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FLUID FERTILIZERS - 1967

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Fluid fertilizers, both clear liquids and suspensions, have been of special interest to fertilizer manufacturers and consumers in recent years. Consumption of liquid mixed fertilizer has been increasing through not so fast as nitrogen solutions and ammonia. Figure 1 shows the trend in liquid mixed fertilizers over the past few years. Solutions and anhydrous ammonia now supply over 60 percent of the total straight nitrogen used, while liquid mixed fertilizers supply only about 6 percent of the fertilizer demand. However, increase in the consumption of liquid mixed fertilizers has been at the phenomenal rate of 25 percent per year.

Manufacture of Liquid Mixed Fertilizers

The plant that produces fluid fertilizers can usually be classified as either a liquid hot-mix or a liquid cold-mix plant. The hot-mix plant is the only type of plant involving neutralization of phosphoric acid with ammonia and the addition of supplemental materials to give the desired formula. The heat of neutralization produces a hot mix. In the liquid cold-mix plant the raw materials used are such that no chemical heat is released.

Hot-Mix Plants

There is considerable variation in the operation of hot-mix plants--batch versus continuous operation, furnace versus wet-process phosphoric acid, orthophosphoric versus superphosphoric acid, method of introducing raw materials into the reactor, and method of cooling to remove heat.

In smaller hot-mix plants used for the production of clear liquids furnace phosphoric acid is usually the choice. There is little difficulty in storage and production, and the price is usually only a little above wet-process orthophosphoric acid. However, some producers use wet-process acid because of its availability and price. These producers must cope with the problem of voluminous precipitate formation when the acid is ammoniated. One solution is to sequester the impurities by supplying part of the phosphate in the form of superphosphoric acid or a base solution 10-34-0 or 11-37-0. The 10-34-0 is a base polyphosphate solution made from wet-process superphosphoric acid. Base solution 11-37-0 is made from furnace phosphoric acid.

Figure 2 is a sketch of a typical liquid hot-mix plant. In this plant liquid raw materials--phosphoric acid, aqua ammonia, urea-ammonium nitrate solution, and liquid base solution 10-34-0 or 11-37-0--are stored in tanks which usually have capacities of 10,000 to 20,000 gallons. Solid raw materials are usually stored in the building that houses the mix tank. The mix tank is a batch type with a capacity of 5 to 20 tons. It is fabricated from either carbon steel or stainless steel and equipped with an agitator. Ordinarily it is mounted on scales, and solid raw materials are weighed in it. Liquid raw materials are pumped from storage through meters to the mix tank. Clear liquids are prepared by first metering in the liquid raw materials simultaneously. When all liquids have been added, potash is conveyed to and weighed in the mix tank.

During the mixing the liquid is recirculated through a cooler to prevent excessive boiling in the mix tank. The temperature of the mixture is usually kept below 180° F.

In this plant all liquid raw materials except aqua ammonia are added through open-end pipes onto the surface of the liquid in the mix tank. Aqua ammonia is added through perforated pipes mounted near the bottom of the tank to get uniform distribution of the aqua ammonia. After the materials are mixed, the finished product is pumped from the mix tank to storage or nurse tanks.

Several manufacturers have succeeded in producing suspensions in a plant of this type. This is accomplished by hot mixing wet-process phosphoric acid, crystalline diammonium phosphate, aqua ammonia, potash, triple superphosphate, and suspending clay. They have satisfactorily produced and applied grades such as 12-12-12, 10-30-10, and 4-12-20.

Other producers have used similar plants for the production of nitric phosphate suspensions. Nitric phosphate suspensions are produced by reacting phosphate rock with nitric acid. Phosphoric acid or a soluble sulfate is usually added so that a suspension of satisfactory availability and a near neutral pH can be produced. The number of suspension plants of this type has not been growing at a very rapid rate, and hot-mixing operations in general have been decreasing in importance during the past few years.

There appears to be a current trend in hot-mix plant operations to have a large central plant producing ammonium phosphate base solutions for use in cold-mix plants. This marketing procedure is similar to that in which large central plants make solid diammonium phosphate 18-46-0 for use in bulk blending. The TVA 11-37-0 demonstration plant, started in 1957, was the first of this type. In this plant superphosphoric acid is used to get a high-analysis base solution, since 11-37-0 can be made with superphosphoric acid compared with 8-24-0 from orthophosphoric acid. Other basic producers of elemental phosphorus now produce a 10-34-0 or an 11-37-0 clear solution.

Recently TVA started producing 12-40-0 base suspension in this plant. This base suspension is used also in cold-mix plants for the production of suspension mixtures.

TVA work has all been with furnace-type superphosphoric acid. The production of wet-process superphosphoric acid has been started at several points around the country during the past 3 years or so. TVA furnace superphosphoric acid (79 to 80 percent P_2O_5) contains about 80 percent of the P_2O_5 in the polyphosphate form, while the wet-process superphosphoric acid (68 to 72 percent P_2O_5) contains about 50 percent of the P_2O_5 as polyphosphate. For this reason the base solution from furnace acid is 11-37-0, and from wet-process acid it is usually reduced to 10-34-0.

Another recent development is the construction of an independent regional hot-mix complex which includes a plant to make superphosphoric acid from elemental phosphorus received from a basic producer. This complex also has a large hot-mix facility for the production of 11-37-0 base solution.

Cold-Mix Plants

Cold-mix plants are so simple that there are few major differences among them. Figure 3 is a sketch of a typical liquid cold-mix plant. This plant is used for the production of clear liquids or suspensions. When it is used for clear liquids, it is not necessary to screen potash that goes into the mix tank. The liquids are weighed in. High-phosphate base solution 10-34-0 or 11-37-0 is usually mixed with urea-ammonium nitrate solution (28 to 32 percent nitrogen) and potash to produce a clear liquid. When a suspension is desired, 12-40-0 base suspension is mixed with urea-ammonium nitrate solution and potash to produce a high-analysis grade. Also, when a suspension is produced, insecticides, herbicides, or micronutrients can be added in desired quantities. The liquids are weighed and mixed in the batch tank (usually 5-ton capacity). This tank is similar to the one used in the hot-mix plant. Cooling equipment, acid-storage tanks, and acid-handling equipment are not required. Therefore, the investment cost of this plant is considerably less than for a hot-mix plant. Some of the clear liquid grades produced are 19-19-0, 7-21-7, 8-8-8, 4-10-10, and 3-9-9.

When 12-40-0 base suspension is used to produce suspension mixtures in this plant, the grades have plant-nutrient concentrations about twice those of the clear liquids. Some of the suspension grades produced are 15-15-15, 7-21-21, 10-20-20, and 10-30-10.

