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NEW DEVELOPMENTS IN FLUID FERTILIZER MANUFACTURE

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The U.S. fluid fertilizer marketing system has matured during the past 30 years. The types of fluid fertilizers used in the United States during 1980 are shown below:

Material	Millions of Tons Used in 1980
Anhydrous Ammonia	5.5
Aqua Ammonia	0.7
Nitrogen Solutions	6.6
Fluid Mixtures	4.6
Total	17.4

Although the use of fluids has increased sevenfold in twenty years, recent USDA data indicate that there was only a slight gain in use of most fluids in the U.S. during the past year. These and other data indicate that about 61 percent of the total nitrogen applied in the U.S. is applied in fluid form (includes anhydrous ammonia); about 16 percent of the P_2O_5 and 8 percent of the K_2O are applied as fluids. Fluid mixtures represent 20 percent of the total mixtures applied in the U.S.

There have been few new innovations in the use of anhydrous ammonia; therefore, most of the comments in this paper relate to new developments in the manufacture of other types of fluids.

One major advance during the past five years has been the use of solid ammonium phosphates to produce fluid fertilizers. Materials such as granular and powdered monoammonium phosphate (MAP), granular diammonium phosphate (DAP) and granular and prilled urea have been used. Five typical tanks in which solid materials are used to produce suspensions are shown in figure 1. A dominant feature of these mix tanks is the large pumps used to recirculate liquids within the mix tank. One of the tanks has a liquid grinder and the other tanks have high intensity agitators. All of the tanks are equipped for adding ammonia and some for adding phosphoric acid. All can convert solid materials such as MAP, granular ammonium polyphosphate (APP), DAP, ammonium sulfate, and urea to fluids. Some companies make their own mix tanks. A typical "homemade" mix tank is shown in figure 2.

These companies usually produce a 10-30-0 or 11-33-0 grade suspension. The grade usually is determined by the source of ammonium phosphate used to produce the suspension. Most suspension producers prefer to produce mixtures having the highest grade without exceeding practical viscosity limits (1,000 centipoise or equivalent to 50 weight oil).

A few companies in the midwest have found they can produce higher analysis suspensions such as a 12-36-0 grade if the product is cooled after it is produced and if it contains about 15 percent of its P_2O_5 as polyphosphate. These companies use a batch cooler similar to the nonpacked cooler shown in figure 3. The base suspension of 12-36-0 grade is rapidly cooled from 145^{o}F to 90^{o}F by recirculating it through the cooler. These companies have found that the use of a small quantity of polyphosphate helps to dissolve the troublesome impurities that usually cause thick gels to form in the base suspension. Because high-analysis grades are rapidly cooled during manufacture the crystals in the suspension are usually very small sized DAP crystals which do not settle during storage. In making these high-analysis suspensions 20 percent of the product P_2O_5 usually is supplied as the 10-34-0 grade solution and 80 percent of this P_2O_5 is supplied by a commercial MAP of grade 11-52-0 to 11-54-0.

<u>Ammonium Polyphosphate Suspension from Merchant Grade Phosphoric Acid</u>

With the continued growth of the fluid fertilizer market, there has not been a corresponding increase in the production of superphosphoric acid.

One reason has been the difficulty of producing superphosphoric acid. In many instances the price of superphosphoric acid has also not been competitive with other sources of P_2O_5 in the market. For this reason many companies have been interested in using merchant-grade phosphoric acid, (54% P_2O_5) for producing fluid polyphosphate materials. Last year TVA built a new plant which uses the TVA process for producing fluid APP of 9-32-0 grade from merchant-grade acid. Figure 4 shows the flow diagram for this new plant.

In this process merchant-grade phosphoric acid is preheated to about 180°F with hot liquid product from the melt dissolution tank. This is accomplished in a shell and tube heat exchanger. The partially cooled product from the acid heat exchanger is then passed through an ammonia vaporizer where it is used to vaporize the ammonia used in the process. The temperature of the ammonia from the vaporizer is usually about 140°F. This ammonia and the hot acid are reacted in the new type pipe reactor. Melt from this reactor is mixed in the melt dissolution tank with partially cooled recirculating liquid from the ammonia vaporizer and cool liquid from an evaporative cooler. Fluid from this tank is cooled in an evaporative cooler. The cooled liquid is mixed in the clay mix tank with an attapulgite clay. This mix tank is equipped with a large recirculation pump and the clay is gelled in the product by recirculating it several times through this pump.

The resulting APP suspension has a 9-32-0 grade and contains 2 percent clay. The polyphosphate content of the product produced this winter is 20 to 25 percent of the total P_2O_5. The product has excellent cold weather storage characteristics. Recently several companies in the midwest have reported that it remains fluid at temperatures below 0°F. Some companies have successfully unloaded it at temperatures close to 0°F. This APP suspension is a good base material for producing high-quality suspension mixtures such as the 5-15-30, 6-18-18, and 7-14-28 grade. Limited studies have been conducted which show that this APP suspension can be mixed with urea-ammonium nitrate (UAN) solution, potash, and water to produce a solution starter grade such as 6-18-6. This product usually does not have troublesome crystals in it and application tests show that it can be applied through conventional gravity flow systems (figure 5). However, TVA field engineers recommend that if this solution is to be injected the application equipment could use a conventional hose or piston pump to meter the material as a band of fertilizer.

Plant tests have shown that noncomplicated mixing equipment can be used to produce either suspensions or solutions from the APP suspension. Figure 6 shows a sketch of this equipment. The small mix tank should be equipped with a recirculation pump that has a 4-inch discharge and the lines to and from the pump should be 4 inches in diameter. The pump should also be used to recirculate fluid tangentially to the walls of the mix tank and to pump the material to storage or to the applicator. The tank is equipped with a small agitator available from an equipment manufacturer or fabricated in a local shop. The investment cost for a mix tank of this type and the associated equipment should be low. It is also recommended that base suspension and the suspension mixtures produced from it should be stored in a tank equipped with an air sparger. Figure 7 shows a cone-bottom tank with an air sparger.

Nitrogen Suspension

TVA has developed a continuous process for producing a nitrogen suspension of grade 31-0-0 containing 1.5 percent clay. It is similar to the conventional UAN solution. Experience has shown that it is very difficult to form a nitrogen base solution by simply gelling clay in the conventional UAN solution. Several companies have tried this method and have failed. TVA research engineers have shown that the best way to gel clay in UAN solution is to add it as fluid clay while the materials are still hot. They have also shown that intense shearing of the clay in the fluid is required. This is accomplished by passing the material through a large high-speed centrifugal pump. Figure 8 shows a sketch of this continuous process. Fluid clay is produced by first dissolving tetrasodium pyrophosphate (TSPP) in hot water and then dispersing this material in more water. This TSPP solution is then metered to a small dilution funnel where it is mixed with still more water plus urea solution. Then this solution is fed to a dispersing tank and attapulgite clay is added. These materials are thoroughly mixed by recirculating them several times through two large recirculation pumps. This fluid clay product contains 9 percent nitrogen and 25 percent clay. Long term field storage tests show that this fluid clay has excellent winter storage characteristics. During the summer, however, there is a tendency for this fluid clay to become very viscous. Therefore, during TVA's introduction of the fluid clay it was recommended that fluid clay not used during the spring season should be diluted with water so that it contains 10 percent clay. TVA has successfully introduced fluid clay and no longer makes the product.

