NML

Annual Report

1976-77

National Metallurgical Laboratory

Jamshedpur, India

ANNUAL REPORT

1976-77

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

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INTRODUCTION

The National Metallurgical Laboratory, during the period under review, has further geared up its research and development activities towards industrial scale implementation through transfer of technology, consultancy service, product development work etc. 1000 tonnes/annum electrolytic manganese dioxide plant is under installation by M/s. T. K. Chemicals Ltd. at Trivandrum based on the NML developed technology. The plant is expected to go into production in August 1977. The Laboratory has also furnished consultancy service to M/s. S. G. Enterprise, Ranchi; regarding design, specifications of equipment etc. for recovery of vanadium pentoxide from alumina sludge based on the NML process. The plant is expected to go into commission in 1977 to produce 54 tonnes of V_2O_5 from Hindalco sludge. The Laboratory is assisting M/s. Rajasthan Graphite (P) Ltd., Calcutta; in setting up a graphite beneficiation plant at Udaipur. In connection with the setting up a steel plant in Nepal, the Laboratory is assisting the consultant of the project, M/s. M. N. Dastur & Co; on evaluation of the raw materials from Nepal and their electric smelting.

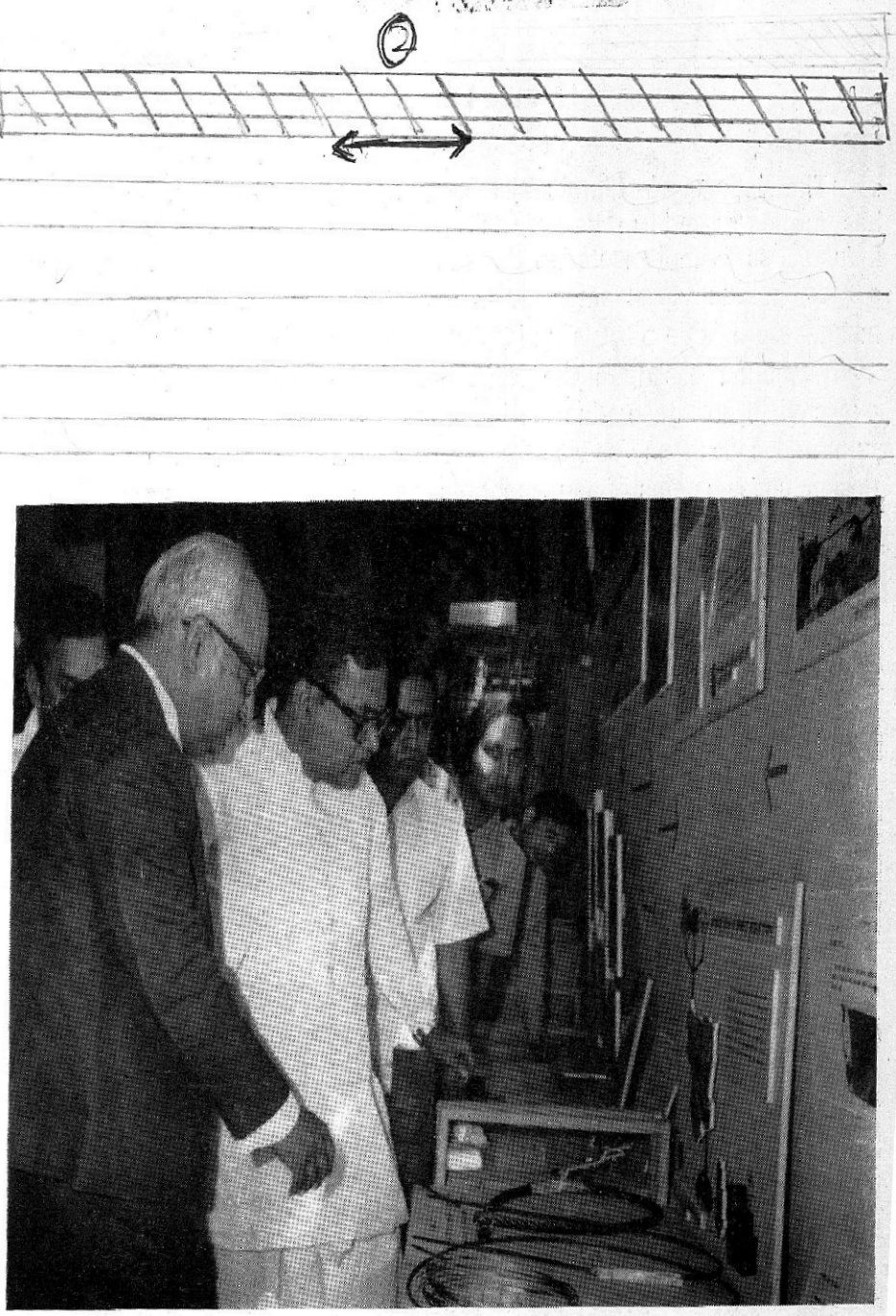
In the field of NML-PM2 alloy aluminium conductor, various product development work is underway. This alloy is now commercially produced by two firms and the technology has been transferred to another firm.

The dental amalgam alloy developed by the Laboratory has been licensed to two firms and its commercial production has been started by M/s. Shakti Industries, Varanasi. The technology of electrical resistance alloys has been transferred to another firm, M/s. Met. Industries, Calcutta.

On behalf of M/s. Hindustan Copper Ltd: Pyrites, Phosphates & Chemicals Ltd; National Mineral Development Corporation; Bharat Coking Coal Ltd; State Geology & Mining Departments and other organisations; beneficiation and agglomeration studies have been conducted on iron ore, copper ore, lead-zinc ore, graphite, magnesite, phosphate, fluorspar, kyanite etc.

The development and testing of high temperature creep resistant steels as per the agreement made with M/s. Bharat Heavy Electricals Ltd., is progressing satisfactorily. The Laboratory is also assisting Reactor Research Centre, Kalpakkam; by undertaking testing of creep behaviour of structural components of test reactor being built by the Reactor Research Centre.

Large scale successful smelting trials in oil fired furnace have been conducted on the extraction of lead from lead concentrate by a new technique (NML-ALNAMA process). A large number of sponsored investigations have been conducted on service failure of metals and alloys.



Prof. V. A. Altekar, Director, explaining to distinguished visitors NML developed products at the CSIR-Govt-Industry Get together at Patna.

The Laboratory has entered into an agreement through CSIR with Metallurgical & Engineering Consultants (MECON), India, Ltd.; for promoting the development of metallurgical industries from research and development level to a commercial scale. Under this agreement, MECON and NML would jointly carryout the work for the study, scale-up, input, development and commercial exploitation of processes and products developed or those to be developed by NML. This also includes preparation of pre-investment feasibility report, assistance in marketing and detailed engineering services.

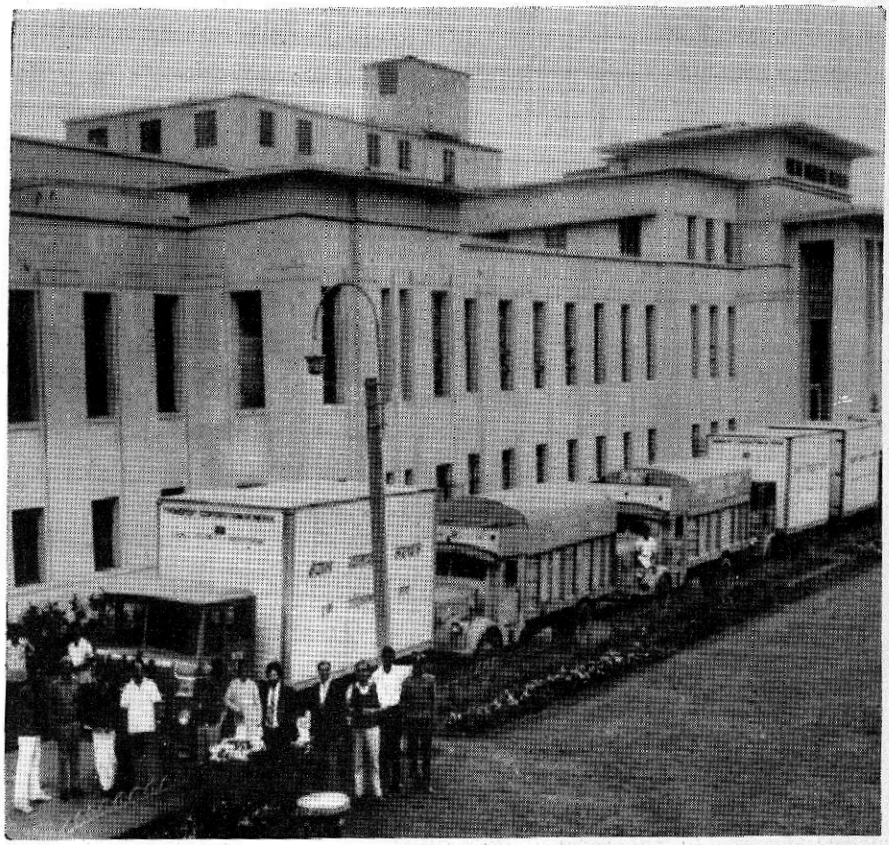
The Laboratory is contemplating to enter into an agreement with M/s. Visvesvaraya Iron & Steel Ltd., regarding the transfer of technology for the production of vanadium bearing slag from vanadiferous iron ores which exist near Bhadravati.

The various Field Stations are assisting the industries of the respective localities through undertaking investigations on their behalf, providing service facilities for analysis and testing of their products, rendering technical assistance and on the spot study of their problems and furnishing solutions. The equi-blast-cum-balanced blast cupola has been set up by more foundries in northern regions based on the design developed by the Field Station at Batala. The NML unit in CSIR Complex at Madras has progressed in diversification of its field of activities. The setting up of ore dressing section in Ahmedabad and metallographic sections in Batala and Howrah Field Stations are progressing satisfactorily. The Marine Corrosion Research Station at Digha is conducting valuable studies on the corrosion of metals and alloys under marine atmosphere.

The 'NML Technical Journal, has received the National Award for its excellence from Directorate of Advertising & Visual Publicity, Ministry of Information & Broadcasting, Govt. of India.

The Laboratory actively participated in organizing the 'CSIR-Industry-Government, Get-together at Patna and Get-together on 'Refractories, Glass & Ceramic Industries in Bihar, at NML. The various products and process developed were exhibited in a number of exhibitions held in different parts of the country.

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



A convoy carrying pig iron smelted at NML to Nepal; from Nepal iron ore.

RESEARCH, INVESTIGATION & DEVELOPMENT PROJECTS

A. ORE DRESSING & MINERAL BENEFICIATION

1.0 Pilot Plant Studies on Beneficiation of Composite Iron Ore Sample from Bailadila No. 4 Mines. *Sponsored by National Mineral Development Corporation.*

Bailadila No. 4 Mines is being developed to meet the requirements of lump ores and fines for the proposed Vishakhapatnam Steel Plant as well as for export purposes.

Detailed studies on crushing, shatter, screening (wet and dry), washing, hydrocycloning, filtration etc. on a composite iron ore sample prepared by mixing in proper proportion five types of ore samples received from Bailadila No. 4 mines were carried out. The tests established that the overall −40+10 mm lumps obtained from wet screening can be directly used for blast furnace, while the underflow from hydrocycloning of slime could be mixed with classifier sand and used for agglomeration.

1.1 Pilot Plant Studies on Beneficiation of Five Iron Ore Samples of Bailadila No. 4 Mines. *Sponsored by National Mineral Development Corporation.*

Five types of iron ore samples (Types I to V) from Bailadila No. 4 mines were received for beneficiation studies including various other tests. These tests were carried out accordingly to "Testing Programme". The size of iron ores varied from about 200 mm down to fines except type V sample, which was mostly fines.

From the test results, it was concluded that −40+10 mm lumps obtained from all the type samples can be directly employed for blast furnace smelting while the classifier sand combined with cyclone underflow can be utilised for sintering. The type V sample, which was mostly fines and which produced 61.8% classifier sand (max. among type samples) and 26.3% cyclone underflow, can be used mainly for sinter making.

1.2 Beneficiation and Sintering of Bailadila Iron Ore from Deposits 4 and 5 for Vishakhapatnam Steel Plant. *Sponsored by National Mineral Development Corporation.*

A composite sample of Bailadila iron ore from deposits 4 and 5 was received for beneficiation and sintering studies for Vishakhapatnam Steel Plant. The sample, as received, assayed 65.0% Fe, 1.6% SiO_2, 3.4% Al_2O_3, 0.025% S, 0.04% P and 1.5% LOI.

The overall—40+10 mm washed lumps weighed 49.3% and assayed 63.9% Fe, 0.9% SiO_2 and 1.6% Al_2O_3 with recovery of 50.8% Fe. The classifier sand weighed 39.0% and assayed 63.9% Fe, 2.3% SiO_2 and 4.0% Al_2O_3 with a recovery of 38.0% Fe. Studies on sintering, are in progress.

1.3 Beneficiation and Agglomeration Studies on a Low Grade Iron Ore Sample from Chandradinga, Assam. *Sponsored by Director of Geology & Mining, Govt. of Assam.*

A low grade iron ore assaying 44.2% Fe, 32.4% SiO_2, 1.7% Al_2O_3 and 0.14% P from Chandradinga, Assam; was received for beneficiation and agglomeration studies with a view to possible utilization of the deposit. The ore contained martitic hematite together with magnetite and goethite.

Straight tabling at different mesh sizes produced concentrates assaying 62.7% to 64.5% Fe with recoveries from 77.7% to 82.0%. Flotation tests yielded a concentrate assaying 50.9% Fe with a recovery of 80.7% Fe.

Pelletization studies were carried out on the concentrate obtained from tabling at —48 mesh size. These studies indicated that good quality heat-hardened pellets, having a compression strength of 325 Kg/pellet could be produced using bentonite and limestone as binders. Raducibility and degradation studies with heat hardened pellets were also made.

1.4 Beneficiation Studies on a Low Grade Iron Ore Sample from Goa. *Sponsored by M/s. EMCO, Goa.*

Detailed bench scale beneficiation studies were carried out on a low grade iron ore sample. The firm desired to obtain a concentrate analysing 60-65% iron which can be used to produce either pellet or sinter feed.

Mineralogical studies indicated that the ore comprised of martitized magnetite and hydrated iron oxides, quartz being the chief gangue mineral. The ore as received assayed 38.9% Fe, 40.8% SiO_2 and 1.9% Al_2O_3. Tests showed that a concentrate assaying 61.9% Fe with a Fe recovery of 76.8% and yield of 47.8% could be obtained from the sample.

1.5 Pilot Plant Studies on Crushing and Screening of Iron Ores and Limestone from Nepal Bureau of Mines. *Sponsored by M/s. M. N. Dastur & Co. (P) Ltd. Calcutta.*

The work was taken up with a view to assist the sponsor in connection with the Nepal Steel Making project by examining the raw materials of Nepal.

Crushing and screening tests on two iron ore samples and a limestone sample were conducted to prepare feed for smelting trials at NML. Results

of wet screening indicated that crushing and wet screening of both upper and lower bench ores at—40 mm size would give better recovery than at —30 mm size, while the chemistry of the lumps are almost indentical. Screen analyses of different products were conducted, Settling rate of slime obtained from —40 mm ores were also determined.

Crushing and screening tests of the limestone sample were also carried out. Bulk density, angle of repose and moisture content of different products were determined.

1.6 Beneficiation Studies on a Magnetite Sample. *Sponsored by M/s. Bharat Coking Coal Ltd. Dhanbad.*

Bench scale beneficiation tests were conducted on a sample of magnetite, assaying 59.4% total Fe, so that the beneficiated product could be used as a medium in coal washery plants. Tabling tests carried out with the sample at—48 mesh size indicated that a table concentrate analysing 68.1% total Fe with an iron recovery of 84.7% could be obtained. Wet magnetic separation after grinding the sample to —65 mesh size, yielded a magnetic fraction assaying 70.1% total Fe (more than 95% magnetite) with an iron recovery of 88.3% in it. This product satisfied the grade requirement for use as a medium in coal washeries.

2.0 Beneficiation of Oxidized Copper Ore from Chapri Deposit. *Sponsored by M/s. Hindustan Copper Ltd.*

Bench scale flotation tests were undertaken on a low-grade oxidised copper ore sample from Chapri deposit, for recovering the copper values present in it. The oxidised ore sample assayed 0.6% Cu only. Flotation tests, did not yield satisfactory results. A few more tests using certain specific reagents have been planned.

3.0 Beneficiation Studies on a Low Grade Complex Copper-Lead-Zinc Ore from Ambamata, Gujarat. *Sponsored by Gujarat Mineral Development Corporation.*

Three Low-grade ore samples having the following analysis were received to study the beneficiation characteristics for the recovery of multimetal values for extraction purposes.

(*i*) Lode Sample : 2.8% Cu, 1.6% Pb, 4.3% Zn.
(*ii*) Dump Sample : 1.2% Cu, 3.4% Pb, 7.3% Zn.
(*iii*) Pit Sample : 2.6% Cu, 2.6% Pb, 4.8% Zn.

All the three samples had very intimate and intricate associations amongst the ore forming minerals themselves as well as amongst the ore and the gangue minerals, necessitating finer than 200 mesh grind for

proper liberation of the ore minerals. Beneficiation studies conducted yielded the following results.

(*i*) Best Cu-concentrate from pit sample
Assay : 31.0% Cu, 10.7% Pb, 4.3% Zn.
Distribution : 29.9% Cu, 10.2% Pb, 2.2% Zn.

(*ii*) Best recovery of Cu from dump sample
Assay : 14% Cu, 15.4% Pb, 7.1% Zn.
Distribution : 51.3% Cu, 21.3% Pb, 4.5% Zn.

(*iii*) Best Pb-concentrate from lode sample
Assay : 16.6% Cu, 31.6% Pb, 4.8% Zn.
Distribution : 19% Cu, 61% Pb, 3% Zn.

(*iv*) Best Zn-concentrate from dump sample
Assay : 0.5% Cu, 0.8% Pb, 55.9% Zn.
Distribution : 3.2% Cu, 1.9% Pb, 56.8% Zn.

3.1 Beneficiation Studies on Low Grade Complex Lead-Zinc Ore Sample from Genekha Area, Bhutan. *Sponsored by Geological Survey of India, Bhutan Circle.*

The sample as received assayed 1.6% Pb, 9.8% Zn, 9.7% Fe, 16.3% S (sulphide), 3.4% SiO_2, 23.4% BaO, 0.06% $SrCO_3$ and 7.3% LOI with traces of Ni, Cd, Co, Au and Ag. Work was taken up with a view to maximum possible recovery of metals of economic value.

Differential flotation tests performed with the sample, indicated that a lead concentrate assaying 58% Pb with a lead recovery of 80% and zinc concentrate assaying 59.2% Zn with a zinc recovery of over 70% in it could be produced. It has also been possible to recover a barite concentrate analysing about 90% $BaSO_4$ from flotation tailing as a by-product.

4.0 Beneficiation of Low Grade Manganese Ore from Keonjhar Area, Orissa. *Sponsored by M/s. Rungta & Sons Chaibasa.*

A low grade manganese ore assaying 40% Mn, 14.0% Fe, 4.1% SiO_2 and 5.5% Al_2O_3 was received for beneficiation studies. The principal manganese minerals in the sample were psilomelane and pyrolusite which were in intimate association with iron hydroxides. Reduction roast followed by magnetic separation yielded a manganese concentrate assaying 53.6% Mn, 9.9% Fe with a Mn : Fe ratio of 5.4:1 and manganese recovery of 55.5%. The Mn : Fe ratio is lower than the acceptable limit of 7:1 required for commercial use.

5.0 Beneficiation of Phosphate Rock Samples from Jhamarkotra, Rajasthan. *Sponsored by Rajasthan State Mines & Minerals Ltd.*

A large deposit of phosphate rock estimated over 100 million tonnes has been located in Jhamarkotra area in Rajasthan. Bulk of the deposit is of low grade type and cannot be directly used for manufacture of phosphatic fertilizers. Work was taken up to upgrade this deposit so as to make it suitable for phosphatic fertilizers.

(i) Calcination Studies on the Composite Sample

Samples of rock phosphate from six different blocks of Jhamarkotra, varying in P_2O_5 content from 13.1% to 27.2% were received. Investigations for upgrading by calcination were carried out on composite sample prepared by blending the six block samples in proportion to their proved reserves. The composite sample assayed 17.5% P_2O_5.

Effect of different parameters like temperature, duration of calcination and size distribution on calcination were studied in a batch test followed by continuous calcination trials in a gas fired rotary kiln. It was observed that from a composite sample an overall grade of 32.9% P_2O_5 can be obtained with an yield of 49% and 92.6% distribution of P_2O_5 in it.

(ii) Flotation Studies on a Composite Phosphate Rock Sample

The different rock phosphate samples from six different blocks of Jhamarkotra deposit were mixed in suitable and specified proportions and a composite sample assaying 17.5% P_2O_5 was prepared. Flotation studies carried out with the sample after being ground to suitable fineness and under optimum conditions, yielded a concentrate after 3 cleanings, analysing 31.2% P_2O_5 with a P_2O_5 recovery of 40.5% P_2O_5 in it.

5.1 Beneficiation Studies on Maldeota Rock Phosphate Sample from Mussoorie, U.P. *Sponsored by M/s. Pyrites, Phosphates & Chemicals Ltd.*

Three different samples of phosphorite from Maldeota, U.P. were received for producing a concentrate suitable for phosphatic fertilizer manufaoture. Samples were blended and the composite sample assayed 16.8% P_2O_5 with calcium carbonate as main impurity. The cabonate gangue minerals were intimately associated with collophane which was the chief phosphorus bearing mineral.

Miscroscopic examination indicated that a fair liberation of collophane from the associated shale and carbonate gangue was below 65 mesh size. Differential thermal analysis indicated the decomposition of calcium carbonate at 900°-950°C. Calcination followed by flotation of the ground deslimed sand fraction yielded the best grade of concentrate assaying 28.3% P_2O_5 with a distribution of 79% P_2O_5.

Sample from Purulia Area.

The sample analysed 24.2% P_2O_5 and 14.5% Fe and consisted of hydroxides of iron, clays and silica as the gangue minerals. The object of the investigation was to reduce the iron content to less than 4% so as to make it acceptable for utilization in fertilizer manufacture.

Gravity methods did not help in reducing the iron content of the sample. Grinding the sample followed by desliming and flotation produced a concentrate assaying 35.0% P_2O_5 with 3.5% Fe. High intensity magnetic separation tests to eliminate the iron minerals are in progress.

5.3 Beneficiation of Purulia Phosphate Sample. *Sponsored by M/s. Fertilizer Corporation of India.*

A sample of phosphate rock was received from M/s. Fertilizer Corporation of India for bench scale beneficiation studies to reduce the Fe content to specified limits. The chemical analysis of a representative sample as well as the analysis of a few of the test products are in progress.

