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1977-78

National Metallurgical Laboratory

Jamshedpur, India

ANNUAL REPORT

1977-78

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

Compiled, Edited & Produced by
P. K. Gupta
P. R. Sastry

Secretarial Assistance
K. V. Easwar

Design & Layout
P. K. Gupta
M. L. Sarkar

CONTETS

B. Refractory Technology

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Similar treatment of scrubbing and cycloning of slime gave a concentrate of 62.5% Fe, 2.28% Al_2O_3 and 85.5% yield for Type III and 61.4% Fe, 4.2% Al_2O_3 for Type IV sample. The concentrates from Type III constituted the pellet feed for internal consumption, while bluedust in suitable proportion had to be added to Type IV concentrate for pellet feed for the same purposes. For producing a concentrate for export grade pellet feed, further beneficiation employing grinding and spiral treatment was followed to produce concentrates assaying 64.6% Fe, 1.68% Al_2O_3, from Type III and 62.5% Fe, 3.23% Al_2O_3 from Type IV sample. The Bolani concentrate (Type III) both for internal and export grade pellets were used as such, while 22.2% and 48.8% blue dust had to be added to concentrates from Gua fines (Type IV) to form the pelletising feed.

Pelletization tests were first conducted on the two concentrates (internal & export grades) from composite samples after mixing with blue dust in suitable proportions. Pellets with good physical properties could be prepared from these samples.

2.0 Beneficiation Studies on a Complex Cu-Pb-Zn Sulphide Ore Sample from Sargipalli Mines, Orissa. *Sponsored by M/s. Hindustan Zinc Ltd.*

The Sargipalli-Lakedega area of Sundergarh district of Orissa reportedly holds a probable reserve of 6.5 million tonnes of Cu-Pb-Zn ores with an average grade of 5.9 of Pb ; 0.4% Cu & 0.6% Zn. The investigation was undertaken with a view to determine the amenability of the ore to physical beneficiation processes to yield major metallic concentrates.

The main valuable metallic constituent of the ore being lead, more efforts were directed to concentrate lead bearing minerals. A lead concentrate assaying 70% Pb ; 1% Cu and 0.7% Zn with 75.4% of Pb recovery was obtained. Production of separate Cu and Zn concentrates with reasonably good grade and recovery was, however, not feasible.

2.1 Beneficiation Studies on Complex Copper-Lead-Zinc Sulphide Ore Sample from Deri, Rajasthan. *Sponsored by Rajasthan State Industrial Mineral Development Corporation Ltd.*

The head sample assayed 1.03% Cu ; 6.1% Pb and 8.1% Zn. The following results were obtained after carrying out a large number of beneficiation tests on the sample.

(i) Zinc concentrate assaying 53.6% Zn, 0.8% Cu and 0.05% Pb with 70.8%, 8.8% and 0.1% distributions respectively.

(ii) Pb-fraction assaying 44.8% Pb, 4.1% Cu and 7.0% Zn with 63.4%, 31.8% and 7% distributions respectively.

(iii) Cu-fraction assayed 29.5% Cu. 1.1% Pb and 2.2% Zn with 39.7%, 0.3% and 0.4% respectively.

3.0 Beneficiation Studies on a Complex Lead-Zinc (Oxidized) Ore from Chakula, Bhutan. *Sponsored by Geological Survey of India, Bhutan Circle.*

Bench scale beneficiation studies were carried out on an oxidised Complex Pb-Zn Ore from Chakula Bhutan, for recovering the mineral values. The sample as received assayed 4.8% Pb ; 22.1% Zn ; 23.8% Fe ; 0.5% S ; 11.8% SiO_2 ; 8.3% Al_2O_3 3.2% CaO ; 1.9% MgO and 14.1% LOI.

Flotation tests produced a rougher Pb-float assaying 50.3% Pb 9.8% Zn with a lead recovery of about 50% in it. Reflotation of the rougher float improved the grade to 62.2% Pb but with a reduced recovery. Production of zinc concentrate with reasonably good grade and recovery was, however, not feasible.

4.0 Beneficiation Studies on Low Grade Manganese Ore Samples. *Sponsored by M/s. Aryan Mining & Trading Corporation (P) Ltd., Jamshedpur.*

A low grade manganese ore sample designated as small chips was received for washing studies to upgrade the manganese content. The sample assayed 41.3% Mn ; 11.9% Fe ; 7.0% Al_2O_3 ; 3.7% SiO_2 ; 2.1% BaO & 11.5% loss on ignition. Bench scale studies carried out which yielded an overall concentrate assaying 46.7% Mn and 7.4% Fe with Mn/Fe ratio of 6.3 and 88.9% manganese recovery.

4.1 Beneficiation Studies on Low Grade Siliceous Manganese Ore. *Sponsored by M/s. Aryan Mining & Trading Corporation (P) Ltd., Jamshedpur.*

A low grade siliceous manganese ore designated as lumpy siliceous ore was received for bench scale beneficiation studies to upgrade the MnO_2 content. The sample as received assayed 33.8% Mn, 53.5% MnO_2 2.2% Fe, 35.4% SiO_2, 2.1% Al_2O_3, 2.7% Bao and

7.2% LOI. An overall concentrate assaying 79.3% MnO_2 and 2.3% Fe with 70.0% MnO_2 recovery in it was obtained.

5.0 Beneficiation of Low Grade Phosphate from Purulia, West Bengal. *Sponsored by M/s. Sadhana Enterprises, New Delhi.*

Further to the studies carried out (reported in previous annual report), high intensity magnetic separation produced a concentrate assaying 36.0% P_2O_5; 1.2% Fe and 7.1% SiO_2 with a recovery of 43.7% P_2O_5. Straight flotation produced a concentrate assaying 35.0% P_2O_5; 3.47% Fe and 4.3% SiO_2 ith a distribution of 32.6% P_2O_5 suitable for fertilizer industry.

5.1 Beneficiation of Low Grade Phosphate from Purulia District, West Bengal. *Sponsored by M/s. Fertilizer Corporation of India Ltd., Sindri.*

A phosphate sample assaying 29.1% P_2O_5, 9.8% Fe and 3.8% SiO_2 was received for beneficiation studies. The object of the investigation was to produce concentrate suitable for fertilizer industry. A concentrate assaying 37.7% P_2O_5; 1.96% Fe with a recovery of 75.0% P_2O_5 satisfying the requirement was produced.

6.0 Pilot Plant Beneficiation Studies on Pyrite Samples from Amjhor, Bihar. *Sponsored by M/s. Pyrites, Phosphates & Chemicals Ltd.*

A comprehensive investigation on beneficiation of run of mine pyrite samples from Amjhor, Bihar; employing simple gravity treatment flowsheet was undertaken to collect necessary data for the proposed 2000 tpd plant to be set up by M/s. PPCL for supply of concentrates to FCI, Sindri. Alltogether five samples of the low grade pyrite as mined were received at different periods and tested for collection of different technological and operating parameters in continuous closed circuit run in the pilot plant. A flowsheet for treatment of the pyrite ore was developed.

7.0 Beneficiation Studies on a Low Grade Graphite Sample from Taliha Mine of Arunachal Pradesh. *Sponsored by Geological Survey of India, N.E. Region, Shillong.*

Mineralogical studies on the sample indicated that graphite which is flaky and micro-crystalline in nature is intricately associated with the micaceous gangue minerals and a very fine grind may be

required for its liberation. Hence only flotation techniques were attempted for upgrading the sample. The results of preliminary flotation studies have indicated that a graphite concentrate assaying about 15% ash could be obtained. Further tests to improve the grade and recovery are in progress.

7.1 Beneficiation of Low Grade Graphite Sample from Almorah District. *Sponsored by Geological Survey of India, Lucknow.*

The graphite sample received was of very lean grade analysing 4.2% fixed carbon, 3.6% volatile matter and 91.0% ash. Tests results indicated that producing an acceptable grade of concentrate was not possible.

8.0 Pilot Plant Studies on Reduction of Silica Content of a Magnesite Sample from Salem, Tamil Nadu. *Sponsored by Geology Department, Govt. of Tamil Nadu.*

Detailed laboratory and pilot plant investigations were undertaken on the beneficiation of a magnesite sample with a view to reducing silica content so as to make the final product useful for refractory industries.

The sample as received assayed 42.2% MgO, 7.0% SiO_2, and 1.0% CaO. Bench scale beneficiation studies using froth flotation method reduced the silica content to 2.26% with an yield of 52.4%. The pilot plant investigation on this sample was primarily aimed to confirm the bench scale results. Results from the pilot plant investigation showed that an yield of 48% with a silica assay of 2.3% could be obtained when the middling was not recirculated. The close circuit operation i.e. by recirculation of middling after regrinding the same increased the yield by about 5%.

9.0 Beneficiation of a Tourmaline bearing Kyanite Sample from Pardi Mines, Bhandara District, Maharashtra. *Sponsored by Maharashtra Minerals Corporation.*

A sample of kyanite was received for beneficiation and removal of tourmaline for use in refractory industry. Muscovite and tourmaline were the principal gangue minerals. The sample as received assayed 50.8% Al_2O_3, 34.1% SiO_2; 0.2% TiO_2; 2.8% Fe_2O_3; 1.8% Mgo; 1.7% CaO; 0.3% Na_2O; 1.4% K_2O and 2.6% L.O.I. The final concentrate produced analysed 60.5% Al_2O_3 with a kyanite content of above 96% and represented a kyanite recovery of around 75%.

A flowsheet has been developed for successfully beneficiating kyanite and removal of tourmaline and mica.

9.1 Beneficiation of Low Grade Composite Kyanite Sample. *Sponsored by Maharashtra State Mining Corporation.*

Samples of kyanite from four different blocks, varying in Al_2O_3 content from 36.42% to 48.90% were received. As desired by sponsors, investigations were carried out on a composite sample by blending the four samples in the proportions given by the consultants. The composite assayed 40.78% Al_2O_3 and 44.48% SiO_2. A concentrate having 60.7% Al_2O_3 with a recovery of 53.2% Al_2O_3 was obtained.

10.0 Beneficiation Studies on a Low Grade Wolframite Sample from Agargaon Area, Maharashtra. *Sponsored by M/s. M. N. Dastur & Co.*

The sample as received analysed 0.07% Wo_3. Preliminary tabling tests at different sizes did not yield encouraging results. A large scale tabling test after several passes yielded a table concentrate assaying about 29.0% WO_3, but the recovery was low. Further work is in progress.

11.0 Beneficiation Studies on a Bulk Sample of Tin bearing Pegmatite from Kupli Hills, Bastar District, Madhya Pradesh. *Sponsored by Director, Geology & Mining, Raipur, M.P.*

Bench scale beneficiation studies were undertaken on a bulk sample of tin bearing pegmatite for recovering tin from the lean ore. The sample as received, analysed 0.4% Sn, 2.2% Fe ; 82.2% SiO_2 and 10.8% Al_2O_3.

Preconcentration of the sample by tabling followed by high intensity magnetic separation indicated that a marketable grade of cassiterite concentrate analysing 60% Sn with a recovery of 70% could be produced.

12.0 Reduction of Ash Content from the Coal Fines of Gidi Washery. *Sponsored by M/s. Coal India Ltd.*

The investigation comprises the various tests conducted on the coal fines sample received from Gidi Washery with a view to bringing down the ash content to below 17%. The sample com-

posed of 10 mesh fines ranging down to 200 mesh and analysed 48.3% F.C, 22.0% V.M. and 27.39% ash. Flotation tests yielded concentrates assaying 11.9% ash and 11.3% ash with 66.2% yield and 62.3 yield respectively.

12.1 Reduction of Ash Content from the Middlings (Sink) from Dugda Coal Washery. *Sponsored by M/s. Coal India Ltd.*

Investigation was conducted to reduce the ash content of the coal middling sample of Dugda Coal Washery. The sample analysed 41% fixed carbon ; 39.3% ash ; 19.3% volatiles and 0.4% sulphur. The final concentrate obtained analysed 61.7% F.C. and 16.7% ash.

13.0 Beneficiation Studies on a Calcium-Silicate Sample from Rajpura-Dariba Area for Recovery of Barite. *Sponsored by M/s. Hindustan Zinc Ltd.*

The sample, as received, analysed 6.78% Zn ; 0.69% Pb ; 0.33% Cu ; 7.8% Fe ; 21.33% $BaSO_4$ 40.6% SiO_2 ; 12.44 S ; 0.51% AL_2O_3 ; 1.4% CaO ; and 0.9% MgO. The ore contained valuable barite and quartz in appreciable quantities. A barite concentrate assaying 90.6% $BaSO_4$ containing 24.8% Ba in it was obtained.

14.0 Studies on Reduction of Iron Content in Silica Sand Samples. *Sponsored by State Mining & Development Corporation, Lucknow, U.P.*

Beneficiation studies were carried out on two glass sand samples from Allahabad employing both physical and chemical methods to produce glass sands of low iron content and size suitable for glass industry. The two samples, Type I & II, as well as a composite one made up of 1 : 1 mixture of the two, analysed 0.35, 0.71 and 0.57% Fe_2O_3 respectively. The two samples of silica sand were amenable to upgrading by simple beneficiation techniques to a Fe_2O_3 content of 0.1% and 0.057%. The Type I was mostly upgraded sand of the size required for the glass industry. However, Type II had about 27% by weight of coarser than 28 mesh fraction which would require some crushing to the size required for glass industry.

15.0 Determination of Physical Characteristics and Mineralogy Studies on Process Secondaries. *Sponsored by M/s. Indian Copper Complex of Hindustan Copper Ltd., Ghatshila.*

Specified tests on some physical characteristics and mineralogical studies on the process secondaries (called reverts consisting

of red jam, matte and slag) were conducted. The red jam and matte were found to be quite dense and compact in nature while the slag was more friable with pores and voids. A fairly good amount of metallic copper both in the red jam and matte would be of more economic value from the recovery point of view. But their crushing and grinding operation to the required fineness would pose a real problem due to the presence of metallic copper at different grain size with its high ductility expansion behaviour. The compressive strength of the sample varied from about 500 kg/sq. cm to above 1100 kg/sq. cm depending on the nature of the samples, the slag being the lowest. The bulk density of the sample was found to be 2.5 tonnes/cubic metre.

16.0 Determination of Bond's Work Index of Basic Steel Plant Slag Sample. *Sponsored by M/s. Hindustan Steel Ltd., Ranchi.*

Bond's Work Index of a basic steel plant slag sample was determined based on the method of F.C. Bond and was found to be 19.2 KWH/Tonne at 250% circulating load, for dry grinding.

16.1 Determination of Bond's Work Index for Dead Burnt Magnesite Sample. *Sponsored by M/s. Orissa Cement Ltd.*

Bond's work index was determined for a sample of dead burnt magnesite. The work index, for 100% — 170 mesh, closed circuit dry grinding was found to be 18.00 KWH/Tonne.

B. REFRACTORY TECHNOLOGY

17.0 Development of High Alumina Refractories using Kyanite and Technical Alumina.

This project aims at developing some suitable high alumina refractory compositions in the range 80-85% Al_2O_3. It is proposed to replace the use of costly fused alumina grains by dense sintered alumina grog in these compositions. During the period under review, dense sintered alumina grog was prepared followed by wet-pot milling, drying, briquetting and sintering. Cylindrical buttons of 2" dia and quarter size bricks were fabricated on bench scale from the thoroughly prepared mix of graded calcined kyanite grains and dense sintered alumina grog. These samples were fired. Different properties of fired samples were determined and it was found that properties obtained were similar to the required specifications of BHEL (Hardwar), MECON (Ranchi) and Carborundum

Universal Ltd. (Madras). Further work regarding making of full size bricks is in progress.

18.0 Development of Synthetic Carbonaceous Product as a Substitute for Petroleum Coke and Anthracite.

Experiments are in progress using the coke supplied by Central Fuel Research Institute, a coal from Bhowrah colliery, a coal from Assam and foundry coke. Bodies have been formed of some compositions and some more compositions are to be made after which calcination and testing of the samples will be done.

19.0 Development of Carbon Bricks for Chemical Industry

Future annual requirement of carbon bricks for chemical industry as assessed by Carbon Panel is of the order of 700 tonnes. Such bricks are required for the manufacture of caustic soda, phosphoric acid, phosphorus, detergents, fertilisers and other chemicals. At present these bricks are being imported. This project aims at import substitution of the product.

Dense carbon aggregate was made, crushed and graded. Certain preliminary batch compositions were tried for making carbon bricks. These bricks were fired and their properties were studied. Based upon these trials, 1/2 tonne of dense carbon aggregate was made and graded. Arrangements are being made to use this material for making different batches of carbon bricks for chemical industry.

20.0 Studies on High Temperature Castables Suitable for 1400-1700°C.

The project aims at the development of high temperature castable for continucus use upto 1700°C which find wide application. It is in continuation of the earlier work done on the development of cements and castables.

Physical properties of the corundum aggregate and high alumina cement (NML made) were studied. Corundum was crushed and properly graded in three different size fraction. Studies were made on the packing density of such fractions. Arrangements are being made by using corundum aggregates and high alumina cement (NML made) in different batch compositions and its properties and performance will be studied.

21.0 Development of Insulating Materials and Insulating Castables.

The project aims at preparation of insulating materials by foaming technique followed by development of castables using light weight aggregates.

As a first step various frothers are used in a laboratory made cylindrical, graduated frothing chamber. These experiments show that the air entraining capacity of a fixed volume of liquid is independent of the quantity of frother used. However the kinetics of entrainment is dependent upto an optimum level beyond which there is negative or no effect. The higher frother content has a greater powder retaining capacity. Green blocks using used fireclay grog are made and sintered after careful drying.

22.0 Development of Graphite-Silicon Carbide Crucibles.

The crucibles which are manufactured at present in the country are reported to give low performance as compared to imported crucibles. These crucibles are manufactured by small scale industries who do not have the facilities and expertise to improve the quality of their products. This project was taken with a view to develop indigenous knowhow and expertise so that the small scale crucible manufacturers are benefited.

Suitable compositions of both clay bonded and carbon bonded crucibles were developed. Studies on physical properties so far indicated comparable to those of imported crucibles. Some big size carbon bonded crucibles having improved properties were made and the results of service performance were awaited. The fabrication of larger clay bonded crucibles is in progress.

23.0 Development of Clay-Graphite Stopper Head from Indigenous Raw Materials. *Sponsored by M/s. Patna State Graphite Mining Co., Titilagarh.*

During the period under review, several compositions of clay graphite stopper head were experimented on bench scale till a suitable composition was evolved and the process paramenters were established for the production of clay-graphite stopper head on pilot plant scale. A number of stopper heads were made in the laboratory and their preliminary dip tests and final inplant trials both were carried out in TISCO which had shown very encouraging

results. There was no spalling, washing, corrosion and erosion Training and demonstrations of the developed process has been rendered to the sponsoring party and the technology has been transferred. The party will start the commercial production of clay-graphite stopper heads very soon.

24.0 Beneficiation of Pithorgarh Magnesite for Use as Refractories. *Sponsored by M/s. Orissa Industries, Rourkela.*

The investigation was taken up to find the suitability of a refractory grade magnesite from Pithorgarh deposit. The sample of magnesite supplied contains high lime in the raw state, of the order of 3% and above as impurities. The main object of this investigation is to reduce the lime content from magnesite by some suitable methods.

The properties so far studied in small brick sample fired at 1600°C shows encouraging results and at present it can be opined that standard size magnesite refractory bricks conforming to IS specification may be manufactured utilising this raw material after beneficiation.

25.0 Testing of Graphite Crucibles for Indian Standard Institution

Physical properties of Indian and foreign crucibles were tested. These include porosity, bulk density, crushing strength, modulus of rigidity besides P.C.E. Tests were also done for determining the ash content and loss on ignition. Based on the data obtained, a report was prepared and submitted to ISI subcommittee for consideration.

25.1 Testing of Binders and Raw Materials.

Two varieties of pitch from Rourkela, one variety from Bhilai and two varieties of tar from Shalimar were tested. The tests constitute the determination of coking value, insoluable matter in pyridine, specific gravity. C/H ratio determination is in progress.

26.0 Refractory Tests Conducted on behalf of Industries.

Testing work as indicated in the following page was conducted.

	Nature of Work	Sponsor	Tests Conducted
i)	Report on Thermal conductivity of refractory bricks	Dalmia Ceramic Ind. Ltd.	Thermal conductivity of 60% Al_2O_3, 70% Al_2O_3 Alinosul, Alite bricks.
ii)	Testing of salem magnesite	Dte. General of Supplies & Disposals, Madras	Grain size, L.O.I. true Sp. gr., Chemical analysis of dead burnt magnesite.
iii)	Report on thermal conductivity of Refractory bricks	Dalmia Ceramic Ind. Ltd.	Thermal conductivity of Sup-60 Sup-70, HA 60 HA 70 FCI and LMB Bricks.
iv)	Report on Thermal conductivity of refractory bricks	Dalmia Ceramic Ind. Ltd.	Thermal conductivity of moderate heat duty, high heat duty kyanite, sillimanite, abrasion resistant, acid resistant and hot face insulation bricks.
v)	Testing of air setting cement	Vulcan Engg. Pvt. Ltd.	Setting time, sintering at 600 and 1000°C, CCS and seive analysis.
vi)	Testing of refractories	Rourkela Steel Plant	Thermal conductivity and coefficient of thermal expansion of magnesite and chrome-magnesite bricks.
vii)	Testing of chrome-magnesite bricks	Hindustan Copper, Ghatsila	Physical properties App. porosity, B.D. CCS, chemical properties MgO. Cr_2O_3 etc.
viii)	Testing of acid resistance bricks	M/s. Gammon India	Acid resistance as per standard specification.

C. EXTRACTION & CHEMICAL METALLURGY

27.0 Extraction and Recovery of Nickel and Copper from Sulphide Concentrates of Uranium Corporation of India Ltd.

The Uranium Corporation of India Ltd. is producing substantial quantity of mixed sulphide concentrates containing nickel and copper. It is proposed to extract and recover nickel and copper in a usable form.

Bench scale studies done for NH_4Cl and NaCl roasting of concentrates. NaCl roasting gave very good recoveries. Solvent extraction studies were done with leach liquor obtained by sodium chloride roasting of copper-nickel concentrates.

28.0 Solvent Extraction of Nickel and Cobalt from Leach Liquors.

The project was taken up with a view to extract nickel and cobalt from an indigenous nickel ore by an improved process to effect an overall economy in extraction. Studies were undertaken for the recovery of nickel and cobalt by roast reduction amononical leaching process.

