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Rio de Janeiro, Brasil

WET PROCESS PHOSPHORIC ACID AS A BASIC FERTILIZER INGREDIENT IN INTERNATIONAL TRADE [1]

by

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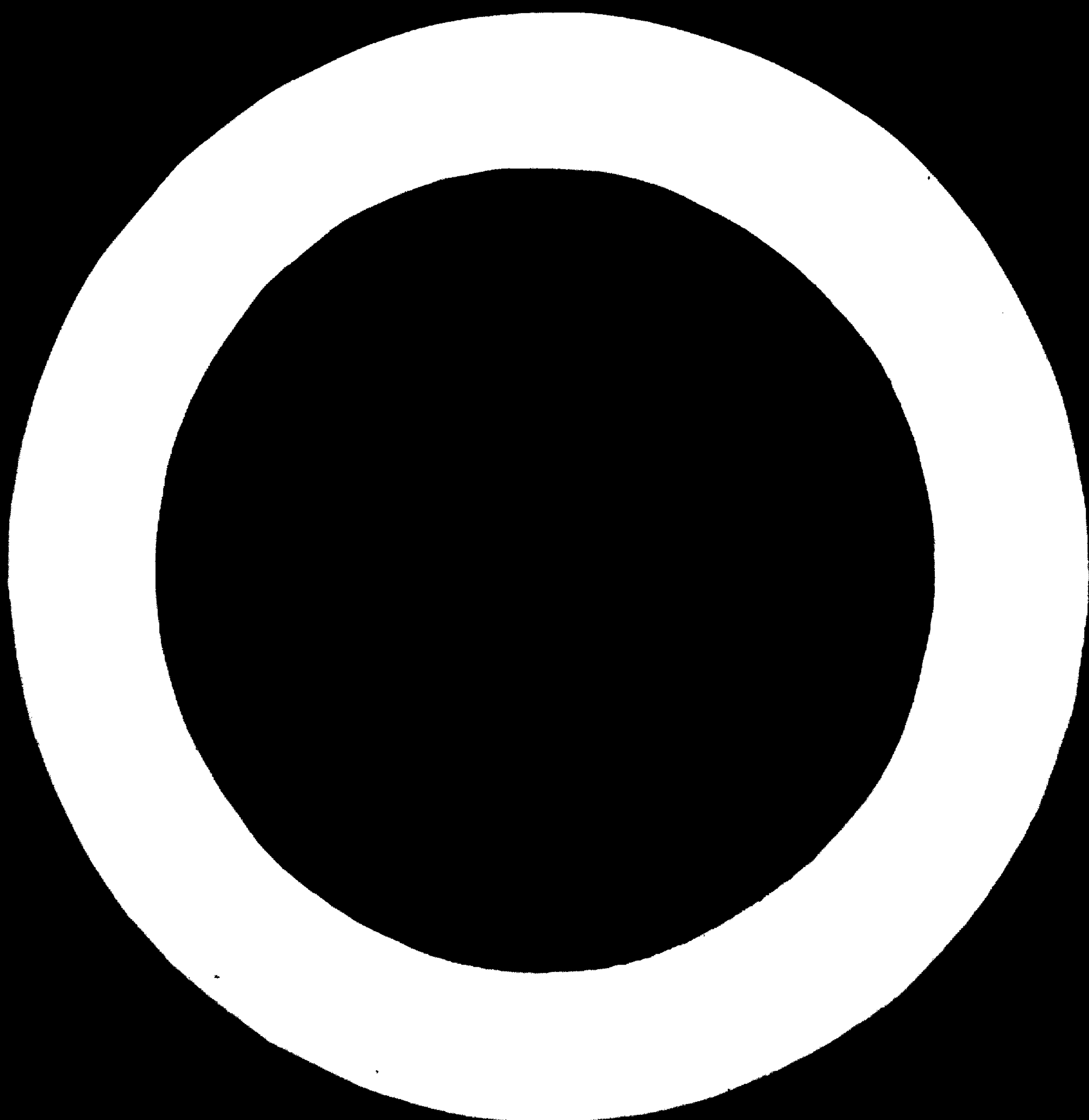


1. BACKGROUND

Regular bulk shipments of phosphoric acid by tanker were initiated in 1969 when the FFM Vassijaure carried its first cargo between Coatzacoalcos, Mexico and Rotterdam, Holland. Apart from the technical achievement of its voyage, its importance also lies in the fact that this is the first time that an off-shore supplier of phosphoric acid has ever attempted to penetrate an established and stable market with imports.

The significance of this advance can be seen in many countries today where the larger fertilizer manufacturers are now completing their calculations on whether to "make or buy" intermediate raw materials such as anhydrous ammonia and phosphoric acid, particularly when an increase in present plant capacity is planned or a new venture is envisaged.

Since this first shipment on the M/V FFM Vassijaure, other shipments have been made to Europe and Australia.

Fertilizantes Fosfatados Mexicanos, S.A. (FFM), now has two such ships in regular operation and by early 1971 will have four tankers supplying such countries as Holland, France, Belgium, England, India, Italy, Australia, Brazil, Ecuador and the U.S.A.

This fleet provides added assurance that continuous and dependable deliveries may be expected by FFM phosphoric acid customers.

To be able to take maximum advantage of such shipments, the buyer must have access to a deep water harbour (34 feet) and of course, have built a receiving terminal capable of holding a full shipload (23,000 metric tons of phosphoric acid). Other combinations can be worked out, such as partial shipments into smaller terminals provided that more than one client is on the same shipping route. Or, if a tanker is partially loaded a higher per ton freight rate applies.

The concept of marketing phosphoric acid in ocean going shipments is successful when the above is available and the following premises also hold true for the user of the product.

1. He is obliged to import phosphate rock or to buy expensive locally produced rock. One ton of P2O5 in phosphoric acid corresponds to approximately 3.4 tons of rock.

2. He is obliged to import sulphur. Approximately 0.95 tons of sulphur correspond to one ton of P2O5. Sulphur and rock freight volume is more than twice that for equivalent P2O5 in phosphoric acid.

3. His P2O5 requirements are not large enough to allow him any cost savings by scale of manufacture (approximately 200,000 metric tons P2O5 per year is now generally considered an economic unit).

4. His forecast requirements are such that he cannot justify an installed production facility operating at 100% capacity

within the first several years of operation. Purchased phosphoric acid provides flexibility in quantities received as required. Idle plant capacity is avoided.

FPM with their plant at Coatzacoalcos have an installed capacity of 400,000 metric tons P2O5 per year. The plant is situated on deep water and has a sulphur source with abundant reserves close by. Phosphate rock has to be imported.