6.0 Pilot Plant Beneficiation of Amjhore Pyrites. *Sponsored by M/s. Pyrites, Phosphate & Chemicals Ltd.*

Investigations were earlier conducted on the beneficiation of Amjhore pyrites with a view to its direct use in Sindri Fertilizer Plant for the manufacture of sulphuric acid, thereby minimising the use of imported elemental sulphur.

Based on the results obtained from these tests and discussions held jointly between M/s. PPCL., NML and Engineers India Ltd. Large scale pilot plant tests on a fresh lot of pyrite sample from Amjhore was sponsored by M/s. PPCL, for collecting project engineering data and arrangements are being made to take up the assignment, for setting up of 2000 tpd commercial plant at Amjhore, under technical consultancy of NML.

6.1 Beneficiation of a Blended Sample of Pyrite/Pyrrohotite Ore from Saladipura Area. *Sponsored by M/s. Pyrites, Phosphates & Chemicals Ltd.*

Bench scale studies on beneficiation of a blended sample was undertaken with a view to upgrade the ore from 19.6% S to about 28 to 30% S by a simpler technique such as gravity concentration method, if possible. A concentrate assaying 30.6% S with a recovery of 76.8% S was obtained.

7.0 Batch and Pilot Plant Beneficiation Studies on a Low Grade Graphite Sample from Thodupuzha District, Kerala. *Sponsored by M/s. Kerala States Industrial Development Corporation.*

A low grade graphite sample assaying 9.1% fixed carbon and 76% ash was beneficiated to produce a high grade flaky concentrate analysing 83% fixed carbon with a recovery of 86% of C, suitable for crucible manufacture. A simple and novel flowsheet for beneficiating the sample has also been developed.

Further tests to improve the fixed carbon content in the concentrate produced were carried out. Based on the results obtained, negotiations are under way with M/s. KSIDC for setting up of a suitable size graphite beneficiation plant at Kerala.

7.1 Beneficiation of a Graphite Sample from Khamman District Andhra Pradesh. *Sponsored by Andhra Pradesh Industrial Development Corporation.*

Beneficiation studies were undertaken on a graphite sample with a view to produce a concentrate suitable for crucible manufacture. The sample as received assayed 22.8% fixed carbon, 7.3% V.M. 67.8% Ash, 2.1% S, 8.7% Fe in ash, 0.3% MgO and 0.5% CaO. The concentrate obtained contained appreciable amount of fine interlocked gangue responsible for lower grade of the concentrate. Neither the grade of the concentrate obtained nor the size, fulfilled the requirements of graphite for crucible manufacture. However, the concentrate could be used for foundry facings.

7.2 Petrological Studies on a Low Grade Graphite Sample of Palamau Dist. *Sponsored by Bihar State Mineral Development Corporation.*

Four low grade graphite ore samples of Palamau district were investigated. The samples assayed from 80% to about 20% fixed carbon and were coarse to fine grain and generally schistose in structure with quartz, micas and amphiboles as the gangue minerals.

8.0 Beneficiation Studies on a Magnesite Sample from Pithoragarh, U.P. *Sponsored by M/s. Orissa Industries Ltd., Rourkela.*

A sample of magnesite from Pithoragarh, U.P. was received for investigating the possibility of reducing its iron content as well as other impurities like silica, alumina and lime to the specified limits i.e. silica less than 1.2%, CaO less than 1.2%, Fe_2O_3 less than 0.5% & Al_2O_3 less than 0.5% so as to make it suitable for refractory purpose. The sample as received assayed 42.2% MgO, 4.0% CaO, 1.3% SiO_2, 2.2% Al_2O_3, 2.0%, Fe_2O_3, 1.4% total Fe and with 48.4% L.O.I.

Beneficiation techniques were attempted to reduce the impurities in magnesite. Since iron was present in solid solution with magnesite, it was found to be rather difficult to remove the iron present in the sample. Flotation

after grinding the sample to suitable fineness was found to be beneficial in rejecting the bulk of silica and alumina in the tailings. The concentrate obtained, assayed 43.7% MgO, 2.9% CaO, 0.7% SiO_2, 1.4% Al_2O_3 and 1.4% Fe, with a recovery of 67.2% MgO.

8.1 Batch and Pilot Plant Beneficiation Studies on High Silica Magnesite Sample from Salem, Tamil Nadu. *Sponsored by Govt. of Tamil Nadu.*

Large deposits of low grade magnesite having high silica content exist in Salem district, which are being selectively mined at present. The investigation was taken up with a view to reduce the silica content to the acceptable litmi for the manufacture of magnesite refractories.

The magnesite sample received for tests assayed 7.5% SiO_2. Bench scale beneficiation studies have indicated that the silica content could be reduced to about 2.0% by employing flotation. Further tests to lower the silica content to less than 2% and improving the yield etc. are in progress.

9.0 Beneficiation of a Low Grade Kyanite Sample Marked BT-3 from Lapsoburu Mines. *Sponsored by M/s. Indian Copper Complex of Hindustan Copper Ltd.*

Bench scale beneficiation studies were undertaken on a low grade kyanite sample from Lapsoburu, designated as BT-3 (East Hill) and assaying 34.6% Al_2O_3, with a view to upgrading it to 60% Al_2O_3 or more, so that the concentrate could be used in refractory industries. Flotation under optimum conditions produced a concentrate analysing 60% Al_2O_3 with an Al_2O_3 recovery of 39.5% in it, which is equivalent to a recovery of 55.6% kyanite.

9.1 Beneficiation of a Low Grade Kyanite Sample Marked BT-4 (West Hill) from Lapsoburu Mines. *Sponsored by M/s. Indian Copper Complex of Hindustan Copper Ltd.*

The kyanite sample from Lapsoburu Mines (West Hill) designated as BT-4, was received for bench scale beneficiation studies with a view to making it suitable for refractory purposes. The BT-4 kyanite sample, as received assayed 25.4% Al_2O_3, 68.2% SiO_2, 0.6% Fe_2O_3, 1.0% CaO, 0.8% MgO, 1.1% $K_2O+Na^{\circ}O$ and 0.4% LOI.

Gravity concentration methods did not yield satisfactory results. Flotation under optimum conditions yielded a refloat concentrate after three cleanings, analysing 57.0% Al_2O_3 with a recovery of 36.2% Al_2O_3. Additional cleanings may help to improve the grade of the concentrate further, but with still lower recoveries. At this stage, after discussions with the ICC authorities further work on this sample was discontinued.

9.2 Beneficiation of a Low Grade Kyanite Sample from Pardi Mines, Maharashtra. *Sponsored by M/s. Maharashtra Minerals Corporation Ltd.*

About half a tonne of kyanite was received from Pardi Mines, Bhandara Dist, Maharashtra; for beneficiation as well as removal of tourmaline to make it suitable for refractory manufacture. The ore assayed 50.8% Al_2O_3 and 34.2% SiO_2. The ore contained about 70% kyanite, 25% muscovite and 7% tourmaline with quartz and corundum and chlorites each below 1%.

Tabling gave encouraging results with about 80% recovery and 60% yield. Test conducted with reground middling improved the yield and recovery of the product. The table concentrate contained tourmaline which was successfully removed to yield a product assaying about 61% Al_2O_3 and mostly free from tourmaline. Other techniques are also being attempted for tourmaline removal. Attempts are also being made to recover if possible, kyanite from the slime and the tailing.

9.3 Petrological and Chemical Analysis Studies on a Low Grade Kyanite Sample from Bharandiha Village, Chakradharpur, Bihar. *Sponsored by M/s. Bihar State Mineral Development Corporation.*

A low grade kyanite sample from Bharandiha village, Chakradharpur; was received for preliminary petrological studies and chemical analysis. Petrological studies revealed that kyanite was the economic mineral and quartz the predominant gangue along with subordinate micas. Kyanite was found mostly liberated at a fairly coarse size of 28 to 35 mesh from the gangue. The ore assayed 24.3% Al_2O_3 and 65.6% SiO_2 and may be amenable to beneficiation by conventional ore-dressing methods.

10.0 Flotation Studies on Low Grade Fluorspar Samples from Kahila and Mandokipal Mines. *Sponsored by M/s. Rajasthan Industrial & Mineral Development Corporation.*

Comprehensive laboratory investigations were conducted on the beneficiation of the low grade fluorspar samples from Kahila and Mandokipal mines with a view to decreasing their gangue content so that the beneficiated product could be used for acid manufacture.

Bench scale flotation tests carried out with the Kahila fluorspar sample analysing 17.5% CaF_2 and 0.9% $CaCO_3$ under optimum conditions, followed by reflotations of the rougher float, produced a final concentrate assaying 97.5% CaF_2, 0.4% $CaCO_3$ and 1.2% SiO_2 with a CaF_2 recovery of 71% in it. The concentrate did not meet the acid grade requirement.

The Mandokipal sample which was of a poor grade, highly clacitic in

nature and assaying only 8.5% CaF_2 and 3.1% $CaCO_3$ when subjected to bench scale flotation tests under optimum conditions did not yield a concentrate of the desired grade. Flotation tests carried out with the mixed sample of Kahila and Mandokipal fluorspar produced a final refloat concentrate analysing 96% CaF_2 with a recovery of 61% CaF_2 in it, which again did not meet the acid grade requirements.

11.0 Recovery of Tin from Tin Bearing Pegmatite. *Sponsored by Director of Mines & Geology, Raipur, Madhya Pradesh.*

A low grade deposit of tin has been located in Bastar district of Madhya Pradesh. In view of the strategic importance of this metal, bench scale beneficiation studies were undertaken on a priority basis. The sample as received assayed 0.4% Sn only. A concentrate assaying 60% Sn with a recovery of 70% Sn in it was obtained.

12.0 Studies on Physical Characteristics of a Sandstone Sample. *Sponsored by Central Mine Planning & Design Institute, Ranchi.*

Studies on physical characteristics of a sandstone sample were undertaken with a view to provide a cheap stowing material in the coal mines. The sample, assayed 79.5% SiO_2, 6.2% Al_2O_3, 9.6% Fe_2O_3 and 3.2% LOI. Bulk density and angle of repose under different conditions were determined. Determination of hardness by Moh's scale and crushing strength indicated that the sample was soft in nature.

13.0 Beneficiation of Silica Sand from U.P. *Sponsored by M/s. State Mining Development Corporation, Lucknow.*

Two types of silica sand samples assaying 98.1% SiO_2, 0.3% Fe_2O_3, 0.8% Al_2O_3 and 97.9% SiO_2, 0.7% Fe_2O_3, 0.9% Al_2O_3 respectively were received for beneficiation studies with a view to remove iron content in the sample, so as to make them suitable for use in glass manufacture.

Super agitation followed by high intensity magnetic separation produced non-magnetic concentrates assaying 0.1% and 0.05% Fe_3O_3 respectively. Further tests with the composite sample are in progress.

14.0 Specified Tests on the Physical Characteristics of a Limestone Sample. *Sponsored by M/s. Tata-Robins-Fraser Ltd., Jamshedpur.*

Specified tests on the physical characteristics of a sample of limestone were carried out. The object of the studies was to collect data for designing of suitable crusher for cement plant.

Shatter test results showed that the amount of —12 mm (1/2") fines produced was about 2%, thereby indicating that the sample of limestone

was compact and hard. Bulk density of the sample at 1/2" size was 1.15 tonnes/cu. metre and the compression strength varied between 370 and 635 kg./sq.cm. The sample analysed 43.8% CaO and 5.35% SiO_2.

15.0 Determination of Work Index Values of Sintered Dolomite received from Bhilai Steel Plant. *Sponsored by M/s. McNally Bharat Engineering Co. Ltd., Kumardhubi.*

A sample of sintered dolomite was received for determining the work index value for dry grinding in open circuit. The data are needed by the sponsor for designing suitable grinding units. The grinding tests so performed indicated that the work index value of sintered dolomite was found to be 45.3 KWH per metric tonne.

16.0 Evaluation of Some "CAFLO" Products as Flocculants. *Sponsored by M/s. Commercial Corporation Ltd., Calcutta.*

Five samples under the trade name "CAFLO" were received for studying their suitability as flocculants. The samples were designated as N-5, N-6, N-7, CC-106 and WW. Another sample of standard quality "Separan" was also supplied by the firm for comparison studies. The settling rates with Goa iron ore slime containing 5% solids and with 0.125 kg/t of the reagent (N-6 & N-7) were 8.025 M/hr, 7.395 M/hr and with 10% solids, the rates were 5.218 M/hr and 6.45 M/hr respectively. Compared to this, the corresponding values obtained with 0.1 kg/t of Separan were 14.58 M/hr. The results obtained with rest of the CAFLO products were very poor.

B. REFRACTORIES TECHNOLOGY

17.0 Development of Clay-graphite Stopper Heads from Indigenous Raw Materials. *Sponsored by M/s. Patna State Graphite Mining Co. Titilagarh.*

The project was sponsored to develop a substitute clay-graphite stopper head from indigenous graphite similar in quality to the imported variety for use in steel pouring operation.

Clay-graphite stopper heads have been successfully developed from indigenous raw materials. Samples have been supplied to sponsor for evaluation and service trial.

18.0 Preliminary Investigation on the Properties and Processing of Beneficiated Kyanite Concentrate. *Sponsored by M/s. Hindustan Copper Ltd.*

Representative samples of low grade kyanite from Lapsoburu area were supplied by M/s. Hindustan Copper Ltd. which were intially upgraded

in the Ore-dressing division of the Laboratory. Exploratory experiments on bench scale were conducted to evaluate the concentrates for their refractory properties and processing. The bench scale studies indicated that the kyanite concentrate of -300 B.S.S. fraction fired to 1650°C could be used as a base material for making high alumina refractories. Though these preliminary results are very encouraging, more work has to be done to establish the final brick properties on both bench scale and pilot plant scale, availing the supplies of bulk concentrates.

19.0 Studies on Graphite. *Sponsored by M/s. Kerala State Industrial Development Corporation.*

Sample of beneficiated Kerala State graphite was received from Ore-dressing Division of the Laboratory. Original sample was reported to have 9.1% fixed carbon and after beneficiation the concentrate contained 83.3% fixed carbon. Experiments were conducted to find out oxidation behaviour and the P.C.E. of the ash in comparison with other graphites from Madagascar, Ceylon and Patna State Mining Co. Results show that beneficiated Kerala State graphite is a promising material for graphite crucible industry and it would be worthwhile to assess its suitability on a commercial scale.

19.1 Testing of Graphite Crucibles. *Referred by Indian Standard Institution & Directorate-General Technical Development.*

Indian Standard Institution and DGTD Panel on 'Graphite Crucible' desired that NML should take up some work on the determination of various properties of Indian graphite crucible and a comparison of these properties vis-a-vis the imported graphite crucible, since NML has been doing work on graphite crucible for developing improved process technology. Accordingly some samples of graphite crucible both Indian and foreign sources were obtained and the physical and various refractory properties like bulk density, apparent porosity, cold crushing strength, modulus or rupture etc. are being studied. The work is under progress and it is contemplated that the study should be made on more representative samples as the number of samples received for testing were less.

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

Samples of magnesite from Pithorgarh deposit were supplied by the sponsor to study its beneficiation by ore-dressing and thermal method for determing the suitability for manufacture of refractories. The beneficiation by ore-dressing method has been reported under item 8.0.

The sample of magnesite from Pithoragarh deposit was found amenable to thermal beneficiation and the CaO content of the sintered magnesite can be reduced from about 7.0% to about less than 2% after the beneficiation. However the SiO_2 content can not be reduced by this method though in

some of chemical analysis it is showing to be less than that contained in the original sintered magnesite. The Fe_2O_8 content seems to be increased by small amount not exceeding 1%. The work is in progress.

21.0 Suitability of Khammam Dolomite for use in Steel Melting Shop. *Sponsored by M/s. M. N. Dastur & Co. (P) Ltd.*

The Project was sponsored to study the suitability of Khammam dolomite for the production of dolomite clinker for use as refractories in the steel melting shops of Vishakapatnam Steel Plant. The work on dolomite consists of the study of the raw material such as (a) study under microscope from the refractory angle (b) sieve and chemical analysis of the sample as received (c) specific gravity (d) crushing and screening characteristic (e) cold crushing strength (f) bulk density and properties of the briquettee and lumps after calcination such as (i) microscopic study (ii) chemiacl analysis (iii) bulk density and porosity and (iv) hydration resistance.

From the above test results it was concluded that the dolomite when mixed with blue dust addition in the powder form and briquetted subsequently and fired to a suitable temperature will give a product for use as SMS grade. The crushed dolomite without any blue dust addition does not give the optimum properties of the product for use in SMS. The dolomite would also be suitable material for L-D furnace refractories for tar bonded dolomite provided it is fired in small lump form at specified temperature.

22.0 Testing of Refractory Castables. *Sponsored by M/s. Associated Cement Co. Katni.*

Work was conducted for testing the properties of percent alumina content, bulk density gm/cc, cold crushing strength, pyrometric cone equivalent of a castable product supplied by the firm. The various parameters as desired were evaluated.

22.1 Testing of Refractory Castables. *Sponsored by Patratu Thermal Power Station, Hazaribagh.*

The different properties tested are maximum service temperature, bulk density and permanent linear change.

23.0 Development of High Alumina Refractories Using Kyanite as Raw Material.

This project aims at developing suitable high alumina refractory composition for use in electric arc furnace roofs using kyanite. During the period, work was done on the development of 85 percent alumina refractories. For producing dense samples, some important variables were studied. It was proposed to make the samples conforming to specifications of Bharat Heavy Electricals Limited and MECON. Further work was continued by

producing dense alumina grog and blending it with kyanite in the finer fraction on bench scale. Satisfactory results conforming with the above standards were obtained. Full bricks of this composition are being prepared for testing various properties.

24.0 Development of Zircon Refractories by Chemical Bonding.

The project was undertaken with a view to develop suitable zircon refractory brick from zircon flour comparable to an imported variety so as to eliminate any foreign collaboration for its manufacture in the country.

Based on the physical properties of imported zircon brick, attempts were made to develop chemically bonded zircon bricks using indigenous raw materials. Bench scale studies were made to fix certain parameters of composition, forming pressure and curing temperatures so as to get the desired properties of zircon compacts. After fixing up the composition and curing temperature; chemically bonded zircon bricks (full size $9'' \times 4\frac{1}{2}'' \times 3''$) were made on pilot plant scale. The properties of these bricks after firing are comparable with imported product as shown in Table 1.

Table 1

Comparison of Physical Properties of Chemically Bonded N.M.L. Bricks alongs with Imported one.

Physical properties	Foreign sample as reported	Foreign sample as done in NML	B 6/S	B 6/P (NML Bricks)	B 6/T (NML Bricks)	C 6/P
Apparent porosity %	19.5-23.5	22.0	18.5	17.6	16.6	17.5
Bulk density gm/cc	3.6-3.72	3.68	3.56	3.54	3.65	3.55
C.C.S. Kg/Cm^2	493-775	475	190	220	308	413
M.O.R. Kg/Cm^2	162-232	121	N.D.	71	141	128
P.L.C. at 1650°C	Nil	0.13%	0.76%	—	0.71%	Nil
Apparent Sp. Gravity	—	4.704	4.37	4.340	4.378	4.330

S.P.—Bricks pressed under screw press.
P—Bricks pressed under hydraulic press.
T—Bricks tamped under pneumatic hammer.

25.0 Development of Synthetic Carbonaceous Product as a Substitute for Petroleum Coke & Anthracite.

In view of the increasing demand for petroleum coke for different carbon products such as carbon refractories, soderberg paste, cathode lines etc. and the absence of indigenous resources of anthracite coal in India, this project was undertaken to develop suitable raw material from indigenously available low ash coals for the production of carbon products.

A collaborative programme of work is being drawn up with Central Fuel Research Institute. CFRI has supplied about 20 Kg of low ash coke. Tests for suitability of this material as well as coal from Bhowrah Colliery are in progress.

26.0 Fused Rock Products and Methods of their Manufacture.

The project was taken up to develop a suitable process for making abrasion resistance fused tiles for use in sintering plants, coke oven etc. using low fusible rocks. Some tiles were made by melting, casting and annealing and their properties were compared with the foreign basalt tiles which are at present used in steel plants. Work is being taken up for making the tiles of different shapes and sizes.

27.0 Testing of Binder and Raw Materials.

Two samples of tar from M/s. Shalimar Tar Products Ltd. have been received. Few more samples of pitch from Bhilai Steel Plant are awaited. Table 2 gives properties of Rourkela pitch studied so far :

Table 2

Properties of Rourkela Pitch

	Insol in Pet. ether %	Insol in Benzene %	Insol in Toluene %	Insol in Quinoline %	Moisture %
Pitch I	55.1	38.5	32.5	13.0	0.09
Pitch II	44.2	26.0	23.4	9.1	0.08
Shalimar Road Tar No. 3	54.0	12.7	11.5	6.0	0.06

C. EXTRACTION & CHEMICAL METALLURGY

28.0 Extraction of Nickel from Low Grade Lateritic Ore from Sukinda.

Laboratory scale studies have been completed on an improved method for the recovery of Ni and Co in roast reduction ammonia leaching process

and large scale trials for roast reduction ammonia leaching are planned. Further studies are in progress for recovery of Ni and Co from ammonia-leach solution by solvent extraction technique.

28.1 Solvent Extraction of Nickel and Cobalt from Leach Liquors.

Solvent extraction experiments for the recovery of Ni and Co from ammoniacal solution were conducted. Experiments are now being planned for continuous solvent extraction and electrowinning of nickel.

29.0 Recovery of Metallic Values by Bacterial Leaching.

Studies were continued for applying bacteria leaching method for the recovery of copper from Malanjkhand and Mosabni low grade ores. Results obtained in column experiments using Rakha mine water as source of bacteria indicate that Malanjkhand copper ore can be subjected easily to bacterial leaching. The rate of copper dissolution and the acid required to neutralise the associated gangue in the ore during leaching have been studied.

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

Studies were made on leaching of Chapri copper ores by agitation and percolation leaching. Good copper recoveries were obtained by percolation leaching without excessive acid consumption.

30.0 Recovery of Vanadium Pentoxide from Vanadium Containing Slag of M/s. Visvesvaraya Iron & Steel Works. *Sponsored by M/s. Visvesvaraya Iron & Steel Works.*

Laboratory experiments have been done for the recovery of vanadium pentoxide from vanadium bearing slag from the first trial at VISL. Encouraging results have been obtained for the recovery of vanadium pentoxide from the slag. Experiments are now being conducted on the slag from the second trial for the recovery of vanadium pentoxide.