29.0 Recovery of Metallic Values by Bacterial Leaching.

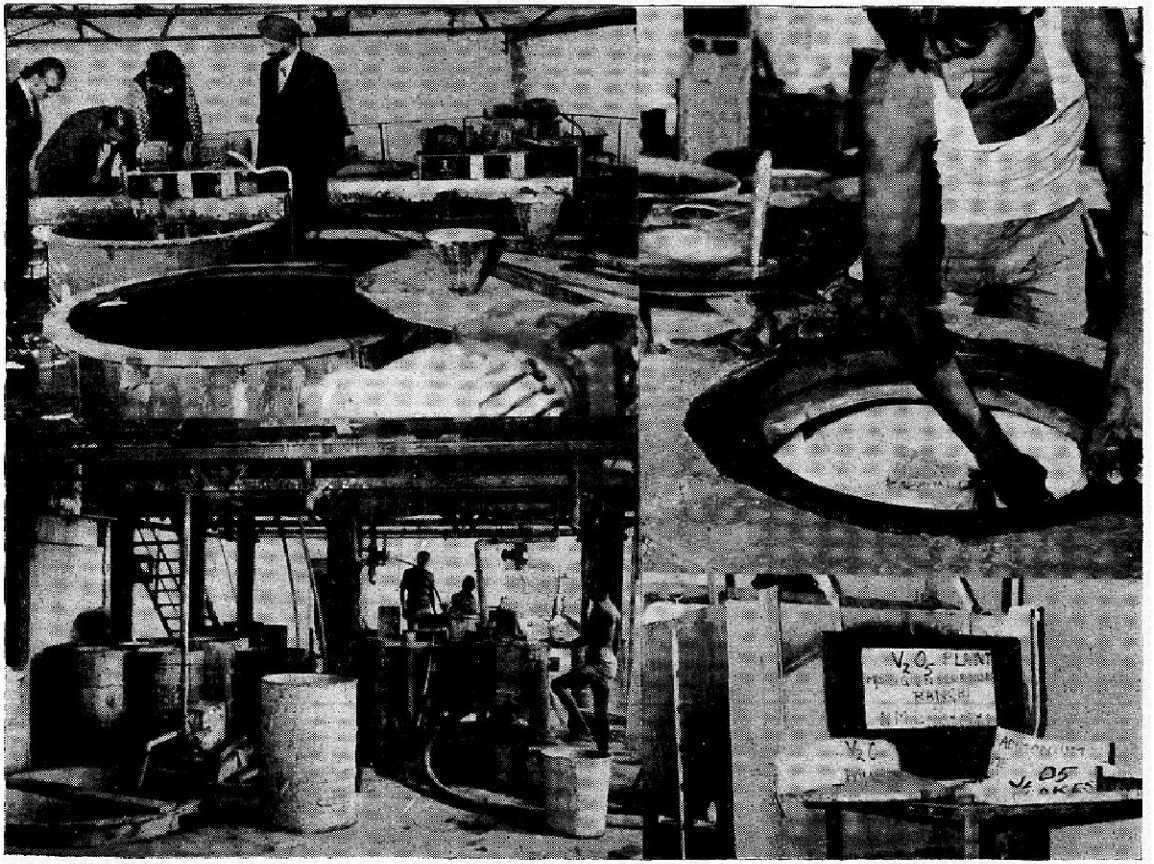
The project was taken up to develop and optimise methods for the recovery of metallic value from low grade ores by bacterial leaching. Bacterial Leaching experiments on different size of copper ores from Malanjkhand and Mosabani were carried out. The data are under compilation.

29.1 Leaching Studies on Chapri Copper Ore. *Sponsored by Indian Copper Complex, Ghatshila, of M/s. Hindustan Copper Ltd.*

The project is completed and report submitted to M/s. Hindustan Copper Ltd.

30.0 Recovery of Vanadium from Sodium based Vanadium Sludge of Aluminium Industry. *Sponsored by M/s. S. G. Enterprise, Ranchi.*

The plant was commissioned for M/s. S. G. Enterprise at Ranchi with NML Consultancy. The plant is producing vanadium pentoxide of acceptable grade for ferro-alloy industry.



A view of the plant for production of Vanadium pentoxide from alumina sludge set up with NML Know-how.

31.0 Recovery of Vanadium Pentoxide from Vanadium bearing Slag of M/s. Visvesvaraya Iron & Steel Works.

Laboratory experiments were done for the recovery of vanadium pentoxide from vanadium bearing slag supplied by VISL from the second trial at VISL. Good recoveries were obtained by roast leach precipitation process.

32.0 Extraction of Lead from Lead Concentrate by Non-blast Furnace Process.

A simple single step low investment, non polluting process for extraction of lead by smelting lead concentrate has been developed on 5 Kg batch to 500 Kg per day scale in gas/oil fired prototype crucible furnace with consistent results of purity and recovery of lead. Large scale trials on tonnes of lead concentrates (62% lead content) have yielded 90% metal recovery of 99.9% purity. Feasibility report of the process for commercial production has been prepared. The technology developed is available for transfer.

32.1 Extraction and Recovery of Zinc and Lead from Siliceous Oxidised Ore from Chakula, Bhutan.

Literature survey was made, preliminary experiments with acid leaching are being conducted.

32.2 Extraction and Recovery of Lead, Copper and Zinc from Deri and Ambaji Sulfide Concentrate.

Literature survey was made and preliminary sulphatation roasting experiments followed by aqueous leaching are in progress.

33.0 Electric Smelting of Dolomite for Extraction of Magnesium.

The project was taken up with a view to design and fabricate 3 140 KVA arc furnace unit for silico-thermal reduction of dolomite on a semi-continuous system, eliminating alloy steel retorts. Designing and fabrication of the furnace units were completed. The foundations for the plant and structures are being laid.

34.0 Purification of Molybdenite Concentrate Suitable for Making Ferro-molybdenum.

The project was taken up with a view to reduce the objectionable

impurities of the molybdenite concentrate obtained from M/s. Uranium Corporation of India Ltd., so as to make it suitable for preparing ferro-molybdenum. Work was conducted on desilication of concentrate by selective acid leaching which gave 97% silica removal. Further studies are in progress.

35.0 Production of Battery Grade Manganese Dioxide from Manganese Carbonate obtained from Low Grade Manganese Ores by Ammonium Carbonate Process.

Samples of battery grade manganese dioxide produced by this process were sent to a dry cell manufacturer. The results were not encouraging. The project is closed.

36.0 Production of Distilled Zinc Dust by Oil Fired Retort Furnace Process. *Sponsored by M/s. Usha Martin Black, Ranchi.*

Successful trials in the oil fired retort Proto-type furnace were carried out to convert over one tonne of galvanizers' dross supplied by M/s. Usha Martin Black of Ranchi into distilled grade zinc. dust.

36.1 Atomospheric Distillation of Galvanizers' Dross.

The process was lincensed and efforts were made to transfer the technology to the licencee.

36.2 Utilization of Metallic Waste By-products with particular reference to Zinc Ash and Zinc Hydroxide.

Zinc ash and zinc hydroxide are produced as by-products in the galvanizing plants and sodium hydro-sulphite industries. A number of entrepreneurs have shown interest in exploiting this technology.

Utilization of other metallurgical by-products such as ferrous sulphate from pickling plants in steel industries and tungsten sludge from tungsten processing plants have been taken up with a view to recover the metallic values or convert them to products which are presently in demand in the country.

37.0 Production of Metal Powders.

The know-how for production of nitrogen atomozied and air atomized non-ferrous metal powders for powder metallurgy and other

applications was licensed out to (i) Paras Metal Powders, Nasik (ii) Nalco Metal Products, Madurai (iii) Metapow, Poona (iv) Micro-metals, Purulia.

The plant of M/s. Paras Metal Powders was successfully commissioned during the year under review. M/s. Nalco were granted a loan by the Tamil Nadu Industrial Development Corporation and their plant is scheduled to go on stream during 1978-79. Transfer of technology to M/s. Metapow and M/s. Micro-metals was completed and their projects are expected to mature during 1978-79.

Meanwhile, work has been taken up for the development of lithographic gold bronze and aluminium pastes. The range of atomized powders developed has also been extended to include (i) aluminium-zinc alloy powders (ii) aluminium-silicon alloy powders and (iii) lead-tin solder powders.

38.0 Recovery of Copper, Lead, Zinc, Nickel, and Elemental Sulphur from Sulphide Mineral Concentrates.

i) *Copper Concentrates* — Electrolysis of the solution for recovery copper ; obtained by leaching a low-grade and complex concentrate in ferric chloride solution was studied in a double compartment cell with insoluble anodes and a cathodic current efficiency of 75%, with a 50% oxidation of ferrous to ferric in the anode chamber, has been achieved.

ii) *Complex copper-nickel concentrate* — Recovery of copper and nickel from the complex concentrate by leaching in ferric chloride solution was studied. 99% recovery of copper and 95-96% nickel was obtained. Increasing the leaching time increased the percentage recovery of nickel to 98% at 25% excess ferric chloride. Methods for separation and recovery of copper and nickel from the leached solution are under progress.

iii) *Lead concentrate* — It was found that leaching of the lead concentrate in ferric chloride solution dissolved out 99 per cent lead from the concentrate, out of which 82% crystallised out on cooling the hot filtered leach solution. Leaching of lead concentrates in ferric sulphate solution was also examined with a view to prepare lead silico-fluoride from the leached lead sulphate. Pure lead was obtained on electrolysis of lead silico-fluoride and regenerated acid recycled to more lead into solution. Studies were also extended

to convert lead sulphate to lead carbonate by treating in an organic solvent which takes lead into a complex.

39.0 Studies on the Processing of Sulphide Concentrates—Recovery of Metal Values as Chemicals Directly from Copper Concentrates.

After preliminary test it was found necessary to beneficiate the copper concentrate by chemical treatment, so as to obtain very pure leach liquor after sulphatisation roasting of the concentrates.

It was possible to remove about 97% Pb and 93% Zn with about 10% Fe from the concentrate, after pretreatment and chemical beneficiation. Copper loss was around 0.8%. Sulphatisation at low temperature with admixture of additives produced 97% of copper as water soluble in the roasted product, with low quantity of Zn and Fe as impurities. Purification of solution and crystallization produced a product, $CuSO_4 .5H_2O$, conforming the I.S.I. specification of technical grade. The process flow sheet has been worked out and further large and cyclic tests are under progress.

40.0 Preparation of Fluorine Chemicals for Metallurgical Use.

One tonne of synthetic cryolite was prepared and sent to M/s. Indian Aluminium for evaluation under service trial at Hirakud.

41.0 Hydro-Electro-Metallurgical Project.

Intensified efforts were made to commence construction of essential buildings at the Adityapur Complex 100 acre site. Construction of the security lodge and of temporary roads was started. The design of the Process Bays was finalized and tenders prepared.

Equipment orders worth over Rs. 20 lakhs were placed for delivery of various units during 1978-79 and 1979-80. Plant and equipment detailed layouts were prepared for other sections such as leaching and the cell rooms. A proposal was finalised for the setting up of a solvent extraction unit based on available equipment.

D. IRON & STEEL TECHNOLOGY

42.0 Study on the Reduction Characteristics of Iron Ore Samples.

The following samples of iron ore lumps and pellets were studied for their reducibility characteristics.

	Samples Description	*Name of Sponsor*
(i)	Pellets from Noamundi iron ore	M/s. TISCO Ltd.,
(ii)	High phosphorus iron ore lumps from Kanwara	Dept. of Mining & Geology, Govt. of Madhya Pradesh.
(iii)	Iron ore lumps from Sakradih	M/s. Torsteel, Calcutta.
(iv)	Iron ore lumps from Daitary	M/s. Orissa Mining Corporation.
(v)	Iron ore pellets for Central Pelletisation Plant.	M/s. MECON.

42.1 Swelling Index, Macro & Microporosity Studies of Iron Ore Pellets. *Sponsored by M/s. Tata Iron & Steel Co. Ltd'*

Swelling index, macro and microporosity of iron ore pellets were determined as per IS : 8624-1977.

42.2 Macro, Micro and Total Porosity of Iron Ore, Sinters and Pellets. *Sponsored by M/s. MECON.*

Studies were carried out on determination of porosity of a sample of iron ore pellets for Central Pelletization Plant.

43.0 Production of Sponge Iron in Vertical Retort Furnace.

Installation of the unit having capacity of 1.2 – 1.5 tonnes of sponge iron per day has been completed. The trial runs for production of sponge iron will start shortly.

43.1 Use of Sponge Iron as Steel Scrap in Steel Manufacture.

Two 25 ton heats made with 40% sponge iron in the charge and continuously cast into 100 mm sq. billets, were processed into wire rods. The processing of these wire rods was followed to study the quality of steel made using sponge iron. The wire rods from these heats did not show any breakage during wire drawing operation.

44.0 Preliminary Matching Bench Scale Tests in Static Bed.

Sponsored by M/s. Gujarat Mineral Development Corporation.

Using Panadhro siderite and lignite sample, the matching bench scale tests in static bed at different ratios and for different soaking time was conducted.

45.0 Electoslag Remelting.

Two heats, one each 13% Cr martensitic stainless steel and 1% C 1% Cr ball bearing steel were made in 0.8 ton electric arc furnace and cast into 100 mm sq. ingots of about 1 metre length. These ingots were forged & reduced to 75 mm dia. in an industry for use as electrodes in electroslag remelting.

46.0 Special Steel Making by Basic Oxygen Process.

Most of structural and fabrication work was completed. Installation of electric hoist and lance is in progress.

47.0 Development of Continuous Steel Making Process.

The launder furnace in which the lining failed earlier, was subjected to certain modifications and a fresh lining of monolithic mass was given. Work has been started to draw a separate water line for the cooling of lances, which will serve as an alternative or stand by. Trial will commence after the completion of this job and thorough overhauling of the compressor.

48.0 Development of High Strength Low Alloy Steel.

Investigation was completed on a number of low carbon 1.5% manganese steels containing vanadium and nitrogen. The steels were found suitable for low temperature use. Further impact tests were carried out with V notch charpy specimens at sub-zero temperatures. Metallographic examinations were carried out to determine grain size and pearlite contents of the steels normalised at different temperatures. Six new compositions of vanadium steels with higher manganese content were made with additions of small quantities of niobium, chromium, copper and molybdenum. Six compositions of low carbon steels containing titanium and manganese 1% were made to investigate the suitability of titanium as a strengthening element in the high strength steels.

49.0 Development of Reduced Nickel Austenitic Stainless Steel.

The objective of this project is to partially replace nickel by

copper and manganese. A patent application has been filed on "Process of making austenitic stainless steel containing chromium, nickel, copper and manganese". Seven compositions of chromium-nickel. copper-manganese steels were made within the optimum compositional range determined in earlier investigation.

50.0 Desulphurization of Ferrous Melts.

(i) By Briquetting Mix.

Proprietary briquetting mixes were developed which are capable of producing high levels of desulphurization in ferrous melts. Starting from usual sulphur levels, the technique found to be capable of achieving final sulphur in both hot metal and steel to less than 0.01% at an efficiency and cost advantage superior to many of the existing processes. The process has been developed on the basis of Kg scale trials which is now extended to pilot plant scale trial. Industrial trial in steel plants is scheduled shortly.

(ii) Desulphurization of Steel by Synthetic Slag.

Several self-fusing exothermic synthetic slag compositions have been developed, which are capable of rendering desulphurization in steel by 50 to 80%. Another potential advantage of the process developed will be in the improvement in cleanliness of steel because of the intimate mixing of the fluid slag with the metal melt. So far the experiments were restricted to kg scale heats Larger scale experiments in 0.8T electric furnace are being planned before undertaking industrial trials of the process. Several new slag composition were developed which can accommodate, unlike the "Perrin Slag" large percentages of SiO_2 and MgO without undue sacrifice in desulphurizing efficiency, thereby facilitating use of cheaper raw materials. One draw back of the process, however is the pick-up of large amount of silicon from the slag into the metal, which has to be controlled for the success of the process.

E. DEVELOPMENT & STUDY ON ALLOYS

51.0 Development of Aluminium Cables & Conductors—Electric Grade Aluminium Alloy NML-PM2.

Industrial Production of NML-PM2

The production of NML-PM2 alloy was continued in the works of the licencees (i) & (ii) indicated in the following page.

i) M/s. Aluminium Cables & Conductors (U.P.) Pvt., Calcutta.

ii) M/s. Galada Continuous Casting Ltd., Hyderabad.

In addition the commercial production of NML PM-2 has also been established at the works of the lincencee M/s. Indian Aluminium Cables Ltd., New Delhi (Faridabad Works) where the commercial production is in progress.

Product Development

i) Bharat Heavy Electricals Ltd., Bhopal is collaborating for the use of NML-PM2 in one phase winding of power transformer of 20/16 MVA, 132/33/11 KV specificiation. The paper covered multilayer strips of different sizes from NML-PM2 have been processed at M/s. Electricals Ltd., Bhopal for winding of the transformer.

ii) Gujarat Electricity Board is evaluating the commercial lengths of NML-PM2 overhead steel reinforced conductors of the following sizes.

a) Weasel conductor (6/1/2.59 mm)
b) Rabbit conductor (6/1/3.34 mm)

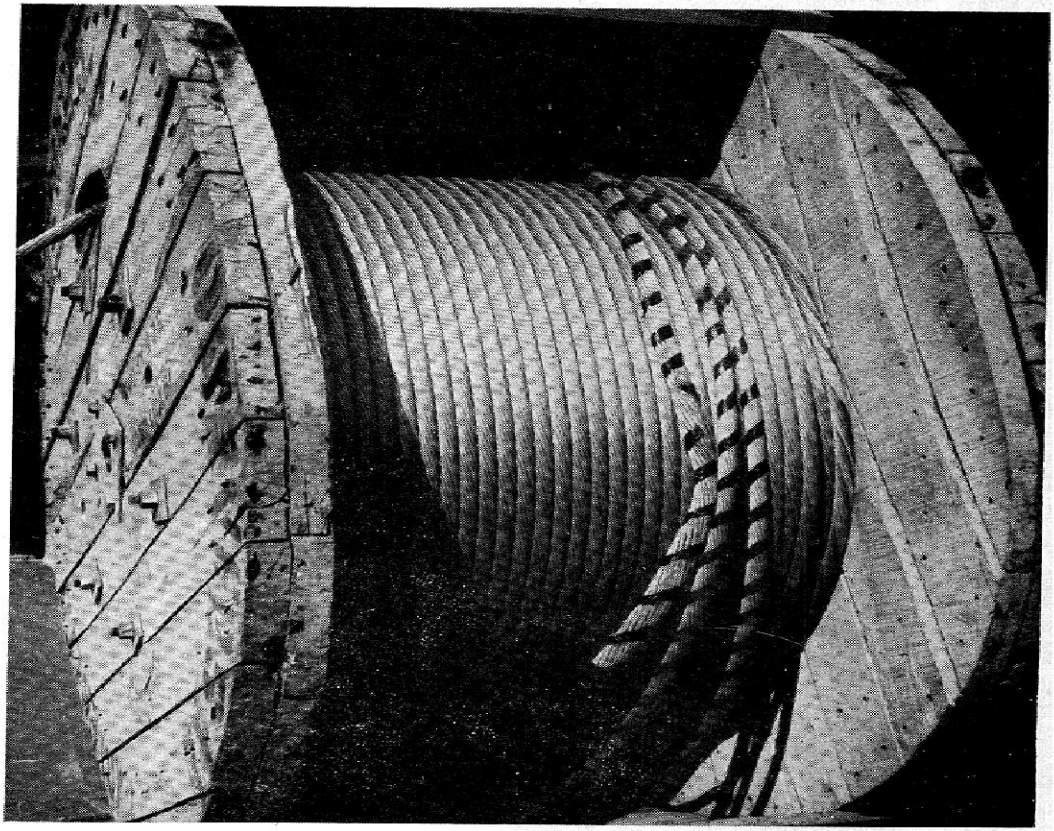
The commercial lengths are being evaluated in the following regions by GEB

a) Mandvi — Madara Taluka Area of Kutch district
b) Bhatia — Dwarka line of Jamnagar district
c) Verakal — Taluka of Junagadha district.

iii) NML-PM2 PVC Cables were processed under NML supervision at the works of M/s. Fort Gloster Industries (Cables Division) Howrah ; for use of the Integral Coach Factory, Perambur in coachwiring.

iv) NML-PM2 PVC Cables were processed under NML supervision at the works of M/s. Asia Cables Corpn. Ltd., Bombay for use of the Integral Coach Factory in coachwiring.

v) Research Designs & Standards Organisation (Ministry of Railway) ; are using NML-PM2 through integral Coach Factory and other railway workshops in the product develop-



19/7/1.4 mm rope lay flexible NML-PM2 conductor for use as Jumper wire by Railways.

ment of signalling cables, coach wiring cables, enamelled winding wires for signalling relay windings, welding cables. A Number of railway coaches were wired with NML-PM2 PVC Cables of 4 sq. mm, 70 sq. mm adn 120 sq. mm size by Integral Coach Factory. The coaches wired with NML-PM2 PVC Cables are now running on various railways in the different regions of the country.

Indian Standards

As a result of continued product development and cooperation from the cable industries and user organisations considering the superiority of NML-PM2 for cable & conductor applications, the Indian Standards for the use of the EC grade aluminium for Cable & Conductor applications have been revised to include NML-PM2 in their ambit. The following I.S. specifications have been revised to include NML-PM2.

i) I.S. 4026 — EC grade aluminium ingots.
ii) I.S. 5484 — EC grade aluminium rods produced by continuous casting and rolling.
iii) I.S. 1841 — EC grade aluminium rods produced by hot rolling.

Certification Mark

The registration of the certification Trade Mark for NML-PM2 is in progress through the Registrar of Trade Marks Bombay.

51.1 Development of NML-PM 53 Aluminium Alloy.

Based on the laboratory scale and semi-commercial scale working of the NML-PM53 aluminium alloy for hot rolling, wiredrawing and stranding, a catenary conductor of 19 standards was supplied through the RDSO Lucknow to Divisional Electrical Engineer, Tundla ; for its field trials and evaluation as catenary conductor. The size for the installations of two spans of 1.5 Km. each of NML-PM53 caternary has been fixed. Further programmes of installation and evaluation of the conductor are in progress.

52.0 Development of Aluminium base Bearing Alloys.

Rough castings of flotating bushes, for use in locomotives, made from aluminium base bearing alloy, PM 401, were sent to R.D.S.O.

Lucknow, for preliminary field trials. The results of the preliminary tests are encouraging. The need to make certain modifications to the casting technology was also brought to light. Further development work to improve the quality of the castings for future trials is in progress.

53.0 Methods to Improve Mechanical and Physical Properties in Aluminium and its Alloys.

(i) Filtration of Liquid Metal.

Based upon results on earlier work, 5 Kg of filter materials were prepared. A special filter unit was designed and commercial scale filtration trials were carried out at M/s. Hindalco, Renukoot; and Ordance Factory at Ambajhari. Samples were brought and analysed. Chemical analysis showed that the filtered samples had low sodium and inclusion contents compared to unfiltered samples. Quantitatively a reduction of more than 50% sodium and inclusions take place due to filtration. The industrial trials also revealed that (i) the filter media is stable at the temperature of molten aluminium (ii) does not affect the normal rate of flow and (iii) the same filter unit can be repeatedly used for 15-20 tons metal. Another important observation was grain refinement in the filtered product. Fig. 1 shows the extent of grain refinement achieved in HE 15 alloy with NML filter unit. At least 25-30% more grain refinement was achieved by filtration with a uniform distribution of grains compared to commercially inoculated samples.

