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TECHNICAL ASPECTS OF SUSPENSIONS

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There are three major reasons for the rapid growth and intense interest in suspensions:

1. Suspensions provide a means of producing high-analysis grades which in many instances have about twice the concentration of clear liquids.
2. They provide a means of incorporating sufficient amounts of micro-nutrients in fluid fertilizers.
3. They provide a means of suspending pesticides and herbicides in a fluid fertilizer so that only one application of both fertilizer and pesticide or herbicide is required.

Production of Suspensions

Suspensions are usually produced by two general procedures: hot mixing and cold mixing. In hot mixing acid and/or superphosphates are usually neutralized with ammonia, and heat is released. In the cold-mix process the liquid raw materials are such that when they are mixed no heat is released.

Hot Mixing

In one type of hot-mix suspension plant orthophosphoric acid (54 percent P_2O_5) is neutralized with aqua ammonia to produce an ammonium phosphate suspension. The concentration of the liquid is so high that ammonium orthophosphate crystals are formed. These crystals are suspended by a gelling clay which is incorporated during mixing. The clay is usually added as a 12 percent pre-gel of clay and water. Most of the potash, which is usually the last material to be added, is also suspended by this clay. Grades such as 12-12-12, 9-27-9, 4-12-20, and 12-15-10 have been produced by this process.

In another hot-mix process nitric acid is reacted with phosphate rock to produce a nitric phosphate suspension. The resulting slurry has a low pH (between 1 and 2), and it would cause corrosion of standard application equipment. If the slurry should be ammoniated to higher pH's, the P_2O_5 availability would decrease to an unacceptable level. However, plant tests indicate that if sufficient phosphoric acid or some soluble sulfate is added, together with additional quantities of ammonia, there can be produced a slurry with higher pH and good P_2O_5 availability which would not corrode equipment. Some of the nitric phosphate suspension grades which have been produced and marketed are 16-8-0, 7-14-7, 6-12-12, and 14-7-7. These are somewhat lower in analysis than those produced as ammonium phosphate or ammonium polyphosphate suspensions; however, the use of nitric acid for acidulation

and to supply some of the plant nutrients provides a means of having low-cost raw materials, provided the nitric acid does not have to be shipped long distances. Nitric acid has a nitrogen content of only 13 percent. This low raw-material cost is the reason for some interest in suspensions of this type.

Others have produced suspensions by using triple superphosphate as the only source or part of the source of the P_2O_5 of the grade. The superphosphate slurry is ammoniated with either aqua ammonia or ammoniating solution. Grades such as 12-12-12 and 9-27-9 have been produced. The advantages of the superphosphate suspensions are:

1. Low-cost phosphate can be used.
2. The ammoniated superphosphate acts as its own suspending agent, and suspending clay is not required.
3. Suspensions of low N: P_2O_5 ratios can be produced.

The main disadvantage in using triple superphosphate is that a superphosphate minus 10-mesh in size is required. Therefore, the usual run-of-pile triple superphosphate must be crushed and screened prior to its being used in suspensions. Because of the sticky quality of the run-of-pile superphosphate, it is difficult to accomplish this crushing and screening operation. This is one of the reasons that many of the producers who were interested in these types of suspensions have given them up for one of the less difficult suspension processes.

Another type of hot-mix plant is the continuous 10-34-0 clear liquid plant which is converted to the production of 12-40-0 base ammonium polyphosphate suspension. This base suspension is marketed through cold-mix plants in a manner similar to the way in which 10-34-0 and 11-37-0 are now marketed through these plants. A 12-40-0 plant can either be located near the source of phosphate rock from which location the base suspension is shipped long distances or it can be a regional plant which services a number of liquid cold-mix suspension plants in its region. The 12-40-0 suspension marketing system is a rather noncomplicated system that has every indication of gaining acceptance by the fluid fertilizer industry.

Figure 1 is a sketch of a regional hot-mix plant for the production of 10-34-0 which has been altered to produce the 12-40-0 base suspension. In the reactor of this plant superphosphoric acid is neutralized continuously with anhydrous or aqua ammonia to produce a clear 12-40-0. This solution is partially cooled in the primary cooler to a temperature of about 140° F., and dry clay is added at this temperature in the clay mix tank. The product is then further cooled in the secondary cooler to 100° F. The clear 12-40-0 in the reactor is kept at 180° F. by the recirculation of clear liquid from the primary cooler to the reactor.

The major crystalline phase in 12-40-0 suspension is an ammonium polyphosphate which is usually in the form of small crystals, whereas the major phosphate crystalline phases in the other hot-mix suspensions are orthophosphate which often grow to large crystals in storage. Field experience indicates that little difficulty is encountered with storing and then applying polyphosphate suspensions, whereas the crystal growth in orthophosphate suspensions often is such

that special application equipment and more elaborate agitation in storage are required.

