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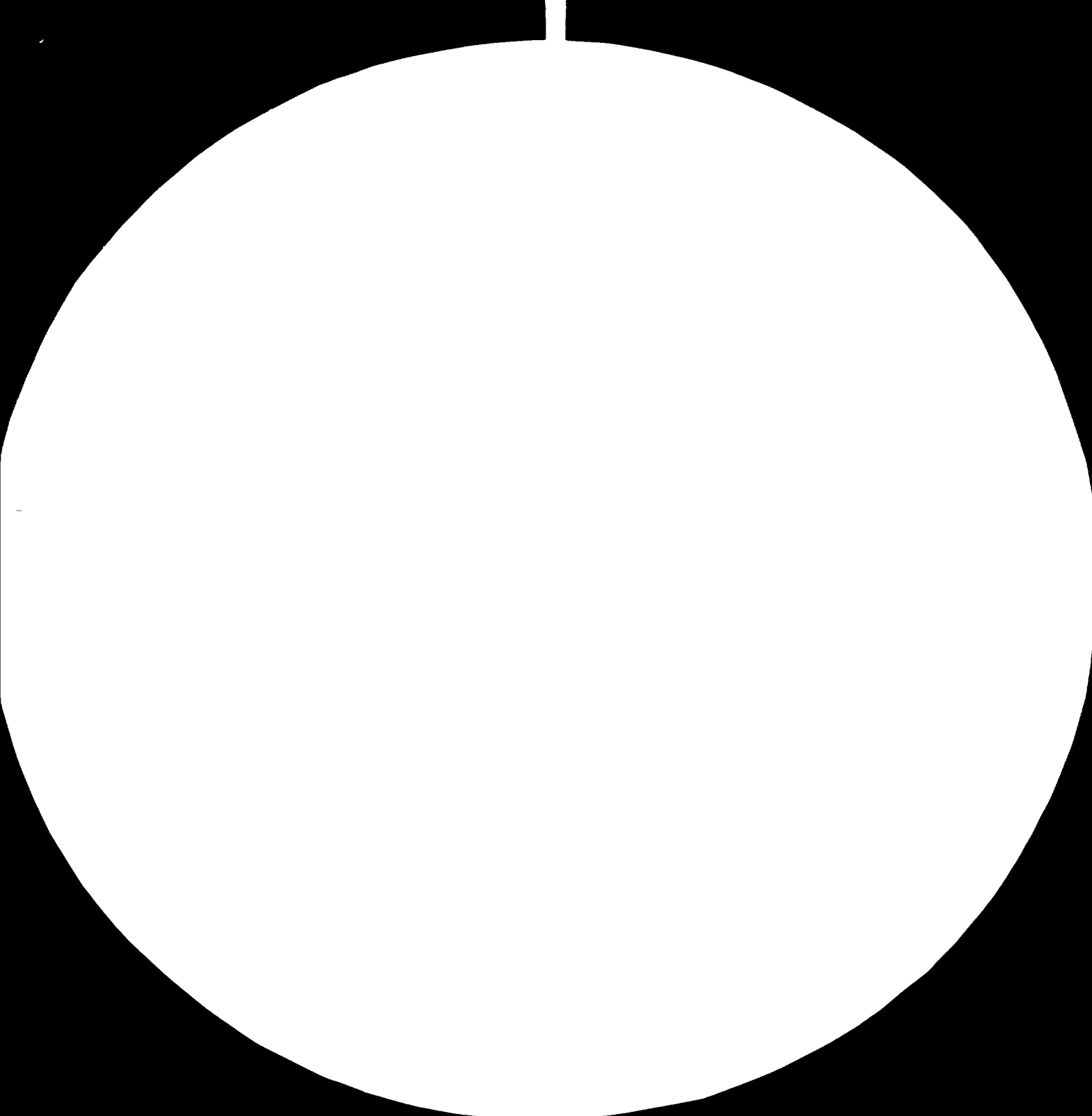

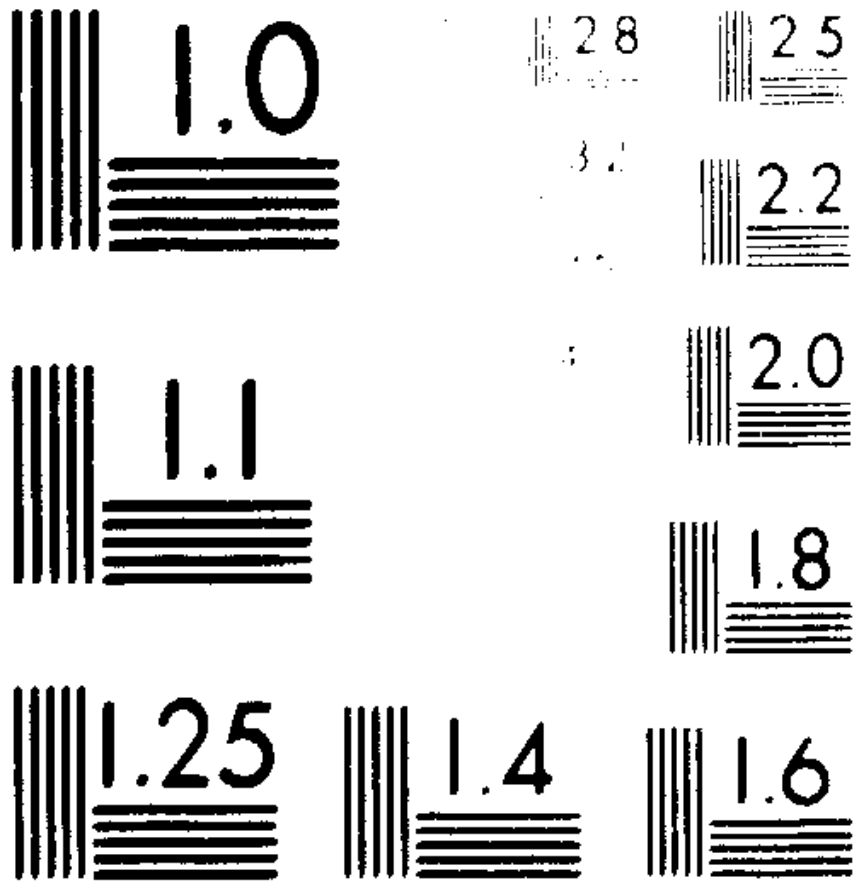
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CENTRAL METALLURGICAL RESEARCH & DEVELOPMENT INSTITUTE

ARAB REPUBLIC OF EGYPT

10419

PROJECT FINDINGS AND RECOMMENDATIONS

UNITED NATIONS DEVELOPMENT PROGRAMME

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

VIENNA

december 1980

CENTRAL METALLURGICAL RESEARCH & DEVELOPMENT INSTITUTE, Egypt

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ARAB REPUBLIC OF EGYPT

PROJECT FINDINGS AND RECOMMENDATIONS

Report prepared

for

The Government of Arab Republic of Egypt

The United Nations Industrial Development Organization

Acting as Executing Agency

for

The United Nations Development Programme

UNITED NATIONS DEVELOPMENT PROGRAMME
THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

December 1980

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INTRODUCTION

The Government of the Arab Republic of Egypt has been engaged in the development of the metallurgical industry in Egypt. During the last decade, the steel production has been expanded from 250,000 to 1,500,000 tonnes/annum and there are plans to develop the iron and steel industry to produce 10 million tonnes/annum of finished steel by the end of the century. The expansion would be based on the latest technological developments as suitable to Egypt. The alumina smelter with a capacity of 100,000 tonnes/annum of aluminium, based on imported alumina, is to be expanded to 166,000 tonnes/annum. The ferro-silicon production is being stepped up and there are plans to produce ferro-manganese and titania rich slag from ilmenite. With the extensive resources of natural gas, a sponge iron plant is being planned and tests conducted. Huge deposits of phosphates have been discovered and there are plans for their exploitation.

Extensive aerial survey for mineral deposits is being undertaken and there are reports of the occurrences of strategic minerals such as molybdenum, tin, copper, lead and zinc. It is hoped that the end of the century will see the increased exploitation of national mineral deposits.

The development of basic metal producing industry in the country is expected to show a big growth of metal fabricating and processing industry. This would result in the establishment of quality steel production as well as machine building industry.

For the development of metallurgical and engineering industries there are a number of factors to be borne in mind, if consideration is to be given to country's needs concerning technical and research services in the framework of metallurgy.

These include:

- Evaluation of indigenous raw materials and their treatment for utilization and recovery of metallic values.
- Development of substitute materials from the indigenously available materials.
- Development of ferrous and non-ferrous alloys, composite materials, etc., in various shapes and forms for different applications.
- Service to the metallurgical and engineering industry for their technological problems.

To meet the research and development demands of the metal producing and consuming industry, the Government of Arab Republic of Egypt took a timely action for the strengthening of the metallurgical research in Egypt and this led to the plans for the establishment of the Central Metallurgical Research and Development Institute in Cairo.

To foster relationship between the industry and research and the formation of a nucleus of CMRDI, UNDP approved a preparatory assistance for US$1,000,000 and this was followed by the 1st phase in 1972-1974, with UNIDO as the Executing Agency. The first phase with UN inputs of US$463,700 provided for supply of some equipment for research in industrial and extractive metallurgy to the value of US$100,000, together with 108 man months for UN experts and training fellowships at an estimated cost of US$74,600 in various metallurgical fields. The Government inputs were LE1,465,276.

The success of the efforts during the first phase created the interest of the metallurgical industry that agreed to participate on equity basis, with the Academy of Scientific Research and Technology, the costs of buildings, services and utilities at the new premises. The Egyptian Iron and Steel agreed to hand over 7000-square meter plot of land adjacent to the Steel Company in El Tebbin, Helwan, for building up the Institute.

With the interest of the metallurgical industry, the 2nd phase of the Institute was approved in March 1974 for a period of 5 years with its main objectives as:

1. To extend the services already started in the 1st phase, where practical problems are being solved with the available means of research in the various fields of metallurgy.

2. Extend the research facilities and establish pilot plants and unit processes at the new site, with a view that the Institute should be capable of undertaking investigations in the diverse fields of metallurgy, both on the laboratory and pilot plant scale.

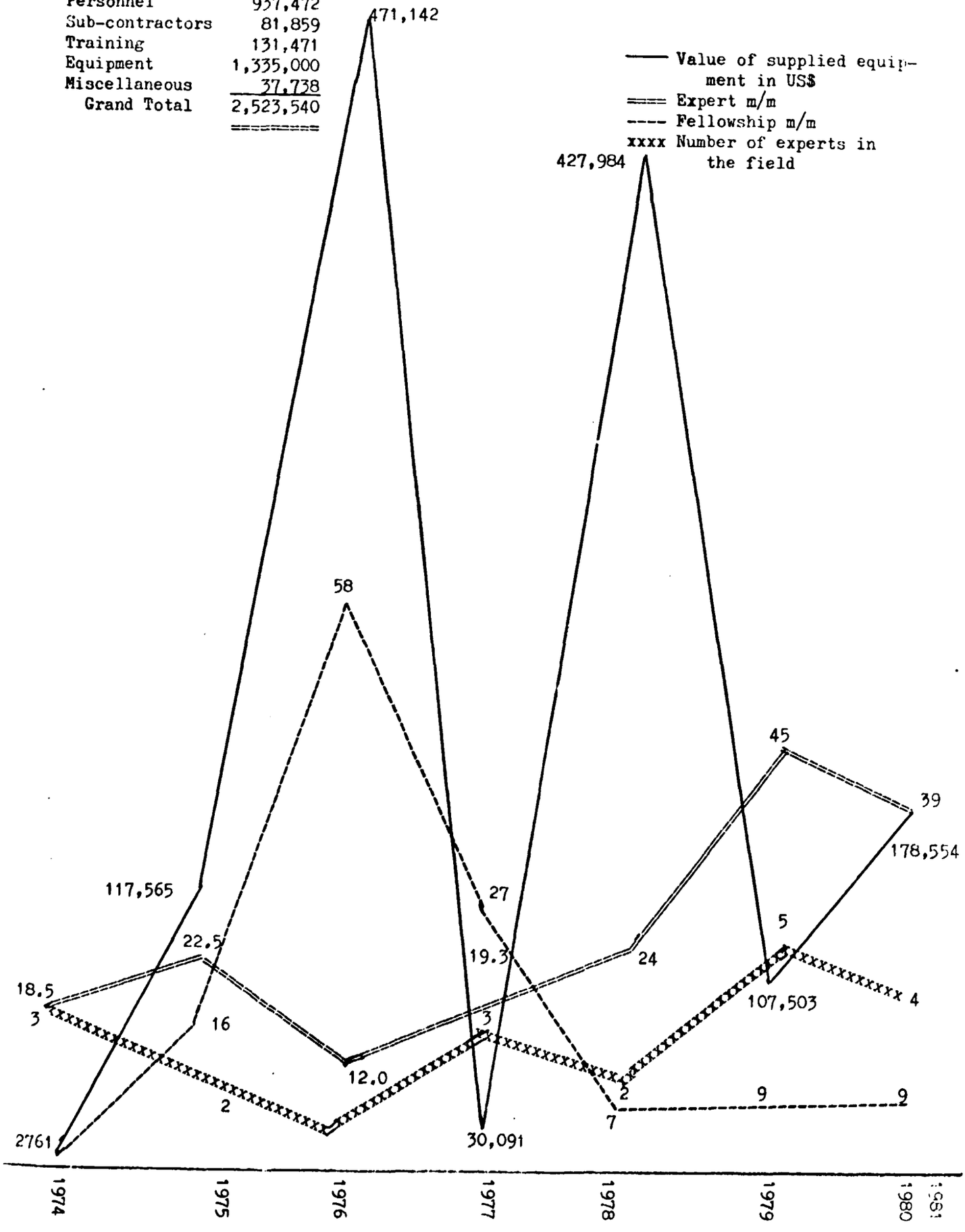
The original UNDP inputs of 1.86 million US$ during the 2nd phase had to be revised to meet the increasing costs of experts and US$345,000 were allocated to 1979, extending the tenure of project and supply of additional equipment. The latest UNDP inputs of US$2.523 million include supply of equipment to the value of 1.335 million US$, 192 m/ms services of experts and training fellowships for 108-man months.

