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HOW TO PREVENT SEGREGATION IN GRANULAR BULK BLENDS

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## HOW TO PREVENT SEGREGATION IN GRANULAR BULK BLENDS

Bulk blending continues to be the major marketing system for fertilizer mixtures in the United States, and it is becoming very popular in other nations. It has been estimated that there are now about 5,000 bulk blending plants in the United States (1) which produce 10.7 million tons of granular mixtures.

The typical bulk blend plant is shown in figure 1. Some of the new storage buildings are made of preformed concrete slabs with holes in the roof above each bin which has concrete floors and walls. Materials are usually removed from storage by front-end loaders and are either weighed in the hopper scale that is supported above the boot of the elevator or in the retaining hopper mounted above a weigh scale. With the arrangement shown in figure 1 only one operator is required to remove materials from storage, weigh the material, and mix and discharge the mixer.

Other companies have elevated storage bins which the operators keeps filled. A sketch of the plant is shown in figure 2. Some companies have automated the system with solenoids and air-actuated valves so that the unit may be operated from the office. Sometimes when the formula is to be repeated several times, a punched card can be inserted into the operating board and the materials are weighed automatically.

In the automated plant of the future, an office employee will simply insert the NPK requirements in the computer, and the computer will calculate the least cost formulation, operate the mixer, and print out the required applicator settings, applicator speed, etc. In this automated unit, the plant operator keeps the retaining hoppers above the weigh scale filled. The bins have indicators to show the level of materials. This is done by placing each bin on a hydraulic weigh scale or by using a pneumatic

device such as shown in figure 3. The level of material in the bin is measured by the pressure exerted by the weight of material on the fluid in the flexible tube. This level is indicated by the height of red oil in the U-tube. Each bin has a separate U-tube indicator which has been calibrated to indicate the level of material in the bin. This system could easily be instrumented to show the levels on a chart.

### Mixers

In most new facilities the capacity of the mixers is at least 5 tons and some are as large as 10 tons. Usually the 5-ton mixer can produce mixtures at 50 tons per hour.

The concrete-type mixer shown in figure 4 is most frequently used in new installations. These mixers are similar to those on concrete ready-mix trucks. The materials are mixed by rotating in one direction and discharged by reversing the direction of rotation. The geometry of the mixer is comparable to the frustum of a cone. The mixer is positioned horizontally on its axis and is slightly inclined. It is particularly popular because it is relatively inexpensive. No elevator is required; the mixer is loaded and the mixture is conveyed to the applicator by inclined conveyor belts. The belts formerly were made of rubber or fabric, and some problems were encountered when they were elevated to a high angle. The granules tended to roll back down the conveyor, and this limited the capacity of the conveyor. Recently some operators have installed metal cleated belts in their conveyors, as in figure 5. The conveyors can be elevated to  $45^{\circ}$  without adversely affecting the output.

There are some problems with this high-capacity mixer. Mixing efficiency tests show that because of its shape and the configuration of its discharge flight, the chemical analysis of products from the mixer varies widely (2).

Tests in which a 15.2-15.2-15.2 grade was formulated and during which several samples were collected as the mixer discharged show that the analyses varied from a 17-13-17 to a 14-23-12 and the average deviation in the analysis samples varied from 1.2 to 2.2 units of plant food. Some believe the flight design causes separation as the mixer is emptied.

One way to improve the efficiency of this type of mixer is to cut slots or holes in the discharge flights as shown in figure 6. The material receives additional mixing as it passes through the holes or slots and over the flights. The refluxing action of the material passing through the holes results in thorough mixing; however, it increases the time required to empty the mixer. Tests with the altered flights show that the mixing efficiency is significantly improved. One company in the southeast encountered considerable difficulty meeting state grade tolerances. After the flights were altered, as shown in figure 6, they reported little or no difficulty in producing mixtures meeting grade tolerances.

Another popular type of mixer is the conventional rotary mixer (figure 7) that is loaded on one end and unloaded on the other by inserting a discharge chute into the drum. Materials are lifted into the discharge chute by the lifting flights at the discharge end. Usually more time is required to empty this mixer than the concrete-type unit. Mixing efficiency tests of the conventional mixer show that in the production of a 15-15-15 grade the average deviations in the analyses of several samples were greatest for  $P_2O_5$  (0.70%), less for  $K_2O$  (0.59%), and even less for nitrogen (0.52%). Analyses of the individual samples varied from 14.57-17.48-15.70 to 16.71-13.58-14.20, indicating efficiency superior to that of the concrete-type mixer.

A less popular mixer is the auger, screw-conveyor type (figure 8). This is a continuous type and uses a variable speed volumetric belt feeder to continuously measure the weight of materials to the mixer. The gates beneath each hopper can be adjusted to provide the desired flow rates of materials. The auger is a specially designed screw conveyor.

The main problem with the auger type of blender is that the accuracy of the volumetric belt feeder is poor. Mixing efficiency tests in which a 15-15-15 grade was mixed show that the average deviation in analyses of all samples was 0.23 percent N, 0.52 percent  $P_2O_5$ , and 0.46 percent  $K_2O$ . Therefore, the composition of the product from this mixer was relatively uniform and the analysis varied from an 18-19-10 to a 17-18-11; however, the average analysis was 17-18-11, which indicates poor measuring of the quantity of materials conveyed to the mixer (formulated 15-15-15). Other plant and pilot-plant tests show it is difficult to obtain consistent results with these volumetric feeders. Gravimetric-type batch weighing is preferred. By frequently calibrating volumetric feeders, accuracy of measuring can be improved.