Cold Mixing

After the 12-40-0 is produced in the regional or basic producing plant, it is shipped to a number of satellite cold-mix plants. Figure 2 is a sketch of a typical cold-mix plant for the production of suspensions from urea-ammonium nitrate solution (32-0-0 or 28-0-0), base suspension 12-40-0 or 11-37-0, and potash. This plant is very similar to the cold-mix plants now installed throughout the country; however, it has more agitation than the conventional cold-mix plant. The plant results indicate that the potash used in suspensions should be screened, because it usually contains a small amount of trash that would cause some clogging of the spray nozzles. Also, it is recommended that all suspensions be strained as they are pumped to or from storage and to nurse tanks. A detail of the strainer is shown in Figure 2, together with details of the mix tank and screen. The mix tank is usually made of mild steel, and it is equipped with a turbine-type agitator. Liquid is recirculated tangentially to the walls of the mix tank by a centrifugal pump that should have a capacity of about 400 to 600 gallons per minute. Some grades which have been produced in a plant of this type are 10-30-10-3Zn, 7-21-21, 3-10-30, 24-8-0-2Zn, 22-11-0-2Zn, 15-15-15, 12-24-12, 16-8-16, and 20-10-10. Other grades containing as much as 10 percent sulfur have been produced with 12-40-0 and flowers of sulfur as the source of sulfur.

Application of Suspensions

Figure 3 is a sketch of a pull-type broadcast applicator that uses air pressure to agitate the suspension in the applicator tank and to force the suspension from a single flooding-type nozzle. Application tests at TVA indicate that a uniform application rate can be obtained throughout 90 percent of the swath. The application rate drops off sharply during the last 1.5 feet on each end of the swath. Figure 4 is a photograph of the spray pattern of liquid drops from this type of applicator as it was passed over a strip of kraft paper. The picture shows that the spray pattern is uniform across the entire surface of the paper.

Figure 5 depicts the actual swath pattern for a suspension from a single flooding nozzle. Notice that very little overlap--about 10 percent--is needed to get uniform application of the material.

Figure 6 is a sketch of another type of applicator for broadcasting suspensions. This is an improved design of the old slinger-type applicator. An agitator in the shape of a sweeping baffle is used to agitate the liquid in the tank. The slinger mechanism is designed so that as it rotates it also causes the material to be pumped from the tank. This type of applicator has been tested with various types of suspensions and has been found to be satisfactory for applying even the most difficult-to-handle suspensions.

Figure 7 shows a type of applicator that is used to inject liquid below the surface of the ground during preplant or in the row as a starter fertilizer. This

applicator has a squeeze pump, and it has been used successfully to apply ammonium polyphosphate suspension. The action of the rollers of the squeeze pump as they move over the hoses causes the suspension to be drawn into and out of the hoses. Therefore, with this pump it is possible to pump and meter suspensions to the applicator knife and then to the ground. These pumps are usually ground-driven, and the application rate is independent of the speed of the applicator. The detail of the knife for this applicator shows that a pipe is welded on the back side of the knife, and the hose from the pump is stuck well down into the pipe. This pipe remains open during application and keeps the tube positioned behind the knife.

Several application equipment companies are now offering modified piston-type metering pumps which will handle the ammonium polyphosphate suspensions. Our tests have shown that the gravity-flow measuring devices which are now used on many corn planters to meter clear liquids are not satisfactory for the metering of suspensions. The salts in the suspensions build up in the tubes to and from the orifice plate of this equipment and clog the hoses. To meter suspensions, there should be some positive movement of the fertilizer through the equipment so that crystals will not settle in the application hoses. This positive movement can usually be produced by several types of pumps.

Recently TVA has developed a high-analysis base suspension which does not contain clay. The analysis of this suspension is 13-45-0. It is produced by neutralizing superphosphoric acid with anhydrous ammonia and quick-cooling the product from the reactor. Very small particles of an ammonium polyphosphate form as a result of quick cooling and they are light enough to be uniformly suspended without the aid of a suspending clay. This product can be diluted and used to produce clear liquids, or it can be used to produce suspensions.

Also, TVA is now introducing a 15-60-0 solid ammonium polyphosphate in our field development programs. We have successfully used 15-60-0 to produce either clear liquids or suspensions. The suspensions from this material are usually produced by making a pre-gel of clay in the water-and-urea-ammonium nitrate solution. Next the solid ammonium polyphosphate is dissolved in this clay solution, and finally the potash is suspended in it.

Figure 8 is a sketch of the mix tank which we recommend for making suspensions from 15-60-0. The important feature of this tank is that it has a good agitator, a reasonably large recirculation pump, and a cone bottom. The cone bottom and recirculation pump prevent the ammonium polyphosphate from settling in dead spots in the tank where it may be difficult to dissolve.

Some of the advantages of ammonium polyphosphate 15-60-0 for producing suspensions are:

1. Some saving in freight cost is realized by shipping a high-analysis solid material to a plant near the use area.
2. Ammonium polyphosphate can be used to produce either clear liquids or suspensions.

The main disadvantage is that most personnel in the liquid fertilizer industry has found it advantageous to handle liquid raw materials instead of solid materials.

We hope that this gives you some of the overall technical aspects concerning suspensions. We will be glad to discuss our experiences in the production and use of suspensions at any time that is convenient to you.