A cold-mix plant serving satellite stations is a further subdivision. Figure 4 is a sketch of a typical station of this type. When clear liquids are to be produced, storage tanks usually contain 10-34-0 or 11-37-0, urea-ammonium nitrate solution, and a base potash grade such as 3-9-9 or 4-10-10. The base potash solutions are produced in a centrally located cold-mix plant and are shipped to the satellite stations. If suspensions are to be produced, the storage tanks contain 12-40-0, urea-ammonium nitrate solution, and a 5-15-30 base suspension. The 5-15-30 is also produced in a centrally located cold-mix plant. The production of the 3-9-9, 4-10-10, and 5-15-30 is a mildly complicated operation, because solid potash must be weighed and dissolved. If satellite stations are used, solid potash handling can be restricted to a minimum number of locations. In most instances potash fluid fertilizer is shipped to the satellite station so that the operation there requires only the metering of liquids. Mixing is accomplished as the liquids are pumped into the nurse tank. When suspensions are made, this nurse tank is equipped with an air sparger, and satisfactory mixing is accomplished by bubbling air through the mixture. Figure 4 shows the mix tank at a satellite location. The mix tank provides additional mixing of a suspension when micronutrients, herbicides, and insecticides are added.

Since the cold-mix plant does not have neutralization facilities, s source of ammonium phosphate base solution is essential. TVA has been the major source of ammonium polyphosphate base solution, but with the rapid increase of wet-process superphosphoric acid production this year, 10-34-0 from commercial producers became the major base solution. It is estimated that superphosphoric acid, both furnace and wet-process, now accounts for about 10 percent of the total phosphoric acid made in this country.

Solid Ammonium Polyphosphate

Instead of a base ammonium polyphosphate solution, a solid ammonium polyphosphate can be used in a cold-mix plant to produce N-P-K mixtures. TVA recently started the experimental production of solid ammonium polyphosphate 15-60-0. This is made by ammoniating furnace superphosphoric acid and granulating the resulting anhydrous melt in a pug mill. The product is useful as both a solid fertilizer and a base material for liquid fertilizers. For liquids it has the advantages of lower shipping cost compared with 11-37-0 and of stability against hydrolysis during storage. Use in either cold-mix or hot-mix plants is feasible, but the latter is preferable, because some ammonia must be added to get the best $N:P_2O_5$ ratio for solubility.

The material can be used in cold-mix plants even though they do not have ammonia spargers in the mix tanks, by using aqua ammonia to supply the relatively small amount of ammonia needed and pouring the material into the tank with the necessary amounts of water and other liquids. Some companies plan to use this material in making 10-34-0 for use as a base solution.

Some Economic Considerations of Fluid Fertilizers

It is estimated that over 60 percent of the liquid mixed fertilizer consumed is now marketed through cold-mix plants. The advantages are the same as those in bulk blending:

1. Low investment, as is needed for the limited sales area and small annual volume.

2. Simple operation so that unskilled help can operate the unit.

3. Adaptability of combining with other services such as elevator operation, feed mixing, and general farm supply.

However, cold-mix liquid units are much less costly than equivalent bulk-blending plants. A cost of less than $10,000 has been reported for a standard cold-mix plant (5 to 10 tons per hour). From a recent survey the average total investment appears to be about $15,000. A comparable bulk-blending unit would probably cost more than $40,000. Cost studies have shown that suspensions produced by the cold-mix route can be produced and applied competitively with bulk blends.

Future of Clear Liquids

Clear liquids will probably continue to grow where high-analysis grades are not so important or where the production of suspensions will not cause a substantial increase in the plant-nutrient concentration of the liquid. In the production of nonpotash grades, very little increased concentration can be expected by the use of suspensions. For example, the 1:1:0 suspension grade is a 21-21-0, whereas the 1:1:0 grade produced as a clear liquid from 11-37-0 is a 19-19-0.

Also, clear liquids will probably continue to be used extensively as starter grades. In this instance a highly concentrated fluid fertilizer is not required, and often some liquid is added with the seed. If too high a concentration of liquid is used, germination damage will probably occur.

Some equipment used on planter attachments for the addition of liquid is not suitable for suspensions. For this reason, the continued use of clear liquids in this type of equipment should be expected.

Future of Suspensions

Suspensions have considerable promise for removing the handicap of low grades in N-P-K fluid fertilizers. In several sections of the country there is a need for micronutrients such as magnesium, zinc, and sulfur. Significant quantities of these micronutrients cannot be dissolved in clear liquids. They must be suspended. In the Northeast a 12-12-12 grade with 3 percent magnesium from 12-40-0 base suspension, urea-ammonium nitrate solution, and Pro/Mesium has been produced. This grade should be an excellent material for potato fertilization.

Suspension mixtures can be stored for as long as 6 months if a simple air sparger is installed in the bottom of the storage tank to agitate the suspension periodically during storage. Figure 5 is a sketch of an air sparger of this type.

Application Equipment for Suspensions

In the beginning suspensions were hard to apply. Most suspensions are broadcast by trucks or pull-type applicators equipped with large flooding nozzles. Some applicators use centrifugal pumps to recirculate the fluid to the applicator tank while a measured part of the fluid is diverted to the nozzle. On other equipment ground-driven positive-displacement piston pumps are used to pump suspensions to the nozzle.

In tests conducted at TVA with a pneumatic pull-type applicator (Figure 6), air was used to agitate suspension in the applicator tank and also to produce pressure to force the liquid from the nozzle. The compressor can be driven by a small gasoline motor or the power take-off of a tractor. Calibration curves for three flooding nozzles used with this applicator are shown in Figures 7, 8, and 9. When a single nozzle is used, the application rate is not affected by changes in pressure as long as a tank pressure between 25 and 30 p.s.i.g. is maintained. The application rate is affected by the following variables:

1. Size of the nozzle
2. Speed of the applicator
3. Height of the nozzle from the ground

This type of applicator is being used satisfactorily by several companies to apply suspensions. Some who want higher application rates often use two or more nozzles and broadcast in swaths up to 80 feet wide. However, with application rates below 500 pounds per acre, it is advisable to use a single nozzle.

Single nozzles have larger holes and give a more nearly uniform spray pattern than multiple nozzles.

Most suspensions applied at the time of planting are knifed into the soil by either a ground-driven piston metering pump or a hose pump. A hose pump which can be used to knife suspensions into the ground is shown in Figure 10. The hose from the manifold or pump is usually held in position behind the knife by being stuck into a 1-inch pipe welded to the knife. The submerged end of this pipe is usually cut at a 45-degree angle. This arrangement seems to stay clean and free of stoppages.

Field results show that it is practical to produce suspensions from base materials 12-40-0, 11-37-0, 10-34-0, and 15-60-0. These suspensions can be applied easily with equipment which usually costs no more than equipment that is used to apply liquids. Results show also that suspensions fill the need for a fertilizer of high analysis and also may be used as carriers of micronutrients, pesticides, and herbicides.