When nitrogen suspension is produced the fluid clay is then mixed with concentrated UAN solution in a gelling tank. The ammonium nitrate portion of the nitrogen solution is a suitable electrolyte to gell the clay which has been dispersed in the fluid clay. Usually a small amount of the 11-37-0 or 10-34-0 grade APP solution is added as a corrosion inhibitor. TVA has shown that this nitrogen suspension has excellent storage characteristics. Clay remains well dispersed and gelled within it and it is an excellent nitrogen base suspension to mix with phosphate base and potash or a potash base to produce high-nitrogen low-phosphate suspensions. Usually this is accomplished in a satellite plant such as shown in figure 9. By using the nitrogen base suspension with other base materials such as the 3-10-30 grade potash base suspension and a 12-36-0 grade phosphate base suspension, it is possible to produce a wide range of NPK mixtures without adding clay at the satellite station. For this reason this type of operation is often referred to as a fluid blend plant. High nitrogen grades of good quality are produced in plants of this type from these materials. Grades such as 24-12-0, 20-10-10, 13-13-13, 15-5-15 have been produced. The nitrogen suspension has also been cold mixed with potash to produce grades that do not contain phosphates such as 22-0-11, 14-0-28, etc.

Urea Phosphate

A recent survey by TVA of their cooperators using the TVA pipe reactor process for producing ammonium polyphosphate solution of grade 10-34-0, show that about 80 percent of this solution is used for direct application or to produce solution grades. Therefore, the industry is still interested in producing solution materials containing a minimum of impurities. A transparent solution should be produced. TVA has developed a new process for producing solid urea phosphate crystals that would be used to produce clear solutions. Figure 10 shows a flow diagram of this process. It involves reacting concentrated urea solution with wet-process orthophosphoric acid (54% P_2O_5) to form a crystalline urea phosphate. The crystals are separated from the mother liquor by a centrifuge. Some of the mother liquor is recirculated to the crystallizer; the remainder is ammoniated and converted into a byproduct suspension. The urea crystals are melted and reacted with ammonia to form a urea-ammonium polyphosphate solution. A flow diagram for this process is shown in figure 11. After crystals have been weighed and melted they are reacted with ammonia and heated with steam to form a urea-ammonium polyphosphate melt. This melt is mixed with more ammonia and water to produce a clear urea-ammonium polyphosphate solution that has a nominal grade of 15-28-0 with 50 to 80 percent of its total P_2O_5 in the form of polyphosphate.

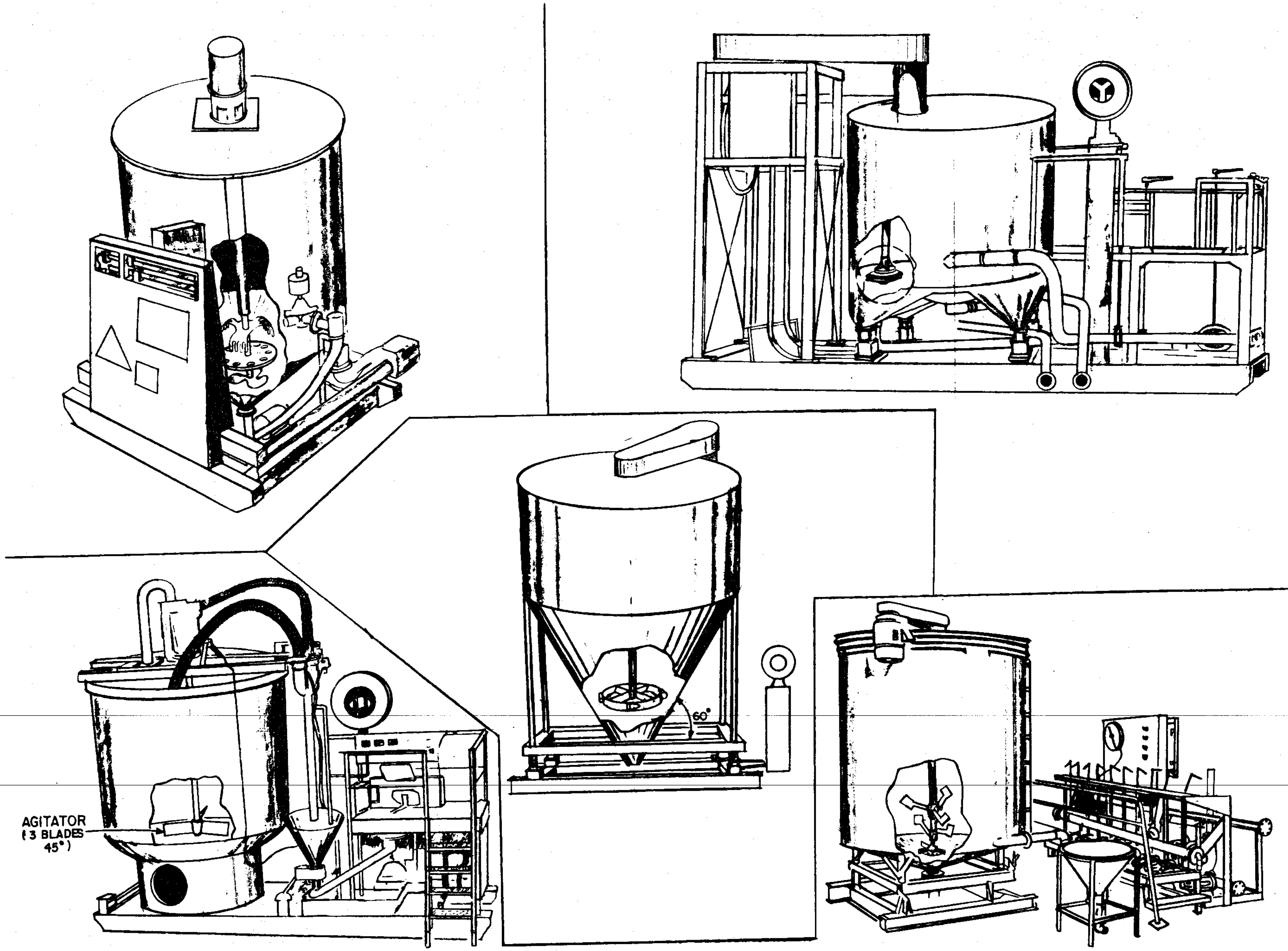
Urea-Ammonium Sulfate Suspension

In many locations it is not feasible to produce ammonium nitrate; and the companies only produce urea and ammonia. TVA has developed a process during which concentrated urea solution, sulfuric acid, and ammonia are reacted to produce a urea-ammonium sulfate suspension. Figure 12 shows a flow diagram of this process. The process has a reactor for reacting sulfuric acid, urea solution, ammonia and water. It also has a first stage cooler for cooling the product; suspending clay is added in this first cooler. After the clay has been gelled the product is further cooled in a second-stage cooler. The resulting product contains 29 percent nitrogen, 5 percent sulfur as ammonium sulfate, and 2 percent clay. It is an excellent suspension for direct application or for the production of NPK and NPKS suspensions.

The Future for Fluids in the U.S.

The fluid fertilizer industry will continue to grow. Some reasons for this growth are:

1. Fluids are easy to transport and handle, and usually can be applied at a much faster rate than solid fertilizers.
2. It is usually easier to apply fluids uniformly than to apply solid materials uniformly.
3. Fluids are excellent carriers of herbicides and micronutrients.
4. Fluids are especially well adapted to new or special types of applications, such as the drip or sprinkler type irrigation units.
5. Fluids can be accurately placed in a row and at locations where they can be used efficiently.