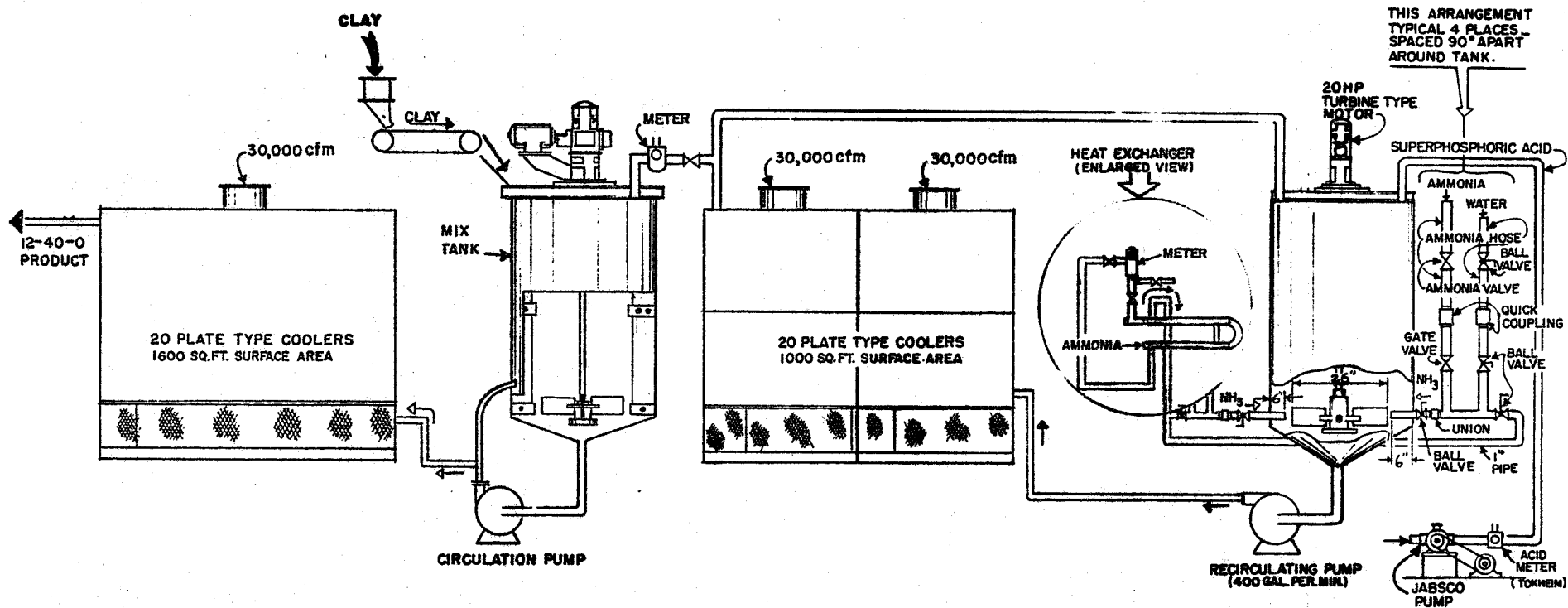


FIG. 1
REGIONAL 12-40-0 BASE SUSPENSION PLANT