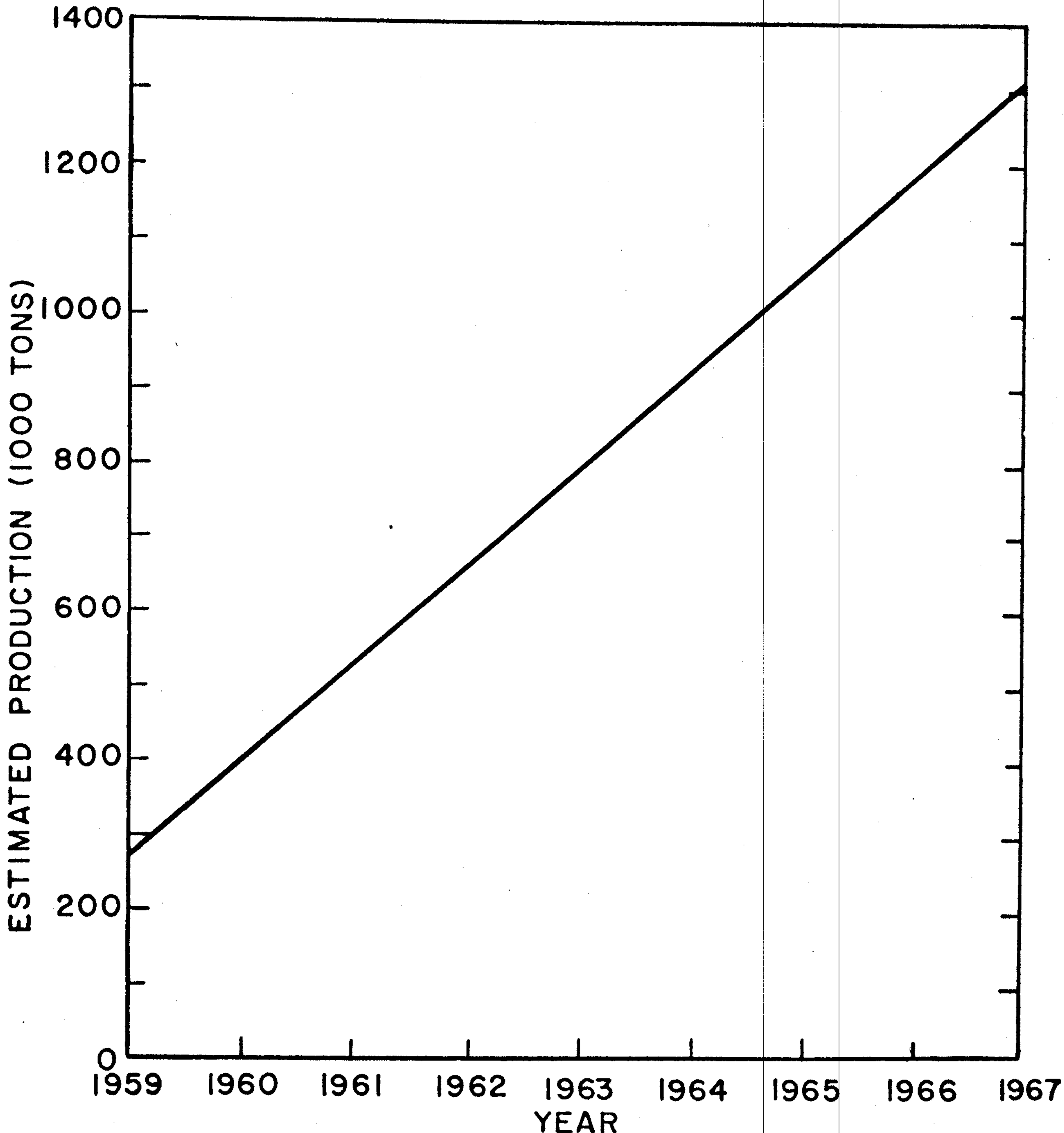


FIGURE I
APPROXIMATE ANNUAL PRODUCTION
LIQUID MIXED FERTILIZERS 1959-1967

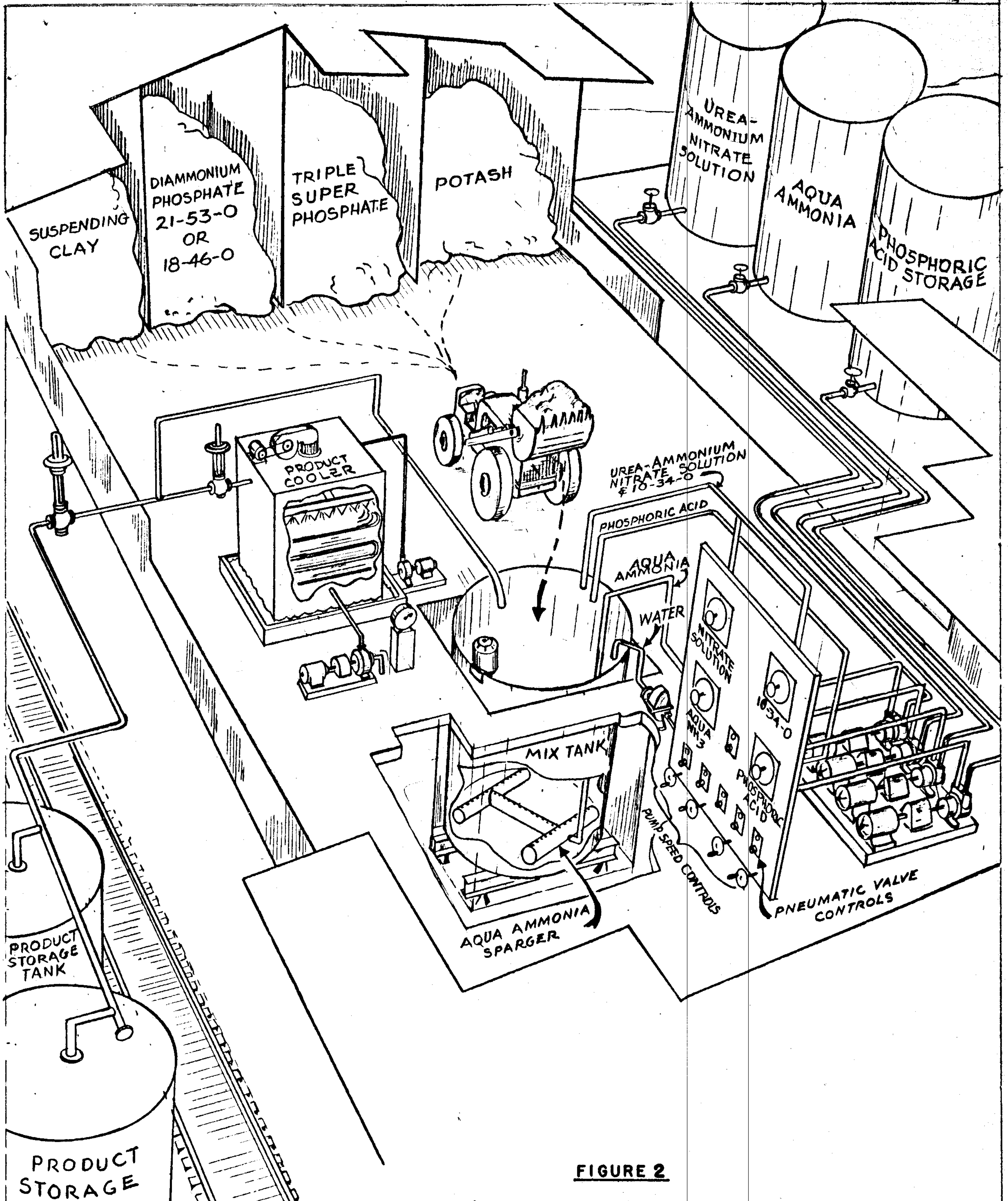