One of the inherent problems with fertilizer grade phosphoric acid has been the deposition of solids from the acid upon storing and handling. This is particularly true with acids made from a Florida type rock.

FPM has installed, within its manufacturing facilities, the ability to cool, age and clarify the finished acid before shipment, thereby ensuring that the ships and the future customers have a minimum solids problem upon receipt and subsequent usage.

Experience to date has shown that this "solids" problem has been solved with respect to storing and shipping.

2. MANUFACTURING PROCESS

A. Rock Preparation

Phosphate rock is imported into the plant at Coatzacoalcos by large bulk carriers (30,000 metric tons) equipped with self-discharging gear. The rock is discharged at FPM's privately owned dock and is then conveyed to a large storage building capable of holding 100,000 metric tons.

Generally speaking, the rock that is purchased requires further grinding to obtain the maximum recovery of P2O5 and to ensure good production control. Large ball mills are used for the final grind to produce a material which passes 60 % through 100 Tyler mesh screen.

A typical flowsheet is shown in Figure I.

(B) Sulphuric Acid Facilities

The company has built two Wellman-Lord contact sulphuric acid plants burning Frasch sulphur.

Each of these plants is rated at 1,500 metric tons per day of 100 % H2SO4.

A typical flowsheet is shown in Figure II.

Molten sulphur arrives at the plant by road trucks and is discharged into an underground pit.

Special demister devices on the ensuring exhaust stacks ensure that the gases leaving the plant contain a minimum of sulphur trioxide and sulphuric acid emission.

The strenght of acid produced can be either 96 % or 98 % H2SO4 and is passed to intermediate storage. Waste heat boilers produce surplus steam at 500 psig and 35 psig at a rate of one ton of steam per ton of H2SO4 produced.

