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EFFLUENT CONTROL PRACTICES IN GRANULATION PLANTS

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As a final step in development of new fertiliser processes, the Tennessee Valley Authority in some cases designs, contructs, and operates demonstration-scale plants. The demonstration-scale plants are built in cases where a completely new product is involved, or when a new process development needs this further stage of proving before the industry can adopt it with full confidence. These plants are of essentially commercial size, with production rates usually ranging from 15 to 20 tons per hour. However, the plants are operated only part time as required to prove the process and to provide quantities of the various products for widespread agronomic field testing, for process evaluation as fertiliser intermediates, and for market development of new products. These units are operated only a few years, and operation is discontinued when the industry has established production capability for the new products.

During operation of the demonstration-scale plants, a number of improvements or innovations usually are made to allow greater process efficiency and economy. TVA's latest demonstration-scale plant is a granulation system that has three different process units. One is a rotary drum-type granulation system for an improved nitric phosphate process, a second is an inclined pan-granulation system for ammonium phosphate nitrate fertilisers, and the third is a process for TVA-developed ammonium polyphosphate using a pug mill or blunger for granulation. The three processes were developed in bench-scale and pilot-plant studies (1, 2, 3 and 4). Operation of the three demonstration-scale plants has been described (5, 6 and 7). A number of improvements and innovations have been made during operation of these demonstration units to eliminate losses in aqueous and atmospheric effluents. Significant savings have been achieved, and potential sources of atmospheric and steam pollution have been almost completely eliminated.

The purpose of this paper is to describe several of the process changes, revised operating conditions, and technique and equipment that have been used. A large part of this experience should be adaptable to other fertiliser process systems and therefore of interest to the industry.

UNIQUE PROBLEMS ENCOUNTERED

In this versatile granulation system the three basically different processes utilise in common several pieces of process equipment. Only one of the process is operated at a time, so it is possible to share equipment for drying, cooling, screening, crushing, and conveying, and a large part of that for air moving, dust collecting, and scrubbing. This has imposed some problems and minor compromises in operation, but also has allowed opportunities for significant innovations in recovery and utilisation of effluents. In early operation, the process losses were quite high and comprised a major part of the losses in the closely monitored effluents from the TVA fertiliser facilities. Over a period of about 3 years the improvements have essentially eliminated losses by closed-circuit effluent control that allows full return of recovered materials to the processes.

DUST CONTROL AND RECOVERY

A major problem in all fertiliser granulation processes is dust control and collection, and recovery of this particulate matter. Dust is present in some feed materials and is generated at several points because of attrition in granulators, rotary dryers and coolers, crushing and screening equipment, and conveyors and elevators. Unless dust is confined and collected, a fertiliser granulation plant becomes a messy, unpleasant place to work. Losses can be significant, and stack effluents can impose problems for the surrounding neighborhood.

General Practices

Several improvements were made in the TVA demonstration plant granulation system to provide for improved dust control and recovery. Although the situation still is not ideal, some of the techniques have been quite effective and may be of general interest. In the initial design, cyclone-type dust collectors were installed, and wet scrubbers were provided on all major air-handling systems. In addition, scrubbers were provided for miscellaneous dust pickup points. In early operation, other sources of in-plant dust emission were identified, mainly at material transfer points, and these were connected to collection and scrubbing systems. A few additional scrubbing circuits were provided later. A recognized general shortcoming in the initial plant layout was several long horizontal runs of ductwork that are subject to severe settling out of dust. Some of these were required because of sharing of equipment by the three processes. This experience points out the importance of designing ductwork for dust and fumes as short and direct as is practical and of ensuring adequate air velocity in them. Air velocity in ducts carrying dust should be in the range of 65 to 85 feet per second. Also, aluminium ducts have been found to be easier to keep clean than ducts made from other materials that were tested in the plant.

Crushers, such as cage mills or chain mills, are a major source of dust. Housings and seals around shafts must be tight. High shaft speed usually results in more dust formation ; operating experience can establish speed of rotation that gives adequate crushing without excessive dust. A simple bypass system for cycling of a large part of the air involved in the fan-type action of the crushers has been found to be quite effective in TVA experience in minimizing dust problems. A sketch of this arrangement is shown in Figure 1. Screens are another major contributor to dust problems. Although screens can be largely enclosed with hoods, ductwork to dust collection systems is difficult to maintain because of vibration that results in breakage. Flexible connections between screens and ducts have been found to be helpful. Although not used in TVA plant, a very good practice is to enclose screens and crushers in a simply constructed room. This will isolate these major sources of dust, confine the dust, and allow cleanup without dispersion into other parts of the plant. Provision for such a feature would be comparatively simple and inexpensive if planned for in the initial design of a granulation plant. If it is not feasible to enclose crushing and screening equipment, use of solid floors instead of grating around this equipment helps confine the dust to this area of the plant.

Other major sources of dust within the plant that contribute to environmental dust problems are material transfer points at the terminal of belt conveyors, at the boot and discharge of bucket elevators, and where cyclone dust collectors discharge onto conveyors. Venting of bucket elevator housings by providing a duct to one of the dust collecting and scrubbing systems is simple and effective. Partial hoods and ducts with good air pickup velocity at material transfer points are essential. Pickup velocity in the range of 2 to 8 feet per second is desirable. Enclosure of belt conveyors in the section where dry dust collectors discharge is essential, or fully enclosed systems such as drag conveyors can be used. TVA has not had good experience where dust and fine material are handled with enclosed conveyors that use cast iron drags and linkages. Binding of the linkages caused by the fine material and dust results in breakage and excessive maintenance.

Tendency of fine material to adhere to belt conveyors and later fall off as the belt passes to the underside of the pulleys is a common problem in dust control and plant cleanliness. Use of brushes or other devices at the end of belt conveyors for cleaning appears to be a good idea, but such devices have not been very effective and reliable in the TVA plants. Buildup and caking of hygroscopic fertiliser dusts usually make these belt-cleaning devices ineffective after short periods. In the TVA plant, the installation of simple plywood or metal collection pans beneath some of the worst points has been helpful. Material that gradually collects can be readily removed at intervals.

Dust particles that adhere to product granules as the material passes through various handling systems (often referred to as "piggyback" dust) can cause problems by sluffing off later at transfer points or in storage and handling. In the TVA plant, practices to avoid recontacting dust from collection systems with the coarser material have been effective in alleviating this problem. A comparatively simple change in routing of fines from the screens directly to the pug mill where it was wetted and granulated accomplished this in the ammonium polyphosphate system.

Dust control in the plant now is effective enough that prescribed maximum levels of 15 milligrams per cubic meter of air are not exceeded except very near the cage mill crushers.

Wet Collection of Dust from Cyclones

TVA has developed and used effectively a system for collection of dust discharged from dry cyclones by collecting it directly as a solution or slurry. This practice worked well for completely soluble dusts in a previous ammonium nitrate operation and was incorporated in the original design of the pan-granulation system. In this system the circulating liquor contained from 4 to 5% N and 15 to 18% P_2O_5 and was at a temperature of about 38° C (100° F). There were essentially no solids in the liquor. A sketch of a cyclone with the wet collection system is shown in Figure 2. Moisture in the cyclones resulting from the direct discharge to the dissolving pots is no problem. The performance is similar to that of cyclones using a conventional dry discharge system. During the first few hours of operation, there is some problem of wet material in the cyclone, but after the cyclone has come to normal operating temperature the moisture problem no longer exists. Later this type of cyclone discharge system was successfully adapted to the nitric phosphate process where the dust is only partially water soluble.

