International Fertilizer Industry Association

IFA Technical Conference

Venice, Italy

2-4 October 1990

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REVAMPING WITH ADVANCED PROCESS TECHNOLOGY AND EQUIPMENT

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ABSTRACT

The operation of many dihydrate process plants built during the past three decades is below the optimum and as such sometimes decisions must be taken as to whether these units should be brought up-to-date by revamping the process or the equipment involved <u>or</u> to shut these units down and buy Merchant Grade Acid from the market.

A number of case studies are described showing where the implementation of "state of the art" technology and equipment has enabled the performance of existing units to be improved giving a new lease of life to an old investment.

SECTION 1 - PROCESS REVAMPING

The first section deals with the process re-vamping of phosphoric acid units to increase their profitibility. The main differences between a revamp in Dihydrate and a conversion to Hemihydrate or Multi-crystal processes are discussed.

SECTION 2 - EQUIPMENT REVAMPING

The second section deals with revamping of individual items of equipment and is divided into two sub-sections.

The first sub-section refers to the application of the latest design of agitators, recirculation pumps and flash coolers within existing units and some details of results obtained industrially.

The second sub-section deals with the conversion of old BIRD-PRAYON filters to the latest design and demonstrates (based on industrial data) how with increases in effective filtration surface, drainage and rotational speed, additional capacity and/or efficiency can result.

Equipment revamping can not only increase process efficiency and instantaneous capacity but also annual capacity too if the on-line time is increased. An increase in on-line time can also in certain cases cause an indirect increase in efficiency too as all shut-downs cause losses.

SECTION 1 - PROCESS REVAMPING

1.1 IN DIHYDRATE

1.1.1 GENERAL

The revamping of Dihydrate units to increase the capacity, or the efficiency or to adapt an old design to a new phosphate is not at all a new occurrence. Many of the Dihydrate units built during the "Golden Sixties" were modified towards the end of the seventies. Perhaps over half of the Mark 2 Prayon units have been modified to include some or all of the features of the Mark 3 and Mark 4 designs. One unit in Canada designed for 380 mtpd P2O5 having been fitted with additional flash cooling capacity and filtration area and now treating a different phosphate, regularly produces 4 times its original design rate with a very acceptable efficiency and a higher acid strength. One option to revamping is to change the phosphate and nothing else. In certain cases this can sometimes create a higher capacity, acid strength and efficiency without any significant capital investment.

1.1.2 SHERRITT-GORDON - Canada

A typical revamp of a Prayon Mark 2 unit using Mark 3 technology and equipment is shown in Figure 1. This is the Sherritt-Gordon unit in Fort Saskatchewan, Canada. The main features are the incorporation of a Digestion Section (which enables the reaction process to be fully completed and a de-supersaturation to take place before the filtration giving an improved filterability and reducing scaling on the filter), the redesign of the flash cooler internals, the incorporation of additional recirculation and the inclusion of better agitation.

Recently PRAYON was asked to give consultancy to this unit to modify the plant to accept a Canadian igneous phosphate and after modifications a successful plant trial was made.

1.1.3 ISAF - Sicily

A similar revamp is at present being executed on one of the two identical Mark 2 PRAYON units at Gela in Sicily but in this case the latest PRAYON Mark 4 technology is being used. The justification for the revamp was a desire to increase the capacity to compensate for some other units of the group that had been shut-down, to improve efficiency and acid strength and to reduce power consumption. The reaction volume is large for the nominal capacity and based on today's design figures it is ample for the additional production rate. However the flash-cooler system does not have sufficient capacity for extra load.

The Mark 2 design sulphuric acid dilution coolers (98-55% H2SO4) are in poor condition and so the additional new low-level flash-cooler has been sized, not only to enable the plant to run at the higher capacity, but also to use 98% H2SO4 directly to feed the reactor as is normal in later PRAYON designs.

To assist in the incorporation of the 98% sulphuric acid it is blended with return acid in mixing-Tees and Mark 4 agitators are being fitted to N° 1 & 2 compartments . The additional recirculation given by the low level flash cooler pump and the increase in size of the pump on the existing flash-cooler should improve filterability.

The client is progressively implementing the new technology as time and money allows. On changing the agitators to the new Mark 4 design the client immediately noticed an improvement in filterability and as the plant was filter limited immediately obtained an increase in capacity at the same efficiency and product acid strength. Although it have been his intention to complete the revamp on one train before moving on to the next (there are two identical units) he has already decided to order these agitators for the second train.. A sketch of the proposed changes is included as Figure 2.

1.1.4 ULTRAFERTIL - Brazil

PRAYON was also asked to give consultancy to a Brazilian phosphoric acid producer to up-date and boost the existing Dorr-Oliver unit situated in Cubatão whilst reducing the atmospheric pollution. The plant was originally designed for Florida phosphate and has been operating on Brazilian igneous phosphate for the most part of the last 10 years. The operating personnel have struggled with the unit to try to maintain normal efficiencies, acid strength and capacity but have never been able to satisfy all these requirements at the same time. There has also been severe scaling from time to time in the filtration circuit due to deposition of fluosilicates.

A decision was taken to evaluate the performance improvement that a revamp could bring. The data showed that for an investment of less than US$ 10 Mio the plant could be made compatible with the new local phosphate and also an increase in production of 65% (from 242 to 400 mtpd P2O5) could be obtained. The pay-back time was less than 3 years. The igneous phosphate treated is extremely sensitive to sulphate, a low sulphate being required to obtain reasonable solubilization and a high sulphate being required to get reasonable filtration rates. The reactor design proposed for the revamp was tested in pilot-plant and based on the results the design was adopted for implementation.

The layout is shown in Figure 3. As can be seen the reaction section is divided into three zones, a feature that exists in the standard PRAYON Mark 4 design of today. The additional volume required for the increased production is situated at the head of the reaction section where the phosphate is added and consists of two rectangular compartments of standard PRAYON design.

The new agitators to be fitted have been selected with due consideration to local and process requirements. An axial flow pump will circulate slurry from the head of the old reactor through a new low-level flash cooler to the head of the new reactor where the phosphate will be added as a filtered cake with about 10% moisture. The slurry overflows by gravity to the existing reactor via a launder. Sulphuric acid pre-mixed with return acid in a mixing-tee may be added to the second compartment of the new reactor or the first part of the old reactor, the old reactor is fitted with a division to create a Digestion or De-supersaturation Section.

Thus the new reaction system will have all the features required for the satisfactory operation of the phosphates now being treated; volume and flash-cooling compatible with the new capacity, a low sulphate zone where the phosphate is added, a higher sulphate zone to assist in the production of shorter/wider needle crystals with a higher filterability, and a Digestion section that will allow completion of the reaction and de-supersaturation to reduce scaling in the filtration section.

1.1.5 JPMC - Jordan

A somewhat similar case but of a totally different magnitude is the latest revamp being concluded at this time for a client in the Middle East. Once again additional production and cooling capacity and a higher acid strength were required whilst operation of the filter without the scaling problems was of interest. The proposed solution (Figure 4) was very similar to the ULTRAFERTIL case but the main difference was the incorporation of additional Digestion volume after the existing reactor as it was impossible to subdivide the existing single-tank design.

Once again the low-level flash-cooler is situated between the existing reactor and the new head of attack. The head of attack consists of two standard PRAYON rectangular compartments situated close to the old reactor, slurry being pumped by an axial flow pump via the flash-cooler to the first compartment where the phosphate is fed. Agitation will be by Mark 4 PRAYON designed agitators giving the right proportion of flow and shear to ensure optimal solubilization conditions.

Sulphuric acid is normally fed to the main reactor but a facility to feed to the second compartment blended with return acid in a mixing-tee has also been provided. The slurry overflows from the second compartment to the main single-tank by gravity through a launder. The existing filter feed pump is used to transfer the slurry from the Attack Section to the Digestion section that comprises three standard PRAYON rectangular compartments. A new filter feed pump feeds the existing filter.

The unit being relatively new is still subject to a secrecy agreement and as such there was an additional constraint as no modifications could be made to the existing supply.

1.1.6 SIMPLOT - USA

Simplot had operated a Singmaster and Breyer dihydrate unit for many years and decided that due to the general state of the equipment, especially the rubber lined steel reaction tanks, a new reaction section was required. The PRAYON tilting-pan filter supplied with the original plant was still in good condition as was the additional belt filter that had been installed. To minimize loss of production it was decided that the old reactor could not be dismantled to allow the building of the new reactor in it's place and alternative space available was limited. The actual width of the plot available was not compatible with the standard PRAYON attack tank design but a special high-aspect ratio design was made that just managed to fit between the railway and the existing maintenance roadway in one direction and the filter building and grinding unit in the other direction.

This unit fitted with two low-level flash coolers, sitting directly on top of the Attack tank as no overhanging of the sides was allowed, was designed for 1090 mtpd P2O5, it is now operated at about 110% of this nominal capacity.

1.2 IN HEMIHYDRATE

1.2.1 GENERAL

The main claim to fame of the single stage hemihydrate process is the high strength acid produced and a reduced dependability on utilities. In cases where these are the main requirements an economic case can be justified. PRAYON's PH11 or single stage Hemihydrate process has not been the subject of a new grass roots plant up to the present time but the process has been demonstrated industrially at the PRAYON unit in Engis proving that the selected process equipment and design enable the figures based on pilot-plant data may be quoted as guarantees.

The in-built flexibility of the PRAYON reactor and the reliability of the equipment supplied have ensured excellent results to be obtained where PRAYON dihydrate units have been converted to high strength attack. The inherent process features of the multi-compartmented PRAYON reactor have been well demonstrated during the past 40 years and both process licensors & consultants as well as production people do not need to be reminded of this fact.