PPI SEC. — TVA

FIGURE I

FIVE TYPES OF MIX TANKS FOR SUSPENSIONS

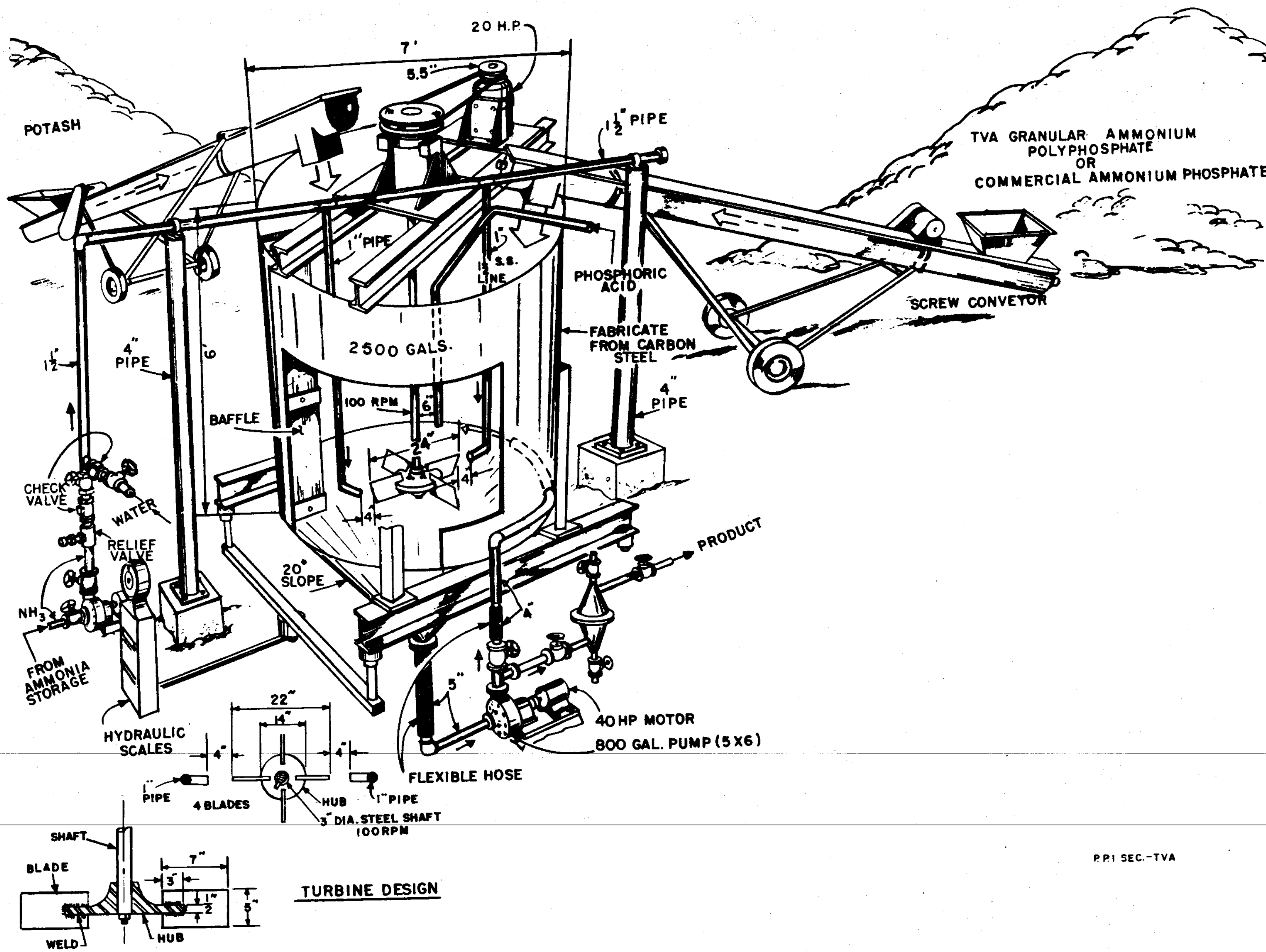


FIGURE 2

MIX TANK FOR PRODUCTION OF SUSPENSIONS FROM GRANULAR AMMONIUM POLYPHOSPHATE OR COMMERCIAL GRANULAR AMMONIUM PHOSPHATES — 12 TON BATCH

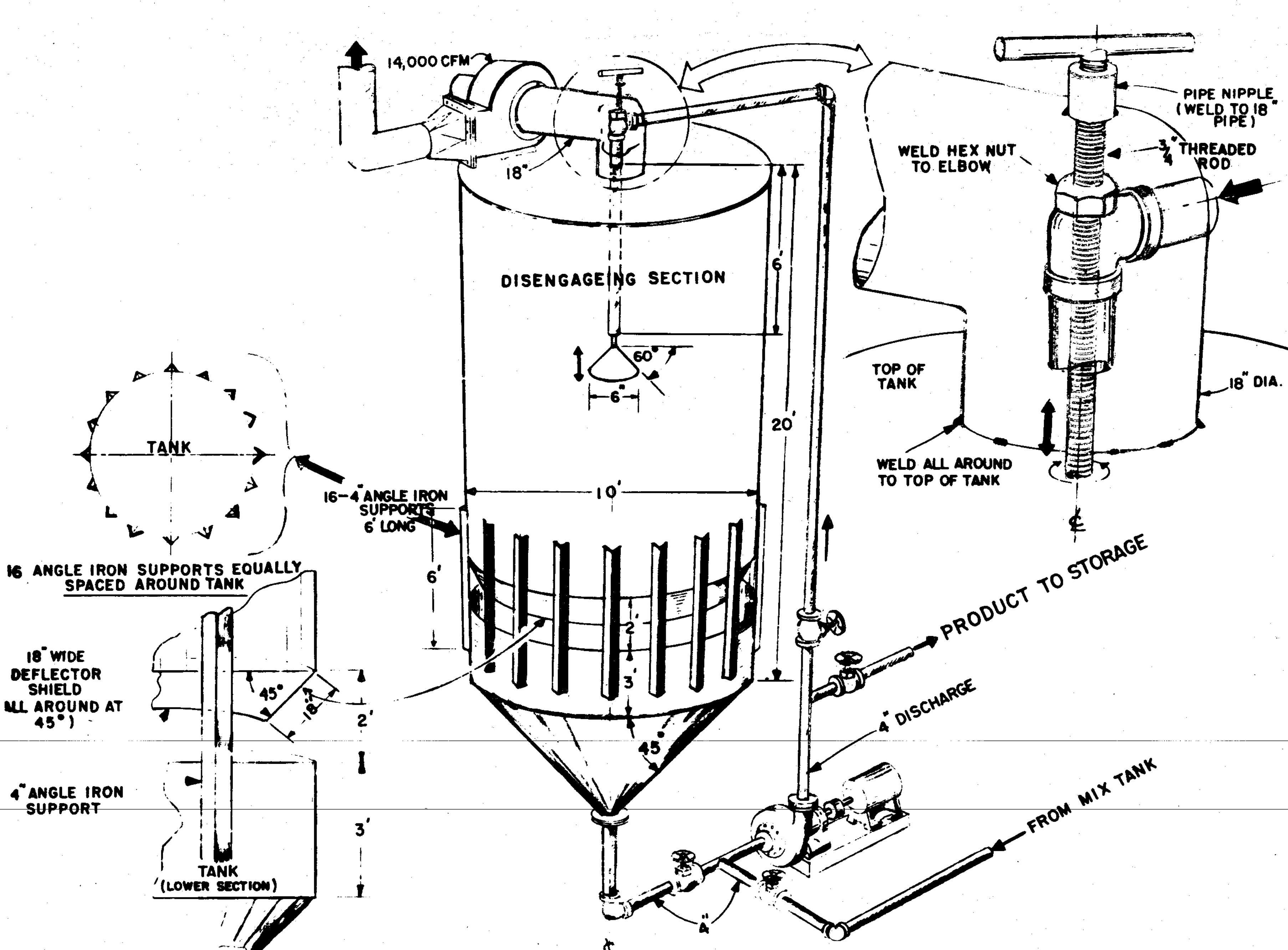


FIGURE 3

SUSPENSION COOLER
(NO PACKING)