(ii) Special Melting Technique for Removal of Volatile Impurities.

Master alloys of aluminium containing 2% Mg were prepared in the specially designed reaction chamber. Using this master alloy, Al containing 2, 4, 7 and 10 wt % Mg were prepared and their ageing behaviour was compared with similar alloys cast by (i) conventional method and (ii) cast after filtration using NML filter. The kinetics showed that the alloys vacuum treated and filtered have accelerated ageing behaviour. The data is being compiled for a report.

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

PM 121 ad PM 122 inoculants have been developed for continuous casting. 200 Kg inoculant wire bars which were cast earlier were

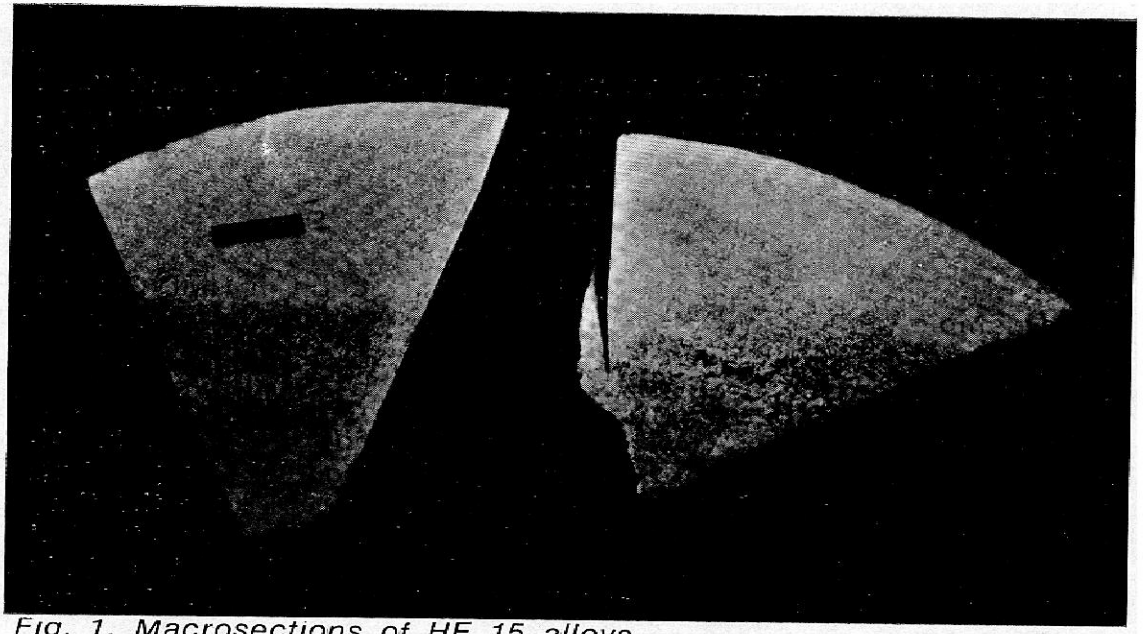


Fig. 1. Macrosections of HE 15 alloys
(i) Cast using NML Filter (10 ft)
(ii) Cast after treatment with commercial inoculant (Reduction 80%)

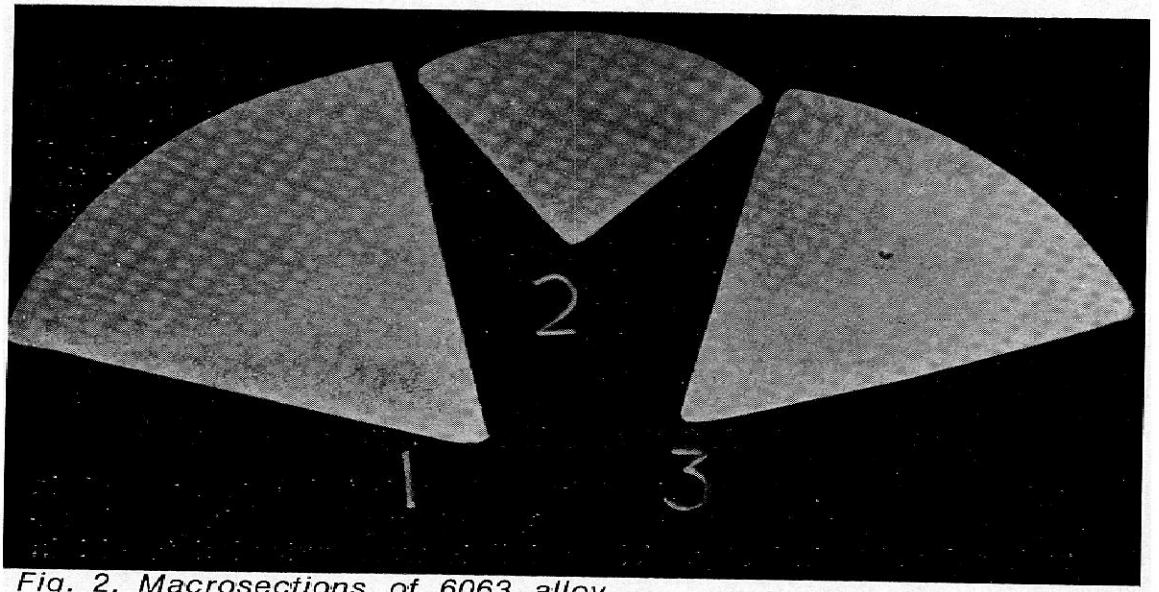


Fig. 2. Macrosections of 6063 alloy
(1) NML PM121 treated
(2) Treated with commercial inoculant
(3) No treatment (reduction 80%)

rolled to $\frac{3}{8}$" dia rods. These were drawn to $\frac{1}{8}$" dia wires and used for the grain refinement on commercial scales. The trails were carried out at M/s. Hindalco, Renukoot; on 6063 alloy and at Ordance Factory, Ambajhari on HE 15 alloy. Fig. 2 shows comparison of typical macro structure of 6063 alloy without any inoculant and with NML PM 121 inoculant. There is 30-35% more refinement in grain size and uniformity of distribution in NML PM 121 treated sample.

54.1 Development of Grain Refiner for Al-Mn-3S Alloys.

In order to get uniformly fine recrystallised grain size in Al-Mn-(3S) alloy, it is necessary to give a prolonged high temperature homogenisation prior to hot rolling. With a view to reduce the time and temperature of homogenisation, the molten alloy was treated with a number of inoculants prior to casting. Results of the study indicate an acceleration of recrystallisation in the inoculated alloys. Experiments under simulated industrial conditions with suitable inoculants are in progress.

55.0 Study on the Effect of Alloying Additions and Heat Treatment on the Mechanical Properties of Wrought Aluminium Silicon Alloys-NML PM215.

(i) Grooved contact wire from NML-PM 215 Aluminium alloy.

Work on aluminium alloy NML-PM 215 for making grooved contact wire as a substitute of copper alloy is in progress for use in railway electrification. Initial industrial trials were conducted to study the efficacy of lubricants, workability of the alloy to withstand the required amount of deformation per pass to obtain the optimum properties in the grooved contact wire. Mechanical and electrical properties of the product were determined. Results show that the aluminium alloy NML-PM 215 holds good potential for the manufacture of grooved contact wire.

(ii) Extrusion of NML-PM 215 aluminium alloy.

Billets of NML-PM 215 aluminium alloy (6" dia) were cast in large quantity by semi-continuous D.C. casting process in collaboration with a leading industry. These billets were extruded to obtain 19 mm dia. rod for eventual utilization in railway electrification. Studies on the mechanical and electrical properties of this extruded rod were carried out. Ageing and microstructural studies have also been conducted.

(iii) Intergranular Corrosion of NML-PM 215 aluminium alloy.

Intergranular corrosion of NML-PM 215 aluminium alloy sheet and effect of alloying additions on intergranular corrosion were studied. The experimental results indicate the beneficial effect of minor alloying addition in improving the resistance to integranular corrosion of the alloy.

56.0 Development of Aluminium base Welding Electrode Wire

Based upon the R & D work, the production technology of the Al-alloy filler wires corresponding to NG-6, BS-2901 specification has been established. The technology includes the melting, casting, extrusion/rolling, wire drawing and surface treatment etc. and the alloy has been formally designated as NML-PM 6. Fairly large quantities of NML-PM 6 filler wires in different gauge diameters have been supplied to M/s. H.A.L., Bangalore ; to meet their requirements. The technology is now ready for commercial exploitation.

The technology for developing the filler wires corresponding to 'EXP 99' for welding high strength Al/Cu alloys has also been established. This development work has been undertaken at the specific request of M/s. Hindustan Aeronautics Ltd, Bangalore. Samples of these filler wires were supplied to HAL for the evaluation and were found satisfactory in meeting their rigid specifications. The NML developed filler wires (corresponding to EXP 99) have been considered by them as a material for "import substitution". They have also requested NML to supply these filler wires in bulk quantities for use at their end.

57.0 Studies on High Strength Weldable Al-Zn-Mg Alloys.

Stress corrosion cracking of the medium/high strength Al-Zn-Mg alloys is one of the severe limitations which restricts their wider use for various civil and defence applications. There are various metallurgical and engineering factors which affect the stress corrosion susceptibility of the alloy. Residual stress in the welded components is one of the important factors which increases the stress corrosion susceptibility. Residual stresses upto 15 Kg/mm^2 in the welded components of the weldable Al-Zn-Mg alloy were experimentally observed by double exposure X-ray technique.

Optical and scanning electron microscopy studies were carried

out for determing the segregation of zinc at the grain boundaries which enhances the stress corrosion cracking susceptibility. Relationship of the width of the weld bead of the components with SCC susceptibility was also examined. The effect of "Dilution" in the weld was also studied. Some experiments on casting the alloy with improved melting technique using NML developed filter were carried out to reduce the oxide and other inclusions and also the sodium content in the melt.

58.0 Development of Thermostatic Bimetals.

A variety of thermostatic bimetals were developed and sent to different industries for the evaluation of actual service performance. Satisfactory performace was reported by the industries after trials The technical knowhow for the manufacture of one series of thermo bimetals has been released to M/s. Thermo Bimetal India Enterprise, Daltonganj.

59.0 Electrical Resistance Alloys.

The hot working characteristics of the ingots received from M/s. Cable Works (NML licencee), were evaluated. Suggestions were offered to control the grain size of the ingots for better workability. Another licencee "Pyrometal Industries", Calcutta ; sent one rod of electrical resistance alloys produced by them according to NML's developed composition, to determine the wire-drawing characteristics and the accelerated life of the alloy. The rod was drawn to the required gauge and the life-value was determined. The process has also been transferred to another party M/s. Beni Electricals Ltd., Calcutta.

59.1 Development of Iron-Chromium-Nickel Alloys.

Domestic heating appliances are required to operate in the lower ranges of temperature. Heating elements which operate at 1000°C and above are suitable for industrial appliances. Work is being carried out to develop an iron base alloy having appreciable amount of chromium with or without smaller percentage of nickel. This alloy will be cheaper compared to conventional alloys.

Few heats were made. The ingots were forged and then drawn to 22 SWG wires. Accelerated life tests are being carried out on them.

59.2 Production of Iron-Silicon-Magnesium Alloy.

100 Kg. of Fe-Si-Mg alloy manufactured according to NML know-how was required by M/s. Visvesvarya Iron & Steel Ltd., Bhadravati. Part of the order has been executed. The material has been supplied in sized form for evaluation.

59.3 Preparation of Nickel-Magnesium Alloy.

100 Kg of Ni-Mg alloy was made for M/s. Industrial Minerals & Metals, Calcutta ; and supplied for evaluation of the product.

59.4 Development of High Temperature Alloy.

The work was taken up to develop suitable iron base alloys for use as heating element to operate at about 1300°C. It is based on Fe-Cr-Al alloy system. Small amounts of other alloying elements were also added to the alloy, to increase the scaling resistance and the workability of the alloy. A number of heats were made. Each ingot was dressed, forged and rod-rolled to $\frac{3}{8}$" dia. rod. The rods were drawn to 22 SWG with interstage annealing. From these studies appropriate temperatures for forging, rodrolling and annealing were established. The physical and mechanical properties of different heats were evaluated. One particular alloy composition of the series showed good accelerated life and high resistivity. Further work to study the effect of Zr and Ce on the workability of the alloy is in progress.

60.0 Development of Soft Solders.

The work was referred to by the Electronic Committee and the objective is to develop a soft solder with low melting point. Various alloys based upon bismuth, lead, tin having melting points about 100°C and working temperature of 120 to 130°C, were tried. It was found that some of the compositions have good spreadability and can be used with advantage for soldering purposes. Numerous heats were prepared and their extrusion characteristics were studied at M/s. Binani Works. It was found that these alloys not only have good extrudability but also have considerable spreading power if used in conjunction with non-conventional fluxes developed at the laboratory. M/s. Philips and Bharat Electronic Ltd., Bangalore ; have been approached for trying the solder and flux at their works.

61.0 Dental Amalgam Alloy.

The process has earlier been released to two entrepreneurs.

Negotiations were made with other interested parties for the release of the process know-how of production technology. In order to develop a low silver amalgam alloy, work was carried out having about 50% silver. Determination of physical properties are in progress.

62.0 Development of Composite Shear Blade.

The project has been taken up with a view to develop the technology of production of composite shear blade for specific applications in the leather and wood craft industries. At present this type of shear blade is not manufactured in this country. The special property of this shear blade is that the blade should be hard on one side as well as ductile on the opposite side. Systematic study on the production of alloy ingots, forging, rolling, cladding and the final heat-treatment is in progress.

F. DEVELOPMENT OF MAGNETIC MATERIALS

63.0 Development of High Permeability Nickel-Iron Alloys.

Sponsored by M/s. Guest, Keen & William Ltd., Howrah.

Work on development of alloys similar to Radio and Rho metal has been completed. It was found that these had saturation induction of 9000 to 15000 gauss and had maximum permeabilities and coercive force values very similar to the alloys known as Radio metal or Rho metal. The maximum permeability for alloys having properties similar to Radio metal varied from 40000 to 50000 and for Rho metal 10000 to 18000. The coercive force of these alloys was of the order of 0.1 oersted.

64.0 Preparation of Anisotropic Ferrite Magnet.

One hundred anisotropic ferrite magnets having Br = 3500 G. H = 1700 Oé and (BH) Max = 3.2 MGOê were made for M/s. Scooter India Ltd. These were tested at their factory and found to be satisfactory.

65.0 Development of Cobalt Rare Earth Magnets.

Preparation of rare earth-cobalt alloy was attempted through reduction-diffusion reaction. Requisite amounts of Sm_2O_3, cobalt and calcium granules were mixed thoroughly and kept inside the furnace in a nickel boat. The reduction diffusion reaction was

carried out in the presence of hydrogen. The product was analysed by X-ray diffraction and magnetic measurements. Since alloy of the type $SmCo_5$ was not formed, the same reaction carried out using pellets of Sm_2O_3 + Co + Ca. Also the reduction was carried out with calcium hydride in a separate experiment. In these experiments the formation of the alloy $SmCo_5$ was not indicated. Further experiments to obtain the alloy are in progress.

66.0 Low Carbon Soft Magnetic Iron.

One eight ton heat was successfully made at Telco, Jamshedpur to establish the commercial viability of the production know-how developed and it was cast into 215 mm sq. ingots. M/s. Telco have commented as follows regarding the heat made.

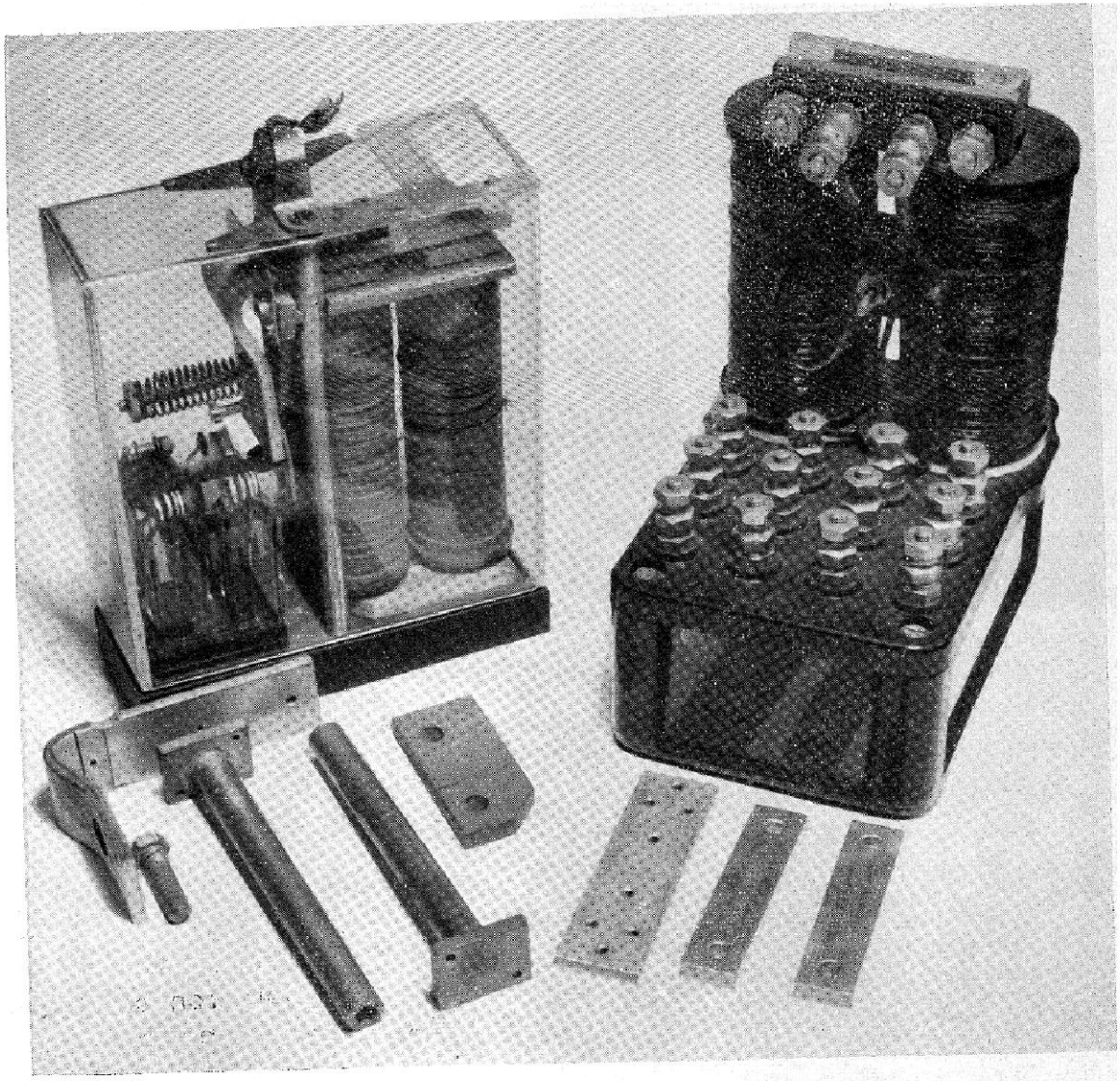
"We are pleased to inform that one Low-carbon iron heat as desired by you was successfully made in the usual heat timings in the normal manner". Telco has made such a low carbon iron heat for the first time and are confident that the technology can be transferred to any electric steel manufacturer".

The reduction of these 215 mm sq. ingots to billets was undertaken in Metal & Steel Factory, Ishapore. The material was used in place of imported low carbon soft iron for making signalling relays, and it was reported by M/s. Westing house Saxby Farmer, Ltd., Calcutta, to have given satisfactory service and the data obtained were within British standard specifications. Material was tested for mechanical properties and conformed to the soft iron specification laid down by Indian Telephone Industries and used by Signal & Telecommunication Workshop, Southern Railway, Podanur. 400 kg. of this soft iron has been supplied to M/s. Bharat Heavy Electricals Ltd., Hardwar.

G. HEAT-TREATMENT & MECHANICAL WORKING OF METALS

67.0 Extrusion Characteristics of Magnesium base Alloys.

Some integrated shaped extruded products of a magnesium base alloy were required by the ISRO, Satellite Centre, Bangalore. The alloy was made and with the modified toolings which were specially designed and fabricated, it was possible to extrude some of the integrated shapes required by the Satellite Centre. After necessary heat-treatment and surface treatment a part of their requirements was



Components made from NML Soft iron for line relays of Indian Railways.

delivered and was found very satisfactory when assessed at their end. Further work is in progress.

68.0 Development of Clad Metals—Copper Clad Aluminium Sheets.

The production technology of this type of clad metal sheet, including cold rolling-annealing was developed for the batch production, on laboratory scale. With slight modification and adjustment, this technology can be adopted for continuous production.

The project is being continued to produce and supply this clad metal sheet to various industries and users. Claded sheets worth of many thousands of rupees were already supplied to various users including Indian Railway. The technology for the production of copper-clad aluminium sheet is being released through NRDC to two entrepreneurs.

69.0 Mechanical Working Facilities

Rolling, forging, wire drawing, extrusion etc. relating to various projects were conducted.

H. TESTING OF MATERIALS

70.0 Central Creep Testing Facilities.

During the period, work on the following project has been conducted.

(i) *Investigation of Creep, Stress-rupture and Stress Relaxation Properties of $1\frac{1}{4}$ Cr-1Mo-$\frac{3}{4}$V-Ti-B Bolting Steel. Sponsored by M/s. Bharat Heavy Electricals Ltd.*

1% creep strain data upto 22,000 hr at 525°, 550° and 565°C, stress-rupture data on both plain and notched specimens at 550° upto 12,000 h, stress-relaxation data both by ring and tensile methods for over 25,000 h at 550° & 565°C, tensile data in the range RT-600°C and for embrittlement behaviour after aging for durations upto 10,000 hr at 550°C, have been collected on one cast of steel. The available data show that the steel conforms to the corrosponding Russian and British (Durehete 1055) grades, and hence the steel has been accepted for import substitution by BHEL.

(ii) *Investigation of Creep, Stress-rupture and Stress Relaxation Properties of En-20 Bolting Steel. Sponsored by M/s. Bharat Heavy Electrical Ltd.*

1% creep and stress-rupture data extending upto 20,000 hr stress-relaxation data upto 6,000 hr at 450°C by ring method and upto about 9,000 h at 500°C by tensile method, tensile data in the range RT-550°C by data for embrittlement behaviour after aging for periods upto 10,000 hr at 550°C have been collected on two casts and further tests are in progress. The results available show that the indigenous steel conforms to the corresponding British Steel. This steel is also accepted for import substitution by BHEL.