FUME CONTROL AND RECOVERY

Control and recovery of vapors and fumes from fertiliser processes are of equal or greater significance than control of dust. Such fumes are evolved from reaction equipment in solution or slurry systems, from evaporators, granulators, and dryers. Evolution can be minimized by proper design of equipment and control of process conditions, but with standards now required recovery likely will be necessary from essentially all exhaust gas systems before discharging to the atmosphere. Several process changes and equipment modifications were made in the TVA granulation systems to allow adequate recovery.

Changes in Process and Equipment

In early operation of the pan-granulation system for production of ammonium phosphate nitrate grades, such as 30-10-0 and 25-25-0, loss of ammonia from the solution preparation system was high. Pilot-plant development work had demonstrated the importance of using two stages of ammoniation of the mixed nitric and phosphoric acids, with an evaporator located between stages. The pH was maintained low enough in the first stage to avoid excessive loss of ammonia there and in the evaporator where the solutions were concentrated to about 96%. Final ammoniation after evaporation allowed low loss from this stage. Because of different operating characteristics of equipment after scale-up to plant size, the pH in the first stage had to be decreased to avoid high loss from the evaporator. As a result the final ammoniation stage was overloaded and loss of ammonia from that vessel was excessive. After full evaluation of several schemes, including some that would require expensive ammonia recovery equipment, the simplest and lowest cost alternative was replacement of the original second-stage ammoniator with a larger vessel. This change allowed operation of the first stage at the lower pH ((1.6) which essentially eliminated loss from this stage and the evaporator ; the larger finishing stage of ammoniation operated with very low loss that could be adequately recovered in the existing scrubbing system. This was a case where a change in equipment and operating conditions to minimize evolution of fumes was a much better solution than installing more elaborate and costly recovery equipment.

Another early problem was excessive entrainment loss because of boiling and foaming in the preneutralizer vessel of the nitric phosphate system. Installation of additional freeboard to provide a 9- by 18-foot vessel instead of the original 9- by 10-foot one solved this problem. These changes were made in the plant after bench-scale tests in glass equipment visibly demonstrated the cause of the problem and means for correcting it. These tests also indicated that a mechanical agitator would not be required in the modified preneutralizer and this facilitated the change and decreased the cost. Sometimes a return to the laboratory for rather simple tests is advisable to determine means for eliminating a problem in plant losses and effluent control. This particular experience points out the importance of providing in initial design generous freeboard on process vessels where vigorous reaction and foaming are likely.

In pilot-plant development of the pan-granulation process for ammonium nitrate-based fertilisers, the potential problem of dust and fume control at the pan was difficult to evaluate. As a result, installation of fume and dust hoods at the pan granulators was deferred in initial design and construction of the demonstration plant system. Early operating periods showed this area to be a serious source of dust, and moderately severe source of ammonia evolution in the plant. After observation of the problem in the plant and some design studies, a very effective hood and scrubber system was installed to completely correct this problem. The actual plant operating experience provided a very sound basis for designing and installing the corrective equipment (including use of short, direct ductwork with smooth sweep bends to avoid problems that had been encountered with other ductwork, design of the hoods to allow good access and adequate visibility into the pans while in operation, and selection of a type of scrubber that had been effective in other systems). Also, sloping the ductwork downward from the pickup point to the scrubber allowed the ducts to be steamed or washed during operation. But, in the early operating periods before installation of the hoods, the serious dust evolution resulted in dispersion of dust throughout that area of the plant. This area was difficult to clean up and some evidence of the early problem is still visible. This experience points out that, in essentially all cases, taking corrective action on any potentially serious dust and fume problems in initial plant design would be highly desirable even though the problems may not have been fully evaluated in development work.

RECOVERY AND REUSE OF AQUEOUS EFFLUENTS

Aqueous effluent streams from fertiliser plants present problems fully as serious or perhaps more so than those by atmospheric effluents. Very significant process losses with serious economic impact can continue undetected if surveillance is not active and continuous and if corrective measures are not taken. In early operating periods of the three processes in the TVA granular combination fertiliser unit, losses were quite high. Atrocious losses of as much as 2 to 7 tons each of N and P_2O_5 per day occurred in the very early days. To avoid losses to a public stream, an expedient of discharging substantial quantities of liquid effluents (mainly from cleanup and floor sump) to collecting ponds was employed in early operation. More effective collection and reuse practices were worked out as operation continued.

Recovery and Reuse of Floor Sump Wastes

The granulation plant system was built with an effective floor sump for collection of spillage, floor washing, pump leakage, etc. However, return of this liquor directly to process was considered inadvisable for the nitrate-based system because of contamination with grease and oils. Several methods of removing oils and other contaminants from the aqueous wastes were studied, some that would involve expensive oil-removal equipment. An infrared spectrophotometer was purchased and used for determining the amount of oil in the aqueous wastes and for evaluating the methods of removing the lubricants from the waste solutions. It was found that the oil and other contaminants could be effectively removed from the aqueous wastes by settling and decantation if an excess of absorbent solids was thoroughly mixed with the waste liquor. The oil adhered to the absorbent solids which settled. None floated to the surface. The clear liquor above the settled solids contained only about 1 ppm of oil after settling for about 6 hours ; this degree of separation was better than would be expected by other alternatives. A mechanical mixer was installed in the floor sump to thoroughly mix the oil and solids with the sump liquor. Ordinarily, enough diatomaceous earth conditioner is lost from the product coating system to provide solids for absorbing the quantity of oil that collects in the floor sump.

After the possible systems for processing the sump liquor in existing or improvised equipment had been evaluated, it was decided to use three abandoned nitric acid storage tanks for processing the aqueous wastes during operation of the pan-granulation and ammonium polyphosphate systems. One of the tanks is used for continuous settling and decantation of the sump liquor and the other two tanks are used alternatively as batch receivers for the clarified solution. After analysis for oil content, the clarified liquor from the tank is returned to the plant as makeup solution for the scrubbers while the other tank is being filled. It was necessary to make only minor modifications to the tanks consisting primarily of additional piping around the tanks to adapt them for an effective settling system. Plastic pipe that is inexpensive and easy to install was used for carrying the liquor between the plant and the settling system. A flowsheet for the aqueous waste treating and recovering system is shown in Figure 3.

During an operating period of about 12 months, reuse of this liquor resulted in savings of about $ 45,000 in process materials. This is a very good return on the modest investment of about $ 8,600 in adapting these facilities for recovery. What had been a serious source of losses, with indication of a difficult and perhaps costly oil-removal step, was corrected essentially by use of existing facilities. This effluent return system is operated as nearly as is practical to reuse the material in each process independently. However, size of the existing collecting tank system that was adapted to this service allows use of effluent from one process in a later operating period of another. After extended periods of operation, the settled solids are removed by slurrying and fed to the nitric phosphate process.

Other effective housekeeping procedures that have been helpful include use of sump liquor instead of fresh water to supply hoses for washing down the floors and especial attention to pump maintenance to minimize leakage. Also, removing of most of the spillage as solids for return to the granulator or dryer has been effective in decreasing the amount of nutrients in the floor sump.

Closed-Circuit Scrubbing System

Wet scrubbers are needed on essentially all air-handling or vent systems in fertiliser granulation plants for final removal of dust and recovery of fumes. Although properly selected and operated systems can effectively remove the fumes and particulate matter, return of the recovered dilute solutions or slurries to process often is difficult or impractical. This was particularly the case for the nitric phosphate system in the TVA plant that has limited tolerance for water input without serious decrease in production rate. Also, the granular ammonium polyphosphate system can use even less water because the product must be anhydrous to retain the desired polyphosphate content. Because of these severe limitations, it was necessary to develop several innovations in equipment and operating technique to allow full reuse of collected effluents within the restrictive water tolerances.

