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NEW ADVANCES IN NITROGEN FERTILIZATION[1]

By

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When the assigned topic, "New Advances in Nitrogen Fertilization" was examined in relation to the other topics covered this week, it appeared that the best approach would be to discuss some of the methods of nitrogen fertilizer application. All the methods to be mentioned are in use, either commercially or experimentally, and each has advantages or disadvantages in specific situations.

When crops are fertilized with nitrogen or any plant nutrient, there are certain basic considerations to be met. The fertilizer should be placed in the soil so that it is available in the root zone of the crop. It should be applied as uniformly as possible and in the quantities desired. The method of application should ensure that minimum losses occur from volatilization or denitrification. Furthermore, the method must not cause injury by the fertilizer to growing plants.

The varying physical and chemical properties of nitrogen fertilizers create a need for different times of application and placement in the soil to meet the requirements just mentioned. To facilitate the discussion, I shall talk about liquid and solid nitrogen fertilizers separately.

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[1] Presented by R. C. Gray to the II Soils Colloquium, Sociedad Colombiana de la Ciencia del Suelo, Palmira, Colombia, September 2, 1971.

The liquid nitrogen fertilizers may be readily divided into two categories: those that must be stored and handled under pressure and those that have low vapor pressure at normal temperatures. Anhydrous ammonia is used as a nitrogen fertilizer in direct application and falls into the first category. It must be handled in equipment that is capable of operating under high pressures--over 14 kilograms per square centimeter at 38° C.--and must be injected 15 to 20 centimeters deep in the soil to prevent loss from volatilization.

The equipment used to apply anhydrous ammonia to the soil consists essentially of a supply tank, a metering device, and knives to penetrate the soil and place the material at the proper depth. The ammonia is metered by adjusting a variable orifice and maintaining a constant speed across the field. If it is desired to have the rate of application constant at variable speed, a positive displacement pump driven from the ground wheel of the applicator should be used.

The type of knife or chisel used to inject the ammonia into the soil will depend on the type of soil and the amount of soil disturbance desired (Figure 1). The texture and moisture content of the soil also have an influence on retention of the ammonia. Very wet or very dry soils and heavy textured soils do not close after the applicator has passed and ammonia may leak out. Sandy soils may not have enough clay content to completely fix the ammonia and losses may occur. When properly applied, there should be no ammonia odor at the soil surface immediately behind the applicator.

An experimental machine has been built that will shoot anhydrous ammonia into the soil surface at extremely high pressure. This makes it unnecessary to disturb the soil surface and is useful in pastures when the furrows formed by the applicator knives might be undesirable.

Anhydrous ammonia is used for direct application because it is a low cost form of nitrogen. Application requires sophisticated equipment and

a rather high level of competence in the operator. It obviously does not lend itself to all soil and crop conditions nor to small farming operations.

The so-called nonpressure nitrogen solutions are somewhat easier to apply and require lower cost, lighter weight equipment. Power requirements are less than with anhydrous ammonia equipment because the nonpressure solutions may be applied on the soil surface.

The same three elements are present in the nonpressure nitrogen solution applicator as in the ammonia applicator--a tank, a metering device (pump in this case), and delivery nozzles. The nozzles are arranged on a boom, and they spray the liquid nitrogen uniformly on the soil surface. The rate of application is determined by the pump pressure, the size of the nozzles, and the forward speed of the equipment. If it is desired to have an application rate independent of the applicator speed, a positive displacement pump driven from an applicator wheel may be used.

It is not necessary for the applicator to be truck-mounted. A tractor-drawn trailer applicator will work equally well in the field. It does not as easily transport liquid nitrogen from the supply point to the field as a truck, however.

The tank and spray pump may be placed on a planter if it is desired to apply the liquid nitrogen fertilizer in a band along the row. Usually a squeeze pump is used for row application. This is basically a roller, pressing on a plastic hose and forcing the fertilizer along the hose.

Often liquid nitrogen fertilizers are used as carriers for herbicides and insecticides. This can be quite successful if care is taken to see that the pesticide is thoroughly mixed with the fertilizer and that the type of application--that is, surface broadcast or band applied--is suitable for both the fertilizer and the pesticide.

If a crop is irrigated, it may be practical to apply liquid nitrogen fertilizers with the irrigation water. This practice is growing in popularity and is being used very successfully with both surface and sprinkler irrigation.

The amount of fertilizer to be used with each irrigation set must be calculated and a metering arrangement set up to inject the fertilizer into the irrigation water at a uniform rate. In surface irrigation, the injection of the fertilizer into the irrigation water should be so timed that the application is uniform and no nitrogen flows off the field. To do this, the water is allowed to flow about three-fourths of the way across the field before the injection of fertilizer is begun. All the fertilizer should be injected by the time the water reaches the end of the field.

