NML

Annual Report

1974-75

National Metallurgical Laboratory

Jamshedpur, India

ANNUAL REPORT

1974-75

NATIONAL METALLURGICAL LABORATORY
COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
JAMSHEDPUR, INDIA

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INTRODUCTION

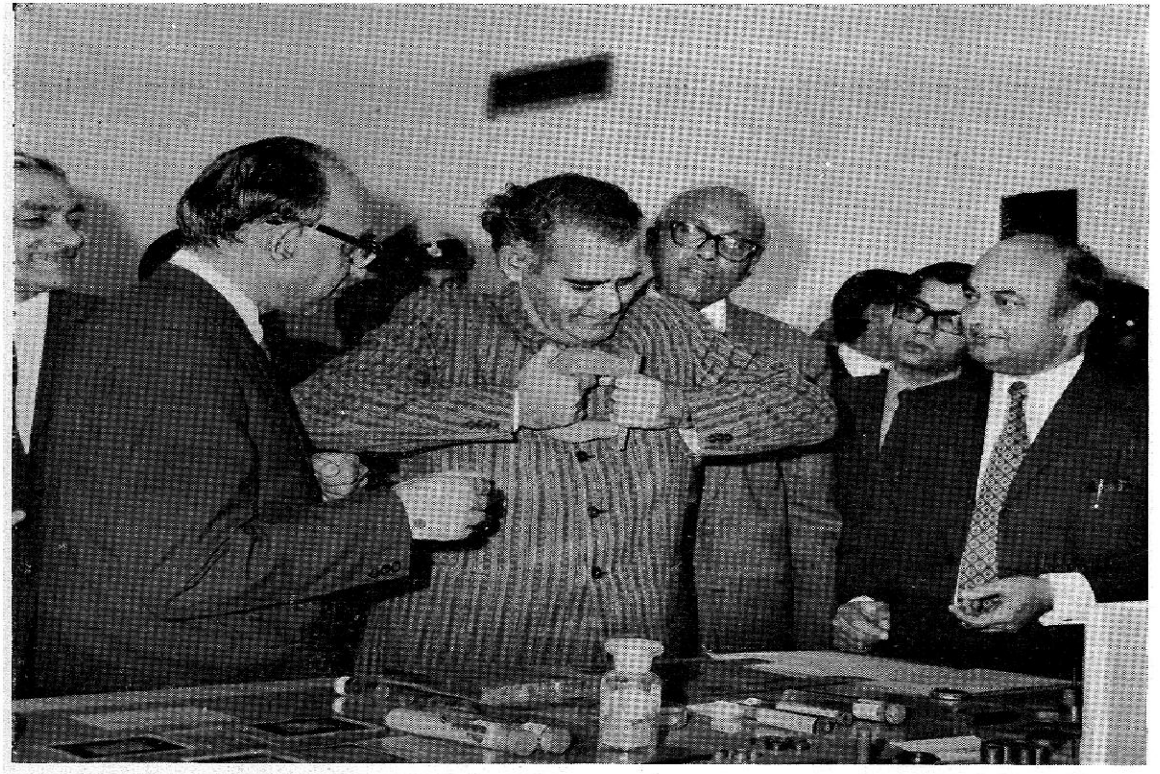
The National Metallurgical Laboratory, during the period under review, has maintained steady progress in its multifarious research and development projects and has stressed on transfer of technology for manufacture of different products. The Laboratory has successfully carried out trials for the production 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 technology of 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 core 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 UNDP 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



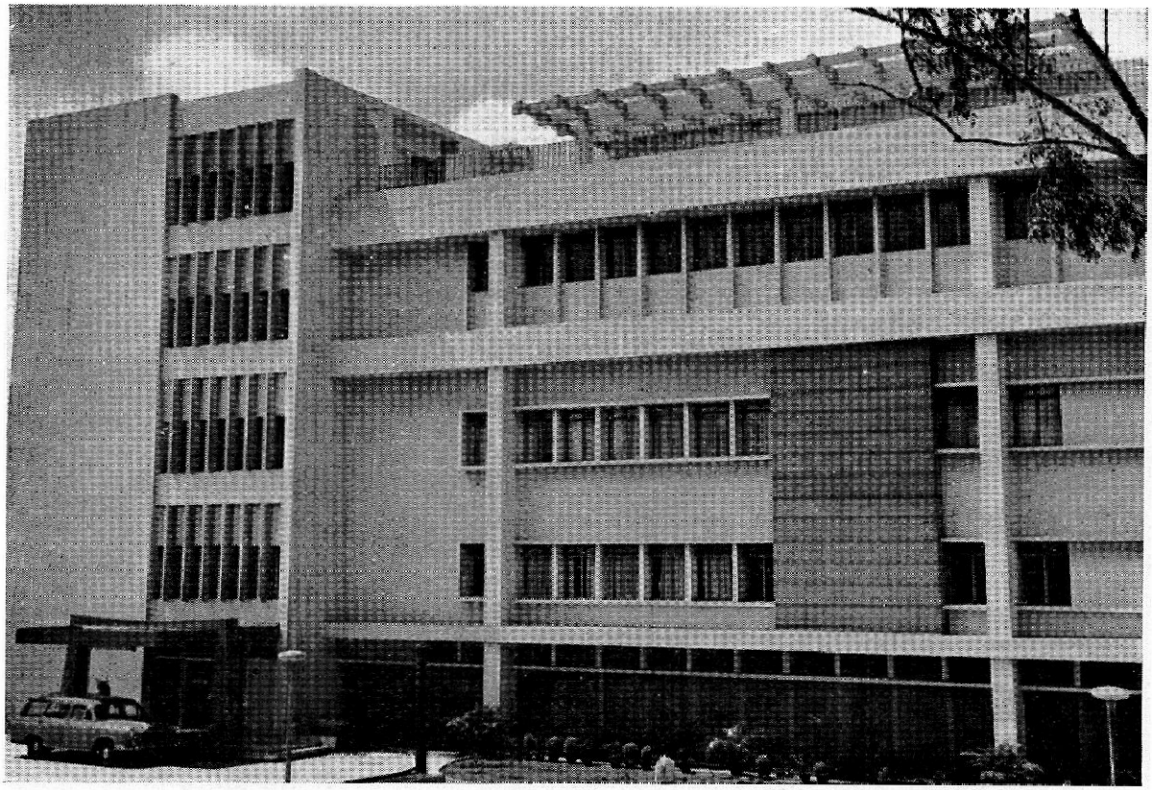
Shri Chandrajit Yadav, Union Minister for Steel & Mines, examining permanent magnet alloy developed at NML.

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 number 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



A front view of the building housing the Creep Testing Laboratory.

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.

A brief resume of the progress of various projects and other activities is furnished in the chapters that follow.

RESEARCH AND INVESTIGATION PROJECTS

A. ORE-DRESSING & MINERAL BENEFICIATION STUDIES

1.0 Pilot Plant Beneficiation Studies on Iron Ores from Meghatuburu Mines (Pt. I-Composite Sample). *Sponsored by M/s. National Mineral Development Corporation.*

Detailed beneficiation studies were conducted on a composite iron ore sample which was prepared by mixing five type samples. The beneficiation studies were conducted as per test schedule prepared by N.M.D.C. All the tests produced lumps of required chemical composition excepting the —10 mm fines which had slightly higher SiO_2 content than what was required. None of the tests could produce lumps and fines in the ratio of 25 : 75 as expected by NMDC Ltd. Hence, further test is being conducted according to a joint decision to improve the grade of fines.

1.1 Pilot Plant Beneficiation Studies on Iron Ores from Meghatuburu Mines (Pt. II—Type samples). *Sponsored by National Mineral Development Corporation.*

Detailed beneficiation studies were carried out on the five type samples from Meghatuburu iron ore mines viz. (*i*) Lateritic limonite, (*ii*) Hard laminated, (*iii*) High siliceous, (*iv*) High aluminous and (*v*) Blue dust samples. The beneficiation studies consisted of crushing the type samples and subsequently wet screening the crushed ore. The lumps and classifier sands were assayed for Fe, SiO_2 and Al_2O_3. The sieve and chemical analyses of the original samples, angle of repose and bulk densities at different moisture contents and shatter tests were conducted for each type sample.

1.2 Pilot Plant Studies on the Beneficiation and Sintering of Kemmangundi Iron Ore (Pt. I-Beneficiation). *Sponsored by M/s. Mysore Iron & Steel Works.*

About eighty tonnes of a composite sample of iron ore from Kemmangundi mines was received for conducting beneficiation studies with a view to producing suitable grades of lumps and fines.

The run-of-mine ore was crushed and processed. Desired grade lumps and fines were produced. The fines produced can be used for sintering.

1.3 Pilot Plant Studies on Beneficiation and Sintering of Kemmangundi Iron Ore (Pt. II—Sintering). *Sponsored by M/s. Mysore Iron & Steel Works.*

Optimum conditions were determined to produce unfluxed as well as fluxed sinters.

A few sintering tests were conducted using varying amounts of blue dust and replacing limestone by limesludge. Further sintering tests are in progress to improve the sinter quality.

1.4 Beneficiation and Pelletization Tests on Ten Samples of Iron Ore for Central Pelletizing Project. *Sponsored by M/s. MECON.*

A project sponsored by Steel Ministry through "MECON" was taken up to study the beneficiation and pelletizing characteristics on iron ore fine samples from Barajamda sector in Bihar-Orissa region, with a view to utilising the huge accumulated dumps as well as current arising. The aim was to produce two types of pellets out of the beneficiated products, for internal consumptions and for export variety. For this purpose seven individual samples—two from each of the three mines, Thakurani, Gua and Bolani and blue dust sample from the latter were taken up for beneficiation. As desired by the sponsors, three more mixed samples were also prepared—designated as composite I, Type I and Type II and beneficiation tests on the same were carried out.

Beneficiation conducted on a composite sample yielded a concentrate assaying 62.2% Fe, 2.98% Al_2O_3 and 2.65% SiO_2 with a yield of about 74% and Fe recovery of 76.5%. Further beneficiation produced an export grade concentrate assaying 2.66% Al_2O_3 with a yield of 44.1% and 49.5% Fe recovery. Pelletization tests are in progress.

1.5 Pelletization of Iron Ores Fines from Rajhara Mines and Comparison of Properties with Cold Bonded Pellets Made by Regional Research Laboratory, Jorhat. *Sponsored by Ministry of Steel & Mines.*

Detailed evaluation studies were carried out with heat hardened iron ore pellets and those prepared by cold bonded process avoiding the use of heat treatment for hardening, developed by RRL, Jorhat. In order to obtain comparative data, pellets were prepared from reportedly the same iron ore fines of Rajhara Mines, from which the cold bonded pellets were prepared. Evaluation of the physical and chemical properties of seven samples of cold bonded pellet samples, and comparison with heat hardened pellets, showed that some of the former pellets gave acceptable results.

1.6 Pelletization of Donimalai Iron Ore Fines and Production of 500 Kg. of Pellets for Tetsing at HYL and Midrex Laboratories. *Sponsored by M/s. MECON.*

Studies on pelletization were undertaken with the fines obtained after washing and hydrocycloning the composite iron ore sample from Donimalai mines with a view to producing 500 kg. of pellets for testing at HYL and Midrex Laboratories. The green compression strength of the pellets was 1.55 to 1.75 kg./pellet and the green pellets could withstand 14 to 22 drops from 500 mm height. The average crushing strength of the heat hardened pellets was 237 kg./pellet.

1.7 Pelletization of Bolani Iron Ore Fines Incorporating Blue Dust and Production of 500 kg. of Pellets for Testing at HYL and Midrex Laboratories. *Sponsored by M/s. MECON.*

Extensive studies on pelletization tests were conducted. Five hundred kg. of heat hardened pellets were produced under optimum conditions and handed over to MECON for testing at HYL and Midrex Laboratories, USA. The green

compression strengths of these pellets ranged between 1.6 and 1.8 kg/pellet and the green pellets withstood 10 to 12 drops from 500 mm height. The crushing strength of the heat hardened pellets ranged between 230 and 260 kg/pellet, tumbling and abrasion indices were 86.3% and 3.9% respectively, the reducibility was 55% and the swelling index 28.0%. The average crushing strength of the reduced pellets was found to be 33.4 kg./pellet.

1.8 Pelletization of Kundremukh Iron Ore Concentrate and Production of Pellets for Testing at HYL and Midrex Laboratories. *Sponsored by M/s. MECON.*

Studies on pelletization were undertaken with a sample of magnetite concentrate obtained from Kundremukh mines, with a view to producing 400 kg. of heat hardened pellets under optimum conditions for testing at HYL and Midrex Laboratories. The sample as received was of fine size.

Results of batch tests showed that the sample needed some treatment. The green compression strength of the pellets was 1.4 to 1.8 kg./pellet and the green pellets withstood 10 to 14 drops from 500 mm height. The average crushing strength of the heat hardened pellets was 224 kg/pellet. Reducibility was found to be 53.0% O_2 removal in 180 min. The swelling index and microporosity were found to be 9.6% and 26.8% respectively.

1.9 Comprehensive Studies on Pelletization of Iron Ore Fines from Noamundi Mines. *Sponsored by M/s. Tata Iron & Steel Co. Ltd.*

The Noamundi Pellet Plant was set up by M/s. Tata Iron & Steel Co. Ltd. to utilise the blue dust and iron ore fines to be generated from their mines and long range project plant at Noamundi. This investigation was taken up to obtain the optimum pelletization parameters for their feed mix with a view to determining parameters for production of quality pellets for their blast furnace.

An independent approach was adopted purely from the point of view of pelletization characteristics of feed constituents consisting of classifier sand, friable flaky ore and blue dust samples, as observed from the Laboratory studies. After detailed studies conditions of obtaining good quality pellets with high yield were determined. The flaky ore constituent was found to contribute substantially to the problems created and needed to be properly manipulated.

1.10 Beneficiation and Agglomeration Studies on a Low Grade Magnetite from Ongole, Andhra Pradesh. *Sponsored by Department of Mining and Geology, Govt. of Andhra Pradesh.*

A low grade magnetite from Ongole district of Andhra Pradesh was received for beneficiation and agglomeration studies. A concentrate assaying 65.5% Fe with a recovery of 82.0% Fe in the product was obtained.

1.11 Pilot Plant Studies on Flowability and Screenability Characteristics of Iron Ore Sample from Meghataburu Mines. *Sponsored by M/s. National Mineral Development Corporation.*

Five samples of iron ores, each weighing about 8 tonnes were received from Meghataburu Mines for studying their flowability and screenability

characteristics. The samples were composed of siliceous and aluminous ores at varying proportions. It was observed that under controlled laboratory conditions, the sample containing siliceous and aluminous ore in the ratio of 90 : 10, had fair flowability and screenability at 7.5% moisture. Further tests are under progress.

1.12 Studies on Screenability of Composite Iron Ore Samples from Meghataburu Mines. *Sponsored by M/s. National Mineral Development Corporation.*

Tests were conducted varying the moisture content of the prepared samples. The percentage of moisture optimum for ease of ore handling was determined. Tests have also indicated the percentage of moisture that would result in production of large amount of dust due to the nature of the ore and blinding of the screens.

1.13 Beneficiation Tests on Three Low Grade Iron Ore Samples from Girar Deposits of Jhansi District, U.P. *Sponsored by Director of Mines & Geology, Lucknow, U.P.*

Three low grade iron ore samples from Girar deposits of Jhansi district, were received for (1) detailed mineralogical examination and chemical analyses (2) Davis tube tests (wet magnetic separation) at different sizes (3) Grindability tests to determine the work index by Bond's method and (4) preliminary static bed bench scale studies for ascertaining the suitability of the iron ore for sponge making, using coal as reductant. These three samples, which were reported to be surface samples were of inferior grade. Mineralogically, the samples were similar.

Davis tube tests were carried out at different sizes and a magnetic concentrate assaying 61-63.5% Fe with low iron recoveries ranging between 35 and 48% was obtained. Tabling tests followed by Davis tube separation tests of the table concentrate yielded magnetic concentrates analysing between 62.7% and 67.4% Fe but with iron recoveries ranging between 50 and 56%. Work Index determination on all the three samples were carried out by Bond's method and the values were found to be 12.99 KWH/tonne, 13.05 KWH/tonne and 12.35 KWH/tonne respectively for the three samples, C-I, B-I and B-II.

1.14 Davis Tube Tests with a Magnetite Sample. *Sponsored by M/s. Tata-Robins-Fraser Ltd.*

A sample of magnetite was received for carrying out Davis Tube magnetic separation tests to determine the percentage magnetics, the specific gravity of the magnetics and the magnetic susceptibility. The tests carried out indicated that about 77.0% of the magnetics could be separated in a Davis tube tester. The total Fe content in the magnetic fraction was 68.6% with a recovery of 97.7% in the product. The concentrate had a specific gravity of 4.55.

1.15 Kutch Bentonite as a Binder for Pelletization of Iron Ore Fines. *Sponsored by M/s. Shree Mangal Mineral (P) Ltd., Saurashtra.*

A bentonite sample, weighing 1 tonne, was received for studying the suitability of the sample as a binder in pelletization of iron ore fines. Two

iron ore samples marked as A and B available in the Laboratory were used for pelletization tests. It was found that the bentonite tested could be tried as a binder for pelletization of iron ore fines.

2.0 Batch and Pilot Plant Studies on Beneficiation of Low Grade Copper Ore from Malanjkhand, Madhya Pradesh. *Sponsored by M/s. Hindustan Copper Ltd.*

Beneficiation studies were carried out on a composite low grade copper ore sample from Malanjkhand mines of Hindustan Copper Ltd. in Madhya Pradesh. Pilot Plant studies indicated a concentrate assaying 27.9% Cu with 96.8% Cu recovery could be produced.

2.1 Batch and Pilot Plant Studies on Recovery of Copper Minerals from Copper-Slag Sample of Indian Copper Complex. *Sponsored by M/s. Hindustan Copper Ltd.*

Beneficiation studies were carried out on a copper-slag sample received from the Ghatsila Works of M/s. Hindustan Copper Ltd. The slag sample assayed 0.798% Cu. The copper bearing constituents were mostly present in intimate association with the gangue constituents and ranged in size from 16 microns to less than 1 micron.