Very likely the most important innovation from our operation that should be of interest to others is a closed-circuit scrubbing system. This system makes effective use of evaporating capability of the air passing through the scrubbing systems. This was facilitated in the TVA plant by the availability of several systems with high air-handling capability. The circuit that was evolved for handling and reuse of the nitric phosphate liquid effluents utilised several of the available scrubbers in series. The necessary water input was controlled as low as practical and was fed to the scrubbing points that required dilute solutions. Recirculation to each scrubber was employed as much as possible, and liquor was fed forward to other scrubbers in the full circuit. The liquor fed forward became more concentrated with soluble materials in solution and insolubles in suspension. In selecting scrubbers for handling liquids with substantial amounts of suspended solids, it is important to minimize complex initial structure and to particularly avoid spray nozzles or other parts with small openings that are subject to plugging. The existing scrubbers were made suitable for this type of operation by replacing all spray nozzles with $\frac{1}{8}$-inch nipples.

A simplified flow diagram of the closed-circuit scrubbing system as used in the nitric phosphate process is shown in Figure 4. This system has available scrubbing circuits with total air-handling capacity of about 157,000 cfm. The adiabatic evaporation obtained, particularly in the large scrubber that handles gases from the dryer, decreases water content of the total input of about 30 gpm to only about 4 gpm in the concentrated slurry fed back to the process. Without use of the "built-in" evaporation system that requires no heat input, return of scrubbing liquids to this process without drastic decrease in production rate would not be possible. It was necessary to control pH of the scrubbing liquid in some of the circuits by addition of a small amount of nitric acid to avoid excessive loss of ammonia in the exhaust gas. The temperature of the scrubbing liquor ranged from 38° to 46° C (100°-115° F).

It was necessary to use antifoam agents in the reaction system of the nitric phosphate plant and in the closed-circuit scrubbing system. A sulfonated oleic acid type was the most effective at the low pH condition (2 or less) in the extraction system and a silicone type at the high pH condition (about 6) in the scrubbing system. Requirements of the two materials was about 0.5 pound of the oleic acid at a cost of about 8 cents per ton of product and about 0.1 pound of the silicone type at a cost of about 5 cents per ton of product.

Condensing-Type Scrubber

Fertiliser process fumes of the general "aerosol" type that are formed in neutralization of nitric acid while preparing solutions that contain ammonium nitrate are difficult to recover by use of conventional scrubbing equipment. High energy-type scrubbers that are quite expensive are required. Fumes from the boiling preneutralizer of the nitric phosphate process are of this type. In pilot-plant development work on the process a comparatively small and simple direct-contact, condensing-type scrubber proved to be very effective. The preneutralizer vessel was closed to avoid airflow and the comparatively small steam flow in the exhaust was readily condensed in direct contact with sprays of water in the scrubber. This technique was extremely effective, and there was no fume or visible plume on the stack ; prior to use of the condensing scrubber, the stack had a very heavy and persistent plume of steam and nitrate aerosol.

This condensing scrubber was scaled up linearly for installation in the demonstration plant system, and the unit has proved to be just as effective as in the pilot plant. This scrubber is only 2½ feet in diameter and 10 feet high and is fitted with five 1¹/₄-inch spray nozzles of the open, single-fluid type.

Once-through water at a rate of about 150 gpm was originally used. Process material recovered in the spray tower had to be discharged from the plant because such large volumes of water could not be returned to the process. Later this scrubber was adapted to use scrubbing liquor instead of fresh water and was included as an important integral part of the closed-circuit scrubbing system (Fig. 5). The water collected by condensation is removed by the evaporative capability of the air in the conventional scrubbing systems.

Indirect cooling for condensation could be used for this type of scrubber to minimize problems with water balance, but exploratory tests indicated that coating of cooling surfaces would probably impose a problem.

Use of Hydraulic Cyclone

A small and simple, but very effective, hydraulic cyclone was built and installed as the final unit in the closed-circuit scrubbing system of the nitric phosphate process as the latest major improvement. A sketch of this device is shown in Figure 6. It is installed to discharge into the second extractor effluent as it enters the preneutralizer vessel. Proper operation depends on a high rate of flow that gives adequate velocity for promoting centrifugal settling of the coarser solid particles and their removal in the discharge flow. In a recent period of operation, the following data were obtained.

(See table overleaf)

	Scrubbing liquor		
	Cyclone feed	Cyclone underflow	Cyclone overflow
Rate, gpm	100	4	96
Analysis, %			
Total N	13.4	13.6	13.4
Total P_2O_5	6.8	8.6	6.7
Solids	8.9	16.1	8.5

With coarser particles removed from the circulating liquor, it was possible to maintain a higher average solids content of the liquor without causing stoppages in the scrubbing system since the coarse particles are the primary cause for stoppages. Maintaining a higher solids content in the liquor essentially eliminated the need for adding makeup water to the system. The thickened slurry returned to process has contained as much as 900 pounds per hour of combined nitrogen and phosphate nutrients.

OPERATING TECHNIQUES

Operator attention to the wet scrubbers and dissolving pots is essential. Prior to the use of the hydroclone, settling out of the sand-type material in the pots and resultant stoppages were very frequent. If the specific gravity in any part of the system gets too high, the scrubber trays in that particular section will begin to plug and this results in a restriction in the airflow. When this occurs, it is sometimes necessary to empty the scrubber, fill it with water, and dissolve the solids (or reslurry them). In some cases with severe stoppages, the manways must be removed and an operator sent inside the scrubber to wash and shovel out the material.

If the scrubbers are allowed to overfill, the solution runs back into the fans. At times, the solution is slung out of the fan housing at the shaft. With unprotected bearings, the solution is slung directly onto the bearings, thereby shortening their life.

At times, the dust in the airstream through the fans will collect on the fan blades in amounts sufficient to cause severe vibration. Unless the operator shuts off the fan and washes it, the fan shaft and bearings will be damaged.

Use of Conductivity Cells

TVA has utilised conductivity cells (probes) to immediately detect excessive losses in aqueous effluent streams from all process areas. This comparatively simple and inexpensive procedure has been quite effective in quickly detecting losses because of leakage, spills, or abnormal operation (8). Effluent water streams from the granulation plant area, acid plants, tank farms, and other locations in the plant are continuously monitored in this way. The rapid detection of losses and correction of the problem have been very helpful in improving operating efficiency and economy and decreasing pollution.

CONCLUSIONS

Although we do not claim to have an ideal plant from standpoints of dust and fume control and recovery, very much has been accomplished by diligent work and cooperation of development, design, and operating engineers, plant operators, and supervisory personnel. High process losses have been essentially eliminated by closed-circuit effluent control, and the plant is a much more pleasant place to work because of innovations in dust and fume control. Also, the improved plant environment and process efficiency have been reflected in better general operation of the three fertiliser processes and morale of operating personnel.

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LIST OF FIGURES

DISCUSSION

Mr. R.D. YOUNG (Tennessee Valley Authority, U.S.A.) : This paper reports on our experiences at T.V.A. in control and recovery of effluents in a multipurpose granulation plant facility. The paper is general and somewhat philosophical rather than technical. The demonstration plant has units for three processes : a drum-granulation unit for a nitric phosphate process, a pan-granulation unit for ammonium phosphate nitrate products, and a pug mill or blunger system for granular ammonium polyphosphate. The variety of equipment involved and the sharing of a large part of equipment by the three processes created some problems - but this afforded some particular opportunities in control of the aqueous and atmospheric effluents.

