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RESTRICTED. ORIGINAL: ENGLISH

ASSISTANCE TO THE NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS, NIGERIA.

PROJ. DP/NIR/87/031

FINAL MISSION REPORT OF CHIEF TECHNICAL ADVISER

Prepared for the Federal Government of Nigeria by the United Nations Industrial Development Organization acting as executing Agency for the United Nations Development Programme.

Based on the work of
WILFREDO A. BELTRAN
CHIEF TECHNICAL ADVISER

NOVEMBER, 1993.

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SUMMARY

The Project DP/NIR/87/031, assistance to the National Metallurgical Development Centre, took off in 1988. Its objective was to improve national capabilities to rationalize the industrial sector through the increased use of local raw materials needed, especially for the Nigerian Steel industry. At the TPR meeting of October 1991, it was decided to reduce the originally intended Nine Sub-projects to only three.

During this mission, progress was made towards the completion of the project. The coal carbonization pilot plant was concluded and the refractory materials sub-project is close to completion. The Mineral Beneficiation Pilot Plant Sub-project did not advance as expected due to economic constraints. The training sub-project can be considered as accomplished.

To conclude the project, it is recommended to set up the infrastructure for the MBPP and start production of prototypes of refractory materials. It is also recommended to continue improving the supporting activities as they influence the performance and sustainability of the project.

INTRODUCTION

Official arrangement

Project Number	-	NIR/87/031
Post Title	-	Chief Technical Adviser
Country	-	Nigeria
Mission	-	Starting date - Nov. 22, 1992
		Finishing date - Nov. 22, 1993

Project background

The Project DP/NIR/87/031, Assistance to National Metallurgical Development Centre, Jos, was established in April 1988 between the Federal Republic of Nigeria and the United Nations Development Programme, with UNIDO acting as executing agency. The project began with Nine immediate objectives until the TPR meeting held in October 1991 reduced them to the following three immediate ones:

1. Utilization of Nigerian coal blends for metallurgical coke production to be used in steel manufacture at Ajaokuta Steel Company.
2. Production of refractories, using local raw materials for metallurgical and allied industries.
3. Development of the most suitable beneficiation processes for indigenous iron ores and local industrial minerals in order to promote their industrial scale production as raw materials for other industries. The TPR meeting also recommended the development of skilled manpower for the metallurgical industry in the above specified fields.

Background of the mission

This Terminal report was prepared by Wilfredo A. Beltran, UNIDO CTA, who started his 12-month mission on November 22, 1992 with a briefing in New York and Vienna, where he was informed about the current situation of the ongoing project.

As specified in the job description, the CTA was expected to assist the NMDC and particularly its research and development staff in the

effective development of technological improvement for production of metallurgical products. During his assignment he was to render daily guidance and act as a coordinator between the government counterpart and UNDP/UNIDO. More specifically, he was expected to assist in the completion of the four sub-projects. (See appendix A.) As is customary, the first task the CTA was expected to fulfill was to make an assessment of the project as found and on this basis prepare an inception report. This task was fulfilled after a month in the field. The CTA also carried out, basis, other duties such as the coordination of the Instrument Maintenance Crew and rehabilitation of the equipment. He also visited companies such as Coal Corporation, PRODA, Delta Steel Co., National Iron Ore Mining Project, and Ajaokuta Steel Company in an effort to identify opportunities for joint projects and mutual cooperation of NMDC with industry. (See Appendices D and E.) The CTA also revised the design report of the Mineral Beneficiation pilot plant and carried out the basic plant design for the coal processing line and drying facilities for the MBPP. (See Appendix F.)

National Counterpart Staff

The following local staff were involved in discussions on the progress of the project:

Dr. Usman M. Turaki	-	D/CE - NMDC (NPD)
Alhaji A.M. Tukur	-	DD/A - NMDC
Dr. G.G.O.O. Uwadiale	-	HOD (Minerals Dept.) - NMDC
Mr. O. O. Olubajo	-	HOD (Metals Dept.) - NMDC
Mr. C.I.C. Nwankwo	-	HOD (SS) - NMDC.
Mr. A. A. Odunaike	-	Project Manager (MBPP)
Dr. O.A. Ogunlana	-	Project Manager (COPP)
Mr. J. O. Nwosu	-	ACC/TA & Head of Refractory Laboratory.

I. PROJECT DP/NIR/87/031 ASSISTANCE TO NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS, NIGERIA.

A. Coal Carbonization Pilot Plant Sub-Project

1. Situation as found at the outset:

At the beginning of the mission, the work directed to providing the necessary infrastructure for the erection of the pilot plant had been somewhat delayed due to economic constraints. Part of the infrastructure was in place, and the pilot plant equipment was already in Jos.

2. Pilot Plant Installation and Commissioning:

After the Federal Government made funds available in January 1993, the work on infrastructure progressed substantially, and toward the end of that month officials of DMT, Germany arrived for the installation of the Coke Oven Pilot Plant. By this time, the LPG Gas Tank was in place, the overhead water tank was ready and the 100kv. Mitsubishi Generator installed. The latter was subsequently replaced with a 100kv Volvo Generator, due to problems encountered during the start-up.

In the middle of February 1993, the Coke Oven Pilot Plant was ignited with the help of Mr. Siebert of DMT, Germany. On February 24, the Coke Oven temperature reached $1150^{0}C$ and the coke oven received its first charge of German coking coal sample at 10%

moisture. On February 25, the first coke was produced. Other tests were performed in the coke oven with the help of Dr. Rohde, but this time using the preheated, briquetting and stamp charge techniques. Dr. Rohde also demonstrated the operation of other equipment of the pilot plant, including that used in the quality control of the coke such as the screen, micum test device, etc.

3. Present situation

a) Infrastructure and Operating Conditions:

So far, the coal carbonization pilot plant is in good operating condition. All the infrastructure needed, including the coal sample storage place, is now concluded. Whenever carbonization tests are not being done, the temperature in the coke oven is maintained at around 900°C. In situations in which the power supplied by NEPA temporarily fails, the standby generator starts up immediately. Notwithstanding the frequent scarcity of gas in town, efforts are made to keep the coke oven temperature at a constant and appropriate level. At present, the LPG gas storage capacity of the COPP is composed of a 3.2 Tonne tank and about 40 cylinders of 50kg each.

b) Testing Work:

After May 21, when the COPP was officially commissioned, no carbonization test was done until Sept. 17 as there was no foreign

coal available. But now that this coal has been arriving in Ajaokuta since August 1993, NMDC has received 13 drums of coal samples supplied by Agro Allied (from Australia) and 12 drums of coal samples supplied by Carbon Energy (from USA.) These samples have recently been characterized at both laboratory level and pilot plant level, and the results were reported to Ajaokuta Steel Co.

c) Maintenance and Spare Parts

Repairs were done on the impact crusher and micum drum switches, as well as greasing of this equipment and of the briquetting machine. Realignhment of the horizontal hole was also done so as to make possible the installation of the ceramic rod for measuring the shrinkage and swelling index force during carbonization. This work was accomplished using the drilling rod sent by DMT Germany. Also, quotation of spare parts for key equipment of the COPP was requested from the manufacturer. The purchase of a Recorder, an LCD Digital Multimeter, a Sieve shaker, and a Thermoelement has been decided, while other spare parts are being evaluated.

d) Cooperation with Ajaokuta Steel Company (ASC)

During the CTA's recent visit to ASC, it was observed that the relationship of NMDC and ASC is excellent. Ajaokuta Steel Company is now very much interested in verifying the quality of the coke and coking coal supplied to them. In this respect, they have sent coke and coal samples to NMDC for characterization tests.

Also, ASC now seems to realize the importance of having a COPP and a Fuel and Energy Laboratory within the country. This fact may facilitate NMDC's approaching ASC for some kind of financial cooperation in order to meet the running costs of the COPP.

B - Refractory Materials Sub-Project:

1) Situation as found at the outset:

The refurbishing of the building near the coal carbonization pilot plant was close to completion, although the Entech Furnace has been already installed and commissioned in this building. The 100 Ton Hydraulic Press supplied by IQBAL Machine International of Pakistan and the drilling machine were delivered, and awaiting installation. The mould for the 100 tonne hydraulic press was missing and the equipment had no manual for its installation.

2) Present Situation:

a) Relocation of the equipment:

Once the refurbishing of the building devoted to housing the main equipment was concluded early this year, the 100 tonne hydraulic press and the drilling machine were relocated and positioned in this refurbished building.

b) 100 Tonne Hydraulic Press and Mould

So far the supplier has not been helpful in providing a manual for the installation and operation of the hydraulic press. On the

other hand, the UNIDO Purchasing Department has given its assistance in contacting possible suppliers of the mould. PLANSON INTERNATIONAL made an offer to provide a mould apparently made by IQBAL Machine International of Pakistan (supplier of the 100 tonne press). After deliberation, NMDC accepted the offer, but also asked UNIDO to find out if the Pakistan supplier could send a technician to install the equipment. The outcome of this enquiry is still being awaited.

The lack of a mould and of the manual for putting this hydraulic press into operation has caused delay in the progress of this sub-project. As a result it was decided that this problem should be solved within NMDC. So far, the NMDC foundry section has already attempted to construct a mould which will be tried out, and the new Instrument Maintenance Crew is now in the process of installing this equipment.

Finally, with respect to the capability of the equipment of producing a prototype of refractory brick for the steel industry, certain limitations are apparent. For instance, this press would exert on a standard brick only about 2.5 tonnes pressure per unit area, while the brick to be used in the steel industry would need a pressure per unit area of about 6 tonnes. Even so, once this hydraulic press is in operation it will be useful for producing

standard prototypes for other industries. Efforts will be made to obtain prototypes for steel industry at standard pressure, but in smaller sizes for pilot testing.

c) New Entech Furnace and Drilling Machin

After the furnace fuse was replaced once, it failed again three months ago and after that did not work until recently. The new maintenance crew solved the problem, which dealt with the electrical connection between the furnace and the switch box. The electrical malfunction of the pillar drilling machine has been similarly solved, as this machine is also vital for the work.

d) Acquisition of Mixer

As part of the preparation of facilities for the production of prototypes of refractory bricks, NMDC decided to purchase a mixer from Industrial Development Centre, Zaria. This mixer is presently under construction and should be ready soon. The acquisition represents a step forward toward the conclusion of the sub-project.

e) Testing work and production of prototypes

Lately, the refractory laboratory has been engaged in some testing work directed to the characterization of refractory bricks and refractory raw materials for Ajaokuta Steel Company. In this respect, properties such as density, porosity, bulk density, etc, are determined. The laboratory has also been involved in moulding

bricks using clays from deposits such as Ekulu (Enugu State) and others, but these bricks were not fired due to problems encountered with the new Entech Furnace.

With respect to the capability of the laboratory to carry out crucial tests on refractory raw materials and bricks, it has certain limitations which need to be overcome by the provision of additional vital equipment. In this respect NMDC, in accordance with the recommendations of Mr. Ivan Budimir, UNIDO Consultant in refractories, sent to UNIDO Vienna a list of laboratory equipment for quotation. These manufacturer quotations recently arrived and are now being evaluated before the decision to purchase.

As for the production of prototypes bricks, this task would be fulfilled as soon as the 100 tonne Hydraulic press is operative and the corresponding mould is ready. These tasks are now being handled by the Maintenance Crew of NMDC.

f) Relationship with the Industry

During the CTA's visit to Coal Corporation, PRODA and Delta Steel Company, he was able to identify, together with the R&D Department of Delta Steel Company, various production and operational problems concerning refractories. The most urgent was in connection with the necessity of producing high grade magnesite (80% MgO) for immediate use at DSC. In this respect, the management of NMDC is

taking steps so that a joint project could be implemented. The disposition of DSC for this kind of work is excellent. (See Appendix D.)

C - Mineral Beneficiation Pilot Plant Sub-project

1) Situation as found at the outset:

The basic engineering design for this pilot plant had been concluded and the report was available. The plant site was cleared and the soil test underway. Some equipment was already arriving and was stored in the foundry building. It was well understood then that the work directed to providing the infrastructure would depend on the availability of funds allocated by the Federal Government. A quick review of the pilot plant design report by the CTA showed that it might be necessary to consider additional equipment such as the weightometer, wet reagent feeders, automatic samplers, dust collector system, etc., for plant control, plant optimization, and environmental purposes. The CTA presented his views to NMDC Management accordingly.

2) Present situation

a) Start-up of infrastructure work:

When the structural drawing based on the UNIDO Consultant's design, the soil test, and the load-bearing capacity information were all concluded by Model Engineering Design and Development Co. Ltd., Mahalli Development Consortium also presented the bill of quantities. However, due to lack of fund, NMDC decided to

reappraise the MBPP infrastructure and design with the aim of lowering costs. As this exercise could imply some modifications, NMDC persuaded Mr. Rao, UNIDO Consultant, to come to Jos as soon as possible, as he was the designer of the MBPP. Now that the reappraising exercise is concluded and part of the funds were released recently, the work for the infrastructure has begun. During reappraisal, the consultant was given all relevant reports expressing some views on the MBPP design so that he could evaluate them and make his own decision.

b) Reception and inspection of equipment:

Some of the MBPP equipment has been stored in the foundry building and some in the open due to lack of space. During inspection of this equipment, it was observed that the items stored in the open have started rusting and their crates were attacked by termites. Although some measures have been taken to protect this equipment from rust, keeping it in a rain-free place would be more appropriate.

Also, a crack was observed on one of the support frames of the rotary scrubber supplied by SAYAJI IRON & ENGINEERING Co, India. This crack, however, can be welded prior to installation. Regarding the equipment supplied by BGRIMM of China, the flotation machines did not arrive with spare impellers as stated in the packing list. Neither could we locate some of the starters requested by the NMDC inspection team during their visit to China. BGRIMM and the Purchasing Department of UNIDO Vienna were both

informed on this matter. To date, the following equipment has been received:

S/N.	EQUIPMENT	SUPPLIER	PURCHASING ORDER
1.	Jones WHIMS	KH.D. Humbold Wedag, Germany.	15-2-0529k
2.	Jaw Crusher 12" x 7'	Mineral Department Australia	15-2-0530k
3.	Hydrocyclone Testing Rig.	Mineral Department Australia	15-2-0530k
4.	Vibrating feeder (2) Mod. D58B	Eriez Magnetic U.S.A.	15-2-0531k
5.	Hopper belt ore feeder (4)	BGRIMM, China.	15-2-0532k
6.	Spiral Classifier (2)	"	15-2-0532k
7.	Thickener	"	15-2-0532k
8.	Conditioner (2) O 750 x 1000mm	"	15-2-0532k
9.	Flotation cells (10)	"	15-2-0532k
10.	Dry reagent feeder	"	15-2-0532k
11.	Water pump	"	15-2-0532k
12.	Double deck screen (2)	TATA Robins Fraser Ltd. India.	15-2-0698k
13.	Rotary Scrubber	Sayaji Iron & Eng. Co. India.	15-2-0697k
14.	Sala Wet Ball Mills (2) 1000 x 1500m	Sala International AB Sweden.	15-2-0549k
15.	Electrostatic Separator Mod. HT (15,25,36) 111-15	Carpco Inc. Flo. U.A.S.	15-2-0539k
16.	Mozley Hydrocyclone Test Rig. Mod. C700	Richard Mozley Cornwall, U.K.	15-2-0503k
17.	Chain Pulley Block.	Bertoni SRl. Italy.	15-3-426k
18.	Sala Vertical Pump (2)	Trellex Allis.	15-3-422k

D - Training

1) Situation as found at the outset

Funds for training were limited, yet many people needed this training. In this respect the candidates were carefully selected according to priorities.

2) Present situation:

a) Research staff trained abroad

From November 1992 to November 1993 the following staff members were trained abroad:

Mr. A.I. Nwankwo Head, of Foundry Lab., Poland.

Mr. I.N. Nnaekezie, Head of Metallography Lab, England.

Mr. M.A.U. Nwoke, Asst. MBPP Project Manager, Canada.

Miss. D.O. Adetoro, Wet Analytical Lab, Germany.

Mr. B.M. Katsina, Instrumental Analytical Lab., Germany.

Mr. A.G. Sanni, Refractory Lab., India.

Mr. A.O. Adeleke, Fuel & Energy Lab., Romania.

Mr. J.A. Nggada, Metallographic Lab., Romania.

Mr. E.I. Mbaya, Metal Testing Lab., Romania.

Mr. I. Shittu, Extractive Metallurgy Lab., Romania.

Mr. E.B. Odetundun, Foundry Lab., Romania.

Miss. P.I. Chukwu, Corrosion Lab., Romania.

One of the reason for training other research staff members than those belonging to the 3 sub-projects is due to the existence in other laboratories of important equipment which was provided by

UNIDO during this project. Obviously, equipment such as the TINUS Universal Testing Machine located in the Metal Testing Lab. needs to be operated by a trained individual. The exercise continues with the training of Mrs. M. Mokwe in Coal Petrology in Romania and Mr. Garagadi in Computers applied to the Mineral Metallurgical industry.

b) Study tour scheme:

The following people undertook study tours to update their professional experience:

Dr. Usman M. Turaki, NPD, D/CE - Vienna, Austria.

Mr. J. O. Nwosu, ACC/TA Refractory Lab., Brazil.

Mr. O.O. Olubajo, HOD (Metals) - Tunisia.

c) Training by UNIDO Consultants:

Mr. Bin Fu, UNIDO Consultant in Wet Chemical Analysis, arrived in Jos on the 10th of September 1993 for a 3 months mission. His task is to improve the performance of the Wet analytical laboratory.

Mr. P. Knowles, UNIDO Consultant in Instrumental analysis, arrived in Jos on the 6th of October 1993 on a 3 months split mission. His task is also to improve the NMDC capabilities in instrumental analysis.

d) Internal training:

NMDC made an effort to organize two courses of two weeks duration each with the help of IAN Assoc. of Zaria. These courses are in

Laboratory techniques, directed to laboratory attendants, and in instrument maintenance, directed to the New Instrument Maintenance Crew and other research officers interested in acquiring maintenance culture. NMDC was also involved in training some of its staff locally.

II. SUPPORTING ACTIVITIES

A - Fuel and Energy Laboratory

1) Testing work:

Recently, this laboratory started its activities of support to the COPP by characterizing some coal samples supplied by Ajaokuta Steel Company. During these tests the laboratory used devices such as the Plastometer, Dilatometer, Swelling Index, Carbolite Furnace, etc. So far, the laboratory has tested successfully about 30 series of coal samples belonging to suppliers such as Carbon energy (USA Coal) and Agro Allied (Australia Coal). The aim of these tests was to verify the quality of the coking coal supplied to Ajaokuta. These samples were also sent to DMT, Germany for comparative test analysis. The information lately obtained from DMT shows good reliability of NMDC results.

2) Capability of this laboratory:

Compared to the situation found at the beginning of this mission, in which most of the equipment was either broken down or not installed, this laboratory is now capable of carrying out the basic determinations (proximate, dilatometric, plastometric analysis and

swelling index determination) directed to the characterization of the coal. Several tests have been carried out to confirm the accuracy of results, which so far seem to be reliable. In short, the reorganization of some key research staff members and the installation and successful rehabilitation of crucial equipment have contributed to this positive change. Finally, as coal research starts with coal petrology, there is a need for NMDC either to rehabilitate the brokendown microscope and its photometer or acquire a new one. In this respect, it may need to be sent to the supplier in Germany for repair assessment.

3) Rehabilitation and Installation of Equipment:

a) Equipment installed:

- Plastometer
- Dilatometer
- LECO precision balance
- Moisture determinator in a Nitrogen Atmosphere.
- NSC device for coke reactivity test
- Ash fusibility equipment.

b) Equipment rehabilitated:

- Carbolite furnace
- Pump of bomb calorimeter
- Memert oven
- Sulphur determinator test (in progress)

- 7kg carbolite coke oven

c) Equipment manufactured:

The swelling index device was manufactured by the Fuel and Energy staff. This device is similar to that used by DMT people and it is giving reliable results.

B - Mineral Processing Laboratory

1) Sampling and Mineralogy

The CTA's inception report contains various recommendations on these matters, and it is suggested to follow them for obtaining accurate and reliable results.

2) Testing equipment needed

In order for the Mineral Processing Lab. to give good support to the MBPP, it should have the necessary testing facilities, especially as some of them will be transferred to comprise part of the pilot plant. In this respect, a selective list of the equipment most needed in the mineral processing lab. and sample preparation lab. was elaborated and passed on to UNIDO - Vienna for quotation. This information arrived and is now under evaluation.

C - Chemical Analysis Laboratory

1) Wet analysis laboratory:

This laboratory was refurbished last year, and throughout this year NMDC has made an effort to provide it with additional basic facilities such as the new analytical balance, a new furnace, a new hot plate, etc, in order that the laboratory work could proceed smoothly.

During this year, the laboratory was engaged from time to time in the analysis of ore samples for clients. However, as the main problem here was the reproducibility of the results, the assayers were sometimes involved in cross-checking their figures. In this respect, there is a need for detailed examination of all factors which might contribute to this error. Sampling, weighing methods, attacking, filtration, titration, quality of reagents, human error, etc, should be among the factors needing to be examined. Mr. Bin Fu, UNIDO Consultant in Wet Chemical Analysis, arrived in Jos on the 10th of September 1993 and he is working towards the improvement of the performance of the laboratory.

2) Instrumental analysis laboratory

Most of the year there was no analytical activity in this laboratory, as most of the equipment was either broken down or in the process of rehabilitation, especially that of the Atomic Absorption which is considered crucial. IAN Associates of Zaria were first involved, without success, in the repair of this equipment.

Recently, Winelight Nig. Ltd. of Lagos (Ex. Philips) was able to repair this equipment successfully and it is now operative. The poor reproducibility problem of the 2 UV-Visible Spectrophotometer, recently repaired by IAN Associates, will also be handled by Winelight Nig. Ltd. Lately, this laboratory has been relocated to a more suitable place. This new location will house equipment such as the two A.A.S, flame photometer, carbon sulphur analyzer, the 2 UV. Visible spectrophotometer and the Gas chromatography. With respect to the X-ray diffraction and fluorescent bought by NMDC not long ago, the X-Ray Diffraction has been installed recently by Industrial Automation (Nig.) Ltd, Lagos, (Ex - Philips) and is ready for manual use. On the other hand, the X-Ray fluorescent is yet to be installed. The computer for this equipment has already been purchased but some parts are yet to be supplied. Mr. P. Knowles, UNIDO Consultant in Instrumental analysis, arrived in Jos on the 6th of October 1993, and he is presently working towards the improvement of this laboratory.

D - Rehabilitation and Installation of equipment

1) Present situation

There were many pieces of broken-down equipment in the Centre. Until recently most of the repairs were undertaken by local contractors, but with few exceptions, most of them did not perform as expected. Under this situation, it was agreed that a new Instrument Maintenance Crew should be formed to work for the time

being under direct supervision of the CTA's office. This crew was then formed by deploying 3 staff members from other sections, from which only one person has the necessary experience as he was preciously heading the Electric/Electronic Section. Obviously, most of the work load is now on the one person, and unless someone else with some experience is employed to help with the work, the progress should be slow. Nevertheless, in spite of limitations, progress in the rehabilitation of testing equipment has been substantial and encouraging. In any case, for better performance of the Instrument Maintenance Crew, it might be worthwhile to send this crew abroad for training with the equipment manufacturer.

2) Equipment installed or rehabilitated

So far, the efforts of the research staff and new instrument maintenance crew, notwithstanding certain difficulties, allowed for the following accomplishments:

a) Equipment installed

- Plastometer	- Fuel & Energy Lab.
- Dilatometer	- Fuel & Energy Lab.
- LECO Precision Balance	- Fuel & Energy Lab.
- Moisture determinator in a Nitrogen atmosphere	- Fuel & Energy Lab.
- NSC Device for coke reactivity	- Fuel & Energy Lab.
- Ash Fusibility equipment	- Fuel & Energy Lab.
- TINUS Universal Testing Machine.	- Metal Testing Lab.
- New 100 tonne Hydraulic Press	- Refractory Lab.

b) Equipment rehabilitated

-	Carbolite furnace	- Fuel & Energy Lab.
-	Pump of bomb calorimeter	- Fuel & Energy Lab.
-	Memert Oven (By IAN Assoc. Zaria)	- Fuel & Energy Lab.
-	7kg Carbolite coke oven	- Fuel & Energy Lab.
-	Transpol NO. 2	- Metallography Lab.
-	Movipol No. 2	- Metallography Lab.
-	Lathe machine	- Metal Testing Lab.
-	Water distiller	- Chemical Lab.
-	New pillar drilling machine	- Refractory Lab.
-	New Entech Furnace	- Refractory Lab.
-	Atomic Absorption (By Industrial Automation Nig Ltd)	- Chemical Lab.
-	Water distiller (By IAN Assoc.)	- Min. Benf. Lab.

E - Other relevant activities

1) Supply of computers by UNIDO

On the 10th of June 1993, the Computer Centre received six carton boxes (Purchase Orders No. 15-2-0998k). The boxes' contents were as follows:

a) Two Gateway 2000 4SX-25 (Hard disc unit)

b) Two color monitors

c) Two keyboards

d) Two Epson printers LQ-1070

e) Two printer ribbons

f) Six power cables

g) Two windows 3 software

h) One Q view software

i) Two set of Dos 5 software

j) Manuals

Installation of the two-computer system was successful except for one small problem. The computer clock battery in one of the hard disk units was dead. This was purchased locally and successfully replaced by the Instrument Maintenance Crew. Both the computer systems are now in perfect working condition.

2) Library

Up till now, no 1993 journals have been received from the supplier. In the respect, the supplier MUNKSGUUARD was written to and their reply came recently saying that NMDC subscription had not been renewed. UNIDO Vienna has been approached recently on this matter and on the possibilities of purchasing essential books related to the three sub-projects.

III. OTHER CTA'S ACTIVITIES AND TASKS

A - Comments on the Mineral Beneficiation Pilot Plant Design Report

A draft of the comments on this matter was made available for internal discussion in May 1993; however as this discussion was delayed, the report was not released until August 1993. With reference to the observations and comments, these are intended to be used as needed by the UNIDO Consultant responsible for the MBPP design or the NMDC staff.

The various recommendations emphasize the importance of a simple and straightforward flowsheet, the use of larger crushers (which are available) and the testing of one Type of ore at a time so that simplification could be done in the area of the fine bin, etc.

Although most of the suggestions were made taking into account the available equipment, there are a few which imply new acquisitions for good process control and optimization. Among these would be the weightometers, wet reagent feeders, automatic sampler, etc. Additional units of Humphrey spirals and wet low intensity magnetic separators may also need to be purchased in order to simulate the operation of the industrial beneficiation plant of National Iron Ore Mining Project at Itakpe. (See appendices B, C and E.)

B - Visit to Coal Corporation, Enugu Project Development Agency (PRODA), Enugu & Delta Steel Co. (DSC), Aladja, Warri.

The visits to these institutions were made with the objectives of assessing the facilities for training, and the disposition for mutual cooperation and joint projects on the basis of problems in the industry. These objectives were met, and suggestions and recommendations were made to the Management of NMDC and those companies visited. For instance, DSC reported problems connected with the generation of fines during pelletizing of the iron ore concentrate, with refractory materials used, etc. This means that the opportunity for NMDC to work with DSC in a joint research project is excellent, and the steps NMDC is taking to materialize this link are commendable. DSC is very much in favour of this kind of approach. (See appendix D.)

D - Visit to National Iron Ore Mining Project (NIOMP) and Ajaokuta Steel Company (ASC).

The visits to these institutions were also made to fulfill similar objectives to those stated in the visit to Coal Corporation and Delta Steel Co. Here too the visit was very helpful in learning the present situation of these companies and their relationship with NMDC. Suggestions and recommendations were made to the management of NIOMP on various relevant issues as a means of contribution.

With respect to recommendations to the management of NMDC, the most relevant are concerned with mutual cooperation, training of the Mineral Beneficiation Pilot Plant (MBPP) personnel, and the possible acquisition of additional testing facilities for the MBPP, so that the iron ore deposit of Itakpe could be tested at the pilot plant using a similar flowsheet to that existing at the industrial plant of NIOMP.

The visit to Ajaokuta Steel Co. was brief. Nevertheless, their good disposition for mutual cooperation was notable. At present their main interest is to verify the quality of the coke and coking coal received, and for this purpose they will continue sending coal samples as soon as they arrive in the country. (See appendix E.)

D - Computerized list of equipment supplied by UNIDO

The elaboration of this list took more time than expected. To begin with, the information was scattered, scarce or non existent. The purchasing orders sent by UNIDO Vienna facilitated the work, at least with the equipment belonging to the present project. The list was finally finished and has been made available to the various departments of NMDC.

E - Basic Design of Coal Processing Line and Drying Facilities of MBPP.

The CTA's visit to Coal Corporation was connected with this task. As per the work, it was completed in October 1993 and the report was sent to the parties involved, including Dr. Rao, UNIDO Consultant for MBPP. This report refers only to the basic plant design of the coal washery and drying facility for the MBPP. The detail engineering plant design, including the general arrangement for each unit process and the overall layout, are yet to be done, hopefully by the UNIDO Consultant. In this respect, equipment manufacturers should be approached to obtain information about equipment specifications and a more realistic equipment cost estimates. As usual this basic design is subject to improvement. (See appendix F.)

F - Coordination of New Instrument Maintenance Crew.

This is another task undertaken by the CTA. Once the new Instrument Maintenance Crew was formed, there was a need for this kind of coordination so that real progress could be made in the rehabilitation and installation of crucial equipment. The process of setting up an effective Instrument Maintenance Crew is underway.

CONCLUSIONS

For more detailed information about the activities carried out during this mission, the reader is advised to refer to the contents of this report.

1) In general terms, progress was made towards the completion of the project. The coke oven pilot plant sub-project has been concluded and the refractory sub-project is close to completion. The mineral beneficiation pilot plant sub-project did not advance as expected due to economic constraint; however, the training program set up for this project has been accomplished.

2) The coke oven pilot plant, with the support of the Fuel and Energy Lab. is now ready to conduct successful characterization and coal carbonization tests. The testing work carried out recently on coal arriving at Ajaokuta Steel Company for quality control purposes, and the results obtained at DMT Laboratory on the same sample, show that the NMDC results are reliable.

3) As compared with the situation found at the beginning of the mission, the Fuel and Energy Laboratory is now capable of giving good support to the COPP sub-project. The reorganization of some research staff members and the successful rehabilitation and installation of key equipment have contributed to this positive change.

4) The lack of a mould and also of the manual for putting into operation the 100 tonne hydraulic press has caused delay in the progress of the refractory sub-project. However, the recent decision of handling this problem within NMDC turned out beneficial, as these problems are in the process of being solved. Also, important equipment such as the new Entech Furnace and the Pillar Drilling machine have been rehabilitated.

5) Due to scarcity of funds for the infrastructure of the Mineral Beneficiation Pilot Plant, NMDC wisely decided to reappraise it and the design in an effort to lower costs. But now that this reappraisal exercise has been concluded with the help of UNIDO Consultants and the Federal Government has released part of the funds, the work for the MBPP infrastructure has begun.

6) Except for the various conveyor belts yet to arrive from Finland, almost all the equipment ordered for the MBPP has arrived in good condition. As for the spare parts of equipment ordered from BGRIMM, China, the flotation cells impellers were not found; neither were some of the starters ordered by the NMDC inspection team during their visit to China. BGRIMM and UNIDO Vienna were informed about this.

7) The training objectives have been accomplished. In spite of limitation of funds, during the mission about twelve research staff members were trained abroad under the fellowship scheme and another three staff members undertook the study tour to update their professional experience. In addition, two UNIDO Consultants in Wet Chemical Analysis and Instrumental Analysis, respectively, arrived to help improve the chemical analysis supporting services.

8) The rehabilitation and installation program of equipment has been carried out successfully. In spite of limitations and difficulties encountered at the beginning, important equipment has been either installed or rehabilitated. These tasks were mostly accomplished by the research staff and the new Instrument Maintenance Unit of NMDC.

9) In addition to other duties, the CTA carried out the review of the Mineral Beneficiation Pilot Plant design report, the basic design of the coal processing line (coal washery), and a drying facility for the MBPP. These reports contain useful observations and recommendation on these matters. (See appendices C an F.)

10) The visits of the CTA to various companies related to the mining and metallurgical industry were important, as they allowed NMDC to have first hand information about training, industrial problems and opportunities for linking with the industry by implementing joint research projects. (see appendices D and E)

RECOMMENDATIONS

1) To support the operation of the Coke Oven Pilot Plant (COPP), it is recommended that NMDC continue making efforts towards requesting Ajaokuta Steel Project for some kind of financial cooperation in order to meet the present running cost of the COPP.

2) As coal research starts with coal petrology, there is a need for NMDC to either rehabilitate the broken-down petrographic microscope and its photometer through the manufacturer or consider the acquisition of new equipment.

3) To speed up the completion of the project, it is suggested that efforts be made to procure funds from the Federal Government so that the infrastructure work for the Mineral Beneficiation Pilot Plant could continue without interruption.

4) To improve the capability of the refractory laboratory, it is recommended to provide it with a few important testing facilities after careful evaluation, as bricks must be characterised after production to indicate specifications. Facilities for grinding and pulverizing are already available in the Centre.

5) For good support to the MBPP, it is recommended that the Mineral Processing laboratory be provided with key testing facilities, especially as some of them will be transferred to MBPP. (See appendix B and chapter II-B of this report)

6) For better performance of the instrument maintenance unit, it is recommended that the crew be reinforced with one or two additional members recruited from outside the Centre and with some experience. Also, they should undergo intensive training in the country and abroad.

7) It is suggested that the mineral beneficiation pilot plant design be simple and straightforward. It should also incorporate facilities for process control and optimization, and be capable of testing the iron ore of Itakpe with a similar flowsheet to that used at the industrial plant now in operation at National Iron Ore Mining Project (NIOMP), Itakpe. (See appendices C and E.)

8) It is recommended to identify at this stage the first ore sample which will be treated in the MBPP once it is erected, so that all provisions in terms of infrastructure, equipment, process flowsheet, etc, could be made in order to meet this important goal.

9) Improvement should continue on the various supporting activities, as they would always influence the performance of the project. In this connection, it is advisable to follow the recommendations given in the CTA's inception report.

10) With respect to the relationship with industry, it is advised that NMDC follow the recommendations given on this matter in the CTA's inception report. At present, there exists an excellent opportunity for NMDC to work with DSC on a joint project (See appendices B, D and E).

IV. APPENDICES

A - Job description

B - CTA's Inception report

C - Progress Reports Numbers 1, 2 and 3.

D - Comments on the MBPP design report.

E - Visit to Coal Corporation, PRODA and Delta Steel C.

F - Visit to National Iron Ore Mining Project and Ajaokuta Steel Co.

G - Design of coal processing line and drying facility for the MBPP.

IV. APPENDIX A

jdnir/11-01 24 March 1992

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

JOB DESCRIPTION

DP/NIR/87/031/11-01

J13210

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Post Title:	Chief Technical Adviser
Duration:	One year, with possible extension for a further period.
Date required:	4 August 1992
Duty Station:	Jos, Nigeria, with travel within the country.
Purpose:	Strengthening of the National Metallurgical Development Centre (NMDC), Jos, to develop modern metallurgical technologies. In the long-term, this will lead to improved productivity in the industry as a whole, substitution of importS, and also better usee of presently unexploited natural resources.
Duties:	The expert will be expected to assist the NMDC, particularly its research and development staff, in the effective development of technological improvement for production of metallurgical products by rendering daily guidance, based on his technological and managerial experience, and act as the co-ordinator between the Government counterparts and UNDP/UNIDO during his assignment. More specifically, he will be expected to:

1. Assist the NMDC, and the National Project Director in particular, in the preparation of the detailed work plan for the project implementation as his first task upon fielding.

2. Assist in setting up laboratories and pilot plants of NMDC, in particular a laboratory for refractory testing and production and pilot plants for coal carbonization and mineral beneficiation.

3. Assist in setting up the most efficient organizational structure for upgrading R and D capability in connection with the research facilities to be established.

4. According to the development of the project implementation based on the elaborated work plan, provide technical advice or be directly involved in such tasks as:

   - formulation of the specifications for equipment to be purchased and assistance in selecting the proper equipment.

   - Preparation of the terms of reference for the specific consultant's services; evaluation of candidates; supervision of the work made by the consultants; and, guiding them in planning future work.

   - Assistance in preparation/organization of training programs inside and outside the country envisaged in the project. Proposing suitable centers of study tour/ training.

5. Prepare periodical progress and terminal reports and other documents required under UNDP/UNIDO regulations.

6. Participate in the Project Implementation Committee (PIC).

7. Participate in the Technical Advisory Committee (TAC).

Qualifications:

A Masters Degree in Metallurgical/Mineral Engineering with a minimum of 15 years experience in research, development, consultancy operations in mineral and metallurgical industries. Management and promotional abilities, including experience to plan and evaluate research programs and to supervise bench-scale and pilot test work.