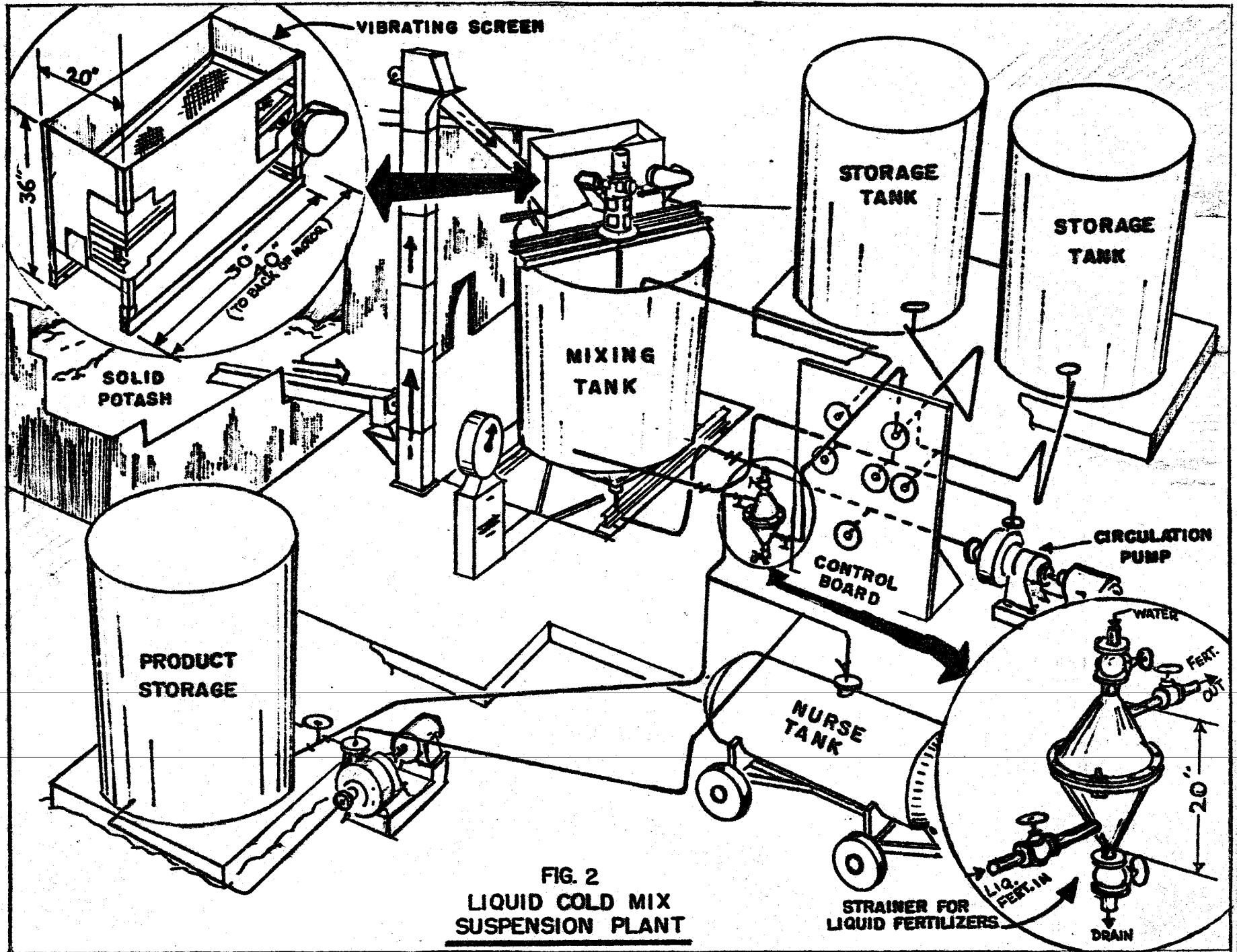


FIG. 2
 LIQUID COLD MIX
 SUSPENSION PLANT

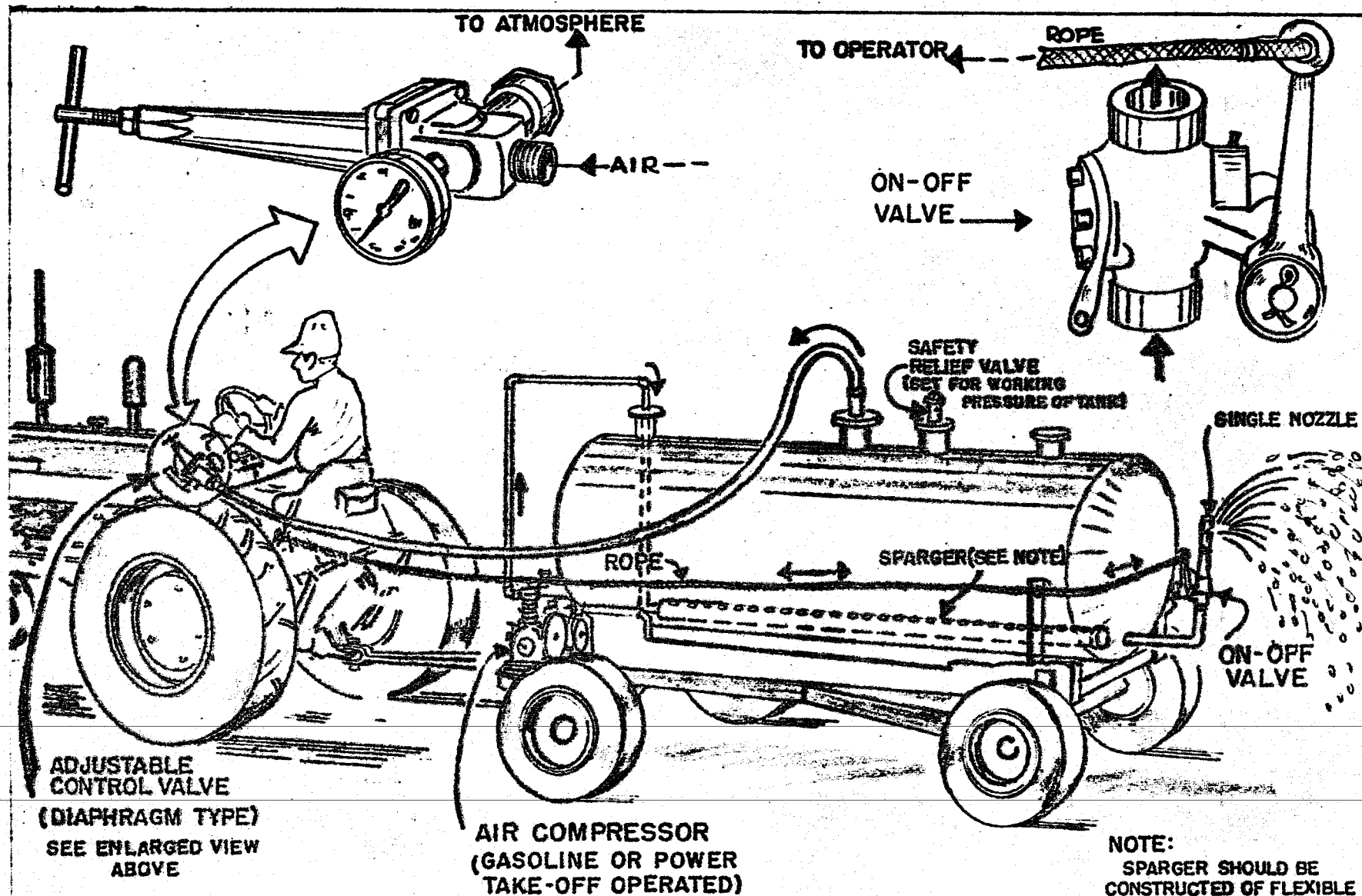


