"TEXASGULF'S LEE CREEK PHOSPHATE EXPANSION"

(focusing on the upgrading of four existing Phosphoric plants)

by

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INTRODUCTION

Expansion is a "by-word" in the phosphate business, but two things invariably hold true: (1) Increased production hits the market at the same time; and (2) Methods of increasing production are many and varied. There are almost as many ways of expanding capacity as there are phosphate producers. Expanding in different ways or employing alternative means to an end is not necessarily "reinventing the wheel", since we all have unique processes. Numerous process variances are required by each producer, and each is tailored to their rock and output maximization with that rock.

North Carolina rock is particularly unique and our phosphate complex at Lee Creek, near Aurora, North Carolina, has developed over the past decade and a half from mining through shipment to take advantage of our rock's properties. In the early 1960's calcination was chosen over grinding, drying, and attack defoaming because of the high organic and carbonate content of our rock (total carbon of about 3%). Reactivity is another rock property that prompted us to modify attack and filtration process equipment. North Carolina rock is more reactive than Florida rock, in our opinion, due to sizing (specific surface), preheat time, relative carbon and fluorine content. Comparisons of sulfate profiles and citrate insoluble losses in reaction systems also indicate that North Carolina rock reactivity is higher than Florida rock.

Rock reactivity means different things to many people, but to us it was another way of saying retention time. The two main areas that adversely affect production are: (1) Rates; and (2) Operating Factors. Both areas were scrutinized using attack/filtration operating logs which in addition to rates and control parameters pointed out downtime due to external and internal reasons. External downtime causes included deficient evaporation capacity and shortages in sulphuric acid, rock or steam. Internal reasons included scheduled and unscheduled maintenance or operational downtime. A similar analysis was done in the other phosphoric areas (evaporation and tank farm), the four sulfuric plants, and the three water treatment plants.

In general, these evaluations pointed out the following deficiencies with respect to phosphoric production:

1. INPUT DEFICIENCIES

   a. Sulfuric Acid
   b. Steam
   c. Rock

2. INTERNAL DEFICIENCIES

- a. Reaction
  - (1) Cooling
  - (2) Agitation
- b. Filtration
- c. Evaporation
- d. Ponds
  - (1) Gypsum
  - (2) Cooling

3. OUTPUT DEFICIENCIES

- a. Tank Farm
- b. Transfer Capacity

The results of these evaluations projected the scope and extent of our expansion which is dealt with in this paper in a process flow format.

SULFURIC

Our existing four sulfuric plants at Lee Creek have a combined designed capacity of 6100 TPD of 93% H_2SO_4. The first two plants were put in line in 1966, a third in January of 1974 and a fourth in September of 1975.

Three water treatment plants supply boiler feed water to eleven boilers which can generate about a miilion pounds per hour of steam. Three of these boilers are the fuel-fired package type while the other eight utilize sulfur generated heat.

Each of our existing sulfuric plants can produce over half a million tons per year, but our total phosphoric requirement of over 1,000,000 TPY P_2O_5 would consume an additional 1,000,000 TPY H_2SO_4 (93%). This sulfuric requirement would then require two plants the size of our existing ones or one plant larger than ever before built.

We decided to build the world's largest sulfuric plant! The advantages were decidedly in favor of one large plant. We calculated that we could save at least 20% by building one large plant, instead of two smaller ones. In addition to the lower capital cost, the operating and maintenance costs of one large plant were estimated to be nearly 30% less than two plants. This, of course, was in view of adding the fifth plant to existing facilities and would not necessarily apply to a "grass-roots" installation. The third big advantage of one large plant, in these economically troubled times, was that it would be 10% more energy efficient.

The realization that about 1/3 of our sulfuric and steam producing capacity would be affected by downtime was of concern, but in view of our package boiler steam capacity and the overriding cost savings in capital outlay and operation we chose to go with one large plant.

We found ourselves on the threshold of mechanical and process feasibility since a plant this large had never been built. Three areas in particular were somewhat borderline. To still be able to maintain a single train design philosophy, we had to address the following:

1. <u>MAIN TURBINE/BLOWER PACKAGE</u>

   The main blower would have to deliver 156,000 SCFM and be driven by 7500 HP steam turbine. There were no turbine/blower sets around in this type of service and with design parameters of this magnitude.