Language: English.

Background Information:

The development of the Nigerian Metallurgical industry has not been balanced. The production of iron ore, metallurgical coals, ferro-alloys and refractory materials is non-existant today and the supply of finished products such as steel and iron castings, sheet and plate fabricated products, tooling wire and wire materials do not satisfy the demand. Thus, Nigeria depends heavily upon the importation of raw materials, semi-manufactured products and spare parts, and with the inability to import them now, it is faced with considerable problems with regard to the operation of metallurgical industries.

Nigeria is facing enormous challenges in the development of its metallurgical industry. It has to reduce its dependence on imported raw materials and provide locally made components for

advanced industries, such as automobile and agricultural equipment industries. At the same time, it needs trained personnel to operate the large steel projects like Delta Steel, as well as to prepare qualified manpower for the creation and development of new mining, metallurgical and manufacturing industries. In the process, it must absorb transferred technology, provide technical assistance to improve the present operations of the metallurgical sector, and should establish qualified laboratories to help in the improvement of the quality of raw materials and manufactured and semi-manufactured products and their standards. In the absence of adequate testing facilities, both public and private industries are, at present, using the services of laboratories in Europe.

In an effort to expand the scope of the Centre and to strengthen its capabilities to enable it to play full role in the Government's efforts in the production of coal raw materials to substitute for imports, technology acquisition, process and product adaptation, the Federal Government has allocated about Naira 42 million (US$ 10 million) for the construction of the Centre buildings at the new site, and has agreed to share 60 percent of the cost of UNDP technical co-operation under a new project. In this respect, a provision of US$ 1 million has been made in the Third Country Programme.

NIGERIA - NATIONAL METALLURGICAL RESEARCH CENTRE
NEW CTA INDUCTION REPORT - PROJ. DP/NIR/87/031

JANUARY 11TH, 1993.

Prepared by

Wilfredo A. Beltran.
CHIEF TECHNICAL ADVISER.

I. ABSTRACT

The purpose of the Project is to strengthen the National Metallurgical Development Centre (NMDC), Jos and to develop modern metallurgical technologies. In the long run, this is supposed to improve productivity in the industry, to encourage the exploitation of the mineral resources, and to diminish the importation of raw materials.

The Project DP/NIR/87/021 was established in April 1988 between the Federal Republic of Nigeria and the United Nations Development Programme, with UNIDO acting as executive agency for the assistance to the National Metallurgical Development Centre, Jos. This Project began with 9 output's until the Tripartite Review Meeting held in October 1991 reduced it to the following 4 outputs:

1. A coal carbonization pilot plant.
2. Equipment of the refractory laboratory.
3. A mineral beneficiation pilot plant.
4. Training of Technical personnel.

This induction report corresponding to my first 15 days of work as

CTA, was requested by UNDP/UNIDO officials during my briefing in Lagos. Therefore, in accordance with their advice, it presents a diagnosis (from my point of view) of the Project and other technical aspects of YYDC. This is followed by some advice and recommendations which may be open for discussion and used as a guideline for work in the Centre.

II. INTRODUCTION

According to the last PIC meeting document, this Project is to end in 1993. Therefore, even though I do not have the exact figure of the amount of money left, I suspect this is limited. Even so, there are some important aspects of the Project still to be taken care of.

A research and development centre of this kind needs to work in applied research, with the final aim of serving the industry of the country. This means that its findings and recommendations should be practical and reliable. In a competitive market, reliability is very important for reputation and credibility. Therefore, in order to serve the industry well, any research centre has to meet the high standard which comes only with time and serious work.

However, at the very beginning, such research centres have to start their activities by acquiring a strong foundation based on mastering a few specialties and building up a strong support

for research activities. This basic technical support usually refers to analytical services, to petrography and applied mineralogy, to sampling, and to good maintenance of instruments and testing equipment. Obviously, the people involved in these activities are the key factors. As such, they should be well trained and possessed of some industrial experience.

With the above reflections in mind, I started reviewing Project documents, visiting various research departments, and talking to the people directly involved in the technical work. The idea of this approach was to acquire first hand information based on facts. Therefore, at this time I prefer not to comment on the quality of research and development work done up to now, as I did not witness them. Instead, I will limit comments and suggestions to the present state of the Project and to the various laboratories as I found them.

III. TECHNICAL SUPPORTING ACTIVITIES OF RESEARCH

1. Applied Mineralogy

Modern mineral beneficiation or processing bases its activities on applied mineralogy. 23 years ago I heard a distinguished lecturer saying in the Royal School of Mines in London that applied mineralogy was the cornerstone of mineral technology. He was right, because in later years, this technology came to be compulsory in most technologically advanced countries. And I

believe that the developing countries have the right to inherit this knowledge.

Now, the mineralogical laboratory of the NMDC is practicing what is called Mineragraphy, and the work is of a qualitative nature as the microscopic analysis is done on a piece of solid ore. This work should be completed with applied mineralogy, which is of a quantitative nature; therefore this analysis should be performed on loose material or ground samples. Afterwards, this sample is sized and each fraction is mounted, polished, and further quantified with the help of a microscope. At other times, the heavy liquid separation techniques are used on each size fraction previous to grain or point counting.

These techniques, and other devices such as the sieve shaker, etc., are not used here. Furthermore, applied mineralogy involves not only identification of minerals, modal analysis, liberation measurements, textural relationship, but also the study of mineral properties and characteristics for purposes of process selection and plant control. It also means having adequate facilities to perform these studies, such as a good rock-cutting device, good mounting techniques and a good polishing machine.

Finally, for outstanding research work in mineral technology, it is advisable to update this technology in the Centre, providing this lab. with the necessary testing facilities and adequate training of personnel.

2. Sample Preparation Laboratory

The importance of sampling is very well understood by the mining industry, and most research institutions. Therefore the industry has developed good sampling techniques which have proved to give good results.

The sample preparation activity in the NMRC takes place in both the Mineral Processing Laboratory and in the room behind it. This arrangement, besides being time-consuming, may originate errors; therefore its centralization in one appropriate room is advisable. The existing jaw and cone crushers are in good condition but the roll crusher is not, and this makes the sample preparation, which calls for the minimum production of fines, difficult. Of the three existing pulverizers, only one is in good condition. The pulverization of small samples for chemical analysis is done by hand, which may sometimes result in the production of coarse samples that are inadequate for chemical analysis. Facilities such as laboratory pressure filters, trays, buckets, water, compressed air, dust extractors, hot plates and ovens, and a platform for coning, mixing and quarting, should all be centralized in the sampling room. This place should be easily accessible to the Mineral Processing and Chemical laboratories.

Because of the importance of this operation and of the results (pilots tests), it is advisable to optimize this service by making the sampling room more adequate and by training the operators in the latest sampling techniques.

2. Analytical Services

A successful research institution will always rely on strong and efficient analytical services; therefore its importance is implicit. The equipment of the instrumental analytical laboratory is out of order, except for the flame photometer which analyses Na, K and Li. For instance, the S.P. 9 UNICAM Atomic Absorption Analyzer gives fluctuating results; the reading of the 290 Perkin Elmer Atomic Absorption is not accurate because of the motor problem, and the LECO sulphur-carbon analyzer used for steel samples is only capable of analyzing sulphur. Besides, the room where this equipment is being housed is too small and hence inadequate.

In the wet analysis section, two out of the four analytical balances, two PYE UNICAM spectrophotometers, and the three muffle furnaces (including the platinum crucible) are out of order. Besides, this lab. has only one small hot plate which obviously limits the overall activity. The lab has enough space for the installation of two or three more hot plates.

In general terms, the capability of the analytical services is very limited, especially that of the instrumental laboratory. Under these conditions, it is necessary to rely for the time being on the wet analysis lab. Therefore it is urgent that we do whatever is necessary to make this lab. operative. This may include the temporary transference of the furnace existing in the pollution control laboratory.

It is also known that the new XRD and XRF will be installed soon, and in this respect it would be advisable to allow only one trained person to operate each of them. I would like to point out that VMDC is making a great effort to buy this equipment, in order to improve its analytical services.

1. Equipment and Instrument Maintenance

At present, the various supporting and research departments of the Centre have a lot of broken-down instruments and testing equipment. On the other hand, the Centre does not have specialists in instrumentation referring to installations and maintenance.

Up to now the repair of some equipment or instruments has been given to local contractors, but the results were not as expected. Therefore, it is advisable to form a special maintenance crew to take care of the various instruments of the Centre. This may be a long process, but it is necessary to start as soon as possible. Obviously, this special maintenance crew will have to be trained both inside and outside the country. Instrument maintenance

specialists are few in this country; therefore it is important for NMDC to start working towards acquiring its own specialists in instrumentation.

Meanwhile, we could carefully handle the present situation on a case by case basis. Spare parts could be ordered and their maintenance should be assessed by the electrical maintenance departments of the Centre. Maintenance of equipment could be given only to well-qualified contractors under special agreements, such as payment only after the equipment and instruments have been sufficiently tested.

As in production, maintenance is also very important in research. Broken-down instruments or testing equipment represent serious limitations for the good performance of any research institution.

IV. RESEARCH AND DEVELOPMENT LABORATORIES

1. Mineral Beneficiation Laboratory

As a rule, I believe that no pilot plant test is done without the bench scale testing work; hence the necessity for the lab. of this kind to be well-equipped and have well-trained professionals.

Roughly, the mineral processing laboratory of the NMDC lacks the following equipment:- Bond grinding mill for work index tests, precision balances for weighing samples, magnetic separators (low

and high intensity), electrostatic separators, hydraulic classifier, cyclone classifier and slurry pump for recirculation, bigger simplex and duplex jigs, vibratory feeder for shaking table tests, timer for flotation cells, binocular microscope, etc. Should the existing spiral concentrator be transferred to the pilot plant, then the lab. will need a spiral concentrator and other gravity concentration devices such as the Reichert Cone, etc. This lab. may also require some equipment for Gold and Silver ore processing or for preconcentration, such as the heavy media concentration device or others.

The existing jigs are very small and they may be better for applied mineralogy work. The existing magnetic testing tube is only used to have a general idea of the mineral property; hence the necessity for a larger magnetic separation testing equipment. The existing Frantz magnetic separator has been broken-down for a long time. Also the hot spot Gallenkamp furnace and the fans of two ovens are not working.

With respect to laboratory research personnel, it is understood that, except for the head of the minerals division, all of the present senior staff seem to expect to be transferred shortly to the pilot plant. If this is so, it is recommended to start recruiting some well-qualified researchers so that the research work at the laboratory level won't be neglected. In other words, should the

research and development work at the laboratory level generate work for the pilot plant, then it is advisable to have at all times a well-equipped lab. and well-trained professionals.

2. Fuel and Energy Laboratory

What I said previously about the bench scale tests and pilot plant tests is also valid in this case. Therefore, now that the coal carbonization pilot plant is being erected, the importance of the laboratory testing work is greater. At present, this lab. has the following malfunctioning equipment:- Oven for moisture determination, crucible for swelling index determination, carbolite muffle furnaces for ash, volatile matter, the automatic bomb calorimeter for determining the calorific value of coal, the sartorius and mettler balance. Besides, the control console of the sulphur determinator equipment needs to be set up; the Gray King Coke Type equipment for tar is without a crucible. The programming of the new Gisslar plastometer needs to be solved and the installation of the new dilatometer calls for a safer place.

Obviously, under these conditions, the capability of this laboratory is limited; therefore I advise paying urgent attention to this matter in order to improve the situation. Before piloting, it will be necessary to perform studies of any foreign and domestic coals at bench scale, and for this purpose earlier NMDC studies would be very usefull refer me.

3. Other Labs. of the Metals Division

The metallographic laboratory is well equipped, and apart from the microscope camera, all the microscopes and polishing devices are in good working condition. It is well known that the scanning electron microscope has been out of order for quite a while and that its repair would be very expensive. Also, the movipol-2 polishing machine recently acquired has never worked properly and needs to be checked into. In general terms, the existing facilities of this lab. may be considered sufficient for handling serious research Projects.

The foundry research lab. seems to lack good furnace equipment for testing. The graphite crucible of the present furnace was broken and a new one was bought recently. The induction furnace bought several years ago with the idea of testing at higher temperatures has never worked. However, as far as sand testing equipment is concerned, this lab. may be considered adequate for good research work except for the sintering point, and the old cast testing equipment, which are broken down.

The sintering and pelletizing extractive metallurgy lab. has certain limitations in its capability because of the following broken-down equipment which are listed below, and the need for modification of the sinter machine:

a) Equipment for reducibility and swelling index test.

b) Equipment for testing the pellets' strength

c) Equipment for measuring the moisture of a sample.

The metal testing laboratory is also well-equipped. Except for the Servo-Hydraulic Universal Testing Machine which was recently repaired and has not been calibrated, and for the portable hardness tester and a precision lathe machine which has never been used, the rest is in good working condition. The TINUS-OLSEN Universal Tester Machine recently acquired has not been working yet as it requires a power supply connection. Besides, as this equipment is somewhat sophisticated, the people involved do not know how to operate it. In general terms, this laboratory is sufficiently equipped to handle research Projects.

V. PROJECT DF/NIR/87/031

1. Coal Carbonization Pilot Plant Sub-Project

On my arrival, the work directed to providing the necessary infrastructure for the erection of the pilot plant had been somewhat detained due to economic constraints, but lately however the Project is progressing thanks to the efforts of the Director/Chief Executive who made the funds available. In any case, the previous working plan for this Project may need to be updated again.

Briefly, the present status of the Project is as follows: All the coal carbonization pilot plant equipment is now in NMDC, Jos ready

to be installed. The 3-Ton crane, the 500KVA transformer, the 100KVA Generator, and the overhead water tank are already in their places. The air compressor are about to be placed, as well as the 1.2 Ton L.P.G. gas tank. I was told that an additional 3.4 Ton gas tank will be here soon. The power supply line is not yet of industrial grid, but a new connection for fresh water supply has been installed. On the other hand, last November officials of NMDC and Ajaokuta Steel Co. had a meeting where both parties expressed their willingness for mutual cooperation. The Director mentioned that the agreement issue is being solved through the Federal Ministry of Power and Steel, which controls both organizations. Now that the coal carbonization pilot plant is close to completion, it might be helpful to reiterate a few guidelines:

a) As this Project is mainly directed to helping the Ajaokuta Steel Co. to lower its operating cost, it is expected that this company should become involved in this pilot plant Project and help to finance its high operating cost. Furthermore, as this pilot plant has to be heated permanently, it is essential that it meet all the requirements for prevention of stoppages, such as the provision of a gas tank of sufficient storage capacity, and a fuel burner to use in emergencies.

b) NMDC had already established that, Ajaokuta Steel Co., as an interested party, has to select the foreign coal on which the testing work would begin. Obviously, they should make this selection on the basis of

the cost of the various imported coals and other criteria which best serve their interest.

c) As a rule, a pilot plant test is performed only after necessary testing work has been done at laboratory or bench scale. This means that after the foreign and domestic coals have been selected, a bench scale testing work programme should begin, directed to gathering the technical information necessary for a successful pilot plant test. Obviously, the previous NMDC research findings regarding blend percentages of foreign (59%) and domestic (41%) coals will be good reference for future work.

d) Pilot plant testing is a serious matter, as its results will be confirmed at industrial scale. Therefore, pilot plant tests should be done with a great sense of responsibility in order to give clients reliable results.

2. Refractory Laboratory Sub-Project

The refurbishing of the new building near the coal carbonization pilot plant is close to completion. Meanwhile, the equipment on the first priority list has been partially delivered. The hydraulic press is already in the Centre but not yet installed. A letter has been sent to the supplier in order to gather more information about the mould needed for this equipment. The Entech Furnace has been already commissioned.

It is understood that the objective of this sub-project is to provide the laboratory with the most indispensable equipment so that it could finally produce a prototype of a refractory brick used in industry. In this connection it will be necessary to clarify matters such as the total amount of equipment requested, according to priorities and delivery schedule. Also, the previous working plan will need to be updated with a more realistic time schedule for completion.

Here too, equipment such as the pyrometric cone furnace, the clay-firing furnace, the electrical hydraulic press and the mettler balance are not in working condition. Obviously, this situation also needs improvement.

3. Mineral Beneficiation Pilot Plant Sub-Project

The present status of the sub-project is as follows:

- The basic engineering design for this pilot plant has been concluded and the report is available.
- The future pilot plant site has been cleared, and the corresponding soil tests will be done very soon.
- Some equipment is already arriving and is being stored in the foundry building.
- The continuation with the work directed to providing the infrastructure will depend strongly on the availability of funds from the local government.

After reviewing the pilot plant design report, I noticed that it does not mention some key equipment, probably due to budget constraint. However, judging from my industrial plant operation experience, I believe the following would be essential for operation of a pilot plant of this kind:

a) Weightometers for the crushing section, and most important, for the grinding section. Pilot plant testing of this nature is a continuous operation; therefore the metallurgical accountancy, materials balance, and the evaluation of process and plant performance will require accurate and continuous measurement of the pilot plant feed, which can only be done by means of a weightometer.

b) Automatic samplers, to be located in a few key places such as the feed, concentrates and tail. These devices would reduce error during continuous sampling of key points of the pilot plant, and therefore help to obtain more reliable results.

c) A hydraulic classifier, which works with shaking tables. Shaking tables are gravity concentrators which work better with a narrow size-range material. In these cases, the hydraulic classifier is usually used to prepare the feed for concentration in shaking tables.

d) Dust control equipment for the crushing section. This device could help to remove the dust which originates during crushing. This pilot plant will be located close to Zaria Road, and the dust created during crushing of dry material may pollute the areas both inside and outside the plant.

In my opinion, the above mentioned equipment is indispensable for pilot plant operation; therefore it is advisable that these matters be kept in mind in accordance with the availability of funds.

Another aspect to take into account is that it is time for the pilot plant manager to start selecting the operating and maintenance crew in order to begin their training, preferably in industiral operation plants.

VI. COMMENTS ON OTHER IMPORTANT ASPECTS

1. Training

At this point and in this area, I think it is advisable to concentrate all efforts in the 3 sub-projects pointed out in the tripartite meeting in 1991. This means that if we want the 3 sub-projects to be successful, then the project training funds, if possible, should be used in these sub-projects and their corresponding technical support activities.

On the other hand, in order to build a solid foundation and also improve the performance of institutions of this kind, it is recommended that training be mostly oriented to people directly involved in the research and development projects, as they are the ones dealing with the everyday research problems.

As the Centre has a lot of faulty instruments and equipment and there is no maintenance crew, it is also recommended to give priority to the training of people who will be directly responsible for instrument and testing equipment maintenance.

Finally, it is preferable that training for pilot plant operation take place in an operation plant, rather than in a research institution which may run its pilot plant only from time to time. Furthermore, training in a very sophisticated, heavily instrumented research centre or operation may not be too appropriate at this point.

2. Research and Development Projects

Now that the Project involves the erection of pilot plants, it is understood that the Fuel and Energy Laboratory, the Refractory Laboratory and the Mineral Beneficiation Laboratory should start research and development work on a Project of national interest. These studies would gather all the necessary information for pilot plant testing work. Therefore, I suggest that research and

development studies be carried out in the following sequence:

a) Applied Mineralogical Studies and Amenability testing

b) Process selection

c) Process testing

- Bench scale
- Pilot plant scale

d) Process evaluation.

The other laboratories at the Centre, especially in the Metals Division, may also begin working on a simple and practical project of quick maturity. Selection of these projects may also need to be done carefully, according to our capability in terms of equipment and experience of the research staff.

3. Technical Services and Relationship with Industry

In industry, especially private industry, credibility and reliability are important factors for a good relationship between clients and customers. This means that the work done for the industry needs to be practical and reliable, as well as technically and economically convenient. Now, this kind of work will usually involve having reliable testing facilities and highly trained people with industrial experience.

In the case of NMDC, the relationship with industry could start on the basis of a few small projects. The research staff needs to

have contact with industry and also gain experience. Therefore the projects at the beginning should be easy to accomplish and successful in outcome, in order to start building up NMDC's credibility. At times it may not even be necessary to charge, as long as industry meets the basic expenses of our research. If the industry does not come to us, we should go to it and offer our help. When the Centre gains more experience and reputation, then it could start charging. Anyway, NMDC is a state institution, and it might help its image if it would collaborate with industry in general.

VII. CONCLUSIONS AND RECOMMENDATIONS

It is highly recommended that for more detailed information, the reader should refer to the report itself, as this section only presents a summary of the content.

1. The Centre has a lot of broken down instruments and testing equipment, which limits its performance. Therefore my advice is to form a maintenance crew and give them intensive training before they start handling these sometimes sophisticated instruments. It is time that the Centre had these kinds of specialists, as the performance level of local contractors may not be as expected.

2. Sampling, analytical services, and applied mineralogy are the basic support activities for any research and development

work. Therefore, in these matters, I suggest the following:

a) Sampling is very important for reliability in research work; hence I recommend centralizing this activity into one ore sample preparation room provided with the necessary facilities for good sampling. At the same time, the operators need to be trained in the latest and most reliable sampling techniques. This measure should optimize sample preparation at NMDC.

b) Services in the instrumental analytical laboratory are very limited by faulty instruments and unreliable results. Therefore it is to everyone's interest that the instruments should be repaired. Under these circumstances, the research centre must depend on the wet analysis laboratory, but this laboratory also has some broken down equipment. In order to improve the situation here, I suggest transferring temporarily the muffle furnace existing in the environmental laboratory and studying the possibilities of repairing the two broken down spectrophotometers and balances. Besides, in order to improve the Wet Laboratory's capacity, it is necessary to install in the existing space one or two hot plates more.

c) Applied mineralogy is the basis of mineral technology, therefore I suggest that the mineralogical laboratory of the Centre acquire this technology in order to help the Mineral Processors more effectively. At present the work of this laboratory is of a semi-quantitative nature, as the microscopic analysis is done on a piece of rock or ore instead of on loose or ground material. An applied quantitative mineralogical analysis does not imply only mineral identification, model analysis, textural relationship or liberation mesh, but also the study of mineral properties and other grain factors which are useful for process selection. It is also important that this laboratory introduce the use of heavy liquids and other mineral separation techniques like the super-panner, etc. Besides, this laboratory needs some basic equipment as well as mastery of the mounting technique for polish sections of loose material, etc.

3. As a rule, no pilot plant test is done without previous bench scale testing work; hence the importance of having a well equipped laboratory and well-trained technical personnel. Therefore, now that coal carbonization and mineral beneficiation pilot plants are about to be erected, it is evident that

their corresponding laboratories either do not have the necessary facilities or that these facilities are out of order. In this respect I give the following advice:

a) The mineral beneficiation laboratory requires key testing facilities such as the Bond Grinding Mill for work Index Testing, Magnetic Separator (high and low intensity), electrostatic separator, hydraulic classifier, and a few others (See report).

b) Now that most of the senior staff are going to work in the mineral beneficiation pilot plant, I suggest forming a mineral processing team so that they can undertake the research and development work at laboratory scale level.

c) The Fuel and Energy laboratory work is limited by several pieces of broken down equipment. Therefore, it is advisable that the people involved examine this situation in depth so as to come to certain solutions in order not to jeopardize the work at both the laboratory and pilot scale levels.

4. With respect to the various laboratories of the Metals Division, even though some of the equipment is not in good working condition, these laboratories are well equipped. For instance, the metallographic laboratory, the sand testing facilities within the foundry laboratory, and the metal testing laboratory all have good testing facilities which could be used for research and development work. Another aspect which may be worthwhile to mention at this point is that some equipment seems to be rather sophisticated, and people at times may find it difficult to put in operation.

5. With respect to the coal carbonization sub-project, there are several aspects which need to be commented on:

a) The provision of the infrastructure has progressed, but not as scheduled due to economic constraints. The people involved are taking the necessary steps to solve this problem before continuing and concluding the work prior to pilot plant installations (see report).

b) Officials of NMDC and Ajaokuta Steel Co. met last November, and both parties expressed their disposition for mutual cooperation. However, no agreement has been signed yet with reference to financing the operating cost of the pilot plant test. The NMDC is aware of this problem and is working on it.

c) As this sub-project is mainly directed to helping the Ajaokuta Steel Co., it is advised that they be brought into the picture. Therefore, as an interested party, Ajaokuta should select, according to their interest, the foreign coal on which testing should begin.

d) To ensure successful work during pilot plant tests, the selected foreign coal should then be tested first at bench scale level, together with the domestic coal also carefully selected. This may take some time; therefore, the bench scale test should begin soon so that the pilot plant people, besides having the necessary technical information, could prepare conditions well in advance of testing. This is why it is important to come to an agreement with the Ajaokuta Steel Co, soon.

6. With respect to the Refractory laboratory sub-project, this has also progressed but not as expected. The refurbishing of the new building is close to completion; but equipment such as the hydraulic press can not yet be installed. Meanwhile the equipment on the first priority list has been partially delieved. On the other hand, this laboratory also has some broken-down equipment, which of course limits somewhat its capability.

7. The basic engineering design for the mineral beneficiation sub-project is concluded, the site has been cleared, and a soil test will be done soon. The continuation with the infrastructure work for this pilot plant sub-project is dependent on the availability of local funds, and the Director/Chief Executive is doing his best to improve this situation. Meanwhile, some equipment has been arriving and is being housed in the foundry building. Looking into the basic engineering design, I noticed that certain equipment seems not to have been taken into account probably due to budget limitation. This equipment includes a weightometer for continuous measurement of the ore entering the plant, a few automatic samplers for continuous sampling of key points during operations, a hydraulic classifier to prepare the feed for shaking table gravity separation, and a dust control system for environmental control at the crushing section. For instance, I would consider a weightometer indispensable for plant control and optimization in a pilot plant, which is a continuous operation. In this connection I would advise the people involved in this sub-project to look into these matters, and consider it worthwhile to study the situation (for more details see report).

8. As far as training is concerned, and in order to make the project successful, I suggest concentrating efforts in the sub-projects and their corresponding research and supporting activities. Furthermore, training should be directed with preference to the people directly involved in the research and development work. Also it is preferable that training for mineral beneficiation pilot plant operation take place in operation rather than in a research institution where the pilot plant may only operate from time to time.

9. With respect to Research and Development Projects, it is necessary that the laboratory scale work be oriented to preparing the way for successful pilot plant tests. In this connection, it is recommended that these laboratories work, if possible, on research projects of national interest. Such projects should be identified well in advance. (For more details see the report).

With reference to other laboratories of the Centre, it is recommended that these laboratories start identifying simple and practical projects of quick maturity so that they could start working on them. The selection of these projects has to be done on the basic of the laboratories capability and other criteria.

10. With reference to Technical Services of NMDC and its relationship to the industry, I advise the various research departments to start working on a few small projects. The research staff needs to have contact with the industry and gain industrial experience; therefore this could be done initially with small and simple projects in order not to jeopardize the Centre's credibility. At the beginning it may not be necessary to charge for our services as long as the customer meets our basic expenses. If the industries do not come to us, we should approach them and offer our help.

NIGERIA NATIONAL METALLURGICAL DEVELOPMENT CNETRE, JOS.

BI-MONTHLY REPORT: PROJ. DP/NIR/87/031

JANUARY TO MARCH 1993

Prepared by

Wilfredo A. Beltran.
CHIEF TECHNICAL ADVISER

I. INTRODUCTION:

At the end of January I presented an inception report with the best of intentions: To assist NMDC without blaming or judging anybody. This report was therefore made in such a way that it could be used as a guideline for improving the overall performance of the Centre. It is in this spirit that its content and recommendations should serve to construct faith and hope for the Centre. If the report is not seen in this way, it could cause friction, the last thing needed at this point.

In the present bi-monthly report I am referring to the current state of the three sub-projects. The work accomplished in other technical areas, which is equally important for the sustainability of the Project, is also commented upon.

II. PROJECT SITUATION

1. COKE OVEN PILOT PLANT (COPP) SUB-PROJECT:

a) Summary of the starting up event:- The work towards provision of infrastructural facilities for the COPP continued with intensity in the month of January 1993. Towards the end of this month Mr. Kossa and Mr. Ruthermann of DMT arrived on site to work on the

installation of the pilot plant. On February 2, the silica brick lining of the oven was inspected successfully.

After 2 weeks, Mr. Siebert of DMT arrived. At this point the LPG gas tank installed was of 1.2 ton capacity, the overhead water tank was ready. The 100KV Mitsubishi standby generator was in place, and the work for the permanent power connection inside the building was still going on. On February 11, the coke oven was lighted but it was stopped shortly afterward (before reaching critical temperature phase) to correct the air supply for the burners. However, owing to subsequent problems encountered with the start-up of the generator and its lack of connection with the coke oven, the lighting had to be delayed until February 16. On the same day, the Volvo generator, in better condition, was brought in from Site II to replace the existing one. Meanwhile all the equipment was given a temporary power connection for testing. Work on internal electrical distribution systems is expected to be completed by end of March 1993.

On February 24, the coke oven temperature reached 1150°C, and the coke oven received its first charge of German coal sample at 10% moisture. On this day Mr. Siebert left and Dr. Rohde, who had arrived the previous day, stayed to continue with the training programme. On February 25, the first coke was discharged. Dr. Rohde performed other tests on March 1, March 4, and March 6, using the preheated, briqueting and stamp charge techniques respectively. He also demonstrated the operation of the other equipment of the pilot plant, including that used in the quality control of the coke such as the screen, micum test device, etc.

Dr. Rohde fixed the dilatometer which was purchased from DMT. He could not perform tests with the Nippon Steel Test Machine, as the N and SO_2 gas cylinders were not installed in time. The people trained in Germany will operate this equipment. Dr. Rohde left on March 9. By the way, Mr. Bello, the Ajaokuta Steel Complex representative, was present at the lighting ceremony and I had a talk with him.

b) Present Situation:- It is known that Ajaokuta has not yet received any foreign coal. Therefore no real testing for Ajaokuta can take place in the COPP until these samples are available. Meanwhile, more supplies of local coal samples are being arranged from Enugu and Okaba. These are for the blending experiments. The Management has decided to appoint a liaison officer in Ajaokuta.

Total storage capacity prepared is made up of a 1.2 ton tank plus a 3.2 ton tank, in addition to 40 cylinders of 50kg each. The 1.2 ton tank is already installed, while the 40 cylinders are available. The 3.2 ton tank, the original capacity negotiated and agreed with Total Nigeria Plc, should also be installed very soon now that the legal documents for its release have been finalized. NMDC Management has also decided to install 2 bigger Tanks (10 tonseach). The past PIC document mentioned the issue of the agreement with Ajaokuta regarding the testing program and cost sharing. This agreement is working out within the Ministry of Power and Steel. It is necessary to point out here that Ajaokuta and NMDC are funded by the Government and both belong to the same Ministry.

Management decided recently that whatever work is left regarding the infrastructure in the COPP has to be finished soon.

2. REFRACTORY LABORATORY SUB-PROJECT

The refurbishing of the Lab. has been concluded and equipment such as the drilling machine, hydraulic press and the Entech Furnace are in their places now. The main connection of power supply to NEPA is still to be done. A letter was sent to the hydraulic press supplier requesting their advice in the issue of moulds necessary for it.

Another matter which I consider worthwhile to mention is connected with the limitations of our 100 TONNE hydraulic press. I just learned that the press with a standard size brick (9" x 4"½ or 9" x 3") can only give a pressure per unit area of about 2.5 tonnes. It is understood that a standard size brick sample to be tested as a prototype in the steel industry needs to be made under a pressure per unit area of about 6 tons. This means that to get a 6 tonne pressure per unit area, the brick would have to be of a smaller size.

3. MINERAL BENEFICIATION PILOT PLANT SUB-PROJECT

The soil test of the plant site is underway and the detail engineering will be completed soon. Up to now, the following MBPP equipment have arrived and are being stored in the Foundry building:

1. JONES WET HIGH INTENSITY MAGNETIC SEPARATOR
   TYPE P40 - KHD HUMBOLDT WEDAGAG, GERMANY.

2. VIBRATING FEEDERS (2 PIECES) MOD. D58B.
   ERIEZ MAGNETICS, USA.

3. CARPCO MOD. HT. LABORATORY ELECTROSTATIC SEPARATOR
   CARPCO INC. USA.

4. SALA WET BALL MILL (2 PIECES) TYPE SRR 1000 x 1500m
   SALA INTERNATIONAL. SWE DEN.

5. JAW CRUSHER. MINERAL DEPOSITS LTD, AUSTRIALIA

6. HYDROCYLONE TEST RIG. MINERAL DEPOSITS, AUSTRALIA.

It has been possible only to peruse briefly the pilot plant design report. However, serious comments may require more detailed study.

III. RESEARCH AND DEVELOPMENT AND THE SUPPORTING SERVICES

In this area, the following, activities and suggestions were carried out:

1. Regarding the Research and Development work, I suggested working at this time on joint projects with industrial companies and with no charge to them except for the basic expenses of the research work and staff. These projects should be specific, of quick maturity and easy to accomplish. Besides, they should be directed to helping the company improve its overall performance. This approach carries many advantages. This suggestion is being

streamlined with earlier NMDC efforts to attract and provide services for the Nigerian industry.

2. Reloction of the Instrumental Laboratory, Sand Testing Laboratory and some equipment of the Fuel & Energy Laboratory. These suggestions have been approved and these labs. will be relocated to a more suitable location from the point of view of sufficient space for testing work and protection from dust.

3. Formation of a Mineral Processing research team by recruiting specialists in this field for bench scale work. The only 2 senior staff existing in this Division will be transferred to the pilot plant; therefore, the laboratory scale work should not be overlookd.

4. Merging of the Petrological Laboratory of the Fuel & Energy laboratory with the Mineralogical Laboratory of Mineral Processing. The idea is to concentrate efforts and resources and form one strong petrological and mineralogical laboratory, with the aim of giving services to the various research laboratories of NMDC. This suggestion has been accepted.

5. Transfer of the Technology of applied mineralogy to Mineral Processing in NMDC. In order to fully apply this technology, it is necessary to train the research staff and provide the laboratory with the basic equipment and instruments which will enable the use of heavy liquid technique or other mineral

separation devices. Because of this suggestion, there was a meeting with the people involved and some recommendations should come from it.

6. Lack of equipment for the Mineral Processing Laboratory. Regarding this matter, I talked with the Heads of the Department to exchange ideas, and probably very soon we will elaborate a list of the equipment most needed. The mineral processing pilot plant will require good support from the mineral processing lab; therefore it should be well-equipped.

7. Formation of a specialized instrumental maintenance crew - This suggestion was approved and NMDC will go ahead with it. This crew should undergo some training within the country before the UNIDO expert in instrument maintenance comes.

8. Maintenance of faulty instruments or equipment by local contractors. At present, IAN Associates from Kaduna/Zaria is being granted a contract to start repairing some of the instruments/ equipment in the Fuel & Energy, and hopefully will look into instruments of the Analytical Services Division and other areas. At present, we are not yet sure about the capability of the company. Ideally, the instruments in the Analytical Services should be repaired before the UNIDO Consultant comes.

9. Testing of the Servo-Hydraulic Universal Testing Machine. This equipment was repaired in 1991 by EPCESCO Engineering. This test , carried out with the mentioned contractor as witness, was not successful as the readings were fluctuating and

unreliable. The Contractor thinks that it is because of the fluctuation of power, therefore he recommended the provision of a automatic voltage regulator. We are studying the situation.

10. Testing of the Sulphur Analyzer equipment located in the Fuel & Energy Laboratory. This equipment was also repaired in the past by EPCESCO Engineering, but because of the previous broken-down control console it was not tested. This time the contractor was called upon to witness the test. The furnace works, but because of the possible lack of precision of the oxygen regulator the test was not concluded. We will continue working on it.

11. Power connection of the TINUS OLSEN UNIVERSAL TESTING MACHINE. This new equipment has not been connected since it was purchased in 1991 by UNIDO/UNDP. Because of the difference in voltages between Nigeria and USA in the case of the 3-phase motor, there is a discrepancy about its connection. EPCESCO Engineering said that it should not be connected directly; others, including our Electrical Department, think that it could be connected directly. To clarify this matter, we are writing to the manufacturer for advice. Besides, as this equipment is somewhat sophisticated and our staff does not know how to operate it, we are checking with the manufacturer about the possibility of training our staff in its use.

12. Reception of equipment by the NMDC store. It was suggested that all UNIDO/NMDC equipment sent to NMDC should be received and registered by the store. This will favour a better control of

the equipment and the spare parts. NMDC Management had earlier on decided to maintain computer registration of all equipment from UNIDO and other sources.

13. NMDC is continuing with the effort of installing the XRD and XRF. The place which is supposed to house these equipment has been refurbished under the direction of the local contractor, who will also install this equipment.

(V) TRAINING

The following research staff just came from training abroad:

Mr. A.I. Nwankwo, Head of Foundry Lab, Poland.

Mr. I.N. Nnaekezie, Head of Metalography Lab, England.

Mr. M.A.U. Nwoke, Mineral Processing Lab. Canada.