FIGURE 2

HOT-MIX PLANT FOR FLUID FERTILIZER

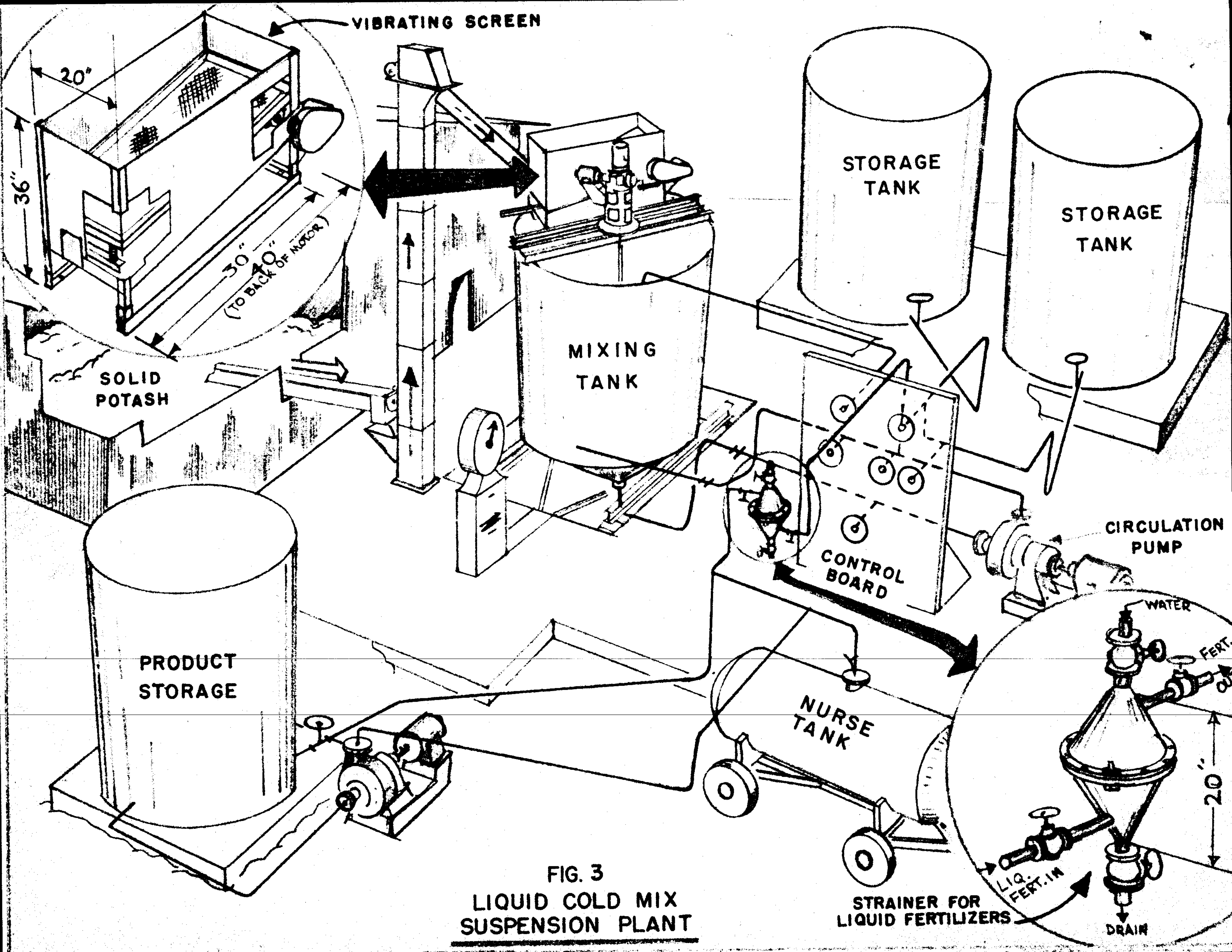


FIG. 3
LIQUID COLD MIX SUSPENSION PLANT

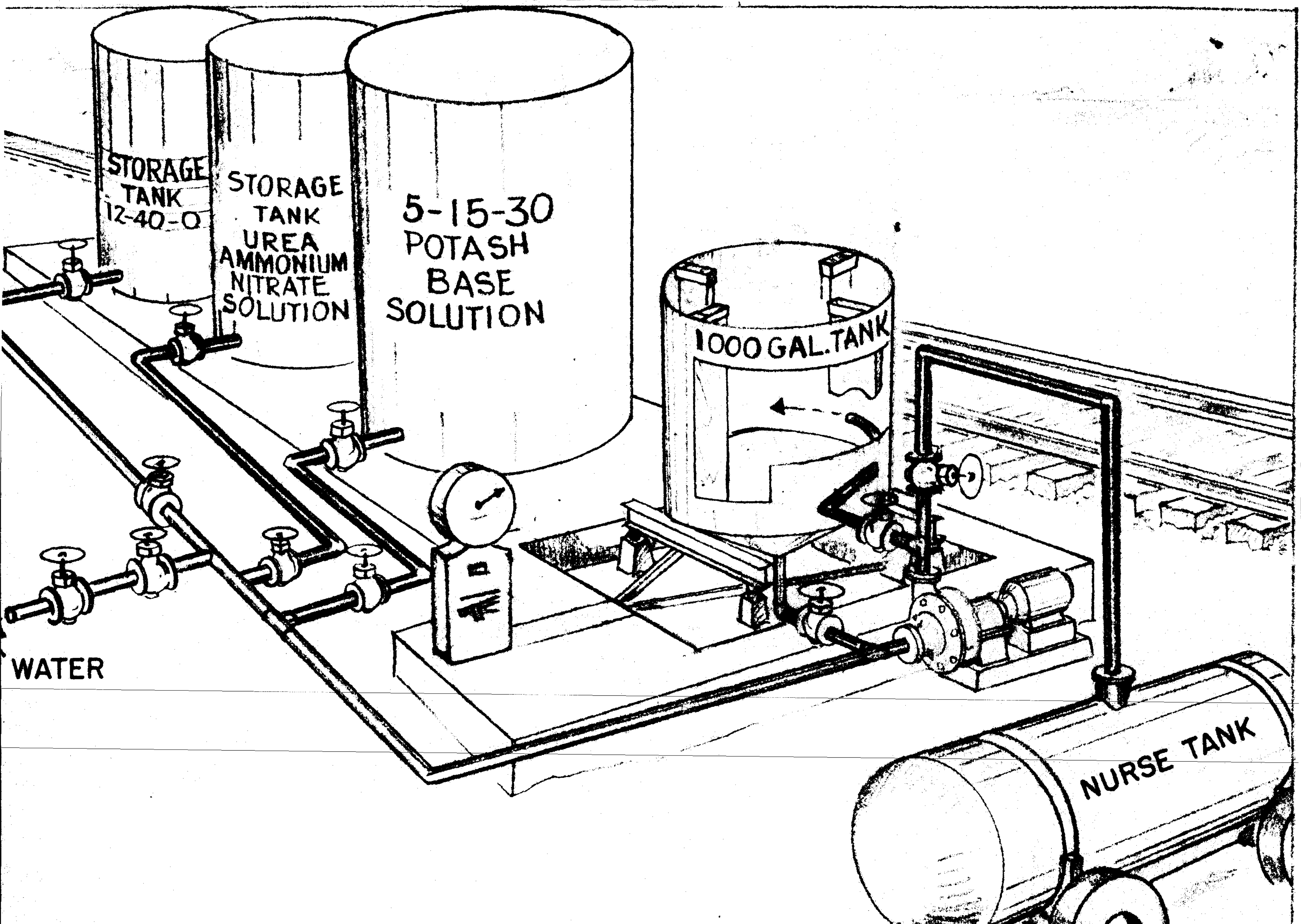