(*iii*) *Strees Rupture Tests on 2¼ Cr-1Mo Steel Forgings. Sponsored by M/s. Bharat Heavy Electricals Ltd.*

Stress rupture tests for duriations upto about 6,500 hr at 500°, 525° and 550"C were completed on three casts. Further tests are in progress. The data available lie within the —20% scatter band of the corresponding German and ASTM (annealed) grades.

(*iv*) *Stress Rupture Tests on 1Cr-½ Mo Steel Forgings. Sponsored by M/s. Bharat Heavy Electricals Ltd.*

Stress-rupture tests for periods extending upto 12,000 hr at 500°, 525° and 525°C were completed on two casts. The test data lie within the scatter band of the relevant ASTM and German Steels. Further tests are in progress.

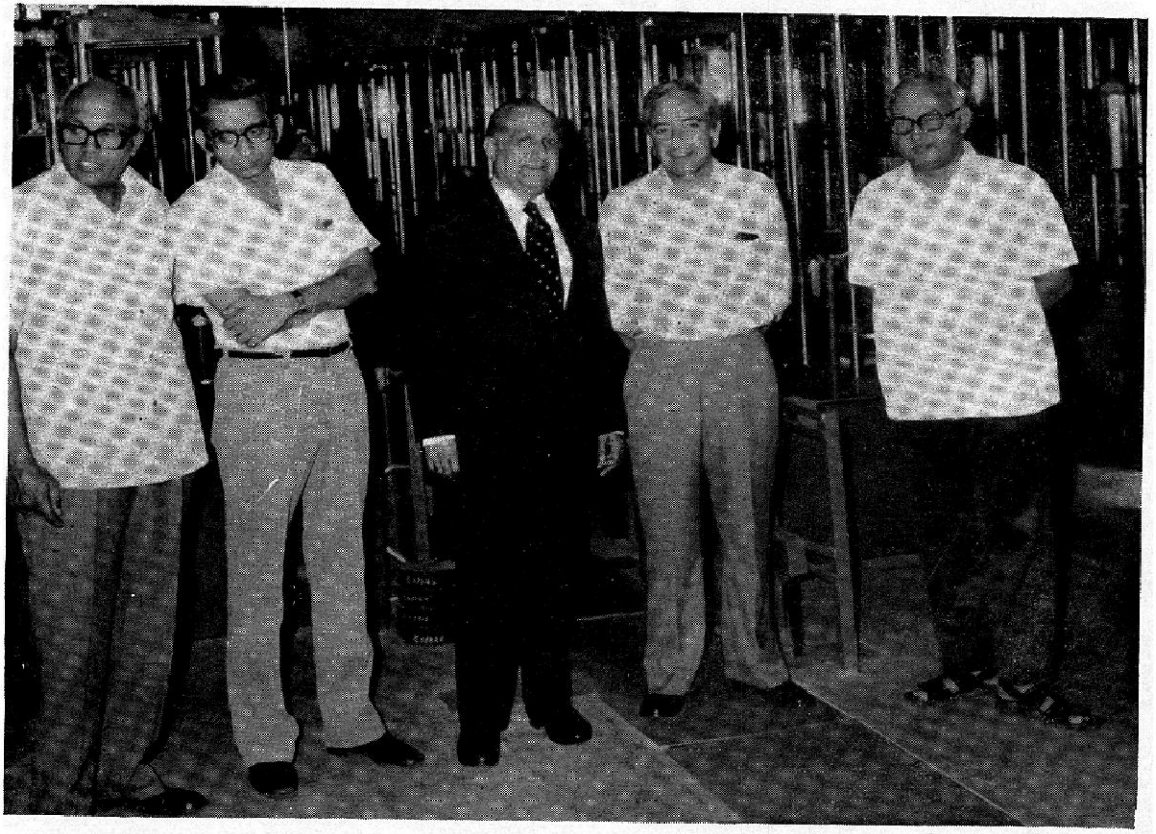
(*v*) *Stress Rupture Tests on 1 Cr-1 Mo-¼ V Steel Castings. Sponsored by M/s. Bharat Heavy Electricals Ltd.*

Stress-rupture tests upto about 4,000 hr at 550°C on six casts were completed. Excepting the data for first few trial casts, the data on the rest lie within the scatter band of the Creusot-loire's steel. In fact two of these casts show much superior rupture strength than any of the Creusot-Loire's casts tested. Further tests are in progress.

(*vi*) *Stress Rupture Tests in ½ Cr-½ Mo Steel Castings. Sponsored by M/s. Bharat Heavy Electricals Ltd.*

Three specimens from two casts have so far been tested at 500°C/24 Kg/mm² and the rupture values of these three tests lie within the scatter band of the Creusot-Loire's Steel. Further tests are in progress.

(*vii*) *Evaluation of Residual Creep Life of Superheaters Sponsored by M/s. Bharat Heavy Electricals Ltd.*



Dr. R. Kumar, Scientist & Project Co-Director, Creep; Shri K. N. Johry, Chief, International Scientific Collaboration, CSIR, New Delhi; Dr. B. R. Nijhawan, UNIDO; Dr. H. Kaufman, UNDP & Prof. V. A. Altekar, Director, NML; on the occasion of the end of the review of UNDP assisted project on Central Creep Testing Facility at NML.

Residual life of convection superheater tubes withdrawn from a Power Station's boiler after serving for 14,000 hr have been ascertained by using accelerated stress-rupture test at constant stress corresponding to service stress (6.09 Kg/mm^2) and temperatures 620°, 600°, 580° and 560°C, all above the designed temperature of 480°C. It has been concluded that although the tube has life of the order of 100,000 hr under designed condition, taking into consideration the conventional safety factor, the tube does not have much life in it.

(viii) Investigation of Creep Tupture Properties of AISI 316 Grade Stainless Steel. Sponsored by Reactor Research Centre, Kalpakkam.

Creep and Stress-rupture tests were conducted on steel plates from three heats of AISI 316 procured by RRC., from French Supplier. Data at 550°, 600°, and 650° ranging between 1000-20,000 hr. have been generated.

(ix) Development of Nickel Free Creep Resistant Austentic Steel.

Two different types of austenitic creep resistant Steel (i) Cr-Mn-C-N, (ii) Cr-Mn have been developed. These have been found to posses elevated temperature properties at par with conventional austenitic steels viz. AISI 316 & Esshete 1250. Whilst Cr-Mn-C-N type is under evaluation at M/s. Madras Engine Valves to find its suitability as exhaust valve in automotive engines, the other steel viz. Cr-Mn is being evaluated at M/s. Flight Refuelling Ltd., England, in order to explore the possibility of using the Steel in the primary circuit of a high temperature reactor. The steel was sent to M/s. Flight Refuelling Ltd. at their request.

(x) Strees Relaxation Testing on Pre-Stressed Concrete Wires. Referred by Indian Standard Institution.

Stress-relaxation testing at ambient temperature conforming to IS 6003-1970 were conducted on pre-stressed concrete wires manufactured indigenously by different manufacturers. The work has enabled ISI to grant ISI making certificate to qualified manufacturers.

(xi) High Temperature Tensile Properties of Welding Electrode. Sponsored by M/s. D & H Secheron & Advani Oerlikon.

Several grades of creep resisting welding electrode materials received from the firm were subjected to high temperature and short-

term creep tests. The work has enabled the electrode manufacturers to control and improve the quality of electrodes.

71.0 Mechanical Testing Facilities

Tensile, compression Olsen ductility, torsion, load elongation, hardness, flattening, expanding, charpy impact and calibration tests of load cells etc. were carried out for various laboratory projects as well as for outside organisations. Total number of samples tested during the year were 1547.

I. METALLURGICAL INVESTIGATION STUDIES ON METALS & ALLOYS

72.0 Failure of Bottom Cover of Reactor of Coking Unit. *Sponsored by M/s. Indian Oil Corporation, Barauni.*

M/s. IOC, Barauni Oil Refinery; sent the failed samples of (a) bottom cover of reactor of coking unit and (b) the nipple of the pressure gauge assembly of the same cocking unit for metallurgical examination.

Metallurgical studies revealed that the failure of bottom cover had taken place on account of thermal fatigue. The nipple of the pressure gauge assembly failed in a brittle manner because of a coarse crystalline structure and the presence of heavy non-metallic inclusions.

72.1 Failure of Economiser Tube. *Sponsored by Chandrapura Thermal Power Station, DVC.*

The economiser tube of boiler No. 4, had failed twice with no sign of erosion or overheating. The temperature of water at economiser inlet was 230°C and pressure 150 Kg/cm^2 approx.

Chemical analyses showed that the tube material was a mild steel generally specified for such purposes. The failure had taken place due to local scale formation on the tube on account of sulphur bearing compounds contained in the hot gases.

72.2 Failure of Stainless Steel 'Spin Head' Equipment. *Sponsored by M/s. Fibretech Engineers & Mfgrs. New Delhi.*

The firm sent the failed sample of stainless steel "Spin Head" during the erection of their synthetic fibre machinery.

Metallurgical examination had shown that although the material conformed to AISI-316, the heat-treatment imparted was far from satisfactory and the cause of failure was attributed to weld decay.

72.3 Failure of Locking Washers for Turbo Generator. *Sponsored by Badarpur Thermal Power Station, Delhi.*

The firm sent a failed locking washer of 100 MW turbogenerator bearings for metallurgical examination.

Results of metallurgical examination showed that they were manufactured from mild steel and the failure had taken place due to fatigue on account of vibrational stresses introduced during service.

72.4 Metallographic Examination of Steel Crusher. *Sponscred by M/s. Tembe Steel Industries, Kolhapur.*

A sample of Handfield steel crusher was received for metallographic examination. It was found that the heat treatment imparted to the material was not satisfactory.

72.5 Failure of Condenser Tube. *Sponsored by Gujarat Oil Refinery, M/s. Indian Oil Corporation.*

The Refinery experinced the failure of a bundle of seventeen condenser tubes in one of their distillation unit within a short period.

Failure analysis of a tube showed that the material was admiralty brass and the failure had taken place due to stress corrosion cracking from dezincified zones as the material was not arsenic inhibited.

72.6 Macro-examination of Hot Roller Spring Steel Sample. *Sponsored by M/s. Rail India Tech. & Eco. Service Ltd., New Delhi*

A number of hot rolled spring steel samples were received for macro-examination as per IS : 3885-1966. Results showed that the samples were mostly unsatisfactory.

72.7 Metallurgical Examination of 132 KV Hangers. *Sponsored by Bihar Electricity Board.*

Three galvanised mild steel hangers for 132 KV transmission line were received for metallurgical examination. Results showed that the material of the hangers contained heavy non-metallic inclu-

sions, inhomogeneous microstructures, non-uniform coating and high hydrogen & nitrogen contents. These features were considered to be deleterious for satisfactory service life.

72.8 Failure of Welded Copper Rods. *Sponsored by M/s. Hindustan Copper Ltd., Ghatshila.*

Repeated weld failures of copper rods produced by the firm were reported. Metallurgical tests showed that the failure was due to the presence of acute ingotism in the wire bars, higher oxygen and bismuth content and their distribution across the section of rods.

72.9 Metallurgical Examination of Stainless Steel Tubes and Pipes. *Referred by Bombay Customs.*

The Assistant Collector of Customs, Bombay, sent 56 samples of imported stainless steel pipes and tubes of different diameter to assess the type of welding. Metallographic examination revealed that all the tubes except one were of seamless quality.

72.10 Metallographic Examination of Spring Steel. *Sponsored by M/s. Rail India Tech. & Eco. Services Ltd., New Delhi.*

Metallographic examination of the sample of spring steel flat, showed that the material was free from harmful defects as per specification IS : 3885-1966.

72.11 Failure of Stainless Steel Utensil. *Sponsored by M/s. T. K. Steel Industries, Poona.*

The firm reported failure of stainless steel sheet during forming of utensils. Test results showed that the material possessed a duplex structure instead of single phase austenitic structure generally used for this purpose.

72.12 Failure of Camshafts for Cumins Engine-NTA. *Sponsored by Central Coalfields, Barkakhana.*

M/s. Central Coalfields Ltd., experienced several failures of indigenously manufactured cramshfts as compared to imported ones for NTA engines.

Metallurgical tests showed that although the chemical composition and mechanical properties were comparable, the failure was due

to fatigue on account of metallurgical notches such as non-metallic inclusions and improper heat-treatment imparted to the indigenous ones.

72.13 Failure of Kuntscher's Intra-medullary Nail. *Sponsored by Magadh University, Gaya.*

A fractured Kuntscher's intra-medullary nail was sent by Magadha University for failure analysis.

It was observed that this implant material did not conform to any standard specifications and the failure had taken place due to stress corrosion cracking.

72.14 Metallurgical Evaluation of Bull Ring Segment. *Sponsored by Chandrapura Thermal Power Station, DVC.*

A sample of a new bull ring segment used for crushing coal was examined with repsect to its chemical composition, hardness and microstructure for assessing the quality of the material.

72.15 Failure of Axle Shaft. *Sponsored by M/s. Narbheram & Co. Jamshedpur.*

Metallurgical examination of the premature failure of a Jeep axle shaft for MD2350 model engine showed that although the material composition and heat treatment were satisfactory, the failure resulted on account of fatique due to poor surface finish of the axle shaft.

72.16 Failure of Super heater Convection-I Tube. *Sponsored by Badarpur Thermal Power Station, New Delhi.*

A piece of failed superheater convection-I tube pertaining to unit-III was received to investigate the cause of its failure. The tube was handling flue gas at 770°C on outside ; steam at 100 kg/Cm^2 pressure and 420°C temp. inside.

Chemical analyses showed that the tube material was a low alloy steel ; tensile strength and hardness values were consistent with chemical composition and microstructure. Whilst the immediate cause of failure was attributed to localised overheating, the presence of mill scale in inner surface of the tube had also contributed to form pits from which cracks initiated.

72.17 Failure of F.D. Fan Impeller. *Sponsored by Badarpur Thermal Power Station. New Delhi.*

The firm experienced the sudden failure of a F.D. fan impeller used for circulation of air continuously. Chemical analysis showed that the F.D. fan impeller blade material conform to IS : 2062 and was a fusion welding quality structural steel. Large number of isolated inclusions, slag stringers and laminations constituated objectionable and deleterious features for satisfactory service life.

72.18 Failure of Cleat Weld Joint in Superheater Tube. *Sponsored by Chandrapura Thermal Power Station, DVC.*

The firm experienced failure at the weld constituting the junction between the cleat made of ISI 310 austenitic steel and the tube made of 1Cr-$\frac{1}{2}$Mo ferritic steel.

It was concluded that the failure was due to migration of carbon and the presence of residual welding stresses.

72.19 Metallographic Study of the Steam Chest of CIES Valve of Unit No. 5 CTPS. *Sponsored by Chandrapura Thermal Power Station, DVC.*

This work was carried out to assist the enquiry committee constituted by the Department of Energy, Govt. of India, to go into the causes of the malfunctioning of turbine unit No. 4 & 5 of CTPS, DVC, Chandrapura.

72.20 Investigation on Ni-hard Grinding Roll for Pulverising Coal. *Sponsored by Chandrapura Thermal Power Station, DVC.*

Studies were made on the samples received with a view to substitute the imported materials with indigenous ones.

72.21 Investigation on Ashcolite Pipe used for Transporting. Slurry. *Sponsored by Chandrapura Thermal Power Station, DVC*

Studies were made with a view to substitute the imported material with indigenous product.

72.22 Investigation on Phosphor-Bronze Impeller & Diffuser Connected with River intake Pump. *Sponsored by Chandrapura Thermal Power Station, DVC.*

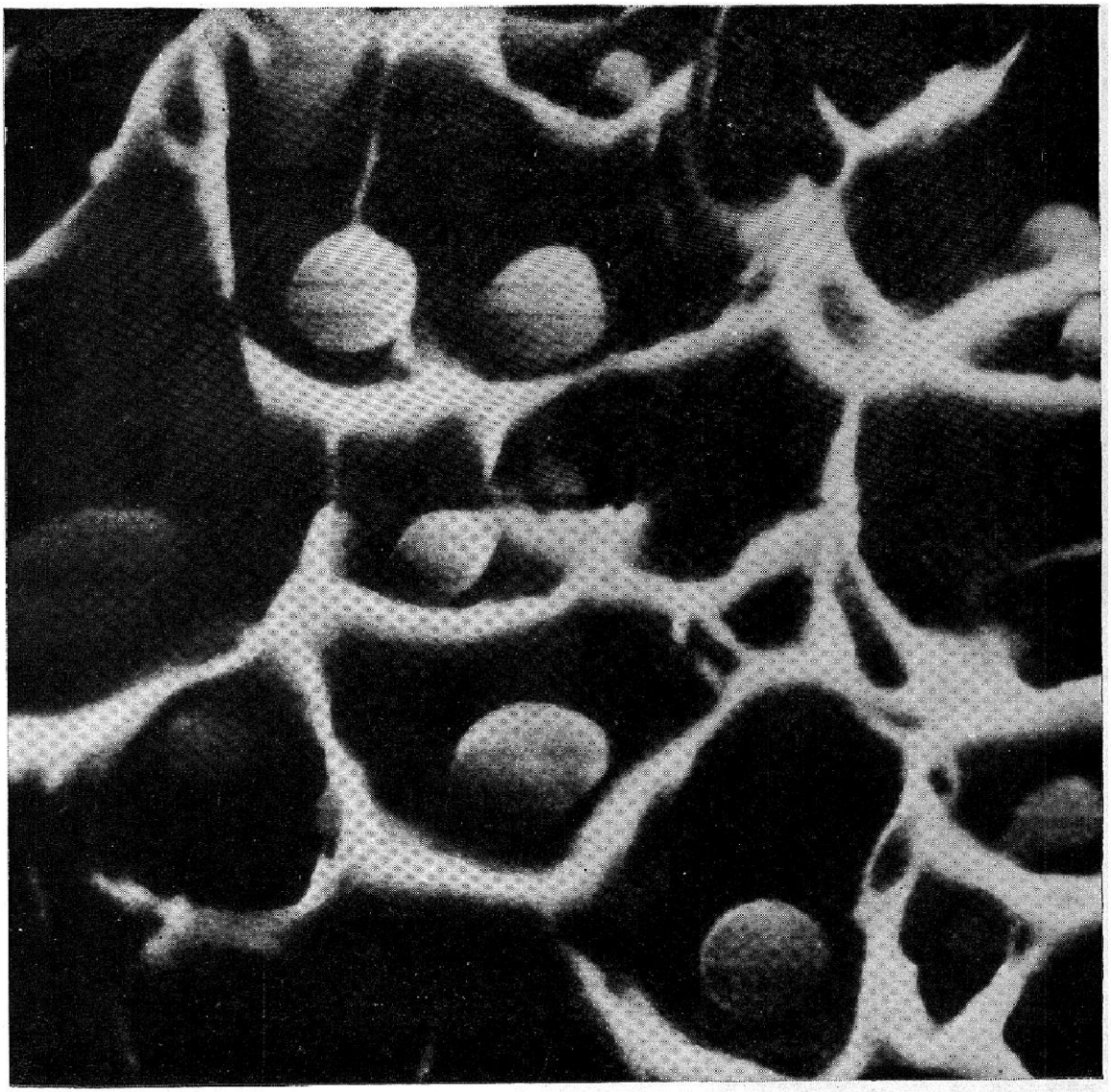


Fig. 3. Scanning electron micrograph of spheroidal inclusion in structural steel *× 2000*

Studies were made with a view to substitute the imported material with indigenous product.

72.23 Scanning Electron Microscope Studies on Failed Mild Steel Tubes & Graphite Electrode.

Steel samples from failed M.S. tubes and other components were examined in Scaining electron microscope. It was found that the material consists of inclusions such as Mn-Al silicates as shown in Fig. 3 Similar studies in graphite electrode show the presence of pores and deposits as in Fig. 4 (a & b) which may result in intiating cracks and finally fails while in use.

J. FOUNDRY TECHNOLOGY

73.0 Heat Resistant Cast Iron

Plant trials on NML-Pyroloy-1000 were carried out in two batches at Tisco. Carrier blade castings used in sheet bar reheating furnace made from this alloy gave highly satisfactory results.

Other applications for the alloy are being explored. Twenty element pins for electric furnace application have been made for evaluation at GEC, Calcutta. Fingers for pipe annealing furnace are being made for evaluation at TISCO & Shantan Pipe & Foundry Co. Ltd., Ujjain.

74.0 Wear & Abrasion Resistant Cast Iron.

The areas where failure due to abrasive wear are experienced were identified at Chandrapura Thermal Power Station (CTPS), Damodar Valley Corporation, Chandrapura. A few samples of wear resistant alloy "NML-WEARNOT" were sent to C.T.P.S. for obtaining comparative performance data during service in the ash collecting tank. Casting on full scale will be undertaken after obtaining the performance trial report. In response to the requirement of pipe from M/s. Bharat Coking Coal Ltd., for transporting sand or coal slurry, 1 metre long and 155 mm dia. pipe with flange was cast at NML in wear resistant alloy for service performance.

Cast composite grinding rolls are used for pulverising coal in thermal power stations. The exterior working surface of the rolls is very hard and the interior soft. In an effort towards import substitution, work is in progress to develop the technique for casting

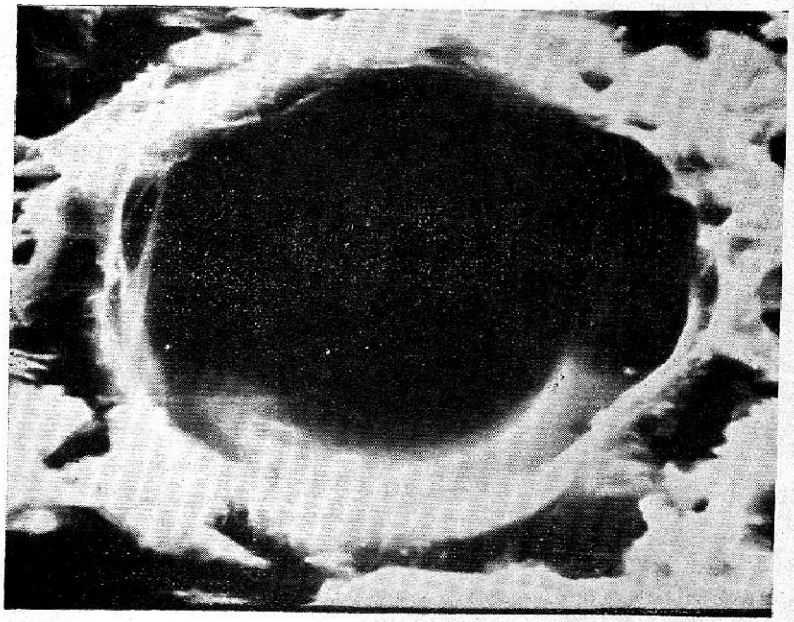


Fig. 4 (a) Voids in fractured sample of used graphite electrode $\times 2000$

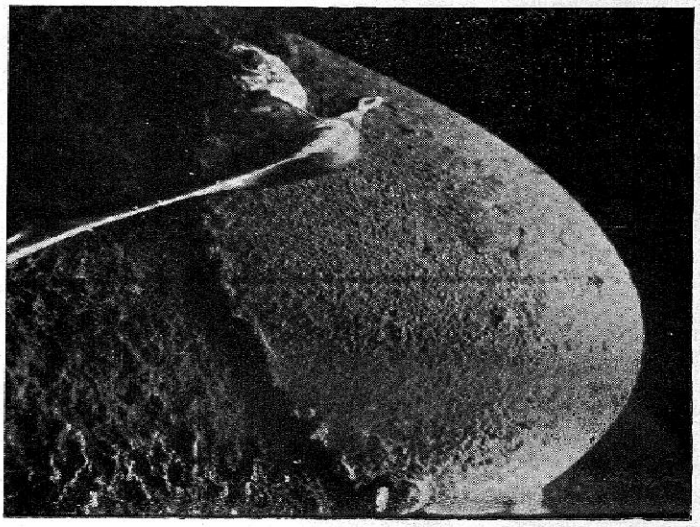


Fig. 4 (b) Adherance of metal drop on used electrode surface $\times 1000$

these composite rolls. Success has been achieved on laboratory scale. Full scale trials for casting a cpompsite roll for actual service trial in the thermal power station are being contempleted.

