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06763

Distr.
RESTRICTED

UNIDO/ITD.342
23 June 1975

ORIGINAL: ENGLISH

UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

DESIGN OF EQUIPMENT FOR PRODUCTION AND PROCESS FOR GRANULATED SINGLE SUPER PHOSPHATE (SSP) 1/

PAKISTAN

(TS/PAK/75/001)

by

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id.75-6103

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1. The existing S.S.P. plant at Jaranwala comprises a 10 ton/hour continuous Moritz Den, and a Moritz Airswept Mill (type BC-8) with a design capacity of 8 tons per hour of phosphate rock. However, the mill never reached design capacity; with Jordan rock 2% H_2O capacity is 6.75 t/hr. at 10% n.o. capacity = 2.5 t/hr.

The sulphuric acid plant is designed by Simon-Carves; capacity is 50 t/day.

2. Neither sulphuric acid nor grinding capacity is sufficient for a 10 t/hr. or 240 t/day production of S.S.P.

A second unit for sulphuric acid is under construction. This unit is identical to the existing one and total capacity will be doubled. A Babcock-Wilcox ball race mill, originally used for grinding coal, is being installed at Jaranwala; expected capacity is 3-4 t/hr.

The combined grinding capacity is expected to produce at least 6.75 tons of ground rock needed for the production of 10 tons S.S.P. per hour .

3. A design was made for a 10 ton granulating plant. This plant contains a rotating granulator, a rotary cocurrent dryer and a furnace based on natural gas. Moreover, a screening unit. Oversize shall be broken and recycled to the screen. Fines are to be recycled to the granulator. Recycle rate to the granulator is estimated to be 1:2.

4. A lay out is made to find a proper location for the equipment items. It was shown that the existing production hall can contain the equipment, providing an extension of 6 x 12 m and a height of 11 m.

5. The existing storage can be used for granular S.S.P. In order to be able to store more material, it is recommended to use wheelloaders, movable belt conveyors and ditto hoppers enabling to make piles of about 5m in height.

6. Total costs are calculated to be Rs. 6,065,000.

7. Operating costs are calculated to be Rs. 30.10/ton for 80,000 t/a and Rs. 32.32/t for 72,000 t/a.

8. The engineering staff of the Daudkhel factory can prepare shop drawings of the equipment described in this report.

9. Manufacture of equipment can be done in Pakistan with the exception of the vibrating screens. Apart from the granulator and rotary dryer equipment can be made at NFC Daudkhel factory. The granulator and rotary dryer can be built at HMC at Taxila.

10. Much attention should be given to a thorough investigation of the Hazara phosphate rock. Benefication processes should be studied. Concentrates thus obtained should be investigated as to further processing. In connexion with this study it is recommended that UNIDO's assistance be requested.

11. In-factory training for a production engineer in a superphosphate granulating plant is to be highly recommended.

12. It is recommended that the final drawings including shop drawings be forwarded to UNIDO for comments and review. Appropriate requests for further assistance be made at the time.

II. INTRODUCTION

The Fertilizer Industry in Pakistan is partly publicly, partly privately owned.

The National Fertilizer Corporation of Pakistan Ltd. (NFC) is one of eleven organizations under control of the Board of Industrial Management (BIM), of the Ministry of Industry. BIM controls the state-owned industries.

NFC was founded early 1974 and at present controls three operating units:

1 - Pak Arab Ltd., operates at Multan a ammonium nitrate and a urea plant fed by a 200 t/day ammonia plant based on natural gas. This plant will be extended. A 900 t/day Kellogg ammonia plant is under construction. It will produce raw material for a Stamicarbon nitrophosphate plant (70,000 t N and 70,000 t P_2O_5 per year, mainly as 23-23-0).

Moreover, 119,000 t N/a as 26% calcium ammonium nitrate and 33,000 t N as urea will be produced. Jordan phosphate rock is used as raw material for the nitrophosphate plant.

2 - At Daudkhel, 200 km N.W.O./Lahore - Pak-American Fertilizers Ltd. operates an Ammonia Plant built by Lurgi and Casales (Coal Gasification) in 1958 and having a capacity of 45 t/day. The ammonia is used to produce sulphate of ammonia by the Merseberg process. In 1971 the ammonia unit was rebuilt to use natural gas and its capacity was enlarged to 90 t/day.

3 - Lyallpur Chemicals + Fertilizers Ltd., with factories at Lyallpur (1951) and at Jaranwala (1967) produces sulphuric acid and single superphosphate.

The Lyallpur Factory produces SSP at a rate of 60 t/day; sulphuric acid is made from elemental sulphur. The plant will be closed when the Jaranwala extension is on stream and the site will then be used for a research station.

The Jaranwala factory will be described later in more detail. (see page 5)

Both factories use Jordan phosphate rock.

NFC plans to construct two more factories.

4 - At Mirpur Mathelo, near the Mari natural gas deposits, a large nitrogen project is being developed. Early 1978 a 1,000 ton/day ammonia plant designed by Topsoe and a Snam Progetti Urea Plant (1740 t/day) will be operating.

5 - In North Pakistan at Hazara, phosphate rock deposits have been found recently. The rock is an apatite type rock and benefication processes are being studied. Several samples are investigated and P_2O_5 contents ranging from 32% up to over 40% are found. The crude rock contains relative large amounts of silica as well as iron and aluminium. Other types contain dolomitic impurities. The Hazara rock phosphate apparently is very hard and tests about its grindability should be made. Crushing to a size suitable to feed a pulverizer should be done by a jaw crusher, a cone crusher or a similar suitable machine. Grinding to a suitable fineness for beneficiation processes should be studied, as well as the beneficiation processes themselves. It is of great importance to reduce the amounts of silica, iron, aluminium and dolomitic impurities.

Plans are made to install at Hazara a 100,000 ton P_2O_5 per year phosphoric acid plant. This plant should be operational by 1978/79. The phosphoric acid shall be transformed into 100,000 t of TSP (45,000 t P_2O_5) and 54,000 tons of P_2O_5 shall be processed into Mono Ammonium Phosphate.

The 60 t/day Ammonia Plant at Multan shall be transferred to Hazara. MAP and urea shall be compounded into a 27-27-0 fertilizer.

Apart from the state-owned companies there are two privately owned fertilizer companies:

1 - Dawood Hercules near Lahore producing 160,000 t N as urea in the gas field area.

2 - ESSO at Dharki - producing 80,000 t N as urea.

Starting in 1978/79, the Fauji Foundation in collaboration with Agrico Chemicals of USA, intend to produce ammonia and urea. Capacity is planned to be 258,000 tons of urea per year. The factory will be located in the gas field area.

Total demands in Pakistan for 1979/80 are projected to be 1,000,000 tons of N and 400,000 tons P_2O_5. As the production capacity of P_2O_5 is planned to be 190,000 tons, import should cover the remaining 210,000 tons of P_2O_5.

III. JARANWALA FACTORY

A. Present situation:

The purpose of the present study is to enlarge the production of single superphosphate at the Jaranwala factory to 240 t/day and to design a granulating plant for the produced SSP.

At present, a sulphuric acid plant of 50 t/day is on stream. This plant is a Simon-Carves/Monsanto design based on sulphur. It was constructed in 1962.

A similar unit is under construction and will bring the production up to 100 tons per day. Most equipment items are produced in Pakistan.

At present, the SSP is made in a Moritz Continuous Den having a capacity of 10 tons per hour or 240 tons per day.

However, this Den was never operated at design capacity, both for lack of sulphuric acid and of grinding capacity. A Moritz Airswept Mill type BG-8 with 3 rollers has a design capacity of 8 tons per hour (100 mesh) with North African rock. When grinding Jordan phosphate, capacity is lower mainly because of its high water content. When dry rock is used (up to 2% H_2O) capacity is 6.75 t/hour which meets the demand for 10 tons SSP.

But at 3% H_2O capacity is 5 t/hour, at 10% H_2O capacity is 2.5 t/hour.

Storage of phosphate rock is in the open air - rock arrives at Karachi with a water content of 2% but gradually it rises to 3-6% and even higher during the short rainy season.

Plans to store under roof are made. But to meet the problem a second grinding unit is under construction.

The mill is a Babcock-Wilcox type E41 ballrace mill formerly used in the Daudkhel Plant to produce powdered coal.

A semi closed recycle system shall be added and it is expected that capacity will be 3-4 tons of rock per hour.

The two mills are expected to produce as a minimum the 6.75 tons needed for the production of 10 tons SSP per hour.

The Hazara rock shall be tested in these mills. It is a very hard type of rock and a powerful crusher is needed to prepare the feed for the grinding mills.

IV. GRANULATION PROCESS

To produce granular SSP the following items of equipment are needed:

a) Drum type Granulator
b) Cocurrent Dryer
c) Screening Section
d) Lump Breakers preferably Cage Mills
e) Internal transportation equipment including bucket elevator, belts, conveyors
f) Ventilation equipment
g) Miscellaneous

Fig-1 presents a flow sheet including all items of equipment and auxiliaries.

It is supposed that the rate of recycle is about 2/3 of the flow of material through the granulator and the dryer. As the feed is 10 t/hour, this implies a recycle of 20 t/hour and a total flow of 30 t/hour through the granulator/dryer combination.

Occasionally, the recycle may reach higher values and capacity must be such that recycle may reach 75% of the total flow. This means a recycle of 30 t/hour and a total flow of 40 tons through the dryer.

Assuming an over capacity of 10% of the Moritz Den, a maximum flow of 44 ton/hour can be expected occasionally. Normal flow will be about 30-35 t/hour. The screening unit has to separate the feed in on size product, oversize and fines.