In fact at the last IFA Technical Conference, Norsk Hydro presented a very good paper (1) which shows that, even with high recirculation, the larger the number of compartments the better the reactor design. PRAYON are well aware, through many years of industrial experience with the Dihydrate process, that a multicompartmented reactor is more efficient and gives better crystallization than a unit with a lesser number of compartments. This paper (Ref 1) is solely a further confirmation of what we at PRAYON have predicted from our studies of High-strength Hemihydrate processes. In another paper about a conversion of a Dihydrate unit to hemihydrate operation presented at the same conference by Brunswick Mining & Smelting (Ref 2) the speaker verbally stated that the results regarding efficiency and filtration rate were higher than those expected by the licensor. This perhaps was due to the fact that the PRAYON tank has more compartments than the standard reaction tank of the licensor.

Normally conversion of a Dihydrate unit into a single-stage Hemihydrate process normally incurs a reduction in efficiency and provided that this reduction is more than compensated by other gains then this type of conversion can be of interest. In fact one unit in Florida which was converted into Hemihydrate operation has now reverted to Dihydrate operation at an increased capacity and efficiency. Also the two single stage hemihydrate units of NORSK HYDRO in Holland (ex Windmill) will be converted to the higher efficiency Hemidihydrate process for economic and ecological reasons. This revamp from Hemihydrate to Hemidihydrate is also an interesting case.

The good operation of a straight hemihydrate process is like driving along a mountain road; a high level of responsibility is required or else you fall far below your target. Overlooking a flooded filter for a short period of time can cause irretrieveable damage to a whole month's efficiency figures.

1.2.2 CONVERSION OF THE PRAYON UNIT AT ENGIS

1.2.2.1. SUMMARY.

The phosphoric acid plant at the PRAYON production unit at Engis is a Central-Prayon Dihydrate-Hemihydrate design. The unit normally runs at about 400 mtpd P2O5 with an acid strength ex-filter of 36-37 % P2O5, a sulphate of less than 1% and a P2O5 recovery better than 98% whilst producing a merchant grade CaSO4. Some details of this unit can be found in a paper presented at the 1988 IFA Technical Conference (Ref 3).

After many continuous (24 h/day) pilot-plant tests on a variety of phosphates the PRAYON hemihydrate range of processes, which are based on the use of the proven standard PRAYON equipment design, needed only an industrial size confirmation of the PRAYON's concept of Hemihydrate reaction.

This confirmation was made possible in March 1986 when the PRAYON Management decided to make the most of the low seasonal activity by operating their CENTRAL-PRAYON plant in the strong acid/hemihydrate attack mode. Some additional information was presented at the 1986 IFA Technical Conference (Ref 4).

After a few minor changes affecting mainly piping and instrumentation, the plant made its transition from Dihydrate to Hemihydrate attack in a very progressive and controlled way, demonstrating a total command of the operating parameters.

The production reached the nominal capacity of 350 TPD P2O5 whilst producing acid above 45 % P2O5 and the high utilization factor obtained with the existing equipment used during the

Hemihydrate operation (reactors, agitators, pumps, flash-coolers, etc...) demonstrates the total suitability of their design for high-strength acid production.

1.2.2.2. TECHNICAL DATA ABOUT THE PH11 DEMONSTRATION.

The flowsheet of the CENTRAL-PRAYON plant before and after its adaptation to PRAYON PH11 single-stage Hemihydrate process is shown in Figure 5 the list of symbols is set out in Table 1 and the list of operational parameters and data in Tables 2 & 3.

The reaction scheme in two steps developed in pilot-plant testing operated as predicted (the first step takes place at a low sulphate level while the second step is operated at a higher sulphate level). The perfect control of these sulphate levels is one of the key points for successful Hemihydrate operation. The ease of control normally associated with the PRAYON reactor design enabled the production of a highly stable Hemihydrate with with a high filterability and low unattacked phosphate losses.

The PRAYON multicompartmented reactor design allows an easy adaptation of the proportion of the volume devoted to the various steps, adaptation that may be required for changes in the phosphate rock characteristics (for instance chemical or grain size analysis).

The concentrations of SiO2, F, Al2O3, MgO, Cl in the phosphate were studied and the ratios F/SiO2 and F/Al2O3 were adjusted by some additives improving the performance in terms of filterability and corrosion a normal practice, for the Central-Prayon operation at Engis.

Accurate metering and a well defined grain size distribution of the phosphate rock are important. PRAYON has found that the required grain size distribution depends on the phosphate's reactivity and specific surface, the acid strength produced, the reactor volume available and the P2O5 recovery expected. This concept is is in agreement with the view cited in Reference (1).

With this information available, it was easy to set the target operating parameters and production of well crystallized and very stable hemihydrate was a feature of the demonstration. In parallel to the industrial operation of the single-stage PH11 process continuous pilot-plant test were conducted on the recrystallization of the Hemihydrate to Dihydrate simulating the PH2 PRAYON Hemidihydrate process. This conversion was easily controlled and the optimum parameters were easily found.

The nominal capacity of the plant had been set at 350 mtpd P2O5 for the test. The test began by operating the plant in the Dihydrate mode at 270 mtpd P2O5 and gradually increasing the acid strength from the normal 36% P2O5 to the target value of 43-47% P2O5. When the slurry had completely converted to the hemihydrate form capacity was increased up to 350 TPD P2O5. The on-line factor during the whole of the demonstration was better than 90 % (a typical value for the Engis unit in CPP is 95%).

The amount of fluorine escaping during the reaction is much higher than a normal Dihydrate reaction but, as the Engis unit's scrubbing system is designed with a highly irrigated system to allow the total treatment of these gaseous effluents in a view to recover the maximum of fluorine values, no problems were detected in this area.

Table 3 summarizes the main chemical analyses. This table also shows that during the test the P2O5 recovery of the PH11 was in the bracket 92-94 % with the existing two-wash filter and a filtration rate of 6-7 mtpd P2O5/m2 was confirmed. With the standard three-wash filter (the normal concept for the PH11) an efficiency of 94-95% can be confidently guaranteed the actual value depending on the acid strength and the phosphate.

The operation of the two tilting-pan filters (these filters operated in series with two washes due to the standard process layout of the Central-Prayon process) was normal with no scaling taking place. The only additives made to the Reaction and Filtration circuit were the normal inorganic additives cited above. The Digestion Section at the end of the Reaction Section ensures that only a stable Hemihydrate and a De-supersaturated acid is fed to the filter which must assist in reducing scaling tendencies.

After the demonstration the plant reverted to its standard Central-Prayon high efficiency, pure hemihydrate format.

1.3 IN MULTI-CRYSTAL PROCESSES

1.3.1 CONVERSION OF DIHYDRATE TO CENTRAL-PRAYON

1.3.1.1 GENERAL

The Central-Prayon Dihydrate - Hemihydrate process was even born as a revamp at the production site of PRAYON in Engis where two Dihydrate plants were grafted together to form the original Central-Prayon unit. The present Central-Prayon plant at Engis is also a conversion of a plant that was originally a Dihydrate unit. This shows up in the layout which is far from perfect due to the space restraints that applied at the time of the revamp.

The main aim of the Central-Prayon process is to produce a pure self-drying hemihydrate suitable for downstream use without further cleaning but three other advantages accompany this as a bonus, the acid strength can be up to 37% P2O5 (depending on the phosphate and the downstream use of the calcium sulphate), the efficiency is over 98.5% and the sulphuric acid consumption is of the order of 5% less than a standard dihydrate process.

During the 1970's all PRAYON dihydrate units were designed as "Convertible Plants", that meant that the design was developed in consideration of an eventual conversion to the Central-Prayon process. In the early eighties this policy was discontinued as it was causing all proposals to be slightly more expensive and in the competitive market was no longer interesting. Recently however with the subject of by-product gypsum being more and more topical a number of potential clients have shown an interest in having this option.

The total additional volume over and above that of a normal dihydrate unit can vary from zero to 25%. An extra first stage separation filter (dihydrate cake without wash) is also required and depanding on the existing filter some modifications may be required to convert it to Hemihydrate filtration.

1.3.1.2 XUAN-WEI - China

One of the latest PRAYON dihydrate units was designed and is being built in China with an option to convert to Central-Prayon in the future. The layout as was developed by DAVY MCKEE for this project can be seen in Figure 6. This not only means that for a marginal increase in installed cost of the new plant the eventual cost of a revamp to the Central-Prayon process will be very much less but also that the operability of the plant in the Central-Prayon mode will be very much easier.

The higher acid strength often means that an increase in capacity of the Reaction and Filtration Sections can be envisaged for the revamp without requiring an increase in the Evaporation.

1.3.1.3 KRASNODAR - Russia

The Russians are at present operating four 1000mtpd P2O5 units built to the Mark 3 PRAYON Dihydrate process. These units are operating extremely well in the Dihydrate mode on Kola and other Russian phosphates, however phosphogypsum disposal is also becoming a problem in the USSR. At the present time PRAYON and the licensee who built the original units (COPPEE-LAVALIN) are in the final stages of negotiations to convert one of these units to the Central-Prayon process. Thus the plants will directly produce about 4000 mtpd of dry hemihydrate for plaster and plaster block applications using a specialised dryer that was developed industrially at the Engis site. This dryer takes the wet hemihydrate with about 15% of free water from the filter discharge and dries it to a free-flowing commercially acceptable plaster powder. The main problem associated with this type of solution is that normally the size of the local market is very much smaller than the potential production.

1.3.2 CONVERSION TO HEMIDIHYDRATE

1.3.2.1 GENERAL

A conversion from Dihydrate to a Hemidihydrate process can normally only be justified if both the cost of phosphate and steam is high. A revamp of this type normally requires a considerable supplementary investment as the retention time required for recrystallization is normally quite significant thus requiring large additional volume and agitation power. Large filtration areas for Hemihydrate filtration also are required thus the space factor is also quite significant and often less than desirable layouts have to be adopted due to space limitations close to the existing unit. Although the calcium sulphate is purer than the dihydrate case it does not reach the level of purity of the Central-Prayon process and as such the gypsum may require cleaning and drying for downstream uses.