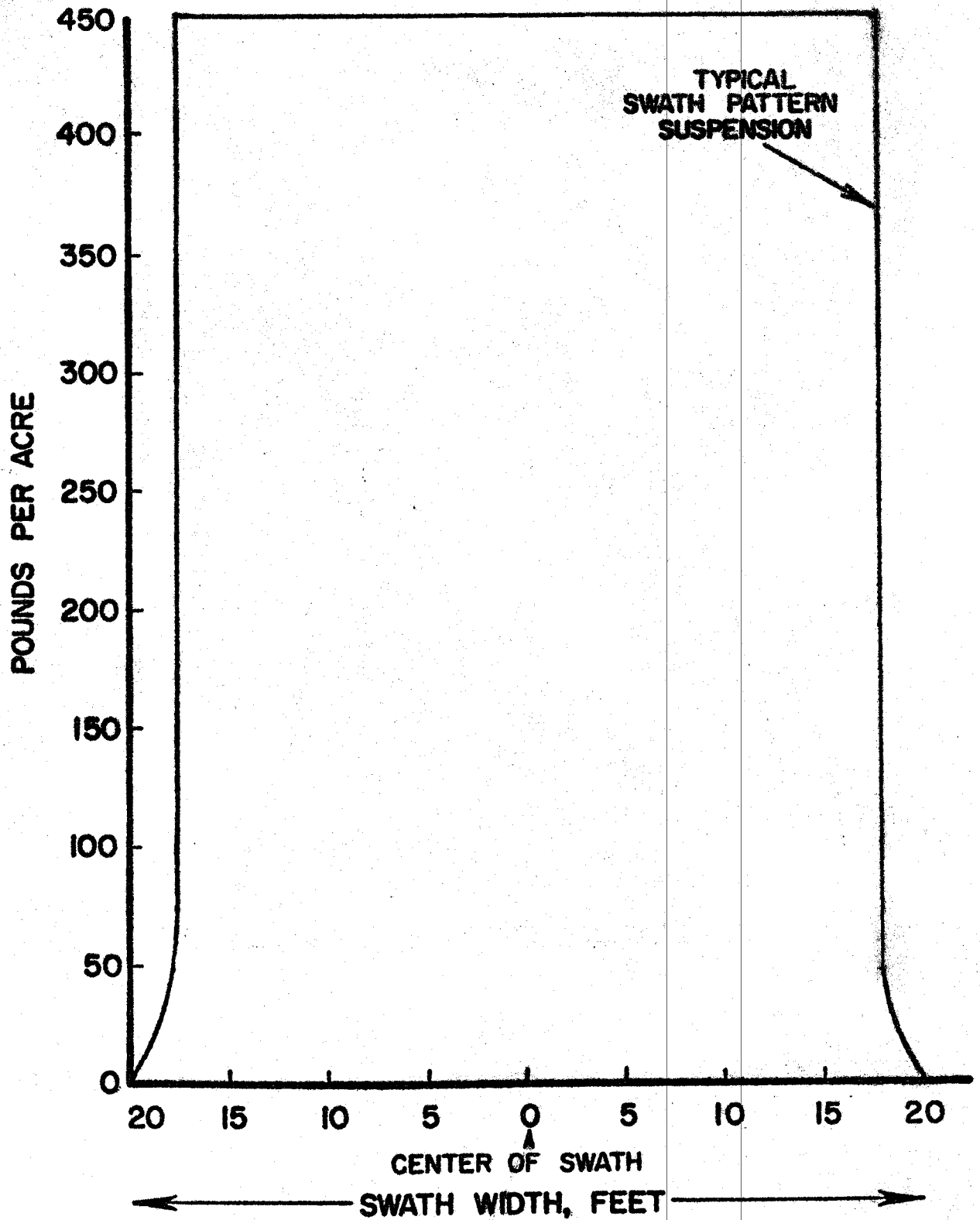
FIG. 3
**AIR PRESSURE BROADCAST APPLICATION TANK
 