The Government inputs during the 2nd phase are about 3.0 million LE towards the cost of the establishment of new facilities at its new premises at El Tebbin excluding the cost of the existing equipment as well as the services of 100 scientists and other supporting staff.

Figure 1 represents the graphical representation of the U.N.D.P. inputs from 1974 onwards during the 2nd phase of activity and Appendix I lists the UNIDO experts and their counterpart staff.

FIGURE 1 - U.N.D.P. INPUTS

	US$
Personnel	937,472
Sub-contractors	81,859
Training	131,471
Equipment	1,335,000
Miscellaneous	37,738
Grand Total	2,523,540



1.0 OBJECTIVES OF THE PROJECT

The purpose of the project was to:

- Establish a bridge between the industry and the Central Metallurgical Research and Development Institute* by undertaking studies on the existing problems of the metallurgical industry.

- Extend the research and development activities of the CMRDI oriented towards the needs of the country.

- Establishment of the new premises at El Tebbin including planning, installation of UNIDO supplied equipment, its commissioning and training of the national staff.

The first two activities have so far been carried out with the existing facilities either in the plants or in the laboratories at the National Research Centre and assistance has been rendered to almost all major metallurgical units in Egypt. However, the last objective of the establishment of the new facilities at El Tebbin has been realised only towards the termination of the 2nd phase and it has not been possible to involve the experts on the projects connected with the operations of the pilot plant equipment for a longer period.

*hitherto referred as CMRDI.

2.0 ACTIVITIES CARRIED OUT & OUTPUTS PRODUCED

The description of the work as outlined in the objectives has been divided into two sections. Section A deals with the activities of the National and International staff aiming at assisting the metallurgical and engineering industry and Section B describes the different stages of the establishment and functioning of the CMRDI at the new premises at El Tebbin.

SECTION A

During the period under review, the activities at CMRDI include:-

- Technical assistance to the metallurgical industry.
- Research and development.
- General consultancy.
- Training.
- Technical enquiries and routine test services.

The following describes the activities carried out in the different fields in the respective groups and the outputs produced.

2.1. Technical assistance to the metallurgical industry

The technical assistance to the metallurgical industries in Egypt has been through:-

- Sponsored projects.
- Industrial problems investigated without any contracts.

The following describes some of the major activities in the respective fields.

2.1.1. Sponsored Projects

The sponsored projects have been either through UNIDO sub-contracts for CMRDI or sponsored to the CMRDI by the outside agencies.

2.1.1.1. UNIDO Sub-contracts

The Project Document had provided for two major sub-contract activities and these included:-

- Beneficiation of iron ores for the removal of alkali chlorides.
- Improvements of steelmaking practice at the non integrated steel works in Egypt.

The two projects were chosen as they were of paramount importance for the steel industry in Egypt. The presence of alkali chlorides in the iron ores not only results in serious corrosion of the sinter unit but the output from the machine is much lower and the product is neither suitable for feeding in the blast furnace. This results in shortage of furnace feed and the full productivity of the steel plant is only possible when the requisite quantity and quality of sinter can be produced. The solution to the problem of alkali chloride in the iron ores of Egypt was thus considered to be a priority issue and included in the sub-contract activity.

During visits to the non integrated steel plant, it was observed that there is considerable scope of improvement, not only in the steelmaking technology at the open hearth and electric furnaces but all other steps starting from charge preparation to the casting of ingots for rolling. Moreover, the ingot mould consumption at one of the plants was almost 2.5-3 times of the normally accepted practice. An improvement in the ingot mould consumption was also likely to result in considerable financial benefits. This problem was best expected to be investigated by a group of experts in the different fields and was thus included as a UNIDO sub-contract activity.

The following describes the findings and the likely economic benefits of the two investigations.

2.1.1.1.1. Beneficiation of Baharia iron ores

The tests on the removal of chlorides from the Baharia iron ores were carried out at Hasan Brkic Institute, Zenica, Yugoslavia and the beneficiation methods investigated included:-

- Washing.
- Thermal treatment followed by dry magnetic separation.

The sample containing 1.19% NaCl, uniformly distributed in the different sized fraction, was crushed to the size recommended for sintering. The crushed sample was subjected to washing tests and it was observed that 2/3 of the NaCl could be removed by simple washing.

The best results were obtained by magnetising roasting and magnetic separation in low intensity magnetic field. The concentrate so obtained contained only 0.12% NaCl. The only problem in adopting this technology is that such fine product cannot be fed to the sintering machine.

Based on the laboratory tests, the pilot plant tests conducted on 300Kg. sample yielded the concentrate containing Fe 53.40%; SiO_2 8.37%; Al_2O_3 2.25%; Cl 0.26%; Na_2O 0.23%; L.O.I. 9.54%; with overall 95.5% recoveries.

It is estimated that the adoption of the washing of iron ores would result in a saving of 0.65 US$/tonne in maintenance of sinter stand. Furthermore, the lower coke consumption - 30 Kg/tonne, and increased blast furnace productivity by 3.5-4%, would result in a saving of approx. 6.6 million US$, with the operating cost of 5.5 million US$ per year, an overall saving of 1.1 million US$ is anticipated, not taking into account the overall increased supply of steel. This proposal is being examined for commercial tests.

2.1.1.1.2. Improvements of steelmaking practice at the non integrated steel works in Egypt

The non integrated small steel plants in Egypt, using cold charges consisting of steel scrap/pig iron are equipped with basic open hearth and electric furnaces. The total capacity of these 3 plants is estimated at 270,000 tonnes/annum and the productivity of these plants could be improved by application of latest technological innovations, reducing production costs and upgrading the quality of steel.

Kobe Steels of Japan were awarded the contract to undertake evaluation of the existing practice and suggest remedial measures and carry out test trials in the plant so as to demonstrate the improvements that could be affected with either the existing or minor modifications possible during their stay in the plant.

Kobe steel had sent a team of six engineers with different specialisations and the team spent approximately two weeks at the various plants - 4 to 5 days for observations, 3 to 4 days for demonstration and 3 to 5 days for discussion and recommendation.

Some of the problems common to all the 3 plants were identified and remedial measures were suggested.

Besides the improvements in the existing practices, new and modern practices and technologies were indicated to be adopted.

In addition to the observations and remedial measures of the common problems, the team had also examined the specific problem of the individual plants and the advice given.

It is concluded that besides increased productivity from existing 270,000 tonnes per year, there is the possibility of decreased operational cost, and even a modest saving of L.E.2/tonne will result in substantial economic gains.

2.1.1.2. Projects sponsored to CMRDI

CMRDI scientists have been increasingly involved in the projects sponsored by the industry and the details of such sponsored projects are indicated in Appendix II.

Most of these sponsored investigations have so far been carried out at the premises at Dokki with the existing and the UNIDO supplied laboratory equipment; in some cases the plant facilities were also used for test trials. It is hoped that in due course, CMRDI will be able to meet most of its running expenses through the sponsored projects that may require to be investigated on the laboratory and pilot plant scale. The pilot plant facilities can also be used for the small scale production of some essential items.

The following describes in brief, the findings and some of the major sponsored projects.

2.1.1.2.1. Beneficiation of the New Valley phosphate deposits laboratory scale studies

A wet concentration flowsheet was investigated in the laboratory to minimise the dolomite content of the ore and to increase its P_2O_5 content. The flowsheet developed comprised of crushing, attrition-scrubbing and classification as a pre-concentration process followed by carbonate flotation circuit of the deslimed finer size fraction -0.152 + 0.02 mm.

Dry concentration processes were also investigated, in case of shortage of water at the site and the steps included:

- Dry grinding in ball mill and air classification of the attritioned product.
- Dry electrical separation methods included high intensity magnetic separation or electrostatic separation.
- Calcination of the washed phosphate for a separation of dolomite by attritioning of the calcine and separation of magnetite by low intensity magnetic separation.

2.1.1.2.2. Pilot plant tests on beneficiation of phosphate rock

Following laboratory studies at CMRDI, & pilot plant tests were planned for upgrading the phosphate rock these consisted of washing, classification and carbonate flotation of the deslimed, -150 microns size fraction.

Two concentrates will be obtained viz a primary concentrate after washing and screening to 150 microns and a secondary concentrate after flotation and vacuum filtering of the deslimed -150 micron fraction.

Representative samples totalling about 25 tonnes from the Abu Tartur phosphate deposits have been received, crushed and screened to - 2mm. The whole quantity has been thoroughly mixed to provide a uniform feed for beneficiation tests. A representative sample has been prepared for chemical and sieve analysis. Pilot plant tests have started at a feed rate of about 0.25 tons/hr.

2.1.1.2.3. Beneficiation of clays from Abu Sebara deposit (Aswan Area)

The X-ray, D.T.A., T.G.A. and chemical analysis was followed by the following bench scale tests for removal of free silica:-

- Degritting and soaking.
- Degritting and attritioning.
- Cycloning of -37mm slimes to separate the -7mm fraction.
- Classification of products.
- Measuring the settling rates of concentrate with and without flocculent for determination of thickner dimensions.
- Generalised flowsheet design.
- Preparation of 10 kg concentrate for further investigation.

The recommended flow sheet has been submitted to the sponsorers.

2.1.1.2.4. Evaluation of an Egyptian natural alum (Western - Desert)

The study comprised the bench scale tests and the prefeasibility study for the production of 100,000 t.p.y. of pure alum from a natural alum deposit at the New Valley Governorate. The report includes the overall ore evaluation and the fractional crystallisation process for the removal of different gangue minerals.

2.1.1.2.5. Beneficiation of bentonites from Fayum

The bentonites from Qasr El Saga, Fayum contain gypsum and quartz between 15 to 20% and the montmorillonite is only 50%, instead of normally acceptable 75% by the foundries and the petroleum industry.

Dry grinding in different grinding machines has been studied, to study the selective grinding of the clay minerals and the gangue constituent. Ball mill has been found to be most selective. Soaking of bentonites in water was also found to desintegrate the clay minerals, thus leaving gypsum and quartz in the coarser fraction.

Based on laboratory scale studies, a flowsheet of the process, has been worked out and this includes soaking the crushed ore using a solid: liquid ratio of 1 to 3, followed by screening on 400 mesh screen. The over-size mainly contains gypsum and sand, whilst the under size is the concentrate. The concentrate is lead to the thickner and filters after addition of flocculent.

A pilot plant test is recommended for feasibility study and economic appraisal.

2.1.1.2.6. Removal of alkalis and beneficiation of El Gedida iron ores

The beneficiation of the iron ores is primarily aimed at removal of the chlorides and alkalis as well as in decreasing the gangue, particularly in the silica.

The programme of studies included:

- Washing.
- Gravity method.
- High intensity magnetic separation.
- Magnetising roasting followed by high intensity magnetic separation.

Two samples were investigated, the first contained high alkali, low silica, whilst the second sample was low in alkali and high in silica. The washing tests have revealed more than 90% of alkali that can be removed after 5 stages of washing.

The tests were in conformity with the earlier studies at Hasan Brik Institute, Yugoslavia.

As a result of the CMRDI studies and the findings of US Steel, the management of the Steel Co. has recommended further pilot plant tests at CMRDI using the available equipment. The objective of such studies would be to study and evaluate the possibilities of simplifying the ore washing, drying flowsheets and the equipment proposed by the Consultants, US Steel. Particular attention will also by given to the possible elimination of thermal drying of the finer fractions of the washed ore.

2.1.1.2.7. Production of phosphoric acid and phosphatic fertilizers from Egyptian phosphate rocks and concentrates

A concentrate from Nile Valley phosphate assaying 31% P_2O_5 was processed with sulphuric acid and the produced phosphoric acid was filtered from calcium sulphate residue. The different factors affecting the leaching process, viz acid concentration, time, temperature and solid/liquid ratio were studied. 90% P_2O_5 recovery was achieved, using 25% H_2SO_4 at 80° C after 120 min. using 2.5 solid:liquid ratio. Acid of 30% has been obtained on using 20% phosphoric acid as a recycle acid. This was concentrated to 54% on heating at 300° for 3 hours.