Nonpressure nitrogen solution may be metered into the irrigation water simply by letting it flow from a supply tank under a constant hydraulic head. Anhydrous ammonia may be introduced into the irrigation water through a sparger, with the same type of metering device described for anhydrous ammonia application equipment.

After the fertilizer injection is turned off, water is kept running until irrigation is completed.

If sprinkler irrigation is used, there must be a positive pressure differential between the fertilizer solution and the water in the irrigation pipe. Injection of liquid nitrogen fertilizer can begin when the irrigation water is first applied and the rate should be timed so that irrigation will continue after the fertilizer injection is stopped to move the fertilizer down into the root zone.

When a moving sprinkler irrigation system is used, the fertilizer injection must continue at all times while irrigation water is being applied. This requires very precise metering to apply the required amount of nitrogen.

Probably a positive displacement pump will be needed and a skilled operator who knows how to adjust the metering pump to match the water application.

Much more nitrogen fertilizer is applied in the dry granular or crystalline form than in the liquid form. Uniform application of dry fertilizers has always been a problem and development of application equipment has been directed toward even distribution as well as saving labor.

Equipment for applying a dry nitrogen fertilizer requires a box or bin for carrying the material, a metering device to measure out the correct rate of application, and a mechanism for delivering the fertilizer to the desired location on or in the soil.

The simplest equipment for broadcasting dry fertilizer is a full width distributor (Figure 2). This is a gravity flow distributor with a supply hopper running the full width of the spreader and an agitator above gate openings. The agitator ensures an even flow of fertilizer with changing levels in the hopper and will crush any lumps that may be present. The rate of flow is determined by adjusting the size of opening in the gates. The agitator is usually driven from one of the spreader wheels.

A similar mechanism may be used for row application of fertilizers (Figure 3). Here the fertilizer is channeled by tubing into a furrow.

Another method of broadcasting dry fertilizer is to use a spinner (Figure 4). The fertilizer is moved from the supply hopper by a belt or screw auger running along the bottom of the hopper. The fertilizer is metered by an adjustable gate and dropped onto a rapidly revolving spinner. Vanes on the spinner scatter the fertilizer more or less uniformly behind the spreader.

The uniformity of the broadcasting depends on several variables. Twin or dual spinners usually give a more uniform distribution than single spinners. The speed of rotation and the point on the spinner where the stream of

fertilizer falls are important. A uniform size of particle is essential since large particles travel farther than small ones (Figure 5). Careful adjustment and careful operation are necessary to obtain a good broadcast pattern.

An alternate system uses a boom instead of a spinner. A screw auger or a drag chain moves the fertilizer from the discharge chute along the boom and the fertilizer drops from openings in the boom. Both sides of the boom must receive equal amounts of fertilizer and the openings must be adjusted for the desired rate.

Any of these applicators may be tractor-drawn or truck-mounted. Many different systems are used for regulating the rate and distribution of the fertilizer. All of them require a skilled, careful operator to achieve uniform application.

A fairly recent innovation has been the development of high-flotation equipment. The use of very large, low-pressure tires permits operation of this equipment on wet lands, on rough fields, and at higher speeds than other equipment. The ground pressure exerted by a loaded vehicle is no more than that under the foot of an average man. These machines are very expensive but permit working under unfavorable conditions and are capable of broadcasting fertilizers very rapidly. They can be adapted for either dry or liquid fertilizers.

Where surface conditions are such that ground application equipment cannot be used, aerial application may be practical. Rice lands and steep hilly lands are examples. A venturi-type system may be used on fixed wing aircraft and a spinner-type distributor on a helicopter (Figure 6). It is difficult to get uniform distribution with aerial equipment. Air turbulence from propellers and wings upset the distribution pattern. Natural air currents interfere also.

In summary, it is hard to get fully uniform application of dry nitrogen fertilizers from most application equipment. The most uniform application can be obtained when the materials are of uniform size and when the equipment is properly calibrated. Application equipment must be maintained in good operating condition and operators must be trained in methods and procedures that will result in uniform application.

Uniform particle size becomes most important when nitrogen fertilizers are applied in blends with other fertilizer materials. When the fertilizer flows into a bin or hopper, there is a tendency for the smaller particles to accumulate in the center and the large particles to roll to the outside. When a gate in the bottom of the bin or hopper is opened, the material in the center flows out first. If the nitrogen particles are small and the other materials large, the first material out will be higher in percentage of nitrogen than desired and that out last will be much lower than desired. The result is a nonuniform application on the field. Uniform particle size can improve the even distribution desired.