The fines have to be recycled to the granulator, the oversize is to be fed to a lump breaker and the reduced product has to be recycled to the screens.

Assuming the feed contains:

25% oversize
30% on size
45% fines

and after breaking the oversize will contain about 21% of fines and 4% of on size granules, the result is 34% of on size product and 66% fines to be recycled (ratio 1:2).

As the broken oversize is recycled to the screens, the total load of the screens is 125% of the original feed or 38-44 t/hour. If however, the oversize amounts to 35%, the total screen load rises to 41-44 t/hour. It is assumed that the screen section should be able to handle 50 t/hour as a maximum. Whether this amount should be handled using either one or two units of screens depends on the equipment available in the country. Screen capacities depend on type of screens. Generally electrically vibrated screens have larger capacities per square meter than the mechanically vibrated types.

V. EQUIPMENT

The different items of the flow sheet (fig ...1) will be discussed separately.

1 - Moritz Den

This Den was installed in 1968; it gives a continuous flow of SSP and works satisfactorily. Discharge is done by a scraper device and an apron conveyor that produces a rather fine product however, containing lumps of different sizes. A typical screen analysis of the product discharged from the den is:

retained on 4 mm screen:	25%
retained on 1 mm screen:	38%
lumps 4" to 6" about:	1%
lumps 1" to 2" about:	3%

2 - Lump Breaker

In order to have a proper granulation these lumps should be broken before the SSP is fed to the granulator. The lump breaker should be a cage mill as this type of breaker can handle rather soft and sticky material like SSP.

A suitable cage mill contains two cages rotating in opposite directions. The cages have a length of 600 mm and a diameter of 300 mm. Speed should be about 1,000 rpm; direct drive by a 1,000 rpm motor (4 HP) is suitable. It is essential that each cage has a separate drive. Clearance between cages should be 10-30 mm and should be adjustable.

Each cage should contain 6 knives of 600 x 66 x 18 mm made out of special steel having a Vickers hardness of 290 to 310 (55 si7 or 65 si7 or similar materials).

The mill should be enclosed in a steel box having appropriate doors. A hopper is directly connected to the box; this hopper should have a depth of about 1,000 mm and discharges on a belt or a screw conveyor.

The apron conveyor should be modified as to its length and its steepness in order to allow a proper feed of the lump breaker. A proper ventilation should be provided for. It can be connnected to the ventilation system of the bucket elevator.

3 - Conveying System

Type and length of the conveyor to the granulator depends on the lay out of the factory. Most suitable is to install the granulation plant in the south end of the building near the den etc. In that case, the cage mill (item 2) can be installed near the Moritz den and be fed by the steel apron conveyor. The subsequent transportation to the granulating plant should then be done using a belt conveyor.

The belt conveyor has to carry 10 t/hour of SSP; a troughed 400 mm wide belt has sufficient capacity. Belt speed should be low (0.8 m/sec.) to avoid formation of dust at the discharge end. Drive is 6 HP.

4 - Granulator (See lay-out plan)

The drum granulator is generally considered as the best type of granulator for SSP as granulation can be easily controlled by varying the amount of steam and/or water used. As well, variation in the slope of the granulator can control the granulation process. Therefore, the granulator should be fitted on a cradle frame that can be tilted to angles between $1^\circ - 5^\circ$.

A suitable granulator has a length of 5,000 mm and a diameter of 1,800 mm.

Rotation should be 12 rpm but preferably alternative speeds of about 9 and 16 rpm should be possible by using a gear box with changeable gears. Drive should be about 15 HP to be designed by the manufacturer. The gear box should drive a pinion that in turn drives the girt gear of the drum shell. The drum should rotate on trunnions and riding rings. One set of trunnions should be fitted with a thrust roll. Trunnions can be made out of steel, however, rubber wheels are used as well and permits a quiet operation. When rubber wheeled trunnions are used another type of drive is possible. In this case, 2 trunnions can be driven, they should be connected to one axis that is driven by an electric motor through a gear box.

No lifters should be fitted as for a good granulating performance a rolling bed of material should be maintained. To prevent oscillating movements of the rolling bed 10 to 12 strips of about 20 mm in height should be welded on the inner side of the drum parallel to its axis. On the inlet side of the shell, a rim of about 200 mm should be welded in order to prevent spillage.

Feed should enter the drum through a chute opposite to the granulating bed (see fig. 2). A fixed steel plate with sufficient openings to observe the process should close the drum. As sufficient ventilation is provided for, no seals between this plate and the drum are necessary.

Three steam inlet tubes (diameter 1") should be provided for; each should have outlet slits of 3 mm x 40 mm parallel to the axis. Inlet number one has to reach 800 mm into the drum and has to have slits over this length. Inlet number two has to reach 1,600 mm into the drum and has to have slits covering its last 800 mm. Inlet three has to reach 2,400 mm into the drum and be fitted with slits covering its last 800 mm. In this way steam can be applied to several spots in the granulator. Each steam pipe should have an appropriate valve. Steam pressure should be 1-1.5 atm. About 400 to 1,000 kg of steam per hour is needed. Steam should be injected in the bed of granules. The slits should be directed at about 45° in the direction of rotation.

Apart from steam as a granulating agent finely sprayed water could be necessary. Therefore, about three nozzles at about 500, 1,300 and 2,000 mm from the feed end to be operated separately should be installed. Each nozzle should have a capacity of about 150 L per hour. The granulator should discharge through a breeching into a chute entering the rotary dryer.

5 - The breeching should be ventilated at the top; a fan having a capacity of 2,000 m^3/hour fitted with a cyclone should be installed. Drive = 5 HP.

6 - The Chute towards the rotary dryer should be made of Corten steel and preferably have a polished inner surface. The lay out should be such that in case of plugging the chute can be easily cleaned without interruption using manual tools (see layout plan).

7 - Rotary Dryer

The dryer should be of the cocurrent type thus avoiding overheating of the SSP granules. Dimensions are diameter 2,300 mm and a length of 18,000 mm. The slope should be between 1° and 2°. Preferably the speed of rotation should be variable using a variable gear box. Speeds should be 2,2; 2,7 and 4 rpm. If only a single speed is to be used, design has to be about 2.7 rpm. At the entrance side the shell should have a rim of 250-350 mm to prevent spilling. The interior of the shell should be fitted with flights and lifters according to the following scheme:

a) 3 m of special flights having an angle of 30° relative to the axis to convey material into the dryer, after 2 m the angle gradually diminishes to 0°. 10 to 12 flights each of 300 mm of height are needed.

b) 13 m of lifting flights parallel to the axis. 12 rows of flights regularly divided over the circumference should be foreseen. Lifters should have a length of 1,850 mm; 7 sets will have a total length of 13,000 mm. Sets No. 1 and 2 should be radial lifters having a width of 300 to 400 mm. Sets Nos. 3-7 should have lips of 45°, width should be 350 mm, the lips should be 250 mm. Each set of lifters should be offset relative to the neighbouring set to ensure more continuous and uniform curtains of falling solids in the gas stream (see fig. 3).

c) The remaining 2 m of the drum should be fitted with flights, having an angle gradually augmenting to 30°, to ensure a proper discharge of the dryer.

Two riding rings (diameter about 2,800-3,000 mm) each with a trunnion roll assembly support the rotary dryer. Rotation is done using a girt gear with a pinion driven by an electric motor and gear box. Diameter of the girt gear should be about 3,200 mm. The riding rings should be fitted at about 3,500 to 4,000 mm from the ends of the shell. The girt gear at about 2,000-2,500 mm from the first riding ring.

The exact dimensions etc. of riding rings, trunnions, girt gear and accessories should be designed in detail by the manufacturer of the rotary dryer. Thrust rolls should be present. Horse-power will be about 40 HP. It is advised to use an appropriate hydraulic coupling between motor and gear box in order to ensure smooth starts. A device to prevent the drum to rotate in opposite directions during a stop is a welcome accessory. Knockers should be fitted to the shell at a distance of about 5,000 mm from the entrance. The shell should be reinforced at the spots where the knockers hit the shell. At the entrance a casing containing the feed chute and an inlet for the dryer flue gas should be fitted. This casing should have doors for inspection and cleaning. At the discharge end a breeching with breeching seals should be fitted. This breeching must have doors for inspection and cleaning. The breeching discharges on either a belt conveyor or a screen conveyor that must have a capacity of about 60 tons per hour. Direct discharge into the elevator might be possible. The breeching should be fitted with a flange to connect it to a ventilation unit.

8 - Furnace

Heating medium is natural gas. Output should be 1.5-2 million K Cal/hr. Construction of the heater should be designed by an experienced manufacturer. Hot air of about 500-550°C should enter the dryer. Volume should be 10,000 to 12,500 Nm^3/hr.; preferably in two streams of respectively primary air and secondary air. Hot flue gases enter the inlet head of the rotary drum. Drying is cocurrent. The ventilator drives consume about 24 HP. The furnace has to be fitted with a thermometer.

9 - Ventilation Unit

In order to avoid an overpressure at the inlet of the rotary dryer, a ventilation fan has to move the combustion gases through the dryer. The fan should have a capacity of about 16,000 Nm^3, in order to be able to cope with leakages. The internal pressure in the dryer has to be slightly under atmospheric pressure (0.05-0.2 cm water gauge). An open duct with damper should be present to facilitate the regulation of pressure throughout the system. As the gases carry away considerable amounts of dust they should pass a cyclone enabling to catch particles of about 50 micron. The collected dust should be recycled to the granulator; a proper way to do this is to discharge the dust on the belt conveyor transporting the fines from the screen section to the granulator(see paragraph 20). About 35 HP is needed to drive the fan.