The phosphoric acid, so produced, was used for studies in connection with production of mono,di,tri-ammonium phosphates.

Based on the laboratory tests and pre-feasibility studies on the utilisation of Egyptian Phosphate rock for the production of phosphoric acid and other phosphates, USAID has agreed to supply CMRDI with a pilot plant for further studies and also train one of the CMRDI scientists on the various aspects of the operations of the pilot plant

2.1.1.2.8. Production of aluminium-fluoride from waste fluo-silicic acid at the superphosphate fertiliser plant -(Kafr El Zayat)

The various parameters for the production of aluminium fluoride by treating the fluo-silicic acid with aluminium fluoride were studied. It was observed that 95% of conversion of aluminium hydroxide into fluoride was achieved using 5% acid at 80° for 30 minutes. The use of higher acid concentration produces a slurry which was difficult to filter. Double stage reaction resulted in 95% conversion in the first stage and 62% in the second stage.

Further tests have been carried out using Egyptian clays after calcination as it results in higher recoveries.

Pilot plant tests have been recommended to the fertilizer company.

2.1.1.2.9. Appraisal of sinter plant practice at Egyptian Iron and Steel Co.

The sintering of Bahariya iron ores containing high alkali chlorides, was commenced with the completion of the 1st stage of expansion at Helwan. The operations of the sinter plant led to serious problems within a short time of commissioning and this was taken up by the management with the equipment suppliers.

The report submitted by the suppliers was examined and CMRDI study revealed that excepting the quality of raw materials for which no better control could be exercised, most other problems arise on account of the cumulative damaging effect of the chlorides.

The CMRDI study examined the effect of various variables as affecting the quality and the functioning of the various units of sinter machine. It was concluded that besides greater quality control measures, the solution to the problem lies in feeding the sinter stand with iron ores of requisite size after removal of alkali chlorides.

As a result of the appraisal, the chairman of the Steel Co. desired CMRDI to undertake an assessment of the operations at the sinter plant at Helwan and formulated a joint team, consisting of the engineers of the Steel Company, scientists of the CMRDI to also study the sintering of the iron ores containing 0,35% alkalis from a selected area in the mine, so that the corrosion on the sinter stands on using the ores with lower alkalis be minimised and higher productivity attained.

The studies revealed that though the corrosion effect on the grate bars is slightly reduced, the strength of the sinter was still poor. It was further observed that a 50% of alkalis are retained in the sinter and this depends on the silica content in the charge.

The only solution to the problem is to remove the alkalis prior to agglomeration.

2.1.1.2.10. Studies on the dephosphorisation and desulphurisation in Electric Steelmaking at Delta Steel

The data collect on the dephosphorisation and desulphurisation in electric steelmaking at Delta Steel Co. were critically scrutinised so as to correlate the removal reactions with the operating conditions i.e. the composition of slag, temperature etc. The plant data have been compared with those derived theoretically and the causes of variations indicated, with a view to improve the furnace operations.

2.1.1.2.11. Evaluation of Maadi sands for foundries

Egyptian foundries use sands from five different deposits and their clay content varies from 5 to 15%. The largest deposits at Maadi contains 5% clay and the particle size varies from coarse, medium to fine. The quality of sands being used by different foundries was examined and the need to use the desired grade was indicated.

CMRDI was entrusted with the studies on Maadi sands, their classifications, chemical analysis and the moulding characteristics. These studies formed the basis for the development of the area and the requisite treatment for the supply of acceptable and desired grade of sand for the different foundries. The plant is now reported to be ready to supply the desired grades of sand to the different foundries.

2.1.1.2.12 Evaluation of foundry raw materials from Somalia UNIDO Subcontract

CMRDI was also contracted by UNIDO to undertake a study on the suitability of Somalia sands, binders, fluxes and charcoal for use in their foundries. The contract had involved the testing of different sands samples and included the physical and chemical characteristics; viz. grain size, surface and shape; permeability, mouldability; compression strength, sintering temperature and other properties that determine their suitability for various foundry applications.

The test on bentonites included the chemical and mineralogical analysis as well as the quantities needed for binding.

The test on the fluxes and charcoal were to determine their suitability for cupola operations.

CMRDI's tests on evaluation of the raw materials for foundry and the recommendations for various applications were highly complimented.

2.1.1.2.13. Operation of hot blast cupola

The hot blast cupola at El Nasr Casting Co. had not been operating satisfactorily and on examining the existing operating conditions, new charge composition and most suitable size of charge was indicated. The fluorspar addition was to be decreased from 10% of fluxing material to 2.5% or alternately soda ash blocks used not only to increase the fluidity but also for desulphurisation, conservation of heat was to be affected by covering the launder and insulation of hot air blast pipes.

In order to effectively control the blast volume, temperature and pressure, the installation of requisite instruments was indicated.

The properties of the lining materials were also determined.

2.1.1.2.14. Improvements in foundry practice at El Nasr Casting Company (Tannash)

After the completion of the training course on quality control, the management of El Nasr Casting Co. desired CMRDI to assist in the implementation on the shop floor of the practices given in the lectures. These included melting, moulding, core-making, and laboratory procedures and the National staff was involved in observing and correcting bad practices, introducing new practices and analysing the effects of the changes.

Some of the more important changes introduced were:-

- Improvements of cupola operation by introducing correct and accurate charging procedure, elimination and unsuitable charge materials, e.g. rusty or alloy steel scrap, oversize pieces etc., reduction of charge weight commensurate with cupola diameter, better coke charge distribution, etc. There was a noticeable drop in rejects due to slag inclusions, cold and/or unsuitable metal.

- Identification of the causes of leaking and pin-holed spun pipe castings due to slag and the aluminium content of the iron. The introduction of tea-pot ladles, entrapped slag.

- Introduction of coal-dust to facing sand for improvement of surface finish not only resulted in better finish but also considerable reduction in fettling cost.

Many other features covering maintenance, patterns, sand mixing methods, equipment recommendations, etc... have been covered.

The Management is highly satisfied with the overall improvements.

2.1.1.2.15. Suitability of Kasr El Saga bentonites for foundry purposes

A study of the properties of the bentonite samples revealed that the samples need activation to meet the specification for different applications. Further tests have been carried on samples from different regions in the area and the binding properties determined by using standard sands prepared for the purpose.

2.1.1.2.16. Materials for sea water condenser tube and fuel additives

The General Egyptian Electricity Corporation desired the specifications of condenser tubes for the power station being set up at Alexandria. The cooling water is contaminated with H_2S and the urea plant being set up in the vicinity will also add to the contamination.

The compositions of the alloys and the details of the tests simulating the actual operating conditions were indicated. Tests on site were also recommended using the rig developed by British Non-Ferrous Research Association. It was further recommended that these tests should be made on the available tubes and not those specially produced or cleaned for tests.

The tests on the rig at the proposed site would be realistic in providing data for the assessment of the suitability of variety of condenser tube materials. These tests together with metallurgical examination of the test pieces and other electro-chemical tests to be carried out in the laboratory would supplement each other.

The Electricity Corporation had also entrusted the evaluation of a number of fuel additives to combat corrosion in the boiler tubes. Plant tests were conducted and most suitable additive recommended.

2.1.2. Industrial problems investigated on an ad hoc basis

The UN experts and the national staff, either jointly or singly have been involved on a number of problems of immediate interest to the industry. Such projects had emanated from the visits to the plants, and study of the operations and discussions with plant personnel. Assistance on an ad hoc basis has so far been rendered free of charge and now there is a shift in the policy, to undertake investigation only when they are sponsored and paid for. The following describes in brief, some of the problems investigated on ad hoc basis.

2.1.2.1. Effect of alkalis on the performance of blast furnace No.3 in the Egyptian Iron and Steel Co.

The presence of alkalis in the charge, fed to the blast furnaces results in operational problems and in order to study the effect

of alkalis as affecting the blast furnaces at the Egyptian Iron and Steel Co., data were collected over a 6 months period; the alkalis inputs (sinter, lime, dolomite, and coke) and outputs (slag, dust, sludge and water) have shown accumulation during the period. Statistical analysis of the data were carried out and mathematical models were derived.

The relations between the alkali loadings, the basicity and the efficiency of alkali removal by slag were obtained. The effect of alkalis on the partition of sulphur and manganese, as well as the rate of coke consumption were determined.

The study reveals that the alkali inputs in the blast furnaces must be decreased. It was further recommended to slightly lower the basicity of slag thus flushing out the accumulated alkalis.

2.1.2.2. Sulphur pick up & removal during steelmaking - plant trials - (Copper Works and National Metals)

Sulphur pick and its removal is a serious problem for steelmaking, from scrap, in open-hearth furnaces, owing to very high sulphur in pig iron, furnace oil and the use of highly oxidised light scrap which results in considerably long refining period, slagging a number of times, all resulting in low productivity. Plant trials on lime injection for desulphurisation were very satisfactory.

2.1.2.3. Evaluation of electrical steelmaking - (Egyptian-Iron and Steel Company)

A study similar to that conducted by Kobe Steel, Japan on UNIDO subcontract has been initiated to evaluate the electric steelmaking practice at the Egyptian Iron and Steel Company. The study critically appraises the existing practice, the effect of the slag basicity, period of oxidation, effect of stirring during oxidation. The effect of slag composition as affecting the refining has been investigated.

2.1.2.4. Production of 13% Cr Steel - (Delta Steel)

Earlier attempts to produce 13% Cr steel at one of the steel plants, had failed owing to the various operating difficulties and the desired grade was being imported with considerable drain on foreign exchange.

Prior to the test trials at the plant, detailed discussions were held with the plant engineers on the methods adopted by them during their tests and these included the fluxes used during melting and refining, the purpose of the double and treble slagging, oxygen lancing and the addition of de-oxidisers and alloying constituents. The anomalies in the chemical analysis during furnace operations were also brought out.

After a detailed analysis of the entire data, the technology to be adopted was suggested and successful tests were conducted and the steel produced to the desired specification. CMRDI was highly complimented by the chairman of the Metallurgical Organization.

2.1.2.5. Sulphur pick in melting of electrolytic copper-(General Metals)

General Metals Company, Cairo was experiencing difficulties during the melting of electrolytic copper, as it invariably resulted in high sulphur pick up - averaging 0.007% against .003% as permissible.

The causes of high sulphur pick were investigated and the modified melting technique was proposed, which consisted in covering the surface by charcoal, rapid melting and deoxidation.

The practice of fire refining of scrap copper was also examined and test trials conducted, to ensure that the deoxidation is complete. The samples were examined under the microscope for the presence of oxides.

The technology so demonstrated resulted in the production of electrolytic copper suitable for the electrical purposes.

2.1.2.6. Production of ingot moulds-(Delta Steel and Nasr - Casting Co.)

Two major types of ingots are being produced in Egypt for casting 150mm^2 billets at the non integrated steel plants and 5 tonne ingots at the Iron and Steel Co. at Helwan. The cost of ingots moulds in steelmaking is one of the key factors in the cost of steel at the steel plants in Egypt as the consumption is several times higher than the standard practice of 15 kg/tonne. A detailed proposal for undertaking studies with a view to improve the ingot mould life was suggested and in order to effectively improve the service life of ingot moulds, the metallurgical examination of prematurely failed ingot moulds was recommended so as to establish the cause of failure and introduction of remedial measures.

2.1.2.7. Causes of scaling and distortion of castings - (El Nasr Steel Pipe and Fittings Company)

The firm was experiencing heavy scaling and distortion of the casting during annealing. As a result of detailed study of the plant practice, it was established that the defects are due to lack of maintenance of equipment causing lack of control of furnace atmosphere, temperature and incorrect readings of the controllers. It was recommended that the firm enters into a routine service contract for the maintenance of its controllers and other equipment.

The defective castings were metallographically examined confirming the causes of defects as indicated above.

2.1.2.8. Production of high strength malleable cast iron fittings - (Nasr Tube Company)

The planned facility as Nasr Tube Co. for the production of malleable cast iron fittings was examined and attention drawn to the likely sulphur pick up from the coke in the hot blast cupola. The melting of the charge, consisting of steel scrap and 20-40% white iron return scrap, in the main frequency induction was recommended.

The details of the heat treatment were determined to meet various specifications of U.T.S. of 35 kgf/mm^2 to 65 kgf/mm^2 and minimum elongation varying from 12 to 3%.

2.1.2.9. Casting of axle boxes for passenger cars

The axle boxes for the passenger cars in a local foundry, frequently cracked and investigations were taken up to ascertain the causes of cracking. The properties of sands used for making the moulds were examined, and also the radiographs showing the defects. The mould and pattern did not call for any changes in their design.

The following changes and control were suggested and carried out resulting in improved recoveries.

- Sand not to be rammed too tight.
- The cores to have more elasticity.
- Proper control of pouring temperature.
- Increase in the period of stripping.