FIGURE 4

<u>SATELLITE COLD BLENDING SUSPENSION STATION</u>

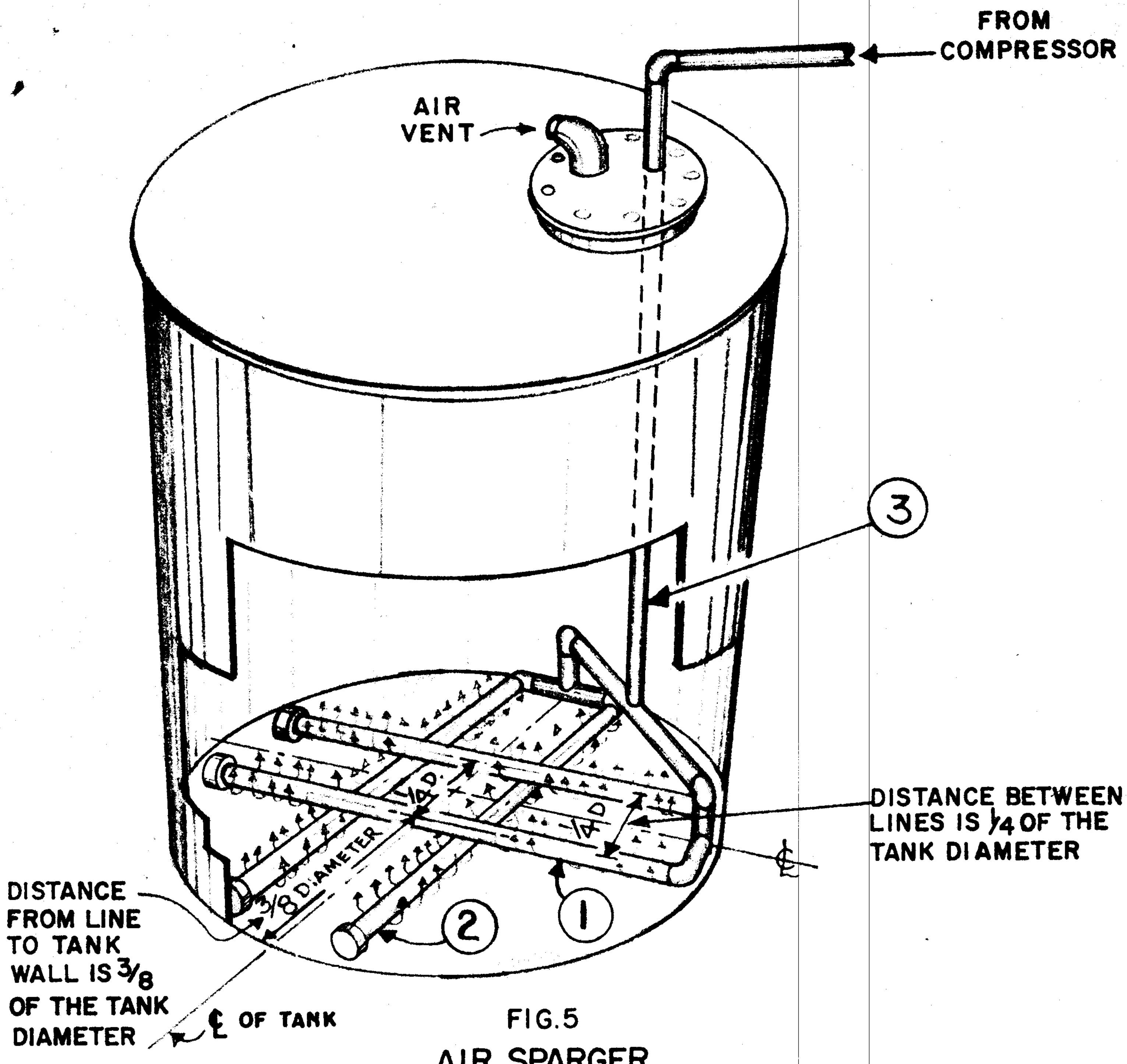
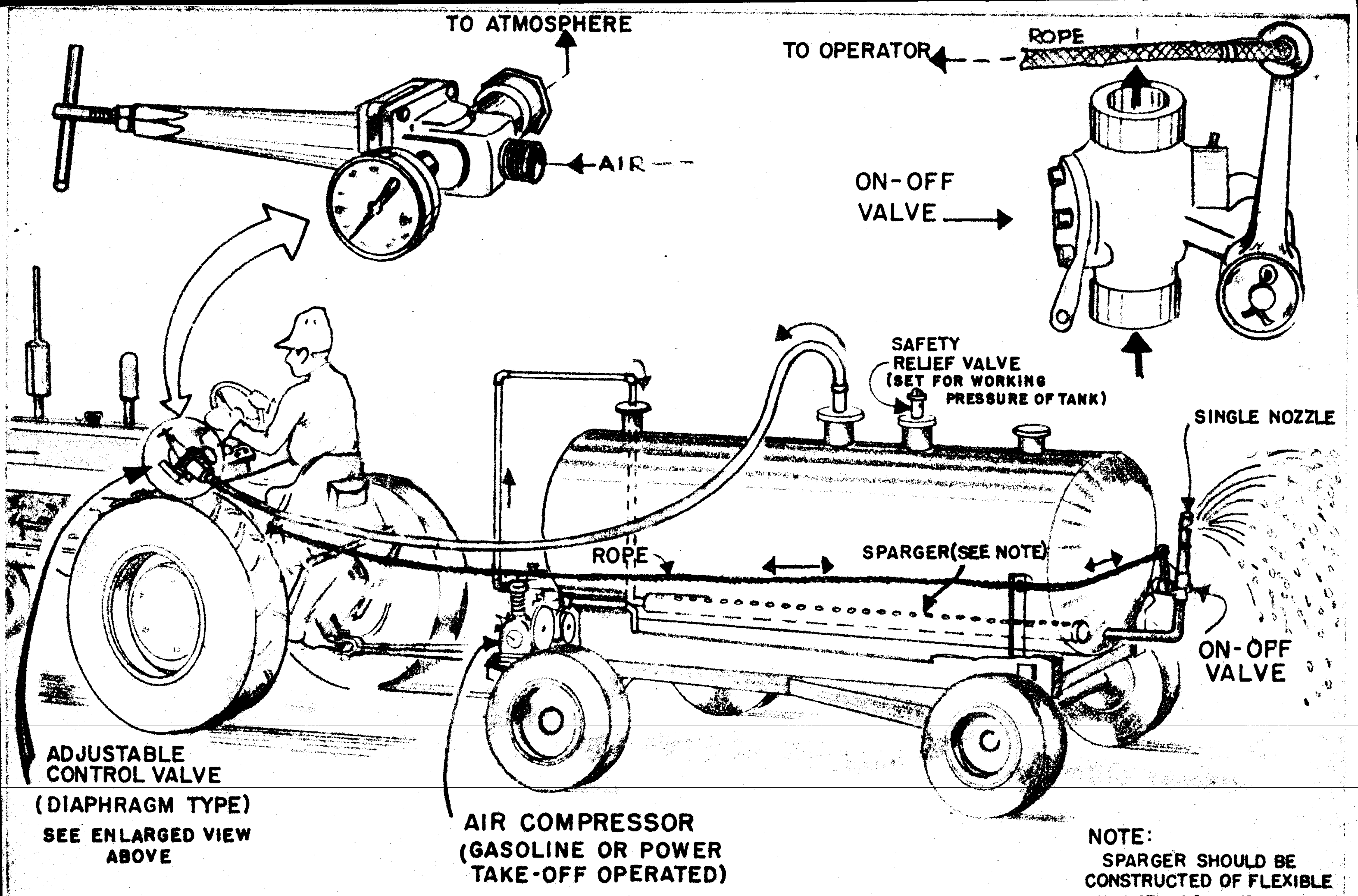


