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DESCRIPTION OF SITE

The ICI production site at Billingham has been established for over 50 years and is currently occupied by several Manufacturing Divisions. Agricultural Division is the major producer on the site and has its Headquarters at Billingham.

On the main site the major activity is the production of ammonia. Four plants, using natural gas as feedstock, produce 4,500 tes of ammonia per day and associated byproduct carbon dioxide. In the same manufacturing group are two Methanol plants and a Urea plant. Alongside the Ammonia group plants are the plants producing fertilizer intermediates. There are six Nitric Acid plants producing up to 3,000 tes HNO_3 /day and a Phosphoric Acid plant. Sulphuric Acid is produced on two 500 tes/day double absorption plants.

Fertilizer production is at the Portrack Site, an area approximately $\frac{1}{2}$ mile from the main site. It is this area on which this paper is based. The site was established in 1957 when the compound fertilizer plant was built. The plant originally comprised two Dorr-Oliver granulation units producing a single fertilizer formulation 12:12:18 based on Ammonium Sulphate, Ammonium Phosphate and potash. In 1964 the plant was extensively modified to change to Ammonium Nitrate-based compound fertilizers. An Ammonium Nitrate neutraliser was constructed with associated Nitric Acid storage fed by a pipeline from the main site. Each granulation unit was equipped with an Ammonium Phosphate reactor to allow on-site production of Ammonium Phosphate slurry previously transferred by tanker from the main site. Product treatment sections were added to each unit to cool and coat the product before transfer to the bulk silos. With the new plants the fertilizer range was expanded to meet the changing needs of the farmers and approximately 12 formulations are now produced. The present capacity of the plant is over 400,000 tes/year.

The Division's first prilled Ammonium Nitrate plant ('NITRAM') was built at the Severnside Site (Bristol) in 1964. The second plant was built at Billingham on the Portrack Site in 1969. Many improvements were incorporated in the design of the new plant to reduce atmospheric and liquid effluents. The main changes were 2-stage Ammonium Nitrate neutralisers, cooling of the Ammonium Nitrate melt before prilling and total condensation of the evaporator effluent. In 1979 a second 'NITRAM' Plant was built on the Portrack Site alongside the existing plant.

The two plants have a combined capacity well in excess of 1,000,000 tes/year.

PORTRACK SITE EFFLUENT SITUATION - 1970/1971

Liquid Effluents

The Portrack Site is close to the north bank of the River Tees. Billingham Beck, a small tributary of the River Tees, runs through the site and the liquid effluent drainage system discharges into the Beck. Analysis of the plant liquid effluents in 1970/1971 indicated continuous high losses of N, P and K from the granulation units with intermittent peak losses of N from the 'NITRAM' Plant usually at plant shutdowns.

Atmospheric Effluents

The Portrack Site is about 1 mile from residential areas of Middlesbrough and Stockton which are both large centres of population. The visual effluents from the site in 1970/1971 were Ammonium Nitrate fume from the 'NITRAM' prilling tower and steam from the granulation unit chimneys. Poor performance of the granulation scrubber system meant that at certain times the gaseous effluent contained very high concentrations of ammonia. Under these conditions, when the prevailing wind carried the effluent towards the nearby coal-fired power station, the mixing of the effluents caused the formation of Ammonium Sulphate aerosol which became dramatically visible.

1 EFFLUENT IMPROVEMENTS FROM 1971 - 1973

Initial efforts were aimed at reducing effluents from the granulation units.

a) Ammonium Nitrate Neutraliser

The neutraliser section was installed in 1964. It consisted of a large neutralising vessel to react the ammonia gas and nitric acid with an overflow arrangement feeding a pumping tank. The neutraliser operates at atmospheric pressure and the ammonium nitrate concentration is restricted to a maximum of 90% before pumping to two falling film evaporators. The steam from the neutraliser with the evolved ammonia and ammonium nitrate passed through a mist eliminator before total condensation and discharge as liquid effluent. Some of the vapour was condensed to provide a sample for pH measurement and control of the neutraliser. Losses from the single stage neutraliser were extremely high arising from both vapour pressure loss and poor pH control. Loss measurements prior to the modifications indicated an ammonia efficiency of only 90%.

Work commenced in 1972 to convert the neutraliser to two-stage operation. In this form the primary neutraliser operates at a pH of 2.5 (10% Ammonium Nitrate solution at 20°C) to minimise the ammonia loss. Only a small reaction volume is required for the secondary neutraliser to lift the pH of the ammonium nitrate solution to 6.5. This was provided by fitting two division plates in the pumping tank to introduce an under and over flow ensuring complete reaction of the ammonium nitrate solution and to avoid by-passing. An ammonia sparger was fitted in the secondary neutraliser and piping modifications were made to take steam from the vessel into the primary neutraliser vapour system. The vapour pH system was discarded and an ICI designed solution pH system was introduced for control of the two neutralisers.

This new system involved taking a sample of the Ammonium Nitrate solution from the neutralisers, dilution with cooled plant condensate and direct pH measurement. The problem of non-linearity of the process response with respect to the inputs was overcome by fitting a lineariser between the pH transmitter and the controller. Following the conversion loss measurements indicated a neutraliser efficiency of over 99% and under periods of steady operation 99.5% was achieved.

b) Recovery Scrubbers

The Granulation Units were equipped with Doyle impingement recovery scrubbers to treat gases from the driers and the plant de-dusting systems. Prior to conversion to Ammonium Nitrate-based fertilizers the use of soluble raw materials created no operating problems with sludge build-up in the scrubbers and process cleaning was rarely required.

Following the introduction of Ammonium Nitrate, the use of insoluble filler (anhydrite) and the production of Ammonium Phosphate in the new reactor systems, the scrubbers had a new duty to perform. Vapours from the Ammonium Phosphate reactor were piped to the recovery scrubbers on each unit to add to the existing load from the drier and de-dusting system. The scrubbers never operated satisfactorily in this situation with regular deposition of solids in the scrubbers, choking of the circulating pipework and the inability of the scrubbers to recover the high ammonia loss from the Ammonium Phosphate reactor system.

A project was completed in 1973 to improve the performance of the scrubbers. A new pumping tank and pumps were installed on the ground floor of the plant on each granulation unit. The tank was positioned directly underneath the recovery scrubbers and the connecting pipework consisted of vertical pipe-runs with only minor horizontal lengths. This modification was designed to avoid choking of the pipes. A 300 M³ tank was converted to store recovered solution from the scrubber system and connecting pipework was installed to allow transfer of solution from the scrubber circulating pumps to the storage tank. Pumps and pipework were also installed to supply recovered solution from the storage tank to the Ammonium Phosphate reactors on each of the granulation units.