2.1.2.10. Service failure in rolling stock bogie - (Egyptian Railways)

A railway bogie frame, which had cracked during service was examined and the metallographic examination did not reveal either an inherent or welding defect. The fracture was traced due to fatigue during service, and was caused by a deep punch mark remaining from the original marking out operation. The punch mark had not been removed by edge grinding after the hole was out, resulting in cracks.

2.1.2.11. Ingots defects - (Egyptian Copper Works)

Defective ingots result in overall poor recoveries and problems at the rolling mill. A study was undertaken to identify the defects, classify into different categories and the probably causes of the formation of defects.

It was observed that the largest number of defects occurred owing to bad pit side practice and lack of control during casting. The management has been recommended suitable controls to eliminate these defects.

2.1.2.12. Metallography study of ingot mould samples

An examination of the random samples of failed ingot moulds from Helwan Steel plant had shown a wide range of defective microstructure in particular poor and inhomogenous graphite flakes size and distribution; presence of large concentrations of MnS and Fe_3P and large areas of free ferrite and porosity.

The examination of the ingot moulds that had served their service life as per the existing practice, had also shown sulphide concentrations and highly ferritic areas associated with poor graphite flake distribution.

This study revealed the factors to be controlled during production.

2.1.2.13. Metallographic study of cast iron sections of Deutz cylinder (Nasr Car Company)

Owing to difficulties observed in locally producing the automobile cylinders, a comparative study was undertaken of the locally produced cylinders and the one produced by Deutz in Western Germany.

After the matallographic examination, it was concluded that hardness varied between the top and bottom owing to changes in microstructure either owing to excessive chilling or too low silicon. The riser had large and big MnS inclusions, resulting in formation of areas of ferrite, and acting as nuclei for porosity and shrinkage cavities.

Based on the studies, the castings are recommended to be cooled less severely. Silicon to be kept high and sulphur content to be reduced and to increase fluidity, phosphorous was recommended to be increased.

2.1.2.14. Metallographic examination of piston rings from Middle Delta Bus Transport Company - (Delta Bus Company)

Four samples were received from Middle Delta Bus Company to compare the structure and properties of the compression piston rings that were worn out in use and locally made in the Company's workshop and elsewhere.

The structure of the piston rings revealed the manufacturing defects which could then be rectified.

2.1.2.15. Study of defects in forging -(Nasr Forge Company)

The Nasr Forge Company had been experiencing difficulties in forging some of the parts and systematic study of the defects was undertaken. This included metallographic examination and deformation analysis.

The technology of forging was suggested and it was recommended that special upsetting die be made for the proposed technology.

Some other defective forging were also examined and the remedial measures for future production were suggested.

2.1.2.16. Study of blank preparations - (Nasr Forge Company)

Nasr Forge Co. had been experiencing difficulties and rejection were heavy in the shearing of 100 mm or above billets, with the result that the rejected blanks could not be used.

After the calculations on the capacity of shear, tests on the factures and the temperature of heating of the billets it was concluded that the temperature need be effectively controlled within a specified range. Further trials with the desired temperature control eliminated the defects. A simplified method to determine and control the temperature with the special colour pencils was suggested.

2.1.2.17. Production of welded chain links - (Nasr Forge Company)

During the visit to the Nasr Forge Co. it was observed that 15% of the 17 mm dia. chain links, welded by upset butt-welding frequently crack. As a first step to the causes of heavy rejections, metallographic examination of the failed links was carried out and excepting minor inclusions no appreciable defect in the steel was noticed.

After the study on the spot, the firm was advised to change the pressure and current according to the melting rate of electrodes. Special instructions were also given to ensure clean ends prior to welding. On further trials it was observed that none of the chains so produced failed during test and in fact the breaking load with stud had reached 14-16 tonnes, as against specified breaking load of 12.2 tonnes.

2.1.2.18. Heat treatment of coils springs for spring manufacture - (Yayat Company)

The grain size of springs as well as the heat treatment including tempering temperature and time, ensuring tempered martensite, greatly affect the properties of the springs so treated. In order to ensure correct treatment and evaluate the existing practice detailed investigations have been undertaken to determine the effect

of various factors including temperature of hardening, quenching and tempering. The effect of the different temperatures and the period of tempering, as affecting the properties and microstructure of the materials have been studied and a suitable treatment indicated to the Management.

2.1.2.19. Production of wire ropes - (Copper Works)

The steel wire rope has been produced at the Copper Works, Alexandria, from imported stock and tests were undertaken so as to improve the quality and productivity particularly with a view to overcome specific problems.

After the technology of wire production was improved upon, further tests were conducted on the production of the desired two grades of steel from the available scrap and an overall recovery of 33% was obtained which is considered satisfactory under the local conditions.

2.1.2.20. Wire drawing and the introduction of mechanical descaling - (Delta Steel)

Delta Steel Mills had been pickling the wire before drawing and owing to the problems involved, it was proposed that pickling be replaced by mechanical descaling with rotating dies. The details of the changes were worked out and the system introduced in the plant.

Addition of sodium algenate to the lubricant was suggested since it results in the increase of the melting point of the lubricant and forming an adhesive layer for the lubricant.

2.1.2.21. Master technology for production of bailing hoops - (Copper Works)

The Copper Works desired to be furnished with a technology for the production of bailing hoops as well as a study of the existing practice.

The changes recommended included composition, temperature of pickling bath and the rinsing practice.

The new sequence of rolling during drafting and the speed was recommended to be controlled within specified limits.

The heat treatment cycle of the rolled strips was furnished as well as the operations of the furnace for blueing of strips.

Full details of quality control operations were indicated and introduced.

2.1.2.22. Study of roll breakage - (Copper Works, Alexandria)

Premature failure of a roll at the National Steel Co. was examined with a view to examine and suggest the remedial measures either during the production of rolls or during their use.

On complete analysis of the operating conditions, it was noted that the steel rolled had contained more than 0.02% aluminium and the cause of roll breakage was attributed to the lower rolling temperature for the steel rolled and minor fractures on the surface due to badly worn groove.

2.1.2.23. Optimisation of production programme of rolling mills in Egypt - Productivity of different rolling mills - at non-integrated Steel Plants.

In order to ensure the maximum production from the existing rolling mills, a committee including the UNIDO Expert, Engineers from the different mills and CMRDI counterpart staff was constituted.

The Committee sub-divided its programme of work into:-

- Evaluation of real bottle-necks in rolling mills and implementation of new technologies.

- Study of working time and proposals for better utilisation of the equipment.

The evaluation of the bottle-necks showed that the increased throughput per hour was possible and the same was established during test trials when the minor troubles lowering the throughput were removed.

The studies of the working time at the different plant and the planning of sequence for rolling of different products enabled to evaluate the possible production of all the rolling mills and a further study on the optimisation of the order distribution among the rolling mills was based on the Vogel approximation method.

2.1.2.24. Improvements of rolling mill practice - (Ayad Company)

The working of the medium scale rolling mill at El Tebbin was critically examined with a view to improve the productivity and diversify the different rolled sections. The details of the new roll pass design ensuring continuous rolling without the stop over of the mill using different sized billets was furnished. It was then possible to use 100 mm billets to roll 10 mm rebar with the existing facilities of cooling bed.

2.1.2.25. Proposals for modernisation of rolling mills in Egypt

Inspite of the increased productivity from each of the mills and larger indigenous production of rolled products, the gap between the supply

and demand has been forecasted to increase. It is then logical to modernise and expand the existing facilities prior to the installation of the new units. Accordingly a study on the possible modernisation of the existing facilities was undertaken. Such studies have been undertaken from time and the latest study (1978) includes:-

- Proposals for modernisation of existing investments and the installation of a new mill at Copper Works, Alexandria.

- Proposals for the modernisation of Delta Steel Mill.

It was shown that the capital investment can be recovered within 5 years after completion of the modernisation.

2.1.2.26. Introduction of quality control in steelmaking and rolling mill - (Copper Works, Alexandria)

A study was undertaken for the quality control measures for steelmaking and rolling for the production of reinforcing bars at Copper Works.

The master technology for melting, casting and rolling of the two grades and sizes of the rebars was worked out and introduced in the plant. Comprehensive training, discussions were also held on the master technologies with the plant personnel at all levels.

The system of data collection and processing by the quality, production controls; material inspection and certification was developed and introduced in the various shops.

The final recommendation also included the establishment of a technological office.

The management has highly complimented the CMRDI for the study which is likely to be extended to other establishments.

2.1.2.27. Fireside corrosion of boiler tubes due to vanadium oxides in the fuel oil

The boiler tubes exposed to the firing end corrode severely at the power stations, burning oil. After detailed discussions at the power station and review of the work already carried out, proposals were made for further experiments which would link more closely the results of the laboratory investigations. The experiments are eventually likely to lead to the use of fuel additives which might be manufactured in Egypt and replace proprietary brands.

2.1.2.28. Corrosion prevention in the oil refineries

In order to effectively evolve corrosion prevention system at the oil refineries, data are being collected from the refineries

regarding the frequent replacement of parts or components. The full details of the process i.e. the working conditions under which the metallic components are in contact are being collected in order to study the causes of e arly failures. The study of the failed components will also reveal whether the right material of construction have been used and accordingly recommendations will be made to use alternative materials.

2.1.2.29. Improvement and galvanising - (Egyptian Iron & Steel Co.)

A study of the galvanised products and the technology revealed that the rejections were high, quality poor and excessive amount of zinc used during the operation. The importance of controlling the coating time as well as thickness were indicated and the beneficial effect of aluminium additions pointed out. The initial field trials indicated that the use of aluminium-zinc master alloy overcame the problems encountered in using aluminium only.

2.1.2.30. Removal of dark spots on anodised aluminium product

The anodised products, from one of the aluminium extrusion unit, occasionally suffered from the appearance of black spots and on the spot study revealed that this was due to the presence of salts being used. The use of demineralised water for making up the process bath and proper storage of the alkaline etching solution eliminated this defect.

2.1.2.31. Utilisation of spent Co-Mo catalyst

Thermal treatment, as a mode for regeneration of the cobalt molybdenum spent catalyst from the nitrogen fertiliser plant was investigated for regeneration. It was observed that the spent catalyst could be regenerated by controlled thermal treatment. The fines produced during the catalytic reaction would also be shaped into pellets after regeneration.

The possibilities of the recovery of molybdenum and cobalt from the spent catalyst, that cannot be regenerated, have also been examined.

2.1.2.32 Failures in service at oil refineries and power stations

CMRDI has recently started service to the oil refineries and the power station for investigations on construction materials that fail in service. The investigation on the evaluation of the failed products and the cause of the failure is extended to a study of working conditions, design and material of construction; necessary recommendations are made either to procure a suitable material or alter the working conditions without hampering the plant operations. Some of the major failures examined are:-

- Rupture in the boiler tube at the power station.
- Failure of an elbow joint connecting the head exchanger of the gasoline storage tank to the refinery.

2.1.2.33. Evaluation of petroleum coke used at aluminium smelter

The petroleum coke samples used for an anode paste were examined for physical and chemical properties, as required for paste manufacture. It was observed that the sample being used has not been calcined properly and heated to 300°C only resulting in high sulphur. The management has been recommended to reject the sample and not use for electrode paste.

2.2 Research and Development Activity at CMRDI

Prior to the start up of U.N. assistance, the then metallurgy section was adequately staffed with about 70 scientists engaged on a number of research projects. With the directive to orient the research activities to the needs of the country, a number of new research projects were started that had a bearing on the industry.

The Project Manager in consultation with the experts had prepared a short and long range programme for the CMRDI, which was examined and approved by a committee consisting of representatives of industry.

The following describes in brief the objectives of some of the major projects under progress that have a direct interest of the industry.

2.2.1. Study of indigenous metallurgical raw materials

The Iron ore deposits at Nasser and El Harra contain an intimate association of manganese minerals with Goethite and hematite and it is desired to remove the manganese minerals to produce a concentrate acceptable for blast furnace feed. As a first step to the study, detailed investigations have been undertaken on the physico-chemical aspects of floatability of different oxides of manganese.

The titano-magnetite obtained as beneficiation of beach sands at Nile Delta contain 17% TiO_2 and 56% Fe and as a first step to utilise the magnetite for its iron values, the concentrate has been further beneficiated to produce a concentrate containing 9% TiO_2 and 62.8% Fe. Flux and fluxless smelting tests are being carried out to produce a titania rich slag and high grade pig iron. The slag so far produced contained 78% and 85% TiO_2 respectively. The partition of Cr and Va is also being investigated.

Pelletisation and super-concentre from el Gedida iron ores and the properties of the pellets, as a possible raw materials for sponge iron production are being examined.

The largest fresh water lake Quarun, at Fayum is getting enriched with various salts contained in sub-oil drainage and irrigation water. Studies are in progress for the removal of gypsum and recovery of magnesium, bromine, etc., and other valuable salts from the lake waters.

The aluminium smelter in Egypt has to depend on the imported alumina for its cell feed and laboratory scale investigations of the possible utilisation of extensive deposits of nepheline syenite, to produce alumina by soda roasting and acid leaching are being conducted. The techno-economic study of soda roasting has revealed the need to utilise the large quantity of slimes, 5 tonnes of slimes are produced per tonne of alumina and laboratory scale studies are in progress for the utilisation of slimes. The studies may lead to the establishment of a large scale pilot plant prior to commercial exploitation.