Another development I might mention is the rapid increase in custom application in the United States. The cost of the larger, more sophisticated equipment has caused farmers to have fertilizer applied by the fertilizer dealer. Often better equipment can be used, the operator becomes more skilled in the use of the equipment, and the farmer is relieved of the work of handling and applying the fertilizer. He can devote himself to other necessary farming operations during the rush period at planting time. Usually the farmer specifies the kinds and rate of application of fertilizer and, in addition, pays a specified amount per acre for the application.

I have enjoyed being here this week and participating in your meeting. I hope I have presented an idea or two that you can use or adapt for your work. Thank you.

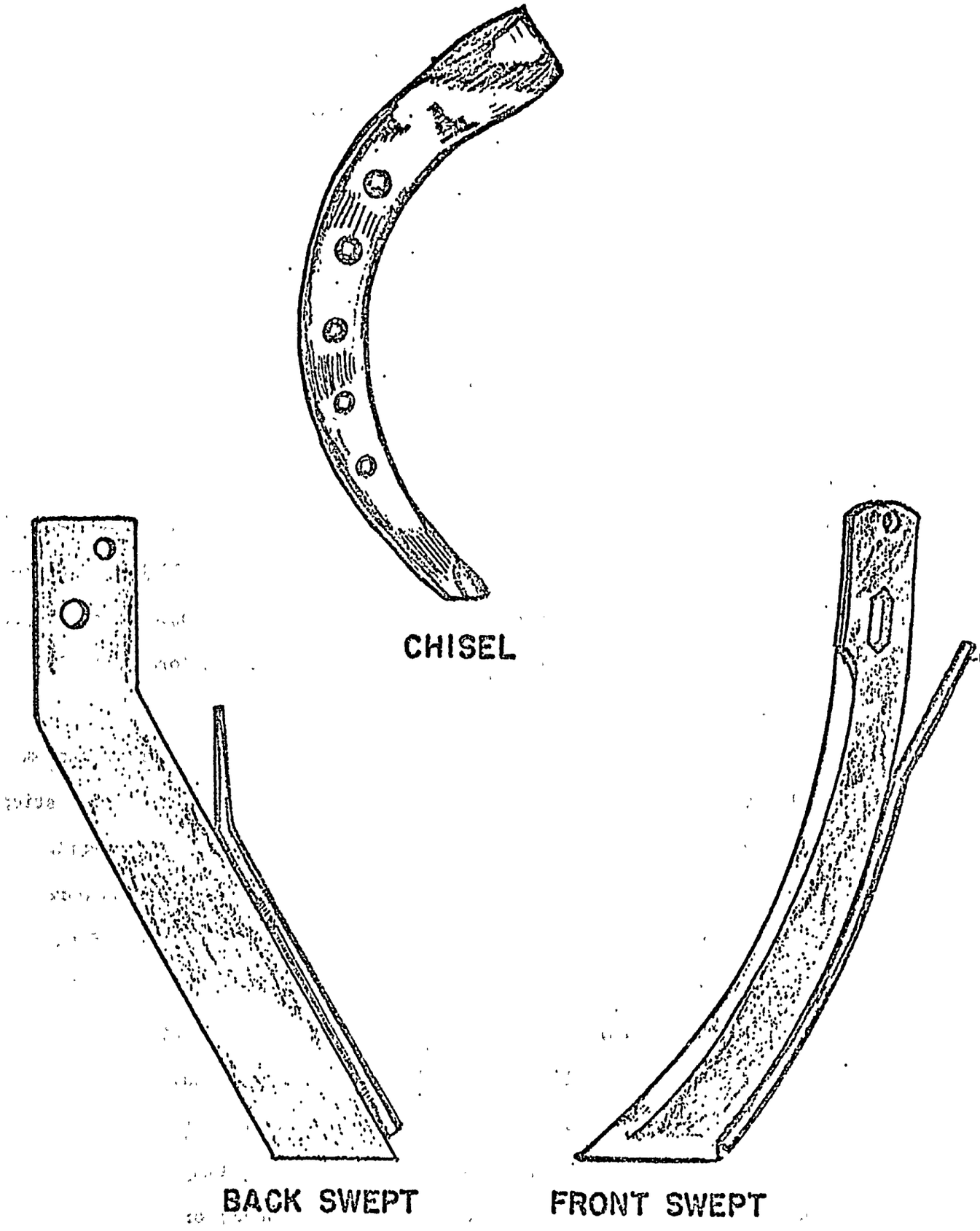

FIGURE 1
APPLICATION KNIVES

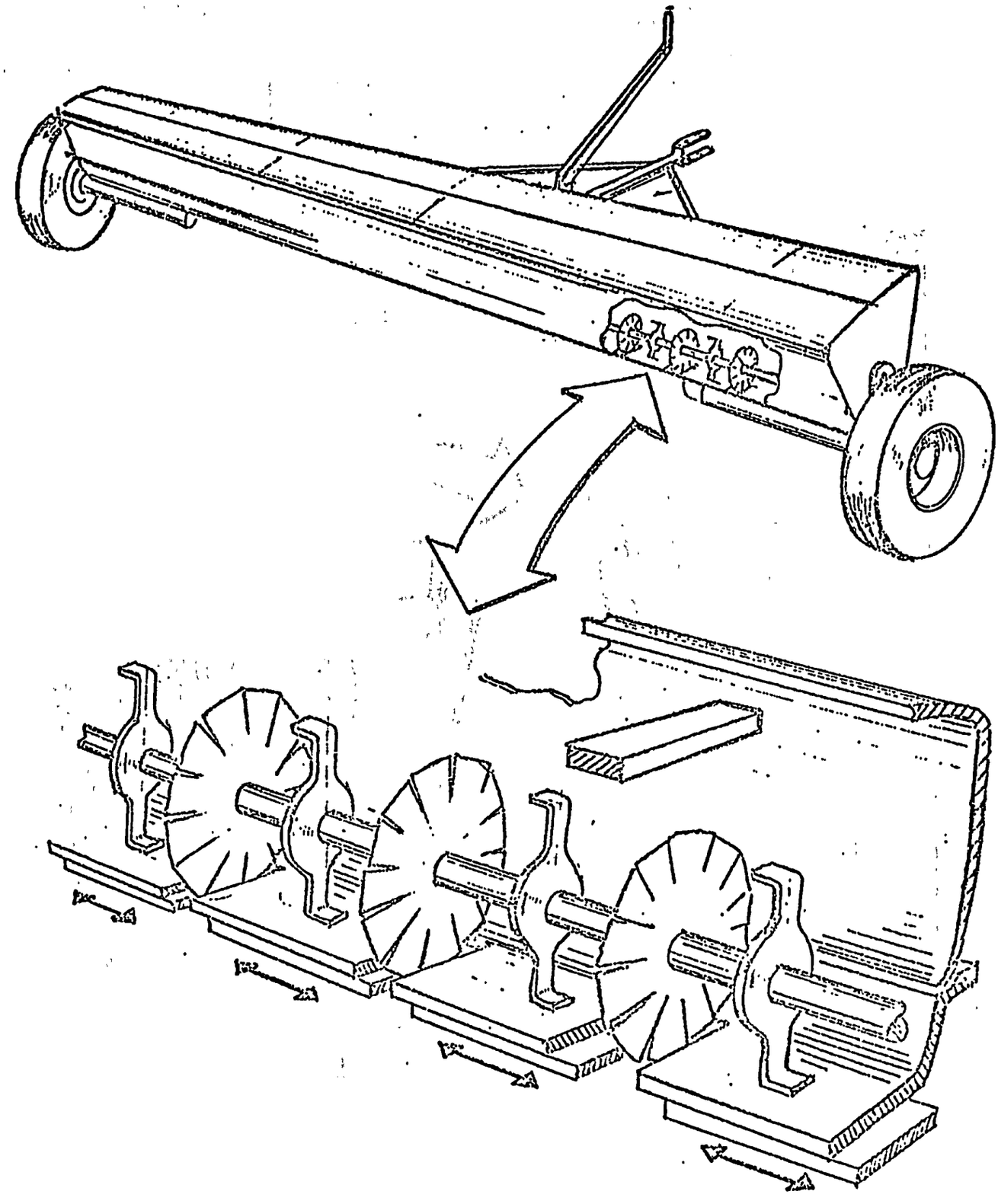

FIGURE 2
GRAVITY FLOW FULL-WIDTH DISTRIBUTOR