2. <u>WASTE HEAT BOILER</u>

   The boiler would be of such size that transportation and erection would be a problem. The boiler would be 13' DIA. x 53' LG., 1224 tubes at 2½" DIA., with a tube sheet thickness of 2 7/8". Steam production would be about 310,000 #/Hr. at 650 psi and end up with 750^{o} F superheat further downstream.

3. <u>ACID COOLERS</u>

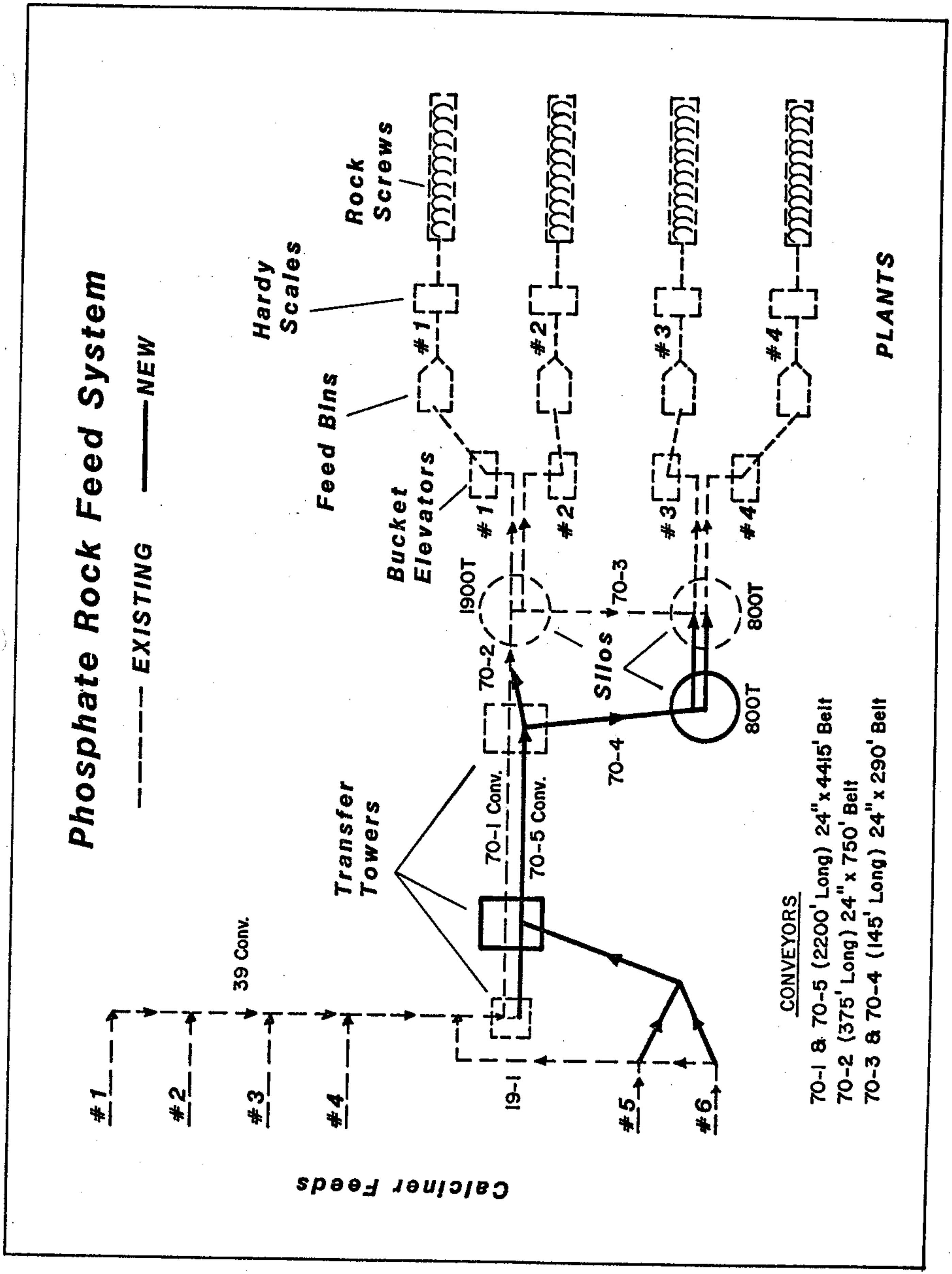
   The acid coolers would be larger than any previous ones and still be anodically protected.