FIG.5

AIR SPARGER

FOR TANKS 10'—22' DIAMETER

1. RUBBER HOSE OR FLEXIBLE PLASTIC PIPE 1 INCH INSIDE DIAMETER.
2. KNIFE SLITS IN PIPE 3/8 TO 1/2 INCH LENGTH, SLITS SPACED ABOUT 2 INCHES APART. POINT SLITS DOWNWARD.
3. STEEL OR RIGID PLASTIC PIPES PLACED PERPENDICULAR AS SHOWN IN THE SKETCH.
4. TO HOLD PIPES IN POSITION, TIE AT CROSSOVER AND WEIGHT WITH METAL AROUND PIPE.
5. INSTALL AIR VENT IN MANHOLE COVER.



NOTE:
SPARGER SHOULD BE CONSTRUCTED OF FLEXIBLE RUBBER HOSE WITH KNIFE SLITS SPACED 2" APART CUT INTO IT. ANCHOR HOSE TO THE BOTTOM OF THE TANK.

FIG. 6

AIR PRESSURE BROADCAST APPLICATION TANK FOR SUSPENSIONS

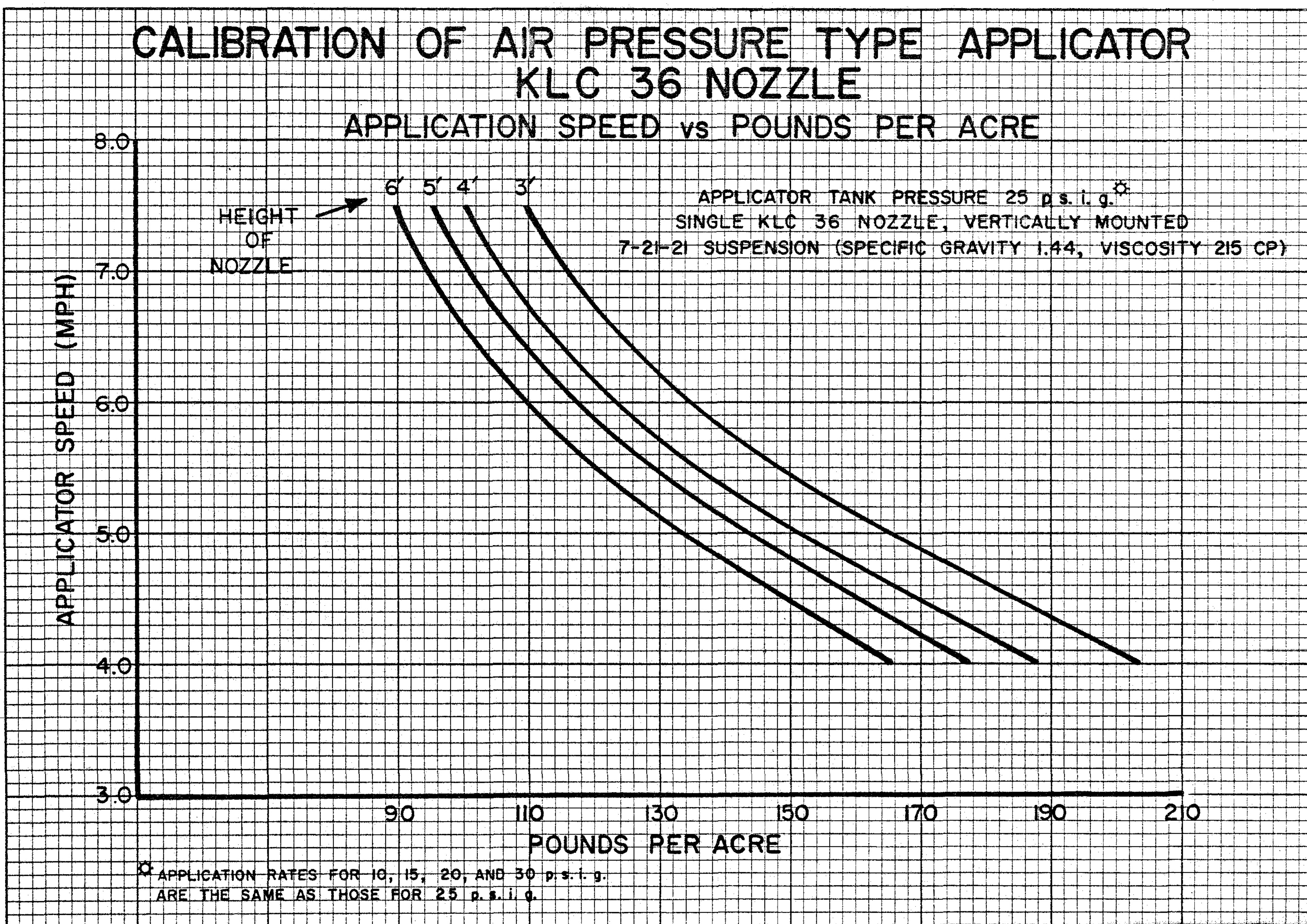

CALIBRATION OF AIR PRESSURE TYPE APPLICATOR
KLC 36 NOZZLE
APPLICATION SPEED vs POUNDS PER ACRE
HEIGHT OF NOZZLE
6′
5′
4′
3′
APPLICATOR TANK PRESSURE 25 p.s.i.g.☼
SINGLE KLC 36 NOZZLE, VERTICALLY MOUNTED
7-21-21 SUSPENSION (SPECIFIC GRAVITY 1.44, VISCOSITY 215 CP)
APPLICATOR SPEED (MPH)
8.0
7.0
6.0
5.0
4.0
3.0
90
110
130
150
170
190
210
POUNDS PER ACRE
☼ APPLICATION RATES FOR 10, 15, 20, AND 30 p.s.i.g.
ARE THE SAME AS THOSE FOR 25 p.s.i.g.