In most bulk-blend plants the mixer discharges into a cone-bottom retaining hopper and the blend tends to cone in the retaining hopper with the result that there is a collection of the large granules near the outside wall of the bin and fines near the center of the bin (3). Figure 9 shows how this separation occurs. For several years TVA has recommended that dividing walls be installed in the retaining hopper (figure 10) to prevent coning. In tests several samples of material were taken when the bin was discharged, both before and after walls were installed. Chemical analyses of several samples taken during emptying of the bin without dividing walls (during production of nominal 17-17-17)

show the average deviation in analyses of several samples for N was 1.3 percent, for P<sub>2</sub>O<sub>5</sub>, 0.4 percent, and for K<sub>2</sub>O, 1.1 percent. Another group of samples was taken after the walls had been installed, and analyses of the samples showed the average deviation between samples was 0.9 percent N, 0.4 percent P<sub>2</sub>O<sub>5</sub>, and 0.8 percent K<sub>2</sub>O. These data again substantiate the need for the wall dividers in the holding bins. It is also recommended that a distribution device be used such as shown in figure 11, to prevent size separation of materials due to coning as they are loaded into flat storage bins.

Materials

Six materials dominate in the bulk blending industry as shown in this table.

Estimated Tonnage of Leading Materials Used in Blending

<u>Material</u>	<u>Estimated Million Tons Per Year (1980)</u>
Diammonium phosphate (18-46-0)	3.1
Triple superphosphate (0-46-0)	1.7
Ammonium nitrate	1.2
Urea	0.9
Potash	4.3
Granular ammonium sulfate	0.5

Diammonium phosphate typifies the type of product desired for bulk blending. Most of it is granular, free flowing, and of proper size for easy handling and uniform application. A typical screen analysis of a commercial diammonium phosphate is tabulated as follows:

Particle Size of Typical Diammonium Phosphate

<u>Screen Size (Tyler Screens)</u>	<u>Accumulative Weight, %</u>
6	<1
8	36
10	86
14	99
20	100

Particle size distribution is the main consideration in production of nonsegregating blends (4). TVA field experiences show that if the particle size fractions of the materials used in blends are within 10 percent of the average screen analysis of all the materials used in the blend, the material will remain mixed when handled and applied properly. The average screen analyses of the conventional materials used in blending are shown in table 1. These analyses are from several producers and the size specifications vary among producers. The screen analysis of potash shows the widest variance, and screen analysis of diammonium phosphate, the least. Screen analyses, plotted in figure 12, show that most materials, except for coarse potash and granular urea (large), have similar particle sizes. A few of the materials do not meet the 10 percent variance in particle size specification.

The screen analyses can be used to determine the likelihood of segregation problems (using the 10% rule). Example 1 demonstrates the blending of diammonium phosphate (DAP), granular triple superphosphate (TSP), and potash. The screen analyses of the materials are given along with the average screen analyses and the maximum deviation of screen size of the materials from the average analyses.

Example 1

Properly Matched Material for Nonsegregating Blend

<u>Material</u>	<u>Cumulative Screen Analysis</u>				
	<u>% Retained on Tyler Screens</u>				
	<u>+6</u>	<u>+8</u>	<u>+10</u>	<u>+14</u>	<u>+20</u>
Diammonium phosphate (18-46-0)	<1	36	86	99	100
Granular TSP (0-46-0)	1	21	80	97	100
Granular potash (0-0-60)	5	37	78	95	98
Average analysis	2	31	81	96	99
Maximum deviation from average	3	10	5	3	2

These data show that the maximum deviations were 10 percent or less and the materials should remain well mixed if handled and applied properly.

In example 2 the materials are prilled ammonium nitrate (AN), granular TSP, and granular potash of indicated screen analyses, average analyses, and maximum deviations.

Example 2

Poorly Matched Materials for Nonsegregating Blend

<u>Material</u>	<u>Cumulative Screen Analysis</u> <u>% Retained on Tyler Screens</u>				
	<u>+6</u>	<u>+8</u>	<u>+10</u>	<u>+14</u>	<u>+20</u>
Prilled ammonium nitrate (33.5-0-0)	<1	10	74	97	100
Granular TSP (0-46-0)	1	21	80	97	100
Granular potash (0-0-60)	5	37	78	95	98
Average screen analysis	2	22	77	96	99
Maximum deviation	3	15	3	1	1

The data show that granular potash has too much +8 mesh material so that its maximum deviation from the average analysis in this size fraction is 15 percent, and extra precautions should be taken to avoid coning and segregation of materials during handling. Precautions could include using flexible hoses such as shown in figure 13 to avoid coning of the blend as it is charged into the applicator. Also, probably a greater overlap would be required during application for the blends of example 2 than those of example 1.

New Materials

Some of the newer materials for blending are listed, and their screen analyses are given in table 2. Several companies have shown considerable interest in the production of granular monoammonium phosphate (MAP) for blending. Five companies produce a substantial quantity of granular

MAP that varies from a 12-48-0 to a 13-52-0. The grade produced most frequently is 11-52-0. It is estimated that over 1.5 million tons of MAP was produced in the U.S. in 1981. The particle size of 11-52-0 grade matches the size of TSP, granular potash, and ammonium nitrate. The particle size of the 11-55-0 and 13-52-0 matches that of granular urea, TSP, DAP, and granular potash. Granular MAP is particularly well suited for blending because of its low  $N:P_2O_5$  ratio which enables production of a wide range of high and low-nitrogen grades when it is blended with potash and a nitrogen material. It is expected that larger amounts of MAP will be used in the manufacture of granular bulk blends.

When DAP is used to produce low-nitrogen ratios such as 1:4:4, a fourth material, TSP, must be used and stored in the blend plant. DAP and TSP will cake and react with each other over a period of time. The caking usually does not occur during bulk handling and application, but some of the TSP-DAP mixtures cake during bag storage. MAP and TSP do not react and their mixtures cause no caking problem.

