technique of aluminium-bronze castings for the 25 kV traction overhead equipment for the Ministry of Railways, production of aluminium powder of high purity and super-pure magnesium metal and ferro-alloys for the Ministry of Defence, Government of India.

Apart from the development work, the Laboratory has maintained steady progress in the operations of its various pilot plants. The pilot plant work on hot-dip aluminizing of M.S. wire has received appreciation from the British Iron & Steel Research Association, U.K., for the quality of the aluminized wire samples produced from the National Metallurgical Laboratory's pilot plant. Several miles length of aluminized steel wire have been supplied to the Post & Telegraph Department, Government of India, for field applications on their telephone lines. The National Metallurgical Laboratory's pilot plant installed for the production of electrolytic manganese and manganese dioxide has been in continuous operation meeting the requirements of manganese metal for research projects on nickel-free coinage alloys, nickel-free manganese brasses and heating elements besides nickel-free austenitic stainless steels using electrolytic manganese after nitriding it at the National Metallurgical Laboratory.

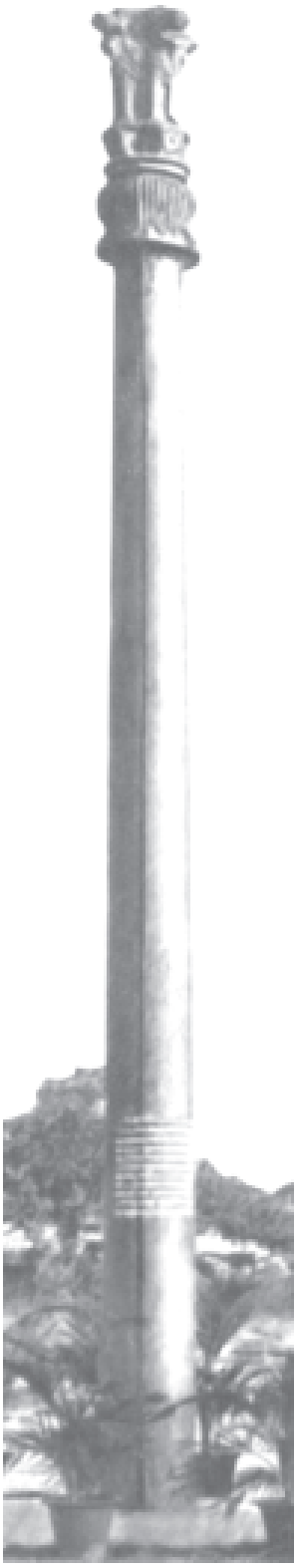
In the Low-shaft Furnace Pilot Plant, recent campaigns on the smelting of iron ores using low temperature carbonized coke from the Singareni Colliery of Andhra Pradesh have yielded very valuable results. The furnace operations have been smooth, fuel consumption has been reasonable and difficulties following hanging and high-top temperatures have also not been encountered. Successful investigations are also currently under way for the utilization directly of non-coking coals from Singareni without any prior drying or carbonization treatments. I am happy to say that the National Metallurgical Laboratory is actively collaborating with the Governments of Maharashtra, Andhra Pradesh, Rajasthan and East Punjab in conducting smelting trials with their regional raw materials in the low-shaft Furnace Pilot Plant. Work is also being initiated to help the Government of Nepal to establish a small scale iron production plant in Nepal using their raw materials. The Low-shaft Furnace Pilot Plant has been in continuous operation round the clock practically throughout the year under review.

A demonstration of the National Metallurgical Laboratory's process on Liquid Gold was also arranged during the year to acquaint interested manufacturers with the technical ‘know-how’ of the process to whom this process has been leased. As metallurgical industries are becoming increasingly conscious of the importance of research in finding effective solution of the industrial problems, numerous technical operational research and investigation problems are being ever-increasingly referred to this Laboratory which are successfully handled by the operational research staff of the National Metallurgical Laboratory; praticularly dominant in these fields has been the problems of Indian foundries.

The NML Technical Journal has stepped into the third year of its publication and has attained a stature at par with other leading Indian and overseas scientific journals. The NML Technical Journal is now being exchanged with the leading metallurgical journals from other countries and at home on a free basis effecting foreign exchange savings.

It is my pleasure to state that not only high research standards and tempo of work have been fully maintained at the National Metallurgical Laboratory, but also that extraordinarily valuable work is being done laboriously, systematically and comprehensively in the National Metallurgical Laboratory.

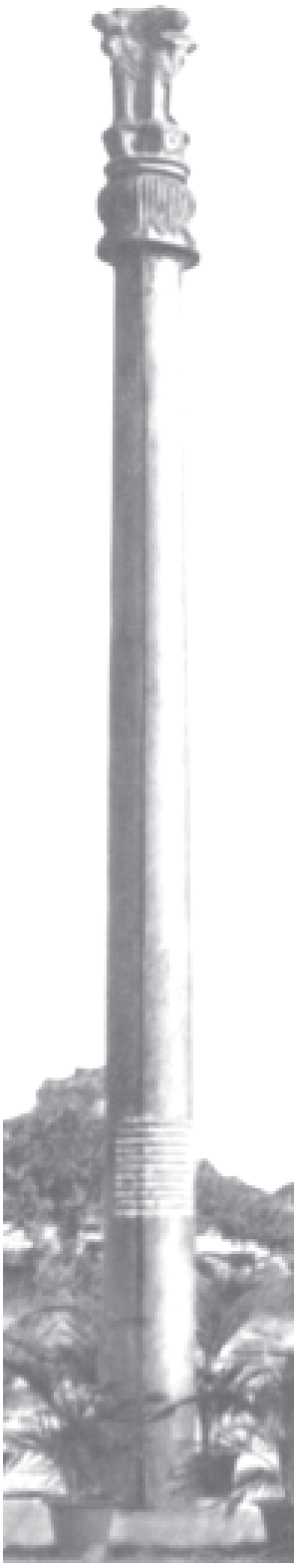
The National Metallurgical Laboratory has always enjoyed the full support and active goodwill of the



Director-General, Scientific & Industrial Research, Professor M. S. Thacker, who has taken a keen personal interest in the Laboratory's activities. The Council of Scientific & Industrial Research have established their usefulness in the various fields of national development and I am indeed very happy to note that the National Metallurgical Laboratory is holding a position of pride in this organization. I would like to express on my behalf and that of other Members of the Executive Council our sincere appreciation of the extremely hard and devoted work that is being done by Dr. B. R. Nijhawan, Director, National Metallurgical Laboratory, and his able colleagues. I would like them to know that the Members of the Executive Council of the National Metallurgical Laboratory deeply appreciate their highly creditable and laudable efforts. Much of the success of the Laboratory's widening scope of work is undoubtedly due to the hard work, research and organizational ability of its Director, Dr. Nijhawan. The National Metallurgical Laboratory is today on the threshold of a great expansion in different spheres during the Third Five Year Plan, and I am sure the Members of the Executive Council and others would join me in offering Dr. Nijhawan and his colleagues our best wishes for fresh laurels and achievements.

J. J. GHANDY
Chairman
Executive Council of the
National Metallurgical Laboratory

Jamshedpur
May 1, 1961



1961 - 62

I have great pleasure in presenting the Report of the Director, National Metallurgical Laboratory, for the year 1961-62.

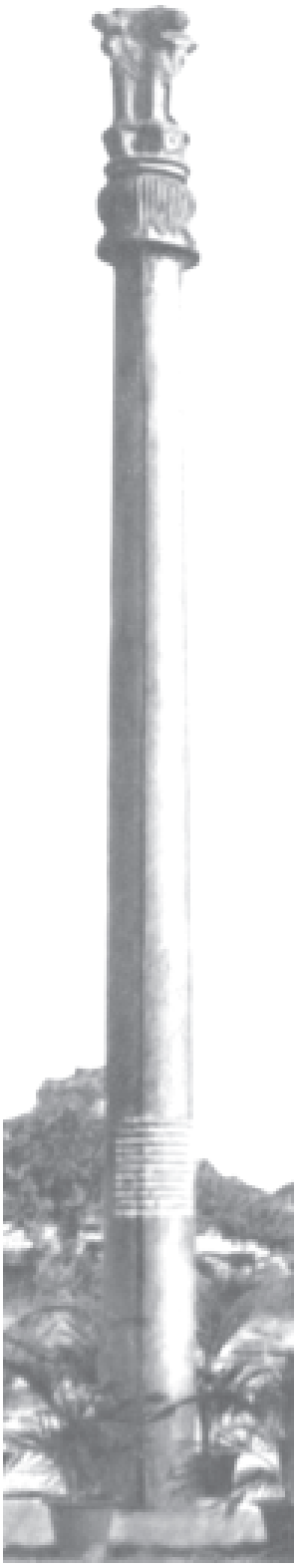
The projected expansion of the National Metallurgical Laboratory during the Third Five Year Plan, is now taking concrete shape, which includes the establishment of a Pilot Plant for beneficiation of indigenous low-grade ores, studies on sintering, pelletizing etc. at a cost of Rs. 3.5 million. The entire equipment for this Pilot Plant had been procured from the U.S.A., transported to the site and the work of erection has made rapid progress. It is hoped that the plant, one of the biggest of its kind in India, will be in full operation next year. Similarly, the expansion of the main building by the addition of the side and central wings has made considerable headway. It is gratifying to note that these additions with all services costing over Rs. 1.5 million will be fully completed during the coming year. The new wings will house laboratories for radio-active isotope tracer research studies, expansion of corrosion laboratories, X-ray flourescence spectroscopy, vibrophore pulsator, vacuum melting units and equipment for pressure leaching and hydro-metallurgical research activities, etc.

The submerged electric arc ferro-alloy pilot plant, built at a cost of Rs. 0.6 million, went into operation on the 12th February 1962 during the Symposium on “Ferro-alloy Industry in India”, organized by the Laboratory.

The expansion envisaged during the Third Five Year Plan also covers the establishment of a full-fledged Iron & Steel Division and an Alloy Steel Division as also the establishment of a Marine Corrosion Research Station at Digha. The plans and designs for the Marine corrosion Research Station at Digha have already been finalized and contract orders have been placed. It is hoped to man and operate this station fully during 1962-63 which will provide the much needed corrosion data for the industry. The Laboratory is also actively collaborating with the Metals Research Committee in organizing research into diverse phases of corrosion of metals and alloys on an all India basis. Incidentally, it has been said that the National Metallurgical Laboratory is one of the leading research laboratories in the country today where considerable work on different aspects of corrosion of metals and alloys has already been undertaken.

Efforts are being made to obtain through the channel of United Nations Special Fund Assistance Programme pilot plant equipment for iron and steel research investigations including Krupp-Renn kilns, Sturzelberg rotary furnaces, equipment for direct reduction of iron ore, L-D oxygen fully instrumented 3-tons converters, pilot continuous casting units and a pilot plant for the study of carbon electrodes and Soderberg pastes for electro-metallurgical applications.

The Laboratory has undertaken the design and fabrication of a pilot basic-lined side-blown converter employing non-oxygenated air blast to refine phosphoric pig iron into acceptable grades of steel. The design and fabrication of a vertical smelting furnace with two sets of tuyeres, to undertake investigations on oil injections, low shaft-furnace gas injection, besides injection of powdered fuels and fluxes through the second set of tuyeres, has been completed for the production of foundry grades of pig iron.



The Laboratory has made a beginning in imparting specialized training in metallurgical subjects. Graduate apprentices have been selected and are being given a course of training to meet the requirements of technical posts in metallurgical industries. Likewise at the artisan level, trade apprentices for mechanical, electrical and electronic instrumentation, mechanical workshop and pilot plant installations are being trained. There has also been a substantial increase in the number of junior and senior research fellowships for those working for higher post-graduate degrees. Such measures are steps in the right direction which will pay rich dividends in due course, not only to the Laboratory but also to the metallurgical industries.

During the year under review the following important Project Investigation Reports have been issued :

(1) Pilot plant studies on beneficiation and sintering of Bolani iron ore for Durgapur Steel Plant of Hindustan Steel Ltd.

(2) Iron production with non-coking coals in low-shaft furnace pilot plant at the National Metallurgical Laboratory.

(3) Report on the operation of low-shaft furnace pilot plant at the National Metallurgical Laboratory for the production of foundry grades of pig iron with raw materials from Andhra Pradesh, and (4) Pilot plant studies on beneficiation and sintering of Barsua Iron ores for Rourkela steel plant of Hindustan Steel Ltd. Also during the year, the Laboratory brought out a publication containing proceedings, technical papers, etc. of the Symposium on "Light Metal Industry in India" arranged in 1961. The publication has been well received and reviewed both at home and overseas.

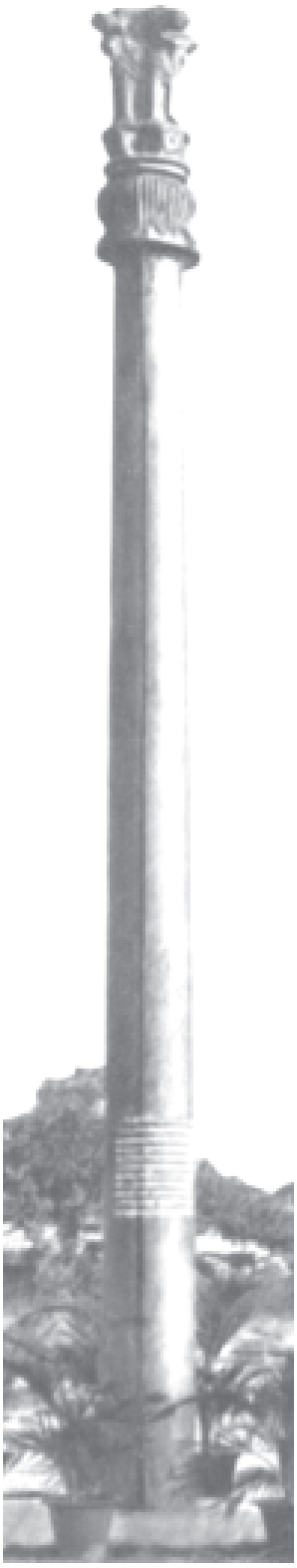
The NML Technical Journal has stepped into its fourth year of publication and the technical papers published are abstracted in leading overseas abstracting services. The number of exchange technical publications has steadily multiplied.

A Symposium on " Ferro-Alloys Industry in India" was arranged in February 1962, which was attended by delegates from practically all over the world, besides those from India. In having attracted valuable technical contributions from specialists in their respective fields, the Laboratory could feel justifiably happy on their success in organizing such international Symposia, which offer stimulation of technical and research ideas and practical initiation to important technical themes. During the Symposium, considerable emphasis was laid on research and development work on the family of ferro-alloys, production techniques of different ferro-alloys from indigenous raw materials, utilization of waste products, etc. These aspects certainly represent challenging fields in which the Laboratory is today actively engaged in its broad-based research and development programme to attain self-sufficiency in minerals and metals.

The ferro-alloy pilot plant is of such a size that valuable information can be obtained on important factors such as electric power, electrode consumption, recovery and yield figures, and economics of production which can be scaled up to enable a fairly accurate appraisal on a larger scale plant being made. Customers' raw materials will be accepted on a contract basis and I am sure this unit will serve a useful purpose not only for the Indian ferro-alloy industry but also for the whole of South-East Asia.

Work on the beneficiation and sintering of Indian iron ores, such as from Kiriburu for the National Mineral Development Corporation, from Rajahara for the Bhilai steel plant of the Hindustan Steel Limited, etc., is being continued.

The steel plants in India are having a serious problem in the utilization of the flux grade limestone in steel-making, which due to its high silica content presents considerable operational difficulties. On an assignment given by the Tata Iron and Steel Co. Ltd., the Laboratory has successfully beneficiated in their pilot plant high silica steel-making limestone and reduced its silica content to below 2 per cent. The limestone briquettes made after beneficiation have undergone successful trial tests in a 235 tons open-hearth steel smelting furnace. Based on the work done, a comprehensive report was submitted suggesting a proposal for setting up a beneficiation plant to treat low-grade limestone at the rate of



250 tons/day detailing the equipment, cost of beneficiation and briquetting of the limestone. Similar work has also been carried out on behalf of Hindustan Steel Limited on four different consignments of limestone from Purnapani quarries, which have also been successfully beneficiated for steel-making use.

The low-shaft furnace pilot plant of the Laboratory has been in operation during the year. Extensive smelting trials have been conducted on raw materials from Andhra Pradesh, East Punjab and Maharashtra State to determine the feasibility of the production of foundry grades of pig iron. On the basis of the work done at the Laboratory, it has been recommended that the setting up of iron production units based on low-shaft blast furnace smelting would be both metallurgically and economically feasible in Andhra Pradesh. The Laboratory has been in continuous touch with the Nepal Government for the establishment of a small scale iron production plant in Nepal, and smelting operations with their raw materials are being initiated at the low-shaft furnace pilot plant.

The pilot plant for the aluminizing of steel has been operated for a considerable period to aluminize the hardware supplied by the Post and Telegraph Department and auto-muffler parts and silencer pipes furnished by the army base camps and automobile industry. The aluminized telegraph wire which was under service trial under marine atmospheric conditions in the Visakhapatnam area has given most satisfactory results and the Post and Telegraph Department now wish to introduce the aluminizing of their hardware products instead of galvanizing them.

The beneficiation of fluorspar for the Rajasthan Government was undertaken and a project report is being worked out for the Government of Rajasthan. The fluorspar has been up-graded to the metallurgical grade standard as also acid grade standard; the latter has been used for the production of cryolite for trials in aluminium reduction cells in the aluminium industry in India.

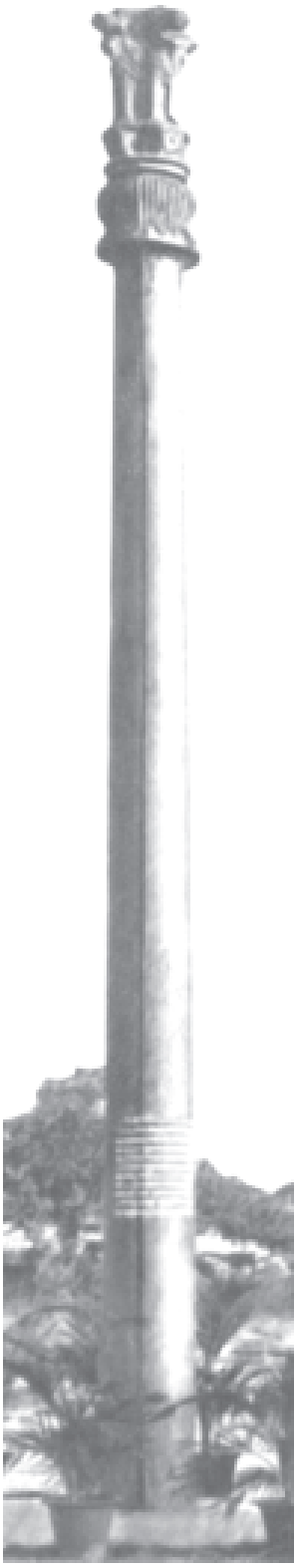
In the context of our successive Five Year Plans, priority is given to the operational and applied research projects, but sufficient emphasis has also been given to fundamental research schemes which have made steady progress.

Continued collaboration has been maintained with the different Ministries of the Government of India for research and development programmes, and I am very happy to say that the National Metallurgical Laboratory is acting as a nucleus for many of the long-range and short-term projects connected with the development of metal and mineral industries such as for the National Mineral Development Corporation for laboratory and pilot plant scale investigations into Khetri copper ores.

Significant progress has been maintained on fundamental research studies such as isothermal transformation studies (T.T.T curves) of Indian plain carbon and alloy steels for which an atlas is now being compiled for use of research and industry, preferred orientation in rolled sheets, solubility of nitrogen in plain carbon and alloy steels, carbon activity in iron and its alloys, study on age hardening of light metal alloys, base exchange studies on clays, reducibility studies of iron ores and sinter. The work carried out attempts an understanding and formulation of certain basic concepts of mechanism of phase transformations, crystal structure and its orientation etc. In the field of refractories, basic studies on the development of basic refractories for L-D oxygen converter, on welding flux, on base-exchange properties of clays etc. have yielded most interesting results. Several problems relating to operational processes, service failures etc. referred to by the industries were successfully investigated and concrete suggestions were offered for the solution of their problems. The Liaison, Information and Operational Research Division undertook preparation of several project reports specially for the foundry industries for the production of different grades of malleable iron products.

Prof. M. S. Thacker, Director-General, Scientific and Industrial Research, during his visit to the Laboratory early this year, spoke of the high standard of research work in progress and the excellent work done by the Director and his colleagues. The Laboratory has always enjoyed the full support and active good-will of Prof. M. S. Thacker, who has taken a keen interest in the Laboratory's activities.

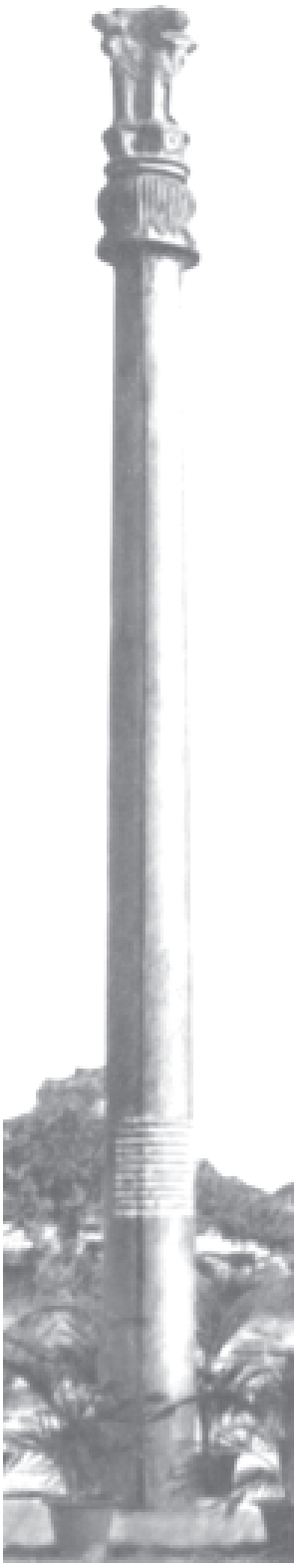
I should like to express on my behalf and that of other Members of the Executive Council our sincere appreciation of the sustained and devoted work that is being done by Dr. B. R. Nijhawan and his able



colleagues. I should like them to know that the Members of the Executive Council of the National Metallurgical Laboratory appreciate their highly creditable and praiseworthy efforts. Much of the success of the laboratory's ever-widening scope of research and pilot plant activities is undoubtedly due to the hard work, research and organizational ability of its Director, Dr. B. R. Nijhawan. The National Metallurgical Laboratory is undergoing rapid expansion in many fields during the Third Five Year Plan, and I have great pleasure in recording our appreciation of the commendable success achieved which augurs well for the future.

J. J. GHANDY
Chairman
Executive Council of the
National Metallurgical Laboratory

Jamshedpur
August 1, 1962



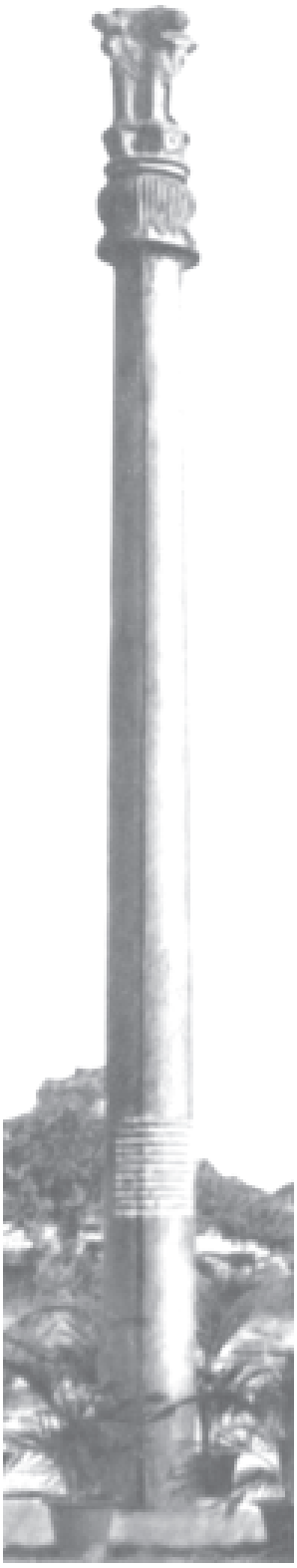
1962- 63

It gives me great pleasure to present the Report of the Director, National Metallurgical Laboratory, for the year 1962-63. I have had the opportunity of visiting the National Metallurgical Laboratory a number of times as also of visiting similar research institutions in India and overseas . I have watched the progress of National Metallurgical Laboratory with great interest. I am particularly gratified to note the high prestige and professional status with which the National Metallurgical Laboratory is held both at home and overseas.

Whilst inaugurating the International Symposium on Iron and Steelmaking organized by the National Metallurgical Laboratory in collaboration with the British Iron & Steel Institute and the Indian Institute of Metals , I had referred to the important and supreme role of research and development in the field of iron and steel production technology . I had also mentioned the importance of undertaking research with indigenous talents employing indigenous raw materials which have been one of the keystones of the excellent progress made by the National Metallurgical Laboratory. I was particularly gratified to listen to what Mr. Maurice Fiennes, President of the Iron & Steel Institute, had said during the Symposium that he was greatly pleased to see the National Metallurgical Laboratory which has set a very fine example of the determination of India to produce her own technology by the use of her own technologists.

Whilst, on the one hand, the National Metallurgical Laboratory has rightly earned high prestige in overseas circles, it has equally earned due recognition from leaders of private sector iron and steel plants , such as Mr. J. R. D. Tata who has often expressed his appreciation of the contributions of the National Metallurgical Laboratory to iron and steel industry in more than one platform. Equally so has been the experience of the Hindustan Steel Ltd. in relation to the National Metallurgical Laboratory which has spared no pains to undertake both short-term and long-range research and pilot plant projects on multitude problems both in the long-range study and appraisal of the vital raw materials as also undertaking development research projects on short-term themes. The National Metallurgical Laboratory has done valuable work on the establishment of small iron and steel plants on a dispersal basis including the establishment of South Indian iron and steel plants and has been an active champion for the installation of small pig iron production plants in the country.

I have also been impressed with the emphasis laid by the laboratory on largescale industrial pilot plants and the notable progress made in the industrial scale implementation of the important processes developed by the National Metallurgical Laboratory, which has resulted in the release of practically all the processes developed at the National Metallurgical Laboratory. The heavy integrated Mineral Beneficiation Pilot Plant, built at a cost of Rs. 5 million and which was inaugurated by Prof. Humayun Kabir, Union Minister for Scientific Research & Technical Education, early this year, at the time of last Symposium, has been acknowledged by the leading scientists as one of the best of its kind in the world. It is particularly pleasing to note that the entire planning, layout and engineering was done by the staff of the National Metallurgical Laboratory. Since its commissioning in February 1963, I find the



plant is being operated round the clock and has already beneficiated hundreds of tons of iron ores and limestone for their utilization in public and private sector steel plants.

Although emphasis has been laid on operational and applied research projects, the laboratory has maintained equally good progress on a number of fundamental projects underway which have yielded fruitful results besides training a corps of research workers.

During the year, I find important pilot plant equipment and research apparatus have been designed and fabricated at the National Metallurgical Laboratory effecting considerable saving of foreign exchange. There has also been a substantial increase in the number of junior and senior research fellowships for those working for higher post-graduate degrees. I also commend the steps taken by the laboratory for imparting specialized training both at graduate and artisan levels in various metallurgical fields which will pay rich dividends in due course, not only to the laboratory but also to the metallurgical industries.

During the year under review, the laboratory completed the following project investigations and their reports have also been issued :

1. Report on the operation of Low-shaft Furnace Pilot Plant at the National Metallurgical Laboratory for the production of pig iron with East Punjab raw materials from Mahindergarh.

2. Report on the operation of Low-shaft Furnace Pilot Plant at the National Metallurgical Laboratory for the production of foundry pig irons with raw materials from Maharashtra State.

3. Report on the operation of Low-shaft Furnace Pilot Plant at the National Metallurgical Laboratory for the production of pig iron with iron ore and limestone from Nepal.

4. The operation of Low-shaft Furnace Pilot Plant at the National Metallurgical Laboratory for the production of pig iron with raw materials from Rajasthan.

5. Pilot Plant Studies on Beneficiation and Sintering of Kiriburu Iron Ore from National Mineral Development Corporation.

6. Pilot Plant Studies on Beneficiation and Sintering of Rajhara Iron Ore from Bhilai Steel Plant of Hindustan Steel Ltd.

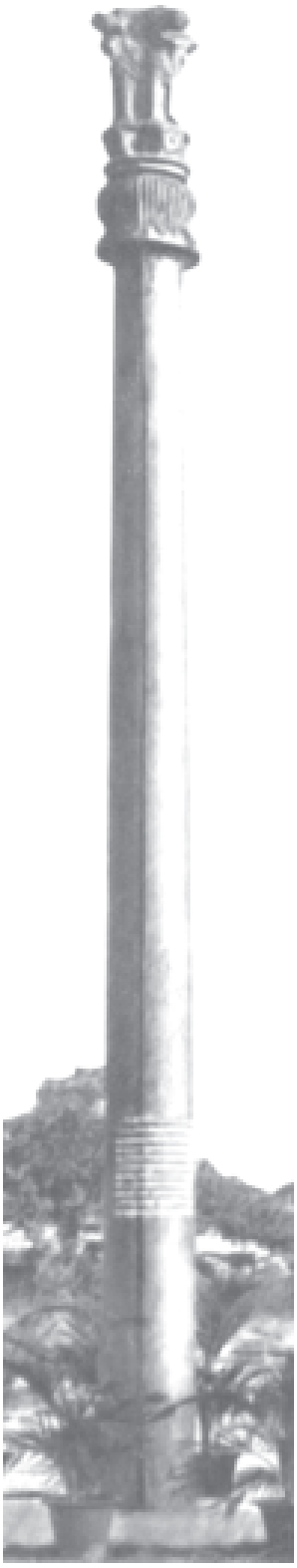
The NML Technical journal has now entered into the fifth year of publication and has established its place as a journal of repute in the field of metallurgy. The National Metallurgical Laboratory has brought out early this year another useful publication relating to the Proceedings of the Symposium on ` Ferro-alloy Industry in India'. As usual, the laboratory has maintained its high standard in the presentation and the technical value of the contents of the publication. The industrial liaison and scientific dissemination activities of the laboratory have given a great impact on the general level of technology of the country.

On my behalf and that of the members of the Executive Council, I would like to express our sincere appreciation of the sustained and devoted work that is being done under the able guidance of Dr. B. R. Nijhawan, Director of the Laboratory. I should like them to know that the members of the Executive Council of the National Metallurgical Laboratory deeply appreciate their highly creditable and praiseworthy efforts. Much of the success of the laboratory's everwidening scope of research and pilot plant activities is undoubtedly due to the hard work, research and organizational ability of its Director, Dr. B. R. Nijhawan.

The National Metallurgical Laboratory is undergoing rapid expansion in many fields during the Third Five Year Plan, and I have great pleasure in recording an appreciation for the commendable success already achieved which augurs well for the future.

Sd/- C. SUBRAMANIAM
Chairman
Executive Council of the
National Metallurgical Laboratory

October 15, 1963
New Delhi



1963 - 64

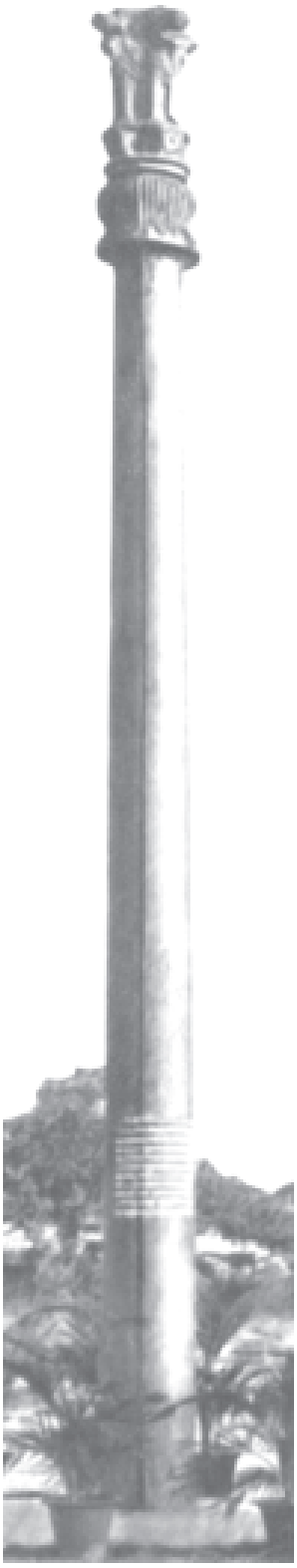
I have great pleasure in presenting the Report of the Director, National Metallurgical Laboratory, for the year 1963-64.

During the period under review, the major expansion programme envisaged during the Third Five Year Plan by the National Metallurgical Laboratory relating to the installation of the integrated Mineral Beneficiation Pilot Plant, the Ferro-alloy Pilot Plant, the construction of Side and Main Wings of the Main Building of the Laboratory, has been completed. With its interest in applied and basic metallurgical research work as commented by the Council of Scientific & Industrial Research Reviewing Committee, the National Metallurgical Laboratory has forged close links and won the confidence of the Indian Mineral and Metallurgical Industries. The Laboratory has achieved outstanding success in multiple fields and has been the main Research Laboratory for the iron and steel industry.

The Reviewing Committee of the Council of Scientific & Industrial Research headed by Sir A. Ramaswami Mudaliar spent some time at the National Metallurgical Laboratory and studied the developments in research and pilot plant activities of the Laboratory. The members of the C.S.I.R. Reviewing Committee and its Chairman have given high praise to the National Metallurgical Laboratory and their Report has acknowledged the outstanding and dynamic work of the National Metallurgical Laboratory whilst recommending further stepping up of research and pilot plant activities in relation to non-ferrous metal industry and preparation of Design and Project Report.

The National Metallurgical Laboratory has continued to actively consolidate the scope of its research and development activities including pilot plant scale trials in direct relation to Indian Metallurgical Industries specific requirements. Research and development work was undertaken at the National Metallurgical Laboratory for developing suitable coinage alloys particularly for lower denominations based on indigenous alloying elements and to the complete exclusion of the use of imported copper and nickel. It was as a result of the collaborative work undertaken by the National Metallurgical Laboratory with the Government of India Mint at Bombay that the Government of India has recently accepted NML's conclusive findings on full scale processing and fabrication trials and have decided that the 3 paisa coins should be minted from aluminium-magnesium alloys.

A Report on the "Substitution of" Imported Copper and other Non-Ferrous Metals by Aluminium and other Indigenous Metals " prepared by Dr. B. R. Nijhawan and Mr. K. N. P. Rao was issued last year by the National Metallurgical Laboratory. The Directorate General of Technical Development of Government of India who examined this Report, have commended it as a comprehensive Report containing valuable recommendations on the subject of substitution of non-ferrous metals and which has a direct bearing on the industry. The full Report of the National Productivity Team on Non-Ferrous Metal Industry which visited U.S.A. and the U.K. with Dr. B. R. Nijhawan, Director, National Metallurgical Laboratory, as the Leader, will be released in the near future. The National



Metallurgical Laboratory has been progressively increasing the scope of its work and related research activities in relation to non-ferrous metals and alloys.

Important research projects relating to the development of substitute alloys and stainless steels have continued to make significant progress - the projects relating to the production of nickel-free stainless steel, nickel and cobalt-free heating elements, production of bi-metals, development of indigenous refractories including graphite crucibles, production of high purity iron powder, alumino-thermic ferro-alloys, etc. In some of these fields, the work of the National Metallurgical Laboratory is ahead of many other research institutions the world over.

Pari passu with the applied development research projects including sustained operations of its several Pilot Plants, the National Metallurgical Laboratory has, during the period under review, greatly intensified its research activities in relation to fundamental basic objective research schemes. There are at present over 14 Research Fellows working on different problems and thereby become eligible for higher degrees including the Ph.D. degree at some of the Indian Universities. The number of Ph.D. degrees awarded during the last two years based on work of basic objective metallurgical research has increased.

Work on various projects undertaken on behalf of Railway Research, Designs & Standards Organization, Railway Electrification etc. has maintained steady progress. Investigations on the corrosion of rails used in Indian Railway tracks were undertaken to investigate possible causes of excessive corrosion of rails, viz. their composition and environmental conditions etc. A long range collaborative research programme for the development of corrosion resistant rail steel is now under way. Further work for the aluminizing of a number of steel and malleable cast iron hardware items was undertaken in NML Hot-dip Aluminizing Pilot Plant and the aluminized materials were supplied to the Railway Electrification authorities for their field trials.

On behalf of Indian Standards Institution, National Metallurgical Laboratory has conducted extended investigations on standard Rajendra silica sand sample, Rajinahal silica sand, Ennore silica sand, Shertallai sand and Neyveli sands as also investigations on fireclay and magnesite stoppers and nozzles samples collected from different iron and steel plants of India to prepare Indian Standards thereon. The high silica sand samples collected from different parts of India by Geological Survey of India are being tested for foundry purposes simultaneously in six Laboratories including the National Metallurgical Laboratory which is acting as the coordinating Laboratory. Extensive smelting trials were conducted with raw materials from various State Governments. Based on the Investigation Project Report submitted by the National Metallurgical Laboratory, the Government of Punjab in collaboration with the Central Government is taking steps to establish a 100,000 tons/annum capacity pig iron Plant. Similar action is under way for the Andhra Pradesh Government.

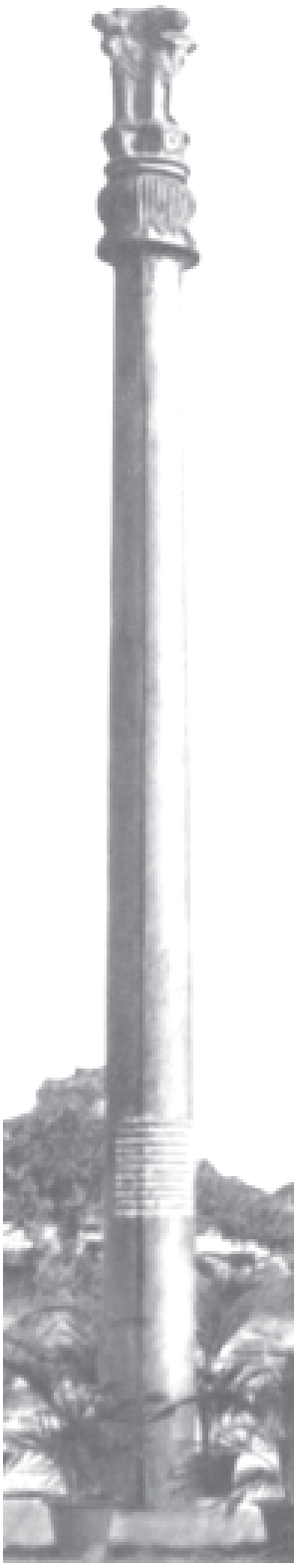
The National Metallurgical Laboratory has established the first Regional Foundry Station at Batala which is functioning to the great benefit of the local foundries. Similar Regional Foundry Stations are shortly to be opened in Howrah and Madras and the fourth one at Ahmedabad. In the field of corrosion research studies, the Marine Corrosion Research Station at Digha in West Bengal will be opened in the near future and will be a landmark in corrosion research studies in this country.

It is gratifying to state that out of twenty-five processes ready for commercial exploitation, twenty-one processes have already been released to the industry.

The NML Technical Journal has entered into the sixth year of publication and is maintaining a high standard as one of the leading journals in metallurgy.

A Symposium on `Utilization of Metallurgical Wastes ' was arranged in March 1964. Like other International Symposia organized by the National Metallurgical Laboratory earlier, this Symposium too drew delegates from all over the world, besides India, and offered stimulation of technical and research ideas and practical initiations to important technical themes.

The Proceedings of the International Symposium on ' Recent Developments in Iron and Steel Making with Special Reference to Indian Conditions' held in February 1963 have just been released by the British Iron & Steel Institute covering the technical papers and the discussions that followed during



the above Symposium organized by the National Metallurgical Laboratory in coordination with the Indian Institute of Metals and the British Iron & Steel Institute. This Symposium publication would be a valuable Reference Text on the subject and has been most commendably reviewed in the world's technical press.

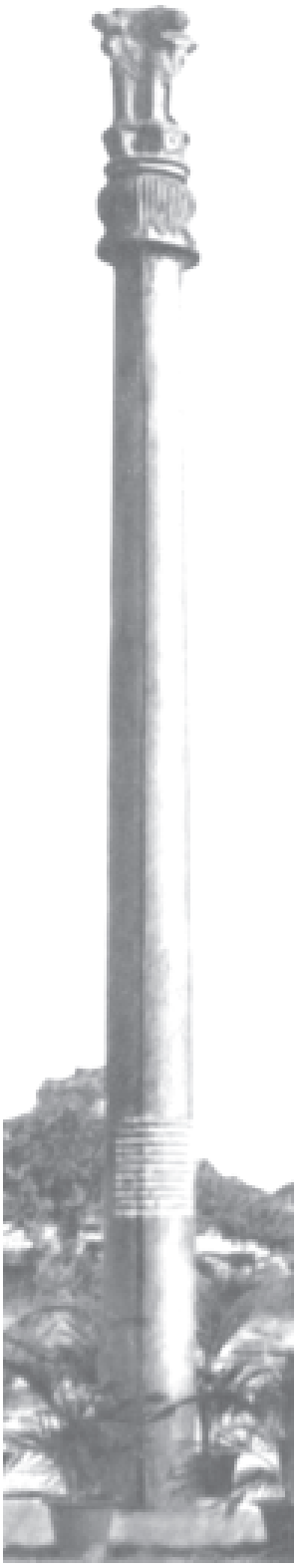
I do not know of any other single laboratory including those in U.S.A. and Europe which possess the multifarious types of research and pilot plant equipment for work on mineral and metal industries under one roof. The progress achieved in the different directions at the National Metallurgical Laboratory reflects the high efficiency of its operation in basic and applied fields.

The National Metallurgical Laboratory is fortunate in being headed by a dynamic Director, Dr. B. R. Nijhawan. On my behalf and that of the Members of the Executive Council, I would like to express our sincere appreciation of the sustained and devoted work that is being done under his able guidance. The Members of the Executive Council of the National Metallurgical Laboratory deeply appreciate the highly creditable and praiseworthy efforts. Much of the Laboratory's ever-widening scope of research and pilot plant activities is undoubtedly due to the hard work, research and organization ability of its Director, Dr. B. R. Nijhawan.

The National Metallurgical Laboratory will undergo further expansion during the Fourth Five Year Plan. I have no doubt, that the commendable success already achieved augurs well for the future of the National Metallurgical Laboratory.

J. J. GHANDY
Chairman
Executive Council of the
National Metallurgical Laboratory

Jamshedpur (India)
October 30, 1964



1964 - 65

I have great pleasure in presenting the Report of the Director, National Metallurgical Laboratory, for the year 1964-65.

As will be seen from the Report, the period under review has for the National Metallurgical Laboratory, been of sustained activity. The laboratory has continued to fulfil its obligations to heavy metallurgical complexes, such as the integrated steel plants, non-ferrous projects besides collaborating with the Planning Commission, various Central Ministries of the Government of India, State Governments, different private sector Bodies and Associations. In accordance with the recommendations of the CSIR Reviewing Committee, researches and development work on non-ferrous metallurgical projects, design engineering, etc., were stepped up.

Another important activity of the National Metallurgical Laboratory has been the preparation of Project Reports for heavy industrial complexes, such as for the Bokaro Steel Plant relating to Kiriburu iron ores, their beneficiation and sintering characteristics.

For the Defence and Ordnance establishments of the Government of India, the National Metallurgical Laboratory has done valuable work in respect of supply of strategic alloys, formulation of technical know-how and in completing short-term ad-hoc investigations and long-term research projects well on schedule.

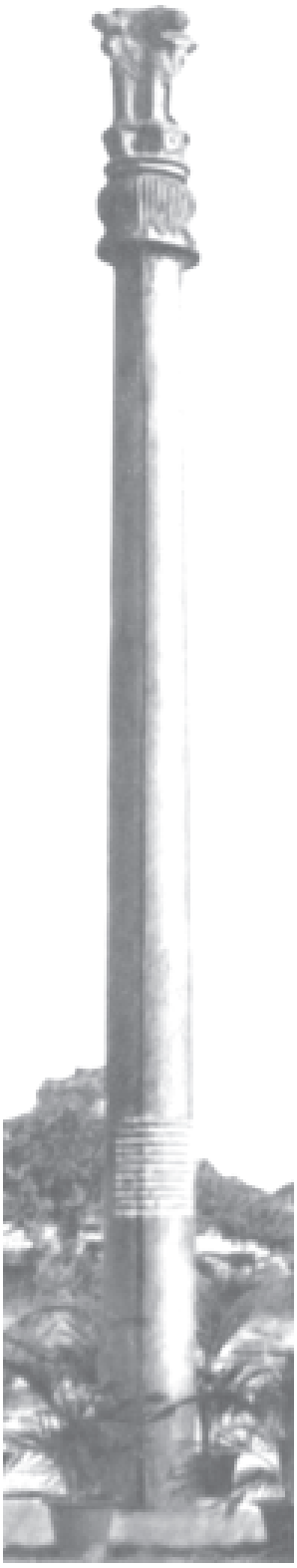
Amongst the various substitution oriented projects underway at the National Metallurgical Laboratory, I may mention the development of technical know-how for the recovery of zinc metal from zinc drosses and wastes on behalf of the Indian Tube Company.

Some new metallurgical processes have been released to the industry during the period under review; such as the abundant and cheap" blue dust" of the Indian iron mines for the production of hard ceramic magnets, an expensive and specialized product.

Work on various projects undertaken on behalf of Railway Research, Designs and Standards Organization and Indian Standards Institution has maintained high tempo of work and progress.

The Government of India some time back set up a Technical Committee under the Chairmanship of Dr. B. R. Nijhawan, Director, National Metallurgical Laboratory and comprising representatives from Hindustan Steel Limited and Tata Iron and Steel Company Limited, to examine the efficient utilization of iron blast furnace capacity in India through suitable preparation of raw materials and by the introduction of proved latest technical innovations. The Technical Committee presented its Report to the Government of India some time back which has greatly appreciated its findings and recommendations that are now finding industrial scale implementation.

The NML Technical Journal has now entered into its seventh year of publication and is maintaining its high standard as one of the leading journals in metallurgy. The Proceedings of the Symposium on



"Utilization of Metallurgical Wastes" held under the auspices of the National Metallurgical Laboratory in February 1964 have received high acclaim at home and overseas.

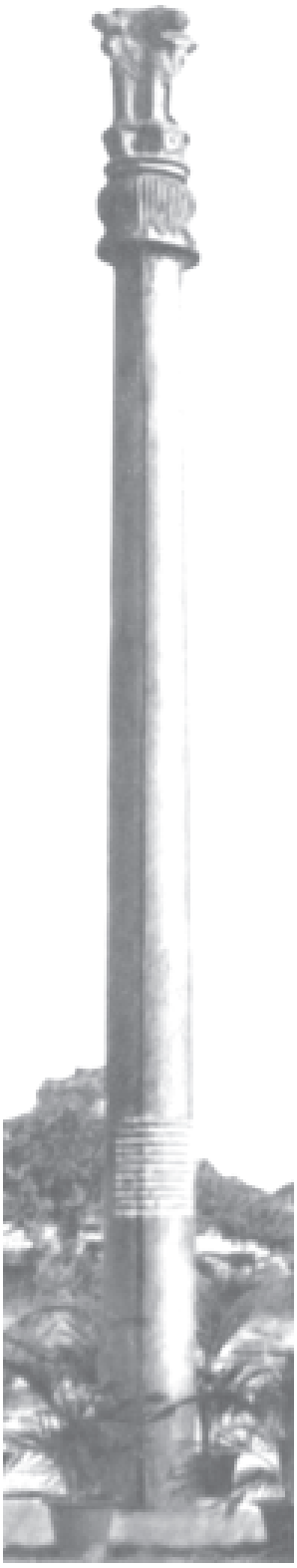
In the field of International Co-operation, the National Metallurgical Laboratory is actively co-operating with International bodies like International Working Group on Bonding Clays, International Standards Organization, International Foundry Congress. India will be the venue of 33rd International Foundry Congress and the National Metallurgical Laboratory is actively co-operating with Indian Institute of Foundrymen in holding this Congress. An International Symposium on "Micro-Metallurgy - the Role of Minute Additions to Ferrous and Non-Ferrous Metals and Alloys" was organized by the National Metallurgical Laboratory in early 1965 which was inaugurated by Shri Asoka Mehta, Deputy Chairman, Planning Commission, Government of India.

Dr. B. R. Nijhawan, Director, National Metallurgical Laboratory, has been conferred the Hony. Membership of the Iron and Steel Institute, Japan; and also awarded a Gold Medal for his outstanding contributions made in the field of metallurgy at the Jubilee celebrations of Japanese Iron and Steel Institute; Dr. Nijhawan is the first Indian to receive this coveted and distinguished honour. He has also recently been awarded the coveted Shanti Swarup Bhatnagar Memorial Award in Engineering Sciences by the Council of Scientific & Industrial Research.

The credit for the excellent work the National Metallurgical Laboratory has been doing in various fields of mineral and metal industries, in basic objective researches and pilot plant scale trials undoubtedly goes to Dr. B. R., Nijhawan and his able band of colleagues. I should like to place on record our sincere appreciation of the sustained hard work by the devoted staff of the Nationai Metallurgical Laboratory under Dr. Nijhawan's tireless and able guidance.

J. J. GHANDY
Chairman
Executive Council of the
National Metallurgical Laboratory

Jamshedpur (India)
October 30, 1965



1965 - 66

In presenting the report of the Director, National Metallurgical Laboratory, for the year 1965-66, I derive particular satisfaction from the fact that its many-sided activities have acquired wider dimensions, and that it has constantly sought and found new avenues of scientific study and research.

Metallurgical industries in India, both in public and private sectors, have their share of national problems and difficulties, emanating mainly from the acute foreign exchange crisis and scarcity of imported raw materials, particularly of ferrous and non-ferrous alloys. The sense of urgency that the import substitution programme assumes at present for taking us towards our cherished goal of self-sufficiency and self-reliance, places added responsibility on institutions engaged in metallurgical research. The performance of the National Metallurgical Laboratory has been impressive from this stand-point. Many of its research studies on substitute alloys have been fruitful, and are now being implemented on a commercial scale. It organized an international symposium on 'Metallurgy of Substitute Ferrous and Non-Ferrous Alloys' earlier this year, and thus gave an opportunity to experts in the field to get together and compare notes on this all-important subject.

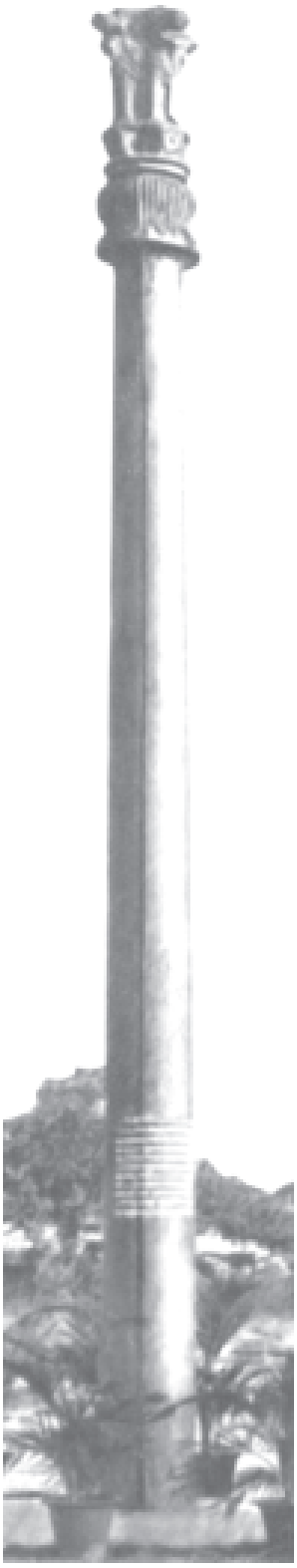
Metallurgy being the hard core of our planned progress, the importance of research in this vital field of national endeavour cannot be over emphasized. The way NML has served the mineral and metal industries strengthens our faith in the future of this institution. It has successfully undertaken a number of metallurgical research projects related to the Third Five-Year Plan, and helped many public and private undertakings by evolving new processes and providing technical know-how. The painstaking work undertaken by the Laboratory on Kiriburu iron ores and their beneficiation, agglomeration and sintering for the Bokaro Steel Plant has been described by the Soviet experts to be of ' a high technical level.

Similarly, the NML Project Report on the Foundry Pig Iron Plant, employing low-temperature carbonized coke made out of Singareni non-coking coals, has its own importance in view of the limited reserves of coking coal in the country. This Report has been prepared after comprehensive investigations at the Low-shaft Furnace Pilot Plant.

On behalf of the National Mineral Development Corporation, intensive pilot plant investigations were undertaken on the beneficiation studies of low-grade copper ores from Khetri, Kolihan and Rakha Mines. NMDC are now developing these low-grade ores with a view to setting up copper smelting plants.

In collaboration with the Central Design and Engineering Unit of the Council of Scientific & Industrial Research, the National Metallurgical Laboratory is setting up a Magnesium Plant at Jamshedpur. A full Project Report is ready and preparatory steps for setting up the plant are well under way. To be built at a cost of Rs. 67 lakhs on a seven-acre plot generously given by the Tata Iron & Steel Company Limited, this plant is expected to produce 250 tons of magnesium a year on a semi-commercial scale.

Foundry technology is yet another field in which the Laboratory has taken tremendous strides. In order to provide technical help and guidance to small-scale foundries situated in different parts of the



country, NML is setting up a network of foundry stations. The second NML Foundry Station, which was formally opened at Guindy, Madras, by Shri R. Venkatraman, Minister for Industries, Government of Madras, in December 1965, marked yet another milestone in this direction. Steps are also being taken to start the third foundry station at Howrah, the fourth at Ahmedabad and the fifth at Agra.

Particularly heartening is the initiative that NML has taken in organizing the 33rd International Foundry Congress in New Delhi towards the end of the current year in collaboration with the Institute of Indian Foundrymen under the aegis of the Union Ministry of Industry. To be held in India for the first time, this Congress will be attended by scientists from more than 24 countries of the world. Besides, the United Nations, for the first time, will sponsor observers from the developing countries. Considering the rapid advances that are being made in foundry technology all over the world, an international gathering of this kind should be of immense benefit not only to India, but also to other developing countries.

Fundamental research at NML has kept pace with applied development projects. Several research theses have been submitted on these fundamental studies, and eight scientists have so far been awarded Ph.D, degrees by different Indian Universities.

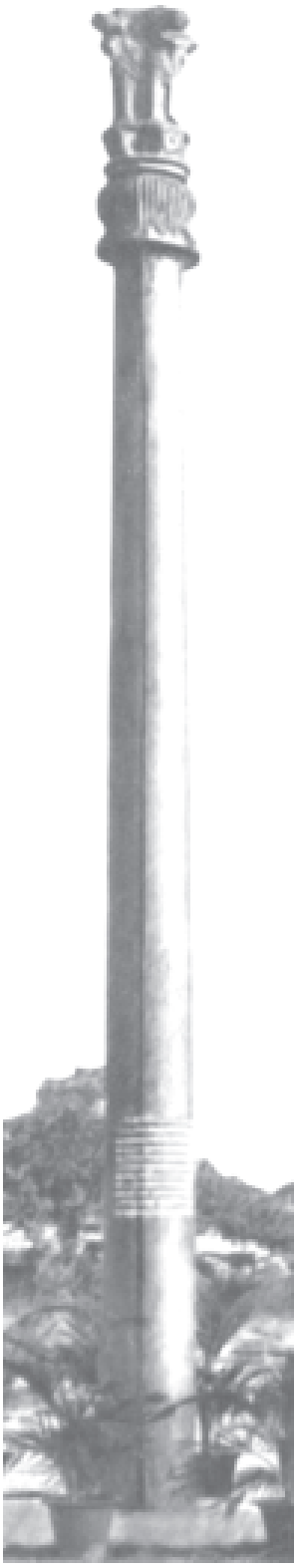
In keeping with the aims of the Government policy on scientific research, the National Metallurgical Laboratory is contributing its utmost towards securing for the people of the country' the benefits that can accrue from the acquisition and application of scientific knowledge'. This outstanding work has received wide appreciation not only within the country but also outside, and the credit goes to Dr. B. R. Nijhawan and his able colleagues.

Dr. Nijhawan's valuable contributions to metallurgical research find a fitting recognition in the Honorary Membership of the Societe Francaise de Metallurgie, Paris, recently conferred on him, and in his selection as Senior Adviser to the Centre for Industrial Development at the United Nations in New York. After about 19 years of dedicated service to the Laboratory and to the country, he will be leaving India shortly for New York to take up his new assignment, and, I am sure, many under-developed countries will benefit by his rich experience in mineral and metallurgical fields.

On behalf of the Members of the Executive Council, and on my own, I would like to record our sincere appreciation of the sustained work that has been done at NML under Dr. Nijhawan's able leadership.

J. J. GHANDY
Chairman
Executive Council of the
National Metallurgical Laboratory

Jamshedpur (India)
July 31, 1966



1966 - 67

The progress of research and development work at the National Metallurgical Laboratory has been steady and rewarding. Besides consolidation of research activities in diverse fields, the research and development projects have been further streamlined to suit the immediate requirement of the country's needs. During the period under review, metallurgical industries both in Public and Private Sectors continued to call upon heavily the assistance of the National Metallurgical Laboratory in the diversified subjects of metallurgical research pertaining to raw material problems, quality production, process control, etc. Steady progress has been maintained on the various pilot plants of the laboratory, e.g. Mineral Beneficiation Pilot Plant, Lowshaft Furnace Pilot Plant, Ferro-alloy Pilot Plant, Electrolytic Manganese Pilot Plant, Hot-dip Aluminizing Pilot Plant, etc. Beneficiation and sintering studies on iron ore samples, limestone, fluorspar, apatite, pyrite, gold ore, etc., were conducted on behalf of Hindustan Steel Ltd., National Mineral Development Corporation, Gujarat Mineral Development Corporation (GMDC), State Governments and other industrial concerns.

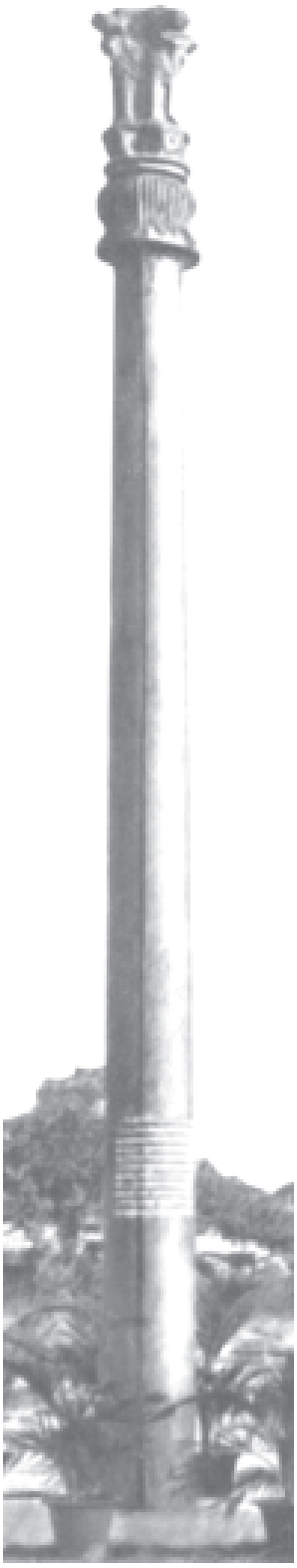
Systematic investigations were conducted on the extraction of nickel from low grade nickel-bearing ores from different regions of the country. The pioneering and challenging investigation on the direct injection of liquid naphtha into the hearth of Low Shaft Furnace with simultaneous enrichment of the blast with oxygen were successfully conducted. Work on behalf of Defence Establishments was conducted on top priority basis. The National Metallurgical Laboratory has so far reconditioned about 9 tons of magnesium powder and supplied to various Ordnance Establishments. The long range research projects on development of substitute alloys and products have yielded encouraging results. The scope of work in the field of non-ferrous metals has been further enlarged and close contact is maintained in this connection with Non-ferrous Metal Manufacturers' Association. Graphite crucible based on NML developed technique is now produced on commercial scale by the licensee firm.

Foundry Stations established so far, e.g. those at Batala, Madras and Howrah, are working in full swing. The Foundry Station at Ahmedabad is almost complete. A number of long and short term projects are under way at the Marine Corrosion Research Station at Digha.

Progress on fundamental projects has been pursued with equal vigour and during the period one scientist has been awarded a doctorate degree on the basis of the thesis submitted by him. The design and fabrication of the many of the pilot plant equipment and apparatus are progressing satisfactorily.

During the period under review, this Laboratory had the privilege of collaborating with the Institute of Indian Foundrymen in organizing the 33rd International Foundry Congress for the first time in any country of east of Suez.

DIRECTOR



1968 - 69

The National Metallurgical Laboratory, during the period under review, continued to extend its contacts with industries by undertaking large number of industrial problems and consolidating its scope of work by making steady, progress in its multiple research and pilot plant projects. Pilot plant scale washing and pelletization studies were undertaken on iron ores from Donimalai on behalf of National Mineral Development Corporation who are interested in setting up a pelletization plant at Donimalai in Mysore State.

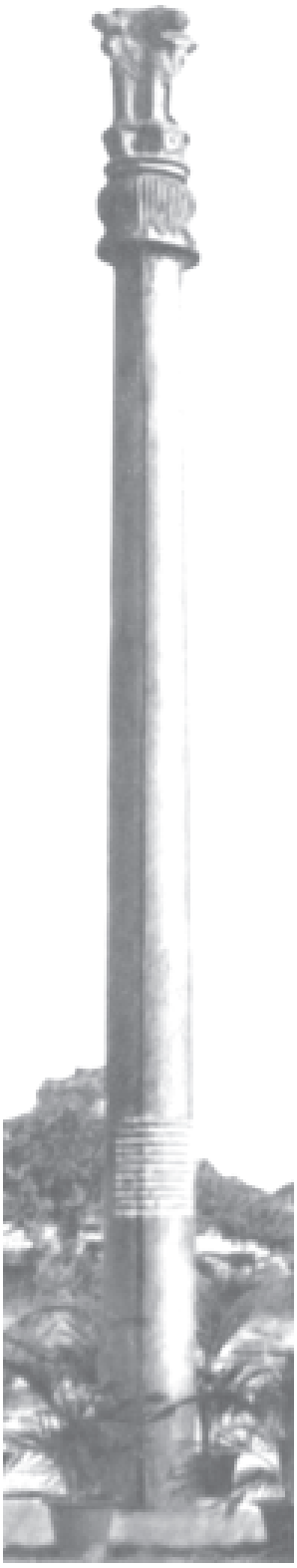
The Laboratory developed flowsheet along with list of equipment needed for a 1000 tonnes/day beneficiation plant on behalf of Hindustan Copper Ltd. for the production of smelter grade copper-nickel concentrate and molybdenum concentrate from low grade copper ores from Rakha Mines. On behalf of Hindustan Zinc Ltd., tonnage quantities of phosphate concentrate was produced from phosphate rock from Udaipur for production of super phosphate. Studies made on phosphate rock from Uttar Pradesh showed that the rock can be upgraded to produce concentrate suitable for super-phosphate manufacture.

Pilot Plant trials for production of silicochrome by single stage electric smelting process was successfully completed and the know-how obtained was furnished to the firm who sponsored the work to start production of silico-chrome. Systematic investigations are underway on the extraction characteristics of nickel from low-grade nickeliferous ores from Sukhinda, Orissa.

Studies on the development of substitute alloys have maintained steady progress. The aluminium conductor developed was found to posses satisfactory electrical, mechanical and corrosion resistance properties and the behaviour of the alloy under the 'Properzi' method of working is being studied.

The sub-merged arc welding flux produced by e licencee firms based on NML developed know-how has given excellent performance in welding pressure vessels. The aluminium based, sacrificial anode developed by the Laboratory has given very satisfactory service under actual service condition. Various Port authorities and anode manufactures have shown considerable interest in this alloy. The Laboratory acted as consultant to Calcutta Metropolitan Water & Sanitation authority in scrutinising data and preparation of a feasibility report on the application of cathodic protection for under ground water pipe lines. Bright nickel plating process developed in the laboratory is under negotiation for commercial scale implementation. Successful work was conducted on plating of gold or its alloys on watch cases and watch straps for decorative and protective purposes. Design and fabrication of different types of apparatus and pilot plant equipment were continued during the period.

Active collaboration was maintained with Indian Standards Institution in formulation of specifications and with Research Design & Standard Organisation of Ministry of Railways on research projects of interest. Ordnance establishments were supplied with different types of special materials from time to time to meet their requirements.



A Symposium on “Recent Developments in Non-ferrous Metals Technology” was organised. The Symposium was attended by a large number of Indian and foreign delegates. Sixty two papers out of seventy five papers received were presented and discussed in seven technical sessions.

The Laboratory published during the year Proceedings of the Symposium on “Metallurgy of Substitute Ferrous and Non-ferrous Alloys” organised earlier. A monograph on “Structure of Electro-deposited Manganese” is under publication.

The various Foundry Stations of the Laboratory continued to extend their assistance to local foundries and conducted investigations on foundry raw materials available in nearby places. The Marine Corrosion Research Station at Digha studied a number of problems on corrosion under marine atmosphere.

A considerable number of short term investigations and specification tests were conducted on behalf of industries and different organisation. A large number of technical enquiries were attended and relevant suggestions were furnished. Standard samples prepared in the Laboratory were supplied to a number of research and industrial organisations for analytical work.

The Laboratory imparted training to students, representatives of industrial firms etc. in various branches of metallurgy.

DIRECTOR

1969 - 70

The National Metallurgical Laboratory, during the period under review, has continued to make steady progress in its multiple research and development efforts in the various diciplines of metallurgy and has continued to forge close link with the industries so as to win their confidence. The full report on the pilot plant investigation on washing and pelletization of Donimalai iron ore was made available to National Mineral Development Corporation who are interested in setting up a pelletization plant at Donimalai in Mysore State. On behalf of M/s. Pyrites, Phosphate & Chemical Ltd., who are interested in setting up a plant for beneficiation of Amjhore pyrite, pilot plant investigation was successfully conducted and proposal for setting up a 1600 tons/day play was submitted.

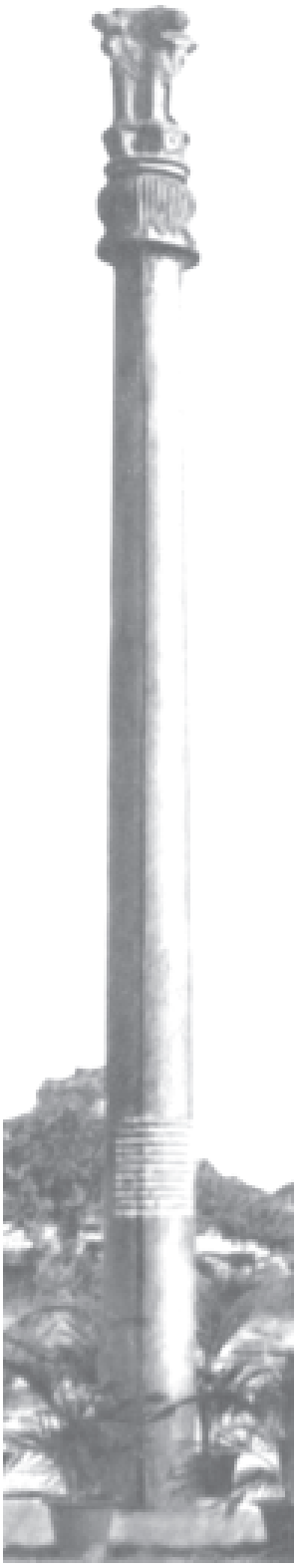
Laboratory and semi-commercial scale working of the PM-2 aluminium conductor developed in the Laboratory had demonstrated its superiority over electrical grade aluminium. Its commercial production was attempted in commercial firms and encouraging result was obtained.

Smelting trials were conducted in the pilot electric sub-merged arc furnace on the ferro-manganese using low temperature carbonized coke of Katkona colliery of Madhya Pradesh. The findings were made available to the sponsoring organization.

The National Metallurgical Laboratory has now entered into international arena and has been approached by United Nations Industrial Development Organization for undertaking pilot plant scale investigation for the production of pig iron from low grade iron ores from Asswan (U.A.R.) after beneficiation, agglomeration and pre-reduction. Negotiation in this connection has been finalised. Another international agreement has been signed for a collaborative research scheme for the preparation of standard reference materials of ferro=alloys with National Bureau of Standard, USA, under PI-480 Programme.