All of these hurdles were overcome, and construction began on October 14, 1980. We expect to put the new plant on line during the first quarter of 1982.

In addition to producing the required tonnage of sulfuric, we had to store it and transfer it to the phosphoric complex. We had four existing 4500 ton sulfuric storage tanks and added a fifth tank at 10,000 tons to give a total of nearly 30,000 tons capacity. Prior to our expansion, two sulfuric acid headers supplied the four plants; one header supplied two plants each. This was an inflexible arrangement which required pressurization of both headers to keep all four phosphoric plants running.

Our expansion increased the number of headers and our flexibility, which in turn would reduce phosphoric downtime due to sulfuric supply problems. The new header system would allow up to two lines to be out of service and still keep the phosphoric plant on line. Increased versatility was also included by tying in pumps and cross-connections at the sulfuric tanks to supply any of the four headers with any of four sets of feed pumps.

Fig. 1


Phosphate Rock Feed System
------ EXISTING
—— NEW
Calciner Feeds
#1
#2
#3
#4
#5
#6
39 Conv.
19-1
Transfer Towers
70-1 Conv.
70-5 Conv.
70-4
800T
Silos
70-2
1900T
70-3
800T
Bucket Elevators
#1
#2
#3
#4
Feed Bins
Hardy Scales
Rock Screws
#1
#2
#3
#4
PLANTS
CONVEYORS
70-1 & 70-5 (2200' Long) 24" x 4415' Belt
70-2 (375' Long) 24" x 750' Belt
70-3 & 70-4 (145' Long) 24" x 290' Belt

ROCK

The next problem was to get enough rock to the phosphoric plants. The pre-expansion rock supply system consisted of one long 24" conveyor (2200 ft. long) feeding a transfer point, then a 375' long belt feeding the main 1900 Ton Rock Silo, which in turn fed the plants. *(See Fig. 1., The pre-expansion system is shown in dashed lines, while new is in solid lines.)

The original rock system had undergone several changes. Prior to this expansion a rate of 450 TPH of rock could be delivered. Our expanded capacity would require an average flow of 650 TPH.

The main bottlenecks in the system were identified, studied, and modified for improvement. Fortunately, the original rock system was designed for rock of a lower density. The main limitation was conveyor capacity, followed by the buckets, Hardy scales, and rock screws. The existing main conveyor (2200') had been sped up as far as we thought we should, so we could either replace the existing belts or add additional ones. Downtime ruled out replacement; spare parts and interchangeability pointed to a second belt like the first. An additional feed belt and a transfer tower were added from #5 and #6 silos to maintain the ability to feed either of the 2200' belts with all calciners. At the next transfer points, belts were added to allow flexibility by avoiding two plants or half of the operation being down with one belt out.

Another silo was added to give a little more surge capacity and to balance the feed system. At a 650 ton-per-hour rate of consumption we would have a little less than four hours surge capacity, but our second belt system could sustain a four plant operation up to nearly twenty hours.

As pointed out earlier, we had an advantage in that our rock has a higher density than original design. This meant that, volumetrically, we had an advantage and that the increased throughput could be accomplished by increasing horsepower and/or speed rather than a complete changeout of equipment. This principle seemed to apply to the last three pieces of feed equipment (bucket elevators, Hardy scales, and rock screws); although, we were borderline with the rock screw.

The existing bucket elevators were originally designed for up to 100 TPH at 80 FPM, so we could get our requirement (160 TPH) by changing the drive sprocket and chain to give 100 FPM.

Due to adequate volume in the Hardy scales, no changes were required.

The original 24" DIA. rock screws feeding the reactors were increased in speed from 50 RPM to 70 RPM with 50 HP motors (originally 25 HP). We've had some problems in this area. The drive would overload, and we've had more maintenance than we would like. We changed the pitch of one section of screw to deliver more tonnage at the original 50 RPM, but are still having a few maintenance problems. Upgraded performance in attack and filtration is so good that we're now looking at further modifications or replacement of the entire screw system.

REACTION

As mentioned in the introduction, adequate attack volume and retention time was the foundation upon which our expansion was based. We calculated our retention time to be over seven hours in each attack tank, even at the expanded throughput. It was determined, however, that reaction cooling and agitation would have to be increased to be proportional to tonnage.