In batch scale studies a concentrate assaying 4.23% Cu with a recovery of 82.9% Cu in it was obtained. Two stage cleaning of the rougher concentrate yielded a concentrate assaying 16.11% Cu with 70.5% recovery in it. Bond's work index of the sample for the grind was determined.

In Pilot Plant studies similar operating conditions were maintained for roughing. The rougher concentrate yielded a final concentrate assaying 20.75% Cu with recovery of 78.1% Cu in it.

3.0 Beneficiation Studies on a Low Grade Complex Cu-Pb-Zn Ore from Ambaji, Gujarat. *Sponsored by M/s. Gujarat Mineral Development Corporation.*

Bench scale beneficiation studies were undertaken on a sample of low copper-lead-zinc ore (lode-complex sample) received from Ambaji. A copper-lead concentrate assaying 19.45% Cu, 10.55% Pb, and 5.6% Zn with distribution of 78.7% Cu, 74.0% Pb and 13.6% Zn in it was obtained. Activation of sphalerite minerals from the Cu-Pb rougher tailings, followed by cleanings yielded a cleaner zinc concentrate assaying 1.3% Cu, 1.28% Pb and 46.5% Zn in it. Further tests to improve the grade and recovery are in progress.

4.0 Size Analyser of Feed and Underflow Samples received from Indian Copper Complex, Ghatshila. *Sponsored by M/s. Hindustan Copper Ltd.*

Two ground copper ore samples designated as "Feed Sample" and "Underflow Sample" were received from the Indian Copper Complex, Ghatshila for complete sizing analysis. Sieve and subsieve analysis of the samples were carried out using standard screens and the infrasizer. Tests indicated that the underflow sample was coarser than the feed sample.

5.0 Beneficiation Studies on a Low Grade Wolframite Sample from Agargaon, Nagpur Dist., Maharashtra. *Sponsored by Geological Survey of India, Nagpur.*

A low grade wolframite ore sample was received for beneficiation studies. A series of tests were performed so as to produce a concentrate of desired grade. The final table concentrate analysed 60% WO_3 with 68% recovery in it. The concentrate fulfilled the grade requirements for commercial utilisation.

6.0 Beneficiation of Low Grade Fluorspar Sample. *Sponsored by M/s. Rajasthan State Industrial & Mineral Development Corporation.*

Beneficiation studies were undertaken on two low grade fluorspar samples with a view to producing acid grade concentrate. The first sample of fluorspar (S.No. 1) was from Kahila deposit. An acid grade concentrate assaying 98.0% CaF_2, 0.40% $CaCO_3$ and 1% SiO_2 with a fluorite recovery of 82.4% was obtained.

The second sample (S.No. 2) received subsequently was a blended fluorspar sample from Kahila and Mandokipal mines. A few tests under optimum conditions established for sample No. 1 as desired were carried out. The blended sample was of inferior grade, high in calcite. Best concentrate obtained assayed only 94.04% CaF_2, 2.5% $CaCO_3$, 1.6% SiO_2 with only 80.3% CaF_2 recovery in it.

6.1 Batch and Pilot Plant Beneficiation Studies with Low Grade Fluorspar Sample from Kahila and Mandokipal Mines. *Sponsored by M/s. Rajasthan State Industrial & Mineral Development Corporation.*

About twentyfive tonnes of low grade fluorspar sample from Kahila and Mandokipal mines were received for batch as well as pilot plant beneficiation studies for producing acid grade concentrate.

Bench scale flotation studies on the individual samples have been completed and the assay results of the test products are awaited. Few flotation tests under optimum conditions on a mixed sample of fluorspar are in progress.

7.0 Bench Scale Beneficiation Studies on Run-of-Mines Graphite Sample. *Sponsored by M/s. Rajasthan State Industrial and Mineral Development Corporation.*

About seventythree tonnes of low grade graphite were received for pilot plant beneficiation studies for developing a technical flowsheet for production of graphite concentrate suitable for commercial utilization. Batch tests with the sample did not yield encouraging results. The final concentrate assayed 62.2% F.C. with a poor recovery of only 23.3% F.C. The low grade poor recovery of graphite was mainly due to fine interlocking of graphite quartz and carbonates. As the bench scale results obtained with the present sample were poor, no pilot plant tests were conducted.

7.1 Batch and Pilot Plant Studies on Low Grade Graphite Samples from Banswara, Rajasthan. *Sponsored by Rajasthan State Industrial & Mineral Development Corporation.*

Three bulk samples of graphite from Tamtia, Sasakota and Kesharpura mines, Banswara Dist., Rajasthan were received for bench scale beneficiation tests for investigating the possibility of upgrading them to a grade suitable for industrial purposes and to develop a flowsheet for the production of graphite concentrate, from a composite sample after pilot plant beneficiation studies.

7.2 Petrological Studies on Forty Seven Graphite Ore Samples of Palamau Dist., Bihar. *Sponsored by Govt. of Bihar.*

A total of 36 core samples, 6 sludge samples and 5 pit samples of graphite taken from the exploratory bore holes of some of the graphite bearing areas of Betla, Pokhri, Kutmu and Hathinala in Palamau district, Bihar, were received for petrological studies.

The studies indicated that the samples were of poor grade, fine grained and sporadic in distribution with the associated quartz-biotite gangue minerals. However, the pit samples received from Hathinala area, which seemed to be a very promising area, indicated that these samples were comparatively of better grades fairly coarse grained and associated with quartz-biotite gangue minerals.

8.0 Batch and Pilot Plant Beneficiation Studies on Phosphorite Sample from Maldeota, Mussorie Area, U.P. *Sponsored by M/s. Pyrites, Phosphates & Chemicals Ltd.*

About 158 tonnes of three different phosphorite samples designated as 'Main Phosphatic Bed Hanging Wall and Foot Rock', from the above area were received for beneficiation studies on a composite sample as desired by the firm with a view to making it suitable for fertilizer production. Some of the tests conducted did not give promising results. Further work is in progress.

9.0 Bench Scale Beneficiation Studies on a Low Grade Limestone Sample from Jhalda Area, Purulia District. *Sponsored by M/s. West Bengal Cements Ltd., Calcutta.*

Bench scale beneficiation studies were undertaken on a sample of limestone from Jhalda area of Purulia district. The main object of the investigation was to produce a concentrate suitable for cement manufacture. A concentrate assaying 49.48% CaO, suitable for cement making could be successfully produced with CaO recovery of 90%.

9.1 Beneficiation Studies on Limestone Sample from Manipur. *Sponsored by Director of Geology & Mining, Manipur, Govt. of Assam.*

Bench scale beneficiation studies were undertaken on two limestone samples from Manipur, designated as (*a*) Low grade and (*b*) High grade, with a view to producing concentrate suitable for use in the cement industry. A concentrate suitable for cement manufacture assaying 49.27% CaO, 1.6% MgO, 8.87% insolubles with a recovery of 90.7% CaO in it was obtained.

10.0 Bench Scale Beneficiation Studies on Gypsum Sample from Nagaur Mines, Rajasthan. *Sponsored by M/s. Rajasthan State Industrial & Mineral Development Corporation.*

A sample of low grade amorphous gypsum was received for bench scale beneficiation studies so as to produce a concentrate suitable for making "Plaster of Paris". A high grade concentrate assaying 46.3% SO_3 (99.4% gypsum equivalent) with a recovery of 72.5% SO_3 in it was obtained. This product was of grade suitable for use in the manufacture of Plaster of Paris.

11.0 Beneficiation of Low Grade Kyanite from Khamman District, Andhra Pradesh. *Sponsored by M/s. Lal Trader & Agencies (P) Ltd.*

A sample of low grade kyanite, was received for beneficiation studies, so as to produce a concentrate suitable for use in refractory industry. A cleaner concentrate assaying 48% Al_2O_3 but with a recovery of 38.7% Al_2O_3 in it was obtained. Further work is in progress.

12.0 Beneficiation Studies on Coal Sample from Bhowrali Colliery.

A coal sample was beneficiated to 6.4% ash with a material recovery of 54.6% in the concentrate. A concentrate assaying 4.2% ash with a weight recovery of 38.9% was also obtained.

12.1 Reduction of Ash Content in a Coal sample. *Sponsored by M/s. Tata Iron & Steel Co. Ltd.*

Beneficiation tests are in progress to reduce the ash content in coal sample received from Jamadoba Collieries of M/s. Tisco Ltd.

B. REFRACTORIES TECHNOLOGY

13.0 Tests Conducted on Castables Specimen Supplied by Haldia Refinery. *Sponsored by M/s. Indian Oils Ltd.*

A number of insulating castables were supplied by Haldia Refinery Project for the following tests:

(*a*) Bulk density
(*b*) Linear Change
(*c*) Modulus of rupture
(*d*) Cold crushing strength
(*e*) Thermal conductivity.

Tests (*a*) to (*d*) were carried out on specimens after drying and firing.

14.0 Tests Conducted on Kovilpatti Dolomite for Salem Steel Plant. *Sponsored by Director of Industries & Commerce, Mining & Geology Branch, Govt. of Tamil Nadu.*

The work on dolomite consists of the study of the raw material and its calcination characteristics to assess its suitability as a steel plant refractory. The tests indicated that the dolomite should be calcined at a particular temperature with some blue dust to obtain a good product.

15.0 Welding Flux.

Further modifications of the compositions, reported earlier, were made and the fluxes were tested for bead on plate tests. Some of the test results of weld metal deposits are given below:

Flux	Welding wire	Weld metal analysis %				
		C	Mn	Si	S	P
1	Modi No. II	0.08	0.8	0.59	0.015	0.02
2	,	0.09	0.66	0.82	0.01	0.02
3	,,	0.06	1.10	1.05	0.04	0.02

In flux 1 Mn content of the metal is slightly low whereas in flux 3 when Mn content has increased; Si content has also increased. These fluxes are being modified to bring down Si content and to increase Mn content of the weld metal.

16.0 Vacuum Induction Furnace Lining.

About 50 kg of specially prepared alumina was sintered and was crushed and graded to make a lining mix. The mix is being sent to M/s. Cable Works (India) Ltd. for field trials.

17.0 Fused Rock Products and Method of Their Manufacture.

Suitable technique of fusing low fusible siliceous rock like tailing sands, rubbles, and basic rocks were successfully melted and blocks were cast and suitably annealed for ready use. Physical properties like bulk density, porosity, hardness, abrasibility and acid resistance were determined which compared favourably with those of samples of foreign origin. Further work on making different sizes blocks is under progress.

18.0 Development of Sintered Fused Silica Products.

Preliminary experiments on the fusion of quartz sand in an electric arc furnace have been carried out and 4-5 Kg fused quartz has been crushed for studying the sintering and slip casting properties.

19.0 Development of Tar-bonded Magnesite Blocks.

About 700 quarter sized bricks have been made by mixing with different fractions of dead burnt magnesite and pitch. Some of these have been tempered in an electric furnace and their physical properties such as bulk density, porosity, firing shrinkage have been studied.

Of the 75 crucible pressed and kept ready for firing, 15-20 crucibles have been fired and given to various research divisions of the laboratory.

21.0 Production of Hot-tops from Indigenous Raw Materials.

The bench scale work is completed. Further work on large scale is being considered. Table I gives the comparative properties of commercially available material and laboratory composition developed.

TABLE 1

Physical properties of hot-tops

	Commercially available ones			Laboratory compositions	
	1	2	3	1	2
Porosity %	62.8	60.9	61.8	51.00	61.00
Bulk density (gm/cc)	0.94	0.94	0.93	0.70	0.91
Modulus of rupture (Kg cm^2)	14.3	24.06	13.06	12.75	31.75
Thermal conductivity (B.T.U./hr/sq. ft/in)					
at hot face temp. 100°C	—	—	—	0.95	1.89
„ „ 200°C	—	—	—	1.65	1.91
„ „ 250°C	—	—	—	1.75	2.09

22.0 Investigations on Clay-graphite Raw Materials and Products.

During the period, experiments were carried out to study the influence of graphite additions on clay-grog bodies and to develop some suitable ladle brick compositions. Buttons, bars and bricks were made from different clay-grog-graphite mixes and fired in a down draft kiln. Various properties such as apparent porosity, bulk density, apparent specific gravity, drying and firing shrinkages, dry and fired crushing strengths, modulus of rupture, volume stability, spalling resistance, thermal conductivity were determined. For studying the microstructural properties, polished sections of these samples were prepared and further work is in progress.

23.0 Carbon Refractories and Studies on Binders and Raw Materials.

During the year under review, the building up of testing facility for evaluation of binders as well as raw materials used in the production of dense carbon aggregate, soderberg paste and carbon refractories was continued. Some of the very important apparatus e.g. electrical resistivity determination apparatus, thermal conductivity apparatus and apparatus for assessing the resistance to sodium attack in the aluminium reduction cell were designed and fabricated in the laboratory.

Effort has been made to collect varieties of tar and pitches from different steel plants in India. In this context, two binders from Rourkela Steel Plant have already been collected and the arrival of several more binders from Bhilai

Steel Plant is awaited. Preliminary studies on coal also have been made to use it as a cathodic raw material in the aluminium reduction cell, in substitution of anthracite coke which is imported.

24.0 Cement Fondu Type High Alumina Cement.

After determining the chemical analysis of the raw materials a number of batch compositions were compounded with various Al_2O_3 & CaO ratios. A number of batches were made and heat treated at various temperature to assess the effect of composition and the temperature of sintering on the quality of cement produced. Based upon this study, certain compositions have been perfected and other process parameters have been fixed. Repeatibility trials indicate the feasibility of producing good cement. Amongst some of the physical properties determined were grinding time and particulate composition ; variation in setting time with respect to surface area etc. A preliminary report for the manufacture of 6000 tonnes per annum of Cement Fondu type high alumina cement has been prepared.

C. EXTRACTION & CHEMICAL METALLURGY

25.0 Extraction of Nickel and Cobalt from Lateritic Nickel Ores of Sukinda.

Studies have resulted in an improved method for the recovery of nickel and cobalt in an efficient and economic way with a nickel recovery of 98 percent.

26.0 Solvent Extraction for Recovering Nickel and Cobalt from Leach Liquors.

Optimum conditions for the recovery of nickel in ammoniacal solution have been carried out. A Laboratory counter current mixer settler unit for use in these studies has been designed and fabricated. Cobalt is recovered from adsorption technique.

27.0 Recovery of Nickel Ores from Ukampahar Area.

In Ukampahar area near Jamshedpur, nickel has been found to occur as anhydrated magnesium nickel silicate in association with goethite. Almost quantitative extraction of nickel has been obtained.

28.0 Bacterial Leaching of Copper Ores.

During the year, two Inter-Laboratory meetings were held, one at Bhubaneswar and another at Poona. Follow up actions on the decisions arrived at these meetings were fulfilled. The exhaustive literature survey made by this laboratory was exchanged with those of others. Mine water solutions and ore samples were collected and was sent to NCL, Poona, for identification for bacterial presence.

Low grade copper from Mosabani Mines, Singhbhum, Bihar and copper ore from Malanjkhand area M.P. were collected to carry out preliminary experiments. The leaching experiments were initiated with a view to finding out

the acid consumption to neutralise the gangue material in the ore bodies and at the same time to find the relative rate of copper dissolution from these ores in presence of mine water and nutrient solutions. Blank experiments are also being carried out side by side in presence of bacteria to study its effect on dissolution. The work is in progress.

29.0 Extraction of Vanadium Pentoxide and Pig Iron from Vanadium Bearing Titaniferous Magnetite.

Successful trials were carried out at Mysore Iron & Steel Works Ltd., Bhadravati; for extraction of vanadium pentoxide and production of ferro-vanadium from the vanadium bearing titaniferrous ores of Masanikere. The slag is the potential source of V_2O_5 required for production of ferro-vanadium.

30.0 Recovery of Vanadium Pentoxide from Vanadium Sludge of Alumina Plants of M/s. Bharat Aluminium Co. and Hindustan Aluminium Co. Pvt. Ltd.

Successful trials have been carried out for extraction of V_2O_5 contained in the sludges of M/s. Bharat Aluminium Co. and M/s. Hindustan Aluminium Co. to produce V_2O_5 of commercial grade.

31.0 Recovery of Lead from Lead Concentrates by an Alternate Process.

Preliminary trials on the recovery of lead from lead concentrate were done. It was found that the process was feasible and needed further development.

32.0 Liquid State Extraction of Magnesium in a Single Electrode 140 KVA Arc Furnace.

Objective of the project is to produce magnesium metal by electro-thermal liquid state reduction continuously or batchwise so as to remove the bottle-neck of utilising high cost retorts used in Pidgeon process which have short life. This would appreciably decrease the cost of magnesium metal production. A single electrode 140 KVA furnace is to be utilised. Detailed drawings have been prepared for the furnace shell, electrode drive unit etc. Arrangements are being made to fabricate the unit.

33.0 Production of Calcium-Silicide.

Calcium-silicide which is mainly used as inoculent in the production of high quality grey iron castings, was produced for the first time in a 500 KVA submerged arc furnace pilot plant in the Laboratory. The alloy conformed to I.S.I. Standard 1387/1967 in all respects. Substantial amount of this alloy was sent for industrial use at HMT, Bangalore and HEC, Ranchi and excellent reports were obtained. Attempts are being made to improve the various operational parameters of this process. Testing of different raw materials required for this process is in progress.

34.0 Roasting of Molybdenum Concentrate to Produce MoO_3.

The Indian copper complex is scheduled to produce 250 kg. of molybdenite

concentrate from their Rakha Mines. M/s. Uranium Corporation of India Ltd., Jadugoda will also produce about 250 Kg. of molybdenite concentrate. Work was undertaken to utilise these concentrates for the production of ferro- molybdenum. A detailed survey of the materials and the conversion practice was undertaken to study the feasibility of producing molybdic oxide and then ferro-molybdenum from these concentrates. Literature survey, a detailed flowsheet and the cost estimate for conversion of molybdenite concentrate to molybdic oxide and for the production of ferro-molybdenum have been prepared.

35.0 Studies on Adsorption Extraction of Cobalt with Lignite.

The extraction of cobalt from ammoniacal solutions by adsorption on Neyveli lignite was successfully investigated. It was found that over 98% recovery was possible. The adsorbed cobalt could be elutriated with acids and the solution treated further for precipitation, etc. Further work on zinc, copper and other metals is being planned with the ultimate objective of evolving a method of selective adsorption for isolation of nickel from associated elements such as cobalt etc.

