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ENERGY SAVINGS WITH THE JACOBS-DORRCO PHOSPHORIC ACID PROCESS

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I INTRODUCTION

Design of larger, more efficient phosphoric acid plants has evolved over the years with the availability of larger and larger equipment, primarily filters and pumps. Today Jacobs can offer single train plants approaching 2,000 STPD P_2O_5. A new single train Jacobs-Dorrco phosphoric acid plant with a guaranteed rate of 1,300 STPD was commissioned this summer. New features include two very large, slow RPM, rubber lined Warman pumps for vacuum cooler feed and the new Bird 30D filter with sloped bottom pans and a 30E preseparation type EX valve. The plant uses wet rock slurry feed, has a low level filter, and the reactor (constructed of membrane and brick lined concrete) is relatively small, providing both energy and capital cost savings.

We will describe this latest Jacobs-Dorrco installation and in addition discuss further energy savings available in the Jacobs-Dorrco process.

II JACOBS 1300 STPD PHOSPHORIC ACID PLANT

The 1300 STPD Phosphoric Acid Plant at Gardinier is a single train with one Jacobs/Dorrco annular single tank reactor and one Bird/Prayon 30D tilting pan filter. The plant is designed to operate with 65% slurry feed of wet ground Florida rock and 98% H_2SO_4 feed.

WET ROCK GRINDING

Most grinding systems in Central Florida are now wet, producing 65% to 69% solids which eliminates the considerable expense of drying rock. Jacobs experience in rock grinding systems in Florida which were conversions of dry mills feeding two Dorrco reactors at Agrico. At Gardinier, Central Florida pebble is wet ground in two 200 TPH KVS mills on an open circuit. Figure 1 is a view of one of the Gardinier mills showing the slurry tank and grits bin. The mill system is designed also to feed wet rock slurry to an older Prayon phosphoric acid plant now being converted from dry to wet rock. Both mills are KVS 15 Ft. (4.6M) diameter by 30 Ft. (9.15M) long overflow mills with rubber liners and 3750 HP motors. The mills overflow to small pump tanks from which the slurry is pumped to mill density tanks mounted on load cells where the solids content is continuously monitored and recorded. The

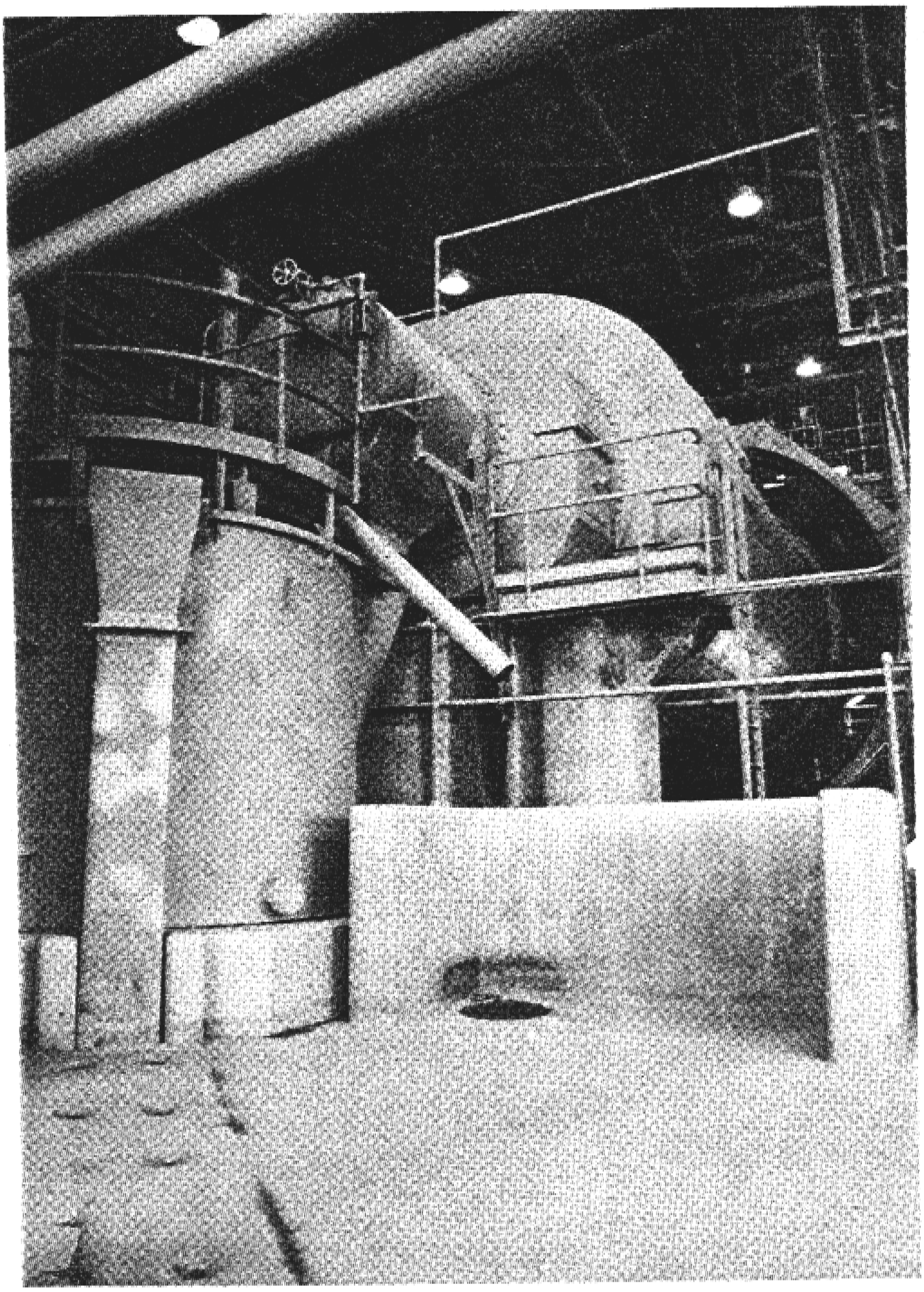


FIGURE 1

200 STPH KVS WET ROCK MILL

mill density tanks overflow to one hour surge tanks from which rock slurry at 67% solids with 4% plus 35 mesh is pumped over 800 Ft.(2.45M) to feed tanks near the phosphoric acid plant.

JACOBS-DORRCO SINGLE TANK REACTOR

Concrete Construction

The Jacobs-Dorrco single tank reactor shown at the left of Figure 2 is 65 foot (20M) diameter annular concrete tank 21 feet (6.4M) high with an 18 foot (5.5M) diameter center section. The reactor is constructed of concrete with a membrane and brick lining.

The first Dorrco plant with a concrete reactor shown in Figure 3 was built at the Coromandel plant in India.

The experience with the Dorrco concrete reactor at Coromandel, in continuous operation for over 14 years, has been superb with virtually no maintenance in all this time. The experience with rubber and brick lined steel reactors has been somewhat less satisfactory. We think it would be fair to say this about most steel catastrophic failures, although, in general, the problems begin to emerge seriously only after 10 or 12 years of operation as a result of lining aging, embrittlement, or softening, due to foam contact, and continual exposure to agitation vibration.

Repairs to aging reactors are not easy. Various corrective measures have included partial replacement with stainless steel. Two steel Dorrco reactors have been given a complete concrete encapsulation. Figure 4 shows the CFI Dorrco annular reactor in concrete at Zephyr Hills. The encapsulation of this reactor is described in Reference (1).

Flow Pattern

Fig. 5 shows the configuration of flows in the Jacobs-Dorrco reaction systems.

Rock slurry is pumped from the attack feed tanks and metered into the Jacobs-Dorrco reactor at up to three points. Sulfuric acid at 98% is metered through dilution tees at two points and fed into the reactor below the slurry level. Recycle slurry overflows the vacuum cooler seal tank, moves around the annular section, underflows to the center section and overflows to the small vacuum cooler feed pump sections. The vacuum cooler pump sections can be isolated from the reactor by stainless steel gates which are lowered to the wier to allow maintenance of either pump with the reactor in operation. Cooling is effected in two 19 foot (5.8M) diameter down flow vacuum coolers equipped with Nash vacuum pumps. The vacuum cooler feed pumps are Warman 550 TUL rubber lined slurry pumps shown in Figure 6 with waterless dynamic seal. These seals reduce dilution by 30 gpm or the equivalent of