75.0 Development of Casting and Heat Treatment Technique for the Production of High Speed Steel Cutting Tools.

A simple machine was designed and fabricated for laboratory scale trial on centrifugal casting of high speed steel cutting tools. Several heats were made to study the effects of centrifugal casting technique on the cast structure of high speed steel tools. Further designing and fabrication of the machine for industrial scale trial on centrifugal casting technique is in progress.

76.0 Development of Self Setting and Fluid Sand Process.

Moulding characteristics under different conditions of temperature and humidity were determined. High temperature tests were also completed. Further work with regard to fludizing the sand mix is being taken up.

K. CORROSION STUDIES ON METALS & ALLOYS

77.0 Studies on Stress Corrosion Cracking of Metals.

It was reported earlier that in copper-mattson solution system, stress corrosion cracking of the metal under continuous relaxation of applied stress developed a series of isolated pits, which on coalescence form crack at later stage. Work is being continued with stainless steel-boiling magnesium chloride system under similar experimental technique to reveal the picture of initial stages of stress corrosion cracking.

78.0 Development of Aluminium Anode for Cathodic Protection

The performance of SUPERAL anode was tested in field trial by putting four anodes of 550 × 140 mm size to the hull surface of RV Gaveshani, an ocean going research vessel, belonging to the National Institute of Oceanography, Goa, for cathodic protection. The performance results, as observed for the year round, were very satisfactory. It is now being arranged to provide cathodic protection of this vessel entirely by SUPERAL anodes. The total weight of anode required will be about one ton. The melting and casting of the anodes is being planned in an industrial plant at Calcutta.

Four SUPERAL anodes were also installed to cathodically protect a part of the pipe line carrying crude petroleum from Naharkhatia (Assam) to Barauni (Bihar). Satisfactory results were obtained. Further installation on larger scale is underway.

79.0 Evaluation of Corrosion Resistance Properties of Commercial ERW Tubes with and without Copper addition.

M/s. Hindustan Steel, Rourkela Plant, is interested for scientific evaluation of the above two products for corrosion resistance. Chemical and electrochemical tests were conducted. No marked improvement in corrosion to the steel without copper.

80.0 Evaluation of Inhibitors for Corrosion Control in Recirculating Cooling Water and Steam Condensate System.

Experiments (static) in presence of different combinations of inhibitors in 3.5% NaCl were carried out. A few combinations of inhibitors (non-chromate based) were selected on the basis of static experements for dynamic tests. Experimental set up for dynamic tests is under progress.

81.0 Studies on Hydrogen Embrittlement of Steel in Aqueous System.

Hydrogen embrittlement of high strength steels in 1N H_2SO_4 containing varying concentrations of thiourea and sodium chloride at 40°C was studied. The results show that thiourea in presence of sodium chloride inhibits both corrosion rate and hydrogen pick up by steels in 1N H_2SO_4. The work, especially on the notched specimens using slow strain rate, is in progress.

L. SURFACE COATING ON METALS

82.0 Bright Acid Zinc Plating Bath.

More plating industries in light engineering are interested to utilise the acid process than the conventional cyanide zinc process

83.0 Copper Plating on Aluminium.

The process for direct plating of copper from acidic solution on properly pretreated aluminium wire has been established. Evalu-

tion tests about the conductivity and resistance of the plated wire about its suitability for use in electrical industries are in progress.

84.0 Nickel-Iron Alloy Plating as a Substitute for Nickel Plating.

Ni-Fe alloy plating containing approximately 70% nickel and 30% Fe having the physical properties similar to that of nickel plating has been taken up. This alloy plating will be much cheaper than the conventional nickel plating since the former will be using an electrolyte much cheaper than Watts Bath for nickel plating. Moreover, 30% of the cost of nickel will be economised by the use of less costly iron in the alloy composition. The process for alloy composition is being standardised.

85.0 Electroless Nickel Plating.

The process has been standardized with sodium hypophosphite as reducing agent.

86.0 Plating on ABS Plastics.

There is considerable demand of plated ABS plastic for use in fan and electronic industry as auxiliary parts of these equipments. A number of enquiries for plating on ABS plastics have been received and some firms are willing to utilise the process in commercial practice. Work is being done to standardise and establish the technology on a commercial scale.

87.0 Development of Alkali Silicate Zinc Dust Coating.

Sodium silicate solution having an alkali to silicate ratio of 1 : 3.5 form the ideal vehicle for zinc dust particles containing 98.5% Zn in alkali silicate zinc painting. A mild steel sample painted with this formulated coating gave better results as observed in potential measurements. A series of compositions formulated with different sizes of zinc dust of different qualities are under study in sodium silicate medium.

88.0 Calorizing and Chromizing of Low Alloy Steel for High Temperature Services.

Studies were carried out on calorizing of 1 Cr–$\frac{1}{2}$ Mo coatings under optimum conditions at a temperature of 700°C. The calorized sample showed only 40% increase in oxidation index over the blank. Experiments were carried on calorizing of $2\frac{1}{2}$ Cr–1 Mo samples, both coating thickness and microhardness increased.

89.0 Coating on Mild Steel Wire from Acidic Copper Sulphate Solution.

Negotiations are in progress to transfer the technology to a few wire plating industries. It was observed that thicker coatings of copper on steel wire by the acidic process by passage of current are preferred choice for utilisation than the immersion process.

90.0 Electro-galvanizing of Steel Wire from the Fluoroborate Bath.

The project has the objective to economise the use of zinc in galvanising practice and to give an uniform bright zinc coating on steel wires as per specification. The electrolyte is free from cyanide and pollution problem will be minimised. The production of electro-galvanised wire will be more as the wire will pass through the electrolyte at a high rate. It will be a better substitute for hot dip galvanizing where the uniformity of zinc coating is not a criteria.

M. STANDARD REFERENCE MATERIALS & ANALYTICAL WORK

91.0 Preparation of Chemical Standards.

So far 31 different types of standard samples have been prepared which are now being sold to meet the demand of industries, educational and research organisations.

The following materials were taken up for the preparation of standard samples.

(i) Alloy cast iron
(ii) High Carbon steel
(iii) Low alloy steel
(iv) High carbon Fe-Mn
(v) Low carbon Fe-Mn
(vi) Ferro-titanium

During the period 107.35 kg of different types of reference malerials were sold.

91.1 Preparation of Spectrographic Standards.

In the preparation of low alloy steel standards, forging, heat treatment and homogeneity tests were carried out on the homo-

geneised samples. All the results of chemical analysis from the co-operating independent analysts were received and finalised. The samples are now to be machined only for making the desired dimension (38 mm dia × 12 mm thick discs) before issuing in the market for sale.

92.0 Analytical Work

(*i*) Chemical and Instrumental Analysis.
5541 samples for 16,674 radicals were analysed.

(*ii*) Analysis of Gases in Metals
149 Samples for 168 radicals were analysed.

(*iii*) Spectrographic Analysis.

(*a*) Qualitative analysis — 286 samples were completely analysed.

(*b*) Quantitative analysis — 1736 radicals from 150 samples were analysed.

(*iv*) X-ray Fluorescence Analysis — 1736 radicals from 855 samples were analysed.

(*v*) Differential Thermal Analysis — DTA studies were conducted on bauxite sample received from Kerala State Industrial Development Corporation; Cu-Pb-Zn ore (Oxides) from Chakulia, Bihar.

(*vi*) Petrological Studies on Ores & Minerals.

Detailed petrological studies were conducted on 28 samples of ores and minerals received for beneficiation and other studies in the laboratory. The reports have been furnished and incorporated in the respective investigation/project reports.

N. APPLIED BASIC PROJECTS

93.0 Structure of Liquid Metals.

Extension of solid solubility upto 8.5% Fe & 3.5% Cr. was obtained on solidifying rapidly the alloys from liquid state. These conclusions are based upon lattice parameter and micro-hardness studies in scanning electron microscope.

94.0 Study of the Physical and Mechanical Properties of Splat Cooled Aluminium Alloys.

The evaluation of the mechanical properties of the binary aluminium alloys containing Si and Ni has been completed. The results indicate considerable improvement in the ductility of the alloys. In the Al-Si alloys the tensile strength is changed only marginally. In the Al-6% Ni alloy the tensile strength is increased by 40 to 50% over the conventional cast alloy. On account of the high ductility, the alloy could be worked to develop tensile properties comparable to the directionally solidified eutectic alloy. Further work with high strength aluminium alloys in progress.

95.0 Studies on the Corrosion Inhibition Mechanism using Radioactive Tracers.

During the period, investigations on the study of the effect of temperature on the inhibition efficiency of chromate were carried out using Cr-51 labelled Na_2CrO_4. The results show that during immersion of mild steel in Na_2CrO_4 (0.00125M) solution at room temperature, a logarithmic growth of an oxide film containing chromium and iron oxides proceeds on its surface, but this film growth does not follow the logarithmic law in the same Na_2CrO_4 (0.00125 M) solution at 40°C as well as at 50°C.

The study of the Cr-uptake by mild steel in Na_2CrO_4 (0.00125 M) solution at the room temperature, 40°C, and 50°C for different immersion periods ranging from 10 minutes to 6 hr. indicates that the Cr-uptake increases with the increase of temperature as well as with the increase of immersion period. The study of the effect of temperature on the open circuit potential change of mild steel specimens with time in Na_2CrO_4 (0.00125 M) solution has also been carried out to throw light on the behaviour of inhibitive ions at different temperatures.

96.0 Development of a Rapid Method for the Evaluation of Homogeneity of NML Standard Samples using Beta-ray Back scattering Technique.

During the period, the design and fabrication of the necessary set-up have been completed. The work for the development of the rapid method and its standardisation has been taken up.

PILOT PLANTS

97.0 Mineral Beneficiation Pilot Plant

Pilot plant investigations conducted on different types of low grade ores and minerals have been reported in the Chapter, Research Investigation & Development Projects' under Section 'A' Ore Dressing & Mineral Beneficiation.

98.0 Dense Carbon Aggregate and Soderberg Paste Pilot Plant.

Another lot of dense carbon aggregate was made and used for making 5 tons of soderberg paste in the pilot plant. This paste was supplied to M/s. Ferro-Alloys Corporation to complete the supply of 30 tonnes of paste for its complete industrial evaluation. It is to be used in three electrodes of closed type furnace for making ferro-manganese. Report of its industrial evaluation or performance is awaited.

190 feet long electrical tunnel kiln has been rectified after removing certain obstructions during the movement of kiln cars when the kiln is working. The tunnel kiln was put to operation and 6 tonnes of dense carbon aggregate was heat tested in this kiln. The tunnel performance is quite satisfactory.

99.0 Electrolytic Manganese and Electrolytic Manganese Dioxide Pilot Plant.

(*i*) The 1000 tonnes per annum electrolytic manganese dioxide plant of M/s. T. K. Chemicals Ltd., based on the NML developed technology went into production in July '77. Necessary assistance was extended by NML Scientists during the commissioning of the plant. By January '78 the firm has sold Rs. 2.33 million worth of electrolytic manganese dioxide and manganese sulphate and reached a production of 60 tonnes finished EMD in Feb. '78. The EMD produced by T. K. Chemicals Ltd. has been well received in the dry cell industry.

(*ii*) Industrial Promotion & Investment Corporation of Orissa along with M/s. Rungta & Sons, have formed a company named M/s. Electrochem. (Orissa) Ltd for production of 3000 tonnes of EMD per annum in a plant to be set up

at Joda-Barbil area based on NML technology. The ore from Silijora-Kalimati mines is being evaluated for the above plant.

(*iii*) Development Corporation of Vidharaba Ltd., intends to set up a 1500 tonnes EMD plant based on NML Technology and have sponsored an investigation for examining the suitability of manganese ore proposed to be used in this plant. The investigation has been completed and the report sent to the party.

(*iv*) M/s. Ferro-Alloys Corporation Ltd., Garividi ; sponsored an investigation for production of manganese sulphate utilising the high manganese slag. The results obtained have been sent to the firm.

(*v*) National Research Development Corporation is coordinating the work regarding the setting up of an EMD plant at Central Research Station, Burma ; based on the technology developed at NML. Part of the equipment necessary for the plant has been shipped to Rangoon. The Burmese manganese ore has been received for necessary tests and collection of required data.

100.0 Hot Dip Aluminizing Pilot Plant.

The pilot plant for wire was put into operation after renovations and further sponsored trials were carried out for M/s. Ashar of Bombay to aluminize over 700 kg of stainless steel and black wire. Efforts were also made to promote the process in the small scale sector such as aluminising of automotive mufflers ; high tension corona effect prone hardware, etc.

The strip aluminizing plant was also under modification for top heating of the hot-dip furnace as the pot type version was found to present problems, of materials of construction, pot-life, and high energy costs.

NML UNIT IN CSIR COMPLEX, MADRAS

The NML Unit functioning in CSIR Comples, Madras; has the facilities to conduct applied as well as basic research in several disciplines e.g. mineral dressing, industrial metallurgy, metallurgical analysis etc, besides furnishing consultancy services and designing apparatus and equipment. The following are the various investigational and other work conducted and underway in this unit.

(i) **Beneficiation of Magnesite Samples.** *Sponsored by M/s. Kemco Industries, Madras.*

The object of the investigation is to find out the extent to which the silica and other impurities could be brought down so that the product obtained after beneficiation and calcination could be used as food grade magnesia. A magnesite concentrate analysing 0.48% silica and representing a weight recovery of 48.6% was produced. About 30 kg of the concentrate was calcined and sent to the sponsors for market evaluation studies. The calcined material analysed 0.9% silica and 96.4% MgO.

(ii) **Beneficiation of Lime Sludge.** *Sponsored by M/s. Indian Oxygen, Calcutta.*

A sample of lime sludge analysing 60% CaO, 38.9% $Ca(OH)_2$, 1.5% SiO_2, 1.4% Al_2O_3 and 0.3% Fe_2O_3 was subjected to washing studies for removal of impurities so that the purified sludge could be used as a starting material for calcium carbonate manufacture. Comprehensive beneficiation studies were conducted but without success.

(iii) **Beneficiation Studies on a Kyanite Sample from Nellore.** *Sponsored by Director of Mines & Geology, Govt. of Andhra Pradesh.*

A sample of low grade kyanite analysing 46.52% Al_2O_3 was subjected to beneficiation studies to produce a concentrate suitable for refractory use. A kyanite concentrate analysing 62.7% Al_2O_3 (97% Kyanite) with a recovery of 88.5% kyanite was produced. The concentrate fulfilled the grade requirement for refractory use.

(iv) **Beneficiation Studies on an Iron Ore Sample from Nainarmalai, Tamil Nadu.** *Sponsored by Geological Survey of India, Tamilnadu.*

The Geological Survey of India as a result of prospecting discovered nearly 200 million tons of low grade magnetite at Nainarmalai, a place about 25 KM from Salem. Detailed beneficiation studies were conducted on a sample analysing 37.8% Fe collected from this area. The studies revealed that a magnetite concentrate analysing 65-66% Fe with recoveries of 82% Fe could be produced. A super-purity magnetite concentrate analysing 71.7% Fe was recovered which represented a recovery of 34% Fe in it.

(v) Beneficiation of Barytes from ABCo Barytes, Sankarnagar, Tamilnadu. *Sponsored by M/s. ABCo Barytes, Sankarnagar.*

M/s. ABCo Barytes, Sankarnagar; are mining and utilising a baryte deposit occuring at Thirumanjolai, Ramnad Dist. Since the baryte content (51.5% $BaSO_4$) is low, the organisation entrusted the work to develop a benefication method so that the beneficiated product could be used for production of barium chemicals. Beneficiation studies conducted yielded a concentrate analysing 96.7% $BaSO_4$ with 84% baryte recovery.

(vi) Beneficiation Studies on Chromite Samples. *Sponsored by M/s. Mysore Minerals, Bangalore.*

A composite chromite sample obtained after blending two low grade chromite samples in equal propertions by weight was subjected to detailed beneficiation studies.

Two chromite concentrates were obtained one suitable for chemical (48% Cr_2O_3) and the other for refractory use (41.5% Cr_2O_3). The overall recoveries of chromite in the concentrates were of the order of 70%.

(vii) Mineral Survey in South India.

A survey was conducted to study the mineral reserves of the four States in the South Viz., Tamilnadu, Kerala, Andhra Pradesh and Karnataka. For this purpose, existing information from the Departments of Geology under the State Government as well as from Geological Survey of India were collected. Discussions were also held with the various officials of the State and Central Governments in order to understand the present projects and exploration underway and the future plans of prospecting. The information was collected primarily with a view to understand the mineral potentials and parti-

cularly in order to assess the need of various mineral dressing operations for low-grade minerals in the four States.

The Survey brought out some important areas of mineral reserves where further action in terms of beneficiation is very desirable with the help of the concerned Govt. agencies. Such areas include limestone, fire-clays, bentonites, complex sulphides, iron ores of Calicut, graphite deposits of Eranakulam ; chromite, graphite sillimanite and magnesite of Karnatakka ; barytes, kyanite sillimanite etc. from Andhra Pradesh. The study will continue further with an effort to monitor closely the mineral reserves as revealed by prospecting operations of the various agencies of State and Central Governments.

(viii) Studies on Iron Ore Samples of Bellary-Hospet Region. *Sponsored by M/s. MECON, Ranchi.*

For setting up of a centralised Pelletisation Plant in Bellary-Hospet region utilising the non-NMDC iron ore deposits, the NML Unit, Madras is entrusted with the task of conducting detailed studies on ten iron ore type samples received from various mines from the area. Detailed studies including sintering and pelletization are being taken up.

(ix) Beneficiation of Limestone Sample. *Sponsored by M/s. Industrial Chemicals, Talaiyuthu, Tamilnadu.*

Samples of siliceous limestone from Ariyalur analysing around 70% $CaCO_3$ are being subjected to a series of flotation studies with a view to make them suitable for manufacture of calcium carbide The best flotation concentrates obtained so far analysed around 1% insolubles with a satisfactory limestone recovery. Pelletisation tests using the limestone concentrate are in progress.

(x) Washing studies on a sand sample from Shertalai, Kerala. *Sponsored by Director of Mines & Geology, Trivandrum.*

Beneficiation studies were taken up on a sand sample received for purification from ilmenite, rutile, zircon and sillimanite. Tabling tests on the sample were completed and the tailings, sand rich in silica, are being evaluated for its use in steel foundries.

(xi) Extraction of Alumina from Nileshwar Bauxite, Kerala. *Sponsored by M/s. Kerala State Industrial Development Corporation.*

Laboratory bench scale studies were carried on a sample of bauxite from Nileshwar, Kerala. The studies included physical mineralogical, chemical, digestion studies and hydrolysis studies on sodium aluminate solutions produced from the leaching step. Studies were also carried out on the setting rates and washing tests on red mud for the recovery of alkali.

(xii) Development of a Fluidised Bed Reactor.

A fluid bed reactor for the roasting of chalcopyrite concentrates is under progress. Initial trials on the fluidisation characteristics of the Chittradurga chalcopyrite concentrate have been completed.

(xiii) Reducibility Studies on Iron Ores. *Sponsored by M/s. MECON, Ranchi.*

Experimental set up for the reducibility studies on iron ores by the Gakushin and Linder tests are nearing completion. A mercury hydrometer has been fabricated for the swelling index studies and experiments are under progress on the studies on thermal degradation of iron ores.

(xiv) Investigation on Foundry Sands. *Sponsored by M/s. Seetharam Mining Co., Nellore.*

In Gudur area of Andhra Pradesh, some deposits of foundry moulding sands of medium and high silica grades were located and a sample was sent for beneficiation and studies on its moulding characteristics for use in foundries of the Southern range. The investigation showed that the Gudur sand was suitable for foundry moulding purposes for medium and heavy grey iron castings and light steel castings with proper mould coats.

(xv) Inter-granular Corrosion Studies on Stainless Steel. *Sponsored by M/s. ABC Valves, Calcutta.*

A few stainless steel samples were received for intergranular corrosion studies. The samples were dipped in boiling copper sulphate-sulphuric acid solution for 240 hr. as per ASTM Standards and the corrosion rates determined by loss in weight method. The intergranular corrosion was also studied under the microscope as per the ASTM charts.

(xvi) **Studies on Descaling Solution.** *Sponsored by M/s. Chemical & Metallurgical Serivces, Madras.*

The firm requested technical assistance to develop improved cleaning solutions for the removal of scales formed inside boilers, heat exchangers etc. The solutions generally consist of acids along with inhibitors so as to prevent corrosive attack of the acids on the main body of the boiler while the scale is being removed by chemical attack. Several modified solutions were formulated for the firm according to the requirements of individual cases of cleaning and the nature of the scale in each particular case. Field trials are in progress.

(xvii) **Heat-treatment of Magnetic Alloy.** *Sponsored by M/s Audiotronics, Madras.*

The firm manufacturing magnetic heads, approached to carry out annealing of magnetic head-Mu-metal cores. The alloy was Hy-Mu-80 and was a high magnetic permeability material made of Ni-Fe alloying (86 Ni-20 Fe). With necessary precautions taken, the heat treatment in Hydrogen was successfully carried out at 1100°C in a tube furnace. The firm was satisfied with the performance of the magnetic core heads.

(xviii) **Defects in Road Wheeler Castings.** *Sponsored by Highways Department Workshop, Govt. of Tamilnadu.*

The Highways Department Workshop sought suggestions to eliminate several defects repeatedly occuring in castings of 1.5 ton road wheeler. Several measures were recommended including combination of pit moulding and top box moulding along with modified gating system. Some of these have been adopted and the trials are in progress.