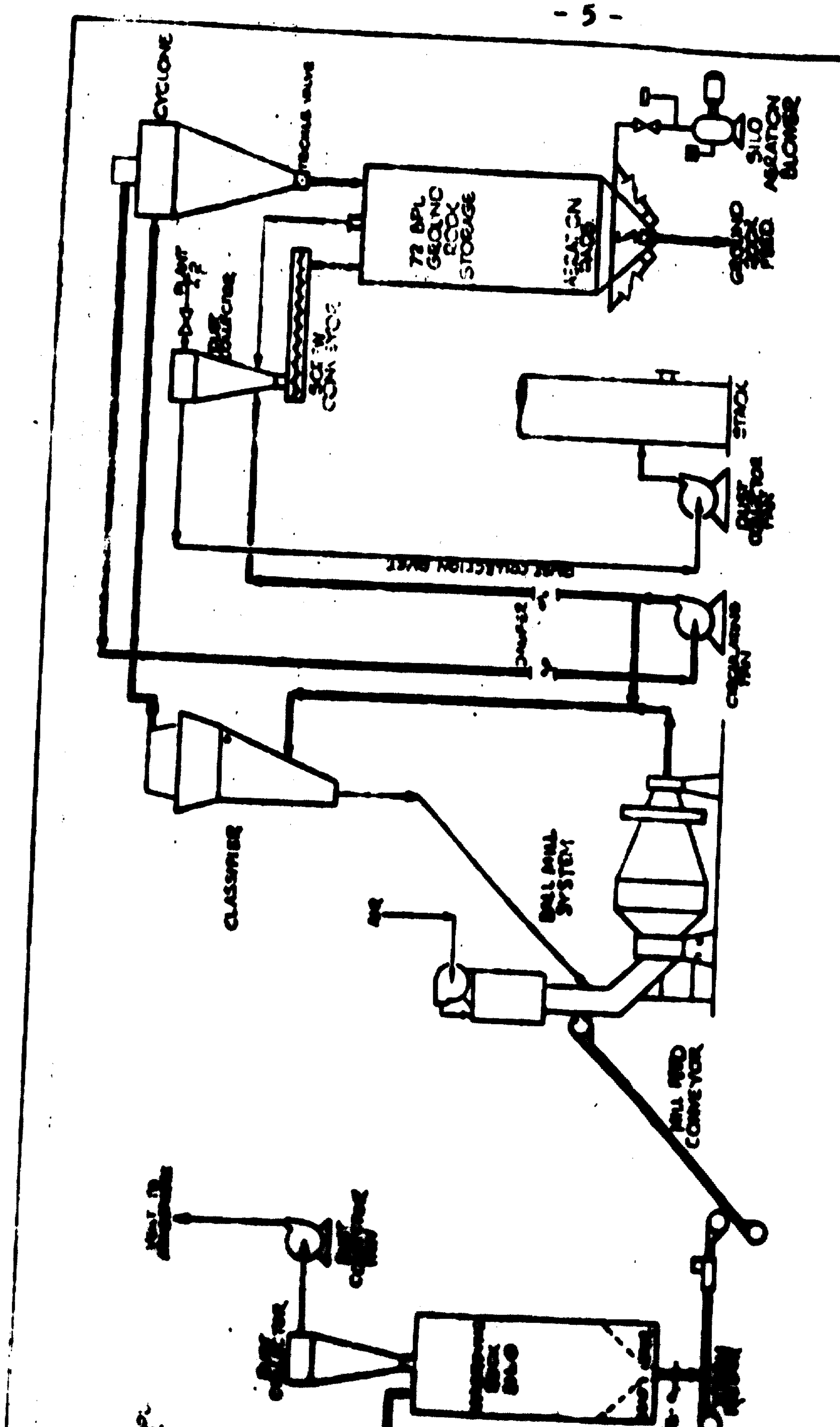


FIG 1
ROCK GRINDING
PROCESS FLOW

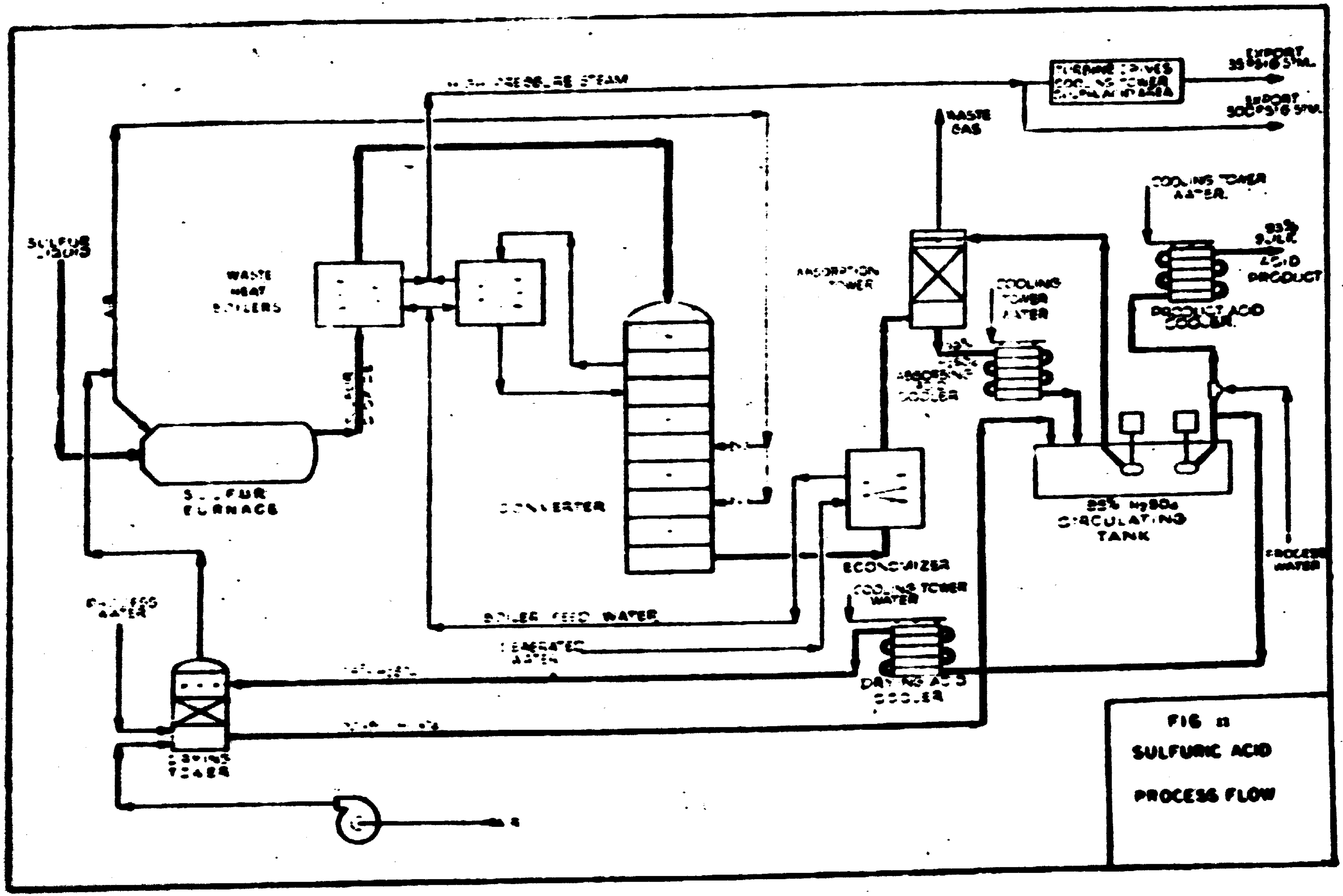


FIG II
SULFURIC ACID
PROCESS FLOW

(C) Digestion and Filtration

The digestion of the ground rock with sulphuric acid is carried out in two trains. Each of these trains is a conventional Prayon dihydrate phosphoric acid plant producing 30 % P2O5 acid from the filter.

Sulphuric acid is first diluted down to 55 % H2SO4 and the heat of dilution is removed by a karbate cooler.

A typical flowsheet is shown in Figure III.

This dilute sulphuric acid is then passed to the first and second digestion compartments. The split between the amount going to the first and the second compartment is dependent upon the grade of rock being used.

The ground phosphate rock is weighed on a batch weigher and then sent by a screw conveyor to the first digestion compartment. At the same time weak recycle phosphoric acid from the Prayon tipping pan filter is also introduced into the first digestion compartment.

It is important to control accurately the phosphate rock feed (±0.5 %) and the sulphuric acid feed (±0.5 %) so that the relative rates can be controlled to maintain the free sulphuric acid in the ensuing reaction slurry between 2 % and 2.5 % by weight.

Based upon periodic sulphate analysis by the operators, the sulphuric acid feed is adjusted to maintain these desired conditions.