Miss. D.O. Adetoro, Incharge of Wet. Analy. Lab. Germany.

Mr. B.M. Katsina, Incharge of Instrumental Lab. Germany.

This kind of training is very important for NMDC, and it is advisable to continue along this line. Because of time and also funds limitation of the project at this point, it is recommended to review the immediate training program and to repeat this execise on a continuous basis.

VI. CONCLUSION

For a more detailed information, the reader is advised to refer to the content of the report.

1. The Coke Oven was put in operation on the 16 of February 1993. The DMT people, in spite of limitations encountered during work, gave us outstanding help in the installation, lighting and operation of the COPP for the purpose of training. At present, the Coke Oven is maintained at around 950^{o}C, and gas consumption is roughly 100kg per day. NMDC is also taking steps to improve the storage capacity of gas. Also it is taking provisions to bring foreign coal from Ajaokuta to start testing work once it arrives in the country.

   Similarly, supply of local coals is being arranged on a continuous basis. For transportation of this coal, the centre has repaired an old Truck which may not be too reliable.

2. With reference to the Refractory Lab. Sub-Project, the laboratory has been refurbished and equipment such as the drilling machine, hydraulic press and the furnace are now in their places. Also, it is worthwhile to mention that the 100 TONNE hydraulic press may have certain limitations for producing the standard size prototype brick for the steel industry.

3. The soil test of the Mineral Beneficiation Pilot Plant site is underway. Meanwhile, some equipment for this pilot plant has been arriving and is being stored in the Foundry building. The Mineral Beneficiation Pilot Plant design Report needs to be studied in depth before further comments are made.

4. Regarding the Research and Development activities of NMDC, I suggested them to start working on specific and joint projects with the industry, following the strategy mentioned in section III of this report. This suggestion is being streamlined with earlier NMDC efforts in this matter.

5. Relocation of some of the laboratory equipment to a more suitable place was recommended in order that they could be better protected from dust, and the research staff could have sufficient space for testing work.

6. Formation of a mineral processing research team for laboratory scale work was recommended for good support of pilot plant testing work. The only two senior staff of this division are in charge of the mineral beneficiation pilot plant and a research team for bench scale work is needed.

7. The technology transfer of applied mineralogy to mineral processing was also recommended as it plays a key role in modern mineral processing. This transfer implies training the staff in this technology and providing the mineralogical lab. with key testing facilities.

8. The Mineral Processing Lab. requires key equipment so that it could give a good support to the future mineral benefication pilot plant. This issue was discussed with the head of the department and a selective equipment list will be elaborated for consideration.

9. Some of the broken down equipment is under repair by a local contractor. However, as this contractor's performance is not reliable, NMDC decided to form a specialized instrument maintenance crew as advised. This crew once formed will hopefully undergo local training before the UNIDO Consultant in Instrument Maintenance comes. It is also hoped that the equipment in the analytical service will be repaired before the UNIDO Consultant in Wet Analysis and Instrumental Analysis comes. The XRF and XRD are in final stages of installation.

10. In March 1993, five senior research staff members came back from training abroad. To continue with this trend, it is advisable to continuously review the immediate training program for the research staff so as to optimize utilization of available funds

11. Other relevant suggestions were also raised regarding the merging of the petrological lab. with the Mineralogical lab, the reception and registration of all equipment by the warehouse; the testing of equipment repaired in the past by local contractors, etc.

12. By talking with DMT people it was revealed that some spare parts and stand by equipment may be needed for the coke oven. A list will be prepared for consideration.

NATIONAL METALLURGICAL DEVELOPMENT CENTRE,
JOS, NIGERIA.

PROGRESS REPORT NUMBER TWO ON THE PROJECT ACTIVITIES. PERIOD: APRIL TO JUNE 1993.

PROJECT DP/NIR/87/031

Prepared by

WILFREDO A. BELTRAN
CHIEF TECHNICAL ADVISER

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PROGRESS REPORT NUMBER TWO ON THE PROJECT ACTIVITIES. PERIOD: APRIL - JUNE 1993 PROJECT DP/NIR/87/031

Prepared by

Wilfredo A. Beltran
CHIEF TECHNICAL ADVISER

I. INTRODUCTION

In June 1993, only bri f comments on the project activities carried out in the second quarter of the year were made, as the compilation for the NMDC quarterly report was underway and the CTA was expected to make his comments on this quarterly report. However, by the end of August and beginning of September, the NMDC second quarterly report was not ready.

Due to the time already elapsed, I decided to present a progress report in September covering activities which were carried out before this period. Nevertheless, this progress report number 2 is presented at the request of the BackStopping Officer in Vienna and contains details of the activities carried out in the project during the period of April to June of 1993.

II. PROJECT DP/NIR/87/031

1. COKE OVEN PILOT PLANT SUBPROJECT (COPP)

a) Construction Work:

In this period the following civil construction and electrical work was done:

- Completion of the gable end of the building.
- Completion of concrete apron and surrounding of the building.
- Installation of the overhead fluorescent tubes.
- Completion of the installation of the lighting arrester.

b) Coal Carbonization Experiments:

Except for during the carbonization test period, most of the time the coke oven is kept at a temperature of about 900°C. Within this period, only one coking experiment was performed due to non-availability of imported prime coking coal samples. The main supply of imported coal samples is yet to be received from Ajaokuta Steel Project. The results obtained in the one experiment carried out were as follows:-

Blend components: Australian coal 95%

Enugu coal 5%

Coking conditions: Heating flue temperature 1150°C

Moisture of blend 10%

Blend bulk density 0.78 $\frac{kg}{cm^3}$

Coking time 18 Hrs.

Coke properties:

Grain size - > 40mm - 82.8%

< 10mm - 10.0%

Coke strength:

Strength - M_{40} - 62.75

Abrasion - M_{10} - 18.2

c) Other Important Matters:

In this period, a gas tank of 3.2 metric tonnes with a regulator was installed, and the smaller tank of 1.2 metric tonnes is to be relinquished in view of high rental costs. The coke oven plant was officially commissioned on May 21st 1993. The 20th anniversary of NMDC was also celebrated on this date. Members of the local and federal government as well as of UNDP/UNIDO, Lagos were represented at the event by the UNDP Resident Representative, Mr. Assefa Fre-Hiwet, and Dr. David Tommy.

During this period, the management of NMDC made an interim decision to merge the COPP and the Fuel & Energy Division and put both Divisions under the responsibility of the COPP Manager. This decision was taken in order to harmonize the activities of both Divisions and prepare the ground for good support of the COPP.

Also in this period, an NMDC Liaison office was established at Ajaokuta. Mr. D.D. Orenusi was appointed to be in charge of this office.

2. MINERAL BENEFICIATION PILOT PLANT SUBPROJECT

a) Structural Engineering Design:

Controversy over the soil test results has delayed the detail structural engineering drawings. After the management terminated the assignment of DEK Consortium, Model Engineering

Services Ltd. conducted the structural engineering design. The work was finished and the bill of quantities is being prepared.

b) Reception of New Equipment and Storage:

About 23 crates of equipment from China and India have arrived. Some of it is being stored in the foundry building and other pieces are stored in the open because of lack of space. These crates have been covered with polyethylene to protect them from the rain, and it was also recommended to put up temporary sheds for the same purpose.

c) Revision and Comments on the Mineral Beneficiation Pilot Plant Design Report by the CTA.

This work was finished and a draft was prepared in May and given to the people involved for internal discussion, which by the way has not taken place yet. The report will be released as soon as the internal discussion takes place.

d) Visit of CTA to Coal Corporation and Project Development Institute (PRODA) in Enugu and Delta Steel Co. in Warri.

The visit to these institutions took place on the 23rd of June and was done with the following objectives:

- To be acquainted with the mining industry of Nigeria.
- To assess the facilities for training the MBPP personnel.
- To get some ideas for the design of the coal washery of the MBPP.
- To assess possibilities of NMDC's cooperation with the mining industry.

These objectives were fulfilled, and a report with the pertinent observations and recommendations was submitted to the management of NMDC and the other institutions (See details of report presented in the appendix).

e) <u>Basic Plant Design of the Coal Processing Line and Drying Facility for the MBPP to be done by the CTA</u>

The PIC meeting held in April recommended the CTA to carry out the basic design of the coal processing line and drying facility for the MBPP. Now that the coal washery plant has been visited and useful technical information gathered, the basic plant design work will start soon. It is planned for both designs (coal washery and drying facility) to be presented in one report, expected to be completed in two or three months time. The design needs to be done carefully in order that the plant could be capable of handling all kinds of situations.

* It was rescheduled to 1985 in October instead of July

3. REFRACTORY SUBPROJECT

a) 100-Tonnes Hydraulic Press:

After our insistence, IQBAL Machine International of Pakistan (supplier) replied that the Hydraulic Press has no manual and that all the instructions should be on the plaque of the machine, but this is not so.

The lack of a manual for this equipment is preventing us from putting it into operation. Besides, the lack of mould also represents a serious problem which hinders the advancement of this subproject. In this respect, UNIDO - Vienna was asked to assist us in the solution of these problems. On the other hand, the CTA, during his visit to PRODA, explored the possibilities of receiving some kind of assistance from this institution along this line, and the prospects for such assistance seems to be good.

b) Procurement of Mixer:

Institutions such as the Industrial Development Centre, Zaria and PRODA in Enugu were visited in order to evaluate their capabilities in the fabrication of an appropriate mixer. Decisions on this matter will be taken soon.

4. EXTERNAL TRAINING

As the funds available for this activity were limited, efforts were made to locate an economical place, with good standards,

so that the funds available could allow for the training of several of the research staff members. In this respect, the metallurgical institute (ICEMSA) of Romania was located for training about six research members. We are also planning to send Mr. A.G. Sanni, of the refractory laboratory, for training in TATA Refractories Ltd, Belpahar, India.

III. SUPPORTING ACTIVITIES

1. FUEL AND ENERGY LABORATORY

a) Testing Work:

In this period, coal proximate analysis tests were conducted on Lafia coal samples provided by a postgraduate student of Enugu University of Technology. The coal samples were also blended with Petroleum pitch from Kaduna Refinery and the proximate analysis carried out. Similar tests was conducted on blend A samples of Pittson coal supplied to Ajaokuta Steel Project. Other tests were carried out to determine the plastic properties of Australian coal as well as Enugu and Australian coal blends.

b) Installation and Rehabilitation of Equipment:

The Geiseler Plastometer and the dilatometer, both versatile equipment in coal research, were installed and put in operation successfully by the research staff working in the section with the help of the New Maintenance Crew. This

equipment is new and was awaiting installation for a long time. Also, the pumping system of the bomb calorimeter was restored to operation. With respect to the sulphur determinator, it requires a fine regulator before it could be test run. As is known, this equipment was repaired by a local contractor, EPCESCO Engineering, two years ago.

c) Fabrication of a Swelling Index Device:

As the rehabilitation of the swelling index machine available in this Lab. was difficult, it was decided to construct a device similar to that used by DMT Germany. The research staff members trained in Germany passed the idea on to the CTA, who then coordinated with them about the construction of this device. Once concluded, the equipment, was tested and proved reliable. This equipment is of great importance in coal research and will doubtless improve the capability of the Fuel and Energy Laboratory.

2. MINERAL BENEFICIATION LABORATORY

As several pieces of laboratory equipment will be transferred to the pilot plant, it was considered necessary to look into the possibilities of procuring some key equipment so that this laboratory could give good support to the MBPP. In this respect, a list of Mineral Processing, sampling, and Mineralogy equipment was elaborated and submitted to UNIDO

Vienna for quotation. The final selection of the equipment to be procured will be done only after careful evaluation.

3. CHEMICAL LABORATORY

No progress in instr. laboratory

With respect to the instrumental lab, the installation of the XRD is underway. Also, IAN Associates (a local contractor) has been engaged in the rehabilitation of equipment such as the 2UV-visible spectro-photometer and the Py-Unicam Atomic absorption, which are crucial for this laboratory. So far no definite results have been obtained from this work, also, the relocation of the instrumental lab. to a more suitable and spacious nearby place has already been decided.

With respect to the Wet Chemical Laboratory, it has been engaged in some chemical analysis for clients. However, the results obtained were not reproducible or reliable. Measures such as a close control of sampling, weighing, attacking and other possible causes for this error have been put into effect.

4. REHABILITATION AND/OR INSTALLATION OF NEW EQUIPMENT

a) Metal Department:

The new lathe machine located in the metal testing lab. and procured during this project is not in working condition due

to the fault identified in the motor. To verify this problem, the motor was tested both inside and outside of the machine. In both cases, the motor became overheated after a few minutes of operation. This means that it will have to be rewound.

With respect to the installation of the TINIUS Universal Testing Machine located in the metal testing lab. and procured during this project, there was some progress. The manufacturer finally sent us a letter indicating how the connection should be made. In fact, the motor has to be rewired before it is connected to the 3-phase power supply. Also, six fuses were included in the letter to be used for safety purposes. This task will be accomplished immediately.

The repair of the Transpol No.2 and Movipol No.2, both procured in this project, are well underway. Actually, the rehabilitation of the transpol 2 is about to be concluded.

b) <u>Scientific Service Department:</u>

The water distiller presently in operation in the Wet Lab. is breaking down continuously and its repair is becoming a time-consuming task. In this respect, we are looking into the possibilities of resuscitating the other water distiller which is available. This distiller is new, but has some missing parts.

IAN Associates of Zaria a (local contractor) has been engaged in the repair of the UV-Spectrophotometers and the Py Unicam Atomic Absorption. They finished the work with the UV-Visible spectrophotometers, but these machines are not giving reliable results. IAN Associates will take them to their workshop in Zaria in order to test them properly. The repair of the Atomic Absorption is yet to be done.

c) Minerals Department:

The plastometer and dilatometer, both new equipment located in the Fuel and Energy Lab. and procured during this project, were installed. The same applies to the LECO New precision balance supplied by UNIDO. The bomb calorimeter (pumping system) was also rehabilitated. However, its control console seems to be giving some problems. This equipment is also located in the Fuel and Energy Laboratory.

5. OTHER RELEVANT ACTIVITIES

a) Computers Supplied by UNIDO:

On June 10th, NMDC received from UNIDO six cardboard boxes with the following contents:

- two Gateway 2000 4SX-25
- two color monitors
- two keyboards
- two Epson printers LQ-1070

- two printer ribbons.
- six power cables
- two windows 3 software
- one Q-view software
- two sets of DOS 5 software
- manuals.

b) Inventory and Computerized List of Equipment to be made by the CTA.

The inventory work of all the equipment of NMDC, including that provided by UNIDO, is underway. As information here is incomplete, UNIDO - Vienna was asked to help us with the provision of all purchasing orders issued during this project. This information will help in the identification and control of the equipment. Meanwhile, members of the Maintenance Crew are visiting the various laboratories and identifying each piece of equipment.

IV. PROJECT IMPLEMENTATION COMMITTEE AND THE TRIPARTITE REVIEW MEETINGS

Both meetings were held in Jos in the month of April. Various issues relevant to the present situation and progress of the three sub-projects, including training, were discussed.

V. CONCLUSION

1 - Whenever there are no carbonization tests underway in the COPP, the coke oven is maintained at between 900°C and 1000°C. During this period, only one carbonization test was carried out due to the unavailability of imported prime coking coal samples. The main supply of imported coal samples is yet to be received from Ajaokuta Steel Project.

2 - In this period, an NMDC Liaison Office was established at Ajaokuta and the COPP was officially commissioned. Also, NMDC management decided to make some changes in the Fuel and Energy Laboratory, such as the deployment of a research staff member to work in this lab, and to put it under the supervision of the COPP Manager. The aim was to harmonize the activities of both the COPP and the F&E section, and prepare the ground for good support of the COPP.

3 - Controversy over the soil test results have delayed the detail structural engineering design of the MBPP. Nevertheless, Model Engineering Services Ltd. has concluded the work of structural design, and the bill of quantities is being prepared.

4 - About 23 crates of equipment from China and India have arrived. Some were stored in the foundry building and others in the open air

due to lack of space in the foundry building. Provisions have been made to protect them from the rain and attack of termites.

5 - The revision of the Mineral beneficiation pilot plant design report by the CTA was concluded, and a draft of the report with the observations and recommendations was made available for internal discussion. The final report will be released afterwards.

6 - The visit of the CTA to Coal Corporation, Project Development Institute (PRODA) and Delta Steel Company was beneficial. The information gathered in the coal washery plant of coal corporation will help in the design of the coal processing line of the MBPP. On the other hand, Delta Steel Co. expressed its willingness to work together with NMDC on joint projects on the basis of the problems encountered at the production plant. The possibilities for mutual cooperation are excellent. (See report in appendix).

7 - The PIC meeting held in April recommended the CTA to carry out the basic design of the coal processing line and drying facility for the MBPP. However, one of the prerequisites for doing this task was to visit the coal washery in Enugu. Now that this visit was undertaken, the work will begin as soon as possible and is expected to finish in two or three months.

8 - The 100-Tonne hydraulic press has no manual for its installation, and our request to the supplier did not bring good results. This situation, along with the lack of mould, is delaying the progress of the refractory sub-project. UNIDO - Vienna was asked for assistance in solving this problem. Also, we are thinking seriously of solving it by ourselves. Should this approach be approved by the Management of NMDC, then the New Instrument Maintenance Crew will be involved in this task.

9 - Institutions such as the Development Centre of Zaria and PRODA of Enugu are being considered for the construction of the Mixer for the refractory laboratory.

10 - After intensive efforts, the Metallurgical Institute of Romania (ICEMSA) was located for training the research staff of NMDC. The money for this activity is limited, hence our intention of locating an economical place to train eight or ten research staff personnel.

11 - During this term, the Geiseler plastometer and the Dilatometer were installed in the Fuel and Energy Laboratory. Also, the pumping system of the bomb calorimeter was rehabilitated.

12 - The research staff of the Fuel and Energy Lab., coordinated by the CTA, was able to fabricate a swelling index device similar to that used by DMT Germany. This equipment proved to be reliable, and will improve the capability of the F&E lab. in the support of the work of the COPP.

13 - The installation of the XRD is underway, as well as the rehabilitation of equipment such as the visible spectrophotometer and the Py Unicam Atomic Absorption. IAN Associates or Zaria is engaged in these repairs, but the final results are yet to be seen. On the other hand, the results given by the Wet Chemical Lab. were not too reliable and measures are being taking to correct this anomaly.

14 - In the Metal Dept. equipment provided during this project was in the process of of being either installed or rehabilitated. Among this equipment are the precision lathe machine, the TINIUS Universal Testing Machine, the Movipol 2 and the Transpol 2.

15 - During this period, two computers were supplied by UNIDO and they are in good working conditions.

16 - The work towards the inventory and computerized list of all equipment existing in NMDC, including that supplied by UNIDO, is

underway. The information about it is scarce and it may take sometime before it is completed. The work has to begin from scratch.

17 - The project implementation committee and the Tripartite Review meeting were held in April 1993. Relevant issues connected with the present situation and progress of the three subprojects and training were discussed. Additional information about these meetings can be found in the summary made available to the parties involved.

PROGRESS REPORT NUMBER THREE ON THE PROJECT ACTIVITIES. PERIOD JULY - SEPTEMBER 1993.

PROJECT DP/NIR/87/031

PREPARED

BY

WILFREDO A. BELTRAN
CHIEF TECHNICAL ADVISER

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PROGRESS REPORT NUMBER THREE ON THE PROJECT ACTIVITIES. PERIOD JULY - SEPTEMBER 1993 PROJECT DP/NIR/87/031

Prepared BY

WILFREDO A. BELTRAN
CHIEF TECHNICAL ADVISER

I. INTRODUCTION:

In March 1993, a rather comprehensive progress report on the project was issued. In June 1993 a second Progress Report was issued, but in the form of "brief comments on the project activities", as the compilation of the NMDC quarterly report for that period was underway. The present progress report No. 3 describes activities referring to the three sub-projects and other relevant supporting activities during the period of July - September 1993

II. PROJECT DP/NIR/87/031

1. COKE OVEN PILOT PLANT (COPP) SUB-PROJECT

a) Running Temperature of Coke Oven:-

Whenever carbonization tests were not being done, the temperature in the coke oven was maintained at around 900°C. As the power supplied by NEPA would fail very often, the standby generator was capable of starting up immediately. Even with the scarcity of gas in town, efforts were made to keep the coke oven temperature at an appropriate level. However, there was at least one occasion on which the coke oven burners were not working for almost two hours due to the lack of electrical power or to malfunctioning of the gas

supply system. On these occasions, the emergency heating system, which still needs to be optimized, helped to keep the temperature at a safe level.

b) Testing:

Since May 21, when the COPP was officially commissioned, no carbonization test was done until Sept. 17 as there was no foreign coal available. But now that this coal has been arriving in Ajaokuta since last month, NMDC has received 13 drums of coal samples supplied by Agro Allied (from Australia) and 12 drums of coal samples supplied by Carbon Energy (from USA). These samples are presently being characterized at the laboratory level. The present carbonization tests, at both laboratory and pilot plant levels, are being done in order to verify the quality of the foreign coals received.

c) Infrastructure:

So far, all the infrastructure needed for the COPP has been concluded. The coal storage place was also finished during this period.

d) Maintenance and Spare Parts:

Repairs were done on the impact crusher and micum drum switches, as well as greasing of this equipment and the briquetting machine. Realignment of the horizontal hole was also done so that the installation of the ceramic rod to measure the Shrinkage and

Swelling Index force during carbonization would be possible. This work was accomplished using the drilling rod sent by DMT Germany. Also, quotation of spare parts for key equipment of the COPP was requested from the manufacturer and is at present being evaluated.

e) Cooperation of NMDC and ASC.

During my visit I observed that the relationship of both institutions is excellent. Ajaokuta Steel Company is now very much interested in verifying the quality of the coke and coal supplied to them. In this respect, they have sent coke and coal samples to NMDC for characterization tests.

Also, ASC now seems to realize the importance of having a COPP within the country. This fact may facilitate NMDC's requesting ASC for some kind of financial cooperation in order to meet the running cost of the COPP.

2. REFRACTORY SUB-PROJECT

a) Laboratory Testing Work

During this period, the laboratory was engaged in some testing work directed to the characterization of a Chrome Magnesite and fire clay samples from Ajaokuta Steel Co. In this respect, properties such as density, porosity, bulk density, etc. were determined. The laboratory was also involved in moulding

bricks using clay from the Ekulu deposit, but these bricks were not fired due to problems encountered with the new Entech Furnace.

b) 100 Ton Hydraulic Press and Mould:

So far the supplier has not been helpful in providing a manual for the installation and operation of the hydraulic press. On the other hand, the UNIDO Purchasing Department has helped us to contact possible suppliers of the mould. Specifically, PLANSON INTERNATIONAL made an offer to provide us with moulds apparently made by IQBAL MACHINE INTERNATIONAL of Pakistan, who supplied us the press.

After deliberations, we agreed with this offer, but also asked UNIDO to find out if the Pakistani supplier could send a technician to install the equipment. We are waiting to know the outcome of this enquiry.

We realize that the lack of moulds and also of the manual for putting this hydraulic press into operation has caused us delay in the progress and conclusion of this sub-project. Therefore, we recently decided to solve this problem by ourselves. So far, our Foundry Section has already managed to construct a mould which will be tried out, and the New Instrument Maintenance Crew is now working on the installation of this equipment. At present we are studying the hydraulic and cooling systems, and starting to work on the electrical connection and plumbing for water supply, etc.

Finally, with respect to the capability of this equipment to produce a prototype of a refractory brick for the steel industry, I expressed my concern about it in my report of March 1993. However, I also realized that this hydraulic press will be useful for producing prototypes for other industries.

c) New Entech Furnace and Drilling Machine:

Neither of these are in operating condition now. During this period, after the Furnace fuse was replaced once, it failed again and since then has not been working. This problem will be studied in detail by our Instrument Maintenance Crew, and so will the electrical malfunction of the drilling machine. Both pieces of equipment, especially the furnace, are key items for the production of prototype bricks; hence the urgency for their repair.

d) Acquisition of Mixer:

As part of the preparation of facilities for the production of prototypes of refractory bricks, the purchasing of a mixer from Industrial Development Centre, Zaria was decided upon after careful evaluation. This equipment is presently under construction and should be ready soon.

e) Relationship with the Industry:

During my trip to Coal Corporation PRODA and Delta Steel Company, I identified, along with the R&D Department of DSC, various

problems connected with refractories. The most immediate was in the production of high grade magnesite (80% MgO) for immediate use at DSC. In this respect, the Management of NMDC was advised to approach them so that a joint project could be implemented. For more detailed information see CTA's visit report which is enclosed.

3. MINERAL BENEFICIATION PILOT PLANT SUB-PROJECT (MBPP)

a) Start-up of Infrastructure Work:

When the structural drawings based on the UNIDO Consultant's design, the soil test, and the load-bearing capacity information were concluded by Model Engineering Design and Development Co. Ltd., the bill of quantities which came to be high was also presented by Mahalli Development Consortium. Based on this information, NMDC decided to reappraise the MBPP infrastructure and design with the aim of lowering costs. As this exercise could imply some modifications, NMDC persuaded Dr. Rao to come to Jos as soon as possible to help us in this aim, as he was the designer of the MBPP. After the reappraising exercise, the work for the infrastructure should begin immediately, as part of the funds for this work have been recently released by the Federal Government.

b) Request for Conveyor Belt System Modification:

In July, Kamet of Finland approached NMDC through UNIDO to study some suggestions for the modification of the conveyor belt system. NMDC gave its views on the matter, but we thought that the author of the design should be consulted on these important issues. In this respect we asked UNIDO Vienna to contact Dr. Rao.

c) Reception and Inspection of MBPP Equipment:

As I mentioned in my previous report, some equipment has been stored in the foundry building and some in the open due to lack of space. During inspection of this equipment, it was observed that the items stored in the open have started rusting and their crates were attacked by termites. Although some measures have been taken to protect this equipment from rust, keeping it in a rain-free place would be more appropriate.

Also, a crack was observed on one of the support frames of the rotary scrubber supplied by SAYAJI IRON & ENGINEERING CO, India. This crack, however, can be welded prior to installation. Regarding equipment supplied by BGRIMM of China, the flotation machines did not arrive with spare impellers as stated in the packing list. Also we could not locate some of the starters requested by the NMDC inspection team during their visit to China. We will inspect the crates again to verify our previous findings.

To date the following equipment has been received:

S/N.	EQUIPMENT	SUPPLIER	PURCHASING ORDER
1.	Jones WHIMS	KH.D. Humbold Wedag, Germany.	15-2-0529k
2.	Jaw Crusher 12" x 7"	Mineral Department Australia	15-2-0530k
3.	Hydrocyclone Testing Rig.	Mineral Department Australia	15-2-0530k
4.	Vibrating feeder (2) Mod. D58B	Eriez Magnetic U.S.A.	15-2-0531k
5.	Hopper belt ore feeder	BGRIMM, China.	15-2-0532k
6.	Spiral Classifier (2)	"	15-2-0532k
7.	Thickener	"	15-2-0532k
8.	Conditioner (2) O 750 x 1000mm	"	15-2-0532k
9.	Flotation cells (10)	"	15-2-0532k
10.	Dry reagent feeder	"	15-2-0532k
11.	Water pump	"	15-2-0532k
12.	Double deck screen (2)	TATA Robins Fraser Ltd. India.	15-2-0698k
13.	Rotary Scrubber	Sayaji Iron & Eng. Co. India.	15-2-0697k
14.	Sala Wet Ball Mills (2) 1000 x 1500m	Sala International AB Sweden.	15-2-0549k
15.	Electrostatic Separator Mod. HT (15,25,36) 111-15	Carpco Inc. Flo. U.A.S.	15-2-0539k
16.	Mozley Hydrocyclone Test Rig. Mod. C700	Richard Mozley Cornwall, U.K.	15-2-0503k
17.	Chain Pulley Block.	Bertoni SRl. Italy.	15-3-426k
18.	Sala Vertical Pump (2)	Trellex Allis.	15-3-422k

III. SUPPORTING ACTIVITIES

1 - FUEL AND ENERGY LABORATORY

a) Testing Work:

This laboratory started its activities of support to the COPP by characterizing some coal samples supplied by Ajaokuta Steel Co. During these tests they used devices such as the Plastometer, Dilatometer, Swelling Index, Carbolite furnace, etc. So far the laboratory has tested successfully coal samples belonging to suppliers such as PASCOE Co.(USA Coal), Carbon Energy(USA Coal) and Agro Allied (Australia Coal). The aim of these tests was to verify the quality of the coal supplied. These samples were also sent to DMT Germany, for comparative tests analysis.

b) Capability of this Laboratory:

Compared with the situation found at the beginning of the year, this laboratory is now capable of carrying out the basic determinations (proximate, dilatometric, plastometric analysis and swelling index) directed to the characterization of the coal. Several tests have been carried out to confirm the accuracy of the results, which so far seem to be reliable. In short, the reorganization of some key research staff members and the

installation and successful rehabilitation of some key equipment have contributed to this positive change. Finally, as coal research starts with coal petrology, we are studying the situation of the broken-down microscope and reflectometer. This situation could at times be a serious limitation in research especially when blending studies occur. We are weighing the thought of sending the microscope to the manufacturers in Germany for repair assessment against the possibility of replacing it with a new one.

c) Installation and Repairs:

During this period, the carbolite furnace was rehabilitated. The moisture determinator in a nitrogen atmosphere was set up and the installation of the NSC testing device was also completed.

2. MINERAL BENEFICIATION LABORATORY

a) Crushing and Screening Services

During this period, the lab. was involved in some crushing and screening activities for clients. The mineralogical lab. also carried out textural analysis on the Chokochoko iron ore deposit.

b) Key Equipment Needed:

In order for the mineral processing lab. to give good support to the MBPP it should have the necessary testing facilities, especially as some of them will be transferred to the pilot plant. In this respect, a list of equipment needed in the mineral

processing lab. and sampling was elaborated and passed on to UNIDO - Vienna for quotations so that we could evaluate the possibilities of acquiring some of it. We are still expecting information on this matter.

3. CHEMICAL LABORATORY.

a) Wet Analysis Laboratory:

During this period, this lab. was engaged in the analysis of some samples for clients. In the last 3 months, several ore samples were analyzed for total iron, calcium, magnesium, silica etc. As the main problem of this lab. was the reproducibility of the results, the assayers were sometimes involved in cross-checking their results. In this respect there is a need for a detailed examination of all factors which might contribute to this error. Sampling, weighing methods, attacking, filtration, titration, quality of reagents, human error, etc, should be among the factors which need to be examined. Mr. Bin Fu, UNIDO Consultant in Wet Chemical Analysis, arrived in Jos on the 10th of September 1993, and with him we expect to make progress in this laboratory. Also, on the 15th of September, 1993 a New electrical balance was installed giving us 2 balances which are in good condition. Also a furnace from the Pollution Lab. was transferred to the Wet Lab. In short, this laboratory has most of the basic facilities for the Consultant to work smoothly. The problem of water shortage in this lab. is yet to be solved.

b) Instrumental Analysis Laboratory:

During this period, there was no analytical activity in this laboratory as most of the equipment was either broken-down or in the process of rehabilitation, especially that of the Atomic Absorption which is considered crucial. IAN ASSOC. of Zaria was first involved, without success, in the repair of this equipment. Recently, Winelight Nig. Ltd., of Lagos (ex-Phillips) was recently granted a contract to repair the A.A.S, and it is now operative. The poor reproducibility problem of the 2 UV - Visible spectrophotometer recently repaired by IAN ASSOC. is yet to be solved.

At present this lab. is being relocated to a more suitable place. This new location will house equipment such as the A.A.S, flame photometer, carbon sulphur analyzer and the 2-UV-Visible spectrophotometers. With respect to the X-Ray diffraction, its installation has been concluded recently by an ex-Phillips contractor, and it is ready for manual use. The purchasing of software for it is being pursued. On the other hand, the X-Ray fluorescent is yet to be installed. The computer has already been purchased but some parts are yet to be supplied. We hope that by the time the UNIDO Consultant in Instrumental Analysis comes most of our equipment will be functioning.

4. REHABILITATION OF EQUIPMENT

a) Present Situation:

There is considerable broken-down equipment in the Centre. Until recently most of the repairs were undertaken by local contractors but with few exceptions most of them did not perform as expected. Under this situation, it was agreed that a new Instrument Maintenance Crew should be formed to work for the time being under direct supervision of the CTA's office. This crew was them formed by deploying 3 staff members from other sections, from which only one person has the necessary experience as he was heading the Electric/Electronic Section. Obviously most of the work load is now on one person, and unless another person with some experience is employed to help with the work, the progress would be slow. Nevertheless, in spite of limitations, progress in the rehabilitation of testing equipment has been substantial and encouraging.

b) Equipment So Far Rehabilitated or Installed:

So far, the performance of the "New Instrument Maintenance Crew", notwithstanding certain difficulties, has been satisfactory. Below is listed some of the main equipment rehabilitated and installed during this period:

- Transpol No.2 - Metallographic Lab.
- Movipol N. 2 - Metallographic Lab.
- Lathe Machine - Metal. testing Lab.

- Tinius Universal Testing Machine	-	Metal testing Lab.
- Water Distiller	-	Chemical Laboratory
- Carbolite Furnace	-	Fuel & Energy

At present they are also engaged in the repair and installation of the following equipment which is considered priority:

- New 100 Ton Hydraulic Press	-	Refractory Lab.
- New Drilling Machine	-	Refractory Lab.
- New Entech Furnace	-	Refractory Lab.
- 7kg Coke Oven	-	Fuel and Energy Lab.

5. TRAINING

a) External Training:

In this period Mr. Sanni, from Refractory Laboratory, has been sent to India for training during 6 weeks. Also we were able to locate a reasonably good training place in Romania as their charges are very low. In this respect, we asked UNIDO - Vienna to help us send six research staff members there for training in September or October 1993. On the other hand, due to limitations of funds, we are still trying to locate a more economical appropriate place for computer and coal petrology training.

b) Study Tour:

Under this scheme Dr. Usman M. Turaki, Director/Chief Executive, is expected to go to a conference in Vienna early in October, and Mr. Nwosu to Brazil for a conference in refractory late in October. Mr. Olubajo and Mr. Odentundun are still expected to go to Tunisia 19th to 21st October, 1993.

c) Internal Training:

Two course of two weeks duration each have been organized by NMDC with the assistance of IAN ASSOC. of Zaria. These courses were in laboratory techniques, directed to laboratory attendants, and in instrument maintenance, directed to the new Maintenance Crew and other research officers interested in acquiring maintenance culture.

6. OTHER RELEVANT ACTIVITIES

a) Supply of Computers by UNIDO

On the 10th of June 1993, the Computer Centre received six carton boxes (Purchase Order No. 15-2-0998K). The boxes' contents are as follows:

a) Two Gateway 2000 4SX-25 (Hard Disk Unit)

b) Two Color Monitors

c) Two Keyboards

d) Two Epson Printers LQ-1070

e) Two Printer Ribbons

f) Six Power Cables

g) Two Windows 3 Software

h) One Qview Software

i) Two set of DOS 5 Software

j) Manuals

Installation of the two-Computer System was successful except for one little problem. The Computer Clock Battery in one of the Hard Disk Unit was dead. We purchased it locally and IT was successfully replaced by our Maintenance Crew. Both the Computer Systems are now in perfect working condition.

b) Library:

Up to now, no 1993 journals have been received from the supplier. In fact we do not know whether NMDC's subscription for 1993 was renewed. In this respect, we have written to the supplier MUNKSGUURD and UNIDO - Vienna enquiring about the situation. We are also compiling a list of important books for the Centre, and UNIDO - Vienna will be approached soon on this matter.

IV. OTHER CTA ACTIVITIES AND TASKS DURING THIS PERIOD

1. COMMENTS ON THE MBPP DESIGN REPORT:

A draft of my comments on this matter was released for internal discussion in May; however as this discussion was delayed, the report was not released until last month. With reference to my observations and comments, these are made from a professional point

of view and are there to be used if needed by the UNIDO Consultant (MBPP) or the NMDC staff as a reference or guideline. This report has been distributed to the parties involved and will also be given to Dr. Rao on his arrival. For more details about it please refer to the report enclosed.

2. VISIT TO NATIONAL IRON ORE MINING PROJECT AT ITAKPE AND AJAOKUTA STEEL COMPANY.

This visit was undertaken with objectives connected to training, mutual cooperation, process and plant design, etc. These objectives were met, and in my report suggestions and recommendations were made to the Management of NIOMP and NMDC on various relevant issues.

The recommendations to NIOMP were made on a personal/professional basis and as a means of contribution, and by no means compromise the views of UNIDO as an institution. With respect to the recommendations to the Management of NMDC, the most relevant are concerned with mutual cooperation, training of the MBPP personnel, and the possible acquisition of additional testing facilities to the MBPP so that the Itakpe iron ore could be tested with a similar flowsheet to that of the industrial plant, etc. My visit to Ajaokuta Steel Company was brief. Nevertheless, their good disposition for mutual cooperation was notorious. At present they are interested in verifying the quality of the coke and coal being

received, and for this purpose they will continue sending coal samples as soon as they arrive in the country. For more detailed information, see the report enclosed.