1.3.2.2 PEQUIVEN - Venezuela

PRAYON and its licensee DAVY MCKEE recently conducted pilot-plant trials and process design to enable an economic evaluation to be made on the conversion of an existing Dihydrate Dorr-Oliver unit in Venezuela to the PRAYON PH2 Hemidihydrate process. The pilot-plant tests made on Riecito phosphate, an indigenous phosphate from Venezuela, gave extremely good results and the proposed layout is shown in Figure 7. The existing dihydrate reactor and filter would be used for the second stage of the process and a new reactor and filter provided for the Strong Acid - Hemihydrate Section. Because of layout problems the two sections would be interlinked by a belt conveyor to transport the Hemihydrate cake to the Dihydrate Section.

The cake would be reslurried in a two compartment repulp tank which would overflow to the existing reactor for the completion of the hydration process prior to final filtration.

1.4 PROCESS REVAMPING - SOME GENERAL COMMENTS

The justification of the revamping of an old plant with a change of process route should never compare the actual operating industrial figures with the process guarantee figures stated for the revamp. Industrial figures on efficiency and guaranteed values are not directly comparable. With time the operating figures may approach the guarantee figures but this may take quite a time. In a paper presented to the AIChE in 1987 it was clearly stated about the SUPRA revamp to Hemidihydrate that the latest information (March 87) was that the plant had achieved 95% capacity for a period of 24 hours. That was in fact more than 6 months after start-up (Ref 5). A similar "running in" period was required for the Revamp from Nissan H to Nissan C at Copebras in Brazil. A boost or a revamp in **the same Process Route** can be embarked on with much more confidence as no new learning curve applies. Revamping a Dihydrate plant in Dihydrate has a lot less process and operational risks than a revamp that changes to another Process Route. A new Process Route means a new learning curve, perhaps climbing more sharply than the original one but even so full production cannot be expected in the first years of operation. An allowance for loss in production due to tie-ins, commissioning and attainment of normal operating values should also be fed into the economic analysis. A comparison of Process Routes and some comments on revamping can be found in Reference (6).

SECTION 2 - EQUIPMENT REVAMPING

2.1 REACTION SECTION

2.1.1 AGITATION

Over the years many process engineers and process consultants have improved (revamped) the agitation systems of phosphoric acid plants and a conversion from the old radial bladed agitators to the pitched blade units and this change has in many cases given significant improvements to the reaction efficiency and filterability.

Up to now only one unit has converted to the Prayon 4 - PHT (Prayon Helicoidal Turbine) Mark 4 design of agitators but the results have been quite remarkable. As the grade of Morocco phosphate has progressively deteriorated, the two twin PRAYON Mark 2 units at Gela (mentioned in 1.1.3) saw their nominal capacity being progressively more difficult to maintain. The actual operating capacity attained on the Morocco phosphate used during 1989 was of the order of 85-90% of the nominal capacity.

On installing two 4 - PHT units (supplied by Lightnin - UK), they immediately noticed an improvement in filterability and are now operating at just above the nominal capacity with the same acid strength and efficiency as before the change. The revamp on the first train was due to be completed, including the fitting of the new Low Level Flash-Cooler and the modification to the reaction tank to provide a Digestion or De-supersaturation Section, prior to starting on the second train but the remarkable results with the agitator means that they are now looking to fit the 4 - PHT units to the second train as soon as possible. The completion of the first train revamp is expected during the annual shut-down in next November.

2.1.2 FLASH-COOLER & REACTOR RECIRCULATION

Two cases of the effects of increased recirculation can be cited as a guide to the possible results that can be attained.

In one PRAYON unit in the Middle East the sole reactor recirculation was the recirculation through the flash-cooler. The temperature difference across the flash-cooler was originally 5°C, the nominal capacity attained due to filtrability limitation was 400 mtpd P2O5 with the formation of medium length needle crystals. When a second flash-cooler pump and line was fitted and the temperature difference fell to approximately 3°C (about double the flow) the type of crystallization changed to clusters and the filtration rate increased by 50% allowing the production on the same filter to be increased to 600mtpd P2O5.

Another case in the USA was at the Uncle Sam plant of Freeport where additional reactor slurry circulation was added without going through the flash-cooler and in this case the Citrate Soluble (Lattice or Cocrystallized) losses fell from 4.5 to 3.5% at the same strength. The mixing-tees for Sulphuric acid and Return Acid had also to be moved from the second to the fourth compartment to allow the phosphate to react more prior to the introduction of the sulphuric acid. The higher recirculation means that the once through residence time in each compartment is decreased. For this reason large increases in recirculation should only be made to units with a Digestion Section to allow the completion of the reaction (as a once through cascade reactor system). If the unit has no Digestion Section then it should be created by modifying the flow pattern within the reactor (refer to the Sicily case).

Sherritt-Gordon mentioned in 1.1.2 in Canada increased the flow through the flash-cooler and used the existing flash-cooler pump to boost the circulation around the reactor and found an improvement in filterability and efficiency but the actual figures are not known.

2.2 FILTRATION SECTION

2.2.1 THE NEW BIRD-PRAYON FILTER DESIGN

A new design of BIRD-PRAYON filter is now being offered to the world market and differs from the previous design by having the following main features:-

- A new design "Fast drain" pan
- Proportion of active area increased
- More efficient Central Valve/Distributor
- New design of pan turn-over mechanism

These features altogether enable a filter with 15-20% more area to be proposed depending on the nominal filter size but also with the hydraulic and mechanical capability to operate if required with an increased rotational speed of the order of 50%. The overall result of the these factors is an increase in filtration capacity of the order of 35-40% for the same nominal filter size. Some details of this new design are set out in a paper presented at the 1989 AIChE conference in Florida (Ref 7).

2.2.1.1 "FAST DRAIN" PAN

The PRAYON pan design has developed quite considerably since the original flat-bottomed Grooved Rubber Mat design. In the USA these mats were replaced with a "Roll-form" profiled stainless steel insert but more recently all BIRD-PRAYON filters have been fitted with a sloped bottom design. This design was adequate when filtration rates were lower but with today's higher filtration rates and consequential higher hydraulic flows they have become a limitiation and a faster draining pan is therefore required. The higher viscosity of the strong acid associated with hemihydrate processes and the desire to have minimum solids retention on the base of the pan has also meant that this type of pan with better drainage will give higher wash efficiencies and less scaling.

A new BIRD-PRAYON pan design was designed and built by BIRD and one pan was installed in parallel with the older sloped bottom pans and tested industrially at the PRAYON production plant at PUURS in Belgium. It is quite remarkable that when fitted with cloths of the same condition the "Fast drain" pan can be visibly diferentiated from the two older pans either side. Drainage time comparisons for the "old" sloped bottom pan and the "Fast drain" pan are shown in Figures 8A & 8B. The more rapid draining will increase the effective cycle time of the pans at the same speed of rotation as the draining time is lost time in the cycle. The better drainage will create a reduction in the wash strengths and subsequently increase the wash efficiency at a given speed or alternatively allow the operator to operate at a higher speed and higher capacity at the same efficiency. The advantages over the previous Rubber Mat design are even more significant than that shown in Figures 8A & 8B.

Five filters with this latest design of pans have already been sold into Dihydrate applications, one for FOSFORY GDANSK in Poland which is now ready for shipping and four have been recently been ordered for the ALKAIM 2 complex in IRAQ. Additionally a new set of "Fast Drain" pans has been sold to ARCADIAN in the USA for their hemihydrate revamp and this unit should be starting up in August or September.

2.2.1.2 FILTRATION SURFACE

The active surface of each pan has be increased on the new filter by better usage of a larger envelope of operation. In simple terms this means a better utilisation of the space available. Also the cloth fixing or "caulking" system has been studied and this has resulted in an increase in the fraction of the pan that is effective. Depending on the nominal filter size the total increase in area will be of the order of 15-20%.

2.2.1.3 CENTRAL VALVE/DISTRIBUTOR

PRAYON initially offered the "AC" (Aspiration Centrale or Central Suction) distributor for Central-Prayon Hemihydrate applications where the early separation of cold gas and hot liquid markedly reduces the scaling tendencies in the filter circuit. More recently this technique has been also applied, on request, to Dihydrate filters where it has also shown to be of great effect at reducing scaling. This design, patented in many countries throughout the world by PRAYON (Ref 8 & 9 and Figures 9 & 10) is now to be offered universally as the standard design world-wide as it has many additional interesting features besides the one originally envisaged.

- Higher hydraulic & gas separation capacity (compatible with "Fast drain" pans)
- Possibility of reduction of filter building height
- Deletion of individual separators and simplified piping

- Variable section cloudy port or pre-suction (minimum solids content & dilution)

Most of these advantages can be easily understood except perhaps the last one. The larger the first section of the filter (Cloudy-port or Pre-suction) not only a lesser quantity of the solids passing the cloth (mostly before the cake has fully formed) reports to the product acid (the second section of the valve) but also a lesser quantity of the water retained in the cloth and wetting the pan surface reports to the product acid. Thus the larger the first section the lower the dilution and the lower the solids content of the acid.

There is of course a maximum value, if the section is too large there will be not enough product acid and the reactor solids content will be uncontrollable. However this maximum section varies with the filterability and if a static division is used then a compromise position must be adopted. By variation of the position of the baffle dividing the first two sectors the optimum position may be selected at any time with the filter in operation. This feature has sometimes in the past been tied to control the operational parameters of the reaction section by an automatically positioned actuator. If the angle of this sector is not optimised then high rotational speed may cause high dilution and product acid solids.

2.2.1.4 PAN TILLING MECHANISM

The turn-over of the pan is effected by the motion of two rollers attached to the pan arm as it moves along the cam tracks. This design has been studied by the use of CAD methods and a new design with lower values of acceleration and subsequent stresses has been defined. This newer design enables higher rotational speeds of the filter at lower stresses than the previous model. This along with the abrasion resistant and shock absorbing materials used for the rollers should ensure a reduction in the overall maintenance cost of the filter.

2.2.2 REVAMPING OF EXISTING TILTING PAN FILTERS

2.2.2.1 GENERAL

The extent of a BIRD-PRAYON filter revamp depends to a great extent on the increase in filtration capacity desired, the actual design and model of the existing filter and the size and also the size and shape of the building and the space around the present filter.