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

Studies were completed on bench, laboratory and pilot plant scale from the vanadium sludge from HINDALCO and similar work is near completion on BALCO sludge. The process has been transferred to the industry and a plant for the treatment of one tonne of sludge per day has been put up at Ranchi for M/s. S. G. Enterprises with NML Consultancy Services.

31.0 Extraction of Lead from Lead Concentrate.

A new process has been developed for extraction of lead from lead concentrates. Experiments were completed on large scale in an oil fired crucible furnace treating about one tonne of concentrate per day to obtain design data for commercial plant. Smelting trials have also been conducted by electrothermal process in an arc furnace.

32.0 Electric Smelting of Dolomite for Extraction of Magnesium.

During the year, a number of equipment of the pilot plant unit such as condenser unit, charging unit, etc. for the production of magnesium were fabricated. Other parts such as furnace shell, roof etc. are also being fabricated and structural drawings have been already prepared and arrangement is being made for making an assembly of the unit.

33.0 Production of Battery Grade Manganese Dioxide and Manganese Chemicals from Manganese Carbonate Obtained from Low Grade Manganese Ore by Ammonium Carbonate Process.

Tests were carried out on decomposition of manganese carbonate. Chemical and X-ray diffraction analysis of the decomposed product were done for the identification of the product. Few dry cells were made for testing purpose.

34.0 Purification of Molybdenite Concentrate to make it Suitable for Preparing Ferro-molybdenum.

Investigations have been completed for removal of copper and nickel impurities from molybdenite concentrates obtained from M/s. Uranium Corporation of India, Jadugoda.

35.0 Static Bed Calcination Studies on Jhamarkotra & Maldeota Rock Phosphate. *Sponsored by M/s. Rajasthan State Mines & Minerals Ltd. and M/s. Pyrites, Phosphates & Chemicals Ltd.*

Calcination studies on composite rock phosphate sample from Jhamarkotra, Rajasthan ; have been conducted in static bed as well as rotary kiln for enrichment of P_2O_5 content. Similar calcination studies have also been made on rock phosphate sample from Maldeota area of Uttar Pradesh.

36.0 Development of Metallo-thermic Process for the Production of Zinc Dust.

Preliminary aluminothermic reaction for the production of zinc in the vapour form has been done.

36.1 Production of Zinc Dust.

Negotiations are underway with two more firms e.g. (i) M/s. Usha Martin Black, Ranchi & (ii) M's. Technocrats, Rourkela; for the production know-how of the process. Trials were conducted during the period to improve the technology. Work has also initiated on the design of a resistor furnace for production of distilled grade zinc dust.

36.2 Recovery of Zinc Values from Galvanizers' Zinc Ash and By-product Zinc Hydroxide from Sodium Hydrosulphite Industry.

Officials of National Research Development Corporation, visited the Laboratory in connection with the preparation of a project report for the process developed for production of zinc oxide from zinc ash. The various steps of the process were demonstrated. A technical appraisal report on the above process is being prepared in collaboration with the NRDC. Negotiations with reputed consultancy engineering firms are proceeding for a turnkey offer of the process developed for production of zinc oxide.

37.0 Production of Metal Powders.

The following assistance was given to the licencees.

(i) M/s. Paras Metal Powder of Nasik were assisted in completing installation and commissioning of their atomization unit.

(ii) M/s. Nalco of Madurai were assisted in obtaining a loan of over Rs. 20 lakhs from the Tamil Nadu Government. Plant installation is scheduled to be completed by December, 1977.

(iii) M/s. Metpow of Poona who were given the know-how earlier was chased up to expedite their project.

(iv) M/s. Micro Metals of Purulia were licensed the know-how and the technology transfer is scheduled in the coming year.

In addition to the above, technology improvement trials were conducted in respect of hydrogen loss and dirt factors of bimetallic powder, water covering area factor of flaky powders, polishing of lithographic powders. Work was also initiated for the development of atomized iron powders.

37.1 Production of Copper Coated Graphite Powder.

The use of copper coated graphite powder instead of a mechanical mixture of copper & graphite powder in the production of sliding contact bearing material will result comparatively higher mechanical strength and thermal and electrical conductivities.

Various processes such as chemical plating, vapor deposition technique and electroplating were examined. Electro-plating of graphite powder was found to be most efficient as adherent and uniform coating could be obtained by this process. Graphite powder of various mesh size has been coated by this technique and coating thickness could be controlled as desired. The process is being scaled up and standardised.

38.0 Development of Copper-Tungsten Contact Tips.

Work was intiated to develop contact tips for high and medium voltage application. The copper tungsten contact tip can be produced by (i) mechanical mixing of the virgin powder followed by compacting and sintering & (ii) compacting and sintering a tungsten powder blank which is later infiltrated with liquid copper. Of these two methods, the latter one gives superior material with enhanced life because the tungsten particles sinters into a continuous three dimensional network. The vacant places are later filled with molten copper. The tungsten particles remains isolated or dispersed in a matrix of copper in material produced by the first method. The process parameters involved in compacting sintering and infiltration of copper-tungesten contact tips were evaluated and the product developed have properties specified according to international standards.

39.0 Recovery of Elemental Sulphur, Copper, Lead and Zinc from Respective Sulphide Mineral Concentrates.

After determining the optimum conditions for maximum recovery of copper and sulphur by direct leaching of copper concentrates in ferric chloride solution, investigatiens were carried out for the recovery of the copper from the leached cuprous chloride solution. A diaphragm cell with insoluble anodes has been set up. A recovery of 75% of copper in powder form, with a power consumption of 1 Kwh per kg. of copper deposited, has been achieved. Further work to examine the percentage oxidation of ferrous to ferric in the anode chamber is progressing.

40.0 Studies on the Processing of Sulphide Concentrates—Recovery of Metal Values as Chemicals Directly from Low & High Grade Copper Concentrates.

Recovery of copper value from high and low grade copper concentrates were carried out after pretreatment of the concentrate. It was possible to remove impurities to more than 97% lead, 30% of zinc, and 8% of Fe from the concentrate. Copper loss was around 1%. The material when further treated at low temperature with admixture of additives, more than 95% of copper was removed as water soluble form along with 80% of Zn and 3% of Fe. Solution after purification was crystallized. Further work is in progress.

41.0 Preparation of Fluorine Chemicals for Metallurgical Use.

(i) Studies on the Purification of Fluorspar from Gujarat Mineral Development Corporation to Cryolite Grade Fluorspar.

G.M.D.C. fluorspar contains higher percentages of Fe_2O_3 and P_2O_5 than required for cryolite grade fluorspar. As all the Fe_2O_3 and P_2O_5 present in fluorspar get into the cryolite produced by leaching method, the fluorspar should preferably contain Fe_2O_3 and P_2O_5 less than 0.1% and 0.01% respectively.

Beneficiated fluorspar concentrate obtained from G.M.D.C. contained Fe_2O_3 0.65% & P_2O_5 0.22%. A single step selective leaching process has been developed for purification of G.M.D.C. fluorspar. Starting with G.M.D.C. fluorspar containing Fe_2O_3 0.75% & P_2O_5 0.22% product containing Fe_2O_3 0.18% and P_2O_5 0.04% was obtained with 98% recovery of calcium fluoride. Laboratory scale experiments have been completed.

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

Large scale experiments for the collection of technical, design and economic data were carried out for setting up of a commercial plant for the production of cryolite with indigenous know-how. The process was demonstrated to Industrial Consulting Bureau, Bombay ; and found to be technically sound and economically viable. Cryolite product evaluation and further large scale experimentation were suggested by the firm before commercialization of the process. Further experiments at 100 kg cryolite per batch were carried out by recyling the spent liquor.

42.0 Hydro-Electro Metallurgy Project.

Layout of process plant and equipment are being worked out. A number of equipments have been purchased. Construction of perimeter wall of land so far acquired has been completed.

D. IRON & STEEL TECHNOLOGY

43.0 Study on Reduction Characteristics of Iron Ore Samples.

The following samples were studied, during the period, for their reduction characteristics, swelling index, thermal degradation, crushing strength after reduction and macro and micro porosity etc.

Sample Description	*Name of Sponsor*
(*i*) Head hardened iron ore pellets	M/s. MECON
(*ii*) Head hardened iron ore pellets	M/s. TISCO
(*iii*) Iron ore lumps	Directorate of Mining and Geology, Govt. of Madhay Pradesh.

43.1 Reducibility, Swelling Index & Microporosity Studies of Heat Hardened Iron Ore Pellets. *Sponsored by M/s. MECON.*

Reducibility, swelling index and microporosity studies on heat hardened pellets of iron ore samples were carried out. The reports were submitted to Laboratory's Ore Dressing Division in connection with the studies carried out for setting up a Central Pelletization Plant.

44.0 Production of Sponge Iron in Rotary Kiln.

After successfully completing the sponsored investigations from Andhra Pradesh Industrial Development Corporation & Industrial Development Corporation of Orissa; for production of sponge iron in a pilot rotary kiln at NML, it was attempted to produce sponge iron using iron ore fines directly in the kiln. Two campaigns were successfully completed to produce sponge iron from iron ore fine. 85-99% metallisation was obtained in the product. More experiments are under way to establish the technical know-how for production of sponge iron from iron ore fines directly.

44.1 Production of Sponge Iron in Vertical Retort Furnace.

Study is being made to produce sponge iron by a different technique in a vertical retort furnace using non-coking coal as reductant. Successful experiments were completed in a 250-350 kg retort to produce high grade sponge iron. The know-how developed is now scaled up by installing a unit to produce about 1.2-1.5 tonnes of sponge iron/day.

44.2 Use of Sponge Iron with Steel Scrap for Steel Manufacture.

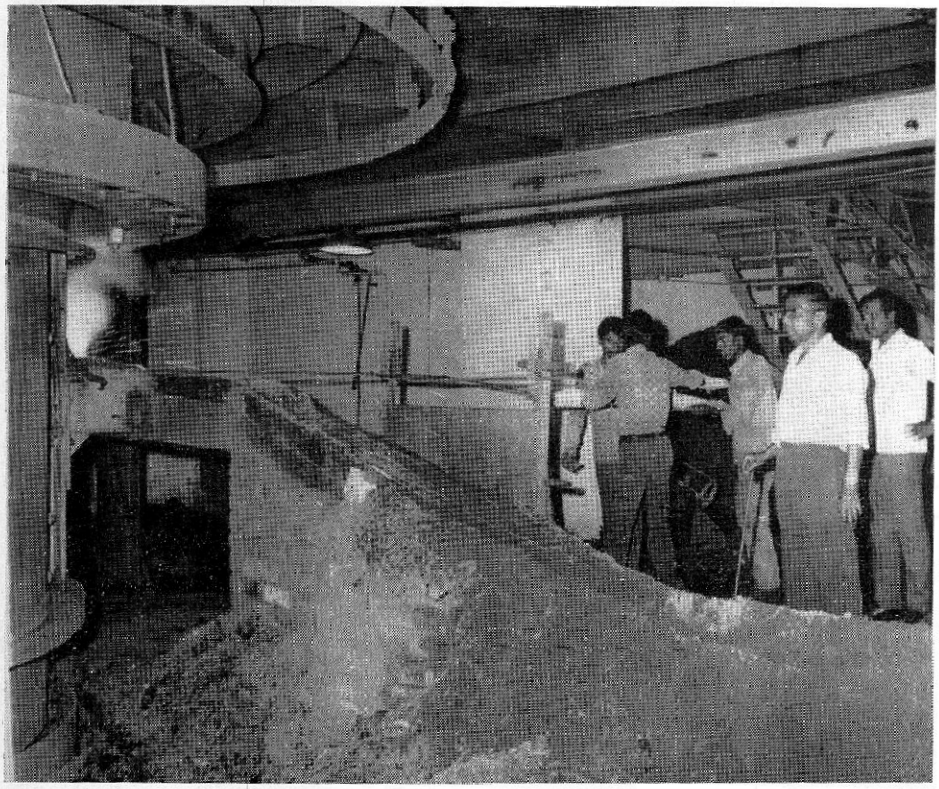
Use of 40% sponge iron in the steel scrap charge in electric arc furnace steel production has been found acceptable in industrial furnaces of 25 tons capacity. This has been achieved without making any modifications in the furnace and utilising the conventional bucket charging system being employed by the industries.

45.0 Electric Smelting of Nepal Iron Ore. *Sponsored by M/s. M. N. Dastur & Co.*

Extensive smelting trials were conducted in the 500 KVA submerged arc furnace on the raw materials—iron Ores and limestone—supplied by Nepal Bureau of Mines for the production of basic grade pig iron suitable for L.D. process of steel making.

45.1 Electric Smelting of Magnetite for Development of Catalyst. *Sponsored by M/s. Food Corporation of India, Sindri.*

Smelting of magnetite in 50 KVA submerged arc furnace was conducted to produce the material suitable for use in the development of catalyst as desired by F.C.I. Sindri.



Tapping of pig iron produced from Nepal iron ore.

46.0 Pneumatic Steel Making in Basic Lined Side Blown Converter.

The project has been completed and is in the transfer of technology stage. During the period a few experiments were conducted to demonstrate the process to the representatives of M/s. MECON, one of the consultants of the process and Hindustan Steel (R&D).

47.0 Special Steel Making in Basic Oxygen Converter.

The various structural and fabrication work is in progress.

48.0 Development of Continuous Steel Making Process.

The structural, electrical and mechanical installation jobs were completed. The initial heating of the refractory lining was taken up. After completing the low temperature heating, the refractory lining was subjected to the high temperature heating when a portion of the lining in the main launder was found to be damaged. The relining of this portion has been taken up.

49.0 Electroslag Remelting.

Martensitic stainless steel was made in the 30 kg air induction melting furnace. Part of the heats was forged and rolled.

50.0 Development of High Strength Low Alloy Steels.

Four 10 kg heats of niobium treated steels were prepared with additions of small amounts of chromium and copper to study the effects of these elements on the structure and mechanical properties. The ingots were forged into 3". One 0.8 ton heat of niobium treated steel was prepared in the direct arc furnace. Five ingots (100 mm×100 mm×1000 mm) of this heat have been sent to CSIR Madras Complex for arranging for rolling into high strength reinforcing rods.

51.0 Development of Maraging Stainless Steel.

The object of the project is to partially replace nickel in austenitic stainless steel by copper and manganese. Investigation is being carried out with eleven compositions of austentic stainless steel containing 17% Cr and copper and manganese in the range of 2 to 4% and 2 to 6% respectively.

The steels were rolled into sheets of 20 gauge thickness. Tensile and Olsen cupping tests were carried out. Anodic polarisation studies are being conducted.

52.0 Development of Self-fusing Synthetic Slag for External Desulphurization of Steel.

Most of the external desulphurization practices in the industry involve considerable capital outlay on infrastructural facilities which are hindrance to their adoption by small scale units or by units requiring occasional needs for desulphurization. Also the processes are suited more for pig iron than for steel.

A process is being developed in which desulphurization can be effected in the ladle by tapping the molten steel into a pool of molten synthetic slag of high desulphurizing capacity. Along with desulphurization. the treatment also brings about substantial decrease in non-metallic inclusion and gas contents in the metal. The powder mixture being developed is self-fusing in nature and can be melted easily in the ladle without the need of a separate melting furnace. The process is easy to adopt and is capable of producing very clean steel.

E. DEVELOPMENT & STUDY ON ALLOYS

53.0 Development of Aluminium Cables and Conductors—Electric Grade Aluminium Alloy NML-PM2.

Industrial Production of NML-PM2

The production of the NML-PM2 alloys has been continued at the works of the following licencees.

(*i*) M/s. Aluminium Cables & Conductors (UP) Pvt. Ltd., Calcutta.
(*ii*) M/s. Galada Continuous Castings Ltd., Hyderabad.

In addition, the technology of the alloy has also been transferred to M/s. Indian Aluminium Cables Ltd., New Delhi; where the commercial production will commence.

Product Development

The product development work on the NML-PM2 has been continued for the production of various types of conductors & cables in collaboration with cable industries as detailed below :—

(*i*)	M/s. Hira Cable Works Ltd.	Fine size wires (upto UISWG, 0.11 mm), enamelled wires, DPC wires and strips.
(*ii*)	M/s. Universal Cables Ltd.	Solidal cable, Welding cable & Jumper wires.

(*iii*)	Radiant Engg. Co.	Coach wiring cables, Detornato lead wires.
(*iv*)	Fort Gloster Industries (Cables Division)	Power cables, Welding cables.
(*v*)	MP Electricals Ltd.	DPC and Paper covered strips.
(*vi*)	Aluminium Cable & conductors (UP) Pvt. Ltd.	Overhead ACSR conductors.
(*vii*)	Bharat Heavy Electricals Ltd.	Testing and evaluation of multi-layer paper covered strips.

Product Evaluation and Market Promotion.

(*i*) Integral coach factory, Perambur, Madras; have wired number of coaches using NML-PM2 PVC cables of 4 sq. mm (7/0.85 mm). The railway coaches are in service trials in Northern Railway.

(*ii*) S.E. Rly. is using PVC insulated cables from NML-PM2 for cabin wiring.

(*iii*) Northern Railway is collaborating for the use of NML-PM2 in railway signalling cables of 12 core, 2.5 sq. mm size, 19/7/1 4 mm rope lay flexible bare NML-PM2 conductor and NML-PM2 enamelled wires for relay windings.

(*iv*) Railway workshops of different railways are collaborating for the use of NML PM2 welding cables such as Integral Coach Factory, Chittaranjan Locomotive Works, Western Railway, Bombay.

(*v*) Gujarat State Electricity Board is installing a 200 km length of overhead ACSR conductors of weasel and rabitt type made from NML-PM2.

(*vi*) Karnataka State Electricity Board is collaborating for the use of NML-PM2 in overhead conductor and is installing power transmission wire line of squirrel ACSR conductor.

(*vii*) As a result of field trials and evaluation of NML-PM2 multilayer paper covered strips, Bharat Heavy Electricals Ltd., Bhopal; is collaborating for one phase winding of prototype power transformer of 20/16 MVA, 132/33-11KV capacity for M.P. Electricity Board.

Indian Standard.

The inclusion of NML-PM2 in the specifications for cables & conductors covered by SMDC and ETDC panels is receiving active consideration and is under formulation.

Certification Mark.

The registration of the certification mark **NML-PM2** to be displayed on finished products for identification is in progress through the Registrar of Trade Mark, Bombay.

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

Number of inoculants have been used to minimise the existing soaking time and temperature. Various parameters in relation to conclusive studies are in progress before practised on industrial scale.

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

Inoculants of PM 121 and 122 prepared earlier, were drawn to 1/8'' dia. wire and experiments were carried out with 1/2 kg. alloy of the LM series to study the effect of these inoculants. The alloys were both chill and sand cast. Grain size measurement using intercept method and a statistical analysis of the data thus obtained showed that these wire inoculants are effective.

Large scale heats sufficient to inoculate about 10 tonnes of aluminium were planned and accordingly 200 kg of the inoculant were prepared in the form of 4''×4'' 48'' bars. These are being rolled to suitable size and drawn to wire form to carry out trials in industrial plant.

56.0 Development of Aluminium base Bearing Alloys.

Aluminium alloys containing lead and tin were cast by unconventional technique to achieve uniform distribution of the soft phases and improved mechanical properties. The castings were sectioned and subjected to metallographic examination, hardness and tensile testing. The alloys were found to achieve tensile strength in the range 18 to 20 kg/mm^2 and hardness in the range 90 to 110 BHN, in the heat-treated condition. RDSO, Lucknow, showed interest in the alloys and rough castings of floating bushes, 12 pieces, were sent to Lucknow for preliminary trials.

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

(i) Filtration of Liquid Metal

Two types of refractory filter media of different sizes were prepared and fired to produce material of sufficient strength. The effect of these media and the size and thickness of refractory bed on the efficiency of oxide removal from aluminium are being studied. About twenty five 1'' diameter ingots were cast with and without filtration. Specimen for mechanical testing are being made. Metallographic study and oxide inclusion study show that there is considerable reduction in the oxide content and improvement in the cleanliness of the product. Further work is in progress.

(ii) Special Melting Technique for Removal of Volatile Impurities

Using the specially designed vacuum chamber with stirring arrangement large scale Al-Mg alloys were prepared. Alloys of Al-Si prepared earlier were tested for mechanical properties and they were compared with the alloys cast under otherwise normal conditions. The average values of number of such tests from each samples is given in Table 3.

Table 3—Comparison of Properties of Al-Si alloys Produced Under Different Conditions.

	U.T.S. Kg/mm^2	% Elongation	% R.A.
Al-8.0% Si			
Treated in vacuum Chamber	18.15	16	17
Normal melting	17.69	5	3
Al-12.9% Si			
Treated in vacuum Chamber	18.87	5	3
Normal melting	17.85	5	3
Al-20.0% Si			
Treated in vacuum chamber	11.62	4	2
Normal melting	11.97	4	2

The table shows that there is considerable ductility improvement in Al-8% Si alloys. Based on these compositions further work is being planned.

58.0 Development of Aluminium Base Welding Electrode MIG Wire.

The technology for the development of electrodes wires corresponding to B.S. 2901 NG6 wire has been developed. The electrode wires have been evaluated for its welding characteristics and mechanical properties at various places, including Hindustan Aeronautics Ltd., Bangalore ; and found satisfactory to meet their specific requirements.

The development of electrode wire/filler wire for obtaining higher tensile strengths (30-32 Kg/mm^2) of the welded zones is underway. Most of this wire is used in Defence Establishments for welding high strength Al-Zn-Mg alloys which is at present imported.

59.0 Development of Thermostatic Bimetal.

A variety of thermostatic bimetals such as general purpose thermostatic bimetal for low temperature and medium temperature use ; high temperature thermostatic bimetal ; high sensitive-high resistivity bimetal ; low resistivity bimetal ; high permeability bimetal ; non-magnetic type bimetal, corrosion resistant bimetal etc. have been developed.

In the present phase of work high sensitive and special type of thermostatic bimetal involving non-ferrous alloys as high expansion component has been developed and production technology studied. Samples of special type thermostatic bimetal such as high sensitivity and low resistivity types have been used by a number of equipment manufacturers and the satisfactory performance reports have been communicated by the following users

(i) Indian Oxygen Ltd., Calcutta.
(ii) Jyoti Ltd., Baroda.
(iii) Shriram Refrigeration Industries, Hyderabad.
(iv) Siemens Electricals, Bombay.