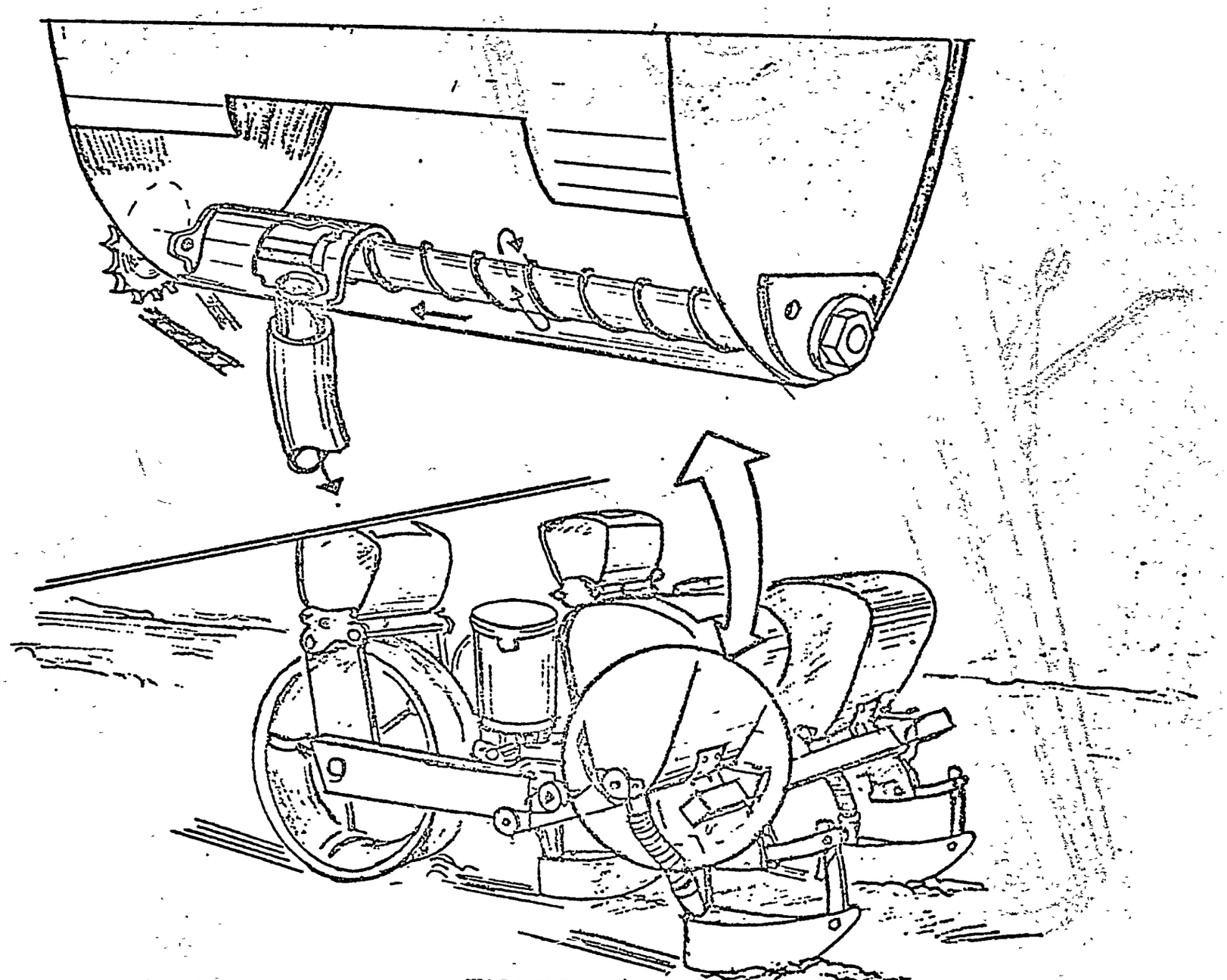

FIGURE 3
BAND APPLICATOR WITH AUGER FEED SYSTEM

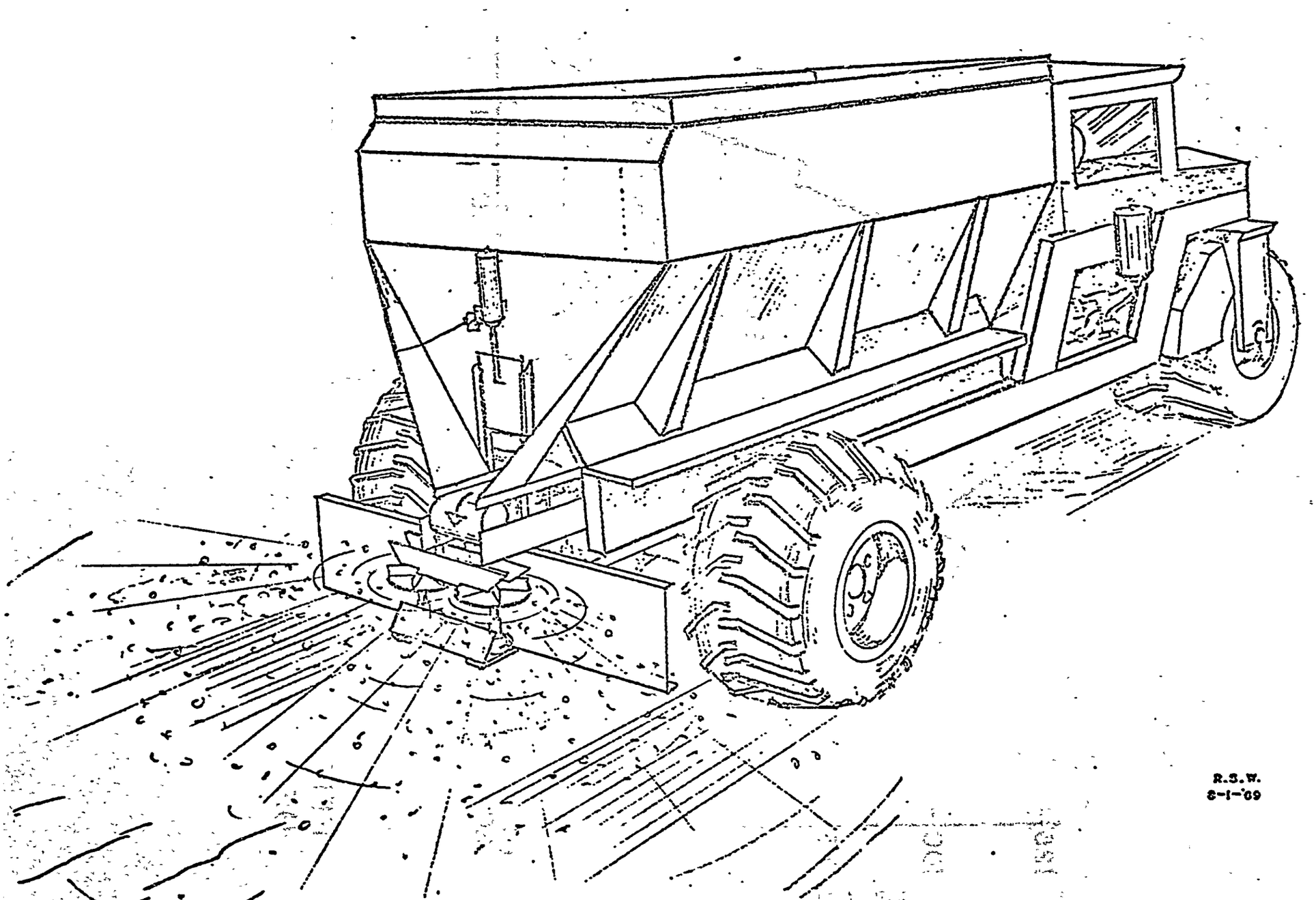

FIGURE 4
DUAL SPINNER HIGH FLOTATION EQUIPMENT

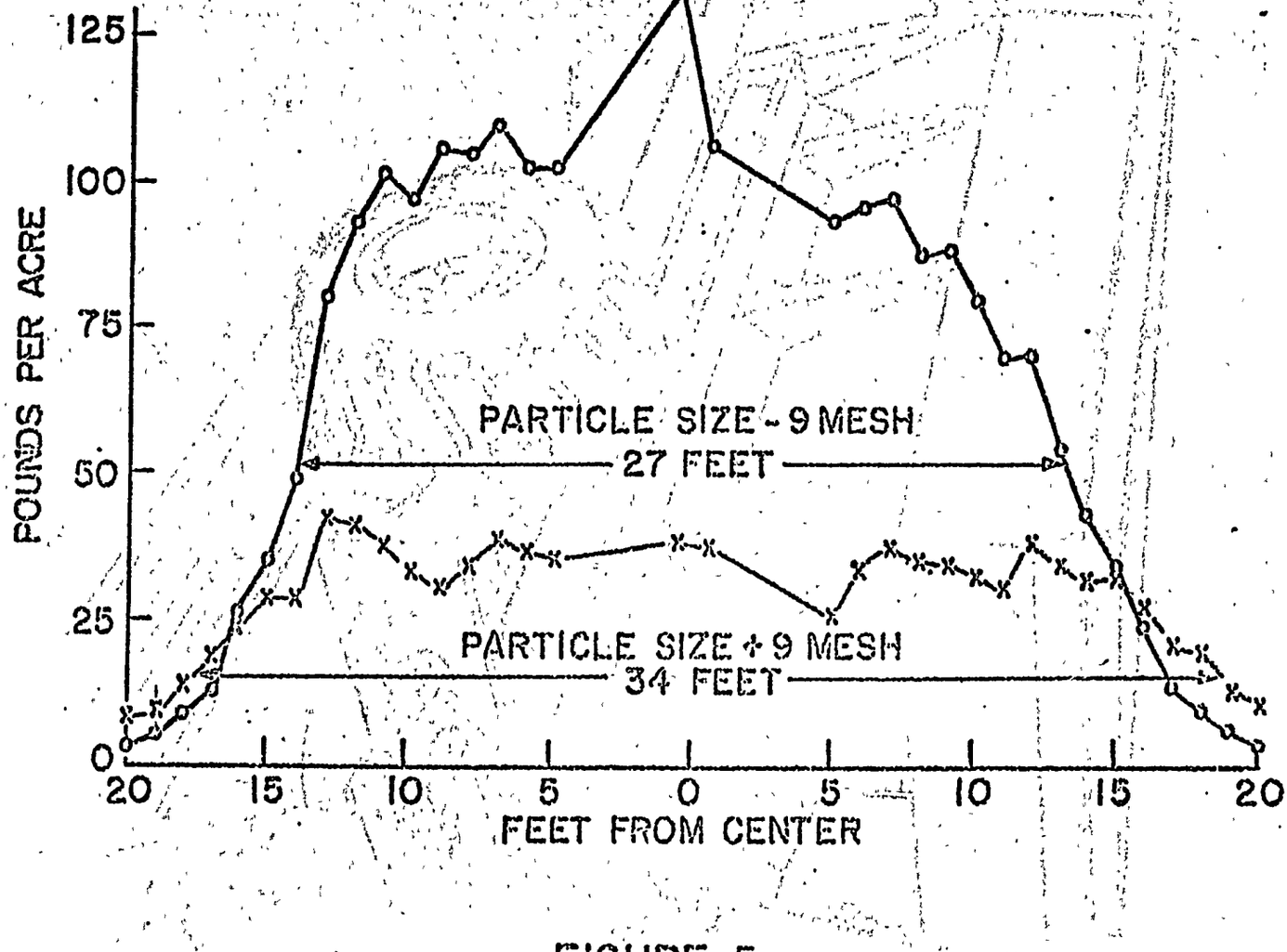

FIGURE 5
EFFECT OF PARTICLE SIZE ON DISTRIBUTION OF FERTILIZER BY A DUAL-SPINNER SPREADER(3)