3. VISIT TO COAL CORPORATION AND PRODA AT ENUGU AND DELTA STEEL COMPANY.

The visits to these institutions were also made to fulfil similar objectives to those stated in the visit to NIOMP. Here too, the visit allowed me to learn about the opportunities for training and mutual cooperation with these institutions. For instance in DSC I learned about problems connected with the generation of fine materials during pelletizing, with refractory material used, etc, and all of them are concerned with production. Therefore, I think there is an excellent opportunity for NMDC to work with them in a joint research project, and DSC is very much in favour of this approach. For detailed information of this visit, please refer to the report enclosed.

4. COMPUTERIZED LIST OF EQUIPMENT SUPPLIED BY UNIDO

The elaboration of this list took more time than expected. To begin with, the information was scattered, scarce or non existent. The purchasing orders sent to us by UNIDO, Vienna made this work easier, at least with the equipment belonging to the present project. The list was finally done and it will be reviewed once more before it is released.

5. DESIGN OF COAL PROCESS LINE AND DRYING FACILITIES FOR MBPP

My visit to Coal Corporation was connected with this task. As per the work, it is well underway and will be presented for internal discussion soon. About the design of drying facilities, the job has not been started yet, but will be completed in time.

6. COORDINATION OF NEW INSTRUMENT MAINTENANCE CREW

This is another activity which is under the CTA and it is a task of a temporary nature. Sometime soon this unit should go back to the Engineering Services Department.

V. CONCLUSION

For more detailed information about the activities carried out within the project during the months of July - September 1993, the reader is advised to refer to the contents of this report.

In general terms, some progress has been made in the project and in other supporting activities which are also important. For instance, the Coke Oven Pilot Plant Sub-Project which is already completed in terms of infrastructure, equipment, etc, is now undertaking carbonization tests on single coal samples. The Fuel and Energy Laboratory is also performing tests at bench scale to support the COPP work.

In the Refractory Sub-Project, some important steps and decisions have been taken recently regarding the rehabilitation and installation of crucial equipment. The local purchase of a mixer is another step towards the conclusion of this sub-project.

With respect to the Mineral Beneficiation Pilot Plant Sub-Project, the money for infrastructure was not released until recently. Therefore, after the infrastructure and possibly the design are reappraised with the intention of lowering costs, the work should begin immediately.

As far as external training is concerned, in this period we were able to find adequate places for training so that with the limited funds available we hope to send about 8 people, along with 4 others for study tours, before the end of the year, and this effort, should basically conclude the training sub-project.

COMMENTS ON THE DESIGN REPORT OF THE MINERAL BENEFICIATION PILOT PLANT (MBPP) MAY, 1993

BY
WILFREDO A. BELTRAN
CHIEF TECHNICAL ADVISER
(PROJ. DP/NIR/87/031)

I INTRODUCTION

As CTA of this Project and a Mineral Processing Engineer, I feel obliged to contribute some ideas in the design of the projected pilot plant, which I think is basically well done. I understand that at this point any drastic changes may not be advisable; however, as the construction has not started yet, I think I still have time to make some suggestions. These suggestions, by the way, should by no means be taken as an obligation or imposition, but simply as independent opinions given from a purely professional point of view.

It is understood that the working philosophy in a pilot plant is that, before testing at this scale, a suitable processing scheme has to be set up according to the bench scale test. Therefore, it is advisable that the equipment be installed with enough flexibility so that it could be easily relocated to form a recommended flowsheet. In this respect, my comments will be limited only to the improvement of very basic processing schemes. Other areas of the design, such as the requirements of water, power, etc; are already well-covered in the report and there is no need for me to go into them.

II. GENERAL BACKGROUND OF THE PILOT PLANT DESIGN REPORT:

Due to limitation of funds, the pilot plant's capacity was set up for 250 kg/hr, with future plans for increasing it to 500 kg/hr. Some of the available equipment in the mineral processing laboratory has been considered as part of the pilot plant. According to the design report, this pilot plant would be able to process three different types of ores simultaneously if required. The pilot plant site, whose topography shows some inclination, was chosen to lie between the Administration Building and Zaria Road.

With respect to housing, the plant is supposed to be accommodated in four different buildings/sheds. The water requirement has been estimated at 33 m^3/day, and the power load at 221 KVA. For tailing disposal, it has been proposed to have three check dams located adjacent to the processing plant, and the possibility of recycling the water was also contemplated. The MBPP design report covers some environmental recommendations as well.

III. PLANT SITE:

In the early days of Mineral Processing, most plants were installed on sloping land following the down-stream direction. In the later years, the construction of plants on flat land became a common practice due to the advantages it offered during operation. However, in the projected pilot plant I understand that the crushing plant will be set up on the

slightly inclined portion of the present plant site following the upstream direction. I suppose this is a matter of viewpoint, but personally I would have preferred to set up the entire pilot plant on flat land, within one building sufficiently high as to house an electrical crane and to allow for a two or three story construction.

IV CRUSHING:

The flow sheet of the crushing section specified in the pilot plant design is shown in drawing No. 1.

1. Observations:

The 127 x 152mm (3B) primary Denver jaw crusher may find it difficult to reduce in one step an 8" or 6" size run of mine ore down to -1 1/2" size, as specified in the design. Subsequently, the 154 x 152mm (5) secondary roll crusher may find it hard to produce the -3/8" size product specified in the design and at the same time handle the tonnage expected. Therefore, it is more likely that a bottle-neck phenomenon may originate at this point.

2. Suggestions:

a) In the light of the above, it might be worthwhile to consider the use of crushers of a larger capacity and the flowsheet presented in fig. No. I. For the primary crusher, I would suggest using the bigger jaw crusher, 305 x 178mm (2c)

just purchased from Mineral Deposit, and for a secondary crusher the gyratory crusher No. 12 which is now in the laboratory, or even the available 127 x 152mm jaw crusher.

b) If good size reduction and product size control is needed, it might be worth considering in the future a third stage and a closed circuit crushing. The latter could be inplemented also in the second stage crushing as shown in fig. No. II, but it is preferable in the third stage.

c) Should a very sticky or clayey ore appear, washing of the ore after the primary crusher, as shown in figure No. III, may be required. This means that the scrubber may need to be relocated temporarily to this point. Therefore, provisions might need to be made during equipment installation for possible future relocation of the scrubber.

d) At times, clients may only request crushing and screening tests of a dry material. For this purpose, it may be good to allocate a space around the crushing section for stockpiling the products. The availability of a mobile conveyor belt would surely help this operation.

V. **FINE BINS:**

The process flowsheet of the pilot plant design, which includes the four fine bins, is presented in drawing No. 22.

1) Observations:

a) The pilot plant has been projected to have four fine bins so that each processing route could have its own bin. According to the design report, this was conceived so that the pilot plant could allow for simultaneous testing of three different types of ores. (See drawing 22). These bins appear to have been designed to function independently, which would seem to make it difficult for them to operate with other processing lines in emergencies.

b) The simultaneous treatment of three types of ores may not be advisable at this point due to possible limitations of present crushing capacity, manpower, water requirement, etc, which roughly would have to be tripled. Furthermore, the material handling (15 conveyor belts and feeders) which this scheme involves seems to make the flowsheet somewhat complicated. (See drawing No. 22).

2. Suggestions:

a) Due to the possible limitations mentioned above, I suggest testing in the pilot plant one type of ore at a time.

b) I also suggest reducing the number of fine bins to one or two of 10 tons each. This scheme could bring benefits in terms of simplification, lower capital costs, and operating efficiency. (See proposed flowsheet in fig. No. IV.)

VI. SCRUBBING, SCREENING AND HYDROCYCLONING:

The process flowsheet of this section, specified in the pilot plant design, is shown in drawings. No. 2. and No. 3.

1) Observations:

The process flowsheet seems to have been based on, among other ores, beach sands or other alluvial deposits where the majority of the mineral components are liberated. Therefore, the process scheme and the equipment considered could very well accommodate the processing of similar ores. In the case of beach sands, this section would only be involved in the preparation of feed for further treatment.

2) Suggestions:

As an alternative, and with the aim of simplification, it might be worthwhile to consider the flowsheet shown in fig. no. V. Also, for the processing of typical beach sands, it may be advisable to consider the process scheme shown in fig. No. VI-1, which by the way will need to be readjusted for the recovery of cassiterite.

VII. GRAVITY CONCENTRATION:

The flowsheet for the gravity separation section specified in the pilot plant design is presented in drawing No. 4.

1. Observations:

a) The fact that screening (+ 1mm - 1mm) is considered before grinding, and its products directed to mineral separation devices, may not be appropriate due to possible poor liberation of values at this coarse-size fraction. Also, grinding in a rod mill which is advisable in gravity concentration has not been considered here as the two new mills are ball mills. The classifier, which has not been considered in the grinding circuit, may not allow the separation of unliberated coarse particles for further liberation.

b) In the design, the jig will be working with coarse particles; however, further grinding of the middlings and tailings seems not to have been taken into account. The same situation occurs with the middlings of shaking tables and the spiral concentrator.

c) With respect to feed preparation for concentration in shaking tables, classification by a hydrocyclone has been considered. However, this device alone may not be

best as the size range of the underflow product is still wide and the flow pressure fluctuation may hinder the separation process.

2. Suggestions:

a) In view of the above, and with the hope of finding a solution to these possible difficulties, it may be advisable to consider the flowsheet shown in fig. No. VII. This scheme takes into account the available equipment, except for the mixer for the underflow which is supposed to guarantee smooth feeding to the shaking tables. In this scheme, the jig is placed after primary grinding for fast removal of values. A classifier is considered in the grinding circuit for removing the coarse particles for regrinding, and depending on the degree of overgrinding, one could decide whether to use one of two ball mills. Finally, screening before grinding has not been considered here.

b) For better shaking table performance, it is advisable to consider preparing the feed with the hydraulic classifier, as shaking tables work better with narrow size-range particles. It may also be advisable to consider in the future the use of two kinds of shaking tables, one for coarse sizes and another for fines or slimes.

c) The capacity of the two laboratory shaking tables of different sizes (12a and 13B) may not be sufficient to handle the proposed feed rate. Therefore it is suggested to look into this matter, as the maximum total capacity of both tables may be about 182kg/hr.

VIII MAGNETIC SEPARATION:

The process scheme for the magnetic separation specified in the pilot plant design is shown in drawing No. 5.

1) Observations:

In the design, magnetic concentration is done right after sizing and grinding. However, as in many cases, a pilot plant flowsheet may need to contemplate a gravity concentration process previous to the magnetic separation process.

2) Suggestions:

In Fig. No. VIII is shown a possible integrated process flowsheet for magnetic concentration, which by the way was prepared taking into account the gravity concentration and flotation processes. As was said before, this flowsheet is only a blueprint, and the final scheme will have to be decided according to the mineralogical characteristics of the sample and bench scale tests.

IX. GRINDING-FLOTATION:

The process scheme for the flotation section specified in the pilot plant design is shown in drawing No. 6.

1) Observations:

a) In the design, the preparation of the fresh feed seems somewhat complicated as it involves three-stage grinding and two-stage classification. However, due to sufficient available grinding capacity this scheme in most cases may not be necessary, as it may cause overgrinding, higher operating cost, and high circulating load in the grinding circuits.

b) With respect to the flotation cells, their arrangements (shown in drawing No. 22) may not favour good performance. The total volume of the six Denver cell units (2.4 cu ft or 0.068 m^3 (24A) seems too small to work as "primary flotation" (Rougher - scavanger). A rough calculation of pulp volume at this point, including 15% of circulating load, would give about 0.51 cu ft per minute; therefore the approximate retention time in this unit would be closer to 5 minutes. On the other hand, the ten new BGRIMM cells (24B) with a total volume of 45.9 cu ft. or 1.3 m^3 seem to be over-dimensioned to work as "cleaners" or even as rougher-scavangers.

2) Suggestions:

a) In the light of the above observations, it might be worthwhile to consider the process scheme of Fig. No. IX. This scheme contemplates a closed-circuit grinding and the use of one ball mill only. Also, the flotation cells have been re-arranged so that at least one type of ore could be floated. For this purpose the larger BRGIMM flotation unit (24B) has been considered to work as Rougher Scavanger (primary flotation), and the smaller unit Denver flotation cell (24A) as cleaners due to the existence of lower pulp volume at this point. Even so, the capacity of the Denver unit would continue being short and that of the BGRIMM unit excessive. In the case of polymetallic ores, the flotation units may require yet another re-arrangement as shown in Figure X, and according to the metal content of the ore.

b) To improve the capacity of the smaller Denver cell unit (24A) it is suggested that additional flotation cells be added, either by acquiring new cells or finding another solution to this problem. The ten new BGRIMM cells recently purchased have plently of capacity to spare; therefore this could be the solution.

c) With respect to liquid reagent feeders, this has not been contemplated in the design. Therefore it may be necessary to consider buying about four duplex and six simplex liquid reagent feeders of the Clarkson type, as in flotation, most reagents are fed in the form of liquids.

d) With respect to the possible need of a higher capacity of grinding and regrinding, the other new ball mill might be put in operation in an open grinding circuit. Should flotation products need to be reground, the tube mill and the hydrocyclone may also be put in operation as an independent regrinding circuit.

X. DEWATERING:

1) Observations:

a) The provision of five settling tanks and a drying pad for dewatering seems to be a good alternative for the time being. However, unless this scheme is strictly controlled, it may generate losses of fine values during dewatering. Besides, the manipulation of the product in this system may be time-consuming, costly, and prone to contamination.

b) According to the design report, only one thickener and one vacuum drum filter will be available. This means that these facilities would be capable of dewatering continuously one type of product only.

2) Suggestions:

a) When funds are available, it would be recommended to have at least two additional dewatering systems. This is in case the mineral processing involves the production of various products as in the case of polymetallic ores.

b) Each dewatering system should consist of one thickener (plus its pump) and a vacuum filter, both of sufficient capacity to yield products of between 8 to 12% moisture.

c) Also, a dryer (rotary) of about 1 ton/hr. capacity may be suggested as part of the pilot plant dewatering system.

XI. PROCESS CONTROL:

Without getting into overly sophisticated or expensive instruments, I think a pilot plant should have basic instruments or equipment which would help process control and thereby process evaluation during testing. In this respect, it would be advisable to provide the pilot plant with weightometers for continuous measurement

of the ore being processed. One could be installed in the crushing section and another in the grinding section. This instrument should not be of a digital type, but electrical and rugged such as those manufactured by MERRICK-USA and used in the Mineral Industry in the sixties.

As reliability of test results starts with good sampling, it is also advisable to provide the pilot plant with Automatic Samplers and installing them at key points of the pilot plant such as the feed, concentrates and tailings. Equipment such as that manufactured by Denver is not sophisticated.

Other process control instruments, for continuous measurement of pH, pulp density etc, are also very important; however, the purchasing of them could be considered later on when the Centre acquires more expertise in instrument maintenance.

As for the idea of purchasing a road vehicle weighbridge now, even though the design report considers buying it later on, it may not be appropriate at this point. However, the previously mentioned process control instruments should be thought of as priorities as they are more urgent than a weighbridge.

XII. ENVIRONMENTAL CONSIDERATIONS:

This issue is well covered in the design report and there is no need for me to go into it. Therefore, I would like just to refer to the dust collector system which I suggest to be installed in the crushing section when funds are available. This system would prevent dust contamination of the surroundings during crushing of dry ores.

XIII. CONCLUSION AND RECOMMENDATIONS:

For detailed information of the contents of this report, the reader is advised to refer to the report itself as this section will only discuss the matter in general terms.

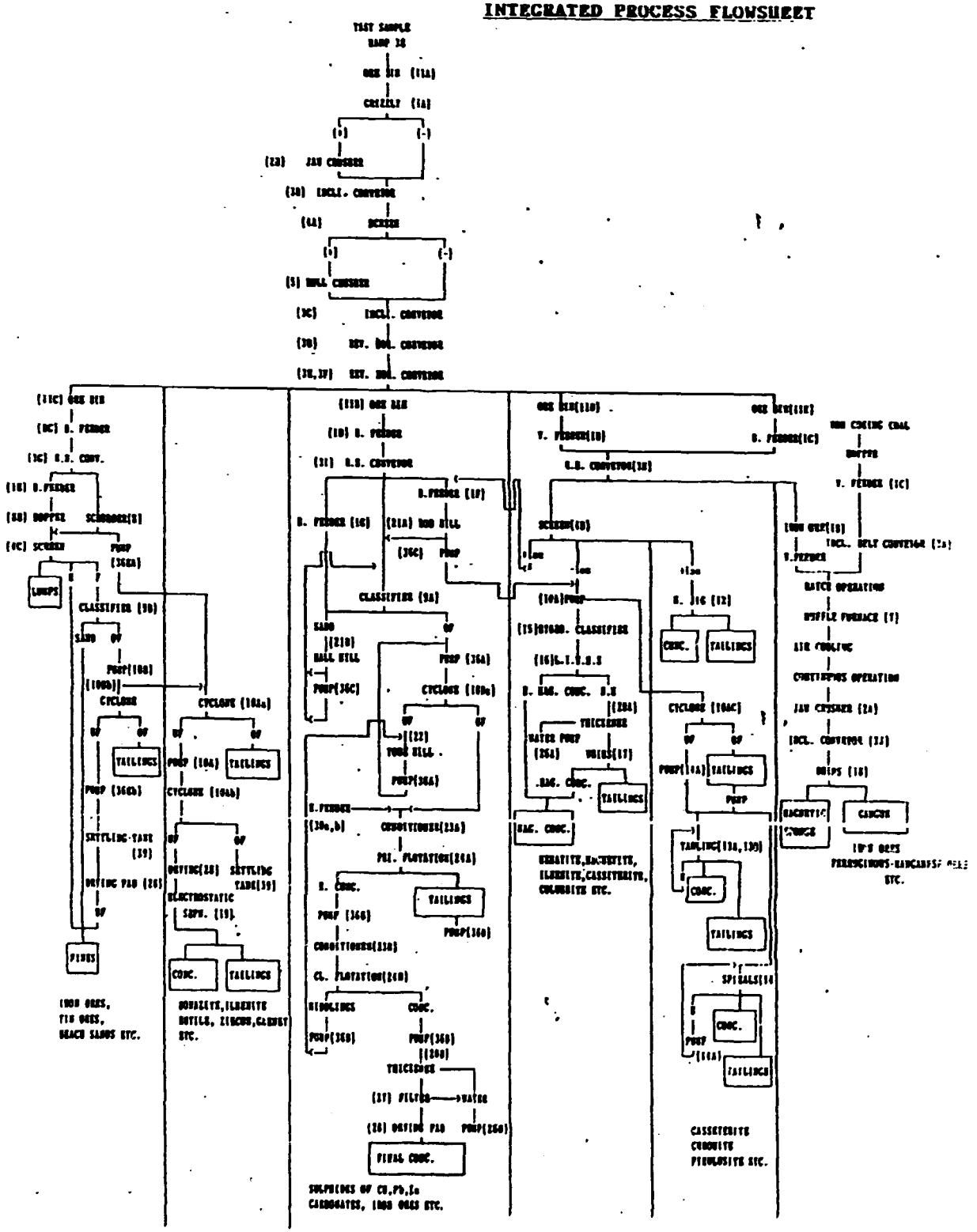
In conclusion, this report was done from a constructive point of view and with the intention of assisting those concerned with the design of the MBPP. In this respect, the observations and suggestions are intended to be helpful and may be used for improvements and future references. The various process flowsheets proposed are presented just to help in explaining my comments, and should be seen only in this light.

As most of the new equipment required has been purchased, and the remaining funds amount to around $ 500,000, it is necessary to be selective and to prioritize. Although most of the suggestions were made taking into account the available equipment, there are a few which imply new acquisitions. Among these would be the weightometers, wet reagent feeders, a magnet for the crushing section, automatic samplers, a bigger shaking table, hydraulic classifiers, electric crane, etc. Additional units of Humphrey spirals and wet low intensity magnetic separators may also need to be purchased in order to simulate the operation of the industrial beneficiation plant of NIOMP at Itakpe. In any case, this matter would require a careful evaluation.

MINERAL BENEFICIATION PILOT PLANT

NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS

INTEGRATED PROCESS FLOWSHEET



DRAWING No. 22

DATE : 13TH OCT. '92

DESIGNED BY: G.S. RAMAKRISHNARAO

APPROVED BY: A.A. ODUNAIKE

TABLE II: DETAILED EQUIPMENT SPECIFICATIONS

EQUIP. NO.	NAME OF EQUIPMENT	SPECIFICATIONS SIZE	CAP. Kh/Hr.	KW.	VOLTAGE V/ph/cy	Qty	Incli. Deg.	Model No.	Wt kg	Eqp. Speed/ Motor RPM.	Overall Dimensions	Supplier	P.O No.	CONDITION OF AVAIL. EQPT.
1A	VIBRA. GRIZZLY	457	1000	0.4		1						MNDC	-	NEW / USD
1B & 1C	HOPPER-ELECT. MAG.VIBRA. FEEDER	356 X 915	500	1.0	230/1/50	2	6	D58B	525		1220 X 676 X 1232	RIBE	0531	
1D - G	HOPPER-BELT ORE FEEDER	500 X 1800									3200 X 1723 X 1760			
		500 X 4000									6875 X 1773 X 1810			
		500 X 5500									7375 X 1773 X 1810			
		500 X 9500	27000	3.0		1			1400	1.5H/S.	11,495 X 1773 X 1810	BGRIMM	0532	
2A,2B	JAW CRUSHER	127 X 152	225	4.0	440/3/50	1			284	325 - 375	1400 X 630 X 910	MNDC	-	NEW
2C	JAW CRUSHER	305 X 178	1000	5.5	440/3/50	1		MDL-JAQUES	1280	350	1410 X 700 X 1170	MIN. DEP.	0530	
3A	BELT CONVEYOR (INCL)	400 X 10M	2000	1.0		1	18					MNDC	-	NEW
3B	BELT CONVEYORS (INCLINED)	400 X 10	2000	1.1		1	18					MIN. DEP.	X	
3C		400 X 50	2000	1.2		1	18						X	
3G, 3I		400 X 3000	2000	1.0		1	18						X	
3E,3AB	BOR. REV.BELT CONVEYORS.	400 X 5000	2000	1.1		1	0						X	
3D	BOR. REV. BELT CONVEYORS	400 X 9000				1								
4A	VIBRATING SCREEN	610 X 914	500	1.5	230/1/50	1	0-50	S-1511				MNDC	-	NEW
4B & C		610 X 1220	1000	2.25	415/3/50	2	16-27	VBF-276			10/800		0698	
5	ROLL CRUSHER(CONE CRUSHER)	254 X 152	2000	8.8	440/3/50	1			660	850-300	1850 X 810 X 218	MNDC	-	NEW
6	AIR CLASSIFIER	457	225			1		44				MNDC	-	NEW
7	MUFFLE FURNACE/(ROTARY KILN)	152 X 152	2	2.0	220/1/50	1						MNDC	-	OLD
8	SCRUBBER/TROMMEL	800 X 1600	500	1.5						22/720		SAYAJI	0697	
8A	FEED HOPPER		500kg											
8C	BELT FEEDER	500 X 2000		1.5						1440				
9A & B	CLASSIFIER	300 X 3000 DOUBLE PITCH	500			2	14-18.5		700	10 & 18	3844 X 756 X 1140	BGRIMM	0532	
10	[illegible] CYCLONE TEST RIG/PUMP/SUMP	250	3.6m³/Hr	1.5	240/1/50	1		C100	950		870 X 500 X 1520	RICHARD MOZLEY	0502	
	10MM CYCLONE		AT	-	-	2		C1005			240 X 240	"	"	
	25MM CYCLONE	Dia 76 X 255 Ht	3.5 BAR	-	-	2		C125			240 X 295	"	"	
	50MM CYCLONE	X 520W		-	-	2		C130			240 X 620	"	"	

EQUIP. NO.	NAME OF EQUIPMENT	SPECIFICATIONS SIZE	CAP. Kh/Hr.	KW.	VOLTAGE V/ph/cy	Qty	Incli. Deg.	Model No.	Wt kg	Exp. Speed/ Motor RPM.	Overall Dimensions	Supplier	P.O No.	CONDITION OF AVAIL. REM.
10A	HYDROCYCLONE TEST RIG/SUMP/PUMP	25L	$3M^3$/Hr	2.2	440/3/50	1	-	MDL/AEV	-	950	Dia 40; 130 X 1210	MIN.DEP.	0530	
	40MM CYCLONE		-	-		1	-	REV 810			Dia 45; 115 X 600		"	
	45MM CYCLONE		-	-		1		CONF.II ERS 98					"	
	10MM/18MM CYCLONE		-	-		1		CONF.II RVE 810					"	
	40MM/37.5MM CYCLONE		-	-		1		CONF. IV RVE 87					"	
	45MM/75MM CYCLONE		-	-		1		CONF. II ERS 98 CONF. IV					"	
11	COOLING KILN												"	
12	MINERAL JIG	102 X 152	70-225	0.18	220/1/50	1	-	B1245A	180	1425	460 X 660 X 1170	MNDC	-0	GOOD
13	MIL PLEY TABLE	1270 X 610	2 X 125	0.4	220/1/50	2		No. 13	135		1700 X 457 X 356	MNDC	-0	GOOD
14	SPIRAL & PUMP	5 TURN	500-1500	1.5	440/3/50	1		SR35MN87	330		710 X 914 X 2539	MNDC	-0	GOOD
15	HYDRO CLASSIFIER (MULTI GRAVITY SEPARATOR)	762 DIA.	100-225	0.2	220/1/50	1			230		876 X 863 X 1320	MNDC	-0	GOOD
16	L.I.M.M.S.		50	1.0	220/1/50	1			100		356 X 610 X 711	MNDC	-0	
17	B R I M S	1.9 TESLA	350	5.0	440/3/50	1		P40	2760		1726 X 790 1960	EIO HUMBOLDT WEDAG	0529	
18	B R I M S (SERIES) CROSS BELT TYPE	152	50	0.5	230/1/50AC 230DC	1		SS-C.B				MNDC	-0	
19	ELECTROSTATIC SEPARATOR.		125-200		230/1/50	1		HT(15,25,36,) -111-15	595		1117 X 660 X 2137	CARPCO	0539	
20A	THICKENER	864 X 762	100	0.18	230/1/50	1		HSQ	380	200	1380 974 X 863 X 1281	MNDC	-0	GOOD
20B	THICKENER	1800 X 1800	54-230	1.1		1		TNZ-1.8	1300		2010 Dia X 1960 X 3430	BGRIMM	0532	
21AA21B	BALL MILL (RL) TRUNNEL	1000 X 1500		11.0	440/3/50	2		SRR 1000 X 1500M	2440		35/1450	SALA	0549	
21C	BALL CHARGE		3300KG	-	-	1						BAMFORDS	X	
22	ROSE MILL (ROD MILL)	305 X 610	50	1.1	440/3/50	1			1050	1425/179	1730 X 937 X 829	MNDC	-0	GOOD
23AA23B	CONCENTRATORS	750 X 1000	$0.5M^3$	1.5		2					750 Dia X 940 X 1540	BGRIMM	0532	
24A	FLOTATION CELLS/COLUMN FLOTATION	0.4Cuft	100	1.5	220/1/50	6	85		270		1600 X 533 X 655	MNDC	-0	GOOD
24B	FLOTATION CELLS	0.13 M^3 500 X 500 X 500	$6M^3$/Hr	2.2		10		SF-0.13	300		5150 X 929 X 1268	BGRIMM	0532	

EQUIP. NO.	NAME OF EQUIPMENT	SPECIFICATIONS SIZE	CAP. Kb/Hr.	KW.	VOLTAGE V/ph/cy	Qty	Incli. Deg.	Model No.	Wt kg	Equ. Speed/ Motor RPM.	Overall Dimensions	Supplier	P.O No.	CONDITION OF AVAIL. EQPT.
25	REAGENT FEEDERS			0.18/0.25									0	
26A & B	WATER PUMPS	20.0M HEAD	6.3M³/Hr	1.5		2		IS-50-32-250J			935 X 450 X 370	BGRIMM	0532	
27	DRUM FILTER	457 X 305	23	2.0		1			750		1067 X 814 X 510	NMDC	-0	
28	SUN/AIR DRYING/DRYER											NMDC	0	
29	PULP DENSITY SCALE	1 LITER				1						DENVER	X	
30	DRY REAGENT FEEDER	170		0.25		2			60	0.5/0.8/1.16	575 X 472 X 750	BGRIMM	0532	
31	ELECTRIC HOIST												0	
32	DUMPER TRUCK												0	
33	FORK LIFTER												0	
34	WHEEL BARROWS	STD. SIZE											0	
35	CHAIN PULLEY BLOCK					1		YBL 100				DEXTON	X	
36A	H & Q SLURRY PUMPS	25		1.0		2			400	1425	480 X 430 X 572	NMDC		FAIRLY NEW
36B	DENVER CENT. PUMPS	38 X 32	500	1.65		2					935 X 432 X 483	NMDC		NEW
36C	DENVER SRL PUMPS	38 X 32	8.7M³/Hr	1.65		2			650		935 X 432 X 483	NMDC		NEW
36D	SAND PUMPS	25	6.9M³/Hr	1.5		2			320		480 X 430 572	NMDC		GOOD
36E	SLURRY PUMPS (RUBBER LINED)	10 M.HEAD	3.5M³/Hr	3	415/3/50	2		SALA SPV-181-40	91		650 X 400 960	TRELLEX ALLIS	X	
37	HANGING MAGNET /ORE BINS												0	

X YET TO BE ORDERED BY UNIDO. * ASSUMED.

x MOTORS TO BE PURCHASED.

. TO BE GOT REPAIRED BY NMDC.

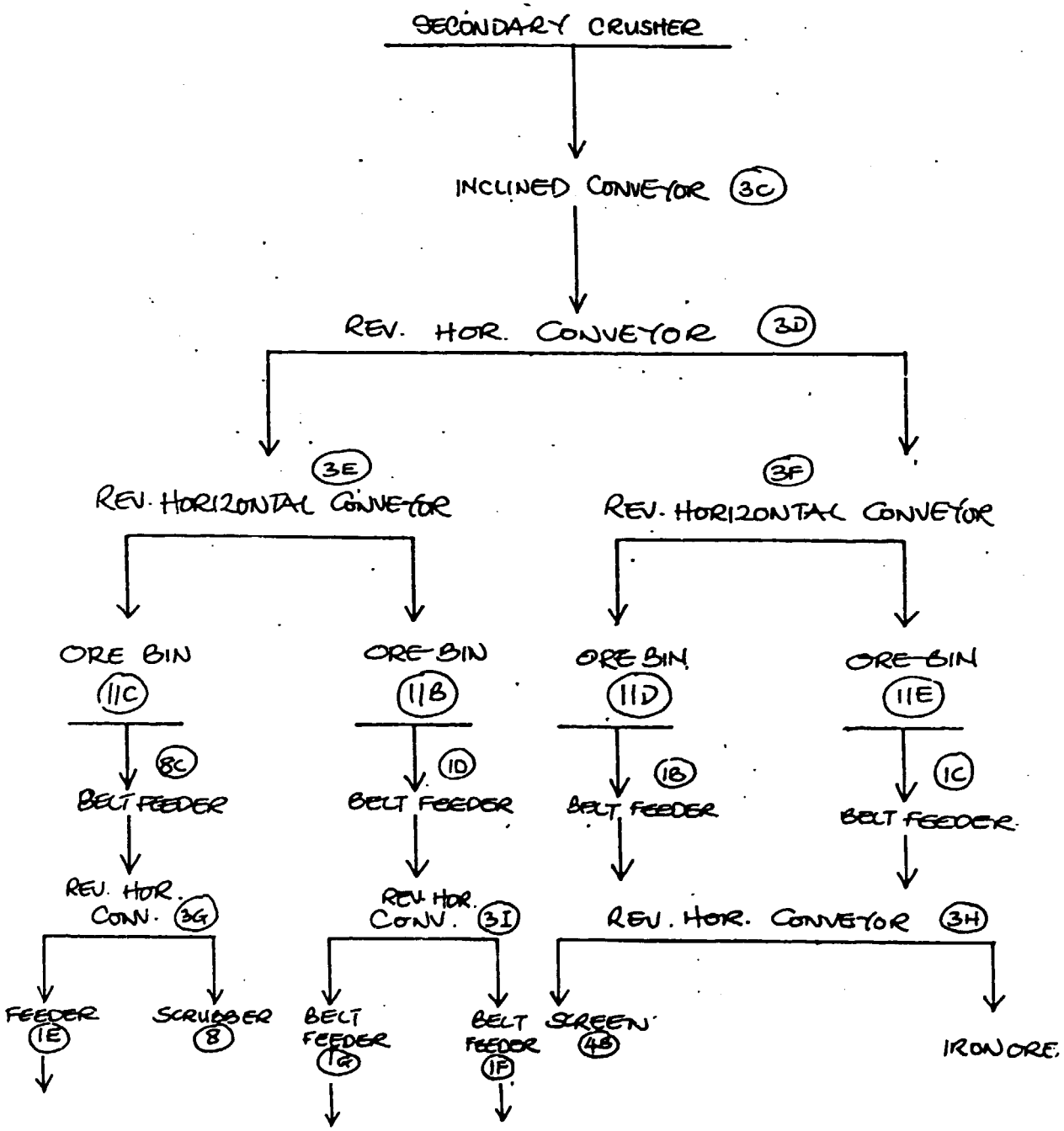
= TO BE GOT FABRICATED/CONSTRUCTED/PROCURED LOCALLY.

* DEFFERED TO SECOND PHASE (TO BE PORCURED AS AND WHEN ADDITIONAL FUNDS ARE AVAILABLE).

Drawing 22

PROJECTED CONFIGURATION OF MATERIAL HANDLING IMMEDIATELY BEFORE AND AFTER THE FOUR FINE BINS

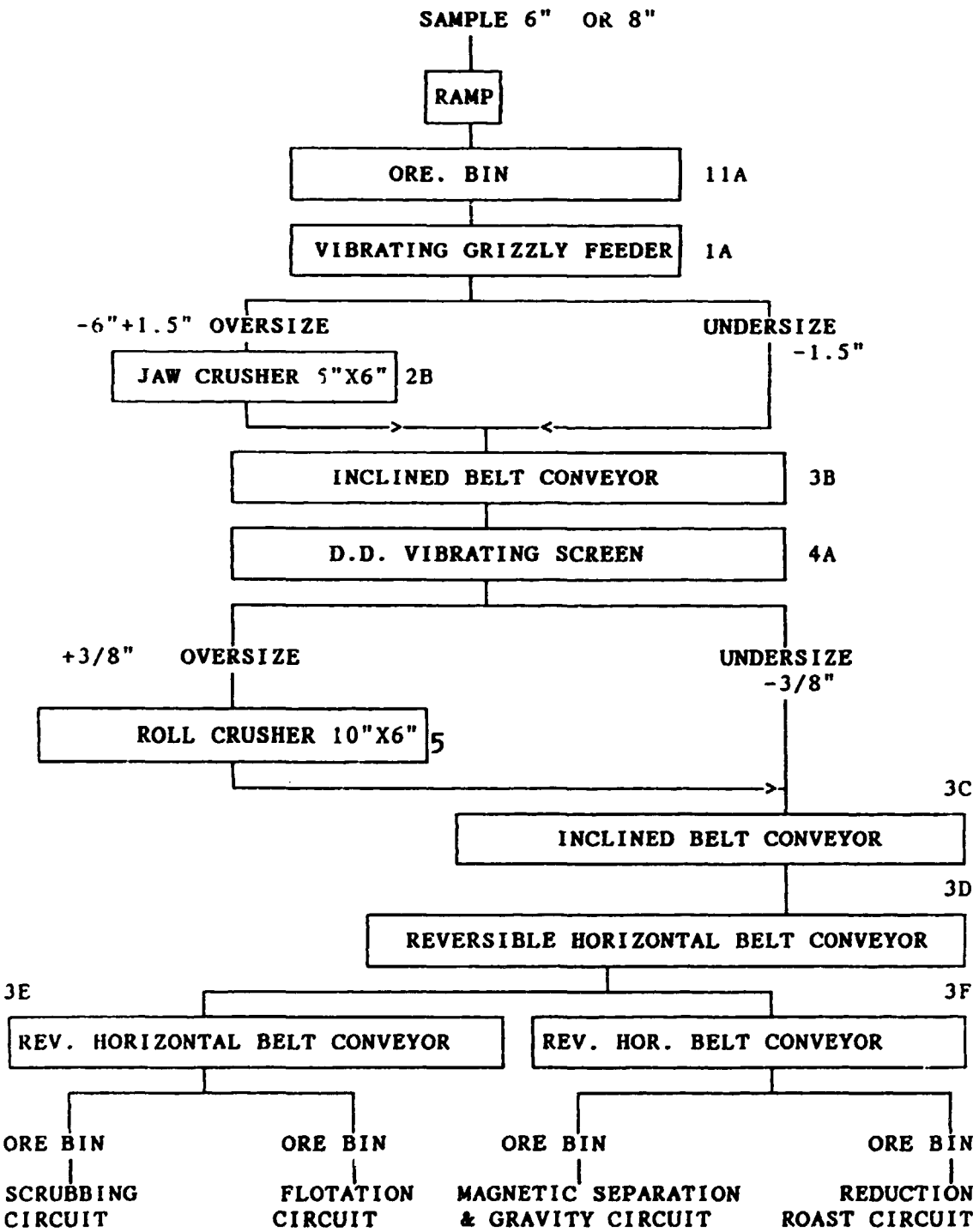
(PILOT PLANT DESIGN REPORT)



MINERAL BENEFICIATION PILOT PLANT

NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS.