A successful Conference was held with top executives and shop managers of iron and steel plants of the country to identify problems of interest of iron and steel plants and to exchange information on problems of mutual interest in which areas NML can divert its efforts. A report on this occasion covering the work done at NML on problems of iron and steel industry which can be fruitfully supplemented with the assistance of iron and steel plants was prepared and circulated. Follow up action of this dialogue is actively pursued.

Conference on 'Development and Testing of High Temperature Materials' was held in collaboration with Research & Development Organization for Electrical Industries, Bhopal. The Conference was attended by scientists and technologists from Research & Development Organization for Electrical Industries, Bhopal; Bharat Heavy Electricals , Bhopal, Hardwar & Hyderabad; Hindustan Aeronautics ; TISCO ; HSL; Mahindra Ugine Steel ; National Aeronautical Laboratory ; Central Mechanical Engineering Research Institute and National Metallurgical Laboratory. The Conference which was convened by Research & Development Organization for Electrical Industries; discussed the scope of



development of creep and heat resisting steels for power plant equipment and testing and evaluation of properties for the newly developed steels. It was recommended that facility must be established at the National Metallurgical Laboratory for setting up at least 150 test point Creep Testing Laboratory. Action has been initiated to establish this Laboratory with assistance of UNDP Special Fund and Govt. of India.

The National Metallurgical Laboratory has undergone a new orientation of its activities in the field of problem identification , project programming, process and product assessment , process development at industrial shop floors, transfer of technology through consulting engineering firms, establishing contact with enterpreneuers , chamber of industries and governmental agencies of various states.

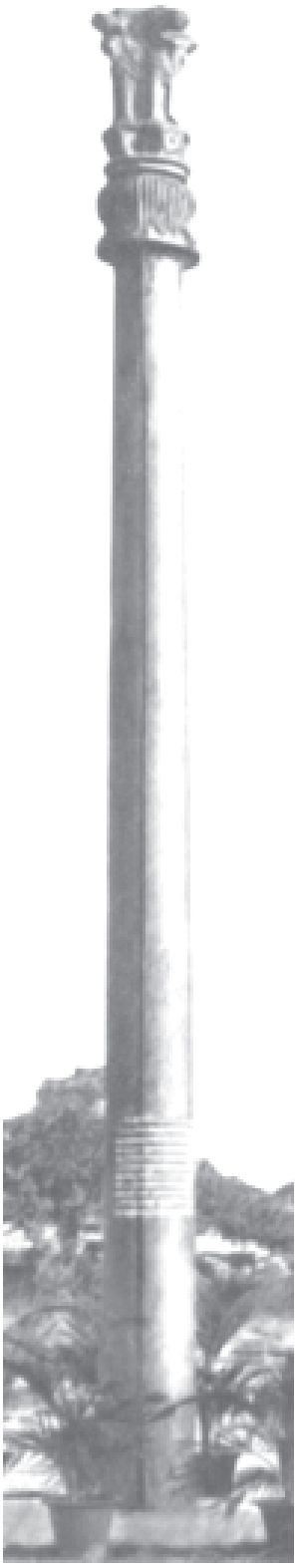
The Laboratory published during the period the following publications in addition to its periodic quarterly NML Technical Journal which is running eleventh year of publication.

1. Proceedings of the Symposium on Recent Developments in Non-ferrous Metals Technology. Vol. I-Aluminium & its alloys. The Vols. II £t III covering copper and other non-ferrous metals are under publication.

2. Monograph on "Structure of Electro-deposited Manganese Metal".

In the field of translation service, action has been initiated in bringing out monthly bulletins containing comprehensive and fully informative abstracts in English translated from French, German & Russian technical journals. Besides a fully documented survey on metallurgical developments reported in various technical journals is being published.

DIRECTOR



1970 - 71

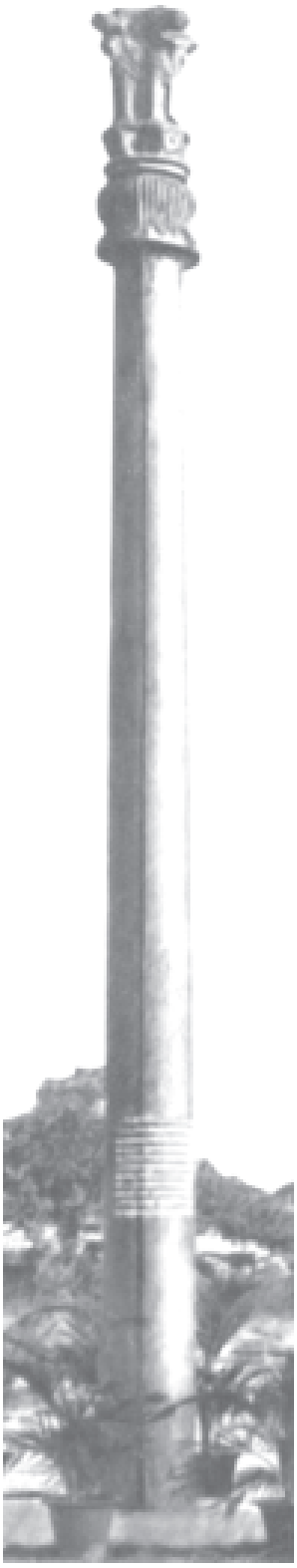
The National Metallurgical Laboratory has passed through another year of all-round progress in its research and development work.

Besides consolidation of research activities in the diverse fields, research and development projects have been further streamlined to suit the minimum requirement of the country's needs. The outstanding achievement of the Laboratory, during the period under review, has been the successful and pioneering trials for the production of tonnage quantities of prereduced iron ore pellets and sponge iron. The production of prereduced blast furnace burden as well as sponge iron forms an important advance in the interest of India's developing steel economy, since the development of a process to produce raw materials for direct steel manufacture is of vital significance to the country. The Planning Commission and the Ministry of Steel have evinced great interest in establishing a well-planned facility at the National Metallurgical Laboratory for larger scale trial production of sponge iron.

During the period, metallurgical industries both in the public and private sectors continued increasingly to call upon the assistance of the NML in diversified fields pertaining to raw material problems, quality of production, process control, etc. The 500 tonnes per day Fluorspar Flotation Plant of the Gujarat Mineral Development Corporation, for which the National Metallurgical Laboratory acted as consultants right from pilot plant investigations to the commissioning stage, has been finally commissioned and our scientists participated in the commissioning trials at Ambadongar. Coming in its wake, the Hindustan Copper Ltd commissioned the NML for consultancy services for their 1000 tonnes per day Copper. Concentrate Project at Rakha. Similarly, the NML was assigned the project for evaluating and providing data required for the design and setting up of a plant for the extraction of nickel and cobalt from Sukhinda deposits in Orissa. The test data, based on laboratory bench scale investigations, have already been supplied to the sponsors.

An event of equal significance and far-reaching importance is the establishment of the ' Central Creep Testing facility ', having 150 test points at the National Metallurgical Laboratory, with assistance from the United Nations Development Programme. The national importance of this project can be visualized from the fact that it was approved not only by the highest executive bodies of the CSIR but also at a Seminar convened by the Laboratory at which besides representatives of the Steel Ministry and research institutes, top representatives of the concerned industries, such as Hindustan Steel Ltd, Tata Iron & Steel Co. Ltd, Bharat Heavy Electricals Ltd and other public and private sector industries actively participated. A significant feature of this project is financial participation by the user Ministries by way of contribution towards capital and recurring expenditure.

Detailed plans have also been worked out for the establishment of Multipurpose large-scale hydro- cum-electrometallurgical facility for the extraction of nickel and other non-ferrous metals. This project has also been approved by the governing body of the CSIR and is proposed to be set up with the financial participation by the Ministry of Steel & Mines.



The long range research projects on substitute alloys have yielded encouraging results. The scope of work in the field of non-ferrous metals has been further enlarged and close contacts have been made with the Non-ferrous Metal Manufacturers' Association and the Ministry of Steel & Mines particularly with their programmes on aluminium, lead, zinc and copper projects. The Director, NML, has been appointed a member of the Board of Directors of Hindustan Copper Ltd. The Non-ferrous Metal Manufacturers' Association are going to hold their Council meeting shortly at the NML. The opportunity will be utilized to identify problems of the industry so that the Laboratory's research activities in the field of non-ferrous metals may be suitably reoriented to meet the industry's immediate requirements.

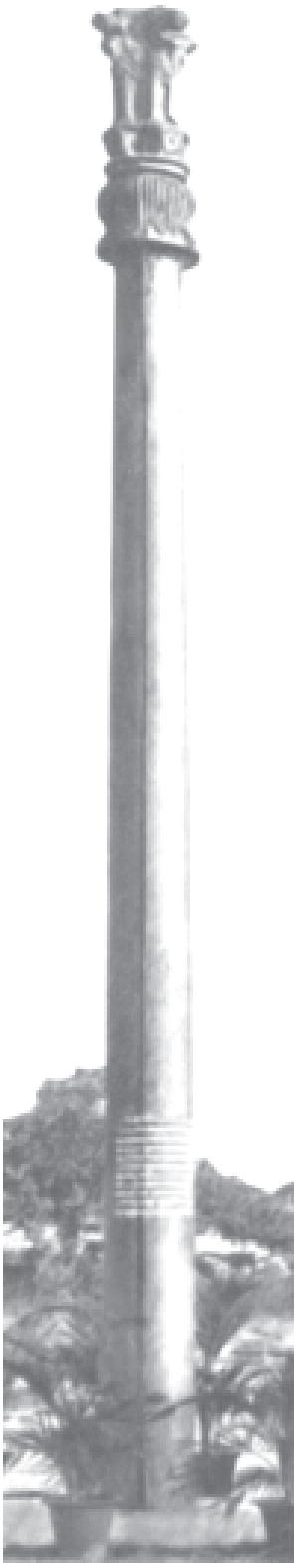
Corrossion is another important field in which NML has done outstanding work and made major strides. The Laboratory is being increasingly called upon by industry to urgently tackle the various corrosion problems faced by them. As a national recognition of the outstanding work done in this field, one of the scientists of the Laboratory engaged on corrosion research has been awarded the National Metallurgists' Day award for 1970.

The Laboratory has also done significant work on the development of ferrite magnets. The importance of this work has been recognized by the Inventions Promotion Board by conferring a Republic Day award on the scientist of the Laboratory who developed this product. The Four foundry stations set up by the National Metallurgical Laboratory at Batala, Madras, Ahmedabad and Howrah have been rendering very useful service to the regional industries. Their assistance has been duly acknowedged by the local industries. Similarly, the Marine Corrosior Research Station at Digha has been conducting very useful studies on metallic corrosion in marine atmospheres and in sea-water.

A programme has been initiated by the Laboratory to maintain close contacts with industry by organizing get-togethers with metallurgical industries and to establish Customer-Contractor relationship with them. Effective use has also been made of several seminars and symposia held in the country by deputing scientists of the Laboratory in large numbers not only to participate in them but also to make use of these opportunities to contact local industrialists and entrepreneurs and for visits to factories for identification of industrial problems. As a result of these increasing contacts and the interaction between scientists of the Laboratory and the industries, several new projects of immediate importance to the country's requirements have been started in the Laboratory.

The total number of projects handled during 1970-71 was 126 of which 98 were of applied nature and 28 on basic research. Twenty six projects were sponsored by industry, 96 were undertaken on the initiative of scientists in the Laboratory and 4 in collaboration with national and international organizations, including the United Nations Industrial Development Organization, National Bureau of Standards, USA, Hindustan Steel Ltd, etc. Nearly 40 projects were completed during the period. During the period under review the Laboratory earned a sum of Rs 3.835 lakhs for services rendered by it to industry and to other research institutions.

DIRECTOR



1971 - 72

During the period under review, the National Metallurgical Laboratory has undergone a further reorientation of its activities in the various research and development projects and has maintained close and purposeful relations with mineral and metal industries both in the public and private sectors. During the hostilities of December 1971 and emergency, the NML as usual rose to the occasion and offered all facilities at their command to meet urgent Defence needs. A significant development has been the completion of the Magnesium Plant and the commencement of successful trial runs. It was a happy augury that the commissioning the entire plant was completed by the month of February 1972 as scheduled. An equally heartening feature has been the production of tonnage quantities of low phosphorus steel from Indian Pig Iron in the basic-lined side-blown converter developed at the NML.

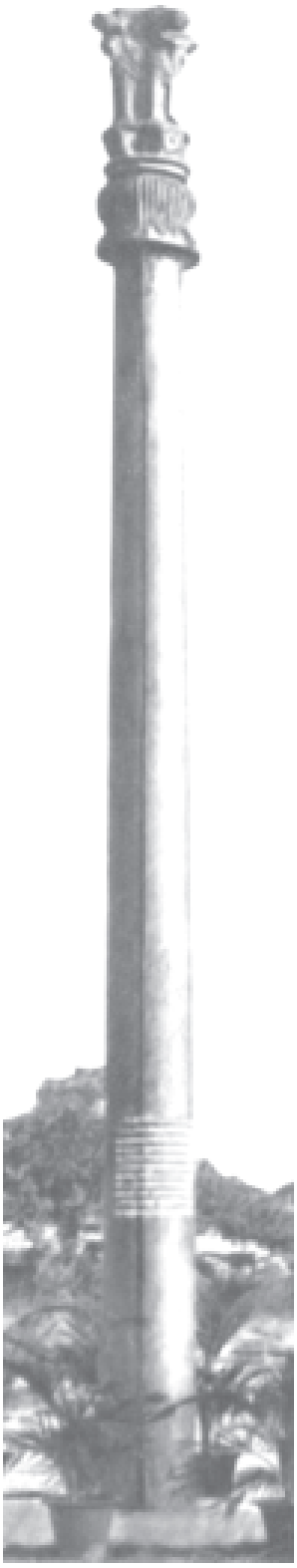
The consumer acceptibility tests on 'Tin free steels' developed at the Laboratory have been highly encouraging and it is now planned to undertake in plant trials for the production of 'TFS' on a large scale.

Despite the disturbed conditions and dislocation of services, the Workshop on `Creation and Transfer of Metallurgical Know how organized by UNIDO was succesfully held at NML from 7th to 11th December 1971 in which experts, fellows and observes from various developed and developing countries participated. The principal conclusions and recommendations which emanated from the five day workshop were that increasing technical self sufficiency should be achieved progressively by the developing countries for the growth and development of their metallurgical industries; imported technology should be improved and modified to indigenous conditions in order to develop local talent, and UNIDO should act as an antenna to transfer the metallurgical know-how and to develop technical consultancy services in the develpoing countries themselves.

The laboratory has been laying greater emphasis to develop interaction with industries and to build `customer-contractor' relationship through Get-together, Seminars and Symposia. Such interaction with industry has not only bridged the credibility gap between research and industry by identification of plant and industrial problems to be fed back to the Laboratory but has also made the industry conscious and aware of the R & D facilities and expertise available at the laboratory which they can utilize profitably, so that the work of the laboratory could be purposeful and relevant to the requirements of the industry. Joint task forces have been constituted for identification of urgent R & D problems and for undertaking following development projects, at Rourkela Steel Plant.

Inplant trials for Aluminising by NML process; Inplant trials of Tin-free Steel production; Establishment of a 5 tonnes experimental L-D converter; and Manufacture of Low Alloy High Strength Steels.

Work on improving the life of the L-D converter lining at Rourkela Steel Plant has already been assigned to the Laboratory. It has also been possible to identify the problem of setting up a custom benefication plant for the graphite ores for Andhra Pradesh and setting up the industrial unit for the manufacture of graphite crucibles in collaboration with the NML.



The researches carried out at the Laboratory have been recognised both in India and abroad and have created confidence amongst public and private sector metallurgical and mineral industries culminating in the engagement of NML as their technical consultants. Hindusthan Copper Ltd., have appointed NML as their consultant for their Rakha Copper Project for setting up and commissioning their 1000 tonnes/day concentrator plant at Rakha mines. The Calcutta Metropolitan Water and Sanitation Authority has assigned consultancy services to the Laboratory for providing technical advice in designing and commissioning of ground beds for cathodic protection to steel water mains under the supervision of NML scientists and for evaluation of data obtained from studies and examination of final report of the contractor. The Dept. of Economic Affairs, Ministry of Finance, Govt. of India has recently assigned to review the present operational efficiency in coinage production in Alipore, Mint. Calcutta. M/s. Manganese Ore (India) Ltd. have also approached NML for technical advice in modernising and mechanising their operations at Balaghat and other mines.

NML has been entrusted with the task of testing raw materials for the projected steel plants at Salem, Vishakhapatnam and Vijayanagar. Kiriburu lumpy iron ores as well as fines after sintering have been evaluated to determine their suitability for use in the Blast furnace of the Bokaro Steel Plant.

The foundation stone of the Central Creep Testing facility was laid on 22nd April 1971 by Dr. Atma Ram, Director General, Scientific & Industrial Research. The detailed design of the building were finalised in consultation with U.N. consultant (Planning) and the detailed drawings and estimates submitted by the Architects have been scrutinised by the Expert Building Advisory Committee. Construction of the building has already started. UNIDO has floated enquiries for the purchase of the required equipment.

After successful bench scale trials with the Asswan iron ores (UNIDO sponsored project), pilot plant scale investigations on bulk samples including beneficiation, agglomeration (pelletising, sintering and heat hardening) and pre-reduction of beneficiated ore have been completed.

Smelting of both heat-hardened and pre-reduced pellets has been done in submerged arc electric furnace producing tonnage quantities of pig iron. The final report containing the consolidated test data is under preparation.

Long-term, tonnage scale, investigations with respective regional raw materials from IDCOL, Bhilai, SITCOM, APIDC, etc. are being sponsored at the laboratory for testing their suitability for the production of sponge iron. PM-2 aluminium conductor, developed at the Laboratory, showed improved strength, electrical conductivity and ductility in the fully drawn condition in industrial scale trials. It compares favourably with the imported grade of aluminium conductors.

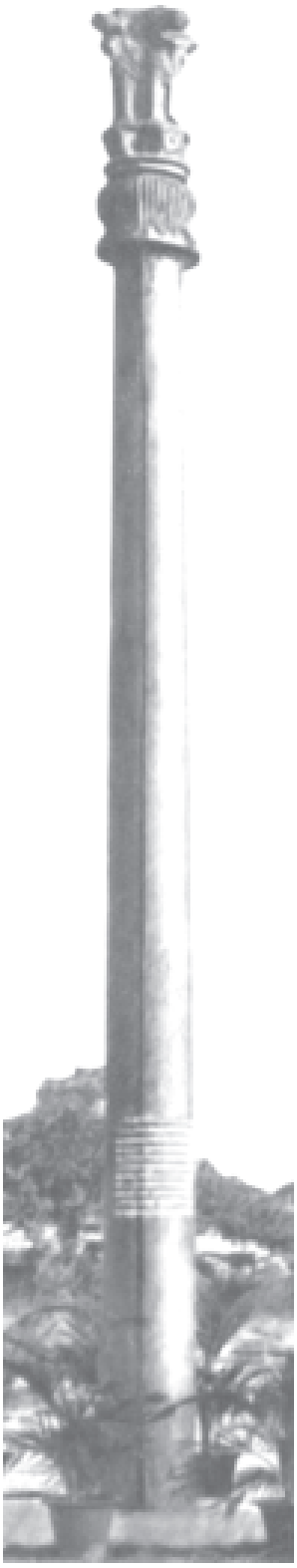
The laboratory has done significant work on the development of refractory materials and a scientist of the Labratory working on refractory mateials has been awarded one of the 9th National Metallurgists' Day award for 1971.

The aid to electroplating industry has been recognised by the Inventions Promotion Board by conferring a Republic Day award on a scientist of the Laboratory.

The total number of projects handled during 1971-72 was 152 of which 47 were sponsored (2 under international organisation), 105 projects were undertaken on the initiative of scientists including 44 projects on basic rsearch. 59 projects were completed.

The activities of Laboratory during the period under review are presented in subsequent chapters. One hundred and eleven research papers were published , presented or communicated for publication during the year. The earning of the Laboratory during the financial year was over 12.2 lakhs for the differnt services rendered to the industry and to other research institutions . Considerable amount of foreign exchange could be saved by the adoption of the processes and products developed by the Laboratory. It is hoped that laboratory will continue the lead in stimulating new developments in processes and products and solving multidiscipline problems of metallurgical and mineral industries of the country in the years to come. The facilities at the Labortory are at the disposal of the industry and it is invited to make good use of these in solving their problems.

DIRECTOR



1972 - 73

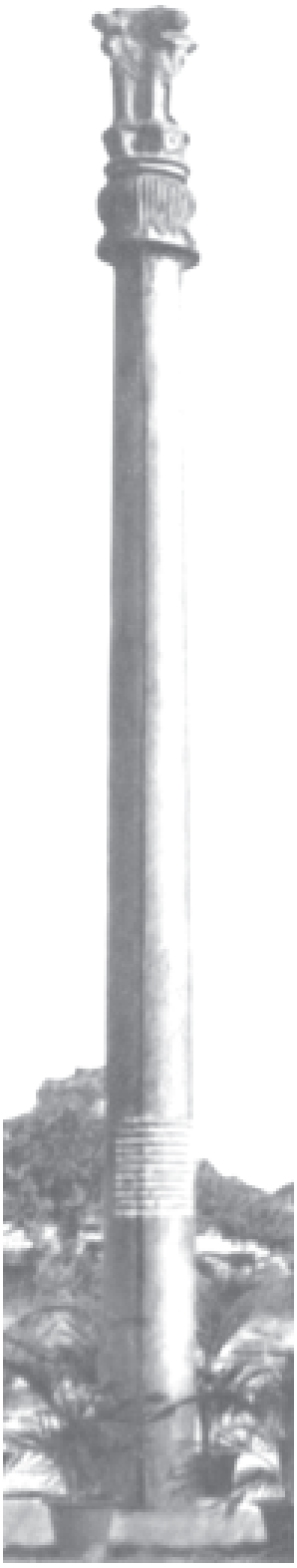
The research and development work of the National Metallurgical Laboratory, during the period under review, have been geared up to generate a continuous dialogue between the researchers, planners, users and industries for identification and solution of problems pertaining to various disciplines of metallurgy against the background of industrial and national needs.

As a result, the laboratory is receiving an increasing number of investigations sponsored by metallurgical and mineral industries who are also keen in exploiting the processes and products developed by the laboratory. In the field of beneficiation and utilization of low grade indigenous ores and minerals, the contributions made by the laboratory have helped the industrial concerns, both in public and private sectors, in determining the suitability of their raw materials for industrial applications. Apart from the detailed investigational work done on batch as well as pilot plant scale, feasibility reports have been prepared and submitted for implementation. Thus work has been done on behalf of M /s. Hindustan Steel Ltd. ; Tata Iron & Steel Co.; Bokaro Steel Ltd. ; Hindustan Copper Ltd. ; Industrial Development Corporation of various States; State Governments; Manganese ores of India; Ferro Alloys Corporation of India; Pyrites, Phosphates and Chemicals Ltd.; Fertilizer Corporation of India; Tinplate Co. of India; Dunlop India Ltd. ; Bharat Heavy Electrical Ltd., etc.

Regarding the processes and products developed by the laboratory, it is significant to mention that negotiations are under way to lease out the technical know-how on the production of steel by side blown basic converter, electrolytic manganese metal and manganese dioxide, synthetic cryolite, extra fine zinc dust etc. besides releasing the processes like production of carbon free ferro-alloys and metal powders for commercial production. A plant is being set up by M /s. Cable Works (I) Ltd., Faridabad, to manufacture electrical resistance heating elements based on the NML developed technique.

The field trials of the telecommunication cables made from aluminium alloy conductor developed by the laboratory has given highly satisfactory performance and action is under way for its commercial scale production and application in place of the copper cables. The first phase of work relating to the development of a suitable lining material for L -D converter of Rourkela Steel Plant is over and the findings have been communicated to the Rourkela Steel Plant authorities . Active consultancy services were provided to Andhra Pradesh Industrial Development Corporation who are interested in the setting up of a graphite beneficiation plant for manufacture of graphite crucibles . In connection with the construction of Tube Railway System at Calcutta , Metropolitan Transport Authorities (Railways) have approached the Laboratory to act as Consultant in connection with the underground corrosion problems due to current leakage.

The laboratory has made considerable progress in setting up the (150 test point) Central Creep Testing Facilities with the assistance of UNDP. The building is coming up rapidly and orders for major items of equipment have already been placed . Work on the establishment of National Metallurgical Laboratory.



Adityapur Complex has been taken up and already hundred acres of land for housing the complex has been obtained in the industrial area of Adityapur, about 16 kilometers from the laboratory. The complex will comprise of semi-commercial industrial plants of sponge iron, rupees one crore hydroelectro- metallurgy facilities, submerged arc electric smelting furnace and mineral beneficiation facilities.

The laboratory organized two 'Open Days' one in August and the other in November. The Open Day in August was meant for general public and students, while the Open Day in November was specially meant for the teaching staff, industrialists, technologists, researchers etc. Both the 'Open Days' drew a record number of visitors who evinced keen interest in the work of the laboratory and its contribution towards the progress of mineral and metal industries of the country.

During the year, the laboratory organized a highly successful international Symposium on "Science and Technology of Sponge Iron and its Conversion to Steel " which was attended by a record number of delegates both from overseas countries and India . The proceedings of the Symposium is now being published . Besides this Symposium, the laboratory held a seminar on ' Bacterial Leaching ' which subject has now come to the forefront and has attracted the attention of a number of research institutions and organizations.

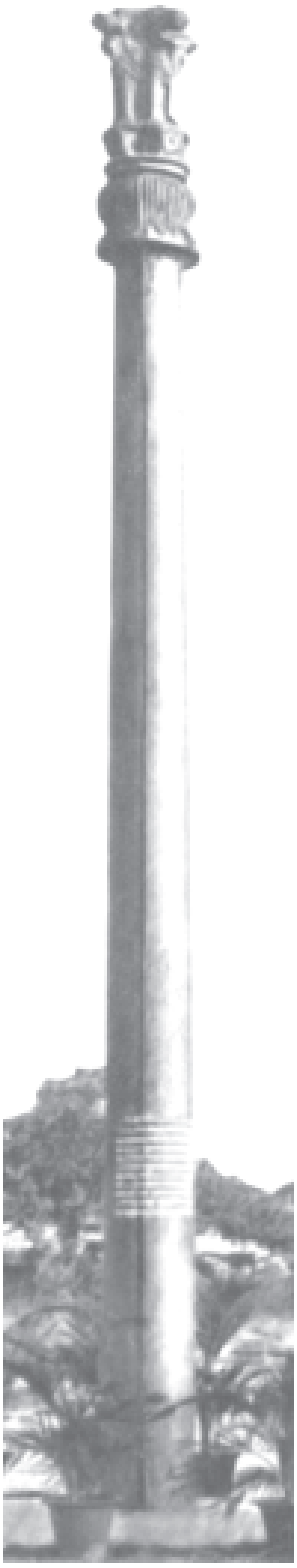
A well illustrated colourful brochure depicting the activities of the laboratory was brought out to commemorate the Silver - Jubilee Independence Year of the country. The "NML Technical Journal " has entered its fourteenth year of publication . The 'Documented Survey on Metallurgical Developments' is another publication , brought out monthly and has stepped into its 4th year of publication.

A number of ' Get-togethers' were held in the different state capitals to appraise the state industries about the products and processes developed by the laboratory as well as the assistance that can be rendered to the metallurgical and mineral industries of the States . The 'Get- togethers' roused considerable interest amongst the state industrial departments and respective industrial concerns.

The Field Stations of the laboratory continued to serve the industries located in their respective areas . The Marine Corrosion Research Station at Digha has been continuing its valuable studies on marine corrosion problems.

NML participated, as a constituent of CSIR, in the 'ASIA-72' exhibition. The different products and processes developed by the laboratory and the assistance that has been and can be rendered were exhibited through samples and well illustrated charts, models etc. A special folder on the activities of the laboratory was brought out on the occasion which was considered to be of very high quality.

DIRECTOR



1973 - 74

The National Metallurgical Laboratory, during the period under review, has continued its efforts towards the industrial implementation of its various development projects as well as finding of solution of assignments sponsored by the industry. A number of major public and private sector industries as well as medium and small scale industries have continuously called at NML with metallurgical problems in their respective fields, culminating in the shape of sponsored research, investigation and development work. Thus work has been conducted on behalf of M/s. Hindustan Steel Ltd., Tata Iron & Steel Co., Ltd., Hindustan Copper Ltd., Hindustan Zinc Ltd., National Mineral Development Corporation, Nepal Minerals Supply, Rajasthan Industrial Mineral Development Corporation, M. N. Dastur & Co., MECON, etc.

The Laboratory has offered its services regarding infrastructure facilities for the extraction of nickel from the Sukhinda nickel ores based on the tests carried out in the Laboratory. This project is sponsored by the Ministry of Steel & Mines, Govt. of India, through their consultants M/s. Chemical & Metallurgical Design Co. The Laboratory will be setting up a pilot plant in their first phase of work.

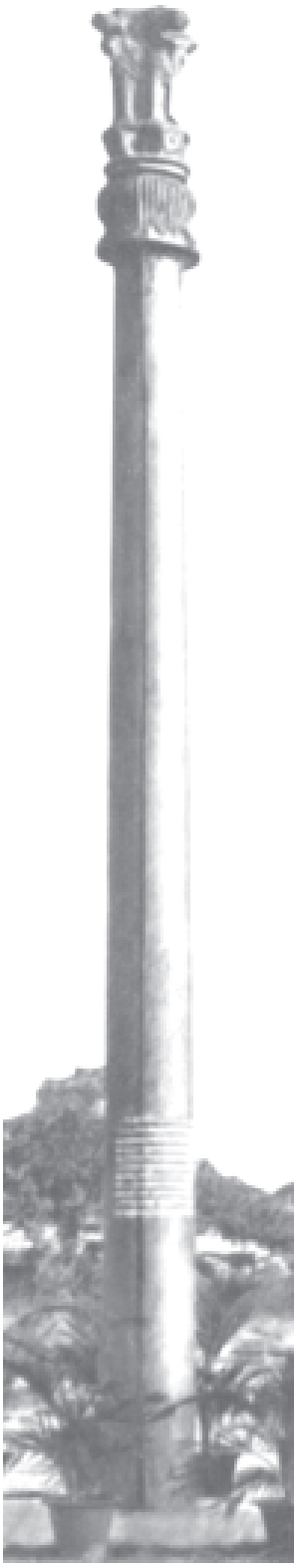
The Laboratory continued to undertake investigations on tonnage scale raw materials supplied by M/s. Andhra Pradesh Industrial Development Corporation Ltd. and Industrial Promotion and Investment Corporation of Orissa Ltd., on production of sponge iron. A technical feasibility report for production of sponge iron of 100 tonpes/day was prepared and sent to Steel Authority of India Ltd.

Work was continued on the product development and market promotion of the multifarious electrical applications of the electric grade aluminium alloy NML-PM2. It is significant that the first ever production of telecommunication cables in India was from NML-PM2 in the form of twenty pair cable. The cable has been laid in the Model Town Area of Delhi by the Post & Telegraph Department. Encouraged by the satisfactory results obtained after extensive and exhaustive evaluation, P&T Department have placed repeat orders for the production of fifty and hundred pair dry core cables from the NML-PM2 alloy. These cables are now under processing at M/s. Hindustan Cables Ltd., Rupnarayanpur.

During the the year, technology of the NML-PM2 alloy was released to M/s. Aluminium Cables & Conductors (U.P.) Pvt. Ltd. and M/s. Bharti Smelting and Refining Corporation Ltd., Bombay. The production of the alloy has also commenced at the works of M/s. Aluminium Cables & Conductors (U.P.) Pvt. Ltd.

Processes on production of extra-fine non-ferrous metal powders by atomization and production of extra fine zinc dust have been released to industries for commercial production. M/s. Cables Works (I) Ltd., Faridabad, have set up commercial plant and started production of electrical resistance heating elements based on NML technology which has licensed out to them earlier.

Considerable progress has been maintained on the setting up of the Central Creep Testing Facility with the assistance of UNDP. The building to house the facility has been completed and a number of



equipments have been installed and work has been initiated. M/s. Bharat Heavy Elelectricals Ltd. have sponsored investigations on the development of indigenous creep resistant steels.

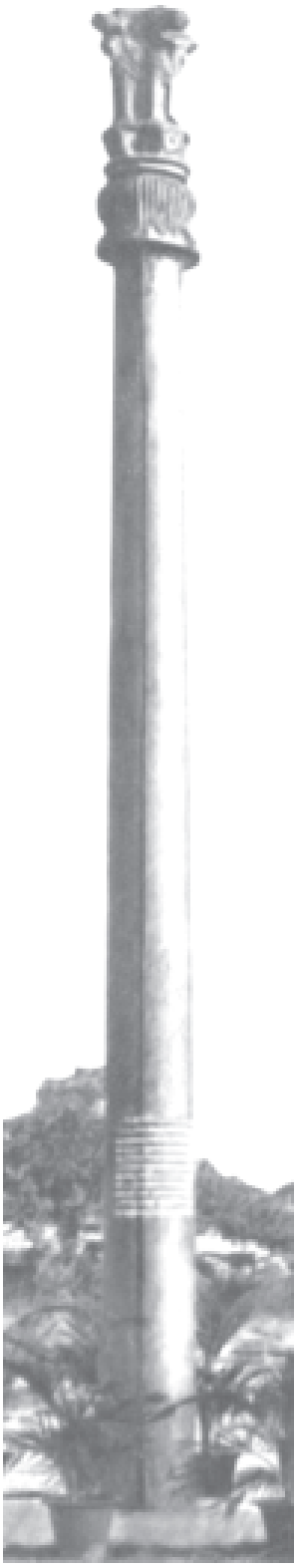
The NML Annual Day-cum-Get Together was held on 26th November, 1973, synchronizing with the inaugural day of the Laboratory twenty three years before. The Laboratory participated in the ' Get-togethers' at Barbil (Orissa) and Hyderabad. In an effort to build linkages at the State level, the Director-General , Scientific & Industrial Research , nominated NML to make systematic study of the Bihar State Fifth Five Year Plan to identify major areas of thrust for industrial, economic and social development by holding a 'Get- Together' at the State Capital, Patna.

The Laboratory has set up a Regional Liaison Centre at Calcutta to bridge the 'Communication gap' between the Laboratory and the Industry. This centre will appraise industrialists and entrepreneurs about the scope of technical assistance that the Laboratory can offer for setting up mineral based and other metallurgical industries.

The Field Stations at Batala, Madras, Howrah & Ahmedabad continued to render useful services to the regional foundry and engineering industries. The Field Stations are now being expanded phase by phase to increase their activities in different directions such as ore-dressing, refractories, metallographic work etc . so as to meet the regional demands . The Marine Corrosion Research Station is conducting a number of valuable projects on the marine corrosion problems of metals and alloys.

The preparation of the Proceedings of the Symposium on 'Science & Technology of Sponge iron and its Conversion to Steel' was taken up and papers were edited and sent for publication. The Symposium was organized by the Laboratory in February, 1973. An illustrated folder depicting the various priced publications of the Laboratory was brought out.

DIRECTOR



1974 - 75

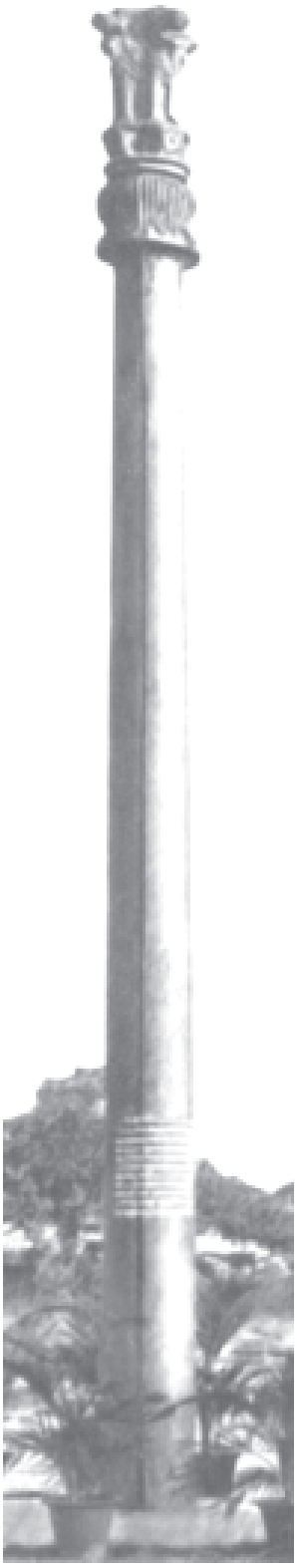
The National Metallurgical Laboratory, during the period under review, has maintained steady progress in its multifarious research and development projects and has stressed on transfer of technology for manufacture of different products. The Laboratory has successfully carried out trials for the production of sponge iron on tonnage quantities. A feasibility report on the production of 30,000 tonnes per annum of sponge iron has been submitted to the Steel Authority of India Ltd and Bihar State Industrial Development Corporation. Tonnage scale beneficiation and pelletization studies on iron ores have been conducted on behalf of National Mineral Development Corporation and MECON. Beneficiation studies have also been conducted on low grade copper ore from Malanjkhand on behalf of Hindustan Copper Ltd.

Work has been continued on the product development and market promotion of the various products from NML-PM2 aluminium alloy conductor. The technologyof production of NML-PM2 has been released to four industrial concerns e.g. M/s. Aluminium Cable & Conductors (P) Ltd., Galada Continuous Castings Ltd., Indian Aluminium Cables and Bharti Smelting and Refining Co. Post & Telegraph Department have installed twenty dry care telecommunication cable made of NML-PM2 in Model Town area of Delhi. The Electricity Boards of Karnataka and Gujarat and Integral Coach Factory, Preambur, have placed orders for different types of conductors from NML-PM2. Indian Standards Institution has taken up the incorporation of NML-PM2 in relevant specification.

The Laboratory has developed know-how for production of bi-metallic powders by atomisation techniques. These powders have been tested by users and have been found to be good substitute for the materials now imported. The process know-how has been released to M/s. Paras Metal Powders, Nasik. The technology on the recovery of zinc metal from galvanizers` dross and production of extra fine metal powder have been released and commercial production is underway. The dense carbon aggregate produced in NML has been sent in tonnage quantities to M/s. Mysore Iron & Steel Works Ltd., Bhadravati & M/s. Ferro Alloy Corporation, Shreeramnagar for in-plant trials. The product has been found to be quite useful. Successful in-plant trials on production and working of low alloy high strength structural steel containing small addition of niobium, was carried out at Rourkela Steel Plant.

The Creep Testing Facility with 400 test points has been commissioned with the assistance of U N D P and NML Scientists. The building for housing the facility has been completed and all equipments were received and installed. A comprehensive research development and testing programme has been initiated. M/s. Bharat Heavy Electricals Ltd. have sponsored a number of investigations on development and testing of creep resistant steels.

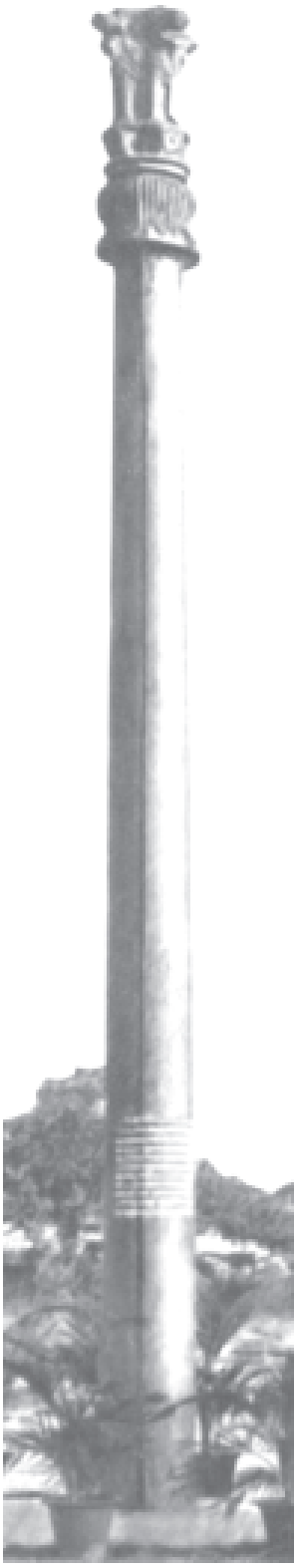
The NML Field Stations have registered creditable gains. The equi-blast cum-balanced-blast cupola developed at Batala Centre has been set up in nearly two dozens of foundries in Northern India. The ore-dressing expansion at Ahmedabad is nearing completion. The Madras Centre is showing increased activity not only in foundry but also in ore-dressing and mineral beneficiation and many other aspects. The Howrah centre is doing useful service to the local foundries. The testing and analysis of various metals, alloys, minerals etc. from the local and nearby industries are done by the Field Stations.



NML actively participated at the Get-Together held at Dhanbad in which a numbar of problems relating to the Laboratory were identified and necessary follow-up action is underway. In the ' Get-Together' arranged at Srinagar organised by Regional Research Laboratory, Jammu; many projects were discussed and identified.

The Proceedings of the Symposium on 'Science & Technology of Sponge Iron and its Conversion to Steel' was published. A new brochure on `Central High Temperature Testing Facility' was brought out. From 26th November, 1974, the Laboratory stepped into Twenty Fifth year of its existence and has initiated a programme for its Silver Jubilee which includes holding of a number of seminars and technical conferences relating to R & D work of the laboratory as well as subjects of topical interest of metallurgical & mining industries. The Silver Jubilee celebration has commenced by holding a Seminar on 26th November on 'High Temperature Materials'. This has been followed by another seminar in February 1975 on 'Aluminium Conductors and Cables' in collaboration with Cables & Conductors Manufacturers' Association of India.

DIRECTOR



1975 - 76

The National Metallurgical Laboratory, during the period under review, has maintained its stress towards the transfer of technology and industrial implementation of its various development projects. India's first sponge iron plant with a capacity of 25-30,000 tonnes per year based on the technology of solid reduction process as developed in the Laboratory has been commissioned at the plant site of M/s. Andhra Cement Company at Vijayawada where the technology was experimented on large scale. With the assistance of NML scientists, M/s. Andhra Cement Co. have modified a cement rotary kiln for production of sponge iron. The trial conducted by the NML scientists at the plant site have produced sponge iron over 90% metallization.

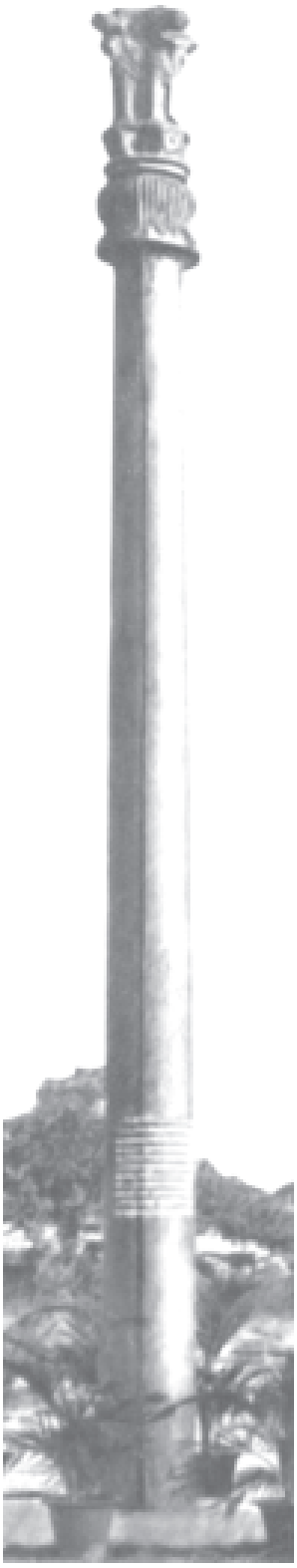
The Laboratory also succeeded in producing ferro-vanadium from the vanadiferous iron ores available near Bhadravati at the Visvesvaraya Iron & Steel Works in their 1500 KVA electric furnace with the NML developed know-how. A significant advantage of the process is that the principal by-product is a high grade pig iron low in phosphorus and silicon which is in great demand for the manufacture of malleable castings and S.G. iron.

The NML-PM2 electric grade alloy aluminium conductor is now produced on tonnage quantities by the various licencees. In recognition of the work on NML-PM2, the Cable & Conductor Manufacturers' Association have given an award to NML with the citation reading "Excellence in R&D on aluminium cables and conductors".

An alternate method of smelting lead concentrate to produce lead has given very encouraging results and it is under negotiation for release to industries. Phase I of Sukhinda Nickel Project for extraction of nickel from nickel ores has been successfully accomplished in collaboration with M/s. Chemical & Metallurgical Design Co. Ltd. The technology of production of electrolytic manganese dioxide has been transferred to M/s. T. K. Chemicals, Bombay; who are setting up a plant at Trivandrum, Kerala, for its commercial production. Production of zinc dust, based on the laboratory's technology is now under commercial production.

For setting up of a Central Pelletization Plant in the Bihar-Orissa region, the Laboratory has conducted comprehensive studies on beneficiation and pelletization of iron ore fines from different areas at the instance of M /s. MECON. On behalf of M/s. Hindustan Copper Ltd. ; Pyrites, Phosphate & Chemicals Ltd. ; Gujarat Mineral Development Corporation; Tata Iron & Steel Co. etc. beneficiation studies have been conducted on low grade copper ore, iron ore, phosphate rock, kyanite, graphite, coal washery fines etc.

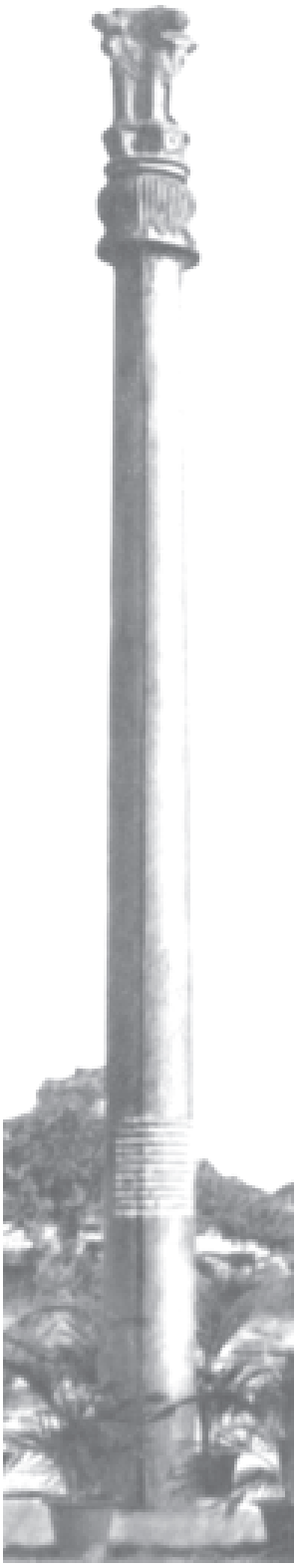
The Creep Testing Facility is being increasingly utilised by the consumer industries with the active co-operation of UNIDO experts and NML scientists working in the field. NML has entered into an agreement with M/s. Bharat Heavy Electricals Ltd. on a project of five years for the development of creep resistant



steels. Commencing from November, 1974 and ending in November, 1975, the National Metallurgical Laboratory observed its Silver Jubilee Year.

During this period a number of seminars and technical conferences were held. The final function was held from 14th to 16th November, 1975, along with the 13th National Metallurgists' Day and 29th Annual Technical Meeting of the Indian Institute of Metals. The function was attended by State dignitories, Director-General, C.S.I. R., eminent scientists and technologists, industrialists, NML staff members and a large number of persons from different spheres of public life. Fortyeight staff members received 25 years service medallion. A special medallion was awarded to Dr. B. R. Nijhawan, Ex-Director, NML, for his outstanding contribution towards the growth and development of National Metallurgical Laboratory under his guidance.

DIRECTOR



1976 - 77

The National Metallurgical Laboratory, during the period under review, has further geared up its research and development activities towards industrial scale implementation through transfer of technology, consultancy service, product development work etc. 1000 tonnesfannum electrolytic manganese dioxide plant is under installation by M/s. T. K. Chemicals Ltd. at Trivandrum based on the NML developed technology. The plant is expected to go into production in August 1977. The Laboratory has also furnished consultancy service to M/s. S. G. Enterprise, Ranchi; regarding design, specifications of equipment etc. for recovery of vanadium pentoxide from alumina sludge based on the NML process. The plant is expected to go into commission in 1977 to produce 54 tonnes of V_20_5 from Hindalco sludge. The Laboratory is assisting M/s. Rajasthan Graphite (P) Ltd., Calcutta; in setting up a graphite beneficiation plant at Udaipur. In connection with the setting up a steel plant in Nepal, the Laboratory is assisting the consultant of the project, M/s. M. N. Dastur & Co; on evaluation of the raw materials from Nepal and their electric smelting.

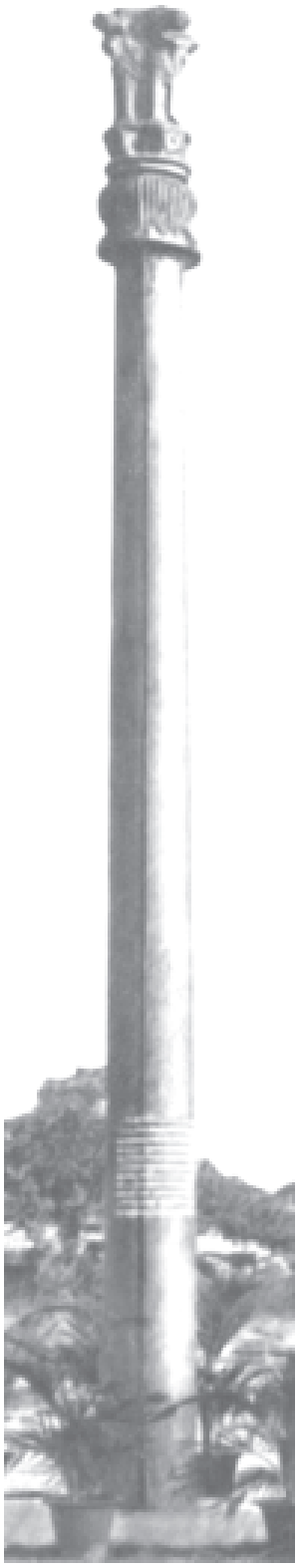
In the field of NML-PM2 alloy aluminium conductor, various product development work is underway. This alloy is now commercially produced by two firms and the technology has been transferred to another firm. The dental amalgam alloy developed by the Laboratory has been licensed to two firms and its commercial production has been started by M/s. Shakti Industries, Varanasi. The technology of electrical resistance alloys has been transferred to another firm, M/s. Met. Industries, Calcutta.

On behalf of M/s. Hindustan Copper Ltd : Pyrites, Phosphates & Chemicals Ltd; National Mineral Development Corporation; Bharat Coking Coal Ltd; State Geology & Mining Departments and other organisations; beneficiation and agglomeration studies have been conducted on iron ore, copper ore, lead-zinc ore, graphite, magnesite, phosphate, fluorspar, kyanite etc.

The development and testing of high temperature creep resistant steels as per the agreement made with M/s. Bharat Heavy Electricals Ltd., is progressing satisfactorily. The Laboratory is also assisting Reactor Research Centre, Kalpakkam; by undertaking testing of creep behaviour of structural components of test reactor being built by the Reactor Research Centre.

Large scale successful smelting trials in oil fired furnace have been conducted on the extraction of lead from lead concentrate by a new technique (NML-ALNAMA process). A large number of sponsored investigations have been conducted on service failure of metals and alloys.

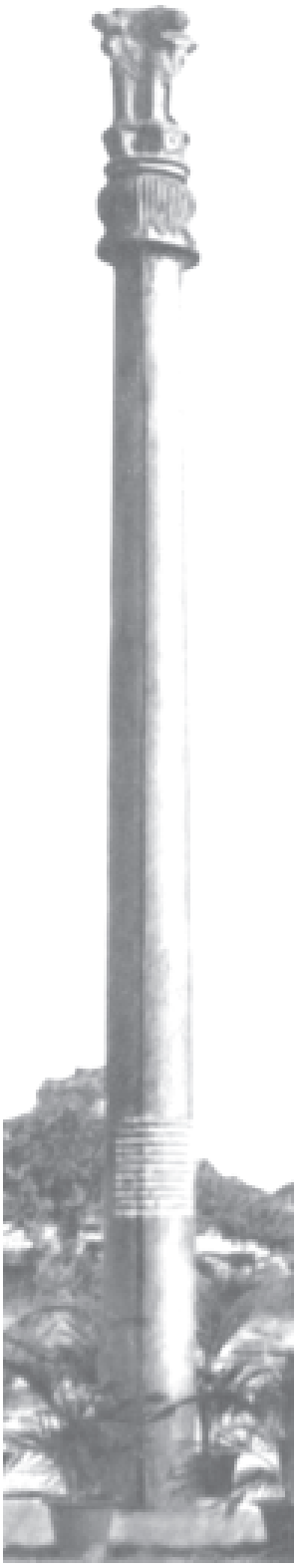
The Laboratory has entered into an agreement through CSIR with Metallurgical & Engineering Consultants (MECON), India, Ltd .; for promoting the development of metallurgical industries from research and development level to a commercial scale . Under this agreement, MECON and NML would jointly carryout the work for the study, scale-up, input, development and commercial exploitation of processes and products developed or those to be developed by NML. This also includes preparation of preinvestment feasibility report , assistance in marketing and detailed engineering services.



The Laboratory is contemplating to enter into an agreement with M /s. Visvesvaraya Iron & Steel Ltd., regarding the transfer of technology for the production of vanadium bearing slag from vanadiferous iron ores which exist near Bhadravati. The various Field Stations are assisting the industries of the respective localities through undertaking investigations on their behalf, providing service facilities for analysis and testing of their products , rendering technical assistance and on the spot study of their problems and furnishing solutions. The equi - blast- cum -balanced blast cupola has been set up by more foundries in northern regions based on the design developed by the Field, Station at Batala . The NML unit in CSIR Complex at Madras has progressed in diversification of its field of activities . The setting up of ore dressing section in Ahmedabad and metallographic sections in Batala and Howrah Field Stations are progressing satisfactorily. The Marine Corrosion Research Station at Digha is conducting valuable studies on the corrosion of metals and alloys under marine atmosphere.

The 'NML Technical Journal, has received the National Award for its excellence from Directorate of Advertising & Visual Publicity, Ministry of Information & Broadcasting , Govt. of India. The Laboratory actively participated in organizing the 'CSIR-Industry- Government, Get-together at Patna and Get-together on 'Refractories, Glass & Ceramic Industries in Bihar, at NML. The various products and process developed were exhibited in a number of exhibitions held in different parts of the country.

DIRECTOR



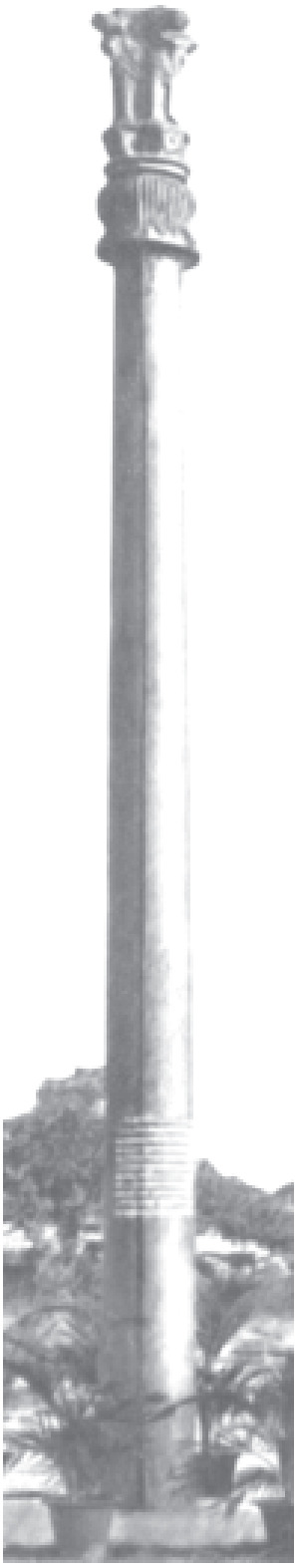
1977 - 78

The National Metallurgical Laboratory's drive towards transfer of technologies and their earlier implementation for commercial scale production has met with further success. The technology on electrolytic manganese dioxide has gone into commercial production. The licencee of the process, Mis. T. K. Chemicals Ltd., have set up a 1000 tonnes per annum plant at Trivandrum at an investment of about Rs. 1.6 crores. The manganese dioxide produced by the firm is finding ready market for dry cell manufacture. In addition to the existing producers of NML-PM2 alloy aluminium conductor, another firm has obtained license and started production. A commercial plant has been set up and commissioned by the licencee's firm for the production of bimetallic powders of copper-lead and leaded bronze. Production of vanadium pentoxide from alumina sludge based on NML know-how has commenced. In the transfer of technologies in all these cases, the NML Scientists have assisted in setting up and commissioning of plants.

National Metallurgical Laboratory has been invited to provide expertise on the technology for production of electrolytic manganese dioxide and setting up a pilot plant of 50 kglday under the Govt. of India assistance programme to Govt. of Burma. The technology of heat-resistant cast iron with nickel and chromium is ready for release. The carrier blades made out of this alloy showed no deterioration in comparison to heavy oxidation and scaling of conventional chromium-nickel heat resistant alloy, when put into service trial in Tisco's sheet mill reheating furnace operating at 900°C. The production technology of lead by 'NML-Alnama' process is also ready for release. Besides, the technology of clay-graphite stopper heads from indigenous raw materials and magnesium based inoculant briquettes for production of nodular cast iron have been released.

To prove the commercial industrial scale viability of melting and rolling of the NML low carbon soft iron, which has been able to meet the requirements of railway signal line relays; the processing of ingots were successfully carried out at Indian Ordnance Factory, Ichapore. Aluminium alloy conductor NML-PM 53 is now under field trials as a catenary conductor in Tundla railway section. High strength low alloy steel developed at NML has been successfully rolled to rounds and reinforced bars to meet the provisions of Indian Standard Specifications. This steel has a versatile combination of high yield strength, ductility and weldability. The R & D work on the development of high permeability nickel-iron alloys in the second phase of sponsored programme is progressing well.

A large number of sponsored investigations on beneficiation and agglomeration studies on low grade ores and minerals have been conducted on behalf of Public and Private sector organisations e.g. Rourkela Steel Plant; Vishakapatnam Steel Project; MECON; M. N. Dastur & Co; Hindustan Zinc Ltd; Pyrites, Phosphates & Chemicals Ltd; Fertilizer Corporation of India; Geological Survey of India; Coal India Ltd; Maharashtra Minerals Corporation; State Mining & Geological Departments etc. It is also gratifying to state that in a meeting held in September 1977, the Ministry of Steel & Mines have entrusted NML to undertake beneficiation, agglomeration and sintering of chromites and studies on manganese ores.



Different grades of creep resistant steels have been tested, evaluated and developed at the Central Creep Testing Facility of NML on behalf of M/s. Bharat Heavy Electricals Ltd; Reactor Research Centre Kalpakkam etc. M/s. Bharat Heavy Electrlcals Ltd have accepted these grades of steel which are being trial ordered by them. Problems relating to service failure of metals ancl alloys in boilers, power plants, production units, etc are being increasingly refered to the laboratory for determination of the causes of failure and remedial measures.

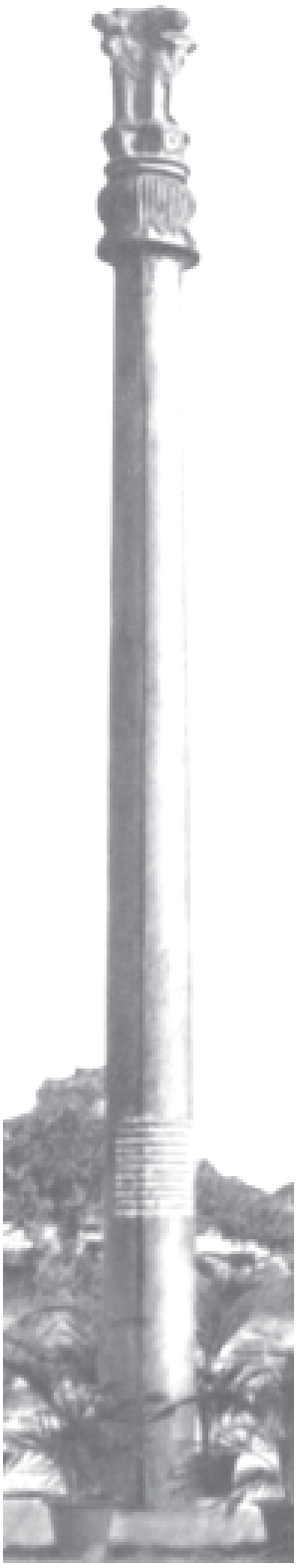
Under promotional efforts for new industrial establishments, NML is actively collaborating with MECON. Proposals are under-way for setting up graphite beneficiation plant in Kerala, electrolytic manganese and manganese dioxide plant in Orissa; magnesite plant in Salem etc. All these proposals are now under various stages of negotiations. NML is also actively assisting and providing consultancy in setting up a graphite beneficiation plant in Rajasthan by M/s. Rajasthan Graphite (P) Ltd, Calcutta.

The R&D projects are periodically reviewed and in the light of the progresses achieved, some projects are considered for further thrust. Projects which have been completed successfully on bench scale are considered for further augmentation, industrial evaluation, consumer acceptability for facilitating their transfer to industries. Similarly, projects which do not show much promising or fruitful results are closed. New proposals likely to have socio-economic impact are reviewed for exploratory studies.

The United Nation Industrial Developmental Organisation held Consultation Meeting on "Adaptation of Steel Technology to the needs of the Developing Countries" at NML from 27th November to 2nd December, 1977. The meeting was convened in collaboration with the Govt. of India. Delegates from Sweeden, Japan, Phillipines, Turkey, Chile, India and representatives from UNIDO Secretariat, Vienna attended. The Director, National Metallurgical Laboratory, who was one of the Indian representatives presided over the Meeting. A meeting of the Co-ordination Council for Engineering Group of Laboratories of CSIR was held under the Chairmanship of Dr. S. R. Valluri, Director, National Aeronautical Laboratory, Bangalore. The meeting was attended by the participating laboratories including NML. The meeting was concerned to take a view on the plan proposals of the engineering group of the Laboratories. The NML also actively participated in the 'Get-together' with the focal theme on the use of NML-PM2 aluminium alloy conductor in electrical industries at Indore, organised by the Small Industries Service Institute; the meeting of the State level R&D Committee for Bihar held at Dhanbad; and the Indian Creep Panel Meeting for which NML holds the secretariat.

NML Technical Journal and other publications of th Laboratory were continued to be well received. There is considerable demand of reprints of papers published in NML Technical Journal from lndia and abroad. A monograph on "Indian Ores & Minerals and their Beneficiation Studies" covering the investigational work conducted in NML, over the past two and half decades, has been prepared, edited and being made ready for publication.

DIRECTOR



1978 - 79

The R & D efforts of National Metallurgical Laboratory provide a selective thrust on projects which have reached final stage of industrial evaluation/ transfer of technology/adaptive technologies with accent on import substitution. Promotional efforts are directed towards industrial establishment of NML processes & products.

During this year, the Laboratory has successfully transfered the technology on production of electrolytic manganese dioxide to Central Research Organization, Government of Burma, Rangoon; under the Technical Assistance Programme of Govt. of India to Govt. of Burma through CSIR and NRDC. NML Scientists have assisted Central Research Organization, Rangoon; in setting up a pilot plant for production of electrolytic manganese dioxide suitable for use in dry cell based on NML developed technology.

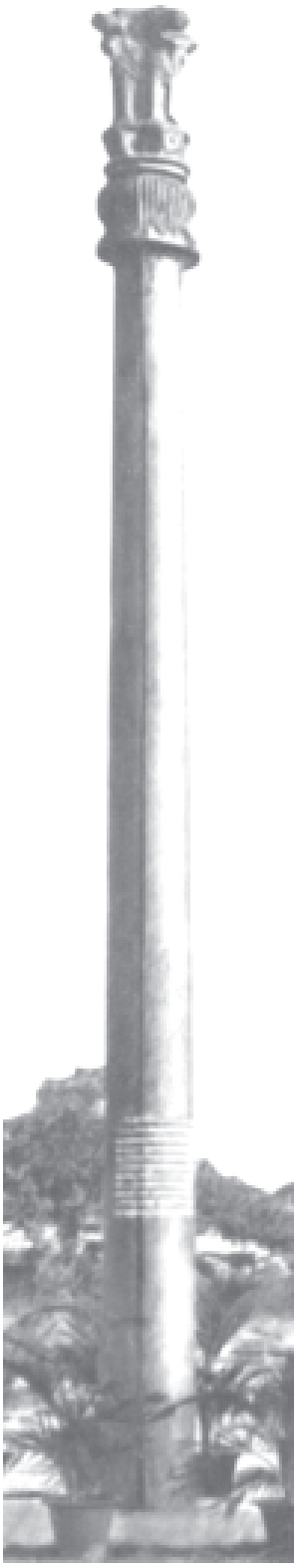
In the field of development, testing and evaluation of high temperature creep resistant steels, phase I of the programme on creep stress rupture and stress relaxation properties at elevated temperatures of steels for Bharat Heavy Electricals Ltd., have been successfully completed. The Laboratory has again been called upon for its service and expertise in this field for their phase II programme. The schedules have been mutually discussed and the work is under initiation.

A large number of sponsored bench and pilot plant projects on mineral beneficiation have been conducted and completed on behalf of public and private sector organizations like Vishakapatnam Steel Plant; Pyrites Phosphate & Chemicals Ltd. ; Hindustan copper Ltd; Hindustan Zinc Ltd; SAIL, Rourkela; Dempo Mining Corporation; Central Coal Fields Ltd; Indian Iron & Steel Co. Ltd.; etc.

Plans are now underway for further industrial scale trials of the know-how on production of heat resistant cast iron alloy,'NML Pyroloy 1000' at the works of M/s. Tata Iron & Steel Co. Ltd. About six hundred blades will now be put into trial for full fledged industrial evaluation at Tisco who are satisfied with the performance of the blades in their earlier trials. The NML developed know-how for reactive filter for aluminium industry has undergone successful field trials at Hindustan Aluminium Corporation, Renukoot; & Ordnance Factory, Ambajahari.

Processes like dental amalgam alloy, copper-clad aluminium sheet, electrical resistance alloy for heating element, nickel-magnesium alloy, thermostatic bimetals, vanadium pentoxide from alumina sludge etc. were released to a number of new firms.

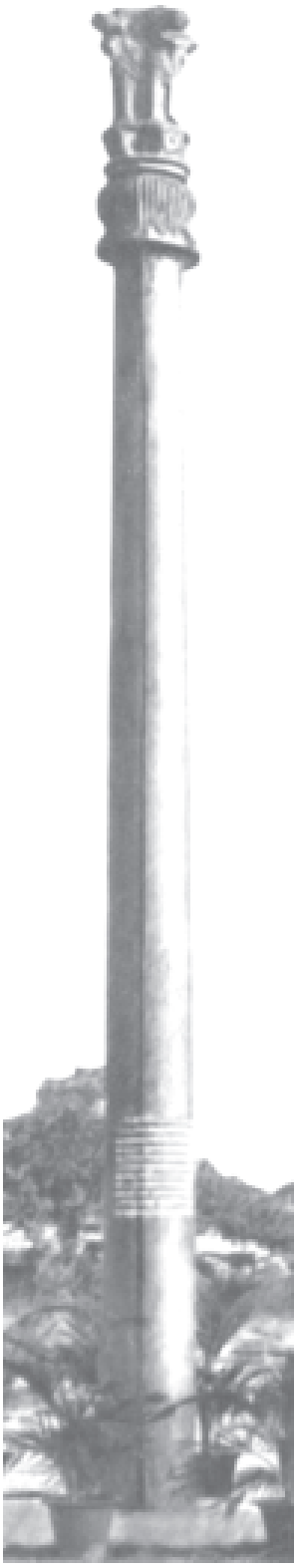
An International Collaborative Project on 'Atmospheric corrosion of metals and Alloys' was negotiated with National Research Institute for Metals, Tokyo, Japan. The Project is to run initially for a period of three years; comprising exposure tests with different metals and protective coatings so as to study various aspects of atmospheric corrosion, both in India and Japan, under similar climatic conditions. Another international collaborative project is under negotiation with SINTEFF-Norway on "Use of non-coking coal for generation of high potential reducing gases in molten metal reactions."



Consultancy services and assistance have been provided to M/s. Rare Metals & Chemicals Ltd., Ranchi; for setting up a plant for production of vanadium pentoxide from alumina sludge based on NML know-how. Consultancy has also been provided to M/s. Dentifils. Jamshedpur; for setting up a unit for manufacture of dental amalgam alloy based on NML know-how. Industrial problems have also been referred to by various CSI R Polytechnology Transfer Centres which were attended to.