10 - the exit gases contain some fluorine compounds. It depends on the local regulations on pollution whether the gases can be vented directly into the air or should be washed before venting.

11 - The dried product discharged from the dryer has to be conveyed to a bucket elevator which in turn transports the product to the screening section.

It depends on the lay out of the elevator relatively to the dryer outlet what type of conveyor is necessary or whether such a conveyor is needed at all.

In the latter case, material from the dryer can be fed to the bucket elevator through a chute. In this case the conveyor should be oonstructed at short distance from the dryer, which might cause an inconvenient situation for cleaning and other maintenance of the dryer. Moreover, the discharge of the elevator is not favourably situated.

Alternatively a screw conveyor can be used enabling a free choice of the position of the bucket elevator. Capacity should be 60 ton/hour which can be handled with a screw diameter of 400 mm. Drive is about 3 HP. Its length shculd be about 3,000 mm. An air-tight connection to the discharge of the dryer can be easily made.

Another alternative is to use a belt conveyor. Width should be 500 mm, belt speed 1.0 m/sec., length about 3,000 mm. Location of the elevator is not as easily done as in the case of when a screw conveyor is used.

A screw conveyor is the best choice.

12 - Bucket Elevator

The bucket elevator has to convey the discharge of the rotary dryer as well as the discharge of the lump breakers that have to be recycled over the screens. Under certain circumstances the oversize can reach a volume of 15 tons/hr. and this volume should be the basis of the design. The bucket elevator is designed to convey 75 tons per hour to avoid overloading.

The conveyor should be a centrifugal discharge bucket elevator. Main dimensions according to DIN 65251 standards are given in the lay out drawing. Bucket size is 500 mm width, diameter chain wheel is 800 mm, chain speed is about 1.2 m/sec. The total height of the elevator depends upon the type of screens and auxiliary equipment to be used in the screening section, it might be about 18 m. It should be kept in mind that the upper part of the conveyor casing can be easily removed to facilitate maintenance and inspection activities. Therefore, ample space to install a hoisting device must be available above the conveyor top. About 1,800 mm will be sufficient. Drive has to be about 18 HP but has to be designed by the manufacturer.

13 - A ventilation Unit comprising a fan and cyclone connected to the top of the bucket elevator should be installed. As a bucket elevator builds up an over pressure at its top the ventilation duct should be connected to the top of the elevator. The same unit should ventilate the screen casings. Dampers in the ducts should enable to regulate the flow through the different items of equipment, an open duct with damper should complete the System. Capacity should be about 5,000 m^3/hr. Drive is 12 HP. The collected fines should be recycled to the granulator.

14 - The product conveyed by the bucket elevator should be screened in order to separate the on size fraction from the oversize and the fines. This could be done by using one screen unit for the total flow of product which amounts to 42 t/hr., normally or about 50 t as a maximum. These rates are rather high to be handled on one screen deck and there are advantages to divide the flow in two separate streams each of 21 m t. Therefore, a device to divide the flow of material should be installed. Such a device would be a

bifurcated chute into which a vane should be fitted in order to control the two flows.

A simple and cheap way to convey the flows to the screen units is to use chutes. An angle of 55-60^{o} is necessary to achieve a trouble-free flow of material. The disadvantage of such a set up is its considerable height, adding to the costs of the bucket elevator and of the structure to hold the equipment.

This disadvantage can be avoided by using vibratory feeders. This implies rather costly investment. However, a more even way of feeding is easily achieved. Vibratory feeders preferably should have an electro-magnetic drive.

Assuming a screen width of 1,500 mm and a free space of about 2,000 mm between both screens, the distance of the centres of both screens is 3,500 mm and the lay out of the feeders must meet this condition.

The height necessary for feeding the screens by means of chutes will be about 2,800 mm. When using vibratory feeders about 1,200 mm will be sufficient.

15 - Screens

Either two sets of two separate screens, each fitted with a hopper or two sets of double deck screens can be used.

Single screens have the advantage of being readily accessable for cleaning and for changing of screen cloth. The disadvantage is that two hoppers - one under each screen - are needed and consequently feeding of the second screen is more complicated. Moreover, the lay out asks for considerable height. Double deck screens are less easily accessable for cleaning and for changing screen cloths. A double deck screen only has one hopper to receive the fines. Oversize and on size products are directly collected from the screens. Moreover self cleaning constructions are more easily possible.

In order to have the same capacity as two single deck screens, the surface of a double deck screen has to be larger, as the feed of the lower deck is different in the two cases.

From a technological point of view, both alternatives are good and providing a good quality can be obtained in the country, the choice should be two sets of double deck screens. The capacity of the screens depends much on the drive. Magnetic vibrators or excentric drives both are feasible. Final design should be made by the manufacturers. It should be mentioned that magnetic vibrators have a smaller amplitude and a higher frequency than mechanical excentric drives and consequently vibrations transmitted to the supporting steel structure are heavier when using mechanical drives.

The total feed to both screen sections is calculated to be 42 t/hour (see page 7) under normal conditions. However, it can rise to 50 t/hour. Assuming that screen capacity falls down gradually (due to partial clogging of the screen cloth) the clean screens should have a capacity of 54 tons per hour, which means 27 tons per unit. The screens should be enclosed in a casing to ensure dust free operation. The casing should have an appropriate fitting for the ventilation duct. Doors for inspection and maintenance activities should be provided for. Power is about 8 HP per screen.

In order to ensure the separation of a fraction of 2-4 mm, screen cloths should meet the following specifications:

The upper screen cloth should have openings of 4½ x 4½ mm.

The lower screen cloth 2 x 20 mm (slits). The exact specifications of the screen cloths depend on the drive; therefore, the manufacturer should advise. Screen cloths should be made out of stainless steel wire.

16, 17, 18: Oversize should be broken and recycled to the screens.

Transportation to the lump breaker preferably should be done using a screw conveyor. Lay out should be such that the lower end of the screen directly discharges into the trough of the conveyor. Each unit should be equipped with a separate screw conveyor. Drive of the screw oonveyor is 2.5 HP.

The lump breakers should be cage mills and the same specifications as mentioned in Chapter III are applicable to the cage mills for breaking oversize. HP = 8.

The broken oversize should be recycled to the screens. The easiest way to do this is to convey them to the base of the bucket elevator (No. 12). A simple chute pipe fed by a belt conveyor or screw conveyor (3 HP) will be sufficient.

19 - The on size product leaving the screen deck of the second screen should be conveyed to the storage. A convenient way to do this is to discharge (both) screens on a belt conveyor passing to the storage much in the same way as in the present situation for powder SSP. Capacity 10-12 t/hr. The existing conveyor should be used.

20 - In the hoppers under the lower screens dust and particles under 2 mm are collected. These fines should be recycled to the granulator. The best way to do this is to use a belt conveyor that must have a capacity of 20-30 t/hr. A troughed belt 400 mm wide has ample capacity. In order to avoid formation of dust at the discharge end, a slow moving belt should be used (0.8 m per second or less) - Drive is 6 HP.

Dust collected in the ventilation units 5, 9 and 13 should be conveyed to this belt conveyor preferably by using chutes. It will depend on the general lay out how this has to be done. Another possibility is to bring the dust to the feed conveyor no.3. As the quantities of collected dust are low even manual transportation could be considered.

VI. LAY OUT OF THE GRANULATING PLANT

The present SSP Unit is built in a building having dimensions of 15.6 x 36 m and a height of about 20.4 m. Next to this space is a lower building 5.2 x 36 and height of 5.8 m.

The Moritz Mill and the Den occupy about 50% of the building. It was shown that it is possible to build the granulating plant into this building providing an extension of about 6 x 12 m having a height of about 11 m is added. In this case the existing unit and the granulating plant will be next to each other thus facilitating supervision and operating conditions. Supervision of grinding unit, Den and granulating plant can be done by one Supervisor.

Alternative places taken into consideration are the building containing the bagging unit and an entirely new separate building. The bagging unit is installed in a 15.6 x 36 x 20.4 m building and apart from being smaller than the production building, it is at 110 m distance from the Den. To cover this distance, a long belt conveyor has to be constructed and supervision would be difficult. A new building near the production building offers no special advantages and adds considerably to the costs.

Therefore, the present production building is by far the best choice. The extension of 6 x 12 x 11 m has a volume of about 800 m^3 and its costs including removal of existing walls etc., are estimated to be Rs. 80,000. The lay out is presented in the drawing showing floor plan and elevations of the complete installation. Copies of the lay-out drawing(scale 1:50; 1-6-75) are available at Lyallpur Chemicals and Fertilizer Ltd. Jaranwala. The lay out does not contain the ventilation units. Moreover, the steel constructions to hold screens,conveyors and granulator are not indicated.

VII. INVESTMENT COSTS ESTIMATES

Costs of the separate equipment units as mentioned in Chapter III are estimated and calculated. Prices are based on previous costs of similar comparable equipment and are corrected using cost indexes as published in "Chemical Engineering", March 1975. Prices are in Pakistan currency (1 US$ = 9.90 Rupees).

As prices now-a-days are far from stable, 15% contingencies are added. Assuming that part of the equipment has been purchased abroad, 8% for freight costs are added.

Apart from the equipment items 1-20, a natural gas pipeline to convey the gas from a nearby distribution point to the factory should be constructed. The distance to be covered is about one mile. A rough cost estimate given by the Sui Northern Gas Pipe Line Ltd. is Rs. 50 to 60 per foot. As 5270 feet have to be covered, costs will be Rs.263,500 to 316,200. An average of Rs.300,000 is a fair estimate. Moreover, Rs. 20,000 are needed for a Reducing Station.