Fig 1. - CRUSHING PLANT - PROCESS FLOWSHEET



DRAWING No. 1

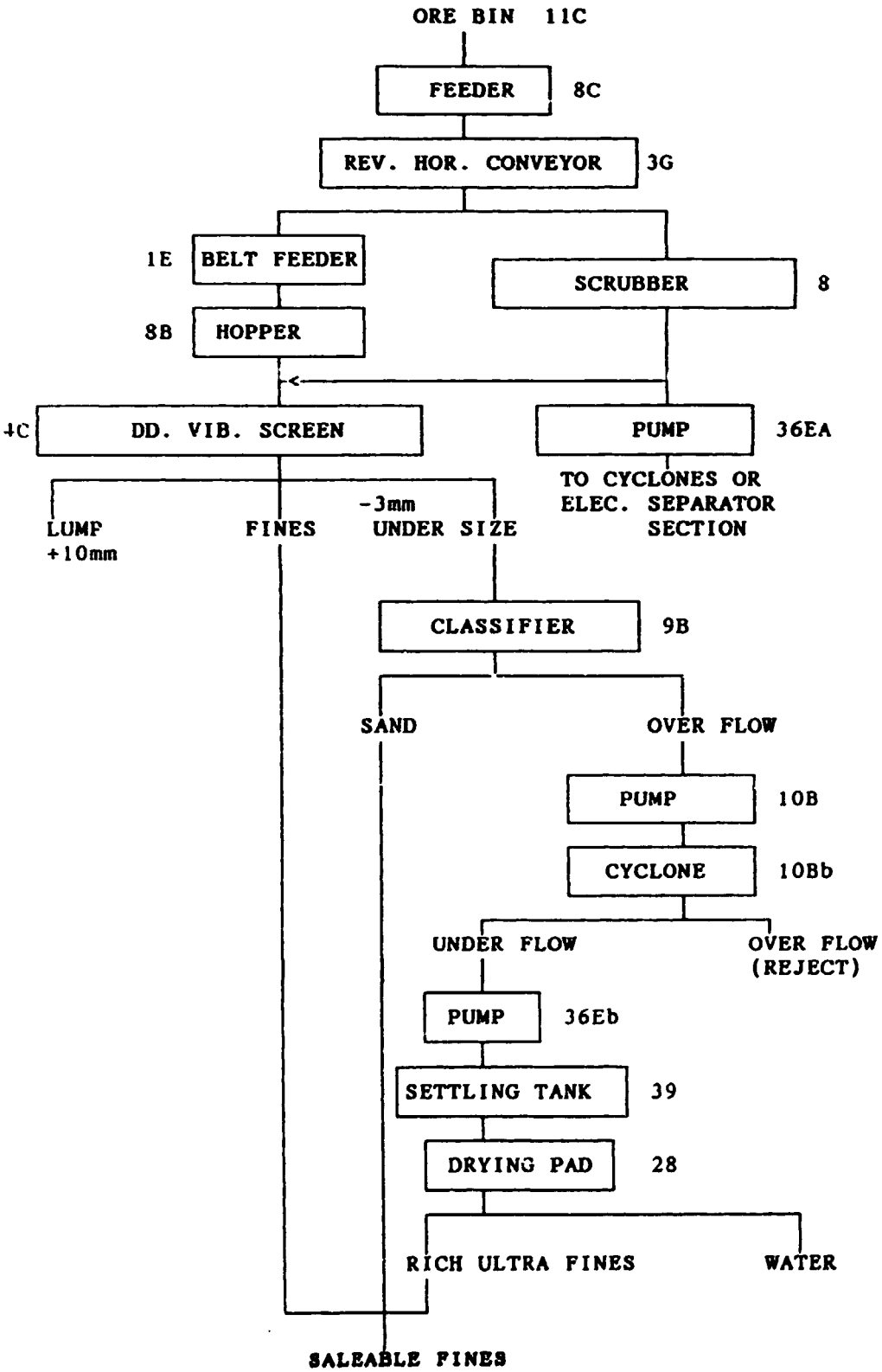
DESIGNED BY: G.S. RAMAKRISHNARAO

DATE 15/9/92

APPROVED BY: A.A. ODUNAIKE

MINERAL BENEFICIATION PILOT PLANT

NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS



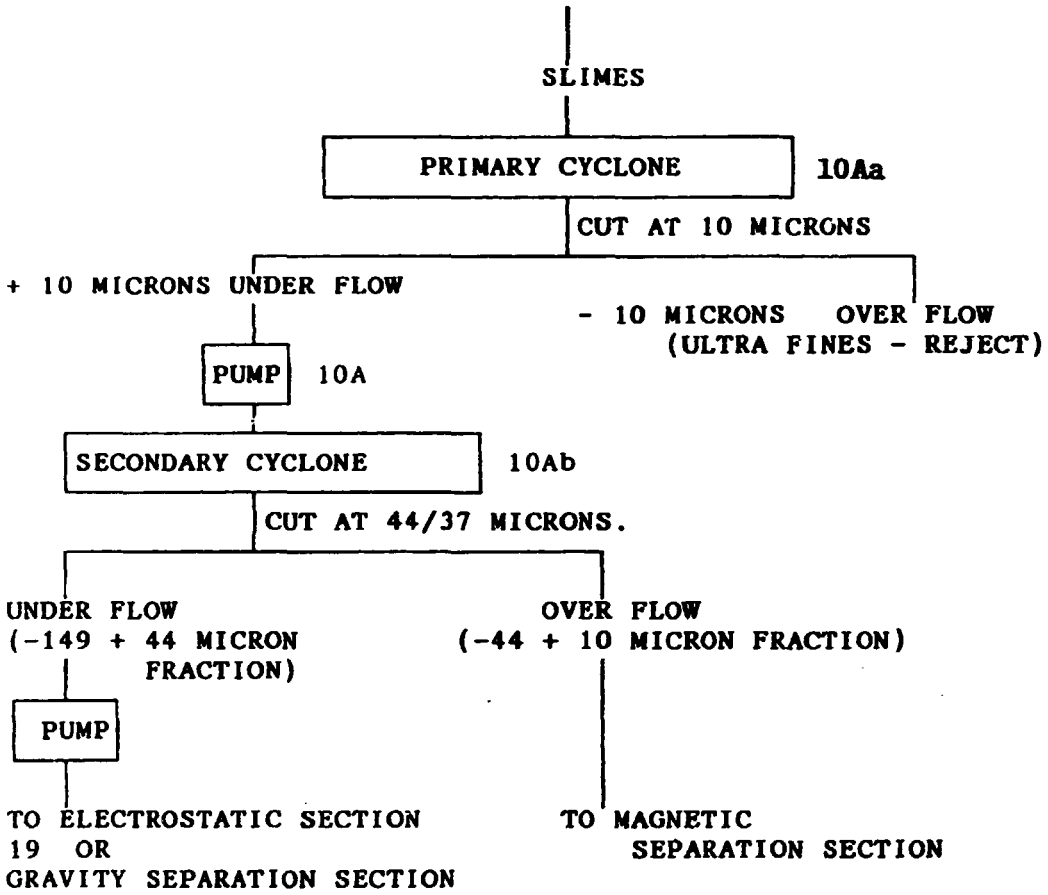
SCRUBBING & SCREENING SECTION

DRAWING No. 2
DATE 15/9/92

DESIGNED BY: G.S. RAMAKRISHNARAO
APPROVED BY: A.A. ODUNAIKE

MINERAL BENEFICIATION PILOT PLANT

NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS



HYDRO CYCLONES SECTION

DRAWING No. 3

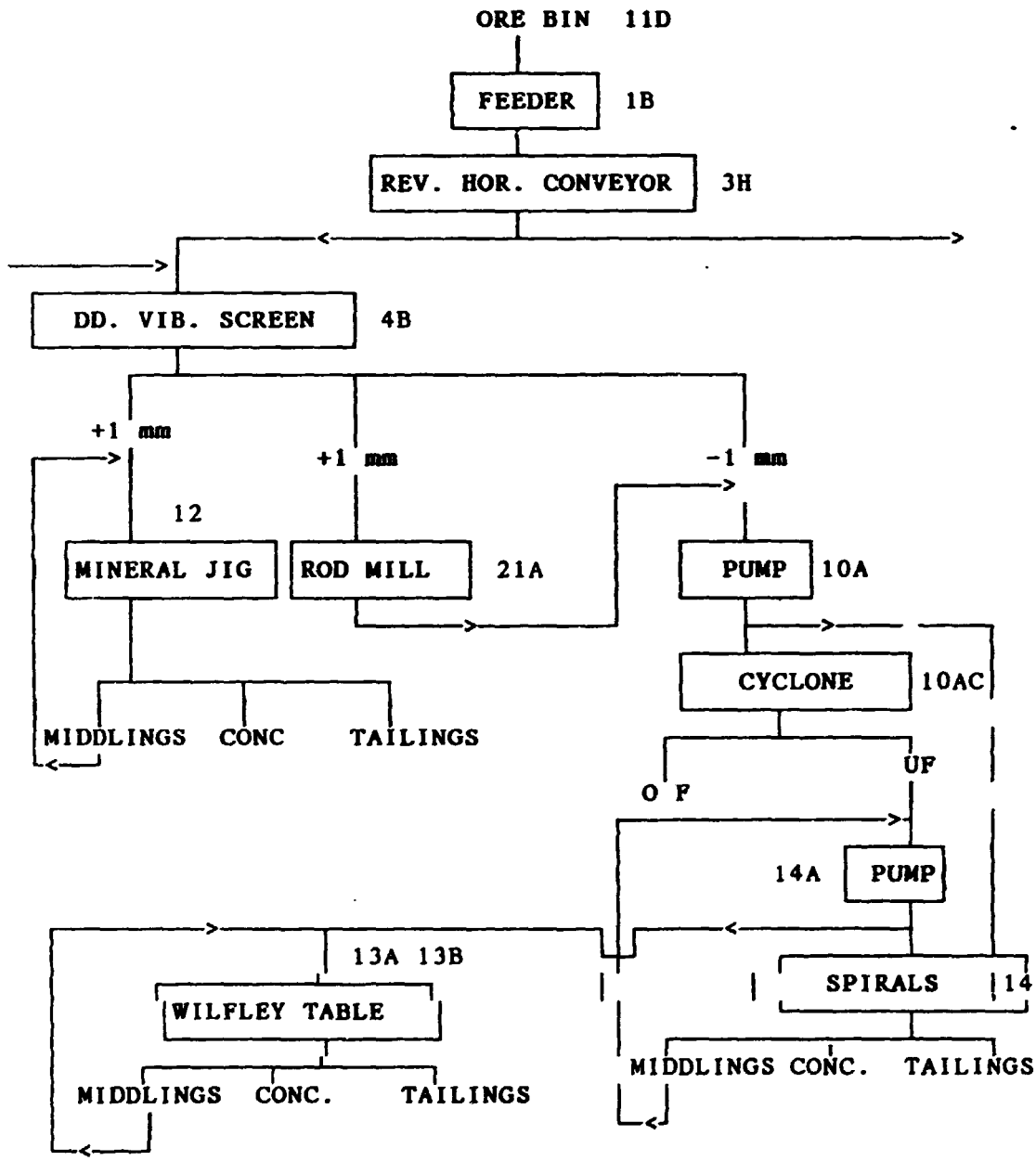
DESIGNED BY: G.S. RAMAKRISHNARAO

DATE: 15/9/92

APPROVED BY: A.A. ODUNAIKE

MINERAL BENEFICIATION PILOT PLANT

NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS



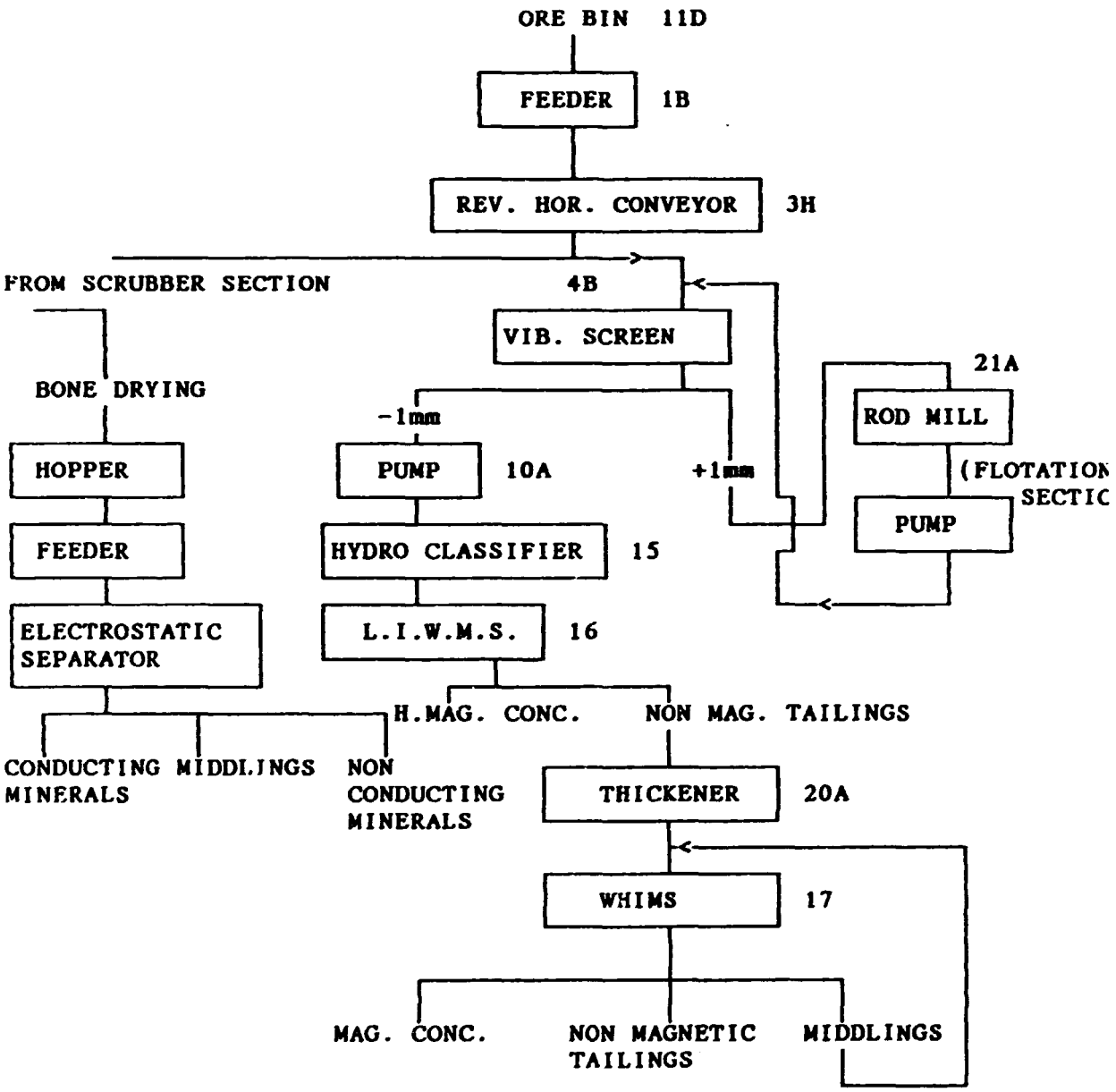
GRAVITY SEPARATION SECTION

DRAWING No. 4 DESIGNED BY: G.S. RAMAKRISHNARAO

DATE : 15/9/92 APPROVED BY: A.A. ODUNAIKE

MINERAL BENEFICIATION PILOT PLANT

NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS



Electrostatic Separation

MAGNETIC SEPARATION SECTION

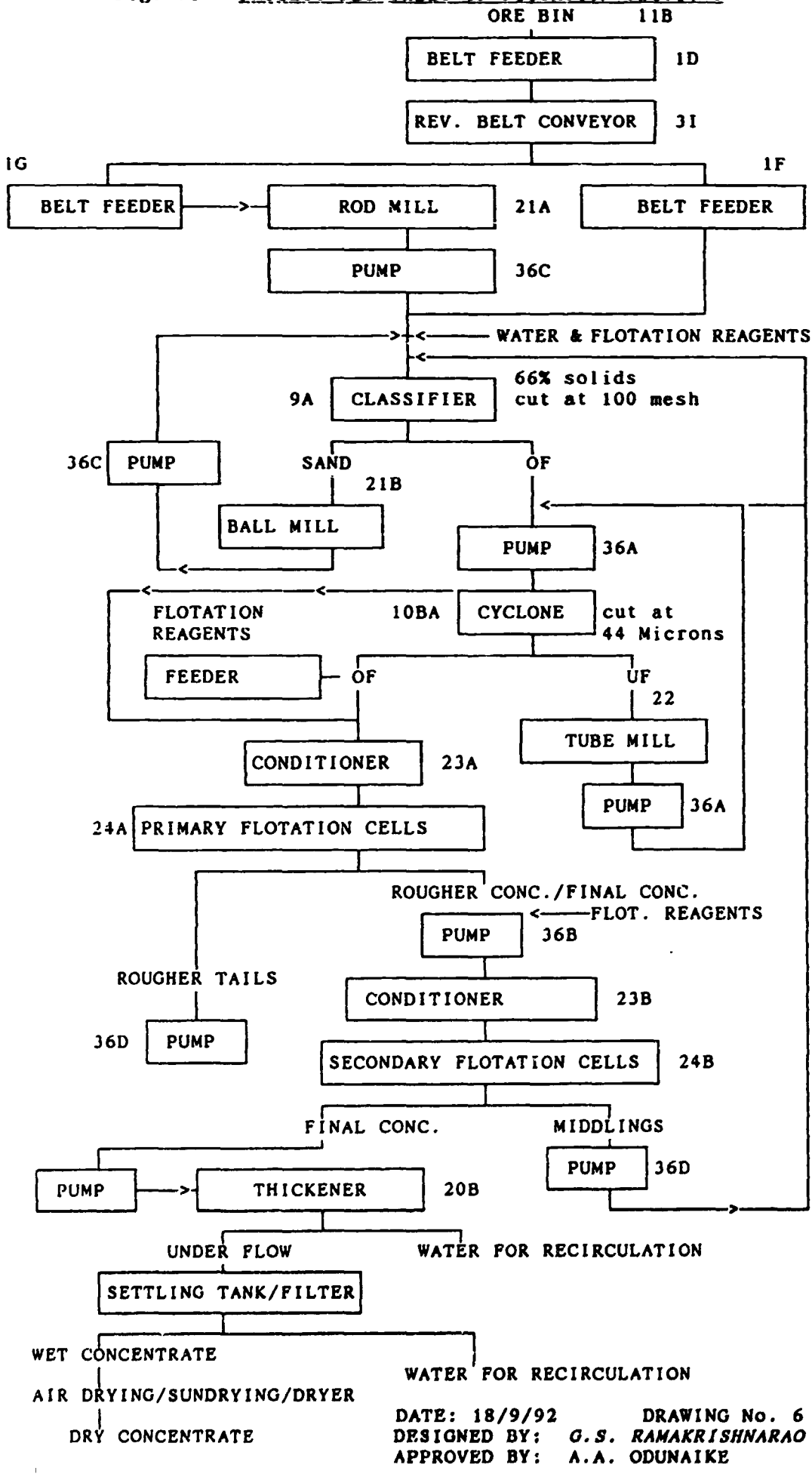
DRAWING No. 5
DATE : 15/9/92

DESIGNED BY: G.S. RAMAKRISHNARAO
APPROVED BY: A.A. ODUNAIKE

MINERAL BENEFICIATION PILOT PLANT

NATIONAL METALLURGICAL DEVELOPMENT CENTRE, JOS

Fig. vi - PROCESS FLOWSHEET OF FLOTATION SECTION.



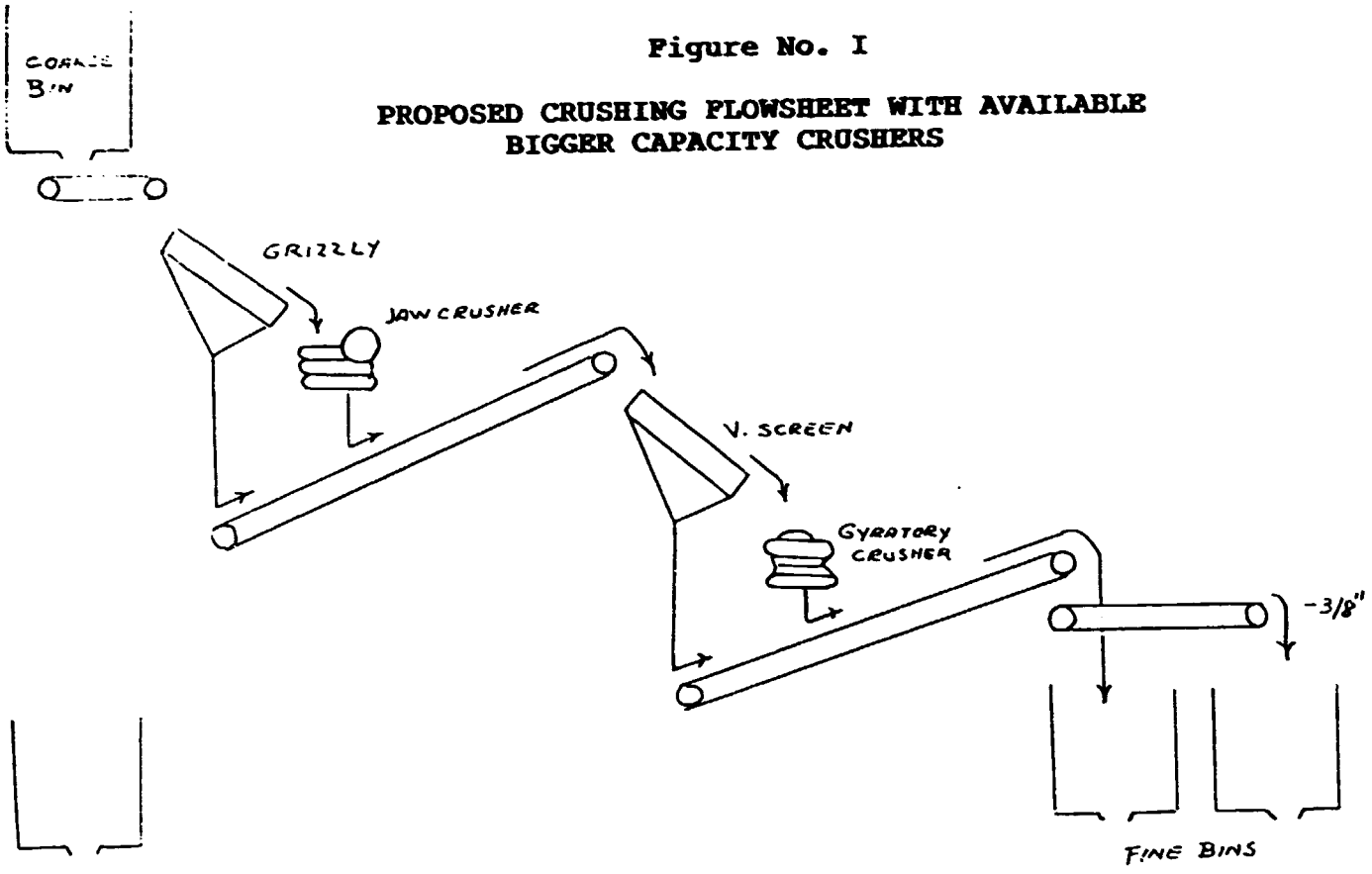
DATE: 18/9/92 DRAWING No. 6

DESIGNED BY: *G.S. RAMAKRISHNARAO*

APPROVED BY: A.A. ODUNAIKE

Figure No. I

PROPOSED CRUSHING FLOWSHEET WITH AVAILABLE BIGGER CAPACITY CRUSHERS



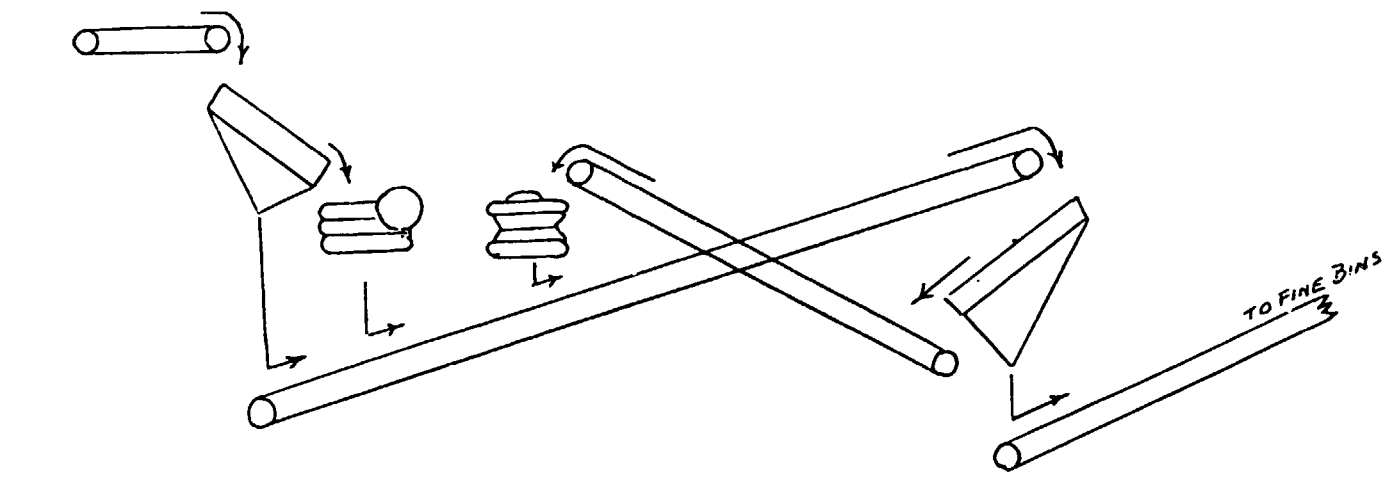


Figure No. II

CONFIGURATION OF POSSIBLE CLOSED CIRCUIT CRUSHING

Figure III

PROPOSED FLOWSHEET FOR CLAYEY AND STICKY ORE

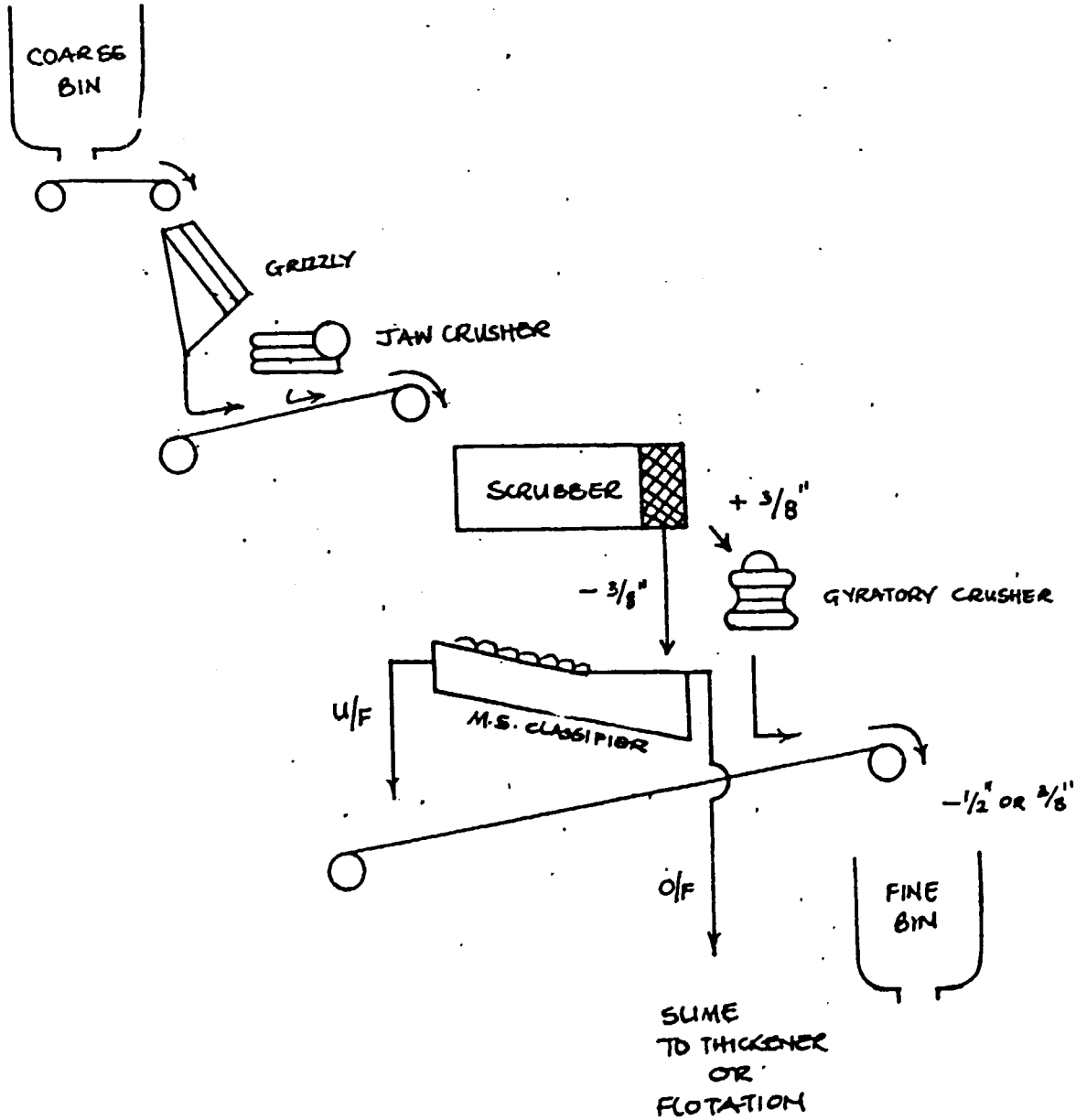
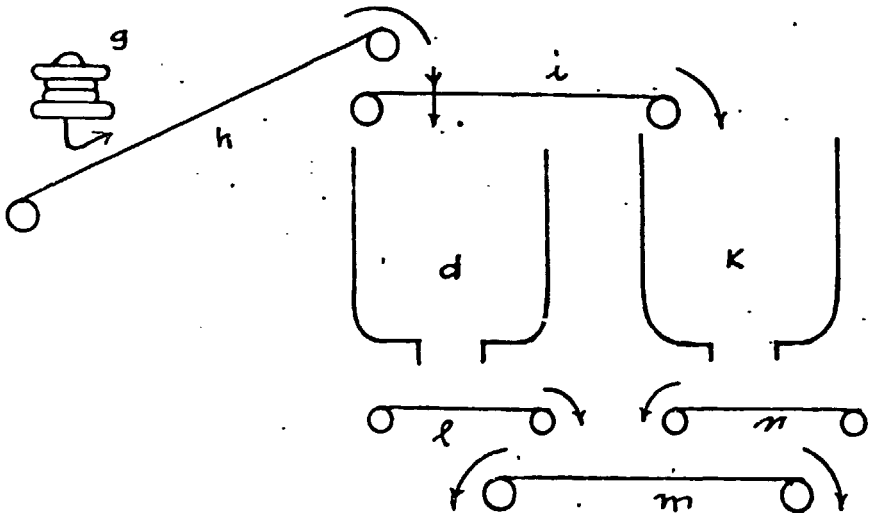


Figure No IV

PROPOSED FLOWSHEET FOR FINE BINS AND THE RECOMMENDED CONFIGURATION IMMEDIATELY BEFORE AND AFTER THE TWO FINE BINS



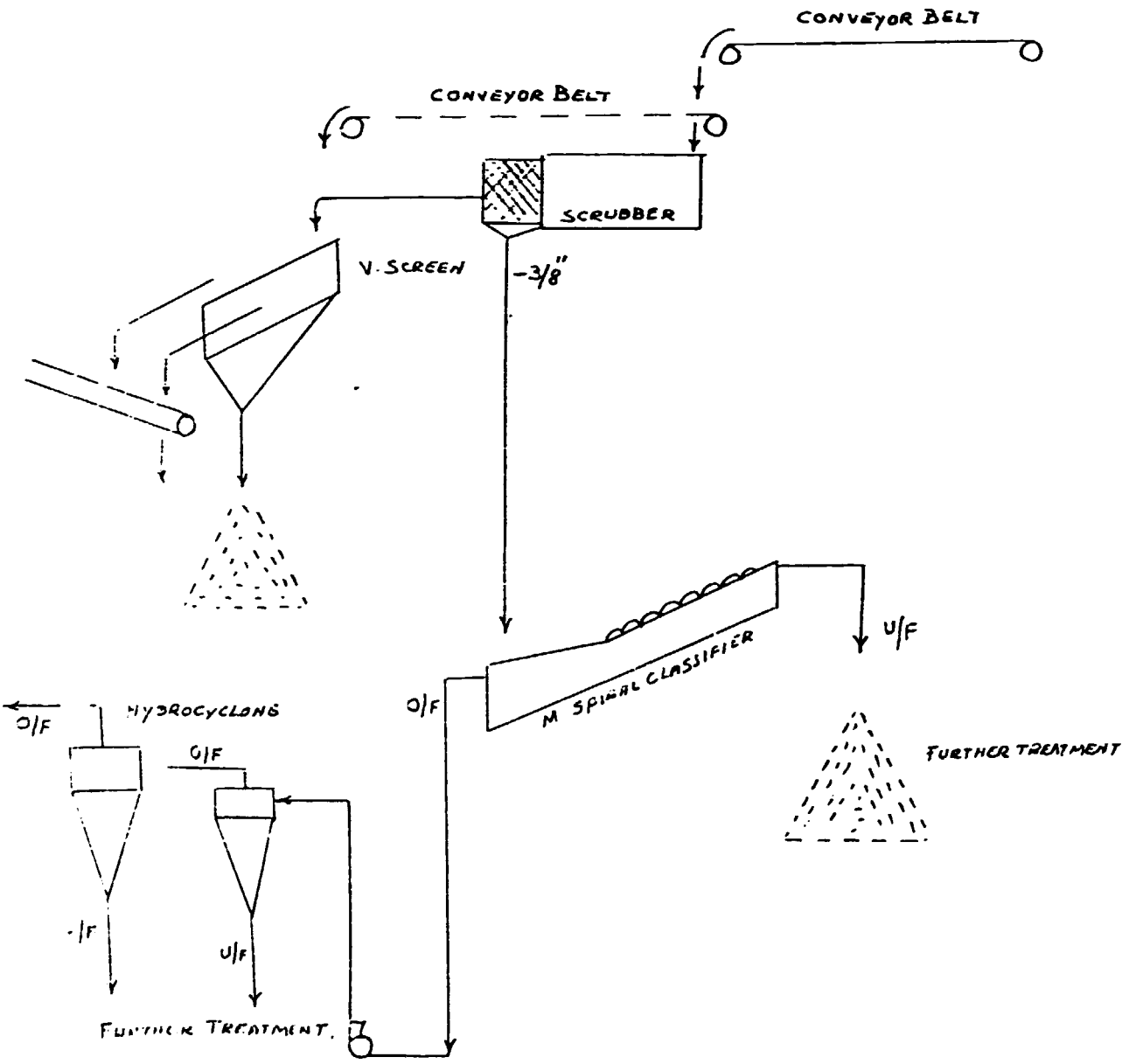
WASHING
SCREENING
CLASSIFICATION

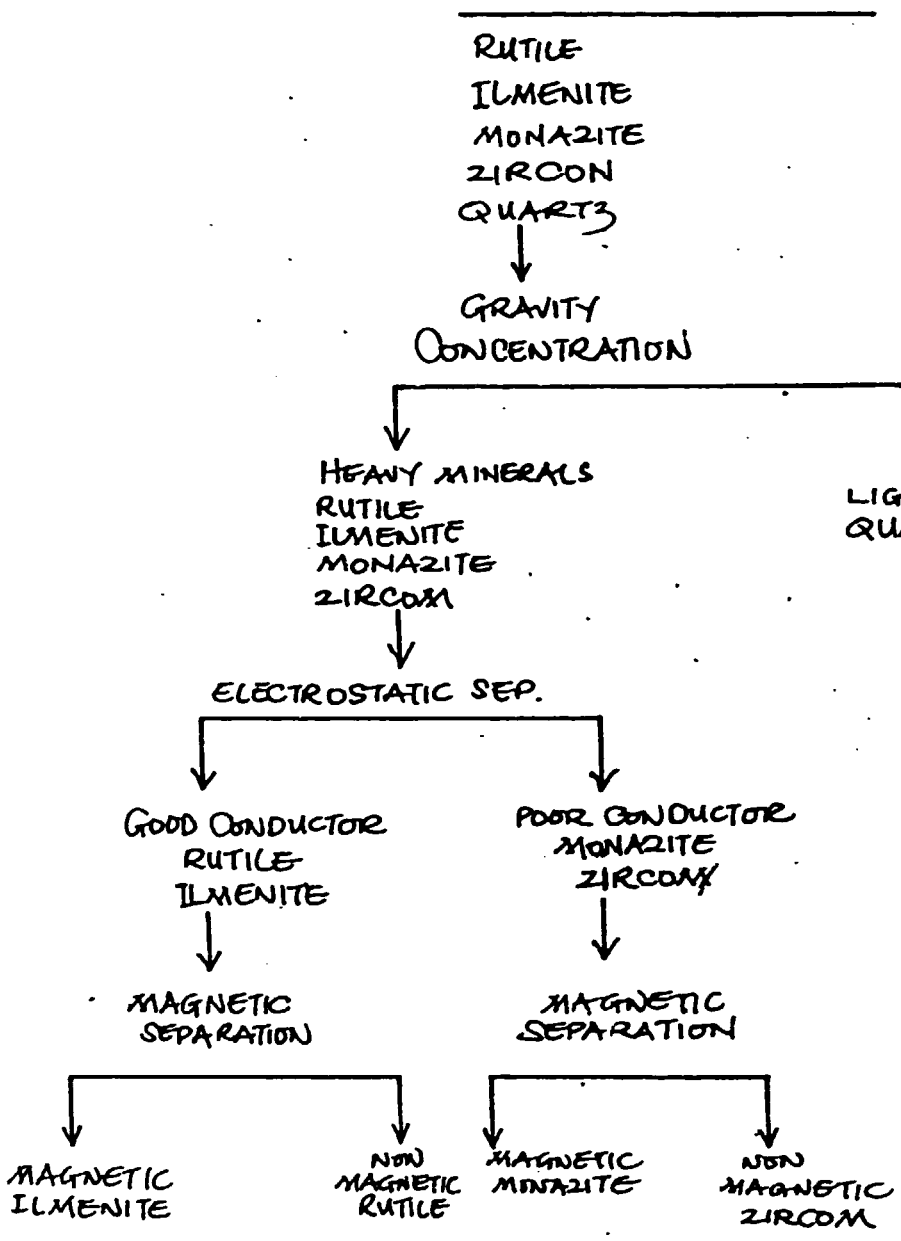
GRINDING
GRAVITY CONC

g — SECONDARY GYRATORY CRUSHER
h — INCLINED CONVEYOR BELT
i — HORIZONTAL CONVEYOR BELT
j, K. — FINE BINS OF 10 TONS EACH
l, m. — FEEDERS
m — REVERSIBLE HORIZONTAL CONV. BELT.