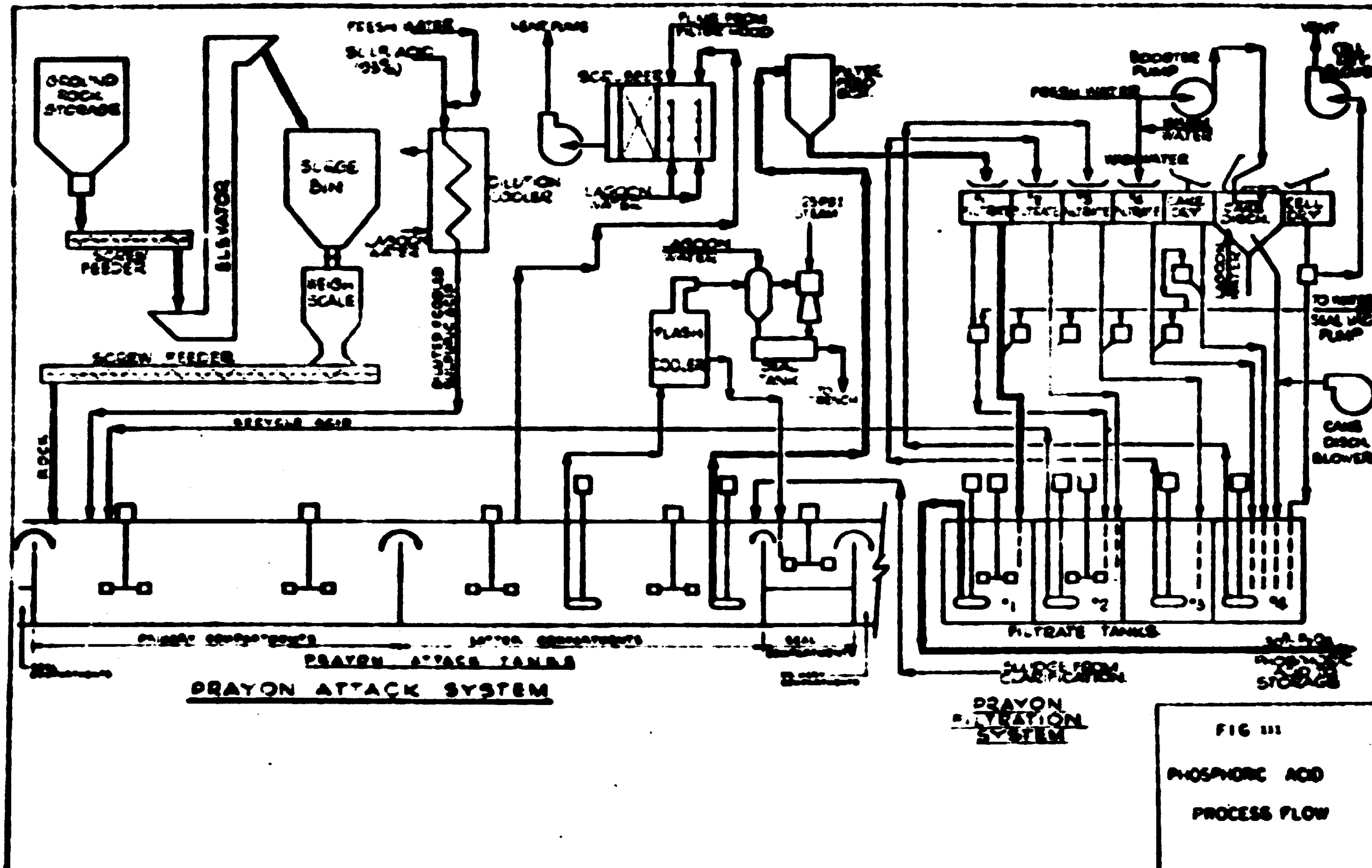


FIG III

PHOSPHORIC ACID PROCESS FLOW

Dilute sulphuric acid is preferred in this process since high concentrations of sulphuric acid result in coating the unreacted rock with gypsum and thereby decreasing the P2O5 recovery.

Since this reaction is exothermic, the heat of reaction has to be removed in order to control the reaction temperature. This is accomplished by pumping the reaction slurry to a vacuum cooler. The cooled slurry drops down a barometric leg and is then split into recycle slurry feeding back into the first digestor and feed slurry to the Prayon filter. The reaction temperature can be controlled by regulating the vacuum to the vacuum cooler.

The Prayon filter consists of a Model [illegible] fabricated from 317 ELC stainless steel with a total area of 1,700 square feet.

The filter is comprised of individual horizontal cells, each of which is supported by bearings, which in turn are fastened to a large monolithic rotating frame.

The cells are piped to a central manifold by means of flexible hoses. The head of this central manifold rotates with the cells whilst the underneath valve remains stationary. This allows for the different wash waters to be collected separately.

The cells, moving with the rotating frame, pass successively beneath the slurry feed box and three wash boxes. The feed slurry is allowed to settle briefly in the cell before vacuum is applied. Wash water is fed via the first wash box. The resulting wash is collected and fed to the second wash box. This wash in turn is collected and fed to the third wash box. This wash is collected and pumped back to the first digestion compartment.

The washed cake is rotated round to the cake disposal area, where the cell is inverted, compressed air is blown from the under-side of the cloth through the central valve, and the cake is ejected from the cell.

This gypsum cake is then washed down a chute with sea water and pumped to the gypsum disposal system.

An important point in considering a wet process phosphoric acid plant is the large quantitites of cooling water required for the various barometric condensers coupled with the disposal of the by-product gypsum.

FFM solved these problems by utilising sea water wherever possible and pumping the gypsum away from the plant by combining it with this sea water as a slurry.

The resulting slurry is then pumped a distance of five kilometers to a large gypsum disposal settling area (3,000 acres). Here the gypsum is allowed to settle and the sea water overflows back into the sea.

Disposing of gypsum into the sea or a river is no longer considered feasible by most government agencies.

A. CONCENTRATION

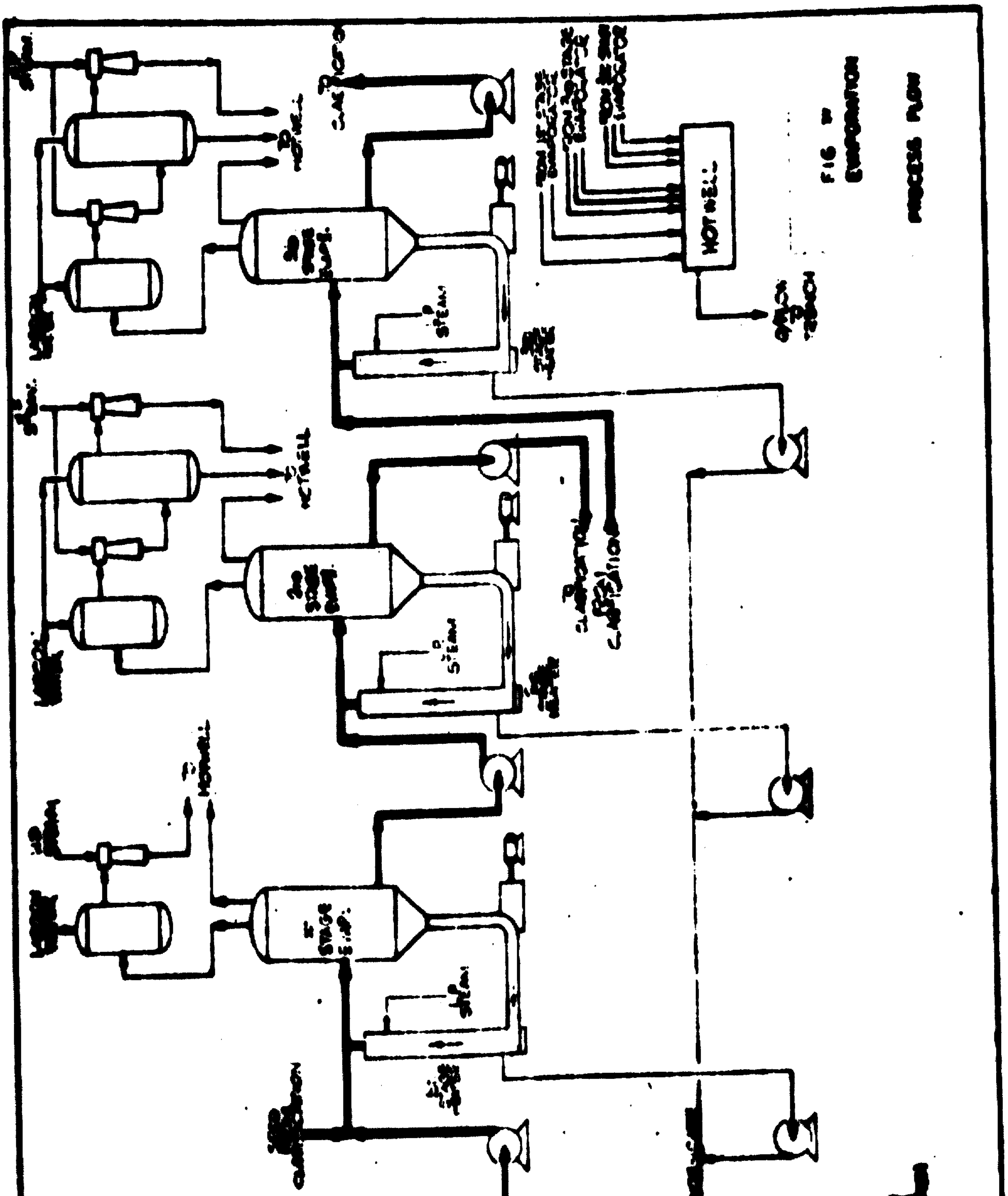
The evaporation system installed uses Swenson evaporators and is designed to concentrate the crude acid from the Prayon filter from 30% to 54% P2O5.