2.2.2. Extractive Metallurgy

The blast furnace refractory lining gets severely attacked by the alkalis present in the sinter feed at the Egyptian Iron and Steel Co. Laboratory scale studies are in progress to determine the attack with varying content of alkali vapours, simulating the blast furnace atmosphere and temperature at three zones viz., top, stack and bosh.

The Egyptian Petroleum Coke contains unusually high sulphur rendering it unsuitable for electrode manufacture. Laboratory scale studies have been completed on the desulphurisation of petroleum coke at varying temperatures up to 1500°C under different at atmospheres of CO_2, steam and hydrogen.

The electrodeposition of copper is the main process used in Egypt for the extraction and refining of copper from its alloys or scrap; investigations are in progress of the electrolytic production of copper from the various copper bearing alloys, without resorting to fire refining. Electrolysis of a lead tin copper alloy is being examined.

The boiler ashes of the power stations contain vanadium and nickel and laboratory scale studies on the recovery of vanadium by alkali roasting of the leached product and thermit reduction of residue for ferro-nickel production, await pilot plant tests.

Non-Metallic inclusions in steel

The presence of inclusions in the steels affects their properties adversely and a study has been undertaken for one of the steel plants in Egypt, to correlate the steelmaking practice by electric arc furnace and the presence of non-metallic inclusions in the finished steel. The study has revealed the behaviour of different processing steps as affecting the cleanliness of the steel.

Non-metallic inclusions present in wire rod affect the operations by lowering the plastic properties of steel. Study has been initiated to study the behaviour of inclusions during deformation so that the appropriate changes may be introduced in the technology which would result in increased throughput and overall yield.

The examination of the locally produced steel for wire rope manufacture revealed considerable variation from the imported stock and stricter quality control measures were recommended to be enforced, should the wires be drawn from the locally produced steels.

2.2.3. Heat treatment

Joints are being produced by cold upsetting of hot rolled and forged drawn bars and rolls. Plastic properties of steel joints are therefore of prime importance and such properties can be developed by suitable heat-treatment. Studies are in progress for development of heat treatment cycle for the 3 grades of Cr-Mo construction steels.

Investigations were undertaken to harden the surface of dies used by Nasr Forging Co. Solid nitriding did not yield satisfactory results and further tests were carried out on chromising the surface with a mixture containing varying mixtures of ferro-chrome, NH_4Cl and kaolin.

2.2.4. Non-Ferrous Alloys

Thermo-mechanical treatment of aluminium bronzes

Aluminium additions in copper alloy changes markedly the stacking faults energy, thus influencing the stress hardening and recovery during and after deformation.

Three compositions have been selected for study on the cast, hot and cold rolled ingots, that will be subjected to up 60% deformation The progress of recrystallisation will be correlated with the properties of the product.

2.2.5. Alloy Steels

Egyptian industry depends on imports for its needs of alloy steels and plans are afoot for the production of alloy steels in the country. Studies have been undertaken at CMRDI on the development of:-

- Cr-Mn-Ni stainless steel part of the nickel is substituted by manganese.

- HSLA steels for use in trucks, lorries, river barges spiral welding, are being studied using aluminium and niobium addition.

- Low alloy Cr-Mo steels for use in the refineries.

2.2.6. Powder metallurgy

As a first step for the development of components produced from metal powder, studies have been undertaken for the electrolytic production of copper powder and iron powder produced by gaseous reduction of millscale and other oxides of iron. The metal powders so produced have been studied for the particle size, surface area, residual stresses and other desired properties needed for compaction.

Studies have also been undertaken on the production of stainless steel powder compacts using ferro-manganese, ferro-chrome, iron and copper powders. The performance tests on the compacts so produced are planned.

2.2.7. Foundry

For the production of S.G. iron studies have been continued for the development of spherodizing and inoculating agents.

2.2.8. Corrosion and surface protection

CMRDI jointly with the Polymers Section of NRC has undertaken up a study and the preparation of corrosion map of Egypt, studying corrosion rates in different regions. Field units have been set up and the corrosion rates of mild steel, stainless steel; aluminium, copper and galvanised steel is being determined at different stations. It has been observed that the corrosion rate is higher at Alexandria, Port Said and Suez.

To study the corrosion effect of alkali chlorides, contained in the sinter charge, as affecting the grates of sinter stand, systematic studies have been undertaken on the attack of cast iron in contact with a mixture containing iron oxides/iron ore/washed iron and pure sodium chloride.

In the studies on electroless plating of nickel, the effect of surface pre-treatment of aluminium and of bath composition as affecting nickel deposits has been examined. A relationship between coating adhesion with the internal stresses and their variation with the structure of coating is being attempted.

2.3. Consultancy and Technical Information

The CMRDI, besides its R and D activity is expected and planned to act as technical consultant to the Government and other agencies

planning to import the know-how and establish new industries. The consultancy rendered by CMRDI includes the overall plans for the development of the metallurgical industry, modernisation of the existing units, establishment of new units - the suitability of the new processes to be adopted in the country, the availability of the desired grade of raw materials and their suitability.

The experts and the national staff have been advising the Government on a number of such projects and a brief summary of some of the major projects is given below.

2.3.1. Development of metallurgical industry in Egypt till 2000 AD

Various studies through UNIDO, World Bank, Egyptian Government as well under bilateral agreement have been undertaken, to forecast the demand of metallurgical products as well as the growth of metallurgical industry in Egypt, till the year 2000 AD.

Atkins of U.K., have been involved in a very exhaustive study and their reports have been examined by CMRDI particularly for the:-

- Demand and the production of different grades of quality steel in Egypt.

- Re-appraisal of the growth rate of different products to meet the local demand.

The status of existing industry has been analysed and the expansion, modernisation of each of the plants and the establishment of new units has been separately examined.

Nippon Kokkon of Japan had also undertaken study on the "Projection and Expansion plans for the Iron and Steel Industry in Egypt" as a UNIDO sub-contract and the CMRDI was involved at all stages of discussions.

2.3.2. Production of quality steels in Egypt

For the development of alloy steels in Egypt the problems for the production of quality steels particularly the high sulphur, availability of high quality scrap and ferro-alloys have been examined and the remedial measures suggested.

The existing melting and rolling facilities have been critically examined and it is concluded that the establishment of a separate unit would be most desirable.

2.3.3. Raw materials for ferro-silicon production

A report on ferro-silicon production critically examines the physical and chemical characteristics of the indigenous quartzite,

reducing agents, iron bearing materials and their effect on the composition of the finished product.

It is recommended that ferro-silicon industry, in Egypt, can use quartzite instead of quartz and substitute reducing agents need be examined.

2.3.4. Production of magnesium in Egypt

With the production and growth development of aluminium industry, the demand of magnesium is likely to go up and the report recommends that production of magnesium need be established in Egypt. The world demand and supply has also been examined. The three processes for the production of magnesium have been critically discussed and it is recommended that an export oriented plant should be based as electrolytic process, and solar energy used for recovery of $MgCl_2 6H_2O$ from sea water.

2.3.5. Production of ferro-manganese from the local ferruginous ores and the starting up of the unit at Abou-Senim, Sinai

An electro-thermal smelting unit for the production of ferro-manganese suffered serious damage during 1967 War and the Government of Arab Republic of Egypt is examining the economic viability of putting the plant into operation.

UNIDO was earlier involved in the detailed terms of reference for a study of the present condition of the different units, their repairs and replacement. The technology of pre-reduction, duplex smelting and agglomeration was also recommended to be re-examined.

The matter is now under active consideration of the Government and the whole programme will be executed through USAID and the Egyptian team includes the CMRDI scientists.

2.3.6. Recommended practice for electric steelmaking for wire ropes and rolls

As desired by Copper Works, code of practice for electric steelmaking for wire ropes and rolls was compiled in a report that included the choice of raw materials; technology of melting and refining, use of different deoxidisers and need for rapid chemical analysis.

For the casting of steel rolls it was recommended that the hydrogen should not exceed 4 cc/100 g; the methods to prevent hydrogen pick up and its removal were outlined.

2.3.7. Use of cast steel rolls, in rolling mills

As a result of investigations on the premature failure of rolls produced at Copper Works, a report indicating the influence of additions

of different alloying on the different grades of cast steel rolls was submitted to the management. The heat-treatment and structure of the pro-euctoid, euctectoid and hyper-eutectoid for different applications was indicated and the physical and mechanical properties so develcped were correlated with the service performance.

The report had recommended the use of listed different types of rolls for different applications and a follow-up action of roll failures was outlined.

2.3.8. Production of cold formed section

At the request of the Helwan Iron and Steel Company, a report on the cold formed sections was compiled and the following aspects of the cold form sections were included:-

- Cold form sections as construction materials.
- Technology of forming tools, and their wear; quality control of strips and products.
- Production shop, its equipment and probable suppliers.

The requirements to stand the service conditions of the different categories were indicated and instances were cited whereby higher buckling strength may be attained by proper design. The other details such as recirculating system for lubrications and quality control factors for maximum productivity were included in the report.

2.3.9. Mill tackle for rolling mills - their demand and production in Egypt

Mill tackles, comprising of different units attached to the mill stand or between the co-operation stands which guarantee the safe guiding of rolled stock are amongst the regular replacement inventory of the rolling mills. In order to initiate their production in the country a classified list of the different items, their chemical composition and the heat treatment was compiled.

The report outlined the step by step approach to initiate production of these items as the implementation is likely to markedly improve economy of Egyptian rolling mills.

2.3.10. Clad steels - survey of technologies

Clad materials offer advantages in major economy of more expensive and gradually depleting materials and at the time combine the surface properties of the materials with the mechanical properties of the base metal. There is a great potential for the development of clad steels and other multimetallic products in Egypt and accordingly a report on this subject was submitted to the Government.

The technology of the production of three metallic Ni-Fe-Al strips, stainless clad plates, bi-metallic knives, copper clad wires, different bi-metallic as well as multilayer tubes have been described.

The report examines the possibilities of the production of clad materials in Egypt and concludes that with the existing facilities it is possible to produce clad wires, bi-metallic tubes as well as stainless clad steels, provided the basic raw materials are available.

2.3.11. Strip aluminising of steel - pre-feasibility study

In view of the non availability of any major zinc deposits in Egypt and the production of aluminium, a feasibility study of aluminising of steel strip described and compared the different processes, their capital and operating costs. It has been shown that the technology based on Sendzimir process, using protective atmospheres can be adopted at the Egyptian Iron and Steel plant since facilities exist for galvanising of cold rolled sheets and no problems are foreseen on changing over to aluminising.

2.3.12. Heat resistant - iron-chromium aluminium alloys

A literature report on the development of heat resistance iron-chromium-aluminium alloys, included the chemical composition of the alloys for various applications and the effect of the variation of the alloying elements as affecting the properties.

The report included the technology of making heat resistant alloys and the precautions to avoid inclusions and segregation of aluminium. The factors affecting the grain size and the means to control the same were also included.

2.3.13. Consultancy services for developing new lay-out for foundries

The modernisation and expansion programme for some of the foundries was studied and the following describes,in brief, the technical services rendered to the foundries.

Delta Steel

Two proposals with Delta Steel for modernisation were scrutinised and a new lay-out was developed after discussions with the plant engineers and a revised plant list was prepared, highlighting the additional equipment to be supplemented.

Latest techniques and developments were also recommended to be included.

Steel Foundry Project - (Egyptian Copper Works, Alexandria)

Advice was sought about the lay-out of the new foundry planned at the Copper Works, keeping in view of the future programme for the production of heavy castings; whilst examining the lay-out of the foundry, the plan to locate a re-rolling mill in the vicinity had also to be kept in view. The plant lay-out was examined in detail and the management informed not to erect the rolling mill in the vicinity, since it would interfere with the growth of the foundry and its utilities such as water, fuel oil, compressed air.

2.3.14. Possibilities of continuous and automated casting in Egypt

In view of the lack of adequate cogging mill facilities in Egypt, 100-150 mm, square ingots and cast causing serious production and organisation problems, not only in providing large number of ingot moulds with their handling and production problems including the large area of casting bay.

The adoption of alternative methods of casting such as continuous or automated ingot casting were examined and the twin cast method introduced in Sweden was recommended to be adopted, and the advantages to suit the local conditions were listed including the running and the capital costs.

2.3.15. External desulphurisation of pig iron

At the request of the Steel Company a report on the external desulphurisation of pig iron has been submitted and this includes the different methods of external desulphurisation. The report also describes the most suitable location of the desulphurisation station in the plant premises and the advantages and disadvantages of the various desulphurisers. Use of pneumatic injections for soda ash for desulphurisation has been recommended as the most suitable method for the local condition.

2.3.16. Planning and new projects in metallurgy

By virtue of CMRDI's contribution to the metallurgical industry the Director is a member of the highest Sectorial Council responsible for the development of metallurgical industry in Egypt. The other senior staff members are also involved with the new projects in Egypt and these include:

- Sponge iron production
- Ilmenite smelting
- Treatment of iron ores
- Exploitation of phosphate deposits
- Production of ferro-manganese

The role of CMRDI scientists in consultancy services has been duly acknowledged by all concerned.