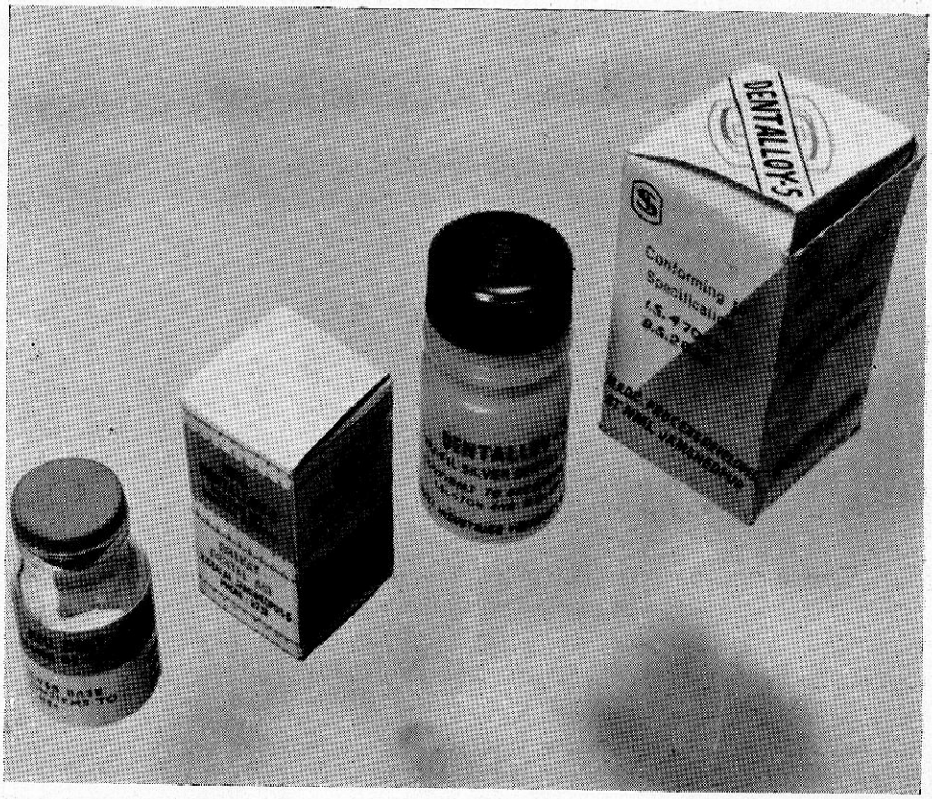
60.0 Development of High Conductivity and High Strength Copper—Titanium Alloys.

Development work was undertaken on copper-titanium alloys which have gained attention in several countries and are presently used as electrical conducting plates and springs, structural materials and find application in instrumentation and space technology.

Initially, few trials of Cu-Ti heats were made. In order to study the time parameter for solution treatment, some specimen were cut from an ingot and were kept in a resistance furnace at 890°C for different period and quenched in water. The microstructures of the specimen were examined. A master alloy containing 10% titanium was also made. Further work is in progress.

61.0 Dental Amalgam Alloy.

The production technology has been successfully transferred through N.R.D.C. to two entrepreneurs. Process demonstration has been given to the interested party and equipments required has been shown. One of the entrepreneurs M/s. Sakti Industries at Varanasi have already started the production of the item. The other entrepreneur M/s. Bharat Dental Aid at



Dental alloy produced commercially with NML developed process.

Jamshedpur will start their production very shortly. Attempts are also being made for exploring the possibilities of developing a cheaper dental amalgam alloy containing less silver.

62.0 Electrical Resistance Alloy.

The process for the production of electrical resistance alloys was demonstrated to an outside party. The melting, casting and mechanical working of the alloys was shown to them. Besides, technical assistance and suggestions were given to M/s. Cable Works to improve the quality of the alloy.

62.1 Development of High Temperature Alloy.

To develop a suitable alloy for use as heating element at about 1300°C, work was initiated with Fe-Cr-Al system. The alloying elements like Co, Ni and Mn were added to improve the plasticity of the alloy. Some heats were made and the ingots were mechanically processed for the evaluation of the properties of the alloy. Further work is in progress.

F. DEVELOPMENT OF MAGNETIC MATERIALS

63.0 Development of High Permeability & Low Expansion Nickel-Iron Alloys. *Sponsored by M/s. Guest, Keen & Williams Ltd., Howrah.*

The second phase of the work relating to the development of alloys having magnetic properties similar to Rho metal, radio metal and HCR alloys and expansion characteristics similar to dumet and invar alloys was taken up. Six heats were made in the vacuum induction furnace and six heats in the air melting induction furnace. Some of the ingots have been hot forged and hot rolled and drawn into the form of rods and wires for studying their characteristics. The specimens are being prepared for testing their magnetic and other physical characteristics. The macro structure of the ingots was also examined.

64.0 Preparation of Magnetic Gamma Iron Oxide.

During the period under review, cobalt doped gamma iron oxide was prepared using yellow iron oxide as the starting raw material. The properties could be upgraded to coercive force 300 to 500 oersted and remanence 1600 to 1500 gauss. A 5 kg lot of gamma iron oxide prepared has been sent to NPL for its evaluation. The project is terminated.

65.0 Preparation of Anisotropic Ferrite Magnet.

their application. The magnets prepared had a BH max of 3.0 to 3.2 mgo. Some work was also carried on the preparation of strontium carbonate from celestite ores and preparation of ferrite magnets from the ore direct. The experiments showed that it is possible to prepare celestite based ferrite magnets with BH max of the order of 4 to 4.2 mgo. The project is terminated.

66.0 Development of Permanent Magnets based on Crystalline Anisotropy and Exchange Anisotropy—Development of Cobalt Rare Earth Magnets.

A solenoid was fabricated for pressing cobalt rare earth powder magnets under a magnetic field of 8000 to 10,000 gauss. A few heats were made from misch metal and cobalt metals. The alloys prepared had shown varying oxygen contents which varied upto .08%. This large amount of oxygen is not permissible in cobalt rare earth magnets. Attempts are now being made to prepare the alloys from oxides by calcium reduction method.

67.0 Low Carbon Soft Magnetic Iron.

Further to the performance report received from M/s. Bharat Electronics Ltd. additional reports have also been received from M/s. Hindustan Aeronautics Ltd., Lucknow and M/s. Bharat Heavy Electricals Ltd., Hardwar. Extracts from these reports are given below :

(i) Extracts from M/s. Hindustan Aeronautics Ltd. (Lucknow)

"The soft magnetic iron sample supplied by NML was put in vibrator assembly and relay. The performance of the prototype using the NML sample in place of imported soft iron core was found satisfactory".

(ii) Extracts from M/s. Bharat Heavy Electricals Ltd., (Hardwar)

"The material supplied by NML was satisfactorily forged and tested for magnetic properties at BHEL, C.P.L. Subsequently the material was forged to required shapes, machined and the components were assembled. The magnetic assembly was magnetised and tested at M/s. Electric Corp. of India Ltd., Hyderabad. Flux density of 3500 gauss was achieved in the air gap which is satisfactory, against the minimum specified value of 3200 gauss".

The above performance reports were obtained on the low carbon soft iron produced in 1 ton electric arc furnace at NML. In an effort to establish the commercial viability for the production of this grade of iron, arrangements have been made to manufacture this iron in an industrial furnace of 8 ton capacity.

67.1 Development of Soft Magnetic Iron.

Vacuum degassing treatment is commonly resorted to in producing soft magnetic iron. Attempts are being made to develop a process technology of producing this material in an electric arc furnace through modified desulphurization, decarburization and deoxidation operation.

G. HEAT TREATMENT & MECHANICAL WORKING OF METALS

68.0 Extrusion Characteristics of Magnesium-base Alloys.

The melting procedure of the alloy AZ 61 was standardised and a number of defect free ingots were cast for extrusion into various integrated shape such as "tee", angle, tube, etc. These integrated extruded products are required by ISRO, Satellite System, Project, Bangalore ; for some of their urgent use. The extrusion parameters including die design is being worked out. Some L-shaped product which have been successfully extruded are being treated to obtain the optimum properties.

69.0 Development of Orthodontic Steel Wire.

It was observed from the work carried out earlier in wire drawing of stainless steel that the performance of Na-stearate and MoS_2 were superior than the other lubricants which were tried. These lubricants however were able to give the required properties only when drawn at lower speed and needed frequent annealing. Some work was carried out on higher speed drawing by introducing the lubricants under pressure. A fixture has been designed and fabricated for this purpose. Work is in progress.

70.0 Development of Clad Metals—Copper Clad Aluminium Sheets.

Copper clad aluminium sheet combines the advantageous properties of both copper and aluminium and possesses good electrical and thermal conductivity. One of the principal uses of this clad metal is transition joint between copper and aluminium conductor. Besides this, this clad metal can also be used as a substitute for copper in many uses such as chasis, radiating fins, wave guide tubings, shielding cans, variable condenser blades etc., where copper side provides the surface for soldering.

The production technology of this clad metal including cold rolling and annealing was developed and reported earlier. The project is being continued to produce and supply this clad metal to various users for thier development work.

71.0 Mechanical Working Facilities.

Rolling, forging, wire drawing and extrusion facilities were extended to various divisions of the laboratory. Forming and shaping of the ingots were

made as desired. This facility has given the opportunity to study the workability of various types of metals and alloys. Aluminium alloy, tube sections and a number of tubes and plates of magnesium base alloy were extruded.

H. TESTING OF MATERIALS

72.0 Central Creep Testing Facilities.

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

(*i*) *Investigation of Creep, Stress-rupture and Stress Relaxation Properties of* $1\frac{1}{2}$ *Cr-IMO-*$\frac{3}{4}$ *V-Ti-B Bolting Steel.*

This investigation on study of creep, stress-rupture and stress-relaxation of the bolting steel form part of the development programme of indigenous high temperature creep resistant materials and aims at ascertaining that the Indian Steels comform to the grades produced abroad.

Creep strain data at 525°C, 550°C and 565°C in the stress range 12-40 kg/mm^2, stress-rupture data at 550°C in the stress range 27-35 kg/mm^2 and stress-relaxation data at 500°C and 565°C lasting upto 30,000 hr are being collected on the first cast of $1\frac{1}{2}$ Cr-1Mo-3/4V-Ti-B bolting steel, produced by MUSCO.

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

Two casts (No. 9455 & 9923) of the steel produced in India by MUSCO, have been received from BHEL, Bhopal ; and creep and stress rupture tests have progressed upto about 18,000 hours.

Although, the rupture data so far available is comparable with the corresponding British data and lie within the $\pm 20\%$ scatter band, the experimental points are close to the lower limit of the British data. Only limited stress rupture data is presently available from the second cast (No. 9923) the creep rate at specific stress level is lower in case of second cast than obtained from first cast (9455). It seems reasonable to anticipate that second cast will have creep and stress-rupture strength higher than that of the first cast.

(*iii*) *Investigation of Creep-rupture Properties of AISI 316 Grade Stainless Steel. Sponsored by Reactor Research Centre, Kalpakkam.*

Creep behaviour being one of the most important aspect of the quality control and design parameters, Reactor Research Centre, Kalpakkam, is interested to get the steels tested and generate baseline data. This was discussed and agreed at the Third Indian Creep Panel Meeting held at Tiruchi.

Taking into account of the availability of test points and the need to obtain a set of meaningful test data at the earliest, a mutually agreed test programme has been conducted as follows :

Steel plates from three heats of AISI 316 grade austenitic steels procured by RRC from a French Supplier, has been tested at three temperature 550°, 660° and 650°C and at three stress levels at each temperature to give expected rupture life in the range 1,000—20,000 hours.

(*iv*) *Stress Rupture Tests on 1Cr-1/2 Mo Steel Forgings. Sponsored by M/s. Bharat Heavy Electricals Ltd.*

Stress-rupture tests on cast C and D of 1 Cr-1/2 Mo steel forgings, supplied by M/s. Bharat Heavy Electrical Limited, Tiruchirapalli ; have been carried out and the tests completed so far have registered rupture times ranging from 1228 to 9338 hr. The stress-rupture tests at 500°C and some of the stress-rupture tests at 525°C and 550°C at stress levels ranging from 9 to 28 kg/mm^2 are in progress. The longest time of individual test in this series has reached 9960 hours.

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

Failure of conventional superheater tubes in service has been one of the major problems in thermal power stations, leading to non-scheduled plant outages and such outages may cost as much as Rs. 2-5 lakhs per day in case of 100 MW unit.

Beset with this problem, the energy system and new products division of BHEL desired to determine the residual creep life of superheater tubes which are used in service for 14000 hr. Stress-rupture tests at selected temperatures and stress levels are in progress and the data obtained so far have been successfully applied to evolving a reliable technique to assess the residual creep life of the material.

(*vi*) *Studies of Boiler Tube Failures in Power Plants.*

Several investigations have been carried out on failed boiler tubes received from different power plants. Factors leading to these failure were ascertained and remedial measures suggested to improve the life of tubes.

(*vii*) *Temperature Properties of Welding Electrode Materials. Sponsored by M/s. D & H Secheron & Advani Oerlikon.*

Elevated temperature tensile tests as well as short term creep have been carried out on several grades of creep resisting welding electrode material received from M/s. D&H Secheron & Advani Oerlikon. The materials were tested in the all weld condition, at selected temperatures and stress levels to give rupture life of about 1000 hours.

73.00 Mechanical Testing Facilities.

Tensile, compression, Olsen ductility, torsion, load elongation, hardness, flattening, expanding, charpy impact and calibration tests of load cells were carried out for the laboratory and other outside organisations. Total number of samples tested during the period is 1720.

I. METALLURGICAL INVESTIGATION STUDIES ON METALS & ALLOYS

74.0 Metallurgical Examination of Chromium Plated Piston Rods. *Sponsored by M/s. Usha Telehoist Ltd. Calcutta.*

The firm requested to determine the cause of defects such as ring marks resembling a crack and pittings on the surface of hard Cr-plated piston rods used in hydraulic cylinders of D-50 type tractor.

Metallurgical tests showed that the ring mark and pinholing on the surface might have arisen due to unsatisfactory surface finish of the base metal, and also the controlling factors during electroplating were not optimum.

74.1 Determination of Delta Ferrite in Austenitic Stainless Steel Weldments. *Sponsored by M/s. D&D Secheron Electrodes Bombay.*

A number of samples of welded austenitic stainless steels was received to determine the ferrite content in the weld metal.

Metallographic examination using ten time count method was used and the results were reported accordingly. The ferrite was observed to be fine in all the samples.

74.2 Failure of Steam Turbine Blades. *Sponsored by M/s. Nasik Thermal Power Station.*

The firm experienced breakage of two blades in the L.P. turbine of a 140 MW turbo generator and requested to investigate the cause of their premature failure.

It was concluded on the basis of the tests carried out and the details received that though both the failed blade materials belonged to the standard 12% Cr-Steel, the steam might have contained a condensate such as acetate and/or ammonia to have a deleterious effect on the endurance limit of the Cr-steel blade material contributing eventually to the failure due to corrosion induced fatigue. The remedy lies in checking the feed water for impurities.

74.3 Metallurgical Examination of Imported Steel Tube Castings. *Sponsored by Oil & Natural Gas Commission, Dehradun.*

A piece of highly corroded and pitted stainless steel casing reported to conform to API-5×—P110 and imported from Canada was received to investigate the cause of pitting and corrosion.

Metallurgical tests showed that the casings had undergone corrosion during exposure to both marine and industrial atmosphere.

74.4 Failure of High Pressure Pipe in Synthesis Gas Line. *Sponsored by M/s. Neyvelli Lignite Corporation, Neyvelli.*

The high pressure pipe line connecting the inlet and outlet of the synthesis ammonia converter thinned down at the outside where it had been clamped on by means of structural steel clampings after 10 years service.

The pipe line material was found to be mild steel. The failure had taken place due to crevice corrosion on account of the formation of oxygen concentration cells at the joint where it was clamped. Crevice corrosion could be avoided by taking precautions at the design stage, to provide the joint with suitable primer or/to coat the surface with an anodic metal.

74.5 Failure of Foundation Bolt. *Sponsored by M/s. Tata Robins Fraser, Jamshedpur.*

A large number of bolts (IS-1875-1971 (C-45)-IV) used in wagon tripller foundation failed during installation due to impact. Accordingly, a sample of a failed bolt was investigated to find the cause of its failure.

It was found that the bolt material did not conform to the reported specification, did not receive normalising heat treatment and was fabricated by welding two steels of different compositions.

74.5 Failure of Superheater Tube. *Sponsored by M/s. IPC, Baroda.*

A super heater tube ($2\frac{1}{2}$% Cr-1% Mo) working at 440°C at a pressure 41.5 Kg/cm^2 failed prematurely. There was heavy localised scale formation on the outside surface of the tube and its thinning at this region. Metallographic examination revealed that the failure was due to 'fly ash' corrosion.

74.7 Metallurgical Evaluation of High Carbon Steel Wire Rods. *Sponsored by M/s. Mukund Iron & Steel Works Ltd., Bombay.*

Samples of high carbon steel wire rods were received for metallurgical examination in order to assess their quality. The samples examined were found of high carbon steel possessing strength consistent to their compo-

sition and heat-treatment. The samples were clean, free from cracks, seams etc. and showed normal pearlitic structure.

74.8 Inclusion Count in Steel Samples. *Sponsored by M/s. Usha Alloy Steel, Adityapur.*

Inclusion count of 12 steel samples was carried out by optical metallographic method. The samples were found satisfactory with regard to the degree of cleanliness.

74.9 Metallurgical Evaluation of Steel Billet. *Sponsored by M/s. Tamil Nadu Steel, Madras.*

A sample of steel billet, 'TNS : QCL—A' was metallurgically examined in order to assess its quality. It was a low alloy steel containing N_2, O_2 & H_2 within normal limits. Metallographic examination revealed the presence of a central pipe and blow holes around it. The general microstructure consisted of ferrite and pearlite ; no decarbonisation was noted and the degree of cleanliness was satisfactory.

74.10 Metallurgical Examination of Cylpebs. *Sponsored by Sawang Colliery.*

Three cylindrical pieces of cylpebs reported to have been imported from Germany for fine grinding of magnetite in their ball mills were metallurgically examined with a view to develop them indigenously.

74.11 Failure of Core Stamping of Generator. *Sponsored by M/s. Damodar Valley Corporation.*

Generator unit—4 was out of service. On dismantling the unit it was reported that a part of core (stator stampings) had melted and was in the form of lumps ; some guide vanes also had fallen out along with their fixing bolts and locking strips. It was apprehended that the failure of stamping might have arisen due to falling of bolts and fusion with stamping material.

Metallurgical examinations of the different samples sent showed that the molten lead metal was similar in chemical composition with core stamping.

74.12 Metallurgical Examination of Aluminium Lining Material of the Drum of Auxiliary Fan. *Sponsored by Sudamdih Colliery.*

The aluminium alloy lining material of the imported auxiliary fan which was obtained in damaged condition was received to investigate the possibilities of any thermite reaction having taken place on the surface and the cause of its deformation. It was concluded from different metallurgi-

cal tests that no thermite reaction had taken place and the lining material was machanically damaged by external agencies.

74.13 Failure of HDS unit. *Sponsored by Haldia Oil Refinery.*

During the start up operation of 23-C-01 Kero-treating column, the low pressure circuit become over pressurised due to failure of safety valves, resulting in bursting and bulging in 12th & 16th tray of the column and subsequent shut down of the plant.

When a high stress was super imposed normal to the rolling direction, the cumulative effect was to develop stresses in the through direction beyond the yield point resulting in the fracture. Metallographic examination revealed lamellar tears, away from heat affected zone of the shell plate with characteristic step like pattern associated with non-metallic inclusions. Similar tears mights have developed in other regions of the shell and although the damaged column was repaired, it would not be safe to run the unit.

74.14 Failure of Electrical Hangers 132 KV Circuit. *Sponsored by Bihar Electricity Board.*

Bihar Electricity Board experienced repeated failures of hangers (IS226—1962) used for suspending insulation strings carrying power conductors on towers in 132 KV Gaya-Hathidah transmission line.

Results of different metallurgical tests showed that the failure of the hangers was due to the absence of stress relieving heat treatment and hydrogen embrittlement during pickling and/or welding. Selection of material and galvanizing treatment should have been made as per IS6158—1971.

74.15 Failure of Structural Steel. *Sponsored by Obra Thermal Power Station, U.P.*

ISMB-600 fabricated column to be erected for 200 MW thermal turbine house got fractured at its top flange of the beam which was weldred on a cover plate about 3-4 hr. before the occurrence of failure.

It was found from metallurgical examinations that the brittle fracture of the column appeared to have taken place due to development of hard and brittle structure on account of fast rate of cooling, and also absence of low hydrogen process in welding.

74.16 Failure of ERW Tubes. *Sponsored by Oil & Natural Gas Commission, Sibsagar.*

Oil and Natural Gas Commission experienced the failure of $\frac{5}{8}$" ERW

line pipes conforming to API-5LX-Grade-X-42 at their Sibsagar project site, Assam.

It was found that although the pipe materials conformed to the specified composition, the quality of the weld was very poor as evidenced by metallographic examination and mechanical tests.

74.17 Metallurgical Evaluation of ERW Tubes. *Sponsored by M/s. Hindustan Steel Ltd. Rourkela.*

Two samples of $\frac{5}{8}$" ERW tubes were received for metallurgical evaluation of the tubes, specially to assess the metallurgical aspects of the welded zones.

The pipe materials conformed to API-5LX-Grade 42 in respect of the specified requirements. However, metallographic examination did not reveal a perfect, continuous, oxide-free weld joint all throughout.

74.18 Failure of Cement Crusher Hammers. *Sponsored by M/s. Century Cements, M.P.*

The firm experienced failure of a large number of 200 TPH capacity secondary-crushers (12-14% austenitic Mn-steel) engaged in crushing limestone in their factory. Five hammers were sent to determine the cause of their failure.

It was found that although the hammers belonged to the family of Hadfield steels, their failures had taken place on account of defective microstructures contributing to poor strength and toughness arising out of improper heat treatment imparted to the material. Successful application depended upon imparting proper heat treament to the hammers.

74.19 Metallurgical Examination of Cast Iron. *Sponsored by M/s. Metal Steel Manufacturing Co. Jodhpur.*

A sample of alloy cast iron was examined in detail by optical metallography in order to determine the various constituents of its microstructure.

74.20 Failure of Bolt for Pad of 100 MW Turbo-generator Bearing. *Sponsored by Badarpur Thermal Power Station.*

A bolt of the adjustable pad of 100 MW turbine bearing failed resulting in the breakdown of the turbo generator set. The failed bolt was received along with its working details to ascertain the cause of failure.

From the results of different tests, the failure of the bolt appeared to have taken place on account of the shearing off of the component at the

root of the thread due to high vibrational stresses encountered while in service.

J. FOUNDRY TECHNOLOGY

75.0 Heat-Resistant Cast Iron.

In plant service trials on 12 No. of carrier blades installed in the sheet bar reheating furnace was continued for a period of 4 months after which it had to be discontinued due to furnace breakdown.

To have better assessment of the material, seventy pieces of carrier blade castings were made with NML heat resistant alloy, given annealing treatment and finished to correct dimensions. These have been installed in the sheet bar reheating furnace on 22.1.77 and is giving satisfactory service. Trials were carried out to assess the recovery on remelting of NML heat resistant alloy in oil fired furnace and in direct arc melting furnace. The recovery was about 70% in oil fired furnace and 85% in arc furnace.