Granular urea can now be purchased from several suppliers. Usually it comes in two sizes--large and small. The blender should select the urea which will segregate the least. Also, the blender should be aware that urea is completely compatible with MAP, DAP, and potash, but it will react with some of the TSP. Hoffmeister has reported that when the hydrated water content of the TSP is less than about 4 percent, there is little tendency for the urea and TSP to react (4). However, when the hydrated water content is as high as 5 percent, the materials react to form a damp mass, and field experience shows that this mixture sticks in elevators, mixing equipment, and applicator spinners and makes a sloppy mess in the roadway within the plant. Because of these problems,

it is usually advisable to avoid using urea with TSP. If urea must be used, granular urea is preferable because it has less tendency to react with TSP than prilled urea. Because of this problem, some companies prefer DAP and MAP as sources of  $P_2O_5$  to mix with urea instead of TSP.

TVA has started the production of two new urea-ammonium phosphate (UAP) grades, 28-28-0 and 35-17-0, that contain about 20 percent of the  $P_2O_5$  as polyphosphate. Storage tests show that these urea-based materials are completely compatible with TSP from the various suppliers. The 28-28-0 grade was stored over the winter (9 months) in a river terminal without caking problems. Granular urea products stored in the same terminal did not store as well as the 28-28-0. Possibly the anhydrous nature of the ammonium polyphosphate portion of the product contributes to its excellent storage characteristics. The same good results are expected with the new 35-17-0 grade TVA has made available for developmental purposes this year.

Another attractive use for the urea-ammonium phosphate materials has been in the manufacture of fluid fertilizer. The blenders are particularly interested in a dual-purpose product such as this, since many of them have both dry and fluid mixing plants.

A new product that has been used quite successfully in blending is TVA's ammonium polyphosphate 12-54-0 grade. It is essentially anhydrous and about 20 percent of the  $P_2O_5$  is in the polyphosphate form. Some companies produce properly sized micronutrient materials such as granular borate, granular zinc sulfate, etc. Other companies coat blends with a powdered zinc and other micronutrients. The powdered materials adhere well to the surface of the granule.

A typical mixer equipped for sticking powdered micronutrients onto granules is shown in figure 14. Usually water is used as the binder although some companies have used liquid fertilizers such as 10-34-0 or 32-0-0. Some companies simply spray the chelated micronutrient solutions into the mixer, and since small proportions are added, it usually does not adversely affect the physical characteristics of the blend. Some companies use a combination of powdered inorganic micronutrients with a chelated solution as a binding agent. This same equipment arrangement is used to spray herbicides onto blends.

New sulfur-containing products are needed for blends. Perhaps the new granular gypsum (18% S), potassium sulfate (50% K<sub>2</sub>O, 18% S), granular ammonium sulfate (21% N, 24% S), etc., will fill the bill. Consideration should be given the production of ammonium nitrate sulfate (30-0-0-5S or 26-0-0-12S), an excellent source of immediately available N and S.

For some time a firm in the west has produced a granular triple superphosphate with sulfur (0-35-0-20S). There is considerable demand for this product; however, because of environmental problems within the plant, the company plans to curtail or stop its production. Perhaps this production could be replaced with a granular monocalcium phosphate sulfate (0-20-0-11S). Some of the old hands in the fertilizer business will perhaps recognize this material as "good old normal superphosphate." This material can be produced in a TVA cone mixer and granulated with steam in a rotary granulator. Some good blending prospects under investigation at TVA are 33-11-0-5S and 12-48-0-5S, urea-ammonium polyphosphate sulfate materials which are completely compatible with other blend materials and have low moisture content and excellent storage

characteristics. The polyphosphate content is advantageous for use in fluids, and small-scale tests show that both products work well in fluid mix plants as sources of N, P, and S for suspensions.

#### Future of Blends

TVA data show that there are now over 5,000 bulk blend plants in the United States. It is doubtful that the number will increase substantially; several have shut down during the past few years. Surveys show that an average of about 5,500 tons of blends is produced annually per plant. It is expected that the tonnage per plant will increase steadily during the next few years. Further mechanization and larger mixers are likely. Larger and more sophisticated application and transportation equipment will be developed.

The marriage between blends and fluid fertilizers should become more binding in future years as materials suitable to both are developed.

### References

1. Norman L. Hargett and Ralph Pay. "Retail Marketing Systems in the U.S.," presented at the 1980 Fertilizer Industry Round Table, Atlanta, Georgia, October 26-30, 1980.
2. G. L. Bridger and I. J. Bowen, Georgia Institute of Technology Contract with TVA Project A-904, Jan. 1, 1966-Dec. 31, 1966, "Tests of Effectiveness of Fertilizer Bulk Blending Equipment."
3. Allen Sargent and George Hoffmeister. "Quality Control in Bulk Blending Plants - Segregation in Holding Bins," TVA Fertilizer Conference, Louisville, Kentucky, July 29-31, 1975.
4. George Hoffmeister. "Use of Urea in Bulk Blends," presented at the Fertilizer Industry Round Table, Washington, DC, November 6, 1975.

Table 1

Particle Size Range of Conventional Blending Materials

<u>Material</u>	<u>Cumulative Screen Analysis, % Retained on Tyler Screens</u>					<u>Sources for Average Screen Analysis</u>
	<u>6</u>	<u>8</u>	<u>10</u>	<u>14</u>	<u>20</u>	
Diammonium phosphate (18-46-0)	<1	36	86	99	100	9
Granular potash (0-0-60)	5	37	78	95	98	13
Coarse potash (0-0-60)	-	6	31	73	94	14
Granular TSP (0-46-0)	1	21	80	97	100	6
Prilled ammonium nitrate (33.5-0-0)	<1	10	74	97	100	8
Urea prilled (46-0-0)	<1	6	68	97	100	9