Three evaporators are provided for each train and are connected in series. These evaporators are vacuum evaporators using forced circulating and the heat for evaporation is provided by low pressure pass-out steam from the sulphuric acid plant. Vacuum is provided by steam ejectors using high pressure steam from the sulphuric acid plant waste heat boilers.

A typical flowsheet is shown in Figure IV.

The three stages concentrate the acid progressively to 38%, 40% and 54% P2O5.

Incorporated at the 40% stage is a clarification stage to remove solids. These removed solids are returned to the phosphoric acid digestion tanks.


HOT WELL
PROCESS FLOW
EVAPORATION

B. CLARIFICATION

Each of the phosphoric acid trains incorporates a separate clarification system. During the clarification of wet process phosphoric acid two general types of solids are encountered.

(a) Initial Solids.- These are the inert solids present in the freshly evaporated acid. These solids precipitate as a result of concentrating phosphoric acid with an excess of sulphuric acid.

This condition is desirable since these solids, largely gypsum, contain little or no P2O5 and are immediately available for removal.

(b) Post-precipitated Solids.- These solids mainly iron and aluminum sludge precipitate with time and cooling sometime after evaporation. On concentration, the acid becomes supersaturated with Fe +++ and Al +++, F-, etc. The compounds post-precipitating are about 50% P2O5.

This sludge is removed by subjecting the acid to a series of cooling, ageing and centrifuging steps.

A typical flowsheet is shown in Figure V.

The removed sludge is then sent to the Granular Triple Superphosphate plant for further processing.

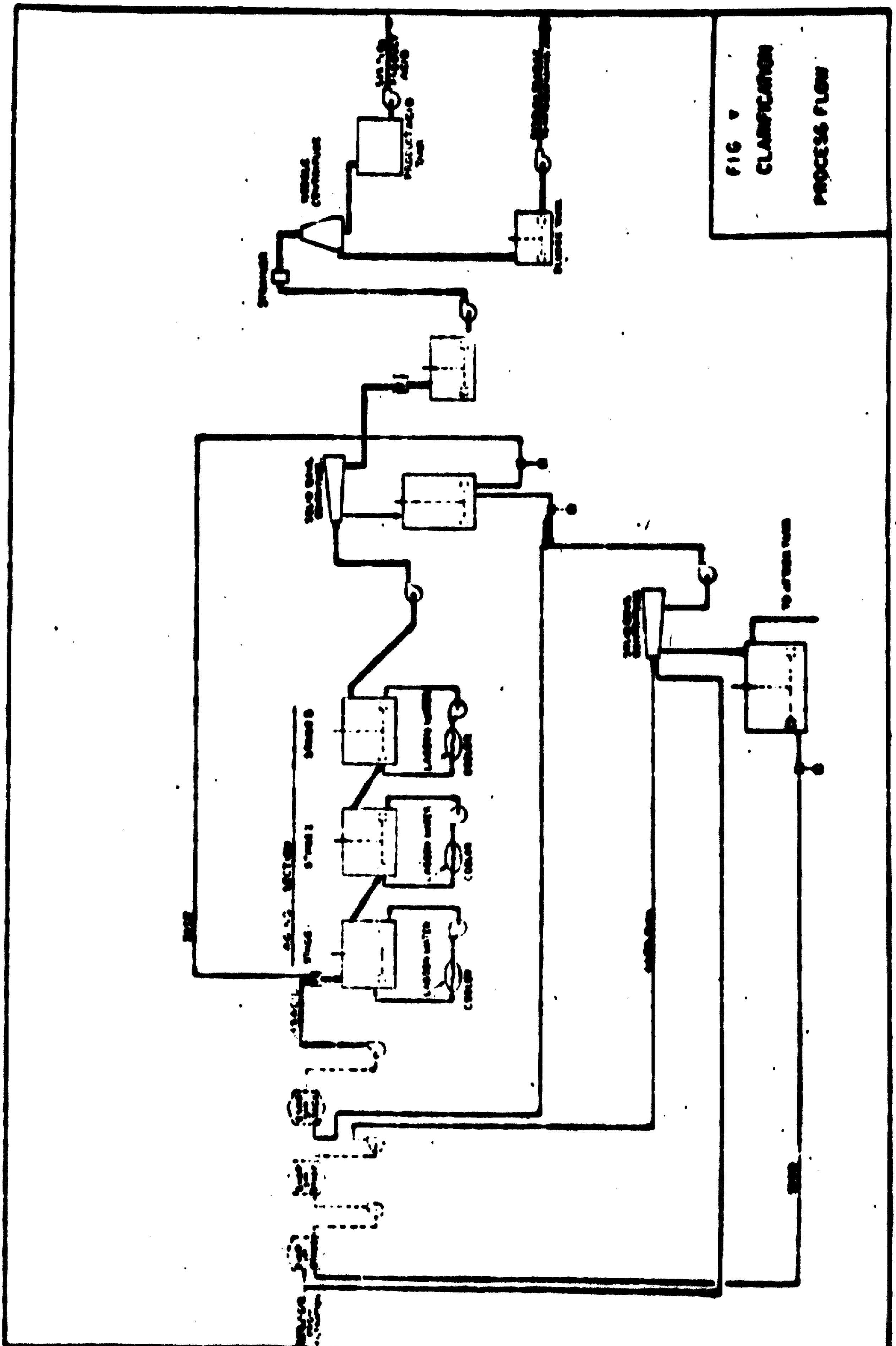


FIG V
CLARIFICATION
PROCESS FLOW

The clarified acid produced usually contains around 1.7 % suspended solids with very little post precipitation. These remaining suspended solids are extremely fine particles and do not present any problems in subsequent handling and storage.