FOR SUSPENSIONS**

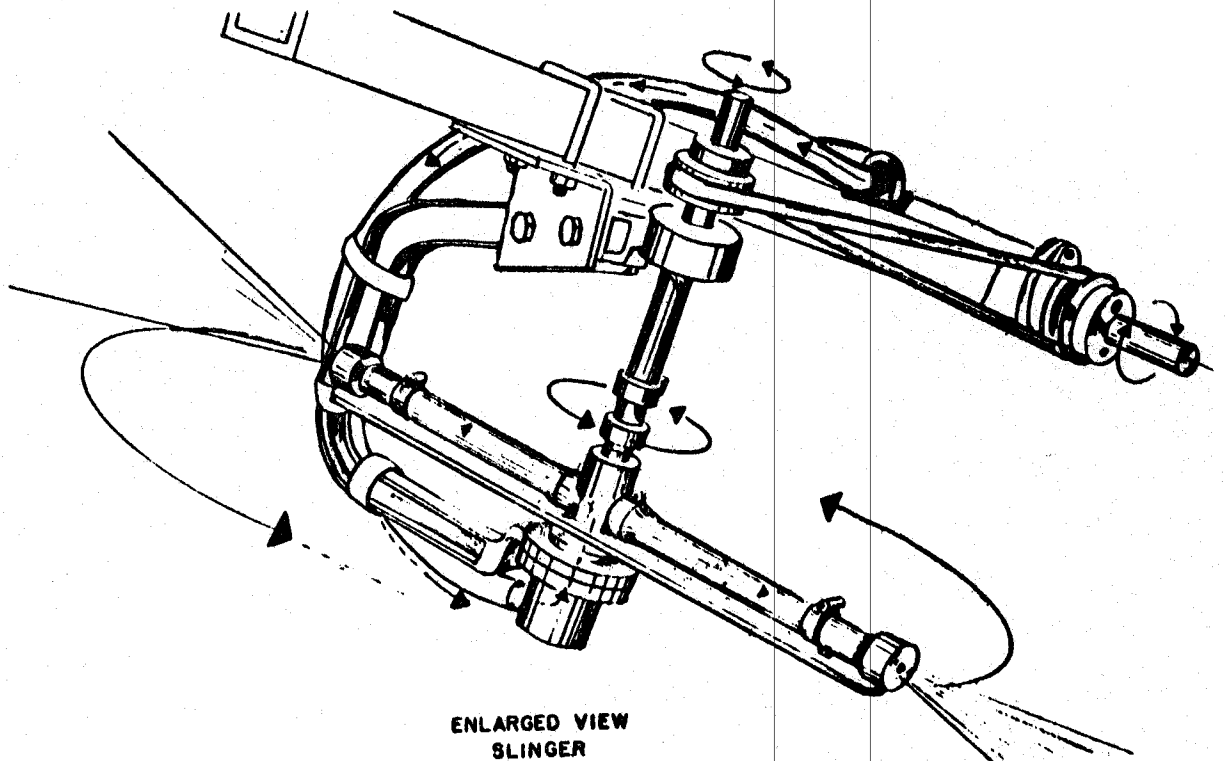
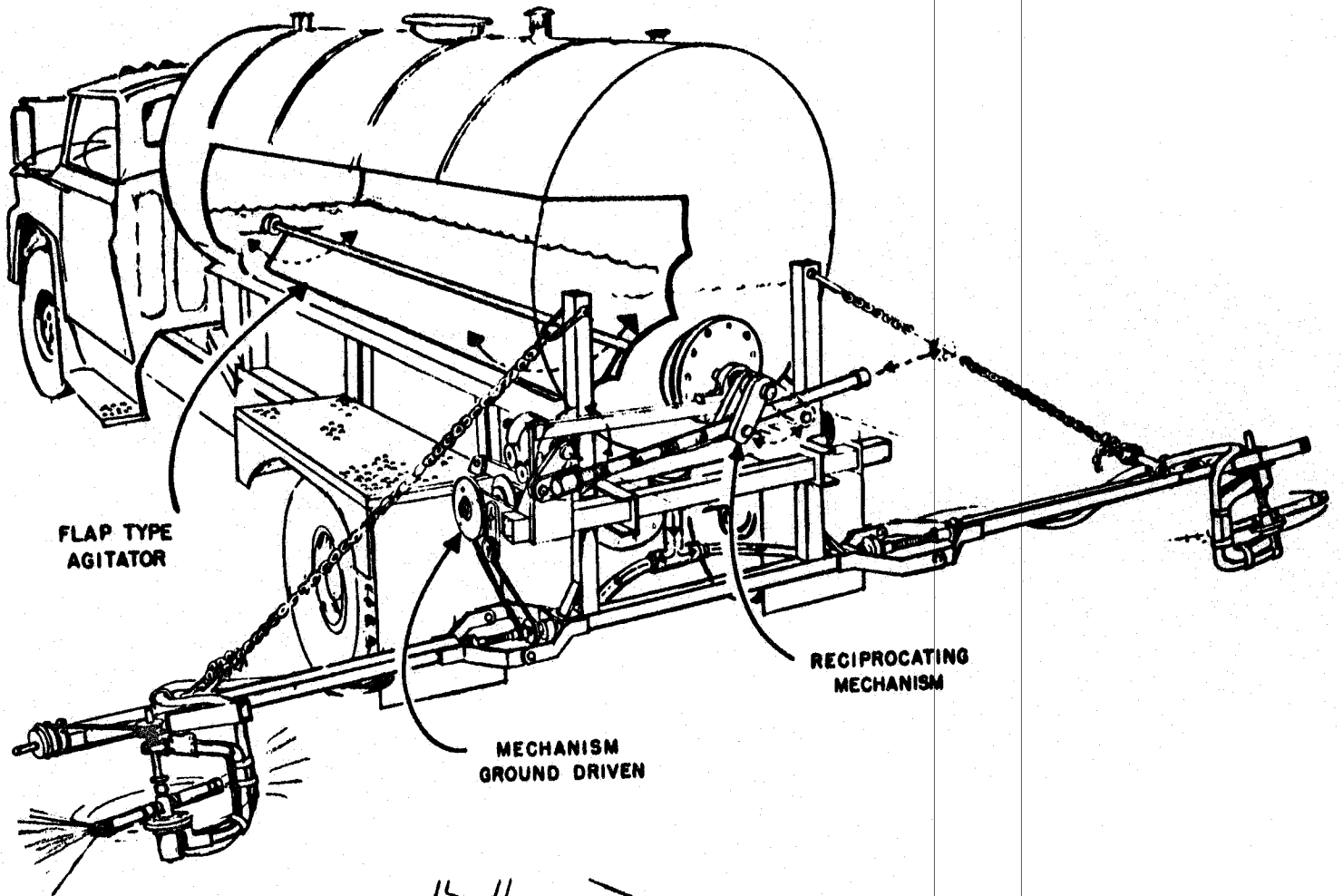