Some main points I would like to emphasize are shown on the following slides.

Slide 1

- Equipment design and operating techniques to eliminate or decrease losses in effluents should be the main effort (an ounce of prevention is worth a pound of cure, or for this ISMA conference I should say, "a gram of prevention is worth a kilo of cure").

- Design and maintenance of ductwork for dust and fumes are very important.

  1. Ducts should be short and direct with smooth sweep bends and slope to facilitate cleaning.
  2. Air velocity in ducts is important (65-85 ft/sec. ; 21-27 meters/sec. is a good range).

- Confinement and collection of dust requires particular innovations in each situation to cope with particular problems.

Slide 2

- Return of scrubbing liquids to process requires good planning and control - particularly when the water balance is tight.

- Utilisation of evaporative capacity of air in scrubbing systems can be very effective in allowing return of liquids to process. A later slide will illustrate this point.

- Simple expedients and techniques can be quite effective.
  1. Sump water for floor washing.
  2. Bypass on crushers.
- Good control and recovery of effluents lead to better overall process efficiency.
  1. Monetary savings.
  2. Cleaner working conditions mean better morale and efficiency for all employees.

I would now like to show a few slides of some simple but effective techniques and equipment we have used. (slides were shown and explained of equipment in Fig. 1, 2, 3, 5 and 6 of the manuscript and of another that illustrated effective use of evaporative capacity of a scrubber. A reproduction of this last slide follows).

Mr. E. UUSITALO (Rikkihappo Oy, Finland) : Effluent of waste products from industry, into the factory and environment, has always been considered a very important technical and economic question. But in this "Conservation Decade" the question is even more pertinent. Up to now there have been several presentations at this Conference concerning effluent control and the environment.

This paper deals with various problems connected with waste products in a fertiliser plant. The reported procedures for reducing the amounts of waste products have been carried out at the T.V.A. fertiliser plant in connection with nitrophosphate, ammonium phosphate nitrate and ammonium polyphosphate processes. There was a very suitable starting point for the experiments in that the fertiliser unit in question at first had 2 to 7 tons losses of nitrogen and phosphorus per day, which is a relatively high quantity. Several methods for improving on this have been described in connection with the conveyors and especially the connecting links of the conveyors, with a view to reducing the amount of dust getting into the environment. There have been presented results of interesting and important experiments comparing the amounts of dust from different types of crushers and screens. It is recommended that the screens should be built in a separate room and the same recommendation may be applied to the crushers. This has already been done in many new fertiliser factories. The dust is first separated from gas in currently known dray cyclones. As a means of making the usual cyclones more suitable and perhaps more flexible too, there is the dissolution of materials which are separated from the cyclones and introduced into the process, in cases where dust is especially soluble in water. With these arrangements a low amount of dust in the factory, of 50 mg/m^3, has been obtained. For separation of fog and drops in the process, gases containing ammonia are washed with nitric acid or phosphoric acid, and it is recommended that ammoniation should be divided into several steps. By increasing gas volume in the reactors considerable improvements have been achieved. The closed water circulation system was developed at the plant to reduce the fertilisers precipitated and dissolved in water and to limit the quantities of water to a minimum. In this way it is thought that annual savings of about $ 45,000 have been obtained from an investment of $ 8,600. This is an excellent result. Insoluble nutrients are removed from the closed water circulation system by using hydraulic cyclones and nozzles have been developed for the purpose. All these improvements have made the factory environment much better. These improvements are surely very economic and are good technology. The authors have given us quite a lot to think about.

Before we start the discussion I should like to put a few general questions connected with the subject of the paper and which were not made quite clear in the paper. They may give a better indication for continuous running plants.

My first question to Mr. YOUNG is how much fertiliser can the plant in question produce per year, and what are the amounts of nutrients getting into the environment after adoption of the reported methods assuming the plant to be in operation about 300 days per year ? How are these losses distributed in the atmosphere, water courses and the environment ?

Secondly, the intensified recovery of waste products and the closed water circulation, with all their control and warning arrangements, involve increased surveillance. How high does the speaker estimate the annual cost to be, either in working hours or in cash, due to these increased functions ?

Thirdly, the intensification of gas washing nearly always means increased pressure losses in the cyclones, scrubbers etc. How much additional force must be applied to the process because of this ?

Fourthly, in the paper, dust and drop losses are given for the nutrients nitrogen and phosphorus. What is the situation in respect of fluorine, how high has the fluorine content in the circulating water risen and how much fluorine is released into the atmosphere after adoption of these improvements ?

As a final question, what kind of detrimental effects did the plant in question have earlier on the environment and did the above methods improve the situation so as to be noticeable ?

Mr. YOUNG : Your first question concerns the capacity of the plant. This is a demonstration plant which we operate on an essentially commercial scale, but only part time on the different processes. We have a capability of from 100,000 to 130,000 tons/year. Losses have been decreased to essentially nil after all these improvements. We have a completely closed circuit water system except for bagging and shipping. We check it regularly and find that we only get small amounts of the diatomaceous earth conditioner in this particular stream. The only gaseous effluent of which there is not quite good recovery is that from the extractor in respect of oxides of nitrogen. We use simple water scrubbing and this does not remove a high percentage of the oxides of nitrogen, but the actual amount involved is well within the total tolerance for the plant. At present we have more ammonia loss from one of the scrubbing circuits than we like. We think this will require some adjustment in the operating conditions rather than adding more acid to the scrubbing circuit.

Your second question concerned the intensified efforts for recovery and what this might cost in money, manpower and time. Actually, in this particular granulation plant no one spends any appreciable time on this particular effort. The operating people have taken over completely after a period of about three years and they take a great deal of interest not only in maintaining these standards but trying to improve them. However throughout the rest of our plant complex we have a number of other problems concerned with our phosphorus furnaces and other activities. Here we have a great deal more improvement to accomplish. We have two or three people who devote a large part of their time monitoring and trying to suggest and effect improvements in this system. We actually need more involvement in this area. We have a great deal more work to do in the plant complex as a whole.

The third question concerned scrubbing and collection of dust and carrying solids in scrubbing circuits. These always increase problems in the dry cyclones and in the scrubbing circuits and he asked what additional equipment cost and what difficulties had been involved in this effort. We found that we needed to add two or three additional scrubbing circuits to the plant after it was built to effect good control. We do have to pay a good deal more attention to scrubbers when we are carrying considerable amounts of materials in solution and in suspension. The original spray nozzles in the scrubbers were replaced with open pipe nipples to allow operation with the slurries.