(xix) **Failure in Light Engine Crankshaft.** *Sponsored by M/s. Enfield India Ltd., Madras.*

The firm requested assistance in conducting investigations of failure of light engine crankshaft reported from their customers and field service centres. Several of these samples were examined metallographically and the causes in individual cases discaused with their plant engineers. Apart from explaining the metallurgical causes of failure, discussions were held with the company to improve the inspection procedures at various stages so as to reduce the number of failures of the crankshafts.

(xx) Failure of Cam Shaft. *Sponsored by M/s. Enfield India Ltd, Madras.*

In the engine mentioned above, a common defect observed by the company was extremely repid wear of the cam shaft used for operating the two valves of the engine. Several of these cam shafts were investigated metallographically along with other plant and engineering data given by the company. Some of these failures were due to improper graphite structure and some were due to low hardness.

(xxi) Defects in Cylinder Head. *Sponsored by M/s. Enfield India Ltd, Madras.*

The cylinder heads of the above engines were die cast with LM2 alloy. It was observed that the spark plugs would cause seizure when fitted in the cylinder head even at the time of engine testing. A study was conducted in the prior treatment given to the components and shop-floor apart from metallographic investigations. It was observed that the seizure may be due to dimensional changes occuring in the die casting aluminium alloy due to incomplete transformation which should be completed by proper heat-treatment.

(xxii) Failure of Ball Pins of Insulators. *Sponsored by M/s. W. S. Insulators, Madras.*

The firm manufactures the ball pins as forgings in EN 8 material. Failures reported by the company were many in number but since the accidental damage caused by such failure has serious implications in power supply, the firm was keen to eliminate all chances of failures. The method of manufacture by the ancillary supplier of the firm was examined closely and several measures were suggested to the company to improve the reliability of the component without losing sight of the economic factors. Measures included light machine forging followed by normalising and certain modifications in the design of the ball pins.

(xxiii) Investigation on Clay Graphite Pencil Leads. *Sponsored by M/s. Madras Pencil Factory, Madras.*

The firm requested technical aid so as to develop specified properties in the sintered clay-graphite products suitable for pencil manufacture. Facilities of the firm as well as their raw-materials were critically examined and selected mixtures of the clays used by the

firm were investigated from the point of view of optimising the temperature-time cycles so as to develop the best possible strength and toughness of the product.

(xxiv) Analysis

350 samples received from various firms were analysed for 1250 radicals in addition to analytical assistance to ore-dressing investigations.

(xxv) Design and Fabrication

The following equipments were designed and fabricated.

(a) 100 KVA arc furnace — Container, shatter frame, cooling ring and lever arrangements, etc.
(b) Pot Sintering Unit.
(c) Pot grate Furnace for heat-hardening of pellets, 50 kg. batch along with arrangements of pre-heating, temperature cycle measurements etc.
(d) Linder Test apparatus for testing the behaviour of iron ores at high temperature and magnetic abrasion.
(e) Spiral concentrator for iron ores.
(f) Semi-automatic carbon analyser — A prototype fabrication of semi-automatic carbon analyser to be used along with 1.5 induction heater developed by CEERI, Pilani was completed.

(xxvi) Setting up of Non-Ferrous Analytical Laboratory. *Sponsored by M/s. Seelans Metal Corpn., Madras.*

Technical assistance is being provided to the firm to set up a laboratory for metallurgical analysis from the point of view of quality control of aluminium sheets and circles asper ISI Standards.

NML FIELD STATIONS

NML Field Station, Howrah.

Field Station at Howrah has rendered technical services to a large number of engineering and foundry industries in and around Calcutta by providing physical testing and chemical analysis of various metals and mineral products. The Field Station has also contacted ferrous and non-ferrous industries for technical guidance regarding specifications, heat treatment, import substitution and solving of processing problems. The following gives an account of the work handled by the Field Station during the period.

(i)	Chemical analysis — No of radicals analysed	1196
(ii)	Mechanical testing — No of tests	133
(iii)	Number of technical enquiries attended	25
(iv)	Number of foundry visits for giving on the spot guidance	8

NML Field Station, Batala

The Field Station has rendered useful service to the small scale foundries of this region in the selection of various foundry raw matrials and their application. The station has also attended the day-to-day problems of the foundry industry by way of periodical visits and suggested methods of improvement for production of quality and graded casting of various kinds. The use of various ferro-alloys and inoculants in some of the local foundry units was introduced. During the period, the following services have been provided.

(i)	Number of foundry visits to guide on the spot	125
(ii)	Number of technical enquiries attended	211
(iii)	Number of samples tested/chemically analysed	96
(iv)	Number of sand samples investigated	4
(v)	Number of samples tested for hardness	8

NML Field Station, Ahmedabad.

The field station did the following work during the period.

(i) Analysis — 816 samples were analysed for 2832 radicals
(ii) Sand & bentonite testing — 3 samples were tested
(iii) Mechanical testing — 1 sample was tested.

ENGINEERING ACTIVITIES

Design Engineering

The following design work was attended during the period.

(i) Detailing/revision of design of apparatus for liquid phase extraction of magnesium and arranging fabrication, procurement and installation of the same. Installation work in progress at present.

(ii) Design of an apparatus for testing permeability of refractory brick samples — detailing in progress.

(iii) Detailing of vertical retort furnace for sponge iron production.

(iv) Design of roasting chamber for recovery of copper chemicals directly from copper concentrates.

(v) Further design/development work was carried out in connection with the production of metal powders by atomization and a modified atomizer is under trial for evaluation of its characteristics.

Mechanical Engineering

(a) Workshop

During the period the following fabrication jobs were conducted.

(i) Controlled atsmosphere high temperature resistivity apparatus.
(ii) Split grips for tensile testing machine.
(iii) Furnace for multispecimen creep testing machine.
(iv) Atomizer and attachements for atomizing trials.
(v) Attachment for shear for cutting square corrosion test specimens.
(vi) Various dies, punches, moulds, etc. including dies for the extrusion press.

Besides the above, over 300 jobs pertaining to preparation of standard test specimen, installation & maintenance work were done.

(b) Pattern Shop

The following major jobs were conducted.

(i) Pattern for heat resistant carrier blades.
(ii) Pattern and core box for electrode holder of electrothermal zinc dust furnace.
(iii) Ring pattern.
(iv) Ramming mould for sleeves.
(v) Moulds for ramming refractory blocks for multispecimen creep testing machine.
(vi) Pattern for furnace grate.
(vii) Perspex counter current leaching apparatus.

(c) Garage

The preventive, breakdown and maintenance jobs of the Laboratory's vehicles were conducted.

Electronics Engineering

A. *Instrumentation of Projects*

(i) Sukinda Nickel Pilot Plant

Thirty pressure meters were repaired and calibrated against dead weight tester.

(ii) Mineral Processing

The Bristol potentiometric recorders and one Beckman pH meter were repaired and calibrated.

(iii) Hydro-electro Metallurgy Project

Carl Zeiss spectrophotometer and Taylor Oxygen analyser were checked and/installed.

(iv) Instrumental Analysis

X-ray fluorescence spectrometer and Pye-Unicam atomic absorption spectrometer were serviced and faults rectified.

(v) Dense Carbon Aggregate Pilot Plant

Several temperature controllers were rectified and re-calibrated.

B. *Major Maintnance, Installation & Calibration Jobs Completed.*

(i) Extrusion press controls
(ii) Rolling Mill controls
(iii) Geiger counting system
(iv) Scanning electron microscope
(v) X-ray diffractometer
(vi) D.T.A. Appratus (Derivatograph)
(vii) X-Y recorders
(viii) Potentiometric recorders
(ix) Digital multimeter
(x) Ultrasonic Flaw detector.

Electrical Engineering

A. Development Work

(i) Electro-thermal Smelting of Lead Concentrate.

Many designs of the furnace for electro-thermal smelting of lead were studied for optimisation. Design of electrodes and metal seal were improved.

(ii) Development of 3-Tonnes High Sensitivity Creep Testing Machine.

Design and preparation of detailed drawings for fabrication of six furnaces were carried out for creep testing machines being fabricated at Central Mechanical Engineering Research Institute, Durgapur

(iii) Design and Development of Isothermal Electric Furnace for Multispecimen Creep Testing Machine.

The furnace was fabricated, assembled and commissioned for proving.

(iv) Extraction of Magnesium in a Single Electrode Furnace.

Various devices and equipment procured were tested.

B. Consultancy for Graphite Beneficiation Plant at Udaipur.

Detailed specifications of substation equipment, power distribution system, electric motors, control system, illumination etc for the plant were worked out ; tenders were scrutinised and selections were made.

C. Design, Planning and Preparation of Layouts.

Design of a number of electric resistance furnace and power distribution systems, planning of their execution and preparation of their lay out were carried out.

D. Preparation of Schedule of Quantities and Specifications : Management of Installation and Commissioning.

For a number of new jobs, schedule of quantitites and specifications were prepared, tenders were invited and finalised and installation and commissioning were supervised.

E. Breakdown Repairs and Preventive Maintenance.

Breakdown repair and preventive maintenance were carried out for electrical equipments of the laboratory, its pilot plants and residential areas, comprising of high tension substations, electric arc furnaces, high frequency furnaces, resistance furnaces, rectifiers, motors and control pannels, temperature and humidity control equipment etc.

Civil Engineering

The following jobs were completed.

1. Tarfelt treatment to the roof leakage at NML.
2. Tarfelt treatment to the Office Building at FPTD.
3. Replacement of old gas main pipe lines at NML.
4. Re-roofing the damaged roof in NML.
5. Installation of pneumatic hammer at the backside of Technical Block.
6. Extension & Modification of the existing shed for housing gas producer unit at MBPP.
7. Shifting & installation of vacuum Arc & electron beam furnace at NML.
8. Modification of the existing area at NML Post Office.

9. Concrete Road for Bank & Post Office.
10. Construction of control room for vertical reduction furnace at MBPP.
11. Lining of rotary kiln at MBPP.
12. Repairing of water line at NML Field Station, Howrah.
13. Modification of the plant rooms for checking of noise from A.C. Plant.
14. Providing drain in dense carbon aggregate pilot plant.
15. Main filter water line to plant area through Tisco.
16. Development of the areas in M.S. Type Flats at Agrico.
17. Bus waiting stand at Agrico & Tuiladungri Colonies.
18. Modification in 'F' type quarters within NML Premises.
19. Water proofing treatment to roofs.
20. Modification for general facilities like First Aid, Maintenance Office/Stores for Civil & Elect. jobs.
21. Maintenance and servicing of various installations, gas & water pipe lines etc.

TECHNICAL CONFERENCES

1. UNIDO Consultation Meeting on Adaptation of Steel Technology to the Needs of the Developing Countries.

United Nations Industrial Development Organisation held a Consultation Meeting on "Adaptation of Steel Technology to the needs of the Developing Countries" at National Metallurgical Laboratory from 28th November to 2nd December 1977.

In line with the recommendation of UNIDO at its "First Consultation Meeting on Iron & Steel Industry" held in Vienna in February 1977, this meeting was convened in collaboration with the Government of India through the association of National Metallurgical Laboratory.

The meeting was attended by the following.

Dr. B. R. Nijhawan	—	Senior (Inter-regional) Industrial Adviser & Chairman of the Task Force on the Iron & Steel Industry, UNIDO Secretariat, Vienna.
Dr. B. Blaszezyn	—	UNIDO Official, Vienna.
Dr. K. H. Yamaguchi	—	UNIDO Official, Vienna.
Mr. R. Amenabar	—	Head, Economic Unit, ILAFA, Chile.
Mr. H. Kunitake	—	General Manager, Technical Coordination Dept. Engineering Division Group, Nippon Steel Corporation, Japan.
Mr. A. V. Arizabal	—	Executive Director, Metals — Industry Research & Development Centre, Phillipines.
Dr. J. O. Edstrom	—	Royal Institute of Technology, Division of Production Technology, Steel & Mining Industries, Sweden.

Dr. B. R. Nijhawan, Senior (Inter-regional) Industrial Adviser & Chairman of the Task Force on the Iron & Steel Industry, UNIDO; Dr. D. Blasezyn of UNIDO, Prof. V. A. Altekar, Director, NML & Shri R. M. Krishnan, Head (Planning), NML; discussing in UNIDO Consultation Meeting.

Prof. V. A. Altekkar, Director explaining to the delegates of the UNIDO Consultation Meeting, some product development work of NML.

Dr. Y. M. D. E. Gucer	—	Director, Marmara Materials Research Institute, Turkey.

India was represented in the meeting by the following.

Prof. V. A. Altekar	—	Director, National Metallurgical Laboratory.
Dr. S. Ramachandran	—	General Manager (R & D) Hindustan Steel Ltd., Ranchi.
Dr. S. R. Pramanik	—	General Manager, MECON, Ranchi.
Shri N. K. Mitra	—	General Manager (Operation) Steel Authority of India Ltd., New Delhi.

The entire session of the Consultation Meeting was presided over by Prof. V. A. Altekar. The discussion of the meeting centred round on the following important topics.

(i) The posibility of, and the necessary arrangement for, involving the institutes concerned in providing the relevant information and assistance to the developing countries in the field of the adaptation of iron and steel technology.

(ii) The need for establishing an international technical and development centre to provide impartial technical advice to the developing countries in establishing steel plants and to provide related consultancy services.

(iii) The problems of alternative technologies in the production of steel and utilization of fuels.

The Proceedings of the Meeting covering the salient points of discussion, decisions arrived at and follow-up action to be taken have been compiled by the UNIDO for strengthening the cause of appropriate technology in the field of iron and steel industry.

The delegates also visited the research divisions and pilot plants of the National Metallurgical Laboratory. M/s. Heavy Engineering Corporation, Ranchi ; also extended welcome to the delegates and took them round in their various production units & plants.

2. Meeting of the Co-ordination Council for Engineering Group of Laboratories of CSIR.

A meeting of the Co-ordination Council for Engineering Group of Laboratories of CSIR was held on 13th January 1977 at National Metallurgical Laboratory. The meeting was presided over by Dr. S. R. Valluri, Director, National Aeronautical Laboratory & Chairman of the Co-ordination Council. The meeting was attended by the following :

Dr. S. R. Valluri	:	Director, National Aeronautical Laboratory.
Prof. V. A. Altekar	:	Director, National Metallurgical Laboratory.
Dr. S. K. Basu	:	Director, Central Mechanical Engineering Research Institute.
Shri K. S. Bhatnagar	:	Chief (Finance), CSIR.
Shri V. S. Narayanan	:	Scientist, Central Mining Research Station.
Prof. A. Rahaman	:	Chief (Planning), CSIR.
Shri M. Ramaiah	:	Director, CSIR, Madras Complex.
Shri Rangaraja Rao	:	Scientist, Central Fuel Research Institute.
Dr. P. K. Rohatgi	:	Director, CSIR — Trivandrum Complex.
Dr. K. D. Sharma	:	Director, Central Glass & Ceramic Research Institute.
Dr. B. B. Sundaresan	:	Director, National Environmental Engineering Research Institute.

Prof. V. A. Altekar welcomed the members and requested Dr. Valluri, Chairman of the Co-ordination Council for Engineering Group to conduct the discussion.

The main purpose of the meeting was to take a view on the plan proposals of the engineering group of the Laboratories. Dr. Valluri in his remarks stated that the main theme of the meeting was the necessity for greater accountability on the part of the laboratories and making the work of the laboratories more purposeful and relevant to national needs. He drew attention to the members to their respective plan proposals and requested to review them again in the back ground of the Planning Commission's expected contribution for the next five year Plan Period commencing from April 1978. In conslusion, Dr. Valluri suggested that a thorough review of the existing research programme of the laboratories should be taken up with a view to decide as to which of these could be fore closed for re-deployment of personnel for better response to changing needs.

The various points emanating from the plan proposals were discussed and the minutes of the meeting along with the observations and recommendation made have been circulated to the participating laboratories for compliance.

PLANNING OF RESEARCH & DEVELOPMENT PROJECTS

Project Planning & Programming

Project-wise planning and programming of Research & Development work was continued on the Fifth Plan proposals. The research programme was periodically reviewed. The Annual Plan for 1978-79 and Revised Budget Estimates for 1977-78 and Budget Estimates for 1978-79 were prepared on the basis of on going and new research projects, pilot plant studies, infrastructural facilities.

A brief review of achievements during 1976-77, projects likely to be comlpeted during 1977-78 and their terminal results expected, areas of major thrust planned in 1978-79, etc. were also made.

Proposals for New Five-Year Plan

Indicative plan proposals for the New Five Year Plan covering the period of five year from 1978-79 to 1982-83 were prepared which included on-going and new R & D project proposals institutional project, extension centres, field stations and liaison Centres, infrastructural facilities etc.

The major thrust in the new Five Year Plan would be to establish large-scale facilities. This would relate to Augmentation of Ore-Dressing and Mineral Beneficiation Facilities to keep pace with the increasing tempo of work in the development of mineral industries plans for the expansion of iron and steel sector and non-ferrous sector. This proposal is under active consideration of Federal Republic of Germany Technical Aid and awaiting the clearance of the Planning Commission.

Augmentation of Extractive Metallurgical Techniques will be continued and fully established during the proposed plan period with UNDP Assistance, for which clearance of the Planning Commission is now awaited. This project has been supported by the Ministry of Steel & Mines who had contributed Rs. 20 lakhs during the last plan period.

The Central Creep Testing Facilities which was established in the Fifth Plan period is now fully booked with all the 150 points, the major user being the Bharat Heavy Electricals Ltd. To meet the

increasing needs of the user industries and to develop our own R & D programme in the form of new creep resistance steels from indigenous raw materials, it has been proposed to expand this facility by providing adequate number of test points through acquiring multi-specimen testing machines, etc. The UNDP has also agreed to provide substantial amount in foreign exchange for acquiring certain critical spares for this facility.

A brief review of the existing Field Stations has been made and further inputs have been planned to make them more dynamic in the years to come. This will particularly apply to NML Unit of the CSIR Complex, Madras; where the Ore-dressing as well as refractory facilities have been strengthened considerably based on the recommendations of the Reviewing Committee set up for this purpose. Likewise, adequate support to the Field Station at Ahmedabad has also been provided.

While dealing with the infrastructural facilities, adequate attention to the replacement and modernisation of equipment has been given. Attention has been given to development of instrumental analytical facilities, library, documentation and information services, technology planning, forecasting and training etc.

The social needs of a vast growing complex at Adityapur have also been stressed particularly regarding housing colony, club and also a central school at Jamshedpur for the children of the NML staff, quest house, training hostels, cooperative stores and more enlarged scope for residential facilities for junior officers, dispensaries, etc which are utterly lacking.

PUBLICATIONS

During the period under review, the following publications were prepared, edited & published.

NML Technical Journal

The issues of NML Technical Journal Vol. 19, 1977 were edited & published. A considerable number of foreign & Indian scientific & technical journals, reports, bulletin etc. are obtained on exchange basis with NML Technical Journal.

Annual Report

The Annual Report of the Laboratory for the year 1976-77 was prepared, edited & published.

Documented Survey on Metallurgical Development

The issues of this publication were brought out.

Monograph on Indian Ores & Minerals

A monograph on 'Indian Ores & Minerals and Their Beneficiation Studies' was prepared, edited & being made ready for printing. The monograph comprises of the investigational work conducted on beneficiation studies conducted on various types of indigenous ores and minerals in NML over the past two & half decades. Besides the investigational work, the monograph contains very wide statistical data on geological and geographical distribution of various Indian Ores and minerals, total reserve, output, export, import etc.

Special Brochure

A special brochure on the 'Achievements & Contributions of the Laboratory during the past decade is being prepared.

Publicity of Processes & Products

Some of the NML developed products & processes which are ready for commercialization were published through newspapers and other media. The relevant write-up & design were prepared for the purpose.

NML News Letter

The monthly NML News letter was brought out

Papers Published and Presented

Details furnished in Appendix I

Research & Investigation Reports Prepared

Details furnished in Appendix II

LIBRARY AND DOCUMENTATION SERVICES

Library & Documentation Work

The Library added 505 new books costing nearly Rs. 50,000/- thus bringing the total holding to 42,110. The services of the Library were extensively used by the Scientists of the Laboratory as well as many external organisations, technical institutions like Tisco; Telco; Tinplate Co. of India; Indian Copper Complex of Hindustan Copper Ltd; MECON; Uranium Corporation of India; Regional Institute of Technology etc.

Seven bibliographical surveys on specific subjects required by the scientists of the Laboratory were prepared and supplied.

The 'Current Awareness Service' was continued as a daily service. The service covers principal contents of journals on metallurgy and allied disciplines appearing in the journals daily received on the Library.

The 'News Clipping Service' and 'Trade Awareness Service' covering the scanning and clippings relating to scientific research policy & planning; relevant trade and commercial news etc. were continued'.

INDUSTRIAL LIAISON & RESEARCH CO-ORDINATION

Get-together and Exhibitions

The Laboratory participated in the one day 'Get-together on Foundry and Forge Industries' organised by National Institute of Foundry & Forge Technology at Ranchi, in April, 1977 ; in collaboration with Small Industries Service Institute, Patna. A small exhibition was also arranged on this occasion where notes and techno-economic data sheets pertaining to products/processes/expertise developed at NML for the benefit of the small scale industry in particular were displayed.

A get-together was organized by the SISI, Indore ; in July 1977 on electric grade aluminium alloy conductor-NML-PM2. As many as 500 industries engaged in the wire cables and ACSR conductors as well as some units engaged in grey iron and steel casting attended the Get-together. The occasion was also made use for displaying some NML Products/Processes.

The inaugural function of this Get-together was presided over by the Superintendent Engineer, M. P. Electricity Board, Jabalpur. Prof. V. A. Altekar, Director ; gave his inaugural address highlighting in brief the main achievements of NML, particularly those relating to MP State. Prof. Altekar also stressed that in order to help small scale industries all over the country, "Extension Centres" have been set up at Batala, Calcutta, Ahmedabad and Madras ; and should the State Government and the industries be interested, one such Centre can even be located in MP, besides the CSIR Polytechnology Transfer Centre at Bhopal. He also extended fullest cooperation of NML in solving any metallurgical problem pertaining to small industries and hoped that this visit will open a new vista in closer cooperation between the MP metallurgical and mineral based industries and NML. Dr. R. Kumar, Scientist, gave a brief account of NML-PM2 alloy and its various applications in electrical industries together with its superior properties as compared to EC grade aluminium.

NML-MECON Agreement

The following is the review of the progress of the agreement on the projects and development work.

(*i*) *Electrolytic Manganese Metal.*

This electrolytic manganese metal pilot plant was operated and demonstrated to the engineers of MECON for collection of necessary data for the preparation of a feasibility report. Subsequent to this visit and associated discussions, MECON has submitted a quotation for preparation of a feasibility report for setting up of a 300 tonnes per year electrolytic manganese metal plant to West Bengal Industrial Development Corpn. (WBIDC). Acceptance of the quotation of MECON is being awaited.

(*ii*) *Feasibility Report for Production of Vanadium Pentoxide from Alumina Sludge.*

MECON has been entrusted with the preparation of a feasibility report for a 5 tonnes per day sludge treatment plant.