Figure 4
Spray Pattern for Suspensions

FIG. 5

APPLICATION PATTERN FOR SUSPENSIONS





ENLARGED VIEW
SLINGER

FIG. 6
SLINGER TYPE APPLICATOR

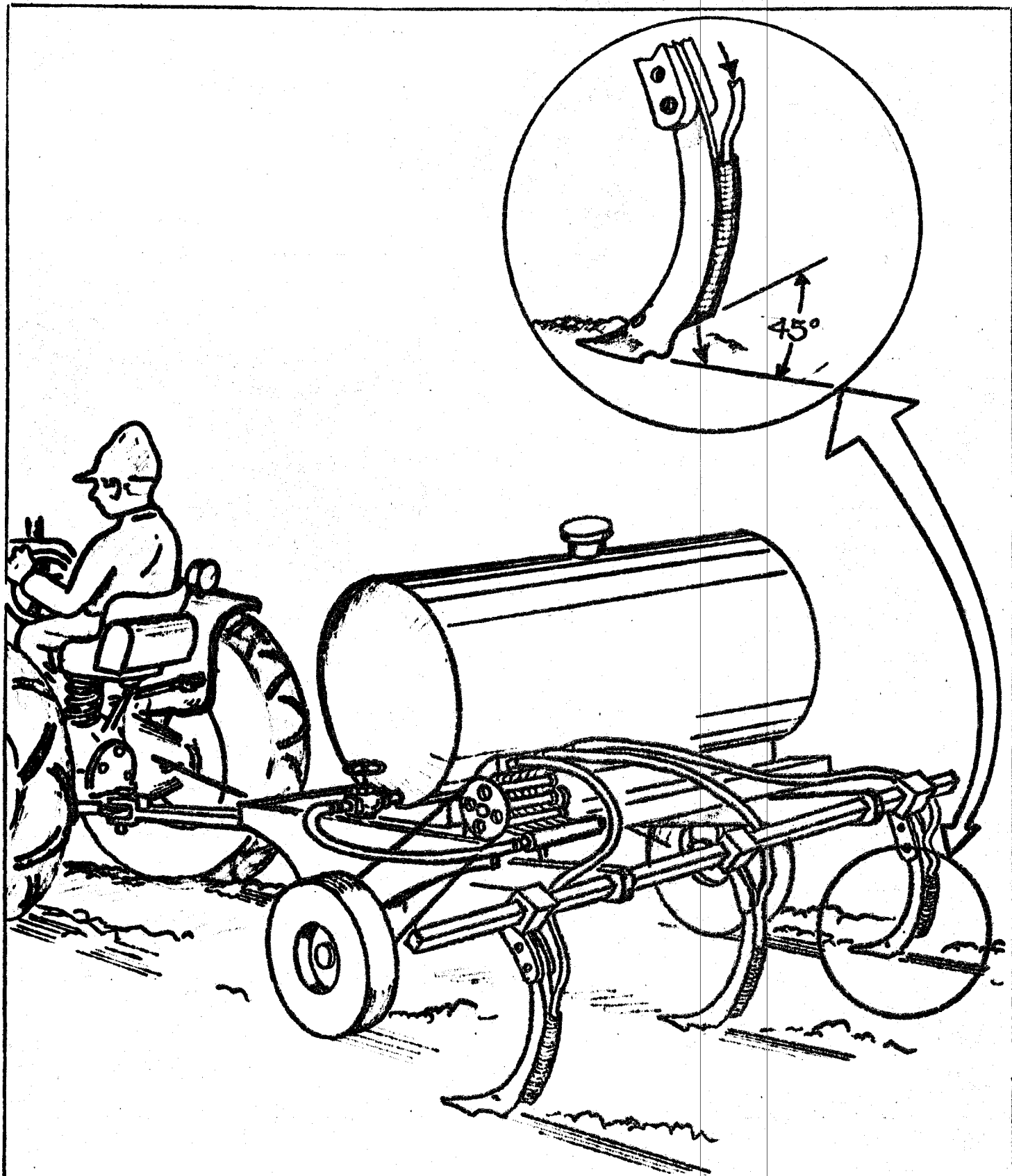


FIG. 7
SUBSURFACE APPLICATION OF SUSPENSION