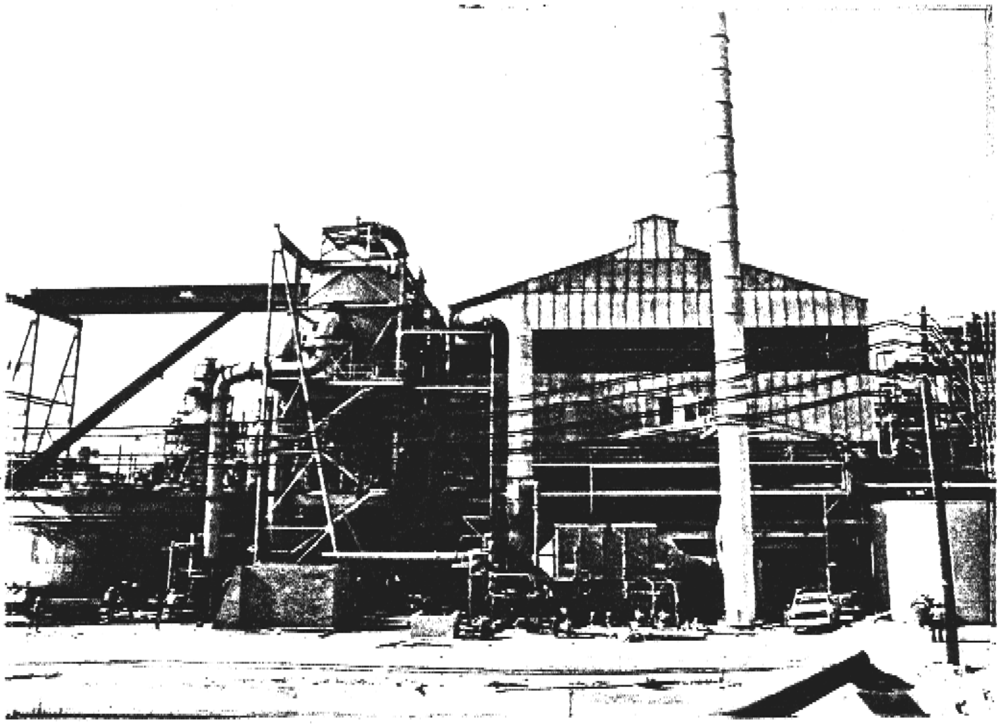


FIGURE 2

JACOBS-DORRCO 1300 STPD

PHOSPHORIC ACID PLANT UNDER CONSTRUCTION

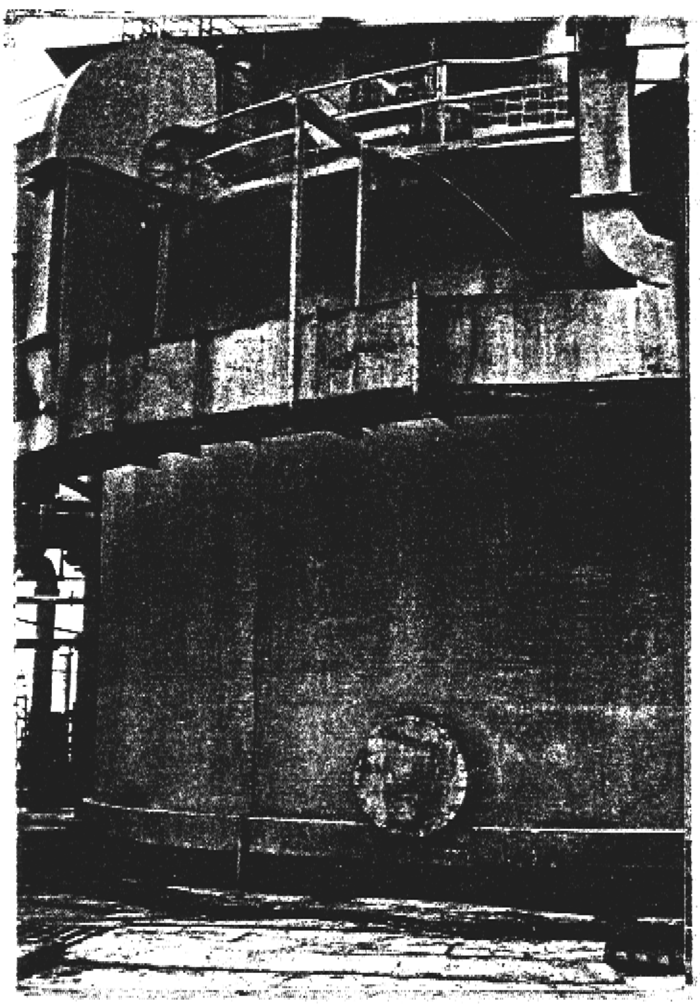


FIGURE 3

CONCRETE REACTOR AT COROMANDEL, INDIA

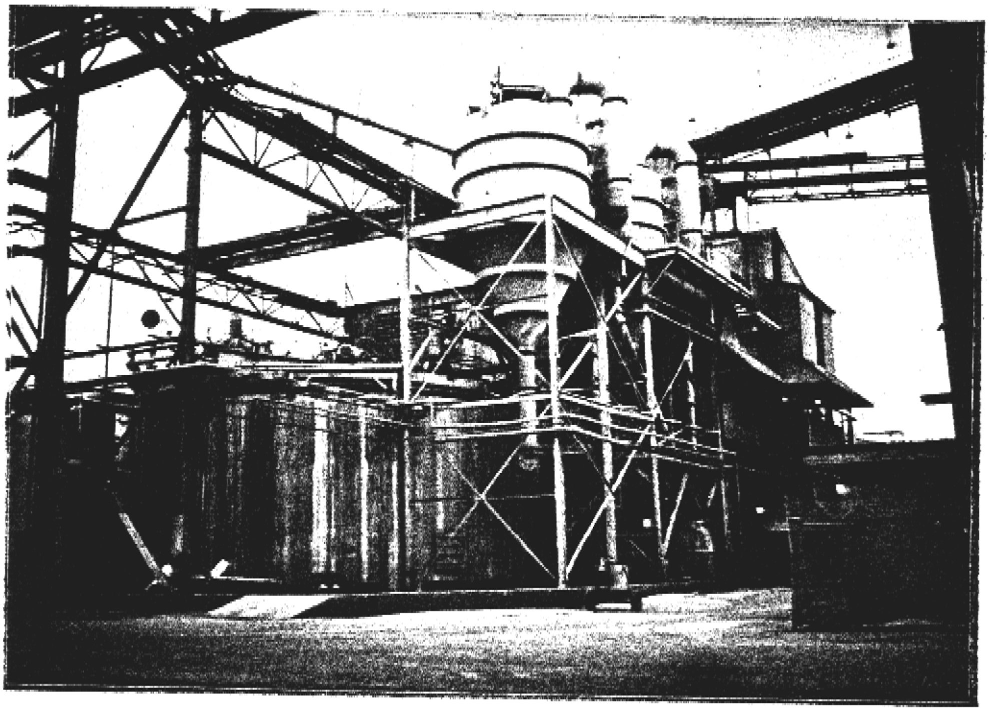


FIGURE 4

DORRCO CONCRETE ENCAPSULATED REACTOR

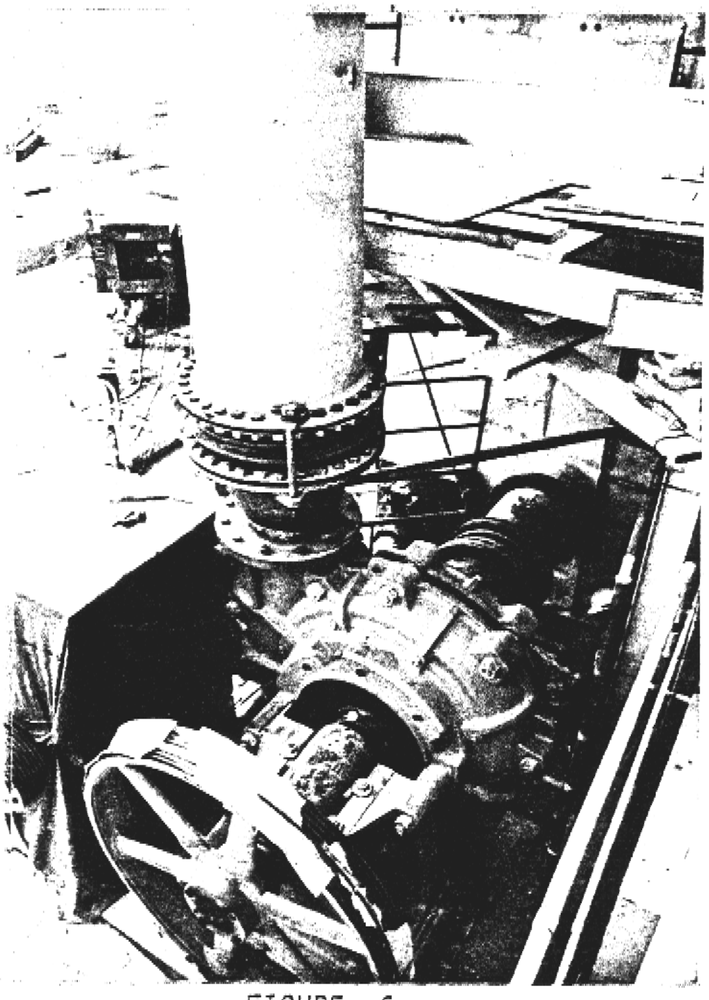


FIGURE 6

WARMAN DYNAMIC SEAL

VACUUM COOLER FEED PUMP

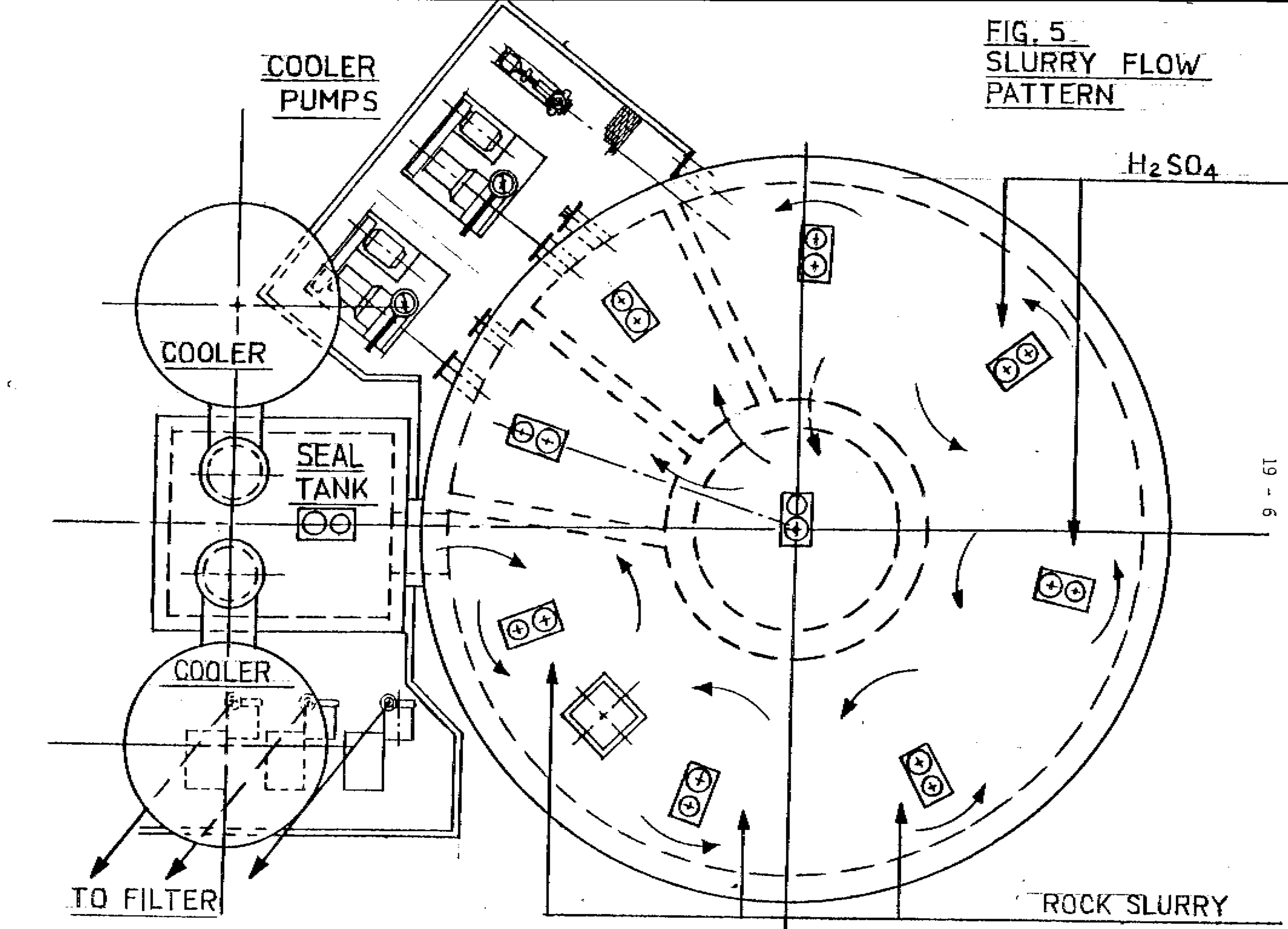


FIG. 5
SLURRY FLOW PATTERN

about $20,000 per year in evaporation steam, also making more pond water available for cake wash.

The cooler pumps take suction from the bottom of the reactor, avoiding siphon legs and are rated at 18,000 GPM ($4090M^3/H$) each. However, substantially larger quantities of recirculated slurry are provided to rock and acid addition points by back-mixing from each mixer to the next as shown by the flow pattern arrows in Fig. 5.

Reactor freeboard is easily controlled between 4 feet (1.2M) and 6 feet (1.8M) and adjustable to 8 feet (2.4M) by a minor built-in modification to accommodate future high organic rock. Flow patterns from the annulus to the center compartment to the vacuum cooler feed compartment are shown in Fig. 7.

The annular design of the Jacobs-Dorrco reactor has permitted normal operation at slurry detentions between 2.1 and 2.5 hours in at least three Dorrco reactors, with good recovery and filtration performance. We believe no other phosphoric acid reactors are routinely capable of operating at high efficiency at such low detention. Later in this paper we will cover potential energy savings in the Jacobs/Dorrco phosphoric acid system. However, a major cost saving any operator can make is to operate a reactor at capacities well above design. Based on the demonstrated Dorrco reactor's detention of 2.1 to 2.5 hours, the Gardinier reactor is potentially capable of 2,000 STPD of P_2O_5. This would, of course, reduce reactor energy expended by about 35%, on a per ton of P_2O_5 produced basis

An automatic Albright and Wilson sulfate analyzer is mounted on the vacuum cooler seal tank and monitors filter feed and recycle slurry percent sulfate on about a four minute cycle. A bubble tube density device monitors changes in density in the same tank.