The modifications were successful in improving the operation of the scrubbers and a recovered solution Specific Gravity (SG) of 1.25 (equivalent to 50% dissolved and suspended solids) was consistently achieved in the scrubbers and circulating pipework without choking problems. When this solution was transferred to the large storage tank settling of undissolved solids caused choking problems in the tank exit pipework and in the supply pipes to the Ammonium Phosphate reactors. The operating SG of the recovered solution in the scrubbers had to be reduced to 1.15 to avoid this problem. This SG constraint was further aggravated by two problems:-

- a) The dust load from the drier and de-dusting systems was much higher than measurements had indicated.
- b) The ammonia loss from the Ammonium Phosphate reactors was almost double the calculated amount due to 'slip' loss particularly at high production rates.

After lengthy experimentation with the system it became clear that acidification of the recovered solution with Phosphoric Acid to recover the ammonia was not possible because of the large quantities of recovered solution produced and the inability of the plant water balance to use the recovered solution in the process. It was therefore decided to operate the scrubbers without acidification and to only recover the dust from the process. Under these circumstances the plant exhaust gases with free ammonia passed to the heat abatement scrubbers to be contacted with once-through river water, and a proportion of the ammonia passed via the plant chimneys to the atmosphere.

2 EFFLUENT PROJECT 1975

A major project commenced in 1975 to achieve control of the Granulation Plant effluents. Because of the need to reduce total liquid effluent discharge from the Portrack Site to the River Tees part of the design for the project included the use of waste effluent streams from the 'NITRAM' Plant on the Granulation Plant.

The key aspect of the design was the plant water balance i.e. the ability of the Granulation Units to use recovered solution. Detailed calculations were completed to check the water balance for all the fertilizer formulations produced on the plant. This data provided the basis for the work on the project.

a) Ammonium Phosphate Reactor Systems

The high ammonia loss from the single-stage reactor systems on each Unit caused problems with the earlier modifications to the scrubbers. The obvious change to improve the situation was to convert from single-stage to two-stage operation. The best arrangement for lowest ammonia loss is operation of the primary reactor at an N:P ratio of 1.1 and the secondary reactor at a ratio of 1.4. In practice solubility problems make operation of the primary reactor at a ratio of 1.1 extremely difficult leading to reactor chokes or the more likely tendency of the operators to allow the N:P ratio to drift upwards thereby removing the benefits of two-stage operation.

The second choice arrangement is Primary N:P ratio 0.8, Secondary N:P ratio 1.4. Although this gives a slightly higher theoretical ammonia vapour pressure loss it is much easier to control. Figure 1 gives the comparison of ammonia loss for the various systems based on theoretical calculations using vapour pressure data.

An important omission in the calculations is the ammonia 'slip' loss which doubled the calculated ammonia vapour pressure loss for the old single-stage reactor system. A feature of the 0.8/1.4 ratio system is that it almost halves the reaction load on each vessel and therefore reduces the 'slip' loss.

Having decided to convert the Ammonium Phosphate systems to two-stage operation with the N:P ratio configuration 0.8/1.4 the next stage of the development involved optimisation of recovered solution usage to improve the plant water balance.

b) Recovered Solution Usage

There are two aspects of this problem, increasing the requirement for water in the Ammonium Phosphate reactors and increasing the solids content of the recovered solution feeding the reactors.

The water requirement in the reactors is related to the concentration of the Phosphoric Acid used. The plant was supplied with Phosphoric Acid at a concentration of 44-46% P_2O_5 . Plans were made to increase the concentration to 50% P_2O_5 but this required the fitting of a de-entrainment device in the Phosphoric Acid evaporator to avoid any increase in P_2O_5 losses from this area. Having provided higher strength Phosphoric Acid it was important to ensure that dilution of the acid in storage at the Portrack Site did not take place. To achieve this all the pumps on Phosphoric Acid duty were replaced with self-sealing pumps i.e. no gland seal water. Pre-heating of the Phosphoric Acid feed to the reactors was considered but this was eventually abandoned.

The next stage of the modifications was aimed at optimising the total solids content of the recovered solution feeding the Ammonium Phosphate reactors. A programme of laboratory research work was carried out to provide data on the properties of recovered solution produced by the different fertilizer formulations. The main conclusion from the work confirmed the earlier plant experience that the optimum SG for the recovered solution was 1.25 equivalent to a total solids content of 50%.

At this level the solution could be easily pumped and did not produce solids settling problems in the scrubbers. It was decided that the recovery scrubbers would be circulated at all times with recovered solution at an SG of 1.25, using the simple pipework system as provided in the earlier project. A short connecting pipeline was provided to supply this recovered solution to the reactor thereby ensuring maximum solids usage in the reactor. Figure 2 is a diagram showing the piping arrangements for the new system. The 300 M³ recovered solution tank was converted to store 'thin' solutions collected from various sources on the plant. The thin solution was fed to the scrubbers on both density control and level control as make-up for:-

- i) The usage in the reactor.
- ii) The substantial evaporation by the hot drier gases.
- iii) Recovery of both dust and ammonia.

A water supply was provided for emergency make-up on either extra high density or extra low level. A Phosphoric Acid supply was provided to acidify the circulating solution on pH control to recover the ammonia from both the reactors and the drier. Figure 2 indicates an important feature of the piping system. In normal operation there is only one valve in the pipework and this valve is either fully open or closed. There are no horizontal pipes in the system as designed to ensure self-draining when either not in use or shutdown.

The Ammonium Phosphate systems had now been modified to use substantial quantities of recovered solution. The Granulation Plant was isolated from the main Plant drain except for the once through river water from the heat abatement scrubbers and the condensed vapours from the Ammonium Nitrate neutraliser. Large open stainless steel troughs were installed as collecting arteries from each granulation unit feeding a collecting sump fitted with an agitator and level controlled pumps. All contaminated streams from the plant e.g. equipment washings, drier washings, tank let-downs etc were directed to the troughs to feed the sump.

The solution from the sump was fed to the large storage tank to feed the scrubbers, as make-up solution.

An additional benefit of the sump was the ability to recover sludges and wet fertilizer from the plant and packing areas simply by tipping into the sump system.

The project was successful in solving the plant water balance problem. Even after using these solutions and washings from the Granulation Plant, including the fertilizer spillages and sludges, there was still capacity to use other solutions.

The final part of the project was a solution collecting system for the 'NITRAM' Plant. A sump was converted to hold low concentration Ammonium Nitrate solution (less than 50%). Piping was installed to direct valuable solutions to the sump from the Ammonium Nitrate neutraliser area, the packing area de-dusting scrubber and other plant areas. Two pumping systems were installed on the sump. The first system operated a circulating loop to wash 'NITRAM' spillage from the prill tower base. The second system exported the collected solution from the sump to the thin solution storage tank on the Granulation Plant. Contaminated 'NITRAM' spillage was collected in solid form and brought to the sump on the Granulation Plant for dissolving and transfer to the solution storage tank.