The possibility of using NML heat resistant alloy in other applications is being explored. A tube casting for use as a hot air tube in soaking pit furnace is being tried. Growth tests under cyclic heating condition at 1000°C is being carried out on different samples.

76.0 Wear & Abrasion Resistant Cast Iron.

Work has been extended to develop wear and abrasion resistant alloy for applications other than impeller blades for shot blasting machines such as coal grinding and crushing machinery, mineral handling and plants having wear problems and industries are being contacted.

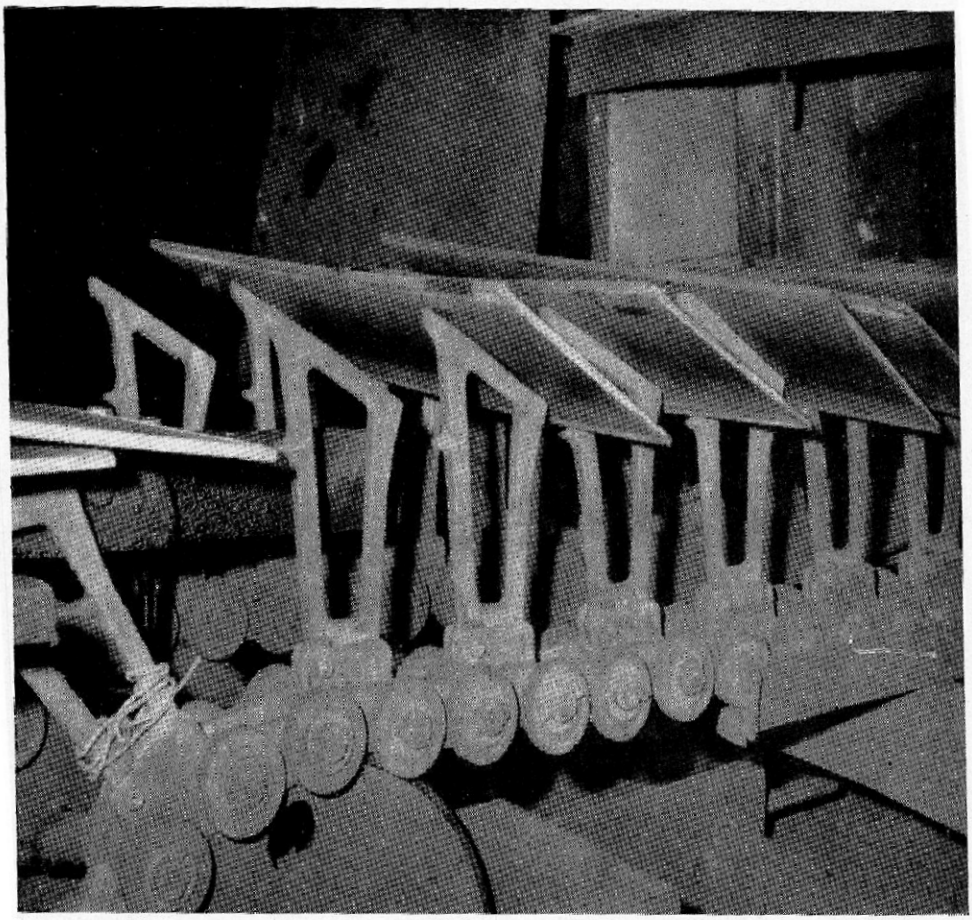
77.0 Development of Casting and Heat Treatment Techniques for the Production of High Speed Steel Cutting Tools.

The effects of various casting techniques on the cast structure of high speed steel tools was studied on laboratory scale. Designing and fabrication of the machine for industrial scale trial on centrifugal casting technique is in progress.

78.0 Development of Special Casting Methods.

Basic data regarding slurry composition for investment casting has been worked out at normal room temperature and humidity. However, these composition have to be re-established under controlled temperature and humidity condition.

Mould coating experiments with plaster of paris facing and CO_2 sand backing has been worked out and a few castings have also been produced.



NML developed heat-resistant cast iron carrier blades under plant trial.

Further work is underway to establish a reliable and successful procedure.

79.0 Production of Nodularising Agent.

Nickel-magnesium alloy produced was successfully used in an industry in a 4 ton furnace for the S.G. iron castings. The 'Know-how' for the production of nickel-magnesium alloy is ready for exploitation.

80.0 Self-setting Agent for Sodium Silicate Sand Process and Fluid Sand Process.

High temperature properties, such as retained strength, high temperature strength etc. of the sodium silicate bonded sand hardened by NML self-setting agent were determined. The effect of different additions such as dextrine, coal dust, molasses, sulphite sand dust, etc. were examined on the high temperature properties.

A new reagent was decided to be tried out for use as self setting agent for sodium silicate bonded sand. The first batch of the reagent was examined but was found to give inconsistant results depending on the bach. Another batch was received and experiments were carried out to examine its suitability for use as a self setting agent. A few casting trials were made. Experiments are also underway to investigate the behaviour of the self-setting agent under different conditions of temperature & humidity.

The design of the mixer for making fluid sand has been finalised for procuring the mixer. The industrial scale trials will be taken up as soon as the mixer is received.

K. CORROSION STUDIES ON METALS & ALLOYS

81.0 Studies on Stress Corrosion Cracking of Metals.

The effect of stress to initiate corrosion cracking of α-Brass, mild steel and stainless steel was studied by a 'stress relaxation technique' which comprises of continual reduction of applied load on the specimen. Irrespective of the metals tested, it was observed that micro-tunnels were developed on the surface which on coalescence form the crack at later stage. These tunnels are believed to be stress activated sites undergoing anodic dissolution during the process of stress corrosion.

The differences in behaviour of the brass and the steel samples, which were apparant from the present state of investigation, were that an acidic media was required to produce tunneling on steel surfaces. This might be explained due to the presence of oxide film on metal surface which can readily be dissolved in acid solutions thereby the stress activated sites are exposed to corrosive environment.

Role of passive film for hindering the process of stress corrosion cracking has further been ascertained by the fact that when steel samples are given a small number of twists and then tested microtunnels are developed even without lowering the pH of the solutions. The geometric pattern of the microtunneling needs further investigations to identify the behaviour of dislocation network and segregated regions in the process of localised corrosion. Work in this line is in progress.

82.0 Studies on De-alloying Phenomenon.

Different parameters of de-alloying phenomenon of Cu-Mn and Cu-Zn were studied in laboratory under accelerated condition. A relationship between corrosion rate (i.e. current density) and potential was postulated and a zone (—50 mv to +50 mv) was identified as susceptible for de-alloying in certain medium.

83.0 Studies on Hydrogen Embrittlement of Steels in Aqueous System.

Hydrogen embrittlement of high strength steels in 1N sulphuric acid containing varying concentrations of thiocompounds at 40°C was studied. The results show that thiocompounds having low molecular weights are not at all suitable pickling inhibitors for high strength steels as these compounds influence higher hydrogen pick up. At medium concentrations of the inhibitors (60-70% efficiency) the steels containing 0.45% C were found to be affected most in respect of hydrogen pick up. The work especially on the notched specimens using slow strain rate is in progress.

84.0 Development of Inhibitors for Recirculating Water Cooling System.

Keeping in view of the pollution hazards due to the use of chromate in the cooling systems, work was taken up to develop non-chromate inhibitors. Experiments were conducted in 3.8% NaCl using different combinations of metallic systems. Corrosion rate, open circuit potential, potential of the couple, current flowing between the couples, conductivity of the solution and pH before and after the experiments were recorded. Corrosion products were also analysed. Based on these data, screening of both inorganic and organic inhibitors are being done on laboratory scale.

85.0 Synthesis of a Few Derivatives of Thiazole and Their Uses as Corrosion Inhibitors.

Work was taken up to study the role of thiazole derivatives for preventing corrosion of aluminium, brass, copper etc. in aquesous systems. Arrangements for the synthesis of the compounds are being made with a view to determine their corrosion inhibiting properties.

86.0 Studies on Corrosion of Steel in Cement Concrete.

An internal investigation was carried out to find out the causes of heavy corrosion of steel reinforcement and consequent roof collapse in a specific case.

The results of the investigation indicated that the heavy corrosion was due to presence of chlorides in the concrete mixture. Spalling and cracking of the roof occurred due to the voluminous nature of rust formed.

87.0 Survey of Corrosion Problems at the Sindri Fertilizers Plant. *Sponsored by M/s. Fertilizer Corporation of India, Sindri.*

The Fertilizer Corporation of India, Sindri Unit, approached the Laboratory for a team of scientists to study the existing conditions of some of their plant equipment and accessories which have shown deterioration due to corrosion and assist them in renovation of these items. The survey was accordingly made and as many as seven diversified problems of different shops were studied.

The problem of water scrubbers in the ammonia plant has been the prime concern. At number of places on the internal surface of the scrubbers, corrosion cavities were formed. Ultra sonic scanning for the shell thickness revealed that at the deepest pit, the thickness has gone down from 34 mm to 19 mm. This needed an assured technique of repair since the scrubber is to work at high pressure. The detailed technique for building up the cavities by spot welding and providing glass lining for the over all surface was suggested for the reclamation of the corroded scrubbers.

Possible reasons for the corrosion problems in other plants such as (i) sagging and cracking of CO-CO_2 converter, (ii) cracking through weld on gas scrubber, (iii) corrosion of the radial compressor in the coke oven plant (iv) corrosion of rich gas main at selective places (v) corrosion of gas reforming boiler and (vi) failure of a oxygen blower in gas reforming plant, were identified and remedial measures were suggested.

87.1 Evaluation of Corrosion Preventive Formulation 'Ruskil' by Potential Stabilization Technique. *Sponsored by M/s. Platipeel Chemicals & Plastics (P) Ltd., Bombay.*

The firm requested to evaluate the protective properties of one of their products 'Ruskil'. The investigation was carried out using electrode potential stabilization technique. The product on application to the rusted surface could modify the rust film and produce effective protective coating.

87.2 Cathodic Protection of Filter Water Mains in Calcutta Metropolitan Area. *Sponsored by Calcutta Metropolitan Development Authority.*

On the basis of the results obtained on four pilot stations installed under supervision of NML, for cathodic protection of the underground pipe lines in some areas in Calcutta, the Metropolitan Authority has now decided to apply similar protective scheme for whole of the metropolitan areas and approached NML for expertise. A team of scientist inspected the existing condition of the pipe line and advised the CMDA to draw up a scheme for execution of the work.

87.3 Corrosion of Steel Rods During Transit & Storage. *Sponsored by M/s. Bhilai Steel Plant.*

One consignment of 1/4" steel rod produced in the Bhilai Steel Plant was exported but it developed abnormal rusting on the surface during transit. It was also reported from the importing country that the consignment which they received from Japan remain free from rusting.

In absence of detailed information regarding packing and despatch condition of the imported and indigenous product, the corrosion behaviour of both the Bhilai and Japanese steel were compared. Japanese steel contained alloying additions of Cu, Cr & Ni and showed better corrosion resistance. Main factor involved was the scale formed which produced higher resistance to corrosion. The scale was comparatively more compact and less porous.

L. SURFACE COATING ON METALS

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

A process to give an adherent coating of copper on steel surface with current and also without it in presence of an inhibitor has been standardised. The conventional process in industries is cyanide copper plating solution having hazards of cyanide. A few industries manufacturing welding electrodes and copper coated wire have shown interest in the process.

89.0 Bright Acid Zinc Plating Bath.

An acid zinc plating bath has been formulated which is suitable for production plating practice. The performance of the plating bath has been proved satisfactory under production trials. Different plating firms are being approached to utilise this technology in production practice instead of the conventional cyanide zinc plating bath.

90.0 Copper Plating on Aluminium.

The main object of the project is to develop a convenient electroplating

bath that will be capable of deposition bright, adherent copper directly into aluminium wire over a wide current density range.

Investigation work is in progress for electroplating on commercial aluminium wire after proper pretreatment. Copper plated samples are being examined and tested in Hindustan Cables, Rupnaraianpur, Asansol, for suitability in cable industry.

91.0 Electroless Nickel Plating.

Experiments are being conducted on laboratory scale to study the plating of nickel by the technique of electroless deposition on mild steel sheets. The standard procedure for the plating of mild steel sheet by this technique is being evolved.

92.0 Calorizing and Chromizing of Low Alloy Steel Parts for High Temperature Service.

Alloys of $2\frac{1}{4}$ Cr—1Mo and $\frac{1}{2}$ Cr—$\frac{1}{2}$Mo—$\frac{1}{4}$V grades were chosen for calorizing experiments with a view to enhance their oxidation resistance since these alloys are used in boilers and space materials. Specimens from the above alloys were made and degreased before calorizing. These samples were subjected to calorizing in a pack process for 5 hr at 900°C and cooled in situ. The samples showed a coating thickness of 150-250 microns with micro hardness varying from 300-350 mu Calorizing experiments at the same temperature but at reduced times 3 hr and 2 hr reduced the thickness. Normalising and tempering of the calorized samples decreased the hardness of the coating and made it more dense. Experiments are underway on calorizing of 1 Cr-$\frac{1}{2}$ Mo castings supplied by Bharat Heavy Electricals Ltd. with a view to increase their oxidation resistance.

93.0 Development of Alkali Silicate-Zinc Dust Coating.

Subsieve analysis of zinc dust produced at NML was carried out and it was found that about 29% by weight is finer than 7.9 microns, 19% by weight is finer than 11 microns, 22% finer than 30.5 microns and the rest in other size ranges. The purity of the zinc powder was found to be 94%. Sodium silicate solution having an alkali to silica ratio of about 1:3.5 was made from commercially available sodium silicate by ion exchange treatment and this silica rich sodium silicate formed the vehicle for zinc rich alkali silicate coatings. Different approaches were made to enrich commercial sodium silicate in its silica content.

94.0 Study on Plating Problems. *Sponsored by M/s. Sen-Raleigh Ltd., Asansol.*

M/s. Sen-Raleigh Ltd., a leading bicycle industry, have been facing plating problems in production practice wherein platings peel off from the

cycle saddle parts when put under tension. The firm referred the problem for investigation.

The problem was investigated and consultancy service was rendered for remedial measures. The investigation finding has been of immense assistance to the industry to avoid the rejection of plated materials.

M. STANDARD REFERENCE MATERIALS & ANALYTICAL WORK

95.0 Preparation of Chemical Standards.

So far 28 different types of standard samples have been prepared which are now being sold to meet the demand of industries, educational and research organisations and instrument manufacturers etc. NML has started production of these specialised products on a modest scale which is intended to be expanded gradually covering production of more and more different ferrous and non-ferrous standard samples.

(a) During the period preparation of the following standard sample were taken up.

(i) Low alloy steels of different compositions having seven alloying elements.

(ii) Alloy cast iron with tentative composition of C-3.0%, Ni-1.8%, Cr-0.4% and Cu- ;0.03%.

(iii) Plain carbon steel with 1.1% Carbon.

(iv) Replenishment of 0.4% carbon steel.

(b) Samples sold during the year :

A total of 120 kg of different types of standard sample of Rs. 1,41,159-00 worth.

95.1 Preparation of Spectrographic Standards.

The compositions of the low alloy steel, standards have been adjusted in such a way that using these it will be possible to analyse the alloying elements of low alloy steel in the range Si-0.05 to 2.0%, Mn-0.05 to 2.0%, Ni-0.1 to 4.0%, Cr-0.1 to 4.0% Mo-0.05 to 1.5%, V-0.05 to 0.8%, Cu-0.05 to 0.8%. Eight heats of variable composition having all the seven alloying elements as mentioned above have been made, forged and heat-treated. Samples from the forged and heat-treated bars have been prepared and sent to different outside organisations for chemical analysis for ascertaining the correct compositions. Homogeneity tests on the forged and heat treated

samples have been carried out by spectrographic methods. The results are very satisfactory. Final certification of these standards will be made as soon as the results are received from the outside organisations.

96.0 Analytical Work.

(*i*) *Chemical and Instrumental Analysis.*

2416 samples containing 9484 radicals were analysed.

(*ii*) *Analysis of Gases in Metals.*

157 Samples were analysed for determination of various gas content. The number of such radicals analysed were 359.

(*iii*) *Spectrographic Analysis*

(a) Qualitative Analysis—175 samples were completely analysed.

(b) Quantitative Analysis—119 samples were analysed for 479 radicals.

(iv) X-ray Fluorescence Spectrometer 332 samples were analysed for 807 radicals

(v) X-ray Fluorescence Analysis by Autrometer. 250 samples were analysed for 300 radicals

(vi) Differential Thermal Analysis—DTA studies were conducted on Bailadila composite (Cyclone overflow) iron, dolomite, Rajhara clay, sandstone, kaolinite, Madagascar graphite.

(*vii*) *Petrological Studies on Ores & Minerals*

37 ore and mineral samples received for beneficiation and other investigations were studied and their detailed petrological reports were furnished which are incorporated in the main body of the investigation reports.

N. APPLIED BASIC PROJECTS

97.0 Structure of Rapidly Solidified Aluminium Alloys from the Liquid State.

Al-Si, led to an extension of solid solution, [illegible]
pseudo binary system. Solidification characteristics of the thin film was found

to pass through stages of pre-dendritic structure after the actual formation of spherical nucleus before being transformed to normal dendritic morphology. Attempts have been made to study the precipitation kinetics of the super-saturated solid solution thin films by determining quantitatively the phases adopting X-ray integrated intensity measurements using integrated intensity power formula substituting the correction due to absorption.

98.0 Study of Physical & Mechanical Properties of Splat Cooled Aluminium Alloys.

A laboratory scale unit for rapidly cooling aluminium alloys from liquid state has been fabricated to evaluate the impact of splat cooling on the mechanical properties of alloys. Al-Si, Al-Si-Cu-Ni and Al-Zn-Mg-Cu alloys were produced under rapidly cooled condition and consolidated by compacting, sintering and extrusion. An evaluation of mechanical properties of the alloys indicated that the tensile strength of the alloy could be improved only to a moderate extent. However, considerable improvement in ductility could be achieved over conventionally processed alloys.

99.0 Studies on Metallurgical Slag.

With a view to standardize the radioactive tracer technique for the estimation of sulphur content in synthetic slags for the studies of partition of sulphur between master alloy of pig iron containing 1.004% of sulphur—35 and synthetic slags, experiments were carried out using suitable radio-active standards. The investigations carried out at 1550°C when slag samples were withdrawn at pre determined intervals, show that the per-centage of sulphur in slags increases with the increase of time interval but after a certain period, the sulphur content tends to be constant. The experi-ments conducted with equal amounts of master alloy and synthetic slag in one case and by decreasing the amount of slag to half in the other case, indicate that the sulphur content in the slag samples in the latter case is higher.

100.0 Studies on the Corrosion Inhibition Mechanism using Radio Active Tracers.

This project has been undertaken with a view to a long term evaluation of the action of corrosion inhibitors for different media generally faced by the industrialists.

During the period under review, the study of the effect of sulphide on the protective properties of chromate has been carried out. The results of the corrosion studies on mild steel in aqueous Na_2S solution of varying concentrations of sulphur from 0.5 to 100 ppm, show that rusting on mild steel surface appears at concentrations of 5 and 10 ppm., staining of surface at 25 ppm and pitting at 50 and 100 ppm respectively. The study of potential change of mild steel with time in Na_2S of varying concentrations of sulphur

(0.5 to 100 ppm), shows that the increasing concentrations of sulphur in Na_2S solution shifts the open circuit potential towards less noble values.

101.0 Kinetics & Mechanism of Alkali Attack on Alumino-Silicate Refractories.

In the last phase of this project, alkali attack tests were done with sodium carbonate and lithium carbonate melts in addition to potassium carbonate melt. It was observed that for blast furnace stack brick, alkali attack with lithium carbonate melt at 860°C was maximum followed by the attack with sodium carbonate melt at 1000°C. To verify the assumption that free silica of the sintered alumino-silicate compact gets preferentially dissolved in molten K_2CO_3 as time progresses, X-ray diffraction patterns of the refractory compacts were taken and studied. It was observed that in case of a siliceous and a rather aluminous refractory compacts, the silica lines decreased and the mullite lines increased with progress of reaction. These studies thus indicate that silica bond attack and depletion were the mechanisms of alkali attack on the alumino-silicate refractory compacts. Photomicrographs of the reacted refractory samples also substantiate the x-ray diffractometer findings.

102.0 Studies on Sintering in the Presence of a Liquid Phase of some Ceramic Systems.

Interpretations of various data collected on the liquid-phase sintered samples were studied. Rate of densification was determined and the activation energy of the process was calculated. Phase identifications by x-ray studies were carried out of the optimum sintered samples of the various systems.

103.0 Fundamental Studies on Bentonites.

X-ray diffraction studies on about 30 bentonite samples were done. Activation studies on 5 specially chosen bentonites were carried out and the effect of activation on liquid limit, gel value, pH, high temperature properties, moulding properties, etc. were completed.

PILOT PLANTS

104.0 Mineral Beneficiation Pilot Plant.

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

105.0 Dense Carbon Aggregate Pilot Plant—Production of Dense Carbon Aggregate and Soderberg Paste.

To study the actual service performance of soderberg paste in all the three electrodes in ferro-alloy furnace a supply of 26-27 tonnes of the paste has been made and sent to M/s. Ferro Alloy Corporation. It will be tested in the presence of NML Scientists. Further trials to make dense carbon aggregate with low ash coal and with suitable blending of raw petroleum coke are in progress and the bench scale results are quite encouraging.

190 ft long electric tunnel kiln designed and fabricated at NML has been put into operation for the heat treatment of dense carbon aggregate. Three tonnes of aggregate was calcined in one trial run. Temperature of the order of 1300°C was attained but there was certain obstructions of the movement in the track. The obstruction has been rectified and furnace will be put to use again.

106.0 Refractories Pilot Plant—Production of High Alumina Cement 65-70% Al_2O_3 and Castable Therefrom.

Refractories pilot plant has produced 11.50 tonnes of calcium aluminate cement with 65-75% alumina content. During this period 34.50 tonnes of kyanite lumps were calcined in gas fired down draft kiln. This calcined kyanite has been crushed and graded to use as aggregate. Thus 46 tonnes of high alumina castable has been made which has been used successfully for lining kiln cars, making saggers, heating slabs for tunnel kiln in the cabron plant and down draft kiln. Besides this, such castables have been used for making and repairing all types of furnaces in the laboratory specially lead melting furances, down draft kiln, globar furnaces etc.

107.0 Electrolytic Manganese and Manganese Dioxide—Large Scale Facilities for Production of Electrolytie Manganese Metal and Dioxide.