FERTILIZER USING A SQUEEZE PUMP

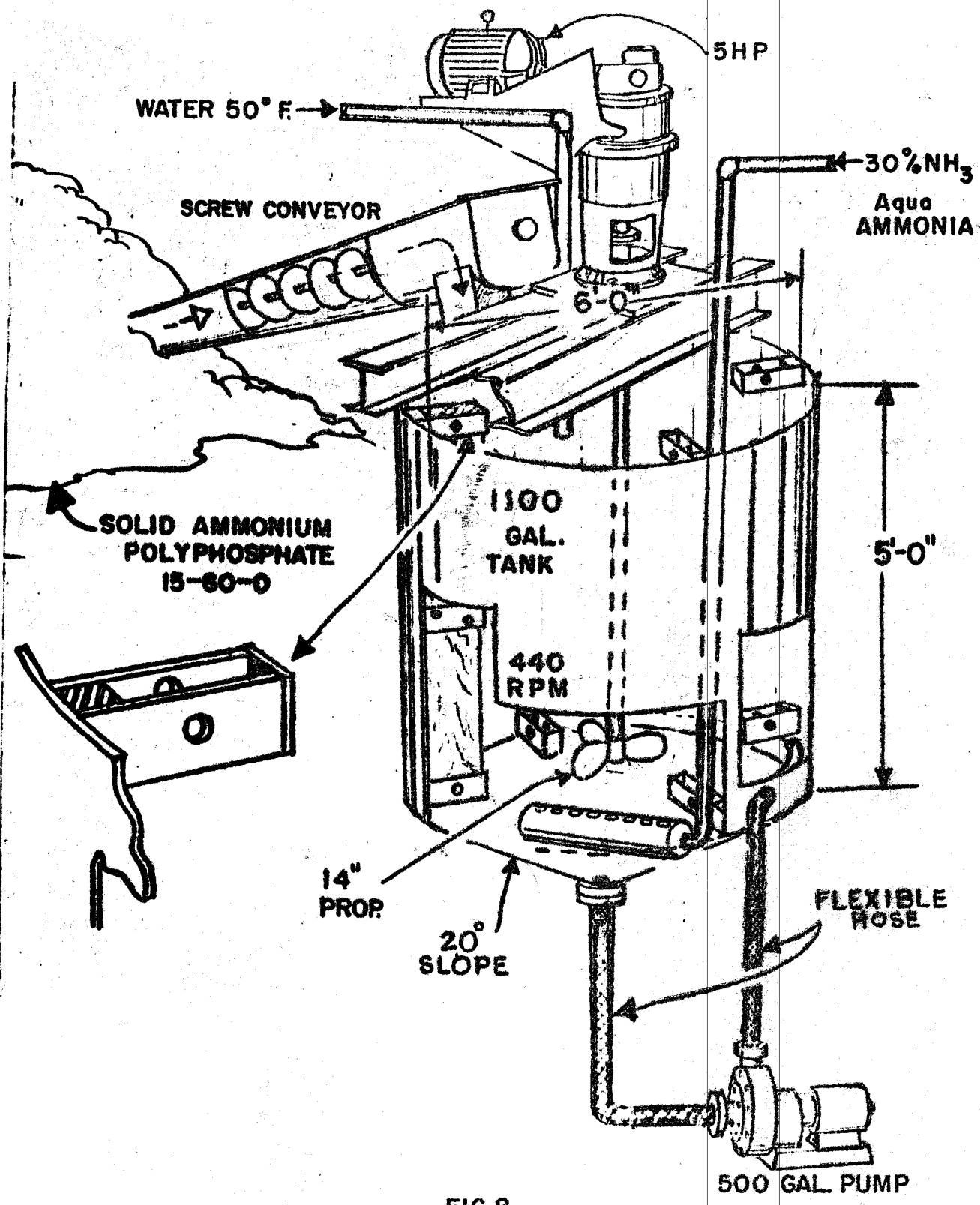


FIG. 8

MIX TANK FOR PRODUCTION OF 10-34-0 FROM
SOLID AMMONIUM POLYPHOSPHATE
OR FOR THE PRODUCTION OF SUSPENSION FERTILIZERS