3 1977 - EFFLUENT TREATMENT FOR GRANULATION PLANT AMMONIUM NITRATE NEUTRALISER

The original neutraliser, installed in 1964, was designed to produce 10.5 tes/hour of Ammonium Nitrate. This system was converted to two-stage operation in 1972 and this significantly improved the operating efficiency. Over the years the demand for compound fertilizers increased and the nitrogen content of the fertilizers also increased. This meant that output from the neutraliser rose to over 30 tes/hour of Ammonium Nitrate. Even with the two-stage configuration the nitrogen efficiency of the neutraliser decreased to 98% in steady running. Following the successful effluent project for the scrubbers this loss from the neutraliser became the major effluent source for the Granulation Plant.

Work commenced in 1976 and a variety of options to treat the neutraliser effluent were studied. These options included ion-exchange equipment, vacuum distillation and new neutraliser design.

At the same time success was achieved in the USA with the installation of Teflon filter units in the top of Ammonium Nitrate neutralisers to treat the contaminated steam and recover particulate Ammonium Nitrate. The system did not recover ammonia known to be present in high quantities in the steam from our neutraliser.

One obvious method of removing the ammonia would be to scrub with Nitric Acid. The main problem with this was that at the operating temperature the vapour pressure of the nitric acid was high enough to cause a vapour phase reaction with free ammonia to form Ammonium Nitrate fume. Research work showed that if the free acid concentration of the Ammonium Nitrate solution used for scrubbing could be controlled below 1% then the nitric acid vapour pressure was extremely low and did not cause formation of the Ammonium Nitrate fume.

Using the available information a scheme was prepared whereby the overheads from the neutraliser were to be treated by passing through Teflon filter elements irrigated by weakly acidic Ammonium Nitrate solution to capture the free ammonia. The scheme had two major drawbacks:-

- a) To achieve a free nitric acid concentration in the Ammonium Nitrate liquor below 1% and recover ammonia with maximum efficiency requires such a high liquor circulation rate that the filter elements would be flooded.
- b) There was concern that the free acidity could not be controlled sufficiently accurately under all conditions to prevent losses by Ammonium Nitrate fume formation after the filter elements.

It was concluded that it was necessary to first pass the neutraliser vapours through a conventional scrubbing section packed with stainless steel rings, irrigated by weakly acidic Ammonium Nitrate solution to remove ammonia. The residual Ammonium Nitrate fume was then removed by passing the vapours through Teflon filter units. Figure 3 shows a diagram of the unit. The Teflon filter units are irrigated by the saturated steam leaving the packed section so that the collected Ammonium Nitrate fume on the filters dissolves and the weak solution falls by gravity into the pumping section.

The equipment is designed for fully automatic control:-

- a) pH Control

The pH of the circulating liquor is continuously measured and this is used to control the rate of addition of nitric acid to the pumping tank section of the vessel.

- b) Concentration Control

The system is designed to control the Ammonium Nitrate concentration at 50% in the circulating liquor. Temperature measurement of the liquor gives a direct correlation with concentration and this is used for condensate addition control.

- c) Level Control

Level control is used to regulate the export of recovered Ammonium Nitrate solution back to the neutraliser.

The unit has operated successfully but has one drawback. If control of the primary neutraliser is significantly upset such that free nitric acid is released into the scrubber this causes serious control problems with the effluent system. A later installation on an associated ICI Plant has both ammonia and nitric acid for pH control. Even with this problem the recovery efficiency of the effluent scrubber is 90% of the total nitrogen leaving the neutraliser in the vapours.

4 EFFLUENT POSITION

The completion of the projects described had a dramatic effect on effluent loss from the Portrack Site. Figure 4 shows the reduction in ammonia loss from the Granulation Plant over the period under review. Accompanying this improvement was an even greater improvement in P_2O_5 and K_2O loss. With the plant effectively isolated from the site drains losses of these nutrients were reduced to less than 5 tes per month.

5 1979 - NO 3 'NITRAM' PLANT

The Division's third 'NITRAM' Plant was commissioned at the Portrack Site in August 1979 and was built adjacent to the existing No 2 'NITRAM' Plant.

DESCRIPTION OF PLANT

Ammonia and nitric acid are reacted in a single neutraliser vessel containing both primary and secondary sections. The steam from the reaction is passed through a packed scrubber and Teflon filter units before passing to an air condenser. The Ammonium Nitrate solution is pumped to a falling film evaporator and the resulting melt is pumped to the top of the prill tower to the single spray plate. The majority of the dust and fume from the tower is collected in a shroud system within the prill tower and the gases pass to a filter system where they are first scrubbed with circulating Ammonium Nitrate solution to remove large particle size material. The gases then pass through glass-fibre candles to remove the Ammonium Nitrate fume.

Product is removed from the tower base and is passed to fluid bed coolers. The hot air from the coolers passes through high efficiency cyclones and is then mixed with the saturated air from the shroud air filter. This is necessary to avoid the formation of a steamy plume from the tower. Figure 5 shows the basic layout of the system.

NEUTRALISER SECTION

Figure 6 shows details of the combined neutralisation vessel. Steam from the neutraliser passes through the packed scrubber where it is contacted with weakly acidic 50% Ammonium Nitrate solution before passing to the Teflon filter elements. The recovered solution passes through a simple overflow arrangement into the primary neutraliser. An essential feature of the neutraliser effluent system is the integral recovery tank which holds drainings from the Ammonium Nitrate system before re-use in the neutraliser.

GASEOUS EFFLUENT TREATMENT

A shroud is mounted within the prill tower surrounding the single spray-plate. Air containing dust, miniprills and Ammonium Nitrate fume is drawn from the shroud to be treated by the fibre filter. Gaseous effluent from the Ammonium Nitrate falling film evaporator is also fed to the fibre filter. In the filter the gases first pass through an irrigated mesh filter to remove dust and miniprills. The circulating liquor is 40% Ammonium Nitrate solution and this is acidified with nitric acid to remove ammonia. This is essential to avoid damage to the glass fibre candles situated immediately after the mesh filter. The candles remove over 98% of the Ammonium Nitrate fume and the clean gases pass to the tower top for discharge to atmosphere.

A steamy plume is avoided by mixing the filter exhaust gas with the hot air from the product fluid bed coolers. The 40% Ammonium Nitrate solution produced in the filter is pumped to the neutraliser scrubber pumping tank.