The erection of the 1000 tonnes EMD and 1000 tonnes manganese sulphate mono-hydrate per annum plant of M/s. T. K. Chemicals Ltd. at Trivandrum is complete and the pre-commission trials of the plant are under way. It is expected that the plant will go into full production in August '77.

The operational data of rotary kiln and other process equipment were supplied to M/s. M. M. Suri & Associates who are consultants of NRDC for the electrolytic manganese dioxide pilot plant to be set up in Burma under the Indian Technical and Economic Co-operation Programme.

Industrial Promotion and Investment Corporation of Orissa Ltd., together with M/s. Rungta and Sons intend to put up a 3000 tonnes per annum EMD Plant in Joda-Barbil area in the joint sector based on the results obtained on evaluation of their manganese ore for production of EMD at NML.

The operation of electrolytic manganese metal plant was demonstrated to the engineers of Metallurgical and Engineering Consultants, Ranchi ; who have been asked to submit a quotation for preparation of a feasibility report for production of 1 tonne/day electrolytic manganese by West Bengal Industrial Development Corporation.

The process developed in the Laboratory for production of electrolytic manganese dioxide has been evaluated by M/s. Engineers India Ltd. for their client who intend to set up a 1500 tonnes per annum EMD Plant in Uttar Pradesh.

108.0 Hot Dip Aluminizing Pilot Plant.

Successful sponsored trials were conducted for the aluminizing of stainless steel wires for heat resistance applications for M/s. R. D. Ashar of Bombay with a trial batch of 100 kg.

109.0 Sukinda Nickel Pilot Plant.

The Sukinda Nickel Pilot Plant project was revived with effect from Jan., 1977 to enable the Consultants, M/s. Chemical and Metallurgical Design Co. of Delhi, to complete the investigations for the Ministry of Steel and Mines. A ten month programme has commenced in January with plant modifications an overhauling followed by trial runs.

1000 tonnes per year electrolytic manganese dioxide plant of M/s. T. K. Chemicals, Trivandrum; set up with NML know-how.

NML FIELD STATIONS

NML Unit in CSIR Complex, Madras.

The NML Unit in CSIR Complex, Madras ; has conducted a number of sponsored investigations on beneficiation and agglomeration of low grade ores and minerals ; development of a fluo-solid reactor for the production of filter aids ; calcination of crystalline limestone ; inter-laboratory project on digital carbon analyses etc. Besides, technical services have been rendered to a large number of industries by undertaking microstructure examination, hardness tests, mineralogical studies, chemical analyses etc. The following are the various investigations conducted and underway in this unit.

(i) Beneficiation studies on two iron ore samples for Yerraballi and Chandoli areas of Karimnagar Dist, Andhra Pradesh (Karimnagar Project).

(ii) Beneficiation and pelletization studies on a limestone sample. Sponsored by M/s. Industrial Chemicals Ltd., Tamilnadu.

(iii) Heavy media separation studies on a magnesite sample. Sponsored by M/s. Burn & Co. Salem.

(iv) Washing of a clay sample from Ramnad district, Tamilnadu. Sponsored by Shri D. J. Raja, Rajendranagar, Tamilnadu.

(v) Treatment of Chrome Sludge. Sponsored by M/s. Binny & Co. Madras.

(vi) Physical tests on seven iron ore samples from Bellary Hospet Area—Sponsored by SAIL, Bangalore.

(vii) Beneficiation studies on a low grade limestone sample. Sponsored by M/s. India Cements, Tamilnadu.

(viii) Physical tests on a limestone sample. Sponsored by SAIL, Bangalore.

(ix) Beneficiation of a magnesite sample. Sponsored by M/s. KEMCO Chemical Industries, Madras.

(x) Beneficiation of lime sludge. Sponsored by M/s. Indian Oxygen Ltd., Madras.

(xi) Beneficiation studies on a low grade kyanite-sillimanite sample from Andhra Pradesh. Sponsored by Director of Geology & Mining, Andhra Pradesh.

(xii) Beneficiation studies on an iron ore sample from Nainarmalai Tamilnadu. Sponsored by Director, G.S.I. Tamil Nadu.

(xiii) Beneficiation of a baryte sample from Tamilnadu. Sponsored by M/s. Abco Barytes, Sankarnagar.

(xiv) Beneficiation of a chromite sample, Karnataka, Sponsored by Mysore Minerals, Bangalore.

(xv) Amenability of Nileswar bauxite for Bayer's process. Sponsored by M/s. Kerala State Industrial Development Corporation.

(xvi) Design of Digital Carbon analyser. Inter-Laboratory Project of NML, CEERI & CSIO.

(xvii) Development of a fluo-solid reactor for the production of filter aids, calcination of crystalline limestones etc.

Field Stations at Batala, Howrah & Ahmedabad.

The technical services rendered by these Field Stations are being increasingly utilised by the regional metallurgical industries in general and foundry industry in particular. The Table 4 gives an account of the nature of technical assistance rendered by the field stations during the period. Technical guidance is furnished in the following fields.

(i) Selection of suitable raw materials—This includes facilities for the analysis of ferrous and non-ferrous metals and alloys, refractory materials, testing of sands, bentonites and other foundry raw materials.

(ii) Application of modern techniques of production scientific methods of metal casting and testing.

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

(iv) To impart technical know-how and guidance to meet stringent export requirements.

Table 4—Nature of Assistance Rendered by Field Stations

Sl. No.	Nature of Service	Batala	Howrah	Ahmedabad
1.	Chemical analysis—No of radicals analysed	847	536	3002
2.	Mould and core raw material testing—No of tests	—	10	59
3.	Mechanical testing—No. of tests	32	13	12
4.	No. of sands and bentonites investigated	2	—	—
5.	No. of technical enquiries attended	429	134	400
6.	No. of foundry visits for giving on the spot guidance	112	77	36

Keeping in view of the increasing demand for analytical services, the field stations are being equipped with equipment for instrumental analysis. To begin with NML Field Stations, Ahmedabad is provided with few instruments such a spectro-calorimeter, electro analyser etc., A very promising increase (800 radicals) in number of redicals analysed compared to last year's figure reveals rising demand of the service. The Field Stations at Batala and Howrah are being provided with the above instruments during the financial year 1977-78.

The equipment for conducting metallographic studies and some non-destructive testing have been received at Field Stations, Batala and Howrah and the facility is about to make a start shortly. This facility has been planned for the Field Station, Ahmedabad, during the year 1978-79.

NML Field Station, Batala ; is doing commendable job in the field of metal casting and many foundries in the northern region are benefitted in producing quality cast irons for diversified needs. More foundries are going in for the "Equi blast cum balanced-blast cupola" designed by the scientists of NML Field Station, Batala.

The establishment of ore dressing wing of the Field Station, Ahmedabad, is progressing. Few basic equipments have already been received and work on the beneficiation of some minerals has started with the collaboration of State Geology and Mining.

Marine Corrosion Research Station, Digha.

The following investigation was conducted during the period.

Studies on Atmospheric Corrosion of Metals.

Elaborate field tests and laboratory studies on both ferrous and non-ferrous metals & alloys exposed at the marine environment have yielded interesting data. From average daily, monthly and yearly corrosion of various metals, it was observed that salinity, humidity and number of wet days are the predominent factors for causing excessive corrosion of metals. A generalised formula to correlate these factors with corrosion of mild steel has been worked out.

ENGINEERING ACTIVITIES

Design Engineering

The following major design and fabrication work was taken up and conducted during the period.

(i) Apparatus for breaking-up of agglomerates, flattening of particles and polishing of ball-milled flaky products.

The mill has been fabricated and is undergoing proving trials.

(ii) Single electrode furnace for electro-thermal extraction of metals.

The furnace will have a 140 KVA capacity and will be suitable for operation under vacuum 5.25 mm of mercury. The equipment is under fabrication/procurement.

(iii) Apparatus for testing abrasion resistance of refractories.

The apparatus designed allows for variable velocities of abrasive particles and angles of their impingement on the refractory target.

(iv) Apparatus for electro-thermal production of zinc dust Work is underway.

Mechanical Engineering

The workshop is providing the following services for the various research & development projects :

(i) Preparation of standard test specimen.

(ii) Fabrication of special purpose apparatus for experimental work.

(iii) Maintenance of Laboratory equipment.

(iv) Checking, assembly and mechanical installation of new equipment.

Electronics Engineering

A. Instrumentation of Project

(*i*) *Hydro-Electro Metallurgy Project*

Testing and installation of the following instruments were completed.

(a) Nucon gas chromatograph — 1 No.
(b) Spectro colorimeters — 2 No.
(c) Oxygen analyser — 1 No.

(ii) *Mineral Processing*

The following instruments were repaired, tested and installed at Mineral Processing & Testing Plant.

(a) Carl-Zeiss spectrophotometer.
(b) Radelkis polarograph.
(c) Philips x-ray spectrometer PW 1410
(d) Cambridge steroscan S 410
(e) Pye unicam atomic absorption spectrophotometer SP 1900
(f) Deltatherm (DTA).
(g) Gamma ray spectrometer
(h) Recorders and controllers
(i) Electron microscope EM6
(j) 200 KV X-ray machine.

Electrical Engineering

A. Development Projects.

(i) *Studies on Electrical Resistivities of Slags and Mattes.*

Different compositions of slags and mattes of lead and magnesium were studied for their electrical resistivities. Various configurations of electrical furnaces to suit the requirements of smelting of lead and magnesium were also studied.

(ii) Liquid State Extraction of Magnesium in a Single Electrode Furnace.

The electric furnace is rated for 140 KVA. Various components of the furnace were under fabrication.

(iii) Development of 3-tonnes High Sensitivity Creep Testing Machine.

Detailed drawings of various parts of a prototype single specimen creep testing machine incorporating all modern features, were prepared.

It was decided to fabricate the machine with all indigenous components except temperature controller, platinum thermometer and heat-resistant alloys for holders and extensometer limbs.

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

Furnace shell and end supports were fabricated. Heat sink of heat resistant material was successfully cast to suit the special configuration of the furnace.

B. Consultancy for Graphite Beneficiation Plant at Udaipur.

In connection with the consultancy for graphite beneficiation plant at Udaipur, preparation of layout of electrical equipment relating to the substation power distribution and control systems was carried out. Cost estimation was also done for the work within the scope of layout.

C. Design Fabrication & Installation.

(i) A number of electrical resistance furnaces were designed and fabricated to meet the specialised needs of research and development projects.

(ii) Design of power distribution system, its installation and commissioning were carried out for a number of equipment in the laboratory and its pilot plants.

D. Preventive Maintenance & Breakdown Repairs.

Preventive maintenance and breakdown repair were carried out for electrical equipment installed for research and development and power supply systems in the laboratory and its pilot plants.

Civil Engineering

Other than normal maintenance of gas, water and other service lines, installation of equipment, the following jobs were completed during the period.

(i) Construction of drinking storage water tank and pumping room in the Laboratory.

(ii) Repairing of floor, drain etc. of electrolytic manganese pilot plant.

(iii) Providing barbed wire over the compound wall on eastern side of the Laboratory.

(iv) Modification of cycle stand at Ferrous Production Technology Division site.

(v) Painting of steel structures at Ferrous Production Technology Division site.

(vi) Construction of drain in front of cement godown and raw materials Stores at Ferrous Production Technology Division Site.

(vii) Extension and modification of existing shed housing gas producer at Mineral Beneficiation Pilot Plant Site.

The following jobs are in progress.

(i) Tarfelt treatment to the leakage roof in the Laboratory.

(ii) Tarfelt treatment to the office building at FPTD.

(iii) Replacement of old gas main pipe lines, in the Laboratory

(iv) Re-roofing the damaged roof of the Laboratory.

(v) Installation of pneumatic hammer at NML Technological block.

PLANNING & APPRAISAL OF RESEARCH & DEVELOPMENT PROJECTS

Project Programming

Projectwise planning and programming of research & development work was continued on the Fifth Plan proposals. The research programme was periodically reviewed. The annual plan for 1977-78 and revised plan budget for 1976-77 and budget estimate for 1977-78 were prepared on the basis of on-going and new research projects, pilot studies, infrastructural facilities etc. The various parameters for each project such as objective priority rating, date of commencement & anticipated completion, areas of socio-economic relevance etc. have been identified. Monitoring of the manhour input and cost of the projects are being worked out.

Augmentation of Extraction Metallurgical Facilities.

A proposal has been submitted regarding the initial commencement of the UNDP project on "Augmentation of Extraction Metallurgical facilities" under a "Preparatory Assistance Phase".

PUBLICATIONS

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

NML Technical Journal

The four issues of NML Technical Journal Vol. 18, 1976 ; were published. The journal won the 19th National Award (Second prize) given by the Directorate of Advertising & Visual Publicity, Ministry of Information & Broadcasting, Govt. of India ; for its excellence in designing and printing under the category 'Monthly & other Magazines—English'.

Annual Report

The Annual Report of the Laboratory for the years 1974-75 & 1975-76 were published.

Documented Survey on Metallurgical Development

The monthly issues of this publication were brought out.

NML News Letter

The monthly news letters covering the important news items relating to R & D work, visitors, staff news, social and sport activities etc. for internal circulation were published.

Handouts & Notes

Handouts & notes on product and process developmental work were prepared and publicized.

Papers Published and Presented

Details furnished in Appendix I

Research and Investigations Reports Prepared

Details furnished in Appendix II

LIBRARY AND DOCUMENTATION SERVICES

Library & Documentation Services.

The Library added 550 new books and 600 journals were subscribed during the year. Extensive reference and bibliographical services of the Library supported by central documental service was availed by many individuals and outside institutions in addition to the scientists of the Laboratory. Bibliographies on the following subjects were completed for UNIES & UNIDO

(i) Cold drawing of rapid and stainless steel
(ii) Steel production and treatment of steel.

The Library has also prepared two more bibliographies for internal use of the Laboratory. A daily bulletin entitled 'Current Awareness Service' covering periodicals received in NML Library everyday, has been started to keep the scientists of the Laboratory informed about the latest developments in their fields of science and technology.

Patent Index.

A comprehensive Patent Index collection has been started by preparing Patent Index Cards of patented processes of metallurgical interest, specially those of particular interest to the projects under-way in the Laboratory, by indexing abstracts of Patents from the Derwent Patent Index Journals as well as from Chemical Abstracts. About 700 such cards have been added to the Central File of Technical Literature Index.

News-Clipping Service.

A large number of important english dailies including commercial dailies are scanned and news clippings relating to scientific research, science planning & policy, trade and commercial aspects of scientific developments etc. are circulated to the scientists of the Laboratory.

INDUSTRIAL LIAISON & RESEARCH CO-ORDINATION

Get-together and Exhibitions

(*i*) *CSIR-Industry-Government Get-together at Patna*

In an effort to build linkages at the State level, the various National Laboratories were assigned to carryout systematic study of the States. Fifth Five Year Plans and other development programme and schemes both in private and public sectors to identify major areas of thrust and locate the science and technology gap where CSIR could be of direct assistance. The NML was entrusted with this task for the state of Bihar. As many as 53 major projects were identified where CSIR Laboratories could interact with their expertise. Based on the discussions held between the state government, authorities and the NML scientists ; 48 projects were finally selected for discussions at the time of the get-together.

The NML with joint collaboration of the Deptt. of Industries & Technical Development, Govt. of Bihar ; Bihar Chamber of Commerce & Bihar Industries Association ; arranged the CSIR-Industry-Government Get-together at Patna on the 14th April 1976. The function was attended by a large number of delegates representing CSIR Laboratories/Institutes, industrialists, entrepreneurs, officials of the Bihar Govt. etc. Industrial exhibition depicting the products/processes/expertise of over 20 CSIR Laboratories/Institutes was arranged along with this get-together. The survey reports were discussed in different technical groups and the recommendations of these groups have been passed on to the CSIR Polytechnology Clinic, Patna for follow up action.

(*ii*) *Get-together at NML on Refractories, Glass and Ceramic Industries in Bihar*

The Laboratory collaborated with the State level R & D Committee for Bihar, Small Industries Service Institute (Govt. of India) Patna Branch and Deptt. of Industries Govt. of Bihar for a Get-together on 'Refractories, Glass & Ceramic Industries in Bihar' which was held on 12th February 1977 at the NML auditorium. The Get-together was arranged to focus some of the urgent technical problems facing the above industries in Bihar and work out specific areas of inputs which could be provided by the National Laboratories like NML, CGCRI was well as other State and Central Govt. agencies engaged in the development of refractories, glass and ceramic products in the State of Bihar.

A large numbers of delegates representing a cross-section of these industries in the State of Bihar attended the get-together and participated in one day seminar. Twenty technical papers were presented highlighting the main technical problems and other obstacles being faced by these

industries. The recommendations adopted at this get-together have been sent to State R & D Committee for Bihar for further follow up action.

(iii) NML participated in the seminar-cum-exhibition on 'Transfer of Technology to Rural India' held at Delhi from 27th July to 3rd Aug. 76.

(iv) NML participated in the exhibition organised by Singhbhum Chamber of Commerce & Industry, Jamshedpur ; on the occasion of their silver jubilee celebration from 3-5 December 1976.

(v) NML participated in the exhibition on 'Survey, Conservation & Utilisation of Resources', organised on the occasion of 64th Indian Science Congress held at Bhubaneswar in Jan. 1977.

Consultancy Services

The following proposals for rendering advisory & general technical consultancy services were received from the enterpreneurs.

a. M/s. Cauvery Cables & Conductors, Bangalore-2.

Nature of consultancy.

(i) Advisory/technical consultancy services for processing of NML-PM2 rod to finished wires for use as domestic cables.

(ii) For setting up of quality control laboratory for testing of conductors & PVC insulated cables made out of NML-PM2.

b. M/s. S. G. Enterprises, Ranchi.

(i) General plant layout, specification and details of process equipments and

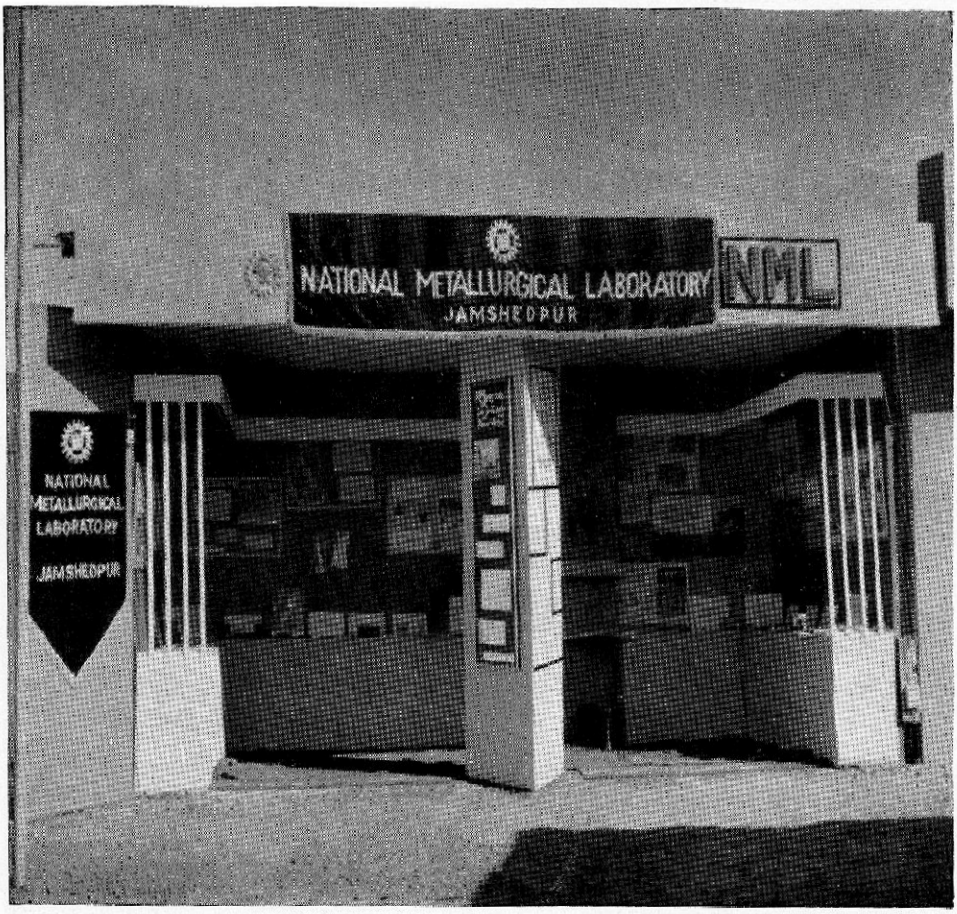
(ii) Assistance in commissioning and operation of plant for extraction of V_2O_5 from alumina plant sludge.

CSIR-NML-MECON Agreement

An agreement has been entered with MECON through CSIR for the study, scale-up, engineering input, development and commercial exploitation of processes & products developed or those to be developed by NML.

To begin with, MECON has associated itself during the year on the following projects.

(i) Graphite project of Kerala on behalf of Keral State. Industria Development Corpn. Ltd.,



A view of the NML stall at the Indian Science Congress Exhibition at Bhubaneswar.

(ii) Magnesite project of Burn & Co. Ltd., for their salem deposit.

(iii) Production technology of high alumina and carbon refractories.

(iv) Process for the production of sponge iron based on gaseous reductant.

(v) Process technology for the production of electrolytic Manganese dioxide.

(vi) Side blown converter process for steel making.

(vii) Preparation of the feasibility report for production of vanadium pentoxide from vanadiferous sludge.

Integrated Rural Development

Government of India has selected 20 districts for carrying out integrated rural development programme. CSIR will be mainly responsible to provide science and technology complex for these districts. NML has been made responsible for one of these districts i.e. Rohtas in the State of Bihar.

Committee Meeting Constituted by D.G.T.D.

A meeting of the Committee constituted by Directorate-General of Technical Development on 'Development of Carbon & Graphite Crucibles & Beneficiation of Graphite' was held at the NML on 20th August, 1976 under the Chairmanship of Prof. V. A. Altekar, Director.

Representatives of DGTD, NML, CFRI, Petro-Carbon Co., Graphite India Ltd. and All India Graphite Manufacturers association attended the meeting.

Training at NML

NML provided training facilities throughout the year to persons deputed from various organisations, such as technical institutions, universities, small industry training institutes, private & public organisations etc. The training related to ore-dressing/mineral beneficiation, physical & mechanical metallurgy, mineralogy and x-ray diffraction, scanning electron microscope, methods for testing of metals & alloys including creep resistance properties.

Photographic & Reprographic Services

Technical photographic and reprographic services as an aid to R & D work has been rendered as per details below :—

(i) Technical photography—Services rendered in various research projects include assistance to scientists for photographic docu-

mentation of the various stages of the research projects upto the final illustrations of the project reports.

(ii) Technical cinematography—The services in this section has been continued and include a 16 mm colour documentary film on 'Magnesium' which is in progress.