Civil works are estimated to be 4% of total component costs for foundations. Steel or concrete structures to carry the granulator, screens, lump breakers, etc. are estimated to be 3% of total equipment costs. Painting is estimated to be 1%. Total costs = 8%.

The building to contain the granulator, etc. has dimensions of 6 x 12 x 11 Its costs including demolition of walls, etc. are estimated to be Rs. 80,000.

The numbers refer to those on flow sheet fig-1.

Item No.	Particulars	Price Rs.
1.	Modifications on existing SSP Unit, mainly as to apron conveyor	10,000
2.	<u>Lump Breakers</u> A recent quotation from Nemag, Rotterdam, Holland (March 1974) amounts to Hfl. 15,000. Present price Rs. 70,000 FOB 3 will cost (see item 17) Chutes from lump breakers each Rs. 2,000 Total power = 24 HP	 210,000 6,000
3.	Belt conveyor length about 25 m width, 400 mm at 2,800 Rs./m. Power = 6 HP	70,000
4.	Granulator length 5 m, diameter 1.80 m, including steam, water, pipes, drive, etc. Power = 15 HP	300,000
5.	Ventilation unit for 4 2,000 N cu.m/hr. including cyclone Power = 5 HP	36,000
6.	Chute	10,000
7.	Rotary dryer, l = 18 m, diameter = 2.30 m, with breechings, drive, etc. Power = 40 HP	1,100,000
8.	Furnace for natural gas 1.5-2 million K.Cal/hr. with fans, etc. Power = 30 HP	480,000
9.	Ventilation unit for 7 16,000 N cu.m/hr. including cyclone Power = 35 HP	180,000
10.	Washer for exhaust gas	p.m.
11.	Screw conveyor to 12 length = 3 m, width = 350 mm. Power = 3 HP	35,000
12.	Bucket elevator capacity 75 t/hour, height 18 m Power = 18 HP	340,000
13.	Ventilation for bucket elevator (and screen casings) 5,000 N cu.m/hour with cyclone. Power = 12 HP	70,000
14.	Divider and chutes to screens	25,000
15.	<u>Screens</u>: 2 double deck screens each 27 tons capacity at 220,000 Rs. Total 6 HP	440,000
16.	2 Screw conveyors to breakers each about 2,5 m of length, width 200 mm, costs each Rs.16,000 Total power = 6 HP	32,000
17.	Included in 2.	

Item No.	Particulars		Price Rs.
18.	Screw conveyor and chute to 12. length: 4 m, width: 400 mm Power = 3 HP		37,000
19.	Belt conveyor to storage. The existing belt conveyor can be used after some modifications.		5,000
20.	Belt conveyor for recycling of fines, length: 25 m, width: 400 mm Power = 6 HP		70,000
	Total Power = 209 HP = 156 KW		
	Cost of equipment		3,456,000
	15% Contingencies		518,400
	Erection costs 12.5%		432,000
	Equipment erected		4,406,400
	Freight cost of equipment = 8% of 3,974,400		317,900
	Utilities:		
	Pipeline for natural gas, 1,600 m	320,000	
	Electricity: cabling + lighting	30,000	
	Steam piping	10,000	
	Total utilities:	360,000	
	Contingencies 10%:	36,000	396,000
	Civil Works:		
	Foundations 4% of equipment Steel structure 3% of " Painting 1% of " 8% from 3,456,000 =	276,500	
	Building	80,000	
	Total civil works:	356,500	
	Contingencies 10%:	36,700	393,200
			5,513,500
	Interest on capital during construction: 1 year at 10% per annum		551,500
	Total:		6,065,000

VIII. <u>OPERATING COSTS</u>

Operating costs contain capital costs (interest, depreciation) and costs like insurance, maintenance and wages. Moreover, variable costs including energy and fuel. Interest on investment is supposed to be 10%, depreciation is 10%. Insurance costs are 2%. Maintenance including labour is 3%, which is a good average value for a granulation plant.

As the plant is in the same building as the existing powdered SSP unit no separate supervision is needed nor should be advised.

Four men per shift can run the plant. The granulator asks for one man with operator knowledge. One man should be in charge of the screens, lump breaker and of recycling conveyors. A third worker should be in charge of the dryer and the combustion furnace, whereas for cleaning and other purposes, a fourth worker is wanted.

The worker in charge of screens, breakers, etc. should be semi-skilled. The worker in charge of the furnace and the dryer should have the level of a fitter. These four labourers are added to the existing shifts of the powdered SSP plant and in order to calculate the added costs of granulation only this group has to be considered. As the plant is run on a continuous base, 4 shifts are needed. Wages including 15% for medical care etc. are:

Junior operator	Rs.	6,900 per year
Fitter	Rs.	5,727 per year
Semi-skilled	Rs.	4,830 per year
Un-skilled	Rs.	4,278 per year
Total per shift:	Rs.	21,735 per year

As there is an excess of steam from the sulphuric acid units, no steam costs are calculated.

The rotary dryer should use the flue gases of a natural gas furnace. Calories needed are 1.5-2 million calories. 1.75 million per hour is a good ave- Information was given by the Sui Northern Pipe Line Ltd. The data concerning the gas are:

i) Cost per 1,000 cu.ft. = Rs. 7.60 which is equivalent to Rs. 0.269 per m^3.

ii) Calorific value 975 BTLU/cf gross which is equivalent to 8680 K Cal/m^3.

iii) Pressure is 8 p.s.i.g. = 0.54 atm., 1.75 million K Cal/hour is equivalent to 200 m^3/hour.

Electricity costs are Rs. 0.30 per KWH.

Fuel and energy costs are calculated for a production time of 8,000 hours per year (333 days), representing a production of 80,000 tons of granular SSP per year.

The remaining time (760 hours or 32 days) are used for maintenance and overhaul activities.

Operating costs are listed below:

Interest on investment	10%	Rs. 606,500
Depreciation	10%	Rs. 606,500
Maintenance including:		
- labour	3%	Rs. 182,000
- insurance	2%	Rs. 121,300
Wages:		
One shift of 4 workers earns Rs. 21,735/year	4 shifts	Rs. 86,940
	Fixed costs: A =	Rs. 1,603,240
Natural gas 200 m^3/hour during 8,000 hours is 1,600,000 m^3 per year. Costs are Rs. 0.269/m^3 - totalling:		Rs. 430,400
Power - installed power is 156 KW during 8,000 hours consumption is 1,248,000 KHW at Rs. 0.30		Rs. 374,400
	Variable costs: B =	Rs. 804,800
	Total operating costs: A + B	Rs. 2,408,040

For a production of 8,000 x 10 t = 80,000 t/a. or Rs.30.10/t.

For different yearly productions cost price per ton is:

Yearly production	80,000 t/y	72,000 t/y
Fixed costs	Rs. 20.04/t	Rs. 22.26/t
Variable costs	Rs. 10.06/t	Rs. 10.06/t
Total:	Rs. 30.10/t	Rs. 32.32/t

IX. STORAGE FACILITIES

The granules when freshly produced have to be stored for maturing. The storage at present used for run of pile SSP is to be used for this purpose. The storage building however, has no mechanical facilities and the present situation is such that SSP is transported by hand carts up to the appropriate spot. A small bulldozer then forms piles of about 3-4 m height. The bulldozer therefore, has to drive on top of the piles. This practice cannot be continued when granules have to be handled as they should be crushed.

In the new situation, other means of transportation are needed.

The best way is to use a belt conveyor with a tipping-off device, that enables to discharge on any spot under the conveyor. As the storage is not very high (its dimensions are 110 m of length, 45 m of width, a total height of 8.5 m and a height of 7.5 m under the trusses). The maximum height of piling would be about 5 m and the width of the pile, assuming an angle of repose of 30^{o}, would be about 17 m. Therefore, two belt systems along the length of the storage each fitted with a tipping-off device plus a belt conveyor connecting both systems would be necessary.

Investment costs would be very high; a rough estimate is 1.5 to 1.8 million Rupees. The storage will then have a capacity of about 8,500m^3 or 7,700 tons.

A better method is the use of wheel loaders that pick up the granules at the discharge in the storage building and convey it to a movable hopper. From this hopper, a movable belt conveyor brings it to a height of about 6 m and forms a 5 m high pile. Such a pile has a conical shape. Its base is about 17 m. The belt conveyor and the hopper are shifted 2-3m after the first pile is completed and in this way gradually the entire length can be filled with granules. Two identical piles can be made at both sides of the storage and in this way about 8,500 m^3 or 7,700 tons of SSP can be stored.

When piling up against the walls - assuming that they can stand the lateral pressure - up to 3m and when using a somewhat different pattern of piling, the storage can contain up to 12,000 m^3 or 11,000 tons of granulated SSP (see fig-4).

The capacity of a Volvo-loader with a 1.3 m^3 bucket (or 1.2 ton) and covering an average distance of 80 M. can be calculated to be about 60-70 tons per hour, which is far more than the production capacity of 10 tons per hour.

This implies that one loader with a 1.2 ton bucket can serve the bagging units as well.

However, a second wheel loader as a stand-by should be purchased. A recent quotation from Volvo (April 1975) shows a price of 110,000 Swedish Krona = 270,000 Rupees CIF East Africa (or Karachi). A hopper permitting to discharge a 2.2 m wide bucket will cost about 30,000 Rupees; a movable belt conveyor of 10 m of length might cost 100,000 Rupees. One as stand-by is to be recommended.

So total costs are:	Hopper	Rs. 30,000
	2 Belt conveyors	Rs. 200,000
	2 Volvo loaders	Rs. 540,000
		Rs. 770,000
Including contingencies 10%		Rs. 850,000

As compared with a belt conveyor system, this is a reasonable price. Moreover, the transportation to the bagging units can be effectuated by the same wheel loaders.