36.0 Production of Atomized Metal Powder.

The process know-how for production of atomized powders of low melting non-ferrous metals from lead to copper was licensed to two entrepreneurs and the technology was transferred to them for implementation. Development of a powder polishing mill was taken up.

37.0 Copper Coated Graphite Powder.

A technique has been developed for coating individual particle of a graphite powder mass with copper by using electro-chemical method. Various particle sizes of graphite have been coated with copper, weight percentage of copper ranging from 0 to 75%.

38.0 Making of Spherical Metal Particles.

Low melting metal such as aluminium, can be centrifugally dispersed to make spherical metal particles. An apparatus and a process has been developed for making such particles.

39.0 Production of Zinc Dust.

The process know-how for the production of distilled zinc dust by the oil-fired retort process released by the NRDC to Associated Pigments Limited of Calcutta was pursued and technology transfer completed to licencee for project implementation.

40.0 Recovery of Zinc from Galvanizers' Dross.

The process know-how for the recovery of pure metallic zinc from galvanizers' dross by atmospheric distillation was licensed to an entrepreneur and transfer of technology will be shortly taken up.

41.0 Recovery of Zinc Values from Galvanizers' zinc Ash and By-product Zinc Hydroxide from Sodium Hydro-sulphite Industry.

The work in the Laboratory has been carried out on 2 Kg. batch scale. Zinc oxide conforming to IS: 3399 of 1965 (zinc oxide for Rubber Industry) was produced from zinc ash by the method developed. Metallic zinc contained in the ash could be separated and agglomerated. One tonne of zinc ash would give on treatment by this process 0.45 tonne of pure zinc oxide and 0.288 tonne of zinc metal. The developed process has been referred to NRDC for release to interested entrepreneurs for commercial exploitation.

42.0 Recovery of Elemental Sulphur, Copper, Lead and Zinc from Respective Sulphide Mineral Concentrate.

More than 95% water soluble copper could be obtained and preparation of copper sulphate as per I.S.I. specification was successful. Investigation was conducted further to utilise the low grade impure copper concentrate as available from Sikkim. Detailed work is under progress.

43.0 Preparation of Industrial Chemicals from Off-Grade Copper Ore Concentrate.

Chalcopyrite concentrate was treated. 77% of the sulphur present was obtained in the elemental form and 99% of the copper was recovered. The work has been done on bench scale and can be utilised for copper concentrates obtained from small pockets of copper deposits to obtain metallic copper or copper chemicals, directly from the concentrates.

44.0 Reduction of Manganese Ores with Low Temperature Carbonised Coke.

The parametric investigation for the reduction of manganese ores with L.T.C. has been completed and it has been found that 98% reduction can be achieved by using 10% of coke by the weight of ore for higher grade and 7% of coke of the weight of ore for lower grade manganese ore. This reduction can be achieved in 30 and 20 minutes respectively. The results have led to the installation of continuous reactor for reduction of manganese ores.

45.0 Preparation of Fluorine Chemicals for Metallurgical Use.

(*i*) *Studies on the Preparation of Cryolite from Gujarat Mineral Development Corporation Fluorspar.*

The fluorspar contains high percentages of Fe_2O_3 and P_2O_5. A single step selective leaching process has been developed for purification of fluorspar. Cryolite prepared from the purified fluorspar contained Fe_2O_3 less than 0.1% and P_2O_5 less than 0.05%.

(*ii*) *Large Scale Trial Experiments of Preparation of Cryolite by Fluoboric Acid Process.*

The fluoboric acid process developed for the preparation of cryolite from fluorspar has been promising in bench scale. For the commercialisation of the process, it is necessary to carry out large scale experiments for the collection of technical, design and economic data.

The process has been referred to NRDC. NRDC has appointed a firm of consulting engineers for the assessment of the process. Process has been demonstrated to the engineers of Consulting Engineering firm by carrying out three experiments and supplying all the relevant data. The process evaluation report has been received from the firm. The report says "NML's process for synthetic cryolite is technically sound. Based on the technical data available and the cost factors assumed, the NML Process appears to be economically viable". The firm has also suggested further experimentation at large scale. Four 100 Kg/batch experiments were carried out and data forwarded to the firm.

46.0 Multipurpose Hydro-Electrometallurgical Large Scale Testing Facilities.

The project is located at NML Adityapur Complex, situated approximately 20 Kilometers from Jamshedpur, where 90 acres of land have been acquired from Adityapur Industrial Development Authority.

Layouts of process plant and equipment are worked out. The central materials handling and storage facilities were finalised. Process layouts based upon unit operations were prepared.

47.0 Sukinda Nickel Project.

Work continued on the setting up of the pilot plant for processing Sukinda nickel ore.

D. IRON & STEEL TECHNOLOGY

48.0 Study on Reduction Characteristics of Iron Ore.

Reduction characteristics of iron ores/pellets play an important role in evaluating iron ores for their usage in blast furnace or sponge iron production. The following investigations have been completed during the period.

(*i*) Comparative Study of Reduction Characteristics of Kalte, Barsua and Barajamda Iron Ores from Rourkela Steel Plant by Bulk Reducibility Test. *Sponsored by M/s. Hindustan Steel Ltd., Rourkela.*

(*ii*) Comparative Study of Reduction Characteristics of Donimalai & Bolani Heat Hardened Pellets. *Sponsored by MECON.*

(*iii*) Comparative Study of Reduction Characteristics of Ettinahali and Ubalagundi Iron Ores by Bulk Reducibility Test. *Sponsored by Salem Steel Plant, Salem.*

49.0 Static Bed Bench Scale Tests for Iron Ores and Coals.

In order to match the iron ore and coals for sponge iron production and also to determine the optimum conditions for maximum metallisation of sponge iron, it is very important to conduct static bed bench scale tests for iron ores and coals. The following investigations were completed:

(*i*) Tests with Baripada Iron Ore with Samla coal. *Sponsored by IDCOL.*
(*ii*) Jhansi Iron Ores with Singareni coal. *Sponosored by Department of Geology & Mining, Govt. of U. P., Lucknow.*
(*iii*) Gandhamaradan Iron Ore with Talcher Coal. *Sponsored by IDCOL.*
(*iv*) Baripada Iron Ore with Rampur Coal. *Sponsored by IDCOL.*
(*v*) Khondoband Iron Ore with Samla Coal. *Sponsored by IDCOL.*
(*vi*) Khondoband Iron Ore with Rampur Coal. *Sponsored by IDCOL.*
(*vii*) Iron Ores from Hospet Area with Singareni Coal. *Sponsored by Andhra Cement Co., Vijayawada.*

50.0 Study of Swelling Index of Heat Hardened Iron Ore Pellets.

One of the important property for assessing the utility of heat hardened pellets for sponge iron manufacture is to determine their swelling index. The following investigations were conducted during the period:

(*i*) Study of the Swelling Index of Bolani Heat Hardened Pellets. *Sponsored by MECON.*
(*ii*) Study of the Swelling Index of Donimalai Pellets. *Sponsored by MECON.*
(*iii*) Study of the Swelling Index of Kundremukh Heat Hardened Pellets. *Sponsored by MECON.*

51.0 Thermal Degradation Test of Iron Ores from Hospet. *Sponsored by M/s. Andhra Cement Co., Vijayawada.*

Thermal degradation test has been conducted to find out the suitability of the iron ores for their degradation behaviour inside sponge iron making furnace.

52.0 Appraisal of Raw Materials for Iron and Sponge Making.

The following investigations were completed during the period:

(*i*) Decrepitation characteristics of Bailadila iron ore deposit for Vijay steel plant.
(*ii*) Decrepitation characteristics of Bailadila iron ore deposit for Salem steel plant.
(*iii*) Decrepitation characteristics of iron ores from Nepal.
(*iv*) Calcination characteristics of limestone from Salem steel plant.

53.0 Production of Sponge Iron in Rotary Kiln with Bayaram Iron Ore and Singareni Coal from Andhra Pradesh Industrial Development Corporation.

To study the suitability of raw materials for the production of sponge iron in the rotary kiln, Bayaram iron ore and Singareni Coal were received from Andhra Pradesh Industrial Development Corporation. As the iron ore as received was found of poor quality for sponge iron production it was beneficiated to improve its grade. With the beneficiated ore two campaigns were undertaken in a 0.76 M. dia and 10.7 M. long rotary kiln.

The first campaign consisted of eleven sets of experimental trials varying

the parameters. Each of the variation was studied to obtain the optimum result. In the second campaign difrerent sets of experiments were conducted. The metallization varied between 82-85%. The average compression strength of sponge iron was 100-110 kg/lump and a tumbling index of 90-93%.

53.1 Production of Sponge Iron in Rotary Kiln with Raw Materials from Industrial Development Corporation of Orissa Ltd.

Three samples of iron ore from Gandhamardan, Khondband and Baripada mines and three non-coking coal samples from Talcher, Samla and Rampur collieries of Orissa were received for investigations for production of sponge iron.

Investigations were conducted with iron ores and coals in the following combination and encouraging results were obtained.

(*a*) Gandhamardan ore and Talcher coal
(*b*) Khondband ore and Rampur and Samla Coals
(*c*) Baripada ore and Rampur and Samla Coals

53.2 Steel Production with Sponge Iron in Electric Arc Furnace.

Sponge iron produced in NML rotary kilns from different iron ores was melted in 0.8 ton electric arc furnace. 40% and 60% sponge was used in the charge and different grade of steels were produced. More industrial trials for steel making with sponge iron are being planned.

54.0 Carburising of Grain Refined Steel in High Temperature.

The object of this project is to develop steels which could be carburised at higher temperature without excessive grain growth so that the time cycle could be materially reduced. This would give rise to increase productivity, higher available furnace capacity and less tendency of case to spalling.

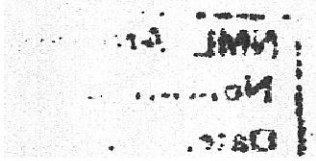
In continuation with the previous work, steels have been made with combined additions of titanium and niobium. Investigations are being carried out on these steels to determine their carburising characteristics.

55.0 Pneumatic Steel Making in Basic Lined Side-blown Converter.

The process was demonstrated to the personnel of Steel Authority of India (SAIL). Besides demonstration work, the study on the life of tuyere block and refractory lining of the converter was made.

56.0 Alloy Steel Making in Top Blown Converter.

The objective is to assess the possibility of producing high chromium steel in the top blown converter. Further experiments were conducted to increase the chromium content of the blown metal. With an aim to obtain 8—9% chromium oxide in the slag, experiments were conducted using-ferro-chromium in the bath. The chemical composition of the blown metals obtained are given in the following page.



Experiments	1	2	3	4
C%	0.126	6.61	0.54	0.45
Si%	0.27	0.37	0.32	0.28
S%	0.041	0.048	0.047	0.044
P%	0.16	0.13	0.06	0.07
Cr%	1.9	1.73	0.03	0.06
Mn%	0.08	0.07	0.03	0.06

From the experimental results, it was observed that 40—50% chromium recovery could be possible which was rather low. Due to the poor quality of lime used in the experiments, the phosphorus content of the blown metal was on the higher side. Further experiments with better quality of lime and better slag composition is under progress.

56.1 Special Alloy Steel Making in Top Blown Converter.

Installations of the oxygen pipe line extension, oxygen lances and equipments are under progress.

57.0 Development of V-N Low Alloy High Strength Structural Steel.

In continuation of previous year's work, mechanical properties and grain size were determined on six compositions of steels containing vanadium and nitrogen. The properties were determined on steels normalised at different temperatures to obtain optimum values of strength and toughness.

58.0 Development of Cr-Ni-Cu Austenitic Stainless Steel.

The investigation has been carried out with eleven compositions of austenitic stainless steels wherein nickel has been partially replaced by varying proportions of copper, manganese and nitrogen. Mechanical properties of the steels have been determined and corrosion tests are being performed.

59.0 Commercial Trials of Niobium Treated Steels.

Based on the results of Laboratory work on low alloy high strength structural steels containing small additions of niobium, industrial scale trials were carried out at the Rourkela Steel Plant.

Two heats of 50 tons of carbon-manganese steels were made in the L.D. converter. In one of the heats ferro-niobium was added in the ladle and in the other the ferro alloy was added in the ingot moulds during teeming. The ingots were rolled into slabs and then subsequently into plates of 8 mm, 12 mm and 18 mm thickness. Efforts were made to control the finishing temperature during the rolling of the plates. Some of the plates were normalised. Samples from different portions of the plates has been spectrographically analysed to determine seggregation and tensile and sub-zero charpy impact tests have been carried out on the samples from ten plates. Yield strength

of 45 Kgf/mm² has been obtained in the as rolled 18 mm plates with 40 ft. lb transition around room temperature. On normalising the yield strength dropped to about 35 Kgf/mm² with transition temperature improving to around —20°C.

60.0 Development of Continuous Steel Making Process.

The various work involved on the installation of the equipments is under progress.

61.0 Electroslag Remelting.

140 KVA electroslag remelting set up was completed. Trial mild steel heats were made to check up the unit in respect of voltage and current stabilization.

The electroslag remelted martensitic stainless steels were subjected to mechanical testing and the report was prepared for M/s. Hindustan Aeronautics Ltd., Koraput. Further work was undertaken for studying the characteristics of synthetic slags used for electro-slag remelting.

E. DEVELOPMENT & STUDY ON ALLOYS

62.0 Development of Aluminium Cables and Conductors.

(*1*) *NML-PM2 alloy aluminium.*

Work has been continued on the product development and market promotion of the various products from the NML-PM2 alloy. The product development and testing of NML-PM2 alloy has been done at the works of the following firms:

(*i*) M/s. Indian Cable Co. Ltd., Jamshedpur.
(*ii*) M/s. Hindustan Cable, Rupnarainpur.
(*iii*) M/s. Fort Gloster Industries (Cable Division) Howrah.
(*iv*) M/s. Hira Cable Works Ltd., Hirakund.
(*v*) M/s. Ordnance Cable Factory.
(*vi*) M/s. Aluminium Cables & Conductors (UP) Pvt. Ltd., Calcutta.

The technology of the production of NML-PM2 alloy aluminium conductor has been released to the following organizations through National Research Development Corporation.

(*i*) M/s. Aluminium Cable and Conductors (UP) Pvt. Ltd. Calcutta.
(*ii*) M/s. Galada Continuous Castings Ltd., Hyderabad.
(*iii*) M/s. Indian Aluminium Cables, Faridabad.
(*iv*) M/s. Bharati Smelting and Refinery Co., Bombay.

Some commercial utilization of NML-PM2 now underway is furnished below:

(*i*) NML-PM2 is successfully used for telecommunication cables. Twenty pairs dry core telecommunication cables have been installed in the Model Town area of Delhi by the Post & Telegraph Department after successful and development work carried out in NML, feasibi-

lity of which has been proved by Telecommunication Research Centre.

(*ii*) M/s. Hindustan Cables Ltd., Rupnarainpur is currently processing 50 and 100 pairs dry core telecommunication cable from NML-PM2.

(*iii*) Enamelled wires and PVC insulated flexible cables have successfully been produced and use of NML-PM2 enamelled wire has found acceptance for coil winding by Indian Railways.

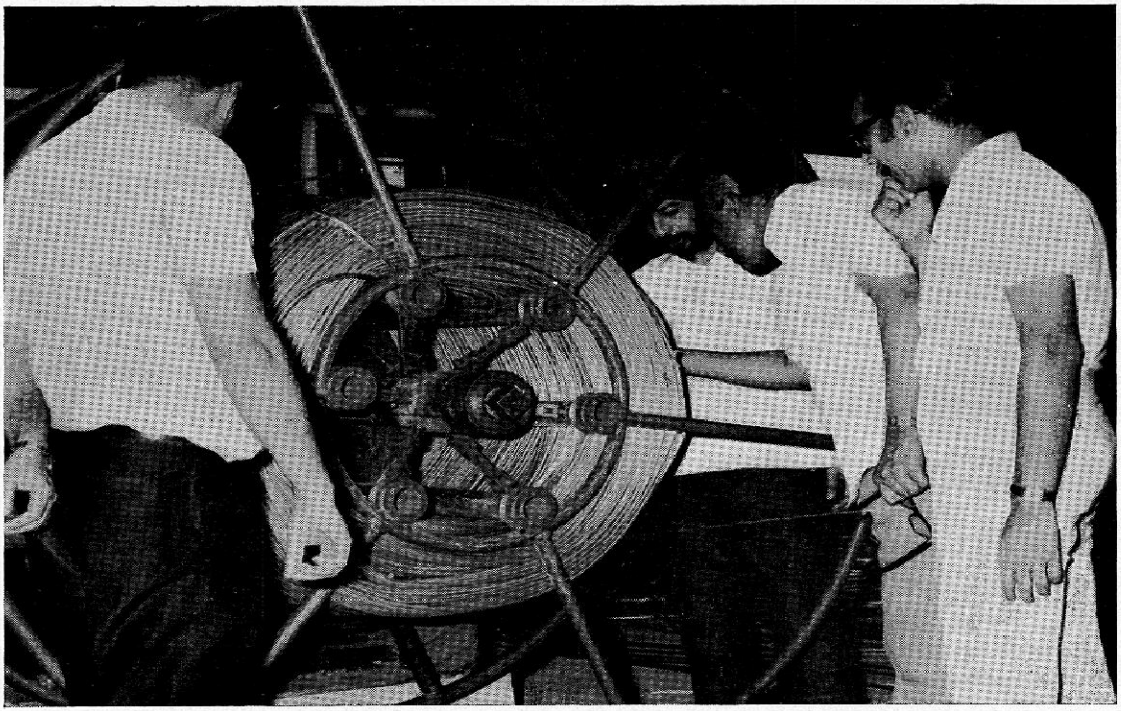
(*iv*) Karnataka and Gujarat State Electricity Boards have placed orders for the ACSR squirrel, weasel and rabbit type of conductors made from NML-PM2.

(*v*) Production of fine wires up to 0.11 mm (41 SWG) has been made possible for the first time on a commercial scale.

(*vi*) Integral Coach Factory, Perambur, has paced order for coach wiring cable of fifty coaches.

(*vii*) Indian Standard Institution has taken up the incorporation of NML-PM2 alloy in the relevant specification.