LIQUID EFFLUENTS

The use of the neutraliser recovery tank eliminates the majority of the liquid effluent. There are two other recovery systems.

a) Packing De-dusting

An extensive de-dusting system is fitted to the Packing equipment. The various air flows with associated dust are fed to a wet scrubber producing a thin solution of Ammonium Nitrate. This solution is used as make-up for the fibre filter.

b) Plant Washings/Drainings

The residual effluent comes mainly from washings in the prill tower area. All washing is by re-circulated Ammonium Nitrate solution which is allowed to concentrate to a maximum of 40% before transfer to the Granulation Plant via the solutions collecting system on No 2 'NITRAM' Plant. This system also recovers pump draining and minor spillage in the neutraliser area.

EFFLUENT PERFORMANCE

It will be appreciated that the only liquid effluent from the new plant is the condensed vapour from the neutraliser scrubber containing only a small residual nitrogen concentration. The performance of the tower effluent system has been very impressive giving a significant visual improvement when compared to the older No 2 Plant tower effluent.

RECENT DEVELOPMENTS

The introduction of No 3 'NITRAM' Plant created an additional flow of weak liquid effluent for use on the Granulation Plant. Modifications were required to increase the ability of the Granulation Plant to use additional recovered solution.

This was achieved by 2 projects:-

a) Plant De-dusting System

The original plant was equipped with a de-dusting system on each granulation unit. This consisted of a central fan drawing air from the dusty areas and transfer points on the unit. The air then passed to cyclones and to the Doyle Impingement Scrubbers which were also fed with air from the granulation unit drier. In operation scrubber back pressure caused deposition of solids in the long lengths of ductwork around the plant. The hygroscopic nature of the dust aggravated the problem with progressive choking of the ducts and the eventual removal or blanking-off of sections of the system. In its final form the de-dusting system was only operating on the screen house. Even in this situation poor performance of the cyclones led to a high dust - load on the scrubbers with subsequent production of recovered solution. The poor performance of the de-dusting system produced high atmospheric dust levels within the plant.

Following test work on the plant with trial units, modern design reverse air impingement bag filters were selected as the basis for a new de-dusting system on each Granulation Unit. Locally mounted bag filters are now fitted to deal with dust problems without any ductwork and with no air flows to the Doyle scrubbers.

The biggest single installation is a 13,000 cfm filter used for the Primary Screenhouse (3 Hummer vibrating units). The individual air flows are 2,000 cfm from above each screen, 1,000 cfm from each screen feed chute and 4,000 cfm of air heated to 80°C to avoid moisture pick-up problems. The filter unit is mounted adjacent to the screens.

The other filter units fitted are all 1,000 cfm self-contained units complete with exhaust fan mounted locally at transfer points and these units control dust emissions from the drier exit conveyor bands, the main elevators, product conveyor band and the raw material import system.

Following the successful installation of the filters the work was extended to include a large filter on the product cooler of one unit handling 24,000 cfm and other smaller filters on the product treatment section. In these cases the new filters have replaced older bag filters which had mechanical and pneumatic rapping equipment.

b) Drier Cyclone Modifications

The main drier air from each granulation unit passes through 8 cyclones before entering the Doyle Scrubbers. Each cyclone suffered from the usual problem of a poor air seal at the cyclone base with subsequent disruption of the air flow pattern, deposition of solids and choking. The bases are now fitted with a collecting hopper, a vibrating section and a plastic sleeve air lock.

The efficiency of the cyclones has improved from 88% to 97% as a result of the modifications with no solids build-up. The system does not work without the vibrator section. The wall thickness of the polythene sleeve is important for efficient sealing.

The 2 projects have reduced the dust-load on the Doyle scrubbers and have increased the ability of the Granulation Plant to use recovered solutions from the 'NITRAM' Plants.

PRESENT POSITION

The three Production plants on the Portrack Site operate as part of an integrated effluent network to minimise both liquid and gaseous effluents. The Granulation Plant is used to recover waste streams from the granulation units and the 'NITRAM' Plants.

The new 'NITRAM' Plant with its liquid and gaseous effluent systems generates only a minor liquid effluent flow within the total site situation. Losses of P_2O_5 and K_2O from the Portrack Site are negligible and the loss of nitrogen is less than 0.5%. Further improvement in the nitrogen efficiency would require a large capital investment which is not economically justified by the possible savings.