X. PURCHASE OF EQUIPMENT

Several manufacturers of equipment in Pakistan were visited and their capability to produce this equipment was discussed. The following companies were visited:

1 - Pakistan Engineering Company Ltd. at Lahore (Peco, formerly Beco)

Although this company was founded in 1933, its activities made a fresh start in 1947 when the company migrated to Lahore. Since 1972, it is a Government-regulated company. PECO is a large company employing 4,000 persons. Workshops are well equipped. A wide variety of machinery produced, among them equipment for chemical plants and distilleries. PECO could make many equipment items needed for the granulating plant and make design and shop drawings from the lay out drawings and the design sheets in this report. However, as to the rolling rings and girt gears, PECO is limited to dimensions of maximum 2 m. These parts of equipment can however, be made elsewhere in the country.

Capacity for welding of steel sheets is limited to 12 mm thickness. This might be prohibitive to the manufacturing of the rotary dryer that should have a wall thickness of about 15 mm (to be designed). They have no experience with vibratory screens.

2 - Rawi Engineering Co. Ltd. at Lahore

This firm has ample experience to produce components for the chemical industry. It is part of a group producing rayon, plastics, acetone and other chemicals.

Lay out of the plant is good; good and modern machinery is installed. However, it is limited to the same maximum dimensions as PECO.

Vibrating screens and bucket elevators were never constructed by Rawi Engineering.

3 - Heavy Mechanical Complex, (HMC) at Taxila

This is a state enterprise that produces since 1971. It was established with the assistance of the People's Republic of China. The equipment was provided by China, among them are very heavy machinery. Lathes and gear cutting machinery up to over 4 m diameter is installed. Welding and cutting facilities for steel sheets up to 40 mm are available. Surface hardening can be done.

HMC is a very modern plant, employing over 3,000 workers. HMC states that it can conveniently cater for the requirements and needs of fertilizer plants, chemical plants and the like. We discussed the possibilities for constructing the equipment for the granulating plant. Apart from the vibratory screens, there were possibilities for the manufacture. Screens possibly could be made when a good and detailed design could be purchased.

However, their design capacity was limited and this could be a bottleneck. Production capacity is sufficiently available for the granulator and the rotary dryer, conveyor belts, chutes and bucket elevators.

As to screw conveyors and cage mills, capacity is limited, but these items could be constructed.

Erection on site can be done with the assistance of HMC supervisors.

4 - The NFC factory at Daudkhel (see Chapter I), has a large and well equipped mechanical workshop. The workshop produces many equipment items for the different NFC factories. Moreover, they have an experienced design department. When discussing the equipment of the granulating plant, the conclusion was that the Daudkhel engineers can produce workshop drawings of all equipment needed. The basis will be the lay out drawings and the data sheets in this report. Design for foundations, steel structures and enlargement of building, can be made. The only equipment they cannot design are the vibratory screens. These are considered as too specialized and the best thing to do is to order screens from a specialized manufacturer. Workshop facilities allow for the production of belt conveyors, screw conveyors, bucket elevators, cage mills and ventilation units, including fans, cyclones, ducts, as well as casings, breechings, etc. Surface hardening

of elevator chains and chain wheels has to be carried out by HMC at Taxila.

As to the rotary dryer and the granulator, designs can be made. But due to the large dimensions, the manufacturing should be done elsewhere. As HMC at Taxila is the only Pakistan company that can make and machine large roller rings and girt gears, the granulator and the rotary dryer should be manufactured by that company. The design and production of the natural gas fired furnace should be made by a specialized engineering firm.

The engineering staff of NFC Daudkhel factory has ample experience and capacity to make the designs and the shop drawings of all equipment with the exception of vibrating screens and gas fired furnaces. Most of the equipment can be made at Daudkhel.

Design for civil works should be made at Daudkhel as well.

Erection can be performed by personnel from Daudkhel and the Jaranwala factory.

The engineering staff of Daudkhel should contact manufacturers and designers for vibrating screens and for natural gas furnaces, and include this equipment in the general lay out.

Some addresses of builders of equipment outside Pakistan known to the expert as reliable firms are mentioned below. It is not pretended that this is in any way a complete survey of manufacturers. Many items can be made in Pakistan.

Belt Conveyors and Bucket Elevators

Moellers Maschinenfabrik
4720 Beckum/Westfalen
West Germany

Nemag B.V. Katendrecht
Rotterdam, Holland

Cage Mills

Nemag B.V. Katendrecht
Rotterdam, Holland

Rotary Dryer and Granulator

Nederlandse Electrolas Mij
Leiden, Holland

Rijn-Schelde-Verolme B.V.
Rotterdam, Holland

Establissements Bourgeois
Nivelles, Belgium

Buttner-Schilde-Haas
subsidiary of Babcock + Wilso
Deutschland Ges.m.b.H.
Krefeld, West Germany

Screens

TEMA
The Hague, Holland

Rhewum
West Germany

Sieb-Technik
West Germany

Ventilation Units

Small complete units containing a fan, a cyclone and a bag filter are produced by Delta Neu,

59013 Lille-Cedex
Sac Postal 2028, France

Units ranging from 510 m^3/hr. at a price FOB Rs.8,150 (January 1975 to 5,400 m^3/hr. at a price FOB Rs.32,600 can be purchased. These units only need a connection to the equipment and to an exhaust pipe.

Some firms able to deliver the complete equipment as well as separate items are:

Joint UNIDO-Romania Centre
B^ul. Balcescu 16
Bucharest, Romania

Chartim Construction Co. Inc.
P.O. Box 97
Como, Texas 75431, USA

In many cases suitable second hand equipment can be purchased at reasonable prices. A renowned and reliable dealer is Cohen Ltd. in London (UK).

When using second hand equipment, it should be necessary to revise the lay out of the plant.

XI. DESIGN DATA FOR BUCKET ELEVATOR

TYPE: Self-supporting centrifugal discharge Chain Elevator

SERVICE: Continuous flow of granulated Single Superphosphate

BULK DENSITY: 900 - 950 kg/m^3

TEMPERATURE: 80 - 100°C

FLOW RATE: Normal 45 tons/hr.

Maximum 70 tons/hr.

DIMENSIONS: Main dimensions should be according to DIN 15251 Standard or similar

Boot:	1600 x 670 mm
Buckets:	500 mm
Chain Wheel:	Diameter 800 mm
Total Height:	11,000 to 12,000 mm
Chain speed:	1.2 m/sec.
Distance between buckets:	700 - 800 mm

DRIVE: To be designed by Manufacturer

SPECIAL FEATURES: Quick opening doors for front and back of Elevator Boot.

Access door at Elevator head for cleaning nozzle for gas removal on elevator head (diameter 150 mm).

MATERIAL OF CONSTRUCTION: Mild steel for constructual parts, no copper alloys in contact with product.

Chains have to be surface hardened.

Chain wheels have to be surface hardened at contact parts with chains.

Buckets be made out of 6 mm steel.

Boot made out of 5 mm steel with structural reinforcement. Upper parts 3-4 mm steel sheets.

DESIGN: Should be according to DIN 15251 Standard or similar.

PAINT: Suitable for use in Fertiliser Factory.

DESIGN DATA FOR BELT CONVEYORS

Required: **Two** To transport granulated single superphosphate products.

A. One Belt Conveyor:

- Load 10-12 t/hr.
- Length about 19,000 mm
- Width 400 mm
- Speed 0.8m/Sec.
- Type: Open Belt Conveyor with a troughed belt
- Three roll sets of rollers, angle 20°

Drive and supports to be designed by Manufacturer. This Belt Conveyor has a slope of about 25°.

B. One Belt Conveyor:

- Load 20-24 t/hr.
- Length about 23,000 mm
- Width 400 mm
- Speed 0.8 m/Sec.
- Type: Open Belt Conveyor with a troughed belt
- Three roll sets of rollers, angle 20°

Drive and supports to be designed by Manufacturer. Belt Conveyor 'B' has a slope of about 11°.

MATERIALS: Mild Steel. No Copper Alloys should be in contact with material.

BELTS: Rubber belt shall be 4-ply reinforced with nylon or equivalent.

Rubber should be resistant to operating temperature (80° - 100°C).

PAINT: Suitable for use in Fertiliser Factory.

DESIGN DATA FOR SCREW CONVEYORS

REQUIRED:

A. ONE Screw Conveyor to transport a continuous flow of un-screened granulated single superphosphate.

B. TWO Screw Conveyors to convey screened under size of same product.

C. ONE Screw Conveyor to convey broken oversize.

PRODUCT SPECIFICATION:

A.
- Maximum 70 t/hr.
- Size range 0.2-10 mm with about 1% + 50 mm
- Length 3,000 mm
- Diameter about 400 mm
- RPM 50-70 - Temp. 80-100°C

Exact dimensions and drive to be designed by Manufacturer.

B.
- Maximum 8 t/hr. for each
- Size range 4-10 mm with about 4% + 50 mm
- Length 2,600 mm
- Width about 200 mm
- RPM 60-80
- Temperature 80-100°C

Exact dimensions and drive to be designed by Manufacturer.

C.
Maximum 16 t/hr.
- Size range 0.2 to 4 mm
- Length 4,500 mm
- Width about 300 mm
- RPM 50-70
- Temperature 80-100°C

MATERIAL OF CONSTRUCTION: Mild steel. Trough made out of 5 mm sheets. No Copper or Copper Alloys should be in contact with materials to be conveyed.

PAINT: Suitable for use in Fertilizer Factory.