Figure 7

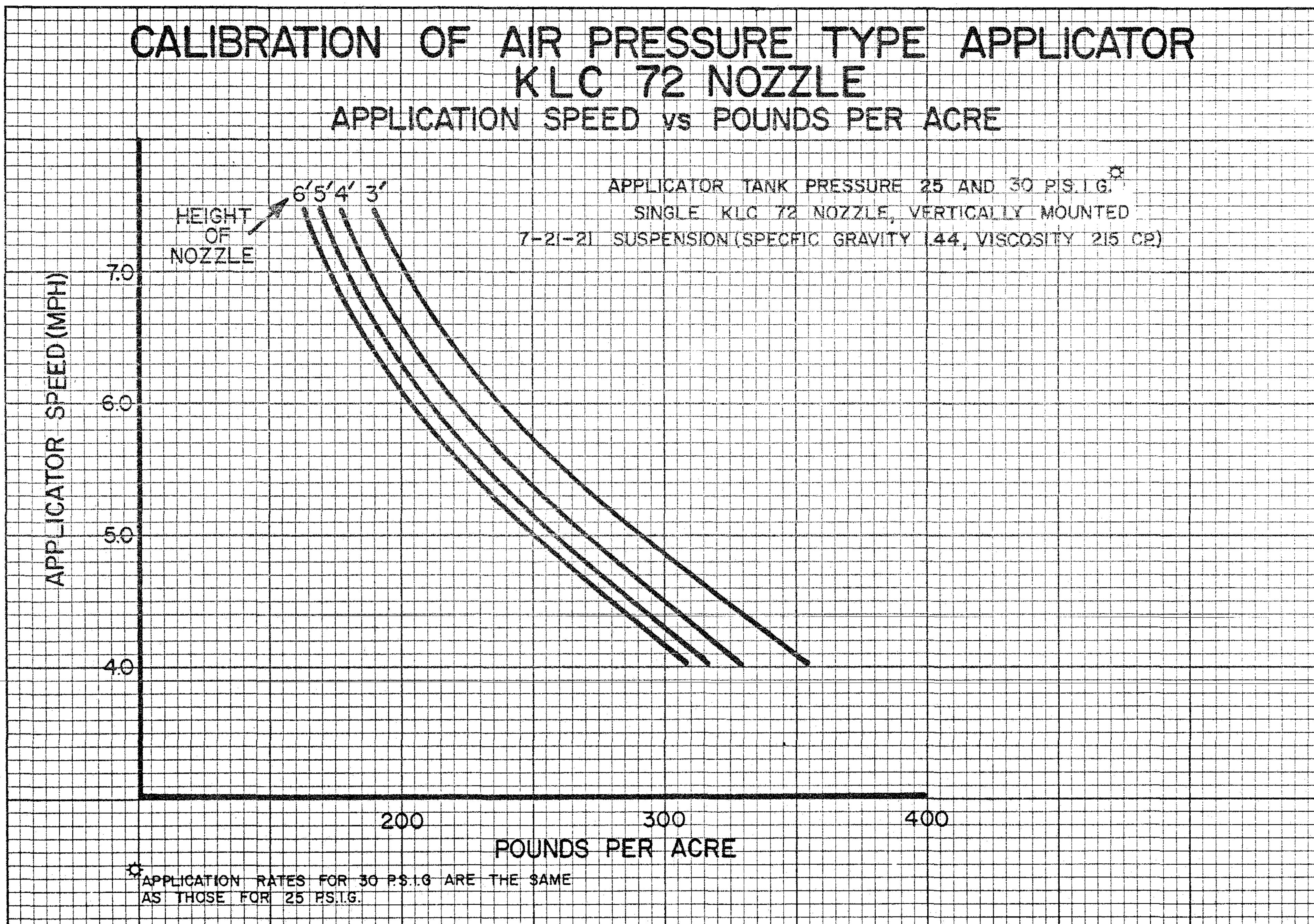

CALIBRATION OF AIR PRESSURE TYPE APPLICATOR
KLC 72 NOZZLE
APPLICATION SPEED vs POUNDS PER ACRE
APPLICATOR TANK PRESSURE 25 AND 30 P.S.I.G.☼
SINGLE KLC 72 NOZZLE, VERTICALLY MOUNTED
7-21-21 SUSPENSION (SPECFIC GRAVITY 1.44, VISCOSITY 215 CP)
HEIGHT OF NOZZLE
6' 5' 4' 3'
APPLICATOR SPEED (MPH)
7.0
6.0
5.0
4.0
200
300
400
POUNDS PER ACRE
☼APPLICATION RATES FOR 30 P.S.I.G ARE THE SAME AS THOSE FOR 25 P.S.I.G.