FIG 1 EQUILIBRIUM VAPOUR PRESSURE AMMONIA LOSS vs N:P RATIO

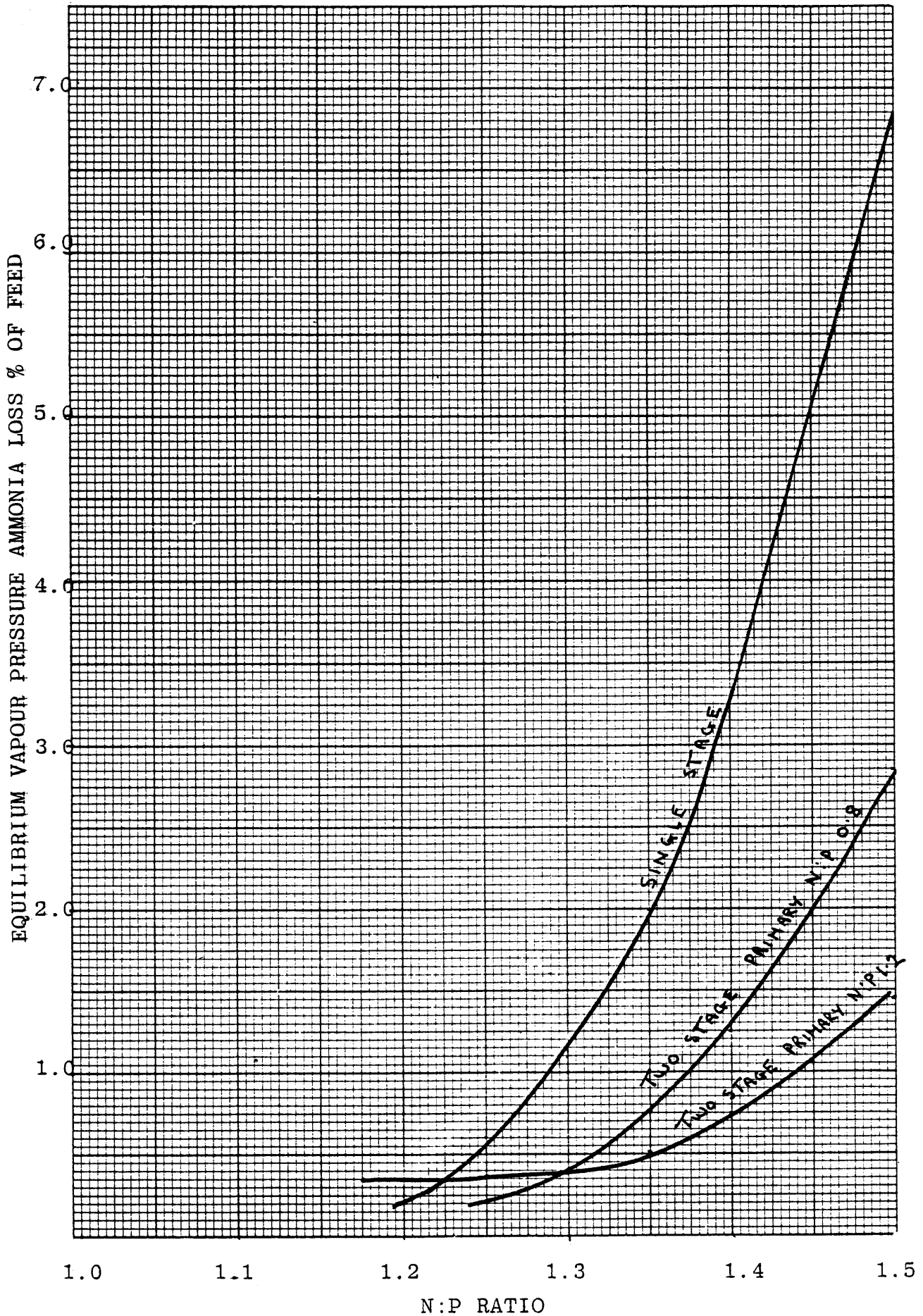
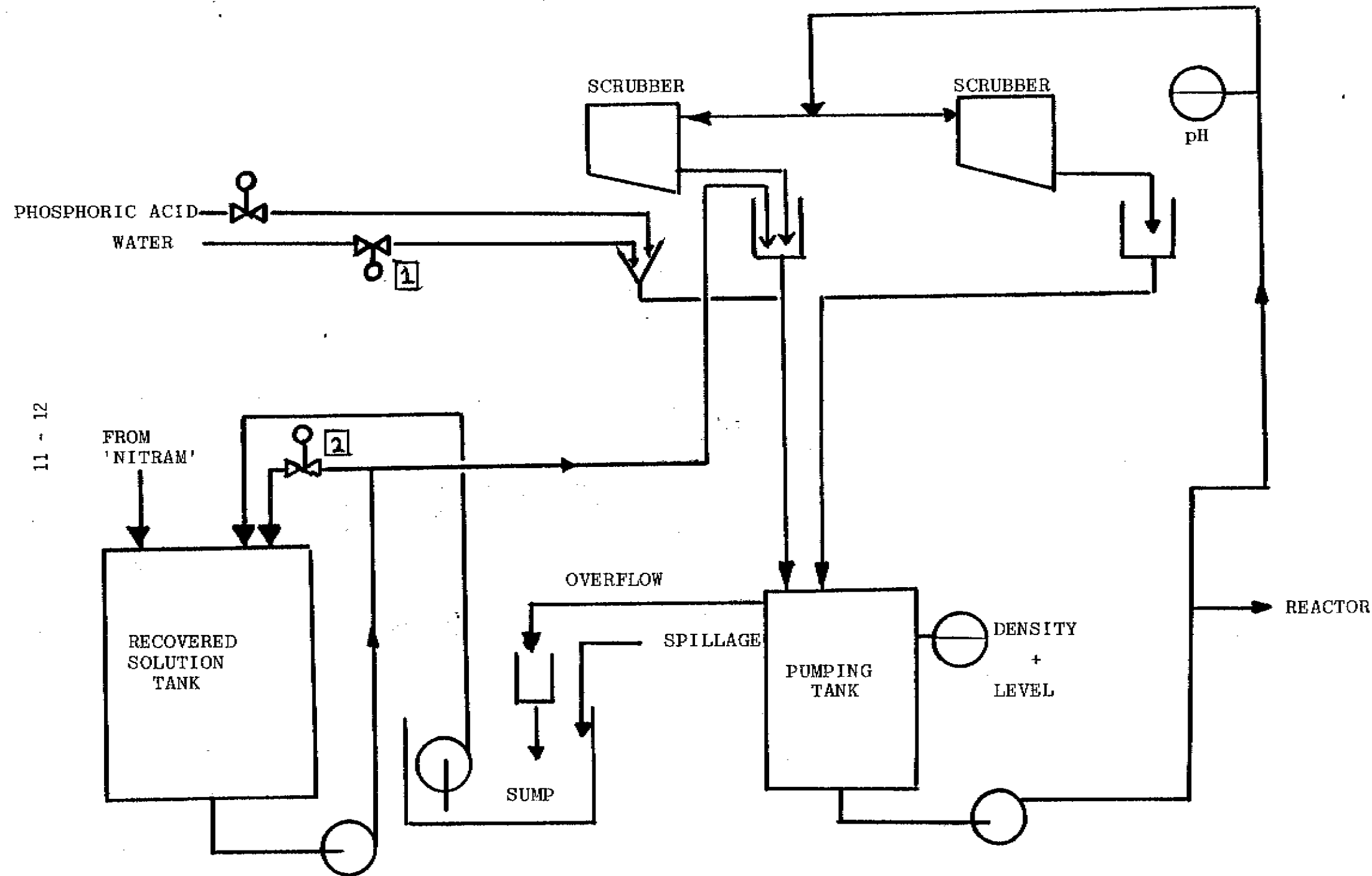