2.4 Training

The training activities for/at CMRDI consisted of:-

- Training of the CMRDI staff.
- Training/teaching/guiding research by the CMRDI staff to the personnel of other organisations, institutes in Egypt.

The following describes the activities in the respective group.

2.4.1. The training of the CMRDI staff consisted of:-

- Overseas training on UNIDO fellowship.
- Training by the UNIDO experts on erection,operation and maintenance of the UN supplies pilot plants and other specialised equipment.

2.4.1.1. Overseas training

The overseas training activity of the national staff of CMRDI, initiated in the first phase, was extended to the 2nd phase so as to cover all the major branches of metallurgy, which had relevance to Egypt. The candidates selected occupied senior positions in their respective sections and had oriented their activities to the need of the industry. Such personnel were fully aware of the current problems of the Egyptian industry in their respective fields and the training was directed so as to enable the fellows to fully utilise the planned facilities for undertaking investigations on topics of interest to Egypt.

The details of the UNIDO fellowship i.e. field of training, duration and the place are indicated in Appendix III.

2.4.1.2. Training by UNIDO Experts

The Project Document had included the services of the experts with specialisation in the respective pilot plants or use of any particular equipment that needed specialised training. These included:-

- Mineral beneficiation
- Foundry
- Plastic working of metals
- Electro-thermal smelting of ores
- Laboratory engineering services
- Instrumental chemical analysis

The recruitment schedules were also planned in a way that the respective experts would spend a considerable portion of their stay on the operation of the respective units. However, unforeseen and considerable delays in the erection of the equipment availability of the utilities enabled to experts to only train the counterpart staff in the operation and maintenance of the respective units.

Besides the training on the operations of the various units, the experts had also conducted the following special lectures on theory and practice pertaining to the use of equipment.

- Thermo-mechanical treatment of metals and alloys.
- Plastic deformation by models and practice.
- Roll pass design.
- Mineral beneficiation pilot plant and its operation.
- Foundry at CMRDI - In-service training.

2.4.2. Training by CMRDI staff

CMRDI staff members have not only been the recipient of training but have in turn been engaged in training others and this includes:-

- Training courses organised by CMRDI.
- Lectures and guiding research at the universities and other institutes.

The following describes in brief the major activities in the respective group.

2.4.2.1. Training courses organised by CMRDI

For the benefit of the engineers and other technical personnel, dealing with metals and working at the different metal producing and consuming industrial establishment in Egypt, CMRDI has been conducting special training programme in different branches of metallurgy. Such courses are planned to acquaint the plant personnel with the theoretical background and latest developments in the respective fields. The courses also include practical training, if needed, for any particular specialisation, and are mainly conducted by the national staff, UNIDO experts, have also occasionally participated if they were present in the field when courses in their field of specialisation were being conducted. The active participation of the plant personnel, narrating their own experiences and individual plant problems not only establishes personal contacts with the scientists at CMRDI but the staff of CMRDI also get first hand information about plant problem and can include the same in their long and short range R and D programme.

Fourteen different courses have been conducted so far and about 400 engineers have been trained since 1974. The following lists a breakup of the training course and the number of trainees in the respective specialisations for the different years.

Training courses arranged by CMRDI

	1974	1975	1976	1977	1978	1979
1. X-ray diffraction and its applications	5	4				
2. Mechanical treatment of ores	4	2				
3. Heat treatment of metals and alloys	23	15	30	26	11	19
4. Physical inspection and uses of isotopes ores and minerals	6	2	7			
5. Galvanising and protection of metals	18	11				
6. Corrosion of metals			18	22	28	18
7. Electroplating			15	20		
8. Ore dressing			3	5		
9. Iron and steel industry				7		
10. Coating of metals					11	16
11. Steel melting technology					5	4
12. Identification and prevention of casting defects					8	14
13. Testing of moulding sands						1
14. Phosphatising					15	

Besides general training indicated above, specialised training course on Quality control in iron foundries was conducted. Requests have been received to present similar course at other foundries.

2.4.2.2. Lectures and researches at the university

Many of the senior staff members of the CMRDI are visiting professors as well as members of the research groups at the universities and other technical institutes in Egypt. The management also encourages this participation as it ensures healthy contacts with the academic circle.

The new entrance at CMRDI are also required to obtain post graduate degrees and their research is jointly supervised by the CMRDI and the university staff.

It is thus seen that CMRDI staff members have not only been receiving more advance overseas training but they also in turn impart the knowledge and experience to others.

2.5 Technical enquiries and routine test services

Besides the technical enquiries from small scale industrialists CMRDI services have been utilised by the metallurgical industry for the

chemical analysis, X-Ray diffraction, metallographic examination, mechanical testing and sand testing for foundries. Such services are generally paid for.

SECTION B

2.6 Establishment and functioning of the CMRDI at the new premises at El Tebbin

Most of the activities, reported under Section A, have been planned and conducted either at the industrial establishments or at the National Research Center, Dokki, using existing or UN supplied laboratory equipment that was installed at Dokki and made use of, this included equipment for metallography, sand testing, heat-treatment, mechanical testing.

The activities for the establishment of the CMRDI at the new premises included:-

- Buildings
- Procurement and installations of equipment

The following describes the activities under the respective groups.

2.6.1. Buildings

The master plan of the CMRDI provided for two laboratory blocks, administrative buildings and eight pilot plant sheds, to be located in an area of 7000 sq. m.

Based on the relevant information, the architects, (Arab Bureau) prepared all the working drawings. As the plans for buildings were finalised and tenders invited in 1975, it was noted that the value of contract far exceeded the available funds and revised plans were drawn up to include all the laboratories in one block and the available rooms in the transformer buildings; the pilot plants were to be located in 4 sheds - 4 meters x 15 meters. This necessitated the re-arrangement of laboratories and pilot plant sheds in a way that no major problems should arise in shifting the respective laboratories and pilot plant equipment as and when the additional laboratory and pilot plant buildings are built.

The Civil Contractors started work in 1975 and the work completed in 1980. The total expenditure for the civil work, utilities, furniture, etc., has now increased to almost LE 3 million from the original estimates of LE 0.8 million.

2.6.2. Supply and installation of equipment

The funds originally provided for the supply of equipment totalled 1.220 million US$ and this included the supply of required laboratory and pilot plant equipment, to undertake investigations in different fields in metallurgy from treatment of ores, to the development of alloys and their tests. The allocation of funds for the equipment was subsequently revised in 1979 to 1.38 million US$ to enable procurement of some essential equipment that could not be procured owing to the overall increases in the prices.

A detailed list of the UN supplied equipment for the various sections is shown in Appendix IV and it will be noted that CMRDI has been equipped with the basic minimum requirements for the metallurgical research laboratory and these include:-

Mineral Processing

- Microscopes for petrological studies.
- Mineral beneficiation pilot plant.
- Sub-merged arc furnace for studies for electro-thermal smelting of ores.
- Equipment for testing of iron ores, sinter and pellets.
- Rotary kiln and autoclaves for extractive metallurgy.

Industrial and Physical Metallurgy

- Metallography - Microscopes, X-Ray diffractometer and quantimet.
- Equipment for testing of foundry sands.
- Heat treatment furnaces.
- Melting units - induction, arc and gas fired furnaces.
- Metal working - Rolling mill, re-heating furnace and hammer.
- Mechanical testing - Plastometer; tensile, impact, hardness and sheet metal testing machines.

Services

Instrumental analysis - Atomic Absortiometer and X-Ray fluorescent units.

Workshop - includes lathes, drilling machines grinding machines, milling machines, providing normal machine shop facilities for a metallurgical laboratory.

Library

To start a library of CMRDI about 2,000 books and journals dealing with metallurgy and other allied subjects have been provided.

The installation of pilot plant equipment at the new premises commenced in October 1978 and the major activity of the experts joining in 1979 has been to help in the installations, commissioning of the equipment, and training the national staff in the operations and maintenance of the respective pilot plants.

3.0 Achievement of objectives and utilisation of project results - impact on the metallurgical industry in Egypt

During the period under review, CMRDI functioning at its old premises, has not only established an image and a name, occasionally referred to as an institute working to the needs and demands of the industry and an example for other to follow. This recognition resulted from the activities, of the UN Experts along with the counterpart national staff that were mainly directed to study and solve the problems of the metallurgical industry in Egypt and a joint team, duly supported by the laboratory facilities, worked at the shop floor in the plant premises. It is hoped that the industry will derive still greater benefits when the laboratory and pilot plant facilities are fully operational at its new premises.

CMRDI's impact on the industry from its findings/studies/demonstrations has been due to the following:-

- Technological improvements of the existing plant practices.
- Introduction of more effective quality control
- Indigenous production of new items
- Training
- Consultancy and technical services

The following describes the impact of some of the major investigations reported in Section 2.

3.1. Technological improvements of the existing plant practices

During the stay of the respective UN Experts, every efforts were made to evaluate the existing plant practices in their field of specialisation and introduce or recommend possible changes leading to overall improvements.

The study of the sintering practice and the properties of sinter revealed the need for proper sizing and control of the charge mix, and improvements in the firing system. The study has established that the primary cause of poor quality sinter, corrosion in the sinter stand and the exhaust system is owing to the presence of the chlorides. These must be eliminated to the acceptable limits. The Steel Company is now examining the establishment of a beneficiation plant.

De-sulphurisation during steelmaking in the open hearth furnaces has been a major problem resulting in longer tap to tap time and the demonstration of the lime injection considerably reduced the refining time as well as lowered down the sulphur in the finished products.

The study of de-sulphurisation and de-phosphorisation during steelmaking in the electric arc furnace established the effect of different variables factors thus enabling better steelmaking practice.

The report of the Kobe Steel on the steelmaking operations in the open hearth and electric furnaces at the 3 non-integrated steel plants had clearly indicated the shortcoming of the then existing practices and overall improvement was demonstrated by proper charge selection and charging in the furnace, flame control, hearth and tapping hole repairs, ladle and ingot mould preparation, use of oxygen to cut down the time cycle.

Similar study has been undertaken by the national staff on the electric steelmaking at the Egyptian Iron and Steel Company.

The high ingot mould consumption from sub-standard moulds has been examined and the code of practice for the casting of ingot moulds furnished to the foundries.

An overall improvement in the wire drawing practice resulted by introducing the changes recommended in pickling, patenting and heat-treatment operations.

The study of defects in forging and blank preparations for forging resulted in the adoption of special upsetting die and the need to ensure that the billets are heated to the correct temperature.

The new heat-treatment cycles developed in CMRDI for dies, springs have resulted in better service life.

The studies in connection with the improvements of the existing practices at one of the foundries have resulted in use of proper sand for moulds, use of correct facing materials, core binders, overall better cupola operations, use of tea pot ladles - all resulting in better castings and lower rejection.

It is thus noted that the improvement in the existing operations have resulted in:-

- Increased productivity.
- Lower rejections.
- Improved quality of products.
- Improved, marketability of the products.

3.2. Introduction of more effective quality control

Though the domestic market of the Egyptian products was assured till recently, the open door policy enabling imports as well as the plans to increase the production, demands quality production for the export market. It thus becomes necessary that the Egyptian industry adopt rigorous quality control measures. CMRDI from its very inception has drawn attention of the metallurgical industry to the need for effective quality control and the following describes the efforts and achievements in this direction.

Some of the metallurgical products demand rigorous controls during production as minor variation considerably affect the properties endangering human lives. It is not only essential that the processing be strictly controlled but the products need be tested and examined for deleterious impurities. The presence of inclusions considerably affect the properties and CMRDI has examined and reported the quality of some of the steels indicating the need to improve.

The chairman of the Egyptian Copper Works agreed to the proposal that CMRDI undertakes the study of quality control measures for steelmaking and rolling mill operations for the production of reinforcing bars. As a result of on-the-spot study, the scope of work was enlarged to also include master technologies, procurement of raw materials and their inspection, data collection and processing, information dissemination, decision making and other administrative matters connected with these.

The management highly complimented the joint team consisting of UN Expert and counterpart staff that took up this study. Similar studies can be undertaken at other plants also.

As a result of the observations of the plant practice for wire rope manufacture, detailed quality control measures at each step were outlined thus enabling the products to meet rigid specification. The adoption of the quality control measures during wire drawing resulting in improved quality, encouraged the management to initiate the production of steel for wire rod and the rigid quality control measures for steelmaking for wire rope manufacture were also furnished.

3.3 Production of new items

CMRDI has also assisted in the indigenous production of some of items and it is hoped that in due course, the present R and D efforts will yield to the commercial production of more and more materials developed indigenously.

The chromium steels containing 13% Cr had been imported, involving huge foreign exchange, till the UN Experts conducted field trials and demonstrated the indigenous production from imported ferro-chrome only.

The wire rope, meeting stringent Lloyd's specification was originally produced from imported wire rod and CMRDI established the indigenous production of wire rod starting from selected scrap.