Using the input of slurry density, the analyzer H_2SO_4 content, and adding a conventional density sensor on product acid, Jacobs can provide computer process control and data recording. Three filter feed pumps with one spare are A.S.H. Rubber lined centrifugal pumps with double mechanical seals and variable speed drives.

FILTRATION SYSTEM

The Bird/Prayon 30D filter is equipped with a new design EX preseparation valve sized for the 30E filter. The oversized valve allows better separation at high production rates, and the EX preseparation design makes it easier to provide a lower level filter installation with conventional barometric seal legs. Figure 8 shows a Bird/Prayon filter building with the filter at 56 feet next to the new filter building in which the filter is located at about 36 feet (11.0M) elevation. A previous Dorrco plant in the Philippines also provided a Bird filter at about the same elevation.

The EX valve shown in Figure 8 has two preseparation chambers in an annulus around the perimeter of filtrate bridge area which allow the air to disengage from the filtrates at the valve elevation rather than several feet lower as in conventional filters. In addition to the cloudy filtration section with its independent seal leg, prior to the product section, this value has an atmospheric dewatering drain between the cell dry and cloudy filtrate. This section will decrease dilution of product and plugging of the cell dry section.

Other features which will enhance filter performance at high rates, include heating of barometric condenser water with steam for cake and cloth wash, and dual distribution boxes for feed and all three washes. The use of new sloped bottom pans shown in Figure 10 allows for faster filtrate drainage and cycle times as low as 2.5 minutes compared to 3 minutes for the conventional 30D filter. The sloped bottom design also has much less tendency to scale and consequently better on-stream factors than the previous pan design.

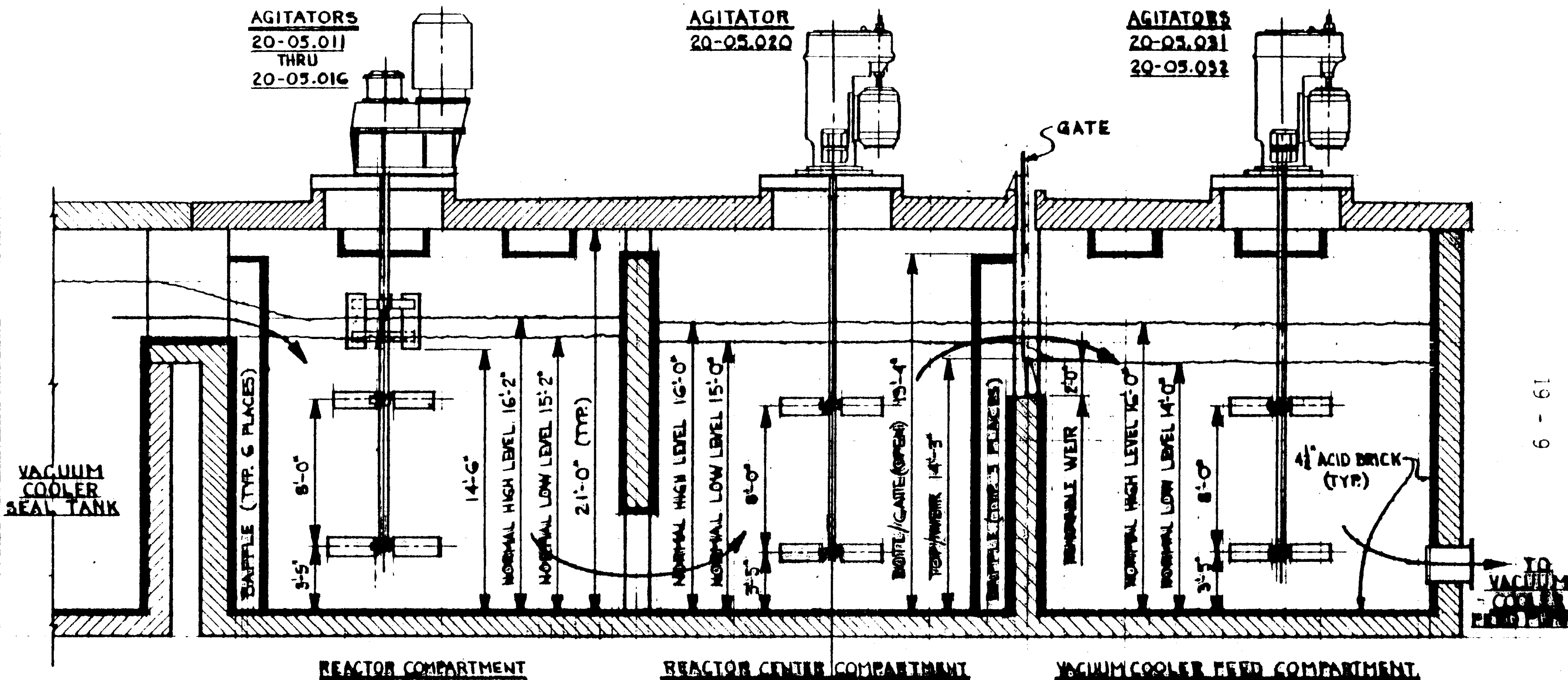


FIGURE 7

REV	HISTORY	BY	CK'D	DATE		BY	DATE		
					DESIGNED			JACOBS ENGINEERING GROUP INC.	JACOBS - DORRCO
					DRAWN	C.T.C.	5-17-82	LAKELAND FLORIDA	SINGLE TANK REACTOR PROFILE
					CHECKED				

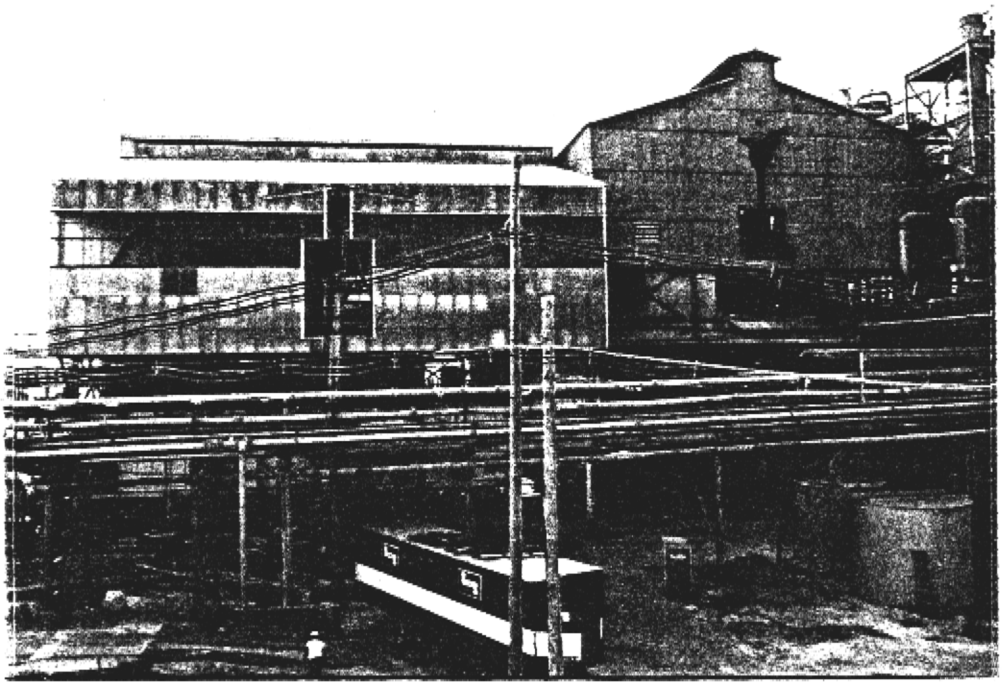


FIGURE 8

NEW LOW LEVEL FILTER BUILDING IS ON LEFT (DURING CONSTRUCTION)