The various Field Stations of the Laboratory continued to render services to the regional industries and undertake sponsored investigations. A Seminar on 'Recent development on mineral preparation and extraction metallurgy of sulphide ore' was held in collaboration with Inst. of Engineers (India), Jamshedpur, Sub-Centre; Indian Institute of Metals, Jamshedpur Chapter & Indian Institute of Mineral Engineers. The Laboratory participated in a number of industrial and trade exhibitions and in 'Get-together' with industrialists, business entrepreneurs. A special brochure and a special folder depicting NML's achievements, activities, services etc. were prepared and are under publication.

DIRECTOR



1979 - 80

The National Metallurgical Laboratory has built up expertise and capabilities in various disciplines of metallurgy which is now well recognized resulting in a constant flow of sponsored projects and collaboration from national and international organizations.

For the establishment of an Iron & Steel Complex at Syria, based on their raw materials, M/s MECON was awarded the contract against global competition wherein the investigations on all raw materials were entrusted with NML. This challenging assignment of beneficiating two low grade oolitic iron ores with strict time schedule was undertaken. Bench Scale studies have revealed that good quality sinters and pellets could be produced with concentrates obtained through various routes of beneficiation. Large Scale pilot plant trials on tonnage quantities of the ore are in progress.

NML had also undertaken comprehensive pilot plant beneficiation studies on low grade ores received from both public sector and private undertakings and developed process flow sheets for the setting up of different ore-treatment plants many of which are coming up, while some of them are in the planning and design stages. Some of the projects which are coming up and presently in different stages are :

(i) Gandhamardan iron ores-Beneficiation and agglomeration plant for Orissa Mining Corporation.

(ii) Saladipura pyrite beneficiation plant for PPCL.

(iii) Coal flotation plants for the treatment of coal fines and middlings at Nandan, Damna, Bolanda and Jagannath collieries of CMPDI, Ranchi.

(iv) Fluorspar beneficiation plant (36 tpd) at Chandidungri, M.P. for M/s. Madhya Pradesh & Maharashtra Minerals & Chemicals (P) Ltd.

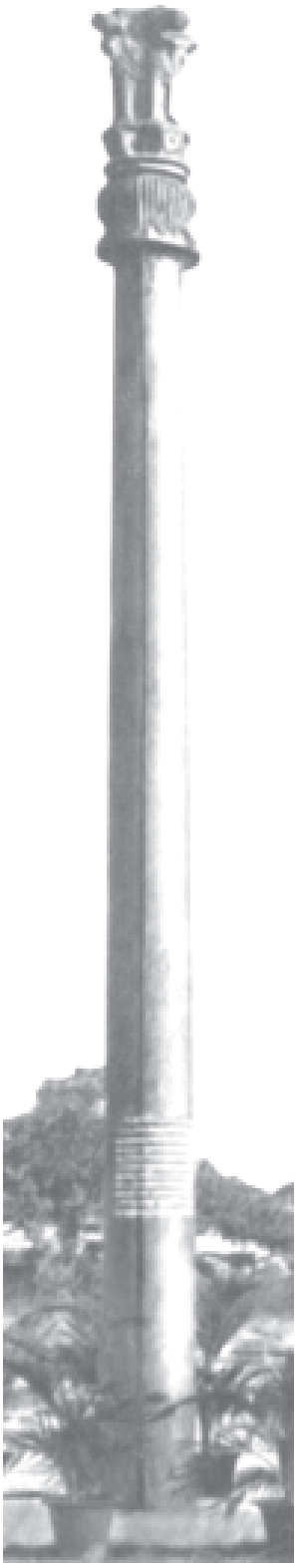
(v) Manganese ores beneficiation plant for TISCO.

(vi) Chromite beneficiation plant for FACOR.

(vii) Kyanite-Sillimanite beneficiation plant for M/s. Maharashtra State Mining Corporation.

With the National Research Institute for Metals, Tokyo, Japan; the Laboratory has taken up a collaborative project on the atmospheric corrosion of metals and alloys. NML has received 300 Japanese steel samples which have been exposed under different atmospheric conditions at Jamshedpur, Digha and Madras.

NML has accepted a package deal for setting up a one-tonne per day pilot plant for production of ferro-tungsten by alumino-thermic reaction, for the Central Research Organization, Rangoon. The assignment is through CSIR/NRDC under the Government of India assistance to Government of Burma under Indian Technical & Economic Co-operation Programme.



During the year, six process know- how have been translated to commercial production by the licencees . Under process technology and product development activities, further strides were made producing 350 carrier bladecastings at TISCO works. These blades have been made out of the heat resistant alloy cast iron developed at NML, designated as NML-Pyroloy 1000. Industrial scale evaluation trials on element pins, made out of this alloy, used in electric arc furnaces has commenced with active co-operation of M/s General Electric Company, Calcutta.

The versatile electric grade aluminium alloy 'NML-PM2' was earlier well received by both the conductor manufacturers and users and that its production was established at three industrial units at Calcutta, Hyderabad and New Delhi. It is a matter of gratification that the application of M/s. Universal Cables Ltd., Satna ; for the transfer of technology of NML-PM2 was finally cleared by the Government of India and technology transfer effected during the month of November, 1979.

The concept of the use of annealed NML-PM2 steel reinforced conductors has been accepted by the Rural Electrification Corporation for field evaluation and 30 km of this type of conductor has been processed by our licencee M/s. Indian Aluminium Cables Ltd., New Delhi. The paper, incorporating these ideas, was published in the Journal of the Institution of Engineers (MM 1978 July) and it was awarded the 1979 Dr. Rajendra Prasad Memorial Gold Medal.

NML had collaborated with Bharat Heavy Electricals Ltd., Bhopal in the development of 16/20 MVA 132/33/11 KV aluminium transformer and one phase out of the three phases of the power transformer was wound with NML-PM2 DPC strips. It is understood that the power transformer has since been made by BHEL and passed the tests. It is now in the installation stages at the M.P. State Electricity Board.

Another important area of thrust of the aluminium technology group has been in establishing alloy melting and solidification technology. NML developed the concept of filtering the molten metal through a bed of refractory filter and towards the end developed "NML Reactive Filter". The NML Reactive Filter was initially evaluated at M/s. Hindustan Aluminium Corporation, Renukoot ; Electrical Manufacturing Company, Calcutta and the Ordnance Factory, Ambajhari ; Nagpur. The production technology of the filter was then transferred through NRDC to M/s. Bhaskar Stoneware Pipes (Pvt.) Ltd., Faridabad.

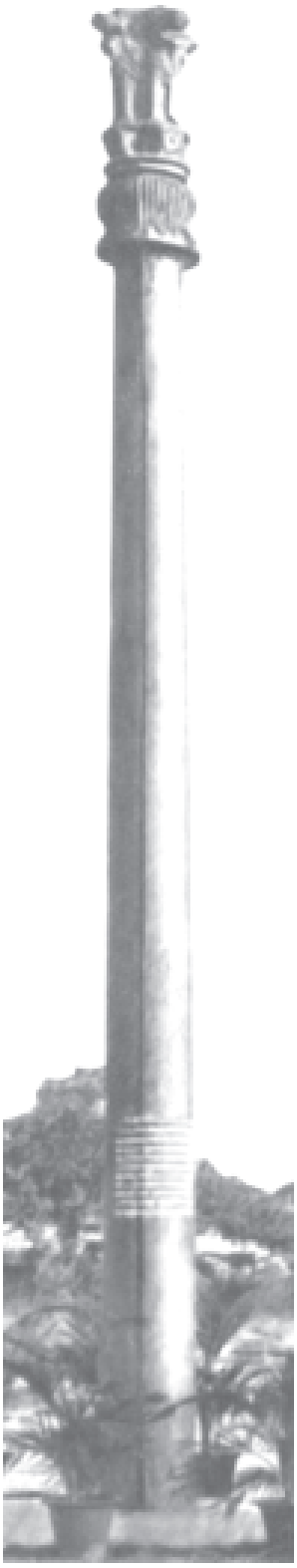
The Ministry of Defence referred some problems in KM Bridge Girders for investigations. It is heartening to state that the recommendations made by the NML after detailed Laboratory investigations have been accepted and adopted for shop practice. In this context, Director-General, Ordnance Factories has stated. "The NML has done very good work of national importance in the field of aluminium alloy technology".

The NML had also several interactions with the small scale industry manufacturers, One such interaction was with the utensil industries for improving the product quality and increase in productivity. After carrying out the investigations, including the field demonstration, the rejection of the finished utensils with respect to the circles was reduced from the existing figure of 32% to about 9%.

Another important area is in the development of filler wires for aluminium and its alloys. The filler wires have undergone extensive evaluations for repair welding of aluminium alloys including aircraft components. The process is now ready for commercial exploitation.

Yet another area of substitution of copper is the development of aluminium alloy bearing metal corresponding to class iv type of bronze . The performance of these bearings have been evaluated at Research , Design & Standards Organisation, Lucknow. The RDSO have informed that NML aluminium alloy bearings (PM 401) conform to their specifications and the RDSO have asked to produce even larger bearings.

Industrial inplant trials for the technologies for the production of high strength low alloy steels, calcium - silicide and clad steels have been planned at Bhadravati works of M/s Visvesvaraya Iron & Steel Works. In-plant trials are underway with the active co-operation of M/s JEMCO, Jamshedpur on the NML developed technology of desulphurization of iron & steel.

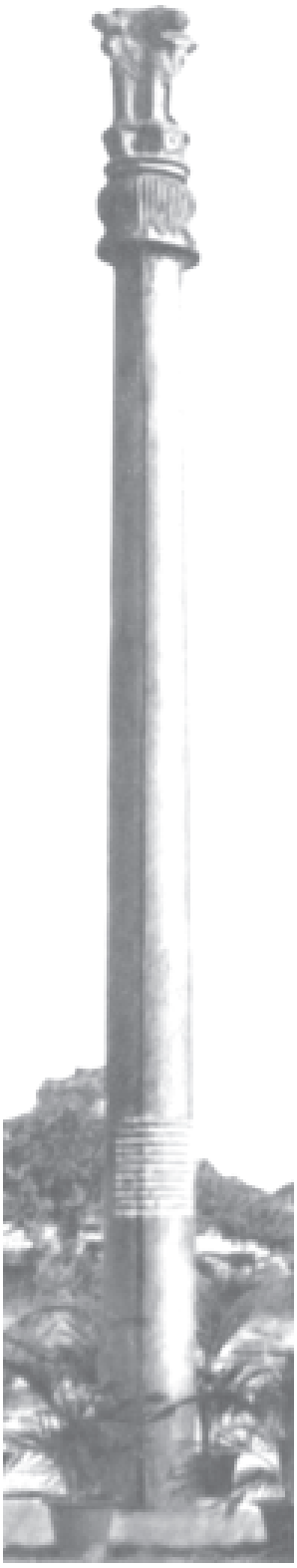


The Laboratory has continued to carry out sponsored investigations on creep resistant steels for M/s Bharat Heavy Electricals Ltd. & Reactor Research Centre , Kalpakkam . On behalf of M/s Guest , Keen & Williams ; nickel-iron alloys having properties similar to Rho - metal. Radio metal and HCR alloy have been developed and report submitted to the firm . Besides, sponsored investigations on failure problems of metals in thermal power plants , chemical & other industries etc, development of beneficiation process of ores and minerals , development of refractory materials , extractive and chemical metallurgical problems, preparation and supply of standard reference materials were conducted and in progress.

The extension Centres at Batala , Ahmedabad , Howrah and NML unit at CSIR Madras Complex continued to cater to the regional requirement and rendered the assistance needed . The activities at NML unit at Madras have since been expanded to include industrial and chemical metallurgical disciplines, beside augmenting its ore -dressing and mineral beneficiation facilities. Dr. Rajendra Kumar, Scientist (in the grade of Director) represented NML as a Member of the Patratu Thermal Power Enquiry Committee constituted by Bihar State Electricity Board to enquire into the causes of failure of superheater header and other pressure parts of unit No. 8.

The Volume 1 of the Monograph on "Ores & Minerals of India -Beneficiation & Agglomeration Techniques for Industrial & Economic Exploitation" is nearing completion and will be published soon. A special colourful brochure depicting the Laboratory's R & D achievements and a special folder depicting the various assistance the Laboratory can provide were published.

DIRECTOR



1980 - 81

The multidisciplinary activities of the laboratory have brought rich dividends in the form of sponsored projects/investigations, consultancy assignment, transfer of technologies. The laboratory has carried out large number of sponsored work, in plant and field trials, large scale trials.

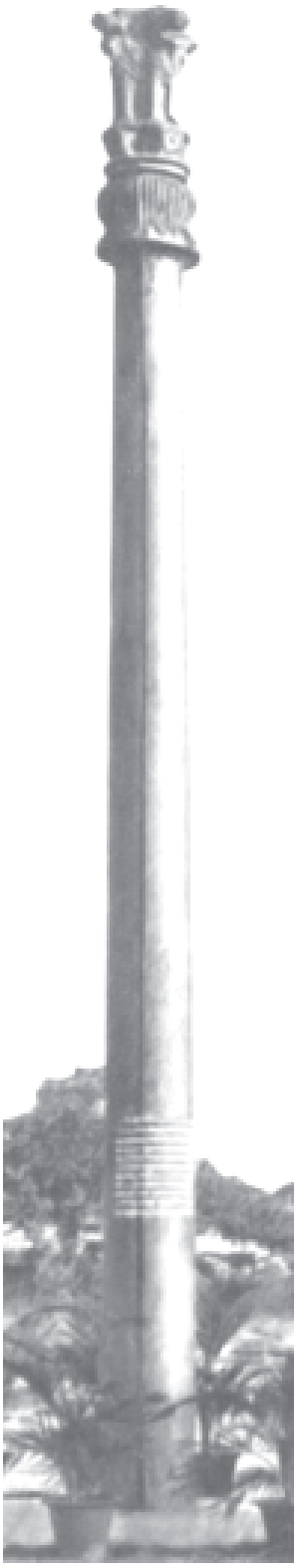
During the period , seventeen products / processes have been established as a result of R & D efforts which are under various stages of evaluation. Three products / processes have gone into production for the first time and thirteen product / processes which are in continuous production are progressing well . The total product value is around Rs . 50 million during 1980-81. A project on the modernization of the Durgapur Steel Plant was taken up in collaboration with British Steel Corporation (Overseas service). Over 100 tonnes of run-of-mine ore sample from M/s Bolani Ore Ltd. were received and detailed large scale studies were successfully completed. The report has been furnished to the sponsors. Detailed bench and pilot plant studies on a low grade pyrite-pyrrhotite sample from Saladipura were conducted on behalf of M/s Pyrites, Phosphates & Chemicals Ltd. who are setting up beneficiation plant for the recovery of sulphur. In this connection Shri G. P. Mathur, Scientist F, visited Lurgi Laboratory on behalf of M/s P.P.C.L. to study the bench scale results on the sample also carried out by the firm.

The international assignment on the beneficiation and agglomeration studies on pilot plant scale on two low grade iron ore samples from Syria, obtained through MECON, was completed. The results of the work has formed the basis for the preparation of the feasibility report by MECON for Govt. of Syria towards the establishment of an iron and steel complex at Syria.

To counteract problems of severe corrosion in the coastal regions, the Gujarat Steel Electricity Board installed two types of conductors made of the versatile electric grade aluminium alloy NML PM2. Encouraged by the good performance of the conductor, Gujarat State Electricity Board and the Central Board of Irrigation & Power jointly convened a Conference at Baroda in April 1981 of representatives of all the State Electricity Boards having coastal regions to serve and decision was taken for wider trials with ACC, NML PM215 conductor in the coastal region.

The Gujarat State Electricity Board has also shown interest in the use of NML-PM53, which is a medium strength medium conductivity aluminium alloy conductor in the coastal region.

Research Design & Standards Organization, Lucknow, Ministry of Railways, Govt. of India; have shown interest in the use of NML-PM215 as catenary conductor in the Railway Electrification Project. The Laboratory has developed PM 401 aluminium alloy bearing bushes as a substitute of bronze bearing and supplied to Research, Design & Standards Organization, for evaluation. RDSO fitted these bushes into steam locomotives. The performance was evaluated under actual running condition and was found satisfactory. Large diameter bushes have been sent to RDSO for further field trials.



The Laboratory has established the production technology of the aluminium alloy welding filler wire corresponding the BS2901 NG6, and IS1278 : 1972NG6 specification. Fairly large quantities of NML-PM16 filler wire in different gauges have been supplied to M/s Hindustan Aeronautics Ltd. Bangalore for evaluation. As a result of increased demand for NML Reactive filter, M/s Bhaskar Stonewere Pipes (P) Ltd. who are producing the material as licencee, are increasing their production capacity. A foreign firm in U.K. is interested in taking up the technology of Reactive filter and it is being processed by National Research Development Corporation. To minimize the rejection rate in aluminium utensil manufacture by small scale utensil industries in Bihar, the Laboratory has rendered its expertise and consultancy. With the assistance of the Laboratory, the rejection rate was brought down to 5-7% from 25-35 percent. A Workshop-cum-Get-Together was organized at Patna in November 1980, where NML developed technology was demonstrated.

Under a collaborative programme of work with M/s. Visvesvaraya Iron & Steel Ltd. on process standardization of high strength low alloy steels, industrial scale heats of niobium and niobium-vanadium steels were made in a 12 ton L.D. converter. These steels find use in the construction of ships, bridges, buildings, pressure vessels, transmission towers, wagon, pipe lines, reinforcement rods etc. It is an import substitution product and country is meeting its demand partially through import.

NML has accepted a package deal for setting up a one tonne per day pilot plant for production of ferro-tungsten by alumino-thermic reaction for the Central Research Organization, Rangoon. The assignment is through CSIR/NRDC under the Govt. of India's assistance to Govt. of Burma under Indian Technical & Economic Co-operation Programme.

The Laboratory has developed technique for assessing the extent of accumulation of creep damage through accelerated stress rupture tests. This technique has already been used to predict the state of condition of the tubes from Central Electricity Board (for Badarpur Thermal Power Station) and Neyveli Lignite Corporation Thermal Power Plant. The Laboratory has developed expertise on the cause of failure of engineering metal components in construction materials. This expertise is in large demand by thermal and hydro-electric power plants, oil refineries, petro-chemical complex, iron & steel industry, coal washeries, mining, cement, textile, paper industry etc. A large number of sponsored investigations including on the spot study have been conducted and the causes of failure were ascertained and remedial measures advised.

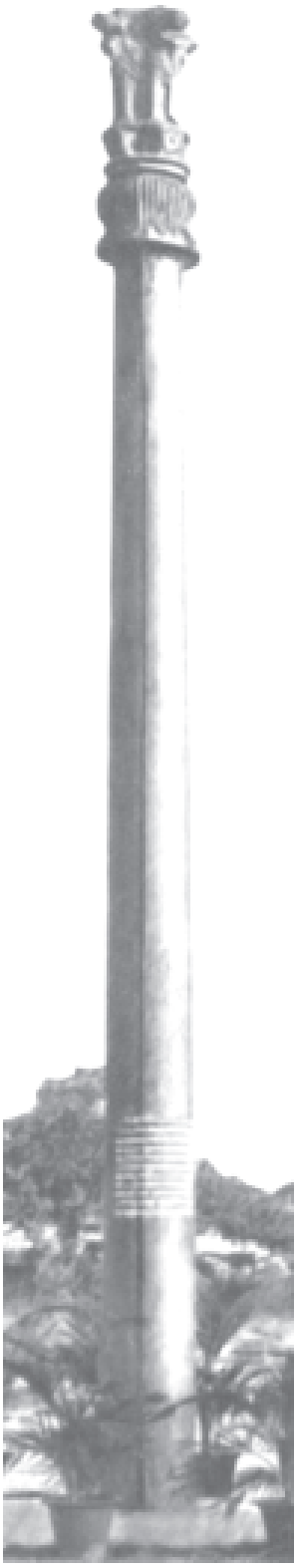
The technology of aluminium base 'SUPERAL' anode for cathodic protection of ships and harbour structure was released to M/s Aluminium Manufacturing Co, Calcutta ; who have started its production and supplying to various dockyards.

The NML Pyroloy-1000-a heat resistant cast iron developed in the laboratory, has found its application in another new item in replacing nickel-chrome finger castings used in pipe normalising furnace. Finger castings made in the laboratory with NML Pyroloy 1000, were used by Indian Iron & Steel Co's Stanton Pipe Foundry at Ujjain, and was found superior to nickel-chrome castings.

An International Symposium on "Modern Developments in Steel Making" was held from Feb, 15-17 1981 ; in collaboration with M/s Tata Iron & Steel Co. Ltd ; Steel Authority of India Ltd. & Indian Institute of Metals. The Symposium was attended by 350 delegates from India and 80 foreign delegates from 20 countries of the world. Representative from United Nations Industrial Development Organization, Vienna ; also participated in the Symposium.

The volume 1 of the Monograph on "Ores & Minerals of India-Beneficiation & Agglomeration Techniques for Industrial & Economic Exploitation" was published and released by the Prime Minister & President of CSIR, Shrimati Indira Gandhi.

DIRECTOR



1981 - 82

The R & D activities of the Laboratory have resulted in the utilisation and potential application of some of the products and processes developed.

Consultancy assignment and a large number of sponsored projects have been assigned to the Laboratory. The Laboratory developed the technology for the production of aluminium-5 percent magnesium welding filler wire according to specification B.S. 2901-1970-NG6. This type of filler wire, which is now imported, is used for welding of sheet metal components in manufacture and repair welding of aero engine components. The NML produced welding filler wire has been used by M/s Hindustan Aeronautics Ltd. Engine Division, Bangalore, who found it quite suitable for the purpose. It has been approved by M/s. Hindustan Aeronautics Ltd, for use in their engine division.

In this connection excerpts from a communication from M/s. Hindustan Aeronautics Ltd. Engine Division, Bangalore is reproduced below :

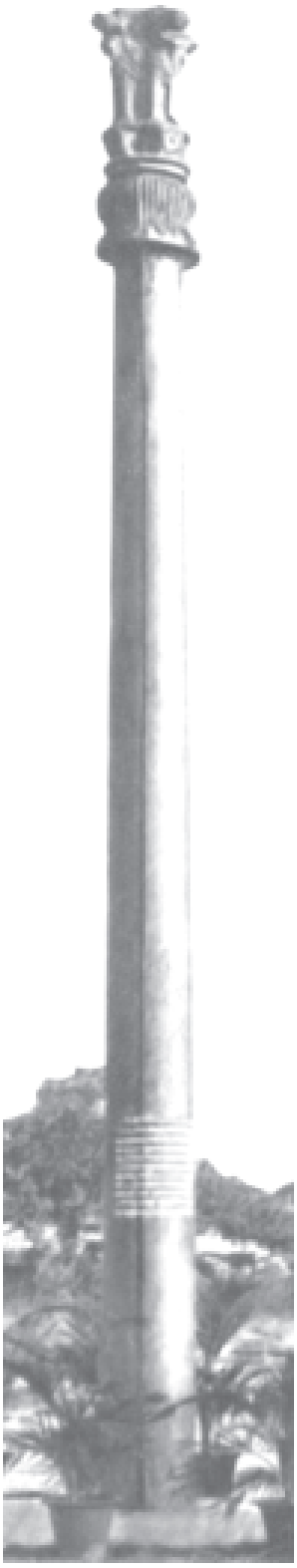
"In an effort to locate an indigenous source for these filler wires, M/s. National Metallurgical Laboratory, Council of Scientific and Industrial Research, Jamshedpur-831007, have developed the subject material and the sample/trial batch material has been tried by us and found suitable. In view of the above it has been approved for use in our Division."

The NML Madras Unit was entrusted to undertake detailed investigation by MECON, the Technical Consultant of the pelletization plant of Kudremukh Iron Ore Company, to establish the parameters for the production of direct reduction/blast furnace quality iron ore pellets from Kudremukh iron ore concentrate. Investigations were carried out as per the specified test schedules. The consultant were provided with the results of the exhaustive studies conducted on characteristics of the concentrate, the pelletization procedure, physical tests on green and hardened pellets etc., which will form the basis for design of the proposed plant. The Laboratory has also conducted a number of sponsored investigations on beneficiation and agglomeration studies of low grade ores and minerals.

The Laboratory has developed a process for the recovery of tin from tin slag. Technology has also been developed for recovering tin from sponge tin which is a bye-product obtained from detinning operation. The processes developed are under negotiation for commercial utilization.

The Laboratory has developed nickel free creep resistant austenitic steel for application in automotive exhaust valve . NML's experimental alloy has been evaluated by M/s TELCO and the results are very encouraging.

Large scale industrial production of wire rods made from high strength medium conductivity aluminium alloy, designated as NML - PM 215, has been made at M/s. Bharat Aluminium Co. Ltd., Korba . There wire rods are being processed for the multistrand overhead conductors for defence requirements. The wire is also being processed for applications of catenary overhead traction wire for use by the Railways.



NML Pyroloy 1000-a heat resistant cast iron alloy-is undergoing industrial evaluation trials for various applications such as carrier blade castings for reheating furnace, element pins for electric heat treatment furnace, grillage line castings for walking beam furnace, spacer castings for gas carburising etc. The evaluation trials have given very encouraging results and various firms are interested in the products.

The Laboratory is offering its service to various thermal power plants of the country by carrying out investigations on prematurely failed components and advising the reasons for failure and remedial measures, quality assurance of creep quality steels, estimation of residual life of used components etc.

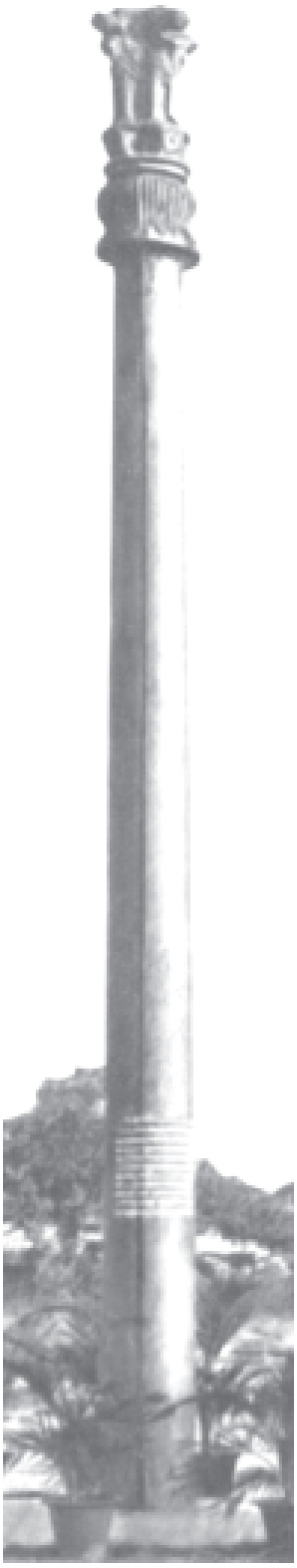
The Laboratory has conducted investigations on the amenability of Chikla manganese ore for the production of electrolytic manganese metal and electrolytic manganese-dioxide on behalf of M/s. Manganese Ore of India Ltd. Based on the investigations the firm proposes to set up commercial plants for production of electrolytic manganese metal and electrolytic manganese dioxide.

The United Nations Industrial Development Organisation, Vienna ; held a Workshop at National Metallurgical Laboratory on "Regional Project for Co-operative Research Among Metallurgical Research and Development Centres in Asia and the Pacific" in December 1981, which was attended by 28 participants from ten different countries. Prof. V. A. Altekar, Director, NML ; was elected the Chairman of the Workshop, Dr. B. R. Nijhawan (Ex-Director, NML), and now senior Inter-regional Adviser, Metallurgical Section, UNIDO, was the Leader of the UNIDO team.

Dr. Rajendra Kumar, Scientist in the grade of Director, has been assigned as Project Co-ordinatior of the project "Boiler Tube failures in Thermal Power Station" of the Central Board of Irrigation & Power for a period of three years 1982-85.

Shri D. D. Akerkar, Scientist, has received the 'Indranil Award' for metallurgy for the year 1980-81, by Mining, Geological Et Metallurgical Institute of India, Calcutta.

DIRECTOR



1982 - 83

I have great pleasure in presenting the annual report of the National Metallurgical Laboratory for the year 1982-83.

National Metallurgical Laboratory went through another year of considerable R & D activity. It is a matter of satisfaction that R and D work of the Laboratory during the past few years have resulted in commercialization of many of its products and technologies.

The 6000 tonnes per day copper concentrating plant of M/s Hindustan Copper Ltd. at Malanjkhand, which the Prime Minister dedicated to the Nation, has been set up based on the process flowsheet developed at NML following the findings of batch and tonnage scale pilot plant work done. Utilizing NML's expertise, fluorspar and graphite beneficiation plants have made considerable progress by M/s Madhya Pradesh and Maharashtra Minerals and Chemicals Ltd. and M/s Tamilnadu Minerals Ltd. Another electrolytic manganese dioxide plant having a capacity to produce 2500 tonnes annually is under negotiation with M/s Electro-Chem, Orissa Ltd. based on NML technology.

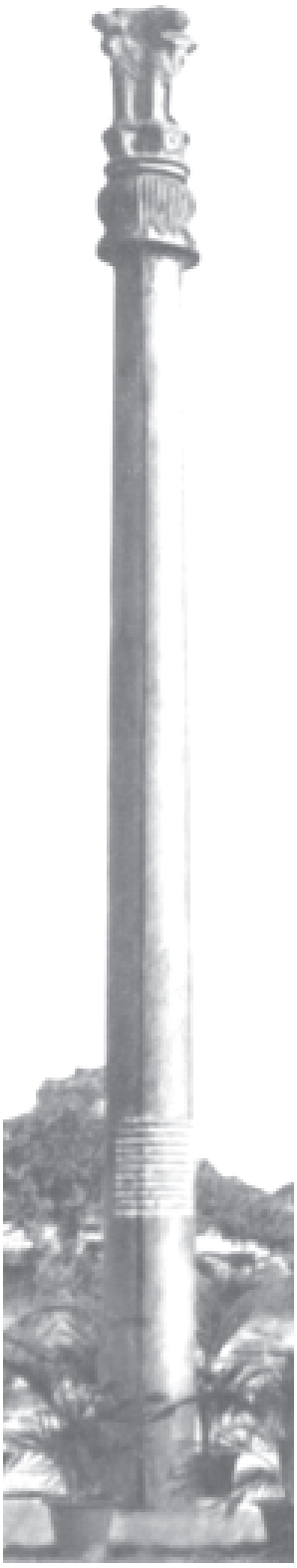
M/s Tin Plate Co. of India is utilizing the technology developed in the laboratory in recovering tin from their tin sludge. Tonnage quantities of refined tin have been produced by the laboratory and returned to the firm. NML developed aluminium base bearing alloy is undergoing service trial in locomotives in place of conventional bronze bushes. Highly satisfactory service report of this bearing alloy has been received from Research, Design and Standards Organization, Ministry of Railways, who are greatly interested in it. In the area of high temperature steels, long term creep, stress rupture and stress relaxation properties of steam turbine bolting steels have been evaluated on behalf of M/s Bharat Heavy Electricals Ltd.

NML is actively associated with Rural Development Programme of CSIR and assisting the rural artisans of Bankura district, W. Bengal, in melting and casting techniques of brass and bronze metals. The laboratory is inter-acting with small scale aluminium utensil manufacturers of Bihar and has helped them in improving the quality and productivity of their product and minimising rejection rates.

With National Research Institute for Metals, Japan ; NML is continuing the joint study on the exposure of different metals and alloys under industrial and marine atmosphere in two countries. NML has established a rapport with Steel Authority of India Ltd. and identified seven projects, work on which has been initiated.

In collaboration with INSDOC, NISTADS and PID of CSIR and Society for Documentation and Information Service, Jamshedpur, a Seminar on "Co-operation in Information Management" was held. The report furnishes a brief review of the activities and achievements of NML during the period. The tempo of R and D which the laboratory is maintaining will no doubt help in commercial utilization of many of its products and technologies in years to come.

Prof. V. A. Altekar
DIRECTOR



1983 - 84

I have great pleasure in presenting the Annual Report of the National Metallurgical Laboratory for the year 1983-84.

This year was a year of considerable R and D activity resulting in more and more utilization of NML developed technology and expertise. For the proposed Paradeep Steel Project in Orissa, evaluation studies of various raw materials particularly the beneficiation and sintering characteristics were completed. Consultancy service was rendered for the establishment of 100 tonnes per day graphite beneficiation plant for M/s Tamil Nadu Minerals. The product value after establishment of the commercial unit is estimated around Rs. 50 millions per year.

Research, Design and Standards Organization, Ministry of Railways, have accepted the electric grade alloy aluminium conductor NML-PM2 for use as enamelled wires in signal relays and have advised their zonal railway workshops to use NML-PM2 wires as substitute to copper wires. The high strength alloy aluminium conductor NML-PM215 is now poised for use as a catenary wire in electrical traction for high voltage overhead transmission lines. South-Central Railway has placed an order for 30 Km length of NMLPM215 catenary wire for trial evaluation.

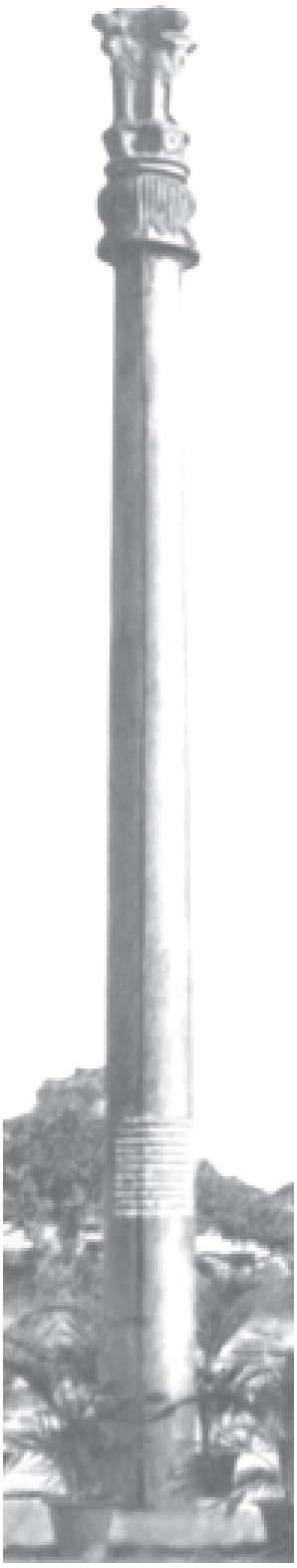
Sustained creep evaluation work on indigenously produced steels in collaboration with Bharat Heavy Electricals Ltd. (R&D) has contributed to the indigenisation of two grades of boiler quality superheater steels with chromium and molybdenum alloying elements leading to import substitution.

Nickel free creep resistant austenitic steels for automotive exhaust valve applications has been developed. Exhaust valves made from the experimental alloy have been fitted in a diesel locomotive for evaluation trial. Estimation of residual creep life of thermal power plant components on behalf of Thermal Power Stations were determined. Metallurgical examination on failure of thermal power plant components were conducted and remedial measures were suggested to minimise the power outage.

A further quantity of 8 tonnes of sludge containing tin was processed and tin metal was supplied to M/s Tinplate Co. (I) Ltd. Calcium silicide production on pilot scale was successfully developed and production parameters were established for commercialization. The project was sponsored by M/s Ispat Project who are planning to put a commercial plant. Precious metals like nickel, cobalt and copper from polymetallic sea nodules were succesfully extracted with high recovery through hydro-metallurgical techniques.

Consultancy services were provided to M/s Zinc Products, Patna; for putting up 500 tonnes/annum of zinc dust. An agreement has been signed with M/s Tapadia and Co. for establishment of 100 Kg/day electrolytic copper powder plant at Jamshedpur.

Clay graphite stopper heads have been evaluated in the Alloy Steel Plant, Durgapur; for teeming steel ladles of 50 tonnes capacity under CSIR-SAIL Collaboration Project.

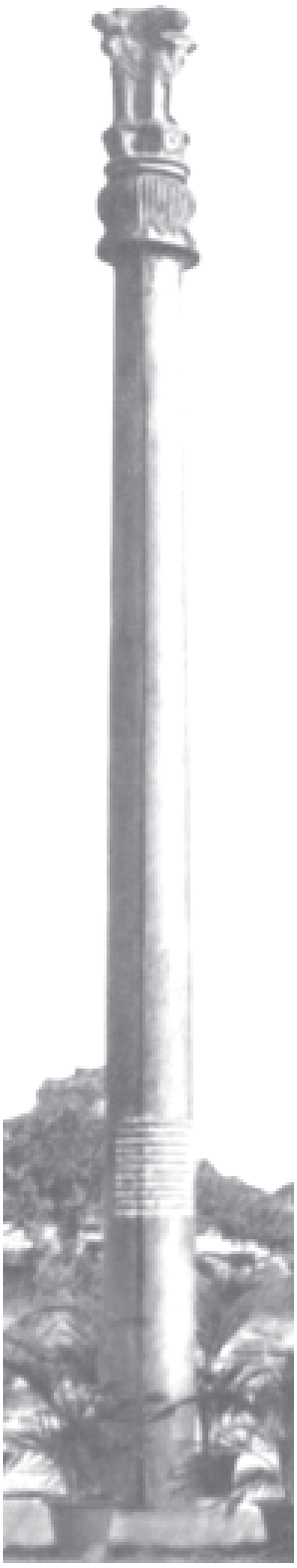


'NML-HOPAL' anode for the cathodic protection of the off-shore oil platforms and drilling equipment has been developed. Technology on calorizing of tube materials has been extensively evaluated and its performance under sulphurous atmosphere has been found to be far superior to the carbon steels which are currently used in heat exchanger tubes.

NML in collaboration with Iron and Steel Division of Indian Institute of Metals, organised a highly successful seminar on 'Problems and Prospect of Ferro-Alloy Industry in India' in October 1983. The seminar was inaugurated by Shri N. K. P. Salve, Union Minister for Steel and Mines, and presided over by Mr. R. H. Mody, Chairman, Tata Steels.

NML published the second and final volume of the Monograph on 'Indian Ores and Minerals' covering the beneficiation and agglomeration studies on a large number of non-ferous, strategic refractory, non-metallic minerals, coal etc. A new colourful brochure on the R and D activities of National Metallurgical Laboratory is under publication.

Prof. V. A. Altekar
DIRECTOR



1984 - 85

I have great pleasure in presenting the annual report of the National Metallurgical Laboratory for the year 1984-85.

As usual this year witnessed a considerable rise in the recognition and utilisation of NML developed technology and expertise.

For the proposed Daitary Steel Project, detailed evaluation studies of the raw materials particularly beneficiation and sintering characteristics of iron ores were completed.

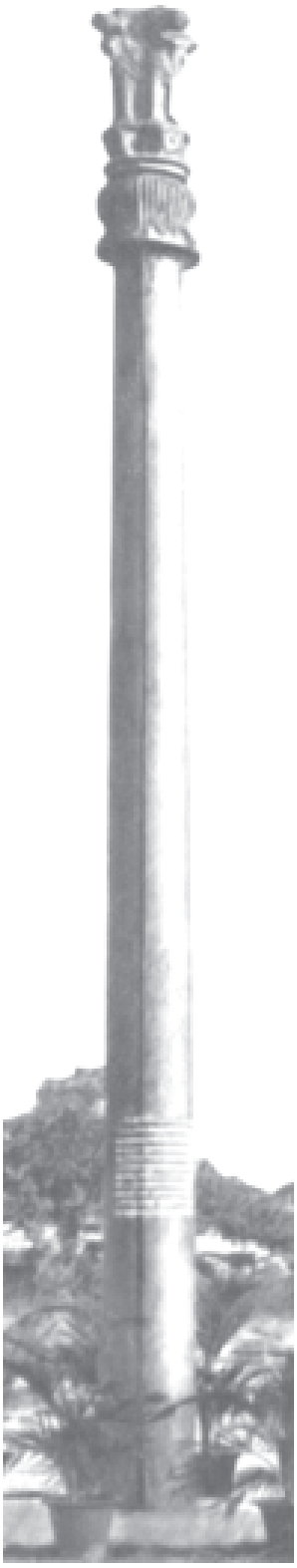
Investigations conducted on five different types of Magnesite of Salem area indicated that a general improvement in recovery could be attained from prevalent 8% to 16.0% to 18.2% of parent rock magnesite and respective flowsheet recommended to M/s. Mineral Development Board, New Delhi for adoption.

Successful investigations were carried out on pelletization of Tiruvannamali magnetite ore and the pellets were sent back to Dept. of Geology, Govt. of Tamilnadu for trials at the plant of M/s. Sponge Iron (India) Ltd., Kothagudam, A.P.

A suitable economic process for the extraction and recovery of Metallic values viz. Nickel, Cobalt, Copper and Manganese from sea nodules was perfected.

Sustained work on development, testing and evaluation studies on indigenously produced steels in collaboration with BHEL (R and D) has contributed to the indigenisation of two boiler grade super heater quality steels with chromium and molybdenum contents for acceptance of these steels for indigenous production thereby leading to Import substitution. For ascertaining the state of health, evaluation and prediction of life of thermal power plant components such as super heater tubes for taking a decision for their continued use or replacement on time to avoid unscheduled outages, a detailed survey and analysis was conducted thereby creating a consciousness in the thermal power plant sector. This evaluation has led to the development of quicker and more reliable methods for arriving at residual life of boiler tubes and their initiation throughout the country. Simultaneously about 25 metallurgical investigations were carried out on the failure of components of thermal power plants and refineries in the country successfully and remedial measures and methodology of reduction of downtime due to outages were suggested.

The first commercial distilled grade zinc dust plant set up by M/s. Zinc Products and Co. P. Ltd., Patna, based on the NML technological know-how and consultancy services provided by NML was formally inaugurated by the Honourable Minister of State for Science and Technology, Shri Shivraj Patil on 30th March, 1985. The plant was commissioned in Nov. 1984. The first lot of 20 tonnes against export orders had been supplied by the firm in Jan. 1985 and a second lot of 40 tonnes is scheduled for export in March/April 1985. The present capacity is over 600 tonnes per annum worth over Rs. 24 crores and the second phase currently being taken up will raise the capacity to 1000 tonnes per annum, the product worth being over Rs. 40 crores.



Nickel free creep resistant austenitic steel for automotive exhaust valves application has been developed. The performance of two valves conforming to DLW-WDM 2 loco engine which are under service trails at Eastern Railway, Calcutta in the air side since August 1984 are reported to give satisfactory performance and are still in good shape. On completion of the trial in air side four valves will be subjected to the exhaust side of the loco engine also.

A new concept of filtering molten aluminium culminated in the development of 'NML reactive filter for aluminium and its alloys, the use of which reduces the level of dispersed solid particles, inclusion of oxides and dross etc., and improve the grain structure of the cast product. Dr. Rajendra Kumar, Scientist Director, Sri C. S. Sivaramakrishnan and Sri R. K. Mohanti have jointly been the reciepients of a certificate of merit of the NRDC Republic Day award for this invention.

Based on very encouraging performance results of the aluminium base bearing alloys in the field of evaluation trials by RDSO Lucknow some more bushes of different sizes have been made and supplied for a second series of evaluation studies.

Work on the preparation of clay-graphite stopper heads of pin type with improved properties and surface finish for use in ladles of 50 tonnes capacity under CSIR-SAIL collaborative project was undertaken and completed. The Inplant trials at Alloy Steel Plant, Durgapur are planned in April 1985.

A memorandum of understanding was arrived at for a joint collaborative venture between NML-CSIR, MECON, and Bhilai Engineering Corporation, Bhilai, for setting up of the first commercial plant of 4000 tonnes per annum capacity of sponge iron utilising the vertical retort direct reduction process know-how developed by NML. This know-how was a modular approach and the commercial plant will have a number of retorts producing 3-5 tonnes of sponge per day.

The technology of diffusion treated steels for utilisation in fertilizer and chemical industries have been extensively evaluated in laboratory and under actual plant conditions, for over a period of 2 years at PDL Sindri, a Government of India undertaking under a joint collaborative programme and the know-how so developed is in the final stages of implementation.

The technology for the production of NML-PM215 high strength aluminium conductor has been released to M/s. Electrical Manufacturing Co. Ltd., Calcutta and the transfer is in progress. The alloy holds potential for use as catenary wire and grooved contact wire for Railway electric traction.

The technology of production of electrolytic copper powder has been transferred to M/s. Tapadia & Co., Jamshedpur who are establishing a 100 kg per day production plant.

The process know-how for the production of filler wires NML-PM6 for MIG welding of high strength aluminium alloys has been released through NRDC to M/s. Karnataka Aluminium Ltd., Mysore and is under the process of transfer.

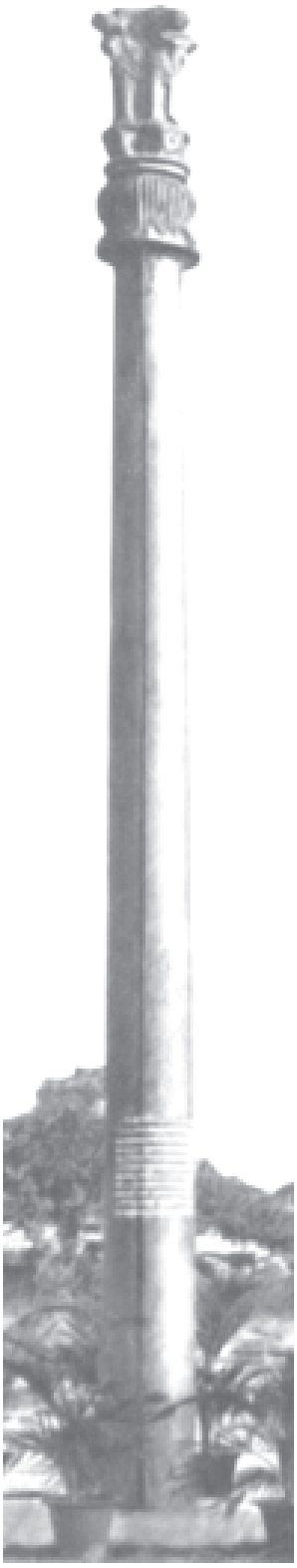
The technology for production of high purity magnesia and magnesium carbonate from low grade magnesite of the type occuring in Salem for use in cosmetics, pharmaceutical and rubber industries is under assignment to NRDC for its release to industries.

The process know-how for the preparation and use of an inhibitor suitable for continuous pickling of steels in hot sulphuric acid solution is under progress for release to the parties.

The NML has provided the necessary technical data on batch and pilot scale trials of different Manganese ores from various parts of India to M/s. Engineers India Ltd. with a view to enabling them to prepare basic engineering package for the technology on production of electrolytic Manganese metal and Manganese dioxide developed at NML.

During the year, recovery of valuable Tin metal from the sludge of electrolytic tinning plant of M/s. Tinplate Company of India was undertaken and about 2 tonnes of sludge was processed.

Prof. V.A. Altekar
DIRECTOR



1985 - 86

I have great pleasure in presenting the Annual Report of the National Metallurgical Laboratory for the year 1985-86.

During this year, the laboratory achieved a significant rise in the recognization and utilization of NML technology and expertise.

Based on the flow-sheet developed by the laboratory, a 72-tonne per day fluorspar beneficiation plant was commissioned at Chandidongri in Madhya Pradesh by MPMMC Ltd. The consultancy was provided for the development of technical flow-sheet, equipment specifications, selection and layout installation of the plant.

Studies on the beneficiation of two magnetite samples from Bihar State Mineral Development Corporation Ltd. were completed and concentrate assaying 85-95 per cent magnetite was produced.

Two samples of chromite from M/s. Mishrilall Mines, Sarubil, were evaluated, and the work on this high grade ore was completed.

Floatation studies on 2 coal fines samples from M/s. CEMPDIL, Bargolai, Assam indicated that concentrate assaying 1.8 and 3.08 per cent ash could be produced.

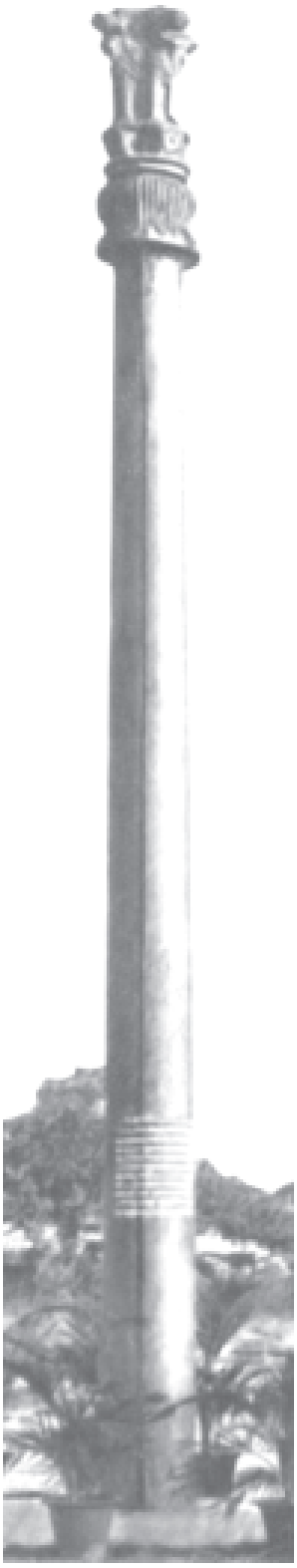
Bench and pilot plant sintering studies on blue dust samples from M/s. NMDC Ltd., Hyderabad indicated that blue dust to the extent of 22.25 per cent could be successfully used for the production of good quality fluxed sinters.

During that year, M/s. Engineers India Ltd. (EIL) were involved in the evaluation of data generated at the NML Pilot Plants for the production of electrolytic manganese dioxide and manganese metal using ores from different parts of India for preparing a basic engineering package of the technologies. In the feasibility report, M/s. EIL have stated that the process for the exploitation of manganese ores is technically viable.

Ammonia leaching and washing of polymetallic sea nodules at a pH, 9.0 carried out during the year indicated high recoveries of over 90 per cent nickel and cobalt. The recovery of copper was found to be 60 per cent and efforts are being made to improve upon the recovery rate.

The copper content of the discarded slag at M/s. Hindustan Copper Ltd., Ghatsila was found to be high and efforts are being made to reduce the same by improving upon the holding process.

A chemical process for the production of pure magnesium carbonate from magnesite, suitable for production of high grade basic refractories was developed. A preliminary techno-economic study of the various processes indicates that the ammonium chloride process is definitely superior to the



other processes. Optimum conditions for leaching of calcined magnesite in ammonium chloride solution were established.

By successful cycles of operation, production of electrolytic and activated manganese dioxide (EMD) simultaneously from a single flow sheet has been achieved.

Chemical processing of oils of vegetable origin to upgrade it for use as mould/core binders in foundry, was taken up.

Samples of (i) Bolting steels having three different compositions from M/s. Mahindra Egine Ltd., Khapoli, and (ii) Super-heater boiling tube steel, from M/s. Alloy Steel Plant, Durgapur were put to rigorous high temperature creep test programmes for period extending up to 33,000 hours. The analysis of the data generated demonstrate that these creep resistant steels, which are used by thermal power plants, are qualitatively comparable with those produced by developed countries elsewhere.

Fatigue properties of over 150 chain links were studied in details. The chain links are produced by M/s. MAMC, Durgapur, for export to USSR.

Joint collaborative project between NML and Fertilizer (Planning and Development) India Ltd., Sindri, on development and performance evaluation of diffusion treated steels in fertiliser and chemical industries was successfully completed. The PDIL Sindri contacted 93 manufacturers of sulphuric acid both in Public and Private Sector, informing the success of Aluminium Diffusion Treated Steel products for heat exchanger tube application. A Bombay firm has evinced interest in commercial production of the product.

Creep evaluation tests (short and long term) of boiler quality plates have been carried out to promote substitution of the corresponding imported grades.

Studies were carried out on magnesite dust received from M/s. Almora Magnesite Ltd. Seven binders were used in briquetting with optimum pressure at 750 kg/cm^2. The properties studied were shatter index, bulk density, porosity, DTA and sintering at high temperature. The results indicated suitability of two of the binders.

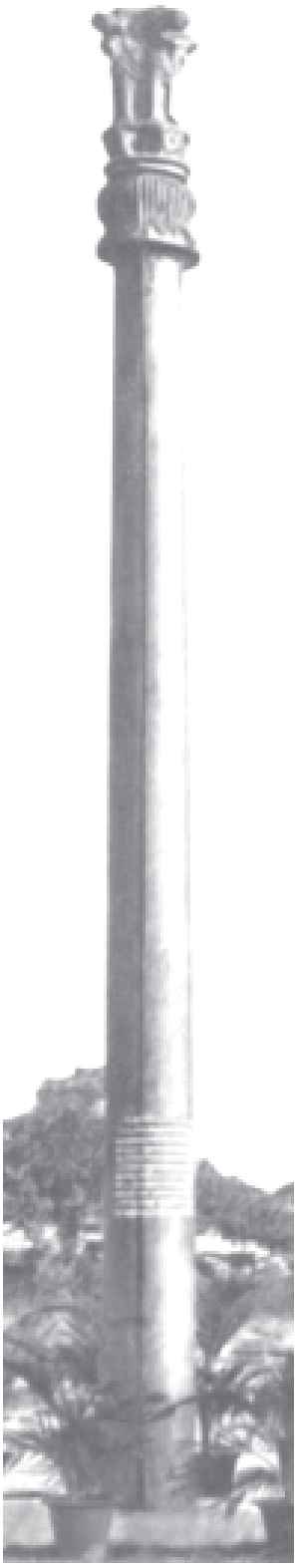
In order to develop refractories using beneficiated kyanite and beach sand sillimanite cylin-drical sample specimens and bars were fabricated with two grades of sillimanite beach sand using clay as binder and some sintering agents as additives using 15 tonnes pressure. The physical properties such as bulk density, CCS, and bending strength were determined. The samples were further fired in electric furnace to a temperature of 1500°C with 2 hours soaking.

Trials carried out for evaluation of the use of pre-reduced iron in LD converter indicate 100 per cent replacement of scrap by pre-reduced iron with no abnormality in blowing behaviour or any deleterious effect on metallurgical parameters. The average dephosphorisation was better-75 per cent compared to 60 per cent of normal heats and within low phosphorous range of 0.01 to 0.02 per cent. The total blowing time (22.8 minutes against 24.5 minutes of normal heats) and early slag formation improved while lime consumption remained the same (129.2 Kg/tonne of crude steel).

Compacted graphite iron has been produced in direct electric arc furnace, using sponge iron and pig iron as separate base charges. Sponge iron yielded 80 per cent recovery. Melts of sponge after carburization and siliconization was inoculated with conventional nodularisers and denodularisers to produce compacted graphite iron.

Production of tubes with mild steel sandwiched between stainless steel in the inner and outer cases was taken up. The mechanical properties, structure of the inter-faces and nature of bonds formed have been studied for a complete evaluation of such composite tubes of various diameters.

High strength toughness aluminium-lithium alloys with low weight for applications in air-craft are under development.



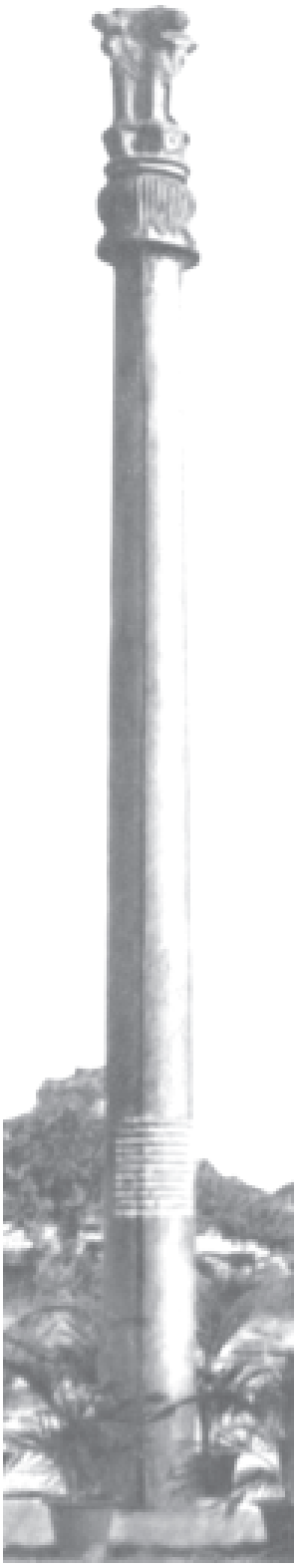
Shape memory alloys based on Cu-Zn-AI system having varying compositions have been made. Ms temperature and order and disorder transformation temperature of one of the alloy have been evaluated. An alternative heat-treatment procedure has also been devised to avoid the stabilisation effect. Anisotropic Mn-AI-C magnets by hot extrusion is under development.

The high output aluminium anode (HOPAL) for cathodic protection has been successfully developed and the technology has been transferred to M/s. Dum Dum Valves and Bearings Ltd. For the first time an indigenous design for the cathodic protection of off-shore oil jackets using NML-HOPAL anode and monitoring system has been submitted to the Oil and Natural Gas Commission.

The laboratory has entered into joint collaboration with Oil and Natural Gas Commission. The following projects have been taken up : (1) Development of formulations for transportation of wet sour crude/ condensate and gas, (2) Some inhibitors have been synthesised and are being evaluated under simulated laboratory conditions and further development for oil/gas wells acidisation (3) Development of formulation for water injection system used in oil wells.

Data based on three years exposure tests on Japanese samples both in India and Japan were collected and the reported results were discussed in the last Asian Pacific Corrosion Control Conference held in Tokyo in 1985. The Indian samples are now subjected to exposure in different climatic conditions in Japan. Similar tests with the Indian samples in India have been completed.

DIRECTOR



1986 - 87

In the year 1986 - 87, NML accomplished the following important tasks :

- defined its objective and motto succinctly for the first time
- radically restructured its divisional and managerial organization
- evolved entirely new procedures of decision making
- decentralised authority and decision making powers and delegated financial and executive powers down the line
- redefined, reoriented and restructured its entire R&D programme
- modernized and renovated R&D facilities
- accomplished the long - standing tasks of cleaning up, maintenance, and disposal
- resolved the problems relating to disciplining and grievance redressal of its employees which were pending for a long time

Director's report briefly outlines these accomplishments since their achievement required almost all of NML's organizational and managerial effort in 1986 - 87.

But, the tasks which lie ahead are more arduous than what has been achieved in 1986 - 87.

Neglected for a long period, NML has accumulated a large number of long standing problems. To survive, NML has to resolve these problems as soon as possible. In addition, the growth being essential for its survival, NML has to simultaneously initiate activities in several new directions. Accordingly, at the end of this report, given is a list of vital tasks, which NML has to complete in the near future.

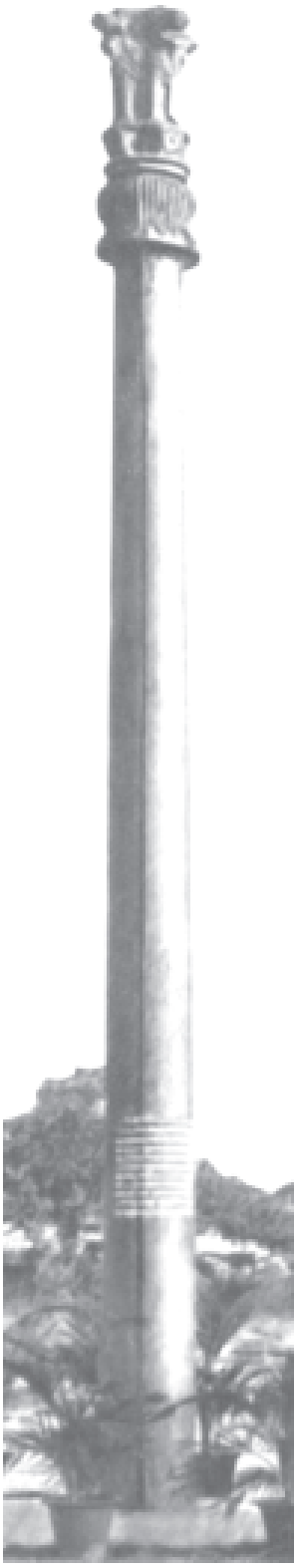
Objectives and Motto

In the early 1986, after a considerable amount of brainstorming amongst them, NML's senior scientists identified the following two objectives for the laboratory :

Our Objectives

Pursuit of Excellence in Research in the preparation and properties of engineered materials Applications of the Results of Researc for the benefit of the Society.

A CSIR laboratory such as NML, is assessed primarily by the application of the results of its research. However, we firmly believe - and it is very important that we never forget - that if NML is to produce



good application of research results, it must meticulously organize a part of its R&D programme, to pursue research projects, simply because the research in these projects promises to be excellent.

The two objectives written above, are prioritized accordingly.

Towards the middle of 1986, NML scientists held prolonged discussion in order to define NML's motto. As a result, it was decided to write the motto in the following format:

Our Motto

National Metallurgical Laboratory Innovating Technology of Materials to Serve People The key words in our motto should be specially noted: 'innovation' to produce new technology based on indigenous resources; the word `materials' substitutes 'metals' -a word which has been traditionally used to designate NML; and `people'. Our focus is neither on a government (central or state) nor on a given sector (public or private) nor on a specific industry (ferrous or non - ferrous) nor on a segment of the population (industrialist or consumers). Our focus is on 'people'.

NML's Organisational Structure

Before 1986, NML had Divisions and Committees but no Groups. It had no clearly defined organizational structure and therefore it is no wonder that very little executive and financial powers were delegated down the line. To achieve its goals and objective, NML had to drastically modify its organizational structure. After considerable internal debate and discussion this year. we concluded that to maintain continuity and to simultaneously promote change, NML's organization should be restructured into 3 different elements as shown below :

Flow of Authority and Responsibility Along Three Different Lines

Divisions - 14 Hierarchy - based
Stabilized Disciplines
Committees - 14 : Consensus -based
Changing Compositions
Groups - 5 Function - based
Non - Hierarchial; Temporary;

Thurst Area Projects

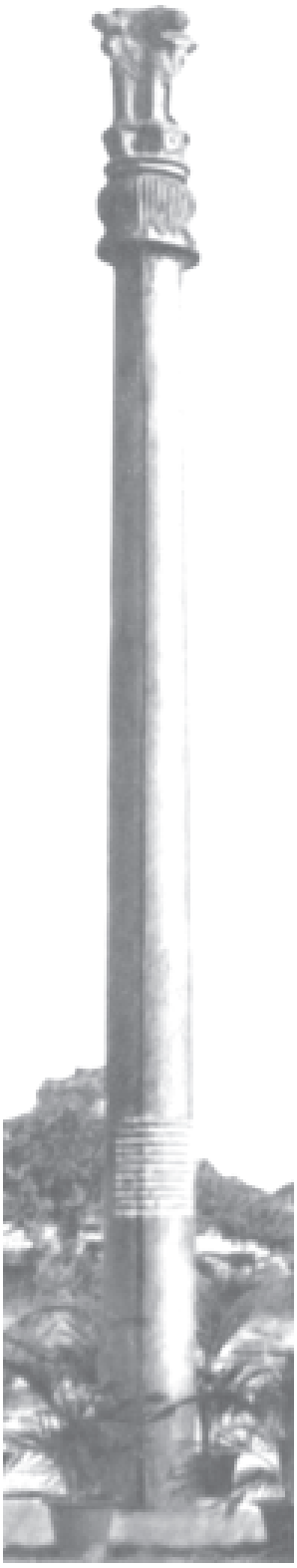
The Divisions follow hierarchy and each Division represents a well -defined and stable discipline. As the Division and its structure would largely remain unchanged for a decade or more, it is this which should give stability, order, continuity, and definition to NML. All these aspects are essential to implement any project or programme according to NML's genius.

To balance the strong features of the conservatism evident in the Divisional structure above, and what is more important to deliberately promote change and creativity, NML would form Groups for each of its five Thrust Area Projects (TAP).

Unlike the Divisions, the Groups are temporary and project oriented. The Groups ignore hierarchy and consist of members drawn from various Divisions and have no specific territory assigned to them in the Laboratory.

Yet, the Group Leader wields all the executive and financial powers and commands the required resources of NML, to carry out the approved TAP tasks- without reference to the Director or the Head of the Divisions.

The conflict inherent in the very basis of the formation of the Divisions and the Groups as described above, has to be resolved through consensus. This is cultured and continuously achieved through discussions in the 14 in-house Committees of NML. Accordingly. NML has now, a very powerful committee structure.



A Committee at NML, is permanent but its composition changes periodically. While examining issues related to its function , each Committee makes decisions , keeping in view the larger interest of the laboratory.

Thus the scope of operation of Groups and Committees cuts across the Divisions, and produces cohesion and integrity in the Laboratory.

Divisions, Committees and Groups at NML

Little rationale could be discerned in the 37 R&D Divisions which existed earlier at NML and the goals, activities and programmes of none of these Divisions were clearly defined. Some of the Divisions consisted of just one scientist and had been formed since the scientist could not work with others ! Yet, others were formed since a given scientist could be kept happy only with a very large territory assigned to him.

To achieve NML's objectives, all the old Divisions have been dissolved, merged and recast to produce 11 new Divisions - each of these represents either a well - defined and stable discipline or an organisationally coherent area of activity. In addition to these 11, three entirely new Divisions have been created: Computer Applications; Process and Project Engineering; and Instrumentation & Electronics.

To facilitate management and organization of its resources, each Division is further organized into 2 to 4 sections. A Division, its goals and its broad area of activity are not expected to change in one or more decades but the reorganization of a Division into Sections could take place more often.

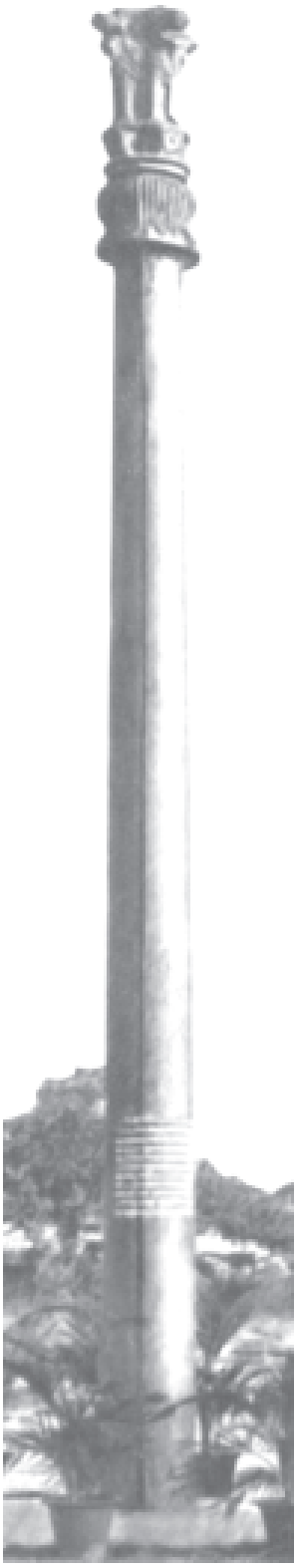
Each of the R&D Divisions and Sections has now defined its goals, activities, projects and the long and short term programmes. The Heads of Divisions enjoy clearly defined executive and financial powers for carrying out Divisional programmes and activities.

Major achievements - Management and Organization of R&D

(1) Organized a new programme for exploratory projects for the pursuit of excellence; (2) Monitoring and evaluation procedures of EXP and SI projects; (3) Tata Steel - NML Interactive proramme - Identification of project, teams and task and signing of MoU; (4) Identification of five thrust area projects - Negotiation with user/funding agency; (5) Recruitment of excellent scientists and Quick Hire Fellows; (6) Select and place order for the purchase of sophisticated equipment worth Rs. 2.4 x 10^7 including the computer; (7) Preparation of guidelines for the assessment promotion and recruitment of scientists; (8) Preparation of a plan for clearing backlog of assessment; (9) Writing a constitution for the in-house committees at NML: formation of functional committees and delegation of power; (10) Formation of three new divisions; (11) Reorganization of divisions including merging of 24 old, to form 8 new R&D divisions; (12) Plan, organize and award contract for construction of 96 scientists apartment; (13) Procedure to enable a scientist to make emergency cash purchase; (14) New procedure for disposal of advance/claim; (15) Cleaning up NML - Disposal of unusable and obsolete equipment and materials; (16) Stoppage of unauthorized subletting and cattle rearing; (17) Recruitment of supporting staff.

The list of achievements shows the NML experienced a turn - around in 1986-87. However, NML has accumulated a large number of problems over many years. Their early solution is essential if the laboratory is to achieve fast progress after this turn - around.

Prof. S. Banerjee
DIRECTOR



1987 - 90

This report is a brief compilation of the achievements of the National Metallurgical Laboratory for the period 1987-90. During this period, the laboratory made good progress in interacting with the users of its technologies and in establishing some very valuable linkages with the industries. The entire R & D programme were restructured and recruitment of a large number of young scientists was accomplished. Facilities and flow of funds were enhanced. Structural changes in the organisation was introduced. Fourteen committees were formed to decentralise decision making process. Mannuals were prepared for the smooth working of these committees. In addition. several reports highlighting activities were also published.