Figure 8

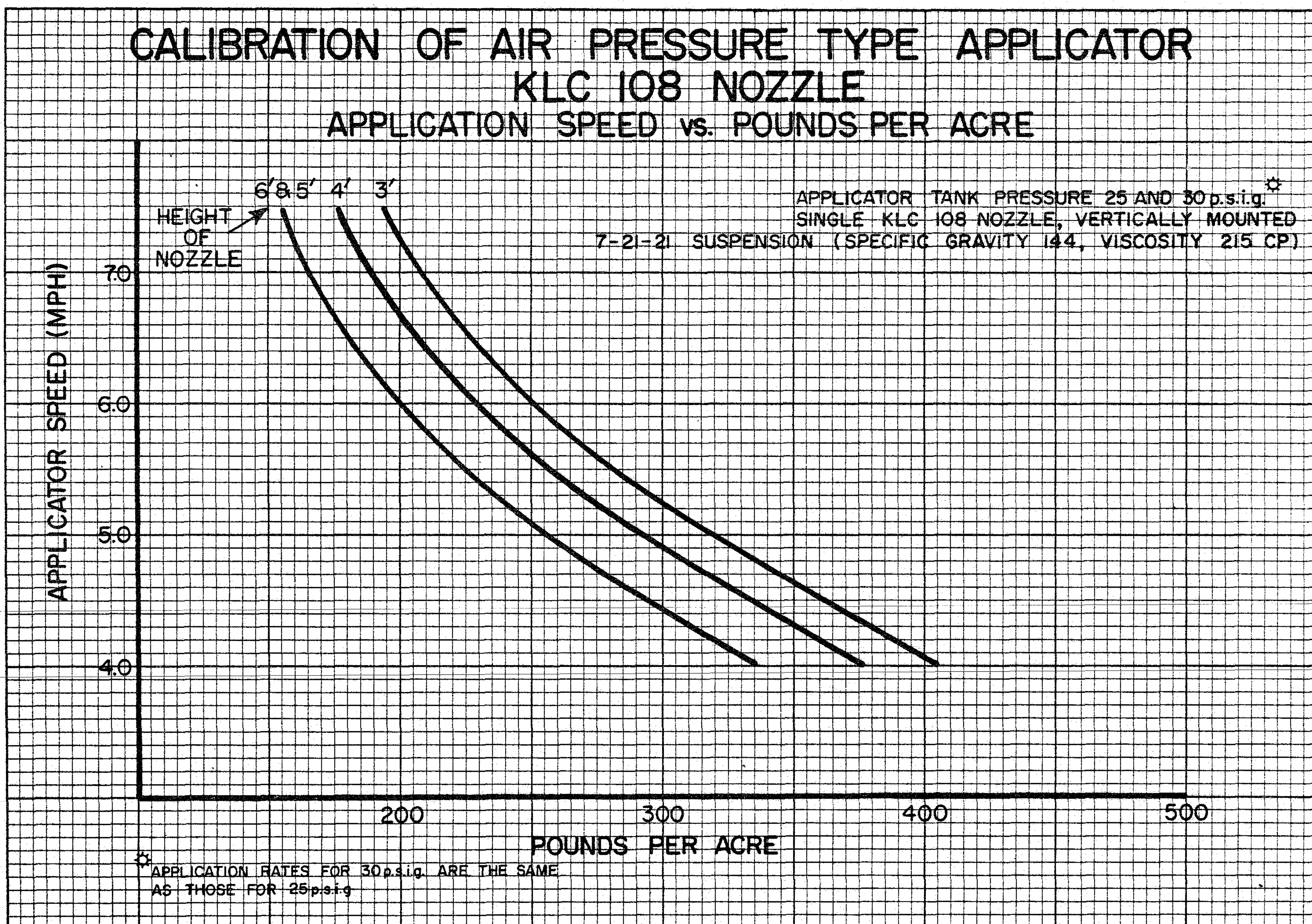

CALIBRATION OF AIR PRESSURE TYPE APPLICATOR
KLC 108 NOZZLE
APPLICATION SPEED vs. POUNDS PER ACRE
APPLICATOR TANK PRESSURE 25 AND 30 p.s.i.g. ☼
SINGLE KLC 108 NOZZLE, VERTICALLY MOUNTED
7-21-21 SUSPENSION (SPECIFIC GRAVITY 1.44, VISCOSITY 215 CP)
HEIGHT OF NOZZLE
6' 8 5' 4' 3'
APPLICATOR SPEED (MPH)
7.0
6.0
5.0
4.0
200
300
400
500
POUNDS PER ACRE
☼ APPLICATION RATES FOR 30 p.s.i.g. ARE THE SAME AS THOSE FOR 25 p.s.i.g

Figure 9

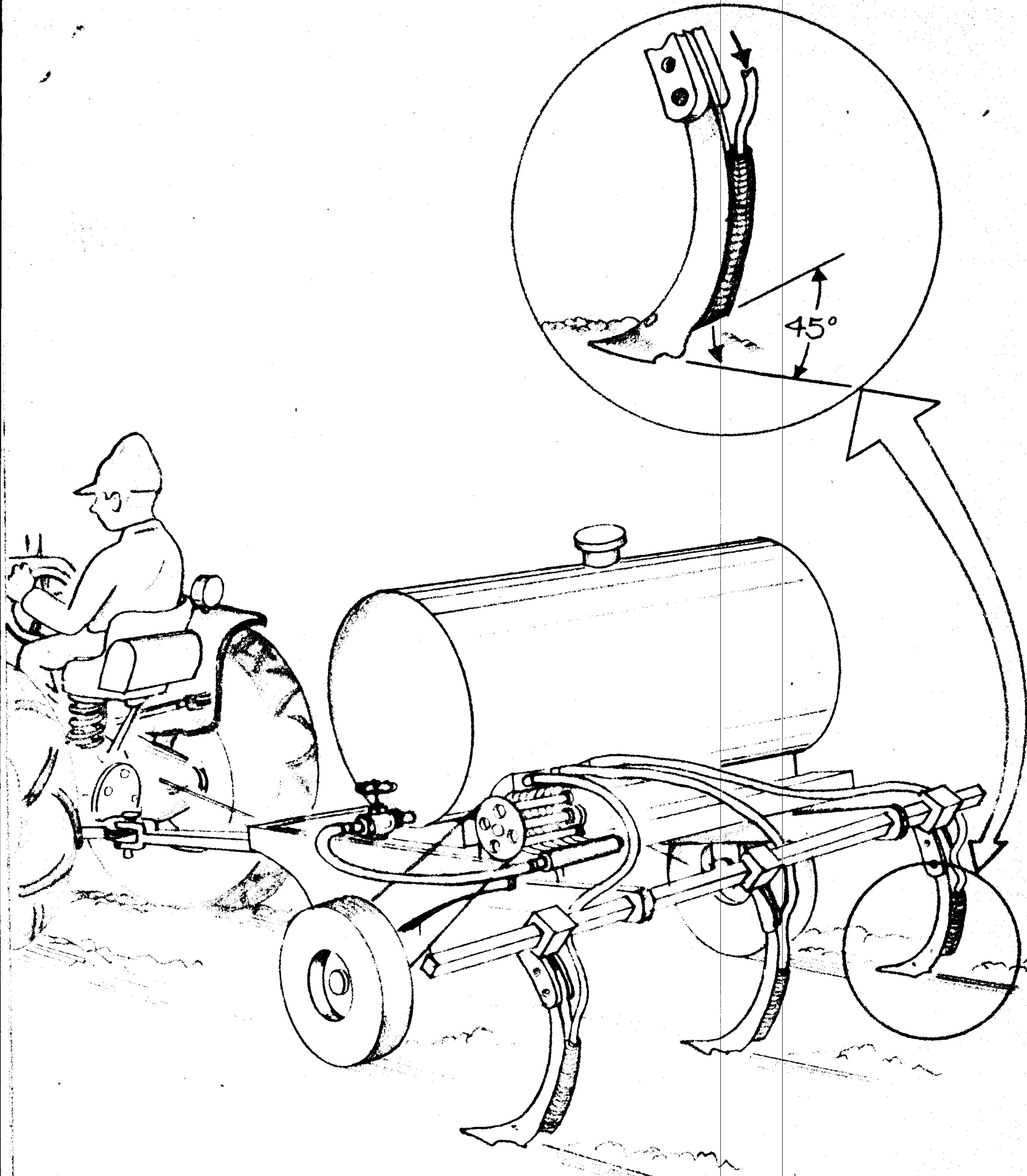


FIG. 10

SUBSURFACE APPLICATION OF SUSPENSION FERTILIZER USING A SQUEEZE PUMP