DESIGN DATA FOR PROCESS SCREENS

MATERIAL:	Granular Single Superphosphate granules
BULK DENSITY:	900 - 950 kg/m^3
TEMPERATURE:	80 - 100°C
FLOW RATE:	Normal 45 ton/hour continuous flow
TOTAL:	Maximum 60 ton/hour continuous flow
SIZE + RANGE: (APPROXIMATE)	25%: + 4 mm 25%: + 2-4 mm 50%: - 2 mm
PRODUCT REQUIRED:	Between 2 and 4 mm
CAPACITY FOR FINISHED PRODUCT:	Normal 10 ton/hour Maximum 12 ton/hour
TOLERANCE:	5%
DRIVE:	To be designed by manufacturer. Magnetic Vibrators or Excentric Drive acceptable.
ARRANGEMENT:	The total load to be handled by two screens (Normal 22.5 t/per screen)
SPECIAL FEATURES:	Screen should be encased to ensure dust free operation. Vent hole located for easy connections to ventilation unit.
CASING:	The screen should be enclosed in a dust tight casing, fitted with proper discharge support for the different fractions. Fines should be collected in a hopper. Doors for inspection, cleaning of screen cloths, changing of screen cloths should be of sufficient dimensions. The fines hopper should have a minimum slope of 60°. Discharge of fines on Belt Conveyor should be fitted with an appropriate device.
PAINT:	Suitable for use in Fertilizer Factory.

DESIGN DATA FOR CAGE MILLS

Each Cage Mill should contain two Cages rotating in opposite directions at about 950 rpm. Each Cage consists of an axis with bearings outside the casing. On the axis are fixed two discs of 300 mm diameter. The distance between these discs is 600 mm. On these discs 6 blades are fixed. Blades have dimensions of 600 x 66 x 18 mm - they are made out of special steel: 65 Si7 or 55 Si7 having a Vickers Hardness of 290-320. Blades are screwed on the discs.

Clearance between the cages has to be adjustable between 10 and 30 mm.

FEED: Superphosphate lumps
Temperature: 80-100°C.

CASING: Made out of steel plate with inspection doors.
casing should have only small clearance with cages.

On top of casing a feed opening covering 500 mm of the cages and having a width of 150 mm should be provided for.

- a hopper at the base should have a minimum slope of 60°.
- hoppers should be fitted with a suitable discharge device on a Belt Conveyor.

DRIVE: Each cage should be separately driven by a direct coupled motor (950 - 1,000 rpm).

MATERIAL: For most parts mild steel.
Axis etc. as designed by manufacturer.
Blades as mentioned above.

PAINT: Suitable for use in Fertiliser Factory.

DESIGN DATA FOR ROTARY DRYER

The dryer is a cocurrent heated dryer.

FEED: Wet granulated Superphosphate from granulator.
Temperature 80 - 100°C.

DIMENSIONS: Length 1,800 mm

Diameter 2,300 mm

Thickness of shell to be designed by Designer (probably a thickness of 15 mm will do).

Slope about 1°-2°. A slope of 1.5° will be a good average.

At the entrance of the Dryer, a retaining ring of 250 to 350 mm should be welded.

Flights and lifters are to be fitted according to the following scheme. (see fig-3a)

From the entrance up to 3 meters:
Flights at an angle of 30° relative to the axis for the first two meters, then gradually dimensicning to 0°. Heights of Flights 300 mm.

13 meters of lifters parallel to the axis, each 1850 mm; in total 7 sets of 12 lifters.

Set No. 1 and 2: Radially arranged straight lifters, width 300 to 400 mm.

Set No. 3 to 7: Radially arranged lifters width 350 mm with lips having an angle of 45°. Lips have a length of 250 mm.

The last 2 meters of the Dryer should be fitted with flights gradually augmenting to an angle of 30° towards the axis.

Each set of flights should be off-set relative to a neighbouring set.

KNOCKERS: A set of 6 knockers at a distance of 5,000 mm from the entrance should be fitted to the shell. The shell should be reinforced where the knockers hit the shell.

RIDING RINGS: Diameter about 2,800 - 3,000 mm to be designed by Designer.

Fastening of riding ring to shell to be designed. Riding rings at about 3,500 to 4,000 mm from the ends of the drum. Designed by Designer.

ROTATION: 2.7 RPM. Preferably a variable Gear Box should allow speeds of 2.2; 2.7 and 4 RPM.

DRIVE: Electric Motor of about 40 HP; exact power to be chosen by Designer.

Gear box as mentioned before.

A hydraulic coupling between motor and Gear Box provides smooth starting. It is not an absolutely necessary item.

GIRT GEAR AND PINION: Girt Gear should have a diameter of about 3,200 mm to be designed by Designer.

Girt Gear should be at about 2,000 to 2,500 mm from the first riding ring.

TRUNNIONS: To be calculated by Designer. One set of trunnion should have thrust rolls.

FEED: Should enter through a chute having a polished interior to prevent sticking.

MATERIAL: Corten steel or similar.

A CASING: Should allow entrance of feed and of flue gas from heater. Design to be made by Manufacturer. No sealing is required at entrance casing. Inspection doors should be provided for.

DISCHARGE: Through appropriate breeching fitted to Screw Conveyor 'A'.

The breeching should be fitted to the shell using an appropriate sealing ring. The breeching should be provided with inspection doors.
The breeching should be fitted with a nozzle for a ventilation unit (16,000 Nm^3/hr.).

DESIGN DATA FOR GRANULATOR

REQUIRED: ONE Rotary Granulator.

SPECIFICATIONS: Length 5,000 mm

Diameter 1,800 mm

Speed: 9, 12 and 16 rpm by using a variable Gear Box.

RIDING RINGS AND TRUNNIONS: To be designed by Manufacturer. One set of Trunnions should be fitted with a thrust roll. No flights or lifters have to be installed. However, strips of about 20 mm (10 to 12 strips) should be welded parallel to the axis.

FEED: Should enter through a chute (see fig-2). A fixed steel plate with openings to observe the process closes the drum. To this plate are fixed the steam and water inlet tubes. This can be properly done by fixing the tubes to a length of structural steel connecting the fixed steel plate and the discharge casing

STEAM INLETS: 3 tubes of 1" diameter each with an appropriate valve; pipes should have slits 3 x 40 mm parallel to the axis. Pipe No.1 reaches 800 mm into the drum and has slits over this length.

Pipe No.2 reaches 1,600 mm into the drum and slits over the last 800 mm.

Pipe No.3 reaches 2,400 mm into the drum and has slits over its last 800 mm.

Steam consumption 400 - 1,000 kg/hour; Pressure: 1-1.5 atm. Fig-2 shows arrangements of steam pipes.

WATER INLETS: Through pipes arranged as the steam pipes but outside granulating bed.

3 pipes each with a nozzle spraying finely divided water on the granulating bed. Location of the three nozzles at respectively about 500, 1,300 and 2,000 mm. from feed end. Capacity 150 l per hour per nozzle.

DISCHARGE: Into a breeching connected to the feed chute towards the Rotary Dryer the breeching should be fitted with inspection doors. The breeching should be fitted with a nozzle to connect the granulator to a ventilation unit (2,000 Nm^3/hr.). The breeching should be designed by the Manufacturer.

DRIVE: There are two possibilities:

A. Drive through a pinion and Girt Gear. To be designed by Designer. As mentioned before, the granulator should have variable speeds of 9, 12 and 16 rpm.

B. When the Trunnions are fitted with rubber wheels the trunnions can be driven directly. Two trunnions are connected with an axis and this axis is driven by a motor through a variable Gear Box . This type of drive does not produce much noise.

Drive is estimated to be about 15 HP but should be calculated by the Designer.

VARIABLE ANGLE: The granulator should be fitted on a cradle frame allowing the choice of any angle between 1° and 5°. A mechanical or hydraulic operated jack should allow for.

Design should be made by the Manufacturer.

Design should allow a proper functioning of the inlet chute as well as of steam and water supply.

Connecting to the ventilating unit should be flexible.

ANNEX

Hazara Phosphate Rock

Large deposits of rock phosphate are found near Hazara, north of Islamabad. Several samples have been analyzed. It was shown that the analysis from several samples taken in the deposit fluctuated from 20% to 40%.

Two types were observed:

- Silicic types with SiO_2 content up to 40%, and

- Dolomitic types with high calcium and magnesium content.

The rock is of magmatic origin and is of the Apatite type. It can be compared with Kola rock phosphate (USSR). It is well known that Kola phosphate has different properties as compared with the rock phosphate of marine sedimentary deposits.

Hazara rock phosphate is very hard as compared with the sedimentary phosphates and its crushability and grindability should be investigated. Such investigations preferably should be combined with a study of benefication and concentration methods.

It is well known that Kola phosphate rock behaves differently as to further chemical attacks to produce fertilizers. It is recommended to carry out extensive investigations with Hazara concentrates.

Studies to be made include:

a) Attacks by sulphuric acid and phosphoric acid to produce respectively single and triple superphosphate;

b) Production of phosphoric acid using both dihydrate and hemihydrate processes;

c) Nitric acid attack to produce compound fertilizers.

These investigations should be carried out on laboratory bench scale as well as on a pilot plant scale.

Thorough investigations may lead to good and sound technologies and can avoid to build processing units that do not give optimal results as to quality, processing costs, etc.