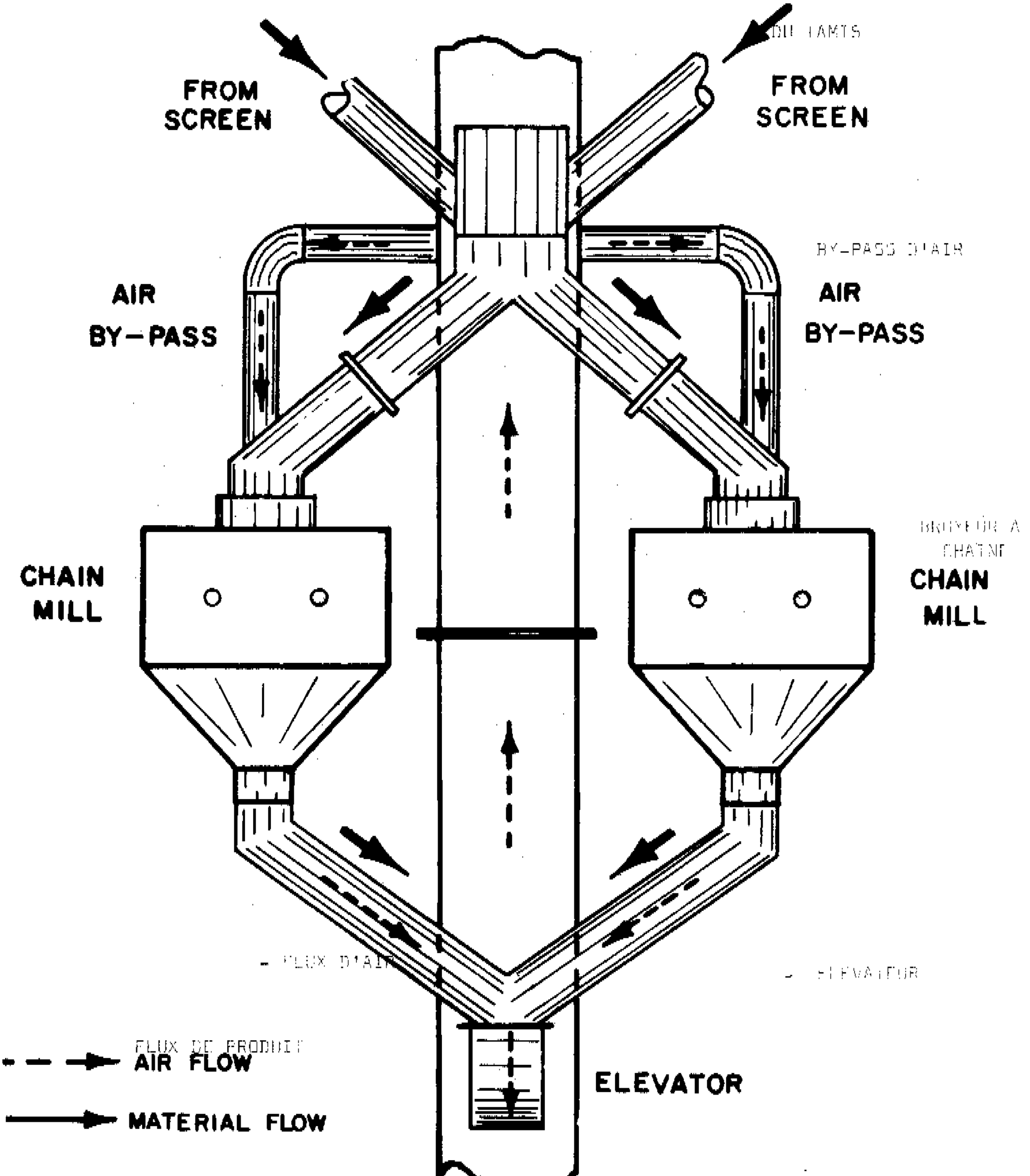
The fourth question concerned our losses of fluorine and other components other than nitrogen and P_2O_5. We are obtaining data for a complete material balance but this was not readily available before I left. Actually the fluorine in the scrubbing circuit builds up to a certain level and then the fluorine compounds or a large part of these compounds precipitate out with the coarse material that is fed into the process. So we actually get most of the fluorine back into the products and we end up with a higher level of fluorine in our final products than we would have had before recovery. We have had no problem in this respect, particularly after using the hydraulic cyclone. This allows greater removal of the coarse material and its return to the process without undue difficulties in the scrubbing circuit.

His fifth question was what kind of detrimental effects the plant had on the environment before these activities were finalised and developed to the state that we have now. We were quite concerned earlier when we had losses as high as 6 to 7 tons per day each of nitrogen and P_2O_5 and we used a procedure of pumping these out to holding pumps for the first several months until we could get some sort of reasonable control procedures. In effect this was not a very desirable thing to do and we still have some problems when we get high rainfall. We show losses in washing from these holding pumps into the streams so this was strictly an expedient, but now, with the closed circuit operation, we have it under control. This is one of the problems when you are trying to get a new plant into operation. There are so many difficulties with the process that everyone is concerned with that, and not giving due attention to losses. In any new plant operation some people should be delegated with full responsibility for effluents and not be concerned with so many tons per hour of production. We did not do this, but this is a very important point.

Mr. E.W. SCHWEHR (Fisons, U.K.) : Would Mr. YOUNG tell us what his experience is in terms of corrosion with NPK dusts, in particular from muriate, when using aluminium ?

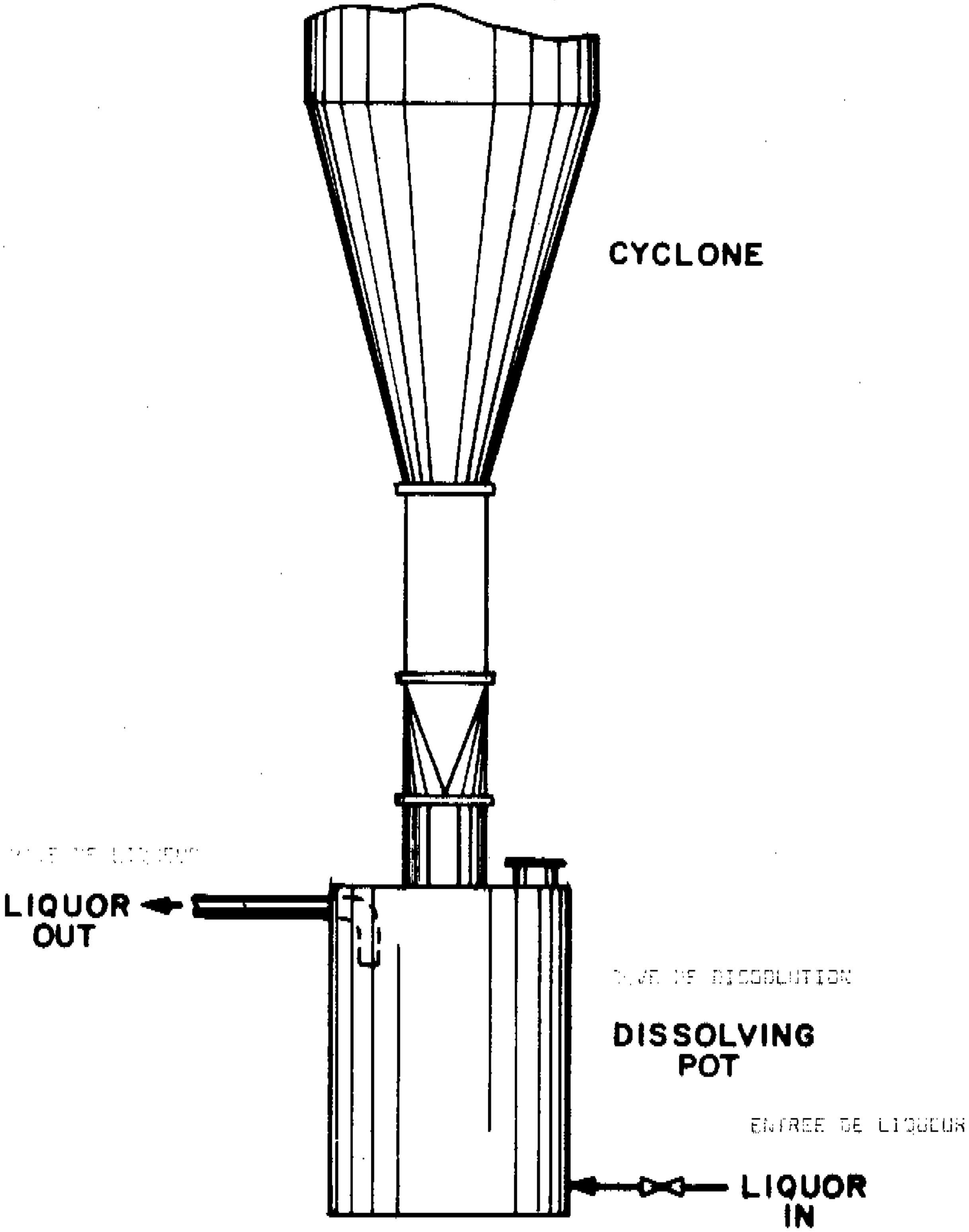
Mr. YOUNG : In our operation we do not produce any potash containing fertiliser at all in our demonstration plants, so we have no experience with that type of product.