Figure No. V.

PROPOSED FLOWSHEET FOR SCRUBBING, SCREENING AND HYDROCYCLONING





NOTE: If Cassiterite were involved, then the scheme would have to be adjusted.

Fig. VI—1

PROCESS SCHEME
FOR TYPICAL BEACH SANDS:

Figure No. VII

PROPOSED FLOWSHEET FOR GRAVITY CONCENTRATION WITH AVAILABLE EQUIPMENT

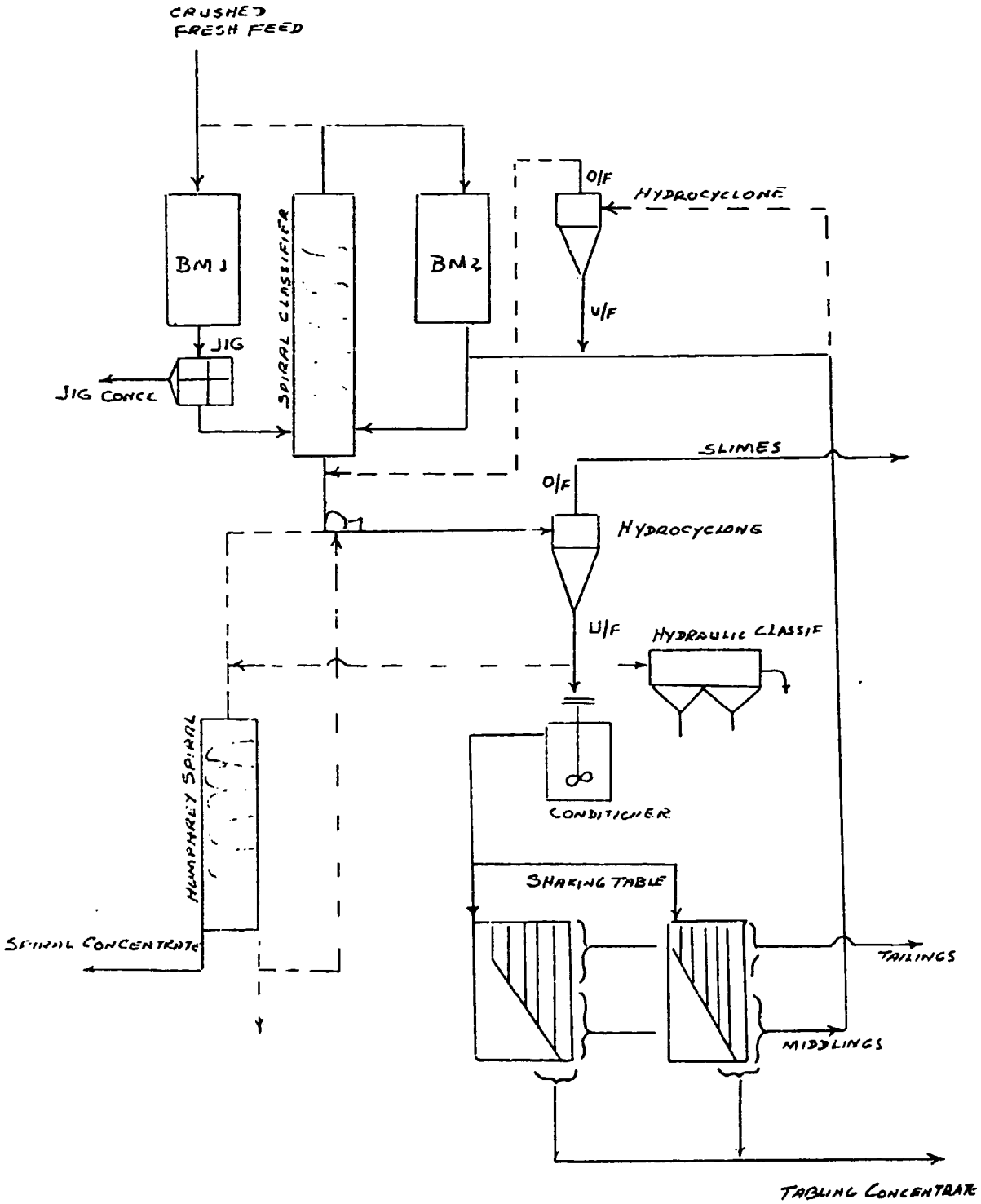


Figure No. VIII

INTEGRATED PROCESS FLOWSHEET FOR MAGNETIC SEPARATION

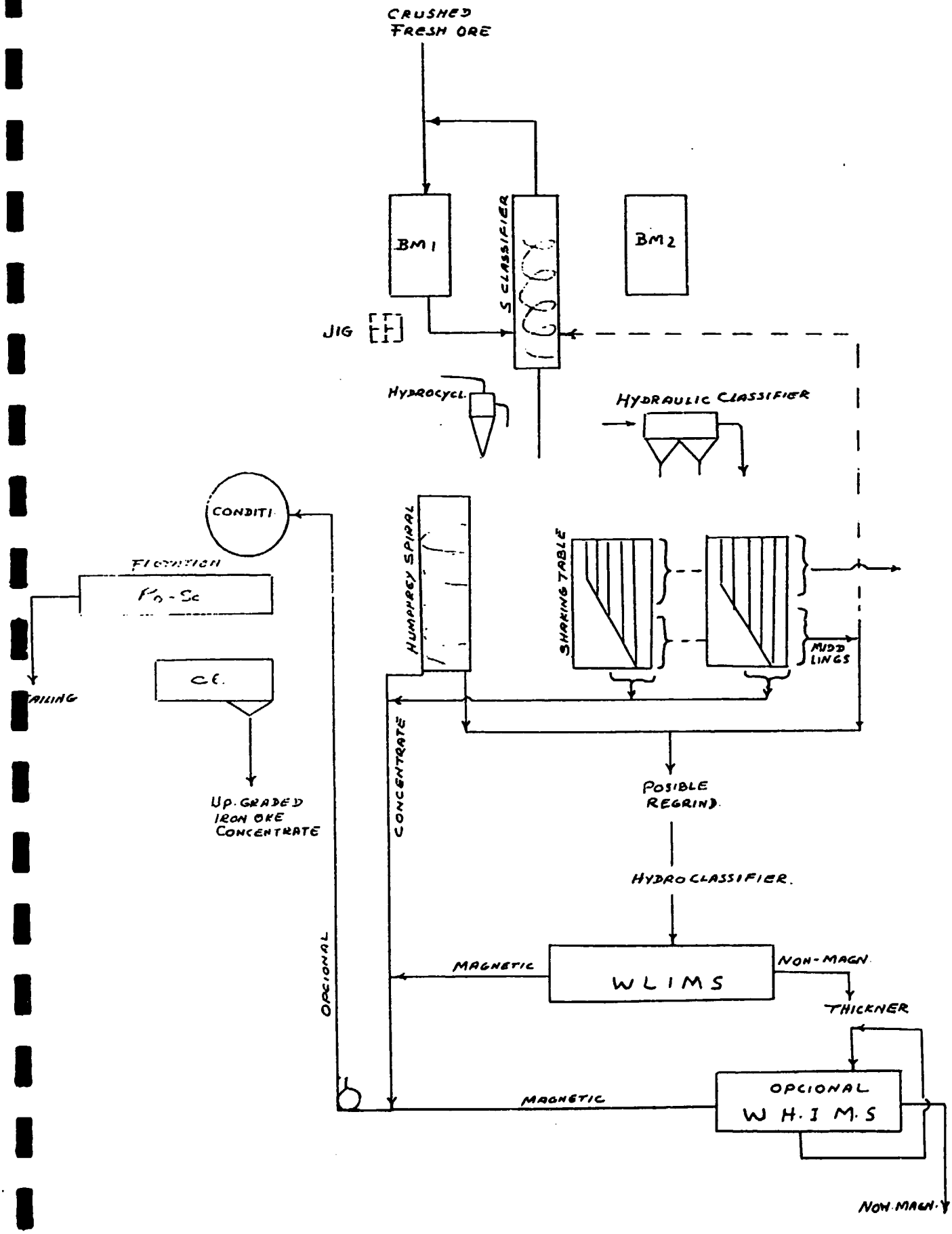


Figure No. IX

PROPOSED FLOWSHEET FOR FLOTATION

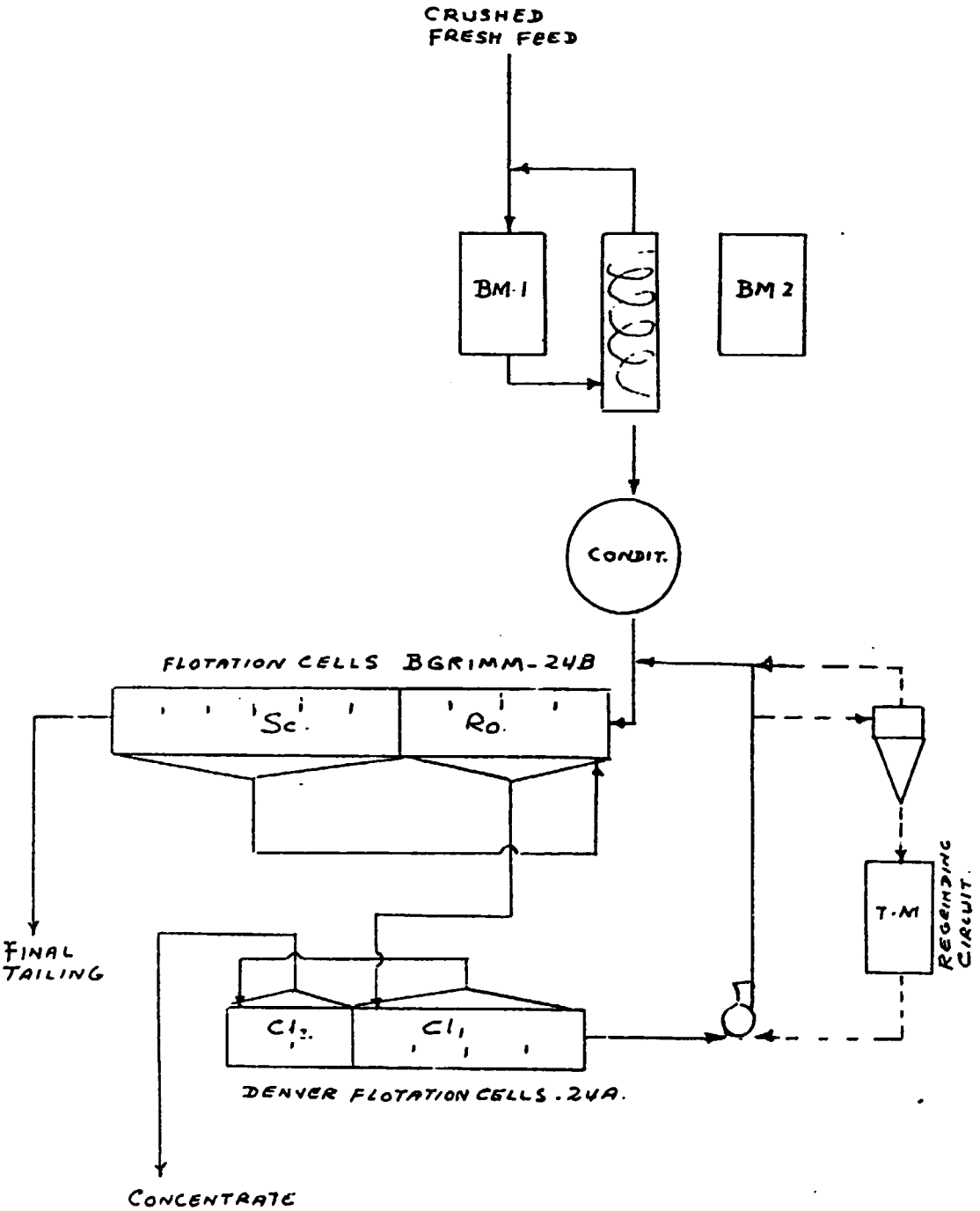
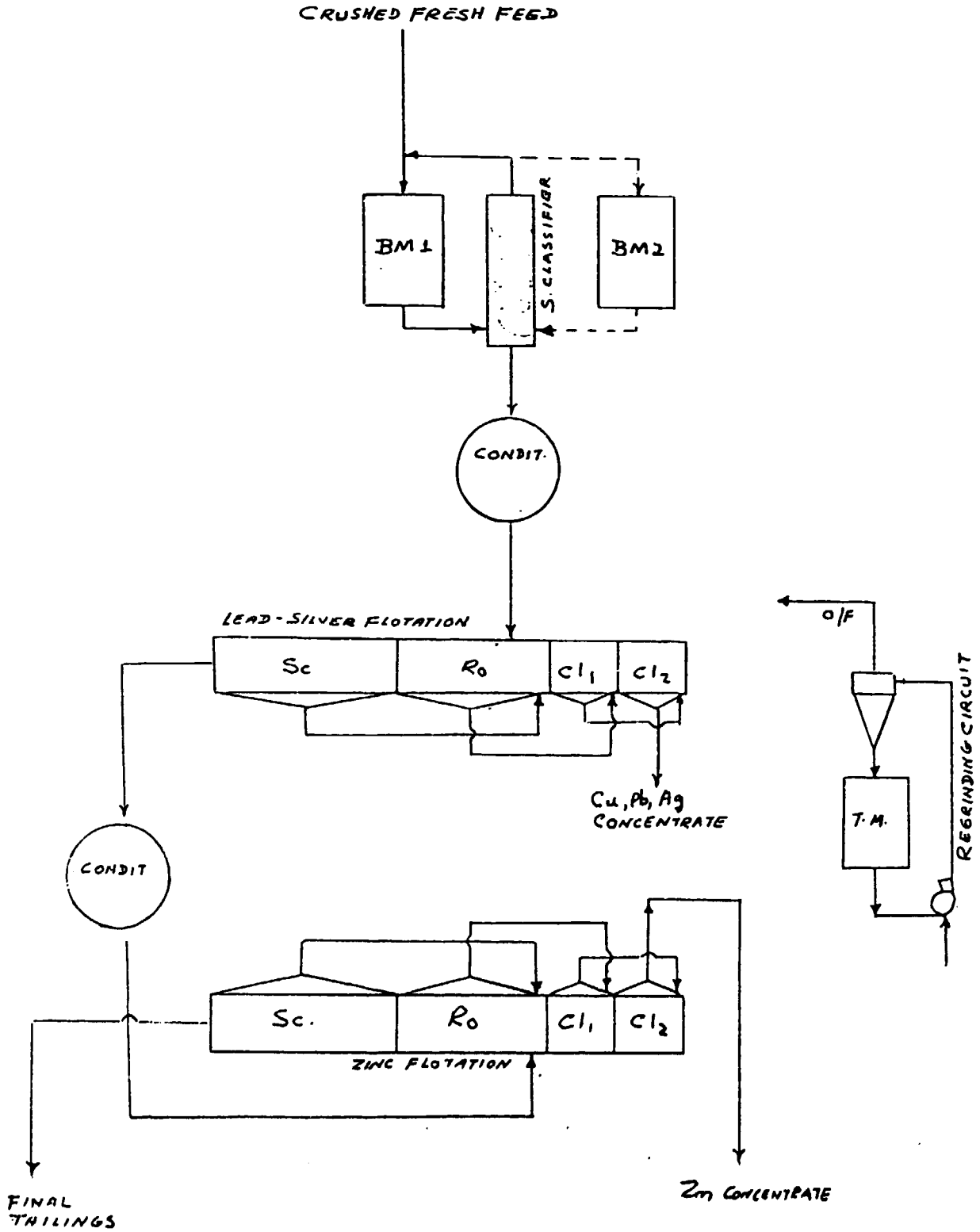


Figure No. X

PROCESS FLOWSHEET FOR THE FLOTATION OF POLYMETALLIC ORE



NATIONAL METALLURGICAL DEVELOPMENT CENTRE

(NATIONAL STEEL COUNCIL)

INTERNAL MEMORANDUM

From: Chief Techincal Adviser	To: Director/Chief Executive
Ref: PR/DP/NIR/87/031/IM/5/12	Date: 7th July, 1993

REPORT OF CHIEF TECHNICAL ADVISER ON VISIT TO COAL CORPORATION PRODA & DELTA STEEL COMPANY

Enclosed please find my report regarding my visit to Coal Corporation, PRODA and Delta Steel Company.

The Coal washery plant at Enugu is a good place for training. In this respect, I suggest that the MBPP personnel be sent to work at this plant as part of their training. On the other hand, when the Mineral Processing Division feels capable, NMDC could help to carry out, IN SITU, a study of control and optimization of the coal washery plant.

With respect to PRODA, this institution seems to have acquired good experience in various fields. In this respect, I suggest you to consider this institution for training the NMDC research staff in refractory, pottery, foundry, glass blowing etc. The institution may also help NMDC in the installation of the 100 Ton hydraulic press, plus the fabrication of its mould, in setting up the pottery production plant, if desired, as a means of generating funds for the Centre, and also in the fabrication of some equipment needed for the refractory laboratory, etc.

As for Delta Steel Company, the opportunity for setting up a joint research project with the company is excellent. Some of the major problems of DSC are connected with the refractory materials (Bricks, Castables, Refractory masses, Recycling of refractory waste), generation of fines during pelletizing, water treatment, etc. The importation of iron ore concentrates is another major problem, but its solution seems to be tied up with the country's mining policy regarding Ajaokuta Steel Comapny, Itakpe Mining Company Delta Steel Company, etc. Therefore, due to the cost implication of the refractory material and the generation of fines problems in everyday

operations, it is advisable that NMDC and DSC join their efforts in the solution of these problems. Studies within NMDC such as the use of non-metallurgical coal (C.D.R.) in the reduction of iron ore concentrate may not be advisable at this point, as the infrastructure needed for this technique does not exist in Nigeria.

By the way, several refractory bricks of various types and shapes were brought from DSC to be used as examples for the fabrication of the mould and for other relevant studies or tests.

Further visits of NMDC officials to the mentioned companies especially to DSC, are recommended in order to identify the problems and discuss the terms of mutual co-operation.

W Beltran

Wilfredo A. Beltran
CHIEF TECHNICAL ADVISER

cc: Mr. Krouzek/Beinhoff, UNIDO, Vienna

Mr. Fre-Hiwet, UNDP, Lagos

Dr. Tomi, UNIDO, Lagos.

Heads of Departments

REPORT OF NMDC-UNIDO CHIEF TECHNICAL ADVISER ON THE VISIT TO COAL CORPORATION, PRODA AND DELTA STEEL COMPANY FROM 21ST TO 27TH JUNE 1993

I. OBJECTIVE OF THE VISIT

1. To be acquainted with the Mining Industry of Nigeria.
2. To assess the facilities for training the MBPP personnel.
3. To have some ideas for the design of the coal processing line of the MBPP.
4. To assess the possibilities of NMDC's Co-operation with the Mining Industry.

II. VISIT TO COAL WASHERY PLANT OF COAL CORPORATION AT ENUGU

1. Staff Members Visited:

Mr. S.K. Olimze	-	Deputy General Manager
Dr. F.I. Nwabue	-	Asst. to Managing Director
Mr. S.C.O. Emeka	-	Asst. General Manager (CPP)

2. Observations:

a) The process design, plant design and the construction, by a Polish Company in 1987, is well done. The process separation used is simple (Dense Media Separation for coarse and fine fractions previously deslimed), the construction is solid and the equipment is still functioning well.

b) The existence of a number of pieces of mineral processing equipment and the presence of skilled personnel both in operation and maintenance made this plant attractive for training. This means that the operation and maintenance crew of the MBPP could be sent to work at this coal washery plant as a means of training.

c) The design capacity of the plant is about 250 Ton/Hr. or 6,000 tons/day; however, the present plant throughput is very much below this capacity. One of the main reasons for the low production seems to be the lack of run of mine coal which at present comes only from Okpara Mine. This means that the only alternative for improving the productivity and lowering the operation cost substantially at this plant is to increase production at the mine so that the plant could work at full capacity.

d) Even with a uniform coal material, a frequent plant control and optimization exercise is always welcome. In this respect, basic determinations such as ash, sulphur, screen analysis, washability tests, etc, of various plant products may need to be done more frequently. This information would also help to

structure the metallurgical balance and accountability of the processing plant, and evaluate the overall plant performance.

e) Some of the testing equipment at the laboratory is not in good working condition, thereby limiting to some degree the plant control and optimization work of this Department. Perhaps it would be worthwhile to prepare an instrument maintenance specialist so that the equipment in the laboratory could be rehabilitated and other instruments kept in good shape.

f) The permanent control of the specific gravity of the medium during operations is outstanding. However, the sink and float laboratory test of the final products, the rejects, and even the plant feed, which was done in the past with good results from the practical point of view, may need to be reactivated. This practical control would allow measurement of the efficiency or sharpness of the mineral separation taking place in the bath or cyclone type sink and float devices.

g) At present, the coal washery plant operates intermitently due mainly to the lack of run of mine coal and

other minor limitations. As this kind of operation is usually costly, it would be interesting to study the viability of first stockpiling the coal material until there is a sufficient amount, and only then starting operation at full capacity and continuously for one or two weeks. In the case of shortages of ore from the mine, the latter approach has always proved to be more convenient both technically and economically.

h) With respect to mutual co-operation, I think the opportunity is unique. Process control and optimization, amenability testing of the various Nigerian coal deposits, etc, are some of the areas in which NMDC and NCC could work jointly. Besides, the coal washery plant has skilled and experienced personnel whose commendable knowledge needs to be absorbed by institutions such as NMDC.

III. PROJECTS DEVELOPMENT INSTITUTE (PRODA)

1. Staff Members Visited:

Mrs. I.C. Akagu	-	Head Information and Doc. Services.
Mrs. N. Onyemehekwe	-	Fuel Laboratory
Mr. B.A. Iteke	-	Special Purpose Division
Mr. E. Okey	-	Refractory (Bricks)
Mr. E.E. Obiako	-	Ceramic Division (Pottery)

2. Observations:

a) In general the accomplishment of PRODA is outstanding. They have developed machineries for various uses and the production of pottery is impressive. They are also doing good work in foundry. Refractories, glass blowing, metal testing, etc.

b) The Ceramic Division (Pottery) is very much involved in the production of pottery such as plates, cups, etc. The demand for these goods is very high and PRODA barely meets the local demand. In spite of their limitations with the capacity of the electrical furnace, this department seems to have the best fund-generating activities of the entire institutions. This example could very well be followed by institutions such as NMDC, which are interested in becoming financially less dependent.

c) PRODA is also involved in the development of coal briquetting for domestic use. So far, the production cost seems not to be so competitive as to encourage massive production. However, the research project objective is good, especially with the deforestation problem going on.

d) PRODA seems to have acquired experience in various fields, and NMDC could gain from this experience through training of implementation of joint projects in fields such as foundry, refractory ceramics, glass blowing, equipment manufacturing, etc.

IV. DELTA STEEL COMPANY

1. Staff Members Visited:

Dr. Afejuku	-	Deputy General Manager
Mr. S.O. Urhoghide	-	Asst. General Manager
Dr. D.O. Obikwelu	-	Manager Research and Development Department.
Mr. I.B. Okeke	-	Asst. General Manager Steelmaking.
Mr. C.U. Duru	-	Asst. General Manager - Direct Reduction.

2. Observations:

a) The designed capacity of DSC plant is about 1.0 million tons/year; however, due to insufficient power supply and other limitations, the company has not been able to run the plant at full capacity.

b) The direct reduction process plant was designed to treat a high grade iron ore concentrate (66% Fe), low level of gangue (2.5% SiO_2 + Al_2O_3), sulphur (0.004% S), phosphorous (0.02% P) and less than 30% fines below 45

microns. Therefore, for good plant performance it is necessary that the iron ore concentrate meet the specification established, and a continuous process optimization exercise be set up with the help of the pilot plant.

c) In 1990 there was joint project (NMDC, DSC. Itakpe Mining Company) for producing superconcentrate out of the Itakpe iron ore and then testing it in the pilot plant at DSC. This project was concluded satisfactorily. By the way, the superconcentrate was produced at NMDC.

d) The generation of fines during pelletizing is one of the major problems. About 15% of the plant throughput is wasted in the form of fines. Therefore, there is a need for a research work here to minimize the production of these fines through plant control and optimization with the help of the pilot plant tests. Should this approach not work, then the research team could start thinking to process these fines for further utilization.

e) The removal of fine solids during the treatment of water with the help of a very expensive flocculent is another problem which faces DSC. These solids in the

water which is used in the plant causes the fast wearout of the water handling system, hence the importance of its elimination. In this respect, it would be worthwhile to test various flocculants existing in the market in order to find the most efficient and economical one. Afterwards, the research could be reoriented to finding local substitutions, such as the DSC idea of using cassava, etc.

f) The high cost of refractory materials is another major problem of DSC. Besides the brick refractories used (Magnesite base, Alumina base or bekafix-z type), there is a great need for ground refractories such as the "castables", the "magnesite masses" (with about 80% MgO) etc, which are used for instance, to repair the wall of the induction furnace. The R&D Department of DSC has already done some work on a local magnesite and so far has upgraded a magnesite from 39% MgO to 75% MgO after calcining. What DSC needs is a magnesite refractory material with a minimum of 80% MgO. The same applies to the Alumina base refractories where high purity is required.

g) DSC is generating a large amount of refractory waste. The cost implication of this waste is obvious and there is an urgent need for doing something about it. The recycling of this material could be one alternative. However, this study needs to be undertaken in conjunction with other research institutions.

h) The importation of iron ore concentrate is another major problem, but its solution seems to be tied up with the country's mining policy regarding Ajaokuta Steel Company, Itakpe Mining Company, Delta Steel Company, etc. The compromise of Itakpe Mining Company to supply Delta Steel Company with about 0.6 million ton/year is yet to be fulfilled.

i) The testing of prototype refractory bricks in an industrial size furnace may not be readily accepted by DSC because of the implications involved in case of failure. Therefore, the prototype produced by NMDC may have to be sufficiently tested before it goes to the industrial scale test. It may even be necessary to construct a bench scale Arc furnace for this kind of test. Also, it would help if the people of DSC were involved in the refractory subproject of NMDC.

j) Most of the consumable are imported, therefore the high cost involved is obvious. To change this situation, the R&D Department of DSC is making a commendable effort to carry out some research work on its own and is sponsoring other projects within the local universities. The problems at Delta Steel are various, and joint projects with institutions such as NMDC on the basis of production and operational problems would be most beneficial to the country.

NATIONAL METALLURGICAL DEVELOPMENT CENTRE

(NATIONAL STEEL COUNCIL)

INTERNAL MEMORANDUM

From: Chief Technical Adviser	To: Director/Chief Executive
Ref: PR/DP/NIR/87/031/IM/5/35	Date: 26th August, 1993

REPORT OF CHIEF TECHNICAL ADVISER ON THE VISIT TO NATIONAL IRON ORE MINING PROJECT AND AJAOKUTA STEEL COMPANY LIMITED.

Enclosed please find my report regarding my visit to NIOMP and ASCL. The new mineral beneficiation plant of NIOMP at Itakpe is unique in this country. In short, it is a good place for acquiring practical knowledge of iron ore processing. In this respect, I suggest that the key personnel of the Mineral Beneficiation Pilot Plant (MBPP) be sent to work there as part of their training. It is also advisable that the Consulting Firm in charge of the structural design and detail engineering design of the MBPP visit that plant in order to become familiar with the structural and detail engineering design of this kind of plant.

As far as mutual cooperation of NIOMP and NMDC is concerned, the opportunity is excellent, especially now that NMDC is about to begin the erection of its MBPP with the assistance of UNDP/UNIDO. This means that both institutions could in the future work in joint projects: for example, in optimizing the industrial beneficiation plant, in testing new products or equipment, in testing iron ores from a new zone of the open pit with foreseeable metallurgical problems, etc, etc.

On the other hand, in order for the MBPP to serve better the industrial plant of NIOMP, it is necessary that the pilot plant have the necessary testing facilities to set up and work with a similar process flowsheet to the industrial plant, which in this case would become a standard. Therefore, in order for the MBPP to comply with the above requirements, it might be necessary to

consider the purchasing of additional testing units such as Humphrey spirals, low intensity magnetic separators, etc, as the industrial plant operates with 3 stages of these mineral separation devices. However, regarding this matter, I advise you to get in touch with the UNIDO Consultant who designed the MBPP so that he could study the situation and give his recommendations. In this connection, the processing flowsheet of the beneficiation plant at Itakpe should be sent to him as soon as possible.

With respect to Ajaokuta Steel Company Limited, the disposition for mutual cooperation is also excellent. In this respect, they will be sending to NMDC samples of coke and coal as they arrive in the country for quality control verification purposes and for further testing in the coke oven pilot plant. Along with the sample, they will also be sending the product specification given by the suppliers and the ones established by ASCL.

Wilfredo A. Beltran.

Copy:

Mr. J.V. Krouzek/C. Beinhoff, UNIDO, Vienna.
Mr. A. Fre-Hiwet, UNDP, Lagos.
Dr. D. Tomi, UNIDO, Lagos.
Head of Departments - (NMDC)
Project Manager - MBPP (NMDC)
Project Manager - COPP (NMDC)

REPORT OF NMDC - UNIDO CHIEF TECHNICAL ADVISER ON THE VISIT TO NATIONAL IRON ORE MINING PROJECT AT ITAKPE AND AJAOKUTA STEEL COMPANY.

From 2nd to 6th August, 1993

Prepared by

Wilfredo A. Beltran.
CHIEF TECHNICAL ADVISER

I. OBJECTIVE OF THE VISIT:

1. To be better acquainted with the Mining Industry of Nigeria.
2. To assess the facilities for training the Mineral Beneficiation Pilot Plant (MBPP) personnel.
3. To learn the process flowsheet of the beneficiation plant at Itakpe and relate it to that of the MBPP at NMDC, Jos.
4. To assess the possibilities of NMDC's co-operation with the mining industry.

II. VISIT TO NATIONAL IRON ORE MINING PROJECT - ITAKPE

1. Staff Members Visited:

Mr. M.B. Wakawa	-	Project Director
Mr. D.N. Nsofor	-	AGM. Beneficiation Plant
Mr. T.I. Adebayo	-	AGM. Mining Operation.
Mr. A.S. Salahu	-	Asst. Manager, Quality Control.
Mr. U.D. Akpan	-	Asst. Manager, Laboratory.

2. Obervations:

a) The development, exploitation and processing of the Itakpe iron ore deposit is, without doubt, one of the most outstanding accomplishments of the National Iron Ore Project (NIOMP) and of the Nigerian Mining Industry in recent years. This project, originally conceived to supply Ajaokuta Metallurgical Complex with 2.2M Ton/year iron ore concentrate and Delta Steel Company with 0.6M Ton/year of Super-concentrate, will soon reach full production. It was executed with the technical assistance of Saframines Consulting Co, and also Koch Consulting Co. who supplied the equipment and installed and commissioned the beneficiation plant.

b) The objective of the open pit mining operation is to supply the beneficiation plant with iron ore of about 36% Fe. However, like other new open pit operations, it seems to be experiencing a few problems:

i) With respect to the problem of dilution, it might help to reinforce a strict grade control before and after blasting. The availability at present of only one geologist in the mine site may not be enough for effective control during the three shifts. The use of reliable sampling techniques and dilution estimates may also help in this case.

ii) With respect to the problem of generation of low grade ore (24% Fe to 28% Fe, etc) during mining, the idea for its pre-treatment before sending to the beneficiation plant may not be appropriate yet at this point. First it might be better to find out the cause and nature of the problem so that efforts could be made to solve it at the root rather than adding an extra process which in the end may become expensive and complicated. For instance, a screen analysis along with the chemical and mineralogical analysis of the size fractions of this low grade material, could be one of the ways to establish the size range and nature of the waste.

iii) With respect to the problem of producing oversize lumps, it is advisable that fragmentation during blasting be improved. In this connection, it might be worthwhile to look into the type of explosive or the blasting hole design being used. As secondary blasting is always expensive, it might be beneficial to encourage research projects in this matter.

iv) As the transportation of the ore from the open pit to the nearby stock-pile and from there to the primary crusher is expensive, the new order to transport the ore directly to the primary crusher should be

welcomed. If the primary crusher is not working, the transportation of the ore from the open pit should be stopped immediately. The use of a walkie-talkie for fast communication in an open pit operation is always worthwhile.

c) The Mineral Beneficiation Plant of NIOMP looks strongly built, well installed and impressive. With time it would hopefully set up a kind of standard of how a mineral processing plant should be in Nigeria. The process design and plant design seem to be well done. Besides, the accomplishment of the Koch Consulting Co. seems outstanding as it only took a little over a year to set up the entire plant.

d) Except for the 4th line which will be devoted to the production of superconcentrate to Delta Steel Co, the beneficiation plant is completed, and at present it is undergoing an operation testing (run test) period so that adjustments can be made in order to meet objectives of operation, production, quality of products, etc. According to the Plant Manager, the processing lines No. 3 and No. 1 have been tested satisfactorily and each of the three lines has been designed to have a throughput of about 315 tons/hr of fresh ore and a production of about 100 tons/hr of iron ore concentrate with about 63% Fe.

e) In general terms, the beneficiation plant is formed by a primary giratory crusher with a capacity of 2000 tons/hr and capable of rendering products of -200mm size. The secondary jaw crusher handles materials above 200mm, especially at times when the primary crusher set is increased to render higher tonnage. Grinding is done in 3 semi-autogenous grinding mills which work in closed circuit with a vibrating screen. The mineral separation is done in 3-stage batteries of Humphrey spirals (Rougher, cleaner, recleaner) which handle particles as big as 14 mesh size, and is complemented by 3-stage low intensity magnets which deal with the O/F of the primary cyclone and tails of the Humphrey spirals. The concentrate and tailing are filtered in horizontal vacuum filters. The plant is also provided with a water recovery system. The metallurgical results being obtained in this testing period are considered satisfactory and are aprox. as follows; Feed value (33 to 36% Fe), concentrate (63 to 66% Fe), and Tailing (11 to 13% Fe). The iron recovery is around 80 to 85%.

f) As plant control and optimization is a continuous exercise in a beneficiation plant, it might be worthwhile here to create the position of Plant Metallurgist to deal with the metallurgical problems of the plant and with the testing work towards process optimization etc. Ideally,

he should be an experienced Mineral Processing Engineer and work directly under the Mill Superintendent or Manager. He should also be in charge of the metallurgical laboratory, which by the way should incorporate additional testing facilities such as the Humphrey spirals, shaking tables, grinding mill, etc. The metallurgical laboratory, together with the sample preparation room, may need to be relocated, due to the nature of the work, near the mineral beneficiation plant.

g) As plant control and optimization with the help of chemical analysis only is limited, it might be worthwhile that NIOMP start considering the possibilities of introducing the use of both the stereoscopic binocular microscope and the polarized microscope for plant control and optimization processes. As is known, the stereoscopic microscope does not need any special sample preparation, while the polarized microscope would need special preparation in the form of briquetting. In short, the textural relationship, liberation analysis, and the performance of any mineral separation device could be truly assessed by studying key samples of the processing plant under the microscopes.

h) With respect to mutual cooperation between NIOMP and NMDC, I think the opportunity promises to be excellent in the years to come. The MBPP of NMDC, of 250kg/hr capacity, to be set up with the assistance of UNDP/UNIDO mainly to help the iron and steel industry, could be used by NIOMP basically for the following purposes: one, to perform the amenability testing of an iron ore coming from a new zone of the open pit mine with foreseeable metallurgical problems, and secondly to carry out tests for process optimization purposes, for trying new products, new processing techniques, etc. Testing at industrial scale is expensive and risky, therefore the availability of a pilot plant becomes very handy.

i) In order for the mineral beneficiation pilot plant (MBPP) to assist the industrial operation of NIOMP, Itakpe more effectively, it is important that the NMDC pilot plant be capable of setting up a similar process flowsheet to the industrial plant so that the Itakpe iron ore could be tested (at least at the beginning) under a similar process scheme and conditions to the industrial beneficiation plant. In this respect, the MBPP of NMDC may have to consider acquiring additional testing facilities such as the Humphrey spirals, low intensity magnetic separators, etc, as the industrial plant operates with 3 stages of these mineral separation facilities.

j) The mineral beneficiation plant at Itakpe is unique in this country and in many ways a good example from a technical point of view. Therefore, in order to facilitate the work of the pilot plant during its erection, it would be advisable for the contractor who will be in charge of the structure and detail engineering design of the MBPP to visit the NIOMP plant so he could acquire firsthand information of what a mineral beneficiation plant is about.

k) The aforesaid uniquness of the mineral beneficiation plant of NIOMP in terms of equipment, process flowsheet, capacity, the presence of foreign technology, etc, makes this plant very attractive for training. In this respect it is suggested that the shift bosses and the operation and maintenance crews of the MBPP be sent soon to work at this plant as a means of training. Besides, these kinds of projects only take place once in a while. Therefore, it would be good for NMDC to send somebody right away to that plant even at this late stage so that some of the know-how of its technology could be absorbed.