C. STORAGE

The clarified 54 % P2O5 merchant grade acid is then sent to final storage.

This consists of large rubber lined tanks (approximately 84 ft. diameter x 40 feet high) which hold up to 10,000 metric tons of acid. These tanks are equipped with slow moving agitators to gently stir the acid to ensure a uniform content and to prevent any subsequent build up of solids on the tank bottom.

FFM currently has four such tanks in operation giving a total storage capacity of 40,000 metric tons of acid. However, three additional tanks are currently under construction, which will provide a total of 70,000 metric tons of acid storage at the plant.

The acid from these tanks is pumped directly by pipeline to the FFM dock and via an unloading arm into the delivery phosphoric acid ships.

3. CAPITAL COSTS AND PRODUCTION COSTS

It is always difficult to generalise on such figures since every location has a different economic position. This can be a question of locating a plant in Florida to take advantage of a relatively low cost source of phosphate rock, or locating in Mexico to take advantage of a relatively low cost source of sulphur. If you consider the production costs presented later you will see that the two basic raw materials represent by far the biggest cost elements.

4. CAPITAL INVESTMENT

In an attempt to be consistent with other studies, a plant capacity of 200,000 metric tons of P2O5 per year has been chosen on a site in Florida.

This assumes that the molten sulphur will arrive by railcar and that the phosphate rock will also be delivered by rail car. It assumes minimum storage of both raw materials within the plant site.

It assumes a conventional contact sulphuric acid plant, dihydrate phosphoric acid plant with rocking grinding and evaporators to concentrate from 30% to 54 % P2O5, clarification and storage of finished product (one month).

CAPITAL INVESTMENT - WET PROCESS ACID PLANT

Capacity 200,000 metric tons P2O5 per year (600 TPD) as 54% P2O5 clarified phosphoric acid.

ITEM	X 000 US$	REMARKS
Process Facilities		
Sulphuric acid	3,500	One unit - 1,600 TPD
Phosphoric acid	4,700	One unit - 600 TPD
Raw material handling and storage	1,500	Rock and sulphur
Rock grinding	900	
Phosphoric acid storage, clarification and shipping	1,500	
TOTAL FOR PROCESS FACILITIES	12,100	
Auxiliaries - Off-sites		
Land	500	500 acres Ca. 1,000 $/acre
Water and treatment	600	
Auxiliary steam boiler	250	
Gypsum and water ponds	1,000	
R.R. sidings and scales	150	
Site improvements	500	
Fire protection and security	100	

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Office and service buildings	500	
Shop equipment	150	
Piping	300	
Power distribution	500	
Mobile equipment	100	
TOTAL AUXILIARIES	4,650	
TOTAL DIRECT COST	16,750	
Engineering, construction and contractors fees	2,500	15%
Contingency and escalation	2,000	10%
TOTAL FIXED CAPITAL	21,250	
Working Capital	3,000	
TOTAL INVESTMENT	24,250	

OPERATING COST - WET PROCESS ACID PLANT

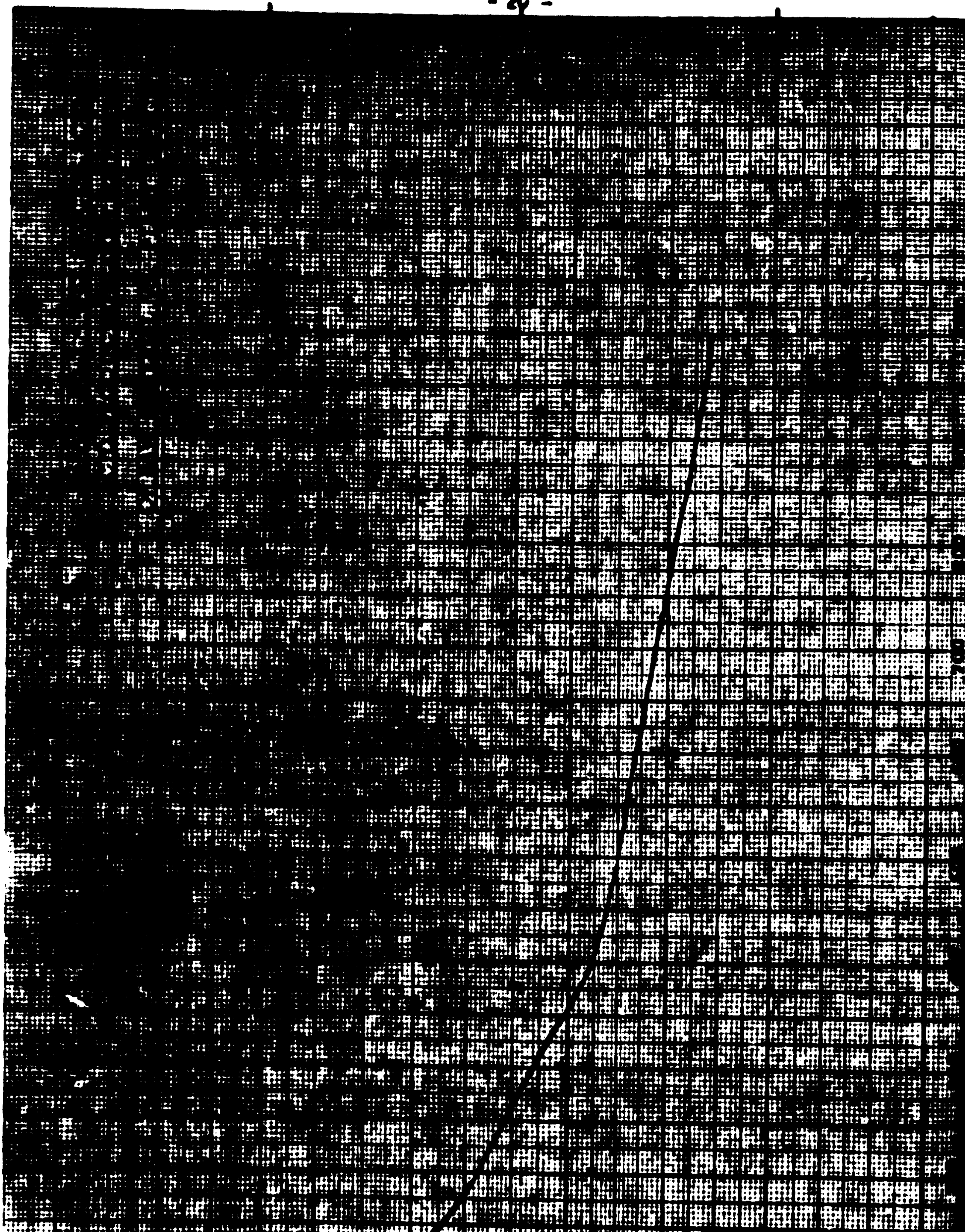
Capacity 200,000 metric tons P2O5 per year. Estimated fixed capital 21,250,000 US$.