We do know from our pilot-plant work that the chloride ion can greatly increase the corrosion in any of the scrubbing circuits and equipment of that type. However, in this particular plant we do not have any potassium chloride added to the fertilisers and I do not recall any particular data on aluminium in our experience.



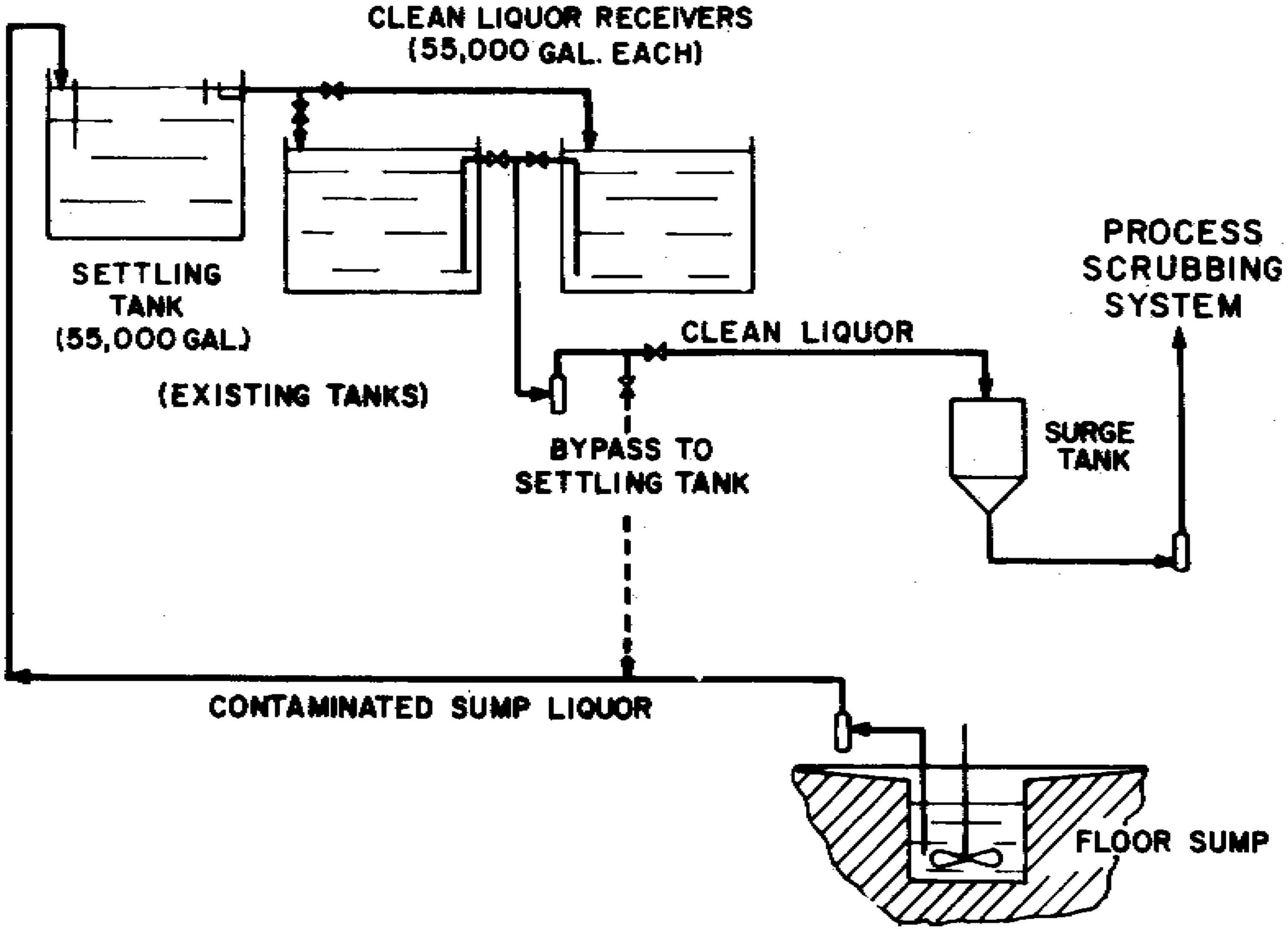
Système de by-pass pour la suppression d'air dans un atelier de broyeur à chaine