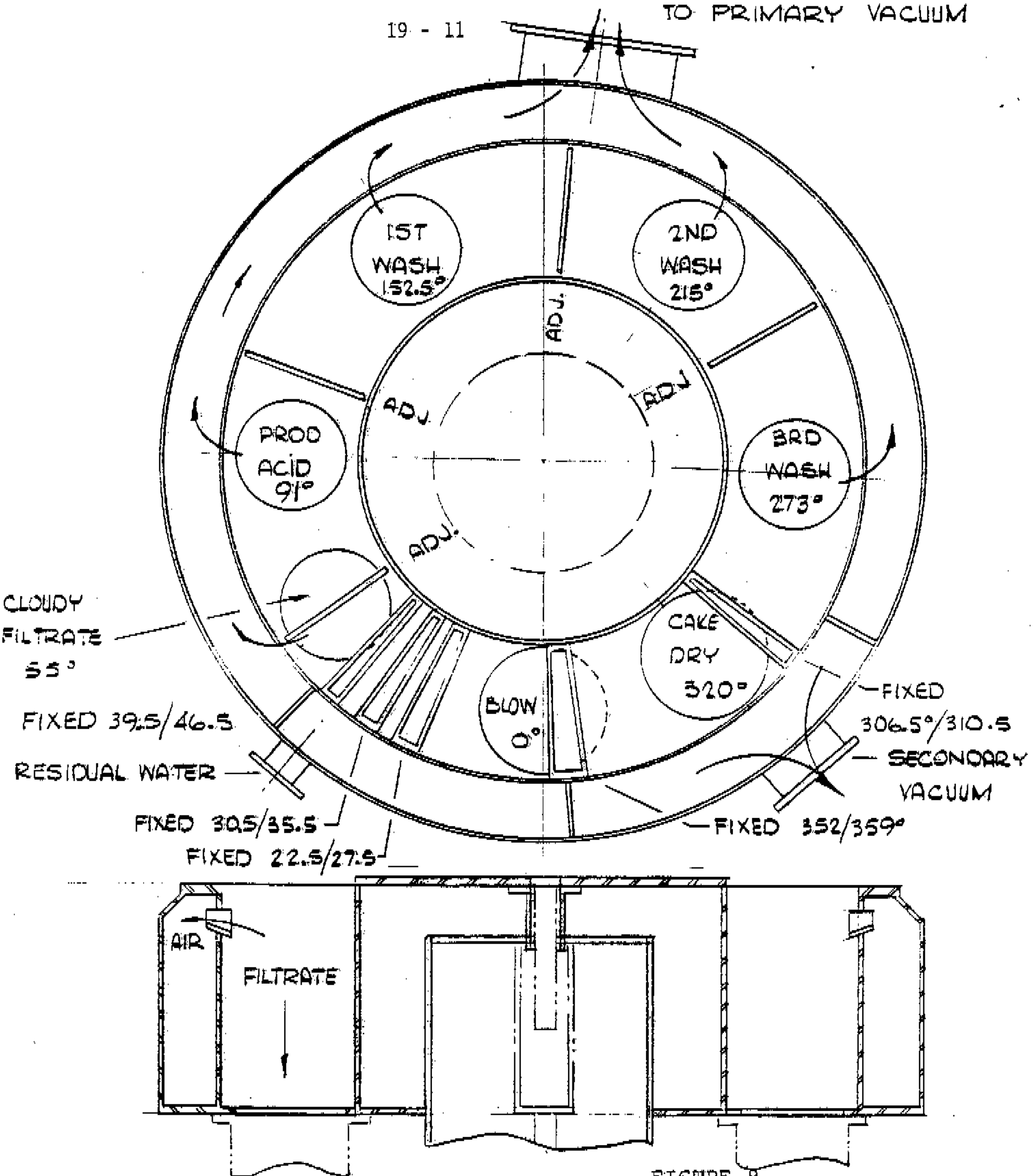


FIGURE 9

JACOBS ENGINEERING GROUP INC
BASIC RESOURCES DIVISION
LAKELAND, FLORIDA

BIRD FILTER
PRESEPARATION VALVE
PLAN - SECTION FIG. 9

SLOPED BOTTOM CELL

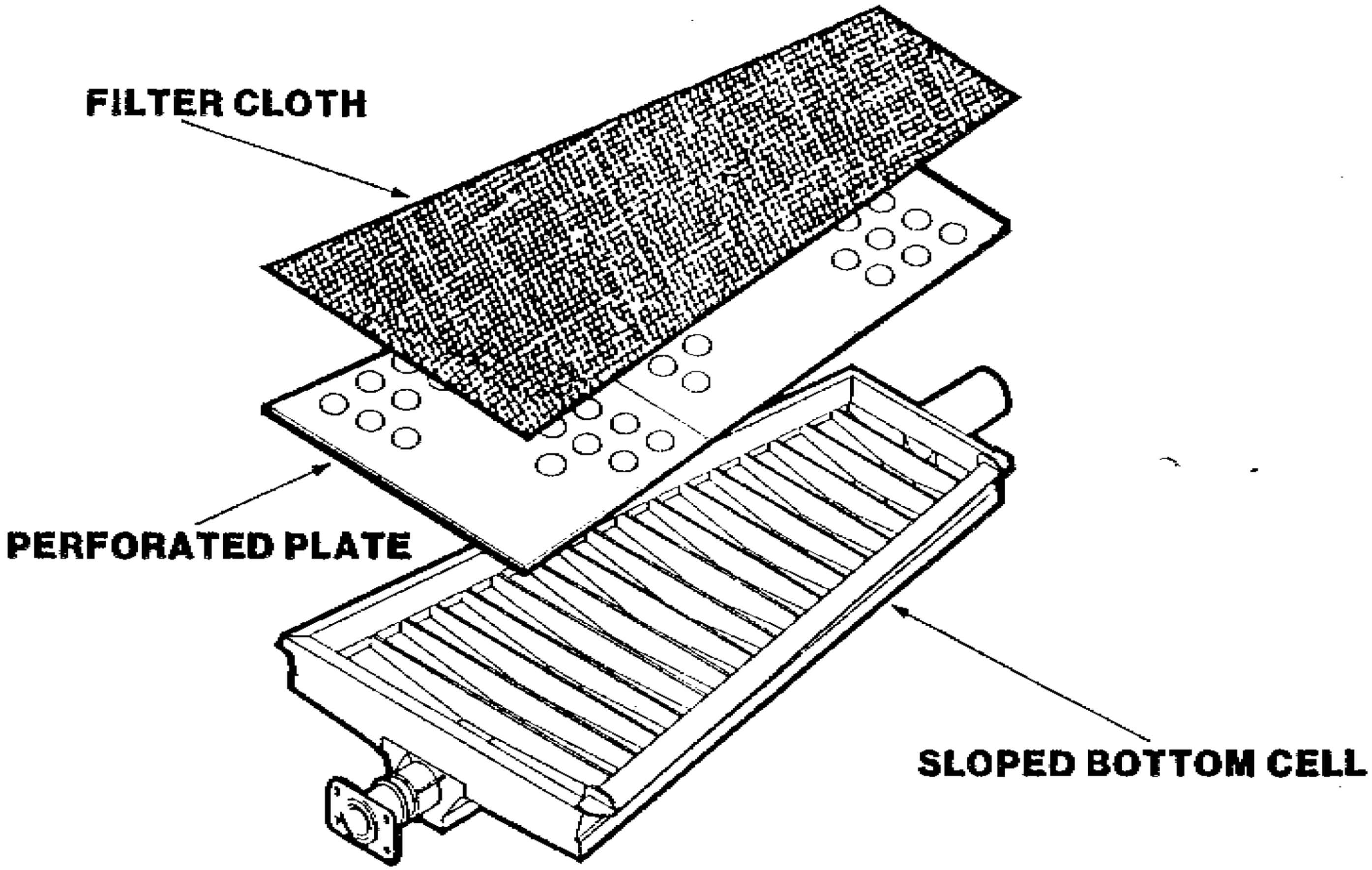


FIGURE 10

BIRD SLOPED BOTTOM PAN

III ENERGY SAVINGS IN THE JACOBS-DORRCO PROCESS

Energy savings now available in the Jacobs-Dorrco phosphoric acid process include, of course, the use of wet rock grinding as well as an innovative partial grinding circuit which can reduce grinding power even further. In the attack and filtration circuit of our conventional dihydrate plant many recent innovations will substantially reduce energy requirements even below those experienced on our new 1300 STPD plant. Among the improvements are low level vacuum coolers, lower power high flow agitator design, and a still lower filter elevation. The most substantial reduction in energy can be achieved by conversion of the modern Jacobs-Dorrco dihydrate plant to hemihydrate with filter acid at above 42% P_2O_5. Such a conversion can be accomplished with a minimum of additional equipment and virtually no down time. Economic considerations have convinced us that the single filtration hemihydrate process will dominate in the near future, given current rock, power, and capital cost trends. Although losses measured directly across the filter are higher than a hemihydrate two-stage process, a closed pond water system produces a recovery only slightly less than current dihydrate processes.

Table I is a summary of potential savings that can be considered in making phosphoric acid:

TABLE I

POTENTIAL ENERGY SAVINGS	$/Ton P_2O_5
Wet Rock vs Dry Rock	7 - 10
Rock Grinding	2 - 4
Agitation & Elevation Mods	1
High Yield Configuration	1 - 3
Hemihydrate	8 - 12

We'll touch on these briefly and what application each has to the Jacobs-Dorrco process.