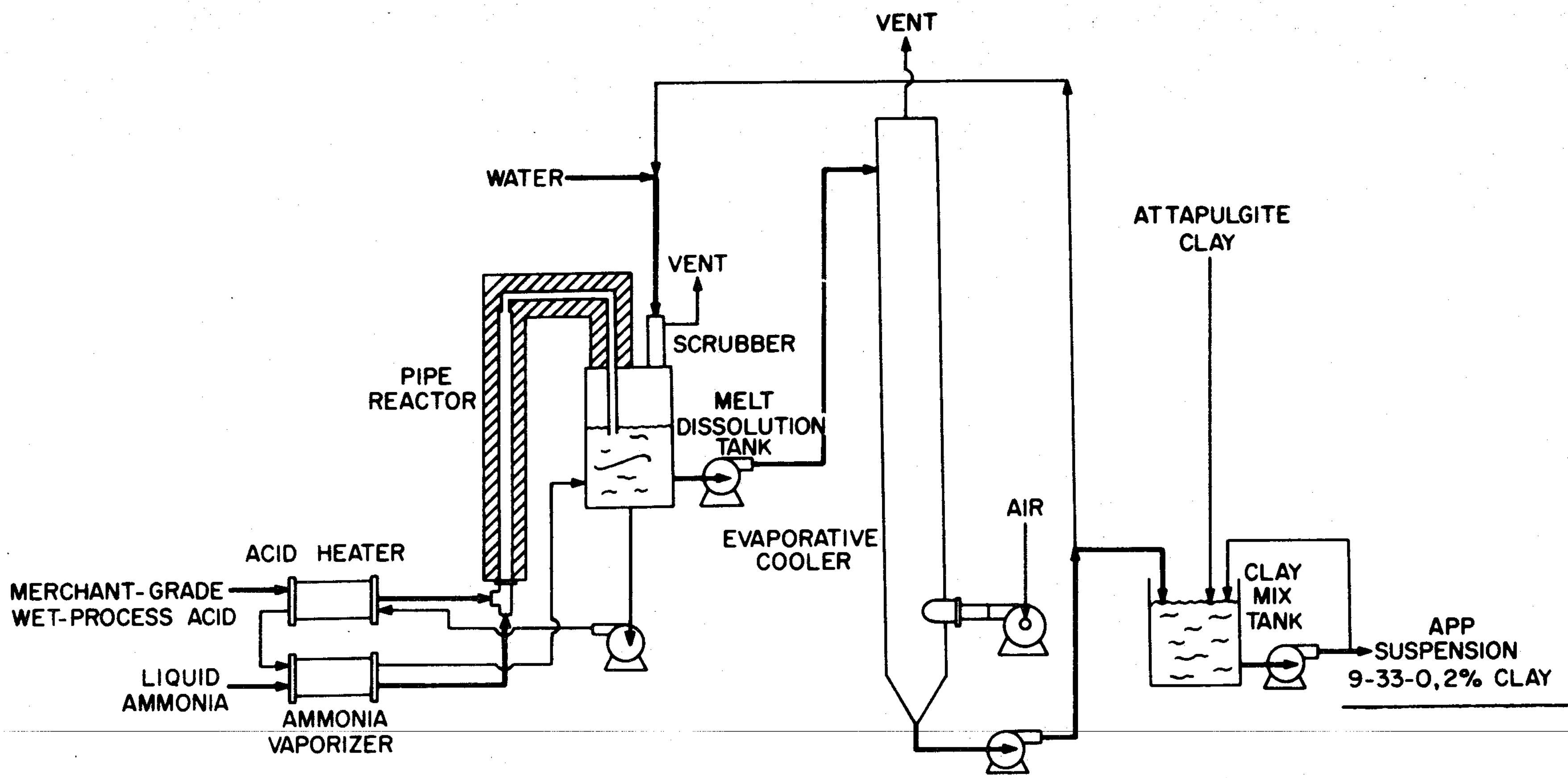


FIGURE 4

AMMONIUM POLYPHOSPHATE SUSPENSION-FLOW DIAGRAM

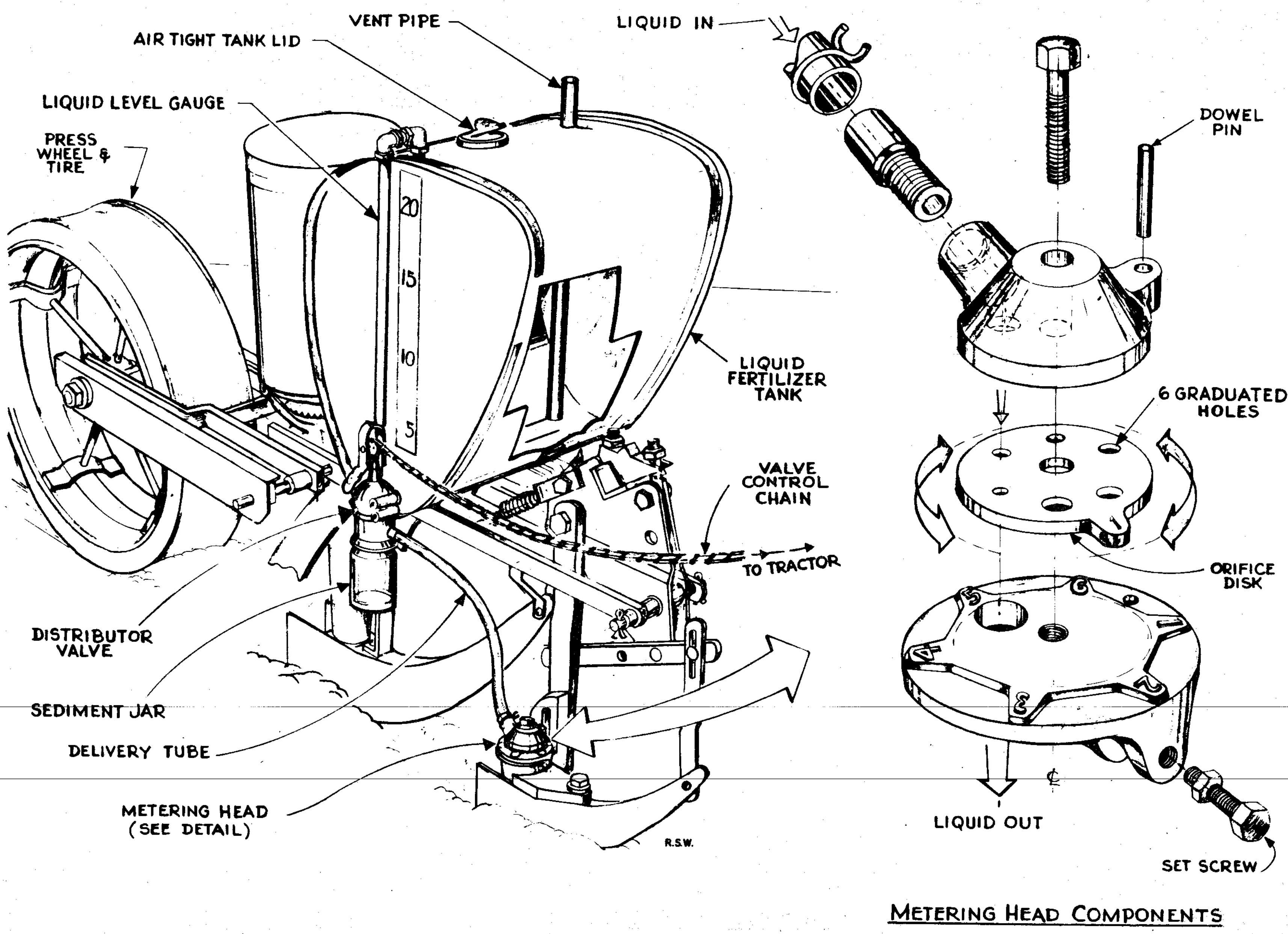


FIGURE 5

LIQUID APPLICATOR WITH CONSTANT-HEAD TANK AND ORIFICE PLATES