III. VISIT TO AJAOKUTA STEEL COMPANY:

1. Staff Members Visited

Mr. A.O. Bello	-	Asst. Gen. Manager (CO & BPP)
Mr. R.K. Salihu	-	Coal Handling Plant (CO & BPP)
Mr. A.G. Hassan	-	Coal Handling Plant (CO & BPP)

2. Observations:

a) At present, one coke oven battery is completed. It was ignited several months ago and since then kept at low temperature. The present temperature fluctuates between 55 and 58^{0}C. The second battery is under construction and is expected to be finished in about 9 months time.

b) Coal and coke are beginning to arrive at Ajaokuta. I was told that the importation of coke is to make up for the balance of 1.3 million ton/year of coke to be produced by the 2 batteries of the coke oven: as for coal, contracts have been given to 8 companies each to supply 25,000 tons of coal. For the time being the coal is stockpiled in an open temporary storage place. From the operation cost point of view and in order to avoid possible contamination during handling, perhaps it would be worthwhile to consider stockpiling the coal in the permanent storage site. This site, which was designed to receive the coal transported by rail from Warri (not ready yet), otherwise has all its facilities in place; what remains is only to prepare the ground.

c) The decision of not starting production in the coke oven until a sufficient amount of coal is stockpiled and a daily supply of 1600 tons of coal guaranteed is wise. The coke oven is lined with silica bricks, which does not allow big fluctuations once it reaches its operating temperature (1200oC - 1300oC).

d) As for the cooperation between ASCL and NMDC, the opportunity is also excellent. With the coke oven pilot plant of NMDC now in operation owing to the assistance of UNDP/UNIDO, both institutions have the opportunity to start serious research work towards the introduction of the use of domestic coal in the production of coke for ASCL, thereby reducing the amount of imported coal. The decision of ASCL to send newly arrived samples of coke and coal to the NMDC laboratory to verify its quality and for further testing in the pilot plant is commendable. Therefore, as sampling is very important for reliability of results during testing, it would be Worth seeing that the coal sample for testing be taken following sampling techniques established for bulk materials, which takes into account particle sizes, particle segregations, etc.

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NIGERIA

BASIC PLANT DESIGN OF THE COAL PROCESSING LINE AND DRYING FACILITIES FOR THE MINERAL BENEFICIATION PILOT PLANT

BY

WILFREDO A. BELTRAN
CHIEF TECHNICAL ADVISER

PROJECT DP/NIR/87/031

OCTOBER, 1993

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I. INTRODUCTION

Lately, owing to a lower quality of coal and to environmental regulations, the importance of coal washery to meet market specification in terms of ash, sulphur, volatile matter, fluidity, plasticity, calorific values, etc, has increased. Therefore, as the coal mineral resources in Nigeria are large, NMDC decided to set up a coal processing line as part of the Mineral Beneficiation Pilot Plant (MBPP). In this respect, the basic plant design of this coal processing line is taking into consideration certain facilities already contemplated in the MBPP, such as the crushing section and other equipment or infrastructure. On the other hand, as the coal mineral is of a complex nature, the design of the coal processing line is being contemplated in such a way as to incorporate all processes available in terms of coal washery.

II. BACKGROUND

The Mineral Beneficiation Pilot Plant (MBPP) is one of the sub-projects being executed under the UNIDO/UNDP Proj. DP/NIR/87/031, and it refers to the erection of the MBPP at the NMDC, Jos. At

present, this pilot plant, now under construction, will have the capacity of 250kg/hr, and will treat most Nigerian ores except coal. However, owing to the existence of large coal deposits within the country (Enugu - Lafia area), NMDC considered it necessary to include in the MBPP a coal processing line and drying facilities. The last PIC meeting held in April 1993 in Jos recognized these necessities; hence the recommendation of asking the CTA for his cooperation in executing the basic plant design for the coal processing line (coal washery) and drying facilities for the MBPP.

III. DESIGN CRITERIA

1 - The coal processing line is considered as part of the Mineral Beneficiation Pilot Plant (MBPP) and it will be sharing some of the facilities and equipment already contemplated for the MBPP.

2 - The capacity of the coal processing will be more or less in line with that of the MBPP.

3 - The process and plant design should be simple and straight-forward in order to favour good process control and optimization.

4 - It should have good flexibility and be capable of testing any kind of coal samples, Non-cokable and cokable. Therefore, it should incorporate all mineral separation techniques available in coal washery.

5 - It should be capable of producing a sufficient amount of clean coal so that the market possibilities and profitability could be assessed.

6 - The equipment should be installed in such a way as to be relocated to set up a determined process flowsheet.

IV. PROCESS SELECTION

1 - CRITERIA

Considering the scope of the pilot plant in a research institution, the coal processing line was designed to be capable of treating various kinds of coal samples with different Mineralogical characteristics. For this purpose, all mineral separation processes which have proved efficient in coal washery were incorporated. Furthermore, the particle size limitation of each process technique incorporated was taken into account for the design of the process scheme.

2 - FEED PREPARATION

Although the use of a rotary crusher is more suitable for coal, it was decided that the processing line should, insofar or possible, make use of the primary and secondary crushers already designed for the MBPP. The crushing section should be capable of receiving sizes as large as 6" or 8" inches and reducing them to the sizes required. As far as screening is concerned, the coal line is incorporating the use of sieve bends and vibrating screens.

3 - GRAVITY SEPARATION

a) Heavy Media Separation Technique This process, though somewhat expensive, was incorporated in the design because it has shown good reliability and efficiency in coal washery. For more effective Mineral Separation, it is preferable that the heavy media separation be carried out on samples within a somewhat narrow size range. For this purpose an open vessel-type heavy media separator is considered for treating grain sizes between 20mm and 100mm. The cyclone-type heavy media separator is considered for treating grain sizes between 0.6mm and 20mm. It also incorporates a medium recovery system which is mainly based on the magnetic separation of magnetite (medium) of about -45 micron size.

b) Shaking Table, Jigs, Humphrey Spiral - These mineral separation devices are also incorporated in the design, as they have proved to work well in coal washery. In this case, the jigs and shaking tables can be used with sizes as large as 20mm (¾") and as small as 0.6mm (30 mesh). As an exception, the Baum Jig type device, which is capable of handling lumps as big as 100mm (4"), has been also considered here as another alternative for treating large sizes of coal at a possibly lower cost. On the other hand, the Humphrey Spiral is also incorporated in the design to treat particle sizes as large as 2.3mm (8 mesh) and possibly as small as 0.150mm (100 mesh).

4 - FLOTATION

This mineral separation process was incorporated in the design, as it has proved to be suitable for recovering fine coal. Most of the time this process is applied in recovering coal particles in the size range of 0.6mm (30 mesh) and 0.045mm (325 mesh). The process also incorporates the desliming operation using a hydrocyclone. It was also reported (DENVER) that coal particles as big as 5/32" (4mm) have been recovered by flotation. In this connection, it is up to the investigator to explore this possibility.

5 - PROCESS SCHEME

The basic coal processing scheme selected for the pilot plant is shown in Figs. 1 and 2. Fig. 1 shows the use of heavy media separation, shaking tables and flotation. Fig. 2 shows the use of heavy media separation both for coarse and medium sizes, and the use of flotation with a previous desliming operation. These basic processing schemes also take into account the use of other mineral separation techniques such as jigs and Humphrey spirals, which can be incorporated at an appropriate point according to the bench scale testing results. Also, the scheme takes into account the use of a recovery system of the medium (magnetite).

V. DESCRIPTION OF FLOWSHEETS

1. FLOWSHEET NUMBER 1.

a) Crushing - This operation takes place using, insofar as possible, the same facilities contemplated for the MBPP. This means that the run of mine coal sample with a top size of about 8 inches will be fed to the grizzly (3). Grains above 100mm (4") will pass to the jaw crusher (4) of sufficient capacity for further reduction, so that the product will be in the size range of 100mm x 0 (4" x 0). Should the coal sample require finer size for liberation, them the secondary crusher can be used.

b) Heavy Media Separator (Open Vessel Type). - The crushed product is fed to the vibrating screen (9) where particles are split into plus and minus 20mm (3/4") sizes. Particles in the size range 100mm x 20mm (4" x 3/4") are fed into the heavy media separator (open vessel-type) where the coal and the refuse are sharply separated. The specific gravity of the medium (magnetite and water) in the vessel should be around 1.5 so that the coal of sp. grav. of 1.3 would float and the refuse of higher specific gravity would sink. As the sink and float products come out of the vessel impregnated with the medium (Fine magnetite), it is necessary to remove them by means of stationary screens (12 and 14) of the DSM type and vibrating screens (13) and (15) which are provided with spray water for rinsing. The oversize products of these screens are both final products of refuse and clean coal. As

the latter product is in the range of 4" x 3/4", in an industrial plant this product may require further sizing and crushing before it is delivered to the market. In a pilot plant this operation may not be needed.

c) Recovery System of Medium - The fine magnetite (-45 u) obtained as undersize of DSM Screens (12) and (14) is pumped back to the heavy medium vessel to restitute the losses. The dilute medium obtained as undersize of vibrating screens (13) and (15) are thickened in the thickener (16), recovered by a magnetic separator (17), and then sent to the storage or dense media separator (11). The use of a less costly device instead of the thickener (16) should, however, be evaluated.

d) Shaking Table Separator - The undersize of vibrating screen (9) is further screened in the vibrating screen (10), where the size range of 20mm x 0.6mm (3/4" x 30M) is sent to a shaking table (24) for concentration. The heavier fraction (refuse) is further sized in the screen (26), where the coarser fraction is rejected as refuse. The finer fraction is sent to a thickener (27) and a filter (29) for dewatering and water recovery. The clean coal product of shaking tables is further dewatered in the filter (30). Dilution of this product is low; therefore it could be directly filtered.

e) Flotation: - The undersize product of the screen (10), with a size range 30M x 0, is deslimed in the hydrocyclone (20). The overflow (-75u) goes to a thickener and filter for dewatering. The underflow fraction of the hydrocyclone (28 mesh x 200 mesh) is floated in the flotation cell (26). As in most cases, the flotation of coal particles will be done in one stage and using reagents which prove to be effective during bench scale tests. The flotation tailing is further dewatered, as well as the flotation concentrate product (clean coal).

2 - FLOWSHEET NUMBER 2:

This flowsheet is conceived assuming that the coal sample would respond to both coarse and fine size range heavy media separation and flotation. In this respect the flowsheet is similar to No. 1 as regards crushing and screening, coarse size range heavy media separator and flotation. The difference relies on the fact that flowsheet No. 2 uses a heavy media separator of a cyclone type (11A) instead the shaking table. As is shown, this device handles particles of 3/4" size down to 30M size. In addition, it is provided with static and vibrating screens (12A, 13A, 14A, 15) for removing the fine medium and rinsing the clean coal product and the refuse.

If the coal sample would require for liberation a finer crushing (say, 100% -3/4"), then it can be done in the second stage crusher. In this case, the crushed coal sample could be stored in the fine bin (6) from which it could be sent directly to the vibrating screen (10) in order to be treated by an HMS cyclone type (11A) and possibly by flotation.

3 - FLOWSHEET VARIATIONS

a) Flowsheet Number 3. - This flowsheet has been considered as an alternative to dense media separation, which is somewhat expensive. In this respect, the Baum-type Jig has been contemplated as a device to handle lumps as big as 100mm (4") size (35). In fact, this device will be able to produce a high ash refuse and a clean coal product after the jig concentrate is passed through the vibrating screen (10). The size range 0.6mm x 0 is then sent to the conditioner (21) and to the flotation cell (22). Finally, the flotation concentrate and the tailing are sent to the dewatering system.

b) Flowsheet Number 4. - This flowsheet, also developed by Denver equipment, also contemplates the introduction of jigs at a coarse and fine size range. For instance, the crushed coal is sent to the vibrating screen (9). The fraction 100mm x 0.6mm is sent to the Baum-type jig (35) for concentration. The undersize fraction of the screen (9), of a size range 0.6mm x 0, is deslimed in a

cyclone (20). The cyclone overflow is rejected but the underflow is sent to the ordinary jig (35A) where a reject is discarded. The concentrate is then further conditioned and floated.

c) Flowsheet Number 5 - This flowsheet variation contemplates the application of a primary flotation to a size range of 1/8" x 0. Afterwards, the coarse flotation is applied to a particle size range of about 5 mesh x 30 mesh, and its tailing is further treated in a shaking table (24). In short, this simplified flowsheet allows removal of the ash content from the finer fraction of the sample.

d) Flowsheet Number 6. - This flowsheet has been set up to process coal samples which require finer crushing. In this case, it is assumed that the coal sample has been crushed down to minus 20mm (-3/4"). The size range 20mm x 0.6mm is concentrated in the cyclone type heavy media separation (11A), and the size range 0.6mm x 0 (-30 mesh) is concentrated by flotation. This flowsheet, except for the use of a vessel-type heavy media separator, is the same as the flowsheet No. 2 already described. In this respect, all the facilities for recovery of medium, desliming, screening and dewatering are the same.

VI. PROCESS CONTROL AND OPTIMIZATION

1 - PROCESS CONTROL

a) Weightometers - The design contemplates the use of weightometers for continuous measurement of the coal sample being processed, whose information is of great importance for process control and optimization. These weightometers would be located in conveyor belts No. 5, 5B and 8, in figure No. 8.

b) Sink and Float Baths - The design also contemplates the use of these baths for testing the efficiency of the heavy media Separation process during operation. For this purpose, various dense media separation baths should be made available at the laboratory for sink and float tests. The densities of the medium in the baths should be the same as those used in the vessel or cyclone-type heavy media separators.

2 - SAMPLING To facilitate the control during testing, the design also contemplates the use of automatic samplers. These devices are supposed to be located in key places of the coal processing line.

VII. DESIGN FEATURES

1 - LOCATION AND HOUSING

The coal processing line is considered as part of the MBPP, and in this respect it will be set up in the same location. On the other hand, in order to lower the capital cost, it was decided that the coal processing line should share some testing facilities with the MBPP.

2 - PILOT PLANT SIZE AND CAPACITY

As in the case of the MBPP, the coal processing line is designed to pass about 250 kg/hr.

3 - CAPABILITIES

a) The coal processing line is designed to treat various kinds of coal. For this purpose, it incorporates all mineral separation devices used in coal washery.

b) It is capable of processing coal samples of various size distribution ranges, including the fines.

c) It is flexible enough so that various flowsheet configurations could be set up according to bench scale test results.

4 - RELATIONSHIP WITH THE MBPP

The coal processing line is designed as part of the MBPP; therefore it will be located in the same building and share various testing facilities such as crushing, shaking tables, jigs, flotation cells and dewatering system.

5 - GENERAL ARRANGEMENT - (PRELIMINARY EXERCISE)

It was advised at the beginning that the general arrangement be made after the reappraisal of the infrastructure and design of the

MBPP is concluded. However, now that it is known that the primary and secondary crushers would stand as they were designed originally, it is foreseen that the coal washery would be located in the main processing building at the MBPP. This means that the coal sample, after primary crushing, could by-pass the secondary crusher if needed in order to reach the 4th floor of the processing building. In this building, a space should be considered for the coal processing line. Roughly, it is estimated that an area of about 154 m^2) on each floor may be needed (total area of 770m^2) to accommodate the various testing facilities. This figure should be revised after the equipment specification is obtained from the manufacturer. A preliminary exercise of this arrangement is shown in figure No. 8. This view is subject to improvement.

6 - SERVICES

Assuming that the MBPP would treat one ore at a time, the water and electrical power requirements considered for it in the design (33 M^3/day) and (221 KVA), respectively, cover the necessity of the coal processing line, and there is no need to incur additional expenses of this nature.

7 - ENVIRONMENTAL CONSIDERATION AND TAILING DISPOSAL.

Coal handling, screening and crushing may at times be very dusty; however, the dust collector facility, which should be contemplated for the crushing section of the MBPP, ought to take care of this

problem. Also, to minimize cost, the coal processing line is designed to use the tailing disposal facility contemplated for the MBPP.

VIII. DRYING FACILITIES FOR THE MBPP.

1 - DESIGN CRITERIA

a) The dryer should be appropriate for drying granular materials in the form of metallic or non-metallic ore concentrates.

b) It should have sufficient capacity to cope with a continuous operation of the pilot plant during 30 days and at the rate of 250kg/hr (Design capacity of MBPP).

c) It should be capable of taking ground products of about 15% H_2O, and dry them down to 5% H_2O or even less. It should be able to handle particles below 60 mesh size.

d) It should generate a minimum amount of losses in the form of fines, and it should be provided with a dust collector system for environmental purposes.

2 - EQUIPMENT SPECIFICATIONS

a) Type of Dryer: After examining the various types of dryers, it was decided that the rotary-type dryer (indirect heat type) would be the most appropriate for the pilot plant of NMDC.

b) Size and Capacity: The rotary dryer should have a capacity of ITPH. This capacity should easily meet the production

of the pilot plant. The 19' x 42" x 12"H size SEPOR Rotary Dryer has a capacity of ITPH, and may be the most suitable.

c) Other Specifications: The rotary dryer should have a dust collector system and temperature control. It should include the motor and starter, and a drive system. It should also have a feeding and discharge mechanism.

d) Approximate Cost Estimate: The cost of a dryer of this type would be around $ 60,000. A more precise figure should be obtained from the manufacturer.

3 - PROCESS FLOWSHEET

Fig. 7 shows the process flowsheet of a dewatering system for the MBPP. This system incorporates a thickener, filter and a rotary dryer.

IX. PRELIMINARY EQUIPMENT SELECTION & COST ESTIMATES

1 - LIST OF EQUIPMENT

a) Criteria - The coal processing line and the drying facility are planned to exist as part of the MBPP already designed. Therefore, in order to lower the capital cost, it was contemplated to share some of the equipment of the MBPP. In this respect, the list of the equipment required will only show the items which are most needed. (See table No. 2.)

b) List of equipment The total list of equipment which will be incorporated in the coal processing line is shown in table No. 1. Table No. 2 shows only the equipment which would need to be bought.

These lists are of a preliminary nature and the final list should be elaborated after the reappraisal exercise of the MBPP is completed, or better still after the MBPP is erected. Some of the material handling equipment needed could be better assessed after the Mineral Beneficiation Pilot Plant is erected. For more realistic equipment sizing and specifications, it is recommended to approach the equipment manufacturers, who should also be given all technical information about the pilot plant.

2 - CAPITAL COST ESTIMATE

A more accurate cost estimate will require confirmation only after the final list of equipment is ready along with the manufacturers' quotations. Therefore, the cost estimate of 352,000 US. Dollars, given here for purchasing the equipment needed, is only an approximation and should be used merely as a reference.

X. CONCLUSIONS AND RECOMMENDATIONS

1. This report refers only to the basic plant design of the coal processing line (coal washery) and drying facility for the MBPP. A detailed engineering plant design, including the general arrangement for each unit process and the overall layout are yet to be done. Therefore, it is recommended that the UNIDO Consultant for the MBPP take up this task and incorporate it in the general MBPP design.

2 - The coal processing line of the pilot plant is conceived as part of the MBPP. In this arrangement, both would share the use of some testing facilities. Its capacity is similar to that of the MBPP (250kg/hr).

3 - The design incorporates in the coal processing line most of the mineral separation process techniques available in coal washery. The heavy media separator, shaking table, jigs, Humphrey Spiral and flotation are among the mineral separation processes used in the coal processing line. However, the various processing flowsheets presented are subject to improvement if necessary.

4 - The coal processing pilot plant will be capable of treating all kinds of coal samples and at various size ranges. The top size could be as large as 1" and the fines as small as 350 mesh or even below. According to the mineralogical characteristic of the sample,

the feed preparation can be accomplished using only the primary crusher or including the secondary crusher. The various process flowsheets were designed to handle all kinds of situations.

5 - Several flowsheet configurations are given as examples of possible cases which could appear during testing. The Baum-type Jig and the heavy media separator (Vessel type) could be used on grains as large as 1". Other gravity concentration devices are used for intermediate sizes, and flotation for the recovery of fines. Manufacturers should be asked if they could provide mineral separation devices to handle sizes as big as 4 inches and at the rate of 250 or 500kg/hr. The pilot plant should have facilities to handle coarse sizes of coal samples.

6 - The coal processing line should be provided with a weightometer to register continuously the weight of coal samples being processed. Also, automatic samples should be located in key places to facilitate plant control and performance evaluation. Sink and float baths based on magnetite medium should also be implemented for process control of the pilot plant.

7 - In order to lower the capital cost, it was decided that the coal processing line should be set up in such a way as to make use of some of the facilities of the MBPP. In this respect, facilities

such as those existing in the crushing section, hydrocyclone, shaking tables, and flotation cells would be used by the coal processing line.

8 - Services such as water and the electrical power supply considered for the MBPP would be sufficient for the coal processing line as long as the pilot plant processes one type of ore at a time.

9 - If funds are not available to purchase the thickeners and filters considered for the dewatering of fine refuse and coal concentrate, then the coal processing line could make use of the dewatering system and the tailing disposal system contemplated for the MBPP.

10 - The lists of equipment given in table 1 and 2 are based on the process flowsheet presented, and if necessary they can be altered according to the improvements introduced in the flowsheets. On the other hand, the equipment cost estimated ($ 352,000) which includes the dryer, is only an approximation and should only be taken as a reference. A more accurate figure should be obtained from the manufacturer.

11 - For more realistic equipment cost estimate, specification, and sizing, it is recommended to approach the equipment manufacturers, who should also be given information such as plant capacity, local power characteristics, process flowsheets and other relevant information they need. Equipment manufacturers know their equipment limitations and advantages, and they usually provide very useful recommendations for plant design.

12 - The type of dryer chosen for the MBPP is the rotary type with indirect heating, and 19' x 42" x 12"H in size. It should be provided with a dust collector system and temperature controller. It is designed to have a capacity of ITPH and to handle particles below 60 mesh. It is also designed to handle granulate materials as humid as 15% H_2O and dry them down to 5% or less.

13 - With the intention of assisting the future detail engineering design, including the arrangement and layout of the coal processing line and drying facility, a preliminary exercise of this arrangement and space area allocation is given in figures No. 8 and 9. Now that it is known that the primary and secondary crusher would stand as they were designed originally, it is foreseen that the coal washery and the dryer would be located in the main processing building of the MBPP. This means that the coal sample, after the primary crusher, could by-pass the secondary crusher if

needed in order to reach the 4th floor of the main processing building. A preliminary estimation points out that a space area of about 154m^2 on each floor (total of 770m^2) may be needed. This figure should be revised after the equipment specifications from the manufacturers are available.

14 - The possible suppliers of equipment are also included in this report to facilitate future contact with them.

15 - Finally, this basic plant design of the coal washery and a dryer is subject to improvement. This is the first work done in the Centre along this line, and if needed it could be used as a basis for more elaborate work in terms of process design and plant design of the coal washery and dryer for the MBPP.

TABLE NO. 1.

PRELIMINARY LIST OF EQUIPMENT INCORPORATED IN FLOWSHEETS NO. 1 TO NO. 6 OF THE COAL PROCESSING LINE AND DRYING FACILITY.

CAPACITY OF COAL WASHERY: 250kg/hr.

CAPACITY OF DRYER: 1 Tonne/hr.

1. Coarse bin
2. Feeder
3. Vibrating grizzly
4. Jaw crusher.
5. Conveyor belt
6. Fine bin
7. Feeder.
8. Conveyor belt
9. Vibrating screen
10. Vibrating screen
11. HMS Vessel type

11A. HMS Cyclone type

12. Static screen (DMS) for refuse

12A. Static screen (DMS) for refuse of cyclone

13. Vibrating screen for refuse

13A. Vibrating screen for cyclone refuse

14. Static screen DMS for float fraction (Vessel)

14A. Static screen DMS for float fraction of DMS (cyclone type)

15. Vibrating screen for float fraction of HMS (Vessel Type)

15A. Vibrating screen for float fraction of HMS (Cyclone type)

16. Thickener for dilute medium.

17. Magnetic separator (Drum) for recovery of medium.

18. Pump slump for hydrocyclone

18A. Pump for recovery of medium

18B. Pump for recovery of medium after magnetic separation

19. Pump for hydrocyclone

20. Hydrocyclone

21. Conditioner

22. Flotation cells

23. Pump for flotation tails.

24. Shaking table

25. Pump for shaking table tails.

26. Vibrating screen.

27. Thickener for refuse (fines)

27A. Thickener for concentrate (fines)

28. Thickener pump (2)

29. Filter for refuse

30. Filter for clean coal concentrate

31. Vibrating screen (optional)

35. Baum type jig.

35A. Jig.

40. Weightometers (2)

41. Automatic samplers (5)

42. Conveyor belts

43. Wet reagent feeders (3)

Notes:

1. Some of this equipment is already considered in the MBPP design.
2. For detail equipment specification and costs, write to the manufacturer.
3. A thickener and its pump are necessary for dewatering the fine coal concentrate (clean coal)

TABLE NO. 2

PRELIMINARY LIST OF EQUIPMENT TO BE PURCHASED FOR THE COAL PROCESSING LINE AND DRYING FACILITY.

CAPACITY OF COAL WASHERY PILOT PLANT 250kg/hr.

CAPACITY OF DRYER: 1Tonne/hr.

	APPROXIMATE PRICE $ UNIT	TOTAL
9-10 Vibrating Screen (2)	12,000	24,000
11 - Heavy Media Separator (Vessel type)	15,000	15,000
11A- Heavy media separatory (cyclone type)	10,000	10,000
12-12A - Sieve Bend Screens DMS (2)	4,000	8,000
13-13A - Vibrating screen (2)	12,000	24,000
14-14A - Sieve Bend Screens DMS (2)	4,000	8,000
15-15A - Vibrating Screen (2)	12,000	24,000
16 - Thickener for dilute medium	6,000	6,000
17 - Magnetic separator (Drum type, LIMS)	20,000	20,000
18A - Pump for medium recovery	2,000	2,000
23 - Slurry pumps (4)	2,000	8,000
27 - Thickener for refuse (fines) 6' O x 6'	6,000	6,000
27A - Thickener for concentrate (fines) 6'x 6'	6,000	6,000
28 - Thickener's pump (2)	2,000	4,000
29 - Filter for refuse	22,000	22,000
30 - Filter for concentrate	22,000	22,000
35 - Baum type jig.	20,000	20,000
35A - Jig 8" x 12"	15,000	15,000
40 - Weightometer (3)	6,000	18,000

41 -	Automatic samplers (5)	3,000	15,000
42 -	Conveyor belts (2)	6,000	12,000
43 -	Wet reagent feeder (3)	1,000	3,000
	Rotary dryer	60,000	60,000
			$352,000

Notes:

1. This cost estimate is purely referential
2. For detail equipment sizing specification and equipment cost estimate, contact the manufacturer.

TABLE NO. 3.

POSSIBLE SUPPLIERS OR EQUIPMENT

SIEVE BEND SNAD
VIBRATING SCREENS

CE. TYLER, USA.
HEWITTROBINS CORP.
SIMPLICITY ENGINEERING USA
DEISTER MACHINE CO. USA
DORR OLIVER CANADA LTD - USA
ENVIROCLEAR CO INC. USA

HEAVY MEDIA SEPARATOR

MC NALLY PITTSBURG, INC, USA
HEYI & PATTERSON INC, USA
WEMIO, USA
MIN PRO LTD, CANADA.
BOXMAG-RAPID LTD, UK.
ERIEZ MAGNETICS - USA

THICKENER & FILTER

DENVER EQUIPMENT, UK
DORR OLIVER INC. USA/CANADA
EIMCO PROCESS EQUIP. USA
ENVIROCLEAR CO. INC. USA
LAROX INC. FINLAND.

MAGNETIC SEPARATOR

BOXMAG - RAPID, UK.
ERIEZ MAGNETICS, USA.
DINGS CO. MAGNETIC, USA
MINERAL DEPOSIT, AUSTRALIA
SALA MACHINE, SWEEDEN.

JIGS, INCLUDING BAUM TYPE

McNALLY PITTSBURG INC, USA
DENVER CO, UK, USA.
KHD. HUMBOLDT WEDAG. GERMANY
MINERAL DEPOSIT, AUSTRALIA,
BOLIDEN ALLIS, SWEEDEN.

WEIGHTOMER

ERRIC MANUF. CO. USA
RAMSEY TECHNOLOGY, USA
HEY & PATTERSON INC.USA
AUTOWEIGHT - USA.

CONVEYOR BELT

ALLIS CHALMERS CORP. USA
BRIDGESTONE CORP. USA
MINPRO. LTD. CANADA
McNALLY PITTSBURG, USA
GEC, MECH. HANDLING, LTD UK

AUTOMATIC SAMPLERS

DENVER EQUIPMENT, USA
MINERAL DEPOSITS, AUSTRALIA
SALA INTER. SWEEDEN.

WET REAGENT FEEDER

CLARKSON CO. USA
DENVER CO. USA
MINPRO, CANADA

ROTARY DRYER

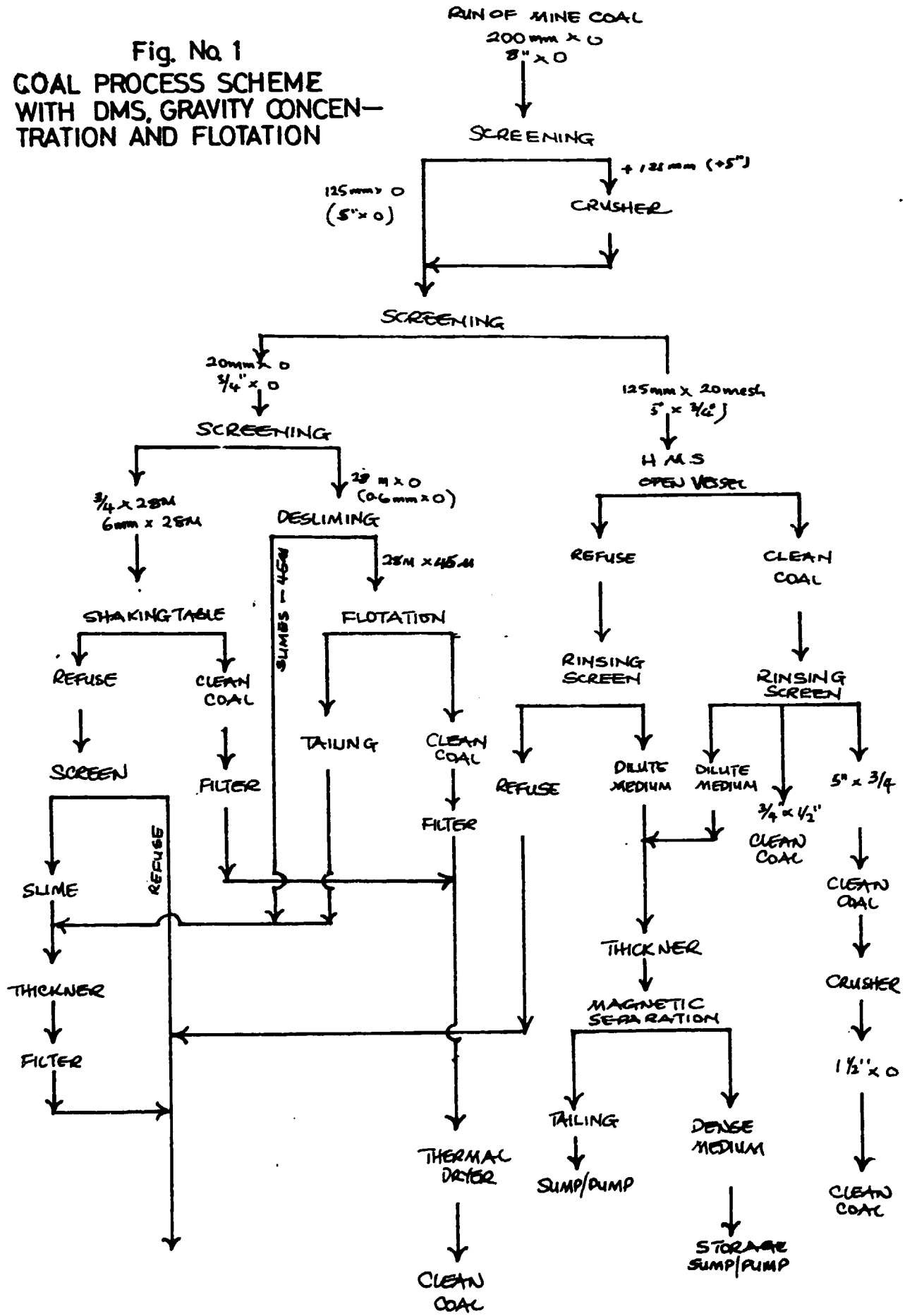
DENVER EQUIPM. UK.
SEEPOR, USA.
GEC. MECH. HANDLING LTD UK
KENEDY VANSA AUN CORP. USA
SMITH F.L. USA

SLURRY PUMPS

WARMAN/INTERNATIONAL, USA.
DENVER EQUPM. USA
DOOR OLIVER INC, USA
ALLIS CHARMERS PUMP, USA
GEC. MECH. HANDLING LTD UK.