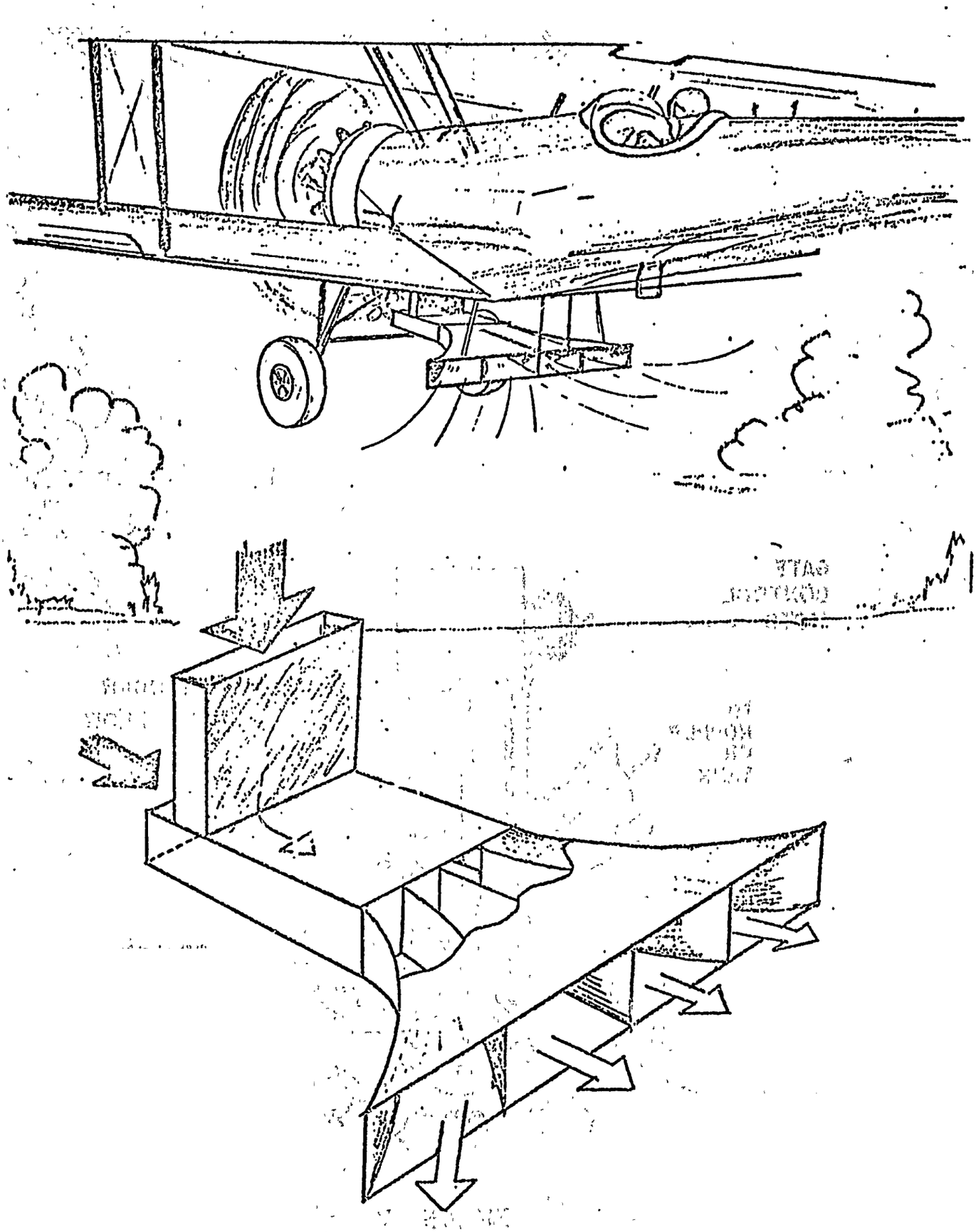

FIGURE 6
VENTURI-TYPE AIRCRAFT DISTRIBUTOR