WET ROCK VS DRY ROCK

Most Florida plants already practice wet rock grinding. The savings of power and fuel in drying the rock are by this time pretty well known and rather easily calculated in a specific case. Some of the problems which initially led to lower recoveries with wet rock have been pretty well worked out, largely by using three washes instead of two, to which many plants had gone, and by practicing adequate dilution and dispersion of sulfuric acid in the absence of sulfuric acid dilution cooling. The latter operation, practiced in many multi-compartment plants, has a rather substantial beneficial effect on gypsum formation and the tendency to form scale in the digestion and filtration system. Since high strength sulfuric acid is rather rapidly dispersed in the Jacobs system by means of several proprietary techniques, the Jacobs-Dorrco reactor has been particularly successful in handling wet rock slurries.

The proprietary features of sulfuric acid addition that permit the easy use of wet rock include:

(1) An annular reaction zone that avoids vortexing rock and sulfuric together, which causes excessive nucleation.

(2) An optimization of sulfuric acid dilution water vs. filter wash water.

(3) Substantial recirculation of slurry by both the cooler feed pumps and by agitation back-mixing in the annulus of the reactor, and

(4) The use of a new sulfuric acid-water mixing technique.

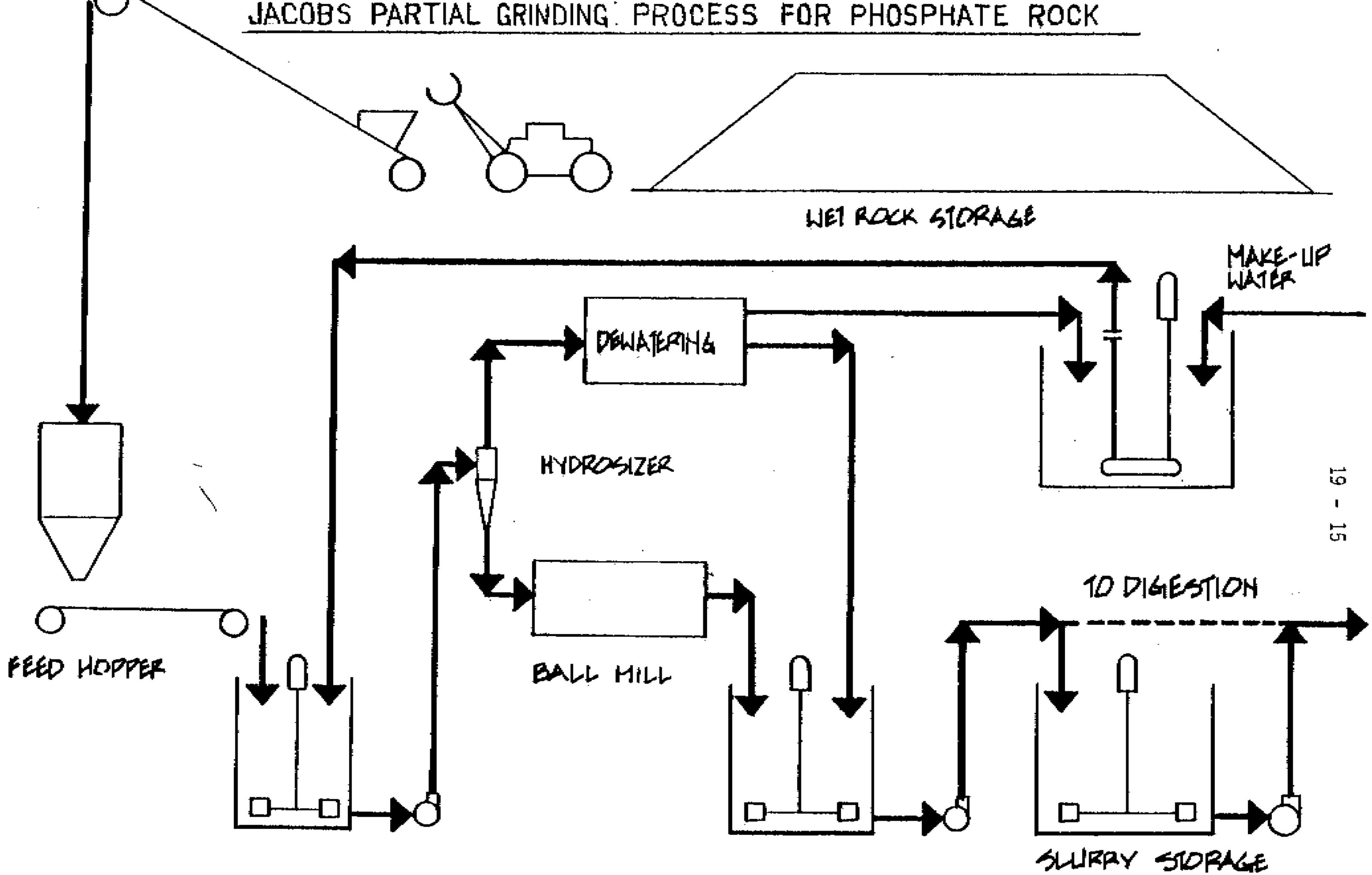
ROCK GRINDING SAVINGS

Some wet grinding circuits are now in operation with various types of classification so that the coarser particles are recycled to the mill. Classifying devices such as vibrating screens and cyclones are used in closed circuit grinding of Florida pebble. The separation is somewhat difficult because of the high viscosity ore sent with most ground pebble, but increases in capacity, hence reduction in power and capital requirements, of 10% or more are possible.

Florida Phosphate rock contains some coarse particles, which because of their shape factor, porosity or a combination thereof, tend to report to the cyclone overflow. We are surprised that no tests have been run using the 270° DSM screen on mill discharge for closed circuit operation. The DSM screen has been successfully used for 48 mesh separations of viscous cement mill kiln feeds, a similar application. In the past, in Florida, rock grinding systems have been concerned mostly with "pebble", a generally - 3/8" + 14 mesh size material. In the future more systems will need to process float concentrate or concentrate size material.

Figure 11 is a flowsheet depicting the Jacobs process for wet grinding of flotation concentrate prior to phosphoric acid digestion. In this process the rock is subjected to hydraulic classification ahead of the mill and a substantial fraction of the rock bypassed around the mills entirely. The fine unground hydrosizer overflow dewatered and the percent solids of the phosphoric acid feed is controlled by water trim to the mixture of ground coarse fraction as fine unground material. Jacobs has run phosphoric acid pilot plant tests on similar sized feed rocks with very low + 48 mesh, and 20% or more minus 200 mesh. The material appears to be nearly an ideal feed for phosphoric acid, resulting in very low insoluble losses and escellent gypsum formation.

JACOBS PARTIAL GRINDING PROCESS FOR PHOSPHATE ROCK



The ultimate integration of the beneficiation plant to produce suitable phosphoric acid feed is suggested here. Many of the newer Florida deposits are laced with MgO in their coarser pebble fractions and it appears that grinding of these materials for MgO removal may further contribute, in the future, to increased concentrate size material being available.

The flowsheet depicted in Figure 11 is also quite suitable for North African and Jordanian phosphate and, in fact, has the advantage of reducing viscosity of these slurry feeds which tend to be viscous in conventional wet grinding circuits. A typical particle size range, for the composite phosphoric acid feed produced from a partial grind of concentrate size material from Florida or North African rocks by the Jacobs process shown on Figure 12.

The split of what is ground and what is bypassed depends on the phosphoric acid process and the rock grind required, the particle size of the feed to classification, and the P_2O_5 recovery sought in the acid plant.

The Jacobs concentrate grinding process can save from 25% to 75% of the normal cost of concentrate grinding, up to \$3/ST P_2O_5. Where the preclassification takes, for example, 50% or more of the rock through grinding then performance in terms of yield, digestion volume required, etc., in the Jacobs phosphoric reaction and filtration system would be expected to be as good or possibly even better than the normal use of totally ground rock. Where only a small fraction is ground, grinding costs are low, but some efficiency may be lost in digestion and filtration.

USE OF COARSE UNGROUND ROCK

Dorrco annular reactors, without special features or significant modifications have successfully treated North Florida, Senegal, and Togo rock, unground, spanning the range of 10% to 30% plus 35 mesh.

However, process control and capacity can be substantially improved and increased when treating unground, coarse rock by using a reactor configuration as shown in Figure 13.

A rather extensive discussion of the operation of the Jacobs reactor on coarse, unground, rocks was covered in a previous ISMA paper. That paper listed screen analyses of many concentrate size phosphates (essentially minus 20 mesh plus 150) which would be suitable for this type of operation.