Scaling is as much a part of making phosphoric acid as gypsum and as a "necessary evil" has to be contended with. To retard scaling is to have a more efficient, longer running process. We added circulation to reduce scaling as much as to reduce temperature. We replaced high maintenance vertical flash cooler pumps with horizontal rubber-lined pumps with higher capacity. Filter feed temperatures are easily controlled and flash cooler scaling has improved dramatically.

There have always been controversies over reactor agitation from too little agitation (not assuring complete reaction/crystallization) to too much agitation (breaking up the crystals already grown). We converted to down pumping agitators to help keep the attack compartments scoured out, utilizing all of the available drive horsepower.

FILTRATION

The heart of our expansion was filtration and choosing the best way to augment our existing tilting pan filters. We compared the major filtration options available and finally chose belt filtration. The filtration options included: (1) more tilting pan; (2) table top; or (3) belt. Other types of filtration were cost prohibitive, partially because of the higher CaO/P_2O_5 ratio and relative filterability ($P_2O_5/Ft.^2$) with our rock.

The most cost effective expansion is not necessary the most process effective, but we intended to find the best conpromise for our situation. The costs considered in evaluating the filter options were capital, operating, and maintenance.

We could not add the necessary filter area in the existing filter buildings, since the filter feed source was the attack tank. Since we had some vacant real estate, we chose to build as close to the attack tank as possible. This building would house whatever filter we chose and that filter would be as close to the ground as possible. We also decided to build concrete compartmented filtrate seal tanks below ground level to help the filtrate downleg requirements.

The filter options (table top, tilting pan, and belt) were all analyzed, and required capital varied considerably. The belts seemed the best to us. Operating and maintenance costs had to be considered and the following four points were preeminent:

1. FILTERABILITY - (Speed)

   Production is our goal; and given crystallization and sufficient vacuum, the way to increase filtration is to move the filtering surface with respect to the feed and vacuum points. It appeared to us that the belt could be run at the fastest speed of the options without mechanical problems. Maintenance costs and mechanical problems brought us to the second point.

2. MECHANICAL SIMPLICITY

   The more mechanically complicated something is: The more maintenance problems one can expect. Using this premise, we ranked the filter options as follows:

   a. BELT - Least complex - mechanically
   b. TABLE TOP - Mid-range
   c. TILTING PAN - Most complex

3. SCALING

   Filter cloth blinding could be combatted most effectively on the belts by washing both sides of the cloth continuously. It should be noted that, in addition to the other N.C. rock properties mentioned, ours is a particularly scaling acid. The high scaling tendency added inpetus to our cloth cleaning desires.

4. DRY DISCHARGE CAPABILITY

   We desired the capability to discharge gypsum in as dry a form as possible to mix with other byproduct streams for land reclamation. The belt filter, we decided, could give us as dry a cake as any. The Japanese have used belts for some time and run belt discharge directly to gypsum dry wall plants.

We chose belt filtration because of these four overriding considerations: filterability (speed), mechanical simplicity, scaling, and dry discharge capability.

Also addressed was the low filter problem mentioned earlier, and with concrete below-grade seal tanks we managed to put the new belt filter at about the same level as the attack tank (a "catwalk" connects the two). The downleg length (from centerline of the filtrate receiver to the centerline of pump suction) was held to 28'. We designed the downleg to be capable of handling the worst contingency, i.e., 25" Hg vacuum and 1.040 tail wash specific gravity. The filter floor was built 18' above grade with the working level 27'9" above grade.

Other unique aspects of our belt filter installation are:

1. Steam tracking utilized on vacuum box and receivers to suppress scaling.
2. Overhead crane and access way.
3. All stainless filter and receivers (wetted 317-L, other 316-L).
4. Multiple feed sources - each belt can be fed from either of two attack tanks and/or underflow sludge.
5. Utilization of boiler blowdown from the sulfuric plants. One set of cloth sprays on the belt sprays hot blowdown water periodically.

As of this writing, we've run the belt filter for five months and are very pleased with it's performance. Of course, we had a few startup problems, i.e., tracking, etc.

For the first quarter of 1981, we've had an operating factor of over 80% on the first belt with the second one going on line the first part of April. The belt's operating factor is already as good as the existing tilting pan filters.