Table 2

Screen Analysis of New Materials for Blending

<u>Material</u>	Cumulative Screen Analysis % Retained on Tyler Screen				
	<u>+6</u>	<u>+8</u>	<u>+10</u>	<u>+14</u>	<u>+20</u>
Monoammonium phosphate (11-52-0) <sup>a</sup>	1.5	33.5	57	83	100
Monoammonium phosphate (11-55-0 and 13-52-0) <sup>b</sup>	2.0	15	83	86	100
Granular urea (46-0-0) large <sup>c</sup>	1	88	100	100	100
Granular urea (45-0-0) small	0	30	85	98	100
Granular ammonium polyphosphate (12-54-0) <sup>d</sup>	2	32	65	94	100
Granular urea-ammonium phosphate (28-28-0 and 35-17-0) <sup>d</sup>	1	25	55	97	100

<sup>a</sup>One Florida producer<sup>b</sup>Average of two producers<sup>c</sup>One producer<sup>d</sup>One producer (TVA new product)

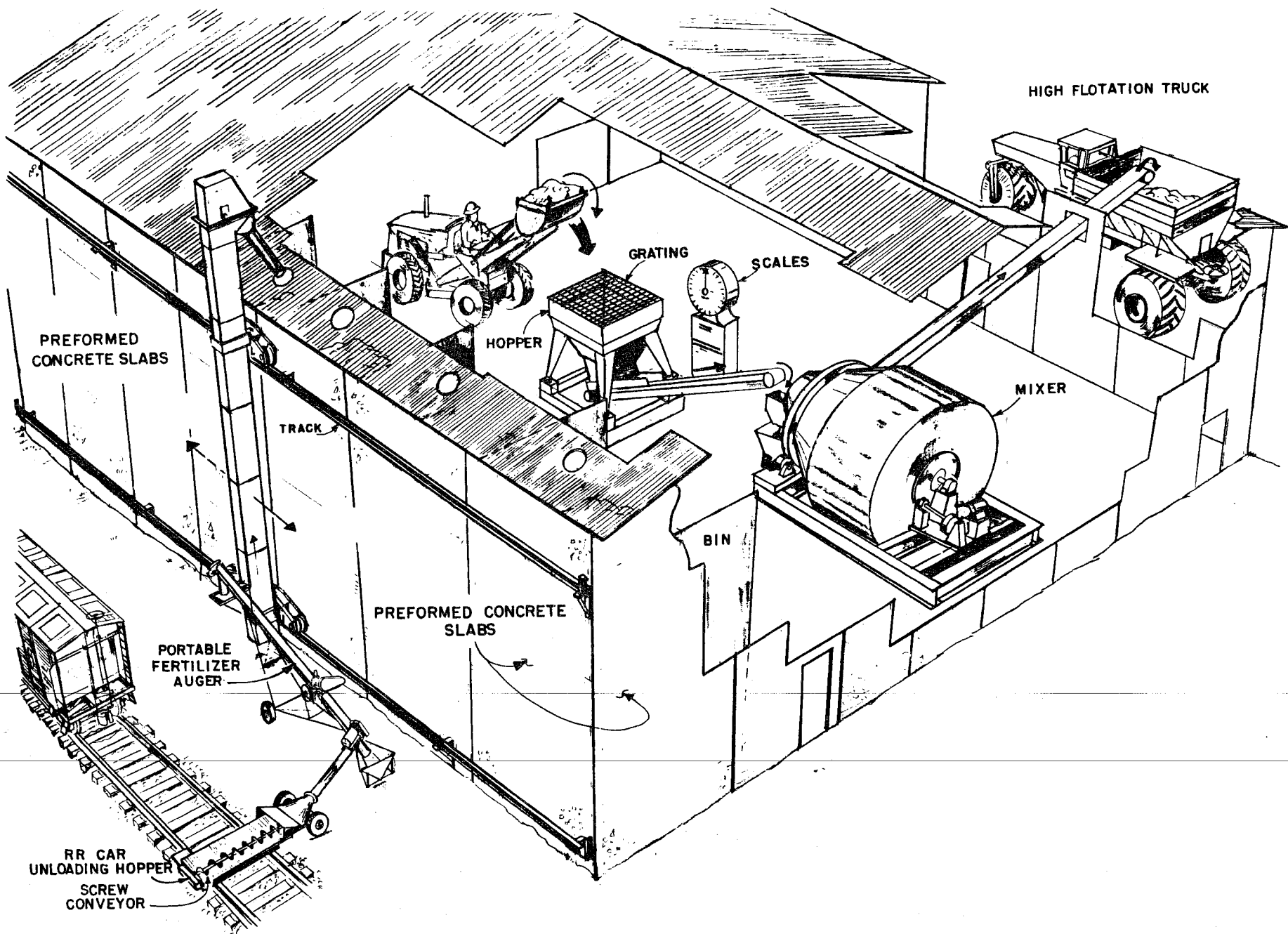
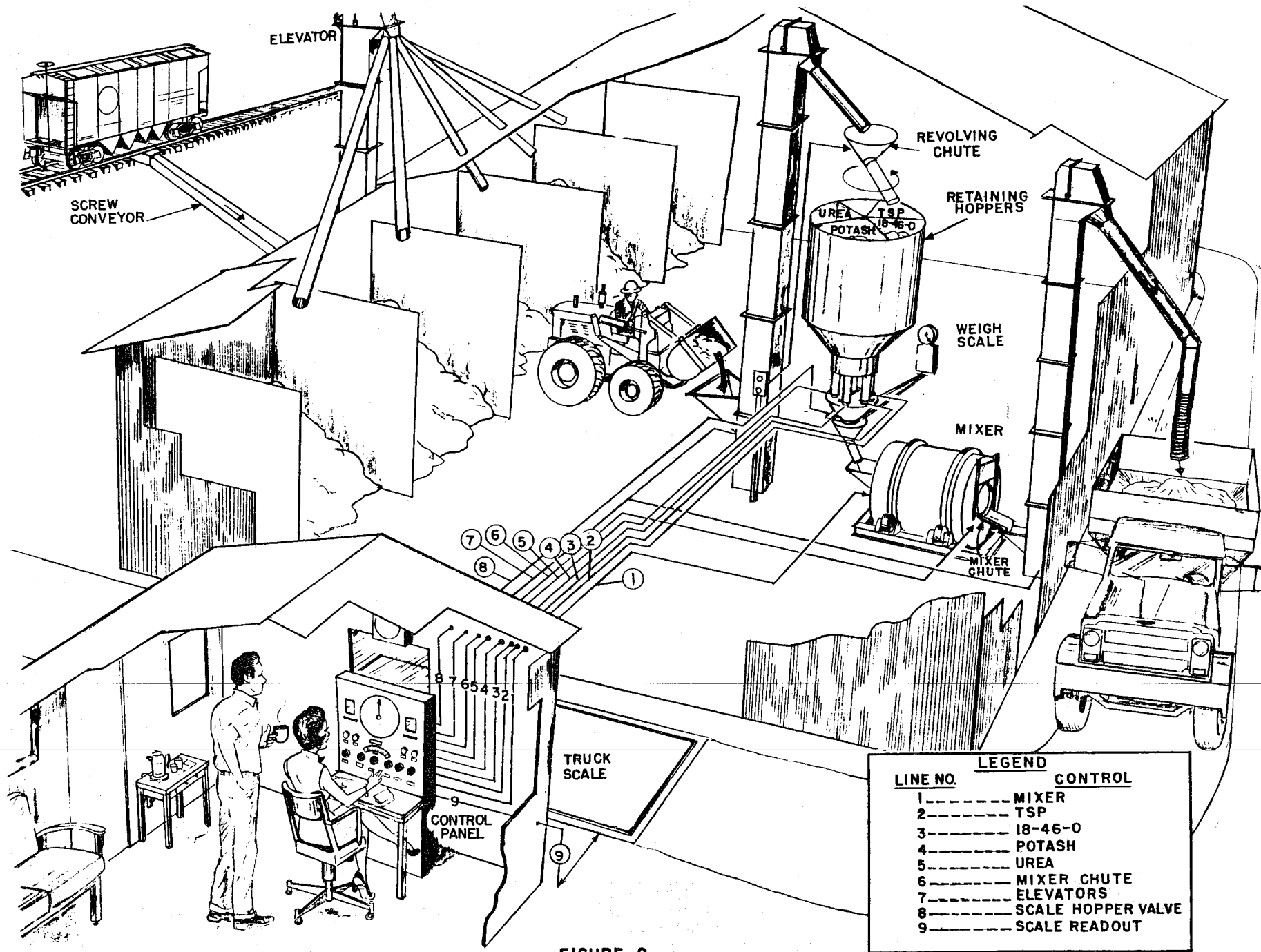