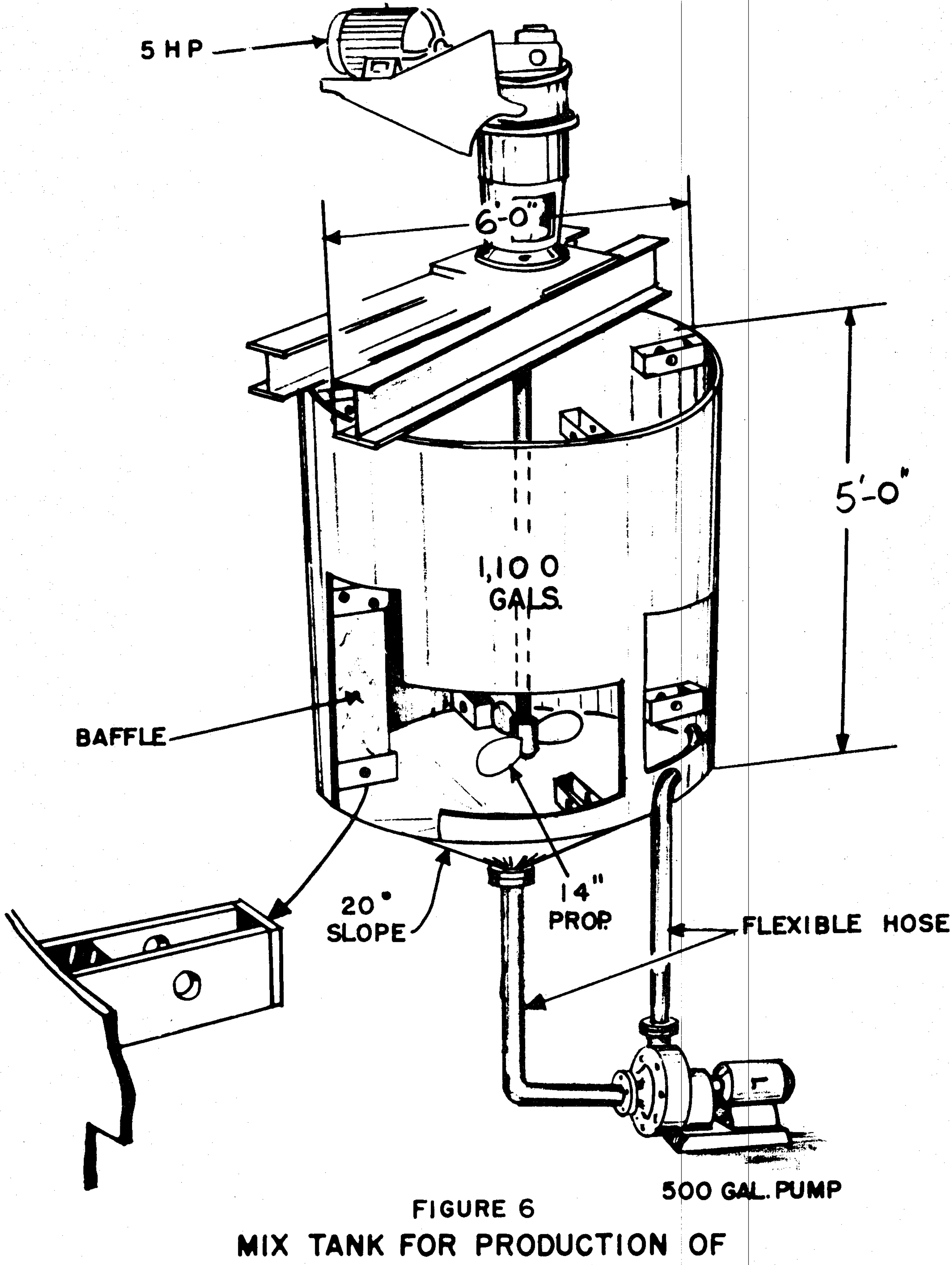


FIGURE 6

MIX TANK FOR PRODUCTION OF
<u>SUSPENSION FERTILIZERS</u>

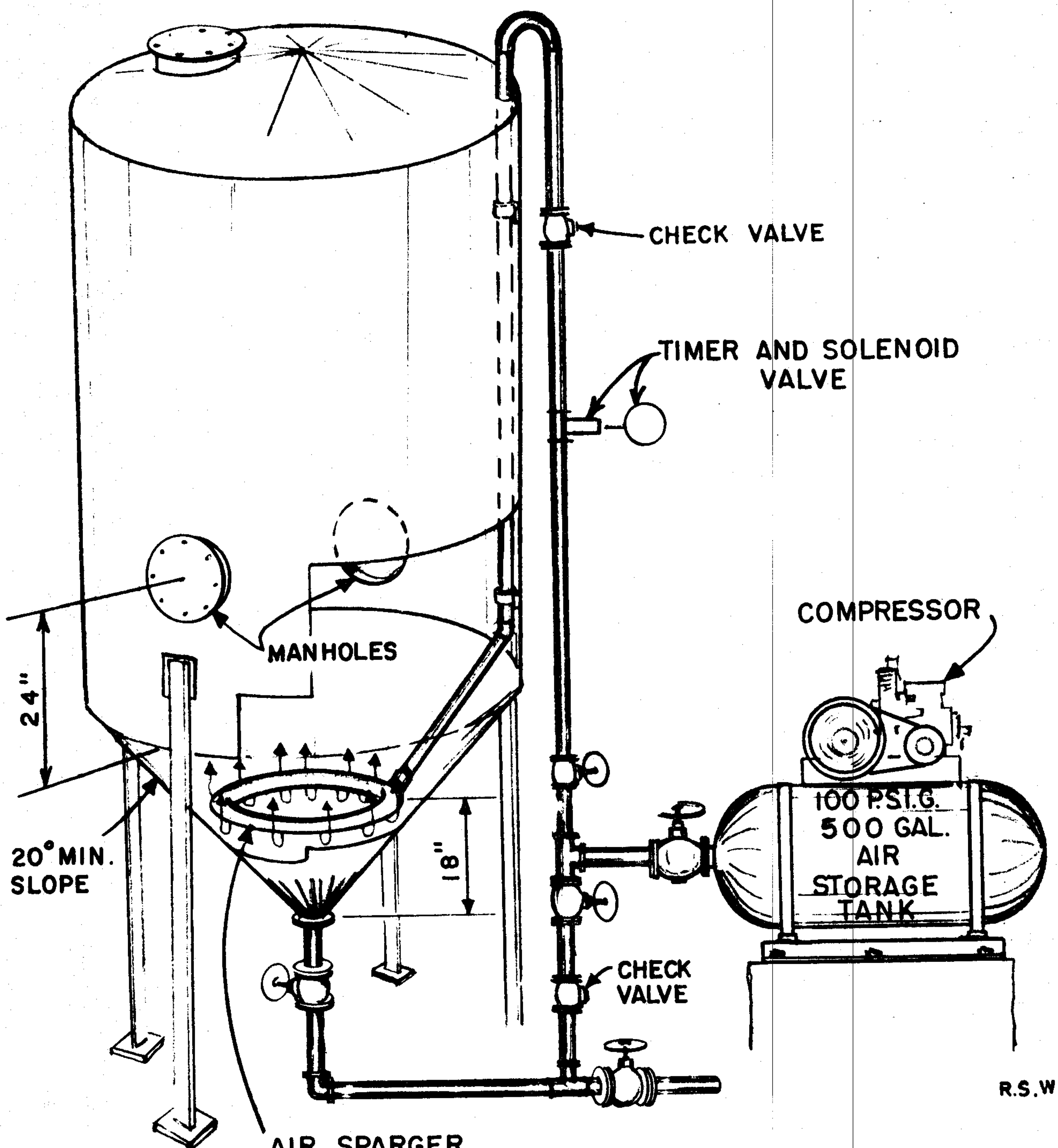


FIGURE 7