FIG 2 RECOVERED SOLUTION SYSTEM



11 - 12

FIG 3 NEUTRALISER EFFLUENT TREATMENT UNIT

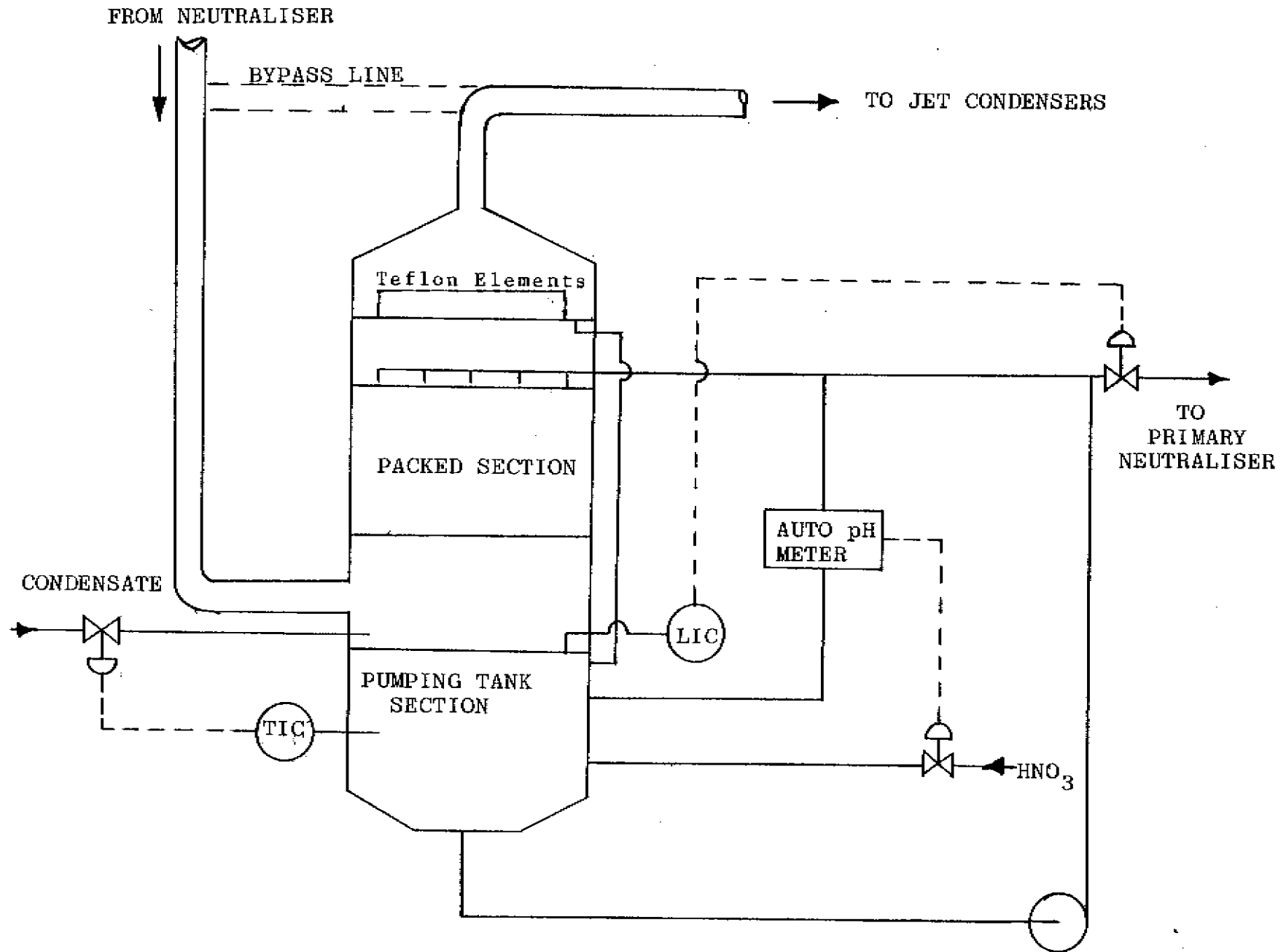