(iii) Reprographic Services—The over all need for the scientists for documentation work viz. photocopy, reflex prints etc. of technical papers as well as slide making for lectures etc. have been attended to.

(iv) General Photography—In addition to the technical assistance to research projects, the general photographic need of the laboratory viz coverage of visits, seminars etc have also been attended to.

Printing & Binding Services

A large number of general and specialised types of printing jobs were conducted during the period. Such work ranged from printing of forms, letterheads to NML news letter, folders, publicity display materials etc. A large number of reports and printed materials were bound.

PATENTS AND PROCESSES

Patents Filed

	Title	*Inventors*
1.	Improvements in or relating to the production of moulds and cores for the manufacture of castings (I.P. No. 1439/Cal°76 dt. 9.8.76)	G. N. Rao S. K. Sinha S. K. Sinhababu
2.	Method and apparatus relating to the production of cellular metal (I.P. No. 1754/Cal/76 dt. 23.9.76)	G. N. Rao S. K. Sinha
3.	A process for electroplating particles of powder mass specially graphite powder with copper, silver or any other metal (I.P. No. 48/DEL/76 dt. 3.12.76)	J. Bhattacharya B. N. Ghosh S. Kishore Singh
4.	A process for removing hexavalent chromium from chrome sludge produced in bichromate plant prior to its disposal (I.P. No. 68/DEL/70 dt. 21.12.76).	P. V. Viswanathan C. Sankaran P. R. Khangaonkar
5.	An improved method and apparatus for making spherical aluminium particles (I.P. No. 66/Cal/76 dt. 12.1.76)	D. D. Akerkar A. K. Nayak
6.	A process for making and production of a new type of heat-resistant cast iron. (I.P. No. 54/DEL/77 dt. 22.3.77)	C. A. Naresh Rao S. S. Dhanjal G. N. Rao V. A. Altekar

Patent Sealed

1.	Improvements in or relating to the manufacturing process of versatile aluminium-alloy aluminium conductor for multifarious applications. (Sealed in India : I.P. No. 139957 dt. 6.9.73) (Sealed in U.K. : U.K. No. 144209 dt. 12.3.74)	Rajendra Kumar Manjit Singh

Processes Ready for Transfer

1. Production of electrolytic manganese metal and MnO_2
2. Production of dense carbon aggregates and soderberg paste
3. Production of copper clad aluminium sheets

4. Production of high alumina cement (65-70% Al_2O_3)
5. Production of orthodontic stainless steel spring wires
6. Production of braze alloy clad aluminium sheets
7. Production of technology of stainless clad mild steel
8. Production of dental amalgam alloy
9. Production of magnesium inoculant briquettes for production nodular cast iron
10. Development of self setting sodium silicate sand process
11. Development of various industrial products from aluminium conductor alloy (NML PM2)
12. Anisotropic ferrite magnets
13. Utilisation of zinc wastes
14. Production of vanadium pentoxide from sludge of alumina plants.

GENERAL

Recipients of Honours, Awards etc.

The NML Technical Journal, August 1976 issue, has won the 19th National Award (2nd Prize) for 'Excellence in Printing & Designing of Books & other Publications' under the category 'Monthly & other Magazines—English'. The award is given by Directorate of Advertising & Visual Publicity, Ministry of Information & Broadcasting, Government of India.

Sarvashri C. S. Sivaramkrishnan & A. K. Bose, Scientists, have obtained the Degree of Master of Engineering (Met) from University of Roorkee.

Foreign Deputation/Training in India and Abroad

Dr. R. Kumar Scientist	Deputed to Vienna, Venezuela, Peru, Bolivia, Chile & Ecuador as a Member of Indian Expert Team nominated by CSIR for the purpose of preparing an out line of a programme of technological calloboration with countries covered by Andean Pact in the areas (i) Production of machine tools (ii) Manufacture of engineering components by metal casting and forgings (iii) Metal working and manufacture of engineering machinery (iv) Manufacture of diesel engine and pumps, tractors and automotive components (v) Railway rolling stock and railway systems including manufacture of railway equipment (vi) Centres for research and development particularly in the field of foundry and forge industry.
Shri G. P. Mathur, Scientist	(i) Attended a meeting at Paris as an expert along with a team of experts from M/s. Rajasthan State Mines & Metals and M/s. Engineers India Ltd. in connection with Jhamarkotra Rock Phosphate Beneficiation. (ii) As a Faculty Member of India Institute of Mineral Engineers, attended the refresher course on "Operation and maintenance of beneficiation plants" organised by I.I.M.E. at Aurangabad.

Dr. P. R. Khangaonkar, Scientist	Deputed to Japan for visiting National Research Institute for Metals and other research institutions and Universities in Japan.
Shri K. M. Chowdary, Scientist	Deputed to U.K. for training in the field of "Creep Testing" under UNIDO/UNDP assistance project on 'Creep Testing Facilities at NML'.
Shri K. Prasad Scientist	-do-
Shri P. K. Gupta, Scientist	Attended a training course on 'Scientific Editing' organised by Publication & Information Directorate. CSIR under the sponsorship of UNESCO.
Shri J. S. Padan, Scientist	Attended the Refresher Course on 'Operation and Maintenance of Beneficiation Plants' organised by Indian Institute of Mineral Engineers.
Shri N. B. Sirkar, S.S.A. Shri B. K. Mitra S.L.A. Shri H. K. Sirkar S.L.A.	Attended Refresher Course on 'Refractory Raw Materials' organised by Jamshedpur Section of Indian Ceramic Society.
Shri V. S. Sampath, Scientist	Attended "CSIR Management Development Programme—First Course on Financial Management for R&D organised by CSIR Management Training Unit, Planning Division, at Regional Research Laboratory, Jorhat.
Shri M. L. Bhutiani, Cost Accounts Officer	
Shri G. Rama Rao, Accounts Officer	-do-
Shri M. L. Bhutiani, Cost Accounts Officer	Attended a Basic Course on "System Design & Development" Organised by Computer Society of India, Jamshedpur Chapter.
Shri P. R. Sastry, S.T.A.	-do-

Shri Upkar Singh, Scientist Shri S. P. Dasgupta, Scientist	Attended an appraisal course on 'Operational Research' organised by Operational Research Society of India, Jamshedpur Chapter.
Shri P. N. Raju, S.L.A.	-do-

Directorship, Chairmanship, Membership etc. on Outside Bodies

Prof. V. A. Altekar, Director	Director	Board of Directors of Durgapur Mishra Ispat Ltd.
	Director	Board of Directors of Bihar Industrial & Technical Consultancy Organisation Ltd.
	President	Indian Institute of Metals for the year 1977 & 1978.
	Chairman	Steel Level Research Development & Design Committees for Bihar.
	Chairman	Indian Creep Panel.
	Member	Advisory Committee of the CSIR Polytechnic Clinic, Patna.
Dr. R. Kumar, Scientist	Co-Chairman	Indian Creep Panel.
	Member	National Council of Indian Institute of Metals.
Dr. Ved Prakash, Scientist	Member	Board of Studies in Metallurgical Engineering, University of Punjab, Chandigarh.
Dr. L. P. Pandey, Scientist	Fellow	Institution of Chemists.
Shri K. D. Maji, Scientist	Member	Indian Association for Radiation Protection.

Shri K. P. Mukherjee, Scientist	Member	Expert Committee of Calcutta Metropolitan Development Authority for cathodic protection of the city water mains.
	Member	ISI SMDC—29
	Associate Member	Institution of Metallurgists, London.
Dr. Inder Singh, Scientist	Alternate Member	Expert Committee of Calcutta Metropolitan Development Authority for Cathodic protection of the city water mains.
	Alternate Member	ISI SMDC—29
	Member	Society for the Advancement of Electro-Chemical Science & Technology.
Shri M. K. Ghosh, Scientist	Member	SMDC 2:2
Dr. P. Sanyal, Scientist	Member	National Academy of Science, India.
Shri K. K. Gupta, Scientist		do do
Shri K. Prasad, Scientist	Associate Member	Institution of Metallurgists, London.
Shri A. N. Mukherjee	Associate Member	Institution of Metallurgists, London.
	Member	Society for the Advancement of Electro-chemical Science & Technology.

Visitors

The following distinguished persons visited the National Metallurgical Laboratory.

1. Shri Saran Singh	Secretary, Department of Steel, Ministry of Steel & Mines, Govt. of India.

2.	Shri R. P. Billimoria	Chairman, Steel Authority of India Ltd.
3.	Shri Y. P. Puri	General Manager (Finance), Steel Authority of India Ltd.
4.	Brig. B. J. Shahney	Director-General, Technical Directorate, Govt. of India.
5.	Shri S. K. Warrior	Vice-Chairman & Mg. Director, Visvesvaraya Iron & Steel Ltd.
6.	Major General V. Minas	General Manager, Indian Copper Complex, Ghatshila.
7.	Shri S. Patankar	Commissioner, Chotanagpur South Division.
8.	Shri P. C. Lal	Chairman, M/s. Indian Tube Co. Ltd.
9.	Mr. Peter Davis	Regional Education Adviser, British Council Division, U. K. High Commission's Office, Calcutta.
10.	Dr. Thaw Tint	University of Mandalay, Burma.
11.	Mr. C. G. Thomas	Scientist, C.S.I.R.O., Australia.
12.	Mr. Nagaaki Yamamotho	UNIDO Consultant.
13.	Prof. E. Topfer	Akademi der Wissenschaftess der DDR, East Germany.
14.	Dr. Ing. Wolfgang Schiebe	
15.	Prof. C. B. Alcock	University of Toranto, Canada
16.	Academician P. M. Solojenhin	Head of the Ore-dressing Department, Institute of Chemistry & Vice-President, Academy of Science of Tajic SSR, U.S.S.R.
17.	Dr. Masatoshi Suzuki	Head of the Corrosion Division, National Research Institute for Metals, Tokyo.
18.	Shri N. S. Bharucha	Broken Hill Proprietory Co., Australia.

19. Dr. T. Bayraktar	Head of Mineral Preparation Department, University of Istanbul, Turkey (UNIDO Fellowship).
20. Dr. M. S. Buyuran	Marmara Scientific & Industrial Research Institute, Turkey (UNIDO Fellowship)

Besides the above, nearly 1,500 other visitors including National Science Talent Scholars, Students, Professors, Technologists, Industrialists, Entrepreneurs etc. visited the laboratory.

Lectures

A number of lecturers were delivered by distinguished Indian & foreign metallurgists, scientists etc. during the period. The following special lectures & addresses were delivered by the NML Staff.

Name	*Subject*
Prof. V. A. Altekar, Director	(*i*) Inaugural address at the short term course on 'Selection of Steels for Engineering Applications' organised by Indian Institute of Metals B.E. College, Chapter.
	(*ii*) Inaugural address at the 'Training course in Operation & Maintenance of Beneficiation Plant organised by Indian Institute of Mineral Engineers.
	(*iii*) "Conservation of raw materials in integrated iron and steel plant" at the National Seminar on 'Conservation of Materials & Re-cycling of Wastes' organised by Jamshedpur Productivity Council.
	(*iv*) 'The research and development work at NML in the field of materials technology, at National Productivity Council, New Delhi.
Dr. R. Kumar, Scientist	"Selection of steels for elevated temperature service" at the short term course organised by Indian Institute of Metals, B.E. College, Chapter.

Dr. R. V. Hargave, Scientist	"Mineralogy of refractory raw materials with special reference to clay materials" at the Refresher Course on 'Refractory Raw Materials' organised by Indian Ceramic Society, Jamshedpur Section.

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 Sections handled the administrative and budgetary affairs of the Laboratory with speed and efficiency.

Safety First & First Aid Sections

Safety measures were taken for operating the various plants and equipment of the Laboratory, gas pipe line etc. and inspection of the safety measure were carried out regularly. There was no major casuality.

The First Aid Section was strengthened. Apart from the first aid dispenseries at NML main building and pilot plants, dispensaries for treating various minor ailments, injuries etc. were opened in the Staff Colonies at Agrico & Tuliadungri are for the benefit of staff members and their families. All these dispensaries are increasingly utilised by the staff of the Laboratory.

Activities of Societies, Club and Canteen

NML Staff Co-operative Credit Society operated its transactions worth nearly two and half lakhs of rupees with efficiency. NML Co-operative Stores continued to supply food stuffs like wheat, sugar, rice etc. to staff member. NML canteen catered to the staff members snacks, lunches, tiffin, tea etc. at a very reasonable rate in comparison to the existing high market rate.

NML Club maintained its sporting activities. The club took part in Shanti Swrup Bhatnagar Memorial Tournament held at Mysore, besides local tournaments in cricket, table tennis, chess cards etc. NML staff member won trophy in bridge tournament. Club also held its own tournament amongst staff members in badminton, table tennis, chess, carrom cards etc. Film shows were regularly organised by the club.

NML Welfare Committees at Agrico, Tuiladungri & Pipe-Line Colonies continued to look after the welfare of the respective areas and residents of of the colonies. Two kindergarten schools are run efficiently by the welfare

committee at Agrico & Tuiladungri. Musci, art and dance classes were regularly held and cultural shows were periodically organised. Film showes were regularly held.

Staff Position

Scientific	197
Technical	573
Administration	142

Budget Figures

Recurring (Non-Plan)

Figures in lakhs of rupees (1 lakh = 10^5)

P-1 Pay of Officer×	24.820
P-2 Pay of Establishment×	28.330
P-3 Allowances×	36.730
P-4 Contingencies	12.000
P-6 Maintenance	2.200
P-7 Chemicals	11.550
Total	115.640

(×Includes Plan Provision 9.800 lakhs)

Capital (Non-Plan)

P-5(3) Apparatus & Equipment (replacement)	3.400
P-5(4) Books	4.000
Total	7.400

Capital (Plan)

P-5(1) Works	17.000
P-5(2) Services	7.570
P-5(3) Apparatus & Equipment (addition)	30.000
P-5(4) Furniture	0.500
P-5(4) Vehicles	1.000
Total	56.070

Pilot Plants (Plan)

PP-1(I)	Equipment	0.500
PP-1(II)	Building	4.300
PP-2	Pay of staff	13.000
PP-3	Raw materials	1.650
PP-4	Miscellaneous	9.000
	Total	28.450
Hydro-Electro Metallurgy Project (Plan)		17.380
	Grand Total	**235.400**

APPENDIX I

Papers Published, Communicated and Presented

1. Blast furnace slags—A study of chemical and mineralogical composition and utilization in cement industry—R. V. Hargave, S. P. Dasgupta & M. R. K. Rao; NML Technical Journal, Vol. 18 (1976) 2.
2. Cellular metal—S. K. Sinha & G. N. Rao; NML Technical Journal, Vol. 19 (1976) 2.
3. Simultaneous squential spectrophotometric method for the determination of silica and alumina in iron ores and sinters—A. C. Biswas, K. K. Padhi & H. P. Bhattacharya; NML Technical Journal, Vol. 18 (1976) 2.
4. Recovery of elemental sulphur and copper values from chalcopyrite concentrate by direct leaching in ferric chloride solution—G. Basu, P. K. Sinha, S. C. Aush, N. Dhananjayan & V. A. Altekar; NML Technical Journal, Vol. 18 (1976) 3.
5. Integral colour anodizing of aluminium and aluminium alloys—T. L. Sharma, Y. N. Trehan; NML Technical Journal, Vol. 18 (1976) 3.
6. Spectrophotometric determination of cobalt by thioglycollic acid—L. P. Pandey, P. Dasgupta & A. Ghose; NML Technical Journal, Vol. 18 (1976) 3.
7. X-ray spectrometric analysis of low alloy steels—S. C. Srivastava & M. K. Ghose; NML Technical Journal, Vol. 18 (1976) 3.
8. Some aspects of designing electric tunnel kilns for ceramic industry—H. Singh; NML Technical Journal, Vol. 18 (1976) 3.
9. Rationalization of blading materials for steam turbines, their requirements and selection—R. Singh, R. Choubey & R. Kumar; NML Technical Journal, Vol. 18 (1976) 4.
10. High strength low alloy structural steel—S. S. Bhatnagar, N. S. Datar, B. K. Guha, R. Chattopadhya & R. K. Sinha; NML Technical Journal, Vol. 19 (1977) 1.
11. Evaluation tests on different protective coatings in marine atmosphere—A. N. Mukherjee, A. K. Dey, S. Rao Addanki & M. N. Singh; NML Technical Journal, Vol. 19 (1977) 1.
12. Recent trends in the use of coke oven refractories—K. C. Ray & P. C. Sen; Proc. of the Seminar on 'Coke Oven Refractories' Published by Indian Refractory' Makers Association, 55-74.
13. Use of fused refractories in blast furnace and its ancillaries—K. C. Ray & P. C. Sen; Tisco Technical Journal, Vol. 23 (1976) 3.
14. Refractories for cupola furnace—N. N. Mathur, R. V. Hargave, & M. R. K. Rao; Tisco Technical Journal, Vol. 23 (1976) 3.
15. Studies on clay-grog-graphite refractory compositions used for iron making—K. K. Singh; Tisco Technical Journal, Vol. 23 (1976) 3.
16. A comparative study of some technological properties of raw materials used in the manufacture of carbon products—B. Chatterjee, N. B. Sirkar & H. P. S. Murthy; Trans. Ind. Cer. Soc. Vol. 35, July-August 1976.

17. Graphite and its refractory products—N. B. Sarkar, P. C. Sen, & M. R. K. Rao; Proc. of Seminar organised by State Planning Board, Govt. of Kerala, Trivandrum.
18. Sulphitisation studies on copper anode slimes—Narender Singh & S. B. Mathur; Trans. Ind. Inst. of Metals. Vol. 29, No. 6, Dec. 1976.
19. Extraction of selenium and tellurium from electrolytic slimes by vacuum sublimation; Jr. of Sulphur Chemistry (U.S.A.) Vol. 9 No. 12 (1974), published in 1976.
20. A close look at Indian safety razor blades—B. K. Guha, & S. S. Bhatnagar; Science Reporter, Nov. 1976.
21. Structure of dilute Sn-Fe alloys—C. S. Sivaramkrishnan & R. Kumar; Trans. Japan Inst. of Metals, June 1976.
22. Structure of Al-Si alloys—C. S. Sivaramakrishnan, R. K. Mahanti & R. Kumar; Accepted for publication in 'Aluminium' (Germany).
23. Development of grain refiners for aluminium and its alloys—C. S. Sivaramakrishnan, R. K. Mahanti, K. Lal & R. Kumar; Trans. Ind. Inst. of Metals, Vol. 29 Dec. 1976.
24. Study of columnar crystalline in Alnico V alloys—Ved Prakash & C. R. Tewari; Trans. of Ind. Inst. of Metals, Vol. 29, No. 5, Oct. 1976.
25. Inhibition of corrosion by thiourea derivatives—Inder Singh, Proc. of 6th International Congress on Metallic Corrosion held at Sydney.
26. Variation in mechanical properties of steels during acid pickling—M. K. Banerjee, Inder Singh & T. R. Soni; Trans. Ind. Inst. of Metals, Vol. 29, No. 4, August, 1976.
27. Use of Cr_{51} in the study of the effects of chloride on passive film on mild steel—K. D. Maji, Inder Singh, & R. Kumar; Trans. of Ind. Inst. of Metals, Vol. 29, No. 5, Oct. 1976.
28. Metallic Corrosion inhibitors—Inder Singh; Chemical Industry Developments, April 1976.
29. Electrode potential—a tool of the corrosion engineer—Inder Singh & V. A. Altekar; Chemical Concepts, Oct. 1976.
30. Corrosion of metals and its prevention—V. A. Altekar; Chemical Concepts, Oct. 1976.
31. Corrosion of metals in chloro-hydrocarbon solvents—Inder Singh, Chemical Concepts, Oct. 1976.
32. Corrosion of Metals and its prevention—S. B. Choudhury; Chem. Ind. Dev. April 1976.
33. Studies on dealloying of Cu-Mn and Cu-Zn brass—A. N. Mukherjee, P. S. Nag & K. P. Mukherjee; Trans. Ind. Inst. of Metals, Vol. 29, No. 3, June 1976.
34. Vital role of inorganic zinc silicate coatings in the protection of steel against corrosion—P. Prabhakaram, A. K. Dey, S. Rao Addanki & V. A. Altekar; Proce of Seminar on 'Industrial Metal Finishing' organised by Electro Chemical Society of India & Ind. Inst. of Metals, Bangalore Chapter, Oct. 1976.
35. Chromizing and its potentialities—P. Prabhakaram & A. N. Mukherjee; same as item 34.

36. NML's role in solving industrial corrosion problems—V. A. Altekar; Chem. Ind. Dev. April 1976.
37. Spectrochemical determination of residual impurities in ferro-chrome by solution spark technique—M. K. Ghosh, S. V. Gopalkrishna & H. K. Chakraborty; Metallurgia & Metal Forming (UK), Vol. 42, No. 12, Dec. 1975.
38. Determination of zinc, silver, copper, iron and antimony in lead metal by atomic absorption spectrophotometry—L. P. Pandey, A. Ghose & P. Dasgupta; Jr. Inst. Chemists (India) 1976, Vol. 48.
39. Analysis of alloys and salt solutions by beta-ray back scattering (Mrs.) A. Bahadur, K. D. Maji & R. Kumar; Jr. of Applied Chemistry & Biotechnology (London), Vol. 25, 1975.
40. National Metallurgical Laboratory—Its activities & contribution; Communicated to Chairman, Electrical Engineering Division, Inst. of Engineers, Bangalore; for the proposed publication to be brought out at the UNESCO International Conference on Education and Training of Engineers & Technicians' to be held in New Delhi, April 1976.
41. Stainless steel and stress corrosion cracking—S. S. Bhatnagar; Presented at the 4th Seminar on Alloy Steel' organised by Alloy Steel Producers Association.
42. Concentration and agglomeration of low grade chrome ores—M. V. Ranganathan, R. Ganesh & S. K. Banerjee; presented at the Symposium on Geology, Exploration, Mining, Mineral Processing and Metallurgy of Ferro-alloy Minerals; Organised by Geology Department, Central College, Bangalore, May 1976.
43. Indian Manganese ores and their beneficiation—P. D. Prasad Rao, A. Peravadhanalulu & G. P. Mathur; same as item 42.
44. Problems relating to beneficiation of Indian iron ores—P. K. Sinha, B. L. Sengupta & G. P. Mathur; same as item 42.
45. Beneficiation of low grade graphite and a tentative proposal for a 50 tons-day plant based on tabling and flotation—M. V. Ranganathan, N. Chakravorty & G. P. Mathur; Communicated at the Seminar on Mineral Resources & Mineral based Industries in Purulia District Organised by West Bengal Mineral Development & Trading Corporation, June 1976.
46. Studies on absorption of cobalt by lignite from ammonical solutions—V. A. Altekar, D. D. Akerkar & (Miss) M. Bagchi; presented at the Symposium on "Surface & Colloid Science" organised by Regional Institute of Technology, Jamshedpur, June 1976.
47. Standard of technical writing for scientific publications—P. K. Gupta & A. N. Kapoor; presented at the Seminar on "Science Publishing in in India—Problems & Prospects" Organised by Publication & Information Directorate, CSIR, Nov. 1976.
48. Editorial responsibilities and problems concerning publication of Documented Survey on Metallurgical Developments'—M. L. Sharma (Mrs.) N. Chakrabarty, V. K. Gupta, and Y. N. Trehan; same as item No. 47.