Rates also have improved with the belt, which is running better than the tilting pans (based on tons P_2O_5 per square foot of active filtration area).

To add to the belt and upgrade the existing plants, we analyzed our log sheets to discover the rate limiting or downtime causing problems. We uncovered periods of mechanical limitation due to pump capacity when approaching instantaneous rates about 40% over design, so the first order of business was to upgrade pumping capacities. The filter feed and filtrate pumps were increased to give pumpability up to 90% over the original design. We utilized variable speed drives on all pumps except the filter wash to give adequate rate variability. We also utilized existing pumps wherever possible.

The vertical gypsum pump on the tilting pan circuit was undersized and was replaced with horizontal pumps. We installed one spare which serves two plants via a unique gypsum slurry tank overflow launder. This allows us to continue running both plants if any of the three gypsum pumps are out.

The results of upgrading the first two plants (#3 and #4) and adding belt filtration have been excellent having broken daily, weekly, and monthly records several times since startup.

EVAPORATION

The upgrading of our existing filtration capacity and the belt filter additions forced more evaporation. At the outset of our expansion we had nine evaporators, and our best product forecast indicated four more evaporators were required. Interchangeability was the key in this area as well. With thirteen evaporators we required interchangeable pipe and duct spools, instrumentation, circulating pumps and motors, heat exchangers, etc.

We found we had room for one evaporator between two of our existing units. Since 30% production demand would require another evaporator as soon as possible, we decided to proceed with one evaporator in that location. By utilizing our spare tube bundle and circulating pump, we got #10 on line in mid-March 1980 or about six months from start to finish.

New real estate was required for further evaporation, so #11, #12 and #13 were made a separate package and located 160' Southeast of the existing units.

The biggest limitation to the older evaporators was pressure drop in the system. We modified the existing units to some degree, but were constrained by gas duct sizing and the like. Our intent was to have the new evaporators designed to get the smallest pressure drop possible without jeopardizing recovery.

The new evaporator design employs a new entrainment separator (1) of an integral, cyclonic design shown in Fig. 2. The integral cyclonic type entrainment separator in the top of the vacuum evaporator vapor body eliminates the pressure drop and cost of additional vapor piping normally associated with cyclonic entrainment separators mounted on top of the flash chamber. A centrifugal action is applied to the vapors and entrained liquid rising from the boiling liquid in the flash chamber by a helical spin plate in