CONE BOTTOM SUSPENSION STORAGE TANK
WITH AIR SPARGER SYSTEM

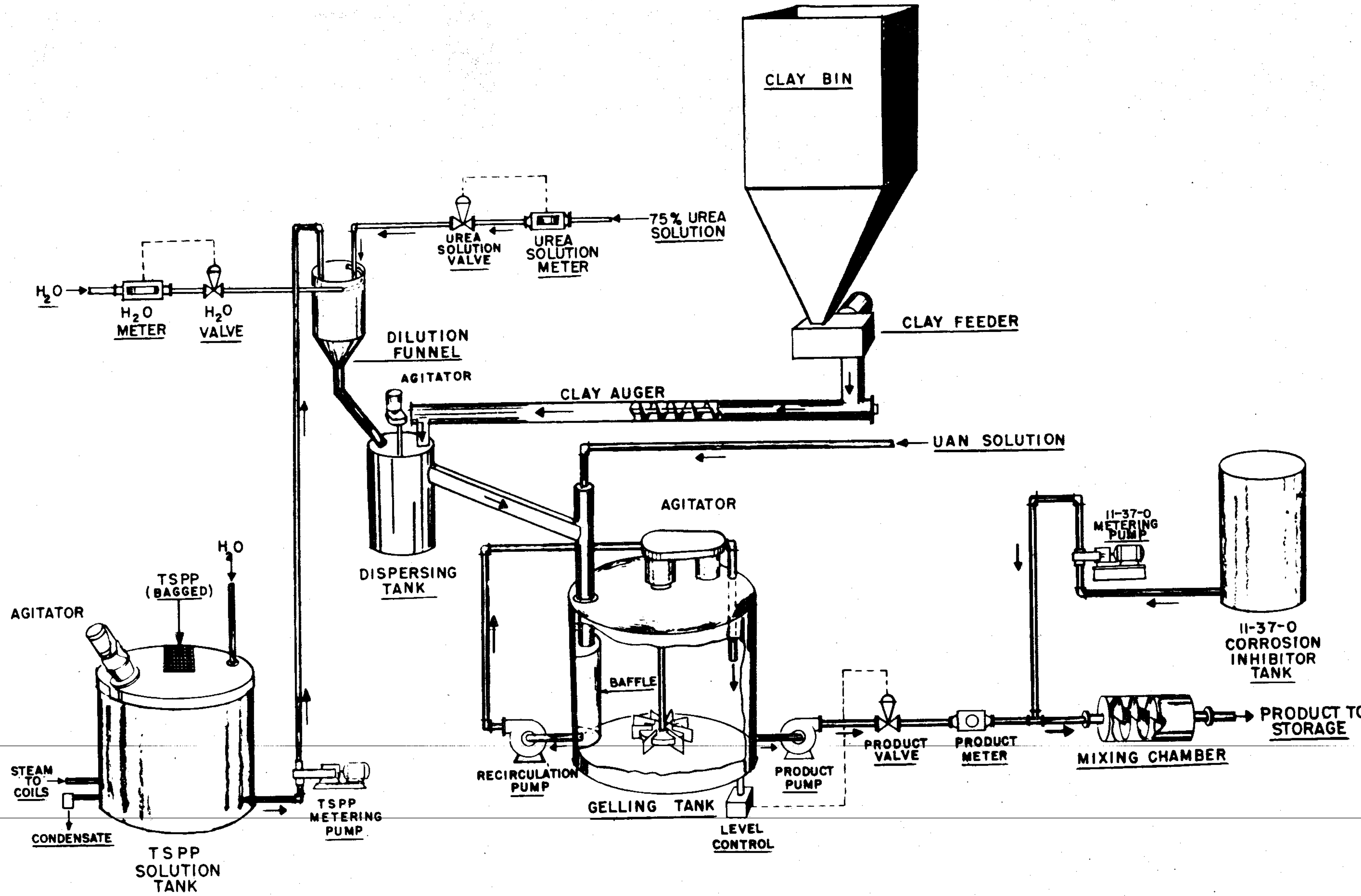


FIGURE 8

PLANT FOR PRODUCTION OF UREA-AMMONIUM NITRATE SUSPENSION FERTILIZER