Various levels of revamping may be considered:-

- Progressive replacement with "Fast drain" pans of greater effective area within the existing envelope.
- Substitution of the following components

* Larger "Fast drain" pans with even greater effective area (increasing the envelope)

* New distributor with higher hydraulic and gas separation capacity

* These options without or with new cam tracks

- Replacement with a larger filter in the same building

Obviously the increase in filtration capacity increases from top to bottom but sadly the price of the conversion also increases from top to bottom as well. In order to evaluate the optimum solution for the needs of any filter operator both BIRD and PRAYON are available to discuss these matters with respect to the specific case.

2.2.2.2 CASE STUDIES

Some examples of implementation of these techniques.

Change of filter size in the same building:-

1979	BASF Belgium	Increase of area 60%
1982	FARMLAND USA	Increase of area 90%
1990	GDANSK Poland	Increase of area 60% (With "Fast drain" pans)

Fitting of "Fast drain" pans within the existing envelope (conversion to hemihydrate)

1990	ARACADIAN USA	Increase of area 9%

The options for up-dating or revamping BIRD-PRAYON filter designs are almost infinite. Each case must be studied from an overall Process and Equipment point of view if the most cost effective solution is to be reached. If further details of the above conversions are required then either BIRD or PRAYON will be pleased to provide them.

SECTION 3 - SUMMARY

This paper attempts to give some general information as to the possibilities of revamping to improve profitability. There is however no general solution, each individual case is different. If anyone is interested to discuss one or more of the above possibilities in detail PRAYON would be only too pleased to be consulted.

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Reference Article

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N Robinson , Paper TA/88/18,
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2 Hemihydrate operating experience at Brunswick Mining & Smelting facilities,
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3 Prayon industrial experience of manufacturing merchant grade phosphogypsum,
A Bourgot & P A Smith, Paper TA/88/16,
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5 Practical retrofitting to the hemihydrate process,
J D Crerar & B T Crozier,
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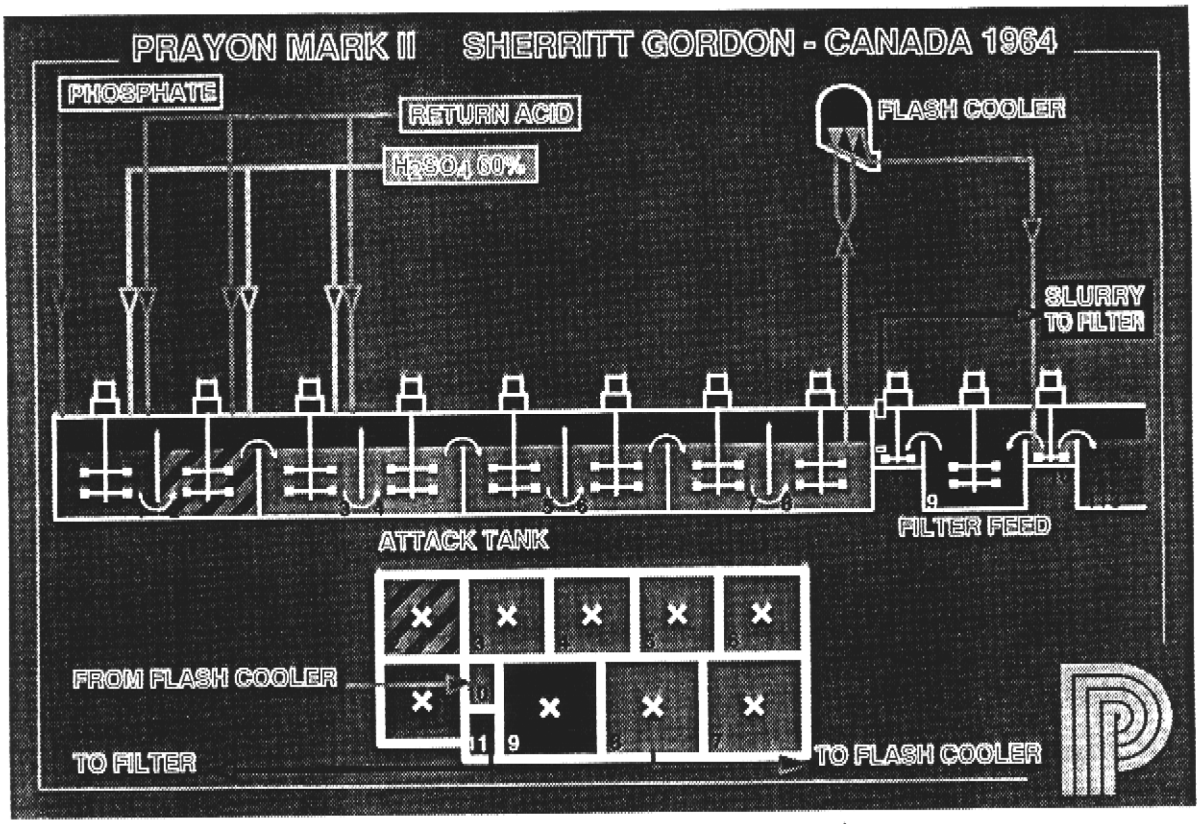
6 Phosphoric acid / Wet process: What process?
P A Smith,
Proceedings N° 269, Fertiliser Society, 13 Oct. 1988

7 How to improve the performance and output of your tilting pan filter by incorporating proven developments from Bird-Prayon,
S Kurowski, K Lindgren & P A Smith,
Peninsular Section AIChE, Clearwater, 27 May 1989

8 Multiple cell filter having a gas discharge,
US Patent N°4,172,791

9 Rotary vacuum filters with a horizontal filtration plane, US Patent N° 4,752,390


PRAYON MARK II SHERRITT GORDON - CANADA 1964
PHOSPHATE
RETURN ACID
H_2SO_4 60%
FLASH COOLER
SLURRY TO FILTER
ATTACK TANK
FILTER FEED
FROM FLASH COOLER
TO FILTER
TO FLASH COOLER

a)

F I G. 1

b)

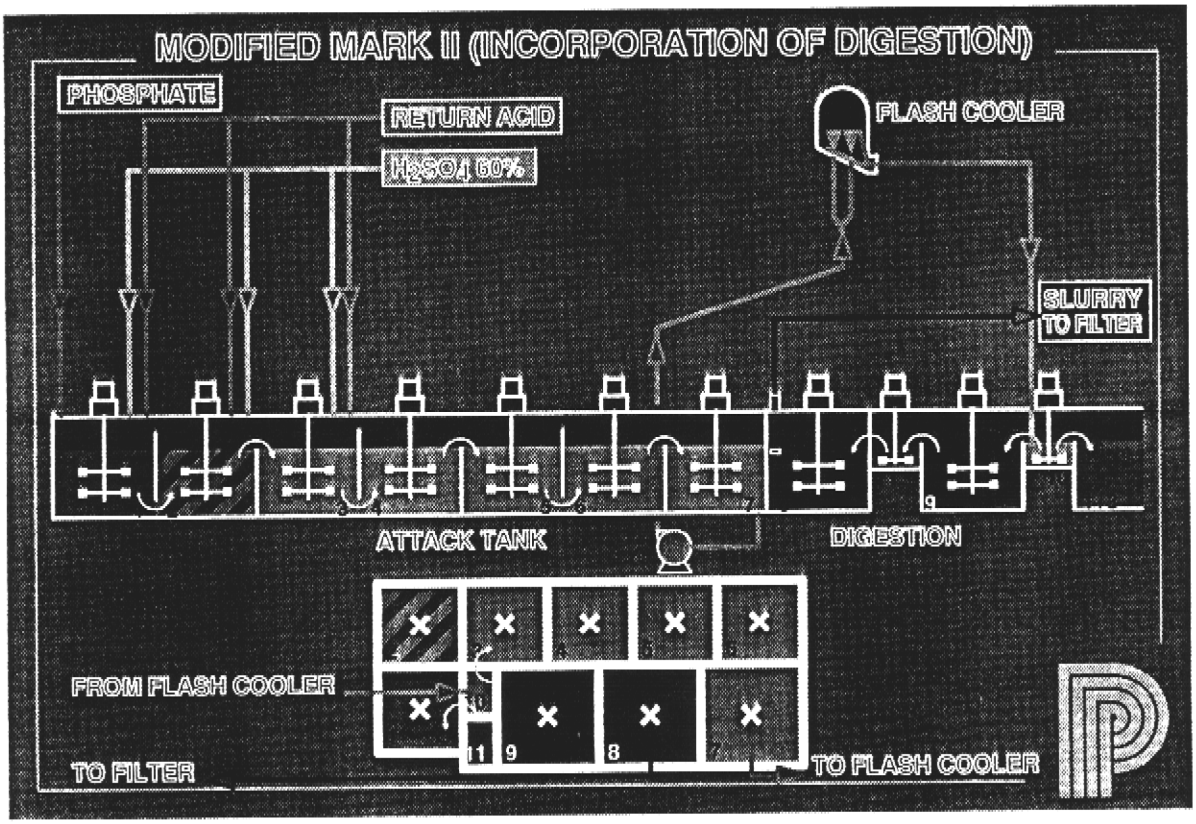

MODIFIED MARK II (INCORPORATION OF DIGESTION)
PHOSPHATE
RETURN ACID
H_2SO_4 60%
FLASH COOLER
SLURRY TO FILTER
ATTACK TANK
DIGESTION
FROM FLASH COOLER
TO FILTER
TO FLASH COOLER