NML succeeded on focussing 65% of its R&D and organisational efforts on only four large Thrust Area Projects, namely : (1) Vertical Retort Direct Reduction and Submerged Arc Furnace, (2) Physico-chemical enrichment of tungsten ores from Degana, Rajasthan, (3) Extraction of Nickel. Copper and Cobalt from polymetallic sea nodules, (4) Component Integrity Evaluation Programme

All these projects are of national importance. The first one was sponsored by SAIL. Beneficiation of tungsten ores from the granite rocks of Degana was sponsored by DMRL, HYderabad. The ore sample supplied, contained 0.04 to 0.07% WO_3. Both the projects have been progressing well. The Department of Ocean Development sponsored the project on extraction of copper, nickel and cobalt from polymetallic sea-nodules. This long term project was in progress. By 1990, we had attained success in processing 1 kg. experimental batches.

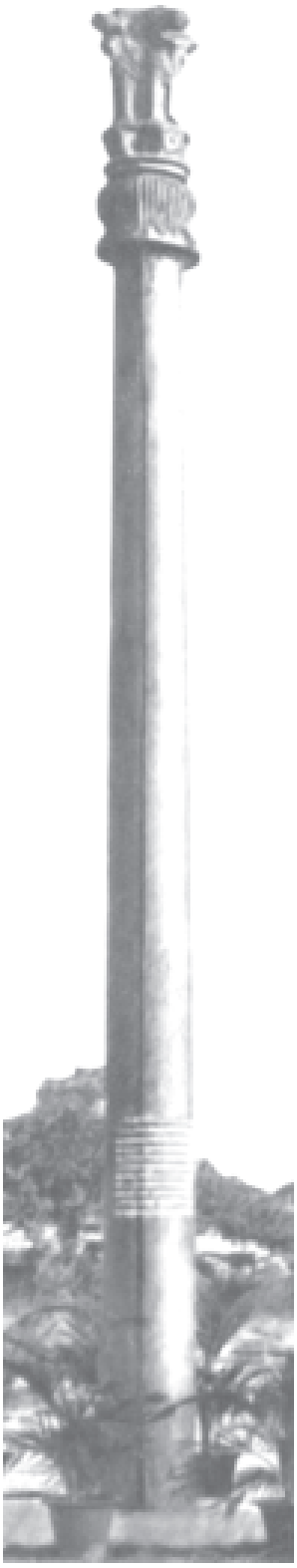
Efforts have been made to organise a Component Integrity Evaluation Programme. Out of the proposed six sponsors, five had already committed funds for participation, namely : (1) Department of Atomic Energy, (2) Steel Authority of India Ltd., (3) Indian Oil Corporation Ltd., (4) Tata Steel, (5) Bharat Petroleum Co. Ltd.

The World Bank agreed to grant Rs. 350.00 lakhs for the purchase of imported equipments for setting up infrastructural facilities under CIEP. The programme has already started and is progressing well.

Agreements were signed with Tata Steel, TCIL, Tata-Yodogawa and SAIL. Metasave inhibitor technology was successfully transferred to Tata Steel and TCIL. Initial trials of Metasave were conducted at Rourkela Steel Plant. Eight factors were identified or sticking together of black steel sheets in pack-rolling and the know-how provided to TCIL.

Many Sponsored projects/investigations were undertaken during this period to have a mix of large, medium and small projects so that men, materials and equipments can be put to maximum use and also raising extra budgetory resources for the laboratory.

During 1987-90, an investigation was carried out to evaluate the economic benefits of R&D to sponsors, society and the nation at large. This created awareness among our scientists and also outside scientific community about the importance of work persued in the laboratory in general.

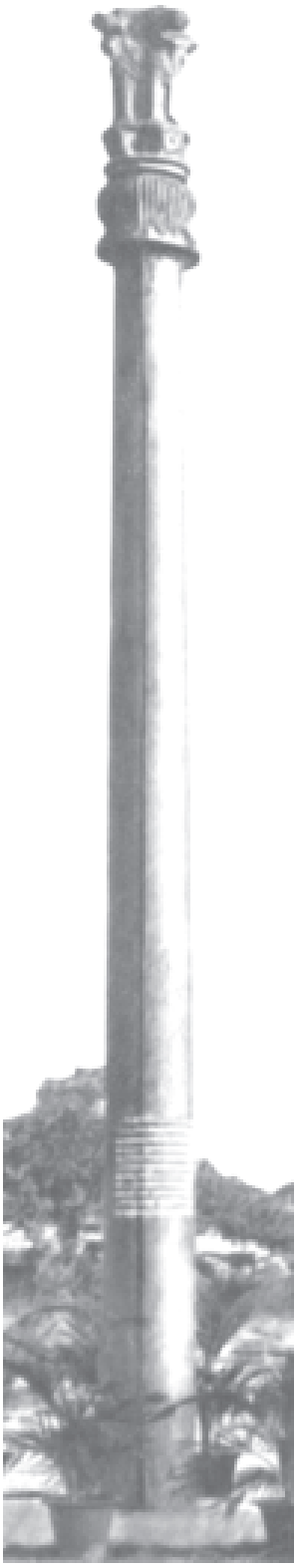


Efforts to procure 15 acres of land and construction of the boundary wall were progressing. The construction work for the Scientists' Apartment was completed.

During the period of report. NML scientists published more than 120 research papers in different reputed journals and filed 36 patent applications.

Due to some unavoidable circumstances, publication of this report was delayed and finally brought out in a consolidated volume (1987-90). Neverthless, most of the important aspects are recorded.

DIRECTOR



1990 - 91

The Annual Report as before, gives a brief account of the achievements and contribution of the National Metallurgical Laboratory, Jamshedpur, for the year 1990-91.

NML pursued both relevance-oriented and excellence-oriented R&D projects. NML was one of the few laboratories which had succeeded in focussing a major part of its R&D and organisational efforts, on only four large Thrust Area Projects. These projects were externally funded and were so planned and executed that they would have large scale impact on the long term industrial development of our country.

The laboratory pursued sixteen Interactive Projects in collaboration with the user organisations like Tala Steel, TCIL, SAIL, TAYO, out of which three projects were completed. Similarly, seven Sponsored Investigation Projects were completed and the other ten were being continued.

Further, 25% of NML's R & D efforts were utilized for the pursuit of excellence-oriented research through the Exploratory Projects. During 1990-91, twenty eight such projects were completed and twety six projects were ongoing. One Sponsored Research Project was completed. Works on five other Sponsored Research Projects were almost near completion.

The laboratory has established excellent interface with the potential users of its technology. This is evident from the fact that during 1990-91, Rs. 336.29 lakhs of external funds were received by the laboratory for carrying out R & D commissioned by the sponsors/users. This external fund amounted to 31.5% of the total expenditure of the laboratory.

A major part of the modernisation work of NML's facilities and equipments were achieved with the use of external funds.

During the year, NML developed four processes i.e. Production of : pickling solution, hydrated lime, magnesium sulphate and trisodium phosphate. Three processes were released. For the first time, 2 new parties went into commercial production and manufactured product worth of Rs 6.96 crores. This increased the laboratory's annual cumulative industrial production turn-over. NML is currently engaged in making a proper assessment of the economic benefit produced by the use of its technologies.

Two plant trial runs for Prevention of Rust on TMDP Coil and Elemental Magnesium Treatment were conducted at TCIL and TAYO respectively. The initial results were encouraging. The techno-economic evaluation of the METASAVE process was accomplished at Rourkela Steel Plant and the results were excellent.

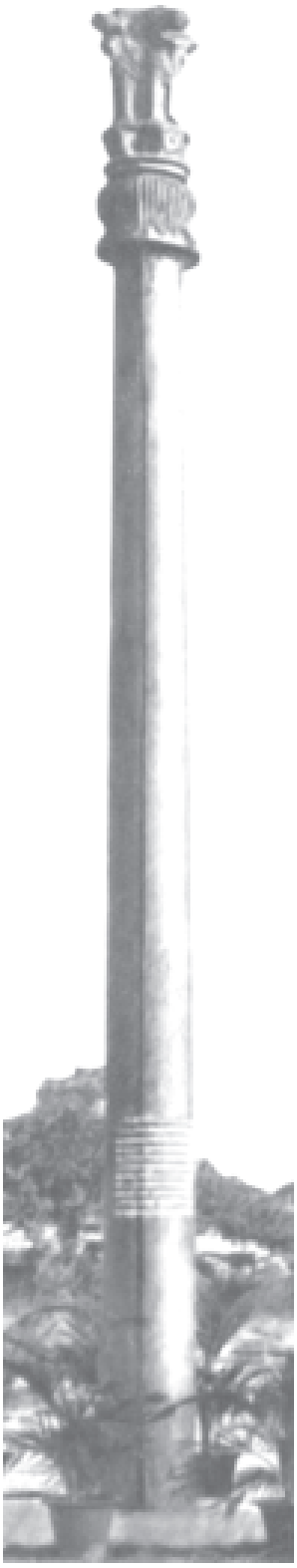
As regards scientific research, 72 research papers were prepared out of which 39 were published in foreign and 33 in Indian Journals. During this period, 22 patent applications were filed and 8 copyrights registered. This is a substantial improvement when compared to the records of previous years.

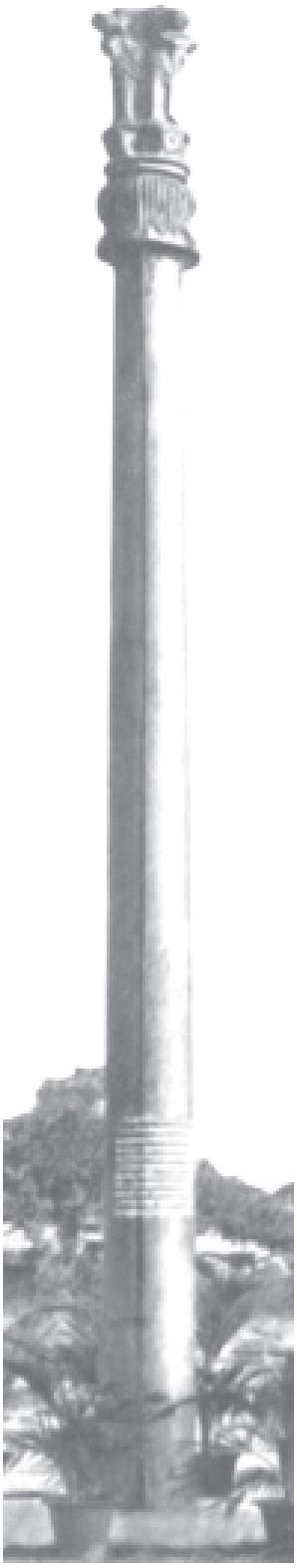
The procurement of 15 acres of land near NML's Agrico Housing Complex and construction of the boundary wall around it, have made good progress.

NML recruited 16 excellent scientists and 3 supporting staff. The average age of the scientists and also the ratio of scientific to non-scientific personnel improved when compared with the corresponding figures in the preceding years.

Jamshedpur
31.03.1991

Prof. S. Banerjee
DIRECTOR





1991 - 92

It is my pleasure to present the Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 1991-92.

As before, NML pursued relevance oriented R&D leading to development of know-how for gainful utilization of natural resources. It has addressed to the various industrial problems and suggested solutions utilizing the expertise generated through different in-house, sponsored, collaborative and interactive efforts. Mention may be made of a few beneficiaries/clients like, Tata Steel; Oil & Natural Gas Commission; Steel Authority of India Ltd.; Indian Petrochemicals Ltd.; Tinplate Company of India Ltd.; Bihar Sponge Iron; Bastar Ispat Udyog; Tamil Nadu Minerals; Andhra Pradesh Paper Mills; Dalmia Magnesite Corporation.

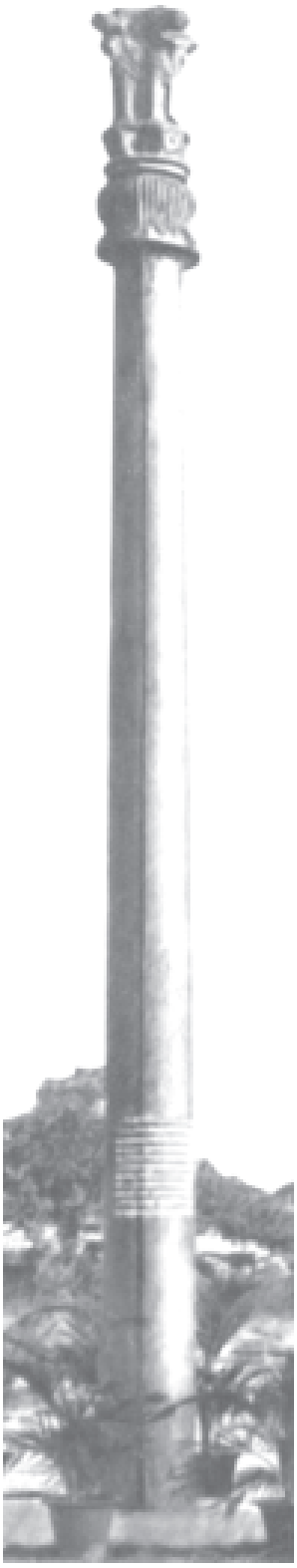
The performance with regards to NML thrust area prpjects is quite encouraging. Out of the four projects, one project entitled, 'Production of low sulphur & low phosphorus liquid iron through VRDR-SAF route was completed. Work on other three projects, i.e. (i) Processingg of polymetallic sea nodules for the recovery of valuable metals (ii) Beneficiation and purification of tungsten ores of India and (iii) Component Integtity and Evaluation Programme (CIEP) are progressing well. The process parameters for treatment of sea nodules at 1 kg. scale to recover copper, nickel (90%) and cobalt (>60%) were optimized. Further, efforts were on to scale up the process to a level of 100 kgs per day.Tungsten ores from Degana, Rajasthan were beneficiated to a grade of 66.8% WO_3 from 3.98% WO_3. The silica and sulphur contents were also reduced to the specifications of DMRL, Hyderabad. These externally funded projects are so planned and executed as to have a long term objective and significant economic impact on our national economy.

With the aim of evolving reliable methodologies for prediction and extension of residual life of critical engineering components and creation of data base on performance characteristics of materials/ components in industries, NML undertook various R&D activities during the reporting period under the aegis of CIEP. Two categories of projects i.e. generic and sponsor--specific are envisaged under the programme. The World Bank is expected to provide a substantial loan for this activity.

Under international collaborative programme, NML pursued two Indo-US projects, namely : (i) Advanced high strength ferrous alloys and (ii) Mechanical properties of advanced ceramics. Another project on computational studies on transport processes in gas stirred melts is progressing well in collaboration with Imperial College, London.

In the area of rural development, NML has developed a chromium-alloyed iron as an improved substitute for plough share. Field trials of NML's product revealed its superiority, both in terms of economy and life. The project was in continuation with the Agricultural Tool Development Programme undertaken by the laboratory in collaboration with Vikash Bharati for the marginal farmers in Chotanagpur tribal belt.

Under the NML-TATA interactive projects, the laboratory pursued a variety of projects, namely: Reduction of Al_2O_3 in iron ore fines from Joda Mines, Passivator for white rust on galvanised steels and



De-ashing of West Bokaro Coal. Similarly, work on other interactive projects like prevention of rolling sticker in pack rolling; Phase inhibitor for protection of TMBP coils from rusting (NML-TCIL); Indigenous technplogy development for low aluminium ferro silicon (NML-SAIL) is progressing well. NML's Passivator (3500 lit.) was evaluated at the Tube Division of TATA STEEL during September-October 1991. An increase in the resistance to white rusting of galvanised tubes was obtained which economised the process of passivation.

Seven sponsored investigation projects were completed and several others are in progress. Similarly, four consultancy projects were completed and the reports were submitted to the concerned parties. Sponsored research projects, concerning the development of silicon carbide whiskers; CTOD and fracture property evaluation of TISCO-TISTEN steel, and column flotation for improving the quality of copper concentrate for the Malanjkhand Copper Project of Hindustan Copper Ltd., are nearing completion.

NML interacted with its potential users and received an external funding of Rs 149.10 lakhs during 1991-92. The laboratory utilized a major portion of this external fund for the procurement of its modern facilities and equipments, Furrher, 25% of NML's R&D efforts were organised for the pursuit of excellence oriented research in the form of in-house exploratory projects. A pilot plant trial for the production of > 25% Ca grade CaSi was conducted successfully in 500 KVA Submerged Arc Furnace at NML during April-May 1991. During the period, twenty nine such projects were completed and twenty one were in progress.

During the period 1991-92, NML Jamshedpur developed twelve processes, namely : 'Production of Sodium aluminate, Sintered magnetite anode, Iron electroforming, Stainless steel powder, Alumina based wear resistant ceramic product, High temperature metal/alloy melting container, Super concentrated blue dust; Reduction of, Ash from non-coking coals, Alkalies in lime stone; Inverse flotation for the Beneficiation of barytes, Iron ore concentrates for its purification; and Column flotation for Improvements in the quality of copper concentrate for copper plants.

Four processes were demonstrated to four different entrepreneurs. Another four processes namely: Production of 1) Stainless Steel powder, 2) Higher temperature metal/alloy melting container, 3) Welding electrode and 4) Recovery of clay and byproduct values from classifier sand and cyclone under flow rejects of washing, were released to four different parties. One party went into commercial production for the first time and manufactured products worth of Rs 210 lakhs. The estimated economic benefits produced by NML, amounted to: Savings produced - Rs 20. crores per annum; Losses avoided - Rs 90 crores per annum; Value addition of the industrial production based on NML's know-how- Rs 671 crores per annum.

NMLJamshedpur organized an international seminar on 'Refractories' in association with Indian Ceramic Society, Jamshedpur Chapter. During 27-29 February 1992. The laboratory also organized an Indo-US pacific workshop on 'Advances in low carbon high strength ferrous alloys (LCFA-92) in New Delhi during 25-28 March 1992. It also imparted training to the students of Regional Institute of Technology, Jamshedpur and Institute of Technology, Sultanpur (U.P.).

During 1991-92, a total number of 66 research papers were published, out of which 36 were in foreign and 30 were in Indian Journals. Moreover, a number of research findings were presented by the laboratory scientists at different seminars, symposia, workshops etc. organized at the national/ international level. 13 patent applications were also filed during the period.

I sincerely hope that NML will continue to maintain the growth in its Research and Development activities and achieve better performance levels in the years to come.

DIRECTOR

1992 - 93

I am happy to present the Annual Report of the National Metallurgical Laboratory for the year 1992-93.

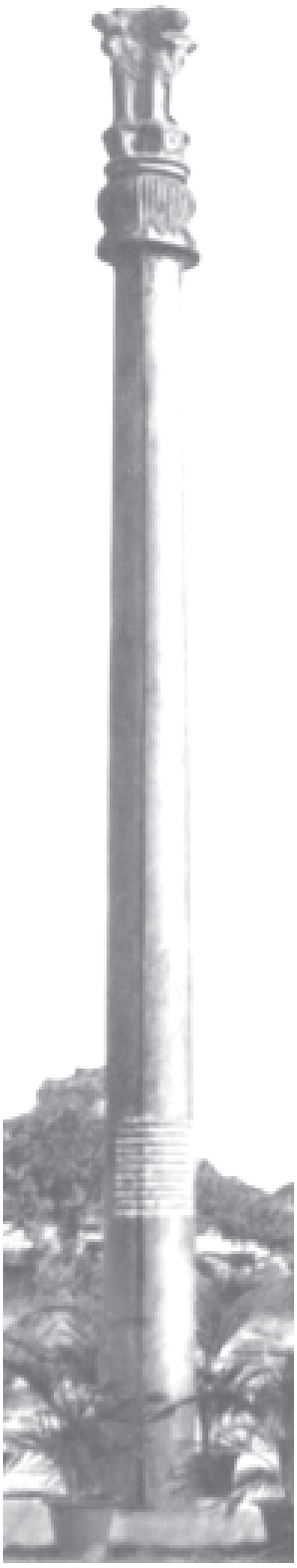
With the present change in the economic policy and greater emphasis on generating extra budgetory resources , efforts have been intensified towards the market oriented R&D as well as technology transfer and information dissemination . Promotional strategies have been adopted with a focus on our facilities and capabilities.

During this period, NML made considerable progress with regards to its three Thrust Area Projects, namely : (1) Processing of polymetallic sea nodules for the recovery of valuable metals, (2) Beneficiation and purification of tungsten ores of India, and (3) Component Integrity Evaluation Programme (CIEP). All these projects are of national importance.

Under the sea nodule project, three campaigns with 100 kg/day were conducted and the recoveries of copper, nickel and cobalt were quite encouraging. Beneficiation of tungsten ores from granite rocks of Degana, Rajasthan is nearing completion. With the NML's process, it is possible to exploit the huge resources of wolframite bearing granite rock ($\sim$ 0.1% WO_3). The progress of the activities under the Component Integrity Evaluation Programme is periodically reviewed by the Programme Management Board. A software for Creep life prediction of engineering components was released to the sponsors. A portion of World Bank's loan of Rs. 350 lakhs for purchase of sophisticated equipments to build up infrastructural facilities for the programme was received during the period. News items highlighting NML's effort under Component Integrity Evaluation Programme have already appeared in the media.

NML persued fourteen interactive projects in collaboration with the user organisations like Tata Steel, Tinplate Company of India Ltd., Indian Oil Corporation Ltd., Steel Authority of India Ltd., out of which ten projects were completed. Under NML-TCIL interactive programme, NML developed a process on vapour phase inhibitor which can be used for protection of ferrous -materials. A passivator for galvanised steel to prevent white rust was also developed in collaboration with Tata Steel.

During the period 1992-93, nineteen sponsored research projects have been carried out and eight of them completed. Mention may be made of few beneficiaries like SAIL, Tata Steel, Tata Robins-FraserLtd., Hindustan Copper Ltd.- Malanjkhand, BPCL, IOC, BARC, NMDC - Hyderabad, U.P.Steels Muzaffarnagar, Govt. of India Mint, Trimax Agency Pvt.Ltd. Madras, Simplex Engg. & Foundry Works - Bhilai, Star Wire (India) Ltd.- Ballabgarh. Similarly, consultancy projects were completed for seven parties i.e. OIL Duliajan; Trimax Agencies Pvt.Ltd., Madras; Durgapur Steel Plant, Durgapur; Kudremukh Iron Ore Co. Ltd., Electrowelds Pvt.Ltd.; Dhanbad Chemicals and Saha Minerals, Sahebganj. Another eleven consultancy projects were in progress. A portion of NML's R & D efforts were also utilized for the pursuit of in-house exploratory research and during this period twenty one such projects were completed. Work on twenty three other projects is at an advanced stage.



During theperiod1992 -93, NML Jamshedpur developed eight processes, namely : (1) Production of sintered alumina grains, (2) Vapour phase inhibitor for protection of ferrous items, (3) Insoluble anode based on magnetite, (4) Passivatorfor galvanised steel, (5) Dephosphorisation of highsilicon hotmetal using lime based fluxes adopting injection techniques, (6) Flow-sheet for treatment of chromite ore, (7) Beneficiation of red oxide sample and (8) Improvements in the quality of zinc and lead rougher concentrates.

During this reporting period, four processes for (1) Zinc oxide from zinc ash & hydroxide, (2) Stainless steel powder, (3) Ferro-vanadium from alumina sludge, and (4) Sintered alumina grains were released to four different parties.

One party went into commercial production for the first time. The economic benefits produced by NML, as estimated, amounted to : Savings produced - Rs 20 crores per annum; Losses avoided - Rs 90 crores per annum; besides considerable value addition to the industrial production through NML's know-how.

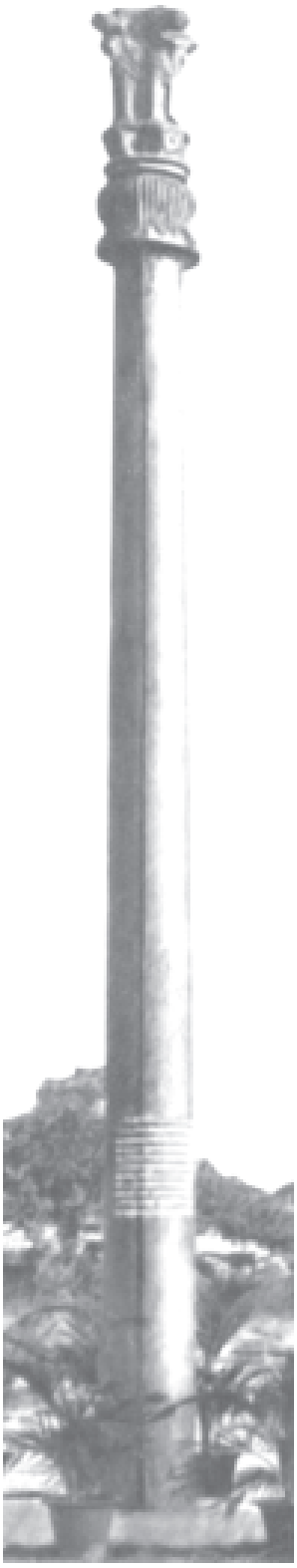
NML's efforts in mobilisation of extra budgetory resources from the users yielded Rs 188.98 lakhs during 1992-93 and a major portion of the fund is utilized for procurement of modern equipments and facilities for the laboratory.

During 1992-93, NML organised two seminars. and one workshop. The national seminar on Research & Process Development in Mineral preparation was held in collaboration with Indian Institute of Mineral Engineers during 14-15 April, 1992. A seminar on Corrosion & Protection was held during 23-24, December 1992 and conducted in Hindi only. The workshop in "Non-Destructive Evaluation of Materials" was organised in collaboration with IIM, Jamshedpur Chapter, during 21-22 January, 1993. The laboratory also celebrated the CSIR's Foundation Day and Hindi Divas in the Laboratory.

During 1992-93, a total number of 88 research papers were published out of which 60 were in foreign and 28 in Indian Journals . More than 92 research papers were presented by the laboratory scientists in different seminars, symposia , workshop etc. at national and international level. CSIR Young Scientist Award 1992 in engineering sciences was received by Dr. S. Chattopadhyay, scientist of the laboratory on account of his outstanding work on electroslag making process.

I sincerely hope that NML will continue to maintain the impressive growth in its Research & Development activities and achieve better performance levels in the years to come.

Prof. P. Ramachandra Rao
DIRECTOR



1993 - 94

I am happy to present the Annual Report of the National Metallurgical Laboratory for the year 1993-94.

With the change in the economic scenario , conscious efforts have been made to reorient the laboratory to face the challenges of liberalisation and globalization. In the previous years, 3/4th of the extra budgetory resources of the laboratory used to accrue from 2-3 large projects. This has resulted in the laboratory being cut off from larger sector of the medium and small scale industries. In order to bring these into the fold and widen the clientele of the laboratory, several attempts were made including active dialogue with Confederation of Indian Industries (Bihar Chapter) and Bihar Industries Association . Several Industrialists from these organizations have visited the laboratory and were apprised of its capabilities. A large number of informative, colourful and area specific brochures stressing NML's facilities and expertise, were brought out and widely distributed at various technical get-togethers, exhibitions, workshops and so on . As a result of these efforts, the contributions from medium and small scale industries to our external cash flow have gone up considerably.

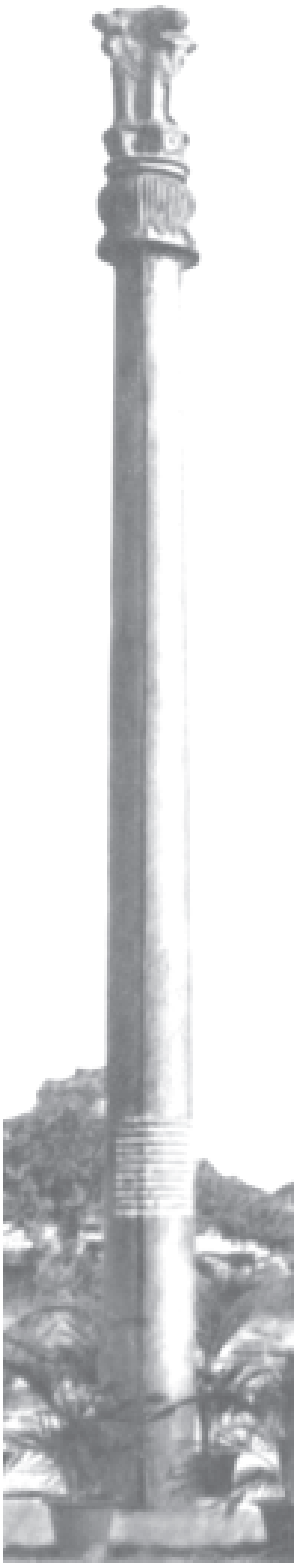
In order to freeze the contact with the industry and to build confidence in them, we have introduced the concept of retainership and also signed four MoUs with the user industries. Under the retainership programme, a company pays an annual fee against which technical service is provided to solve their day-to-day problems. This is in addition to the already strong linkages existing between the Tata Iron & Steel CoLtd. and NML. Strong efforts have also been made to project the capabilities of the laboratory at various exhibitions and marketing get togethers.

One activity requiring particular attention has been the dissemination of latest technical information to the industry through the conduct of workshops. Two of such workshops have been conducted during this period. These have proved to be highly successful and have led to manymore requests coming from the industries. These close interactions with industry on one to one basis have also sharpened the outlook of our scientists and made them aware of the needs of the industry.

During this period, NML made considerable progress with regards to its three Thrust Area Projects, namely : (1) Processing of polymetallic sea nodules for the recovery of valuable metals, (2) Beneficiation and purification of tungsten ores of India, and (3) Component Integrity Evaluation Programme (CIEP). All these projects are of national importance.

The project on beneficiation of tungsten ores from Rajasthan to enhance WO_3 content from 02 - 0.03% to 70%, is successfully completed. This has led to the development of a flow-sheet, which combines both physical and chemical beneficiation routes.

Under the sea nodules project, large scale (100 kg/day), trials are being conducted to scale up operations for the recovery of copper, nickel and cobalt from the bench scale trials of Phase-I. So far this programme received funding to the tune of Rs 4.00 crores from the Department of Ocean



Development. Results obtained to-date are encouraging and the group is persuing the programme energitically.

Under the CIEP programme, 14 generic and 5 sponsored specific projects have been under progress, generating the necessary background and methodology for the prediction of remaining life and failure in industrial components. A large data-base has been created and several userfriendly software have been developed for the use of the sponsors. It is a good example of close interaction between NML and industry with a total financial support of about Rs 2.5 crores from the TISCO, SAIL, IOC, BPCL, DAE and an additional soft loan of aboutRs 3.5 crores from the World Bank.

In the area of MineralProcessing, besides routine assignments undertaken follow a synergic approach towards conservation of mineral resources of the country. The activities include : Evaluation and on site advice on mineral resources, waste utilization, pollution abatement, feasibility reports, trouble shooting and upgradation of working plants, assistance in plant design and commissioning. Societal benefits that are financially intangible include : Conservation of Mineral Wealth, Indian alternative resource for a strategic metal like tungsten, utilization of high ash coals, averting pollutants through utilization of fines of various ores.

In the areas of Material Processing, Characterization and Evaluation, besides routine activities, many national and international assignments were completed. The results of these projects are at various stages of commercial evaluation and scale up. To quote a major few : Sticker problem in hot rolling; Superplasticity in ultra high carbon steels; Indo-US programme on ultra-low carbon high strength steels for off shore application; mechanical properties of Advanced Ceramics; improvements in mechanical and magnetic properties in commercial HSLA steels; high purity iron powder (electrolytic) and components there from; SiC whiskers.

Four different grades of creep resistant steels produced in the country underwent extensive creep evaluation. As a result the production of these steels have been indigenised and also existing creep data base got further extended. Life extension studies on several critical components at Renusagar Power Plant and also that of FCCU-1 Reactor of HPCL were carried out. Know-howfor NML's Ni free steels for exhaust valve application was transferred to Mls. Star Wire (India) Ltd., New Delhi and a few commercial heats produced and rolled into desired shapes. The exhaust valves operates at a temperature of $700^{O}C$.

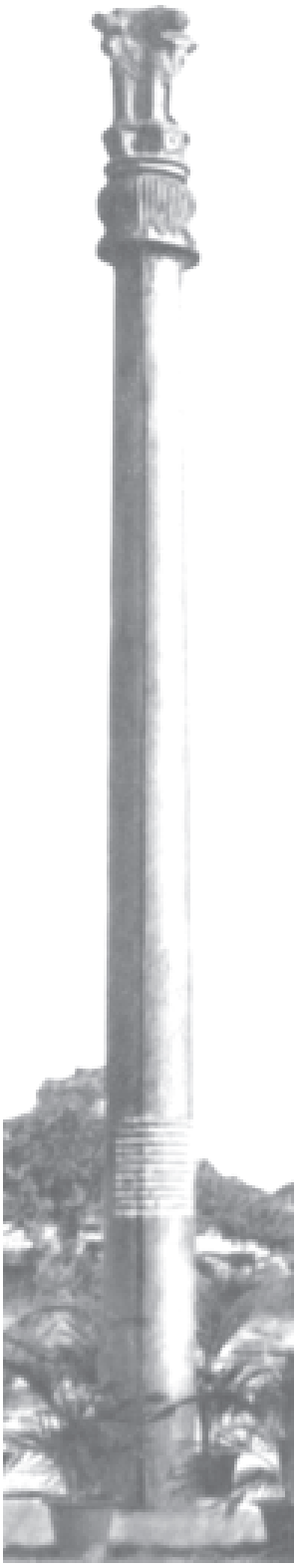
Significant achievements in the area of Ferrous Processing include knowhow/technology for production of 75%ferro-silicon by using barely 10% charcoal and rest non-coking coal and coke; production of industrial floor and decorative tiles utilizing steel plant wastes; increasing oxidation resistance of carbon/graphite by high temperature heat treatment; development of torpedo ladle car mixes and industrial utilization of CIL coke from Dankuni Coal Complex of Coal India Ltd.

In the area of Non-Ferrous Processing, besides the DOD project on sea nodules, many other sponsored and collaborative projects were under pursuit. Mention may be made of a few : Electrolytic manganese dioxide from manganese ore for Mls MOIL, Nagpur; Smelting studies on nickel chromium cobalt bearing magnetite from Nagaland; Recovery of gold and silver from the dross and technology for nickel production from over-burden.

In the area of Corrosion Protection, several collaborative and sponsored projects were carried out. Technologies developed relate to cathodic protection of pipe lines, corrosion of metals under marine environment, improved flux for galvanizing plants, quality improvement of tin plated sheets. Further, work in the areas such as corrosion fatigue, stress corrosion cracking and hydrogen embrittlement are under progress.

The technologies ready for exploitation by the end of March, 1994 are: (1) Electrolytic iron powder from sponge iron fines, (2) Production of ceramic tiles & decorative blocks from iron ore slimes, fly ash etc., (3) Chemical $Mn0_2$ and activated MnO_2, (4) Galvasave, and (5) Ceramic crucibles for C & S determination in metals.

During 1993-94 four processes i.e. (1) Production of copper powder, (2) Production of Ni free valve, (3) Fly ash based wear resistant ceramic products, and (4) Calorising of steel, were released to four different parties.



NML's efforts in mobilization of extra budgetory resources (EBR) from the users yielded Rs 189.21 lakhs during 1993-94 and a major portion of the fund is utilized for procurement of modern equipments and facilities for the laboratory. Public Sector including Government departments contributed 80% of the EBR while the Private Sectors' share was 20%. The essential strength of a laboratory is the quality of its personnel. Several attempts have been made to augment these resources and attract young talent.

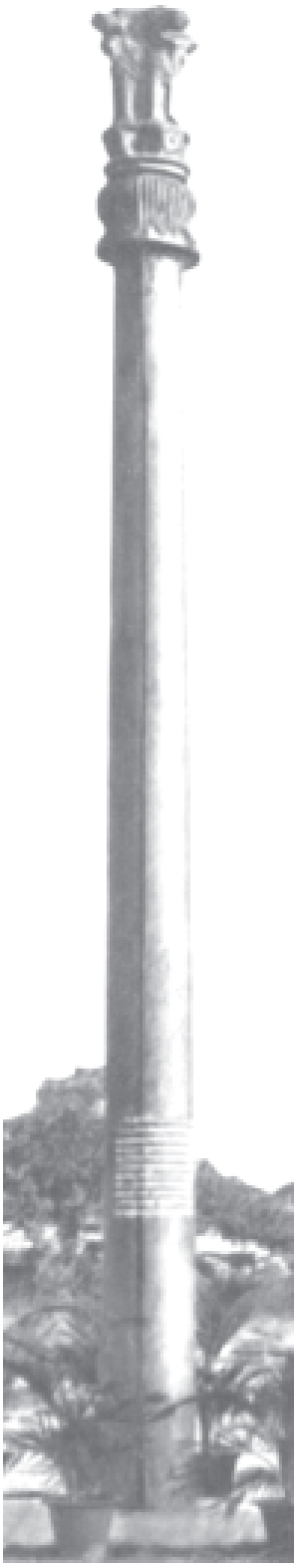
Towards this end, steps have been taken to establish a Hostel facility in the existing Magnesium Plant site and completed the recruitment of number of QHFs and RAs as also fill up some of the vacancies. In this connection, it should be noted that Jamshedpur's special problem of being a private industrial town with little rental accommodation is a major hurdle in attracting talent. Creation of further facilities in terms of Scientist Apartments is very essential. Work to this effect is underway.

NML celebrated its Foundation Day on 26th November, 1993 for the first time ever since its inception in 1950. The laboratory organized an open -day for the local school and college students. To mark the occasion, laboratory instituted two prestigious awards : (1) Professor VA Altekar Award for the Best Technology and (2) Dr.B .R.Nijhawan Award for the Best Technical Paper. The Laboratory also celebrated CSIR's Foundation Day and Hindi Divas.

During the year 1993-94, a total number of 85 research papers were published, out of which 42 were in foreign and 43 in Indian Journals. 8 patent applications were filed. More than 80 research papers were presented by the laboratory scientists in different seminars, symposia, workshops etc. at national and international level.

I sincerely hope that NML will continue to maintain the impressive growth in its Researach & Development activities and achieve better performance levels in the years to come.

Prof. P. Ramachandra Rao
DIRECTOR



1994 - 95

It is my proud privilege to present this Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 1994-95.

With the changed environment heralded by the policy of economic liberalisation, coupled with a decline in support from Government NML had to revise its strategy and aim at earning a considerable part of its annual revenue from its users during this period. This has resulted in increase in the external cash flow of our laboratory by 62% over that of last year. Further, a committee was constituted to suggest organisational changes, if any, to match the changes in environment i.e. technology, market and policies. The committee has been assigned the task of : (i) defining the change as perceived by the staff, (ii) designing the methodology for bringing about the change, and (iii) improving the effectiveness of any individual in the system.

In the past, India was predominantly a seller 's market. As a result , any incremental improvements through R & D were never considered as critical inputs by the industry. With the announcement of the new industrial policy by the Government, however, the industry began to look towards the R&D laboratories to provide critical input so as to remain competitive through improved quality, affordable price and new value-added products. This has paved the way for fruitful interaction with the industry . NML has been providing qualitative science-based technical services not only to improve the product quality by improving the mechanical , physical and chemical properties and striking the correct composition/formulation of new materialsl alloys but also to implement cost reduction by improving yield , productivity, reducing energy and material consumption, extending life of equipment/machining and reducing rejection. All these were possible with the re-organisation and launching of an effective marketing drive. Promotional strategies have been adopted with a focus on our facilities and expertise generated.

During this year, NML has once again entered into the Global Market. A tripartite MoU was signed with M/s Gujarat State Fertiliser Corporation (GSFC) and M/s Rajasthan State Minerals & Metals Ltd. (RMML), who are planning to set up a fertiliser plant in Uganda. RMML was assigned the task of exploitation of the 200 million tonnes phosphate deposits of that country. NML conducted investigations relating to (i) characterisation of deposits, (ii) evaluation of the earlier flow-sheets proposed by foreign firms, and (iii) suitability of the simplified flow-sheet. Results obtained sofar at NML were encouraging. Pilotplant studies are in the offing.

NML took the lead role in collaborating an Indo-US project entitled, "Fundamental Investigations in Advanced Ferrous Alloys" with Academia - Industry joint effort on Indian side, and Naval Research Laboratory on the US side. Besides NML, Tata Steel, Indian Institute of Technology-Kharagpur, Indian Institute of Technology-Madras, Banaras Hindu University, University of Roorkee, RDCIS-Steel Authority of India Ltd, Bengal Engineering College, and Regional Engineering College-Rourkela, are the partners in this project which promises to evaluate a new generation of steels for marine applications. Some

material for investigation has already arrived from the US. The total value of the project is Rs 155.00 lakhs.

Under international collaboration programme, a project with Brunel University, London has been approvedby the European Commission for the recovery of nickel, copper and cobalt from complex Indian oxide minerals. NML is also poised for collaboration with Tata Steel and Sheffield University, U.K., in the area of Thermo-mechanical treatment of steels. Two of our scientists visited the USA and China for long term interaction in the areas of "Non-Destructive evaluation of materials & Processing of transformer materials" and "Foaming behaviour of different slag system during iron and steel making processes" respectively.

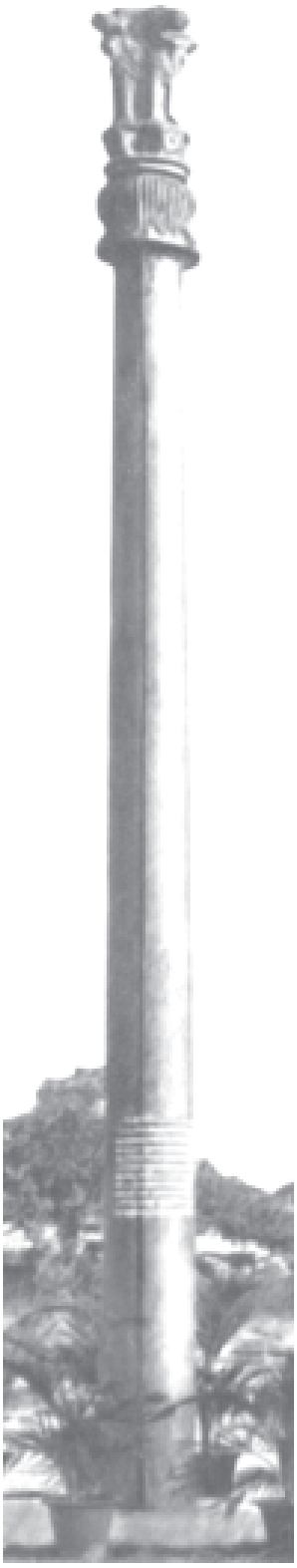
During this period, NML made considerable progress with regards to its two Thrust Area Projects, namely : 'Processing of Polymetallic Sea Nodules for recovery of valuable metals" and "Component Integrity Evaluation Programme (CIEP). Both these projects are of national importance. Under the sea-nodule project, based the bench scale data (1 kg. batch), the process was scaled up to a level of 100 kg. nodules per day. Under the CIEP Programme, 14 generic projects in five different areas have been completed. These were taken up to evolve and standardise reliable methods for integrity assessment and life extension of critical engineering components of aging plants and equipments subjected to high temperature, corrosive environment and cyclic loading. A number of user friendly computer softwares have been developed. Enhanced capability and the expertise developed was also utilized in the life extension work for Neyvelli Lignite and Ministry of Defence in the analysis of the failure of MIG aircraft components.

Several sponsored projects have been taken up during this period. M/s. South Eastern Coalfield, Bilaspur has assigned work on "Hydrostatic testing of water pipe lines". A project on "Modelling of high temperature deformation of single crystal turbine blade material" was funded by Aeronautical Research and Development Board. Encouraged by our exploratory results, M/s Kudremukh Iron Ore Company Ltd., has assigned NML a project to produce iron ore super concentrate suitable for ferrites, a value added product. Tata Steel sponsored three projects, namely : (i) Cathodic protection of pipes at Dam Pump house, (ii) Development of an inhibitor for recirculating cooling water system, and (iii) Optimisation of ferro-chrome production at Bamnipal, Sukinda. The results obtained so far in these projects were encouraging. Indian Foundry Association sponsored the work on "Air pollution control system for foundries of Calcutta". Similarly a project on "Development of laminated brass to required specications" was sponsored by the Indian Ordinance Factory, Kanpur.

Mathura Oil Refinery sponsored failure investigation works on light vacuum gas oil heat exchanger tubes. DMRL, Hyderabad assigned a project on "Production of high nitrogen bearing austenitic steels" for the purpose of developing appropriate ESR technology. Development work on HSLA steel was undertaken for Naval Chemical and Metallurgical Laboratory, Bombay. The results obtained so far in these projects were highly encouraging. At the instance of Indian Space Research Organisation, Trivandrum, work on preparation of nickel based super alloys was under progress. Recognising our earlier efforts in brass and bell metal casting for tiny sector, particularly to rural artisans of Bankura, West Bengal, CSIR has assigned NML a project for training and demonstration activities to develop value added operation.

During 1994 -95, four processes , i.e. (i) NML Galvasave, (ii) Galvaflux, (iii) Long-life Radiator-Fluid, and (iv) 21-4 N Steel were released to four different parties. Three processes went into commercial production .These are : (i) NML Galvasave (2 MT/ month), (ii) Galvaflux (2 MT/month), and (iii) Stainless Steel Powder (100 kg/day). Recently a tripartite agreement among NML, TISCO and M/s Global Markets, Jamshedpur was signed for commercialising the technology of "Ceramic tiles" developed at NML from iron ore slimes, BF slag, fly ash and other similar waste materials. The project has been progressing well.

Technologies ready for exploitation by the end of March, 1995 are : (i) cold phosphate coating, (ii) production of aluminium fly ash composites, (iii) extra fine nonferrous powder by atomization, (iv) vapour phase inhibitor for protection of ferrous items, (v) insoluble anode based on magnetite, (vi)flow-sheet for the treatment of chromite ore, (vii) beneficiation of red oxide sample, (ix) Improvements in the quality of zinc and lead rougher concentrates, (x) dephosphorisation of high silicon hot metal



using lime based fluxes adopting injection techniques. Further, there are several technologies at various developmental stages.

NML's efforts in mobilization of Extra Budgetary Sources (EBR) from the users yielded Rs 308.00 lakhs during 1994-95 and a major portion of the fund is utilised for procurement of modern equipments and facilities for the laboratory. Public Sector including Government departments contributed 75% of the EBR while thePrivate Sectors' share was 25% (an increase by 5% over that of last year).

Strong efforts have also been made to project the laboratory's facilities and expertise at different scientific fora. Workshops/seminars/get-together organised at NML, served as an effective tool for disseminating technical information to the users. Six programmes were conducted during the year 1994 -95. These are : (i) Heat treatment and surface engineering of iron and steels, (ii) Utilization of industrial waste (in Hindi), (iii) Tailoring of properties through mechanical processing - A practical approach, (iv) Alternative charge materials for electric arc and induction furnaces, (v) Workshop for small scale foundries - As a part of skill-cum-technology upgradation programme, and (vi) Calcium carbide operations: Present and future.

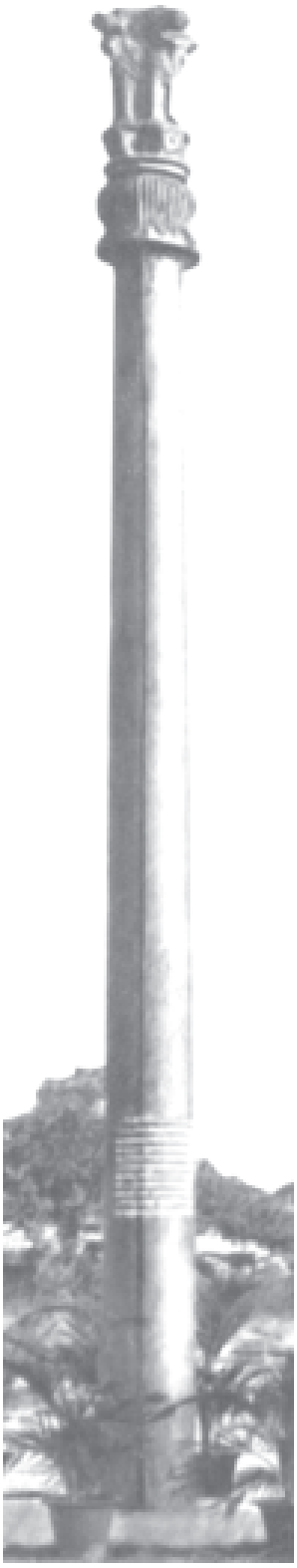
In the changed economic scenario it becomes even more important to project the combined strengths of laboratories in the CSIR system. Keeping this in view, NML took the lead and brought out a colourful booklet entitled "Mineral Processing Facilities & Expertises in CSIR". It is hoped that all the seven participating laboratories will work as one entity while dealing with the industry.

I am happy that during 1994-95, NML scientists bagged different prestigious awards like, Distinguished Aluminus Award, Distinguished Materials Scientist Award, National Metallurgist Day Award, Nucor Group Award and Madras University Award. NML celebrated its Foundation Day on 26th November, 1994. To mark the occasion, it also organised an open-day for the local school and college students. Three Awards : (i) Nijhawan Award for best paper, (ii) Altekar Award for best technology, and (iii) a certificate of Appreciation for Distinguished Service rendered to the laboratory, were given away on this occasion. The laboratory also celebrated CSIR Foundation Day and Hindi Divas.

During the year 1994-95 a total number of 100 research papers were published, of which 40 were in foreign and 60 in Indian Journals. 7 patent applications were filed. More than 135 research papers were presented by the laboratory scientists in different seminars, symposia, workshops etc. at national and international level.

I am thankful to the members of the Research Council for their fruitful contributions and co-operation in the pursuit of R & D undertaken by the laboratory. I sincerely hope that NML will continue to maintain the impressive growth in R & D activities and contribute more to the cause of the industry.

Prof. P. Ramachandra Rao
DIRECTOR



1995 - 96

It gives me great pleasure to present the Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 1995-96.

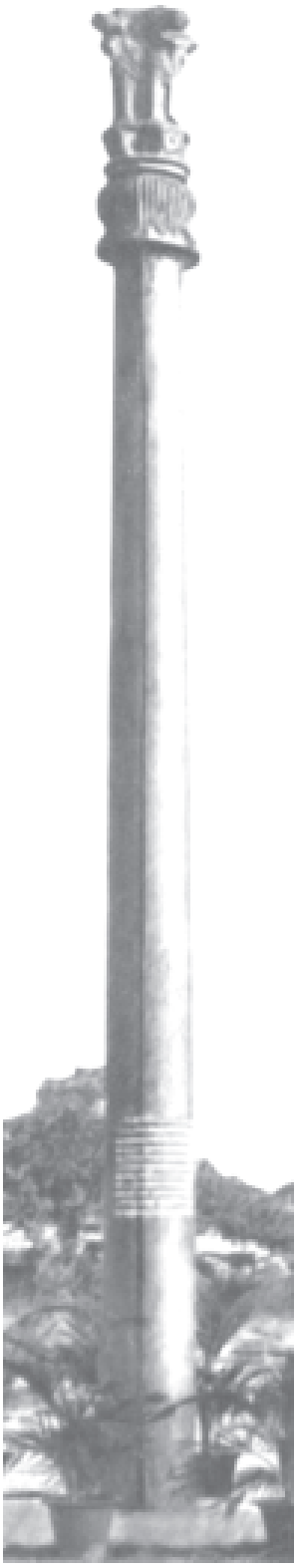
The current competitive economic scenario coupled with a decline in governmental financial support has stimulated the entire CSIR family to face the challenges squarely. Our concerns ranged from perceptions of change amongst our scientific community to formulation of goal oriented research and development plans.

A committee was constituted to suggest organisational and related changes if any, to match the changes in environment i.e., technology, market and policies. The findings of the committee reveal that a majority at NML feels proud of being here and ready to accept the challenges ahead. However, a sizeable respondents also feel the dominance of procedures over performance, and an inadequate deployment of manpower in view of the continuous superannuation of staff every month. These issues are being addressed vigorously.

Spurred on by the dynamism and exhortations of our Director-General, Dr. R. A. Mashelkar, we at NML, have expended a great deal of effort in a critical self evaluation and set forth the 'Goals' for the Ninth Five Year Plan. The highlights are as follows :

1. To move towards the path of self-financing by generating Rs. 2500 lakhs from external sources, as against Rs. 1100 lakhs in the Eighth Five Year Plan, mostly from industrial customers. Closed to 50% of the laboratory expenditure to the met with external funding as against 24% in the last five years.
2. To develop at least one exclusive and globally competitive technology in niche areas.
3. To develop and transfer 60 technologies and ensure that about 25% of them go into commercial production.
4. To hold 60 patents (one tenth of them as foreign patents) and publish 600 papers.
5. To earn 5% of operational expenditures from royalties/premia and 15% through foreign collaborations/assignments.
6. To organise 2 International and 20 National seminars/workshops.
7. To produce 25-30 specialists of National/International repute in several subareas of interest to the Laboratory including business promotion, intellectual property rights and general administration.

During the period under review, the Laboratory undertook an exercise on formulation of its long and short term research plan. It is a matter of considerable pride that the entire scientific staff of our



laboratory had spiritedly participated in this exercises. The entire research and development activities of the laboratory fall into four identified areas (i) Industrial Processes which include Mineral Beneficiation, Extraction of Metals, Development of Refractories and Process Fundamentals and Modelling, (ii) Engineered Materials which include Synthesis and Development of Materials, Materials Forming Processes and Microstructure of Materials, (iii) Resource and Environment Conservation which includes Waste Utilization, Secondary Metals/Recycling, Corrosion and Protection, Components Integrity Evaluation and Pollution Control and (iv) Advanced Centres which include Accreditation of Testing/ Calibration Facilities, Analytical Testing, Mechanical Testing, Non-Destructive Evaluation, Corrosion Testing Centres and an Electronic Data Base for Materials.

As on today, our business plan involves directing 80% of the efforts in the projects/problems/jobs assigned by industry on sponsorshop basis and delivering results within a mutually agreed time frame. Remaining 20% efforts are being directed towards projects based an ideas generated and registered in our long term R&D plan of the Laboratory and producing results that will enthuse a sponsor to finance scale-up studies.

During the year 1995-96, NML undertook three international collaborative projects, namely (i) Beneficiation and Zinc extraction studies for M/s. Nepal Metal Company Ltd., Kathmandu under Indo-Nepal venture, (ii) Recovery of nickel, copper and cobalt from complex Indian oxide mineral deposits in collaboration university of Leeds and sponsored by Commission of European Communities. Brussels and (iii) Fundamental investigation on advanced ferrous alloys - an Indo-US venture. Results obtained in all these three projects are satisfactory.

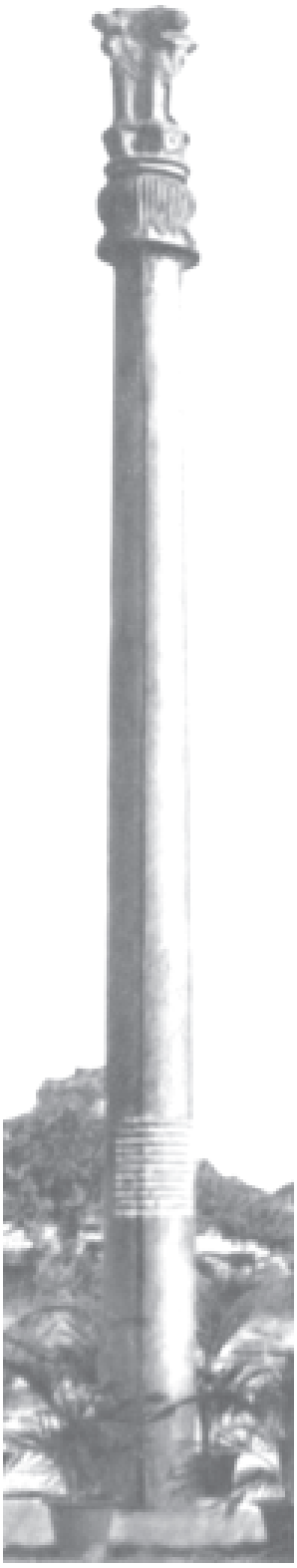
NML made considerable progress with regard to its two Thrust Area Projects namely, (i) Component Integrity Evaluation Programme (CIEP) and (ii) Processing of polymetallic sea nodules for recovery of valuable metals. Under CIEP NML has developed facilities and expertise of international standard in the area of remaining life prediction and failure analysis. The first phase of CIEP, which was initiated in April 1993 under the financial support from SAIL, IOC, BPCL, AEC, Tata Steel and soft loan from World Bank was successfully completed in 1995.

Encouraged by the success of the first phase of the programme, a plan was drawn up for the second phase. Under this plan services are to be provided to each sponsor in their required specific areas. In addition, a limited number of generic projects will be taken up. The main emphasis will be on the development of non-destructive means of evluating accumulated damage and microstructural/property changes in service exposed materials.

Under the DOD funded sea nodule project, NML has developed the indigenous technology for the exploitation of sea nodules and completed 10 campaigns on 100 kg/day scale and generated data for further scale up. Our future target is to (i) select a proecess route for scale up studies on 500 kg/day (ii) conduct 5 campaigns of 40 days each to treat about 20 tonnes nodules in each campaigns and (iii) establish the process parameters and viability.

Several sponsored projects have been taken up during this period M/s. Larsen & Tubro Ltd. has assigned work on improvement in the grade and recovery of graphite at their TAMIN Graphite Plant, Shivganga. A project on 'Demonstration of column flotation technique for improvement of their existing beneficiation process' was sponsored by GMDC and DSIR and it has been carried out at NML Unit, Madras. Encouraged by our exploratory results. M/s. Tamilnadu Mineral Ltd., Madras has signed MoU with NML for preparation of a detailed project report for setting up of a modern sand processing plant. Similarly, several more MoUs were also signed. To name a few Assistance in setting up of a Testing and Evaluation (Analytical & Mechanical) laboratory with M/s. National Testing & Research Laboratory, Calcutta. Life assessment of ageing power plant components with M/s. RPG-PR Power Engineering Pvt. Ltd., Calcutta; Improving strand productivity of Visakhapatnam plant with Hindustan Zinc Ltd.; Making Ferro-titanium with M/s. Easier Engg. & Foundry Ltd., Jamshedpur; Nickel free SS and special alloys with DMRL and VSSC.

Recognising our earlier efforts. M/s. Kundremukh Iron Ore Company Ltd. has sponsored two projects, namely : (i) Ceramic floor/wall tiles from iron ore slimes and (ii) Synthesis of Mn-Zn and Ni-Zn ferrites using beneficiated iron ore fines of KIOCL. All these projects are nearly completed and significant results have been achived.



During 1995-96, two processes i.e., (i) HCL inhibitor and (ii) Corrorion and scale inhibitor (CORISCA-95) were released to two parties. One process i.e., Radiator Coolant (PRIXOL) went into Commercial production and launched into the market. Several novel technologies are now ready for release. These cover the areas of metal powders, pollution control, waste utilisation and software for industrial applications.

NML's efforts in mobilization of Extra Budgetory Resources (EBR) from users yielded Rs. 210.74 lakhs during 1995-96 and a major portion of the fund is utilized for creating more facilities and enhancing capabilities for the laboratory. A sum of Rs. 30.00 lakhs was also spent from our Laboratory reserve fund to meet our capital investment.

Workshops/Seminars/Get-togethers organised at NML, served as an effective tool for disseminating technical information to the users. Six programmes were conducted during the year 1995-96. These were related to different areas, namely : (i) Boiler Corrosion, (ii) Modern Methods of Chemical Analysis, (iii) Environmental & Waste Management in Metallurgical Industries, (iv) Transport Phenomenon in Metallurgical Processes, (v) Bijlikii Bachhat in Hindi and (6) Workshop for small scale foundries - as a part of skill-cum-technology upgradation programme.

I am happy that during 1995-96, NML scientists bagged different prestigious awards like Distinguished Aluminus Award, CSIR Young Scientist Award and the binani Gold Metal of IIM. The Laboratory celebrated CSIR Foundation Day and Hindi Divas with enthusiasm and usual fanfare.

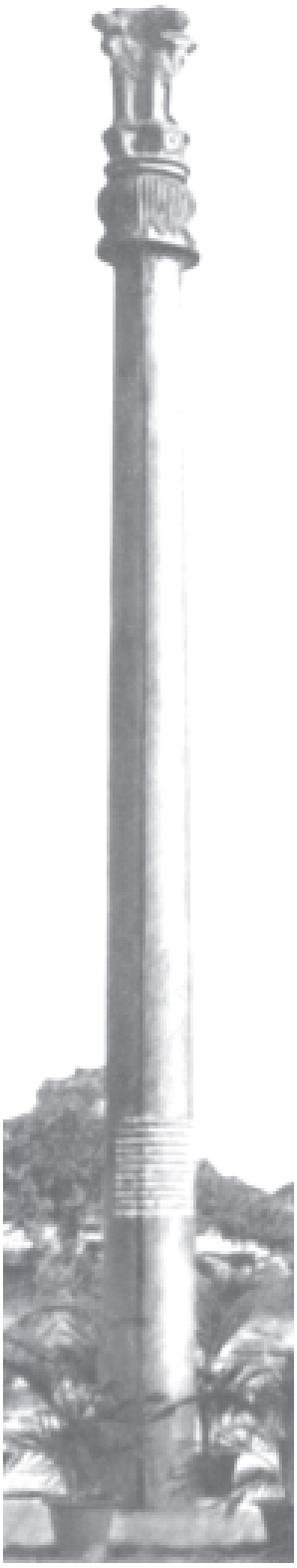
During the year 1995-96, a total number of 110 research papers were published, of which 37 were in foreign and 73 in Indian Journals. Four patent applications were filed and five more were communicated to the CSIR patent office, New Delhi. More than 120 research papers were presented by the laboratory scientists in different seminars, symposia, workshops etc. at national and international level.

I am thankful to the Chairman and Members of the Research Council for their fruitful contributions and immense co-operation in the pursuit of R&D undertaken by the laboratory. The council has been a source of strength and encouragement.

I sincerely hope that NML will continue to maintain the impressive growth in R&D activities and contribute even more to the growth of the industry.

Prof. P. Ramachandra Rao
DIRECTOR

Jamshedpur
31.03.1996



1996 - 97

The year 1996-97 has been a year of great excitement and satisfaction.

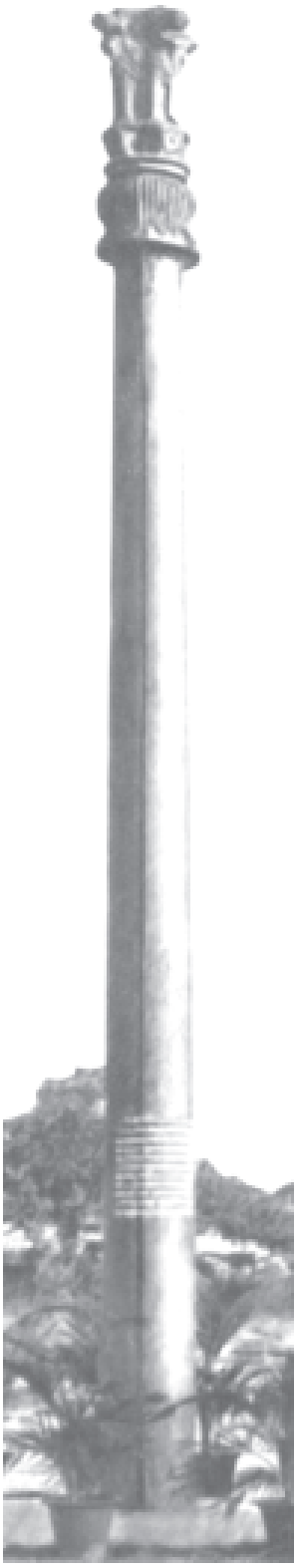
With the present change in the economic policy and greater emphasis on generating extra budgetary resources, we had intensified our efforts to provide market oriented R&D knowledge-base support to Indian industries. The industry responded favourably and has begun to look towards us for critical inputs to remain competitive through improved quality, affordable price and value-added products.

We have traditionally been providing qualitative science-based technical services involving characterisation of materials with respect to their mechanical, physical and chemical properties. Increasingly, we have been stepping up our efforts in developing newer materials, reducing cost of production, improving yield and productivity, conserving energy and environment. All these activities were made possible with a suitable reorganisation of our methods of functioning, introduction of participative management and effective marketing.

Promotional strategies have been adopted with a focus on our facilities and expertise generated. I am delighted to record here that during 1996-97, six workshops and three national level seminars were oraganised at the laboratory. More than 500 delegates drawn from over 150 private/public sector industries, research/ academic institutes and representing various levels of management participated in these seminars/workshops. Their appreciation and continued interaction is of immense value to us. Further, the publications of these proceedings in a marketable "book form", has not only enriched our total activities but has also earned appreciation and drawn the attention of our target groups. This will definitely contribute towards our business development in near future.

CSIR in general and the National Metallurgical Laboratory (NML) in particular have been striving to reach out to the customer needs. It is a continuous effort to exploit our strengths, capability and expertise and translate them into commercially use the products, processes and services. In this process, adoption and formalisation of a Quality Management System, is of primary importance as a check on the consistency of our outputs and also to win the confidence of our customers. ISO-9000 is a Quality Management System, which won world wide acceptance. We have decided to get accredited to this universally acceptable standard. The task is formidable, but not impossible. Efforts are underway to formalise and document existing procedures and to train people in this quality management system It is expected that the activity would be completed by March 1998.

NML has made considerable progress with respect to its international collaborative projects, namely, (i) Recovery of Nickel, Copper and Cobalt from complex Indian oxide mineral deposits in collaboration with University of Leeds sponsored by Commission of European Communities, Brussel and (ii) Fundamental investigation on advanced ferrous alloys - an Indo-US venture. The Laboratory continued with two of its thurst area projects viz., (i) Component integrity evaluation programme and (ii) Processing of polymetallic sea nodules for recovery of valuable metals. Results obtained in these two projects were encouraging.



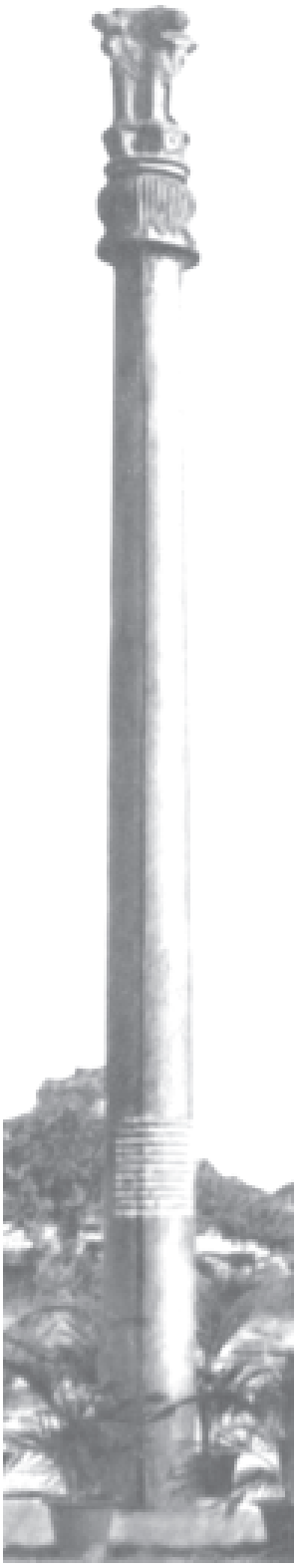
There are about 6000 foundries currently operating, mostly as clusters, at Ahmedabad. Agra, Batala, Coimbatore and Howrah and most of these are coke based. Coke-based foundries are plagued by pollution control problems. Normal stack emission from foundries ranges from 400 to 3000 mg/m^3 of suspended particulate material (SPM). As per the directive of the Honourable Supreme Court of India, pollution has to be within the acceptable limits fixed by the Central Pollution Control Board (CPCB) which specifies that the SPM level in the Cupola emissions must not be more than 150 mg / m^3. As a result of this stringent specifcation most of the foundries are facing uncertainties of existence. Many have already shut down. Considering the enormity of the problem from technical, economical and social angles, NML carried out considerable Research and Development work during this reporting period and developed a less capital intensive and dry gas cleaning system of various modules/sizes in order to meet the requirement of Cupolas that ranges from 2 t/ hr to 25 t/hr capacities. This technology has been successfully transferred, on a turnkey basis, to save the closure of some units. Based on the design developed at NML, a few foundries of Howrah, West Bengal constructed Gas cleaning facilities in their Cupolas and obtained results within the specifications of CPCB. The first NML-CPCB demonstration pollution control unit was set up in M/s Crawley & Ray, Howrah. The second demonstration unit with NML technology was set up in M/ s. Shree Uma Foundry Pvt. Ltd., Liluah (Howrah) in April 1996. The work was funded by the Indian Foundry Association, Calcutta. In July 1996, NML's technology was utilised by Indian Iron & Steel Co. (IISCO), Kulti - a subsidiary of SAIL. It's Central Growth Works (CGW) at Kulti has the distinction of having 12 Cupolas which are the oldest and the biggest in India. The foundries at CGW were threatened by closure in case the suspended particulate matters were not brought down below 150 mg / m^3 from the then existing level of $\sim$ 2000 mg / m^3 before January 1997. They requested NML to design and install Gas Cleaning System (GCP) in 3 sets of their Cupolas on a turnkey basis. It is for the first time that NML undertook a turnkey job worth of Rs. 144 lakhs and completed the same within six months from concept to commissioning. This has enabled the CGW-Kulti Works (SAIL), to meet the deadline set by the Hon'ble Supreme Court of India. The systems erected by NML are functioning efficiently and have met the CPCB's norms effectively.