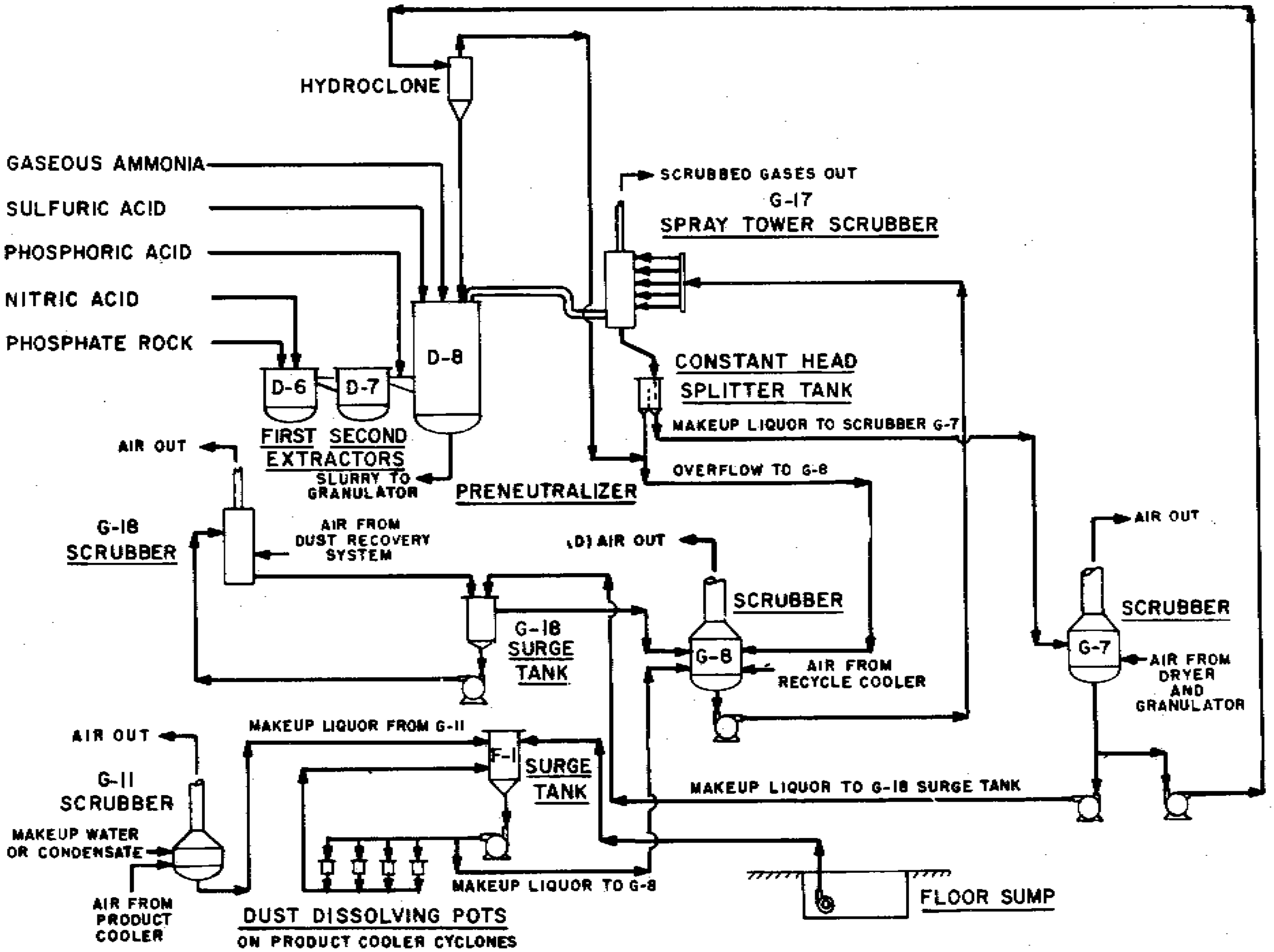
FIG. 1

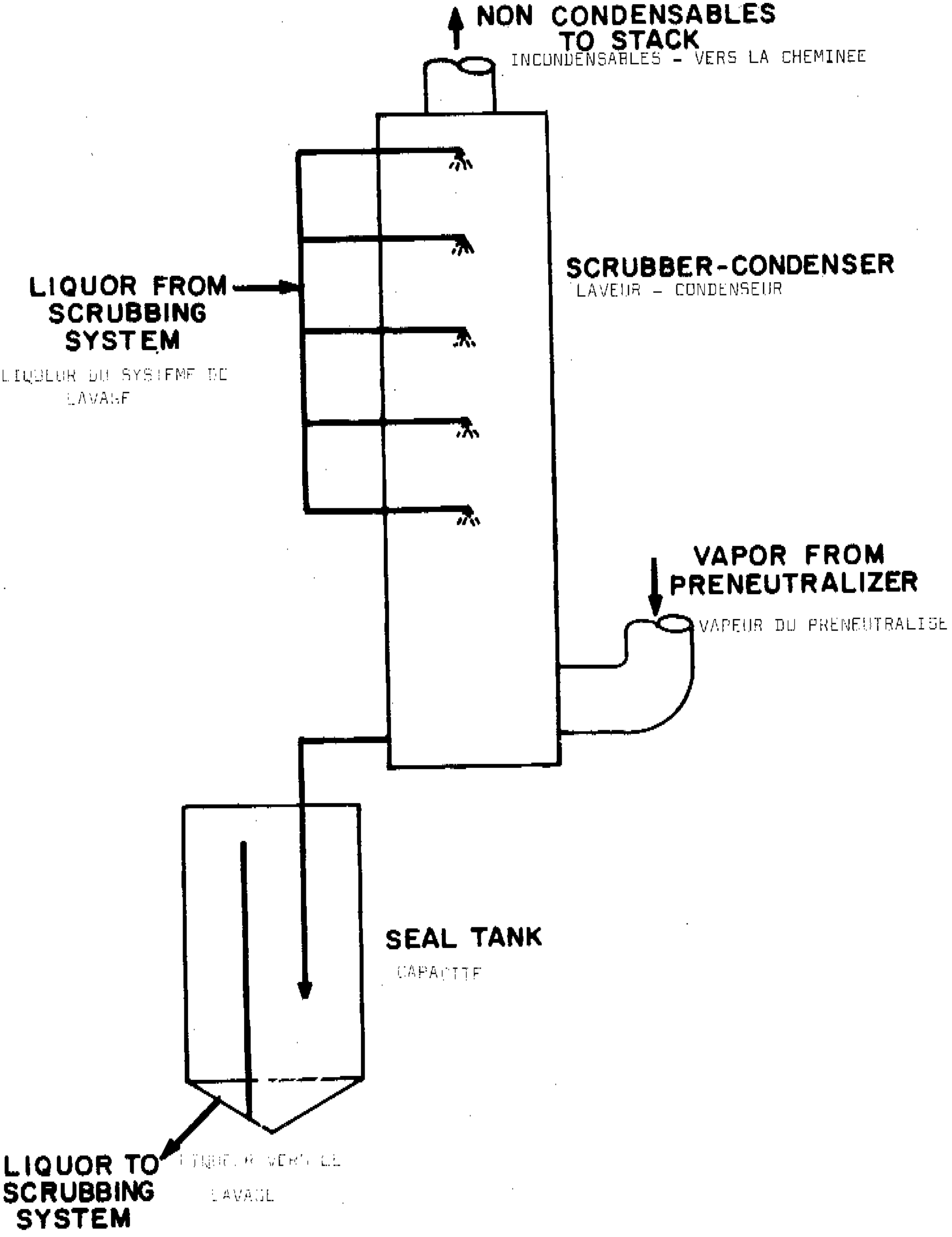


CYCLONE AVEC SYSTEME COLLECTEUR HUMIDE

Fig. 7

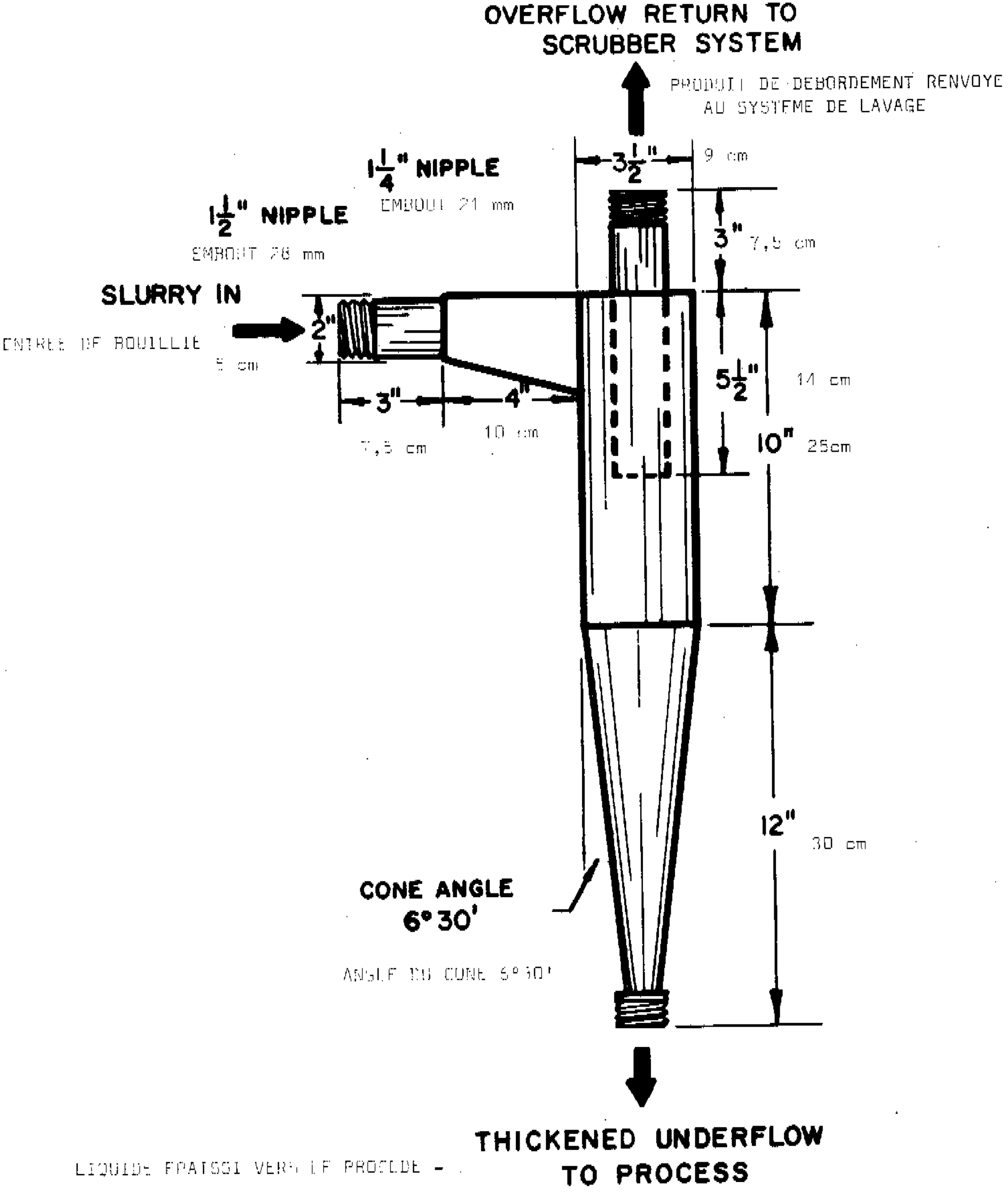

CLEAN LIQUOR RECEIVERS
(55,000 GAL. EACH)
SETTLING
TANK
(55,000 GAL.)
(EXISTING TANKS)
PROCESS
SCRUBBING
SYSTEM
CLEAN LIQUOR
BYPASS TO
SETTLING TANK
SURGE
TANK
CONTAMINATED SUMP LIQUOR
FLOOR SUMP


HYDROCLONE
GASEOUS AMMONIA
SULFURIC ACID
PHOSPHORIC ACID
NITRIC ACID
PHOSPHATE ROCK
D-6
D-7
D-8
FIRST SECOND
EXTRACTORS
SLURRY TO GRANULATOR
PRENEUTRALIZER
SCRUBBED GASES OUT
G-17
SPRAY TOWER SCRUBBER
CONSTANT HEAD