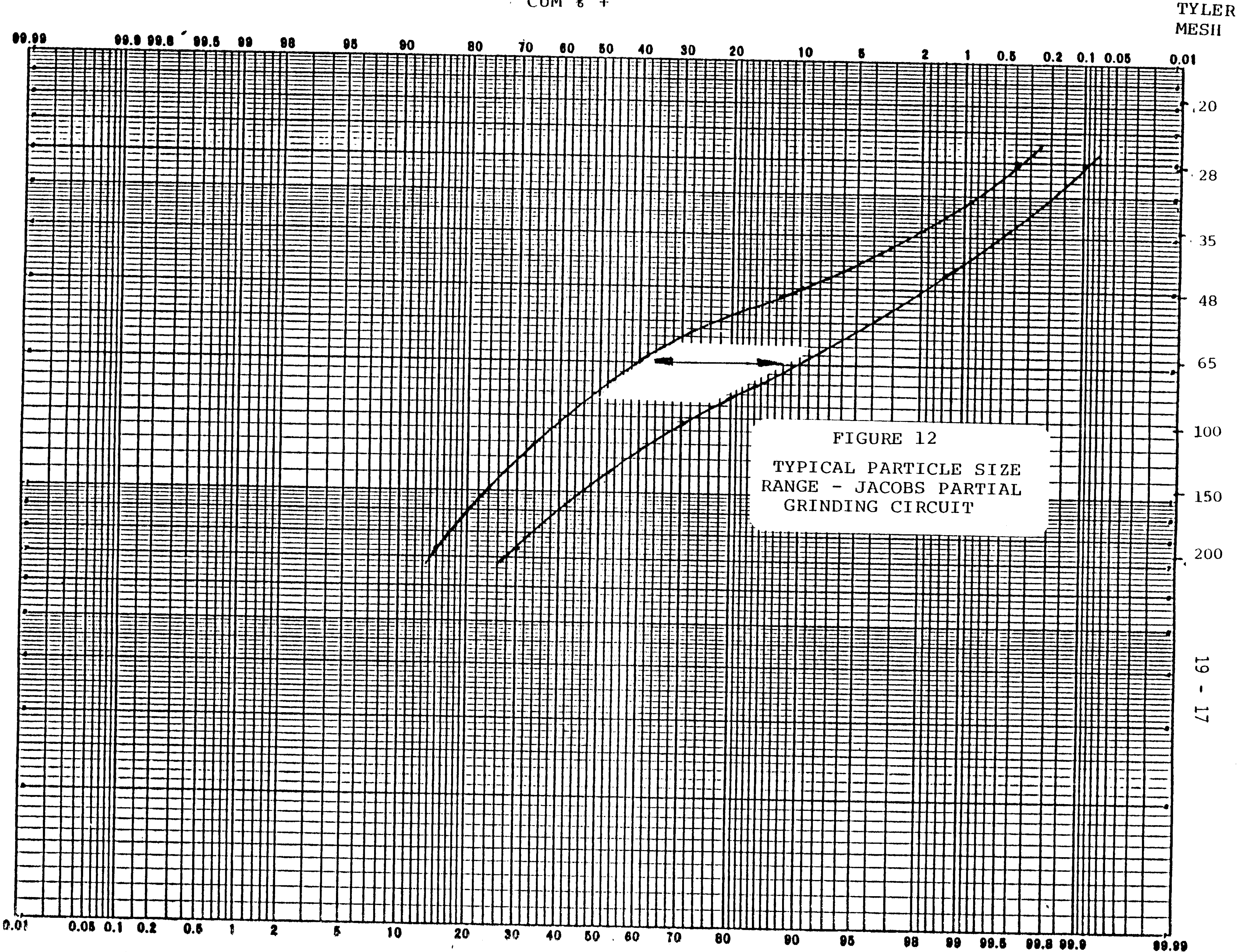


FIGURE 12

TYPICAL PARTICLE SIZE RANGE - JACOBS PARTIAL GRINDING CIRCUIT

The bulk of reaction volume is used to digest coarse rock at an optimum sulfate level; this is as high as possible to minimize solid solution loss and to minimize poorly filterable gypsum but low enough to prevent rock coating. A second stage sulfate adjustment to provide optimum filtration is accomplished by further sulfuric addition to the vacuum cooler feed compartment. In the system shown here the sulfate levels in the two zones may be varied by anything from zero to as much as 1.0% or more depending on particle size and reactivity of the rock. The first rock digestion zone may be maintained, for example, at 2.0 $\pm$ 0.2% total SO_4 and the second zone maintained at 2.5 $\pm$ 0.2% total SO_4.

If concentrate size (essentially minus 20 mesh) rock is available, the use of unground rock would save $3 to $4 per ton of rock, (3) plus improve the water balance vs. ground rock slurry. Jacobs phosphoric acid pilot plant facilities are available for testing this mode of operation.

AGITATION AND ELEVATION SAVINGS

High flow agitation is the substitution of air foil or 32° pitch impellors for 45° pitched blades or straight bladed turbines. Several agitator vendors currently offer variations and we in the phosphate industry are seeing the introduction this "high flow" type agitation. Horsepower savings are 30% to 50% or more for equal flow volumes, but particle shear is greatly reduced.

Most new phosphoric acid plants are being built with equipment at lower elevations than in the past. Savings are 400 to 500 HP in pump HP a 1300 STPD plant for low level flash coolers. The low level coolers have been around a while, but and still now it's getting too expensive to put coolers at 50 feet ations have elevation (15M). We use a pump feeding the cooler rather than one on the down leg. We believe this makes the layout better, has most of the power savings. Several Dorrco reactor install low level coolers.

The filters are also coming down. This does not, per se, reduce energy, but at the same time we are reducing filter vacuum pump power and reducing the design vacuum. If a process upset occurs, there are methods other than relying on high vacuum to remedy the situation. Also it is documented in a number of situations that reducingvacuum results in less valve, receiver and downleg scaling.

Taking advantage of high flow agitation, low equipment elevations, and such things as electric vacuum pumps, and reused water, the total power required in the Jacobs-Dorrco reaction and filtration system is about 45 KWH/ST P_2O_5 for the latest, most energy efficient, design. This is about 12 to 15 KWH per short ton P_2O_5, or 60 cents at 4 cent power, less than the previous Jacobs design; including capital savings associated with the lower level coolers and filter, let us say about $1.00/T P_2O_5. Even the draft tube type reactors would save only 5 to 8 additional KWH/ST P_2O_5 at the expense of certain process flexibility.

As described previously in this paper, the Jacobs-Dorrco reactor has been demonstrated to be capable of operating at relatively low detentions without fine grinding or significant loss of efficiency. To illustrate the impact of this let us assume a Jacobs-Dorrco plant is built with 4.0 hours detention at 1300 STPD but then is expanded to 2000 STPD by increasing feed rates and reducing detention. With additional cooling and filtration at 2000 TPD the following energy comparison can be made:

P_2O_5, STPD	1300	2000
Slurry, Detention, Hours	4.0	2.5
Reaction & Cooling, KWH/T P_2O_5	32	23
Filtration KWH/T	12	12
TOTAL KWH/T	48.0	37.5

The above illustration is, we are sure, the same senario played in previous years in phosphoric acid production. Slurry detentions have been steadily going down and the volume required by the reactor is a major factor in terms of energy used.

HIGH YIELD CONFIGURATION

By the addition of a separate filter feed tank, with from 30 to 60 minutes detention, it is possible to operate a high yield configuration in which digestion in the main volume of the reactor takes place at a high sulfate level. The slurry then going to filtration is treated with about 5% of total rock feed to desulfate the acid prior to filtration. Figure 14 shows the setup required to add this mode to the Jacobs-Dorrco phosphoric acid plant. The filter feed tank is operated at constant level for proper reaction conditions, by recycling a small portion of slurry back to the annulus.

The process was first indicated in 1965 in a description of the Dorrco reactors at Agrico, South Pierce, Florida.(4) More recently another similar process is described in Reference (5).

A typical set of conditions in the Jacobs system, would operate the annular reaction zone at perhaps 3.5% to 4.0% H_2SO_4. Samples for sulfate control of the annulus would be taken from the vacuum cooler seal tank. Additional rock is added to the filter feed tank, where a relatively low sulfate is carried, for instance in the range of 1.5% to 2.0% or less. This lower sulfate insures rapid attack of the rock added at this point. But since most of the gypsum is precipitated at the higher sulfate level, solid solution losses can be very low, about 2% of the P_2O_5 fed or lower, and over all yields across the filter, in the range of 96.5% to 97.5% are possible, compared to 95.5% to 96.5% for the single sulfate level mode. The process requires relatively fine rock, especially low in the 28,35 and 48 mesh fractions. Something in the range of 1% to 4% plus 35 mesh is required. The use of wet rock slurry feed makes it easy to run a rock line to the filter feed vessel. However, the water in the rock slurry prevents any increase in acid strength that otherwise would occur with this process.

We should note here that there has been recent interest in this mode due to efforts to maximize yield during periods of low production. Jacobs phosphoric acid pilot plant facilities are available for testing this mode of operation.