FIG 4 GRANULATION PLANT AMMONIA LOSSES

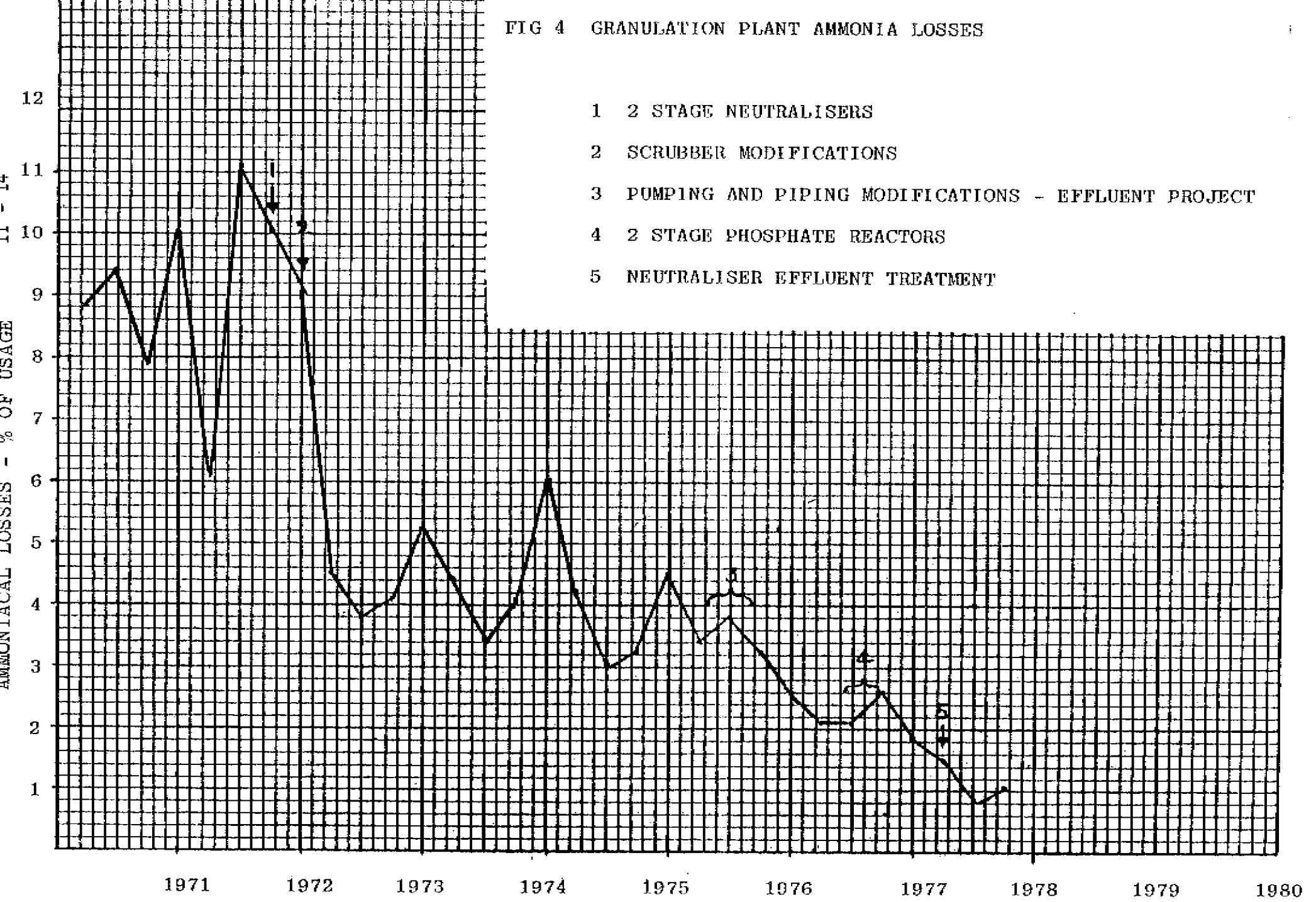
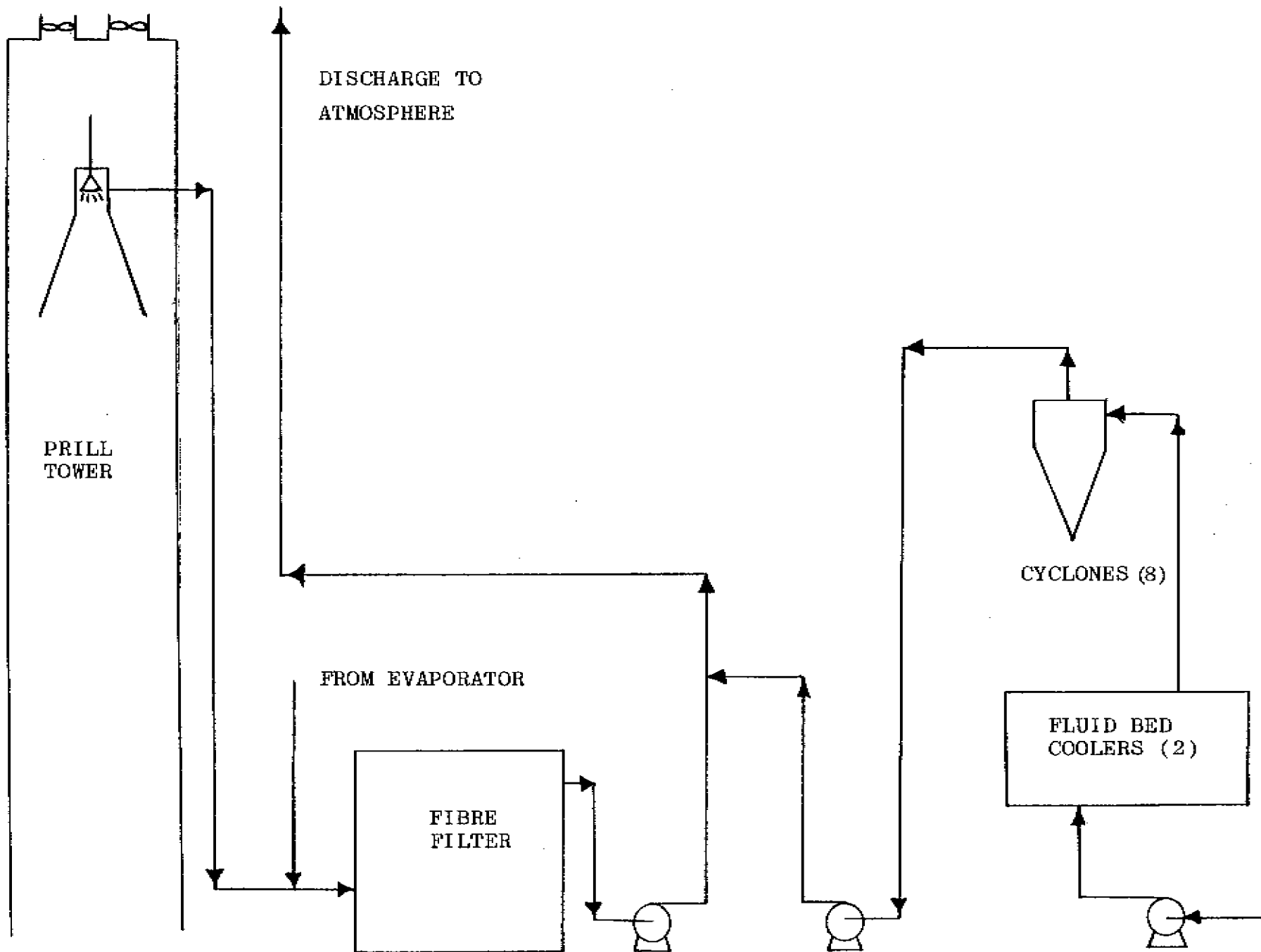
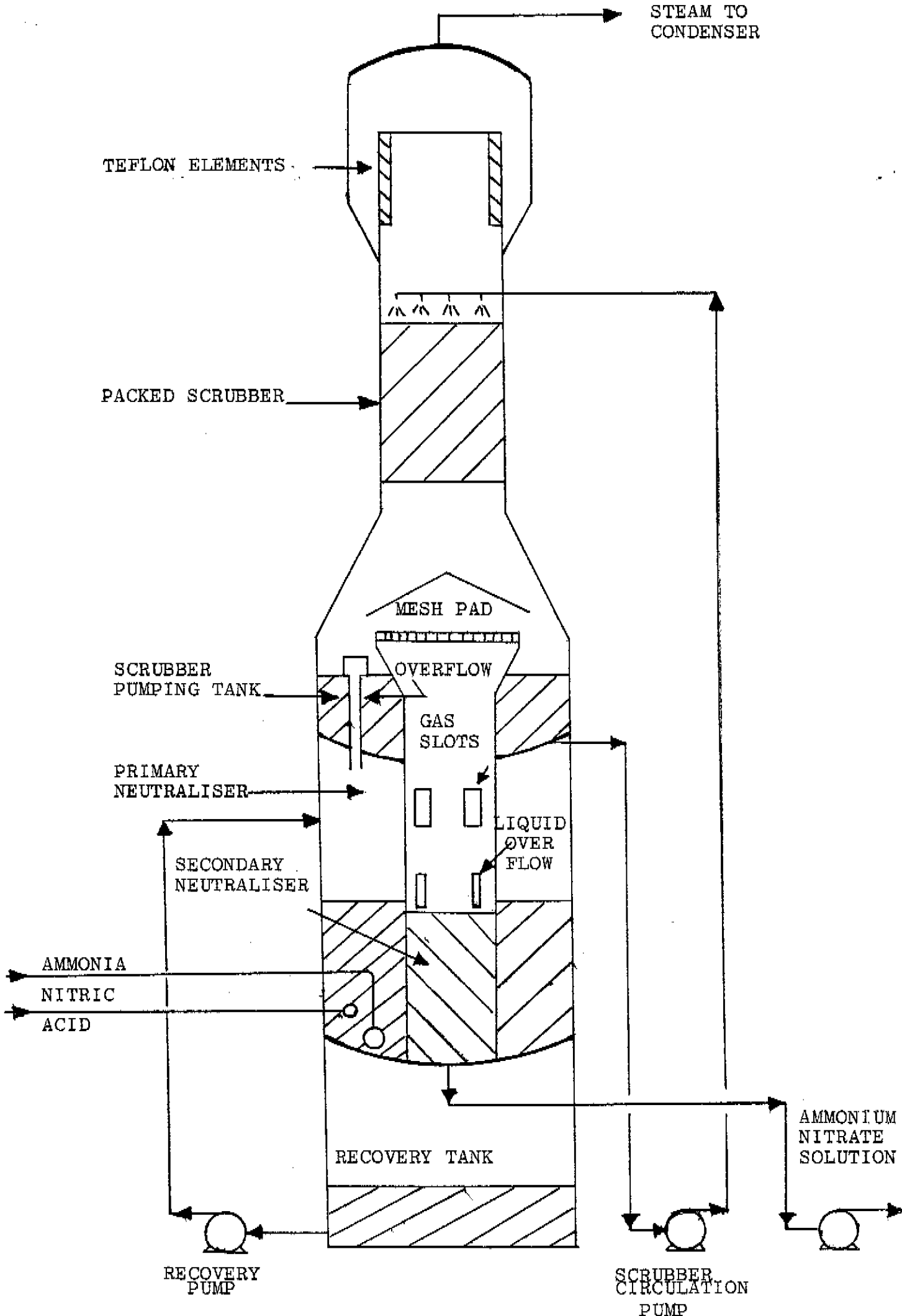