(*viii*) The application has been sent to the Registrar of Trade Mark, Calcutta for registering the certification mark NML-PM2 for the alloy.



Production of electrical conductor at M/s. Galada Continuous Castings Ltd., Hyderabad; from PM2 alloy aluminium conductor, developed at National Metallurgical Laboratory.

(2) *NML-PM53 aluminium alloy.*

The Laboratory scale studies on the development of aluminium alloy conductors have given encouraging results for the alloy designated NML-PM53 alloy. The alloy develops high strength at a conductivity values of 53-55% IACS. The Laboratory studies have shown that the alloy can be used for catenary wires in the railway electrification. In order to test the practical viability of the alloy, semi-commercial trials were performed at the works of Indian Cable Co. Based on encouraging results obtained, the Railway Research Design & Standard Organization, Lucknow, have agreed to perform the field trials with this alloy. RDSO have desired to supply the 19/2.70 mm stranded conductor made from NML-PM53 alloy preparation of which is underway.

63.0 Preparation of Master Alloy & Development of Inoculants for Aluminium and its Alloys.

Statistical calculations of grain-size of the specimens from LM series of alloys cast with and without inoculants were carried out and average grain-size, standard deviations and co-efficient of variations were calculated. Mechanical properties of these specimens were determined from hounsfield tensometer tests.

64.0 Grain Refinement of Aluminium Alloy.

Effect of NML developed inoculants or aluminium and its alloys (PM121 & PM122) on the grain-refinement of wrought Al-Zn-Mg alloys (7004, 7005, 7039) was studied. Effect of grain refinement in both cast (sand and metal mould) and wrought conditions of the above alloys has been studied. The results were compared with that of indigenous and imported master alloy which is commonly used as grain refiner. Mechanical properties and grain size measurement by linear intercept method of the inoculated alloys in cast and wrought and heat-treated condition were determined.

65.0 Development of Grain-Refiners for Al-Mn Alloy.

Inoculated 0.2% and 0.4% alloys were studied. Different parameters of homogenisation, rolling and annealing procedures were examined along with metallographic studies of recrystallisation and grain-size. X-ray studies of the samples were made. Tensile test measurements were carried out.

66.0 Study on the Effect of Alloying Additions and Heat-treatment of Wrought Al-Si Alloys.

15 compositions of Al-Si alloys with varying amount of alloying additions (PM201 to PM215) have been prepared and after homogenization they were hot forged to 5/8" square bars. After turning to 1/2" dia rod, they were wire drawn to 11 SWG. Mechanical properties of these alloys in the wire form under different heat treated conditions have been determined. Metallographic work of the above sample under different heat-treated conditions has been done.

67.0 Study on the Phenomenon of Quench-Sensitivity in High Strength Al-Zn-Mg Type Alloys.

It is proposed to study the effect of chromium on quench-sensitivity of

high strength, Al-Zn-Mg-Cu alloys. Three alloys of Al-Zn-Mg-Cu with varying amount of Cr content have been made in metal mould. Chromium was added in the form of master alloy. After machining to billets, they were extruded to 1.0" dia rod. Effect of Cr. on quench-sensitivity has been studied using the 1" dia rod samples. Effect of duplex aging on quench-sensitivity has also been studied.

68.0 Effect of Inhomogeneities on the Mechanical and Physical Properties of Al and its Alloys.

Properties of a series of Al-Si and Al-Mg alloys were determined. The alloys were prepared in a specially designed vacuum chamber with attachment for mechanical stirring when the materials are in molten state. The properties were compared with alloys of identical composition melted in ordinary atmosphere. In certain composition range the alloys thus produced, showed improved mechanical properties.

69.0 Production of Dense Castings of Aluminium and its Alloys.

Aluminium containing varying percentage of Si were cast with and without application of pressure in cylindrical graphite moulds. The mechanical properties of the alloys cast under pressure were determined and showed considerably higher value of tensile strength over the alloys cast under stationary conditions. Percentage of porosities also showed lower value in the former. Similar experiments were carried out in aluminium alloys containing varying percentage of Mg and Zn and high mechanical properties were obtained.

70.0 Thermostatic Bimetal.

Production technology of general purpose (all-ferrous type) thermostatic bimetal was developed and the production technology was leased for commercial exploitation. In the next phase of the work thermostatic bimetal suitable for use over higher temperature ranges was developed. In the present phase, properties and production technology of high expansion Mn-Cu-Ni alloy was studied; and high sensitive type thermostatic bimetal using Mn-Cu-Ni alloy as high expansion component was produced on laboratory scale. The high sensitive type thermostatic bimetal has been sent for industrial evaluation; the process is being further standardised.

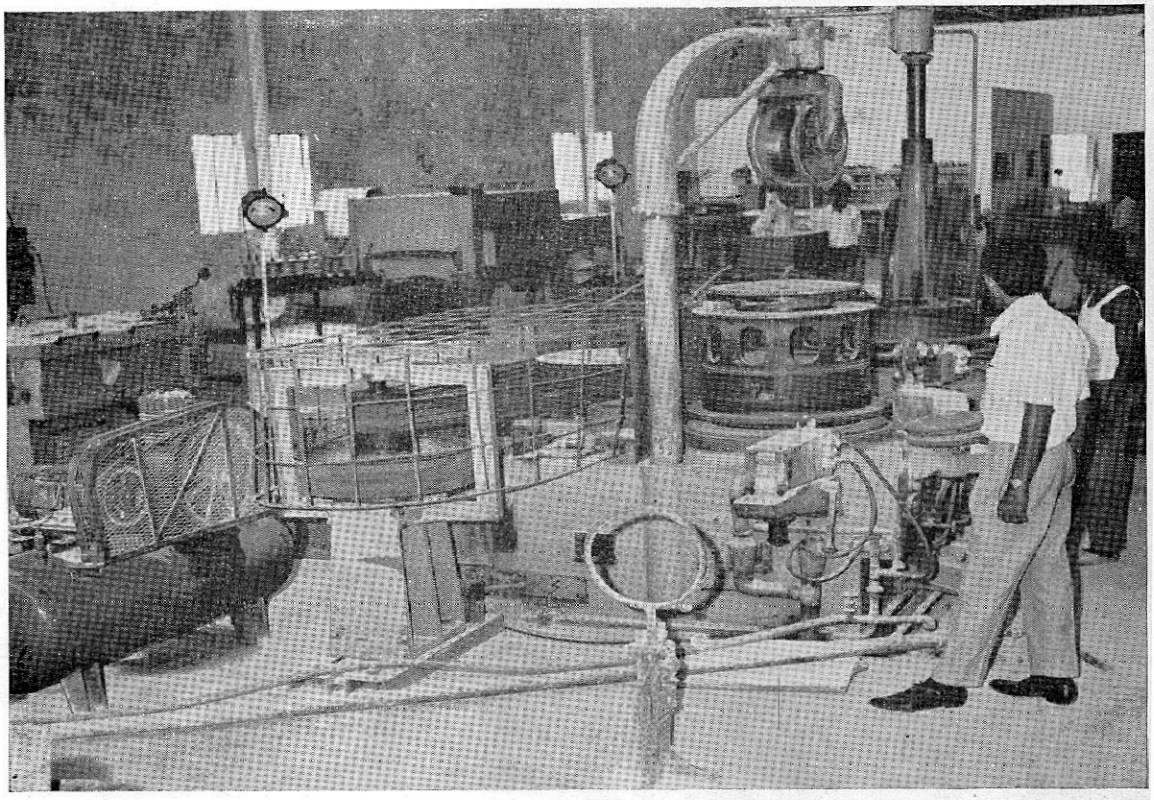
71.0 Nickel-Silver.

18% nickel-silver is mainly used as a spring material in telephone industries. During the year, several heats were made in order to make lengthier strips which is required by the I.T.I. for the performance trials. Attempts were also made to make actual springs from the rolled strips for studying their service performance.

72.0 Electrical Resistance Alloy.

In the course of transfer of technology, various problems encountered by M/s. Cable Works (India) Ltd. (the NML licencee) in course of the production of the alloy were successfully solved. Suggestions for improving the chemistry and quality of the alloy were also provided to the party. Wire-drawing technique has also been greatly improved. The wires from the firm were

tested physically and mechanically and found to conform well as per specification. In connection with the transfer of technology of the process to M/s. Burjwal Electricals Ltd. a team of NML scientists visited their works and demonstrated the production technology.



Manufacture of electrical resistance alloy at the Faridabad works of M/s. Cable Works (India Ltd.), based on the technology developed at National Metallurgical Laboratory.

73.0 Dental Amalgam Alloy.

Dental amalgam alloy is a silver base alloy with appreciable amount of tin and minor additions of copper and zinc. This alloy is used for restoring the decayed teeth. During the year, several heats were made for standardising the various parameters concerning melting and casting.

74.0 Development of Nickel-Iron Alloys.

Extensive trials were carried out on the development of nickel-iron alloys on 8 to 10 kg. heats. The ingots were tested for their magnetic properties. The test results showed that the alloys had initial permeability of 40000, maximum permeability 1.5 to 1.8×10^3, coercive force 0.015 oersted and saturation induction of 7500 gauss. Further work is in progress.

F. DEVELOPMENT OF MAGNETIC MATERIALS

75.0 Preparation of Gamma Iron Oxide.

Studies on the preparation of gamma iron oxides were continued. In the period under review, the gamma iron oxide doped with cobalt was prepared. The cobalt content was varied in stages. It was found that it was possible to prepare gamma iron oxide with coercive force 300 to 500 oersted and remanence about 1100 gauss. The undoped gamma iron oxide has coercive force of 230 to 250 oersted only.

76.0 Preparation of Isotropic and Oriented Ferrite Magnets.

The investigations have shown that with the equipment available in the laboratory coupled with fabricated components, it is possible to prepare oriented ferrite magnets with BH max of 3 m.g.o., coercive force 2200 oersted and remanence 3300 to 3500 gauss.

77.0 Magnetic Properties of Mnalfe Alloys.

The alloys investigated showed that they are capable of developing a permeability of 8000 to 9000 and a coercive force of 0.3 oersted for B-13000 to 14000 gauss. These properties are attractive in comparison to those of silicon sheets or soft iron.

78.0 Low Carbon Soft Magnetic Iron.

Soft iron was supplied in the ingot form to N.E. Railway, Gorakhpur. Soft iron ingots were forged, rolled and machined. Some samples were sent to M/s. Bharat Electronics Ltd., Bangalore for their evaluation.

Industrial forging trials of different heats of NML soft iron were successfully completed and cast billets of 100 mm were reduced to 50 mm square bars.

G. MECHANICAL WORKING OF METALS

79.0 Melting and Extrusion Characteristics of a Magnesium Base Alloy.

Sound ingots of a magnesium base alloy were made in gas fired furnace using suitable flux and degassers. The billets made out of the alloy were successfully extruded to various sections such as rounds, flats and tubes. The extrusion parameters such as temperature, soaking period and extrusion speed have been studied in detail.

80.0 Drawing of Stainless Steel Orthodontic Wire.

Work was conducted to evaluate the performance of different lubricants in wire drawing of the stainless steel wires which were pre-coated earlier. The wires were tested at NML as well as at Tata Main Hospital and found to be well comparable to the imported wire used in T.M.H. for dental purpose.

81.0 Development of Clad Metal.

(i) Copper Clad Aluminium Sheets.

The technology of cladding copper on aluminium sheet of different thickness ratio has been fully developed. The critical annealing condition for batch annealing as well as continuous annealling has been established so that ductile copper clad aluminium sheet without any brittle intermetallic at the interface could be manufactured. Copper clad aluminium sheets manufactured at NML by the above technology are in supply to the Indian Railways for their research and development work.

(ii) Stainless Clad Mild Steel.

This clad metal combines the corrosion resistance of stainless steel with the structural properties of mild steel, and has got economic advantage over solid stainless steel. The production technology of stainless clad mild steel has been developed. Fabrication of the pack, development and application of appropriate separating medium as well as other parameters connected with the roll bonding of this clad product has been studied and standardised. The process is ready for commercial exploitation. Further development work is in progress.

(iii) Copper Clad Mild Steel.

Important characteristics of this clad metal is achieved by the combination of good thermal conductivity and corrosion resistance of copper and the structural properties of mild steel. The clad metal is also used in chemical industries. Technique for roll bonding of copper clad mild steel has been developed.

(iv) Braze Alloy Clad Aluminium Sheet.

Technology has been developed for cladding appropriate brazing alloy to aluminium sheet so that the composite clad product contains a layer of brazing alloy on its surface, which facilitates the fabrication of complex brazed structures. All the parameters involved in roll cladding the braze alloy to aluminium sheets have been optimised. The process is ready for commercial exploitation. Further development work in connection with fluxless brazing is in progress.

H. TESTING OF MATERIALS.

82.0 Central Creep Testing Facilities.

During the period under review good progress has been made in the various facets of the establishment of the Central Creep Testing Facilities. The civil work of the building and most of the electrical services have been completed. All equipment were received and commissioned through UNIDO. Work on the following projects has been conducted.

(i) Development of Nickel Free Creep Resistant Austenitic Steels.

In the first phase of the project, the optimum alloy composition with res-

pect to the C and N contents was established and the solution treatment procedure was standardised to give desired creep strength rupture ductility. During this phase the beneficial effects on high temperature strength of some selected strong carbide and/or nitride forming elements were studied. Alloy (C32) gave very promising creep strength which was better than AISI-316 steel and approaching that of Eashete 1250 which is proprietary Fe-Cr-Mn-Ni type alloy of United Steel Co., U.K.

(*ii*) *Development of High Temperature Bolting Steel.*

Several experimental heats were made. Out of these, 9 heats came near to the expected composition and were considered promising for further detailed study. The ingots have been hot forged and rolled into bars. Each bar has been given identical heat-treatments. Creep test specimens have been made out of these heat treated bars and the creep testing at various stress levels which are expected to give rupture lives of 3000-10000 hr. have been started. Some of the tests have already progressed up to 3000 hr.

(*iii*) *Investigation of Creep and Rupture Properties of 1% Cr-1% Mo-3/4% V-Ti-B Bolting Steel. Sponsored by BHEL, Hardwar.*

The bolting steel under investigation has been manufactured for the first time in India by Mahindra Ugine Steel Co. Ltd. Assessment of the elevated temperature properties is essential before the material can be used in power plant applications. The objective of the present programme is to determine the creep, stress rupture, aging embrittlement and stress relaxation properties of the steel for duration up to 10,000 hr. and compare the results with international data. Tests have been carried out on one cast of steel but further casts are expected shortly so that some estimate of cast-to-cast variation can be made.

(*iv*) *Stress-relaxation Testing of High Temperature Bolting Steels.*

(*a*) Ti-B bolting steel from Bharat Heavy Electricals Ltd., Hardwar.

Stress-relaxation tests were taken up on 8 specimens. These rings already completed a test duration of 3,000 hr.

(*b*) En 20B : Bolting Steel.

Stress relaxation tests are planned on EN20 bolting steel samples.

(*v*) *Elevated Temperature Testing and Evaluation of Properties of En20 Steel. Sponsored by Bharat Heavy Electricals Ltd., Bhopal.*

The programme of testing for tensile, creep stress rupture and stress relaxation has been drawn up. Creep tests for period up to 20,000 hr and stress rupture tests are in progress.

(*vi*) *Development of Indigenous Creep Testing Equipment.*

This is an inter-laboratory project for the development of an indigenous 'Creep Testing machine'. Three CSIR laboratories, namely, National Aeronauti-

cal Laboratory, Bangalore; Central Mechanical Engineering Research Institute, Durgapur and National Metallurgical Laboratory, Jamshedpur; are involved with specific responsibilities to develop the instrumentation and control system, design and development of the mechanical parts of the machine, and development of the creep furnace and high temperature materials for components respectively.

A proto-type machine was assembled at the NAL, with the components designed and fabricated by the respective laboratories, was proved to be successfully operating up to about 500°C. Based on the experience gained with the machine assembled at NAL and with the imported equipment at NML and as a result of the discussions at the two co-ordination council meetings of the project held in November, 1974 and March 1975, it was decided:

(*i*) In the existing model, there is a limitation on loading and is possible only up to 2 tons.
(*ii*) The floor space occupied by the present machine is much more than the specified 0.5 sq. meter as required by NML.
(*iii*) To work on the improvement of the design of the machine to suit the design features of modern creep testing equipment.

Accordingly the preparation of the drawings of the various components are underway at NML. Once these drawings are ready, the machine is planned to be fabricated at NML and use NAL's temperature controller, strain measuring parts and data-logging device with this unit.

83.0 Fatigue Testing.

Fatigue testing of grooved aluminium contact wire referred by the Indian Railways and also the aluminium conductors developed at NML were carried out for a comparative study. In both the cases, identical stress condition was maintained keeping the mean stress O. Fatigue limits (endurance) were determined and compared. Further tests on aluminium catenary wire is in progress.

I. INDUSTRIAL FAILURE STUDIES ON METALS AND ALLOYS

84.0 Metallurgical Investigation on the Failure of 1500 KW Power Turbine. *Sponsored by M/s. Charotar Sahakari Khand Udyog Ltd., Palaj, Gujarat.*

The failure took place after a trial running of the plant for about 8 hours by the seizure of the high pressure inner gland linear with the main shaft of the turbo set. The results of metallurgical tests carried out showed that the failure of the turbine took place due to some misfitting resulting in frictional heat and severe galling seizure.

84.1 Metallurgical Investigation on the Failure of the Convection Coil Tube of Heater H-102 of the Xylene Plant. *Sponsored by M/s. Indian Petro-Chemicals Corporation Ltd., Baroda.*

The failure of the convection coil was attributed to localised overheating and was found a typical case of short time creep rupture. On-stream inspection techniques were suggested as valuable tools to aid for improved safety against failure.

84.2 Metallurgical Investigation on Low Carbon Chain Links of Kiln No. III. *Sponsored by M/s. Kalyanpur Lime and Cement Works Ltd., Rohtas, Bihar.*

The chain links were used to receive heat from the flue gas and to transfer that heat to the partly dry slurry; these were found to have been heavily pitted in service.

The pitting was found to have arisen due to electro-chemical corrosion associated with localised composition difference in the metal, or might have caused by the moisture adhering to the surface.