An alternate strategy for mitigating environmental problems of the foundry industry is to substitute coke that is employed by the industry for operating the cupolas. Coke can be substituted by natural gas or low sulphur diesel oil. A proposal to this effect was made to TIFAC, DST, New Delhi and it received substantial financial support. A team of enthusiastic colleagues have not only designed a coke-free cupola but also fabricated many subsidiary systems such as the grate, refractory balls, charging systems, safety devices, etc. An existing 225mm ID cupola was successfully converted within a very short time of six months to run on diesel or gas. The success of these trials have greatly encouraged the team and steps have already been taken to transfer the technology in association with M/s. TATA-KORF, to those who are in urgent need of the same.

Several other sponsored projects have been taken up during this period. To mention a few - NMDC Hyderabad has assigned work on fabrication, procurement and supply of 3" dia lab. column flotation system to NML's Madras centre. A project on development of wear resistant ceramics from fly ash was sponsored by NALCO, Bhubaneshwar to NML. M/s. ACC Chaibasa sponsored work on beneficiation of low grade lime stone. ARDB has sponsored work on development of low cost bamboo composites as structural material. Tata Steel sponsored projects like corrosion characteristics of steel bar, reduction in pollution and acid consumption in pickling shop of their Tube Division. NTPC sponsored projects involving *in-situ* metallography at selected points of boiler and turbine assembly, metallurgical assessment of service exposed pendent superheater tube and so on.

M/s. Kudremukh Iron Ore Co. Ltd. (KIOCL) is generating a huge amount of iron ore tailings. NML has developed a technology to produce floor and wall tiles from these iron ore tailings. 100 numbers of market size tiles in glazed and unglazed forms were produced and suplied to M/ s. KIOCL for market evaluation. NML has also provided the necessary techno-economic data to the party for setting up commercial plant.

During 1996-97, five processes i.e. (i) Electrolytic iron powder, (ii) Extra fine Aluminium powder, (iii) Recovery of copper from waste solution and (iv) Production of copper powder and (v) Gas cleaning



system for foundries were released to seven parties. Two processes, namely, (i) Prixol -Radiator Coolant and (ii) Gas Cleaning Systems for foundries has been commercialised successfully.

NML's effort in mobilization of Extra Budgetory Resources (EBR) from users yielded Rs. 315.96 lakhs during 1996-97 and a major portion of the fund is utilized for creating more facilities and enhancing capabilities of the laboratory. A sum of Rs. 56.3 lakhs was also spent from laboratory's reserve fund to meet the capital investment.

I am happy that during 1996-97, NML scientists bagged many prestigious awards like INSA Prize for Materials Science, Mascot National Award, Indranil Award and ARDB Award for excellence in R&D.

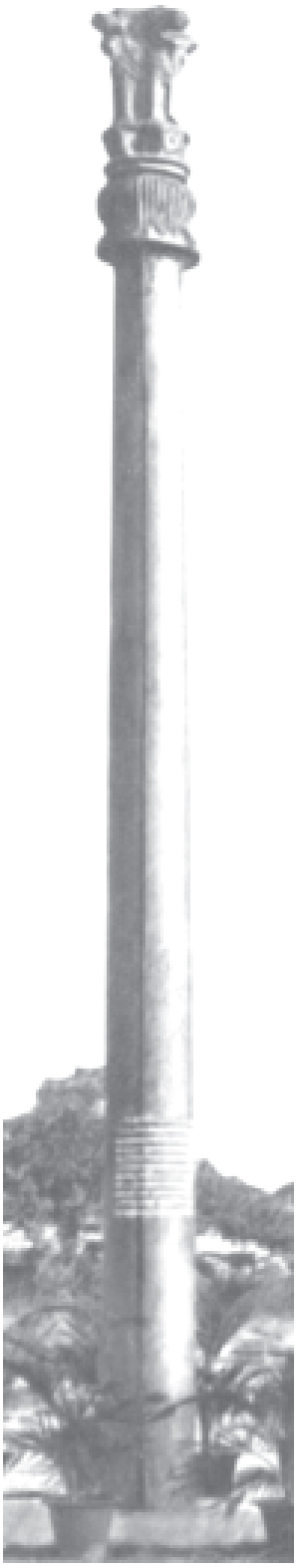
As is the practice, the Laboratory celebrated CSIR Foundation Day and Hindi Diwas with enthusiasm and fanfare.

During the year 1996-97 a total number of 131 research papers were published, of which 41 were in Foreign and 90 in Indian Journals. 13 patent applications were filed. More than 150 research papers were presented by the laboratory scientists in different seminars / symposia/ workshops etc. at national and international level.

I am thankful to the Chairman and Members of the Research Council for their fruitful contributions and immense co-operation in the pursuit of R&D undertaken by the laboratory. The Council has been a source of strength and encouragement.

I congratulate all my colleagues for their excellent team work, dedication, discipline and sincerely hope that NML will continue to maintain the impressive growth in activities and contribute even more to the well-being of the industry.

Prof. P. Ramachandra Rao
DIRECTOR



1997 - 98

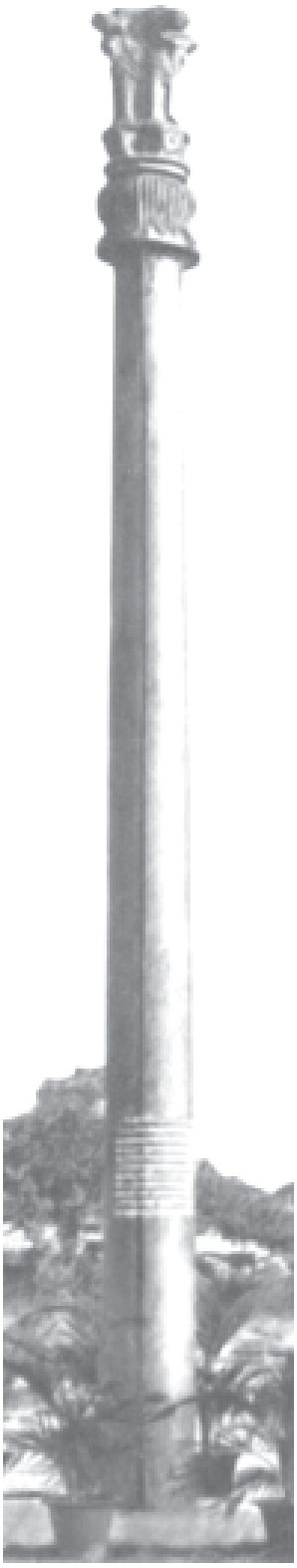
It is once again my pleasure and privilege to present the Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 1997-98. The year has been one of great excitement and immense satisfaction.

Our Director General, Dr. R. A. Mashelkar visited the Laboratory on March 7, 1998. During this memorable visit he inaugurated NML's Business Development Centre, which has been created to facilitate close professional interaction with our customers. He expressed his satisfaction over the pace at which the Laboratory is marching towards commercialisation of its R&D products and services.

Efforts are on in whole CSIR in general and NML in particular to reach out the customer and satisfy his needs. In this process, adoption and formalisation of a Quality Management System, is of primary importance, not only as a check on the consistency of our outputs but also in winning the confidence of the customers. ISO-9001 is a Quality Management System which has received world wide recognition. Realising that adoption of such a system is the need of the hour, NML has put in motion several activities towards qualifying for ISO 9001 certification. The quality policy and objective statements of NML were released on August 14th, 1997 followed by adoption of rigorous and continuous activities like keeping the work space and surroundings clean, tidy and well organised, disposing off old and obsolete equipments, weeding out old records etc. The demanding tasks of evolving quality systems; drafting quality manuals, plans and procedures; training in quality audit and initiating corrective actions / modifications have been taken up in great earnest. The tasks are formidable but eminently achievable. We hope to pass the final audit soon and receive the certificate before the end of the year.

With reference to R&D programmes, NML has made considerable progress in its international collaborative projects, namely, (i) Recovery of Nickel, Copper and Cobalt from complex Indian oxide mineral deposits in collaboration with University of Leeds sponsored by Commission of European Communities, Brussel, (ii) Fundamental investigation on advanced ferrous alloys - an Indo-US venture, (iii) Thermo-mechanical characterisation an modelling of ceramic coatings in power plant application - an Indo-German collaboration and (iv) Development of process for concentration of Ganesh Himal lead-zinc ore from Nepal with MECON. Ranchi / Nepal Metal Company Ltd., Kathmandu. The Laboratory continued to work on two of its thurst area projects viz., (i) Component integrity evaluation programme and (ii) Processing of polymetallic sea nodules for recovery of valuable metals. Results obtained in these two projects were encouraging.

As the metallurgical community is well aware, the foundry industry at Agra has been passing through a crisis following the Honourable Supreme Court's directive on minimising environmental pollution. NML was commissioned by TIFAC, Department of Science and Technology, New Delhi to undertake the development of a gas fired cupola. NML has taken up the task in great earnest and conducted nearly fifty trials on the pilot scale of one ton per hour in a cupola which was modified to work on low



sulphur diesel oil as also on liquid petroleum gas. The success achieved has prompted us, during 1997-98, to enter into a tripartite agreement with M/s. Tata Korf and the Agra Iron Foundries Association. Following the agreement the technology developed at NML has been transferred to M/s. Tata Korf and a demonstration unit of two tons per hour capacity has been erected in a foundry identified by the Agra Iron Foundries Association. The cupola was first fired on May 11 th 1998 and trials are in progress for standardising industry operational parameters. We are keenly looking forward to this technology taking root not only in Agra but also in several other foundry clusters in various parts of the country.

Several other sponsored projects have been taken up during the year. Notable amongst these are - (i) Evaluation of recommendation of corrosion resistance mechanical properties and chemistry of CRS bars for Sardar Sarovar Narmada Nigam Ltd., (ii) Beneficiation of iron ore fines for M/s. Jindal Strips Ltd., (iii) Studies on Sintering of iron ores for M/s. Bellary Steels & Alloys Ltd., (iv) Bench scale studies on characterisation, beneficiation and extraction of vanadium and titanium for Department of Mines & Geology. Ranchi, (v) Recoveries of values from barite sludge samples for M/s. Kores India Ltd., Mumbai. (vi) Beneficiation of Iron Ore Samples from Orissa for M/s. Hamersley iron, Australia (vii) Implant test studies on ultra high strength steels for DMRL, Hyderabad, (viii) Improvement of corrosion resistance of Tempcore Rebars for M/s. Visakhapatnam Steel Plant, (ix) Development of suitable solvent for the cleaning of Power plant components / pipelines having multi metal system for NTPC, Noida and (x) Evaluation CRS rebars for Tata Steel.

Similarly, several Grant-in-Aid projects were also undertaken. Department of Science & Technology has extended aid to several projects like - Mechanisation of blacksmith's hammer & development of improved fuel efficient furnace for artisanal blacksmiths; Development of an appropriate technology for traditional brass & belt metal artisan; Textural development of AISI-316 Austenitic stainless steel during cold rolling and annealing; Metal status of the soil, water & vegetables of Patamda; Synthesis of nano-sized metal powder by a chemical route; Self propagating high temperature synthesis of Zirconium di-boride. Ministry of Mines, Govt. of India has extended support to a project on Extraction of magnesium through Magnetherm process, valued at Rupees 229 lakhs.

Several consultancy, collaborative/interactive projects, technical services were undertaken during 1997-98. Most of them were completed and some are in progress.

During 1997-98, four processes i.e. (i) Ceramic tiles from ferro chrome and other industrial waste (ii) Eco-friendly cupola, (iii) Wear resistant ceramic products using fly ash and (iv) High temperature ceramic material have been developed. Three prosesses i.e. (i) Production of Pig Iron from eco-friendly cokeless cupola, (ii) Modified Electroless Nickel Plating and (iii) Production of Electrolytic Iron powder from Sponge iron fines has been under commercialisation.

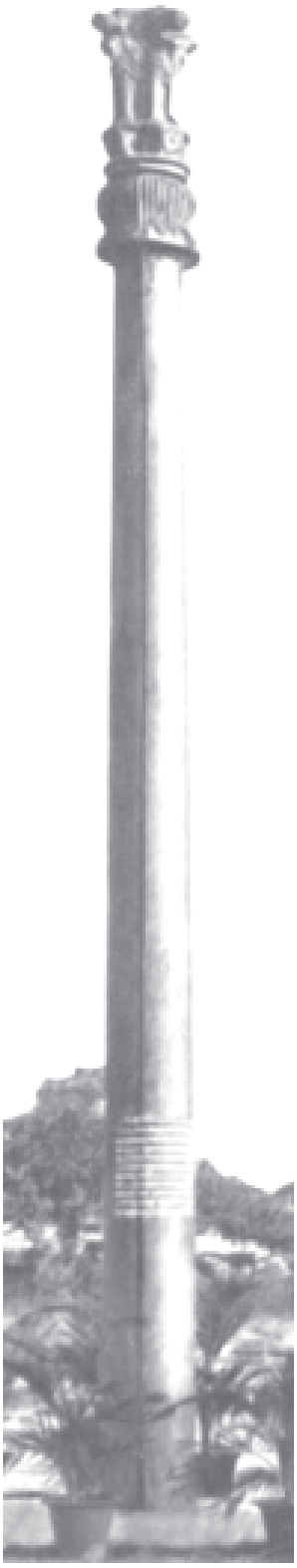
NML's effort in mobilization of Extra Budgetory Resources (EBR)from users yielded Rs. 364.40 lakhs during 1997-98 and a portion of the fund is utilized for creating more facilities and enhancing capabilities of the laboratory. A sum of Rs. 56.216 lakhs was also spent from laboratory's reserve fund to meet the capital investment.

NML has organised four Seminars/Workshops during 1997-98. More than 500 engineers/ scientist/ technical managerial staff were sponsored by the industries alone, to attend and interact with NML Scientists for mutal benefits. Similarly many research scholars and academicians representing organization like IISc, IIT, REC and other premier Engineering Institutes participated in these workshops/ seminars. The proceedings were also published by NML and available on sale.

As is the practice, the Laboratory celebrated CSIR Foundation Day and Hindi Diwas with enthusiasm and fanfare.

I am happy that during 1997-98, NML scientists bagged many prestigious awards like Refractory Technologist Award 1997, NACE International Corrosion Awareness Award 1997, CSIR Young Scientist Award 1997 and few others.

During the year 1997-98 a total number of 120 research papers were published. The impact factor of the publication has gone up significantly. 13 patents were granted and 11 patent applications were

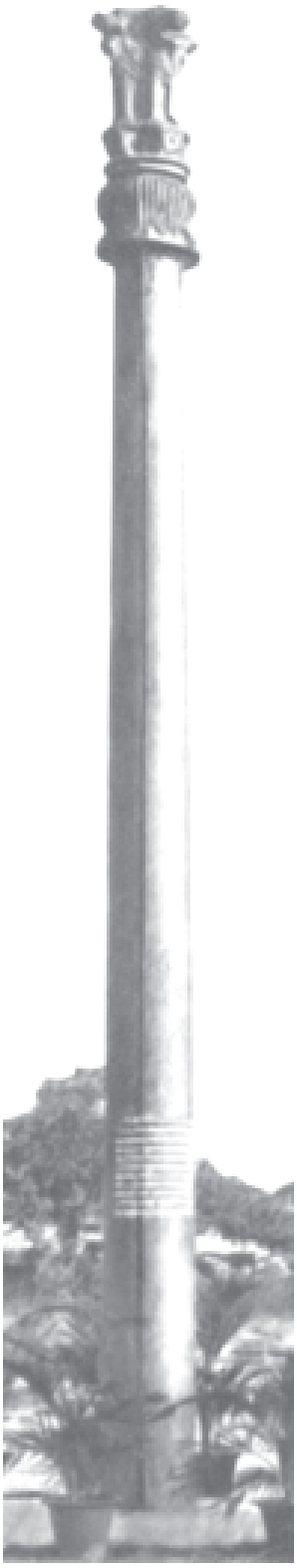


filed. More than 100 research papers were presented by our colleagues in different national and international seminars / symposia/ workshops.

I am thankful to the Chairman and Members of the Research Council for their fruitful contributions and immense co-operation in the pursuit of R&D undertaken by the laboratory. Our Director-General and Officers of the Council have been a source of strength and encouragement.

I sincerely hope that NML will continue to maintain the impressive growth in R&D activtttes and contribute even more to the growth of the industry.

Prof. P. Ramachandra Rao
DIRECTOR



1998 - 99

It is my proud privilege to present the Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 1998-99. The year has been one of great challenges and immense satisfaction.

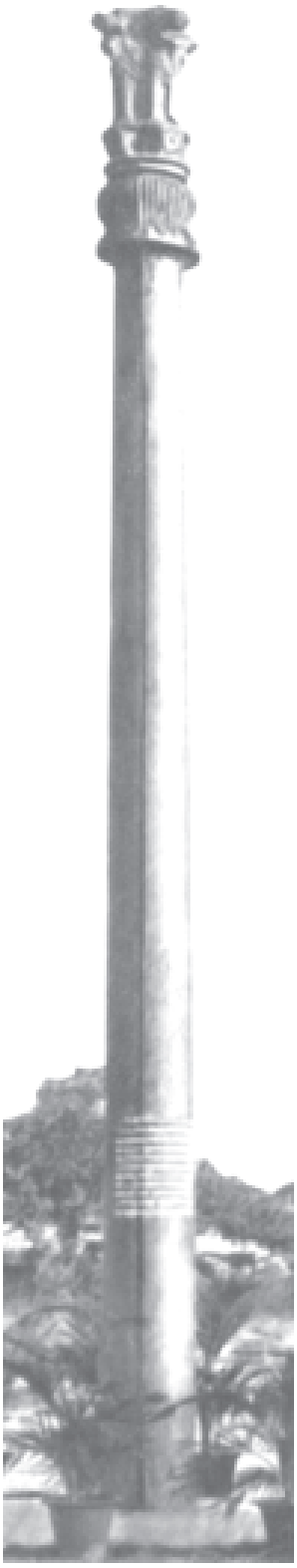
The post liberalisation period has seen significant changes in the industrial and R&D policies. Under the leadership of Dr. R. A. Mashelkar, FRS, our Director General efforts are underway to reach out to the customer and satisfy his needs. Our laboratory has also been in step. Under the Chairmanship of Dr. J. J. Irani, Managing Director, Tata Steel, Jamshedpur, the Research Council recommended that NML should pursue certification by an International Organisation for Standardisation (ISO) and meet the objeective of developing a basis for a comprehensive quality management system. Accordingly, NML focussed on ISO 9001 which contains specific requirements for quality system elements for design, research and development functions and signed a MoU with a German ISO certification body : "Rheinisch Westfalischer Technische uber Wachung Verein" (RWTuV).'

The strategy to reach the goal of ISO 9001 certification was to address four major areas - (i) Commitment of the staff, (ii) Documentation control, (iii) Design control and (iv) Calibration of instruments. In November 1998, the Third Party Auditor TUV CERT (INDIA) examined NML's quality management systems and the degree to which actual practices adhered to that system. They found no showstoppers. It resulted in a recommendation of ISO 9001 for NML, Jamshedpur and its associated field station at Madras. In February 1999, NML received a certificate as an organisation registered to ISO 9001 for goods and services, and described as follows : Research, Development, Consultancy, Technical Services and Testing in the area of Minerals, Metals, Materials, including Metallurgical Waste and Pollutants for NML's world-wide operation. I congratulate all my colleagues for this praise worthy team spirit and achievement.

With reference to R&D programmes, NML has made considerable progress. Many international collaborative projects, such as (i) Recovery of Nickel, Copper and Cobalt from complex Indian oxide mineral deposits in collaboration with University of leeds sponsored by Commission of European Communities, Brussel, (ii) Fundamental investigation on advanced ferrous alloys - an Indo-US venture, (iii) Recycling of red mud, refractories and flue dust in collaboration with Department of Materials, University of Leeds, UK and (iv) Development of process for concentration of Ganesh Himal lead-zinc ore from Nepal, Kathmandu have been pursued. During 1998-99, the Naval Research Laboratory, Boston, USA has sponsored fundamental investivations on deterioration of paints and coatings on HSLA 100 steel. These studies are progressing well.

The Laboratory continued to work on two of its thurst area projects viz., (i) Component integrity evaluation programme and (ii) Processing of polymetallic sea nodules for recovery of valuable metals. Results obtained in these two projects were encouraging.

The foundry industry at Agra has been passing through a crisis following the Honourable Supreme Court's directive on minimising environmental pollution. NML was commissioned by TIFAC, Department



of Science and Technology, New Delhi to undertake the development of a gas fired cupola. The success achieved, within an year, has prompted us to enter into an agreement with M/s. Tata Korf for transfer of technology. A demonstration unit of two tons per hour capacity has been erected by M/s. Tata Korf in a foundry identified by the Agra Iron Foundries Association. The cupola was first fired on May 11, 1998 and trials for standardising industry operational parameters have been completed successfully. We are now keenly looking forward to this technology taking root not only in Agra but also in several other foundry clusters in various parts of the country. Once again, I congratulate all my colleagues for this praise worthy team spirit and achievement.

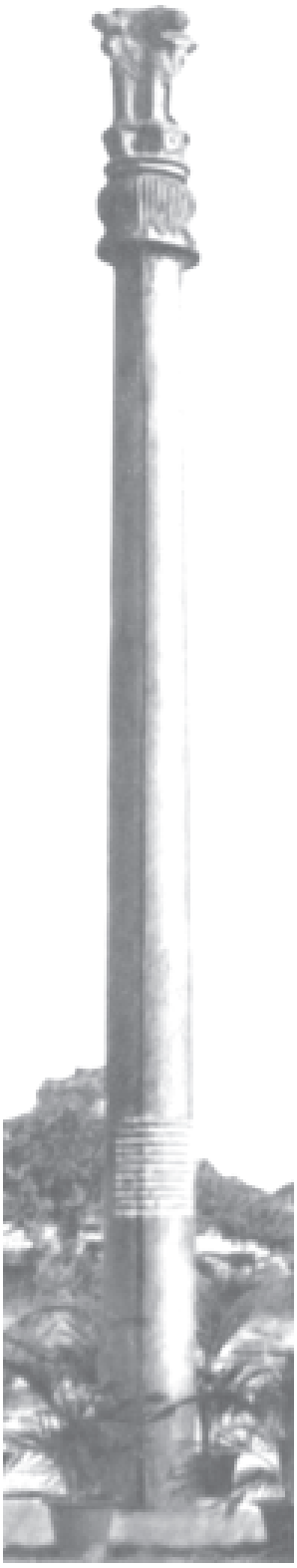
Several other sponsored projects have been taken up during the year. Notable amongst these are - (i) Characterisation, beneficiation and extraction of vanadium and titanium from Vanadiferrous and Titaniferrous ores for DGM, Ranchi; (ii) Investigation of the premature failure for Essar steel; (iii) Failure analysis of 6" dia inter gas header at LPG recovery plant for GAIL, Vijapur; (iv) Studies on sintering of Iron ores for Bellary steels; (v) Beneficiation of waste dumps for Trimex Agency, Madras; (vi) Production of super alloys for Vikram Sarabhai Space Centre; (vii) Improvement of metal powder quality for ACME Metal Powder Pvt. Ltd., Pondicherry; (viii) Improvement of corrosion resistance of tempcore rebars for Vishakhapatnam Steel Plant; (ix) Inhibitor for room temperature cleaning of boiler component for NTPC; (x) Evaluation of CSR rebars in simulated concrete environment for Tata Steel; (xi) Extraction of nickel from Sukinda overburden for TISCO; (xii) Development of rapid solidification technology for magnesium alloys for Vikram Sarabhai Space Centre (xiii) Improvement of surface finish of copper and copper based alloys for M/s. Alcobex Metal Ltd. Jodhpur; (xiv) Development of mixed metal atomised powder for Maruti Trader, Surat; (xv) Failure analysis of boiler tubes for Neyvelli Lignite Corporation Ltd.; (xvi) Residual stress analysis for TELCO; (xvii) Use of sponge iron in Electric arc furnace for Usha Martin Industries Ltd.; (xviii) Recovery of values from barite sludge sample-phase II for Kores India Ltd.; (xix) Melt spinning of Nd-Fe-B alloys for Thapar Corp., Patiala; (xx) Beneficiation fo low grade barytes of Cuddapah origin for Indian Barytes & Chemicals, Chennai.

Similarly, several Grant-in-aid projects were also undertaken. Ministry of Mines, Government of India has extended support to a major project on Extraction of magnesium from indigenous raw materials. Department of Science & Technology has extended aid to several projects like - (i) Micromagnetic study on ferromagnetic materials; (ii) Development of an ICP-AES technique for gold hall marking as an alternative to free assay technique; (iii) Synthesis and characterisation of AIN-SiC composites; (iv) Thermochemical modelling and simulation for energy optimisation and quality control in ferro-alloys products; (v) Mossbaeur studies of the precipitation process in steels; and (vi) Self propagation high temperature synthesis of Zirconium chloride and so on. Department of Steel and Mines, Research and Technology Mission, Delhi has extended support to the project on Development of Iron making processes used by tribals of India.

Several consultancy, collaborative/interactive projects, technical services were undertaken during 1998-99. Most of them were completed.

During 1998-99, ten processes, namely (i) EZPER - A process for production of zinc powder from zinc dross; (ii) Recycling of vanadium plant effluent; (iii) Production of low carbon ferro-chrome; (iv) An improved process for the simulataneous electrolytic production of zinc metal and manganese dioxide from zinc sulphide concentrate and manganese ore; (v) Production and protection of electrolytic copper powder from scrap; (vi) Iron silicon manganese alloy; (vii) Nickel magnesium alloy; (vii) High purity magnesium carbonate/magnetia from magnesite; (ix) Electrolytic iron powder from sponge iron fines; and (x) Reduction grade iron powder for paracetamol/bulk drugs of dye stuff industries have been developed.

Five processes, namely - (i) Production of pig iron from low shaft furnace, (ii) Extraction of zinc & electrolytic manganese dioxide from zinc sulphide (iii) Improvement in surface finish of copper based alloys; (iv) Electroless nickel plating, and (iv) Production of high purity electrolytic iron powder from sponge iron fine were transferred to entrepreneurs. Three processes, namely - (i) Ferro-vanadium from alumina sludge, (ii) Production of stainless steel powder and (iii) Paint grade stainless steel powder used for making paint have gone into commercial production. Our business efforts during 1998-99, have been fruitful.



Since we have embraced a Quality Management System, we are also committed to Total Quality Management. Accordingly besides the implementation of total quality concepts and techniques in developing globally competitive and eco-friendly technologies ensuring optimal utilisation of natural resources for the benefit of the society, we also have to accomplish our strategic objective to attain international recognition through outstanding research publications.

During the year 1998-99 a total number of 125 research papers were published. The impact factor of the publication has gone up significantly. 14 patents, 2 copy right were filed and 8 patent applications were sealed. More than 100 research papers were presented by our colleagues in different national and international seminars/symposia/workshops and business fora. In this connection, it is gratifying to note that one of our publications with a impact factor of 10.0 has topped CSIR's list of publications for 1998-99. There is an all round awareness of the need for quality publications in reputed journals. The laboratory has also kept its commitments to the Director-General CSIR in terms of external cash generation, patent filling, societal missions and business development. To augment a sense of belonging, pride in our acheivements and continued devotion to the laboratory NML adopted a song which reflects the activities and prospects of the organisation, on our last Foundation Day, 26th November, 1998.

NML's effort in mobilising Extra Budgetory Resources (EBR) from users yielded Rs. 365.20 lakhs during 1998-99 and a portion of the fund was utilized for creating more facilities and enhancing capabilities of the laboratory. A considerable sum of money was also spent from laboratory's reserve fund to meet the capital needs.

NML has organised six Seminars/Workshops during 1998-99. More than 550 engineers/scientists and technical managerial staffs were sponsored by the industries alone, to attend and interact with NML scientists for mutual benefit. Similarly many research scholars and academicians representing organisation like IISc, IIT, REC and other premier Institutes participated in these workshops/seminars. The proceedings were published and NML marketed these publications. We are regularly receiving orders from across the country and abroad. As is the practice, the Laboratory celebrated CSIR Founday Day and Hindi Diwas with great enthusiasm and fanfare.

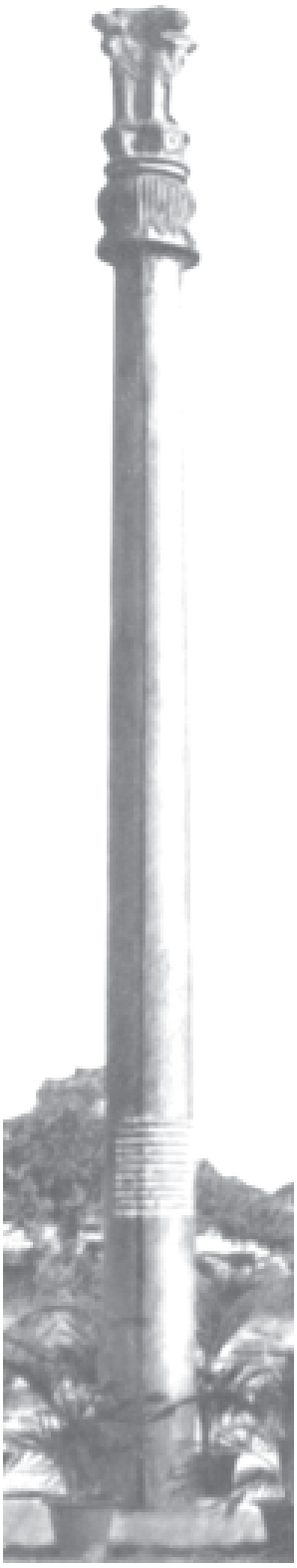
I am happy that during 1998-99, NML scientists bagged many prestigious awards like Distinguished Engineer Award, Shri Om Prakash Bhasin Foundation Award, Nayudamma Award, MRSI Distinguished Lectureship Award, Metallurgist of the Year Award, CSIR Young Scientist Award and few others.

In the area of human resource development, the laboratory has been endeavouring to counter the large scale superannuations with new recruitments. The superannuation in all categories stood at 56 during 1998-99. Recruitment of 16 scientsts and 30 others technical administrative cadre could be achieved during the same period.

I am thankful to the Chairman and Members of the Research Council for their fruitful contributions and immense co-operation in the pursuit of R&D undertaken by the laboratory. Our Director-General and Officers of the Council have been a source of strength and encouragement.

I sincerely hope that NML will continue to maintain the impressive growth in R&D activities and contribute even more to the growth of the industry.

Prof. P. Ramachandra Rao
DIRECTOR



1999 - 2000

It is my proud privilege to present the 50th Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 1999-2000 - A witness to the sunset of one millennium and the sunrise of another. A true, once in a millennium experience when we look back on the year 1999-2000. It gives us pride and satisfaction.

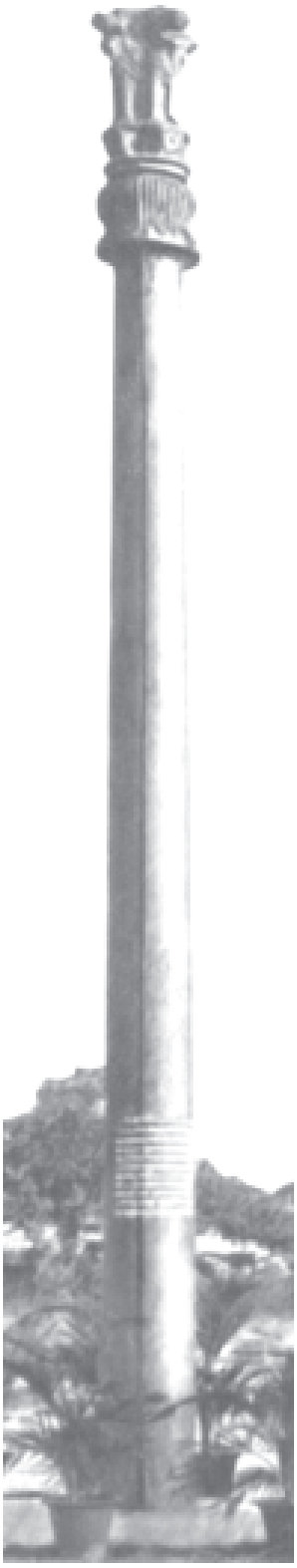
The Hon'ble Prime Minister's declaration on 3rd January 2000 at the Science Congress at Pune, to raise the spending on R&D from the present level of 0.86 to 1.0% of the GNP is a welcome sign for the scientists of the country. A liberalized India has opened up innumerable opportunities against stiff global competitions. Emphasis is being shifted from tangible products to intangible services. We are in the business of R&D services. We have celebrated a land mark event on 22nd April 1999 when our Director General, Dr. R. A. Mashelkar received ISO-9001 certificate on behalf of the Laboratory from Mr. S. N. Talukdar of TUV-CERT India Ltd., New Delhi. On this occasion Dr. Mashelkar has also unveiled a collage, which indicated our commitment to customer's delight.

ISO 9001 certification had helped us in gaining customers' confidence. We have been assigned a very prestigious project worth Rs. 157.2 million on "Maximizing blast furnace productivity with Indian iron ores", by the Department of Steel to execute in collaboration with RDCIS, SAIL and Tata Steel. The management of the project involved, besides high level scientific and technical inputs, effective and efficient linkages with industry and academia. Similarly, several more were also negotiated and many of them boosted our external cash flow to more than Rs. 10 million - an all time record achieved during 1999-2000.

With reference to R&D programmes, NML has made considerable progress. Many international collaborative projects, such as (i) Fundamental investigation on advanced ferrous alloys - An Indo-US venture, (ii) Recycling of red-mud, refractories and flue duest in collaboration with Department of Materials, University of Leeds, U.K., and (iii) ILTP Project on comparative Geology, Mineralogy, Geochemistry and origin of Apatite ores with Russian have been pursued.

The laboratory continued to work on the thrust area projects of Component Integrity Evaluation Programme (CIEP). The emphasis has been to solve industrial problems through failure analysis, remaining life assessments, non-destructive testing and stress analysis. During 1999-2000 several sponsored specific projects were completed and more than fifteen projects were ongoing. Some of the notable beneficiaries were - M/s. MECON Ltd., Surat; Tata Steel, TELCO, Usha Martin, Jamshedpur; Eastern Coal Field Ltd., Burdwan; ABB Ltd., Vadodara and Gontermann Peipers (I) Ltd., Calcutta.

The foundry Industry at Agra has been passing through a crisis following the Honorable Supreme Court's directive on minimizing environmental pollution. A technological and ecologically significant landmark was created during the period of the report when Tata Korf Engineering Ltd., - a Tata Group of Company aided by NML, put up an eco-friendly melting furnace on commercial trial in a foundry



near the Taj Mahal. We are now keenly looking forward to this technology taking root not only in Agra but also in several other foundry clusters across the country.

NML has undertaken a programme which is structured to improve the performance of existing SSI units by developing strengthening managerial skills and technical competence of the enterprises in collaboration with SIDBI. Likewise, the laboratory also has organized seven courses on Skill-cum-Technology up-gradation programmes (STUP) for Rural Artisans and Technicians during 1999-2000.

Several other sponsored projects have been taken up during the year. Notable among these are - (i) Establishing the relationship between accelerated CRI values and actual performance of reinforced CRS bars for TISCO; (ii) Beneficiation of low grade barytes of Cuddapah origin for M/s. Indian Barytes & Chemical Ltd., Chennai; (iii) Beneficiation of iron ore fines to produce ferric oxide and iron ferrite for M/s. Mineral Sales Pvt. Ltd.; (iv) Studies on the improvement of compressive strength and abrasion resistance of tiles for M/s. Ultra Tiles Pvt. Ltd.; (v) Development of mixed metal powder for diamond polishing wheel for M/s. Maruti Hightech Coating Pvt. Ltd.; (vi) Optimization of preheat temperature in rotary kiln for reducing power consumption at Fe-Cr plant at Bamnipal for Tata Steel; (vii) Optimizing of corrosion resistance performance of galvanized coating; (viii) Semi-commercial column flotation trials on the recovery of sillimanite for M/s. Indian Rare Earth Ltd., Chatrapur; (ix) Beneficiation of limestone for M/s. Someshwara Cement & Chemicals Ltd., Hyderabad; (x) Extraction of Zinc from Zinc Ore for M/s. Nepal Metal Co. Ltd.; (xi) Improvement of corrosion resistance of tempcore rebars for M/s. VSP, Visakhapatnam.

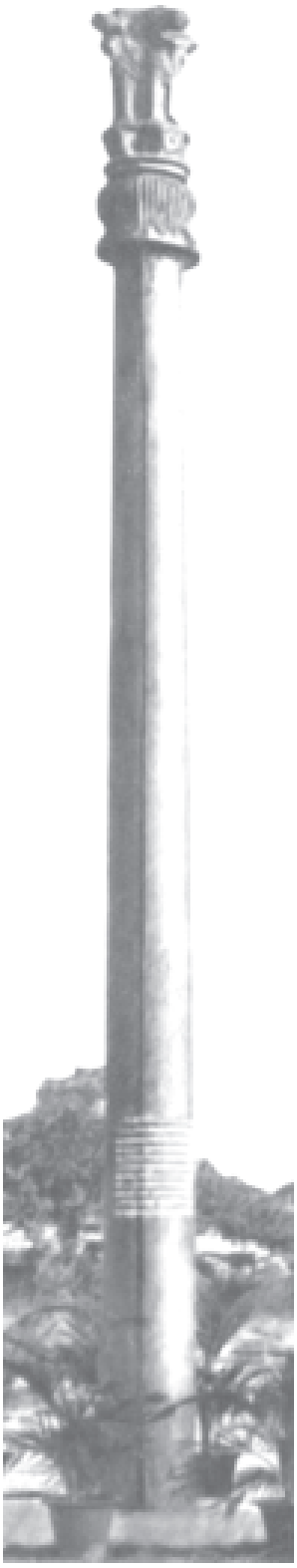
Similarly several Grant-in-Projects - were also undertaken. DST has extended supports to several projects, viz., - (i) Synthesis and Characterization of AIN-SiC composites, (ii) Thermomechanical modelling and simulation studies for energy optimization and quality control in ferro-alloys products; (iii) Mossbuer studies of the precipitation process in steel; (iv) Development of eco-friendly closed multipot furnace for glass melting; (v) Micro-magnetic study on ferro-magnetic materials; (vi) Development of an ICP-OES techniques for hall-marking of gold : an alternative to fire assay techniques; (vii) Development of low silver brazing alloys for joining ceramic to metal; (ix) Dephosphorization of high carbon liquid ferro-manganese; (x) Improvement of the properties of cast Al-Alloy by application of electric or magnetic field during solidifcation; (xi) Synthesis and sintering of titanium boride for industrial application; (xii) Reduction of hydrogen entry and consequent hydrogen embrittlement in steel substrate by ion-implantation. Department of Steel and Mines, Research & Technology Mission, Delhi; Ministry of Rural Development; Environmental and Forest; Joint Plant Committee, Ministry of Iron & Steel, Government of India have extended support to projects relating to rural technologies used by tribals.

During 1999-2000, several collaborative/interactive projects and consultancy/Technical services valued at more than Rs. 10 million were undertaken. Most of them were completed.

Nineteen MoUs relating to process development, technical collaboration, marketing agreements, services etc., were signed during 1999-2000. Six processes, namely - (i) Flux for magnesium alloys; (ii) useful solution to establish superiority of corrosion resistance steels; (iii) value added products from pickle liquor; (iv) Reduction grade iron powder; (v) NML-Pikasurf, and (vi) Ramming masses used in induction furnace have been developed.

NML participated in several promotional meets. Mentioned may be made of few like-India International Trade Fair, held at Pragati Maidan, New Delhi; The Tech Fest organised at IIT Bombay; and Swadeshi Vigyan Mela organised by IIT Delhi. Over all our business efforts during the year have been fruitful. Two processes, namely - (i) Pollution Control System for Secondary Lead Smelting and (ii) Value added products out of ETP effluent solid waste were transferred to two entrepreneurs. One process i.e., the pollution control system for secondary lead smelting has gone into commercial production for the first time.

In a market like the one we had during the year, the customer had the privilege of being more demanding than even before. Realizing this and in order to have a better competitive edge, the laboratory spent Rs. 160 million towards its modernization of facilities. Inauguration of NML-NPL calibration centre at



the laboratory, extensive coverage of the local area networking, preliminary discussions on bench marking with M/s. Anderson Consultants and so on are the some of the immediate steps, NML had taken care of. More International R&D organizations are showing keen interest to collaborate with the Laboratory and consultations are in progress with Czechoslovakia, Spain, Russia, amongst others. Six NML Scientsts were also deputed to visit abroad.

During the year 1999-2000, a total number of 126 research papers were published. 11 Patents and 2 copy rights were filed. More than 110 research papers were presented by our colleagues in different national and international seminars/symposia/work-shops and other business fora.

On 3rd December 1999, NML organised the inaugural function of the year long Golden Jubilee Celebration programme. The function was inaugurated by Dr. R. A. Mashelkar, DG-CSIR. Dr. J. J. Irani, MD, Tata Steel and Chairperson, Research Council of NML presided over the function. Many dignitaries/ Scientists of national and international eminence attended the functions. Former NML Director and Sr. Consultant UNIDO, Dr. B. R. Nijhawan was also present. Dr. Mashelkar delivered the maiden Golden Jubilee lecture on "Innovation Engineering - The New Paradigm'. NML also hosted the XXXII Shanti Swarup Bhatnagar Memorial Tournament (Indoor) Finals, for the first time.

NML has organised three International symposia namely - (i) Environmental and Waste Management in Iron & Steel Industries (Dec. 7-8, 1999); (ii) Indo-Russia Micro Symposium on Non Ferrous Extractive Metallurgy in the New Millennium (Dec. 7-9, 1999) and (iii) International Seminar on Non Ferrous Metals and materials in the Twenty First Century with a Satellite Symposium on Aluniniran (Feb. 9-11, 2000).

Obivious to everything else, NML toiled ceaselessly, heart and soul, to erect the challenges of a difficult business envirornnent. Our efforts are being enthusiastically acknowledge. I am happy that NML Scientists bagged many prestigious awards like Shri Om Prakash Bhasin Foundation Award, CSIR Young Scientist Award, IIM Awards, KANO Award and many others.

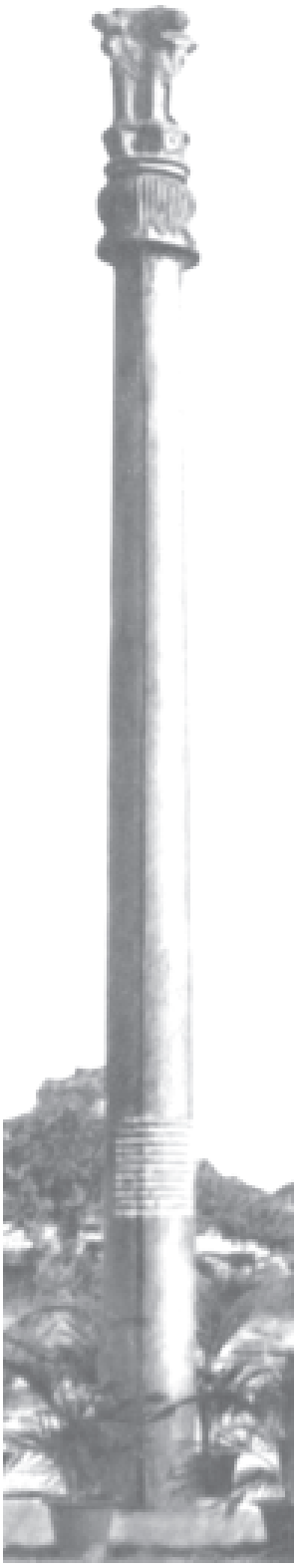
In the area of human resource development, the laboratory has been endeavouring to counter the large scale superannuations with new recruitments. The superannuation in all categories stood at 53 during 1999-2000. Recruitment of 16 scientists and 15 others technical/administrative cadre could be achieved during the same period.

I am thankful to Dr. J. J. Irani, Chairman and Members of the Research Council for their fruitful contributions and immense cooperation in the pursuit of R&D undertaken by the laboratory. Dr. R. A. Mashelkar, our Director-General and Officers of the Council have been a source of strength and encouragement.

I sincerely hope that NML will continue to maintain the impressive growth in R&D activities and contribute even more to the growth of the industry.

Prof. P. Ramachandra Rao
DIRECTOR

November 26, 2000



2000 - 01

It is my proud privilege to present the 51st Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 2000-01.

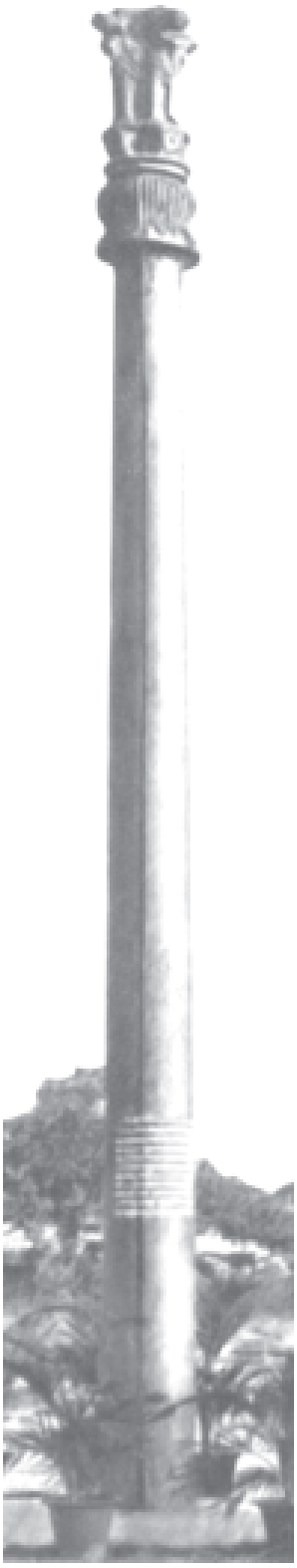
With the changed business environment heralded by the policy of open market, coupled with a decline in support from Government, NML has revised its strategy giving greater emphasis on cooperative marketing to remain competitive in terms of its resource mobilisation and productivity. During the year, NML has been providing qualitative science based technical services to the industries to improve their product quality by improving the mechanical, physical and chemical properties and striking the correct composition/ formulation of new materials/alloys. Methods of cost reduction by improving yield and reducing rejection have also been suggested.

All these were possible with a focus on our facilities and expertise generated and an effective marketing drive. NML's efforts in mobilization of Extra Budgetary Resources (EBR) from the users yielded Rs. 7.72 crores during 2000-01.

With reference to R&D programme, NML has made considerable progress. The Indo-US project on `Fundamental Investigations on Advanced Ferrous Alloys' was successfully completed on 29th December 2000 in partnership with Naval Research Laboratory, Washington and many academic institutions in India. The ongoing international collaborative projects, such as - (i) Recycling of red mud, refractories and fine dust in collaboration with Department of Materials, University of Leeds, UK; (ii&iii) Project on Comparative Geology, Mineralogy, Geochemistry and origin of Apatite ores; and project on synthesis and sintering of zirconium diboride - alumina composite by SHS process under the ILTP programme with Russia; (iv) Studies on physically based constitutive equations for design and life prediction at elevated temperature : modelling and validation with Imperial College, UK have been pursued.

The laboratory continued to work on the thrust area projects of Component Integrity Evaluation Programme (CIEP). The emphasis has been to solve industrial problems through failure analysis, remaining life assessment, non-destructive testing and stress analysis. During 2000-01 several sponsor specific projects have been completed and more than twelve projects are ongoing. Some of the notable beneficiaries were - M/s. Kolaghat Thermal Power Station; National Fertilizer Limited; Bharat Petroleum Corporation Limited; Reliance Industries Limited; MECON Limited; Central Power Re - sectrch Institute; Offshore Testing & Inspection Services (I) Private Limited: Nevveli Lignite Corporation Limited; Ahmedabad; Electric Co. Limited; Ammunition Factory, Khadki' TATA STEEL, Jamshedpur; Indian Farmers' Fertiliser Cooperative Limited,- National Fertilizer Limited; Kanoria Chemical & Industries Limited; Power Grid Corporation Limited, New Delhi; Tata Cummins Limited, Jamshedpur; ABB Limited; IAF, Nagpur; Eastern Coal field Limited.

The foundry Industry at Agra has been passing through a crisis following the Honourable Supreme Courts directive on minimizing environmental pollution. A technological and ecologically significant



landmark was created when Tata Korf Engineering Limited - a Tata Group of Company aided by NML, put up an eco-friendly melting furnace on commercial trial in a foundry near the Taj Mahal. We are now keenly looking forward to this technology taking root not only in Agra but also in several other foundry clusters across the country.

NML has undertaken a programme which is structured to improve the performance of existing Small Scale Industry (SSI) units by developing / strengthening managerial skills and technical competence of the entrepreneurs and senior executives of the small enterprises in collaboration with Small Industries Development Bank of India (SDBI). The underlying intention is to enable the participant entrepreneurs / senior executives to assess their existing performance level and determine ways of enhancing it. It also aims to create awareness amongst the SSI units on process improvernents, technological developments etc., and to induce the units to upgrade their technological level. The programme is designed for homogeneous groups of entrepreneurs / senior executives in terms of the size of the units, owner profile, nature of industry and present working status. Few R&D projects were also ongoing in the area of rural development.

Several sponsored projects have been taken up during the year 2000-01. Notable among these are - (i) Optimization of pre-heat temperature in rotary kiln for reducing power consumption at Fe-Cr plant for Tata Steel, Jamshedpur; (ii) Optimizing of corrosion resistance performance of galvanised coating for Tata Steel, Jantshepdur; (iii) Upgradation of quality of Metasave and NML Galvasave for Cold Rolling Mills for M/s. Metoil Corporation; (iv) Optimization of the performance of corrosion inhibitor for M/s. Navdeep Chemicals Pvt. Ltd.; (v) Development of special purpose specimen milling machine for Ordnance Factories; and (vi) Performance evaluation of epoxy coated vis-a-vis TMT CRS rebars embedded in concrete for Tata Steel, Jamshedpur; (vii) Studies on the improvement of compressive strength and abrasion resistance of tiles for M/s. Ultra Tiles Pvt. Limited; (viii) Development of mixed metal powder for diamond polishing wheel for M/s. Maruti Hightech Coating Pvt. Limited and (ix) Semi commercial column flotation trials on the recovery of silliminite for Indian Rare Earth Limited, Chatrapur.

Similarly several Grant-in-Projects were also undertaken. Department of Science and Technology, New Delhi, has extended support to a large number of projects. Some of these are - (i) Mossbuer studies of the precipitation process in steels; (ii) Development of eco- friendly closed multi pot furnace for glass melting; (iii) Micro-magnetic study on ferro-magnetic materials; (iv) Development of an ICP-OES technique for gold hallmarking of an alternative to fire assay technique; (v) Development of low silver brazing alloys for joining ceramic to metal; (vi) Dephosphorisation of high carbon liquid ferro-manganese; (vii) Improvement of the properties of cast Al-alloy by application of electric or magnetic field during solidification; (viii) Reduction of hydrogen entry and consequent hydrogen embrittlement in steel substrate by ion; (ix) Development of Al-Ti and Al-Ti-B master alloys and their thermo mechanical treatment for better grain refining (x) Studies on bio-processing of Indian Ocean Nodules with reference to extraction of valuable metals for Research & Technology Mission, Delhi, Ministry of Rural Development, Environmental and Forest; Joint Plant Committee, Ministry of Iron & Steel, Govt. of Indian have extended support to several projects.

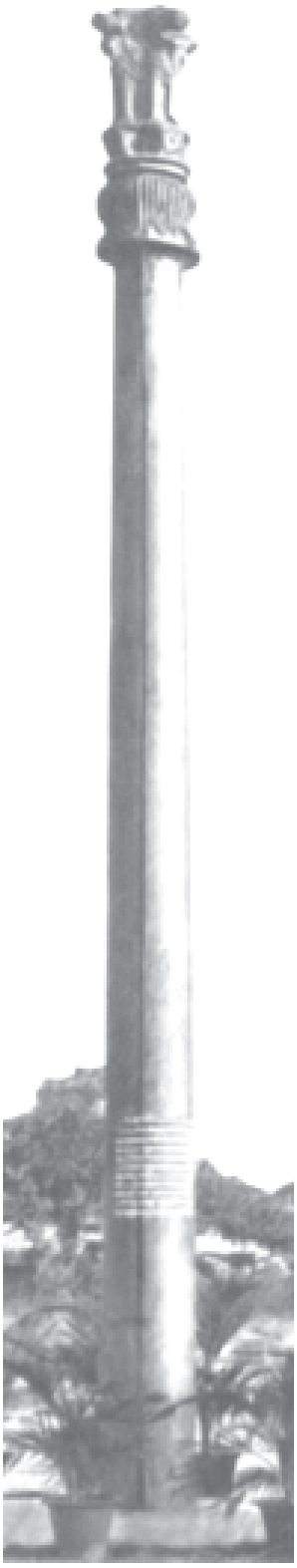
The prestigious project on "Maximizing blast furnace productivity with Indian iron ores", supported by Steel Development Fund, Department of Steel, Govt. of India is progressing well with the participation of many academic institutions, consultancy agencies and R&D laboratories.

During 2000-01, many collaborative interactive projects and consultancy technical services valued at more than Rs. 1.0 crore were undertaken and completed.

Twenty MoUs relating to process development, technical collaboration, marketing agreements, services etc., were signed during 2000-01.

Five processes (i) White portland cement for mosaic and tiles and (ii) Ramming masses for induction furnace lining, (iii) Recovery of nickel and alumina from nickel spent catalyst, (iv) Process for production of zinc powder from industrial waste and (v) Mixed metal powder for making a diamond polishing wheel have been developed.

Six processes, namely - (i) Vapour phase inhibitor; (ii) RELIEF (Software); (iii) CLIP (software): (iv) Electrolytic Manganese Dioxide; (v) Grates for cokeless cupola; and (vi) Ceramic balls for cokeless



cupola have been transferred. Three processes have gone into commercial production viz., - (i) Pig iron (25 ton/day capacity) by M/s. Polybond Insulation Private Limited, Bhilai; (ii) Refractory balls for cokeless cupola by M/s. Aditvapur Dies, Jamshedpur and (iii) Grates for cokeless cupola by M/s. Aditvapur Dies, Jamshedpur:

During the year 2000-01, total number of 135 research papers were published. 9 Patents and 3 copyrights were filed. More than 120 research papers were presented by our colleagues in different national and International seminarrs/symposia/workshop and other- business fora. NML Golden Jubilee Valedictory Function was organised on November 26, 2000. Dr A.P.J. Kalam, Principal Scientific Advisor, Govt. of India was the Chief Guest. To mark the occasion a book on *"Metallurgy in India - A Retrospective"* was also released by Prof V.S. Ramamurthy, Secretary, DST, New Delhi. Dr J.J. Irani, M.D., TATA STEEL and Chairperson, Research Council of NML presided over the function. Many other Dignitaries/Scientists of National and International eminence attended the function.

NML has organised four seminars/workshops during 2000-01. More than 250 Engineers/Scientists and Technical / Managerial Staffs were sponsored by industries alone to attend and interact with NML scientists for mutual benefits.

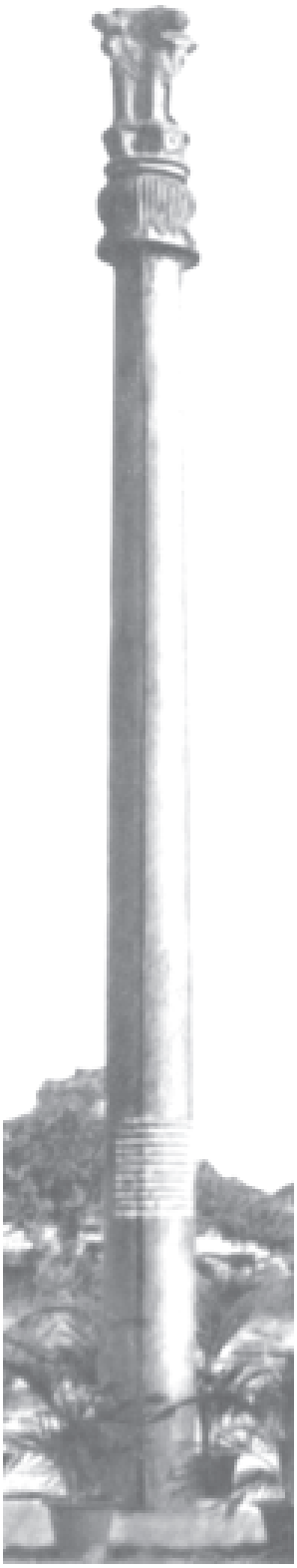
Similarly many research Scholars and academicians representing organisation like IISc., IITs, RECs, and other premier institutes participated in these workshops/ seminars. Many eminent personalities vistied the Laboratory to deliver lectures. Special Events like - National Technology Day; World Environment Day; CSIR Foundation Day; Hindi Diwas, National Science Day were also celebrated.

I am happy that during 2000-01, NML Scientists bagged many prestigious awards. These are - FICCI Award; VASVIK Award; CSIR Young Scientist Award; Prof B.C. Haldar Memorial Award; KHARE Award and CORCON-2000 Best Paper Award.

I am thankful to Dr. J.J. Irani, Chairman and other Members of the Research Council for their fruitful contributions and immense cooperation in the pursuit of our activities.

I sincerely hope that NML will continue to maintain an impressive growth in R&D activities and contribute even more to the growth of the industry in times ahead.

Prof. P. Ramachandra Rao
DIRECTOR



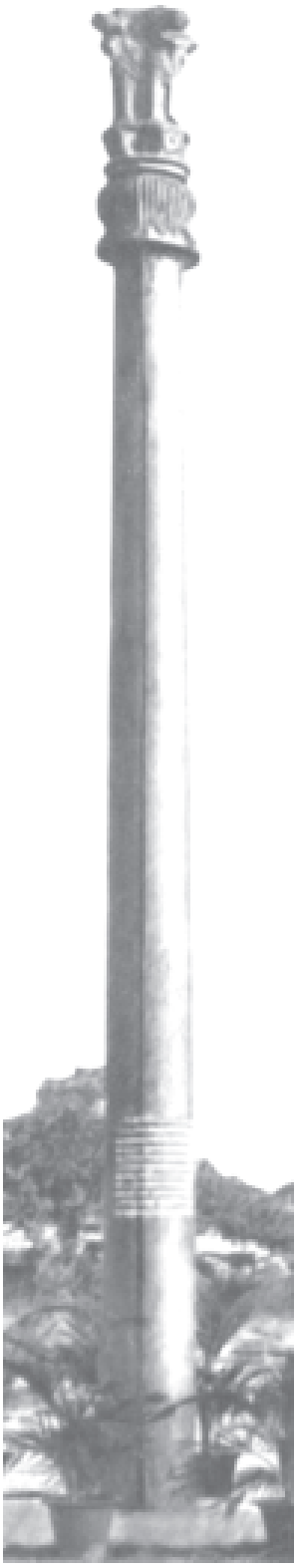
2001 - 02

While CSIR was beginning to enter into its Diamond Jubilee year, I took over as its Director of National Metallurgical Laboratory, Jamshedpur the third in the CSIR family of 40 laboratories on June 3, 2002. I am pleased to be associated with this unique 52 year old R&D house of research and innovations as its Director. It has in the past 52 years grown in strength and size under the leadership of its previous illustrious Directors offering its R&D products, processes and expertise to industries in the form of design, consultancy, technical services, certified reference material, and testing in the area of minerals, metals, and materials including metallurgical waste and pollution. During the last one year (2001-2002) under the leadership of the earstwhile Director Prof P Rarnachandra Rao, presently the Vice Chancellor of BHU, Varanasi, NML attempted to bring a sharp focus to the requirement of our customers and we renewed our efforts to tailor our R&D activities to suit these requirements in offering our R&D products, processes, consultancy and technical services. A critical constituent of NML has always been its outstanding manpower and infrastructure striving to achieve excellence in its R&D and scientific pursuit of international standards.

During the year 2001-2002, NML's financial position in terms of extra budgetary sources from the users has visibly strengthened as it yielded a sum of Rs.5.28 crores. There are apparently three important drivers of growth in NML. First is the laboratory's Component Integrity Evaluation Programme under which several new projects have been marketed. The emphasis has of late been on the estimation and extension of life for critical engineering components mainly in the core Industrial, Air force and Railways sector, and on understanding the cause of failure which is likely to bring the benefits as conservation of materials and energy, reduced down time and safety to the engineering components.

The second driver of growth has been through attempting to maximising blast furnace productivity with Indian iron ore with the financial support of Min. of Steel, Govt. of India, under the Steel Development Fund scheme and extraction of Magnesium from indigenous raw material sponsored by Mininistry of Mines, Govt. of India. NML jointly with SAIL and Tata Steel intend to develop a knowledge base for characterising the process dynamics of the blast furnace to improve blast furnace operations and hot metal quality. Other collaborators in this project are IIT(K), IIT(B), IIT(M), IIT(KGP); CDAC, Pune; MECON, Ranchi; and RDCIS-SAIL, Ranchi. The project of magnesium extraction involves setting up of a pilot plant for production of 100 kg per day magnesium using indigenous ore to exploit the emerging market, for the auto majors such as Ford, BMW, Hundai etc.

The third driver of growth has been contract R&D comprising Grant-in-aid, Sponsored and Collaborative Projects, Technical Services and Consultancy projects to various Government agencies public and private industries. The laboratory with the financial support of Dept. of Science and Technology, New Delhi, has undertaken large number of projects in its diversification pursuit. The scope and expanse of research in these projects is quite varied from Synthesis and characterisation of AIN-SiC composites to Thermochemical modelling and simulation studies for energy optimisation and quality control in ferroalloys production using submerged arc furnace; from Comparative Geology, mineralogy



geochemistry and origin of apatite ores of Indian iron ore series (W. Bengal, India) and Fedorovskaya Formation (South Yakutis, Russia) to Micromagnetic study on ferromagnetic materials; from Investigation on the suitability of non-edible rural vegetable oils in mould lcore making and preparation of resins to Development of low silver brazing alloy for joining ceramic to metal/ceramic; from Dephosphorisation of high carbon liquid ferromanganese to Improvement of the properties of cast aluminium alloys by application of electric or magnetic fields during solidification; from Synthesis and sintering of Titanium Diboride for industrial application to Reduction of hydrogen entry and consequent hydrogen embrittlement in steel substrate by ion implantation.

NML in its endeavour to overcoming crisis of Agra foundry industries following the Hon'ble Supreme Court directives on the ecofriendly production of foundry grade iron, in collaboration with Tata Korf Engineering Ltd., a Tata Group of Companies, developed and put up environmetally benign and energy efficient cokeless cupola for foundry grade iron to save Taj Mahal and neighbouring historical monuments. The technology is intended to cater to the needs of not only of Agra foundries but also of several other foundries across the country.

Besides, the laboratory has contributed in a big way to the ferrous and non-ferrous industries including the corrosion protection of the materials. It has developed the criteria for the suitability of rebars for use in Sardar Sarovar Narmada Nigam Limited sponsored by M/s Sardar Sarovar Narmada Nigam Ltd., Gujarat; a process for extraction of zinc from Ganesh Himal Zinc-Lead ore of Nepal sponsored by MECON, Ranchi; and a flow sheet for beneficiation of low grade chromite ore sponsored by M/s. Orissa Mining Corporation, Bhubaneshwar.

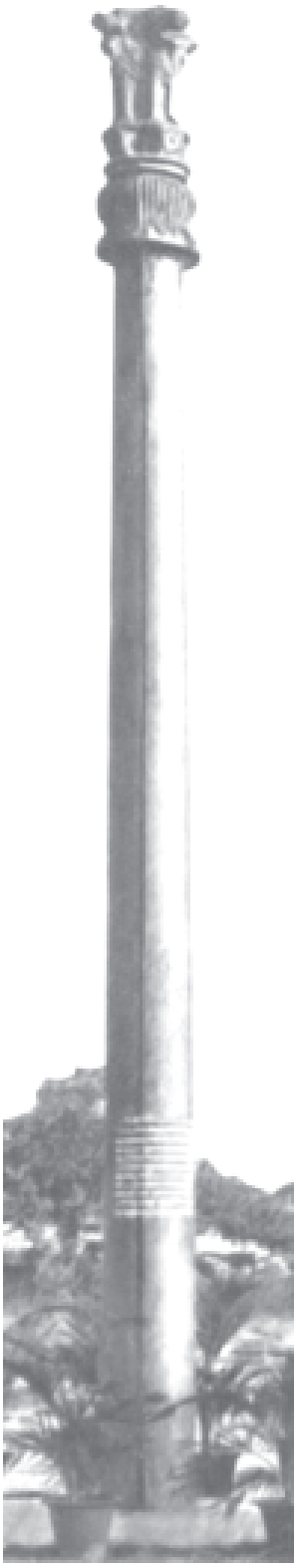
NML with its bench scale and pilot plant facilities has successfully completed some other interesting projects viz. Melt spinning of Nd-Fe-B alloy sponsored by Thapar Centre for Industrial R&D, Patiala, Performance evaluation of epoxy coated vis-a-vis TMT CRS rebars embedded in concrete sponsored by M/s Tata Steel, and Beneficiation study of quartz and feldspar generated during mining of mica sponsored by M/s Development of mineral resources & technology upgradation fund, Hyderabad.

In addition to these three drivers of growth, the enhanced actitities of NML have been facilitated by accomplishing projects sponsored by various Government agencies and ministries in industrial and space sectors. In these projects support was extended by the Ministry of Tribal Affairs, New Delhi, for Exploration of value addition to vegetable oils (sal & kusum) available in minor forest areas for industrial applications; Ministry of Environment and Forests, New Delhi, for Life Cycle Assessment study for steel sector - Aeronautical Development Agency, Bangalore, for Studies on thermal characterisation of LCA brake disc; Indian Space Research Organisation, Bangalore for Biomimetic synthesis of inorganic materials under microgravity.

Some international collaborations with Russia under the ILTP programme have also been successfully handled during the year 2001-2002. The projects under these programmes are Synthesis and sintering of Titanium Diboride for industrial application, Studies in development of flotation reagents for processing of complex, Study on controlled adsorption of the surfactants and polymers on oxidic mineral systems for enhanced beneficiation of iron ores in their sub-sieve range.

NML's Intellectual PropertyAssets grew rapidly comprising 96 research publication in National and International Journals, 10 Indian and 7 International patents and 2 Copyrights. 50 renewed patents application coupled with the presentation of more than 81 papers in several seminars, conferences and symposia is seen as essential for the profitable growth of the Laboratory. In order to reach out to the fraternity of professional, engineers, scientists and managers from leading R&D organisations, industries and academia, NML initiated in organising several seminars, workshops in 2001-2002. In this programme the faculties and the participants were drawn from leading organisations of the country and abroad.

In the past it was predominantly a sellers market due to which the improvement in R&D were never considered to provide greater inputs by the industries . Now with the announcement of the new industrial policy of the Government of India and that of the newly created state of Jharkhand the industries are increasingly looking forward to the R&D organisations. It would help industries to remain competitive



to improve qualities of product, and make affordable pricing in launching their products. This has paved the way for NML to act as a provider of high quality technical inputs not only to improving product quality but also to implement cost reduction and reducing rejections . NML has recently undertaken the diagnostic study to help rehabilitate the sick units of Jharkhand involving processing and extraction of metal, minerals and materials.

The R&D related business initiatives have been possible because of the state -of-the-art technology back bone within our laboratory coupled with the data base and human resources. Because of the empowerment that we are able to provide, we have successfully celebrated the special events of international repute and national importance. These include World Environment Day, National Technology Day, National Science Day, CSIR Foundation Day, Hindi Divas, and CSIR Programme for Youth on Leadership in Science (CYPLS), to mention a few.