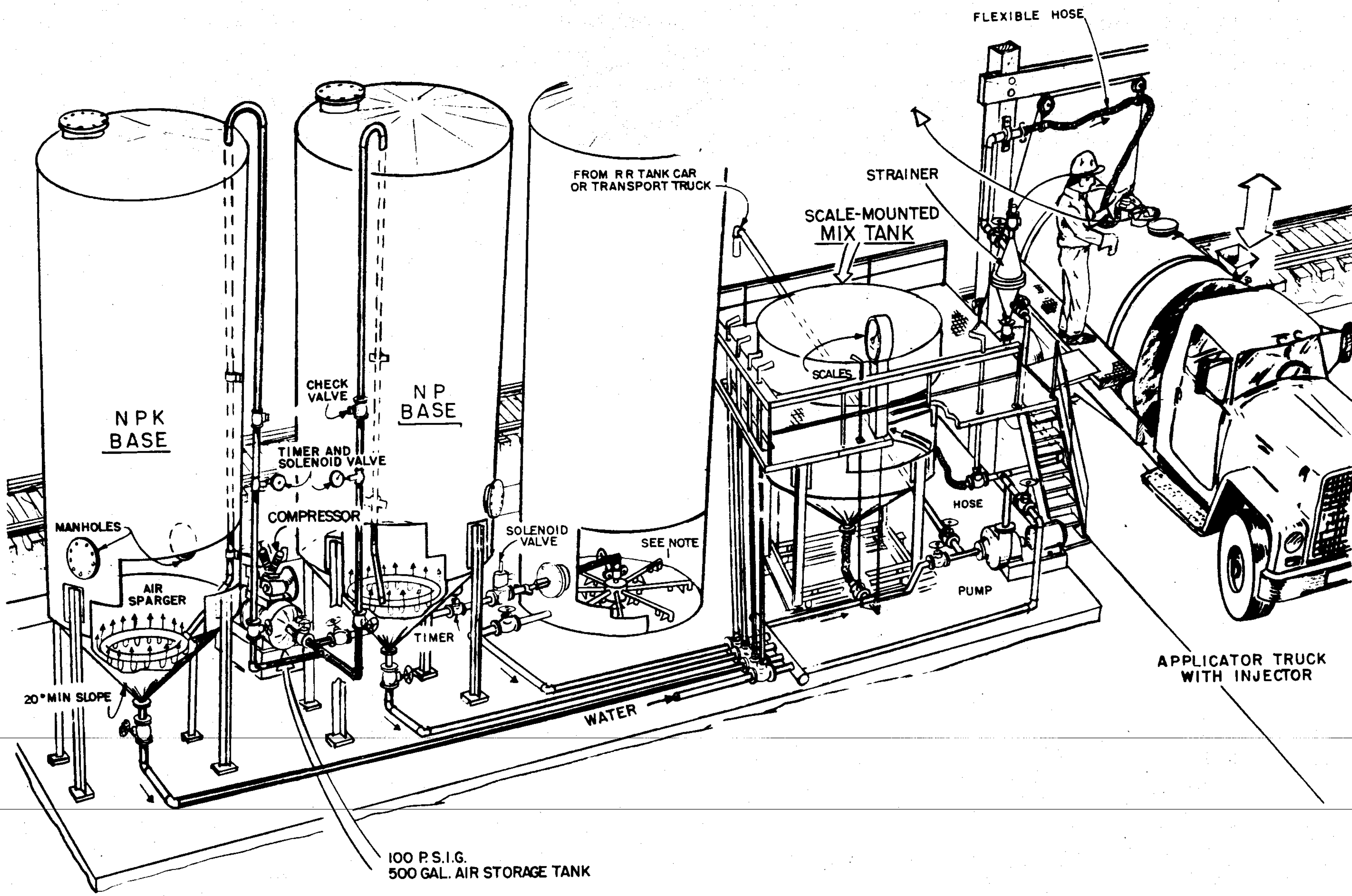


FIGURE 9

SUSPENSION SATELLITE PLANT

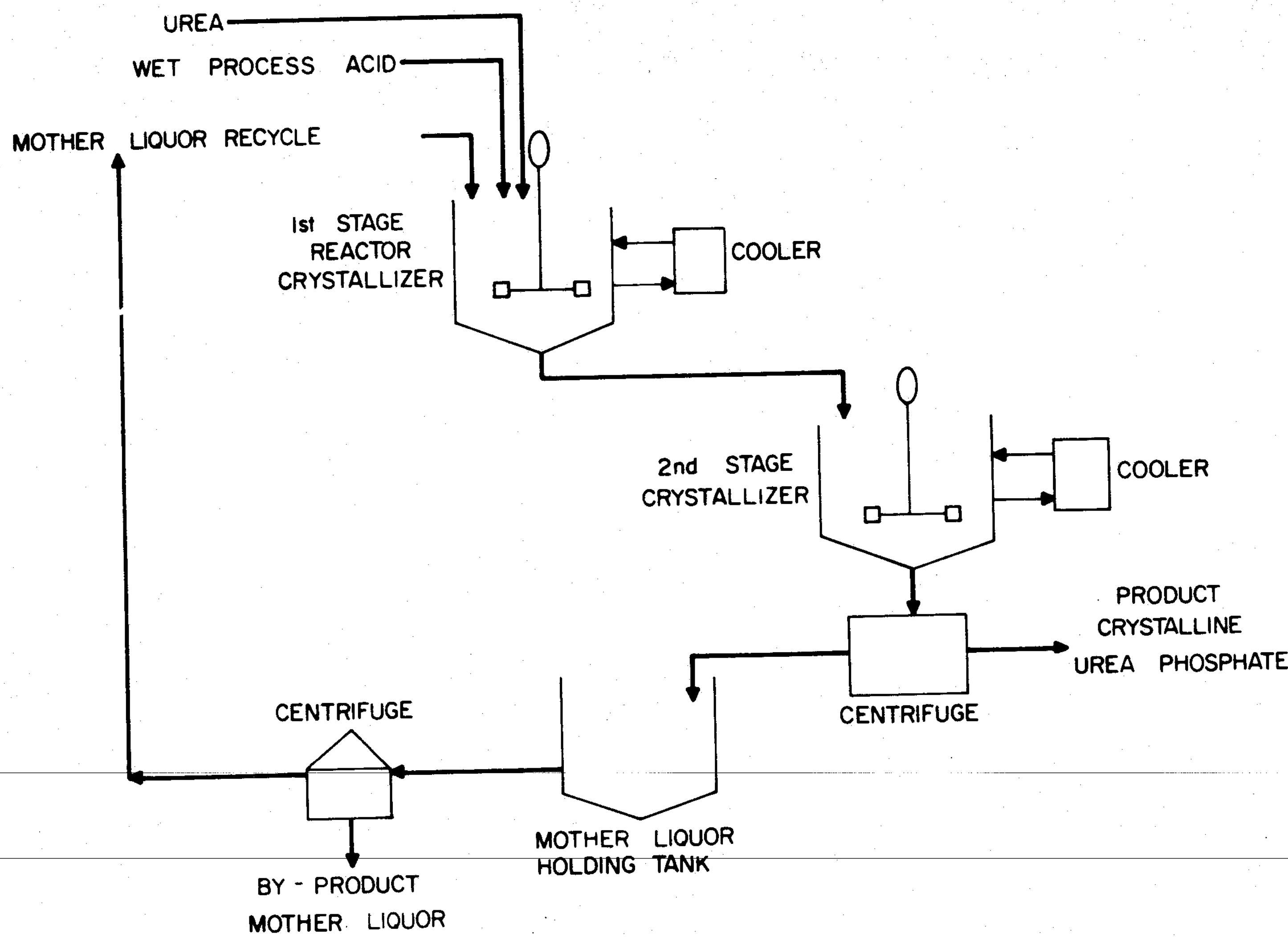


FIGURE 10

PRODUCTION OF PURIFIED CRYSTALLINE UREA PHOSPHATE

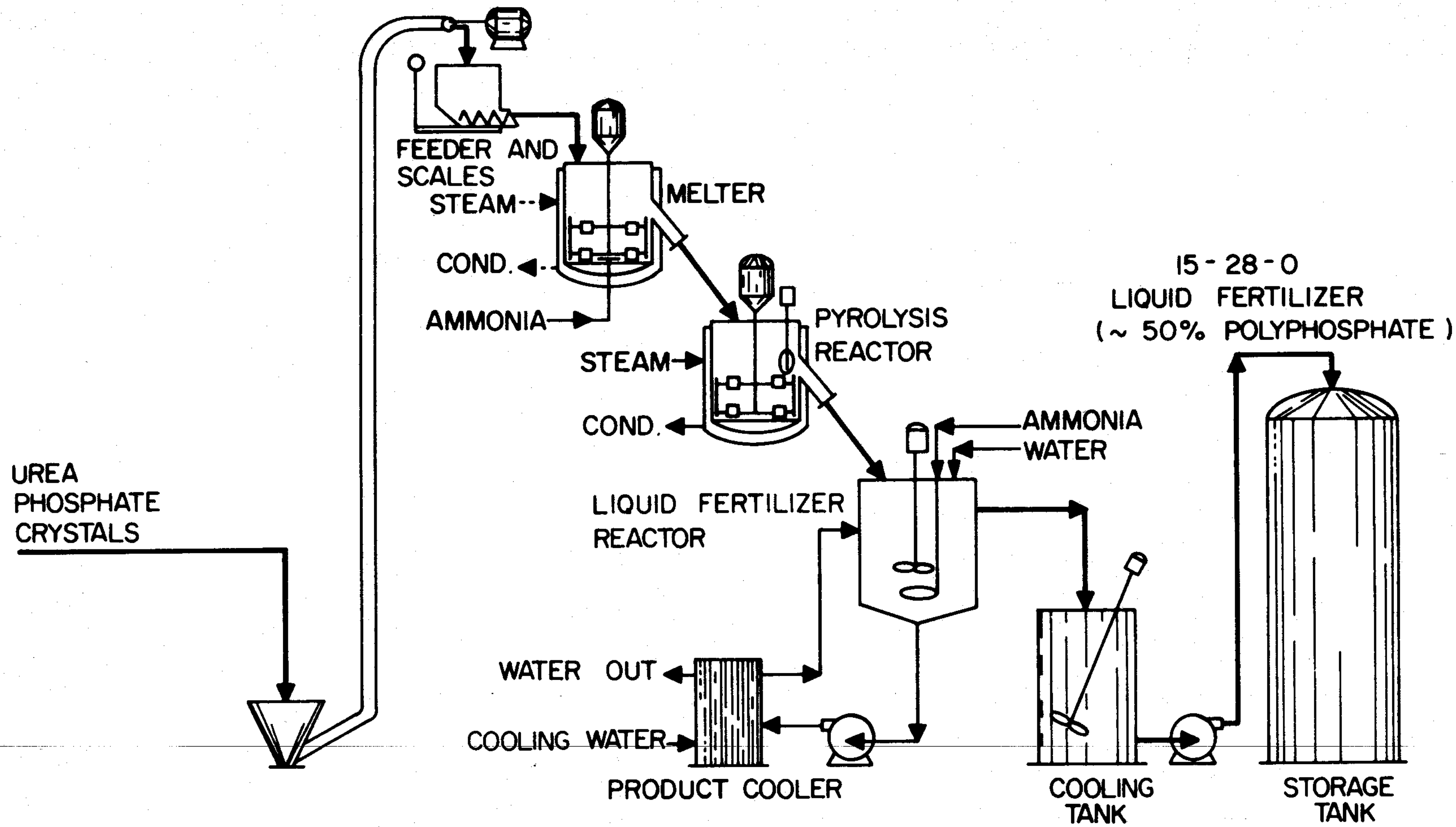