FIGURE 1

**BULK BLEND PLANT WITH CONCRETE-TYPE MIXER**



LINE NO.	LEGEND	CONTROL
1	MIXER	
2	TSP	
3	18-46-0	
4	POTASH	
5	UREA	
6	MIXER CHUTE	
7	ELEVATORS	
8	SCALE HOPPER VALVE	
9	SCALE READOUT	

FIGURE 2  
HIGHLY AUTOMATED BLEND PLANT WITH REMOTE OPERATING BOARD

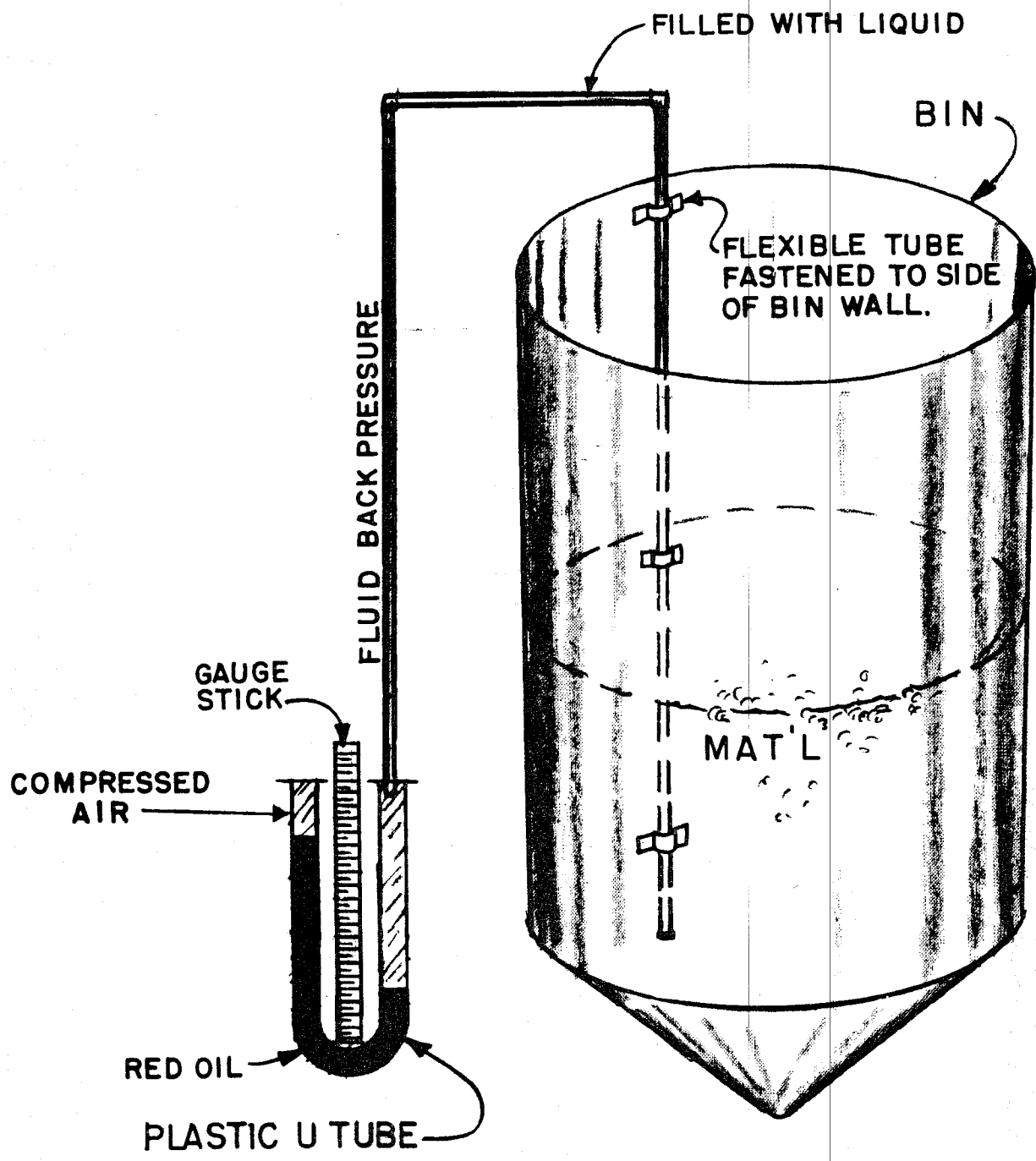


FIGURE 3  
PRESSURE—TYPE BIN INDICATOR