SPLITTER TANK
MAKEUP LIQUOR TO SCRUBBER G-7
OVERFLOW TO G-8
AIR OUT
G-18
SCRUBBER
AIR FROM DUST RECOVERY SYSTEM
(D) AIR OUT
SCRUBBER
G-8
AIR FROM RECYCLE COOLER
G-18
SURGE
TANK
AIR OUT
SCRUBBER
G-7
AIR FROM DRYER AND GRANULATOR
AIR OUT
G-11
SCRUBBER
MAKEUP WATER OR CONDENSATE
AIR FROM PRODUCT COOLER
MAKEUP LIQUOR FROM G-11
F-1
SURGE
TANK
MAKEUP LIQUOR TO G-18 SURGE TANK
MAKEUP LIQUOR TO G-8
DUST DISSOLVING POTS
ON PRODUCT COOLER CYCLONES
FLOOR SUMP



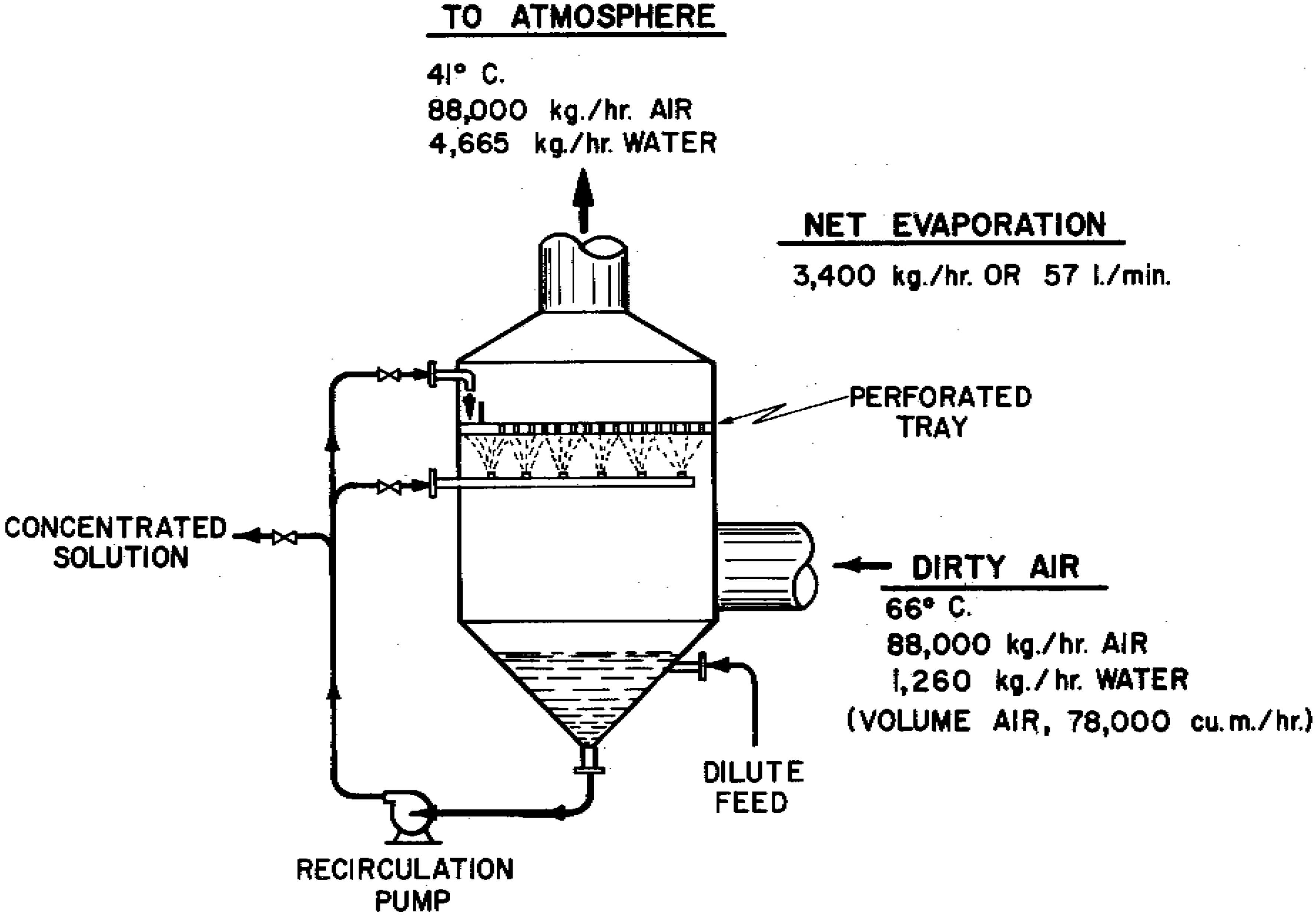
Lavage, zone à condensation

FIG. 3



Hydrocyclone

FIG. 6



USE OF EVAPORATIVE CAPABILITY OF A SCRUBBER