It is hoped that in due course, the present laboratory scale studies after large scale pilot plant tests will lead to the production of:-

- Ferro vanadium and nickel from boiler ashes.
- Inoculants for S.G. iron.
- Wear resistant cast iron for grinding mills.
- Resistance wire for heating elements.

- Alloy and structural steels.
- Aluminium containing heat resistant cast iron.

3.4. Training output

CMRDI's trained staff members have earned recognition for their knowledge and experience and increasing number of plant engineers attend the training programme arranged by CMRDI in the various subjects.

The scientist of CMRDI and the UN Experts also visit plant and have had on-the-spot in-plant training on the various operations at one of the foundries and a steel plant.

3.5. Quantification of gains to the Industry

An effort was made to quantify the gains to the industry, but under the local conditions it was difficult, specially since the activities were confined to the improvements of the existing practices. It is only when a new product is introduced that such figures could be indicated, e.g. for the production of 13% Cr steel for which the technology was furnished by CMRDI the saving in foreign exchange has been accepted by the industry to more than 1 million US$ per year.

4.0 FINDINGS

The findings relate to the present status of R and D capability at CMRDI, its weak and missing links that need be strengthened. The observations on the present status of metallurgical industry in Egypt; its problems and challenges have also been described separately. The project's objectives have been fairly and squarely achieved during the implementation of its two phases.

4.1. R and D capability at CMRDI

4.1.1. The CMRDI research staff exceeding 100 are academically well qualified to undertake research in various branches of metallurgy and have to their credit a large number of publications in the overseas journals of high academic standing.

A large number of senior staff members have also obtained their post graduate degrees overseas and though the earlier overseas training was confined at the universities only, it is only now that efforts have been made to train staff members on the pilot plant and industrial operations.

4.1.2. The UNIDO experts with all the delays in the erection and availability of the utilities did a commendable job in providing the basic training in the operation of the specialised equipment and the respect pilot plants, the national staff has, however, a long way to go to gain adequate experience for the most effective utilisation of the provided facility.

4.1.3. The industrial experience of the CMRDI staff is mostly based on the studies and investigations jointly undertaken with the UNIDO experts and for CMRDI to play an increasingly more effective role, in undertaking problems of the industry and gaining confidence of the plant personnel, it will be desirable to strengthen the industrial experience at all levels.

4.1.4. It appear difficult to recruit competent and qualified personnel to man the engineering services including design engineering, electrical and mechanical workshops. The same applies to technicians and unless immediate remedial measures are taken, the operation and maintenance of pilot plants and heavy equipment will be seriously affected.

4.1.5. Though the CMRDI staff has obtained requisite experience in the appraisal of the project reports submitted by the consultants, they have not developed the requisite experience to prepare preliminary project reports for industrial projects. Such reports would include the availability of raw materials, critical appraisal of the different technologies, a market survey, waste products, material balance, pollution control, etc. .

4.2. Metallurgical Industry in Egypt

4.2.1. Excepting the aluminium industry, which has developed a considerable export market, the products of other metallurgical industries in Egypt are mostly for local market, with the result that whatever is produced is sold. This thus acts as a great retarding influence to the introduction of effective quality control measures and only sporadic efforts are made to improve the quality, when particular items are imported and available in plenty.

4.2.2. The industry enjoys the benefit of the supply of utilities fuel and power at very low rates, which are highly unrealistic and thus the industry does enjoy a protection which to a certain extent hampers the healthy growth and development to compete with others.

4.2.3. The industry suffers from a serious handicap that it has little control on the raw materials that it consumes such as refractories metallurgical coke, fuel oil, steel scrap, pig iron for foundries and open hearth steelmaking, foundry sands, fluxes, ingot moulds. Whatever is produced and is available, has to be accepted.

4.2.4. The plant operations also suffer considerably owing to non-availability of the requisite control instruments.

4.2.5. The national standards, their formulation, implementation and certification do not appear to be very effective.

4.2.6. The training of the supervisors/engineers recruited for various operation needs be oriented in a way that they can face the challenge with confidence.

5.0 RECOMMENDATIONS

The recommendation for improving, strengthening and follow-up action by the Government, including the Academy of Scientific Research and Technology, the C.M.R.D.I. and the UNDP/UNIDO have been separately described in the following sections.

5.1. Academy of Scientific Research and Technology

5.1.1. To issue Presidential Decree for the formulation of CMRDI.

5.1.2. To formulate bye laws and regulations to ensure that CMRDI functions as an autonomous institute with its own budget under an overall umbrella of the National Research Centre/Academy of Scientific Research and Technology.

5.1.3. To assit in the twinning arrangement of bilaterial agreement for exchange of scientists.

5.1.4. To ensure that CMRDI is associated in all committees concerned with the decisions for import of technology and know how for metallurgical industry. Only that technology should be imported that cannot be furnished by the CMRDI.

5.1.5. To arrange with the concerned Ministry/Organisation that CMRDI is involved as one of the counterpart agencies with to and fro overseas missions for negotiations commissioning, demonstrations, tests, etc., for metallurgical operations.

5.1.6. To develop a system of promotion that an overall pyramidical structure is maintained, in organisation set up.

5.1.7. To grant ad hoc allowance for the existing staff of CMRDI, on being shifted to El Tebbin.

5.1.8. To arrange allocation of houses from the Government residential colonies being developed in the vicinity.

5.1.9. To develop a residential colony for CMRDI staff in the vicinity of El Tebbin.

5.1.10. To arrange an independent review of the functioning of CMRDI by personnel of international repute every 3 years or so.

5.2. C.M.R.D.I.

5.2.1. Establish and strengthen the activities in the varicus sections of the groups as outlined below:

i) Laboratories

a. Refractories
b. Fuels
c. Welding
d. Waste disposal and pollution control
e. Computer centre

ii) Research administration

a. Research programming, monitoring and follow-up action.
b. Liaison and information

iii) Engineering services

a. Design engineering
b. Mechanical and electrical workshops
c. Instrument repair and maintenance

iv) Develop metallurgical advisory and consultancy services.

5.2.2. Arrange plant training/visits for varying periods of the different categories of research personnel. This training to be followed by overseas training at middle or lower levels of scientists.

5.2.3. Undertake critical evaluation of the existing metallurgical practices vis-à-vis accepted code of practice. This would not only result in identifying new areas for further investigations but the experience gained will be very useful in bridging the gap between research and industry.

5.2.4. Ensure that the pilot plant facilities at CMRDI are profitably used for training, demonstration or small scale production of items needed in small quantities. This would ensure a full time engagement of the technicians.

5.2.5. Develop and incentive scheme that does not deter engineers and others engaged in routine service for the research projects.

5.2.6. To overcome the problems of recruitment of technicians and constant movement, develop an apprentice scheme whereby the school leaving students would receive training in various trades for which training facilities would be available at CMRDI. Such a scheme could also cover graduate apprentices.

5.2.7. Efforts should be made for each research section to undertake industrial sponsored projects. The number of such projects to depend on the available manpower; it should, however, be planned that within 5 years the institute should attain financial self-sufficiency.

5.2.8. Organise special seminars/workshops on topics of interest and ensure a follow-up action of the recommendation. The scope of such seminars be gradually widened to topics of regional, inter-regional and international interests.

5.2.9. A special cell be formed for the follow-up action of the UNIDO Experts terminal reports.

5.2.10. A next phase of building activity to include the second laboratory building to be followed by the next pilot plant block.

5.2.11. Develop facilities for certification and inspection of metallurgical raw materials as well as products and issue of chemically analysed standard samples for reference.

5.2.12. Extend services and facilities to small and medium scale sector that cannot recruit highly trained personnel or maintain the requisite supporting laboratory facilities.

Such extension services should gradually develop into the establishment of regional or field service stations.

5.3. U.N.D.P./U.N.I.D.O.

5.3.1. In order to derive the maximum benefit of the UNDP/ UNIDO supplied equipment and extend the metallurgical advisory services, it is recommended that Expert services for CMRDI be included in the next country programme cycle.

5.3.2. In order to ensure full use of UNIDO supplied equipment for the next 5 few years, it may be desirable to allocate 25,000 US$ from the next country cycle for the purchase of spares.

5.3.3. CMRDI staff members should be included in the training programmes in foundry, steelmaking, metal-working, and quality control organised by UNIDO.

5.3.4. CMRDI possesses the requisite infrastructure that can be expanded and supplemented to meet the requirements of a Regional Metallurgical Research Centre. UNIDO may guide and assist in the establishment of a regional centre at CMRDI

5.3.5. It is considered essential that Resident Representative, UNDP, should continue to be a member of the High Consultative Committee of CMRDI after the UNDP/UNIDO assistance is over.

5.3.6. The problems of metallurgical industry in developing countries though varying in degrees, are more or less similar. It is recommended that UNIDO arranges a get together of the metallurgical research institutes in developing countries so that problems of common interest be identified thus initiating mutual cooperation amongst themselves.

LIST OF INTERNATIONAL AND COUNTERPART STAFF

Name of Expert	Post Title & Nationality	Post No.	Date of Arrival	Date of Departure	Name of Counterpart Staff
Prem P. Bhatnagar	Project Manager (India)	11-01	Mar 1972	Dec 1980	Dr. Adel Abdel Azim
P.K. Gupte	Industrial & Physical Metallurgy (India)	11-02	Apr 1974	Sep 1975	Dr. Tabie El Bassiouni
Dr. R. Wusatowski	Plastic Working of Metals (Poland)	11-03	Jul 1977	Oct 1979	Eng. Fernace Assaad El Hakim
R. Jennings	Mineral Beneficiation and Agglomeration (UK)	11-04	Apr 1979	Nov 1980	Dr. Aziza A. Youssef
W. Dyakowski	Engineering Laboratory Services (Poland)	11-05	Jul 1979	Aug 1980	Dr. Bahaa Zaghloul
Derek Worth	Foundry	11-06	Feb 1979	Oct 1980	Dr. Adel Abdel Moneim Nofal
Dr. J.S. Llewelyn Leach	Corrosion and Surface Protection (UK)	11-09	Jan 1977	Mar 1977	Dr. Saher Shawki
	Plastic Works of Metal	11-03	2 months	Expected to arrive in 1981	
	Non-Ferrous Extractive Metallurgy	11-08	4 months		
	Electro-thermal Smelting	11-14	3 months		
	Instrumental Chemical Analysis	11-15	3 months		

LIST OF PROJECTS SPONSORED TO CMRDI

Year	Title of Project	Sponsorers	Contract Value LE
1974	Evaluation of Maadi sands and sand deposits for foundry and glass manufacture.	Sinai Manganese Co.	5,000
	Production of high grade iron concentrate for sponge iron production.	General Organisation for Industrialisation	6,000
1975	Appraisal of the sinter plant practice.	Egyptian Iron and Steel Co.	5,000
	Evaluation of alum deposits of Beer El Shaharea - New Valley	Marble and Alabaster Quarries	400
	Testing of Khas El Sogha bentonites	Sinai Manganese Co.	40/sample
1976	Appraisal of the proposal for the production of phosphoric acid from Abu Tartur phosphate deposits.	Iron and Steel Complex	4,000
	Beneficiation of El Gedida Iron ores	Egyptian Iron and Steel Co.	4,000
	Beneficiation and activation of bentonites deposits of Fayum	Sinai Manganese Co.	2,000
1977	Study of the properties of the hot blast cupola lining	El Nasr Casting Co.	500
1978	Laboratory and pilot plant tests on beneficiation of Abu Tartur phosphate	Iron and Steel Complex	55,000
	Beneficiation of Abu Sabeira clay deposits	Egyptian Company for refractories	6,000
	Evaluation of fuel additives for thermal power station	General Egyptian Electricity Corporation	6,000
	Desulphurisation and dephosphorisation of plain carbon steel	Delta Steel Company	2,000

Year	Title of Project	Sponsorers	Contract Value LE
	Study of non metallic inclusions in steel	Delta Steel Company	15,000
	Testing of Somalia sands, binders and fluxes for foundry	UNIDO Sub-contract	4,000 US$
	Testing of bentonites for foundry purposes	El Nasr Casting Company	300
1979	Selection of materials for sea water condensers tubes	General Egyptian Electricity Corporation	4,000
	Evaluation of the Mamrawin phosphate ores	Misr Phosphate Company	10,000
	Production and process improvement in the galvanising plant	Stelco	3,000
	Evaluation of Bir El Shab Alum deposits		6,000
	Quality control for the production of ingot moulds, spun pipe and pipe fittings	El Nasr Casting Company	5,000
	Utilisation of fluorine gase evolved during super phosphate production	Kafr El Zayat Fertiliser Company	5,000
1980	Testing of samples of phosphate ores from New Valley	General Organisation of Industrial and Mineralogical Complexes	3,000