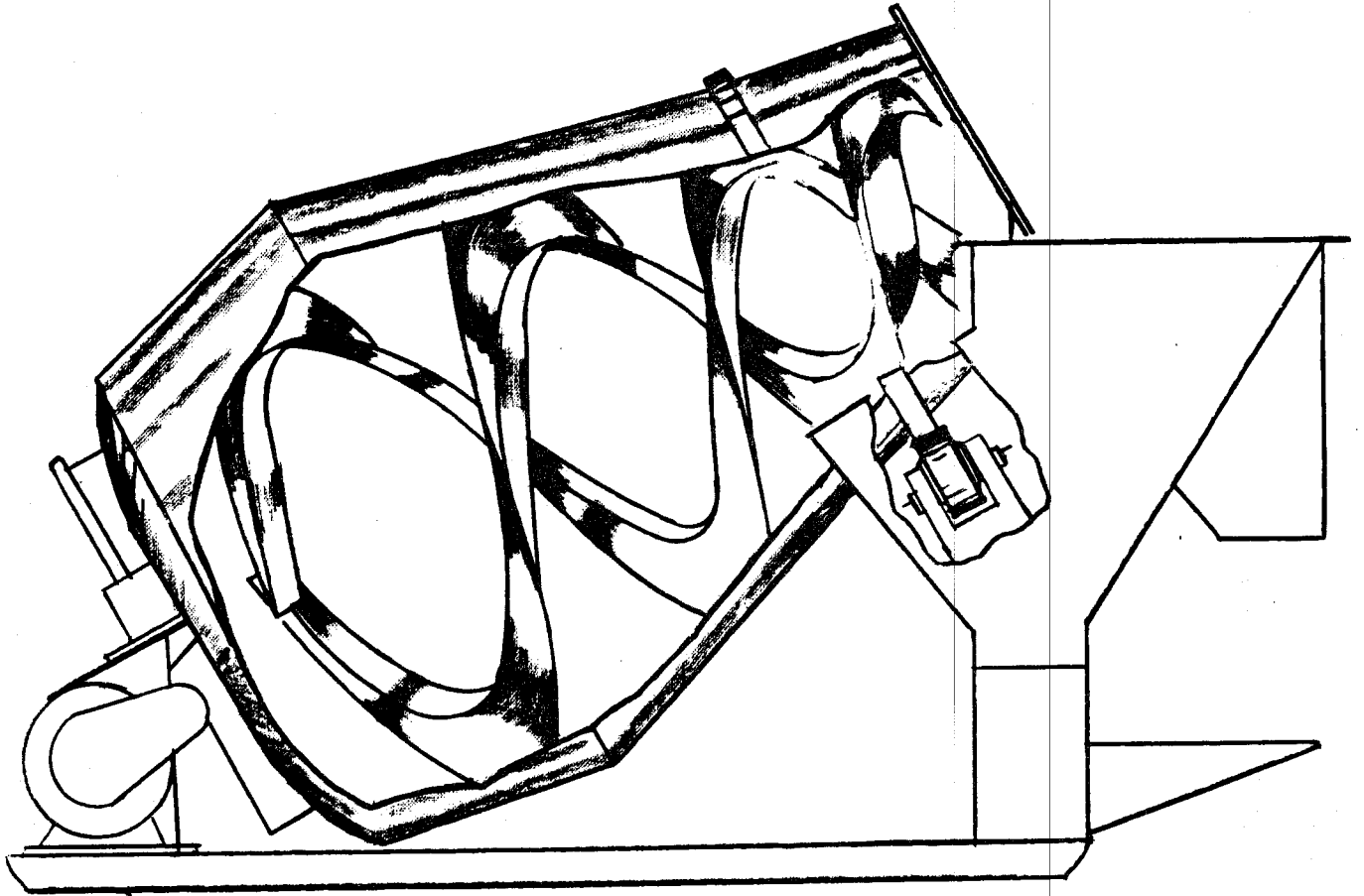


FIGURE 4  
CONCRETE MIXER-TYPE BLENDER

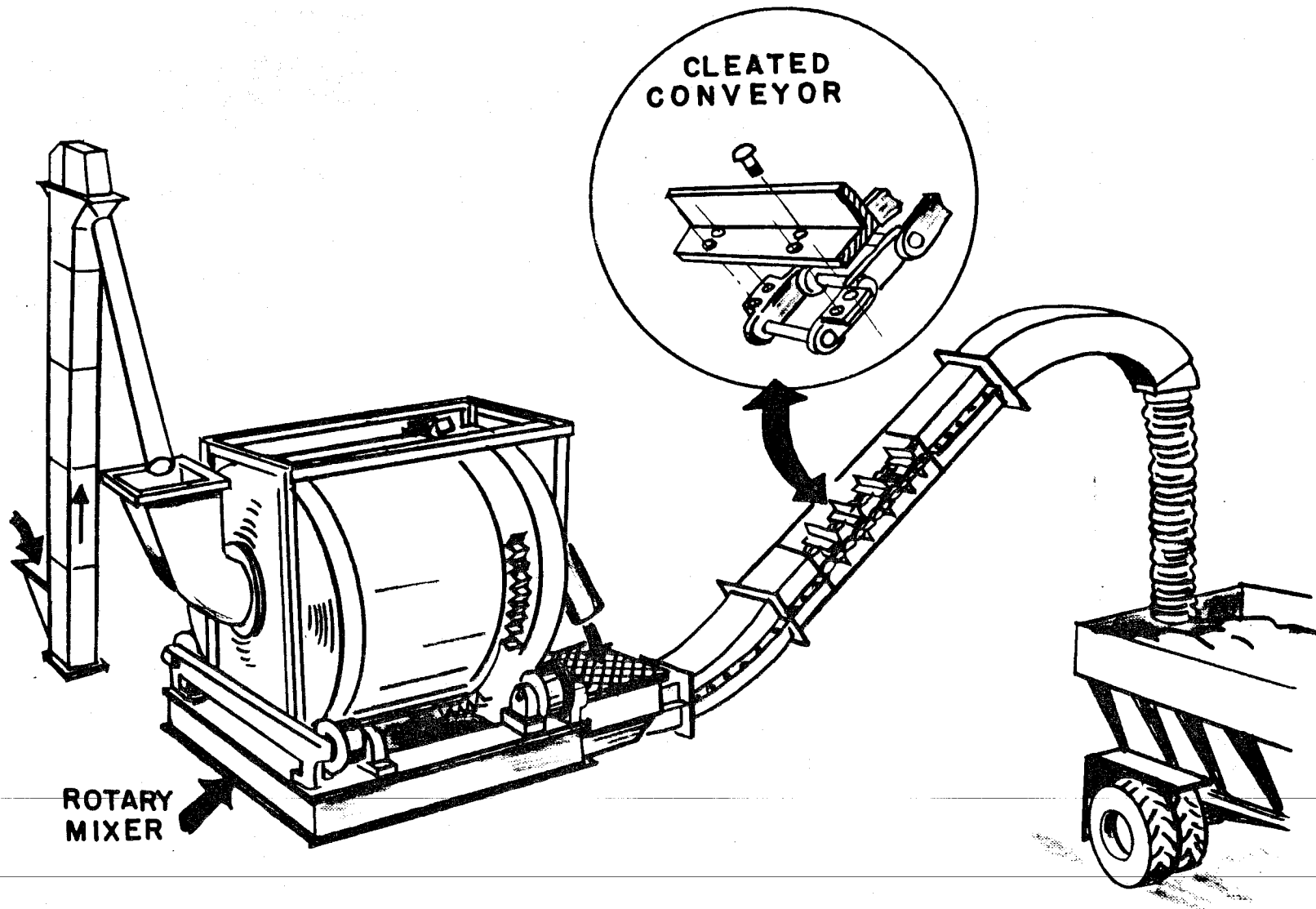
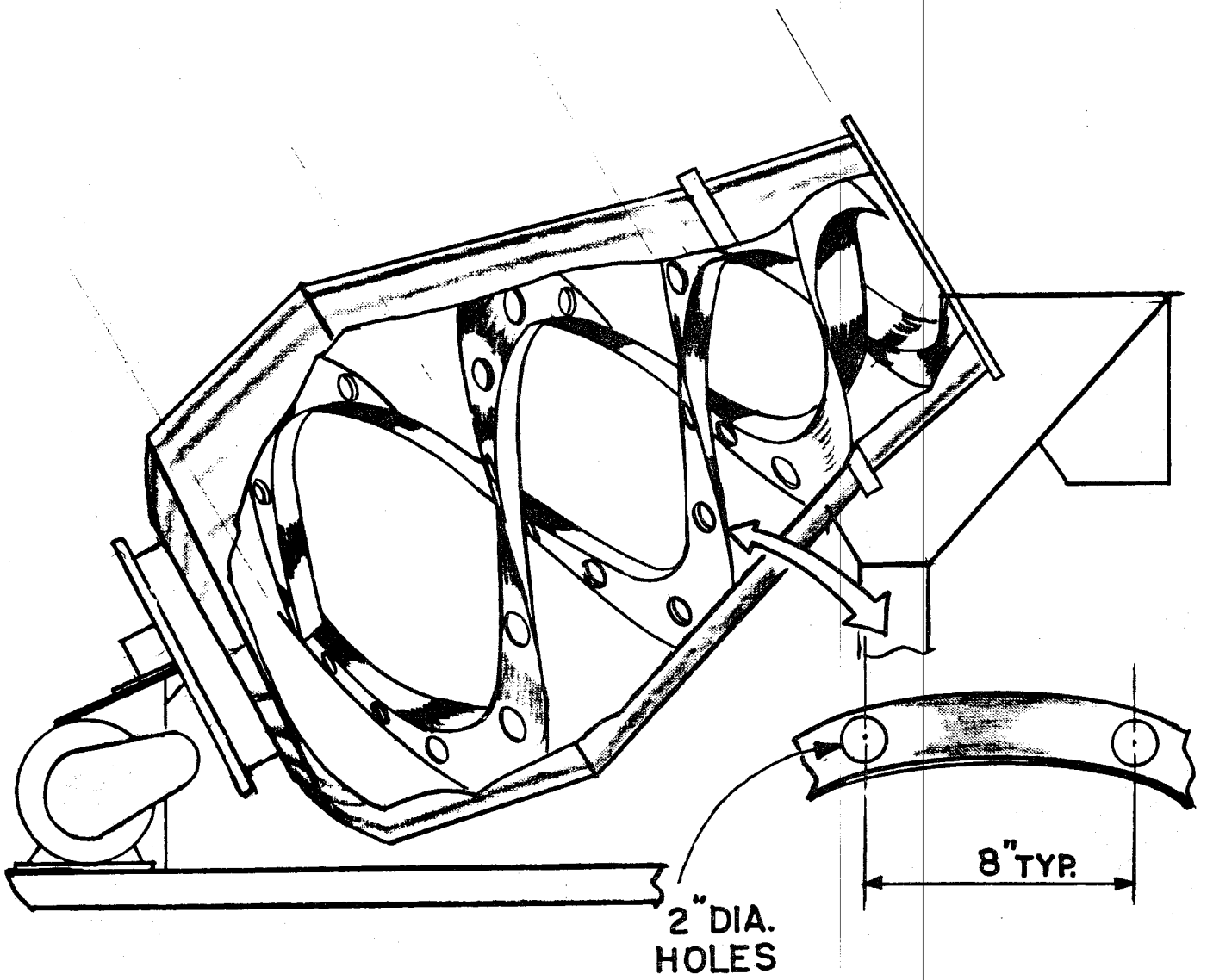