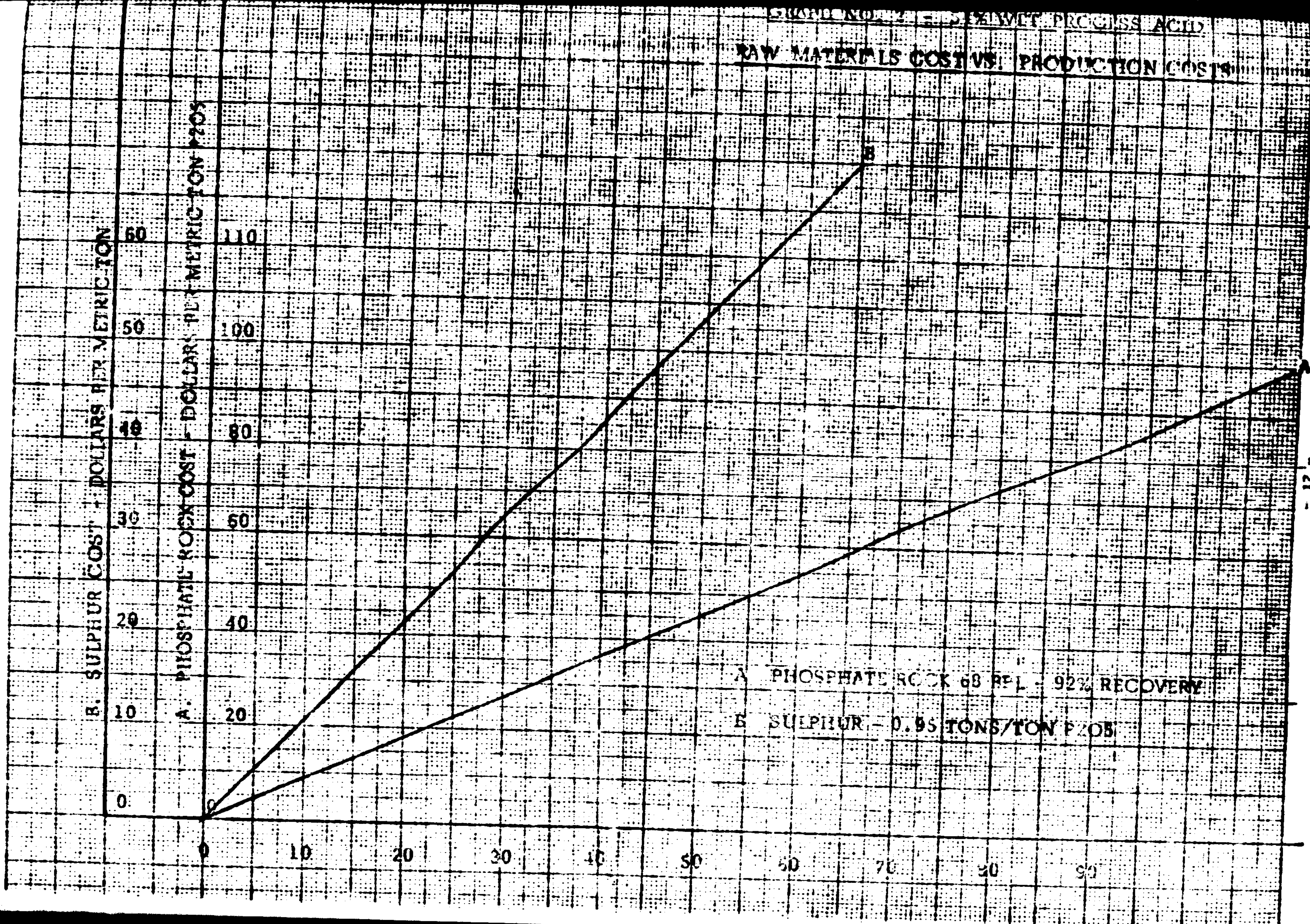
	Units	Units /MT P2O5	$/Unit	$/MT P2O5
Raw Materials and Supplies-				
Phosphate rock	M. Tons	3.49	5.50	19.20
Sulphur	M. Tons	0.95	37.00	35.20
Electricity	KWH	275	0.005	1.38
Water - raw	M. gallons	30	0.02	0.60
boiler feed	M. gallons	1.0	0.40	0.40
process	M. gallons	14.0	0.05	0.70
Steam			No charge	-
Operating supplies				0.40
Maintenance supplies	3% of direct cost			2.50
Mobile equipment				.25
TOTAL RAW MATERIALS				60.63

$...

Operating labour	.47 man hours Ca. 4$	1.88
Maintenance labour	2% of direct cost	1.67
Supervision and overhead salaries	25% of total labour	.89
Fringe benefits	30% of total labour	1.34
TOTAL LABOUR		5.78
Other-		
Taxes and insurance	2% of fixed capital	2.12
Depreciation	10% of fixed capital	10.60
TOTAL FACTORY COST		79.13
General Expenses-		
Administration and selling 1.5 x 10 US$ per year		7.5
TOTAL COST*		86.63

*This cost does not include interest on loans, nor profit




WET PROCESS ACID
RAW MATERIALS COST VS. PRODUCTION COSTS
B. SULPHUR COST - DOLLARS PER METRIC TON
A. PHOSPHATE ROCK COST - DOLLARS PER METRIC TON P2O5
0
10
20
30
40
50
60
20
40
60
80
100
110
0
10
20
30
40
50
70
90
A
B
A PHOSPHATE ROCK 68 BPL - 92% RECOVERY
B SULPHUR - 0.95 TONS/TON P2O5

As you can see from the Graph I that if you consider a plant to manufacture 100 metric tons P2O5 per day with the same raw material costs as assumed for Florida, then the increased production costs would be approximately 20 US$/MT P2O5.

If we now assume a location such as India where both sulphur and rock have to be imported and that the delivered CIF prices for these raw materials are:

Sulphur	35 $/MT FOB
Freight	12
Storage and handling	5
	52.0 $/MT
Phosphate rock	6.0 $/MT FOB Tampa
Freight	12.0
Storage and handling	2.0
Total Cost of rock delivered plant	20.0 $/MT

Equivalent landed P2O5 cost using 68 BPL rock (31.3 % P2O5) = 54.0 $/MT P2O5

Then using Graph II we can see that the total raw material cost would be 107 $/MT P2O5 as compared with 54.40 $/MT P2O5 in our Florida location.