FIG. 2

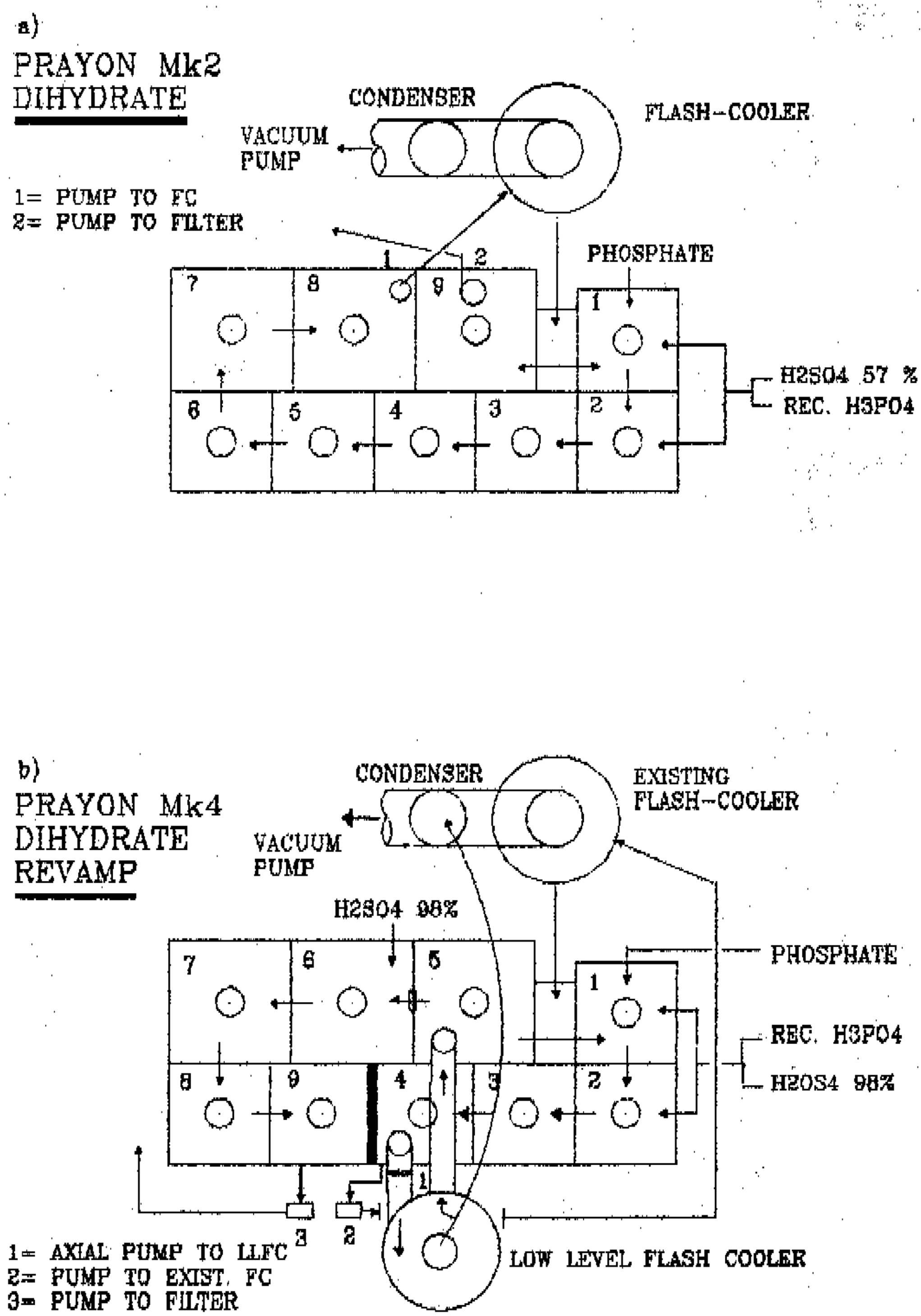

a)
PRAYON Mk2
DIHYDRATE
CONDENSER
FLASH-COOLER
VACUUM
PUMP
1= PUMP TO FC
2= PUMP TO FILTER
PHOSPHATE
H2SO4 57 %
REC. H3PO4
b)
PRAYON Mk4
DIHYDRATE
REVAMP
CONDENSER
EXISTING
FLASH-COOLER
VACUUM
PUMP
H2SO4 98%
PHOSPHATE
REC. H3PO4
H2OS4 98%
LOW LEVEL FLASH COOLER
1= AXIAL PUMP TO LLFC
2= PUMP TO EXIST. FC
3= PUMP TO FILTER

FIG. 3

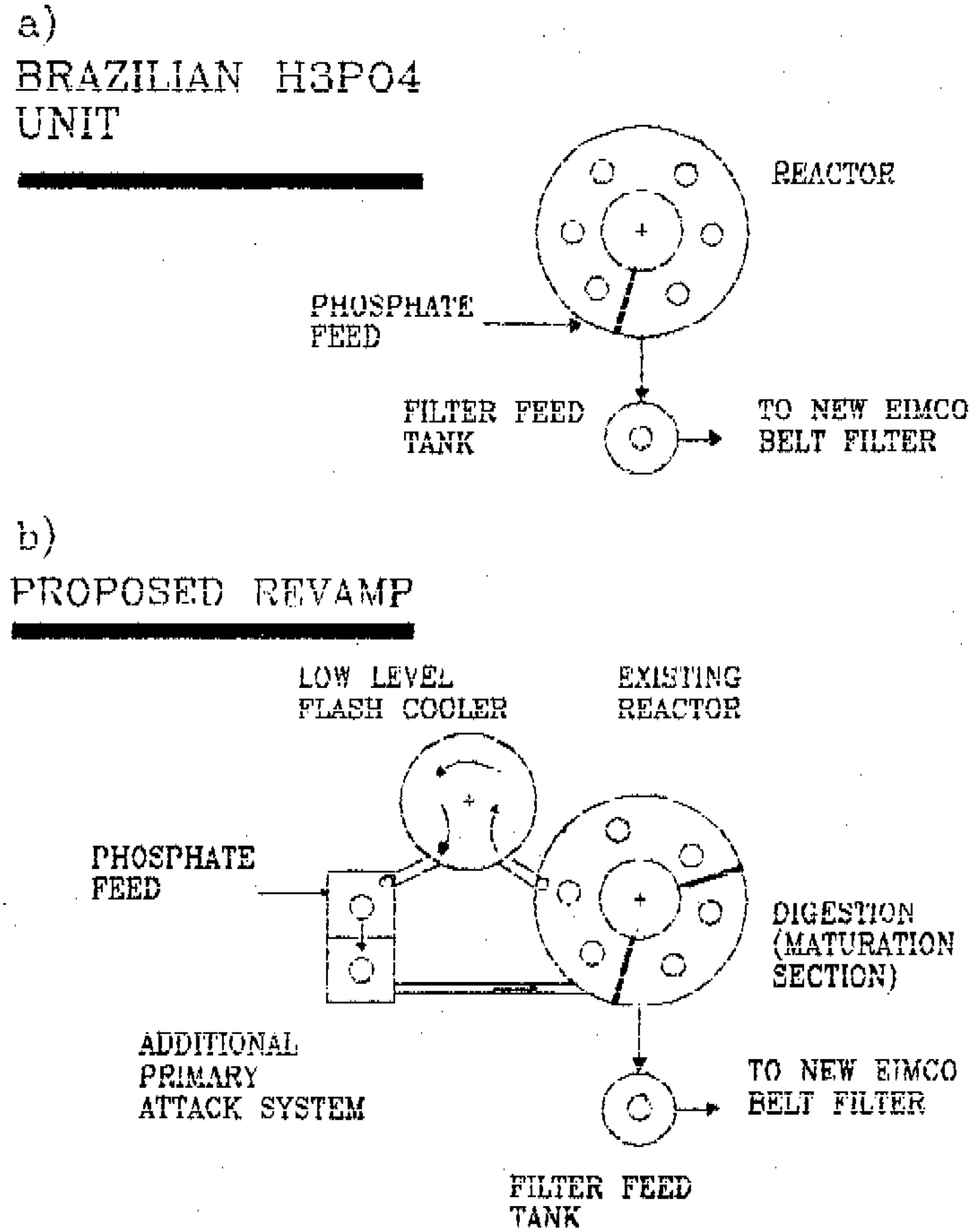
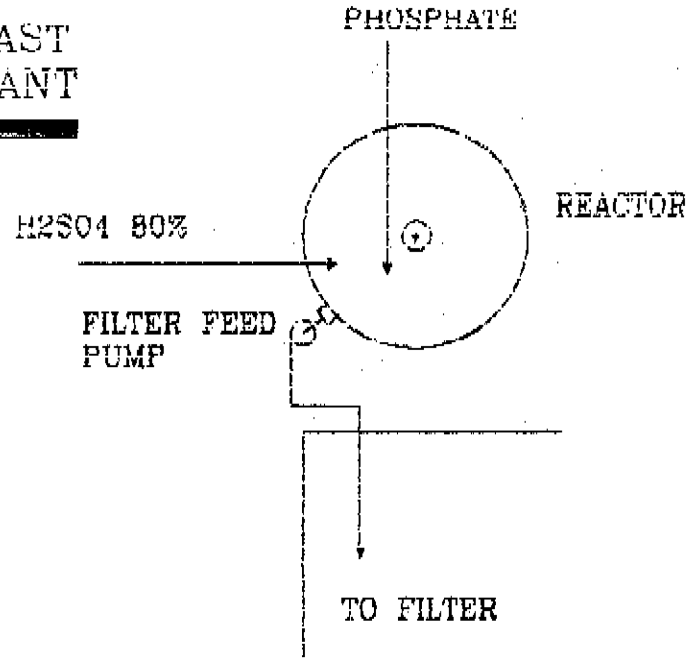

a)
BRAZILIAN H3PO4 UNIT
REACTOR
PHOSPHATE FEED
FILTER FEED TANK
TO NEW EIMCO BELT FILTER
b)
PROPOSED REVAMP
LOW LEVEL FLASH COOLER
EXISTING REACTOR
PHOSPHATE FEED
DIGESTION (MATURATION SECTION)
ADDITIONAL PRIMARY ATTACK SYSTEM
TO NEW EIMCO BELT FILTER
FILTER FEED TANK