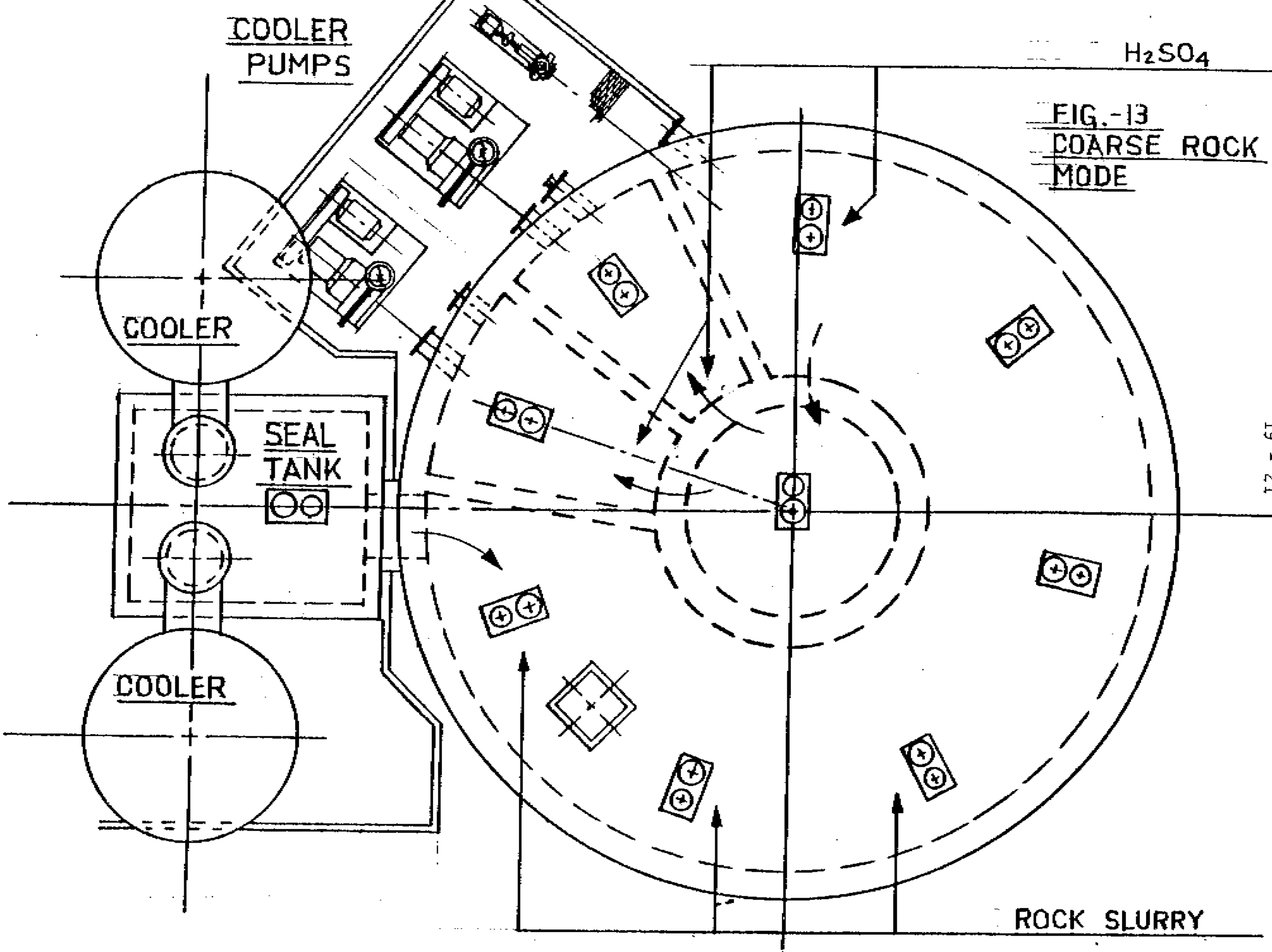


FIG.-13
COARSE ROCK
MODE

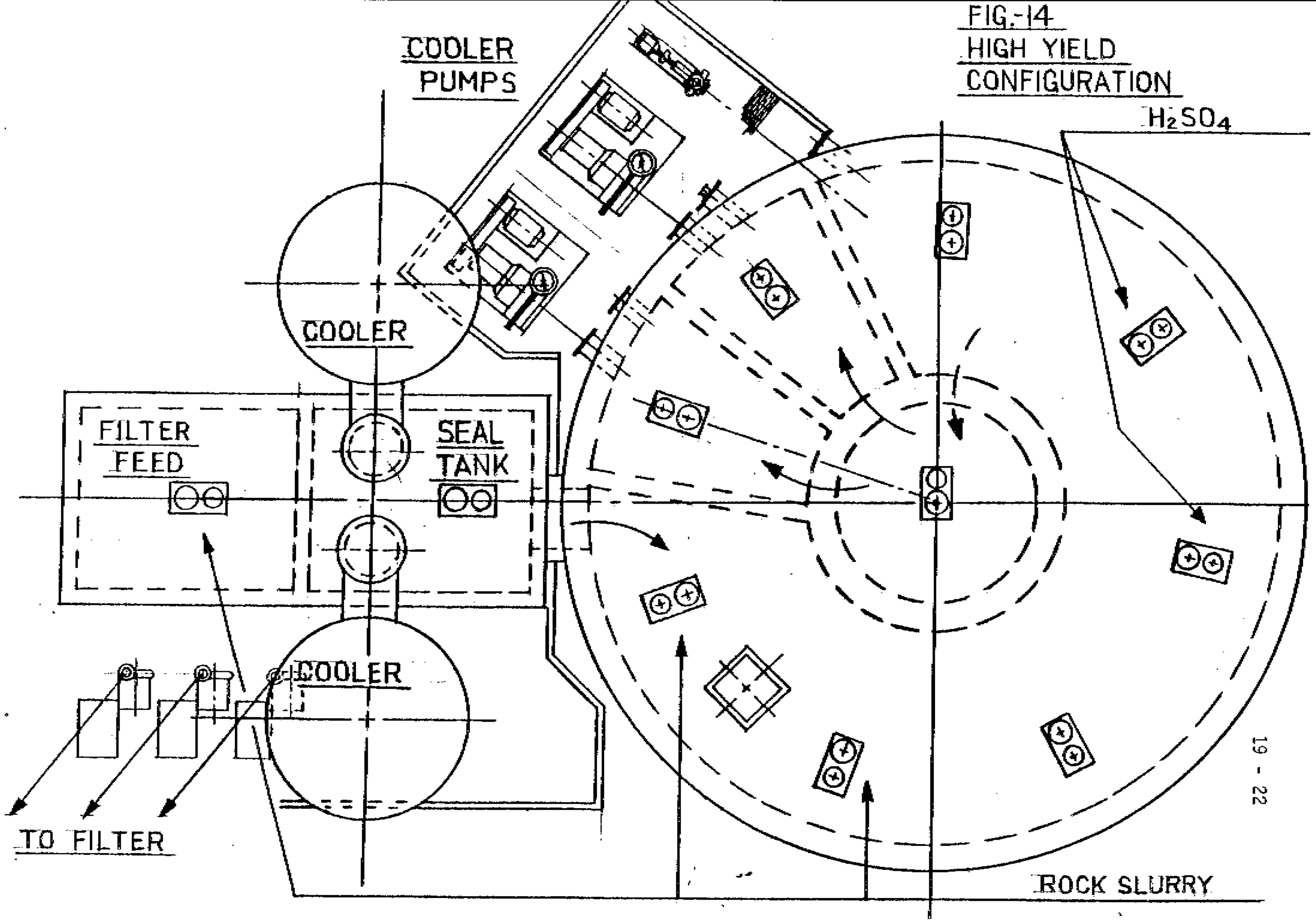


FIG.-14
HIGH YIELD
CONFIGURATION

HEMIHYDRATE OPERATION

Referring back again to table 1, the largest potential saving to phosphoric acid producers occurs with conversion to higher strength acid. This basically results from power which can be generated from the steam not used for evaporation.

Table 2 summarizes a recent capital cost comparison done by Jacobs for 68 BPL Florida Rock. For some other phosphates not so filterable as dihydrate the costs for the dihydrate plant would be higher reflecting more filtration area.

Table 3 is a simplified sample calculation for operating costs comparing single stage hemihydrate with dihydrate and two stage hemi with a filter for handling recrystallized gypsum. The numbers are based on recoveries of 94%, 96% and 98% of P_2O_5 fed respectively for single stage hemihydrate, gypsum, and two stage hemihydrate.

In order to get to the \$12 value of our range of \$8 to \$12/short ton P_2O_5, by our figures, a rock price of about \$60/T is required, which is the case in areas remote from the rock source, and the two stage hemi process is required. However, the range of \$8 to \$12 benefit is reported to be the experience of at least one current hemi operator, using only a single stage process.

Jacobs reaction system normally used for dihydrate can be designed to operate in the single stage hemihydrate mode. Such an arrangement is shown in Figure 15. The annulus is used as the rock digestion zone and sulfuric acid is added in the second stage made up of the cooler feed compartment, coolers (low level), and cooler seal tank. In the hemi mode recirculation of slurry is controlled to make a high sulfate zone and a low sulfate zone. Unground concentrate at 15% moisture is suitable. Wet ground pebble would require a dewatering by centrifuge.

Commercial experience with many different phosphates is lacking on hemihydrate, but contrary to some past opinion, hemihydrate crystal formation seems to be rather uniform in type despite wide differences in rock source. In all cases we have observed, the hemi crystal appears to be a rather uniformly sized cluster or raspberry configuration. Hemi crystals from Kola and Florida rock are pictured in Reference (6). In contrast, dihydrate processes make a wide variety of crystalline forms from raspberries to rhombic crystals, including twinned individual crystals.

The trend to hemihydrate process is favored by:

(1) Rising rock and energy costs.

(2) Improved operating factors in existing hemi plants. Two current single stage hemi plants report operating factors comparable to well run dihydrate plants.

(3) Better mechanical solutions to filtration scaling and plugging problems, through improved filters and a bettter understanding of the problems.

(4) Stable acid is formed with low post-precipitation, and lower impurities than produced by dihydrate.

The single stage hemi process also seems to be potentially capable of better recovery than previously reported. In Florida, and the U.S.A., and in most areas of the world, a closed water system is required. The pond is therefore the second stage separator, and a substantial portion of the P_2O_5 liberated in recrystallization prior to pond settling can be recovered. This can increase the yield of a single stagge hemi process by 2% of the P_2O_5 feed. Since the pond water in such an operation can build up to a level perhaps 2% P_2O_5 higher than current pond concentrations, a half displacement fresh water wash on the filter, prior to cake dry could increase P_2O_5 recovery significantly.

We believe there will be continued interest in both retrofits and new plants as hemi technology becomes accepted.