FIGURE II

UREA PHOSPHATE CONVERSION PILOT PLANT

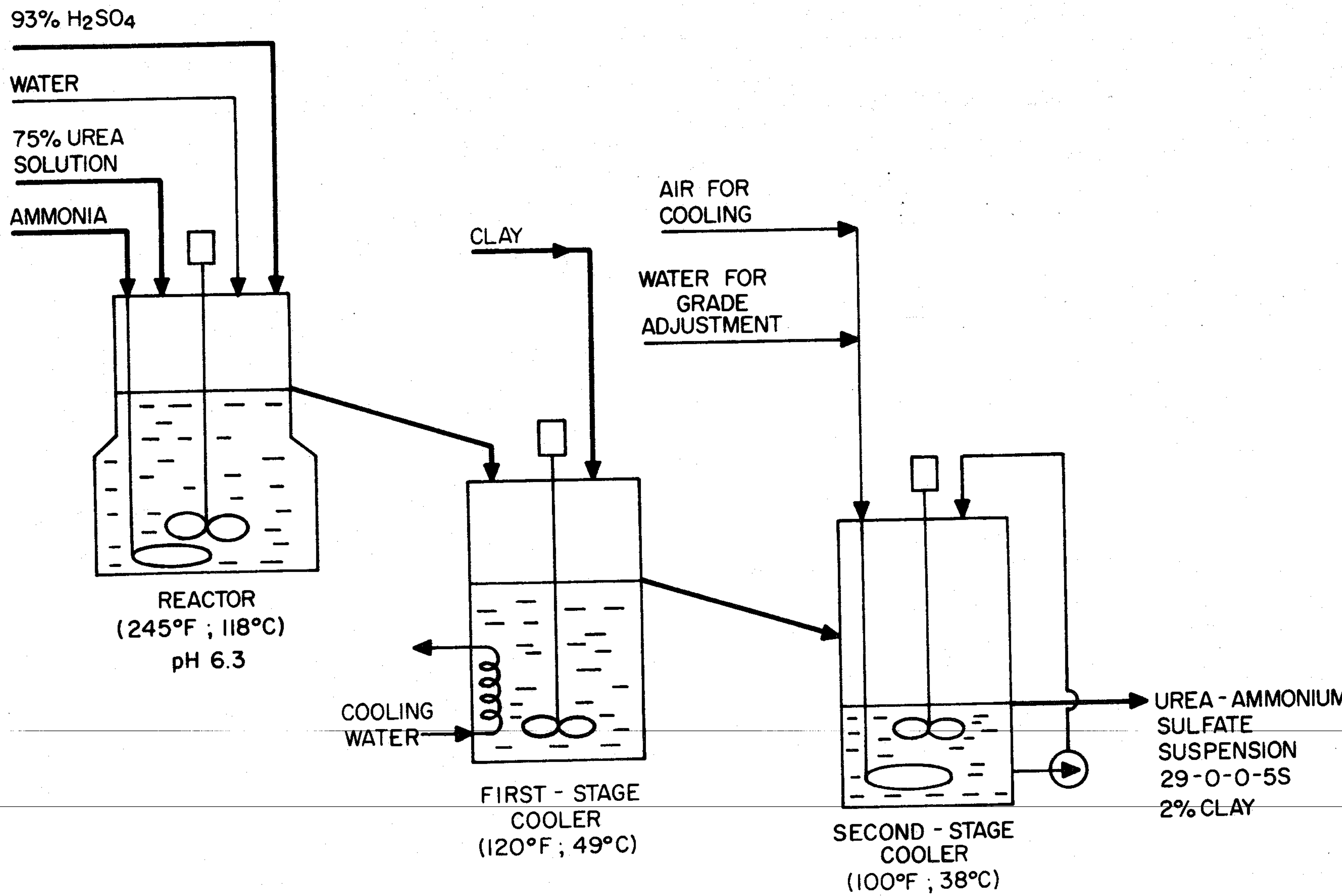


FIGURE 12

PILOT-PLANT FOR PRODUCTION OF UREA-AMMONIUM SULFATE SUSPENSION FERTILIZER