84.3 Investigation on the Failure of De-Superheater Tube. *Sponsored by M/s. Indian Oil Corporation, Gujarat Refinery, Baroda.*

The desuperheater tube was used to carry water taken as a side stream from main boiler feed water line; it failed by severe thinning after a service life of 9 years. The failure appeared to have taken place due to a combination of 'On-load' corrosion and corrosion fatigue.

Sufficient care to protect the internal surface of the tube by chemical cleaning, and reduction of oxygen content to very low levels in feed water could have saved the tube from such failures.

84.4 Metallurgical Investigation on the Failure of Smelter Air Preheater Tubes. *Sponsored by M/s. Hindustan Copper Ltd., Ghatshila.*

The heating elements belonging to the second row of the air preheater plant failed. It was due to ingress of hot sulphur bearing gas into coarse graphite flakes of the tube. Such failures can be reduced by (*i*) the elimination of growth aspect in gray irons by suitable alloys, or (*ii*) aluminising the available materials, or (*iii*) using elements made from CRALFER.

84.5 Investigation on the Breakage of Teeth of Fluted Rolling Bar used in Texmaco-Zincer Spinning Machine. *Sponsored by M/s. Texmaco, Calcutta.*

The fluted roller bar of Texmaco-Zincer Spinning machine is used to make yarn from cotton. Metallographic examination showed that quenching cracks in the case caused the teeth to spall off when subjected to stress in service. Improved techniques of liquid carburising can help to reduce the brittleness of the case of the fluted bar.

84.6 On-the-spot Examination of MG Cylinder PM No. 5. *Sponsored by M/s. Orient Paper Mills Ltd., Brajrajnagar, Orissa.*

An axial crack developed on the surface of an imported MG cylinder PM No. 5, used for the purpose of drying as well as for glazing papers. It was suggested that any practice which would lead to aggravate an already bad situation is not advisable. If the cracks were superficial and skin deep, they should be machined off and thoroughly checked before put into operation again.

J. FOUNDRY TECHNOLOGY

85.0 Development of Heat Resistant Casting for Reduction Boxes.

Initially seven rectangular boxes were cast and induction furnace was used for melting of ferrous charge. These rectangular boxes were made without the additions of Ce, Ti and Mo and were cast in the upside-down position. There were casting defects and oxide entrapment in the bottom of the box. During high temperature oxidation test these boxes developed cracks at the bottom and top corners. Later cylindrical boxes were cast and the casting technique has been perfected. More than 40 boxes have been cast with minor additions of Ce, Ti and Mo.

86.0 Development of a New Mould Coating Process.

Experiments were carried out with different bonding agents with a view to standardize the composition for spraying as well as for pouring. Different parting agents were tried in order to find out the most suitable material for obtaining clean strip.

87.0 Development of Special Casting Method.

Work has been started on designing of apparatus etc. for testing of waxes for wax pattern making. It is proposed to design suitable slurry mixing equipment and also obtain wax injection equipment. After the equipment and apparatus are fabricated/obtained, experimental work for development of the process will be taken up.

88.0 Inoculation with NML Developed Calcium Silicide.

Several heats were carried out with direct arc furnace to compare the inoculating effect of NML Calcium-Silicide as compared to imported varieties on cast iron. Tensile tests and microstructure studies were conducted.

89.0 Development of Cupola Iron Melting.

In order to have a comparative study on the effects of oxygen enriched hot air blast and using hot air blast alone on the cupola iron melting, few experiments were conducted. Two types of cokes having two different ash contents of 23% and 28% were used in the experiments. It was found that in order to get molten metal temperature of 1400°C using 28% ash coke, the coke rate has to be increased to 25% in the case of normal air blast, while using preheated air blast of 350°C, 15% coke could be used. With the increase of 100°C in the blast temperature, the molten metal temperature could be increased by about 15-30°C.

A systematic study on the effects of using oxygen enriched hot air blast in cupola iron melting was also made.

90.0 Self-Setting Sodium Silicate Bonded Sand.

Based on the development work carried out in the laboratory, inplant trials and demonstrations were carried out at the foundries of TISCO, HEC and

IISCO. Moulds and cores weighing from 10 kg up to several tonnes were made and castings produced satisfactorily by the above process. The work is completed.

91.0 Fluidized Sand Process.

The work during the year has been mainly with regard to development of a suitable design of mixer. After trials with the cement mixer, a slurry mixer used for refractory materials was modified and tried with fluid sand. Fluid sand moulds and cores weighing about 50 to 60 kg. have been made using this mixer. Efforts are under way to modify a paddle type of sand mixer to test its suitability for the above purpose.

92.0 Development of Aluminium Cast Iron.

A total of twelve heats were made with additions of Cr, Ti and Mo. Some of these heats were made in 20 KW induction furnace and some in 30 kg. capacity direct arc furnace. The pouring temperature was adjusted and the metal was poured using a bottom pouring ladle into predried tensile test specimen moulds and step bar moulds. Tensile test, oxidation and growth tests and microscopic examination were carried out.

K. CORROSION STUDIES ON METALS & ALLOYS

93.0 Atmospheric Corrosion of Metals and Alloys.

The role of the corrosion products in controlling corrosion rates of structural steel over extended periods of 8 years have been studied. It has been noted that at the initial period of exposure the rust formed on both mild steel and low alloy steels was loose and non-protective but with the increase in the exposure period a considerable amount of changes on the characteristics of rust was noted so as to form a tightly adherent protective coating. Such changes were more pronounced in the case of low alloy steel than for mild steel; in the latter case the corrosion rate reached a steady state with very little change with further exposure. Progressive decrease in corrosion rate of low alloy steel with time was noted which can be correlated with the changes in Fe^{2+} and SO_4^{2-} contents of the rust. The SO^{2-} content in the rust was present in excess of the stochiometric formulation of ferrous sulphate indicating the formation of basic copper sulphate. This was further confirmed from the low porosity of the rust formed on low alloy steel and enrichment of Cu in rust found in micro-probe analysis.

94.0 Development of Aluminium Anodes for Cathodic Protection.

'Superal' an aluminium base sacrificial anode, successfully developed in NML has been found highly suitable for cathodic protection of ship hull and underground pipeline, particularly at the hot spots where soil resistivity is lower than 1000 ohm per cm. Arrangements are being made to conduct service trials using 'Superal' anodes in sea going vessels and buried pipelines.

95.0 Temporary Protective Treatment for Copper and Brass Articles.

A passivation treatment process, developed in NML has been found highly

suitable on bench scale for the protection of copper and brass surfaces from tarnishing during storage and transit. Arrangements are being made to conduct a large scale service trial with copper conductors including wires, rods, bars, strips, etc.

96.0 Testing of the Performance of the Various Inorganic Surface Coating on Steel Exposed to Industrial Atmosphere of Jamshedpur.

Long term atmospheric exposure test was undertaken to evaluate different protective coatings such as galvanised, aluminised, cladding etc. on structural steels and aluminium. Tests have been completed and the final report is under preparation.

97.0 Studies on the Phenomenon of De-alloying of Copper Base Alloys.

De-alloying tendency of four Cu-Zn and Cu-Mn alloys was studied using galvanostatic technique. Selective leaching of Zn or Mn from the alloys was noted on the anode surface leaving behind a porous copper deposit. The extent of attack was noted to be potential bound phenomenon and have concurrence with the theoretical predictions of the potential —pH (Pourbaix) diagrams.

98.0 Studies on the Stress Corrosion Cracking of Copper Base Alloys.

Stress corrosion cracking susceptibility of 70 Cu—30 Zn and 95 Cu—5 Al alloys at temperatures of 30, 40, 50 and 60°C and at stress level of 5, 10, 15 and 20 kg/mm^2 was studied in Mattsson's solution. The extent of crack initiation was linear indicating that at the early stages of initiation cracks were more or less of equal depth. However at the latter stage the greater changes of resistances occurred possibly due to the interaction of the formation of fresh cracks and propagation of some of these deeper into the metal and thereby reducing the effective cross section.

99.0 Joint Action of H_2S and Organic Compounds in Acid Pickling of High Carbon.

The formulation of an acid pickling inhibitor for steels has been completed. The action is now being taken to test the inhibitor on scale. A detail programme is being laid for such trials.

100.0 Utilization of By-product from a Chemical Industry for Formulating Acid Pickling Inhibitor.

The formulation of an acid pickling inhibitor for steels has been completed. The larger trials to get feasibility data are under progress.

101.0 Studies on Hydrogen Embrittlement of Steel in Aqueous System.

High strength steels are normally considered susceptible to hydrogen embrittlement. Extreme care is therefore necessary in surface treating of this type

of steel such as pickling, electroplating, etc. involving hydrogen evolutions. With an objective to reduce hydrogen pickup by steels in such operation by use of inhibitors and with an ultimate aim to eliminate the risk of hydrogen embrittlement a few thio-based compounds were studied in H_2SO_4.

102.0 Development of Aluminium Base Alloy Powder Coating on Iron and Steel Surfaces for the Purpose of Corrosion Resistance.

A series of alloys of different compositions have been made and their electrochemical properties have been assessed. On the basis of the result, powder of one composition of the alloy was made and using this powder as pigment paint, formulations were made and tests are in progress.

L. SURFACE COATING ON METALS

103.0 Copper Coating on Mild Steel Surface/Wire from Acidic Copper Sulphate Solution.

A process to electroplate an adherent coating of copper on steel surface from acidic copper sulphate solution has been standardised. The conventional process as practised in industries is cyanide copper plating solution which is hazardous.

A bright acidic copper sulphate solution as a substitute for cyanide copper plating has also been standardised. Some of the cycle industries are interested to utilise the bright copper plating from the acidic bath as an undercoat for nickel plating.

104.0 Development of Bright Acid Zinc Plating Bath as a Substitute for Cyanide Zinc Plating.

Due to hazards in cyanide zinc plating and the difficulties in effluent treatment, many of the plating industries want to change over to bright acid zinc plating bath.

Work has been taken up on the formulation of acid zinc plating bath and a composition has been worked out. A suitable brightener to work in the above composition is being sought. The feasibility of the bright plating composition in production plating practice is under investigation.

M. STANDARD REFERENCE MATERIALS & ANALYTICAL WORK

105.0 Preparation of Standard Samples.

So far twenty-five different types of standard samples have been prepared which are now being sold to meet the demand of industries, educational and research organisations, instrument manufacturers, etc. NML has started production of these specialised products on a modest scale which is intended to be expanded gradually covering production of more and more different standard samples of both ferrous and non-ferrous metals. Work completed during the period covers :

(*a*)	Brass No. 42.1	30 kg.
(*b*)	Nickel Steel No. 21.1	22 kg.
(*c*)	Cast Iron No. 1.5	90 kg.
(*d*)	Al-Si Alloys	26 kg.

New samples released for sale during this period :

(*i*)	Ferro silicon No. 31.1	12 kg.
(*ii*)	Nickel No. 21.1	22 kg.
(*iii*)	-do-	92 kg.

105.1 Preparation of Spectrographic Standard Sample.

Preparation of plain carbon steel standards is complete and ready for sale. The standards have been prepared under standardised rigorous laboratory conditions and issued for analysis of plain carbon steels. Homogeneity of the standards was examined spectrographically by vacuum direct reading spectrograph and was found satisfactory. Chemical analysis were made on millings of the samples. The values indicated for the certified elements represent the averages of the results from chemical analyses made by several reputed organisations.

106.0 Analytical Work.

(*i*) *Chemical and Instrumental Analysis*—1544 samples and 5454 radicals were analysed.

(*ii*) *Spectrographic Analysis.*

(*a*) Qualitative Analysis—269 samples were completely analysed for major, minor and trace elements.

(*b*) Quantitative Analysis—147 samples for 371 radicals were determined.

(*iii*) *X-ray Fluorescence Spectrometer.*

Philips semi-automatic sequential type X-Ray Fluorescence spectrometer has been installed and put into commission. The instrument is a versatile one for quick and accurate analysis of major, minor and trace elements in metals, alloys, ores, minerals, etc. In the first instance, the instrument is being standardised for the analysis of metals and alloys and in view of that, standardization and calibration for the alloying elements in low alloy steels, high alloy steels, stainless steels, brass and bronze have been carried out for undertaking regular analysis of samples.

N. APPLIED BASIC PROJECT

107.0 Liquid Metals and Solidification.

Previous observation upon metastability of rapidly solidified Al-Si alloys shows that extension of equilibrium solid solidibility could be achieved by solidifying the alloy rapidly from the liquid state. The results were attributed due to the preferential association Al-Si atoms in the liquid state in hypo and Si-Si in hyper-eutectic alloys. Later study in the same line shows that the bondings between unlike atoms in the system were destroyed due to the addition of Mg

in Al-Si alloys forming Mg_2Si and as a result of which no extension of solid solubility could be attained in pseudo binary Al-Mg-Si system, which is an indirect evidence of the formation Al-Si clusters in liquid state, responsible for the extension of solid solubility.

108.0 Determination of Concentrations of Water Solution of Salts and Analysis of Alloys by Beta Ray Back Scattering.

The project has been completed and the results of the investigations have been compiled.

109.0 Determination of Sulphur in High Alumina Slag by Radio Active Tracer Technique.

The experimental technique for the studies of transfer of sulphur from pig iron in slags using radio-active tracer has been established using suitable radio-active standards.

110.0 Studies on Corrosion Inhibition Mechanism Using Radio Active Tracer.

During the period under review, the investigation has been carried out using Cr^{51} for the study of film growth on mild steel in presence of water containing known amount of chromate and the mode of Cr-uptake on mild steel surface in presence of varying concentrations of NaCl at room temperature. The study of the effect of NaCl on the open circuit potential change of mild steel with time in Na_2CrO_4, has also been carried out to throw light on the behaviour of inhibitive ions in presence of aggressive ions.

111.0 Liquidus and Phase Equilibrium Studies on High Alumina Slag.

Earlier an investigation on liquidus of high alumina slags in restricted composition range of 24, 26, 28 and 30% Al_2O_3 plane was completed. The alumina content in B.F. slags presently being produced in India is of the order of 24% but no comprehensive data are available on liquidus and phase equilibria of the slag system with fixed impurities. This work was started with the intention of getting a general idea of the liquidus of blast furnace slags in this particular alumina range.

About 20 compositions have been selected on 24% Al_2O_3 plane and calculations were made for different compositions. A few compositions were made using a platinum crucible for further study. This investigation is expected to be of considerable help in assessing the variations in the operative compositions of iron blast furnace slags.

112.0 Study of Reactions Between Molten K_2CO_3 and Some Alumina Silica Refractory Samples.

The alumino-silicate refractory samples were made from (*i*) pure oxides and (*ii*) naturally occurring alumina and silica minerals. Compacts containing different quantities of alumina were made and sintered. Their physico-chemical properties have been determined. The sintered compacts which had

different mullite contents were subjected to attack in molten potassium carbonate at different temperatures and rate of alkali attack was determined.

113.0 Studies on Liquid Phase Sintering in Some Ceramic Systems.

In continuation of the work done earlier, a study of the sintering characteristics of the samples prepared in presence of liquid phase was undertaken. Three different systems were chosen and samples for various liquid contents were prepared. Important properties were determined for dry and fired samples and the results interpreted. It is possible to sinter the sample approaching theoretical density at a lower temperature with sufficient soaking with the help of liquid formation. Densification is achieved through solution and reprecipitation process. Further work is in progress.

114.0 Fundamental Studies on Bentonites.

The effect of gases on moulding properties of fourteen samples of bentonites has been completed. Samples have been prepared for DTA and X-ray diffraction studies. Studies on activated bentonites namely the effect of gases has been taken up.

PILOT PLANTS

115.0 Mineral Beneficiation Pilot Plant.

Pilot plant investigations conducted on different types of low grade ores and minerals have been reported between pp 4-10.

116.0 Dense Carbon Aggregate Pilot Plant.

Ten tonnes of soderberg paste supplied to a ferro-alloy manufacturing firm have been used as electrode in their ferro-silicon furnace and the performance has been reported as very satisfactory. Similar report has been received from M/s. Mysore Iron & Steel Works who have tested ten tonnes of soderberg paste in their electric pig iron furnace.

Electrical tunnel kiln which is about 190 ft long and is required for the heat treatment of carbon bricks and other refractory products could not reach more than 850°C. Redesigning of its heating elements and circuit diagram was taken up. Moreover 30 kiln cars were lined with castables and equal number of saggers were made from castables to complete the heat treatment arrangements of the carbon bricks in the tunnel kiln.

117.0 Electrolytic Manganese and Manganese Dioxide Pilot Plant.

During the period, electrolytic manganese dioxide plant was operated on several occasions to enable the engineers of a consultant engineering firm to collect necessary data for preparation of a complete Project Report. The service of the consultant engineering firm was engaged by an interested entrepreneur. Bench scale and pilot plant studies were carried out with the manganese ore and a waste chemical effluent containing sulphuric acid supplied by the interested entrepreneur for preparing the complete material balance.

During different campaigns, about 1472 kg. of electrolytic manganese dioxide was produced of which 250 kg. has been ground, washed free of electrolyte and dried.

Manganese metal plant was also operated during the period for a short time and about 130 kg. of manganese metal was collected.

118.0 Hot-dip Strip Aluminizing Pilot Plant.

The strip aluminizing proto-type plant installation was completed and mechanical commissioning trials commenced. Work was initiated on the aluminizing of malleable castings for a sponsor and encouraging results were obtained.

ENGINEERING ACTIVITIES

Design Engineering

The design office continued work on the development of equipment for production of metal powders and finalised the optimized atomizer. The complete process details, from atomization to the production of sieved and blended powder for packaging, were worked out and equipment obtained and installed. Based on the know-how gathered, the process was leased out to a number of parties. The know-how included supply of working drawings for the fabricated/machined components, specifications for purchased items and equipment layout.

Drawing for equipment layout, details of special items such as furnaces and burners for the transfer of know-how for production of shock-cooled zinc dust were completed and supplied to the licensee.

In addition to supplying design and drawing services to the laboratory, the design office also undertook supply tracings for graphs, etc. and blue prints.

The design office also participated in the design and preparation of various exhibits for display and dissemination of NML know-how for the various processes. A complete and effective display was arranged in the Regional Liaison Centre in Calcutta.