FIG 5 PRILL TOWER EFFLUENT SYSTEM





TA/82/11 Control of effluents from fertilizer plants, by J.H. MARKHAM, Imperial Chemical Industries PLC, Agricultural Division, United Kingdom

(DISCUSSION : Rapporteur Mr. T. HEGGEBØE, Norsk Hydro, Norway)

Q - Mr. WAHYU KARUNA, Petrokimia Gresik, Indonesia

Could you give a brief information on how the "on the plant tests" were conducted before decision was made to use reverse-air-impingement bag filters?

A - The decision to use reverse air impingement bag filters was taken to avoid problems with traditional rapping equipment. This type of filter had been successfully used on phosphate rock dust suppression applications within the Billingham site. The main decision involved the choice of manufacturer for the bag filters.

Q - Did the tests involve experts from various manufacturers of bag filters?

A - The on-plant tests involved the installation of test units on a similar duty within the Granulation Plant. Manufacturers are invited to design and erect the test installations to give the best presentation of their filters.

Q - How much did the test cost in % to the total cost of the improvement (material cost only)?

A - The cost of the test work was entirely borne by the filter manufacturers.

Q - Have the bag filters been used in other plants for the same function and the same service? When the decision was made? (Commercially proven for the same type of service).

A - Only one similar installation at the ICI Granulation Plant at Severnside, England, was known to be operating on a similar duty at the time the decision was taken to adopt the reverse air bag filters.

Q - Do you find any differences between the small filter (1000-2000 cfm) and the big filters (13000-24000 cfm) in terms of:

- a. Operating availability?
- b. Maintenance cost?

A - Since the installation there has been no observed differences between the small and large filters. The operating availability has been almost 100% and maintenance costs have been negligible.

Q - Do you have problem of moisture condensation in the ductline before drier cyclone? If yes, how do you cope with the problem?

A - There are no moisture condensation problems in the ductwork before the drier cyclones.

Q - You mention efficiency of cyclones 88-97%.

- a. Can you measure the efficiency on plant accurately?
- b. Is the cyclone efficiency constant at various plant prod-rate? How do you control it?
- c. Do you still have to clean the ductline periodically? Monthly, yearly - and how?

A - a. We believe that the efficiency measurements are accurate but the important point is the relative improvement in cyclone efficiency.

- A - b. The air rate through the drier is constant regardless of plant production rate and this gives constant cyclone efficiency.
- c. The ductings have not been cleaned since the cyclone modifications. Regular inspection indicates no dust deposits in the ductwork.

Q - Mr. G. BRUSASCO, Fertimont SpA, Italy

Referring to your No 3 Nitram neutralizer on Fig. 6, I have the following questions

1. What are maximum concentration and temperature that you fix in the primary neutralizer solution for safety reasons? Are you introducing automatically safety water at the fixed temperature level?
2. Can you tell the construction material for nitric acid and ammonia spargers?
3. How much NH_3 and NH_4NO_3 is still in the steam to condenser?

A - 1. The maximum concentration of ammonium nitrate in the neutralizer is 90%. There are three temperature measuring probes in the neutralizer and the automatic systems operate on a 2 out of 3 voting system to give the following response:

- a) 148° C - alarm
- b) 150° C - ammonia and nitric acid rates off
- c) 152° C - drench.

2. The spargers are constructed of titanium.

3. The NH_3 and NH_4NO_3 in the steam to the condenser varies depending on neutralizer and scrubber pH control. The overall nitrogen efficiency is better than 99.7%.

Q - Mr. N. DE LA VILLEON, SPIE BATIGNOLLES, France

Can you give some details on the automatic sampling, dilution and analysis device for concentrated ammonium nitrate in the 2nd neutralizer?

A - The sample is taken continuously from the neutralizer through a steam jacketed pipe to feed a dilution cell. In the cell the ammonium nitrate solution is mixed with cooled condensate to achieve a controlled temperature of 55° C. The diluted sample is then fed to a pH cell for continuous measurement.

Q - Mr. K.C. KNUDSEN, Superfos, Denmark

1. Who is the manufacturer of the teflon filter unit shown in Fig. 3 and the glass-fibre filter element shown in Fig. 5?
2. Could you indicate gas velocity and pressure drop over these two units?

A - 1. The manufacturer of the teflon filter units and the glass fibre filter elements is Monsanto Enviro-Chem, Brussels.

2. The gas velocity and pressure drops for the units are:

Glass Fibre - 0.5 ft/sec face velocity
25 m bar pressure drop

Teflon - 2 m/sec face velocity
60 m bar pd

Q - Mr. W. VERHEUL, UKF, Netherlands

Which type of filter do you use to reduce the amount of AN effluent from the AN

neutralizers and evaporators and what is the efficiency in relation to the size of droplets?

A - a) Manufacturer as in A4.

b) The particle size of the ammonium nitrate fume leaving the prilling tower is 65% less than 1 micron and the achieved removal efficiency with the glass fibre elements is 98%.

Q - Mr. F.P. ACHORN, Tennessee Valley Authority, USA

You indicate you use 2 preneutralizers for production of N:P:K fertilizer. Do you use Florida rock? If so, have you seen an increase in citrate insoluble P_2O_5 in product as the retention time is increased?

A - We do not use Florida rock and we have seen no change in the citrate insoluble P_2O_5 content of the fertilizers.

Q - Mr. J. LE PAGE, SCPA, France

Do the two stages refer to DAP or to the attack of phosphate rock?
(ref. Mr. Achorn's question).

A - The two stages refer to production of Mono/Di ammonium Phosphate (N:P 1.4) slurry to feed to the granulator.