ACKNOWLEDGEMENTS

Numerous people from various organizations were met. They provided valuable information in discussions and contacts. Listed below are organizations and people who were involved:

UNDP

Mr. C. Jan Kamp	Deputy Resident Representative
Mr. S. Skoumal	Senior Industrial Development Field Adviser
Mr. G.T. Toro	Technical Adviser

National Fertilizer Corporation of Pakistan Ltd. (NFC)

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Mr. Aftap Ahmad	General Manager (technical)
Mr. Abdur Rasheed	General Manager (commercial)
Mr. Mohammed Akram	Chemical Engineer
Mr. Talata Chugtai	Chemical Engineer

b) Jaranwala Factory

Mr. Syed Shahabuddin Ahmad	General Manager
Mr. Munir Ahmad	Chemical Engineer
Mr. A.R. Abasi	Production Chemist
Mr. Zahar Alam Shah	Civil Engineer
Mr. A.R. Maan	Assistant Process Engineer

c) Lyallpur Factory

Dr. M. Ishaque	General Manager
Mr. Mohammed Younis	Chemical Engineer

d) Daudkhel Factory

Mr. Abdul Majid	General Manager
Mr. Ayub Shah	Mechanical Engineer

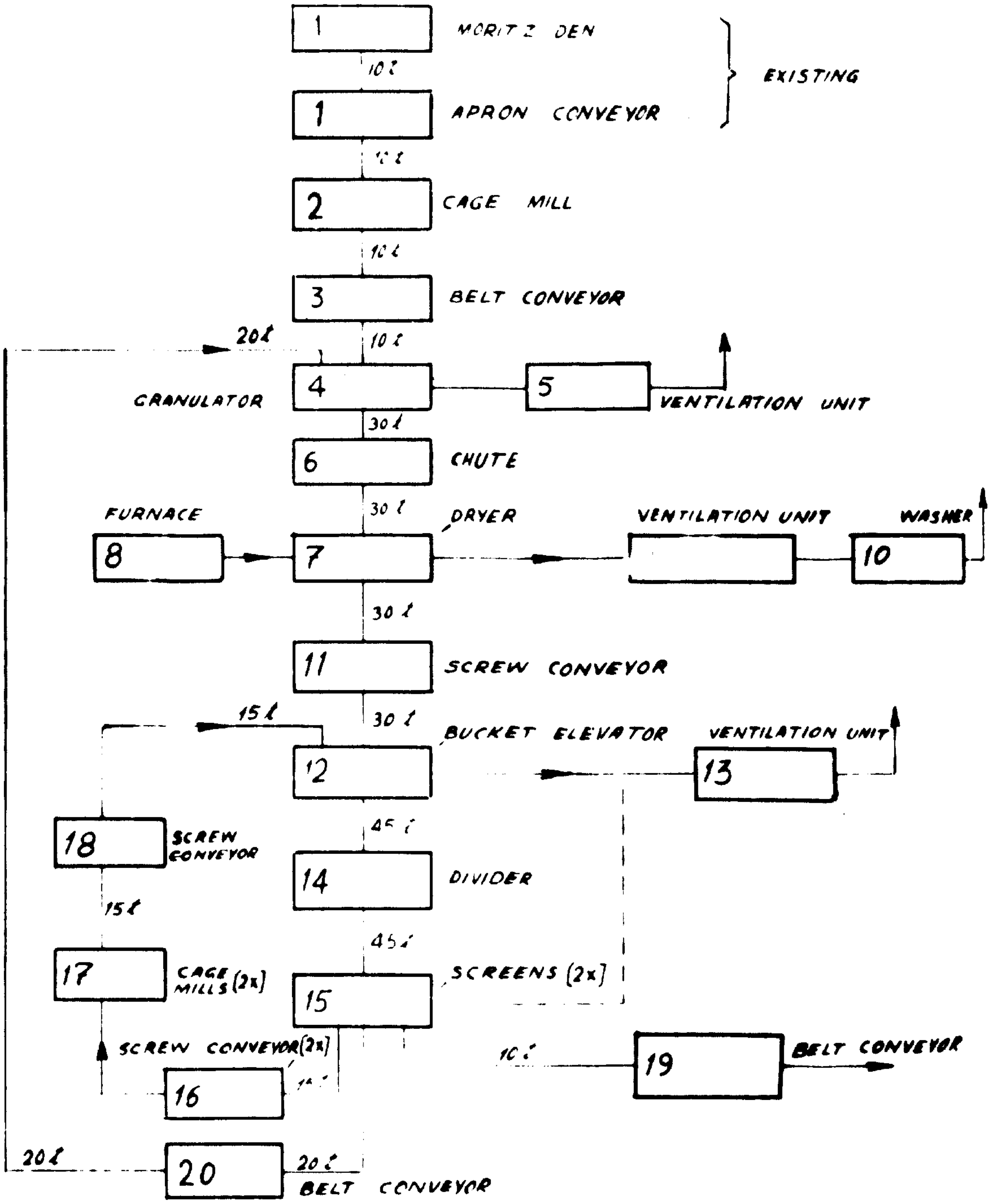


FIG. 1 FLOW SHEET

S. S. P GRANULATION PLANT

NFC. LYALLPUR CHEMICALS & FERTILIZERS LTD. JARANWALA

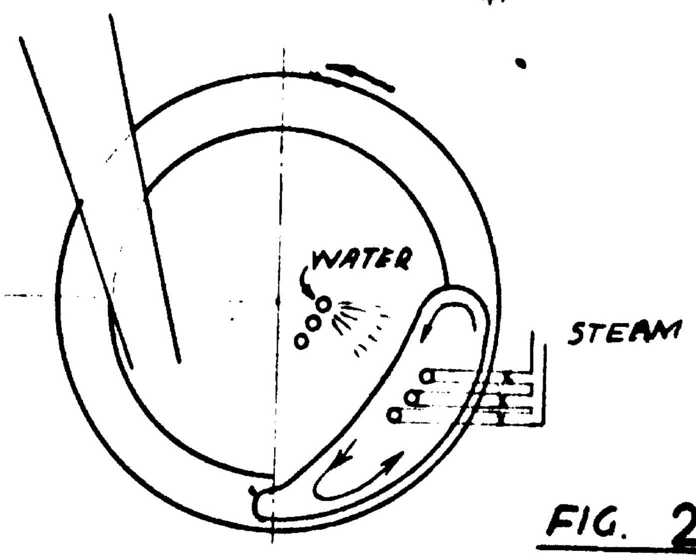


FIG. 2

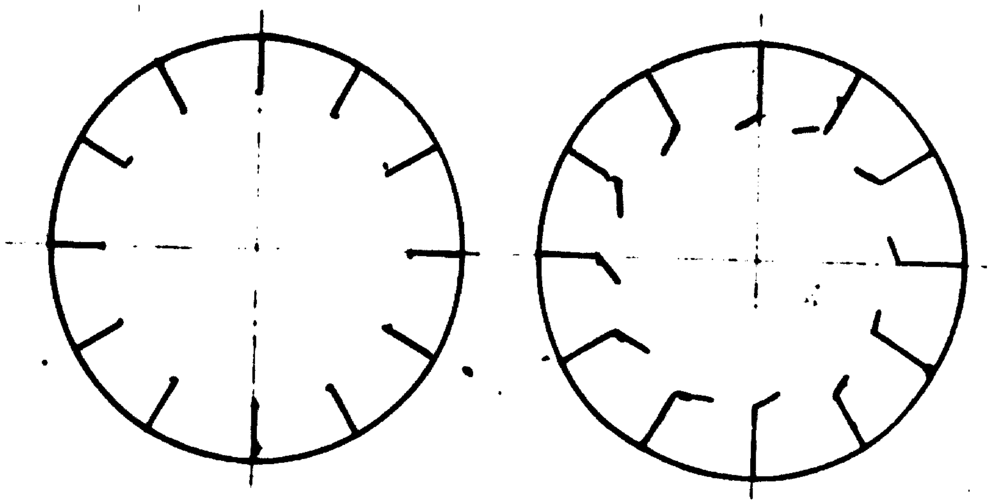
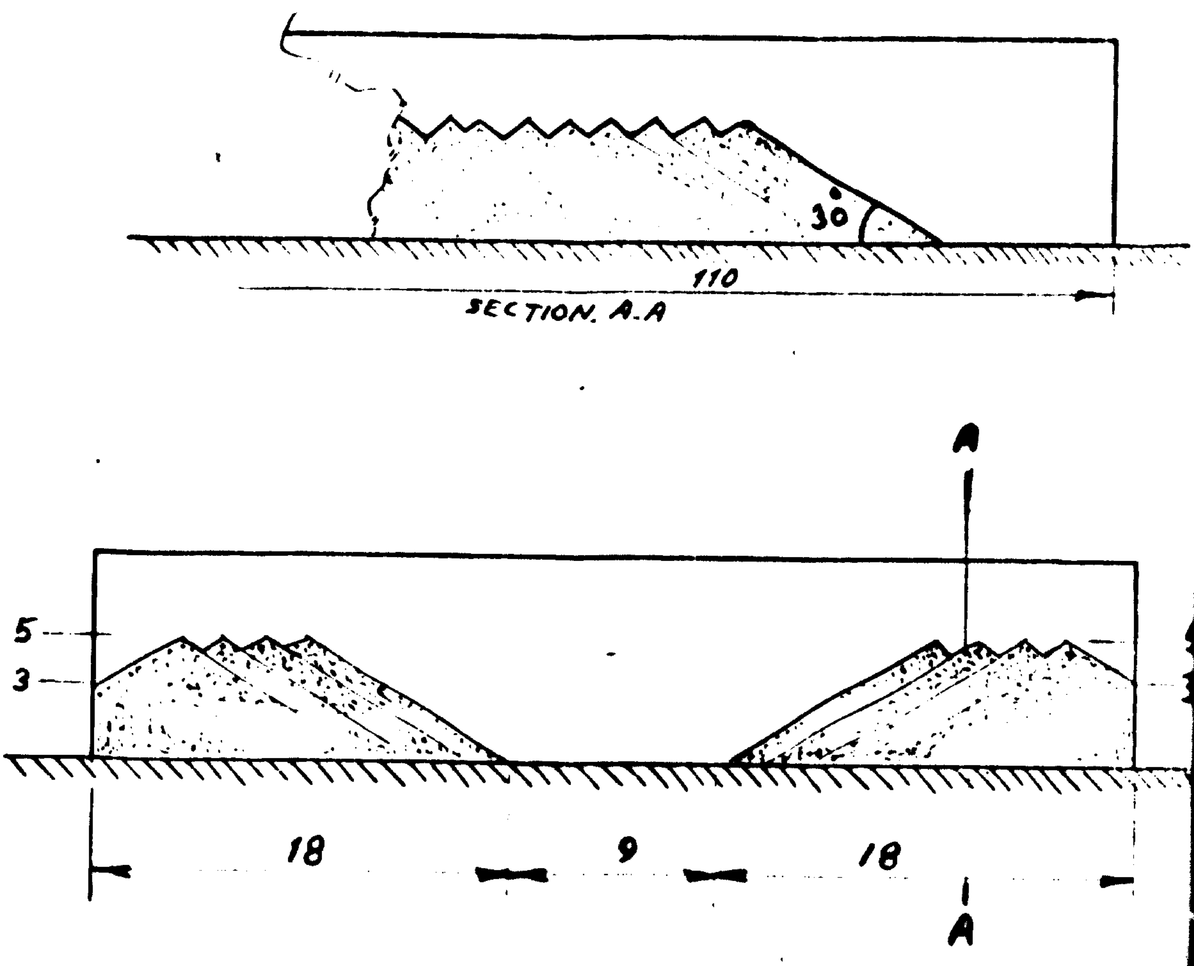
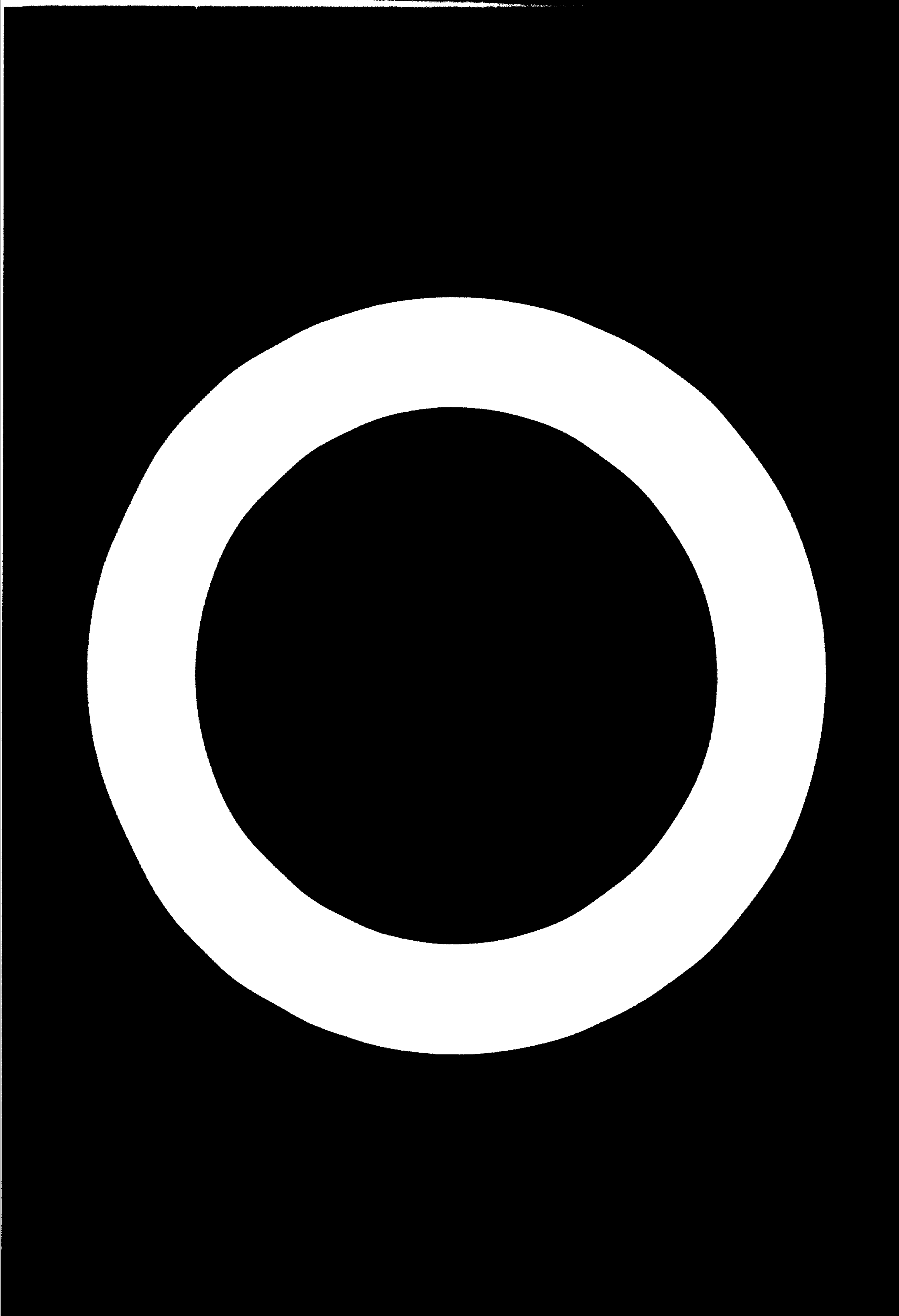
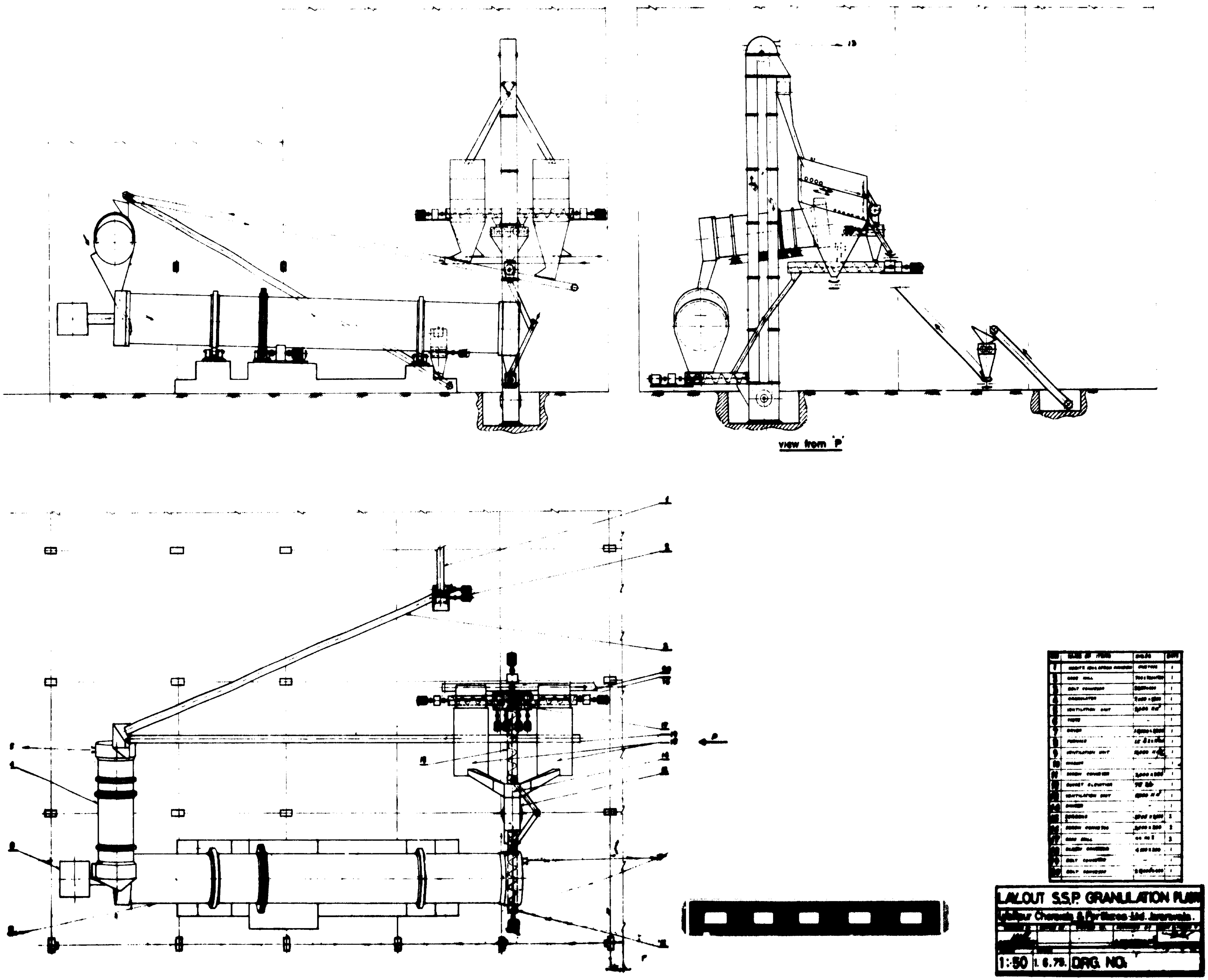


FIG 3

FIG 4 STORAGE






view from 'P'
LAYOUT S.S.P. GRANULATION PLANT
1:50
1. 6.75.
DRG. NO.

76.01.13