FIG. 4

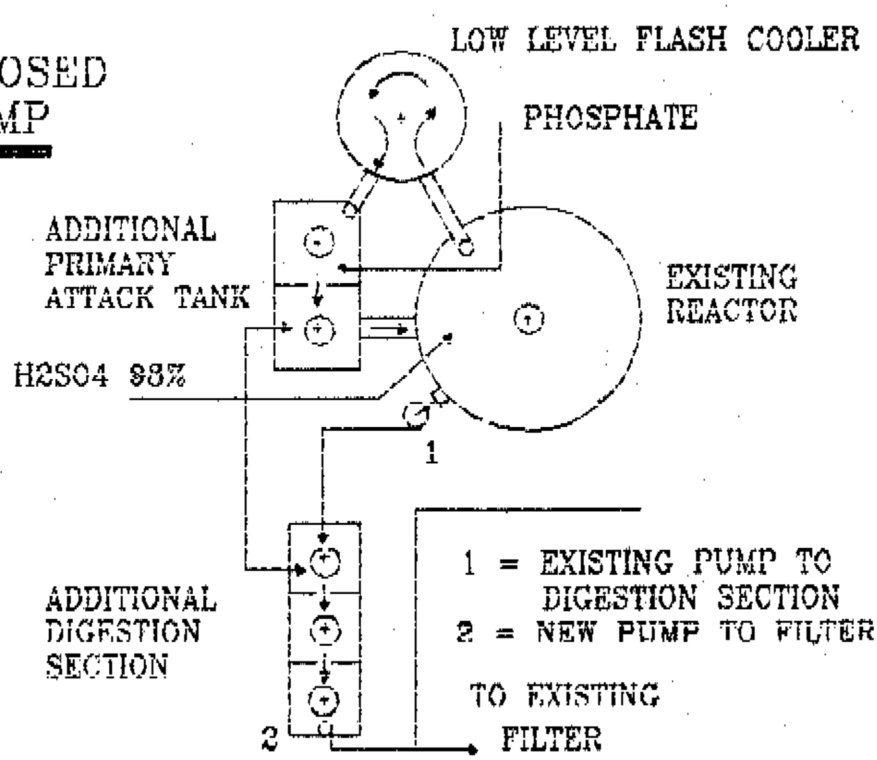
a)

MIDDLE EAST
H3PO4 PLANT



b)

PROPOSED
REVAMP



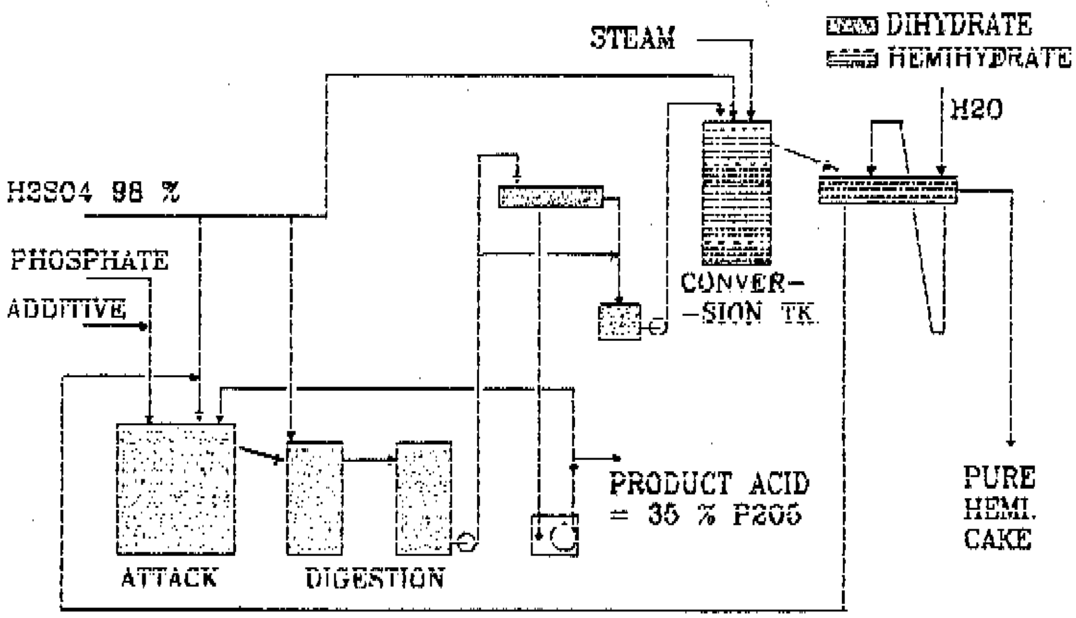


FIG. 5 A BASIC CENTRAL-PRAYON PROCESS FLOW-SHEET

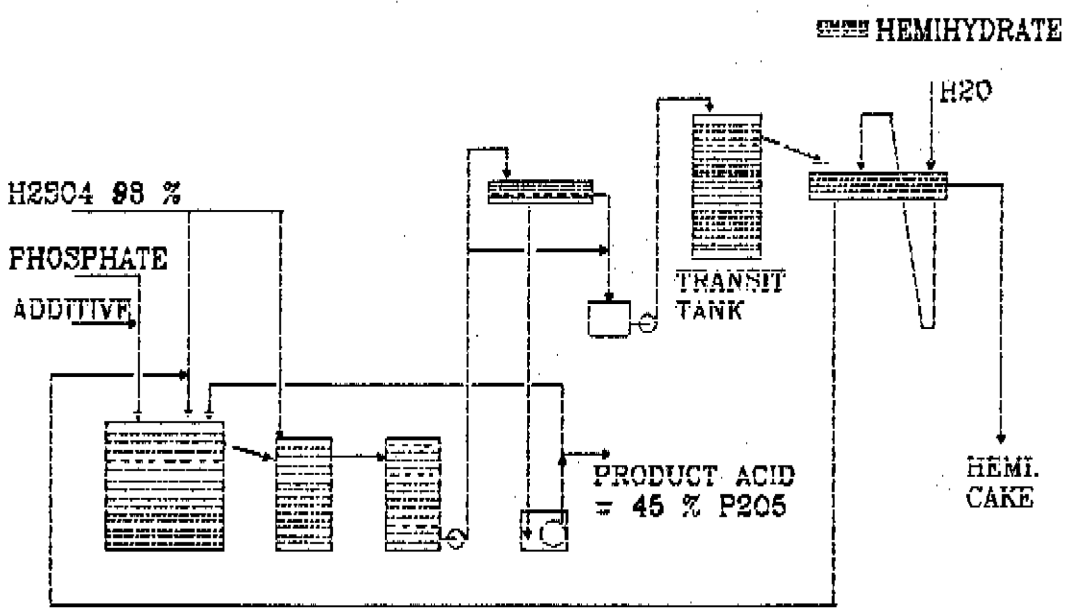
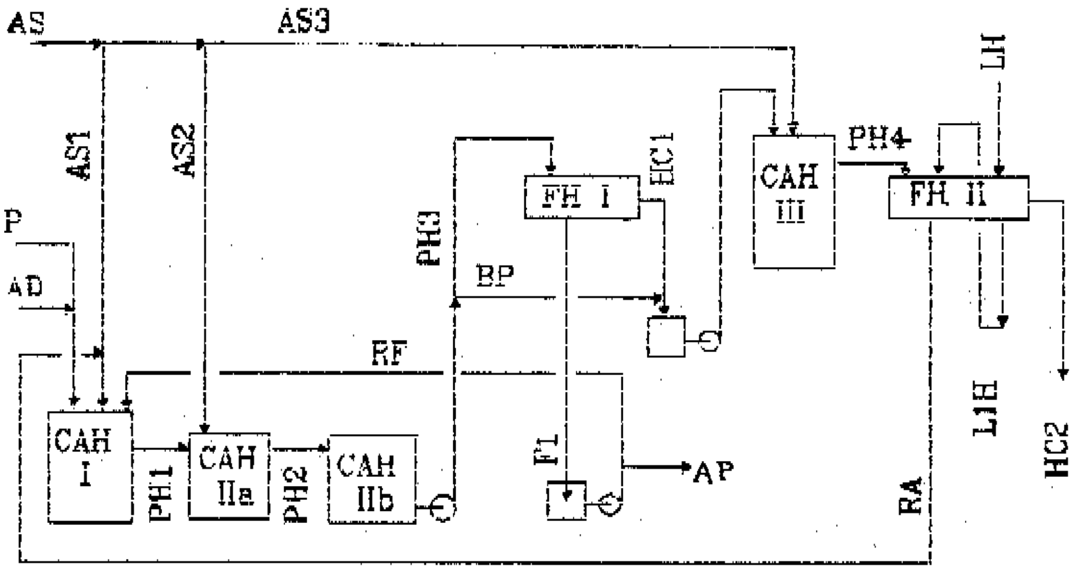


FIG. 5 B FLOW SHEET SHOWING CONVERSION OF ENCIS C.-P. PLANT TO OPERATION IN "PH 11" (SINGLE STAGE PRAYON HEMIHYDRATE PROCESS)

TABLE I - PRAYON PLANT - ENGIS "PH 11" INDUSTRIAL SCHEME



SYMBOLS :

PH 11 = PRAYON HEMIHYDRATE PROCESS/ONE CRYSTAL/ONE STEP
CAH I,II, III = HEMIHYDRATE REACTION TANKS
FH 1 = HEMIHYDRATE PRODUCT ACID FILTER
FH 2 = HEMIHYDRATE FILTER
P = PHOSPHATE
AD = ADDITIVE
AS 1, 2, 3 = 98 % H2SO4 TO HEMIHYDRATE REACTION TANKS
PH 1,2, 3,4 = HEMIHYDRATE SLURRY
FPH 1, 2 = FILTRATE OF HEMIHYDRATE SLURRY
BP = HEMI. SLURRY BY-PASS OF FH I
LH = WASH WATER ON FH II
L1H = 1st WASH ON FH II
HC 1 = HEMI. CAKE FROM FH I
HC 2 = HEMI. CAKE FROM FH II
F 1 = FILTRATE FROM FH I
AP = PRODUCT ACID
RF = RETURN FILTRATE FROM FH TO CAH I
RA = RECYCLE ACID FROM FH II TO CAH I