If we now add this additional cost to the additional production cost, we can arrive at a cost advantage of approximately 72 US$/MT P2O5 in favour of the Florida producer.

Of course from the margin must be deducted the cost of freight from the plant to the port, the cost of terminalling in Tampa, the ocean freight, and the cost of a terminal in India. These factors will now be discussed.

(1) LOADING-OUT FACILITIES

In the case of FFM, these facilities are an integral part of the plant. FFM possesses its own deep water port facilities adjacent to its plant and the final product storage tanks are the same as the loading out tanks for the ship.

In other cases one would have to consider moving the product from the plant to a terminal alongside a deep water dock.

To consider loading a ship with 23,000 metric tons of phosphoric acid solution one would need three large storage tanks. These tanks could be mild steel, rubber lined and fitted with agitators. Interconnecting pipework and pumps would be needed with sufficient capacity to load a ship within 24 hours. Typical capital investment figures for a terminal in Tampa, Florida would be as follows:

	US Dollars
Three storage tanks	600,000
Agitators	170,000
Dikes	10,000
Foundations	50,000
Pumps	20,000
Piping and valves	100,000
Electrical	25,000
	975,000
Engineering 15%	146,000
Contractors fee 5%	49,000
Contingency	150,000
TOTAL	1,320,000

The contingency has been deliberately inflated to allow for any piling of foundations or for an increase in the length of the loading line from the tanks to the ship.

If we now assume that the whole 200,000 metric tons of P2O5 would be exported through such a terminal, then we could expect the following operating costs:

	$/MT P2O5
Labour - 4 men/yar Ca. 8,000 Sca.*	0.15
Maintenance- 6% of installed cost	0.39

Electricity - Ca. 0.008 $/KWH	0.03
Leasing land and dock	1.00
Taxes and insurance 2 % of installed cost	0.13
Depreciation 10 years	0.65
Overhead 100 % operating labour	0.15
Interest 10 % on ½ of installed cost	0.33
R.O.I. on ½ installed cost Ca. 20 %	0.66
TOTAL	2.49

(2) TRANSPORT FACILITIES

FFM will have by the end of 1970 a fleet of three tankers in operation, and by the end of 1971 a fleet of five tankers.

Each of these ships is capable of carrying a minimum of 23,000 metric tons of acid. Such a cargo will require a port draft of 34 feet.

The ships employed by FFM are on long term charter from the Grangësberg Company in Stockholm, Sweden. These ships are converted ore carriers.

The cargo tanks are lined with stainless steel and they are equipped with recirculation equipment and heating coils. The overall dimensions of a typical ship are: Lenght: 595 ft. - Breadth: 74 ft. They have six separate compartments and could carry partial loads of phosphoric acid along with other liquid products, or various grades of phosphoric acid. This latter point could be important to smaller customer since PFM will have available next year four different grades of phosphoric acid. These different grades will enable producers to consider the manufacture of dry fertilisers such as triple superphosphate and ammonium phosphate liquid fertilisers such as 11-37-0, sodium tripolyphosphate for detergents or other industrial phosphates and animal feed phosphates.

The capital cost and operating costs for this type of ship has to remain confidential, but it can be stated that this freight cost is sufficiently attractive to PFM to have convinced them that the concept of moving merchant grade phosphoric acid around the world in large tankers out of Mexico is a feasible proposition.

(3) UNLOADING FACILITIES

To obtain maximum economic advantage from this type of business it is necessary for a potential client to be able to receive a full shipload at any one time. This implies that he must have a terminal installation capable of receiving 23,000 metric tons of phosphoric acid which in turn means an investment very similar to the figures shown previously for the loading facilities in Tampa, Florida. (Page 24).

This capital investment of course can be offset against any investment necessary to build phosphate rock handling and storage, sulphur handling and storage, a sulphuric acid plant and a phosphoric acid plant along with the necessary off sites.

FPM believes that with a yearly throughput of four or five times the storage capacity that the investment and the necessary operating costs can be considered to be approximately five to six dollars per metric ton P2O5.

ADVANTAGES OF IMPORTING PHOSPHORIC ACID OVER LOCAL MANUFACTURE

Provided that a prospective client has access to a deep water dock, the following advantages can be cited:

1. The capital investment required for a would-be producer of fertilisers is greatly reduced since, apart from the terminal cost, the only investment is the production unit to manufacture the NPK or NP solid fertilizer materials. This concept becomes even more attractive if one considers the manufacture of liquid fertilisers.

2. In most cases phosphoric acid can be purchased for the same or lower cost price than he could have manufactured phosphoric acid without incurring the capital risk.

3. The phosphoric acid purchaser is not subjected to any of the effluent and pollution problems inherent with sulphuric acid and phosphoric acid plants.

4. Purchase requirements for P2O5 can generally be ordered to suit the local market demands.

5. The Buyer has available to him the technical service department of a specialized large company with skills and experience in the manufacture of phosphate fertilizer products.

6. It enables an existing single superphosphate manufacturer to convert production facilities to concentrated superphosphate and/or NPK fertilizers for a modest capital outlay and thereby allows him to compete with high analysis fertilizers producers within his local marketing area.

Probably the most difficult hurdle which still has to be overcome is the problem of import duties, taxes and costly port charges levied in some countries.

Several countries have an import duty on phosphoric acid, while permitting the duty free importation for phosphate rock and sulphur or lower duties on manufactured solid P2O5 products such as MAP, DAP and TSP. The reasoning, of course, is not difficult to understand in countries with existing manufacturing facilities, since the local producer fears competition from the more economical large producer and transporter of phosphoric acid. However, in the interest of supplying agriculture with lower cost fertilizer products PFM believes that this attitude is a luxury which any nation can no longer afford.

Today the financial problem of obtaining capital for investment at attractive interest rates and to a lesser degree the availability of foreign exchange for the purchase of phosphoric acid seems to be a problem in some countries.

PFM believes that the correct approach to this problem is to encourage the developed countries who supply industrial development funds to the developing and underdeveloped countries to make these funds available for the purchase of the intermediate fertilizers raw materials anhydrous ammonium and phosphoric acid from other developing countries. This would permit two developing countries to utilize funds granted by developed countries for trade between themselves. In this way PFM believe that industrial development among developing countries would take place at a more rapid pace.

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