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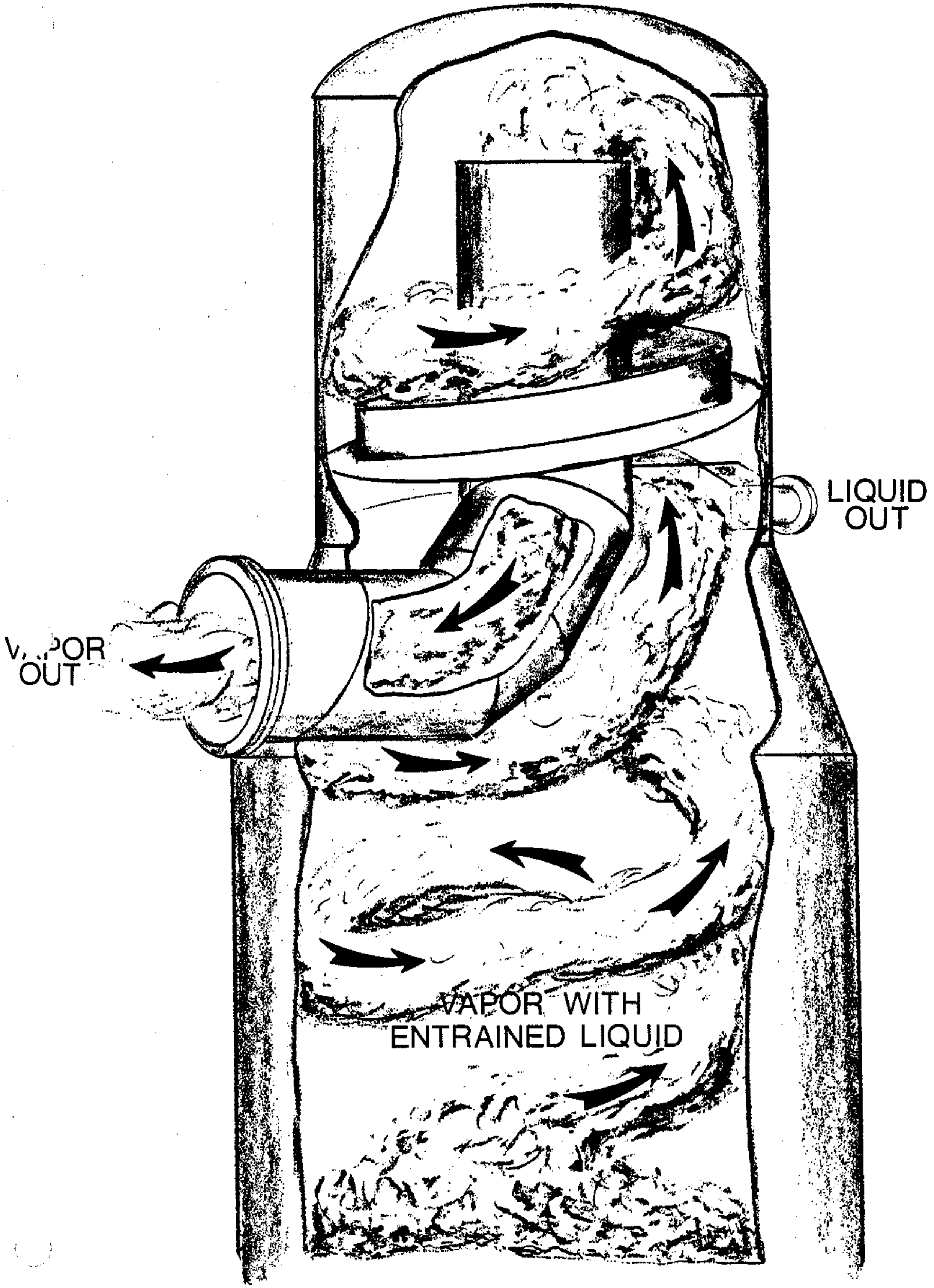
(1) Patent Applied for by Gulf Design

INTEGRAL CYCLONIC ENTRAINMENT SEPARATOR FOR EVAPORATOR FLASH CHAMBER(1)



(1) PATENT APPLIED (Gulf Design) Fig. 2

the separator. These vapors flow through the annular opening formed by the center pipe and the outside wall. The desired centrifugation and inlet velocity are obtained by varying the height and width of the annualr opening.

P_2O_5 entrainment is deposited on the wall by centrifugal force and flows down the wall by gravity into a trough at the outside edge of the spin plate at the separator wall. Collected liquid entrainment flows down the trough counter current to vapor flow. Any entrainment which may be carried up the wall by the vapors is trapped and recovered by a "catcher plate" installed on the wall below the center vapor pipe inlet. The vapors continue flowing upward in a spiraling motion created by the spin plate to the top of the separator where they reverse direction and flow downward through the center pipe which extends through the spin plate and elbows through the flash chamber.

In this design, the outlet vapor nozzle is at a lower elevation than other top mounted separators, thus the length of outlet vapor piping to the associated barometric condenser is reduced. Overall, the reduction of inlet and outlet vapor piping results in more effective utilization of allowable pressure drops for entrainment separation.

Our new evaporators (11 through 13) were put on line February 3rd of this year and are running very well. These evaporators gave us our smoothest startup of our expansion to date and are averaging above designed rates (approximately 15% above the older evaporators which were debottlenecked in 1978 or 30% higher than the older evaporators as originally designed).

GENERAL

In addition to the other phases of our expansion (rock and sulfuric supplies, reaction, filtration, and evaporation), we upgraded the following:

1. Added two, 850 ton 30% tanks and one, 1200 ton 54% tank to increase storage, surge, and operating factors.

2. Added an agitated sludge filter feed tank to collect all underflows for feeding one of the belt filters.

3. Added another 100 acres of gypsum pond utilizing a unique peripheral drainage scheme. A special seepage ditch had to be installed due to part of our gypsum pond being constructed on reclaimed land.

4. In the process of adding over fifty acres to the cooling pond area and placing diversion dikes or "fingers" in the existing pond.

5. In the process of installing a new pond water reuse system to optimize available cooling water by redistribution of hotwell load.

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