TABLE 2

PRAYON PLANT - ENGIS "PH 11" OPERATION

PARAMETERS AND DATA

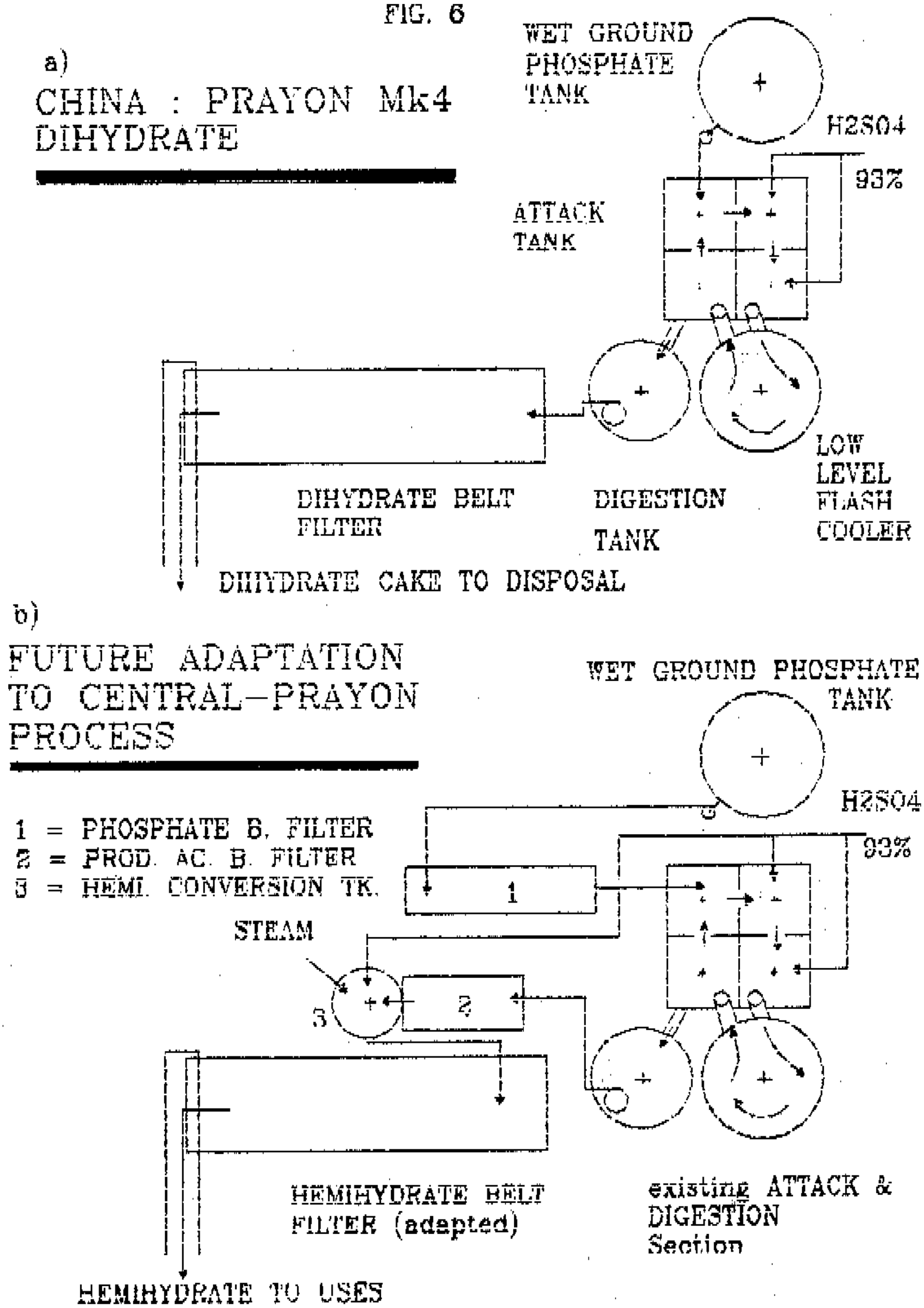
CAH I :	P	= 31 TO 39 T/H
	AS 1	= 98 % H_2SO_4 INTRODUCED IN # 2 & 3
	AD	= 1 % OF P
	V	= 1 M^3/T P_2O_5.24 H
	T°	= 85 - 90°C
	SO_3	= 10 Gr/l (RANGE = 8 TO 12 Gr/l) - (0.5 TO 0.8 %)
	d FPH1	= 1.51 - 1.52 (45 TO 46 % P_2O_5)
	d PH 1	= 1.68 - 1.7 (28 TO 30 % SOLIDS w/w)
CAH IIa & b :	AS 2	= 98 % H_2SO_4
	V	= 1 M^3/T P_2O_5.24 H
	T°	= 80 - 83°C
	SO_3	= 20 TO 25 Gr/l (1.3 TO 1.6 %)
	d FPH3	= 1.52 ($\geqslant$ 46 % P_2O_5)
	d PH3	= 1.68 TO 1.7 (30 % SOLIDS w/w)
FH 1 :	F1-AP	= PRODUCT ACID SEPARATION
CAH III :	AS 3	= ZERO FLOW
	V	= 0.5 M^3/T P_2O_5.24 H
FH2 :	PH 4	= TOTAL FLOW - TWO WASHES
		FILTRATION COEF. $\geqslant$ 6.5 T P_2O_5.24 H/M^2
	LH	= 50° C
	HC	= DRY DISCHARGE EVACUATION BY BELT CONVEYORS

PRAYON-PLANT ENGIS
PH11 OPERATION
ANALYSES :

TABLE 3

DESIGNATION	PHOSAH PHOSPHATE	A PROD FFAH II	SETTLED ACIDS (22/03/86)		HCFAH III CALCIUM SULPHATE
			Filter.acid	Concent. acid	
Density	-	1500 to 1520	1533	1664	-
- H_2O tot	0,16	-	-	-	-
- On dry basis 100 - 250°C	-	-	-	-	-
- H_2O 50-250°C					
P_2O_5 tot	39,8	45 to 47	46,1	55,8	1,3 to 1,6
CaO	54,2	0,10	0,059	0,021	39,5
SO_3	0,07	1,5 to 1,9	1,6	1,7	56,5
F	2,5	0,70	0,63	0,33	0,5 to 0,7
SiO_2	0,2	0,30	0,27	0,024	0,06
Al_2O_3	0,028	0,40	0,088	0,12	0,20
Fe_2O_3	0,31	0,30	0,42	0,53	0,015
Na_2O	0,088	0,002 to 0,004	0,002	0,009	0,065
K_2O	0,039	0,02	0,024	0,030	0,030
MgO	0,59	0,6	0,71	0,96	0,025
CT	0,57	0,05	0,05	0,05	0,05
U_3O_8	16 ppm	18 ppm	20 ppm	24 ppm	2 to 3 ppm

FIG. 6


a)
CHINA : PRAYON Mk4 DIHYDRATE
WET GROUND PHOSPHATE TANK
H2SO4
93%
ATTACK TANK
DIHYDRATE BELT FILTER
DIGESTION TANK
LOW LEVEL FLASH COOLER
DIHYDRATE CAKE TO DISPOSAL
b)
FUTURE ADAPTATION TO CENTRAL–PRAYON PROCESS
WET GROUND PHOSPHATE TANK
H2SO4
93%
1 = PHOSPHATE B. FILTER
2 = PROD. AC. B. FILTER
3 = HEMI. CONVERSION TK.
STEAM
1
2
3
HEMIHYDRATE BELT FILTER (adapted)
existing ATTACK & DIGESTION Section
HEMIHYDRATE TO USES