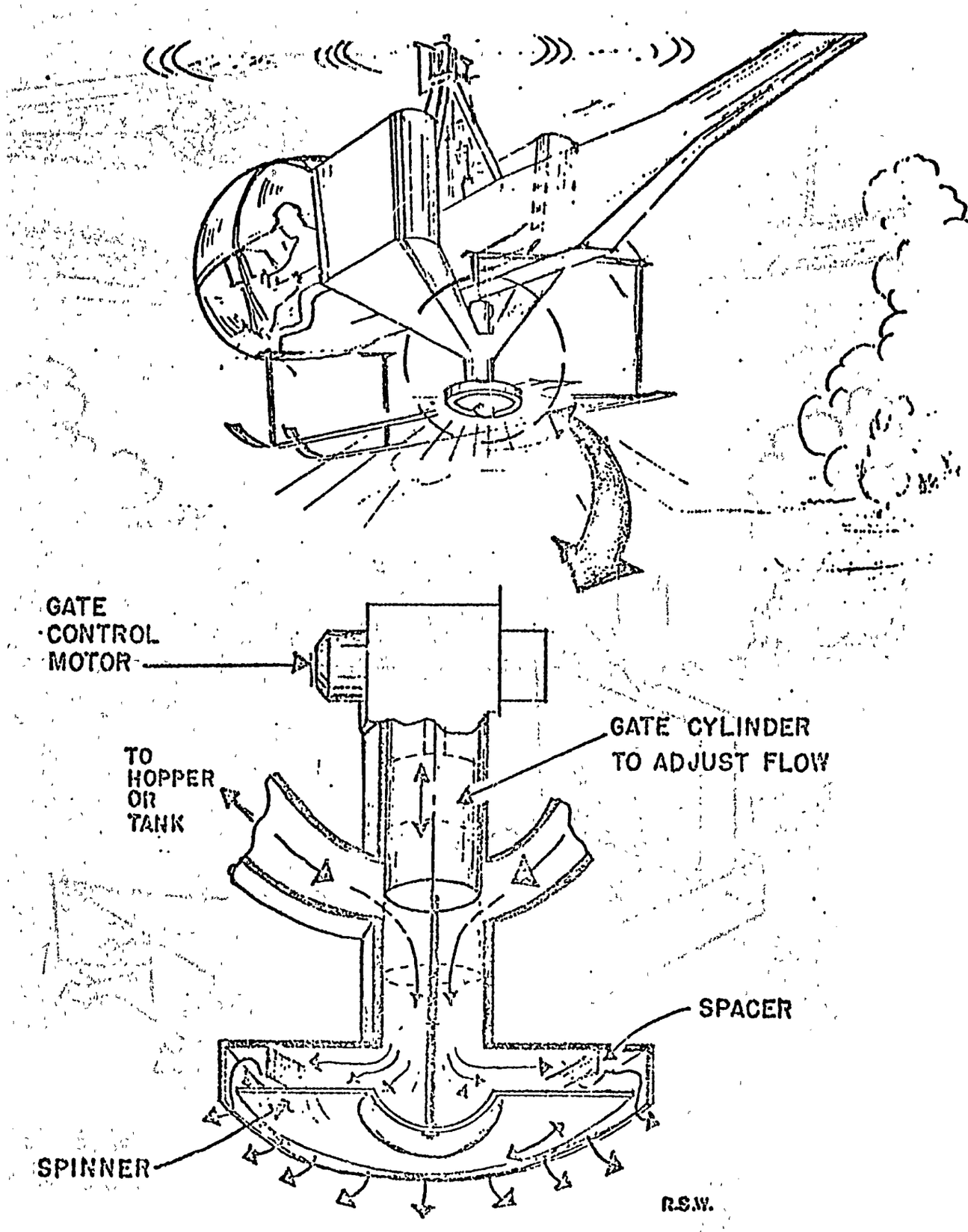

FIGURE 7
STANDARD HELICOPTER DISTRIBUTION SYSTEM
FOR DRY FERTILIZERS