(*iii*) *Side-blown Converter Process for Steel Making.*

The process demonstration of the side-blown converter was held earlier when the representatives of MECON, R & D of HSL were present. MECON has since observed that though the side-blown converter process is technically feasible, the process does not appear viable based on the parameters obtained during the demonstration run. In view of this, the process is being withdrawn from the active list.

(*iv*) *Graphite Beneficiation-cum-Crucible Manufacture Project of Kerala State Industrial Development Corporation, Trivandrum*

Sample of concentrate obtained by beneficiation at NML was tested by a crucible manufacturing company at Rajahmundry who have reported that the sample is found suitable for graphite crucible manufacture. Further details as desired by MECON on the know-how have been conveyed to MECON. A 10 kg sample of the concentrate produced by the NML had been sent by KSIDC to Japan for its evaluation.

(*v*) *Testing of Iron Ores*

Details of the investigations as prepared by MECON on the (a) beneficiation, sintering and pelletization of iron ore from Ballari-Hospet Region and (b) iron ores from the mines of Messrs Salgaocar and Bros. Goa, were worked out and the time schedule and charges had been framed and communicated to MECON.

(vi) High Alumina Refractories

Time schedules, raw material requirements and the charges for carrying out the pilot plant scale tests for the manufacture of high alumina and the high grog fire clay product have been furnished to MECON, who are negotiating with one of their clients for getting these investigations carried out at NML.

Industrial Problems Reterred to NML by CSIR Polytechnology Transfer Centres.

A number of industrial and technical problems were referred to NML by various CSIR Polytechnology Transfer Centres at Patna, Bhopal, Hyderabad, Bangalore and Ahmedabad. Some of the problems were also sponsored by the industrialists/entrepreneurs. Wherever possible, free advice had been also given to the small scale industrialists/entrepreneurs particularly those from cottage type industries.

Summer School at Regional Institute of Technology, Adityapur (Jamshedpur)

Prof. V. A. Altekar, Director ; inaugurated the 'Summer School' on 'Advance course in metal melting' at RIT on 30th May 1977. The course was sponsored by Indian Society for Technical Education and attended by various participants from all over the country. Scientists and scientific staff from NML also attended the course which lasted for a fortnight.

Meetings

(i) State Level R & D Committee for Bihar

During period under review, two meetings of the State level R & D Committee for Bihar were held at Dhanbad and Gaya in July and December, 1977, respectively under the Chairmanship of Prof. V. A. Altekar, Director. In connection with these meeting, get-togethers were held in which small scale industrialists, entrepreneurs, Bihar State Govt. Officials, representatives from SISI Patna, ISI, NRDC, engineering colleges of Bihar, CSIR Polytechnology Clinic Patna, banks etc. participated.

A meeting convened by Ministry of Mines and Metals regarding recovery of vanadium and gallium from sludge of alumina Plants

was held on 19.8.77. The meeting was attended by representatives from HINDALCO, BALCO, CSIR, CECRI and NML. The progress on vanadium and gallium recovery was discussed. Members attending the meeting were appraised of the successful operation of V_2O_5 plant at Ranchi which is producing 250 kg V_2O_5/day, with the expertize/know-how provided by the NML.

PATENTS AND PROCESSES

Patents Filed

	Title	*Inventors/ Authors' Name*
1.	A process for making austenitic stainless steel containing chromium, nickel, copper and manganese (IP No. 239/Del/77 dt. 14.9.77)	S. S. Bhatnagar B. K. Guha and R. K. Sinha
2.	A process for simultaneous electro-winning of zinc, manganese dioxide in the same cell from sulphur bearing zinc concentrate and manganese ore (IP No. 521/ DEL/77 dated 28.12.77)	V. A. Altekar A. N. Pandey and K. N. Gupta
3.	Improvements in or relating to the use of aluminium/alloy alluminium conductors and processing thereof (IP No. 1818/ CAL/76)	Rajendra Kumar and Manjit Singh

Transfer of Technology to Industrial Firms

The technology of the following processes have been transferred to the industrial firm for commercial exploitation.

	Processes	*Firms*
1.	Magnesium inoculant briquettes for the production of nodular cast iron	M/s. Damani Traders, Calcutta.
2.	Production of thermostatic bimetals	M/s. Thermo-bimetals India Enterprises, Daltonganj, Bihar.
3.	Production technology of dental amalgam alloy	M/s. Dentifils India, Jamshedpur.
4.	Production of electrolytic manganese dioxide	M/s. T. K. Chemicals, Bombay.
5.	Development of claygraphite stopper heads from indigenous raw materials (sponsored Project)	M/s. S. K. Mitra, Calcutta.

6.	Electric grade alloy aluminium conductor, NML-PM2	M/s. Indian Aluminium Cable Co. Ltd, New Delhi (Works, Faridabad),
7.	Production of Vanadium pentoxide from alumina sludge	(i) M/s. Rare Metals & Chemicals, Ranchi (sponsored project), (ii) M/s. Wire-Cond. Delhi Pvt. Ltd, Delhi.
8.	Manufacture of liquid gold	(i) M/s. Bharat Pulverizing Minerals Pvt. Ltd. (ii) M/s. Andeep (India) New Delhi.
9.	Production of bi-metallic powders	M/s. Paras Metal Powders Nasik the licencee has completed the installation of the plant (300 t per year) and trial runs are in progress.

Processes Ready for Release

1. Production of copper clad aluminium sheet
2. ,, ,, NML Pyroloy-1000 (Heat resistant cast iron)
3. ,, ,, iron-silicon magnesium alloy
4. ,, ,, high alumina cement and castables
5. ,, ,, dense carbon aggregates for manufacture of carbon refractories and soderberg paste
6. ,, ,, 'Superal' aluminium anodes for cathodic protection
7. ,, ,, NML-PM 3 — aluminium alloy conductor
8. ,, ,, lead from lead concentrates
9. ,, ,, low carbon iron for soft magnets
10. ,, ,, electrolytic manganese metal
11. ,, ,, improved clay bonded and carbon bonded graphite crucibles.

PHOTOGRAPHIC, REPROGRAPHIC & PRINTING SERVICES

Photographic & Reprographic Services

(i) Technical Photography

Photographic services such as macro and photomicrography fracture photography as an aid to R & D work was rendered and proper documentation of various stages of the research projects was also done for illustration of the project reports.

(ii) Reprographic Services

Documentation work viz. photocopying, reflex prints etc. of technical papers as well as slide-making for presentation of papers in various technical conferences were attended to.

(iii) Photographic Services for Publicity and Exhibition

Big size artistically mounted blow-ups and colour translites of various NML expertizes were done for display at NML Museum as well as in various exhibitions in India and abroad.

(iv) General Photography

In addition to the technical assistance to the research projects, the general photographic needs of the laboratory such as of visits, seminars etc. were covered.

Printing Services

The printing & binding section has conducted the following types of jobs.

(i) Printing of monthly NML News Letter.

(ii) Printing of NML-Handouts on processes & products.

(iii) Printing of forms, letter heads etc. for the Laboratory & Field Stations.

(iv) Printing of cards & forms for Library & Research Divisions.

(v) Cover printing of technical reports and issues of Documented Survey on Metallurgical Developments.

(vi) Various types of printing needed for technical conferences, get-together, exhibitions etc.

(vii) Binding of technical reports, monthly issues of Documented Survey on Metallurgical Developments etc.

GENERAL

Recipients of Honours, Awards etc.

Dr. P. R. Khangaonkar, Scientist F, has obtained the 'Indranil Award' for 1976-77 from the Mining, Geological & Metallurgical Institute of India for his contribution in the field of ferro-alloys metallurgy.

Foreign Deputation/Training in India and Abroad

Prof. V. A. Altekar, Director	Deputed to Vienna to attend as an UN Consultant, the Working Group Meetings on (i) Iron Ores and (ii) Coking Coals, organised by UNIDO.
Dr. R. Kumar, Scientist	Deputed to Turkey to serve as an Expert on Solidification under UNIDO assignment.
	Deputed to Yugoslavia, Switzerland, France on a Creep study tour on a UNIDO fellowship. Also visited U.K. in connection with the CTPS enquiry work.
Shri G. P. Mathur Scientist	Deputed to Vienna on an UNIDO assignment in connection with "Establishment of an Industrial and Technical Data Bank for Iron & Steel Sector".
Shri G. N. Rao, Scientist	Deputed to U.S.A. under the India—U.S. Exchange Programme—National Science Foundation, Washington Visited some major malleable iron, S.G. iron, die—casting and investment casting foundries in U.S.A.
Shri P. C. Sen, Scientist	Deputed to German Democratic Republic on a bilateral exchange programme for visiting the Institute of Refractories and refractory industries in GDR.

Dr. Inder Singh, Scientist	Deputed to Japan for participation in the collaborative research work at National Research Institute for Metals in the field of 'Corrosion of metallic materials in natural environment in Japan'.
Mrs. K. Banerjee, Library Officer	Deputed to Vienna on an UNIDO assignment regarding processing the information materials for 'Industrial & Technological Data Bank for Iron & Steel Sector'.
Shri C. R. Tewari, Scientist	Participated in the Summer School Programme on 'Advanced Course of Metal Melting' at Regional Institute of Technology, Adityapur (Jamshedpur).
Shri C. A. Naresh Rao, Scientist	-do-
Shri R. Srinivasan, Scientist	Attended a training course relating to 'Demonstration on latest advances in analytical instrumentation' Organised by M/s. Blue Star in Collaboration with M/s. Perkin Elmer, Madras.
Shri R. U. K. Nayar, Storekeeper	Attended 'Stores management Course' conducted by Productivity Council, Madras.
Shri P. Viswanathan, Fine Mechanic	Attended a course in Tamil on 'Important aspect of moulding' organised by Institute of Indian Foundrymen, Madras.

Directorship, Chairmanship, Membership etc. on Outside Bodies

Prof. V. A. Altekar Director	Director	Bihar Industrial & Technical Consultancy Organisation.
	President	Indian Institute of Mineral, Engineers.
	Corresponding Member	XIth International Mineral Processing Congress.

Dr. R. Kumar, Scientist	Chairman	Indian Institute of Metals, Jamshedpur, Chapter.
	Member	Academic Council, NIFFT, Ranchi.
	Member	Materials Process Panel of Aeronautics R & D Board, Ministry of Defence.
	Member	Enquiry Committee, constituted by Ministry of Energy, Govt. of India ; regarding the cause of power failure in Chandrapura & Badarpur Thermal Power Station.
Shri G. P. Mathur, Scientist	Secretary	Indian Institute of Mineral Engineers.
Dr. P. R. Khangaonkar, Scientist	Member	Board of Studies, Madras University.
	Member	Southern Regional Council, Inst. of Indian Foundrymen.
Shri A. P. Chowdhury Scientist	Fellow	Iustitution of Instrumentation Scientists & Technologist (India).
Shri K. N. Srivastava Scientist	Member	Bihar State Research & Development Committee.
Shri G. N. Rao, Scientist	Member	Foundry Sectional Committee ISI/SMD—17.
Dr. L. P. Pandey, Scientist	Member	Member, ISI—SMDC : 2-Methods of Chemical Analysis.
Shri R. D. Gupta, Scientist	(i)	Member, Orthopaedic Instrument & Accessories Sectional Committee, ISI.

	(ii)	Alternate Member, Steel Castings Sectional Committee — SMDC : 20-ISI.
Dr. Manjit Singh, Scientist	(i)	Jt. Secretary, Indian Institute of Metals for the year 1977-78.
	(ii)	Member, SMDC II-ISI-Copper and Copper Alloys.
	(iii)	Alternate Member, SMDC 10-ISI-Light Metals and Alloys.
Shri Upkar Singh, Scientist		Member, Institution of Engineers.
Shri C. R. Tewari, Scientist		Member, ISI-SMDC 25/P-6 Panel on Code of Practice for Magnetic Flaw Detection.
Shri Santokh Singh, Scientist		Associate Member, Institution of Metallurgists, London.
Shri S. Rao Addanki, Scientist		Fellow Member, The Society for Advancement of Electrochemical Science & Technology, India.
Dr. S. K. Narang, Scientist		Fellow Electrochemical Society of India.
Shri T. R. Soni, Scientist	(i)	Member, Non-destructive Testing Society of India.
	(ii)	Member, ISI-SMDC-25-Panel of Non-destructionve Testing of Metals.
	(iii)	Member, ISI-SMDC-25/P-2 Panel of Ultrasonic Testing of Metals.
	(iv)	Member, SMDC-25/P-3-Panel of Reference blocks for routine checking of ultrasonic flaw detectors.

Shri S. Deb, S.S.A.	Associate Member of Indian Institute of Metals.

Lectures

A number of lectures were delivered by eminent Indian & Foreign Scientist, metallurgists etc. during the period. The following special leactures & addresses were delivered by the NML staff.

Name	*Subject*
Prof. V. A. Altekar,	(i) Sir Thomas Holland Memorial lecture for 1978 at the Mining, Geological & Metallurgical Institute of India, Calcutta.
	(ii) The inaugural address at the Summer School on 'Advanced Course in Metal Melting' at Regional Institute of Technology, Adityapur (Jamshedpur) organised by Indian Society for Technical Education.
	(iii) Chief Guest Address at the Fifth Seminar on "Tool, Alloy & Special Steel" at Madras, organised by Alloy Steel Producers' Association.
Dr. R. Kumar, Scientist	Special Lectures at the Summer School on "Advanced Course in Metal Melting" at RIT Jamshedpur.
Dr. P. R. Khangaonkar, Scientist	(i) 'Metallurgical research in Japan' at the Institution of Engineers, Madras.
	(ii) 'Iron & Steel making in India' at the Institution of Engineers, Trichy Sub-centre.
Dr. D. J. Chakrabarty Scientist	"External desulphurisation of hot metal and steel" at the summer school on "Advanced Course in Metal Melting" at RIT Jamshedpur.

Name	*Subject*
Shri R. D. Gupta, Scientist	"Sponge iron melting in electric arc furnace" at the Summer School on Advanced Course in Metal Melting at RIT, Jamshedpur.
Dr. Inder Singh, Scientist	'Corrosion prevention in Chemical plants' & 'Corrosion prevention and its control' at the lecture course organised by National Productivity Council, Calcutta.

Visitors

Nearly 1200 visitors visited the Laboratory. The category of visitors included state dignitories, foreign experts, entrepreneurs & industrialists, student etc. The following foreign expert visited the laboratory during the period.

Name	*Country*	*Purpose*
Dr. H. A. Davices, Dept. of Met., University of Sheffield, U.K.	U. K.	General visit.
Dr. T. Naniov, First Secretary, Embassy of the peoples Republic of Bulgaria.	Bulgaria	Exchange of Scientist Programme between India/Bulgaria.
Dr. M. J. Jonly, In-Charge, Minerology and Petrology Sec. Australian Mineral Div. Authority, Adelaide, Australia.	Australia	India/Australia Science and Technology Agreement.
Mr. R. F. Thomson, Managing Director, A. G. Egerton Engg. Co., (Bromly) Limited, Bromley, U.K.	U. K.	Demonstration of pneumatic crimp joining machine.
Dr. B. R. Nijhawan, Sr. (Inter-Reg.) Ind. Advisor and Chairman of the Task Force on the Iron & Steel Industry, UNIDO, Vienna.	Vienna	End of Review of the UNDP Assisted Project on Central Creep Testing Facility at NML & also to attend the UNIDO con-

Name	*Country*	*Purpose*
		sultation meeting on Adaptation of Steel Technology to the Needs of the Developing Countries.
Mr. Djoewito Atmovidjojo, Director, National Research Institute for Bandung, Indonesia.	Indonesia	Process for the production of lead and mineral dressing.
Mr. Sukarna Jaya, Asst. Director, National Res. Instt. for Metallurgy, Bandung, Indonesia.	-do-	-do-
Mr. Reno Demey, Metallurgist, National Res. Instt. for Metallurgy, Bundung, Indonesia.	-do-	-do-
Mr. Mohammad Daniles, Metallurgist, Nat. Res. Instt. for Metallurgy, Bandung.	-do-	-do-
Dr. Dertile Berg, Managing Director, Foundation for Metallurgical Research, MEFOS Lulca.	Sweden	Swedish Technical Experts.
Dr. Theo Lehner, Research Metallurgist, MEFOS, Lunea.	-do-	-do-
Dr. Staffan Ekelund, Head Dept. of Mechanical Metallurgy, Sweden Institute for Metals Research, Stockholm, Sweden.	-do-	-do-

Name	*Country*	*Purpose*
Dr. T. Fukushima, Technical Officer, The Prime Ministers' National Research Instt. for Metals, Tokyo, Japan.	Japan	Collaborative Research Project.
Acadomincian Kolotyrkin, Director, Karpov Instt. of Physical Chemistry, MOSCOW.	U S S R	General Visit.
I. A. Stapanow, Director, Senior Scientist Ship Building Tech. Instt., Leningrad.	-do-	-do-
Mr. D. I. Denisove, Interpreter.	-do-	-do-
Mr. R. P. Selton, Central Electricity Research Laboratory, CEGB, U.K.	U. K.	-do-

Activities of Societies, Club and Canteen

NML Staff Co-operative Credit Society continued its transaction and circulated nearly eight lakhs of rupees. Besides, giving loan, the Credit Society is also operating Savings accounts for the members. Dividends to share holders are given. The NML Co-operative Stores maintained the supply of food grains, e.g. wheat, sugar, rice at the controlled rate. The NML Canteen catered to the staff members daily snacks, lunch, tea & coffee at reasonable rate.

The NML club maintained its sporting, cultural and social activities. The club organised various indoor tournaments including cards, chess, table tennis, badminton etc. facilities were also

provided by the club for playing these games. A football tournament between the various sections and divisions of the Laboratory & pilot plants was organised. Cricket practice was arranged. The club also subscribes to various magazines and newspaper for the Members. Periodic film shows were also held.

The kindergarden schools at Agrico and Tuliadungri colonies were managed efficiently. There is a regular rise of students in these two schools. Music, art and dance classes were held regularly.

Purchase & Stores

Purchase & Stores kept up their activities by procurement of capital equipment, raw materials, consumable stores for various research and development projects, construction and maintenance work.

Administration & Accounts

Administration & Accounts Section handled the administrative and budgetory affairs of the Laboratory.

Safety First & First Aid Sections

Safety measures are enforced for operating the various plant equipments of the Laboratory, gas pipe line etc. and inspection of safety measures was carried out periodically. There was no major casualty.

The dispensaries and first aid sections were strengthened. The dispensaries in the residential colonies of the NML Staff rendered service to the Staff members and their families. The first aid sections at NML main building & pilot plants attended the minor injuries. Medicines were given to the ailing staff members.

Staff Position (Sanctioned Strength excluding Class IV)

Scientific	251
Technical/Auxiliary Technical	630
Administrative	188
Research Fellows	17

Budget Figures

Recurring (Non-Plan)

Figures in Lakhs of rupees (1 Lakh = 10^6)

P-1	Pay of Officers	21.800
P-2	Pay of Establishment	26.610
P-3	Allowances & Honororium etc.	28.460
P-4	Contingencies	14.500
P-6	Maintenance	2.700
P-7	Chemicals	12.130
	Total	106.200

Capital (Non-Plan)

P-5	Apparatus & Equipment (replacement)	5.000
P-5	(4) Library books & journals	2.000
	Total	7.000

Recurring (Plan)

P-1	Pay of Officers	2.550
P-2	Pay of Establishment	3.120
P-3	Allowance & Honorarium etc.	3.330
	Total	9.000

Capital (Plan)

P-5(1)	Works	10.000
P-5(2)	Services	5.000
P-5(3)	Equipment (Addition)	25.000
P-5(4)	(i) Furniture (Addition)	0.500
	(ii) Vehicles (Addition)	1.200
	Total	41.700

Pilot Plants (Plan)

PP-1 (i)	Equipment	3.500
PP-1 (ii)	Building & Services	1.000
PP-2	Provision for staff	12.500
PP-3	Purchase of raw materials	0.500
PP-4	Miscellaneous & Contingencies	3.000
	Total	20.500

Hydro-Electro Metallurgy Project (Plan) 15.500

Grand Total **199.900**

APPENDIX I

Papers Published, Communicated and Presented

1. Heat resistant cast iron — S. D. Dhanjal, C. A. Naresh Rao, G. N. Rao & V. A. Altekar, NML Technical Journal Vol. 19 (2) 1977.
2. Preparation of anhydrous magnesium chloride in fluidised bed — P. K. Som, S. K. Roy Choudhury & H. K. Chakrabarti, NML Technical Journal Vol 19 (2) 1977.
3. Quantitative estimation of elements and compounds by X-ray integrated intensity measurements — Mrs S. Devi & S. K. Bose; NML Technical Journal, Vol. 19 (2) 1977.
4. Spectrophotometric determination of vanadium by diphenyl carbazide — L. P. Pandey; NML Technical Journal Vol. 19 (3 & 4) 1977.
5. Comprehensive methods of chemical analysis of low alloy steel — P. Sanyal, Rajeev & K. K. Gupta; NML Technical Journal Vol. 19 (3 & 4) 1977.
6. Rapid indirect volumetric method for determination of silicon in ferro-silicon — S. N. Jha, A. C. Biswas & H. P. Bhattacharya; NML Technical Journal, Vol. 19 (1977) 3 & 4.
7. Ferro-chrome slag as hardener for sodium silicate bonded sand — S. K. Sinhababu, S. K. Sinha & G. N. Rao; NML Technical Journal, Vol. 19 (3& 4) 1977.
8. Corrosion of steel reinforcement in concrete structures — A case study of concrete roof collapse — S. Rao Addanki, K. P. Mukherjee & V. A. Altekar; Communicated at the Workshop on "Corrosion & Control" organised by SAEST.
9. Absorption of thiourea & its derivatives on different carbon steels — M. K. Banerjee & Inder Sing same as item 8.
10. Electrochemical measurements for the evaluation of an anti-corrosion formulation — K. Chandrasekhar Pillai & K. P. Mukherjee; same as item 8.
11. Failure analysis of a water pump impeller — R. D. Gupta, R. Kumar, & V. A. Altekar, presented at the Workshop on "Materials for Erosion & Corrosion" organised by National Productivity Council, New Delhi.
12. Super hard materials for erosion and corrosion — V. A. Altekar, same as item 11.
13. Super hard materials for erosion and corrosion — Status of indigenous development — R. D. Gupta, same as item 11.
14. Graphite beneficiation at NML — M. V. Ranganathan, N. Chakravarty & V. A. Altekar; communicated at the Seminar on

"Resources for Engineering Technology" organised by IIT Bombay.