PROPOSED CONVERSION OF AN EXISTING DIHYDRATE UNIT TO PRAYON "PH 2" (hemi/di) PROCESS

FIG. 7

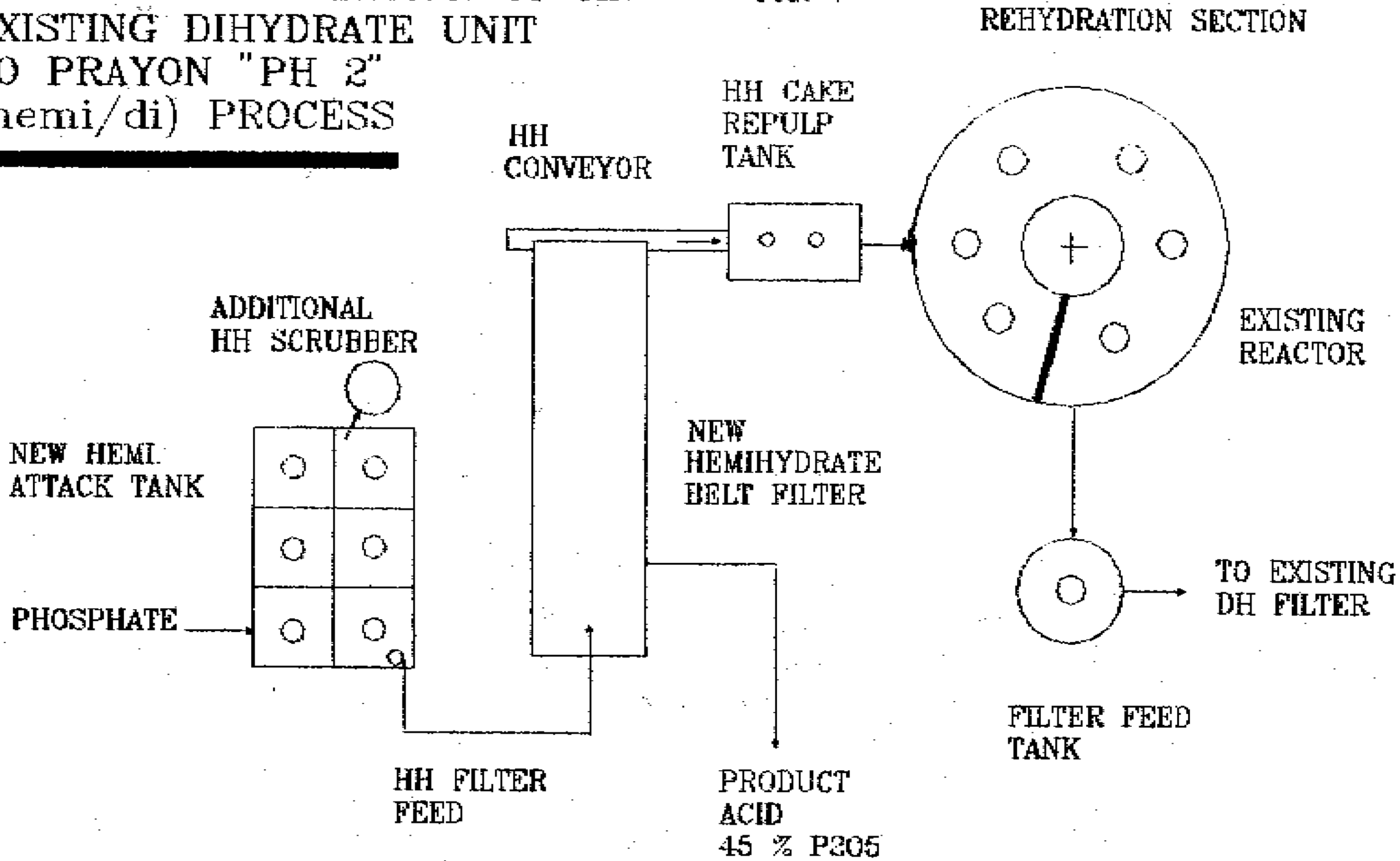
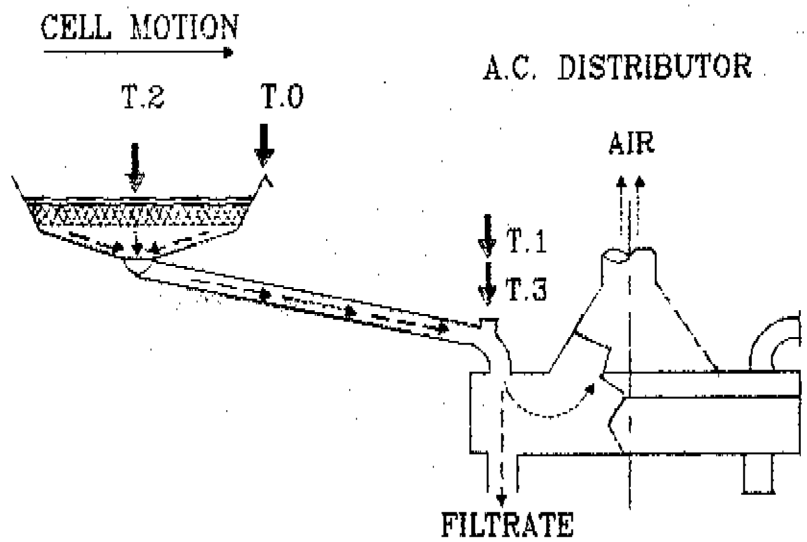
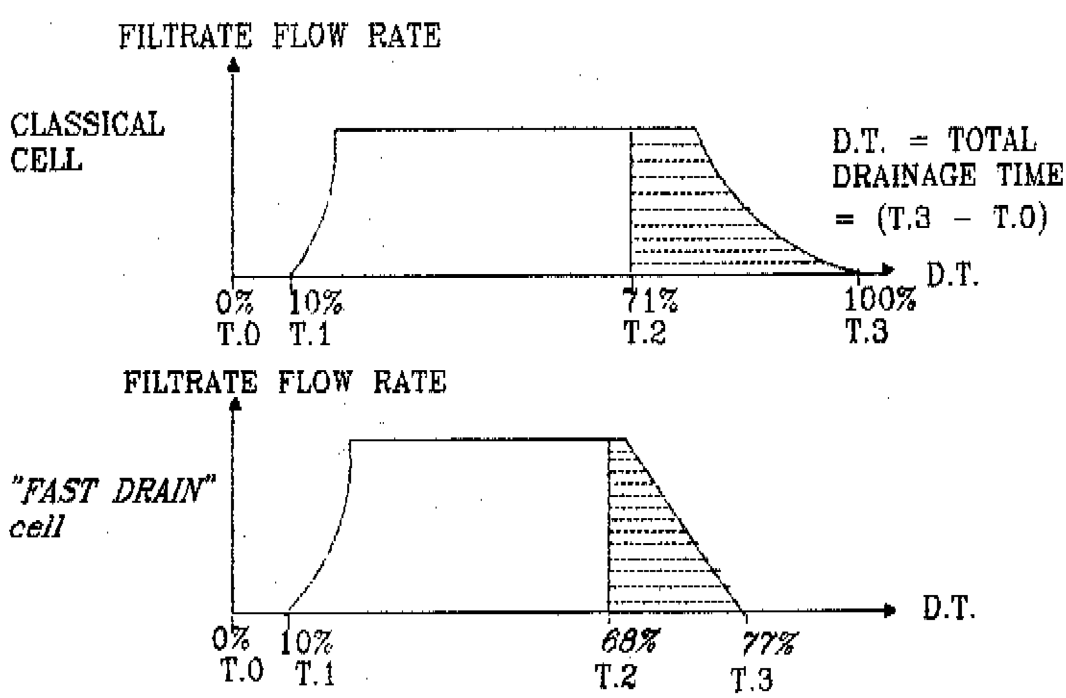


FIG. 8 PRAYON FILTER : "FAST DRAIN" CELL

a)



T.0 = FIRST WASH LIQUOR ON THE CAKE
T.1 = ARRIVAL OF FIRST DROPS IN DISTRIBUTOR
T.2 = CAKE SURFACE DRYNESS
T.3 = END OF FILTRATE



United States Patent [19] [11] **4,172,791**

Davister [45] **Oct. 30, 1979**

[54] MULTIPLE CELL FILTER HAVING A GAS DISCHARGE

[75] Inventor: Armand L. Davister, Liege, Belgium

[73] Assignee: Societe de Prayon, Prayon, Belgium

[21] Appl. No.: 730,637

[22] Filed: Oct. 7, 1976

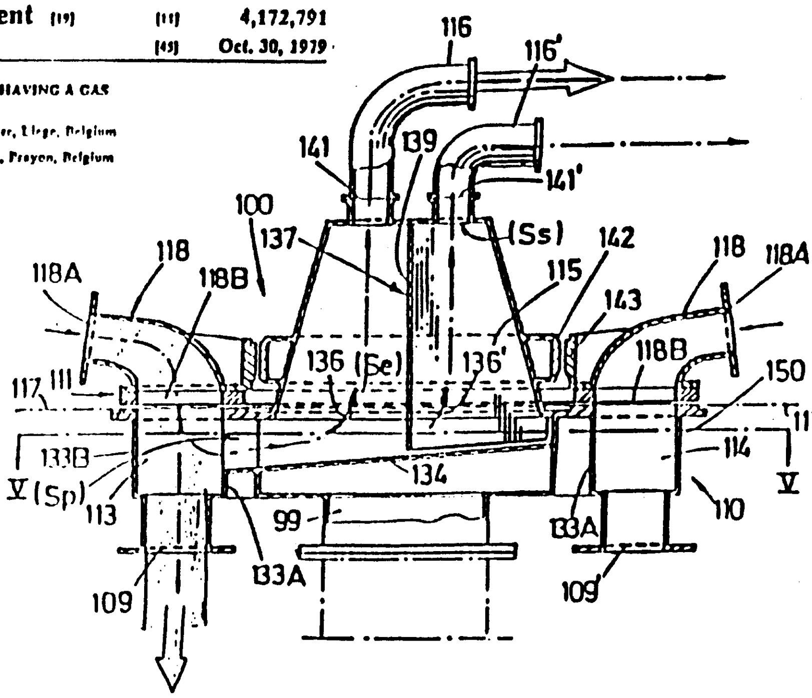


FIG. 9

United States Patent [19] [11] **Patent Number: 4,752,390**

Martin et al. [45] **Date of Patent: Jun. 21, 1988**

[54] ROTARY VACUUM FILTERS WITH A HORIZONTAL FILTRATION PLANE

[75] Inventors: Georges-Francois Martin, Flémalle; Armand L. Davister, Liège, both of Belgium

[73] Assignee: Prayon Developpement S.A., Belgium

[21] Appl. No.: 810,308

[22] PCT Filed: Feb. 28, 1985

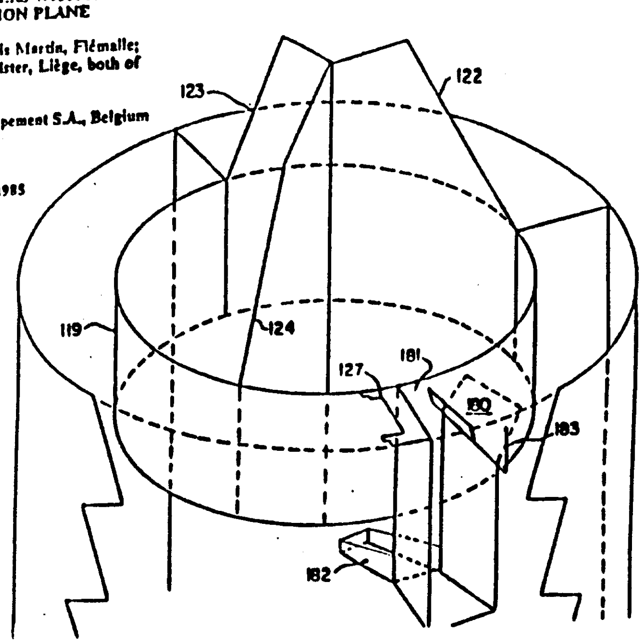


FIG. 10