Mechanical Engineering

Following major fabrication works were done during the period :

(*i*) Apparatus for polishing metal powder.
(*ii*) Extrusion dies.
(*iii*) Precision components for commissioning of Creep Laboratory.
(*iv*) Modification of strip aluminizing plant.
(*v*) Explosive welding set up.
(*vi*) Dies, punches, moulds, fixtures for various projects.

1112 test specimens were prepared for different projects and investigations.

Electronics Engineering

A. Development Projects.

(*i*) *Solid State Thermogravimetric Balance.*

A differential junction FET amplifier has been designed and is under fabrication.

(*ii*) *Proportional Temperature Controller (Thyristor Type).*

Circuit using triacs is under design with integrated firing circuit.

B. Instrumentation.

(*i*) *Sukinda Nickel Project.*

Pre-installation work for the following instruments were completed:

1.	Potentiometric temperature indicators	4 nos.
2.	Rotameters (flow meter)	50 nos.
3.	Dial thermometers	30 nos.
4.	Pressure gauges	30 nos.
5.	Draught gauges	4 nos.
6.	Sight Glass gauges	20 nos.

(*ii*) *Hydro-Electro-Metallurgy Project.*

Installation of following instruments were completed:

1.	Taylor Servomex Oxygen Analyser type 0A250/251	one unit
2.	AIMIL Gas Chromatograph (Sl. No. 74105)	one unit
3.	Carl Zeiss Spectrophotometer (Jena VSUZ-P)	one unit
4.	Spekol Spectrocolorimeter ZV	two units
5.	Conductivity meter	one unit
6.	Systronics PH meter	one unit

(*iii*) *Creep Project.*

Installation of solaratron data logger, instron tensile testing machine and proportional temperature controllers were completed (jointly with UNIDO and Creep Staff).

C. Maintenance, Installation and Calibration.

Following are the major maintenance, installation and calibration jobs done during the period.

(*i*) Pre-installation work for Cambridge stereoscan. (Scanning electron microscope), Philips X-ray fluorescence spectrometer, Philips X-ray diffractometer and pye-unicam atomic absorption spectrophotometer.
(*ii*) Repair and modification of electron microscope EM 6 (jointly with GEC).
(*iii*) Polarographs.
(*iv*) Potentiostats.
(*v*) Rolling mill control units.
(*vi*) Gas chromatrographs.
(*vii*) Spectrophotometers.
(*viii*) Various types of recorders and controllers.
(*ix*) Nucleonic instruments for isotope Laboratory.
(*x*) Vacuum furnace controls.
(*xi*) DTA units.
(*xii*) Autrometer.

Electrical Engineering

A. Development Projects.

(*i*) *Electroslag Refining Equipment.*

140 KVA ESR equipment already installed was commissioned. Trial runs were conducted. Several modifications in the automatic control system were carried out to match various components as well as to suit the process requirement. Electrical parameters such as impedence, voltage, current feed rate etc. were studied in relation to their requirements during starting and running operations as well as for proper co-ordination of voltage and current controllers.

(*ii*) *Design and Development of Electrical Isothermal Furnaces of 2.00 KW for Creep Testing of Metals and Alloys.*

Based on the proven design and materials developed earlier, it has been planned to fabricate six more furnaces to be used with the creep testing machines being developed in N.M.L.

(*iii*) *Electrical Furnace for Vertical Shaft Reduction Unit.*

Another furnace with modified design and materials was fabricated. This furnace gave better performance in relation to the longer uniform zone and consequently power consumption per Kg. of material produced was reduced but the refractory support has not given satisfactory service.

(*iv*) *Design and Development of Electrical Furnace for Production of Magnesium.*

The design of the furnace is based on slag resistance heating. Various parameters such as voltage, current, size of the furnace in relation to the resistivity of the slag to be used as resistor are under consideration.

B. Engineering Monitoring and Project Management.

Engineering monitoring and project management of contractual work on electrical sub-station, internal wiring and temperature and humidity control system of central creep testing facilities, involving very specialised electrical engineering services were undertaken.

C. Design, Fabrication and Installation.

(*a*) A number of electrical resistance furnaces were designed and fabricated to meet the specialised requirements of research and development work of the laboratory.

(*b*) Design of power supply systems and their installations were carried out for several equipment in the laboratory. Some of them are briefly described below:

(*i*) 80 KVA diesel alternator in the sub-station of central creep testing facilities.

(*ii*) 12 Nos. single specimen and 7 Nos. multi-specimen creep testing machines.
(*iii*) Vacuum chamber.
(*iv*) Scanning electron microscope.

D. Preventive Maintenance and Breakdown Repair.

A number of break-down repairs of various electrical network were carried out. Preventive maintenance of electrical equipment comprising of power transformers, circuit breakers, rectifiers, motors, hoisting equipment, arc and resistance furnaces, high frequency furnaces, control devices etc. were carried out.

Civil Engineering

Other than the normal maintenance of gas, water and other service lines modification at various places, installation of equipments, the following jobs were completed during the period :

(*i*) Water proofing treatment to the roof of MCRS, Digha.
(*ii*) Central Creep Testing Facilities offices and auditorium.
(*iii*) Sanitary and plumbing work of Central Creep Testing Facilities office and auditorium.
(*iv*) Working benches for D.C.P., NML.
(*v*) Providing roof for the two rooms inside the D.C.P. Plant, NML.
(*vi*) Periodical painting of air conditioning units, ducts, air grills etc. in NML.
(*vii*) Cutting and fixing in position 6 mm thick M.S. Plate to convert the cable trenches in Creep Building, NML.
(*viii*) Replacement of damaged roof sheet and louvers at MBPP (NML).
(*ix*) Providing white washing to compound wall and towers in NML.
(*x*) Modification to the existing building to house the State Bank Branch at NML & NML Co-operative Stores.
(*xi*) Tarfelt treatment to R.C.C. and corrugated roof sheet of State Bank Branch, NML.
(*xii*) Tarfelt treatment to curved sheet roof of cement godown of FPTD, NML.

The following jobs were taken up and in progress :

(*i*) Periodical painting and white washing (internal & external) main building of NML, Jamshedpur.
(*ii*) Periodical painting and white washing of Pilot Plant Bay in NML, Jamshedpur.
(*iii*) Periodical painting and white washing of Tech. Block in NML, Jamshedpur.

Field Stations at Batala, Howrah & Ahmedabad

The NML Field Stations at Batala, Howrah & Ahmedabad have been rendering useful service to the industries located in the respective regions by way of offering technical guidance on the diverse aspects of foundry technology such as:

(*i*) For selection of proper raw materials. This includes facilities for the analysis of ferrous and non-ferrous metals and their alloys, testing of sands, bentonite and other foundry raw materials.

(*ii*) For the application of modern techniques of production, scientific methods of metal testing and casting etc.

(*iii*) To achieve quality control and improve productivity by elimination of casting and moulding defects.

(*iv*) To improve production techniques to meet export requirement etc.

This has been possible due to on-the-spot assistance given by the field staff to a number of foundries in their respective regions. Extensive work has also been carried out by the field stations in exploiting and investigating the regional resources with regard to foundry raw materials in collaboration with the Geological Survey of India and the respective State Geology and Mining Departments.

The following table gives an account of the nature of technical assistance rendered by the three Field Stations.

	Batala	Howrah	Ahmedabad
1. Chemical analysis—No. of radicals analysed	422	393	1577
2. Mould and core raw material testing No. of samples	1	—	17
3. Mechanical Testing No. of samples	3	153	—
4. No. of Technical Enquiries attended	289	203	346
5. No. of Foundry visits	60	81	10
6. No. of sands and bentonites investigated	3	5	8

NML designed "Equiblast-cum-Balanced Blast Cupola" is receiving keen interest from the foundries of northern region. As many as 21 firms have utilised

Equi-blast-cum-balanced-blast cupola, designed at NML Field Station, Batala, in operation in a Foundry.

the design of the modified cupola with the technical guidance of NML scientists. An investigation was undertaken to improve the soil pipe castings produced by the foundries of Howrah region so as to meet export demand. The problem was referred by the Export Inspection Council of India. Many of the foundries involved in the manufacture of the above castings could not meet the stringent specifications laid down for export especially hydraulic pressure test. A team of scientists from Field Stations and NML have investigated the problems and suggested suitable measures for improving the quality to meet export demands.

Civil work of the ore dressing wing of the NML Field Station, Ahmedabad is nearing completion.

NML Unit in CSIR Complex, Madras

To popularize the know-how developed by the National Laboratories in the Southern Regions and to bring in a closer liaison with the industries, the CSIR established a Madras Complex in which the NML Unit has been functioning since 1974. The NML Unit has taken up a number of activities in the fields of testing, investigation of failures, and technical aid to the industries in the spheres of foundry, engineering metallurgy, ore dressing, chemical metallurgy etc. The Unit has also taken up inter-disciplinary projects in collaboration with Units of other laboratories at the CSIR Madras Complex, such as development of high intensity magnetic separator (NML-MERADO), development of direct reading rapid carbon analyser (NML, CEERI, SCIO), and use of laterite in light weight aggregates (SERC, NML, CECRI). A number of sponsored investigations have been completed by the Unit.

Marine Corrosion Research Station, Digha

The station is conducting a number of investigations connected with sea water corrosion problems.

TECHNICAL CONFERENCES

1. Seminar on Aluminium Conductors and Cables

A seminar on "Aluminium Conductors and Cables" was held on 13th & 14th February, 1975 in collaboration with Cable and Conductor Manufacturers' Association of India, New Delhi. The subject matter of the seminar is of great topical interest in view of the current trend in the country for the substitution of copper by aluminium or its alloys in cable and conductor application. The scope of the seminar covered the following broad facets of the subject matter:

(1) General and economic considerations in using aluminium in electrical engineering.
(2) Physical, electrical and engineering characteristics of aluminium compared to copper as a choice of conductor material.
(3) Development in the use of aluminium in transmission and distribution lines.
(4) Development in the use of low, medium and high voltage power cables, insulated cables etc. and the difficulties associated in the manufacture and use of these cables.
(5) Developments in the field of winding wires and enamelling of these wires and the problems involved.
(6) Joining technique for aluminium.
(7) Use of aluminium strip conductors in electrical equipments.
(8) Aluminium in telecommunication cables.
(9) Corrosion and its prevention in aluminium and alloy aluminium conductors for different electrical applications.
(10) Developments in the field of aluminium and its alloys for electrical and telecommunication applications.
(11) Prospects and problems: Requirement of 5th Five Year Plan, creation of additional capacities, regular dialogue between the State Electricity Boards and the industry and research institutions etc., raw materials, excise duty, standard contract form, terms of payment and conversion of metals etc.
(12) Prospects of export: Market survey for the present is for alloy cables and conductors, export incentives and pricing etc.

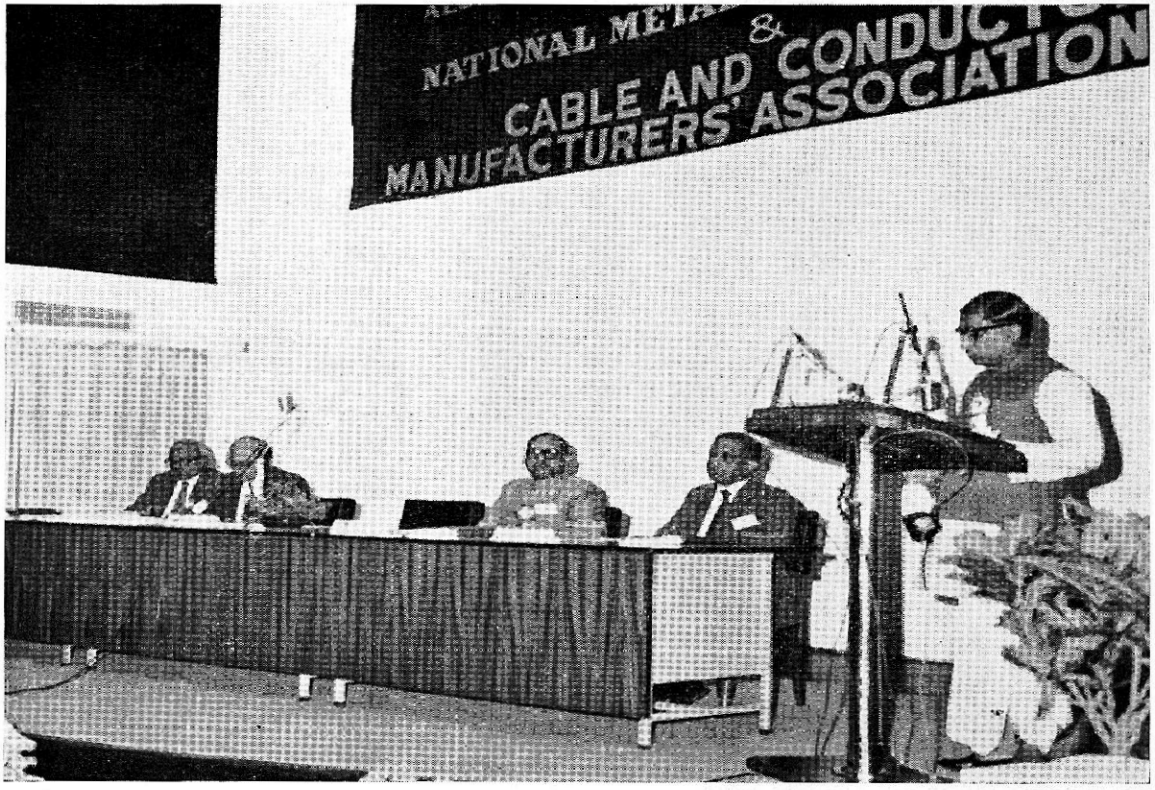
The seminar was inaugurated by Shri Chandra Sekhar Singh, Hon'ble Minister for Industries & Technical Education, Govt. of Bihar. The valedictory session was presided by Shri Sukhdev Prasad, Hon'ble Deputy Minister for Steel & Mines, Govt. of India. The seminar was attended by a large number of delegates representing primary aluminium producers, electricity boards, railways, electrical industries, cables and wire manufacturers.

Sixteen papers on the various aspects of the subject matter were presented and discussed in three technical sessions and following are some of the important recommendations of the seminar.

(*i*) Since 'NML-PM2' alloy aluminium conductor (developed in the National Metallurgical Laboratory) has satisfactorily undergone industrial production trials and the results are uniformly good, the government should

adopt an aggressive policy in its favour and take steps for the manufacture of larger quantities of electrical winding wires progressively for uses on the production of motors and transformers, control cables, flexible wires and for fine wire applications which will considerably cut down the import of copper.

(*ii*) The government should give maximum encouragement and adequate assistance to NML to develop the alloy further for its uses in the manufacture of cables and conductors on a wide scale to increase the availability of such conductors in this country.



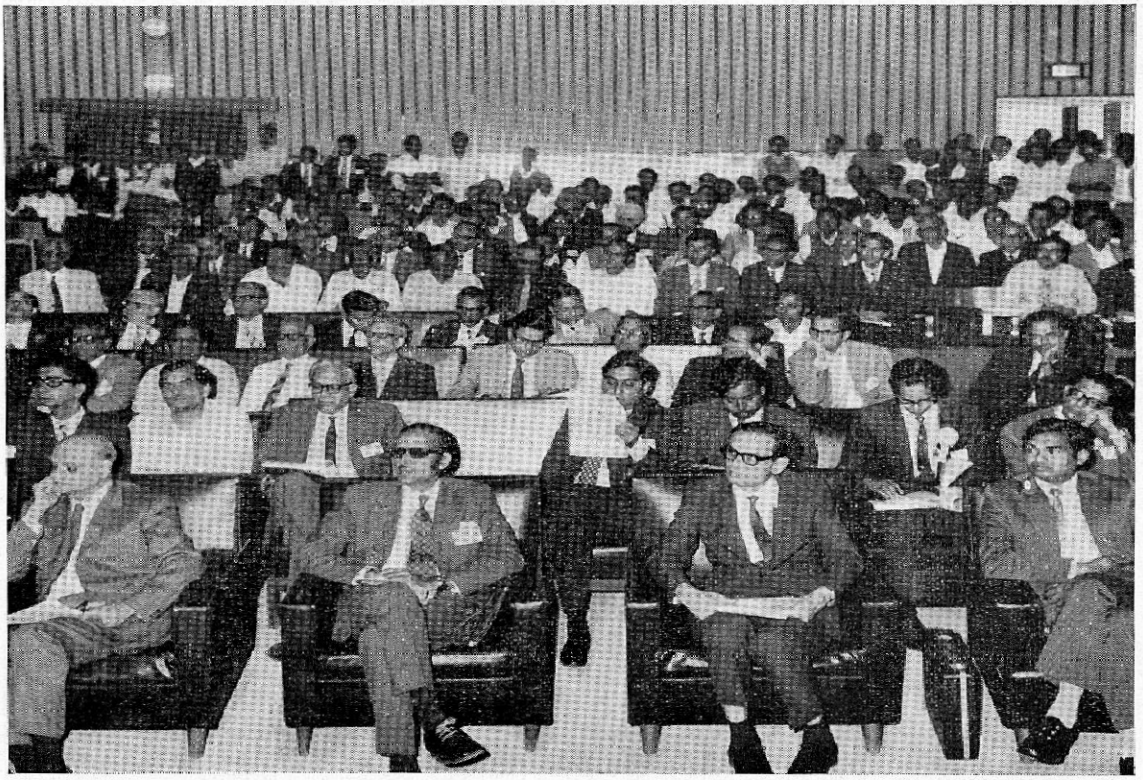
Shri Chandra Sekhar Singh, Minister of Industries & Technical Education, Govt of Bihar, delivering his inaugural address at the Seminar on 'Aluminium Conductors & Cables'.

(*iii*) The Rural Electrification Corporation and other Central authorities should take steps for standardization in the sizes and types of conductors and conductor accessories to be used in the transmission losses and such standard specifications, when introduced and accepted by the Department, should have mandatory enforcement.

(*iv*) The technology of 'Aluminizing of steel wires' developed at National Metallurgical Laboratory could also be utilized in collaboration with the State Electricity Boards for production of experimental quantities of ACSR wires

using aluminized steel core. This work may be done in consultation with the Central Water and Power Commission.

(*v*) The developments in the areas of connectors and jointing techniques are not commensurate with national investment in the field of cables and conductors since conductors are an integral part of any electrical transmission and distribution system and many failures have been noted at such points. Research and Development facilities at the National Metallurgical Laboratory may be utilized for the purpose of developing good and satisfactory connectors.