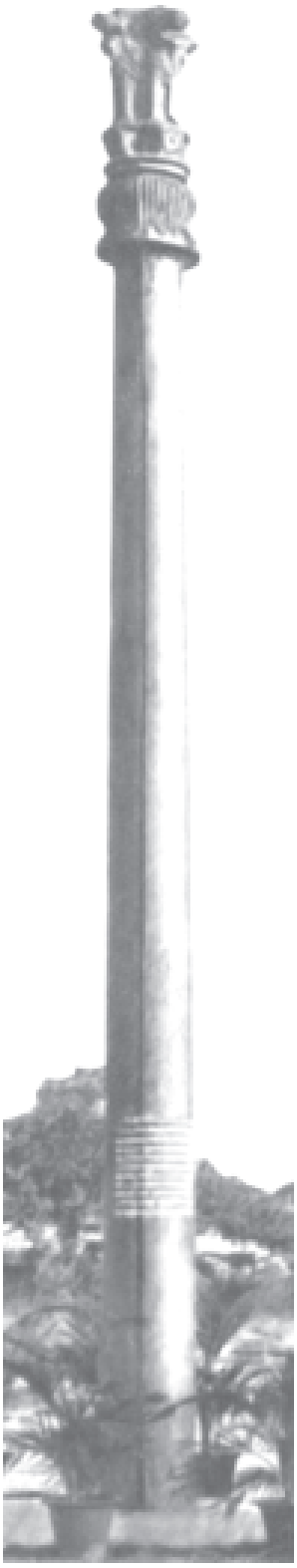
NML has undertaken aprogramme to improve the performance of existing Small Scale Industry (SSI) units by developing/ strengthening managerial skills and technical competence of the entrepreneurs and senior executives of the small enterprises in collaboration with Small Industries Development Bank of India (SIDBI).

Our scientists bagged many prestigious awards These include National Technology Day awards, IEEE best paper award, LERIG best paper award, THERMANS best paper award, Peravadhanulu best paper award, IIM best paper award.

I wish to place on record my sincere gratitude to Shri P Parvathisem, Chairman Research Council and other members of the Research Council for their fruitful contributions and immense co-operation in the pursuit of our R&D and scientific activities.

The challenging environment ahead fills us with a sense of excitement and we believe that the collaboration between NML, industry, academia and R&D organisations would help enhance our capacity and determination to compete and succeed. Our scientists are on the forefront of the scientific and technological changes and financial development. I am sure, we shall continue to harness their resources and expertise to maintain an impressive growth in R&D activities, and contribute even more towards the industrial growth in the near future.

Prof. S. P. Mehrotra
DIRECTOR



2002 - 03

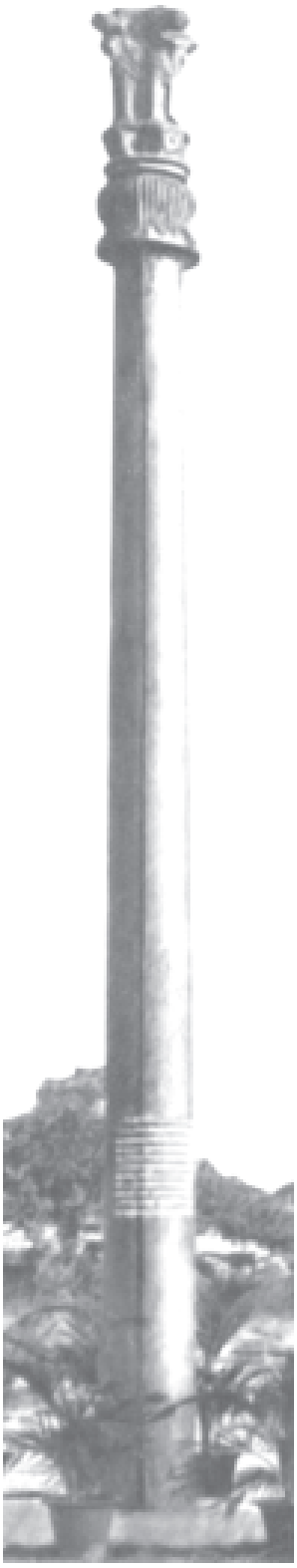
It is my proud privilege to present the 53rd Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 2002-03 -A witness to the Diamond Jubilee Year of our CSIR family. Thereby, the year was more eventful too.

During the last five years there has been a tremendous change in the economic, political and technological environment the world over. India has been no exception. Its economy is being gradually liberalised to enable its smooth integration into the global economy. This poses a challenge to all sections of Indian Society: how to harness effectively the potential of Science & Technology in the socio-economic sphere.

The business as such, has become increasingly a network of strategic partnership among designers, technology providers, manufacturers and the market place. Further, marketing can no longer be the sole responsibility of a few specialists. Rather, everyone in the organisation may be charged with the responsibility of understanding customers aspirations and contributing to developing and delivering value for them. This is how, CSIR has facilitated in formulation of Tenth Five Year Plan (TFYP), effecting a network approach. The primary R&D activities of National Laboratories are expected to be pursued through the networked projects. Over the past one year, NML has registered good progress in terms of formalisation of our participation in several of 57 networked projects of CSIR. In the project on Custom Tailored Special Materials, NML has four major responsibilities: (1) Development of hydroxyapatite based bioceramics through biomimetic route for biomedical application; (2) Fabrication of superhard material and castings; (3) Fabrication of advanced high temperature - Ceramic composites by hot iso-static pressing; (4) Development and characterisation of amorphous non-crystalline soft & hard magnetic materials for sensors and high energy product magnets: The other network projects in which NML has major participation include: Developing New Building Construction Materials and Capacity Building for Coastal Placer Mineral Mining. In the latter project NML is responsible for Characterisation and bench scale studies for beneficiation of beach placer of Kerala-Karnataka coast, and conceptual flow-sheet development for the production of high quality beach sand minerals by column flotation. In the network project on advanced manufacturing processes NML is responsible for the development of Squeeze casting technology for automotive components; and production and characterisation of bulk amorphous materials.

In addition, through effective pursuance, a networked initiative on "Technology for Engineering Critical Assessment" has been proposed as a TFYP project. This proposal is planned to be executed by a team of engineering laboratories of the CSIR family and other R & D organisations and academic institutions, with NML acting as the nodal co-ordinator.

The progress of the two NML Mega projects - (1) Maximising blast furnace productivity with Indian iron ore with the Financial support of Ministry of Steel, Govt. of India, under the Steel Development Fund scheme and (2) Extraction of magnesium from indigenous raw material sponsored by Ministry of Mines, Govt. of India has been quite encouraging. Under the BF project NML jointly with SAIL and



Tata Steel is developing a knowledge base for characterising the process dynamics of the blast furnace to improve blast furnace operations and hot metal quality. Other collaborators in this project are IIT, Kanpur; IIT, Bombay; IIT, Madras; IIT, Kharagpur; CDAC, Pune; MECON, Ranchi and RDCIS SAIL, Ranchi. During the year 2002-03 some major laboratory infrastructure has been added. NML with the help of Department of Science and Technology (DST), Govt. of India is going to launch its centre for infrastructure asset management by non-destructive evaluation techniques. The establishment of the N DT Centre is under progress, The other infrastructure components added include : a Computational Centre with a super computer Param-10,000, a major facility to determine melting, softening, characterisation of iron ore/ sinters, Precision and analytical mass comparator for NML's calibration centre, laser flash thermal constant measuring unit, Impact Echo System, Thermography equipment, Hindhivac Sputtering Unit, Cement testing equipment.

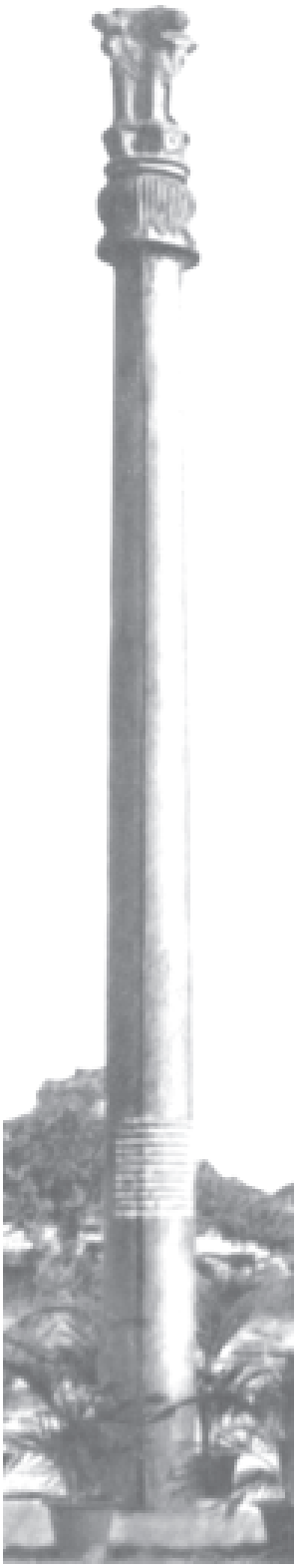
New Millennium Indian Technology Leadership Initiative project on 'Improved Granular Processing: Towards energy efficiency in cement manufacture' supported by CSIR has been progressing well.

NML in its endeavour to overcoming crisis of Agra foundry industries following the Hon'ble Supreme Court directives on the eco-friendly production of foundry' grade iron, developed and put up environmentally benign and energy efficient eco-friendly coke less Gas fired Melting Furnace for foundry grade iron to save Taj Mahal and neighbouring historical monuments. Trial runs were conducted in the demonstration plant of Agra Foundry Association. The technology is ready for commercial exploitation, is intended to cater tathe needs of not only of Agra foundries but also of other foundries across the country.

Laboratory continued to work on its thrust area projects of Component Integrity Evaluation Programme (CIEP). The emphasis has been to solve industrial problems through failure analysis, remaining life assessment, non-destructive evaluation and stress analysis. During the last one year, several sponsor specific projects were completed. Some of the notable beneficiaries were Tata Steel, Jindal Steel & Power Ltd., Bharat Heavy Electrical Ltd., CESC Ltd., Hindustan Aeronautics Ltd., South Eastern Railways, Central Power Research Institute. Under CIEP, several projects are going on as per schedule. Mention may be made of: (I) Uni-axial creep rupture test for residual life assessment and Creep rupture test for RLA for M/s ALSTOM Power; (II) RLA of primary reformer tubes for National Fertilizers Ltd.; (III) Health assessment of heater tube of Indian Oil Corporation Ltd.; (IV) Creep Rupture test for M/s Thermax Babcock and Wilson Ltd.; (V) RLA-creep rupture test for Tata Power; (VI) Metallurgical failure investigation of aeroengine for Indian Air Force; and (VII) Development of silt erosion resistant materials for turbines of hydrogenerators for Central Electricity Authority.

Under the bilateral co-operations, NML continued to reinforce partnership with Indian as well as overseas organisations in the core areas of metallurgy and material science. Indian industries, Academia and Govt. Organisations, namely, Tata Steel, Jamshedpur; National Aluminium Company Ltd., Bhubaneswar; Process and Product Development Centre, Agra; GMDC Research Centre, Ahmedabad; IIT Kanpur; IIT Kharagpur; Dept. of Science & Technology; Indian Space Research Organisation, Bangalore; Dept. of Ocean Development; Ministry of Rural Development and Dept. of Biotechnology were involved. Similarly, mention may be made of Overseas institutes/ organisations like Iowa State University, U.S.A.; Dept. of Materials, University of Leeds, UK; Engineering and Physical Sciences Research Council, U.K.; (IZFP), Saarbrucekh, Germany; South Yakutia, (Russia) and Russian Academy of Sciences, Institute of Structural Macrokinetics and Materials Science (ISMAN), Moscow and Russian University. Under Integrated long term Programme (ILPT), through DST, the progress of the projects on synthesis of sintering of TItanium diboride for industrial application; studies in development of flotation reagents for processing of complex ores; study on controlled adsorption of the surfactants and polymers on oxidic mineral systems for enhanced beneficiation of iron ores in their sub-sieve range were quite encouraging.

During the year, 11 numbers of Grant-in-Aid projects, 3 sponsored projects, 7 consultancy projects, 1 collaborative project and 21 technical services projects were completed, The beneficiaries were - M/ s Watch and Nagar Industries Pvt. Ltd., Tata Power Ltd., Tata Steel, Thapar Centre for Industrial R&D, MECON Ltd., The Orissa Mining Corporation Ltd., Sardar Sarovar Narmada Nigam Ltd., Fertiliser Corporation of India Ltd., SAIL, Dept. of Industry, Jharkhand, Power Grid Corporation of India Ltd., Jindal Steel & Power Ltd., CESC Ltd., HAL, Central Power Research Institute, South Eastern Railways,



Indian Air Force and many more. Likewise, 44 Grant-in-Aid projects, 7 sponsored projects, 8 consultancy projects, 2 collaborative projects and 7 technical services projects are ongoing.

During the reporting year, three processes, namely, (I) Electrolytic Iron Powder, (2) Manufacturing of Pickling Inhibitor for descaling of steel in HCL acid solution and (3) Galvasalt-an improved production technology were transferred. 10 numbers of business MoUs were also signed.

With regard to the Intellectual Property Assets, I am happy to state that performance has been quite encouraging. 7 National and 14 International patents and 2 copyrights were filed. 80 research papers in International and 63 papers in National Journals/Proceedings were published reflecting a qualitative as well as quantitative improvement as compared to previous years.

The laboratory is holding periodic get-togethers of industrialists, business people and Govt. officers to apprise the industries the products and processes developed by laboratory and the assistance that can be rendered for their commercial exploitation and to study and investigate the problems for the betterment of the products.

During the year, 14 workshops and seminars were held. Out of these, mention may be made of the mega events like the National level seminar/ workshop on - Resurgence of Metallic Materials - The current scenario; Remaining life assessment and extension ,of aged components of thermal power plants and Petrochemical industries; Promotion of Entrepreneurial industries; Promotion of Entrepreneurial Skills for Empowerment of Women; and Intellectual Property Assets in Business Development. As part of CSIR Diamond Jubilee celebrations, a series of lectures have been planned by eminent personalities from metallurgy and material science. Three lectures were organised during this reporting period. The maiden lecture on this series was by Shri B. Muthuraman, Managing Director, Tata Steel on "Development in Steel Research." The other two lectures were delivered respectively by Dr. Placid Rodriguez, Chairman, Recruitment & Assessment Centre, DRDO, Delhi on "Non-Destructive Evaluation in Science and Technology" and by Prof. K.L. Chopra, Formerly, Director, IIT, Kharagpur on "Two Dimensional Nano-Materials-A review. CSIR Diamond Jubilee was celebrated throughout the year with the organisations of different events in the laboratory.

Several other regular events like - Hindi Diwas, CSIR Programme for Youth on Leadership in Technology Day were also celebrated.

NML participated in the Technology Fair held at Zibo City, China through TIFAC, New Delhi; Jharkhand Udyog Mela held at Ranchi; Concept 2003 held at NIT Campus, Jamshedpur and TechFest R&D Exhibition 2003 held at IIT, Mumbai with the objective of creating awareness about NML/CSIR, its achievements and supporting its business development efforts.

During the year under review, NML has achieved the ISO 9001: 2000 certification. having successfully undergone upgradation audit. Unlike ISO 9000: 94 version, the revised standard lays much emphasis on Quality Management System whose bedrock is the process approach and measurability of its outputs leading to sustainable development of the organisation's business and its customer's satisfaction resulting in 'Customer Delight' which is also our commitment.

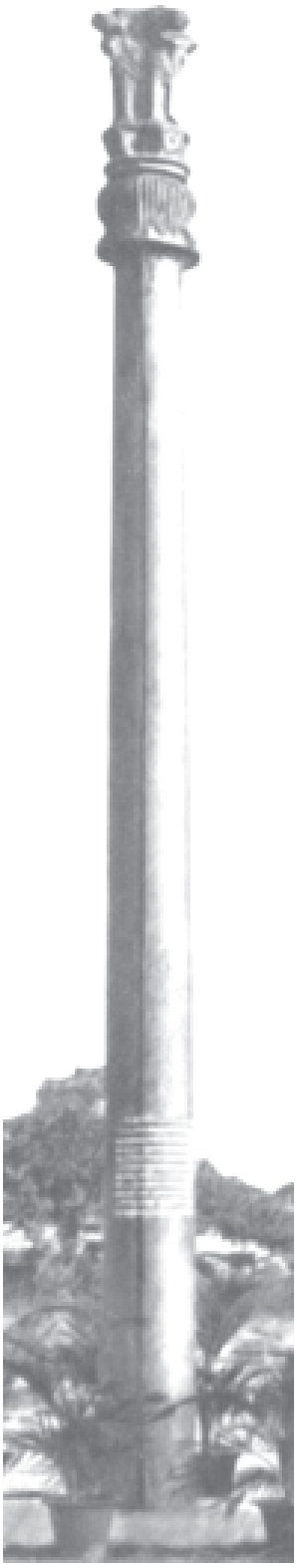
During the year, NML's effective marketing drive could mobilise an extra budgetary resources worth Rs.660 lakhs.

Several prestigious awards and recognitions have come to NML Scientists. These include CSIR Young Scientist Award; MRSI Young Scientist Award; SAIL Gold Medal-2002; Best Metallurgical and Materials Engineers Award-2002; IIME Mineral Beneficiation Award 2002; Deokaran Award for 'Glass' 2002 and Best Paper Awards.

During the year, 94 NML staff had undergone training and 104 personnel sponsored by outside agencies were imparted training at the laboratory. 12 Scientists were on foreign deputation and 4 obtained higher degree/diploma.

I sincerely hope with the total involvement of all my colleagues at NML, we will maintain the impressive growth in R&D activities and contribute even more to the growth of the industry in the years to come.

Prof. S. P. Mehrotra
DIRECTOR



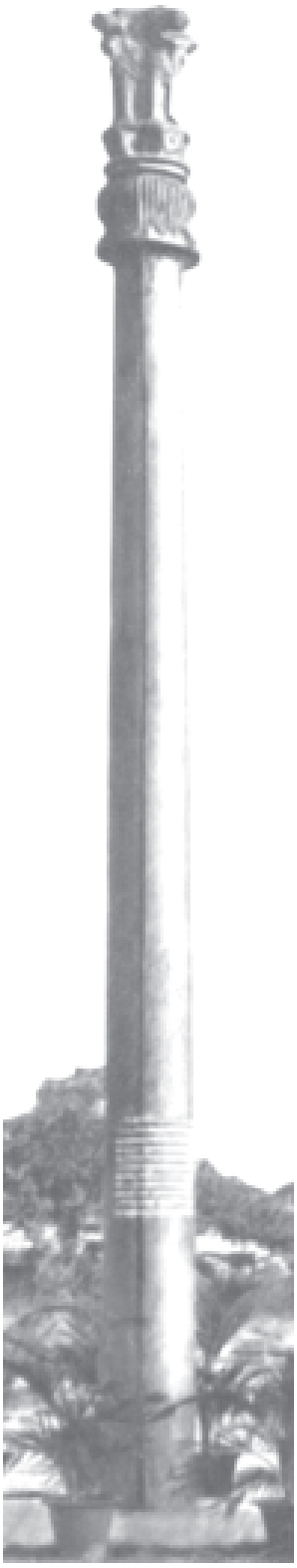
2003 - 04

It is my proud privilege to present the 54th Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 2003-04.This report records highlights of the activities underwent during the reporting year.

It was a momentous occasion for NML when His Excellency, Dr. A.P.J. Abdul Kalam, the Hon'ble President of our country visited us on February 13, 2004. This was the first time in our more than fifty years of existence that the President of the Nation visited our Laboratory. During his brief stay, His Excellency Dr. A.P.J. Abdul Kalam interacted with scientists, who had displayed their work through poster presentations. His Excellency, himself one of the most eminent scientists of our country, was very appreciative of the multidimensional research being carried out at NML. The interactive question/ answer session, which followed the poster display, would remain etched in the memory of all those who were present that day for a long time for the shear depth and understanding of scientific and humanitarian issues covered by the Hon'ble President.

With the change in the economic scenario, conscious efforts have been made to reorient the laboratory to face the challenges of liberalization and globalization. In the previous years, three fourth of the extra budgetary resources of the laboratory used to accrue from 2 to 3 large projects. This often resulted in the laboratory being cut off from larger sector of medium and small-scale industries. In order to bring these into our fold and widen the clientele of the laboratory, several innovative attempts have been made. On November 7, 2003, 22 members of the Technology Upgradation Panel, Confederation of Indian Industries (CII), Jharkhand visited the laboratory. Several issues of mutual interest came up during their interaction with our scientists. Visiting Industrialists were apprised of NML's capabilities and effected a positive marketing drive. This has led to more frequent bilateral interactions between these industrial units and NML resulting in larger contributions from medium scale to small-scale industries towards laboratory's external cash flow.

NML believes in progress through partnership at all levels: local, national and global. And the strategy has not only thrown up wonderful opportunities, it has also significantly transformed the organisation into a co-operative mode. Under the CSIR Network Programme, NML has been participating and contributing with its involvement in 46 ongoing activities, within the 11 major Network projects relevant to the laboratory. These include : (1) Bioprocessing of lean grade ores/concentrates/wastes and bioremediation of effluents and acid mine drainage; (2) New Building construction materials and technologies for sustainable development; (3) Computational mechanics for modelling analysis and design of high performance structures, materials and process applications; (4) Developing capabilities in advanced manufacturing technologies; (5) Catering to development of specialized aerospace materials; (6) Custom tailored special materials; (7) Coal Resource Quality Assessment for specific end users; (8) Quality Enhancement of coal for its efficient utilization; (9) Capacity building for coastal placer mineral mining; (10) Environment friendly leather processing technology; and (11) Industrial waste minimisation and clean up.



In addition, through effective pursuance a network project on Technology for Engineering Critical Assessment (TECA) with NML acting as the nodal implementing Agency, was sanctioned by the planning commission under the Tenth five year plan. The programme forms a major activity in one of the niche areas of NML to develop technologies for Engineering Critical Assessment (ECA) for the generic class of structures and components viz. pressure vessels and pipelines of the thermal and nuclear power plants, petrochemical and process industries airframes and aeroengine components infrastructural assets of the transportation industry; namely, concrete and steel bridges, railway wheels and railway tracks offshore structural components.

The project also involves Engineering Critical Assessment for sub-structural and surface processes, signal and image processing techniques for damage assessment, sensor devices for surveillance. Seven other sister CSIR laboratories, namely, CRRI, New Delhi; RRL, Bhopal; NAL, Bangalore; SERC, Chennai; CGCRI, Kolkata; CBRI, Roorkee; CMERI, Durgapur and with IIT, Kharagpur and IGCAR, Kalpakkam in consultative capacities.

The progress of the two NML Mega projects - (1) Maximising blast furnace productivity with Indian iron ore with the financial support of Ministry of Steel, Govt. of India, under the Steel Development Fund scheme, and (2) Extraction of magnesium from indigenous raw material sponsored by Ministry of Mines, Govt. of India - have been quite encouraging. On 'Magnesium extraction', extensive campaigns were conducted resulting in production of 115 kg of metal in the form of 'sponge'. The reported recovery is 75% and attained purity is 96%.

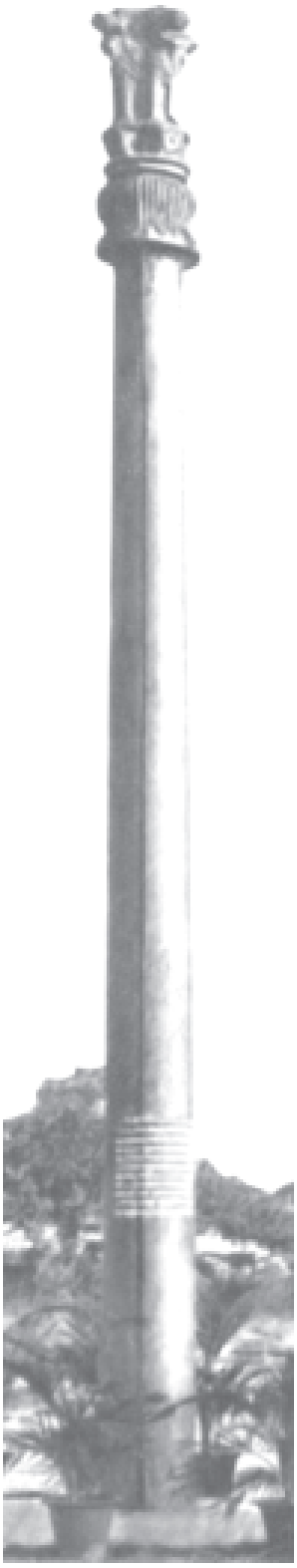
Under the Blast Furnace project, jointly with SAIL and Tata Steel, the principal objective is to develop a knowledge base for characterising the process dynamics of the blast furnace to improve blast furnace operations, hot metal quality and its productivity. Other collaborators in this project are IIT Bombay; IIT Madras; IIT Kharagpur; IIT Kanpur; CDAC Pune; and MECON Ranchi. Process models developed and validated with plant data are being further calibrated for implementation at plant(s).

Promising results have been obtained from the experimental activities under the project. On the initiative of the Secretary, Ministry of steel (MoS), the above findings were presented in a workshop organised in Kolkata which was attended by more than 70 experts from several steel plants who appreciated the work accomplished and strongly recommended continuation of the work for successful implementation. Subsequently, on Empowered Committee's strong recommendations, the MoS has approved the project extension till December 2005 with expanded mandate for successful implementation of the process model/real time simulator at the designated blast furnaces. The burden distribution model has been tuned with operating data from BF No.1 at Bokaro Steel Plant. The freeze line model has also been validated using the data from BF 'G' at Tata Steel, and the thermo-chemical model is being validated using data from the special probes in BF'G' at Tata Steel.

The New Millennium Indian Technology Leadership Initiative project on 'Improved Granular Processing : Towards Energy Efficiency in Cement Manufacture' has been progressing well. It is conclusively shown that the utilisation of BF slag and fly ash can be increased upto 85% and 60% in the respective blended cements. The focus in this project is on blended cement formulation based on attrition and vibratory mill slag and fly ash, self-hydration of slag, clinkerless cement and attrition milling of slag. The progress made in the project has been highly appreciated by the Steering Committee.

NML, in its endeavour to overcoming crisis of Agra foundry industries following the Hon'ble Supreme Court directive on the eco-friendly production of foundry grade iron, developed and put up environmentally benign and energy efficient ecofriendly Gas Melting Furnace for foundry grade iron to save Taj Mahal and neighbouring historical monuments. Trial runs were successfully conducted in the demonstration plant of Agra Foundry Association. Several successful trials of the 3t/hr gas based cupola were carried out and demonstrated. The technology is intended to cater to the needs of not only of Agra foundries but also of several other foundries across the country.

In the strategic sector, work on the 'Processing of Polymetallic Sea Nodules' project, sponsored by Department of Ocean Development (DOD), Govt. of India, has been in progress. The ongoing activities are aimed to separate and recover Cu, Ni and Co from leach liquor of sea nodules by bulk sulphide



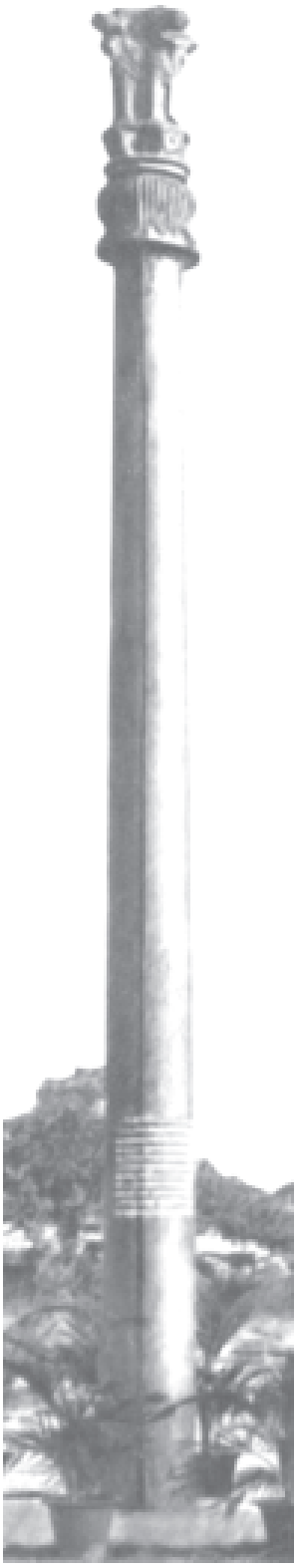
precipitation-chloride leaching-solvent extraction - electrowinning route. In the recent meeting of the Standing Committee of DOD at NIO, Goa, the members highly appreciated improvement in cobalt recovery from 50 to 80%. Work on setting-up a pilot plant at NML to produce ferro-silico-manganese from leached sea nodules residue is in progress.

The laboratory continued to work on its thrust area projects of Component Integrity Evaluation Programme (CIEP). The emphasis has been to solve industrial problems through failure analysis, remaining life assessment, non-destructive evaluation and stress analysis. During the year 2003-04, several sponsored specific projects were completed. Some of the notable beneficiaries included - Tata Steel, Jindal Steel & Power Ltd., Bharat Heavy Electrical Ltd., CESC Ltd., Hindustan Aeronautics Ltd., South Eastern Railways, Central Power Research Institute, Orissa Mining Corporation Ltd., Hindustan Aeronautics Ltd., AIADA, Govt. of Jharkhand, Oil and Natural Gas Corporation Ltd., National Thermal Power Corporation Ltd., and Indian Air Force. Under CIEP, several projects are also going on as per schedule. Mention may be made of the works, like - Creep rupture and LCF testing for Indira Gandhi Centre for Atomic Research; Evaluation of fatigue and fracture behaviour of narrow gap pipe weldments of similar and dissimilar metals for Bhabha Atomic Research Centre; Metallurgical examination of failed pins connecting 2nd stage disc to 3rd stage compressor of R-29 aeroengine for IAF, Halwara; Residual stress measurement of rails for Jindal Steel and Power Ltd.; Stress rupture test for boiler tubes for Central Power Research Institute; Failure analysis of arming vane of tail unit 100 mk-6 involved in flying accident of MIG aircraft for Indian Air Force; Metallurgical analysis of a fractured knot from Hartzell Propeller for HAL, Barrackpore; Accelerated creep rupture test of tube/ pipe samples for Central Mechanical Engineering Research Institute; Mechanical properties and microstructural assessment of 1st stage turbine blade for National Thermal Power Corporation Ltd.; Stress rupture test for boiler tubes for Central Power Research Institute; Accelerated creep rupture test of GEB Wanabori; Stress rupture testing of tube samples of RSTPS for Tata Power Company Ltd.; Identification of material used in track machine components for South Eastern Railway; Evaluation of plasma nitrated VIth stage stator guide vanes of TY-2-117A aeroengine of MI-8 helicopter for Indian Air Force; Creep rupture test for RLA study for Ennore Thermal Plant for Mecon Ltd.; High temperature tensile tests for Heavy Engineering Corporation Ltd.; and Evaluation of retained austenite in a rotary slide valve for Hindustan Aeronautics Ltd.

During the year 2003-04, some major laboratory infrastructure has been added. State-of-the-art facilities for offering scientific services include : Analysis pro-keen view and SIS workstation extended to transmit the TEM image on a video screen which helps in various types of analysis; 3D particle image velocimetry (PIV) system for flow visualisation and the study of whole field characteristics of the fluid flow - it is capable of making 3D measurements of the flow under study; PARAM-supercomputer to enhance the design and analysis capabilities in the areas of computational fluid dynamics, computational transport and rate phenomena, computational mechanics, 3D visualisation graphics, computational metallurgy and associated disciplines; Atomic Force Microscope for more precise surface characterisation; Laser Flash Thermal Diffusivity System for measuring thermal diffusivity, specific heat, and thermal conductivity of solid sample from room temperature to 1600°C . It is hoped that the new Non-Destructive Evaluation Centre which is equipped with some of the most advanced state-of-art equipment, will provide new capabilities in predicting the failure and assessing the residual life of components in strategic sectors like power plants, petrochemical industries and railways. The Centre has already set up facilities like Real-time X-ray Radioscopy 225kV system; Ultrasonic flaw detector in the frequency range of 50kHz - 500 kHz; Impact Echo System (Hand Held) with 9 impactors; Notebook Computer complete with A/D card - 1 unit for non-destructive testing of concrete and masonry structures; Hand Held Thermal Imaging System Agama 550 with accessories that monitors the target temperature change based on the relationship between the materials temperature evolution and mechanical behaviours.

During the year, 5 Grant-in-Aid projects, 28 Sponsored projects, 4 Consultancy projects, Collaborative projects and 19 Technical services projects were completed. Likewise, 46 Grant-in-Aid Projects, 22 Sponsored projects, 3 Consultancy projects, 7 Collaborative projects and 7 Technical services projects are ongoing.

During the reporting period, 4 processes in the area of advanced materials were developed and one eco-friendly iron-melting furnace technology (cokeless cupola) was ready for commercialisation. CLIP software was transferred to CMERI, Durgapur.



Further, seven MoUs were signed viz. : (1) IIT Kharagpur ; (2) Utkal NDT Centre, Bhubaneshwar; (3) MECON Ltd ., Ranchi ; (4) BARC, Mumbai; (5) Meghalaya State Electricity Board, Shillong; (6) M/ s. Associated Power Team (P) Ltd., Hyderabad; and (7) NRDC , New Delhi.

With regard to the Intellectual Property Assets, 17 National and 2 International patents and 1 copyright were filed. In addition to 86 research papers in International Journals and 33 papers in National Journals, 15 papers in International and 21 papers in National seminars/symposia Proceedings were also published during the reporting year.

Six National Seminars/Workshops were organised. Mention may be made of the the National Seminar on Pollution in Urban Industrial Environment; Workshop on Quantitative NDE in Condition Monitoring (QNDE-04) and Seminar on Recent Developments in Metallurgy. A short term training programme on Advances in Mineral Processing was also organised. Several other regular events like - National Technology Day; Hindi Diwas; CSIR Foundation Day; NML Foundation Day; National Metallurgists' Day; CSIR Programme on Youth for Leadership in Science were also celebrated.

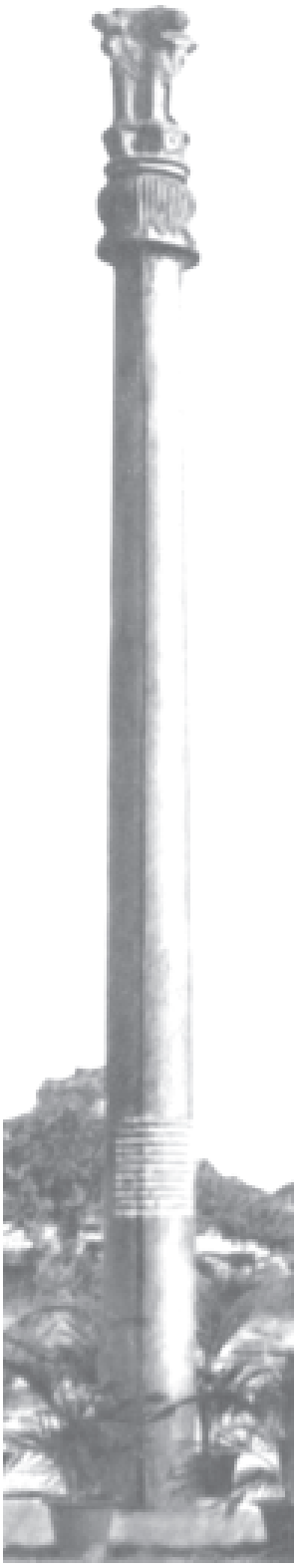
As part of the CSIR Diamond Jubilee celebrations, a series of lectures by eminent personalities from metallurgy and material science was organised. The lectures included :'Development in Steel Research; by Shri B. Muthuraman, Managing Director, Tata Steel; 'Non-Destructive Evaluation in Science and Technology'; by Dr. Placid Rodriguez, Chairman, Recruitment and Assessment Centre, DRDO, Delhi; 'Two Dimensional Nano-Materials - A Review; by Prof. K. L. Chopra, Formerly Director, IIT, Kharagpur; 'Order and Disorder in Alloys' by Dr.S.K.Banerjee, Director, Materials Group, BARC, Mumbai; 'Fuel Cell: Efficient Power Sources of 21st century' by Prof. K.T.Jacob, Dept. of Metallurgy, Indian Institute of Science (IISc), Bangalore; 'Genetic Algorithm and Multi-Objective Function Optimization with the Jumping Gene (Transposon) Adaptation-A primer', by Prof. Santosh K.Gupta, Dept. of Chemical Engineering, Indian Institute of Technology, Kanpur; 'Mathematical Modelling: A Wonder Tool If Judiciously Used'; by Prof. S.P. Mehrotra, Director, NML, Jamshedpur; 'R&D Challenges in the Technology of Fast Breeder Reactors for Energy Security in the Country' by Dr. Baldev Raj, Director, Materials, Chemicals & Reprocessing Groups, Indira Gandhi Centre for Atomic Research, Kalpakam; 'Research & Development in Steel Making - My Experience" by Prof. A. Ghosh, Retd. Professor, Dept. of Materials & Metallurgy, IIT, Kanpur & Consultant, Tata Steel, Jamshedpur and 'Some Thoughts on Leadership and Knowledge' by Dr. Sanak Misra, Managing Director, Rourkela Steel Plant.

NML organised CSIR Diamond Jubilee Exhibition at the premises of Institution of Engineers' (India), Jamshedpur Chapter, which was quite successful in creating public awareness of CSIR's technologies. NML also participated in three major exhibitions: S&T Exhibition held at Shillong, Meghalaya; Swadeshi Mela at Gopal Maidan, Jamshedpur; and the India International Trade fair held at Pragati Maidan, New Delhi. This year CSIR's main focus in the Trade fair was on Engineering Design capabilities in its different National Laboratories. NML presented the Engineering Design relating to its three processes, namely - (1) Gas Cleaning System, (2) Cokeless Cupola and (3) Magnesium Technology. The exhibits were also supported by models. More than 5000 visitors comprising students, teachers, R&D workers, Entrepreneurs, Industrialists and Dignitaries visited the stall and showed keen interest in various NML technologies, facilities and in-house publications.

During the year under review, NML achieved the ISO 9001: 2000 certification having successfully undergone upgradation audit. All newly reorganised divisions documented their procedures/activities for the fulfilment of the requirements of the Quality Management Systems of ISO: 9001: 2000. The surveillance audit conducted by TUV has now brought all the Divisions under the ambit of ISO 9001:2000, thus making our Laboratory a truly ISO 9001:2000 organisation.

The finalisation of the document on the master plan is on the way as we decided to first carry out a rigorous SWOT analysis for the laboratory. A scan of the internal and external environment is an important part of the strategic planning process. It is a tool for auditing an organisation and its environment and is the first stage of planning on key issues.

During the year 2003-04, NML's effective marketing drive could mobilise an extra budgetary resources worth Rs. 591.9 lakhs.



Several prestigious awards and recognitions have come to NML Scientists. These include the Fellow of National Academy of Sciences, India; Fellowship of the Institute of Toxicology & Environmental Sciences, Kolkata (2003); MRSI Medal in the field of Materials Science & Engineering; Raman Research Fellowship (CSIR), 2004; Boyscast Fellowship (DST); Gold Medal of The Mining, Geological & Metallurgical Institute of India 2002- 2003; 19th IETE Bimal Bose Award, 2002-2003; IIM Best paper Award in oral and poster presentation at NMD, 2003; Best Paper Award-2003 of the Society of Geoscientists and Allied Technologists (SGAT).

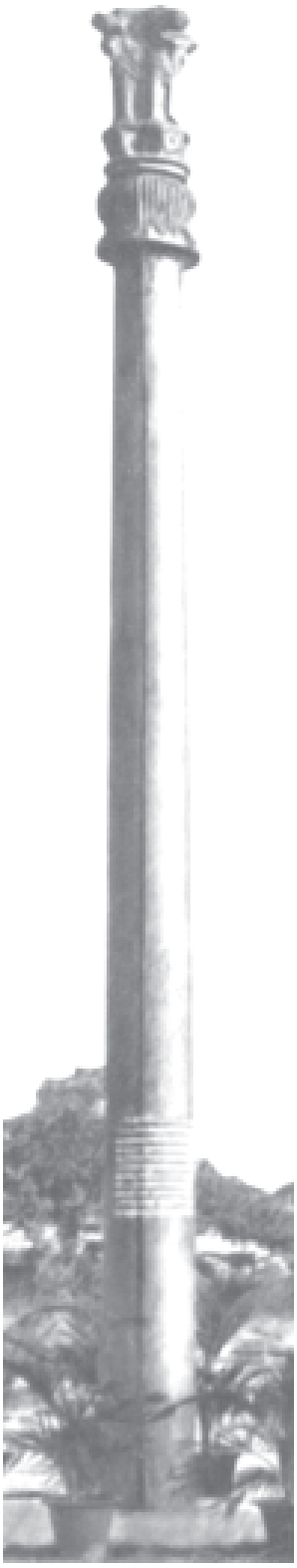
During the reporting year, 170 NML staff members had undergone training outside as well as inside the laboratory and 350 personnel sponsored by outside agencies were imparted training at the laboratory. 10 Scientists were on foreign deputation and 4 obtained higher degreesidiplomas.

Dr. R. A. Mashelkar, Director General of CSIR, has been a role model for many of us, both as a scientist an administrator par excellence. I take this opportunity to express our sincere thanks and gratitude to him for his guidance and continuous support in all our endeavours. I also gratefully thanks Shri P. Parvathisam, Former Chairman of Research Council (RC), and Shri B. Muthuraman, present RC Chairman and all RC members for the interest that they took in NML's activities, their very constructive suggestions and timely guidance.

I would also like to put on record that the significance achievements and the progress made during the reporting year have been possible primarily due to positive attitude and very enthusiastic participation of most of my colleagues at NML, and I whole heartedly compliment them for their team spirit and efforts.

I sincerely hope, with their support and total involvement we shall not only be able to maintain the impressive growth in our R&D activities but also ensure our meaningful contributions to the national endeavour of making India a developed country by 2020.

Prof. S. P. Mehrotra
DIRECTOR

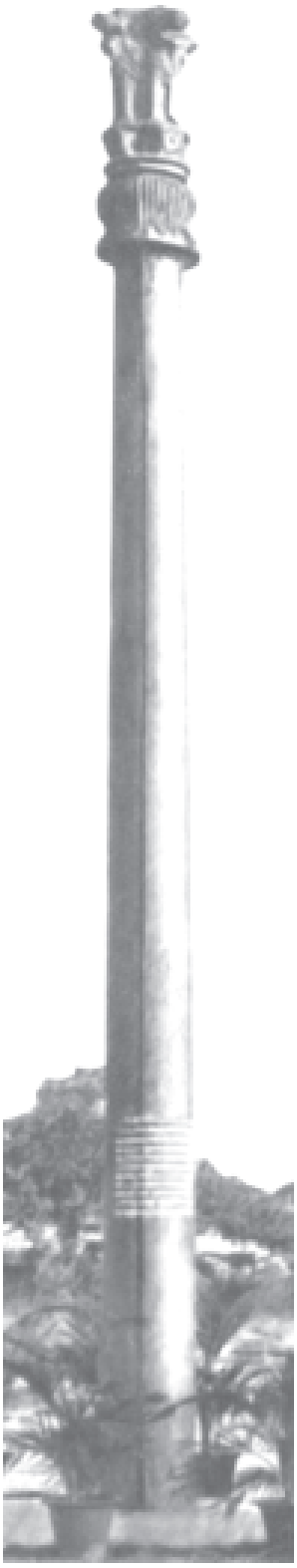


2004 - 05

It is my proud privilege to present the 55th Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 2004-05. This period has been a year of great excitement and satisfaction. Like previous years, Laboratory continued to bring a sharp focus to the requirement of our customers and we renewed an effort to tailor our R&D activities to suit these requirements in offering our R&D products, processes, consultancy and technical services.

Under the CSIR Network Programme, NML has been participating and contributing with its involvement in 63 ongoing activities, within the 14 major Network projects relevant to the laboratory. These projects include: Bioprocessing of lean grade ores/concentrates/wastes and bioremediation of effluents and acid mine drainage; New Building construction materials and technologies for sustainable development; Computational mechanics for modelling analysis and design of high performance structures, materials and process applications; Developing capabilities in advanced manufacturing technologies; Catering to development of specialized aerospace materials; Custom tailored special materials; Coal Resource Quality Assessment for specific end users; Quality Enhancement of coal for its efficient utilization; Capacity building for coastal placer mineral mining; Environment friendly leather processing technology; Upgradation of SI base units, National standards of measurement and Apex calibration facilities and creation of high quality network of testing and calibration laboratories and preparation & dissemination of certified reference materials; Industrial waste minimisation and clean up; Design analysis and health assessment of special structures including bridges. Further NML has also been participating in three projects relating to Information Science and products where NISCAIR as the nodal agency and NML as one of the participating member. These are National Science Digital Library, Traditional Knowledge Digital Library, and e-Journal Consortium. All the activities under these network projects are progressing as per schedule.

In addition, through effective pursuance a network project on Technology for Engineering Critical Assessment (TECA) with NML acting as the nodal implementing Agency, sanctioned by the planning commission under the Tenth five year plan formally launched on 1st April 2004. The programme forms a major activity in one of the niche areas of NML to develop technologies for Engineering Critical Assessment (ECA) for the generic class of structures and components viz. pressure vessels and pipelines of the thermal and nuclear power plants, petrochemical and process industries airframes and aeroengine components infrastructural assets of the transportation industry, namely, concrete and steel bridges, railway wheels and railway tracks offshore structural components. The project also involves Engineering Critical Assessment for sub-structural and surface processes, signal and image processing techniques for damage assessment, sensor devices for surveillance. Seven other sister CSIR laboratories, namely, CRRI, New Delhi; RRL, Bhopal; NAL, Bangalore; SERC, Chennai; CGCRI, Kolkata; CBRI, Roorkee; CMERI, Durgapur and with IIT, Kharagpur and IGCAR, Kalpakkam in consultative capacities have been associated. The project is of three years duration and the total expenditure outlay for the project is Rs.14.98 Crores.



The work carried out in the first year of the programme has resulted in substantial output as reflected in the measurable performance parameters. Equipment and facilities of a total worth of about Rs 500 lakhs are in various stages of procurement and installation. 21 technical papers have been published in refereed journals, 17 papers have been presented, 12 technical reports have been prepared and copyrights have been filed for software based on the work being carried out under TECA. There have been 38 instances of industrials interactions that have taken place in the research areas being pursued under TECA, of which about 12 are already being formalised into externally funded projects. A few new areas of activities are being initiated at NML based on the requirements projected through TECA. These include wear and abrasion behaviour of industrial materials, radiography and image processing for 3-D defect characterisation and advanced NDE.

The progress of the two NML Mega projects - (1) Maximising blast furnace productivity with Indian iron ore with the financial support of Ministry of Steel, Govt. of India, under the Steel Development Fund scheme, and (2) Extraction of magnesium from indigenous raw material sponsored by Ministry of Mines, Govt. of India - have been quite encouraging.

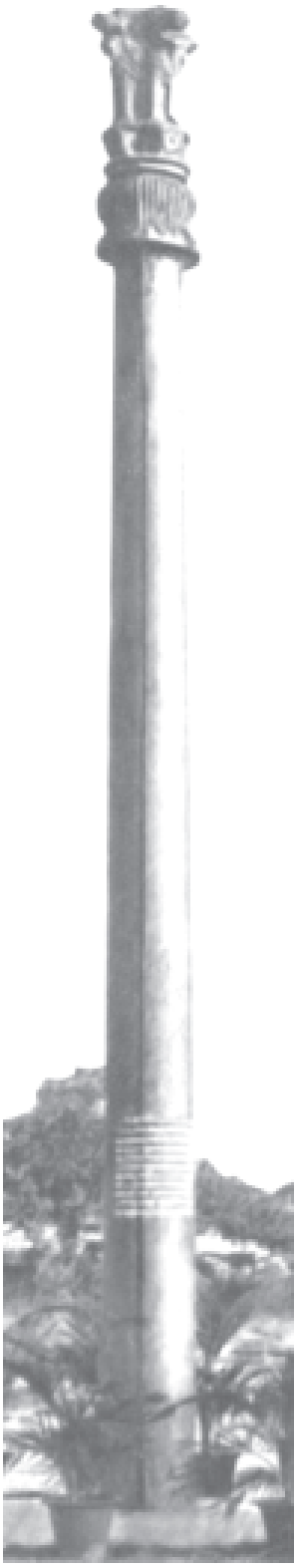
Under the Blast Furnace project, jointly with SAIL and Tata Steel, the principal objective is to develop a knowledge base for characterising the process dynamics of the blast furnace to improve blast furnace operations, hot metal quality and its productivity. Other collaborators in this project are IIT Bombay; IIT Madras; IIT Kharagpur; IIT Kanpur; CDAC Pune; and MECON Ranchi. Process models developed and validated with plant data are being further calibrated for implementation at plant(s).

Promising results have been obtained from the experimental activities under the project. A meeting of the Empowered Committee was held on 20th April 2005 at Udyog Bhavan, New Delhi where the progress of the work carried out was reviewed. It gives me great pleasure to share with you that three models have already been completed and two others are on the advanced stage of completion. These models will be tried in the designated blast furnaces of TISCO and Bokaro Steel Plant and once tested can be implemented in other blast furnaces as well. A workshop was organised on June 17th, 2005 at NML where representatives from steel plants, academia and R&D laboratories participated. An interactive two-day workshop also organised at Bokaro Steel Plant on September 14-15, 2005 for dissemination of knowledge developed on blast furnace.

On Magnesium extraction, a proto-type reactor for studying the extraction of magnesium from calcined dolomite was commissioned and operated. Experiments were carried out to investigate the influence of various operation parameters such as power supply, argon flow rate, and electrode immersion on the nature of the process. A thermodynamic model of the process was developed to describe the process. Based on the model predictions, experiments were carried out to control the level of impurities such as calcium, silicon and aluminium in the magnesium produced. It was demonstrated that the levels of these impurities could be reduced by controlling the process parameters.

The New Millennium Indian Technology Leadership Initiative project on 'Improved Granular Processing : Towards Energy Efficiency in Cement Manufacture' has been progressing well. The monitoring committee of the NMITLI project in its meeting on March 30, 2005, reviewed the progress of the project and expressed satisfaction on the progress and direction of research work. The project is extended for one year with a fresh mandate to revalidate the results on fly ash containing cements for three fly ash samples from different sources spread all across the country. Work done under the project on the hydration of mechanically activated blast furnace slag has been recognised for its novelty by a prestigious international journal. As an offshoot of this project, interesting work has been initiated by the Lab in the area of geopolymer. Geopolymer exceeding 120 MPa strength have been prepared first time using mechanically activated fly ash.

I would like to mention here that our Madras Centre has undertaken a project under CSIR's NMITLI programme on 'Hydrogen energy towards the development of anode, cathode and electrolyte materials for intermediate temperature solid oxide fuel cell' and finally the assembly of a single cell to work in the temperature range 600-800°C. The objectives of this project include in addition to the development of an electrochemical cell, basic studies on material compatibility through phase equilibrium measurements and studies on the stability of these materials in aqueous and nonaqueous suspensions



and its implication on electrophoretic deposition of cathode and electrolyte layers on anode substrates.

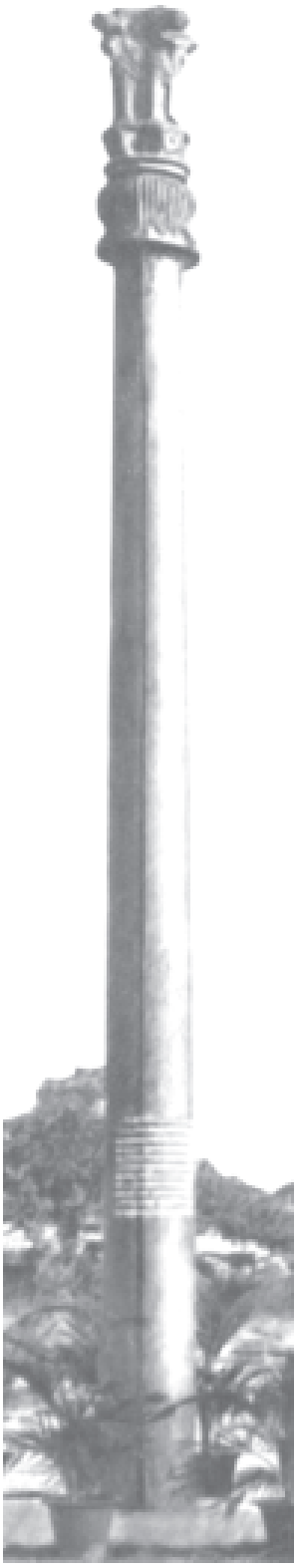
In the strategic sector, work on the 'Processing of Polymetallic Sea Nodules' project, sponsored by Department of Ocean Development (DOD), Govt. of India, has been in progress. The ongoing activities are aimed to separate and recover Cu, Ni and Co from leach liquor of sea nodules by bulk sulphide precipitation-chloride leaching-solvent extraction - Electrowinning route. Shri P. K. Biswas, Advisor, Planning Commission, Government of India along with Shri S. K. Das, Advisor, DOD, and Dr. P. K. Sen, GM, Engineers' India Ltd., New Delhi visited NML in May, 2005 to review the progress on the project entitled 'Polymetallic Sea Nodule' and gave valuable inputs. A Standing Committee Meeting, Chaired by Dr. M. S. Nagar, Former CMD, Indian Rare Earths was held at NIO, Goa in the month of June to review the progress achieved for the period January to June, 2005. The Standing Committee expressed its satisfaction for the work carried out at NML.

The laboratory continued to work on its thrust area - 'The Component Integrity Evaluation Programme (CIEP)'. The emphasis has been to solve industrial problems through failure analysis, remaining life assessment, non-destructive evaluation and stress analysis. During the year 2004-05, several sponsored specific projects were completed. Some of the notable beneficiaries include - Madras Fertilizer Ltd., Chennai; Central Power Research Institute, CMERI, Durgapur; Tata Steel; Bongaigaon Refinery & Petrochemicals Ltd.; IQC Training and Services Ltd., Chennai; Indian Air Force; Mailam India Ltd., Pondicherry; Energo Tech, New Delhi; National Thermal Power Corporation Ltd.; Satluj Jal Vidyut Nigam Ltd., Jhakri; and Jindal Steel & Power Ltd. Under CIEP, several projects are also going on as per schedule. Mentioned may be made of the works like - Failure Analysis of drain lines at GAIL plant, Lakwa; Creep Rupture and LCF Testing for Indira Gandhi Centre for Atomic Research; Evaluation of Fatigue and fracture behaviour of narrow gap pipe weldments of similar and dissimilar Metals for Bhabha Atomic Research Centre; Investigation of samples of JSPL for Jindal Steel & Power Limited; Accelerated Creep Testing of Cr-Mo steel Grade for Indian Seamless Metal Tubes Ltd, Pune; Residual Stress Measurement for radial gates for Alstom, Vadodara; Accelerated Stress Rupture Test on Boiler Tubes for IQC Training and Services Pvt. Ltd, Chennai; Study on ductile fracture of piping material for Bhabha Atomic Research Centre, Mumbai; Non-Destructive microstructural assessment of 1st stage bucket of GT for National Thermal Power corporation; Accelerated Creep Rupture Test of NTPC Vindhyachal Unit for Thermax Babcock & Wilcox Ltd., Pune.

Advanced NDE Centre for Infrastructure Asset Management is being established at NML with grant from the Department of Science & Technology. The total cost of the project is Rs. 1309.20 lakhs with contribution from NML to the tune of Rs. 949.20 lakhs.

The second Facility Management & Advisory Committee (F-MAC) for this project was held at New Delhi on May 18, 2005 chaired by Dr.Bladev Raj. The meeting was followed by two workshops. The first one was intended for the petrochemical Industries. About 20 participants from various oil industries took part in the workshop. Shri A.K.Mehta, F-MAC member and Ex-GM, of IOC-R&D Centre, Faridabad pointed out the need of newer NDE techniques relevant to petrochemical Industries. It was decided to form two Task Forces on 'Time of Flight Diffraction (TOFD) Technique' and on 'Acoustic Emission (AE) Technique' to disseminate to the user industry about the technologies available with the Indian groups and also to infuse synergy amongst various groups to utilize their strengths. The second workshop was meant for Railway industries. Shri K.P.S. Verma, Executive Director-RDSO, and Member of F-MAC took the lead to bring together the Railway industry representatives and NDE research groups on one platform. Shri P.N. Garg, Chief Commissioner of Railway Safety pointed out areas like fracture of railway wheel, RLA assessment of bridges needs special attention for development of newer NDE techniques. He also suggested for organising another Joint Workshop of Railways with NDE Experts.

A large number of characterisation, processing and software facilities have been acquired and/or installed by NML during the reporting period to facilitate our R&D programmes. A few prominent amongst these are: (i) Integrated SEM-EBSD-EDS microscope, (ii) Laser Ablated ICP-OES, (iii) FTIR, (iv) Laser Extensiometer, (v) Zeta Probe Analyser, (vi) Slow strain rate and corrosion testing system, (v) Atomic Absorption Spectrometer, (vi) Grinding station with vibrating mill, (vii) Screening vibrating probe, (viii) Microwave Lab-station for synthesis, (ix) X-ray analytical microscope, (x) Elemental CHNSO



analyser, (xi) Up-gradation of ATS creep testing machines, (xii) Accessories for fatigue testing machines, and (xiii) X-ray generator. The Internet bandwidth of the laboratory was insufficient and the scientists were facing hardship for downloading papers and sending manuscripts for publication. Necessary initiatives were taken for the enhancement of the bandwidth from present shared 64Kbps to shared 2Mbps.

During the reporting year, 10 Grant-in-Aid projects, 35 Sponsored projects, 2 Consultancy projects, 3 Collaborative projects, and 12 S&T Service projects were completed. Likewise, 36 Grant-in-Aid Projects, 24 Sponsored projects, 4 Consultancy projects, 5 Collaborative projects, and 3 S&T Service projects are ongoing.

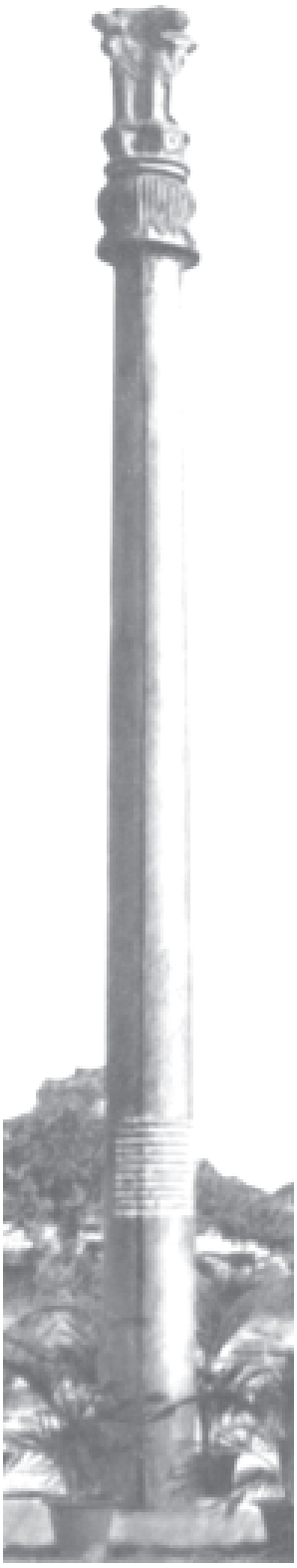
During 2004-05, two processes, i.e., (i) Process optimisation for extraction of nickel from a spent catalyst, and (ii) Biomimetic technology for the synthesis of nanosized hydroxyapatite powder were developed. Further, twelve MoUs were signed with fourteen parties, namely - NRDC, New Delhi; CECRI, Karaikudi; NPL, New Delhi; NCL, Pune; CGCRI, Kolkata; IIP, Dehradun; BARC, Mumbai; Meghalaya State Electricity Board, Shillong; Indian Ocean Garnet Sands Co. Pvt. Ltd., Tuticorin; Indian Rare Earths Ltd., Orissa; Eucare Pharmaceuticals Pvt. Ltd., Chennai; Korea Institute of Geoscience & Mineral Resources of the Republic of Korea; Ambica Chemical & Industrial Corporation, Kolkata; and Test Metal Corporation, Kolkata With regard to the Intellectual Property Assets, 7 National and 11 International patents filed. 3 National and 5 International patents were granted. 4 copyrights were registered. Regarding research publications, in addition to 86 research papers in International Journals and 49 papers in National Journals, 11 papers in International and 2 papers in National Seminars / Symposia / Conference proceedings were published during 2004-05.

With the present change in the economic policy and greater emphasis on generating extra-budgetary resources, we have intensified our efforts to provide market oriented R&D Knowledge base support to Indian Industries. The industry is responding favorably and has begun to look towards us for critical inputs to remain competitive through improved quality, affordable price and value-added products. During the year 2004-05, NML's effective marketing drive could mobilise an extra budgetary sources worth Rs. 8.5 Crores.

During the year under review, NML achieved the ISO 9001: 2000 certification having successfully undergone upgradation audit. All newly reorganised divisions documented their procedures/activities for the fulfilment of the requirements of the Quality Management Systems of ISO: 9001: 2000. The surveillance audit was conducted by a newly appointed Certifying Body TUV Suddeutschland India Pvt. Ltd. and brought all the Divisions under the ambit of ISO 9001:2000.

NML Madras Centre has been awarded NABL accreditation for several of its testing and calibration activities. These include accreditation for chemical testing (analysis of iron, copper and aluminium alloys by AAS and OES), mechanical testing (Rockwell, Vickers and Brinell tests, microscopic tests for grain size, coating thickness, case depth and inclusion rating and testing of tiles), thermal calibration (thermocouples and RTDs from 0 to 1000°C) and mechanical calibration (onsite verification of hardness test machines). The calibration centre and the analytical chemistry centre at the main laboratory are also attempting to get NABL accreditation.

The functioning of a professionally managed organisation is facilitated by a master plan that defines its vision and objectives. Following this line, it has been felt necessary to prepare an R&D master plan and vision document for the NML. A number of meetings and brain storming sessions have been held in the laboratory to identify the niche areas to be pursued at NML to optimally utilise its manpower and infrastructure. For an R&D organisation like ours, the following aspects are identified as the essential parts of the vision document - (i) Identification of the areas in which R&D is to be pursued by the laboratory singly or in collaboration with other organisations (within the country and abroad) - in the short and long run, and (ii) Discussion on methodology (in terms of manpower deployment, infrastructure development and financial outlay) as to how the R&D activities should be pursued. The finalisation of the document on the master plan was somewhat delayed as we decided to first carry out a rigorous SWOT analysis for the laboratory - a scan of the internal and external environment is an important part of the strategic planning process. The master plan vision document has already been presented in the Research Council and is likely to be released soon.



Acting on the directive received from the CSIR for the identification of a research theme involving most of the scientists of the laboratory, a series of intense introspective meetings were conducted. Taking into consideration industrial and national relevance, growing market demands, the laboratory's research tradition, research appeal and scope for allround participation, a proposal 'Development of technologies for light metallic materials' was prepared for the approval of the Research Council as the Supra Institutional Project of NML. Within the scope of this proposal are forays into alternate extraction routes for light metals, beneficiation of low-grade ores, value additions to light metal alloys through advanced processing, forming and alloying. Mathematical modelling activities under this project include creation of virtual platforms for alloy selection and processing.

Several prestigious awards and recognitions have come to NML Scientists. These include CSIR Young Scientist Award-2004 Silver Medal of the Mining, Geological and Metallurgical Institute of India, Calcutta; Metallurgists of the Year Awards of Indian Institute of Metals for the year 2004; and MRSI Medal for the year 2005.

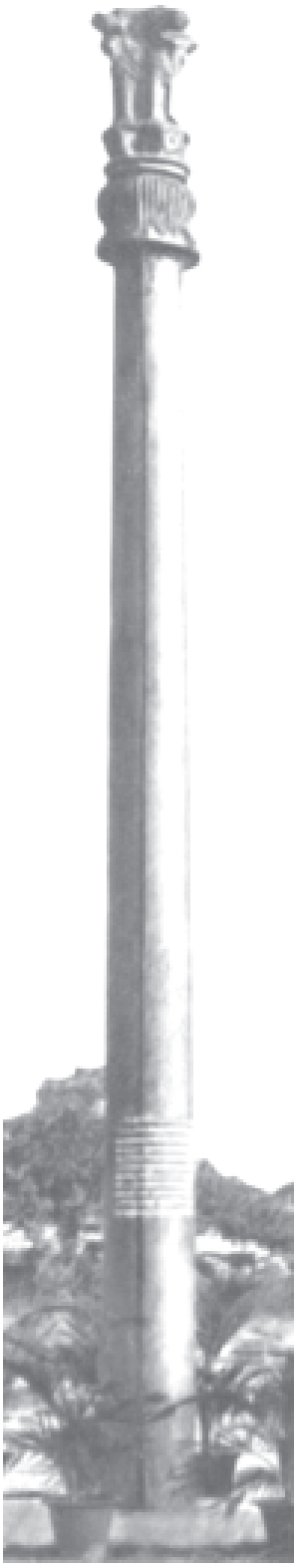
During the reporting year, 102 NML staff members had undergone training outside as well as inside the laboratory and 375 personnel sponsored by outside agencies were imparted training at the laboratory. Seven Scientists were on foreign deputation and two obtained Ph.D. degrees. Three National Seminars/ Workshops were organised, namely, (i) Corrosion, Failures and Mitigation (CFM-2004), (ii) Amorphous & Nanocrystalline Materials: Synthesis and Characterisation, and (iii) Prevention of Corrosion in Steel Structures (PCSS-04). Further, one National Seminar in Hindi on the topic 'Water: Conservation, Purification and Harvesting' was also organised. Several other regular events like - National Technology Day; Hindi Diwas; CSIR Foundation Day; National Metallurgists' Day; CSIR Programme on Youth for Leadership in Science were celebrated. A meeting of the Committee constituted by the Chairman, Research Council for the representatives of Industry, Academia and R&D laboratories of Eastern India under the chairmanship of Director, National Metallurgical Laboratory was convened on 25th January 2005. Nine members from various organisations deliberated on two issues: (i) Purchase and utilisation of equipment for research purposes, particularly in terms of avoiding duplication in order to make optimum utilisation of limited funds, and (ii) Ability to recruit scientists at entry level, given the competition that the metallurgical industry is facing from sectors like IT.

All the members representing various sectors felt both the issues to be of vital importance for the growth of metallurgical sector. The strategy was to address both the issues jointly and a 'three-link chain' business model was proposed. The first link comprising to industry-academia-R&D organisations would initially try to understand the problem and propose a working model. The second link of the chain would be that of industry-R&D organisations, which would develop the prototype based on the proposed model and the last link of the chain would be respective marketing groups.

NML participated in India International Trade Fair held at Pragati Maidan, New Delhi during November 14-27, 2004. The exhibits were also supported by models. More than 6500 visitors comprising students, teachers, R&D workers, entrepreneurs, industrialists and dignitaries visited the stall and showed interest in various NML technologies, facilities and in-house publications. The main theme of the exhibition was to focus on knowledge base for medium and small-scale industries.

NML celebrated its Foundation Day on 25th November, 26th November being a holiday. The Chief Guest for the occasion was Dr. R. Chidambaram, Principal Scientific Advisor to the Government of India. Dr. Chidambaram in his lecture presented the human face of atomic energy and very vividly talked about the rural programmes initiated by the Atomic Energy Commission. This day was celebrated with an open house function for school children where hundred children from fifteen different schools participated in interactive sessions with the scientists of the laboratory. Breaking from the tradition, this year it was decided to celebrate the Foundation Week with equal and considerable participation of the family members of the staff. The celebrations included a Quiz Competition, Sports Day functions and a Cultural Evening.

The quiz competition was keenly contested by 36 threemember teams comprising of a male member, a lady member and a child. Sports day was organised on 20th November and about 200 participants joined in the 26-event sports day. A grand cultural evening was organised on 26th November by the

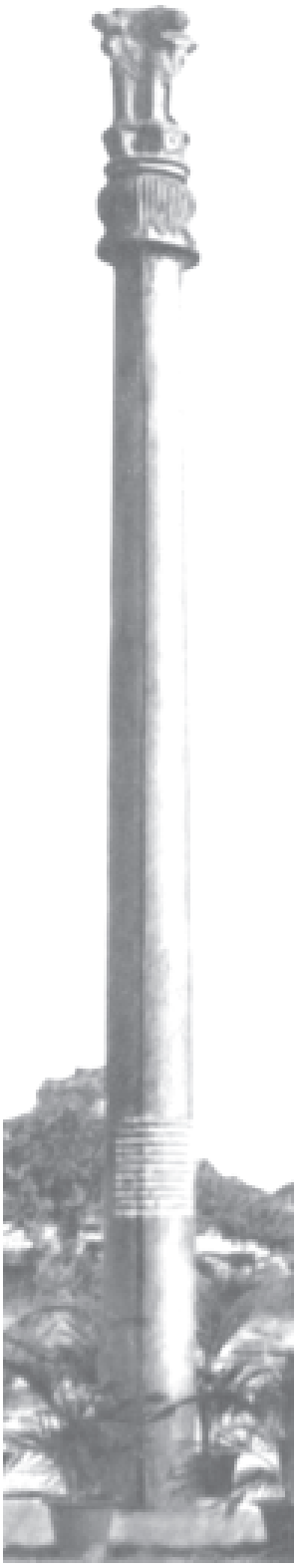


Staff members and their spouses. The cultural evening was attended and appreciated by around 800 members of the NML family.