TRAINING

Subject	Duration Months	Name of Fellow	Name of Institute and Country
Ore microscopy	6	Dr. S.N. Boulos	Leeds Univ., UK
Mineral beneficiation	6	Dr. Tewfik R. Boulos	Warren Spring Lab., UK
Iron and steelmaking	13	Dr. Kamel A. Shehata	Imperial College, UK
Hydro-metallurgy	9	Dr. Adel M. Kamal Ismail	Institute Fur Metallurgie, Berlin(FRG)
Electro-metallurgy	9	Dr. Safa M. Ezz Eldin Afifi	Imperial College, UK
Utilisation of metallurgical wastes for recovery of me-metallic values	6	Dr. Samir Zaki El Tawil	Warren Spring Lab., UK
Industrial and physical metallurgy-alloy steel	12	Dr. Kamal Abd El Rabbo Mohamed	Sheffield Univ., UK
Foundry	9	Dr. Adel Abdel Moneim Nofal	Fulmer Research Institute, UK
Metal Working	12	Fernace M. Assad El Hakim	Univ. of Sheffield, UK
Welding technology	12	Abdel Reheem Braikaa	Granfield Institute of Technology, UK
Surface protection	6	Dr. Farid Hanna Saad	Precision Mechanics Institute, Warsaw, Poland
Corrosion	6	Dr. Nabil Nassif Girgis	Univ. of Manchester, UK
Services - instrumental analysis	6	Said Ibrahim Salman	Max Plank Institute, FRG.
Ore dressing pilot plant operations and economic evaluation	3	Dr. Aziza A. Youssef	Tour to USA and UK
Development of aluminium alloys	3	Dr. El Tabie Bassyouni	Hungarian Institute, Budapest.
Documentation	6	Nomination awaited	Any place

LIST OF UNIDO SUPPLIED EQUIPMENT

Mineral beneficiation and agglomeration

- Polarizing microscopes, complete with the photographic attachment
- Stereoscopic microscope, Model SZ-III
- Ore polishing machine, floor type
- Electromagnetic Davis tube tester
- Pelletizing pan
- Sinter machine
- Ore feeder
- Jaw crusher
- Bucket elevator
- Portable vibrating screen
- Roll crusher
- Ore sampler
- Ore feeder
- Ball-mill
- Spiral classifier
- Laboratory hydroclassifier
- Mineral jig
- Unit flotation cell
- Cell to cell flotation machine
- Thickener complete
- Drum vacuum filter
- Spiral wet reagent feeder
- Wilfley concentrating table
- Rapid laboratory wet drum separator
- Super agitator and conditioner

Iron ore testing

- Moisture determination balance
- Sub sieve sizer
- Pellet testing machine
- Wearo-meter

Extractive metallurgy ferrous and non-ferrous

- Hydraulic press, Apex model A.24, with one set of spare parts
- Birlec 100 KVA experimental submerged arc melting furnace
- Laboratory rotary calciner, indirectly heated, gas-fired
- High pressure autoclave
- Fast rise potentiostat

Foundry

Sand testing equipment

- Infra rapid drayer
- Agitator
- Continuous clay washer
- Laboratory sifter
- Sieves
- Sintering furnace
- Laboratory core sand mixer
- Laboratory mixer
- Sand rammer
- Flowability testing fixture
- Split specimen tube
- Transverse strength core box
- Tensile strength core box
- Shatter index tester
- Permeability meter
- Mould permeability tester
- Universal strength machine
- Transverse strength attachment
- Tensile strength attachment, PZV

- Core drying oven
- Optical pyrometers
- Fluidity test pattern
- Speedy gas detector
- Drying oven
- Atlas Copco rammer
- High frequency melting unit
- Miniature crucible furnace
- Babyarc furnace, capacity 55 kgs.

Heat Treatment

- Tempering furnace
- Sintering furnace
- Electrode Salt bath furnaces
- High temperature box furnace
- Muffle furnace

Metallography

- Micro hardness tester, Shimadzu M
- High temperature metallurgical microscope
- Universal dilatometer with vacuum equipment
- Specimen mounting press and powder
- Inverted type metallurgical microscope
- Incident light microscope
- X-Ray diffractometer
- Quantimet

Metal testing

- Industrial X-Ray unit
- Ultrasonic testing unit
- Universal testing machine
- Universal impact testing machine
- Surface finish tester
- Torsion plastometer
- Sheet metal tester
- Surface roughness measurement instrument
- Multipoint recorder

Metal Working

- Pneumatic power hammer
- Experimental rolling mill, for hit and cold rolling
- Gas-fired heating furnace, operating range of 750^{o} to 1200^{o}
- Total radiation optical pyrometer 8,000
- Infra-therm digital pyrometer

Chemical analysis

- Atomic absorption spectro-photometer
- X-Ray fluorescence unit to be received at site

WORKSHOPS

Mechanical workshop

- Bench drilling machine
- Upright drilling machine
- Universal lathe for machining rolls
- Small universal lathe
- Universal milling machine
- Vertical milling machine
- Surface grinder
- Universal tool and cutter grinder
- Drilling machine up to 5,0 mm
- Drilling machine up to 35,0 mm
- Hand operated shear
- Guillotine shear
- Cut-off hack saw
- Electrical welding machine
- Lathe for carpenter shop
- Workshop tools
- Workshop microscope

Electrical workshop

- Multavi 3 multimeter with circuit breaker
- Multimeter-microtester

Surface coating

- Meniscograph soderability tester with accessories

Powder metallurgy

- Atomising unit

Library

- Books and journals

LIST OF REPORTS BY UNIDO EXPERTS

General Planning Organization set up, research programme, etc.

1. Organization set up for CMRDI.
2. Utilities at the CMRDI.
3. Proposed programme for research and development.
4. Pilot plants in metallurgical research; master plan for CMRDI.
5. A tentative research programme and organization set up for a quality control activity in a steel mill.
6. A tentative research programme for the elaboration of technology of production of a new steel product.
7. Master programme for CMRDI.
8. Research planning diagrams.
9. Research plans, their programming, monitoring and follow-up at the industrial research institute in the developing country.
10. Engineering and other auxiliary services at CMRDI.
11. Industrial research institutes in the developing countries. Their establishment and functioning. Case study for Central Metallurgical Research and Development Institute.
12. Contract research-accounting and financial control.
13. Role of metallurgical research and development institute for transfer of technology in the developing countries.
14. Development of metallurgical industry in the next decade - challenges and prospects.

Mineral beneficiation

1. Guide lines for the orientation of ore-dressing tests towards practical objectives.
2. The concentration of iron ores.
3. Treatment of Maadi sands.
4. Some preliminary consideration on washing of salts from El Gedida ores.
5. Estimates of the capital and operation cost of reduction roasting grinding and wet magnetic separation of El Gedida ores.
6. Comments on US Steel consultants' report relating to the beneficiation of Baharia iron ore and resulting predicted blast furnace coke rates.
7. Beneficiation of Abu Sebera clay for Egyptian Company for refractories.
8. Washing of iron ore-iron ore sampling, etc., Helwan Iron and Steel - works.
9. Note on the problems of Baharia iron ores.

Agglomeration and iron ore reduction

1. Alkali problems in blast furnaces at Helwan Iron and Steel works.
2. Possible improvement in ironmaking practice at Hadisolb.
3. Survey of sintering of iron ores at the Helwan Iron and Steel Company and future development.
4. Some methods to study the properties of iron ores, sinters and pallets.
5. Notes on the operation of a laboratory scale electric furnace for sponge iron production.
6. Sinter production, quality control and sintering trials on Baharia iron ores at Helwan Iron and Steel Company.

Steelmaking

1. An outline of a scheme for basic lined side-blown converter steelmaking.
2. Technical survey on casting pit side practice in Egyptian works to improve ingot mould life.
3. A brief survey of possibilities of continuous and automated casting in Egypt.
4. General recommendations on electric steelmaking practice in Arab Republic of Egypt.
5. The production of 13% Cr steel.
6. A note on the sampling and analysis at steel mills.
7. A report on the recommended practice for electric steelmaking for wire ropes and rolls.

Metal Melting

1. Notes on the operation of a laboratory ESR unit.
2. A report on casting of nickel silver ingots.

Foundry

1. An explanatory note on high silica sand for use in foundries.
2. Note on Egyptian bentonites.
3. Recommendation for operation of hot blast cupola in Delta Steel mills.
4. Ingot mould manufacture.
5. Comments on the steel foundry projects at Copper Works Alexandria.
6. Report on the casting of Axel-box housing for passenger cars.
7. Foundry sand at the foundry of the Iron and Steel Co. Helwan.
8. Training course - quality control in iron foundries.

Metal working

1. Use of cast steel rolls in rolling mills.
2. Report on improvement in the technology of patenting and surface preparation of wires for steel wire ropes for Copper Works.
3. Blank preparation and defects on forged pieces in Nasr Forge Co.
4. Cold formed sections.
5. Study of the existing technology of rolling and a new roll pass design and technology for Delta Steel Co.
6. Study of the existing cold wire drawing technology and possibilities of improvements in Delta Steel Co.
7. Recent technology of the production of wire rope.
8. Steel melting, rolling, drawing, heat treatment and control of wires for wire rope production, Copper Works,Alexandria.
9. Wire rope production-grades, quality requirements, inspection schedules for steel ingots, wire-rods and wires for the steel-wire ropes.
10. Optimisation of the orders distribution among the ARE rolling mills.
11. Plastic deformation by models and practice.
12. The National Metal Company-proposals for increased production and future use of existing rolling mills.
13. Copper Works - productivity and proposals for modernisation of rolling mills.
14. A mechanisation device for stand No. 1 of intermediate train Copper Works.
15. Case study for the recoveries for the production of wire-rods at the Egyptian Copper Works, Alexandria.
16. Master technology for bailing hoops production.
17. Mill tackles for rolling mills - their demand and production in Arab Republic of Egypt.
18. Introduction of operational system for reinforcing bars production at the Copper Works, Alexandria.

Heat Treatment, Metallography and Welding Testing, etc.

1. Study of roll breakage.
2. Metallographic study of cast iron sections taken from Deutz cylinder.
3. Metallography study of ingot mould samples.
4. Metallographic examination of samples of welded chains supplied by Nasr Forge Co.
5. Service failure in rolling stock bogie.
6. Expansion, contraction, distortion and residual stresses in welding.
7. Some notes on the technology of liquid metals.
8. Tables of properties of liquid elements, density surface, tension, viscosity.
9. Tables of specific heats, thermal conductivity, electrical resistivity.
10. Examination of non metallic inclusions in the steel for wire rope production.
11. Metallography examination of defects in forged steels.

Surface protection

1. Strip aluminising of steel-pre-feasibility studies.
2. Clad steels. A survey of technology.
3. Technology for aluminising of mild steel wires.

Miscellaneous

1. Ferro-silicon - its raw materials.
2. Production of Magnesium in Arab Republic of Egypt.
3. Comments on the development of the metallurgical industry in ARE.
4. Comments of Atkins final report on the development of iron and steel industry in Egypt till year 2000.

Alloys steels

1. Heat resistant iron-chromium-aluminium alloys.
2. Prospects for the required development of the quality steel production in Arab Republic of Egypt.

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2. X-ray study on Egyptian phosphates. Desert Inst. Bull. ARE Vol. 22, No. 2 (1972).
3. Thermal analysis of Egyptian phosphates. Desert Inst. Bull. ARE, Vol. 23, No. 2 (1973).
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5. X-Ray mineralogy of some quarternary Nile Sediments. Published in the prehistory of the Nile Valley Academic Press, New York (1976).
6. A contribution to the geochemistry of the Jurassic rocks in the Western desert, Egypt. Ain Shams Univ.,Faculty of Science Bull, Vol. 21, 1977.
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11. Clay mineralogy of the Pleistocene terrace sediments along the Mediterranean coastal zone, Egypt. Desert Inst. Bull. (1977).
12. A contribution to the mineralogy and petrology of the Holocene along the Mediterranean coast of Egypt. Desert Inst. Bull. (1977).
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14. Origin of the Kareem sands in El Morgan field. Gulf of Suez Petroleum Co. Exploration Dept., report No. 162 (1977).
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LIST OF INDUSTRIAL PLANTS/ORGANISATIONS/FIRMS TO WHICH CMRDI HAS RENDERED ASSISTANCE

1.	Helwan Iron and Steel Works El Tebbin, Cairo	The only integrated steel plant in Egypt
2.	Delta Steel Company Mostorod	The 3 non-integrated steel plants in Egypt.
3.	National Metals Abu Zaabal	
4.	Copper Works Alexandria	
5.	Nasr Forge Company El Tebbin	The only major forging and heat treatment unit in Egypt.
6.	Nasr Pipe Fittings & Tubes Co. Helwan	The only pipes and tubes plant in Egypt.
7.	Nasr Casting Co. at Alexandria and Tanash	
8.	General Metals	Non-Ferrous refiners and fabricators.
9.	Egyptalum-aluminium smelter Naga Hammadi	
10.	Ferro-Silicon Project Edfu	
11.	Sinai Manganese Company	Supplier of foundry materials Fe-Mn producer.
12.	Egyptian Organisation of Industrialisation	The apex body of planning of the industries in Egypt.
13.	Iron & Steel Complex	The apex body for executing the new projects for Iron and Steel phosphates.
14.	Eyad Rolling Mills Helwan	Private sector rolling mills.