15. Control of inclusion morphology and cleanliness of steel by rare earth addition — D. J. Chakravarty, R. N. Guin & V. A. Altekar ; Presented at the Fifth Seminar on "Tool, Alloy & Special Steel" organised by Alloy Steel Producers Association and published in Tool & Alloy Steel Vol. 12 (3) March 1978.
16. Aluminium — Challanges and prospects — R. Kumar ; 119th Anniversary number of Indian & Eastern Engineer, pp. 61-64 1977.
17. Some applications of Scanning electron microscope in material science and technology — N. K. Das, A. N. Sinha, S. K. Bose & R. Kumar TISCO technical Journal, July 1977.
18. Materials for electrical and electronic industries — R. Kumar ; Key note paper presented at the Seminar on "Metals and Materials in Electrical Industries "organised by Institute of Engineers (India), Vadodara, Feb. 1978.
19. Development of aluminium alloys for electrical applications — R. Kumar, Manjit Singh & Kishori Lal ; Same as item 18.
20. Liquid state treatment — an emerging technology ; key note lecture by R. Kumar — Internation conference on "Metal Sciences — The Emerging frontiers" organised by Metal Science Division of Ind. Institute of Metals & Deptt of Metallurgical Engineering, Banaras Hindu University.
21. Metastability and structural transition of rapidly solidified aluminium alloys from the liquid state — S. K. Bose & R. Kumar ; same as item 20.
22. Models for liquid metals — A metallurgical appreciation — C. S. Sivaramakrishnan & R. Kumar ; same as item 20.
23. Structure and mechanical properties of rapidly cooled aluminium alloys — V. V. Rao, S. P. Mukherjee & R. Kumar ; Same as item 20.
24. Grain refinement in aluminium-manganese alloys — R. Kumar, A. N. Sinha & V. V. Rao ; same as item 20.
25. Ausrolling of spring steel for automobile application — S. P. Chakrabarty, S. P. Choudhury & R. K. Dubey ; same as item 20.
26. Filtration of aluminium and its alloys — R. Kumar & C. S. Sivaramakrishnan ; presented at the 3rd Annual Technical Conference on "Recent Development in Non-ferrous Technology" held at Ind. Instt of Science, Bangalore.
27. Some application of SEM in material science & technology — N. K. Das, A. N. Sinha, S. K. Bose & R. Kumar ; Tisco Technical Journal Vol. 24 (3), July 1977.
28. Effect of residual elements and pouring temperature on the cast

morphology of Al-Si alloys — N. K. Das, R. K. Mohanty C. S. Sivaramakrishnan & R. Kumar ; Aluminium, Vol. 53, Nov. 1977.

29. Structure of liquid aluminium-silicon alloys modified with Na, P and S — R. Kumar, C. P. Sivaramakrishna & R. K. Mohanty ; Aluminium, Vol. 53, June 1977.
30. NML — PM 2 conductor — A special versatile electric grade aluminium alloy conductor — R. Kumar, & Manjit Singh, Communicated for presentation at a Meeting on "The aluminium applications in the electric field" in Itally Feb. 1978.
31. Why NML PM 2 — An electric grade aluminium alloy ? R. Kumar; Railway world, Vol. III, No. 4, 1977.
32. Quality control in Conductor and cable industries — Manjit Singh & R. Kumar, presented at the Conference on "Modernisation of Cable and Wire Industries" convened by Small Industries Service Institute, Patna, January 1977.
33. Correlation of stress corrosion susceptibility of medium strength weldable Al-Zn-Mg alloys with precipitate distribution and morphology — R. Kumar, B. K. Saxena & Kishori Lal ; presented at the Symposium on "Structure Property Correlation & Instrumental Techniques in Materials Research" organised by Dept of Atomic Energy, held at Regional Engg. college, Rourkela, Oct. 1977.
34. Beneficiation of some of the Indian clays for industrial purposes —M. V. Ranganathan & N. Chakraborty ; Mineral Wealth, Vol. XIII(2), July-December 1977.
35. Thermal beneficiation studies on rock phosphate from Rajasthan —T. C. De, N. Chakraborty & G. P. Mathur ; presented at the 30th Annual Technical Meeting of Indian Instt. of Chemical Engineers at Chandigarh, December 1977.
36. Recovery of copper values from copper slag—D. M. Chakraborty ; Proc. of the Symposium on "Utilisation of Mineral and Metallurgical Waste & By-products" organised by Regional Research Laboratory, Bhubaneswar & Ind. Instt. of Metals, Bhubaneswar Chapter, Dec. 1977.
37. Agglomeration studies on LD Dust from Rourkela Steel Plant— H. Patnaik ; same as item 36.
38. Utilization of fine grained raw materials for the production of high phosphorous iron—J. Goswamy, A. N. Kapoor & V. A. Altekar ; same as item 36.
39. Recovery of tin from tin plate scrap—B. N. Singh ; same as item 36.
40. Studies on the recovery of tellurium and selenium from solution by cementation—Narinder Singh, S. B. Mathur & V. A. Altekar ; same as item 36.

41. Recovery of iron powder from waste pickle liquor—S. N. Sinha & S. K. Roy, same as item 36.
42. Role of NML in the beneficiation of raw materials for refractory and ceramic industries—A. Peravadhanulu & S. K. Banerjee, Presented at the All India Seminar on "Raw Materials for Glass, Ceramic and Refractory Industries" organised by GSI, Shillong.
43. Processing of industrial minerals and ores at NML with special reference to Gujarat—A. Peravadhanulu, S. K. Banerjee & G. P. Mathur ; communicated for publication in Mineral Wealth.
44. Surface phenomena in the flotation of minerals—B. Rama Devi, & P. R. Khangaonkar ; Presented at the Symposium on "Surface Phenomena in Metallurgical Process" organised by IIT Bombay & Ind. Inst. of Metals Bombay Chapter, April 1977.
45. Liberation Analysis—C. Satyanarayana & P. R. Khangaonkar ; presented at the 31st Annual Technical Meeting of Ind. Instt. of Metals, November 1977.
46. Use of castables and high alumina refractory for lining reheating furnaces—M. C. Kundra & K. K. Singh ; presented at the seminar on "Refractories for Reheating and Heat-treatment Furnaces" organised by Indian Ceramic Society, Jamshedpur Chapter, January 1978.
47. Fibre insulating refractories in reheating and heat treatment furnaces—A. K. Bose & M. R. K. Rao ; same as item 46.
48. Thermal conductivity of some indigenous refractories—K. C. Ray, P. C. Sen, N. B. Sirkar & M. R. K. Rao ; same as item 46.
49. Development of zircon refractories by chemical bonding—M. C. Kundra R. V. Hargave, T. K. Gangadharan & M. R. K. Rao ; presented at the 31st Annual Session of Indian Ceramic Society, April 1977.
50. Calcination studies on Maharashtra kyanite—M. C. Kundra & H. P. S. Murthy same as item 49.
51. Quantity of binder as a factor affecting the properties of carbon pastes—H. P. S. Murthy, B. Chatterjee, N. B. Sirkar & B. K. Mitra ; Indian Journal of Technology, Vol. 15, October 1977.
52. Use of dense carbon aggregate as material for soderberg paste —M. C. Kundra, B. Chatterjee, N. B. Sirkar, M. R. K. Rao, K. R. K. Rao & H. P. S. Murthy—Presented at the Seminar on "Carbon Technology" organised by BALCO, March 1978.
53. Mineralogy and liquidus behaviour of Indian blast furnace slag— R. V. Hargave & M. R. K. Rao ; presented at the Annual Session of Indian Ceramic Society (Golden Jubilee) at New Delhi, March 1978.
54. Round up on research in foundry and metal solidification at

India's National Metallurgical Laboratory—P. K. Gupta ; International Cast Metals Journal, Vol. 2, No. 4, December 1977.

55. Economic utilisation of some ferro-alloys in steel making—N. Subramanyan, D. D. Akerkar & V. A. Altekar ; presented at the Seminar on "Recent Trends in the Production of Ferro-alloys" organised by Institute of Engineers, Nagpur, Dec. 1977.
56. Small scale powder metal production possibilities—M. J. Shahani ; presented at the Annual Meeting of Powder Metallurgy Association of India, February 1978.
57. Atomized copper and copper based powders—R. G. Ganguly, Upkar Singh, M. J. Shahani & V. A. Altekar ; The Metallurgist & Materials Technologist, January 1978.
58. Chlorination of magnesites—P. K. Som, S. K. Roychoudhury & S. C. Aush—Trans of Ind. Instt. of Metals ; Vol. 30, No. 2, April 1977.
59. External desulphurization of hot metal and steel—Status survey —D. J. Chakravarty & A. K. Basu ; Proceedings of the Symposium on "Recent Developments in Steel-making, Castings & Forgings, organised by BHEL, Hardwar, Oct. 1977.
60. Heavy forgings of alloy steels—R. K. Dubey & S. K. Gupta ; same as item 59.
61. Explosive forming, welding and compaction of metal powders—S. K. Banerjee, J. Bhattacharya & B. N. Ghose ; the Indian & Eastern Engineer, 119th Anniversary Number.
62. Thermostatic bimetals—J. Bhattacharya, B. N. Ghose & S. K. Banerjee ; The Indian & Eastern Engineer, 119th Anniversary Number.
63. Development of thermostatic bimetals for electrical industries—J. Bhattacharya, B. N. Ghose & S. K. Banerjee ; Proceedings of the National Seminar on "Metals & Materials in Electrical Industries "organised y Inst. of Engineers (India), Vadodora, February 1978.
64. Some technological factors influencing the SCC of high strength weldable Al-Zn-Mg alloys—B. K. Saxena, K. Lal, C. S. Sivaramakrishnan & R. Kumar ; Presented at the Conference on "Recent Developments in Non-ferrous Metal Technology", held at Ind. Instt. of Science, Bangalore, August 1977.
65. Heat treatment and magnetic properties of some Alnico alloys—Ved Prakash & C. R. Tewari ; TISCO Technical Journal, July 1977.
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73. Corrosion and its prevention during transit and storage—Inder Singh & V. A. Altekar ; Presented at First National Conference on "Corrosion & its Control" organised by SAEST, June 1977.
74. Standard reference materials—The role of NML—P. Sanyal & L. P. Pandey ; presented at the 47th Annual Convention of the National Academy of Sciences, March 1978.
75. Standard samples—Preparation, standardisation and their utilisation—V. A. Altekar & L. P. Pandey ; communicated for publication in ISI Bulletin.
76. X-ray fluorescence spectrometry in metals and minerals analysis —S. C. Srivastava ; communicated for publication in Journal of Mines, Metals & Fuels.
77. Recent advances in potentiostat in electrochemical science and corrosion technology—A. P. Choudhury & P. K. Bagchi ; presented at the Symposium on "Instrumentation" organised by Institution of Instrumentation Scientists & Technologists, January 1978.
78. Projects at NML for small scale sector—V. A. Altekar ; Communicated to Small Industries Service Instt. Patna.
79. Some recent achievements of NML—B. M. Dutt & K. N. Srivastava ; Indian Nation, 20.1.1978.
80. Cold heading of steels—S. S. Bhatnagar ; presented at the 5th Seminar on "Tool & Alloy & Special Steel" organised by Alloy Steel Producers' Association.
81. A basis of selection of through hardening steels—S. S. Bhatnagar, Presented at the Seminar on "Alloy steels for Automobile Industries" organised by Ind. Instt. of Metals, Durgapur Chapter.

82. Determination of lead in barium ores—V. N. Choudhury, K. C. Ghose, K. C. Misra, B. C. Mukherjee & A. K. Chatterjee ; communicated for publication in Journal of Institution of Chemists (India).
83. Some observations on material selection and corrosion problems encountered in Oil refinery and petrochemical industries—G. G. Nair, B. N. Halder & R. Kumar ; communicated for publication in Chemical Engineering World.

APPENDIX II

Research & Investigations Completed and Reports Prepared

1. Flotation studies on a composite sample of rock phosphate from Jhamarkotra received from Rajasthan State Mines & Minerals Ltd.—S. Prasad, K. K. Bhattacharya, T. C. De, N. P. Srivastava, N, Chakravarty & G. P. Mathur (IR 920/77).
2. Studies on thermal beneficiation of rock phosphate sample from Jhamarkotra region of Rajasthan—A. K. Saha, Dr. A. K. Nayak & D. D. Akerkar (IR 920/77).
3. Beneficiation and Pelletisation studies on a few iron ore fines samples from Bihar — Orissa Region for Central pelletisation project of Steel Authority of India Ltd.—N. Chakravarty, H. Patnaik & G. P. Mathur (IR 921/77).
4. Bench scale beneficiation studies on Cu-Pb-Zn complex sulphide ore samples from Ambaji, Mines of GMDC Ltd.—D. M. Chakraborti, S. K. Sengupta, S. K. Banerjee & G. P. Mathur (IR 922/77).
5. Leaching studies of low grade copper ore fines Chapri—D. Jha, D. Baghchi, M. Yassen & D. D. Akerkar (IR 923/77).
6. Determination of certain physical characteristics of a limestone sample received from M/s. Tata Robins Fraser Ltd, Jamshedpur —P. N. Pathak, M. V. Ranganathan & S. K. Banerjee (IR 924/77).
7. Beneficiation of low grade phosphate from Purulia dt., West Bengal received from M/s. Sadama Enterprises, New Delhi— P. D. Prasad Rao, V. K. Sharma, S. K. Banerjee & G. P. Mathur (IR 925/77).
8. Moulding characteristics of Kagna river sand marked No. 1 received from ACC Vickers Babcock Ltd., Shahabad—R. R. Dash & G. N. Rao (IR 926/77).
9. Moulding characteristics of National river sand marked No. 2 received from ACC Vickers Babcock Ltd., Sahabad—R. R. Dash & G. N. Rao (IR 927/77).
10. Moulding characteristics of glass sand sample No. A received from State Mining Corpn. Lucknow, U.P.—S. K. Sinhababu, T. A. Beck & G. N. Rao (IR 928/77).
11. Moulding characteristics of glass sand sample No. B received from State Mining Corpn. Lucknow, U.P.—S. K. Sinhababu, T. A. Beck & G. N. Rao (IR 929/77).
12. Determination of Bonds work index of a basic steel plant slag sample, received from M/s. Hindustan Steel Ltd., Ranchi P. N. Pathak, D. M. Chakraborty & S. K. Banerjee (IR 930/77).

13. Beneficiation studies on a low grade magnetite sample from Nainarmalai, Tamil Nadu—K. Vijayaraghavan, P. V. Raman & P. R. Khangaonkar (IR 931/77).
14. Bench scale beneficiation studies on a bulk sample of tin bearing pegmatite (Mother Rock) from Kupli hills, Bastar dt. from the Director Geology & Mining, Raipur, M.P.—P. N. Pathak, M. V. Ranganathan, S. K. Banerjee & G. P. Mathur.
15. Report on digestion tests on bauxite sample received from M/s. National Industrial Development Corporation Ltd. (A Govt. of India Enterprises)—M. S. Mahanty, C. Sankaran & D. D. Akarkar (IR 933/77).
16. Beneficiation of a tourwative bearing kyanite sample from Pardi Mines, Bhandara Dist. Maharashtra received from Maharashtra Minerals Corp.—N. Chakravarty, A. K. P. Srivastava, M. Rafiuddin & G. P. Mathur (IR 934/77).
17. Studies on reduction of iron content of silica sand samples from state Mining and Development Corpn. Lucknow, U.P.—U. J. Chattraj, S. R. Ghosh, P. K. Sinha, B. L. Sengupta, N. Chakravarty & G. P. Mathur (IR 935/77).
18. Beneficiation of low grade phosphate from Purulia Dist. West Bengal received from M/s. Fertilizers Corpn. of India Ltd., Sindri —P. D. Prasad Rao, V. Ramaiah, S. K. Banerjee & G. P. Mathur (IR 936/77).
19. Determination of Bond's work index for dead burnt Magnesite sample received from M/s. Orissa Cement Ltd.—S. K. Sil, D. M. Chakravorty, S. K. Banerjee—(IR 937/77).
20. Beneficiation studies on a low grade Baryte sample V. Mohan, P. V. Raman & P. R. Khangaonkar (IR 938/77).
21. Development of clay graphite stopper heads—K. K. Singh, & M. R. K. Rao (IR 939/77).
22. Moulding properties of Kagua & National River sands designated No. 1 to No. 2 respectively blended at various proportion—R. R. Dash & G. N. Rao (IR 940/77).
23. Microstructural study on "All India specimen"—R. Kumar, B. S. Saxena, C. S. Sivaramakrishnan (941/77).
24. Reduction of silica content of a magnesite sample from Salem —Madras—S. K. Sil, S. N. Prasad, S. C. Maulick R. Ganesh & N. Chakravorty (IR 942/77).
25. Studies on exposure tests lacquer coated brass sample—D. K. Khan & D. K. Basu (IR 943/77).
26. Beneficiation studies on chromite samples from Mysore Minerals, K. Vijayaraghavan, P. V. Raman & P. R. Khangaonkar.
27. Beneficiation studies on a low grade graphite sample from Almora

Dist. received from Geological Survey of India—A. K. P. Srivastava, P. D. Prasad Rao & S. K. Banerjee (IR 945/77).

28. Bench scale beneficiation studies on a low grade graphite from Manasoti Area, Daltonganj, Bihar, M. Das, N. Chakravorty & G. P. Mathur (IR 946/77).
29. Beneficiation and filtration studies on Iron ore slime samples received from Bursua Iron Ore Beneficiation Plant of Rourkela Steel Plant of HSL—A. K. P. Srivastava, H. Patnaik, N. P. Srivastava & N. Chakravorty (IR 947/77).
30. Investigation of the failure of a waste heat boiler tube at the FCI Namrup—K. M. Choudhury, R. Singh, S. C. Bose & R. Kumar (IR 948/77).
31. Baking studies on clay graphite pencil leads from M/s. Madras Pencil Factory, Madras—T. K. Gangadharan & P. R. Khangaonkar —(IR 949/77).
32. Investigation on sand sample received from M/s. Jamshedpur Engineering & Machine Manufacturing Co. Ltd., Jamshedpur — S. K. Sinhababu, T. A. Beck & G. N. Rao (IR 950/78).
33. Investigation report on the suitability of high manganese slag, supplied by Ferro-alloys Corporation Ltd. Garividi for production of manganese sulphate—P. L. Sengupta, N. Dhananjayan (IR 951/78).
34. Extraction of alumina from Nileshwar Bauxite Kerala sponsored by M/s. Kside, Kerala—P. R. Mukundan, K. Vijayaraghavan, P. V. Vishwanathan, C. Satyanarayana, C. Shankaran & P. R. Khangaonkar (IR 952/78).
35. Defects in aluminium & sheets—R. Kumar, Kishorilal, P. K. Ghosh & A. K. Mishra (IR 953/78).
36. Reducation characteristics thermal degradation and alkali determination of daitory iron ore from M/s. Orissa Mining Corporation, Bhubaneshwar—A. K. Sinha Mahapatra & K. N. Gupta (IR 954/78).
37. Determination of physical characteristics and mineralogy on process secondaries received from M/s. Indian copper complex of HCL, Ghatsila—B. Banerjee, S. N. Prasad, A. Peravadhanlu & S. K. Banerjee (IR 955/78).
38. Investigation of Kutch Bentonite Marked DBI from M/s. Ambica Minerals Kutch, Gujarat State—R. R. Das & G. N. Rao (IR 956/78).
39. -do- DB 2 (IR 957/78).
40. -do- DB 3 (IR 958/78).
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Minerals Gujarat—R. R. Dash & G. N. Rao (IR 962/78).

45. -do- SH (IR 963/78).
46. -do- SH (IR 964/78).
47. -do- SH (IR 965/78).
48. Beneficiation studies on complex Cu-Pb-Zn sulphide ore sample from Sargipalli Mines, Orissa of M/s. Hindustan Zinc Ltd.—D. M. Chakrabarti, S. K. Sengupta, S. R. Banerjee, G. P. Mathur (IR 966/78).
49. Reduction characteristics and thermal degradation behaviour of Sakaradih Iron Ore—A. K. Sinha Mahapatra & K. N. Gupta (IR 976/78).
50. Batch scale beneficiation studies of low grade manganese ore sample designated as small clips (varies) received from Aryan Mining & Trading Corporation (P) Ltd.—M. C. Das, S. K. Sil, N. P. Srivastava & N. Chakravarty (IR 968/78).
51. Suitability of the manganese ore sample supplied by directorate of Geology and Mining, Govt. of Gujarat for the production of electrolytic Manganese dioxide—N. Dhananjayan & P. L. Sengupta (IR 969/78).
52. Leachibility of Mosabani and Malanjkkhand copper ores by micro organisms — A comparative study—A. K. Saha, S. R. Srinivasan & D. D. Akerkar (RR 367/77).
53. Recovery of copper from dilute process streams — comparative cost study of conventional and solvent extraction process— A. K. Saha, S. R. Srinivasan & D. D. Awerkar (RR 368/77).
54. Purification of Molybdenite concentrate from Jadugoda mines by ferric chloride leaching—A. K. Saha, S. R. Srinivasan, D. D. Akerkar & V. A. Altekar (RR 369/77).
55. Studies on purification of Molybdenite concentrate—A. K. Saha, S. R. Srinivasan, D. D. Akerkar (370/77).
56. Studies on thermal decomposition of manganese carbonate for the production of battery grade Manganese dioxide—M. G. Bodas, D. D. Akerkar (RR 371/77).
57. Calcination studies on Maharashtra Kyanite—M. C. Kundra & H. P. S. Murthy (RR 372/77).
58. Development of Zircon refractories by chemical bonding—M. C. Kundra, T. K. Gangadharan, R. V. Hargave & M. R. K. Rao (RR 373/77).
59. Steel supported annealed ML-PM2 conductor—A new concept for distribution lines—R. Kumar (RR 374/78).
60. NML-PM2 conductor—A special versatile Electric Grade Alloy Alluminium Conductors—R. Kumar & Manjit Singh (RR 375/78).
61 Bench scale beneficiation studies on low grade graphite samples

from M/s. Bihar Mineral Development Corporation—P. N. Pathak, M. V. Ranganathan, N. Chakravarty & S. K. Banerjee (RR 376/78).

62. Reduction of ash content from the middling (sink) of the Pugda coal washery—P. D. Prasad Rao & N. Chakravorty (RR 377/78).
63. Thermal beneficiation studies on rock phosphate from Rajasthan —T. C. Dey, N. Chakravorty & G. P. Mathur (RR 378/78)
64. Ferro-Chrome slag as hardner for sodium silicate bonded sand —S. K. Sinhababu, S. K. Sinha, G. N. Rao (RR 379/78).
65. The effect of humidity and temperature on the hardening characteristics of sodium silicate bonded self setting sand mixes— G. N. Rao, S. K. Sinha, T. A. Beck (RR 380/78).
66. Quality control in conductor & cable industries—Manjit Singh & R. Kumar (RR 381/78).
67. Use of castables and high alumina refractories for lining reheating furnaces — M. C. Kundra, & K. K. Singh (RR 382/78).
68 Use of dense carbon aggregate as a base metal for soderberg electrodes — M. C. Kundra, B. Chatterjee, N. B. Sarkar M. R. K. Rao, K. R. K. Rao & H. P. S. Murthy. (RR 383/78).