Director General, CSIR, Dr. R.A. Mashelkar visited NML on April 10, 2004. Dr. Mashelkar inaugurated the newly installed Atomic Force Microscope in the laboratory. An exhibition depicting the ongoing R&D at the Laboratory was organised at the NML Auditorium Foyer. I take this opportunity to express our sincere thanks and gratitude to him for his guidance and continuous support in all our endeavors. I also gratefully thank Chairman of our Research Council, Shri B. Muthuraman, and all RC members for the interest that they take in NML's activities, their very constructive suggestions and timely guidance.

I sincerely hope, with the total involvement of all my colleagues at NML, we shall maintain the impressive growth in our R&D activities and contribute even more to the growth of the industry in the years to come.

Prof. S.P. Mehrotra
DIRECTOR

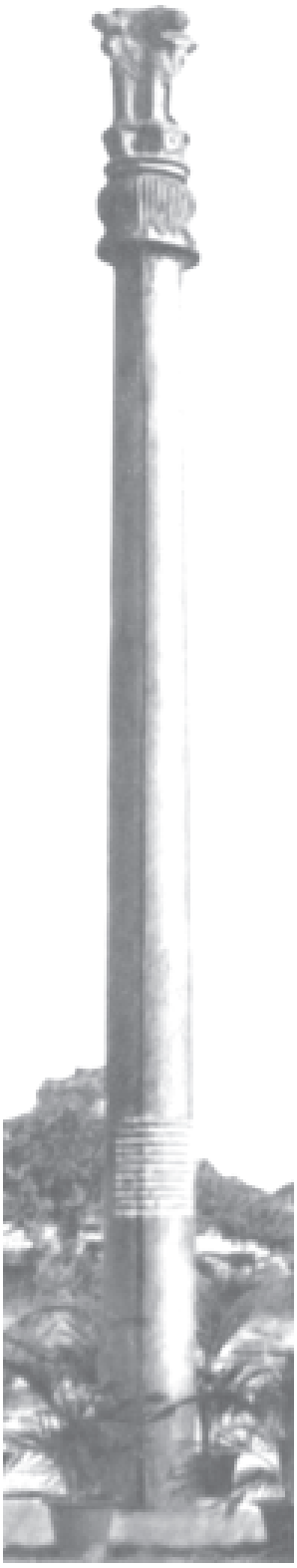


2005 - 06

It is my proud privilege to present the 56th Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 2005-06. I am glad to share with you the progress of various R&D activities and events pertinent to the laboratory during the reporting period. Overall, the period has been a year of great satisfaction.

Under the CSIR Network Programme, NML has been participating and contributing in 63 ongoing activities, within the 14 major Network projects relevant to the laboratory. These projects include: Technology for Engineering Critical Assessment (TECA); Bioprocessing of lean grade ores / concentrates / wastes and bioremediation of effluents and acid mine drainage; New Building construction materials and technologies for sustainable development; Computational mechanics for modelling analysis and design of high performance structures, materials and process applications; Developing capabilities in advanced manufacturing technologies; Catering to development of specialized aerospace materials; Custom tailored special materials; Coal Resource Quality Assessment for specific end users; Quality Enhancement of coal for its efficient utilization; Capacity building for coastal placer mineral mining; Environment friendly leather processing technology; Upgradation of SI base units, National standards of measurement and Apex calibration facilities and creation of high quality network of testing and calibration laboratories and preparation and dissemination of certified reference materials; Industrial waste minimization and clean up; Design analysis and health assessment of special structures including bridges. Further NML has also been participating in two projects relating to Information Science and products with NISCAIR as the nodal agency and NML as one of the participating members. These are National Science Digital Library, and e-Journal Consortium. All the activities under these network projects are progressing as per schedule.

The network project 'TECA' has been progressing well with NML acting as the nodal implementing agency. Seven other sister CSIR laboratories, namely, CRRI, New Delhi; RRL, Bhopal; NAL, Bangalore; SERC, Chennai; CGCRI, Kolkata; CBRI, Roorkee; CMERI, Durgapur along with IIT, Kharagpur and IGCAR, Kalpakkam in consultative capacities are associated with the project. The work carried out in the second year of the programme has resulted in substantial output as reflected in the measurable performance parameters. 41 technical papers have been published in refereed journals, 27 technical papers have been published in proceedings, and 4 copyrights and 2 patents have been filed. The emphasis of research activities being carried out under TECA has been to work on issues directly pertinent to user industries. Contacts with industries have resulted in spin-off sponsored projects of total worth of Rs 622.96 lakh. NML is undertaking 25 sub-activities under TECA. A few of the important outcomes that are the result of NML's activities are: (i) Conceptual design for a portable ball indentation apparatus for in-situ determination of mechanical properties of in-service equipment; (ii) Development of magnetic non-destructive evaluation system for microstructural degradation of components at elevated temperatures; (iii) Development of rejuvenation protocols for nickel base superalloys GTD-11 and Hastelloy-X, and cobalt base superalloy FSX-414 used in aero- and gas-turbines; (iv)

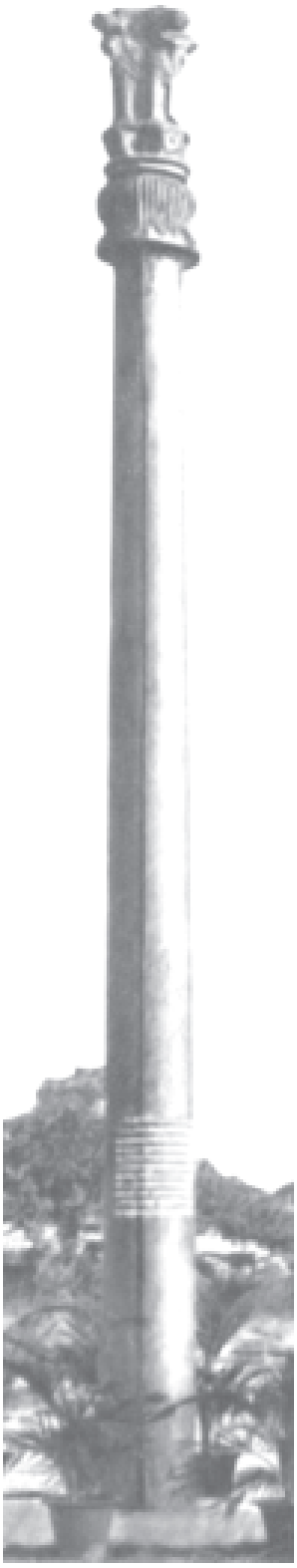


Development of a software for the prediction of erosion rate in boiler components, and (v) Fractal based structure-property correlation of engineering materials and components.

The monitoring committee constituted by CSIR carried out the second and third reviews of 'TECA' on September 23-24, 2005 and May 23-24, 2006 under the chairmanship of Dr. Placid Rodriguez, AICTE-INAE Distinguished Visiting Processor, IIT Chennai. Dr. P.K. Biswas, Advisor, Planning Commission, and an important link between CSIR and the Planning Commission, was invited to participate in the third review meeting. Members of the Monitoring Committee appreciated the plan of implementation of the project and the quantum of work achieved since the inception of the project. A large number of facilities and equipment worth approx. Rs. 500 lakhs have been procured at NML under the project. As part of a special review exercise for all the TFYP network projects of CSIR, TECA was reviewed by Dr. R.A. Mashelkar, DG-CSIR, on March 23, 2006. Dr. Mashelkar was also very appreciative of the implementation strategy and output of the programme, and opined that some of the activities should be logically followed up in the Eleven Five Year Plan (EFYP) period.

NML has also significantly contributed in other 13 ongoing CSIR Network projects. Custom-tailored materials has resulted in superhard TiB_2 reinforced Al_2O_3 composites which were prepared in-situ by SHS dynamic compaction technique and revealed extraordinary hardness values. Similarly, through bio-mimetic processing, high strength polymer-Hydroxyapatite composites have been developed, which have a good potential for application in tissue engineering and biological valves. In another programme, active brazing alloy paint has been developed for ceramic to ceramic joining. NML has networked with CMERI to develop a squeeze casting system, for which the design has been frozen and will shortly be fabricated. NML's initiative at production of wide ferromagnetic metallic glass ribbon has seen the indigenous design of the complex rapid solidification set up, followed by "made to order" fabrication of the system which has now been completed. Our programme to delineate the mode of occurrence and distribution of precious and rare metals in high sulphur coals and their pyritic wastes and to explore their recovery, has led to an understanding of the mode of occurrence and gold content. We have enriched some fractions with >5 ppm gold which can be considered as a source for the noble metal. In the same project, the presence of Gallium in significant quantities in the high ash fractions has been confirmed. NML, along with four other sister laboratories, is involved in the development of a general purpose finite element software package "FINEART" which is undergoing various testing procedures, verification and benchmarking with other commercial software packages. FINEART has adaptive meshing capability and would cost about 20 times less than a high end commercial FE package. Similarly, progress of other CSIR Network projects undertaken by laboratory are also quite encouraging.

Under the New Millennium Indian Technology Leadership Initiative (NMITLI Project) on "Improved Granular Processing: Towards Energy Efficiency and Resource Conservation in Cement Manufacture: Mechanochemical Activation in Improved Blended Cement Processing", the results obtained so far have been reproduced and revalidated using three fly ash samples from different sources. The combinations of mechanically activated fly ash and non-activated fly ash in the Portland pozzolana cements have also been evaluated for more effective use of milling device. An interesting offshoot of this project has been the development of fly ash based geopolymers. New types of self-glazed tiles conforming to European Nation (EN) specifications have been produced at temperatures below 100°C . Geopolymer pavement tiles have also been developed from fly ash using cold setting process. These tiles have exhibited much higher compressive strength compared to conventional cement based pavers. The project was successfully completed on March 31, 2006. The achievements of the project were reviewed in joint meetings of the Monitoring Committee and Steering Committee in January 2006 and again in April 2006. Both the Committees unanimously expressed their satisfaction that the mandate of the project, i.e., development of technology to increase the utilisation of BF slag from 40 to 80% and fly ash from 25 to 50% in blended cements, was fulfilled in terms of 'proof of concept'. I am happy to inform that the findings of this prestigious mission oriented project are well received by the industry in India and abroad. Grasim Industry (Cement Division) has shown keen interest to work jointly with NML, on an exclusive basis, for further development of the technology on Portland Pozzolana Cement (PPC) based on mechanically activated fly ash. In another interesting development, SWS Steinwerk Schelklingen GmbH & Co. KG, Germany, has approached NML for collaboration on its technology on reactive blast furnace and Portland Slag Cement. The letter of intent, sent by the German firm is being examined by NML for finalization and initiation of the work.



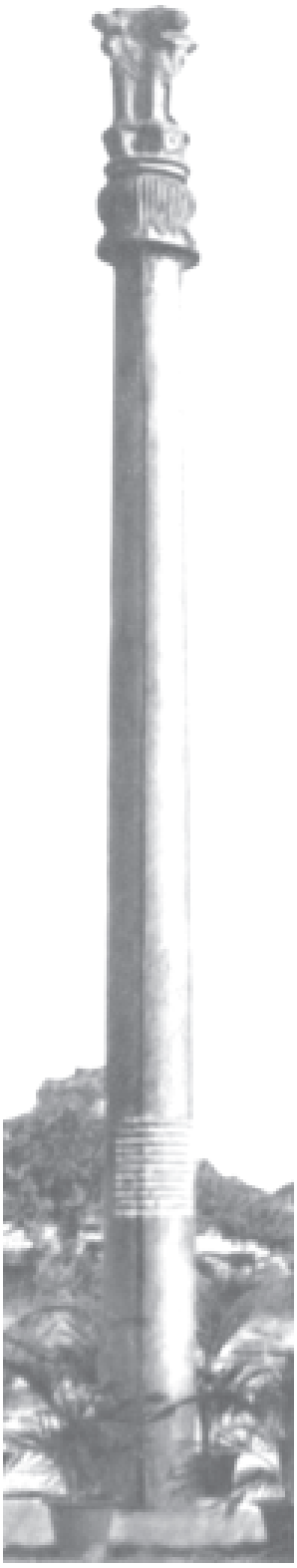
The other NMITLI project on Intermediate Temperature Solid Oxide Fuel Cell (ITSOFC) is being pursued at NML Madras Centre. Pure single-phase lanthanum cobaltite (LCO), lanthanum ferrite (LFO), lanthanum gallate (LGO) and Sr-doped lanthanum cobaltite (LSC), lanthanum ferrite (LSF), and lanthanum gallate (LSG), which are to be used in the fuel cell, have been successfully prepared by different routes. The synthesis conditions have been optimized to yield high surface area and very low particle size to enable the preparation of colloidal suspensions for subsequent electrophoretic deposition. Studies on phase equilibrium, stability of colloidal suspensions and electrophoretic deposition are showing encouraging results. After evaluation of the various synthesis processes, the Pechiney process has been adopted for bulk synthesis to obtain phase purity and small particle size. The stability of the synthesized powder in aqueous suspension has been characterized by zeta potential and rheological measurements. Studies on the stability in non-aqueous suspensions are in progress. The electrophoretic deposition process for the electrolyte on anode substrate has been standardized while studies on the electrical conductivity of the perovskite oxides and the assembly of a single cell are in progress.

The progress of the two NML Mega projects - (1) Maximizing blast furnace productivity with Indian iron ore with the financial support of Ministry of Steel, Govt. of India, under the Steel Development Fund scheme, and (2) Processing of Polymetallic Sea Nodules sponsored by Department of Ocean Development, Govt. of India - have been quite encouraging.

Under the Blast Furnace Project, technology for improved operation of blast furnaces has been developed through comprehensive process models, validation of models using state of the art experimental facilities and their integration in a real-time process simulator (RTPS). The models and the RTPS have been tuned and installed at Bokaro Steel Limited (BSL), BF No.5. In order to disseminate the knowledge gained in this project, a workshop on 'Blast Furnace Modelling and Real Time Simulation' was jointly organized by NML, BSL, and RDCIS at Bokaro during October 19-20, 2005. About eighty participants from nine different steel plants and representatives from the Ministry of Steel attended the above workshop. Attempts are underway to install the models-RTPS at Tata Steel, BF 'F'. Request has also been received for implementing the technology at BSP, Bhilai. Accordingly, hands-on demonstration of the process models as well as the RTPS were organized at BSL, Bokaro, during February 16-17, 2006, April 6-7, 2006, and June 27-28, 2006. Representatives from RDCIS-Ranchi, BSL-Bokaro and BSP-Bhilai actively participated in the programme. The project is treated as completed on March 31, 2006. The completion report which includes contributions from RDCIS-SAIL and Tata Steel, has been submitted to the sponsoring agency - Ministry of Steel.

In the DoD sponsored project on Polymetallic sea nodules, the current focus is on the utilization of leach residue generated in the processing of sea nodules. A novel two stage smelting process has been developed to recover manganese as ferro-silico-manganese. A pilot plant to process 350 kg/ day leached residue has been set up. The Department of Ocean Development, Govt. of India, in its Standing Committee Meeting on December 19-20, 2005 at NCARO, Goa, appreciated NML's achievements and progress in the project. A Standing Committee Meeting of the Ministry of Ocean Development (MoD) on "Polymetallic Sea Nodule Programme" in India was held at NML, Jamshedpur during April 28-29, 2006. The meeting was chaired by Dr. M.S. Nagar, former CMD, Indian Rare Earths. The other members present were Dr. T.K. Mukherjee, Advisor to Director, BARC, Dr. B.K. Saha, Dy. D.G., GSI, Prof. P.K. Sen of IIT, Kharagpur and Dr. M.P. Wakdikar of MoD. Shri P.K. Biswas, Advisor, Planning Commission was the special invited guest for the meeting. Various R&D organisations like RRL (Bhubaneshwar), NIOT (Chennai), HZL (Udaipur) and NML presented their work on technology development on processing of sea nodules, exploration, mining of sea nodules etc. The committee was satisfied with the progress of the work at NML. The Standing Committee members also visited the newly built-up ferro-silico-manganese pilot plant for leached sea nodule residue treatment.

The laboratory has continued to work on its thrust area - 'The Component Integrity Evaluation Programme'. The emphasis has been to solve industrial problems through failure analysis, remaining life assessment, non-destructive evaluation and stress analysis. During the year 2005-06, several sponsored specific projects were completed. Special mention may be made of the works like - Failure Analysis of drain lines at GAIL plant, Lakwa; Creep Rupture and LCF Testing for Indira Gandhi Centre for Atomic Research; Evaluation of Fatigue and fracture behaviour of narrow gap pipe weldments of



similar and dissimilar metals for Bhabha Atomic Research Centre; Investigation of samples of JSPL for Jindal Steel & Power Limited; Accelerated Creep Testing of Cr-Mo steel Grade for Indian Seamless Metal Tubes Limited, Pune; Residual Stress Measurements for radial gates for Alstom, Vadodara; Accelerated Stress Rupture Test on Boiler Tubes for IQC Training and Services Pvt. Limited, Chennai; Study on ductile fracture of piping material for Bhabha Atomic Research Centre, Mumbai; Non-Destructive microstructural assessment of 1st stage bucket of GT for National Thermal Power corporation; Accelerated Creep Rupture Test of NTPC Vindhyachal Unit for Thermax Babcock & Wilcox Limited, Pune and many more.

The results of the sponsor specific R&Ds are also quite encouraging. ISRO's Space capsule Recovery Experiment (SRE) envisages the development of a 600-kg recoverable satellite as a co-passenger of Cartosat-2 on board PSLV. After its launch by PSLV, SRE will remain in orbit for a few days during which it will be used to perform two materials science experiments in micro-gravity environment. The on board experiment on "Effect of microgravity on the biomimetic synthesis of hydroxyapatite nanoparticles" has been conceptualized and designed by NML. The joint efforts of NML and Indian Satellite Application Centre-ISRO Bangalore over the last four years has led to the design and fabrication of a biomimetic pay load that has qualified as a flight model for SRE.

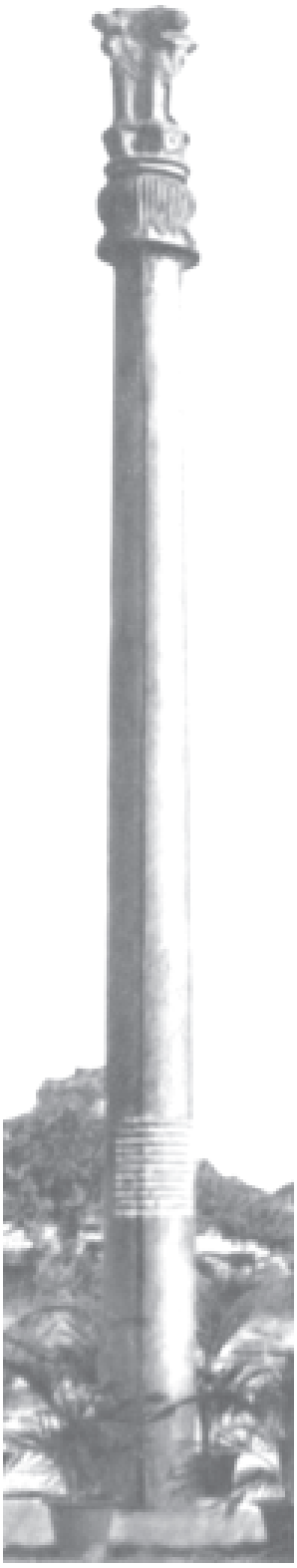
Another interesting finding of NML, I would like to mention, is the development of nano composite hard coatings. We have been able to achieve modulus and hardness of the order of 273 GPa and 44 GPa respectively for Si-C-N films whereas a hardness and modulus of 37 GPa and 500 GPa have been achieved for titanium diboride coatings on industrially important substrates such as silicon and steel. The film shows an appreciable (40%) elastic recovery after indentation. Surface studies show that the presence of different phases and bonds in the film controls the hardness of the film. That CN bond influences the mechanical properties of the film is established by XPS and nano-indentation studies. These coatings are potential materials for wear & oxidation resistance and high temperature applications.

Novel SHS processing technique to synthesize and also to in-situ densify depending on the requirement to fabricate very fine and nano ceramic monolithic and composite powders have been developed for high temperature, oxidation resistance and wear resistance applications. US patent has been granted for one and a patent has been filed for the other.

Yet another interesting finding is the development of non-linear ultrasonics, an upcoming non-destructive technique that has been used to study materials degradation. The potential of the technique in evaluating fatigue damage and to locate the position of failure much earlier to its occurrence has been established. The application of the technique in corrosion pitting study in aluminium alloy also is showing very exciting results.

Under the International collaborations programme, I had the opportunity to present a proposal on the setting up of a 'Indo-Russian Advanced Research Centre on Non-ferrous and Rare Metals (IRCNFRM)' to the Joint Council meeting of the Russian Academy of Sciences and DST held at New Delhi on November 7-8, 2005. Seventeen Russian institutes have agreed to participate in this initiative. The proposal was appreciated and accepted by the Joint Council, and DST has agreed to support the Centre at NML under the framework of Indo-Russian Long Term Programme (ILTP). A working document has been prepared in collaboration with Prof. A.I. Kholkin of Kurnakov Institute of General and Inorganic Chemistry (RAS), Moscow. In the recent past, the Laboratory has forged important international linkages and collaborations with: (1) Korea Institute of Geoscience & Mineral Resources (KIGAM) on 'The possibility of using low grade material to produce high quality Fe-Si-Mn alloy', and (2) Central Metallurgical Research and Development Institute, Egypt on 'Pelletization of magnetite ore fines to make them suitable for direct reduction'.

The Non-destructive evaluation (NDE) facility for Infrastructure Asset Management has been set up. The 3rd meeting of the Facility Management and Advisory Committee (FMAC) constituted by the DST to monitor the progress of the Facility was held on January 9, 2006 at NML. In pursuance of the recommendations of the Committee during its last meeting, a workshop on Electro-magnetic NDE Techniques for Materials Characterization (ENDEM-06) was organized at NML on January 10-11,



2006. About 50 delegates from various industries and research organizations participated in the workshop. On the recommendations of the oil industry two Task Forces were created. One on AET (acoustic emission testing) and the other on TOFD (time of flight diffraction) / IRIS (internal rotary inspection system) for condition monitoring of storage tank bottoms and hydro-crackers. A number of representatives from various oil industries presented their cases/problems in the meeting and expressed that there is a need of indigenous development of such techniques for condition monitoring of storage tank bottom and hydro crackers. NML has already taken initiative to develop these techniques for oil industry. The task forces have met, and a joint visit made to Mangalore Refinery and Petrochemicals Limited (MRPL) for AE monitoring during pressure testing of storage vessels. As an activity of the Facility, a joint inspection of a railway bridge was carried out by NML and CRRI, New Delhi, on the Delhi-Rewari rail link that was recently converted to broad gauge. The objective of the exercise was to ascertain the soundness of the weld joints. The work was carried out for Rail Vikas Nigam Limited, in collaboration with RDSO, Lucknow, and Northern Railway.

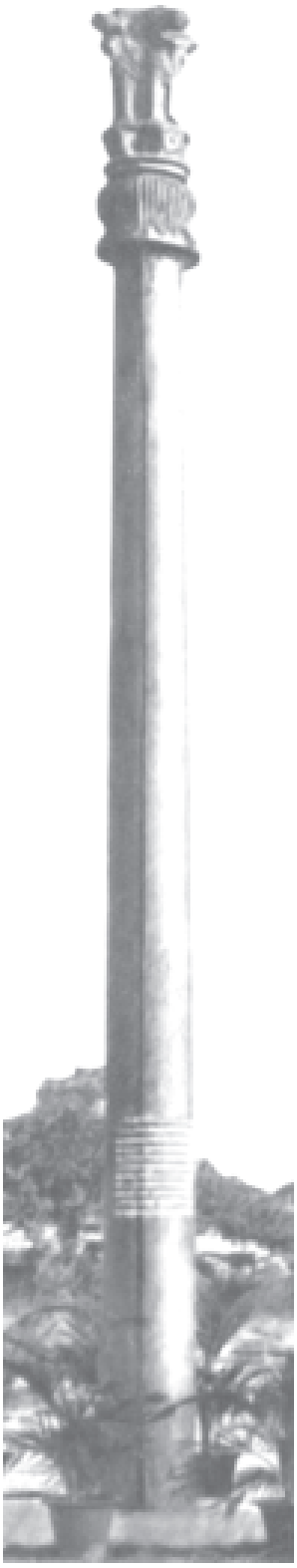
A large number of new R&D facilities have been acquired and installed during the reporting period to facilitate our R&D programmes. These include: (1) FTIR (Fourier Transform Infrared) Spectrometer (2) Modular Compact Rheometer - MCR 101 (Anton Paar, Germany), (3) High Temperature Chamber Furnace-HT 1800M (Linn High Therm GmbH, Germany), (4) Thermogravimetric Analyzer (Thermo Electron Corporation, USA), (5) Ion Selective Electrodes (Thermo Electron Corporation, USA), (6) Electrophoretic Deposition Set-up, (7) Toxicity, leaching, characterization, procedure (TCLP) equipment, Millipore (P) Limited, Bangalore. (8) Floatex Density Separator (9) A Carbon Coating Unit (10) High Power high Frequency Ultrasonic system (SNAP System), (11) Electromagnetic Acoustic Transducer RPR 4000, RITEC Inc., (12) Integrated SEM-EBSD-EDS system [Model Hitachi S-3400N]-HKL Channel 5 EBSD-Thermo Noran NSS-300], (13) Surface profilometer, adhesion strength testing instrument, and (14) Pilot Plant for Ferro-Silico-Manganese. Major renovation of erstwhile EMD Pilot Plant, Upgradation of the old AAS, have been carried out.

During the reporting year, 14 Grant-in-Aid projects, 41 Sponsored projects, 4 Consultancy projects, 4 Collaborative projects, and 2 S&T Service projects were completed. Likewise, 39 Grant-in-Aid Projects, 23 Sponsored projects, 4 Consultancy projects, 5 Collaborative projects, and 1 S&T Service projects are ongoing.

During 2005-06, 14 MoUs were signed, with the following organisations : (1) BARC, Mumbai, (2) Mainawati Steels Industry (P) Limited, Kathmandu, (3) Department of Mines, DST, Ministry of Steel, DGM-Govt. of Nagaland, (4) Jindal Steel & Power Limited, Raigarh, (5) Korea Institute of Geoscience & Mineral Resources (KIGAM), (6) Vikram Sarabhai Space Centre, Trivandrum, (7) Queen's University, Belfast, (8) Ashapura Minechem Limited, Mumbai, (9) Calcutta Electricity Supply Corp., Titagarh, (10) Ramakrishna Vivekananda Mission - Institute of Advanced Studies (RKVMIAS), Kolkata, and (11) M/s. Calpro Mineral Technologies Limited. After setting up the first industrial column at IRE, Chatarpur for sillimanite beneficiation NML has signed on MoU with M/s. Calpro Mineral Technologies (P) Limited, Salem to assist the latter in setting up flotation column to process low-grade limestone. Accordingly NML has designed 1.2 m dia flotation column fully automated to process 7.0 tph of low-grade limestone. Reverse flotation process i.e., flotation of gangue has been suggested to produce high-grade concentrates assaying 96% $CaCO_3$ and less than 1.0% SiO_2 in a single stage operation. Installation of flotation column has been completed and the initial trials are under progress.

With regard to the Intellectual Property Assets, 15 National and 5 International patents were filed. 3 National and 1 International patents granted, 3 copyrights registered, and 25 Patent applications renewed. Regarding research publications, in addition to 95 research papers in International Journals and 31 papers in National Journals, 27 papers in International and 7 papers in National Seminars / Symposia / Conference proceedings were published. Altogether, 160 research papers were published during 2005-06, out of which 115 papers were in SCI Journals, highest ever published in a single year.

With the present change in the economic policy and greater emphasis on generating extra-budgetary resources, we have intensified our efforts to provide market oriented R&D Knowledge base support to



Indian Industries. The industry is responding favorably and has begun to look towards us for critical inputs to remain competitive through improved quality, affordable price and value-added products. During the year 2005-06, NML's effective marketing drive could mobilize an extra budgetary resources worth Rs. 6.42 Crores.

During the year under review, NML achieved the ISO 9001:2000 certification having successfully undergone upgradation audit. All newly reorganized divisions documented their procedures/activities for the fulfillment of the requirements of the Quality Management Systems of ISO: 9001:2000. The surveillance audit was conducted by a newly appointed Certifying Body TUV Suddeutschland India Pvt. Limited, and brought all the Divisions under the ambit of ISO 9001:2000.

Several prestigious awards and recognitions have come to NML Scientists. These include MRSI Medal for the year 2005, NACE award for best corrosion research Laboratory of India, 2005, Raman Research Fellowship, Distinguished Engineer's Award, Misra Award for Best Technical Paper, Peravadhanulu Award, Tamotia Award on Environment, Wolfson Distinguished Award, IIME Best Paper award, National NDE Award, Mascot Award, and BOYSCAST fellowship.

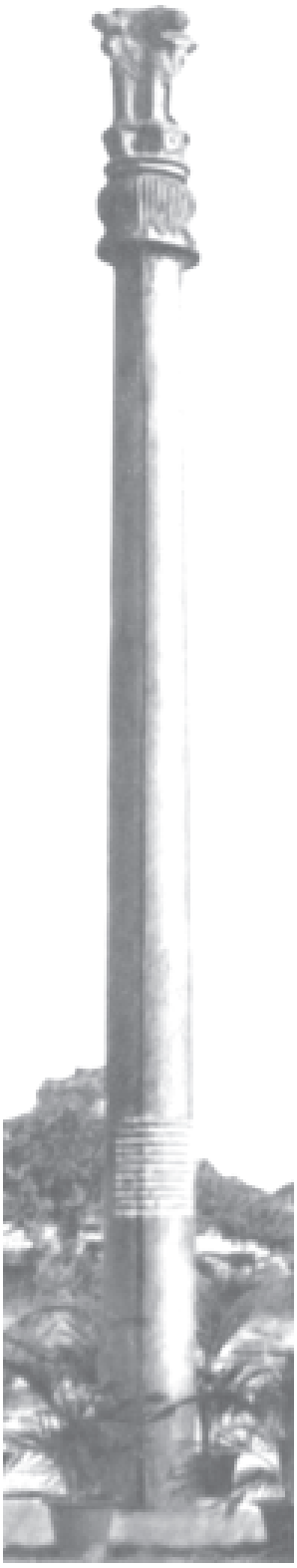
During the reporting year, 105 NML staff members underwent training outside as well as inside the laboratory, and 380 personnel sponsored by outside agencies were imparted training at the laboratory. Eleven Scientists were on foreign deputation and 4 obtained Ph.D. degrees.

NML organized a 5-day course on ‘Metallurgy for Engineers' (MFE 2005) during December 5-9, 2005. The laboratory has been organizing this Continuing Education Course in alternate year since 2001. MFE 2005 was attended by 42 participants from Industries, Academic Institutions and R&D Organization from different parts of the country.

NML and Tata Steel jointly organized the International Seminar on Mineral Processing (MPT-2006) under the auspices of the Indian Institute of Mineral Engineers (IIME). About four hundred delegates including forty five foreign dignitaries from fourteen countries deliberated on the challenges facing the mineral industry worldwide during this mega event held from March 8 to 10, 2006 at Hotel Taj Coromandel, Chennai. This conference provided a forum for the academic, research and industry professionals in India to interact with internationally renowned experts which included Prof. Eric Forssberg, Chairman of the International Mineral Processing Council, Prof. G. Onal, of Istanbul Tech. University and Chairman of the International Mineral Processing Congress and Prof. G.J. Jameson of University of New Castle, Australia and the inventor of famous Jameson Flotation cell. One of the highlights of the seminar was an Indo-Korean symposium on "Waste Recycling" organized jointly by IIME and Korean Institute of Geosciences and Resources (KIGAM) to commemorate the 30 years of existence of KIGAM. This symposium deliberated on different aspects of utilisation, and recycling of various industrial and electronic wastes, the two areas which NML is also pursuing vigorously.

During 2005-06 the Laboratory had the privilege of interacting with several internationally recognized experts in diverse fields of materials science and metallurgy. The distinguished visitors included: Prof. Ivoka Dragieva, Central Laboratory for Electrochemical Power Source, Bulgeria Academy of Science, Sofia, Bulgaria; Dr. A.K. Tyagi, Head, Solid State & Structural Chemistry, BARC Mumbai; Prof. G.S. Roonwal, Department of Geology, Delhi University; Prof. D.C. Jiles, Director, Wolfson Centre for Magnetics Technology, Cardiff University, U.K.; Prof. J. F. Knott, University of Birmingham, U.K.; Dr. Richard Davies, Oxford Nanoscience Limited, UK; Dr. Bhaskar Sengupta, Queens University, Belfast, U.K.; Prof. Narendra B. Dahotre, University of Tennessee, USA; Dr. C. W. Nam, Korea Institute of Geoscience & Mineral Resources, Korea; Prof. Varadarajan Seshadri, Universidade Federal de Minas Gerais, Brazil; Prof. N.Z. Lyakhov, Director, Institute of Solid State Chemistry & Mechanochemistry, SBRAS, Novosobrisk, Russia; Prof. T.R. Ramchandran, Emeritus Scientist, Nonferrous Technology Development Centre, Hydrabad (formerly Director JNARDDC, Nagpur), amongst others.

NML participated in the India International Trade Fair held at Pragati Maidan, New Delhi during November 14-27, 2005. The exhibits were also supported by models. More than 7200 visitors comprising students, teachers, R&D workers, entrepreneurs, industrialists and dignitaries visited the stall and showed interest in various NML technologies, facilities and in-house publications. The main theme of the exhibition was 'Knowledge base for medium and small-scale industries'.



Several regular events like - National Technology Day, Hindi Diwas, Vigilance Week, CSIR Foundation Day, CSIR Programme on Youth for Leadership in Science were celebrated. NML also celebrated its Foundation Day on November 26, 2005. The Chief Guest for the occasion was Prof. P. Ramachandra Rao, Director, Institute of Armament Technology, Pune and former Vice-Chancellor, Banaras Hindu University. The day was celebrated with an open house function for school children where more than hundred children from ten different schools participated in interactive sessions with the scientists of the laboratory. Like last year, this year also it was decided to celebrate the NML Foundation Week. The one week long Foundation Day celebrations included a Quiz Competition, Sports Day and a grand Cultural Evening. In all these events, a large number of NML family members participated enthusiastically and with joy. Several other Social events like Picnic, Cultural Evenings, Fate, Childrens' workshop and Get together on all major religious festivals were organized by the NML Staff Club and its Ladies' wing.

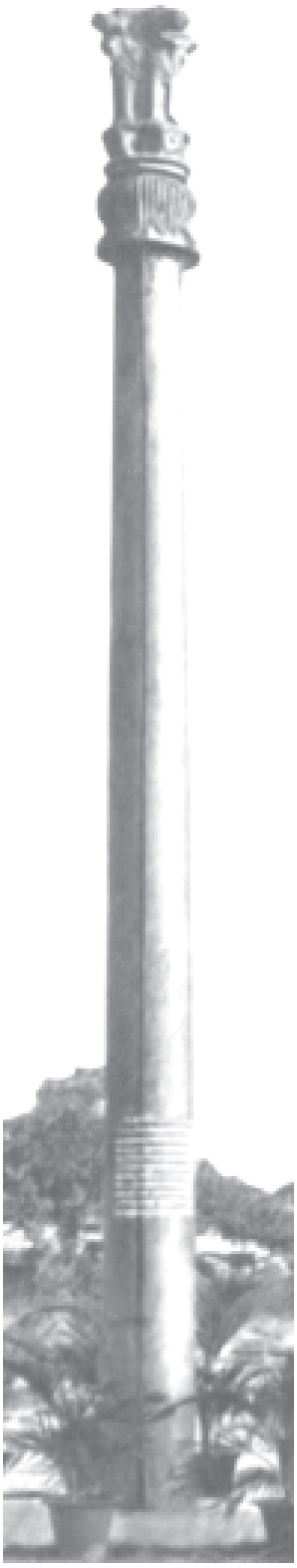
Having firmed up the vision document, the road map in materials research for this laboratory has been formalized. This happened at a very convenient time for almost immediate utilization in drawing up the research agenda for the Eleventh Five-year plan period. After prolonged and in-depth discussion among the scientists of this laboratory, the generic research programmes were drawn up and submitted to CSIR for consideration. To give further impetus to our long term plan and vision in the area of mechanical activation of solids, an advanced centre on mechano-chemistry has been proposed in the EFYP of the Laboratory. I am also happy to mention here that International Mechanochemistry Association has given NML the privilege to host the VI International Conference on Mechanochemistry and Mechanical Alloying (INCOME 2008) towards the end of 2008. In order to prepare its EFYP proposal DBT has formed a committee on Nanobiotechnology. The committee submitted its report to DBT and recommended for establishing four centres on Nanobiotechnology in the country. One of the centres on Biomimetics has been proposed to be set up at NML.

I take this opportunity to express our sincere thanks and gratitude to Dr. R.A. Mashelkar, Director General, CSIR for his guidance and continuous support in all our endeavors. I also gratefully thank Chairman of our Research Council, Shri B. Muthuraman, MD, Tata Steel and all RC members for the interest that they take in NML's activities, their very constructive suggestions and timely guidance.

NML has had a very satisfying and robust twelve months through the combined efforts of all its employees, not only in research and technological issues but also in the areas of cultural, sports and social acvitities.

I sincerely hope, we will continue to be an organisation with an impact on the materials and metallurgical future of our nation.

Prof. S.P. Mehrotra
DIRECTOR



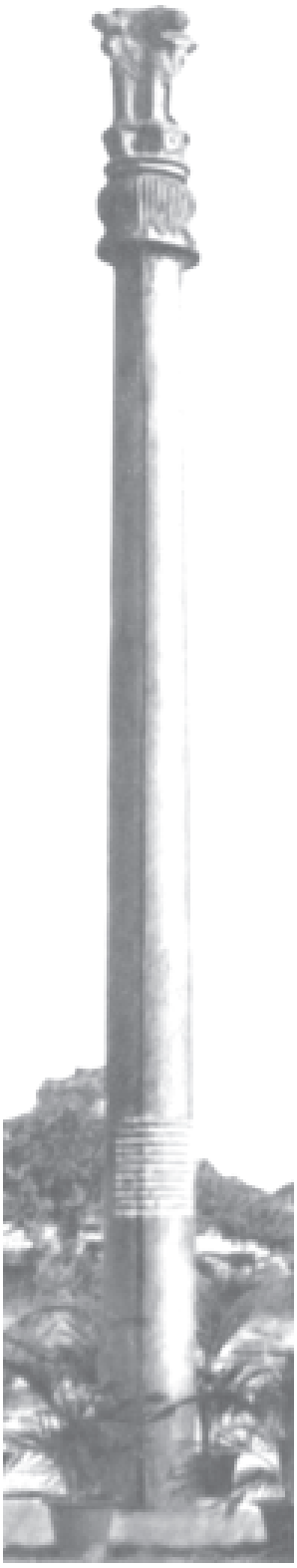
2006 - 07

It is my proud privilege to present the 57th Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 2006-07. This period has been a year of great excitement and satisfaction.

Like earlier years, Laboratory continued to prioritise the customers' need and renewed the effort to tailor our R&D activities to suit these requirements in offering R&D products, processes, consultancy and technical services.

Under the CSIR Network Programme initiated during theTenth Five Year Plan, NML participated and contributed towards 63 ongoing activities, within the 14 major Network projects relevant to the laboratory. These projects include: (1) Technology for Engineering Critical Assessment (TECA); (2) Bioprocessing of lean grade ores/concentrates/wastes and bioremediation of effluents and acid mine drainage; (3) New Building construction materials and technologies for sustainable development; (4) Computational mechanics for modelling analysis and design of high performance structures, materials and process applications; (5) Developing capabilities in advanced manufacturing technologies; (6) Catering to development of specialized aerospace materials; (7) Custom tailored special materials; (8) Coal resource quality assessment for specific end users; (9) Quality enhancement of coal for its efficient utilization; (10) Capacity building for coastal placer mineral mining; (11) Environment friendly leather processing technology; (12) Upgradation of SI base units, National standards of measurement and Apex calibration facilities and creation of high quality network of testing and calibration laboratories and preparation & dissemination of certified reference materials; (13) Industrial waste minimisation and clean up; (14) Design analysis and health assessment of special structures including bridges. All these network project completed as per schedule. Further NML has also been participating in two projects relating to Information Science and Products where NISCAIR as the nodal agency and NML as one of the participating members. These are - e-Journal Consortium and National Science Digital Library.

In the network project on Technology for Engineering Critical Assessment (TECA), NML has served as the nodal agency. Seven sister CSIR laboratories, namely, CRRI, New Delhi; RRL, Bhopal; NAL, Bangalore; SERC, Chennai; CGCRI, Kolkata; CBRI, Roorkee; CMERI, Durgapur along with IIT, Kharagpur and IGCAR, Kalpakkam, in consultative capacities have participated in the project. The three year project with a total expenditure outlay of Rs.14.98 Crores has resulted in several important outcomes : (i) Experimental quantification of high temperature fatigue behaviour of thermal barrier coated materials for gas turbine applications, (ii) Creation of data base on fatigue crack growth and fracture behaviour of primary heat transport piping materials of nuclear power plants, (iii) Design and fabrication of a portable automated ball indentation apparatus for in situ determination of mechanical properties of in-service equipment, (iv) Development of magnetic non-destructive evaluation system for microstructural degradation of components at elevated temperatures, (v) Development of rejuvenation protocols for nickel base superalloys GTD-11 and Hastelloy-X, and cobalt base superalloy FSX-414 used in aero- and gas-turbines, (vi) Development of a stochastic model based software for



the prediction of erosion rate in boiler components, (vii) Fractal based characterisation of fracture toughness of engineering materials, (viii) Development of a Non-linear Ultrasonic Technique for Damage Assessment, (ix) Enhancement of material performance by grain boundary character determination, (x) Software based life assessment and life management of critical components, (xi) Thermodynamics based predictions of high temperature oxidation and corrosion, and (xii) Use of acoustic emission monitoring for identification of fracture processes.

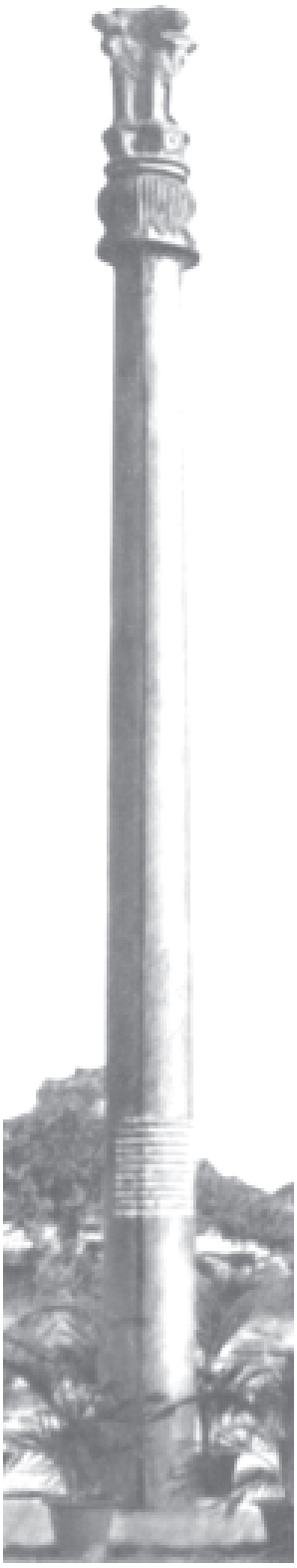
The R&D work carried out under TECA, led to 65 technical papers in refereed journals, 63 presentations in conferences, seminars and symposia, and filing of 6 copyrights and 3 patents. Through the training and supervision imparted during the course of implementation, 32 persons obtained higher qualifications, working on modules of activities carried out for the project. Equipment and facilities of a total worth of about Rs 500 lakh have also been created under this project.

NML has significantly contributed in other 13 CSIR network projects. I would like to mention a few where my colleagues contributed as major partners. In the project on 'Advanced Manufacturing Technology' our scientists have developed a technology for preparing about 30 mm wide and 30 micron thick continuous metallic glass ribbon through melt-spinning technique. The prepared materials have excellent soft magnetic properties in their nanostructured state and suitable for transformer cores and as sensor elements. Attempts are now being made to develop brazing alloys suitable for space application using the same technology. Under the network project on Custom tailored speciality materials, NML scientists have developed amorphous wire through in-water quenching technique which has high strength and is suitable for development of giant magnetoimpedance (GMI) materials. This material can be used for GMI-based sensor for NDE applications. Under the programme on Super hard materials, nano-carbon nitride and silicon carbonitride coatings, with 273 GPa and 44 GPa modulus and hardness, respectively, have been developed. Nano composites of boride, carbide and oxide based in-situ composites of 99% density have been successfully developed with SHS processing. Similarly, through bio-mimetic processing, high strength polymer Hydroxyapatite composites have been developed, which have a good potential for application in tissue engineering and biological valves.

Under the network project on Aerospace materials, nano crystallined powders of TiB_2 were sprayed on graphite, and super alloys substrates by plasma spray to prepare coatings having improved adhesion strength, excellent wear resistance, and oxidation resistance at more than $700^{O}C$. Also under the same programme Ni based high temperature brazing alloys have been successfully developed to join various ceramic materials, such as SiC-SiC, SiC-Al_2O_3, Al_2O_3-Al_2O_3. The joints have shown good strength with stability upto $1350^{O}C$.

R&D work on bioleaching of uranium is poised to open a new vista for exploiting low grade Indian ores/dumps/tailings, which are otherwise not very attractive due to poor metal recovery and high energy consumption. Under the CSIR Network Project on Bioprocessing of lean grade ores/ concentrates/wastes NML has made good strides in the bio-processing of low-index silicate ore of Turamdih mines containing 0.03% U_3O_8. The process optimized on bench level successfuly scaled up to 2.0 ton column. A project proposal for further scale up upto 100 ton column is under consideration of BNRS.

In the project on Quality enhancement of coal for its efficient utilization, it is established that for Munidih and oxidized Munidih coal fines (particles less than 75 micron) excellent yield values can be obtained at low target ash levels in clean coal using advance flotation techniques. Under the coal resource quality assessment for specific end uses, the washibility studies, proximate analysis with special emphasis on the valuable and noble metals have been investigated on the coal samples collected from North Eastern Region of India. It is noted that Meghalaya samples are most promising with respect to valuable trace metal like Ga, Ge and Au. Under Industrial waste minimization and clean-up project, NML's work reveals that alkali treated and adopted *A.niger* is suitable for removing chromium from a model tranning solution, and for alkali pretreated biomass. Bio-sorption is 52% Cr(III) for 2000 ppm feed as against metal removal of 65% from a diluted feed of 1000 ppm solution in 24 hours. NML has also established one NABL accredited Calibration Centre and for the first time in the country developed a set of Spectroscopic Standard for Plain Carbon steel.

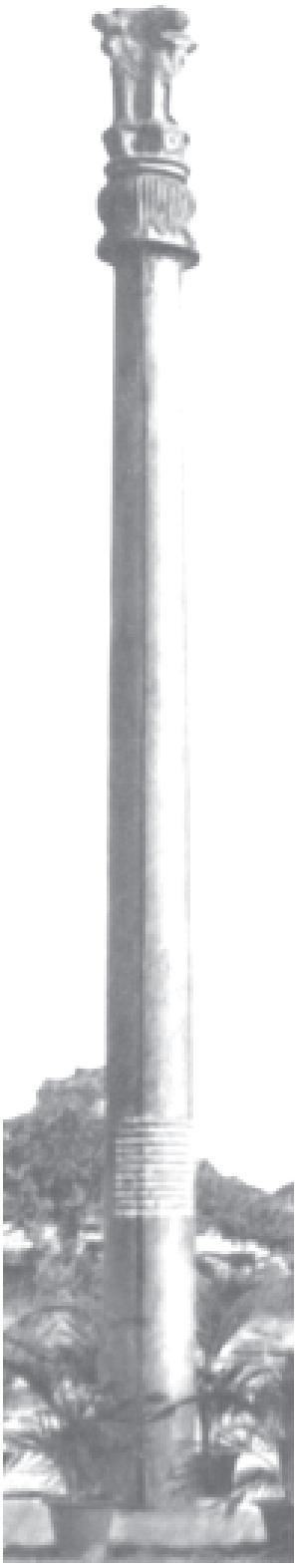


The New Millennium Indian Technology Leadership Initiative (NMITLI) project on 'Development of fuel cells based on hydrogen being pursued at NML Madras Centre is progressing well. Pure and Sr-doped $LaGaO_3$, $LaFeO_3$ and $LaCoO_3$ have been synthesized by various chemical routes namely, combustion, co-precipitation and Pechiney methods. The effect of various process parameters on the phase purity, particle size and surface area and morphology of the synthesized powders are determined by XRD, laser light scattering, BET and scanning electron microscopy. The electrophoretic deposition process for the electrolyte on Ni-LSGM anode substrate have been standardized in terms of electrodes, solvent, current density etc. Studies on the electrical conductivity of these perovskite oxides as a function of temperature and the assembly of a single cell are in progress.

The progress of the two NML Mega projects - (1) Maximising blast furnace productivity with Indian iron ore with the financial support of Ministry of Steel, Govt. of India, under the Steel Development Fund scheme, and (2) Processing of polymetallic sea nodules of Indian Ocean following Reduction Roast - Ammoniacal Leaching - Solvent Extraction - Electrowinning route to recover Copper, Nickel and Cobalt, sponsored by Department Ocean Development, Govt. of India - has been quite encouraging. NML has successfully designed and developed a Real Time Process Simulator (RTPS) for Indian iron making blast furnace under the Blast Furnace project. The RTPS has been installed at Bokaro Steel Plant for BF-5. Encouraged by the successful installation and satisfactory performance, the Bhilai steel plant also approached us to design and install RTPS for some of their blast furnaces. I am happy to inform that the Ministry of Steel has given its formal approval to this proposal and a new project entitled "Reduction of Coke Rate Using Probing and Modeling Techniques in BF No.6 and BF No.7 of Bhilai Steel Plant", has recently been approved by the Ministry under the Steel Development Fund scheme. This project has been conceptualized jointly by NML and RDCIS/ Bhilai Steel Plant to utilize the technology as a part of their modernization programme. The contract value for the NML led activities under the project is Rs.247 Lacs. The major objective of this project is to exploit the knowledge base, generated in the concluded project (in the form of comprehensive process models as well as a real-time process simulator), towards reduction of coke rate by increased auxiliary fuel injection and thus lowering the cost of hot metal production.

In the processing of polymetallic sea nodule project, the process has been scaled up to 100 kg per day scale and the recoveries of metals are 95% Cu, 95% Ni and 80% Co. The leach residue generated after ammonical leaching of sea nodules contains considerable amount of Mn. NML has developed a process on pilot scale for the treatment of leached residue to recover Mn in the form of ferro-silico-manganese, which is used as a deoxidiser in the steel industry. Leached residue has also been utilized for adsorption of arsenic from ground water and removal of heavy metals from various effluents.

The laboratory continued to work on its thrust area – 'The Component Integrity Evaluation Programme (CIEP)'. The emphasis has been to solve industrial problems through failure analysis, remaining life assessment, non-destructive evaluation and stress analysis. During the year 2006-07, several specific sponsored projects were completed. Some of the notable beneficiaries include - M/s. Tata Tube, Jamshedpur; M/s. BHEL, Tiruchirapalli; M/s. Fine Manufacturing Industires; M/s. Advances System Laboratory, Hyderabad; M/s. Indira Gandhi Centre for Atomic Research; M/s. Bhabha Atomic Research Centre; M/s.. Jindal Steel and Power Limited, Hisar, M/s. Kolhapur Steel Limited, Kolhapur; M/s. Mott MacDonald, Noida; M/s. CESC Limited; M/s. Tata Steel, Jamshedpur; M/s. Central Power Research Institute; and M/s. Gala Precision Technology, Thane.Under CIEP, several projects are also going on as per schedule. Mention may be made of a few - Evaluation of fatigue and fracture behaviour of narrow gap pipe weldments of similar and dissimilar metals; and Study on ductile fracture of SA333 Gr.6 PHT piping materials; for M/s. Bhabha Atomic Research Centre, Mumbai; RLA study of cooling water heater at power plant, for M/s. SAIL, Durgapur; Creep rupture and LCF testing for M/s. Indira Gandhi Centre for Atomic Research, Kalpakkam; Creep fracture properties evaluation of steel as per specification HY18573, for M/s. Kolhapur Steel Limited, Kolhapur; Residual life assessment of 2 Nos. primary reformer tubes, for M/s. Indo Gulf Fertiliser, Lucknow; Stress rupture test of boiler tube, for M/s. Central Power Research Institute, Koradi; Metallurgical investigation on aircraft components; Failure analysis of aircraft component; and Failure analysis of bolts of wheel hum assembly of aircraft, for M/s. Indian Air Force; Assessment of creep rupture and elevated temperature tensile strength of steel, for ISTM Limited, Pune and so on.



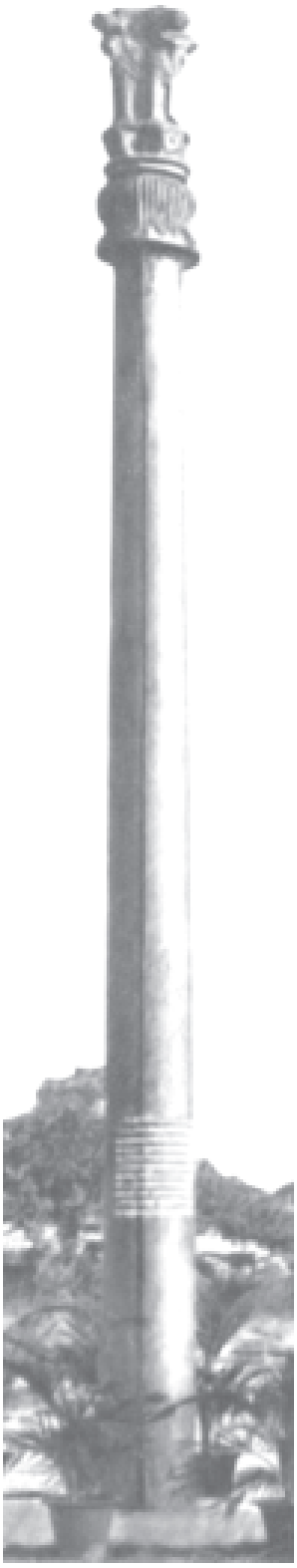
The project on Non-destructive Evaluation (NDE) Facility for Infrastructure Asset Management has made a significant progress. The “Facility Management and Advisory Committee (F-MAC)” of the project, under the chairmanship of Dr. Baldev Raj, in its last meeting, held at IGCAR, Kalpakkam on 1st November, 2006, reviewed the project. The members of the committee highly appreciated the progress made by the project. The committee has recommended that although the project ends shortly, the present F-MAC committee may continue for another three years. NML is now interacting with Indian Railways, Petrochemical industries, NTPC and several other organisations for initiating collaborative projects in the 2nd phase.

In the recent past NML has exploited its expertise in the areas of damage assessment and imaging using ultrasonic and non-linear ultrasonic (NLU) methodologies to study pitting corrosion in alloys, especially aluminium alloys. NLU has been successfully used for the first time for damage quantification due to pitting in 7075 Al alloys. This work particularly relates to the spectral analysis of received ultrasonic signals to quantify the localised damage due to corrosion pitting in airframe materials. Besides applying NLU, NML is also involved in high frequency ultrasonic imaging of pitted samples and correlating the results with pitting distributions obtained through image analysis. The pitting phenomenon is analyzed statistically and the kinetics of pitting assessed through a change in the statistical distribution parameter of pits rather than deterministic equations relating pit dimensions to time. The results of image analysis and ultrasonic imaging are being correlated with the NLU results to establish the potential of this new technique to quantify the localised damage due to corrosion pitting.

Indian Space and Research Organization (ISRO) successfully performed its first and most prestigious Space Capsule Recovery Experiment (SRE-1) in January 2007, bringing India into the select club of space capable nations, namely - USA, Russia, European Union and China. It has been an equally glorious event to the NML family as SRE-1 carried on board a Biomimetic Payload reactor, conceptualized and designed by NML, to study the effect of microgravity on the biomimetic synthesis of hydroxyapatite nanoparticles. Successful on board experimentation has made NML, perhaps the first Indian laboratory to carryout in situ synthesis of nanoparticles in space. Structural characterization of the nanoparticles synthesized in space manifested the formation of highly ordered bulk structure made from ordered assembly of hydroxyapatite nanoparticles having dimensions in the range of 2nm - 4nm. Biocompatability of these samples is being studied in collaboration with Centre for Cellular and Molecular Biology, Hyderabad. NML does acknowledge the support and cooperation it received from Indian Satellite Application Centre-ISRO Bangalore in the successful completion of this national mission.

The Department of Information Technology (DIT) has sponsored a project on Process Simulation for Optimisation of Ferroalloy Production in Submerged-Arc Furnace valued at Rs. 62.2 Lakhs. The project aims at developing a simulation package that helps in optimizing the ferroalloy production processes through reduction in specific power and raw material consumption. The process simulator will be tested and installed at the Angul Ferroalloy plant (Orissa) of Nava Bharat Ventures Limited (NBVL).

With the globalisation, world of scientific talents are joining hands to establish alliances that would help create a universal knowledge pool. Realising the need and mutual benefit of International S&T co-operation, NML has signed bilateral programes with different countries through DST, DSIR and DBT. Under the International collaborative programme, several projects with South Korea, European Commision, Russia, US and Bulgaria are going on as per the schedule. The collaborative R&D areas include - Process flow-sheet development for recovery of heavy minerals; removal of hazardous metal elements from leach liquour of electronic scrap; low cost technology development for in-situ ground water treatment; Nanowire technology; Dense ceramic composites; Fatigue damage and deformation evaluation; Paints and coating on HSLA steel and so on. We are also striving to create an Indo Russian Advanced Centre on Nonferrous and Rare Metals, under the aegis of Integrated Long Term Programme (ILTP) of Cooperation between Department of Science and Technology (DST) and Russian Academy of Sciences (RAS). The areas to receive thrust under the Centre include Mechanochemistry and Mechanical Activation of Solids, Solvent Extraction, Autoclave Processing, Electrothermal Processing, and Flotation Technology. I am also happy to mention here that the International Mechanochemistry Association (an affiliate member of IUPAC) in its general body meeting held at



Novosibirsk during July 2006 has given NML the privilage to host VI International Conference on Mechanochemistry and Mechanical Alloying (INCOME-2008) during December 1-4, 2008 at Jamshedpur.

Recently NML has ventured into a new area of imparting training to foreign institutions as several countries are showing interest in sending their officials to our Laboratory for customized training. Two different training programmes were specially designed and executed for training the faculty members of Caribbean Industrial Research Institute (CARIRI), Trinidad Tobago and those from Jomo Kenyatta University of Agriculture and Technology (JUKAT), Dept. of Mechanical Engg., Nairobi, Kenya. A training course has also been conducted for EU-India Trade under Investment Development Programme (TIDP). TIDP has been launched as a joint programme of the Department of Commerce, Ministry of Commerce and Industry of Government of India and the European Union's Delegation of the European Commission in New Delhi.

A large number of equipment have been purchased and installed during the period to facilitate the ongoing R&D activities of the laboratory. Some of the major ones are: Portable XRF, Carbon Coater with accessories, Low Pressure Autoclave, Table top Microscope, UHV Analysis System, Inductively Coupled Plasma-Mass Spectrometer, Computer Controlled Emission Analyser, Universal Hardness Tester, Ultrasonic Immersion Scanning System, Vibrating Sample Magnetometer, Tension-Torsion Testing System with Internal Pressurisation, Creep Testing Machines, Air-jet Hot Erosion Tester etc. As per the envisaged mandate of CSIR under the ICT, efforts are being made to provide a desktop PC for every scientist/officer of NML to cater to the need for undertaking computational, on-line access to e-journals application development and document preparation activities. Substantial number of PCs have been procured and distributed among the users. It has also been planned to upgrade all obsolete PCs in the laboratory to the level of latest available technology.

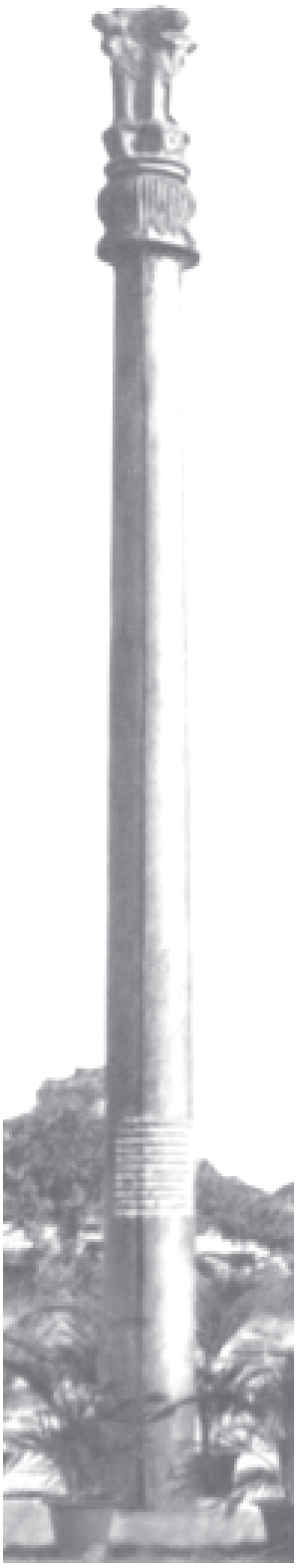
During the reporting year, 17 Grant-in-Aid projects, 33 Sponsored projects, 5 Consultancy projects, 4 Collaborative projects, and 14 Net work projects were completed. Likewise, 46 Grant-in-Aid Projects, 49 Sponsored projects, 4 Consultancy projects, 4 Collaborative projects, and 3 S&T Service projects are ongoing.

During 2006-07, fourteen MoUs were signed with twelve parties, namely - (i) Korea Institute of Geoscience and Mineral Resources of the Republic of Korea; (ii) Carribean Industrial Research characterisation and corrosion studies of metal samples Institute, Trinidad & Tobago; (iii) Samro International, New Delhi; (iv) Institute for Steel Development & Growth, Kolkata; (v) Test Metal Corporation, Kolkata; (vi) Silcarb Heating Elements Pvt. Limited, Bangalore; (vii) Nav Bharat Ventures Ltd., Hyderabad; (viii) Indian Rare Earths, Kerala; (ix) Somu Organo Chem (P) Ltd, Bangalore; (x) Department of Engineering, Metallurgical and Mining IIT Kharagpur; and (xi) Jomo Kenyatta University of Agriculture and Technology, Dept. of Mechanical Engg., Nairobi, Kenya.

With regard to the Intellectual Property Assets, 4 National and 13 International patents were filed. 14 National and 6 International patents were granted, and 2 copyrights were registered. Regarding research publications, in addition to 133 research papers in International Journals and 33 papers in National Journals, 57 papers in International and 7 papers in National Seminars/Symposia/ Conference proceedings were published. Altogether, 231 research papers were published during 2006-07, out of which 133 papers were in SCI Journals, highest ever published in a single year. Further, NML's effective marketing drive could mobilise an extra budgetary sources above Rs. 6.46 Crores.

During the year under review, NML achieved the ISO 9001: 2000 certification having successfully undergone upgradation audit. The surveillance audit was conducted by Certifying Body TUV Suddeutschland India Pvt. Ltd. and brought all the Divisions under the ambit of ISO 9001:2000.

For the 11th Five-year Plan period, NML's has submitted project proposals in four categories identified by CSIR, namely - Supra Institutional Programme, Network projects, Inter-agency projects and Centres of Excellence. Some of the projects got sanctioned from CSIR and some were under considerations. NML has launched its theme project (also called SUPRA project) on "Development and Forming of

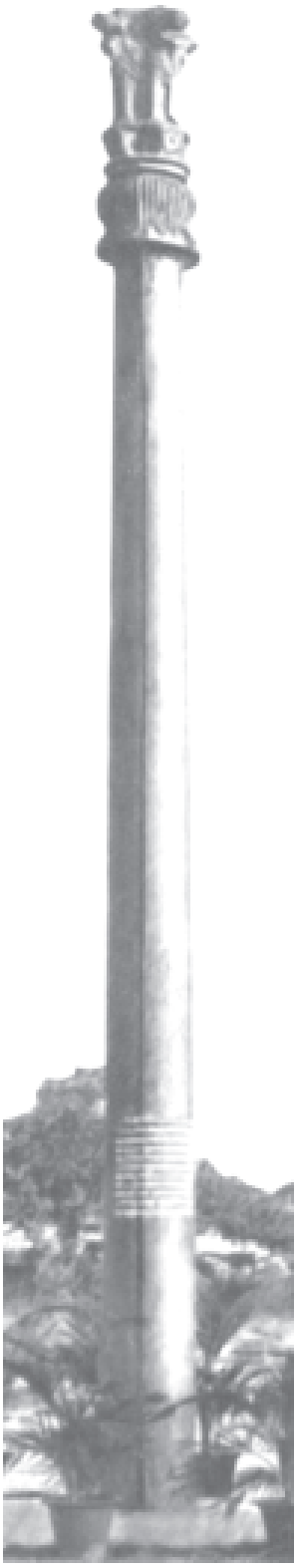


Performance Driven Special Steels". This programme will see the maximization of cross discipline skills with allmost all of our research divisions and most of the supporting divisions involved in its execution. The programme aims to develop ultra high strength steels with yield strengths in excess of 1600 MPa and ductility in excess of 8%. Another genre of steel that is to be developed is high strength high formability grades, exploiting transformation induced plasticity and twin induced plasticity phenomena. Additionally the SUPRA project will also explore the development of steel foams, develop advanced joining processes like friction stir welding and diffusion bonding for high strength steels as well as develop surface coatings and surface engineering protocols for such steels. Virtual platforms for casting simulation, mechanical property prediction, assessment and optimization of various physico-chemical processes for special steels will be created with the aim of property and process optimization. The SUPRA project with its focused deliverables, state of the art content and excellent team composition is expected to make a mark in Indian steel research.

In the 11th Plan period, NML will have significant involvement in the network project "Development of advanced lightweight metallic materials for engineering applications" being co-ordinated by AMPRI, Bhopal. NML's diverse contributions will be in the development of specialty light alloys and metallic foams, in thermomechanical processing of light metals and alloys and in surface processing of light metals and alloys. NML is also one of the partners in a Network programme on the development of specialty inorganic materials for diverse applications with CSMCRI, Bhavnagar as the nodal laboratory. Under this programme NML will work on four different modules namely - Development of special clays as water purifiers, Development of ceramic coatings, Development of processes for making ultra-pure metals, and Development of sensors for field estimation of water contaminants. The concept for a networked research initiative on "Technology for Assessment and Refurbishment of Engineering Materials and Components" (TAREMaC) has been short listed by CSIR. The project proposal is currently awaiting final approval by the Expenditure Finance Committee of the Planning Commission.

During 2006-07, several recognition and Awards have come to NML Scientists. Prominent amongst them are: Prof. S.P. Mehrotra - N.P. Gandhi Memorial Lecture of IIM; Dr. A. Mitra, Metallurgist of the year Award of IIM in the group – Metal Sciences; Dr. Rakesh Kumar, Metallurgist of the year Award of IIM in the group – Environment, Energy Conservation and Waste Management; Dr. Lokesh Pathak, MRSI Medal Lecture Award of MRSI & CSIR Raman Research Fellowship; Rakesh Kumar, Sanjay Kumar, S. Badjena and S.P. Mehrotra, Nijhawan Award (for Best Tech. Paper); S. Prabhakar, G.B. Raju, S. Subbarao, D.S. Rao and T.V. Vijay Kumar, Alteker Award (for Best Technology); J. Pal, M.C. Goswami, S. Ghosh, Manoj Kumar, R.K. Minz, D.P. Singh and A.K. Upadhyaya, Best In-house project; S.K. Das, S. Tarafder, P.K. De, S. Das, and S. Sivaprasad; and S. Palit, N. Parida, S. Sivaprasad, D.K. Bhattacharya and R.N. Ghosh, 2nd best in-house project; Rakesh kumar, Sanjay Kumar, S. Badjena and S.P. Mehrotra, IIME Best paper Published Award – In the area of Environment issues related to Mineral Processing (2007); B. D. Pandey, IIME Best paper Published Award – In the area of Extractive Metallurgy (2007); S.K. Das et. al., Best paper published in the Journal of Institution of Engineers and The K.F. Antia Memorial Prize – 2006.