FIG.-15
HEMI-HYDRATE MODE

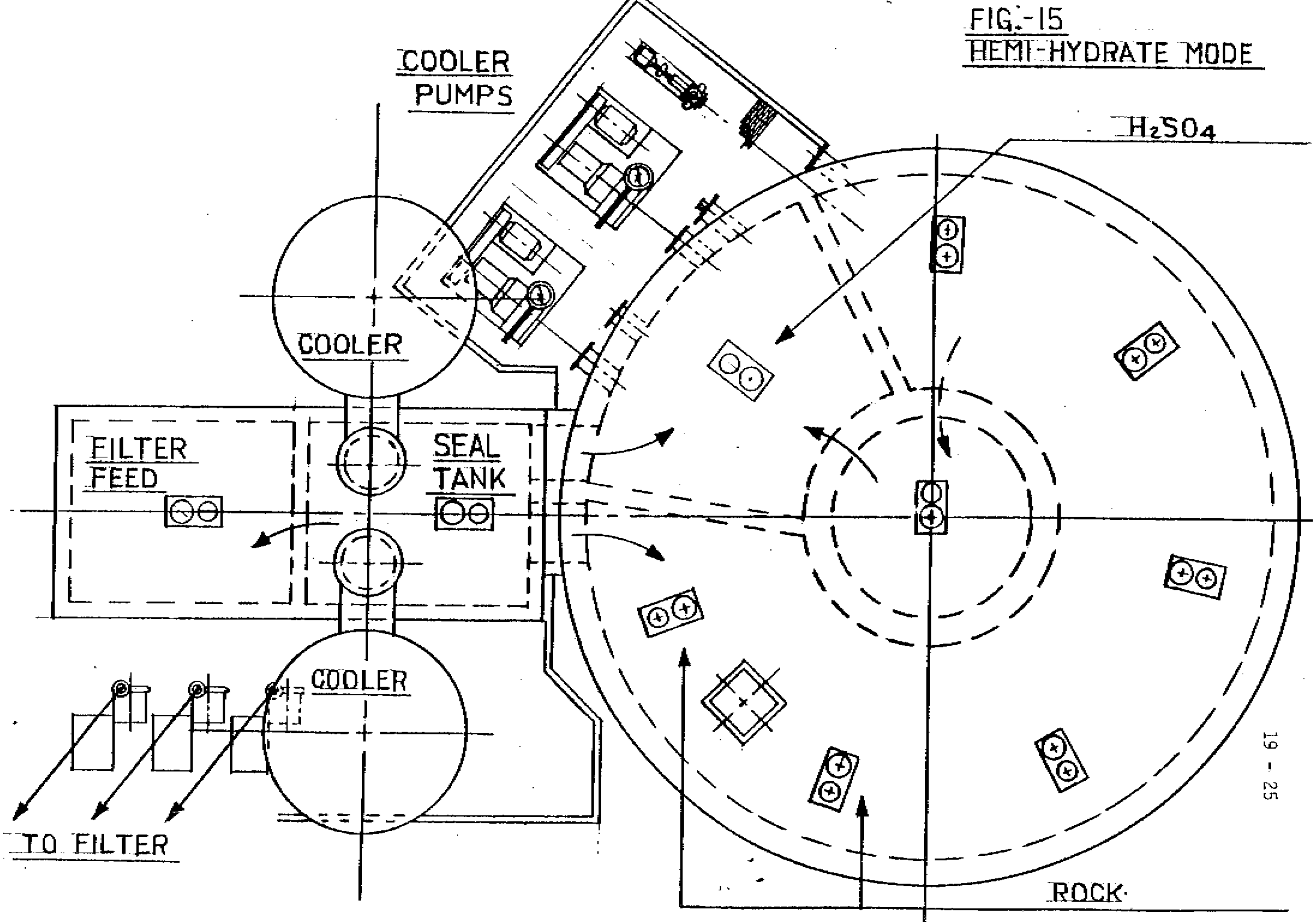


TABLE 2

ECONOMIC COMPARISON

DIHYDRATE VS HEMIHYDRATE

CAPITAL COST COMPARISON

MILLION $ (U.S.) (1982)

	DIHYDRATE	HEMIHYDRATE SINGLE FILTRATION	HEMIHYDRATE DOUBLE FILTRATION
Attack and Filtration	18.5	25.5	38.25
Evaporation (54% P_2O_5)	11.0	3.0	3.0
Clarification and Storage	5.0	4.0	4.0
TOTAL	34.5	32.5	45.25

TABLE 3

OPERATING COST

HEMIHYDRATE VS DIHYDRATE

1,300 STPD P_2O_5

408,000 STPY

	DIHYDRATE			HEMIHYDRATE SINGLE FILTRATION			HEMIHYDRATE DOUBLE FILTRATION		
	UNIT CONS.	UNIT COST $/TON	ANNUAL $ M	UNIT CONS.	UNIT COST $/TON	ANNUAL $ M	UNIT CONS.	UNIT COST $/TON	ANNUAL $ M
Dep.,Ins, Txs		6.76	2,760		6.37	2,600		8.87	3,620
Rock @ $35 Di- $34.50 Hemi 31% P_2O_5	3.36	117.50	47,981	3.43	118.34	48,281	3.29	113.51	46,310
Sulfuric Acid @ $60	2.74	164.40	67,075	2.70	162.00	66,096	2.67	160.20	65,362
($10.25) Steam Credit		(28.09)	(11,461)		(27.68)	(11,293)		(27.37)	(11,167)
Labor		1.62	660		1.62	660		1.94	790
Maintenance		5.58	2,275		6.37	2,600		8.87	3,620
Reagents		2.00	816		3.00	1,224		3.00	1,224
Power @ 4.5¢/kwh	90	4.05	1,652	70	3.15	1,285	95	4.28	1,746
Steam @ $5.01/st	2.25	11.27	4,598	.70	3.51	1,432	.70	3.51	1,432
TOTAL		285.19	116,356		276.68	112,885		276.81	112,937
Difference (Di vs Hemi)					(8.51)	(3,472)		(8.38)	(3,419)

DIHYDRATE ROCK @ $35/STON

HEMIHYDRATE ROCK @ $34.50/STON (unground)

TABLE 4

STEAM VALUE CALCULATION

Assume No Fuel Requirement

Steam extracted at 50 PSIA

or condensed at 2" Hg Absolute

2000 (1174-910) = 528,000 Btu/ton

$$\frac{528{,}000 \text{ Btu/ton}}{3{,}413 \text{ Btu/kwh}} \times .72 = 111.4 \text{ kwh/t}$$

111.4 kwh/t x $.045 = $5.01/ton

Assume All Steam Condensed

2000 (1450-910) = 1,080,000 Btu/ton

$$\frac{1{,}080{,}000}{3{,}413} \times .72 = 227.8 \text{ kwh/ton}$$

$.045/kwh x 227.8 kwh/ton = $10.25/ton

TABLE 5

TURBINE GENERATOR

POWER CALCULATION

DIHYDRATE

To Phos-Acid	244,000 lb/hr (1450-1174)	=	67,344,000 Btu/hr
To Condenser	112,000 lb/hr (1450-910)	=	60,480,000
			127,824,000 Btu/hr

$$\frac{127{,}824{,}000 \text{ Btu/hr}}{3{,}413 \text{ Btu/hr}} \times .72 = 27.0 \text{ MW}$$

HEMIHYDRATE

To Phos-Acid	76,000 lb/hr (1450-1174)	=	20,976,000 Btu/hr
To Condenser	275,000 lb/hr (1450-910)	=	148,500,000
			169,476,000 Btu/hr

$$\frac{169{,}476{,}000 \text{ Btu/hr}}{3{,}413 \text{ Btu/kwh}} \times .72 = 35.8 \text{ MW}$$

	DIHYDRATE	HEMIHYDRATE
Total Power Available, MW	27.0	35.8
Power For H_2SO_4, MW	10.5	10.5
Power For Export, MW	16.5	25.3

REFERENCES

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3) "Recent Performance and Innovations in Dorrco Process Phosphoric Acid Plants"
D. W. Leyshon,
ISMA, October 1978 - Orlando, Florida

4) "Manufacture of Phosphoric Acid from A.A.C. Black Rock Using the Dorr-Oliver Single Tank Reactor"
J. G. Kronseder, R. L. Kulp, D. W. Leyshon, and A. Jaeggi
Fertilizer Industry Round Table, 1965, Washington, D.C.

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C. Djololian
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(6) "Dorr-Oliver HYS Phosphoric Acid Process"
W. C. Weber, E. J. Robers, I. S. Mangat, and E. Uusitalo
Fertilizer Society, December 1969

TA/82/19 Energy savings with the Jacobs-Dorrco phosphoric acid process, by P.S. WATERS, D.W. LEYSHON, Jacobs Engineering Group Inc., USA

DISCUSSION : (Verbatim report of the tape recording)

Q - Mr. T.A. WILLIAMS, Albright & Wilson, United Kingdom

Your paper refers to an on-line sulphate analyzer. In your opinion, how significant is on line analysis to the performance of existing dihydrate and hemihydrate plants and to the future application of computer control to phosphoric acid plants?

A - We feel that an on-line analyzer will enhance the operation of phosphoric acid plants. As we say in the paper, with that and only a few more items of intrumentation, it will be quite possible to provide a plant with computer control, the other items being the density of N° 1 filtrate and the density of the reactor systems.

Q - Mr. M. BEHAR, Israel Mining Industries, R & D Centre, Israel

The question refers to high yield configuration. Does this operation with fine phosphate rock addition in the filter feed tank affect the filtration rate? If not, down to what SO_4 level can you operate with a good filtration rate?

What are the corresponding solubilities of calcium ions?

A - The filtration rates have not generally been affected by a small addition of rock to the filter feed tank due to the very small amount added. The sulphate levels are lower than in the rest of the slurry.
Ca^{++} solubilities have been found to follow the standard curves for SO_4 and Ca^{++} solubility product constants.

Q - Mr. A. NICOTRA, ANIC SpA, Italy

Did you have any trouble of slurry losses in the connection of the bottom succion pump tube with the concrete walls?

A - No, we had no problem with that connection. With bottom succion we don't have the problems that the top type centrifugal pumps had in the past.

Q - Mr. E. UUSITALO, Kemira Oy, Finland

In your paper, on page 13, you say "the most substantial reduction in energy can be achieved by conversion of the dihydrate plant to hemihydrate":

1. With what rock phosphate the conversion is possible?
2. How does the plant capacity vary when changed from dihydrate to hemihydrate?
3. Have you realized in practice the conversion from dihydrate to hemihydrate?
4. What order of energy savings could you get in conversion from dihydrate to hemi-process?

A - 1. There would be a wide range of rocks that would be possible for that conversion. Hemihydrate processes work on many different types of rocks, Kola or Morocco rocks. Each individual rock will have to be evaluated with the economics.

2. We feel that with the proper modifications the change in capacities will be nominal. There are obviously some changes in filtration rates from Florida dihydrate to most of the hemihydrates that will have to be taken into account in any modification that is made.

3. No. We have not yet done that conversion.

4. Our number shows that a saving of the order of US $ 8-12/t P_2O_5 could be possible with the conversion from the dihydrate to the hemihydrate. Probably you are on the lower end of the 8 to 12 with current rock and power costs. Those numbers are of course very sensitive to where you are evaluating it. With rock at 60-70 $ t these numbers would be changed drastically from the 35 $/t we used for our analysis. As power changes and steam changes you also get quite a bit of change in the ranking of the numbers. One of the big changes would be if you have heat use for the excess steam rather than being required to drop it across the turbine. You loose about 1/3 of the heat as you drop it across the turbine and condense it whereas if you could use it in another process on the complex as heat, rather than a 5 $ credit I showed in my paper, you could achieve as high as 13 $ or more for the steam.

Q - Mr. J. ENRIQUEZ, Davy McKee Corporation, USA

You mention that the Gardinier 1300 t/d P_2O_5 plant was commissioned during the summer. Can you give data on length of operation, rates and recoveries obtained?

A - The plant was started in early September and was operated above design rate after 11 days. During a two week period at above design rate recovery averaged more than 96% of P_2O_5 fed with product acid of 29% P_2O_5.