A view of the delegates attending the Seminar on 'Aluminium Conductors & Cables'.

2. Seminar on Steels for High Temperature Service

With the advent of the manufacture of high pressure boilers, pressure vessels, steam power plants and aero-engine etc. in the country, testing and development of creep resistant steels become essential to avoid the import of technology as well as of the creep resistant alloys to the tune of several crores of rupees per annum. Viewed in this context, a seminar on 'Steels for High Temperature Service' was held on 26th November, 1974.

The Seminar was inaugurated by Shri J. G. Keswani, General Manager & Director, M/s. Indian Tube Co. Shri Rusi Modi, Managing Director, Tata Iron & Steel Co. Ltd. presided over the function.

Delegates from various cross sections of the industry and R & D organizations involved in the use and manufacture of steels for high temperature service attended the seminar. The seminar was also attended by Dr. B. R. Nijhawan, Senior Inter-Regional Industrial Adviser, United Nations Industrial Development Organization; and UNIDO & UNDP representatives. The utilization of the Central Creep Testing Facility at NML established with the assistance of UNDP for the purpose of development and testing of high temperature service steels was stressed upon. Twelve papers were presented and discussed in two technical sessions.

Shri J. G. Keswani, General Manager & Director M/s. Indian Tube Co., delivering his inaugural address at the Seminar on 'Steels for High Temperature Service'.

PUBLICATIONS

During the period, a number of publications and special reports were prepared covering the research and development activities. Following will give a brief account of such publication and related materials.

NML Technical Journal

The journal entered into its sixteenth year of publication and continued to be well received by metallurgical research and development organizations, industrial and government bodies, industrial entrepreneurs etc. both in India and foreign countries.

Proceedings of the Symposium

The Proceedings of the Symposium on "Science and Technology of Sponge Iron and its Conversion to Steel" was published.

Brochure

A brochure on 'Central High Temperature Testing Facility' was prepared and published. The brochure gives an account of the creep testing facility established with UNDP assistance to cater to the industries for development, testing and evaluation of creep resistant alloys.

NML News Letter

A monthly newsletter was started for internal circulation.

Special Reports

The Fifth Five Year Plan Report of the Laboratory was drafted. A project document on 'Augmentation of Mineral Beneficiation and Extraction Metallurgical Facilities at NML' was prepared and submitted to UNDP for UNDP assistance in implementing the project proposal. Another project document on 'Augmentation of Corrosion Research Facilities at NML' was also prepared and submitted to UNDP for their assistance for setting up the facilities in the Laboratory.

Press Releases

Periodic press releases were issued to appraise the general public about the function and contribution of the laboratory.

Handouts & Notes

Handouts and notes on the various products and process development were prepared and distributed on 'Get-Togethers' with industrial entrepreneurs.

Documented Survey on Metallurgical Development

Issues of this monthly publication were continued to be published.

Papers Published and Presented

Details furnished in Appendix I.

Research and Investigation Reports Prepared

Details furnished in Appendix II.

INDUSTRIAL LIAISON AND RESEARCH CO-ORDINATION

Interaction of CSIR laboratories with Bihar State's Fifth Five Year Plan

In an effort to build linkages at the State level, DGSIR, has nominated NML to make systematic study of the Bihar State Fifth Five Year Plan in order to identify major areas of thrust in industrial, economic and social development of the State as also to make a detailed and critical study of the plans, programmes and schemes of the State and the industries both in the public, private, large and small sectors. Such a study will make it possible to identify the scientific and technological gaps where CSIR could be of direct assistance to the State.

A consolidated report entitled "Study of the Fifth Five Year Plan of the Govt. of Bihar with special reference to industrial and other sectors" has been prepared and circulated to the Directors of CSIR laboratories/ institutes, senior officials of the Ministry of Industrial and Technical Education, Govt. of Bihar for their valuable comments for follow-up at the proposed get-together to be held at Patna.

Industrial Evaluation Trials

The product evaluation trials having been completed by independent outside agencies and satisfactory consumer reports have been received on the processes/products such as electric grade aluminium conductor (NML-PM2), soderberg paste from dense carbon aggregates, zinc dust, self setting sand, zinc oxide from zinc ash and zinc hydroxide, and sponge iron for steel making etc.

Processes Ready for Release to the Industry

The technical know-how developed on a number of processes such as zinc oxide from zinc wastes, wear and abrasion resistance cast iron (NML wearnot), production of low residual iron and soft iron, 'Superal' aluminium alloy anodes for cathodic protections, vinyl coated steel and aluminium, production of nickel-silver (Ni-Ag) strips, treatment of metallic fines for metallic recovery, synthetic cryolite are available for exploitation by the industry.

Feasibility Report on NML Developed Process

A process feasibility report on the technology of the Production of Electrolytic Manganese Dioxide was prepared and sent to the Ministry of Mines and Metals (Govt. of India), New Delhi.

Collaboration with Consulting Engineering Firm

M/s. T. K. Chemicals Ltd., Bombay will be setting up a commercial plant of 1000 tonnes per annum capacity of electrolytic manganese dioxide using

the NML know-how earlier developed. M/s. M. M. Suri & Associates, New Delhi, the Consultants to the firm, and NML are working jointly for the development of process flow sheet etc.

Industrial Get-togethers

NML participated in the technical 'Get-togethers-cum-Exhibitions' held at Dhanbad, organized jointly by Central Mining Research Station and Central Fuel Research Institute, Dhanbad and at Srinagar organized by Regional Research Laboratory, Jammu. The industrialists were appraised of the various products/processes developed at NML. Keen interest for exploitation of NML processes/products such as sponge iron, NML-PM2, graphite crucibles, metal powders, hot dip aluminizing of ferrous materials, were shown by industries and many projects were discussed and identified particularly in the field of mineral based industries covering evaluation of raw materials, minerals/ores and development techniques and process flowsheets for beneficiation and agglomeration of low grade minerals/ores.

The NML Regional Liaison Centre

The centre is being used most effectively by the industrial community of West Bengal as well as other States.

Training at NML

35 trainees from various Universities/IITs/State Govts. have undergone/are taking practical training in the varied disciplines of metallurgy or its allied fields for a period ranging from a week to 10 weeks. The Board of Practical Training, Eastern Zone, (Govt. of India), Calcutta have also deputed two candidates to NML under their stipendiary scheme for practical training lasting 1 year at NML.

Ten trainees from NIFFT, Ranchi, were imparted special lectures/practicals for 2 days on PW 1410 X-ray Fluorescence Spectrometer Unit. A team of 23 scientists comprising 6 foreign experts from USA, Australia, and the continent and eleven scientists from Thailand, Philippines, Indonesia, Burma, Malaya, Bangladesh, Sri Lanka, and Afganistan who participated in the training seminar on Regional training course on uranium and thorium prospecting and ore evaluation held on 26th Nov. 1974, visited NML.

Photographic and Reprographic Services

Technical photographic and reprographic services as an aid to metallurgical research and sponsored investigations has been continued. In addition coverage of the progress of different research projects for publications as well as Symposia, Seminars have also been photographed regularly during the year under review.

Printing Services

The printing section has rendered numerous services to the NML by way of printing the monthly NML Newsletter, various types of brochures and folders related to R & D activities of the laboratory. Office stationery forms for

NML/NML Field Stations, various cards and blocks for inclusion in Research and Investigation reports were printed. Varying types of printing jobs pertaining to Seminars/Symposia, Get-togethers and Exhibitions were undertaken. Regular printing jobs of the Documented Survey on Metallurgical Developments—*a* monthly abstracting service and their bindings have also been done.

Delegates/Team Visits

(*a*) SAIL & CSIR Collaboration team for proposal of sponge iron. In this connection a team composed of Mr. Wadud Khan, Chairman, SAIL & Secretary, Union Steel Ministry, Prof. Y. Nayudamma, DGSIR, and Chief of Technology Utilization, CSIR, visited NML.

(*b*) A combined team comprising of representatives from DGTD, NRDC, Deptt. of Science & Technology and CSIR visited NML for appraisal of Technology on Refractories Development at the NML particularly carbon refractories/aggregates/pastes and cathode blocks. Technical sessions were held with two parties viz. M/s. Petro-carbon & Chemicals Ltd., Calcutta and M/s. A. V. M. P. Arunachalam, Madras.

(*c*) A team of UNIDO Foundry experts visited NML and got themselves acquainted with R & D facilities available at the NML.

Visitors

Besides a large stream of visitors from industries, universities, small industries, service institutes, State Govts. and other technical institutions, pouring at the NML, for their varied interests in various disciplines of metallurgy, as many as forty-seven distinguished visitors including some from abroad visited the laboratory.

PATENTS AND PROCESSES

Patents Filed

	Title	*Inventor(s)*
1.	Improvements in or relating to production of soluble granules used in making cellular metal. (Pat. No. 1549/Cal/74-B dt. 11.7.74)	S. K. Sinha and G. N. Rao.
2.	A process for production of hot reducing gases for production of sponge iron and the like.	Prof. V. A. Altekar.
3.	Improvements in or relating to recovery of selenium from copper refinery slimes. (Pat. No. 2109/Cal/74 dt. 23.9.74)	Narinder Singh and S. B. Mathur.
4.	A process to cast aluminium surface with vinyl compositions and the products thus coated. (Pat. No. 284/Cal/74 dt. 11.2.74)	Dr. P. Prabhakaran S. R. Addanki and A. N. Mukherjee.
5.	Extraction of nickel and cobalt values from lateritic and limonitic nickeliferous ores by coal reduction and ammonical leaching in presence of a catalyst. (Pat. No. 113/Cal/75 dt. 21.1.75)	B. N. Singh M. Mahanty D. D. Akerkar and Prof. V. A. Altekar.

Processes Released to Industry

(*i*) *The following NML Processes have been released for commercial utilization*

	Processes	*Firms*
1.	Extra-fine non-ferrous atomized metal powders (non-patented).	M/s. Matapow Industries, Poona.
2.	Bi-metallic metal powders by atomization (non-patented).	M/s. Paras Metal Powders, Nasik.
3.	Recovery of zinc by atmospheric distillation (non-patented).	M/s. Narbheram & Co., Jamshedpur.
4.	Electric Grade aluminium alloy conductor (NML-PM2) (patent application filed).	M/s. Galada Continuous Castings Ltd., Hyderabad.
5.	Production of carbon-bonded graphite crucibles (patented).	M/s. Silcarb Crucibles Pvt. Ltd., Vapi.

(*ii*) *Status of Licencees of NML Process Know-hows*

1. Electric Grade Aluminium Alloy Conductor (NML-PM2)

   M/s. Aluminium Cables & Conductors (UP) Ltd., Calcutta, one of the licencees, have commenced production since January, 1974.

2. Electrical Resistance Alloys for Heating Elements—Commissioning of the Plant.

   The plant of M/s. Cable Works India Ltd., one of the licencees, was inaugurated on 11th April, 1974. The firm has also commenced production and is marketing the product under the name "Thermo-alloy". The NML is actively associated with the firm for solving their problems of initial production such as melting technology etc. and liaison is being maintained with the firm.

3. Zinc Dust

   M/s. Associated Pigments Ltd., Calcutta, the licencee, is setting up a small production unit at Calcutta in the first instance. Two furnace units each approximately 200 tonne/year are expected to be commissioned during the year.

GENERAL

Recipients of Honours, Awards etc

Dr. R. Kumar, Scientist	Awarded Degree of Doctor of Metallurgy (D. Met) from University of Sheffield, U.K. The first Indian ever to receive such honour.
Shri K. N. Gupta, Scientist	National Metallurgist Award by Ministry of Steel & Mines, Govt. of India.

Foreign Deputation/Training in India and Abroad

Dr. R. Kumar, Scientist	(*i*) Visited Rumania under Indo-Rumanian Exchange Programme. Also visited West Germany. (*ii*) Visited U.K. under Indo-British Exchange Programme.
Shri G. P. Mathur, Scientist	Visited Moscow as a Member of the delegation to attend a meeting on Malanjkhand Copper Project.
Shri S. Rafiuddin, Scientist	Deputed to West Germany to attend the 10th International Seminar on Research and Study in Chemical Engineering and Physical Chemistry.
Shri B. K. Guha, Scientist	Participated in the Short Term Course on Heat Treatment Technology organised by B. E. College Chapter of Indian Inst. of Metals.
Shri K. M. Chowdhary, Scientist	Deputed to U.K. for specialised training in the field of Creep research, Creep testing and Creep data processing.
Shri R. Singh, Scientist	-do-
Shri M. R. Das, Jr. Scientific Asst.	-do-

The Following UNIDO Experts joined the Creep Project

1. Mr. D. C. F. Lunn	Chief Technical Adviser of Creep Project.
2. Mr. G. W. Russel	Equipment Installation Engineer of Creep Project.
3. Dr. T. B. Gibbons	High Temperature Materials Expert of Project.

Directorship, Chairmanship, Membership etc. on Outside Bodies

Prof. V. A. Altekar, Director	(*i*) Chairman, Tundoo Lead Smelter Committee. (*ii*) Member of the Experts Committee for the establishment of Research & Development Board for Iron and Steel Industries. (*iii*) Member of the Technical Committee for the establishment of Aluminium Research Institute in India. (*iv*) Adviser to Industrial Development Bank of India.
Dr. R. Kumar, Scientist	Member of Senate of Indian Inst. of Technology, Kharagpur.
Dr. M. R. K. Rao, Scientist	Member of the Panel for Refractory Industry constituted by Directorate-General of Technical Development.

AIR Broadcast

Prof. V. A. Altekar, Director	Development of Science & Technology. Talk broadcasted at All India Radio, Ranchi on 22nd January 1974.

Lectures

A number of lectures were delivered by distinguished metallurgists, scientists and technologists during the period. The following special lectures were delivered by NML staff:

Dr. R. Kumar, Scientist	Key note lecture on 'Aluminium Conductors and Cable Industries—Prospects & Trends' Seminar on Aluminium Conductors & Cables organised by NML and Cable and Conductor Manufacturers Association, Feb. 1975. Also delivered lecture in W. Germany Universities at their request during his visit to W. Germany.
Shri M. J. Shahani, Scientist	Production of Metal Powders—At Powder Metallurgy Association of India Short Course, University of Roorkee, December 1974.

Purchase and Stores

Purchase & Stores kept up their activities by procurement of capital equipment, raw materials, consumable stores for the various research projects, pilot plant activities, constructional work etc.

Administration & Accounts

Administration and Accounts Section handled the general and overall

administration and budgetary accounts.

Safety First and First Aid Section

No major casualty took place during the year. Regular inspection to safety measures were carried out. The First Aid Section treated minor injuries, indisposition caused to staff members on duty.

Activities of Societies, Club and Canteen

NML Staff Co-operative Credit Society operated its transactions worth over rupees two lakhs with efficiency. NML Co-operative Stores continued to supply rationed foodstuff, stationery articles to the staff members.

NML Club maintained its sporting and social activities. It took part in local tournaments in Cricket, Table Tennis, Cards etc. and also organized tournaments for NML staff and their families. A number of film shows were organised by the Club. The NML Canteen is supplying to staff members meals, snacks etc. at reasonable price.

NML Welfare Committees at Agrico & Tuiladungri Colonies continued to look after the cleanliness of the colonies, running of kindergarten school, arranging cultural & film shows, etc.

Staff Position

Scientific	190
Technical	444
Administrative	149

Budget Figures

Figures in Lakhs of Rupees

Recurring

P-1 Pay of Officers	21·933
P-2 Pay of Establishment	25·292
P-3 Allowances	25·395
P-4 Contingencies	12·202
P-6 Maintenance	1·653
P-7 Chemicals etc.	10·973

Capital

P-5 Works	5·781
Apparatus & Equipment	14·522
Miscellaneous	1·280
Library Books	1·312

Pilot Plants	19.286
Construction of Quarters	13.500
GRAND TOTAL	153.129

APPENDIX I

1. Some observations in the production of ferro-phosphorus in low shaft furnace—V. A. Altekar, A. N. Kapoor, J. Goswami, R. S. Singh, S. R. Ghosh & S. B. Ghosh; NML Technical Journal, Vol. 16 (1974), 3 & 4, pp 27-34.
2. Electric grade aluminium alloy—Rajendra Kumar & Manjit Singh; NML Technical Journal, Vol. 16 (1974), 3 & 4, pp 35-40.
3. Spectrophotometric determination of vanadium by hydroxylamine hydrochloride—L. P. Pandey; NML Technical Journal, Vol. 16 (1974), 3 & 4, pp 46-48.
4. Degassing of aluminium & its alloys—K. Lal & Rajendra Kumar; NML Technical Journal, Vol. 16 (1974), 3 & 4, pp 49-56.
5. Possibility of conversion of Indian phosphoric basic pig iron to steel using basic side-blown converter—A. N. Kapoor, S. K. Biswas & R. Santokh Singh; NML Technical Journal, Vol. 17 (1975), 1 & 2, pp 1-9.
6. Manufacture of soil pipe castings to export specification—M. N. P. Verma, A. Dutt, G. N. Rao & R. Kumar; NML Technical Journal, Vol. 17 (1975), 1 & 2, pp 15-20.
7. A note on the analysis of nickel in the nickel complex with the help of X-ray fluorescence—S. C. Srivastava & B. Subhashini; NML Technical Journal, Vol. 17 (1975), 1 & 2, pp 21-22.
8. A continuous and self-regulating method for making copper powder by electrolysis—S. K. Singh & D. D. Akerkar; NML Technical Journal, Vol. 17 (1975), 1 & 2, pp. 23-26.
9. Extraction of selenium and tellurium from electrolytic slimes by vacuum sublimation—Narinder Singh & S. B. Mathur; Journal of Sulfur Chemistry (USA), Sept. 1974.
10. Inhibition of corrosion of aluminium alloys in sodium hydroxide solution—A. N. Mukherjee, Inder Singh & V. A. Altekar; British Corrosion Journal, August, 1974.
11. Cold extrusion of copper powder—J. Bhattacharya; Metallurgia and Metal Forming (UK), Vol. 42 (1975) 2, p. 36.
12. Explosive cladding of large and relatively thick flyer plates—B. Crossland, J. A. Cane, S. K. Banerjee & H. K. Wylie; Proceedings of the Fifth International Conference for High Energy Rate Fabrication, Denver, USA, 1975.
13. Hydrogen absorption and fracture of steel in presence of thio-compounds—V. A. Altekar, Inder Singh, M. K. Banerjee & T. R. Soni; Fourth European Symposium on Corrosion Inhibitors, University of Ferrara, Italy.
14. Direct reduction of iron ores for steel making—V. A. Altekar & V. S. Sampath; Communicated to Vigyan Pragati.
15. The present status of sponge iron technology—V. A. Altekar, & V. S. Sampath; Journal of Steel Rolling Mills Association Monthly, Vol. 1 (1974) 5, pp. 193-199.
16. Prospects of sponge iron plants in eastern region—V. A. Altekar; Presented at the Symposium on 'Mineral Based Industries in the Eastern Region' held at Regional Research Laboratory, Bhubaneswar, December, 1974.
17. Production of alloy steels by basic oxygen process—V. A. Altekar & S. K. Tiwary; Presented at the Seminar on 'Basic Oxygen Steel Making Process' organised by Ind. Inst. of Metals, Jamshedpur Chapter and Iron & Steel Divn. of Ind. Inst. of Metals, December 1974.