Fig. No. 1

COAL PROCESS SCHEME WITH DMS, GRAVITY CONCENTRATION AND FLOTATION



FLOWSHEET N. 1
COAL PROCESSING WITH DMS., GRAVITY CONCENTRATION AND FLOTATION

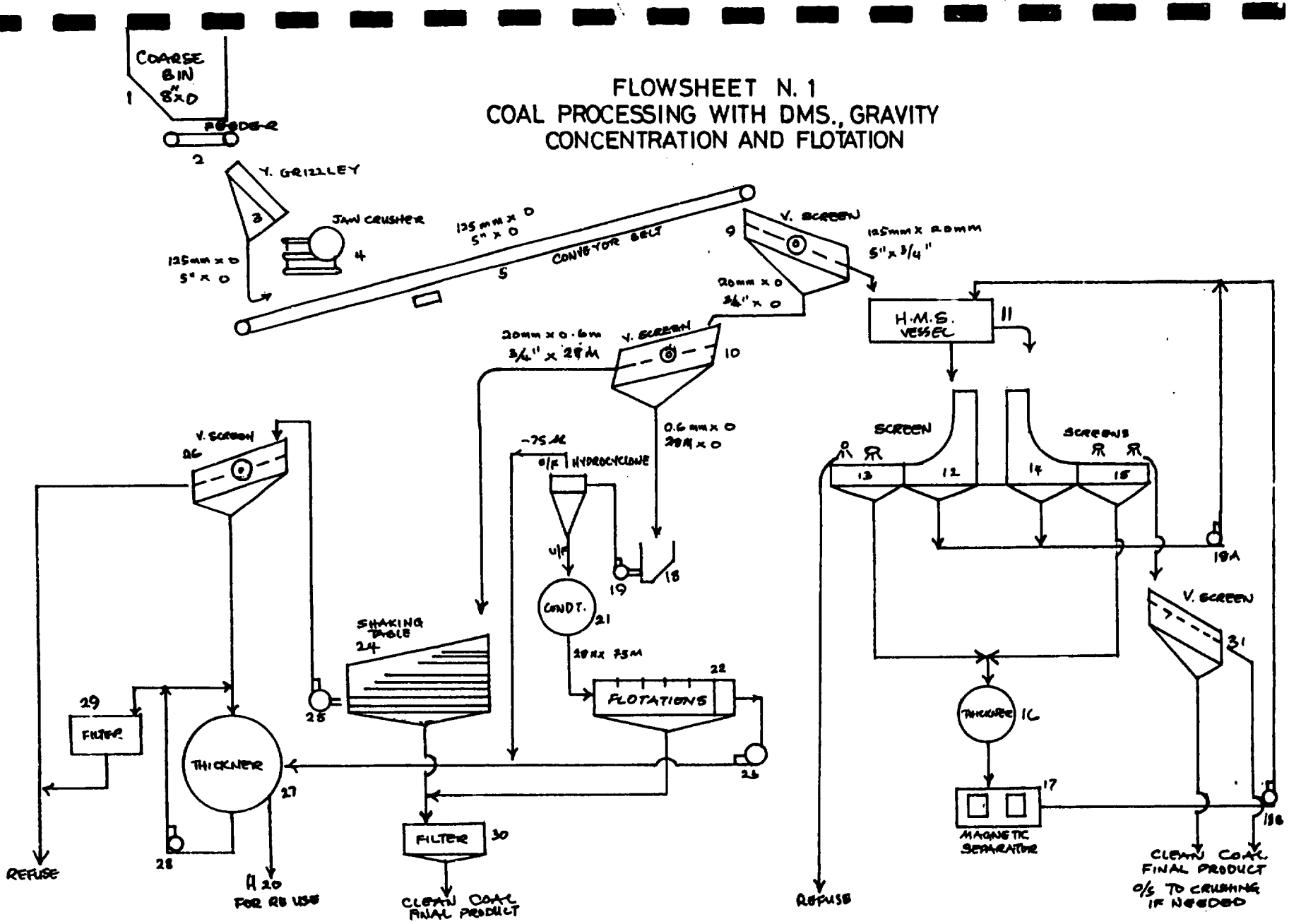
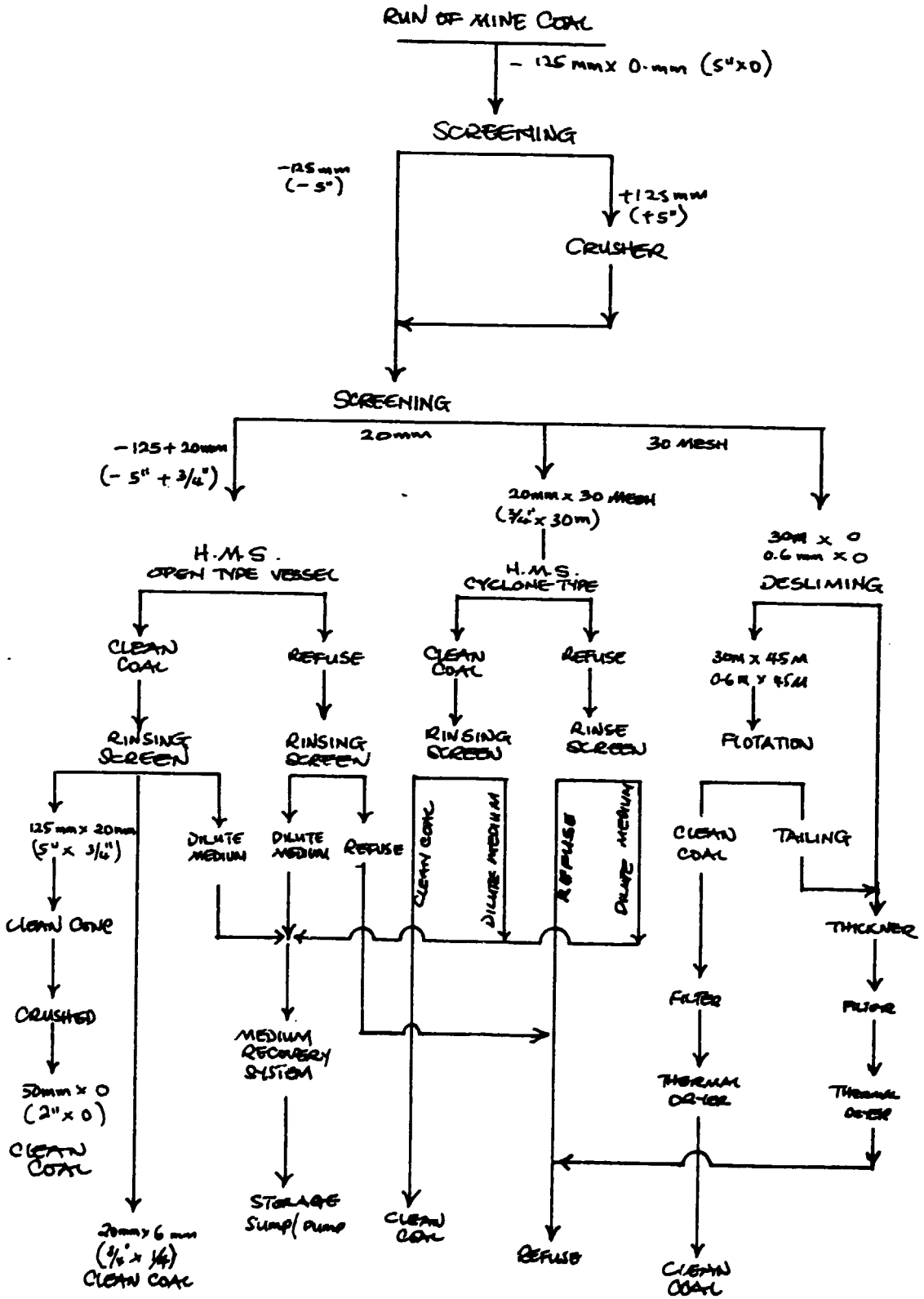


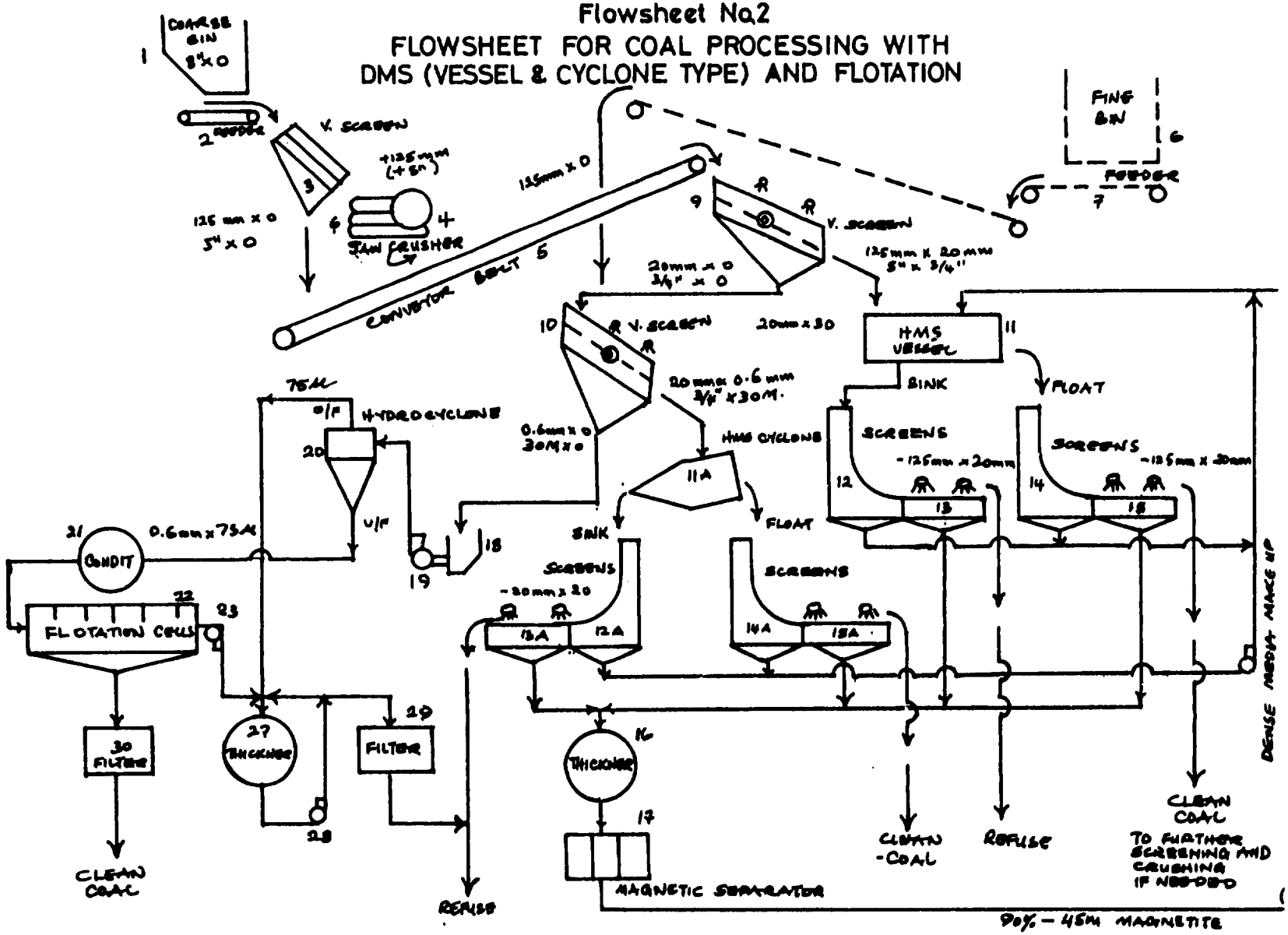
Fig. No.2

COAL PROCESS SCHEME WITH DMS (VESSEL & CYCLONE) AND FLOTATION

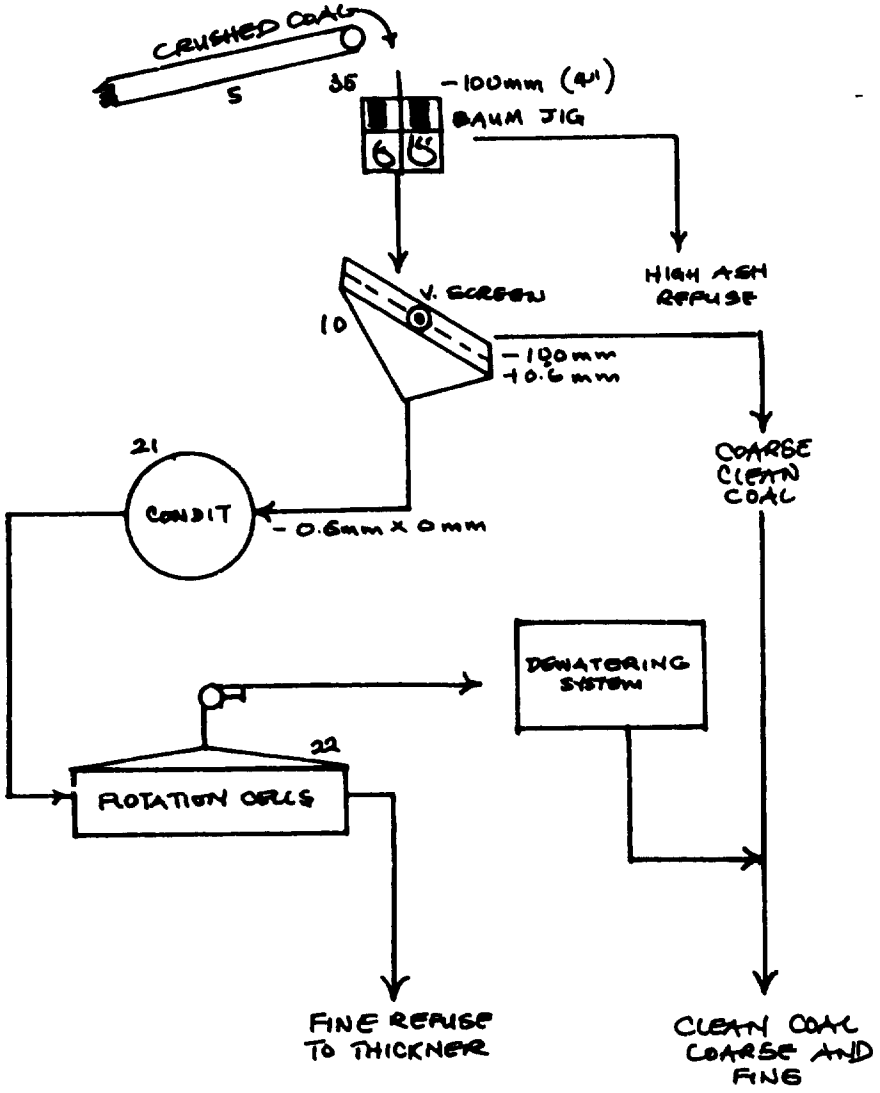


Flowsheet No.2

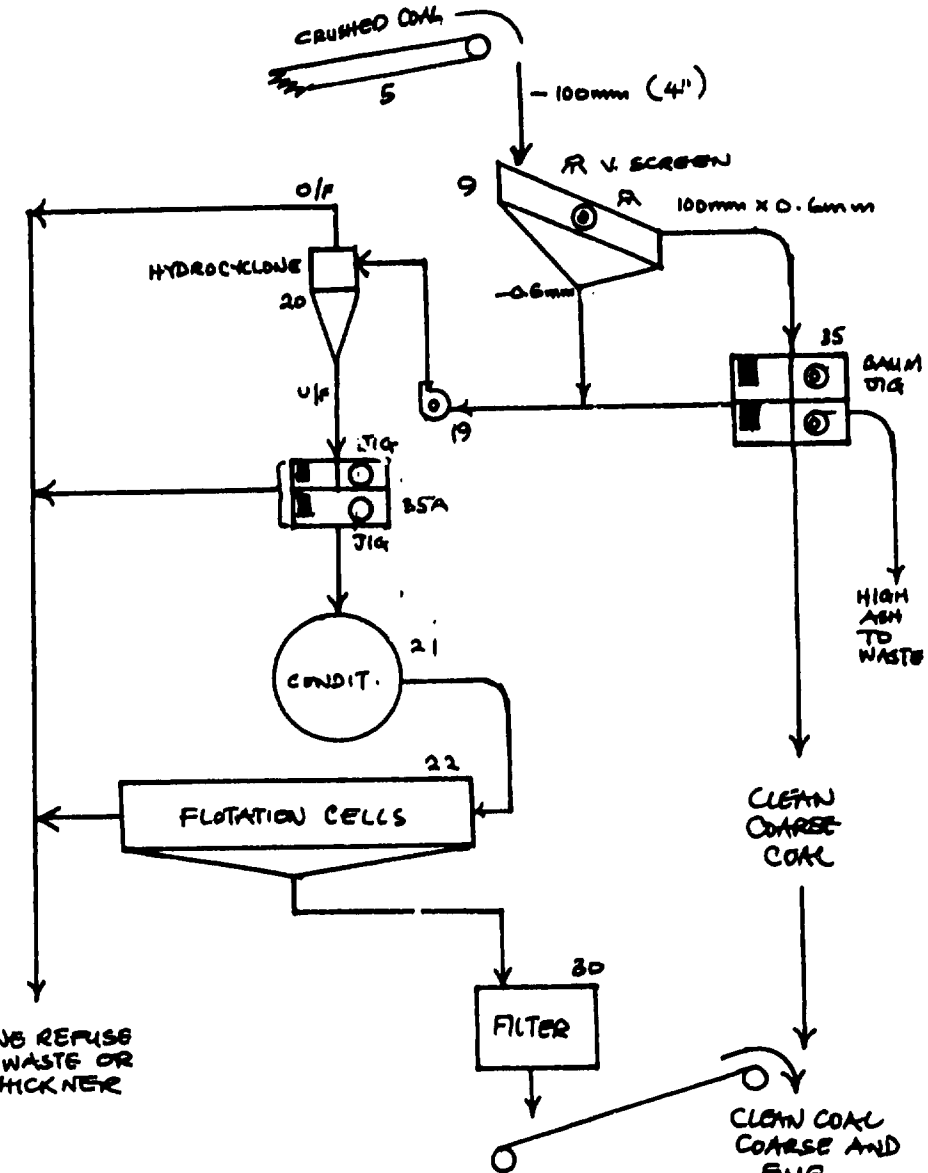
FLOWSHEET FOR COAL PROCESSING WITH DMS (VESSEL & CYCLONE TYPE) AND FLOTATION



FLOWSHEET NO. 3.
COAL PROCESSING WITH GRAVITY
CONC. AND FLOTATION



FLOWSHEET NO. 4
COAL PROCESSING WITH GRAVITY
CONC. AND FLOTATION



FLOWSHEET NO. 5
COAL PROCESSING

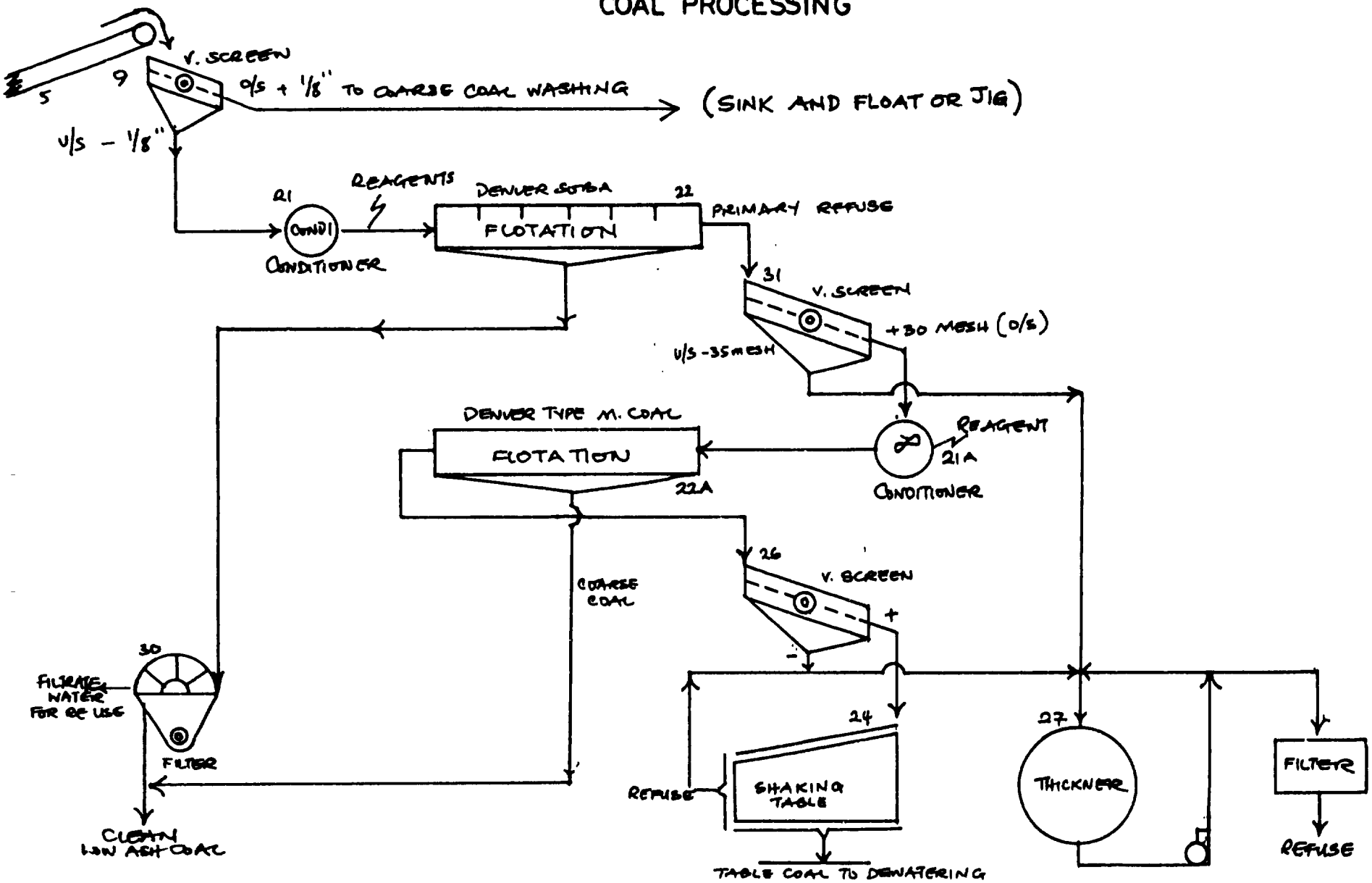


Fig. No. 6
COAL PROCESSING WITH DMS AND FLOTATION

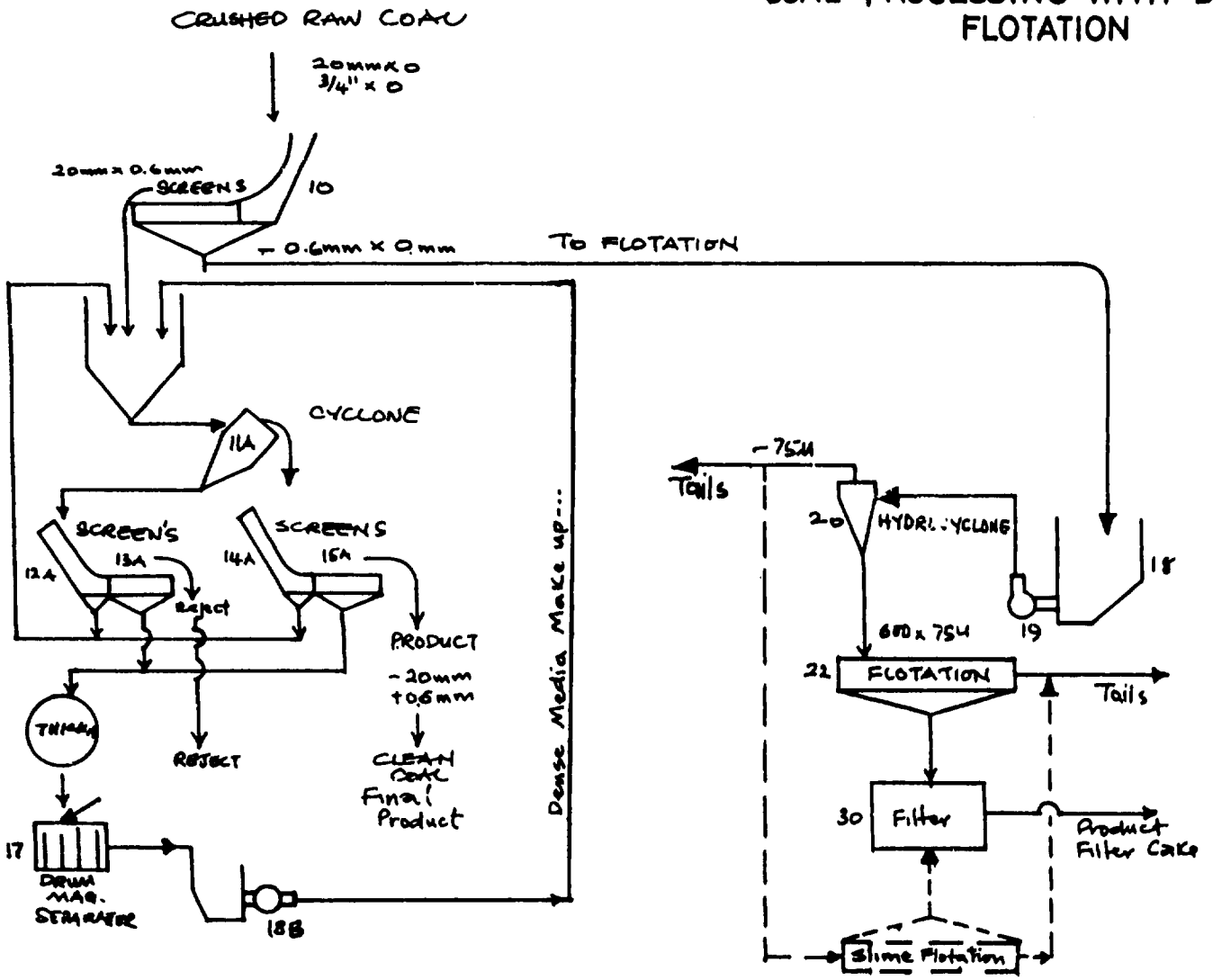
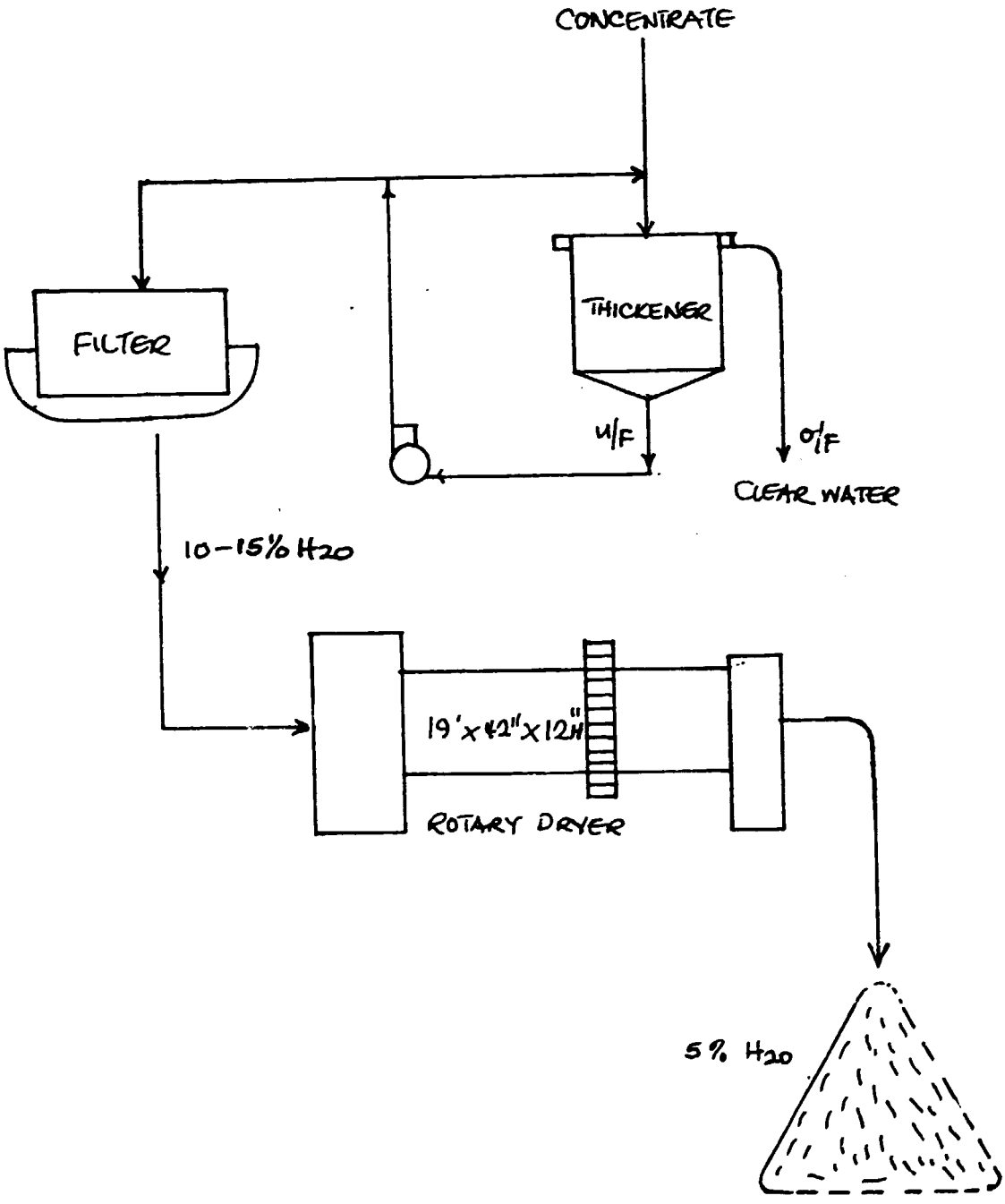


Fig. No. 7

DEWATERING SYSTEM FOR THE MBPP



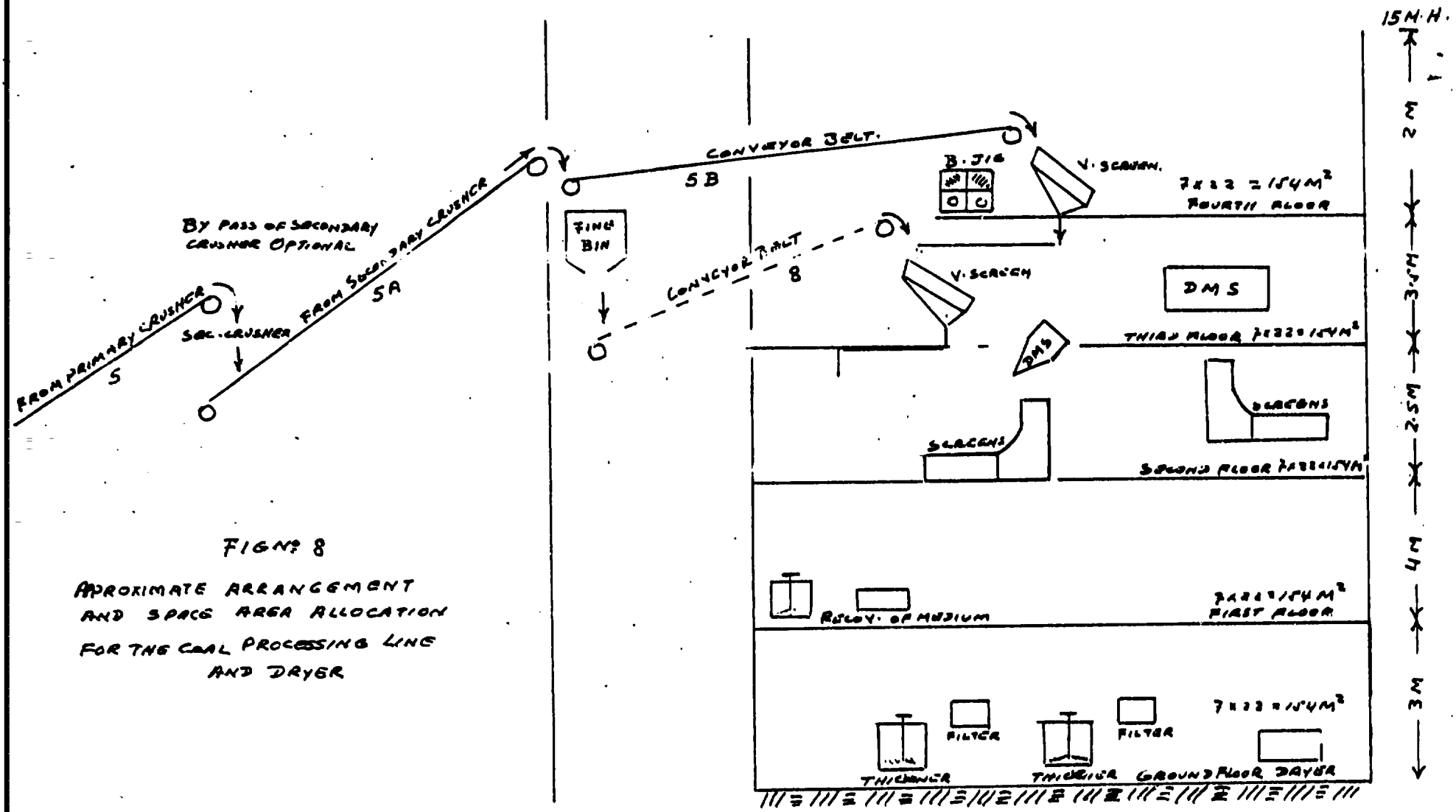
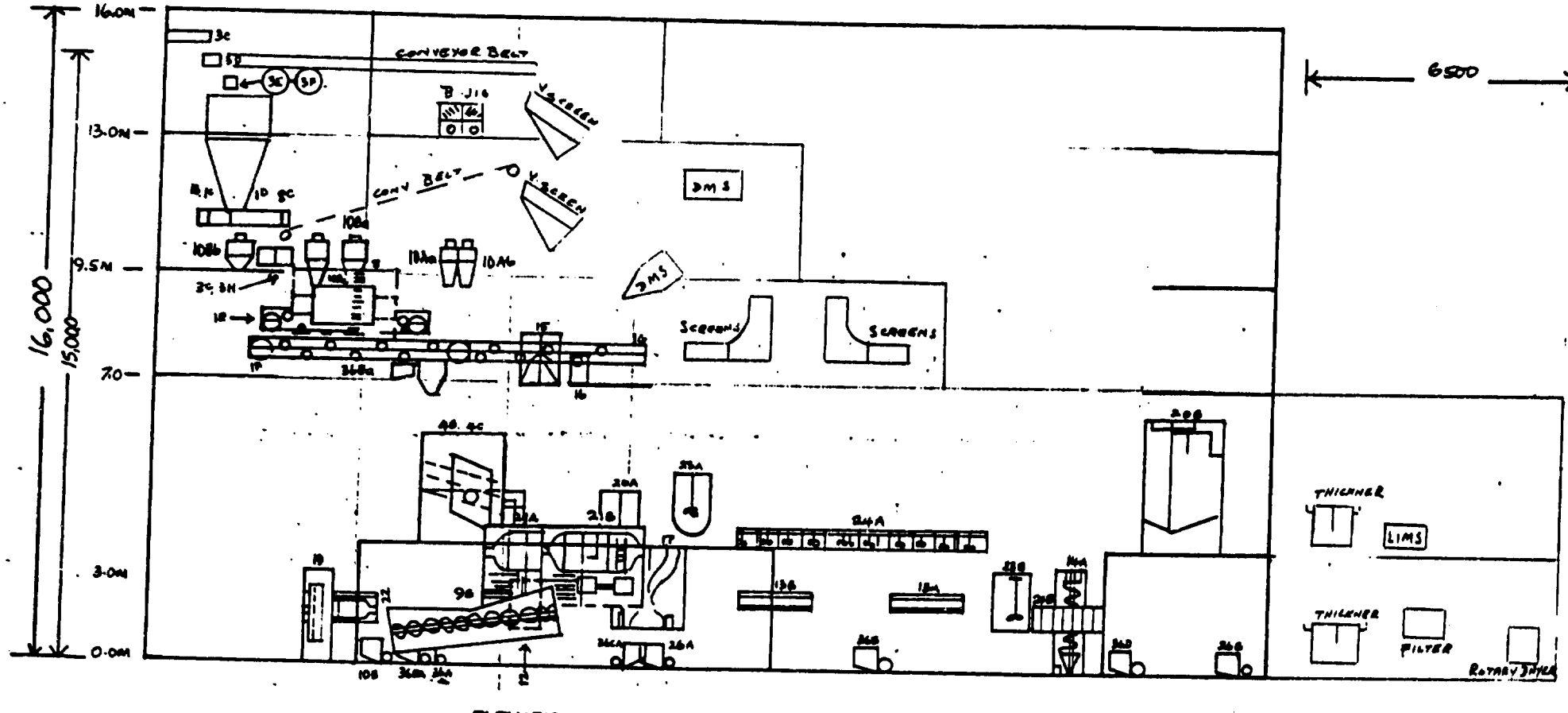


FIG Nº 8

APPROXIMATE ARRANGEMENT AND SPACE AREA ALLOCATION FOR THE COAL PROCESSING LINE AND DRYER

FIG N° 9



ELEVATION FROM ADMINISTRATION BUILDING

5000 — 10,000 — 8000 — 4000

12,000