During reporting period 17 scientists were deputed abroad (USA, Germany, UK, S.Korea, Bulgaria). A large number of scientists and technocrats visited NML and shared their views with our scientists. Some of the prominent visitors include Dr. R.K. Dayal, Head, Corrosion Science and Technology Section – Reactor Materials, Materials Characterisation Group, Indira Gandhi Centre for Atomic Research;, Dr. J.P. Singh, Program Manager and Sr. Scientist, AFSOR, Asia Office at Japan; Prof. Barry L. Mordike, Institut fur Werkstoffkunde and Werkstofetechnik, Germany; Dr.Volker Uhlenwinkel; Institute fuer Werkstofftechnik, Universitaet Bremen, Germany; Dr. Keith Dicks, Oxford Instruments, UK; Shri Varun Jha, Vice-President, (Chattisgarh Project), Tata Steel; Mr. S. Karmakar, Team Leader, INCAT- A Tata Technologies Co; Dr. & Mrs. B. R. Nijhawan, Ex-Director, NML; Prog. Prof. J. F. Knott, OBE, FRS, Univ. of Birmingham; Prof. D. C. Giles, Director, Wolfson Centre for Magnetic Technology, Cardiff Univ.; Prof. T. R. Ramachandran, Emeritus Scientist, NFTDC, Hyderabad; Dr. S. Mazumdar, Director, JNARDDC, Dr. T. Ramasami, Secretary, DST; Dr. P. Rama Rao, Former DST, Secretary, and ISRO Dr. Brahma Prakash Distinguished Professor; Dr. Vimal Kumar, DST; Prof. B. Sengupta, Queens University, Belfast; Dr. R. A. Mashelkar, DG, CSIR; Dr. Askok Nayak, Global Director, ALCOA and Mr. S.K. Maheshwari, CEO, Grasim.



An international trade exhibition, Hannover, Messe 2006 with India as partner country was held during April 23-28, 2006 at Germany. In one of the world's largest technology exhibitions, India, represented by over 330 companies showcased its vast potential for partnerships that she offers for trade investment and technology collaboration for mutual benefits. For the first time NML participated in this International Exhibition. During the exhibition NML identified strong strategic partnerships with countries like Germany, France, Tunisia, Kazakhstan, Taiwan etc for various collaborative and sponsored projects in the area of Nano-Materials, Water Resources and Technologies, Minerals Processing and Engineering, Engineering Components Evaluation, Characterization and Assessment using Destructive and Non-destructive Techniques, including futuristic technologies of biomaterials and metals from industrial wastes. NML is presently working on a common agenda and strategy for exchanging and offering its cutting edge technologies, R&D products and Services, globally. NML also participated in 6th International Trade Fair on Minerals, Metals, Metallurgy & Materials (MMMM-2006) at Pragati Maidan, New Delhi during September 11-14, 2006 and in the 60th NtMD-ATM of IIM Exhibition held at XLRI Campus during November 14-17, 2006 and 60th NMD-ATM Exhibition of Indian Institute of Metals held at XLRI Campus, Jamshedpur during November 14-17, 2006.

During 2006-07 five scientists (Gr. IV), two technical officers (Gr. III), eleven technical assistants (Gr. II) and two in administrative catagories joined the laboratory. I take this opportunity to wish them all a very successful and productive professional career at NML.

A National seminar was organised jointly by the laboratory and the Indian Institute of Metals, Jamshedpur Chapter on Remaining Life Assessment and Extension of Aged Components of Thermal Power Plants and Petrochemical Industries (RLA-2006) on 26–27 July 2006. Another National seminar on Coal was organised in Hindi by the laboratory March 26-27, 2007. Several other regular events like - National Technology Day; Hindi Diwas; CSIR Foundation Day; National Metallurgists' Day; CSIR Programme on Youth for Leadership in Science were also celebrated.

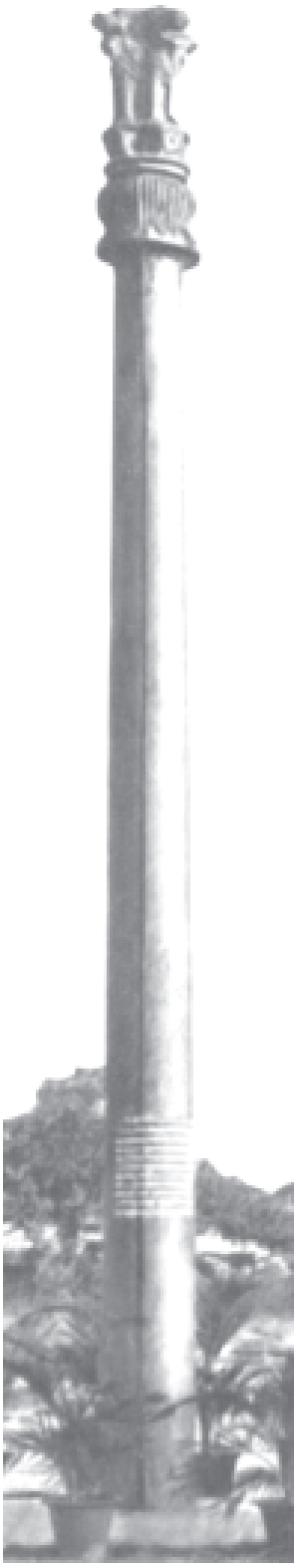
108 NML staff members had undergone training outside as well as inside the laboratory and 380 personnel sponsored by outside agencies were imparted training at the laboratory and two obtained Ph.D. degrees.

The social activities of NML have also been carried out very effectively with the help and participation of all the staff members and their families. The Foundation Day celebrations were appreciated by about 800 people where a number of variety entertainment programmes were performed by our staff members and their spouses. Sports and quiz programmes were conducted with a lot of fanfare. Ms. S. Das a noted classical singer from Bhubaneswar rendered her performance at the Agrico colony and enthralled the audience.

NML also hosted the 38th SSBMT (indoor) zonal tournament where 10 CSIR laboratories from northern India participated. The participants were highly appreciative of the manner in which the tournament was conducted. I thank all my colleagues for putting up such a fine show and exhibiting in the finest manner the true NML team spirit.

I sincerely hope, with the continued devotion and dedication of all my colleagues at NML, we shall maintain the impressive growth in our R&D activities of the globalised economy and contribute even better in the years to come.

Prof. S.P. Mehrotra
DIRECTOR



2007 - 08

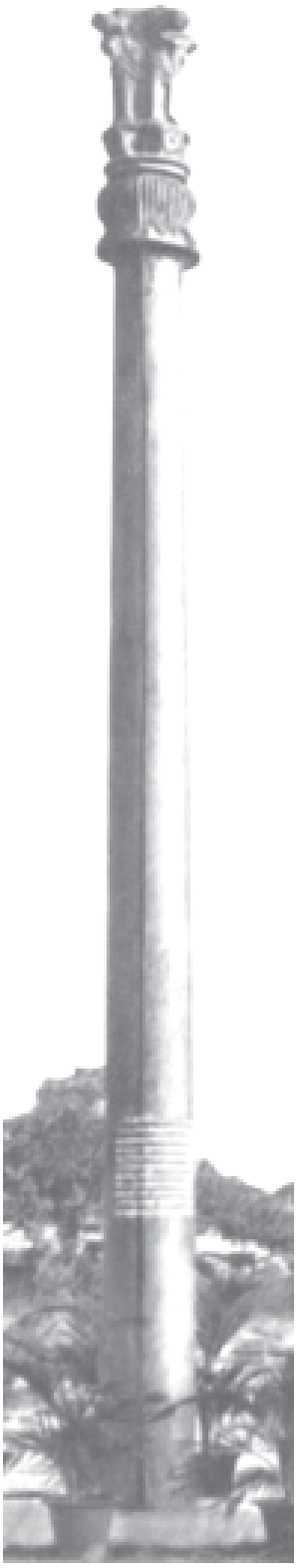
It gives me immense pleasure to present the 58th Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 2007-2008. The report highlights the progress of various R&D activities and events pertinent to the laboratory. Overall, the period has been a year of great satisfaction. Industrial and pure scientific problems are multidisciplinary in nature. The solution to these problems requires the knowledge of more than one branch of science and calls for team work. CSIR laboratories have witnessed this through the success of the network projects during the 10th Five Year Plan.

The finalization of the CSIR 11th Five Year Plans took place during 2007-08. One of the most important initiatives contributing to the development of the focal thrust of the laboratory is the Supra-Institutional Project (SIP) wherein majority of the groups within the laboratory participate. Under this programme NML initiated the project on "Development and forming of performance driven special steels" which was accorded CSIR's approval in August 2007. The project aims to develop technologies for manufacturing performance driven special steels for automotive, aerospace, power, construction, railways, ship building and other sectors poised for rapid growth. The prime focus in the project is on the development of indigenous high strength high formable steels and value additions through complementary processing. Studies on deformation behaviour of TWIP steels have been initiated. Additionally melting of quenched and partitioned steel has been carried out. This project has also produced two types of filler alloys for joining steels having low weld ability.

Under the programme, ESR steel has been produced at IIT-Mumbai and is presently being characterized. A number of activities for establishing virtual platforms are in progress which include generic heat transfer modelling and artificial neural network modelling for prediction of mechanical properties.

NML has endeavoured to carve out a niche for itself by working through network projects in the 10th Plan. The emphasis has been laid on networking of expertise, resources and facilities so that the project would target substantial increase in value of inputs of S&T in knowledge driven areas. In the 11th Plan, experience drawn from the 10th Plan has encouraged NML/CSIR to launch yet another set of network projects that are multidisciplinary in nature. The output of network projects is expected to bring in a new direction and also generate new areas of business for NML. The proposal on the network project entitled, "Technology for assessment and refurbishment and engineering materials and technology (TAREMaC)" under NML's nodal leadership got the approval of the Governing Body of CSIR on 28th January 2008. The project (valued Rs. 30.00 Crores) is a sequel to NML's previous activities in the areas of structural integrity evaluation and engineering critical assessment programme.

The other network projects in which NML is one of the participating laboratories are - Development of specialty inorganic materials for diverse application; Development of advanced light weight metallic materials for engineering applications; Development of advanced eco-friendly energy efficient processes for utilisation of iron ore resources of India; Engineering of structure against natural and other disasters; Zero emission research initiative; and Advancement in Metrology.



NML is a major partner in the network project, "Specialty inorganic materials for diverse applications", in which CSMCRI, Bhavnagar, is the nodal laboratory. This network programme is looking into a wide range of novel inorganic materials covering a broad spectrum of applications, many of which are futuristic in nature. NML has initiated work on chrome free passivator, ultra pure metal powder, ceramic coating on steel surface, organic modified clays and layered double hydroxides as water purifiers, and electrochemical sensor materials for As (V) / As(III) field testing in groundwater.

NML's mandate in the network project on "Development of light-weight metallic materials for engineering applications" where AMPRI, Bhopal is the nodal laboratory, include: (i) Preparation of specialty alloys, (ii) Looking at the downstream processing of light metallic alloys, and (iii) Other value addition processing. In SERC, Chennai, coordinated project - "Engineering of structures against natural and other disasters", which aims to address engineering issues to mitigate the effects of natural disasters, NML is working to provide inputs towards evaluation of the behaviour of materials used in critical installation such as the primary heat transport piping in nuclear power plants subjected to extreme loading. Evaluation of cyclic and dynamic fatigue and fracture behaviour of relevant structural materials form the core of the activity.

Analytical Chemistry Centre of the laboratory is engaged in preparing metallurgical certified reference materials (CRM) for the last three decades and presently markets more than 24 CRMs and has a client base of more than 250 organizations.

Development of a couple of coal standards with varying ash and sulphur content and sponge iron standard with varying degrees of metallization will make the country self sufficient for all metrological requirements of coal and sponge and also save foreign exchange. This is the mandate for NML in the NPL, New Delhi coordinated network project on "Advancement in metrology".

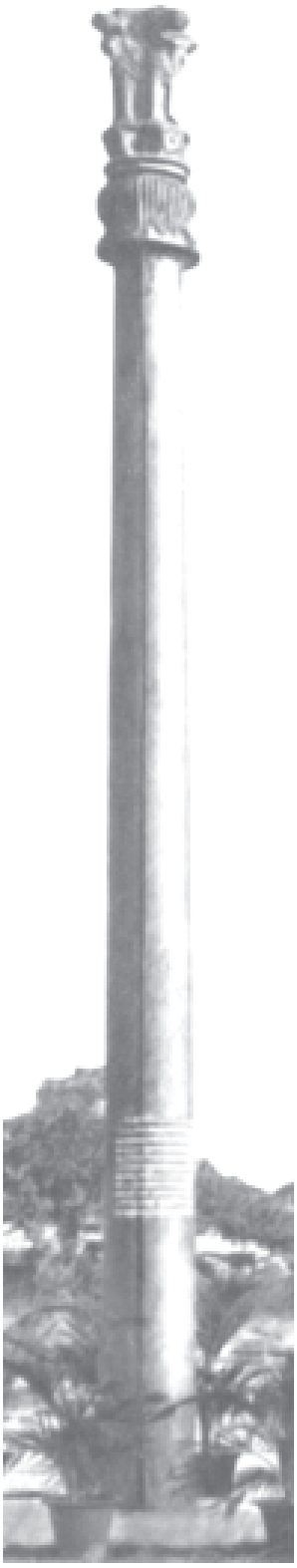
The present day process of knowledge generation and diffusion is characterized by a shift from research based stand alone scientific disciplines to transdisciplinary and inter institutional networking. NML would like to synergize with academia, industry and Government to build World Class facilities and identify, niche areas where NML/CSIR as a part of "Team India" could make a major impact.

To look into adverse effects of mine-water discharge into rivers and the consequent impact on the ground water table and aquatic lives of mining regions, an inter-agency project, "Development of cost-effective mine water reclamation technology for providing safe drinking water" is being implemented with CIMFR, Dhanbad, as the nodal laboratory and NML as the major partner. NML has been entrusted with the development of a low cost technology for upgrading the mine water to potable quality. This will not only augment the drinking water needs of the region, but will also lower the pollution of the existing water sources of the area.

Safe drinking water is a major concern in the national perspective. Of all the sources in the rural areas of Jharkhand, tubewells are considered to be the safest as the water comes from anaerobic conditions and are free from micro-organisms. Paradoxically, a substantial number of tubewell waters in the state of Jharkhand are very rich in minerals such as iron, calcium, magnesium, copper and arsenic making them unsuitable for drinking. The villagers then have to depend on unsafe water sources such as open dug wells, rivers or ponds. A large amount of Government money is wasted due to non-utilization of these tubewells. NML, has been continuously striving to develop appropriate technologies for providing safe drinking water to the villagers at an affordable price. In this context NML has undertaken a rural sector project on "Use of natural occurring minerals for providing safe drinking water at domestic level in the state of Jharkhand".

The New Millennium Indian Technology Leadership Initiative (NMITLI) project on "Development of fuel cells based on hydrogen" being pursued at NML Madras Centre is progressing well. The systematic development of a new indigenous solid oxide fuel cell has been achieved. The salient features of this fuel cell are: (i) it is based on new materials (indigenously synthesized) for electrolyte ($La_{1-x}Sr_xGa_{1-y}Mg_yO_{3-\delta}$ LSGM), cathode ($La_{1-x}Sr_xFe_{1-y}Co_yO_{3-\delta}$ LSCF) and anode (LSGM + NiO), (ii) It is operational at a temperature of 600-800°C and can use reformed hydrocarbons directly.

The outcomes of the two NML Mega projects - (1) Maximizing blast furnace productivity with Indian iron ore, and (2) Processing of poly metallic sea nodules of Indian Ocean following Reduction Roast



- Ammoniacal Leaching - Solvent Extraction - Electrowinning route to recover Copper, Nickel and Cobalt, has been very satisfactory. As a sequel to the Steel Development Fund (SDF) supported project on "Maximising blast furnace productivity with Indian iron ores", NML is now working on the development of Real-time Process Simulator to reduce coke rate using probing and more comprehensive modeling techniques for the Blast furnace of Bhilai Steel Plant. Following the general philosophy of networking, in this programme NML has involved IIT-Madras and IIT-Mumbai as partners.

Building on NML's successes and significant achievements in the DOD sponsored programme on extraction of metal values from poly metallic seanodules, the laboratory is currently concentrating on extraction of Co through a roast reduction route, recovery of Cu, Ni and Co by bulk sulphide precipitation, followed by chloride leaching, solvent extraction and electro winning, and recovery of Mn from leached residue and toxicological studies of the waste. The programme has been funded for over Rs. 10 Crores.

The laboratory continued to work in its thrust area - "The Component Integrity Evaluation Programme (CIEP)". The emphasis has been to solve industrial problems through failure analysis, remaining life assessment, non-destructive evaluation and stress analysis. During the year 2007-2008 several sponsored research projects were completed. Some of the notable beneficiaries include - M/s. Bhabha Atomic Research Centre, Mumbai, M/s. Steel Authority of India Limited, Durgapur, M/s. Indira Gandhi Centre for Atomic Research, Kalpakkam, M/s. Kolhapur Steel Limited, Kolhapur, M/s. Indo Gulf Fertiliser, Lucknow, M/s. Central Power Research Institute, Koradi, M/s. Indian Air Force, M/s. ISTM Limited, Pune. Under CIEP, several projects are also under progress and as per schedule.

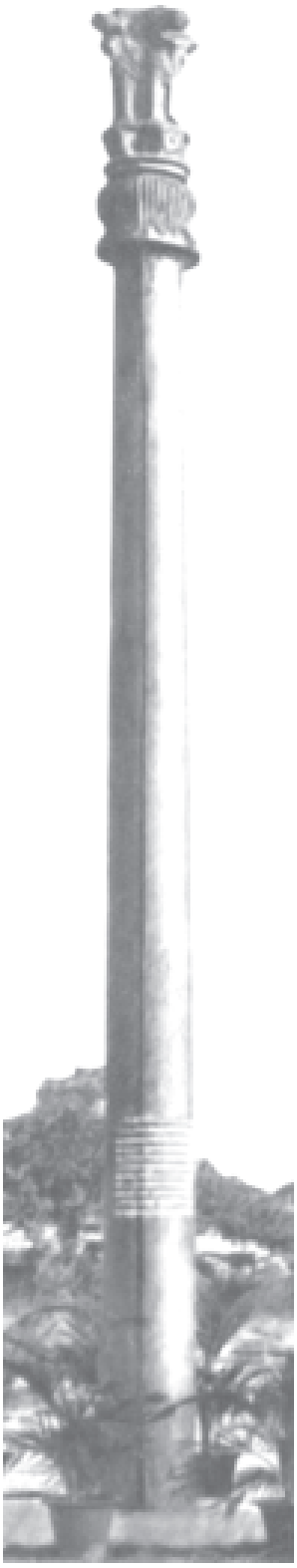
The project on Non-destructive Evaluation (NDE) Facility for Infrastructure Asset Management has made good progress. NML now intends to provide a scientific procedure for acoustic emission testing of tank bottom for monitoring and prioritizing the tanks according to whether they should be opened for inspection and to determine follow-up inspection requirements. NML also intends to provide recommendations for inspection, including the type of inspection and the inspection interval for the remaining life of storage tanks.

NML has ventured into a number of high impact programmes on strategic material and alternative processes. NML is involved in various investigation studies of the Indian Air Force. NML has contributed in identifying the causes of damages in the second stage nozzle guide vanes, HPTR and LPTR blades of aero engines, coupling shaft, bevel gears and copper plug of aero engines. NML has also investigated and analyzed the broken control rod of wheel turning mechanism of the MIG-21 Fighter Aircraft of the IAF. These and similar activities which are continuously being pursued at NML would help improve the performance of different kinds of aircrafts and enhance the lives of men and machines.

As a part of a national perspective Plan for R&D in the power sector, NML is pursuing a project on the "Development of silt erosion resistant material for turbines of hydro-generators", sponsored by CEA. The projected cost of the activity is Rs. 299.79 lakhs over a period of three years. Through elaborate discussions with CPRI, NHPC, BHEL and IIT Roorkee, the primary project deliverable has been defined as the development of a material with improved performance in terms of mechanical properties and erosive wear resistance as compared to the presently used 13 Cr-4 Ni stainless steel.

Electronic waste is a major concern and its management requires immediate attention considering the rate of obsolescence of electronic components. In spite of the magnitude of the problem, it has not been addressed in a structured and Planned fashion in India. NML's initiative in the area has resulted in a project on "Development of processing technology for recycling and re-use of electronic waste" sponsored by Department of Information Technology. Such wastes have significant metal values including precious metals and are difficult to recycle in an environment friendly manner. An indigenous technology for recovering metal values and reducing health hazards is being developed through this project.

In another Department of Information Technology funded project on "Process simulation for optimization of ferroalloy production in submerged arc furnace", worth Rs. 63 lakhs, a process simulator has been installed in the Angul Ferro-alloy Plant of Nava Bharat Venture Limited. Keeping in view the large Ilmenite deposits in beach sands in the country, and the increasing thrust on the greater utilization of the these resources, a project on "Production of high purity Rutile from Ilmenite by selective reduction



and segregation of iron" has been taken up in collaboration with Tata Steel. Obtaining Rutile, (TiO2), which is extensively used as a pigment, is the ultimate objective in this project. An alternative process route involving segregation of the iron produced during the reduction of Ilmenite from TiO_2, by carbon, "in-situ", and subsequent separation of the same through physical means is underway.

With the open economy and globalisation, international scientific talents are joining hands to establish alliances that would help create a universal knowledge pool. Realising the need and mutual benefit of International S&T co-operation NML has signed bilateral programmes with different countries through DST, DSIR and DBT.Under the International collaborative programme, several projects with South Korea, European Commission, Russia, US and Bulgaria are going on as per the schedule.

NML has embarked upon international collaboration for technological developments and knowledge dissemination. Our collaboration with ALCOA Inc., USA, under the aegis of CSIR-ALCOA Innovation Council, has given us a good opportunity to expand our base in aluminium research on industrially relevant contemporary topics. Intense interaction over the last one year has culminated in finalization of six specific projects in the areas encompassing mechanical activation, bohemite precipitation, water treatment, geopolymers and pelletisation. We can expect some very exciting outcomes from these projects paving the way for several innovative technologies.

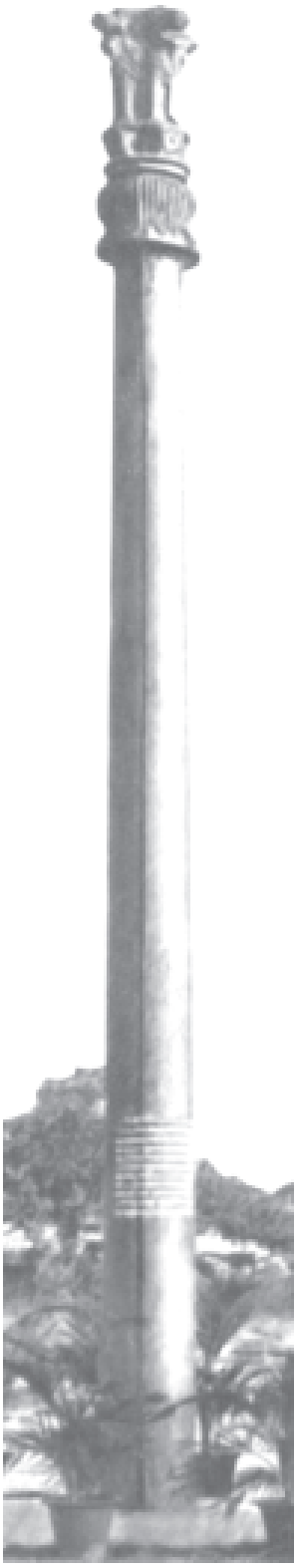
Four research projects were jointly undertaken by NML and Korea Institute of Geoscience and Mineral Resources (KIGAM) covering the areas of mutual interest. These were: (i) Development of a process for the removal of hazardous metal elements from leach liquor of electronic scraps following solvent extraction and recovery of valuables; (ii) Development of technology for recovering heavy minerals from sea sand; (iii) Further studies on beneficiation of Korean sea sand and synthesis of Rutile from Ilmenite; and (iv) Studies on recovery of manganese as Fe-Si-Mn from low manganese containing materials.

A theme meeting on "Nanostructured Advanced Materials" was organized in the laboratory during March 27-29, 2008 as a part of CSIR-ISTAD activities on cutting edge technologies. There were 12 overseas experts from USA, UK, Spain, Slovakia, Australia and Singapore. Representatives from 10 CSIR laboratories including NML who are involved in the development of nanostructured materials attended the 3-day theme meeting. To focus the CSIR activities on nanomaterials four major areas were taken up for discussion in the meeting. These were: (1) Biomaterials; (2) Ceramics, Composites and Hard Coatings; (3) Magnetic Materials; and (4) Structural Materials. As an outcome of this theme meeting, a major International Collaborative network project with a total financial outlay of around Rs. 45 Crores is under active consideration of CSIR.

A large number of equipment have been purchased and installed during the period to facilitate the ongoing R&D activities of the laboratory. Some of the major ones are : Computer Controlled Magnetic Barkhausen Emission Analyzer; Pulverisette 6 - Planetary Mono Mill; Reflectance Mode UV-VIS Computer Controlled Spectrophotometer; Inductively Coupled Plasma-Mass Spectrometer; Ultrasonic System with Time of Flight Diffraction; Bomb Calorimeter, Ultrasonic C-Scan System; Low Pressure Glass Reactor PARR Autoclave; Hitatchi Table Top Microscope; Portable XRF Spectrometer; Portable Electrochemical System; MATLAB Software with Modules. Under the aegis of CSIR-ICT initiative considerable augmentation of IT resources for the laboratory has been accomplished.

During the reporting year, 8 Grant-in-Aid projects, 30 Sponsored projects, 3 Consultancy projects, 3 Collaborative projects and 2 S&T service projects were completed. Like wise, 54 Grant-in-Aid projects, 42 Sponsored projects, 7 Network projects, 1 Inter Agency project, 1 Rural Sector project, 1 Supra Institutional project, 8 Consultancy projects, 4 Collaborative projects, 1 S&T service project, are ongoing.

During 2007-2008 nine MoUs were signed with eleven parties, namely (i) M/s. Mishra Dhatu Migam Limited, Hyderabad, (ii) M/s. McNally Bharat Engineering Limited, Kolkata, (iii) IGCAR, Kalpakkam, (iv) Vikram Sarabhai Space Centre, Thiruvanathpuram, (v) M/s. DUCOM Instruments Private Limited, Bangalore (vi) M/s. Eucare Pharmaceuticals Private Limited, Chennai, (vii) IIT Madras, Chennai, (viii) Somu Organo Chem (P) Limited, Bangalore, (ix) Jomo Kenyatta University of Agriculture & Technology, Kenya, (x) KIGAM, Korea, and (xi) Indian Rare Earth Limited, Kerala.



Efforts are being made to facilitate the transfer and subsequent commercialization of the NML developed technologies, processes and products. The know-how for biphasic calcium phosphate nano-bioceramic for dental and orthopaedic applications, has been transferred to M/s. Eucare Pharmaceuticals, Chennai. The same company had earlier purchased NML know-how on production of nanosized hydroxyapatite powder which is now being marketed as "SYBOGRAF". The automated ball indentation technique developed under NML's nodal 10th Five Year Plan Project, has now been licensed to M/s. Ducom Instruments Private Limited, Bangalore, for manufacture.

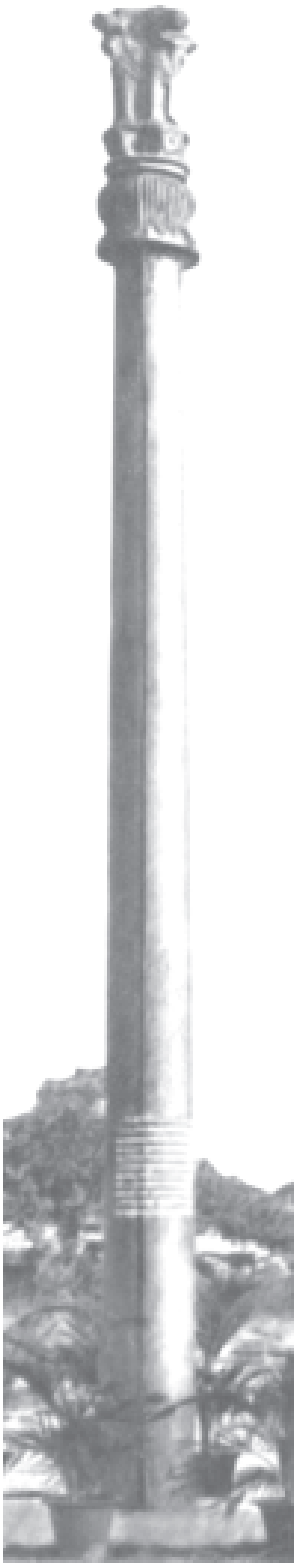
With regard to the Intellectual Property Assets, 7 National patents were filed during 2007-08. 15 National and 3 International patents were granted, and 9 copyrights were registered. Regarding research publications, in addition to 116 research papers in International Journals and 23 papers in National Journals, 11 papers in International and 20 papers in National Seminars / Symposia / Conference proceedings were published. Altogether, 170 research papers were published during 2007-2008, out of which 92 papers were in SCI Journals. Further, NML's effective marketing drive could mobilize an extra budgetary resource above Rs. 9.46 Crores.

During the year under review, NML achieved the ISO 9001:2000 certification having successfully undergone upgradation audit. The surveillance audit was conducted by Certifying Body TUV Suddeutschland India Private Limited and brought all the Divisions under the ambit of ISO 9001:2000.

During 2007-08, several recognitions and Awards have come to NML Scientists. Prominent amongst them are: Dr. D.D.N. Singh - Metallurgist of the year Award of IIM in the Ferrous group; Dr. V.C. Srivastava - Young Metallurgist of the year Award of IIM; Prof. S.P. Mehrotra - Tata Gold Medal of IIM; Dr. Ashok Kumar Ray - MRSI Medal Lecture Award of MRSI; Dr. A.K. Vaish - Distinguished Engineers Award of Institution of Engineers (India); Dr. S. Prabhakar and Dr. G. Bhaskar Raju - National Mineral Award of Ministry of Mines, Govt. of India; Dr. T. Mishra - Young Chemist Award by Orissa Chemical Society; Dr. Ratnakar Singh and Mr. K.K. Bhattacharyya - Best Paper Award in the International Conference on Beneficiation of Fines & It's Technology, organized by Tata Steel and IIME Jamshedpur Chapter; Dr. Ajoy Kumar Ray, Dr. K. Venkateswarlu, Dr. Sarmistha Sagar Palit and Mr Abhijit Kar - Best Poster in the International Workshop of Indian Ceramic Society; Mr. H.N. Bar and Dr. Satadal Ghorai - Boyscast Award; Dr. B.D. Pandey, IIME Mineral / Coal Beneficiation Award, and Dr. T. Mishra, Hindustan Platinum Award for Best Poster Presentation; Dr. S. Prakash, Dr. S.K. Pal, Ms. A. Madhukar, Shri K.D. Pathak and Shri S.K. Bose - CSIR Innovative Suggestion Award. Mr. Anuj Mohan Pradhan, Section Officer of Accounts Division won the Consolation prize in Oral Literature category of 'Indian Literature Golden Jubilee Literary Translation Prize Competition' by the Sahitya Academy, New Delhi.

During the reporting period, 24 scientists were deputed abroad (Bulgaria, China, Germany, Ireland, South Africa, South Korea, UK, USA). A large number of Scientists and technocrats visited NML and shared their views and expertise with our scientists. Some of the prominent visitors include - Dr. H.K. Park, Distinguished Principal Investigator, Dr. C.W. Nam, Principal Researcher, Korea Institute of Geo Science and Mineral Resources (KIGAM), South Korea; Prof. K.A. Padmanabhan, Professor of Eminence, Anna University; Dr. Somnath Bhattacharyya, Leibniz - Institut fur Oberflachenmodifizierung Leipzig, Germany; Dr. K Hamunantha Rao, Professor, Department of Chemical and Metallurgical Engineering, Lulea University of Technology, Sweden; Dr. Kiptanui Jonah Arap Too and Mr. Michael Kamau Njuguna from Jomo Kenyatta University of Agriculture and Technology Kenya; Dr. Ashok Naik (ALCOA, USA), Dr. Dave Olney (Alcoa World Alumina, Australia), Dr. Matthew F. Cesario (ALCOA, USA); Prof. Nick Gatheru Wanjohi, VC - JKUAT; Mr. Horacoi Belenguezr, Permanent Secretary, Ministry of Mineral Resources, Mr. Obete Francisco Matine, Director Nacional Adjundo, Republic of Mozambique; Dr. H.K.D.H. Bhadeshia, Professor of Phycial Metallurgy, Material Science and Metallurgy, University of Cambridge, UK; Prof. Walter Arnold, Saarland University, Saarbruecken, Germany; Prof. B. Mishra, Colorado School of Mines, USA; Prof. Paul Calvert, University of Masschusetts, Dartmouth USA; Dr. D.C. Jiles, Cardiff University, UK; Prof. Ezaz Huq., Rutherford Appleton Laboratory, UK; Prof. R.A. Andrievskiy, Russian Academy of Science, Russia; Prof. Vazquez, Institute of Materials Science, Madrid, Spain; Prof. Peter Svec, Institute of Physics, Slovakia.

During 2007-08, eight scientists (Gr. IV), three Technical and Supporting staff (Gr. III, II and I), and four in Administrative categories joined the laboratory. I take this opportunity to wish them all a very successful and productive professional career at NML.



The Laboratory organized several national seminars / workshops / short term courses during the reporting period. Mention may be made of the seminar on Advanced Gravity Separation (30 August - 1 September 2007); workshops on Metal Testing Standards (3 December 2007); Industrial Corrosion : Evaluation and Mitigation (5-7 December 2007); Short term courses on Processing of Iron Ores (28 November - 1 December 2007); Metallurgy for Engineers (10-14 December 2007); Special Metal Casting and Forming Processes (25-26 February 2008); Extraction of Nonferrous Metals and their Recycling (27-29 February 2008).

NML is also venturing into technical training of personnel both from India and Abroad. These training courses provide the essential foundation needed for addressing day to day issues for managing plant operation, conducting research, and growing business operation in the field of mineral, metals and materials. More than 380 personnel across the country have been trained through different programmes organised at the laboratory during the reporting period. Five academic staffs from Jomo Kenyatta University of Agriculture and Technology, Kenya visited NML during October 7-13, 2007 for training in the area of Mining and Mineral Processing Engineering and also to explore possibilities of further collaboration with NML. I am happy to mention here that the International Mechanochemistry Association (an affiliate member of IUPAC) has given NML the privilege to host the VIth International Conference on Mechanochemistry and Mechanical Alloying (INCOME-2008) during December 1-4, 2008 at Jamshedpur.

Several other regular events like - National Technology Day, Hindi Diwas, CSIR Foundation Day, National Metallurgists' Day, CSIR Programme on Youth for Leadership in Science were also celebrated.

As a part of the NML Foundation Day Celebrations, NML staff members along with their spouses and children very actively participated in various cultural and sporting activities. NML Family Quiz programme was organized on 20 November 2007. NML Sports Day was conducted at NML Flats, Agrico on 2nd December 2007. Some of the most popular and revered personalities of the NML family were chosen as the torchbearers for the inauguration. More than 250 athletes aged between 4 years and 60 years, representing a wide spectrum of the NML family, participated in various sporting events. NML hosted the "Hussain Zaheer Memorial Bridge Tournament" during 29-30 March, 2008 which was attended by top bridge teams of CSIR and some of the best local teams of Jamshedpur. NML Bridge team emerged as runners-up in the event.

NML has had a very satisfying and robust twelve months of R&D activities. In this context, the role played by the Research Council Members in finalization of the new R&D projects, monitoring of the ongoing projects and related activities is highly commendable. I would like to express my sincere gratitude and thanks to our RC Chairman, Dr. Baldev Raj, and all other RC members for their keen interest in NML's activities, their continuing guidance, support and encouragement.

I also take this opportunity to thank all my scientist colleagues, technical staff members, all my colleagues and staff members of various sections of administration for their continuous support and cooperation. It is only through their unending love, commitment and untiring efforts that NML can live up to the expectations the Nation bestows upon it.

Prof. S.P. Mehrotra
DIRECTOR

2008 - 09

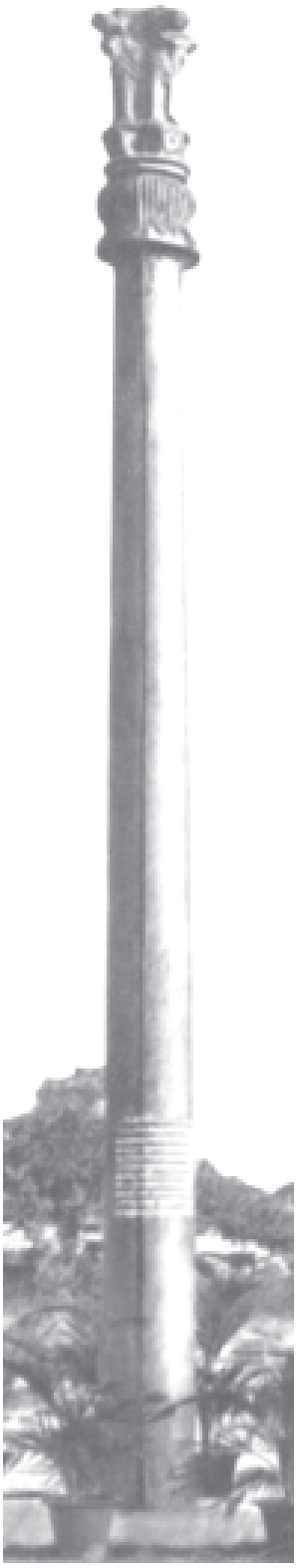
It is my proud privilege to present the 59th Annual Report of the National Metallurgical Laboratory, Jamshedpur for the year 2008-09. This period has been of great excitement and satisfaction.

With the change in the global economic scenario, conscious efforts have were made to reorient the laboratory to face the challenges of liberalization. Laboratory continued to prioritise the customers' need and renewed the effort to tailor our R&D activities to match these needs in offering R&D products, processes, consultancy and technical services.

In the Supra-institutional Project on "Development and forming of performance driven special steels" studies on various Fe-Mn-Si-Al-C alloys have been carried out. This has included studies on the effect of strain and strain rates on the phase transformation in these alloys. Sputtering and SMAT treatments have been carried out on a variety of substrates. Presently, the modelling activities in this programme are focusing on heat treatment simulation, modelling of forming operations and material property prediction.

The networked research initiative in CSIR's XIth Five-year Plan under NML's nodal leadership called "Technology for assessment and refurbishment of engineering materials and components" (TAREMaC) is now well underway. Seven sister laboratories, namely, CGCRI Kolkata, CMERI Durgapur, IMMT Bhubaneswar, NAL Bangalore, NPL New Delhi and SERC Chennai have been participating in the project. Under the project, activities spanning the generic areas of non-destructive evaluation, microstructural characterisation, oxidation, erosion, creep, fatigue and fracture, and surface engineering have been planned. Interactions are being sought with academic institutions in specific areas. While some of the activities continue as logical sequel to NML's network project in the previous plan period, many of the activities are entirely new, based on the requirements of the engineering industry with respect to their critical equipment and processes. These include development of surface engineering protocols and coating technologies, and modelling material behaviour in typical service environments. The project is also being utilized to modernize existing and develop new research infrastructure. The technical progress in the project in the initial phase is satisfactory. There has been good output in acoustic emission based monitoring of corrosion, development of sensor devices for damage assessment, modelling of ratchetting fatigue and modelling of high temperature erosion-corrosion. Work has been initiated on miniaturization of a portable ball indentation system, study of creep behaviour of turbine materials, development of erosion retardant substrate materials and risk-based analysis of remaining life. Regular contact and consultations are being maintained with the project partners within CSIR. Efforts are being made to involve and obtain participation of stakeholder in industrial sectors. Encouraging engagement has been made with TISEC (a tank-bottom inspection agency), the Indian Air Force, BARC, GTRE and a few other organizations.

Eight other network projects in which NML is participating as a partner are progressing well. These include : Development of speciality inorganic materials for diverse application, Development of advanced light weight metallic materials for engineering applications, Development of advanced eco-friendly energy



efficient processes for utilisation of iron ore resources of India, Engineering of structure against natural and other disasters, Zero emission research initiative, Biomimetic nanomaterials and structures for health applications, Advancement in Metrology, and Advanced nanostructured materials. The inter agency project, 'Development of cost effective mine water reclamation technology for providing safe drinking water' which aims to convert the underground coal mine water suitable for drinking is also making good progress.

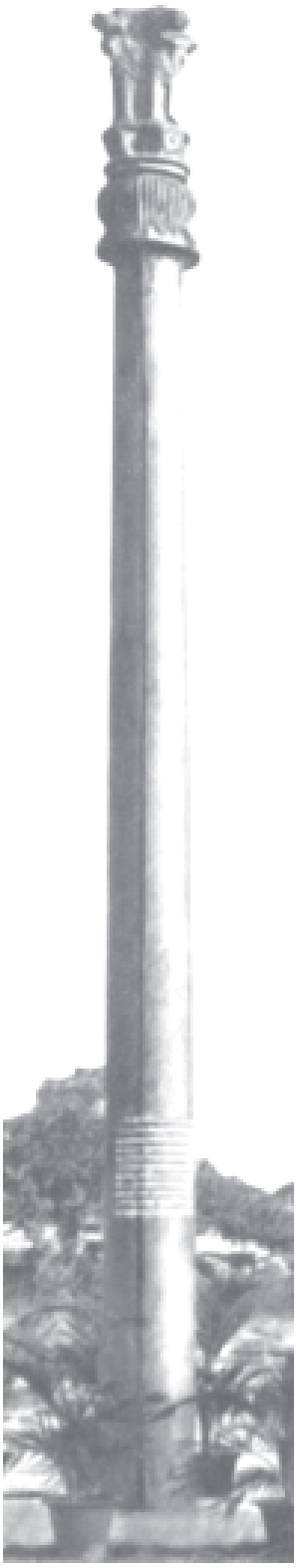
Development of a complete technology package for recovering metals, plastics and glass from electronic waste is the objective of the project on 'Development of processing technology for recycling of electronic waste' sponsored by the Department of Information Technology (DIT). Collaboration with Central Institute of Plastics Engineering and Technology, Bhubaneswar and Videocon Industries Limited, Bharuch has been established to achieve the objective. A protocol for disassembly and sorting of e-waste has been developed. Pulverized e-waste has been subjected to various physical separation techniques and the starting material with 23% total metal could be enriched to over 68% total metal. Activities such as pilot scale operation of physical beneficiation, metal recovery from metal rich concentrate, blending of waste plastics and processing of waste glass from e-waste are under way. The project has recently received excellent review by the DIT appointed committee.

Encouraged with the research work pursued by NML under Xth plan, the Ministry of Earth Sciences (MoES) has sanctioned about Rs. 10 crores under the current five year plan. The current emphasis in the programme is on the recovery of all the metals and utilisation of residues from sea modules. The programme includes: (i) Direct smelting of sea nodules for the recovery of valuable metals, (ii) Roast reduction and ammonia leaching of sea nodule and smelting of leach residue to recover copper, nickel and cobalt along with manganese as ferro-silico-manganese, (iii) Design and setting up of a pulse sieve column for more efficient separation of copper, nickel and cobalt from leach solution, and (iv) use of leach residue as a filtering media for removal of toxic metals like arsenic. Based on the results, setting up of a pilot plant for treatment of 100 kg sea nodule per batch is in an advanced stage.

Recognizing NML's expertise and contributions in the area of iron ore beneficiation, MECON on behalf of SAIL has awarded NML the project on 'Beneficiation studies on iron ore samples from Gua and Bolani Mines of SAIL', and the work on this project has commenced during November 2008. The mandate of this project is characterisation of ores from different deposits, bench and pilot scale beneficiation studies, and development of process flow-sheet which will be integrated in Bolani and Gua Iron Ore Mines of SAIL to upgrade the existing flow-sheet. The present practice of exploitation of iron ores in India basically involves selective mining to maintain a high grade of feed followed by washing to produce washed lumps and fines for utilisation in iron making through blast furnace. The project addresses the serious limitation in treating low grade ores where a significant portion of the material is discarded as off-grade fines and slimes causing loss of iron values and results in environmental pollution problems. It is hoped that this project will show the path for rationale utilisation of Indian iron ores leading to resource conservation.

The Ministry of Coal, Government of India has taken up an ambitious plan to expand the coal exploration capacity during the XIth Five Year Plan period. The present capacity of existing analytical laboratories is highly inadequate to meet the enhanced requirement of core coal analysis which is estimated to be over 1.35 lakh in XIth Plan. NML has joined hand with CIMFR Dhanbad in the nationally important project 'Quality evaluation of coal core explored from different regions of India'. Coal India Ltd. would extend a total grant of 36 Crore for this project which has CMERI Durgapur and IMMT Bhubaneswar as the other partners. Nearly 40% present of the coal core analysis under the project will be carried out at NML. The project which will result in the development of coal core quality database will also result in capability building at NML in terms of creation of state-of-the-art coal testing facility with an automated sample handling and online information management systems.

NML in the recent past developed a number of fly ash based geopolymer products. Notable among these are self glazed tiles, high strength cement (>120 MPa) and pavement tiles involving synergistic utilisation of wastes along with fly ash. These has been a particular concern about the commercialization of these products. Moving in this direction, we approached Fly Ash Utilisation (FAU) programme of DST and submitted a proposal for the setting up of a pilot plant for the production and large scale evaluation of pavement tiles. This project is in the spirit of CSIR800. Once the pilot plant demonstration of the pavement tiles is done with



a complete technology package, there is an immense potential for the mushrooming of small to medium scale plants based on this technology.

The New Millennium Indian Technology Leadership Initiative (NMITLI) project on "Development of fuel cells based on hydrogen" being pursued at NML Madras Centre is progressing well.

Under strategic sector, NML is involved in various investigation studies of the Indian Air Force. The Laboratory contributed in identifying the causes of damages in the second stage nozzle guide vanes, HPTR and LPTR blades of aero engines, coupling shaft, bevel gears and copper plug of aero engines. Further case to case studies were under progress.

Three new Certified Reference Materials (CRM) were released during this period. These include two plain carbon steels and one iron ore standards. With this, the total number of CRMs being marketed has risen to twenty nine standards. NML is also preparing strategic standards of supper alloy for MIDHANI, Hyderabad, and a set of five standards for hydrogen in zirconium alloys for BARC Mumbai.

In the area of International Collaboration, the following projects sponsored by ALCOA Inc, USA have been completed : (i) Amenability of electrochemical techniques for the treatment of wastewaters generated from aluminium industry, and (ii) Assessment of Fluoride removal capability of novel materials, FEOL, ALOL and ZACL from contaminated water sources. Two projects have been initiated in area of E-waste recycling (i) Removal of hazardous metal elements from leach liquor of electronic scraps by solvent extraction and (ii) Recovery of Pb and Sn from the liberated resin of PCBs swelled by organic, sponsored by Korea Institute of Geoscience and Mineral Resources (KIGAM). Three more research projects jointly undertaken by NML and KIGAM covering the areas of mutual interest were also progressing well. These were: (i) Development of technology for recovering heavy minerals from sea sand; (ii) Further studies on beneficiation of Korean sea sand and synthesis of Rutile from Ilmenite; and (iii) Studies on recovery of manganese as Fe-Si-Mn from low manganese containing materials.

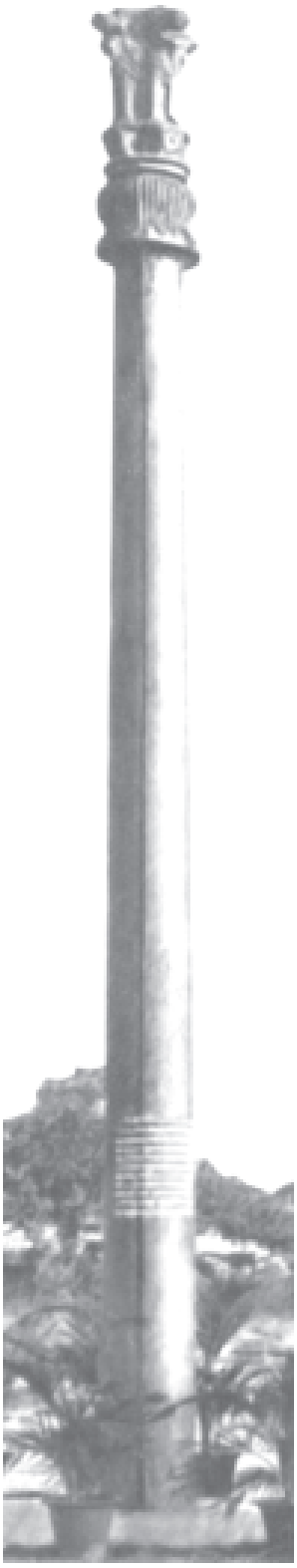
NML finds a prominent place in the Indo-US Center of Biomaterials which is a multi institutional collaborative project funded by Indo-US Science and Technology Forum with IIT Kanpur as the nodal agency. Besides IIT Kanpur and NML, other Indian partners include IIT Bombay and NFTDC Hyderabad. The participating US institutes include Brown University, Washington University, University of Texas and Materials Processing Inc. Under this Center, NML will be collaborating with Brown University to study the biocompatibility as a function of dimensions and topography of nano bioceramics and nano-composite hydrogels for hard and soft tissue scaffolds respectively.

We are now into the information age and continuous efforts are being made to have modern IT infrastructure at NML. A high speed Local Area Network (LAN) with a fiber optics backbone speed of 10 Gbps and node connectivity of 1 Gbps has been installed and commissioned during January 2009, and replaced the old LAN system. In addition to Scientists getting access to the publishers' database through their desktop system, an Online Public Access Catalog (OPAC) is hosted through 11 nodes in the Library Hall for online access of e-journals and other literature. The Video Conferencing (VC) facility which is capable of connecting wide variety of video conferencing setup across the global is now functional. The facility was inaugurated by DG-CSIR during his visit on 30th January, 2009. The Lecture Hall and the Auditorium have also undergone renovation and upgradation in this period.

A number of new equipments have been installed and commissioned during this period. These include a fully portable X-Ray residual stress analyzer; Cold isostatic press; Pendulum type instrumented charpy machine; Servo-Electric closed loop system; Phases array module with 16:128 Elements; and a bench top LC-MS/MS triple Quadrupole mass spectrometer.

During the reporting year, 24 Grant-in-Aid projects, 64 Sponsored projects, 2 Collaborative projects and 2 S&T service projects were completed. Like wise, 41 Grant-in-Aid projects, 34 Sponsored projects, 9 Network projects, 1 Inter Agency project, 1 Rural Sector project, 1 Supra Institutional project, 4 Consultancy projects, 3 Collaborative projects, 4 S&T service project, are ongoing.

During 2008-09, 14 MoUs were signed with 12 parties, namely, IIT Madras, IIT Bombay, IIT Roorkee, GTRE Bangalore, Chakradhar Chemicals Pvt. Ltd., Muzaffarnagar, Central Power Research Institute,



New Delhi, Tata Steel Jamshedpur, MECON Ranchi, VSSC Thiruvananthapuram, Test Metal Corporation Kolkata, Vacuum Techniques (P) Ltd. Bangalore, and Institute of High Technology Kazakhstan.

With regard to the Intellectual Property Assets, 11 National and 9 International patents were filed during 2008-09. 12 National and 4 International patents were granted, and 11 copyrights were registered. Regarding research publications, in addition to 153 research papers in International Journals and 7 papers in National Journals, 9 papers in International and 13 papers in National Seminars / Symposia / Conference proceedings were published. Altogether, 182 research papers were published during 2008-2009, out of which 144 papers were in SCI Journals. Further, NML's effective marketing drive could mobilize an extra budgetary resource above Rs. 10.16 Crores.

During the year under review, NML achieved the ISO 9001:2000 certification having successfully undergone upgradation audit. The surveillance audit was conducted by Certifying Body TUV Suddeutschland India Private Limited and brought all the Divisions under the ambit of ISO 9001:2000.

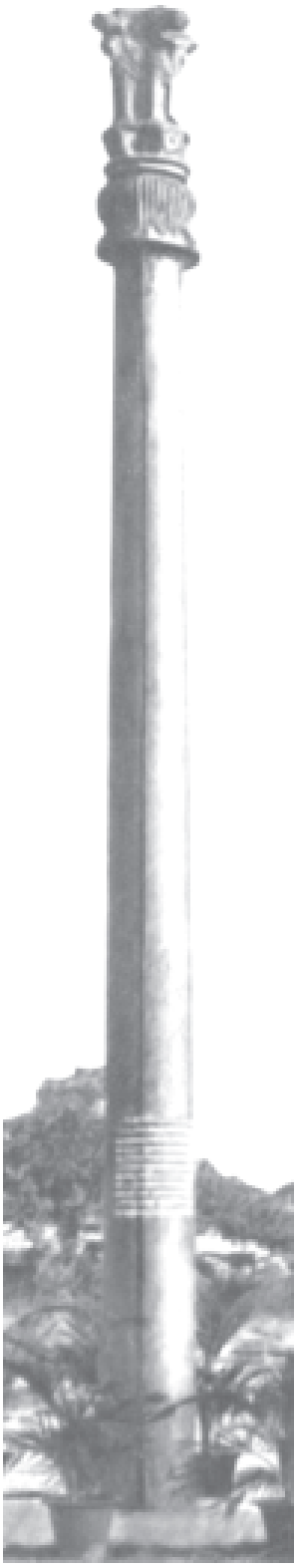
During 2008-09, several recognitions and Awards have come to NML Scientists. Prominent amongst them are : Vasvik Award - Dr. Suman K. Mishra; Young Scientst Award - Dr. R. K. Sahu; National Mineral Award - Dr. G. Bhaskar Raju and Dr. S. Prabhakar; Khare Award for Best Paper Presentation - T.C. Alex, Rakesh Kumar, S. K. Roy and S. P. Mehrotra; NACE International Gateway - Dr. I. Chattoraj; BOYESCAST Fellowship - Mr. Arpan Das, Dr. A. K. Mohanty and Dr. D. Mondal; Raman Research Fellowship and CSIR-DAAD Exchange Fellowship - Dr. Sanchita Chakravarty and Dr. S. Sivaprasad; IIM Prize for Poster Presentation - Dr. S. K. Sahu, Dr. P. Khan, Dr. B. D. Pandey and Dr. T. R. Mankhand; National Award for Best Employee with Disability - Mr. Ajay Mandhyan.

The International Mechanochemistry Association (IMA) (an associate member of IUPAC) entrusted the responsibility to host VI International Conference on Mechanochemistry and Mechanical Alloying (INCOME 2008) at Jamshedpur. This was the first time that the Conference took place in Asia, and Jamshedpur (India) joined the rank of earlier venues of INCOME - Koasice (Slovakia) in 1993, Novosibirsk (Russia) in 1997 and 2006, Prague (Czech Republic) in 2000 and Braunschweig (Germany) in 2003. Dr. T. Ramasami, Secretary, Department of Science and Technology, was the Chief Guest and delivered the inaugural lecture on 'Revealing beauty and wonders of nano world'. Nearly 250 delegates, including 60 overseas delegates representing 15 countries, participated in the Conference and over hundred papers in 18 oral and 2 poster sessions were presented. Participation of students and young researchers was particularly encouraged and sizeable number of them participated and presented papers. Noted world renowned experts in these areas delivered plenary/invited lectures. This included names like Prof. Peter Balaz (Slovakia), Prof. Horst Han, Prof. H.-J. Fecht, Prof. V. Sepelak (Germany), Prof. J. Foct (France), Prof. Elena Boldyreva (Russia), Prof. S. Yariv (Israel) from overseas, and Prof. K. A. Padmanabhan, Prof. P. Ramachandra Rao, Prof. S. Ranganathan, Prof. G. R. Desiraju, Prof. A. Nangia, Dr. A. K. Chatterjee, Prof. B. S. Murty from India. A large contingent of Korean scientists headed by Dr. Kang-In Rhee, Director, RRDC, Korea Institute of Geoscience and Mineral Resources made special efforts to reach Jamshedpur and participate in the Conference.

The Laboratory organized several national seminars / workshops / short term courses during the reporting period. Mention may be made of the seminar on Agglomeration and characterisation of iron bearing raw materials, held during April 16-18, 2008.

NML is also venturing into technical training of personnel both from India and Abroad. These training courses provide the essential foundation needed for addressing day to day issues for managing plant operation, conducting research, and growing business operation in the field of mineral, metals and materials. NML received an assignment from JKUAT, Kenya to impart training to R&D personnel of JKUAT Kenya in mining and mineral processing. More than 380 personnel across the country have also been trained through different programmes organised at the laboratory during the reporting period.

During the reporting period, 26 scientists were deputed abroad (Bulgaria, Belgium, France, Russia, China, Germany, Ireland, Czech Republic, Japan, South Africa, South Korea, Turkey, Singapore, Malaysia, UK, USA, Ukraine). A large number of Scientists and technocrats visited NML and shared their views and expertise with our scientists. Some of the prominent visitors include - Dr. Saibal Roy, Senior Scientist,



Microsystems Center, Tyndall National Institute, Ireland; Prof. Charles Christopher Sorrell, School of Materials Science and Engineering, University of New South Wales, Sydney, Australia; Prof. Sam Zhang Shanyong, Director, Thin Films Technology Program, School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore; Dr. Yang Hyunsoo, Asst. Professor, Department of Electrical and Computer Engineering, International Centre for Nanoscience & Technology, Singapore, Prof. Fathi Habashi, Laval University, Canada; Prof. Damodar Acharya, IIT, Kharagpur; Prof. R. K. Gupta, University of Alberta, Canada; Dr. Maksym Karpash, Ivano-Frankivsk, National Technical University of Oil and Gas, Ukraine.

Prof. Samir Brahmachari, DG-CSIR visited NML during January 30-31. He addressed all segments of NML staff, including Head of the Departments, senior scientists (E-II to G), younger scientists (B to E-I), functionaries and administrative staff, and they had the opportunity to listen from him directly about the vision of CSIR and his expectations from everyone. DG in his address specially highlighted the role of CSIR in the changing national and global scenario. Besides pursuing its R&D, CSIR is to focus on programmes under the umbrella of CSIR800 that will result in better life for the 800 million Indians. DG also talked about Finishing School Programme which is to start under the aegis of CSIR-AIST (Advance Institute of Science and Technology, Ghaziabad). He informed that the decision to grant deemed university status to CSIR-AIST is pending with the cabinet Subcommittee and may be taken soon.

Several other regular events like - National Science Day, Hindi Diwas, CSIR Foundation Day, NML Foundation Day, CSIR Programme on Youth for Leadership in Science were also celebrated.

The role played by the Research Council Members in finalization of the new R&D projects, monitoring of the ongoing projects and related activities is highly commendable. I would like to express my sincere gratitude and thanks to our RC Chairman, Dr. Baldev Raj, and all other RC members for their keen interest in NML's activities, their continuing guidance, support and encouragement.

Last, but not the least, I would like to place on record that the reporting period was steered by the then Director, Prof. S. P. Mehrotra, who superannuated on 30 April, 2009. On behalf of NML and of my own, I acknowledge the leadership, guidance, and motivation received by all members of the staff during his entire tenure.

I also take this opportunity to thank all my scientist colleagues, technical staff members, all my colleagues and staff members of various sections of administration for their continuous support and cooperation.

Dr. Sukomal Ghosh
ACTING DIRECTOR

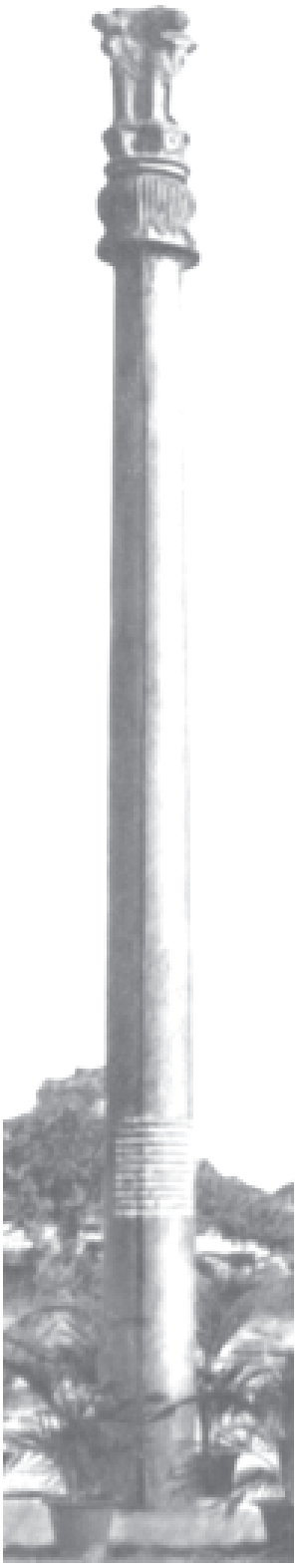
2009 - 10

It is such a great privilege to be penning the foreword for NML's annual report of 2009-10. I assumed office just about two months back and I feel overawed occupying this chair of this great institution which has such an illustrious heritage and legacy, occupies such a unique position in the country's R&D hierarchy and enjoys the patronage and goodwill of not only the scientific community but the people at large. I can't but resist quoting Pt Jawaharlal Nehru when he inaugurated NML on the 26th of November 1950. I think of the combination of this laboratory with the steel works in this city, of the marriage of science with industry for the progress of both...". Sixty years hence, these words are as relevant as it were then, in fact more so now. It is my pledge to remain committed to NML's pursuit of marrying science with industry for the progress of both.

The year 2009 -10 for NML has been both eventful and productive. The saddest event for us this year was the untimely demise of our past director Prof. Patcha Ramachandra Rao, an outstanding scientist, a compassionate human being and one of the most ardent well wishers of NML. With a deep sense of grief, we at NML pay homage to our beloved friend, philosopher and guide. His thoughts will remain etched in our memory for a Iong time. During this year, our previous director Prof. Surya Pratap Mehrotra also completed his tenure at NML and left to rejoin IIT Kanpur. We thank him for his significant contributions in taking NML forward. Dr. Sukomal Ghosh took over the acting directorship and did a wonderful job in managing the laboratory for close to a year. NML recorded its highest ever external cash flow of close to Rs 11.5 crores last year and the highest ever number of SCI publications. I take pride in complimenting team NML for raising the bar and setting new benchmarks of performance.

We pursued a wide range of projects during this period which included multi-laboratory networked projects, the supra-institutional project on steel funded by CSIR, a large number of industry sponsored projects and also a significant number of innovative research projects funded by the grant-in-aid bodies. We had set ourselves specific goals, science and technology, targets and deliverables in each of these projects. It is gratifying to mention that in most of the projects, the promised deliverable and targets were achieved within the time deadline and received a favorable review. It is also appropriate to acknowledge that in at least one project, we could not fulfill the expectations of the review committee and we are putting in place mechanisms to ensure that with respect to project deliverables, we are on brief, on time and on budget all the times. The projects undertaken have resulted in technology development and transfer or development of new materials or development of new evaluation protocols or economic savings to the industry or new scientific insights.

Some of the significant project outcomes in the last year are the installation and commissioning of 150 tonnes/day sillimanite beneficiation plant at Indian Rare Earths at Chavara, development of commercial flotation reagents for iron ore in collaboration with M/s Somu Organics, development of complete technology packages in collaboration with MECON for iron ore beneficiation plants at Gua and Bolani, carrying out site trials of the Real Time Process Simulator developed by NML in the blast furnaces of Bhilai Steel plant, reduction in galvanizing losses of Zn in several galvanizing industries,



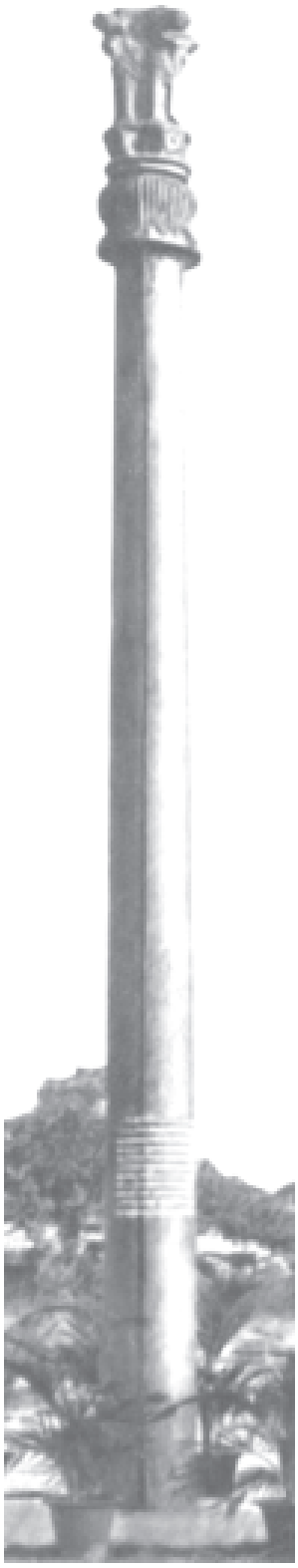
transfer of technology for a portable Automated Ball-indentation system, transfer of technology for the recovery of Pb from Zn leach residue, NDE protocols for damage assessment, rejuvenation protocols for high temperature materials, development of magnetic sensor and sensor devices and steel foams.

Major programs on recycling of electronic waste, processing of ocean nodules, bio-processing of minerals, direct reduction iron making processes, smelting of ferroalloys, electrothermal extraction of Na, coal mine-water reclamation, processing of light metal alloys, failure analysis, creep property evaluation and fatigue & fracture behavior database for a wide range of materials, rapid solidification processing of magnetic alloys, biomimetic materials, corrosion evaluation and mitigation, industrial waste processing and standard reference materials are continuing.

Overthe past several years, NML has continued to be in the national limelight with respect to national awards and prestigious fellowships. This year, NML has bagged one of the "Metallurgist of the Year" award of the Ministry of Steel and Mines and a fellowship to the Indian Academy of Engineering. Several of the younger scientists have secured prestigious fellowships such as the Raman Research Fellowship, Boyscast Fellowship and Indo-US fellowships.

Stepping into the next year, we have set ourselves much higher goals and S& T targets and we keep in mind the increasing emphasis placed by the government on the relevance of our research to industry and the society and its irnpact. We will be working for a larger share of industrial funding, focusing more towards technology development in partnership with the stakeholders and more effective utilization of the scientific and technical infrastructure available. We are striving to change; to keep up with the changing times; change to bring in more focus, more relevance, a more professional work culture, accountability, transparency and more impact; change ultimately to meet the aspirations and expectations, of the stakeholders and the people a change that is consistent with continuity. In this context, I am once again tempted to quote Pt. Jawaharlal Nehru during his inaugural speech at NML "We carry a heavy burden of the past and the past helps us and the past hinders us; and the problem is how to combine that past with the present and the future, how to have changes and how to have continuity and how to have both together". I look forward to your continued support and patronage in realizing our goals and vision.

Dr. S. Srikanth
DIRECTOR



A Tribute...

Prof. V. A. Altekar
(04-03-1925 to 31-08-1989)

Prof. P. Ramachandra Rao
(21-03-1942 to 10-01-2010)

We avail this opportunity to express our sincere gratitude to :

All eminent, illustrious and distinguished personalities from Government of India, Government of the State of Jharkhand, Establishments of Govt of India, Academic and R&D organizations, Academies and Professional Societies, Esteemed industries in Public and Private Sectors, CSIR and NML associates and Well wishers....

for their 'Good wishes' and shared 'Reminiscence'.

We are also grateful to Director General, Council of Scientific & Industrial Research for his guidance received from time to time.

We also put on record the services and extended help received from all Members of the Staff of National Metallurgical Laboratory to this grand endeavour in celebration of Diamond Jubilee of NML.

Souvenir Publication Group

Published by :
Information Management & Dissemination Centre (NML)
on behalf of Director, National Metallurgical Laboratory
Jamshedpur - 831 007, India

एन एम एल - स्वर्ण जयंती पर वि
राष्ट्रीय धातुकर्म प्रयोगशाला में स्वर्ण जयंती समार
कैलीब्रेशन सेंटर व निकेल प्लांट का उद्घाटन कल
नई सदी के लिए कई और नवीन यो
राष्ट्रीय धातुकर्म प्रयोगशाला : अनुसंधान व उपलब्धियां
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टूर्नामेंट उद्घाटित
अनुसंधान के क्षेत्र में अपनी योग्यता सिद्ध की है एन एम एल ने
राष्ट्रीय धातुकर्म प्रयोगशाला की स्वर्ण जयंती
Jamshedpur all decked up for Keenan's 60 years celebration

Celebrating 60 years of NML with a cover
Special cover of NML rele
अब कचरे से निकलेगा सोना
साइंस विज्ञ में जेएच तारापोर चैंपियन
एनएमएल ने पूरे किये 60 साल
खिलौने के दाम में मिलेंगे मोबाइल!
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NML celebrates 69th Foundation Day of CSIR
राष्ट्रीय धातुकर्म प्रयोगशाला में हिन्दी पखवारा शुरू

ISBN 81-87053-84-7

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