18. Role of selenium and tellurium on machinability of steel—Narinder Singh & V. A. Altekar; Jr. of the Institution of Engineers (India), Vol. 8, No. 1, November, 1974.
19. Weldability of medium strength Al-Zn-Mg alloys—V. A. Altekar; Presented at the National Seminar at Trichy. Jan-Feb. 1975.
20. Impregnation of porous sintered skeleton by solid lubricants—J. Bhattacharya & B. N. Ghose; Trans. of Ind. Inst. of Metals, Vol. 27, No. 6 December, 1974.
21. Copper clad aluminium sheets for transition joints—J. Bhattacharya & B. N. Ghose; 116th Anniversary Number, Indian & Eastern Engineer, 1975.
22. Pollution and modern trends in extraction metallurgy process—V. A. Altekar & V. S. Sampath; Communicated to Jr. of Indian Chemical Manufacturers' and Allied Publication.
23. Fly ash and flue dust as sources of germanium—Narinder Singh & V. S. Sampath; Presented at the Seminar on "Coal Utilization for Power, Solid & Liquid Fuels, Fertilizers and Chemical" organised by Indian Chemical Manufacturers' and Allied Publication, Bombay, March 1975.
24. Stress corrosion cracking of metals-studies made at NML—V. A. Altekar; Presented at the Seminar on "Metals & Materials in Chemical Industries" organised by Industrial Metallurgy Division of IIM at Baroda, March 1975.
25. Uses of inhibitors in chemical industries—Inder Singh & V. A. Altekar; Presented at the seminar as in Sl. No. 24.
26. Importance of aluminium and its alloys in chemical industries—A. N. Mukherjee & Inder Singh; Presented at the seminar as in Sl. No. 24.
27. Some observations from the view point of corrosion on selecting stainless steel for the process industries—K. P. Mukherjee; Presented at the Seminar as in Sl. No. 24.
28. High temperature ferrous materials in chemical industries—M. R. Kulkarni, V. S. Sampath & V. A. Altekar; Presented at the Seminar as in Sl. No. 24.
29. The development of clad metals and its application in chemical industries—S. K. Banerjee, B. N. Ghosh & J. Bhattacharya; Presented at the Seminar as in Sl. No. 24.
30. High temperature testing of creep resistant steels for long term service—R. Choubey & R. Kumar; Presented at the seminar on "Steels for High Temperature Service". Organised by NML, Nov. 1974.
31. Aluminium Cable and Conductor industries—Prospects and trends—R. Kumar; Presented at the seminar on "Aluminium Conductors & Cables" organised by NML and Cable & Conductor Manufacturers' Association, Feb. 1975.
32. Development of alloy aluminium conductors—G. K. Ghosh, C. S. Sivaramakrishnan, Manjit Singh & R. Kumar; Presented at the seminar as in Sl. No. 31.
33. Corrosion studies of NML-PM2 alloy—M. N. Singh, K. P. Mukherjee, R. K. Mahanty, Manjit Singh & R. Kumar; Presented at the Seminar as in Sl. No. 31.
34. Power Crisis—A challenge to material science and technology—R. Kumar; Presented at the Symp. on "Energy Crisis" organised by Indian Inst. of Metals.
35. Study of columnar crystallization on Alnico V alloys—Ved Prakash & C. R. Tewari; Presented at the 28th Annual Technical Meeting of Indian Institute of Metals, Nov. 1974.

36. An investigation on the micro-structure of Alnico magnets—Ved Prakash & C. R. Tewari; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
37. Studies on melting and extrusion of magnesium base wrought alloys—G. D. Sani, S. C. Dev, R. K. Dubey & R. Kumar; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
38. Troubles associated with hydrogen during pickling of high carbon steels—Inder Singh, A. K. Dey & V. A. Altekar; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
39. Effect of thio-semi carbazide on corrosion of mild steel and hydrogen absorption—Inder Singh; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
40. High temperature performance of a surface alloyed stainless steel—V. A. Altekar, S. M. Arora & A. Nag; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
41. Corrosion behaviour of NML-PM 2 alloy and electric grade aluminium—R. K. Dua, R. Kumar & Manjit Singh; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
42. Development of new composition for aluminium base bearing alloys—S. K. Banerjee, S. C. Dev & J. Bhattacharya; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
43. Studies on desulphurization behaviour of cupro-nickel and slag—B. K. Saxena, C. S. Sivaramakrishnan & R. Kumar; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
44. Production of calcium-silicide—N. N. Patra, B. V. S. Yadavalli & D. D. Akerkar; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
45. Chlorination of fly ash and flue dust to recover germanium—Narinder Singh & S. B. Mathur; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
46. Recovery of tungsten oxide from tungsten carbide scrap—Premchand & V. A. Altekar; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
47. Calcium metal production by thermal reduction of lime by aluminium powder in vacuum—A. K. Nayak, A. Kumar, D. D. Akerkar & V. A. Altekar; Presented at the 28th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1974.
48. Present status of sponge iron technology at NML—V. A. Altekar, G. P. Mathur, K. N. Gupta & B. L. Sengupta; Presented at the seminar on "Iron & Steel Industry—Planning to Commissioning" organised by MECON, Ranchi, Nov. 1974.
49. Effect of iron oxide addition on the direct bonding in chrome-magnesite—N. N. Mathur, M. R. K. Rao & P. C. Sen; Presented at the 39th Annual General Meeting of Ind. Ceramic Society, March, 1975.
50. A comparative study of some technological properties of raw materials in the manufacture of carbon lining—B. Chatterjee, N. B. Sirkar & H. P. S. Murthy; Presented at the 39th Annual General Meeting of Ind. Ceramic Society, March, 1975.
51. Technique of high temperature phase equilibrium—studies on dry silicate oxide system—R. V. Hargave & M. R. K. Rao; Presented at the 39th Annual General Meeting of Ind. Ceramic Society, March, 1975.
52. First firing of ceramics—A review—K. K. Singh & A. V. Subramanhya;

Presented at the 39th Annual General Meeting of Ind. Ceramic Society, March, 1975.

53. Concentration of economic minerals like magnetite, chromite, vermiculite, bauxite, wolframite etc.—M. V. Ranganathan, S. K. Banerjee & G. P. Mathur; Presented at the Seminar on 'Export Potentialities of Minor Minerals" held at Gua, Dec. 1974.
54. Status of technology and development in the beneficiation of minor minerals with special reference to chromite, phosphate rock and graphite ores in the country—N. Chakraborty & G. P. Mathur; Presented at the Seminar as in Sl. No. 53.
55. Metal powders by atomization—R. G. Ganguly, Upkar Singh & M. J. Shahani; Presented at the Annual Technical Meeting of Powder Metallurgical Association of India, January 1975.
56. Magnesium production process residue as hardener for sodium silicate bonded sand—T. A. Beck, G. N. Rao & V. A. Altekar; Indian Foundry Journal, Vol. 21, No. 3, March 1975.
57. Metallurgical considerations governing selection of aluminium alloys for light weight bridges—B. K. Saxena, K. Lal, C. S. Sivaramakrishnan & R. Kumar; Presented at the Seminar on "Design, Development & Production of Light Weight Bridges" organized by Ministry of Defence, January 1975.
58. Preferred orientation in extruded aluminium alloy and aluminium rods—K. D. Maji; Indian Journal of Technology, Vol. 12, Sept. 1974.
59. Analysis of alloys and salt solutions by beta-ray back scattering—Mrs. A. Bahadur, K. D. Maji & R. Kumar; Communicated to Journal of Applied Chemistry & Biotechnology, London.
60. Electric grade aluminium alloy (NML-PM2)—an ideal substitute of copper for electrical industry—R. Kumar & Manjit Singh; Presented at the Symposium on "Power Distribution" organized by CACMAI & NAYE, December, 1974.

APPENDIX II

Scientific Investigations Completed and Reports Prepared

1. Batch and pilot plant studies on beneficiation of low grade copper ore from Malanjkhand, M.P. for H.C. Ltd.—D. M. Chakravarti, S. K. Sengupta, B. L. Sengupta, S. K. Banerjee & G. P. Mathur (IR777/74).
2. Moulding characteristics of Aujhar sand received from the Director of Geology & Mining, Lucknow (U.P.)—R. C. Arora, M. N. P. Verma & G. N. Rao (IR 778/74).
3. Moulding characteristics of Hindal-Dandi sand received from the Director of Geology & Mining, Lucknow (U.P.)—R. C. Arora, M. N. P. Verma & G. N. Rao (IR 779/74).
4. Investigation on Phuljhari sand, Dist. Burdwan, W. Bengal, Part IV—Amitava Das, Ashimesh Dutt & G. N. Rao (IR 780/74).
5. Investigation on Phuljhari sand, dist. Burdwan, W. Bengal, Pt. III—Amitava Das, Ashimesh Dutt & G. N. Rao (IR 781/74).
6. Investigation on sand from Chatikunj, Dist. Bankura, W. Bengal—Ashimesh Dutt & G. N. Rao (IR 782/74).
7. Investigation on sand from Telipara, Dt. Burdwan, West Bengal—Ashimesh Dutt & G. N. Rao (IR 783/74).
8. Investigation on sand from Bulbani, Dt. Burdwan, West Bengal—Ashimesh Dutt & G. N. Rao (IR 784/74).
9. Moulding characteristics of Misrapari sand from Director of Geology & Mining, Lucknow, U.P.—R. C. Arora, M. N. P. Verma & G. N. Rao (IR 785/74).
10. Testing of pine oil samples received from M/s. Camphor & Allied Products, Bareilly, U.P.—S.K. Sil, M. V. Ranganathan & S. K. Banerjee (IR 786/74).
11. Reducibility studies on iron ore composite sample and sinter of Donimalai—V. S. Lakhminarayan, N. V. Nagaraja & K. N. Gupta (IR787/74).
12. Size analyses of feed and underflow received from M/s. Indian Copper Complex, H.C.L., Ghatshila—S. K. Sengupta & S. K. Banerjee (IR 788/74).
13. Investigation on bentonite samples (Sample No. H1 to H7 and BB1 47)—R. Prasad, P. R. Sastry & G. N. Rao (IR 789/74 to IR 796/74).
14. Pelletization of iron ore fines from Rajhara mines and comparison of properties with cold bonded pellets made by R.R.L., Jorhat—N. Chakravarty, Joga Singh & G. P. Mathur (IR 797/74).
15. Kutch bentonite as a binder for pelletization of iron ore fines—P. K. Sinha, B. L. Sengupta & S. K. Banerjee (IR 798/74).
16. Beneficiation of low grade fluorspar samples from R.I.D.C., Rajasthan—M. V. Ranganathan, S. Prasad, S. K. Banerjee & G. P. Mathur (IR 799/74).
17. Beneficiation studies on a barite sample from Manganaperta area, Andhra Pradesh—K. Vijayaraghavan, C. Satyanarayan, R. Ganesh, P. V. Raman & G. P. Mathur (IR 800/74).
18. Petrological studies on 47 graphite samples of Palamau district, Bihar, received from Govt. of Bihar—Bhaskar Banerjee, A. Peravadhanulu, S. K. Banerjee & G. P. Mathur (IR 801/74).
19. Pellitization of Donimallai iron ore fines and production of 500 kg. of pellets for testing at HYL Midrex Laboratory on behalf of MECON—P. K. Sinha, V. K. Sharma, B. L. Sengupta & G. P. Mathur (IR 802/74).
20. Bench scale beneficiation studies on ROM graphite sample from Rajasthan State Industrial & Mineral Development Corporation—R. Ganesh, S. K. Banerjee & G. P. Mathur (IR 803/74).

21. Beneficiation and agglomeration studies on a low grade magnetite from Ongole, Andhra Pradesh, Pt. I—Beneficiation studies—B. L. Sengupta, S. K. Banerjee & G. P. Mathur (IR 804/74).
22. Beneficiation studies on a low grade wolframite sample from Agargaon, Nagpur Dist.—C. Satyanarayana, P. V. Raman, S. K. Banerjee & G. P. Mathur (IR 805/74).
23. Davis tube tests with a magnetite sample received from M/s. Tata-Robins-Fraser Ltd., Jamshedpur—M. V. Ranganathan & S. K. Banerjee (IR 806/74).
24. Laboratory scale tests on three limestone and two iron ore samples for Salem Steel project (IR 807/74).
25. Comprehensive studies on pelletization of iron ores from Noamundi mines of Tisco—N. Chakravorty, Joga Singh, S. N. Prasad & G. P. Mathur (IR 808/74).
26. Pelletization of Bolani iron ore fines incorporating blue dust and production of 500 kg. of pellets for testing at HYL Laboratories of Midrex on behalf of MECON, Ranchi—P. K. Sinha, B. L. Sengupta, S. K. Banerjee & G. P. Mathur (IR 809/74).
27. Pilot Plant beneficiation studies on iron ores from Meghataburu mines of NMDC Ltd.—Pt. I: Composite sample & Pt. II: Type samples—R. K. Kunwar, S. C. Maulik, Joga Singh, B. L. Sengupta & G. P. Mathur (IR 810/74 & IR 811/74).
28. Beneficiation studies on limestone from Manipur, Govt. of Manipur, Imphal—V. Mohan, M. V. Ranganathan, S. K. Banerjee & G. P. Mathur (IR 812/74).
29. Batch and pilot plant studies on recovery of copper minerals from copper slag sample of Indian Copper Complex, H.C.L., Ghatshila—D. M. Chakravarti, S. K. Sengupta, B. L. Sengupta & G. P. Mathur (IR 813/74).
30. Pilot plant studies on the beneficiation and sinter of Kammangudi iron ore from M/s. Mysore Iron & Steel Works Ltd., Bhadravati, Mysore—S. R. Ghosh, S. Prasad, V. K. Sharma, B. L. Sengupta, S. K. Banerjee & G. P. Mathur (iR 814/74).
31. Studies on crushing and screening of eight iron ore samples from deposits 4 & 5 of Bailadila mines for Vizay steel plant—P. K. Sinha, V. K. Sharma, B. L. Sengupta, S. K. Banerjee & G. P. Mathur (IR 815/75).

    Pt. II—Decrepitation characteristics.
    Pt. III—Reduction characteristics—N. V. Nagaraj, A. K. S. Mahapatra, M. K. E. Unni & K. N. Gupta.

32. Beneficiation tests on three low grade iron ore samples from Giyar depsoits of Jhansi district—M. V. Ranganathan, S. K. Sil, S. K. Banerjee & G. P. Mathur (IR 816/75).
33. Studies on screenability of composite iron ore samples from Meghataburu mines—NMDC Ltd.—P. D. Prasad Rao, B. L. Sengupta & G. P. Mathur (IR 817/75).
34. Report on investigation of creep, stress-rupture and stress-relaxation properties of bolting steel 1% Cr—1% Mo—3/4%V-Ti-B-sponsored by M/s. Bharat Heavy Electrics Ltd., Hardwar, (Pt. I)—R. Choubey, R. Singh, K. Prasad & S. C. Bose (IR 818/75).
35. Beneficiation studies on coal sample from Bhadrah Colliery—S. K. Sil, S. Raghunath Rao & S. K. Banerjee (IR 819/75).
36. Studies on lime sludge received from M/s. Seshasayee Paper Board Ltd.—

K. Vijayaraghavan, C. Satyanarayana, P. V. Viswanathan, C. Sambaran, P. V. Raman & P. R. Khangaonkar (IR 820/75).

37. Bench scale beneficiation studies on gypsum sample from Nagaur mines, Rajasthan (received from RSIMDCO)—R. Ganesh, S. K. Banerjee & G. P. Mathur (IR 821/75).
38. Comparative study of reduction characteristics of Kalta, Barsua and Barangida iron one of Rourkela Steel Plant—N. V. Nagaraja, M. K. E. Unni & K. N. Gupta (IR 822/75).
39. Investigation on Kovilpatti dolomite, its suitability for refractories—R. V. Hargave, K. C. Ray, P. C. Sen, M. R. K. Rao & H. P. S. Murthy (IR 823/75).
40. Pelletization of Kundremukh iron ore concentrate and production of pellets for MECON to be tested at HYL and Midrex Laboratories—P. K. Sinha, N. Chakravarty & G. P. Mathur (IR 824/75).
41. Bench scale beneficiation studies on a low grade limestone sample from Jhalda area, Purulia dist. for M/s. West Bengal Cement—M. V. Ranganathan, S. K. Banerjee & G. P. Mathur (IR 825/75).
42. Parametric investigation for the reduction of manganese ores with l.t.c. in vertical shaft (RR 342/74).
43. Studies on the corrosion resistance properties of PM-2 aluminium alloy developed in NML—M. N. Singh, H. R. Thilakan & K. P. Mukherjee (RR 343/74).
44. Non-metallic foundry raw materials for moulds and cores—G. N. Rao & V. A. Altekar (RR 344/74).
45. Creep testing and evaluation of elevated temperature properties of indigenous high temperature steels for long term service—R. Choubey & R. Kumar (RR 345/74).
46. In-plant sponge iron trials at H.E.C., Ranchi (RR 346/74).
47. Production trials of cellular metal at NML—S. K. Sinha & G. N. Rao (RR 347/75).