49. Slip casting characteristics of some non-plastic refractory materials—Kerala beach sand sillimanite—A. V. Subhramanya; communicated at the Seminar on 'Electronics and special Ceramic Materials' Organised by Defence Metallurgical Research Laboratory, Hyderabad Nov. 1976.
50. Some applications of scanning electron microscope in material science technology—N. K. Das, A. N. Sinha, S. K. Bose & R. Kumar; presented at the Seminar on 'Recent Development in Heat-treatment & Metallography' Organised by Ind. Inst. of Metals (Jamshedpur Chapter), Oct. 1976.
51. Heat treatment and magnetic properties of some Alnico alloys—Ved Prakash & C. R. Tewari; same as item 50.
52. An investigation on the microstructure of Alnico II alloys—Ved Prakash & C. R. Tewari; same as item 50.
53. Evaluation of corrosion resistance properties of nickel free stainless steels developed in National Metallurgical Laboratory—M. N. Singh, K. P. Mukherjee, B. K. Guha & V. A. Altekar; presented at the 30th Annual Technical Meeting of Ind. Inst. of Metals, Nov. 1976.
54. Production of vanadium enriched slags by electric smelting of vanadium bearing titaniferous magnetites and oxygen blowing—B. V. S. Yadavalli, N. N. Patra, D. D. Akerkar, P. V. Viswanathan, C. Sankaran, P. R. Khangaonkar, N. Subramanyan, V. A. Altekar, Desaratha & Lingo gowada; same as item 53.
55. Melting trials with cast iron boring briquettes in cupola arc furnace—V. A. Altekar, Santosh Singh, G. N. Rao, P. S. Virdi & R. Dash; same as item 53.
56. Sponge iron melting in electric arc furnace—NML experience—V. A. Altekar & R. D. Gupta; same as item 53.
57. A comparative study of the leachibility of Mosabani and Malanjkhand copper ores by micro organisma—A. K. Saha, S. R. Srinivasan & D. D. Akerkar; same as item 53.
58. Selective separation and extraction of nickel from ammonical Leach liquors using a chelating agent—(Miss) M. Bagchi, D. D. Akerkar & V. A. Altekar; same as item 53.
59. Sintering of Al-ZrO_2 particulate composites—A. K. Bose & G. S. Upadhaya; same as item 53.
60. Vital role of inorganic zinc-silicate coatings in the protection of steel against corrosion—P. Prabhakaram, A. K. Dey, S. Rao Addanki & V. A. Altekar; presented at the Conference on Industrial Metal Finishing' organised by Electro-chemical Society of India, Oct. 1976.
61. Chromizing and its potentialities in industrial applications—P. Prabhakaram & A. N. Mukherjee; same as item 60.
62. Indian clays for various industrial applications—A. V. Subhramanya; Communicated at the All India Seminar on Clays' organised by GSI, Kerala Circle, Dec. 1976.
63. Studies on some plastic fire clays for Andhra Pradesh—K. K. Singh, same as item 62.
64. Chlorination of fly ash and flue dust to recover germaniun—Narinder

Singh & S. B. Mathur; Presented at the First Indian Chemical Engineering Congress at Calcutta.

65. Extraction of tellurium from anode slimes obtained in copper electrolytic refining—Narinder Singh & S. B. Mathur; Presented at the Second Indian Chemical Engineering Congress at Waltair.
66. Sponge iron melting trials in mini steel plants—R. D. Gupta & V. A. Altekar; Tool & Alloy Steels, Annual 1976 (Dec. 76).
67. Effect of residual elements and pouring temperature on the cast morphology of Al-Si alloys—N. K. Das, R. K. Mahanti, C. S. Sivaramakrishnan & R. Kumar; accepted for publication in Aluminium Journal, Germany.
68. Atmospheric corrosion of metals—V. A. Altekar & K. P. Mukherjee; Presented at the Symposium on 'Surface & Collid Science' Organised by Regional Institute of Technology. Adityapur; June 1976.
69. Sea Water Corrosion: Laboratory and field tests on different metals—D. K. Basu, D. K. Khan, K. P. Mukherjee & V. A. Altekar; presented at the Symposium on 'Protection of Materials in the Sea' organised by Naval, Chemical & Metallurgical Laboratory, Bombay, Feb. 1977.
70. Studies on corrosion of metals in tropical marine environment—V. A. Altekar, D. K. Khan, A. K. Dey & K. P. Mukherjee; same as item 69.
71. "Aluminium industry: Challenges & Prospects"—R. Kumar; presented at the Seminar organised by M/s. Hindalco and published in their Souvenir.
72. Standard samples—preparation, standardization & their utilization; communicated for publication in J. Sci. & Ind. Research.
73. Metal foam and its application—G. N. Rao; communicated for publication in Minerals & Metals Review.
74. Quantity of binder as a factor in the properties of carbon pastes—H. P. S. Murthy, B. Chatterjea, N. B. Sirkar & B. K. Mitra; Communicated for publication in Indian Journal of Technology.
75. The present status of sponge iron and its relevance to Indian conditions—V. A. Altekar & V. S. Sampath; communicated for publication in the special issue of SAIL.
76. Conservation of metals and energy input therefore—V. A. Altekar & & V. S. Sampath; communicated for publication in Quarterly journal of Energy Management & National Productivity Council.
77. Localised corrosion: Cause of stainless steel failure—S. B. Choudhury & K. P. Mukherjee; Presented at the Symposium on 'Production & Application of Stainless Steel' organised by Alloy Steel Plant, Durgapur, January 1977.
78. Production and application of stainless steel—N. R. Nag & R. Kumar; same as item 78.
79. Deep Drawing of stainless steel sheets—S. S. Bhatnagar; same as item 77.
80. Application of solution technique using synthetic standards in spectrochemical analysis—M. K. Ghose; Presented at the Seminar on 'Testing & Evaluation' organised by National Test House, January 1977.

81. Determination of chromium in low alloy steels by atomic absorption spectrophotometry—L. P. Pandey, A. Ghose, P. Dasgupta & A. S. Rao; same as item 80.
82. Production technology of dental amalgam alloy—V. A. Altekar, R. K. Dubey & P. Basak; Presented at the 31st Indian Dental Conference, Jan. 1977.
83. Corrosion problems in recirculating cooling water system—M. K. Banerjee, Inder Singh & V. A. Altekar; Communicated to Symposium on 'Surface Phenomena in Metallurgical Process' organised by I.I.T. Bombay, Feb. 1977.
84. Benzotriozale as a corrosion inhibitor—(Mrs.) Suman, Inder Singh & V. A. Altekar; same as item 83.
85. Hydrogen in steel—M. K. Banerjee & Inder Singh; same as item 83.
86. Relative susceptibility of H_2 absorption and inhibitive efficiency of some high carbon steels—M. K. Banerjee & Inder Singh; same as items 82.
87. Some problems of technology transfer in India—V. A. Altekar & V. S. Sampath; Presented at the 2nd Annual Technical Conference on Transfer of Technology (Metals & Materials)' organised by Ind. Inst. of Science, Bangalore.
88. Control of indirect cost in R&D—M. L. Bhutiani & V. S. Sampath; presented at the Diamond Jubilee Symposium of Central Water & Power Research Station, Nov. 1976 and published in the Proceedings on 'Modelling Techniques in Hydraulic Engineering CWPRS'—Diamond Jubilee Symp. Vol. II.
89. Beneiciation low grade ores & minerals of Bihar for industrial utilization—P. A. Prasad Rao A. Pervadanlulu, S. K. Banerjee & G. P. Mathur; presented at the Seminar on "Industrial Utilization of Non-metallic Minerals of Bihar" organised by GSI & SISI, Patna.
90. Beneficiation of refractory minerals—role of NML—H. Patnaik, N. P. Srivastava & G. P. Mathur; same as item 89.
91. Effect of additives on hot strength, retained strength and breakdown properties of sodium silicate bonded sands—T. A. Beck, G. N. Rao & V. A. Altekar; presented at the Symposium on 'Modern Trends in Moulding Materials' organised by I.I.T. Khargpur, March 1977.
92. How to upgrade lean bentonites for foundry use—R. R. Dash, S. K. Sinhababu & G. N. Rao; same as item 91.
93. Sintered high speed tool steels—A review—J. P. Tiwary & S. S. Bhatnagar; presented at the 3rd Annual Technical Conference of Powder Metallurgy Association March, 1977.
94. Effect of thiosemicarbazide on metal disolution and hydrogen absorption by mild steel in acid solution—Inder Singh; communicated for presentation at the 2nd International Congress on Hydrogen in Metals', Paris.

APPENDIX II

Research & Investigations Completed and Reports Prepared

1. Pilot plant investigations on the production of sponge iron in rotary kiln with iron and coals from Orissa for IDCOL (Orissa)—B. L. Sengupta, S. R. Ghosh, H. B. Barari, H. Patnaik, B. K. Paul, Syed Rafiuddin, U. K. Sharma, K. N. Gupta, & G. P. Mathur (IR 864/76).
2. Moulding Characteristics of sand sample no. "8" from Directorate of Geology & Mining, U.P.—R. C. Arora & M. N. P. Verma (IR 865/76).
3. Beneficiation and pelletization studies on a limestone sample from M/s. Industrial Chemicals Ltd., Tamilnadu—P. R. Khangaonkar (IR 866/76).
4. Washing of a clay sample from Ramnad District, Tamilnadu—K. Vijayaraghavan, C. Satyanarayan, R. Srinivasan, P. V. Raman & P. R. Khangaonkar (IR 867/76).
5. Beneficiation studies on two iron ore samples from Chandoli and Yeraballi, Karimnagar (A.P.)—V. Mohan, R. Srinivasan, C. Satyanarayan, P. V. Raman & P. R. Khangaonkar (IR 868/76).
6. Bench Scale flotation studies on low grade fluorspar sample from Kahila and Mandokipal deposits for Rajasthan Industrial & Mineral Development Corporation—M. V. Rangnathan, B. N. Pathak, S. K. Banerjee & G. P. Mathur (IR 869/76).
7. Petrological & chemical analysis studies on a low grade kyanite ore sample from Bharandiha village, Chakradhapur, Bihar from Bihar State Mineral Development Corporation—S. K. Banerjee & G. P. Mathur (IR 870/76).
8. Beneficiation and agglomeration studies on a low grade iron ore sample from Chandradinga, Assam—S. C. Maulik, R. K. Kunwar, B. L. Sengupta, S. K. Banerjee & G. P. Mathur (IR 871/76).
9. Pilot plant studies on beneficiation of composite iron ore sample from Bailadila—4 mines of NMDC—Tirath Singh, R. K. Kunwar, S. P. Dasgupta, P. K. Sinha, S. R. Joti, J. S. Padan, N. Chakrabarty, S. K. Banerjee & G. P. Mathur (IR 872/76).
10. Corrosion prevention of watermeter—A case study—R. M. D. Mayour & P. R. Khangaonkar (IR 873/76).
11. Bench scale beneficiation studies on a magnetite sample for M/s. Bharat Colliery Coal Ltd., Dhanbad—M. V. Ranganathan, P. N. Pathak, S. K. Banerjee & G. P. Mathur (RR 874/76).
12. Beneficiation studies on a low grade limestone stample from M/s. India Cements, Sankri—K. Vijayaraghavan, C. Satyanarayan, P. V. Raman & P. R. Khangaonkar (IR 875/76).
13. Studies on chrome sludge from M/s. Binny Ltd., Madras—K. Vijayaraghavan, P. V. Viswanathan, C. Sankaran, P. V. Raman & P. R. Khangaonkar (IR 876/76).
14. Production of electrolytic metal powder (IR 877/76).

15. Recovery of magnesite from a magnesite sample from Daltanganj (IR 878/76).
16. Bench and pilot plant scale flotation studies with copper ore from Khetri Copper Complex, Hindustan Copper Ltd.—V. H. Chattoraj, A. K. Srivastava, S. K. Sengupta, S. Rafiuddin, H. P. Barari, B. L. Sengupta, N. Chakrabarty & G. P. Mathur (IR 879/76).
17. Benefication of a low grade kyanite sample marked 'BT-3' from Lapsoburo mines of M/s. Indian Copper Complex, Ghatshila—Prasad Rao, M. V. Ranganathan, B. K. Sharma, S. K. Banerjee & G. P. Mathur (IR 880/76).
18. Report on production of electrolytic metal powders for M/s. Electro-metallics, Cochin—K. S. Vijayaraghvan, R. M. D. Nayar, & P. R. Khangaonkar (IR 881/76).
19. Bench Scale beneficiation studies on a low grade kyanite sample, designated BT-4 (West hill) from Lapsoburu Mines of M/s. Indian Copper Complex, HCL, Ghatshila—M. V. Ranganathan, S. N. Prasad, S. K. Banerjee & G. P. Mathur (IR 882/76).
20. Davis tube test for determining the percentage magnetics in a magnetite sample from coal washery—M. V. Ranganathan, S. K. Banjeree & G. P. Mathur.
21. Moulding characteristics of sand received from M/s. Singarani colleries, Kottgudam—K. S. Vijayaraghavan, R. M. D. Nayar, N. V. Naidu & P. R. Khangaonkar (IR 884/76).
22. An investigation report on suitability of dolomite for use as SMS grade (IR 885/76).
23. Beneficiation of a graphite sample from Khammam dist. A. P. received from Andhra Pradesh Industrial Development Corporation—S. K. Sil, R. Ganesh & S. K. Banerjee (IR 886/76).
24. Studies on the physical characteristics of a sandstone sample from the Central Planning & Design Institute, Ranchi—S. Biswas, B. Banerjee, P. K. Sinha, A. Pervadhanlulu, & B. L. Sengupta (IR 887/76).
25. Evaluation of some of the "CAFLO Products" as floculants for M/s. Commercial Corporation Ltd.—S. K. Sengupta, M. V. Ranganathan, S. K. Banerjee & G. P. Mathur (IR 888/76).
26. Evaluation of the protective properties of the rust stabiliser "Ruskil" by electropotential stabilization techniques—K. Chandrasekhar Pillai, K. P. Mukherjee & V. A. Altekar (IR 889/76).
27. Calcination studies on Jhamarkotra rock phosphate (IR 890/76).
    Pt I—T. C. De, K. K. Bhattacharya, N. Chakrabarty & G. P. Mathur.
    Pt II—A. K. Saha, A. K. Nayak & D. D. Akerkar.
28. Beneficiation studies on Maldeota rock phosphate sample from Mussouri U.P.—S. Prasad, T. C. Dey, N. Chakrabarty & G. P. Mathur (IR 891/76).
29. Studies on the thermal beneficiation of rock phosphate from Maldeota—A. K. Saha, A. K. Nayak & D. D. Akerkar (IR 891/76).
30. Determination of work index values of sintered dolomite received from Bhilai Steel Plant from M/s. McNally Bharat Engineering Co. Ltd.—Joga Singh & G. P. Mathur (IR 892/76).

31. Investigation on bentonite—G. N. Rao (IR 893/76).
32. Bench scale beneficiation studies on a magnesite sample from Pithorgarh, U.P. for M/s. Orissa Industries Ltd., Rourkela—K. K. Sharma, S. N. Prasad, M. V. Ranganathan, N. Chakrabarty & G. P. Mathur (IR 894/76).
33. Studies on the reducibility, swelling index and crushing strength after reduction of Noamundi iron ore pellets—M. K. E. Unni, A. K. Sinhababu & K. N. Gupta (IR 895/76).
34. Beneficiation of low grade manganese ore from Keonjhar, Orissa—S. P. Dasgupta, S. K. Sengupta & S. K. Banerjee (IR 896/76).
35. Beneficiation of low grade mangensite sample from M/s. Kemco Industries, Madras—K. Vijayaraghavan, C. Satyanarayan, P. V. Raman & P. R. Khangaonkar (IR 897/76).
36. Physical tests on four samples of iron ore received from SAIL, Bangalore—K. Vijayaghavan, P. V. Viswanathan, P. V. Raman, C. Sankaran & P. R. Khangaonkar (IR 898-76).
37. Physical chemical and calcination studies on a sample of limestone from SAIL, Bangalore—K. Vijayaraghavan, P. V. Viswanathan, C. Satyanarayan, V. Mohan, C. Sankaran, P. V. Raman & P. R. Khangaonkar (IR 899/76).
38. Petrological studies on low grade graphite samples of Palamau district, Bihar—B. Banerjee, A. Pervandhanlulu & S. K. Banerjee (IR 900/76).
39. Investigation on creep stress rupture and stress relaxation properties of En20B bolting sheet Pt II—R. Singh, K. M. Chowdhary, K. Prasad, M. R. Das, S. C. Bose, R. Choubey & R. Kumar (IR 901/76).
40. Investigation on creep stress rupture and stress relaxation properties of $1\frac{1}{4}$ Cr-1Mo—$\frac{3}{4}$V-Ti-B-bolting steel Pt IV—R. Singh, K. M. Choudhary, K. Prasad, M. R. Das, S. C. Bose, R. Choubey & R. Kumar (IR 902/76).
41. Studies on beneficiation of a blended sample of pyrite from Saladipura area by gravity methods—S. Biswas, L. Sahoo, P. K. Sinha, B. K. Paul, H. B. Barari & S. K. Banerjee (IR 903/76).
42. Metallurgical examination of aluminium in lining material of the drum of the auxiliary fan—B. N. Halder, G. G. Nair & R. Kumar (IR 904/76).
43. Beneficiation tests on a low grade iron ore sample from M/s. Emco Goa (P) Ltd.—S. Biswas, S. R. Joti, N. Chakraborty, S. K. Banerjee & G. P. Mathur (IR 905/76).
44. Pilot plant studies on beneficiation of iron ore fines from Borga mines supplied by M/s. Panduronga Timblo Industries, Marmagao, Goa—Tirath Singh, P. K. Sinha, J. S. Padan, N. Chakraborty, S. K. Banerjee & G. P. Mathur (IR 906/77).
45. Pilot plant studies on crushing and screening of iron ores and limestone from Nepal Bureau of Mines—V. S. Chattoraj, S. R. Ghosh, P. K. Sinha, B. L. Sengupta & S. K. Banjeree (IR 907/77).
46. Reduction and thermal degradation studies on Khanwara ironore (M.P.)—A. K. Sinha Mahapatra & K. N. Gupta (IR 908/77).

47. Investigation on failure of boiler tubes at Power House No. 1 M.P.E.B. Korba, M.P.—S. C. Bose, R. Singh, K. M. Choudhury & R. Kumar (IR 909/77).
48. Specified tests on the 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 910/77).
49. Pilot Plant studies on beneficiation of five iron ore samples from Bailadila 4 mines from M/s. N. M. D. C.—T. Singh, R. K. Kunwar, S. P. Dasgupta, P. K. Sinha, S. R. Joti, J. S. Padan, N. Chakraborty, S. K. Banerjee & G. P. Mathur (IR 911/77).
50. Beneficiation studies on a low grade kyanite sillimanite sample from Andhra Pradesh—V. Mohan, P. V. Raman & P. R. Khangaonkar (IR 912/77).
51. Bench Scale flotation studies on an oxidised copper ore sample from Chapri, Bihar, received from M/s. Indian Copper Complex, HCL/, Ghatshila—V. S. Chattoraj, S. C. Moulik & S. K. Banerjee (IR 913/77).
52. An appraisal of occurence and requirements of kyanite in India and a preliminary investigation on the refractory properties and processing of beneficiated kyanite concentrate from M/s. Indian Copper Complex, HCL, Ghatshila—M. R. K. Rao, N. B. Sirkar, P. C. Sen & R. V. Hargave (IR 914/77).
53. Beneficiation studies on a limestone sample from M/s. Indian Oxygen Ltd., Calcutta—K. Vijayaraghavan, C. Satyanarayan, P. V. Raman & P. R. Khangaonkar (IR 915/77).
54. Batch and pilot plant studies on low grade graphite from Thodupuzha area, Kerala ; received from Kerala State Industrial Development Corporation—R. Ganesh, M. C. Das, V. Ramaiah, N· Chakraborty & G. P. Mathur (IR 916/77).
55. Bench Scale beneficiation studies on low grade complex Pb-Zn ore sample from Genokha area, Bhutan—Joga Singh, M. V. Ranganathan, N. Chakraborty & G. P. Mathur (IR 917/77).
56. Electro-thermal smelting of Nepal iron ores—B. V. Yadavalli, S. K. Singh, M. S. Mohanty, A. K. Saha, M. G. Bodas, N. Subarmanyan, & D. D. Akerkar (IR 918/77).
57. Metallurgical investigation on the development of K. M. bridge girders—R. Kumar, B. K. Saxena, K. Lal, P. K. Ghosh, & K. Sukyumaran (IR 919/77).
58. Formation of metastable phase in Al-Mg-Si alloys by rapid solidification —R. Kumar & S. K. Bose (RR 356/76).
59. Fluid sand process—T. A. Beck, G. N. Rao & V. A. Altekar (RR 357/76).
60. Foundry experiences with the NML self setting sodium silicate sand process—G. N. Rao, T. A. Beck, A. Srinivasan & S. D. Deshnikar (RR 358/76).
61. Moulding properties and pH of gas treated bentonites—R. R. Dash & G. N. Rao (RR 359/76).
62. Melting trials with cast iron boring briquettes in cupola and arc furnace—V. A. Altekar, Santokh Singh, G. N. Rao, P. S. Virdi & R. R. Dash (RR 360/76).

63. Metal foam and its applications—S. K. Sinha, G. N. Rao & V. A. Altekar (RR 361/76).
64. The creep properties and microstructure of austenitic steel containing manganese—R. Choubey, T. B. Gibbons & K. Prasad (RR 362/77).
65. Effect of additions on hot strength, retained strength and breakdown properties of sodium silicate bonded sands—T. A. Beck, G. N. Rao & V. A. Altekar (RR 363/77).
66. How to upgrade lean bentonite for foundry use—R. R. Desh, S. K. Sinhababu & G. N. Rao (RR 364/77).
67. Heat resistant cast iron—S. S. Dhanjal, C. A. Naresh Rao, G. N. Rao & V. A. Altekar (RR 365/77).
68. DTA, TG & DTG study on zircon samples—R. D. Gupta (RR 366/77).