FIGURE 5  
BLEND PLANT WITH METAL CLEATED CONVEYOR



49 HOLES PER RIBBON

PPI SEC. -TVA  
R. S. W.

FIGURE 6  
CONCRETE MIXER-TYPE BLENDER WITH  
ALTERED FLIGHTS TO IMPROVE MIXING  
EFFICIENCY

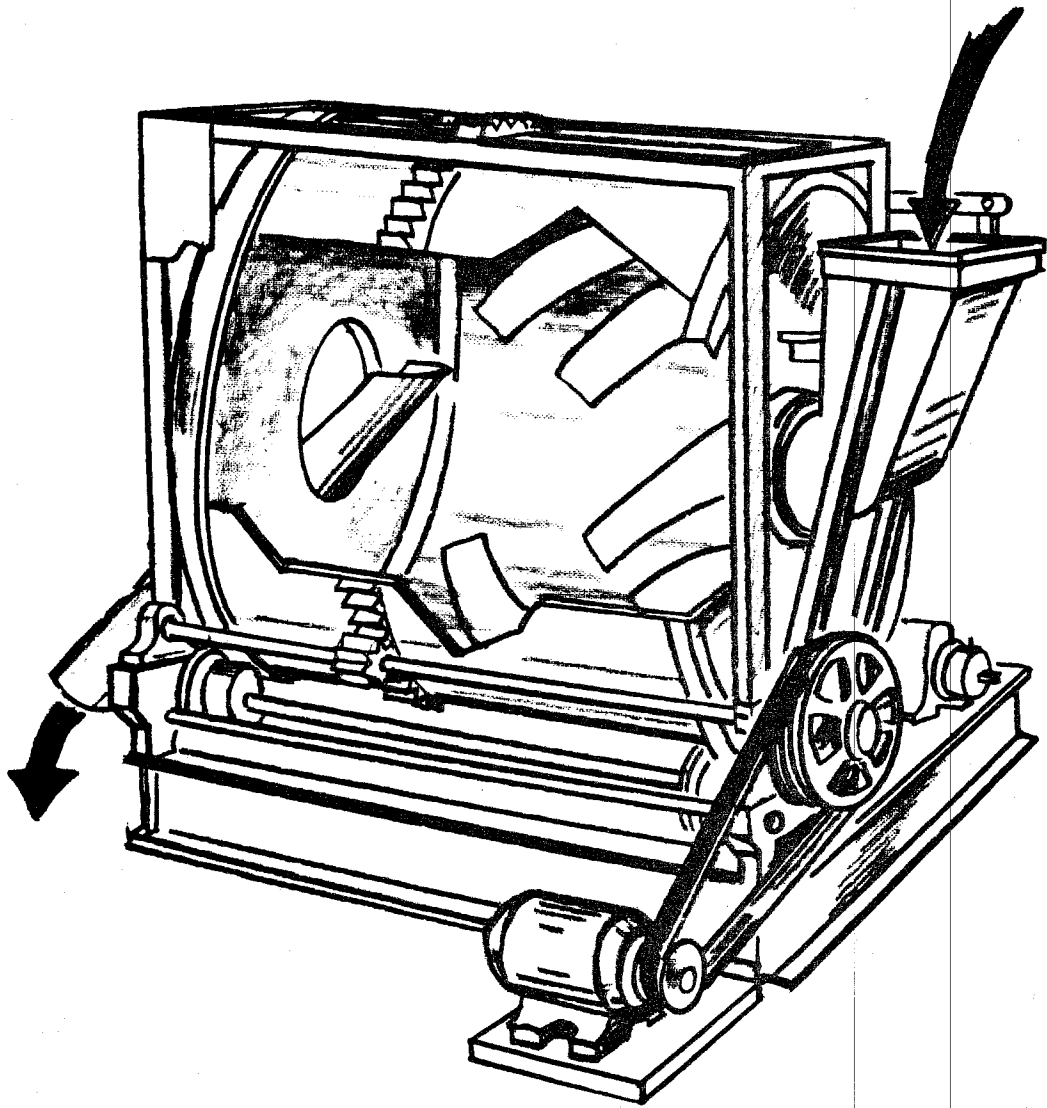


FIGURE 7  
ROTARY MIXER

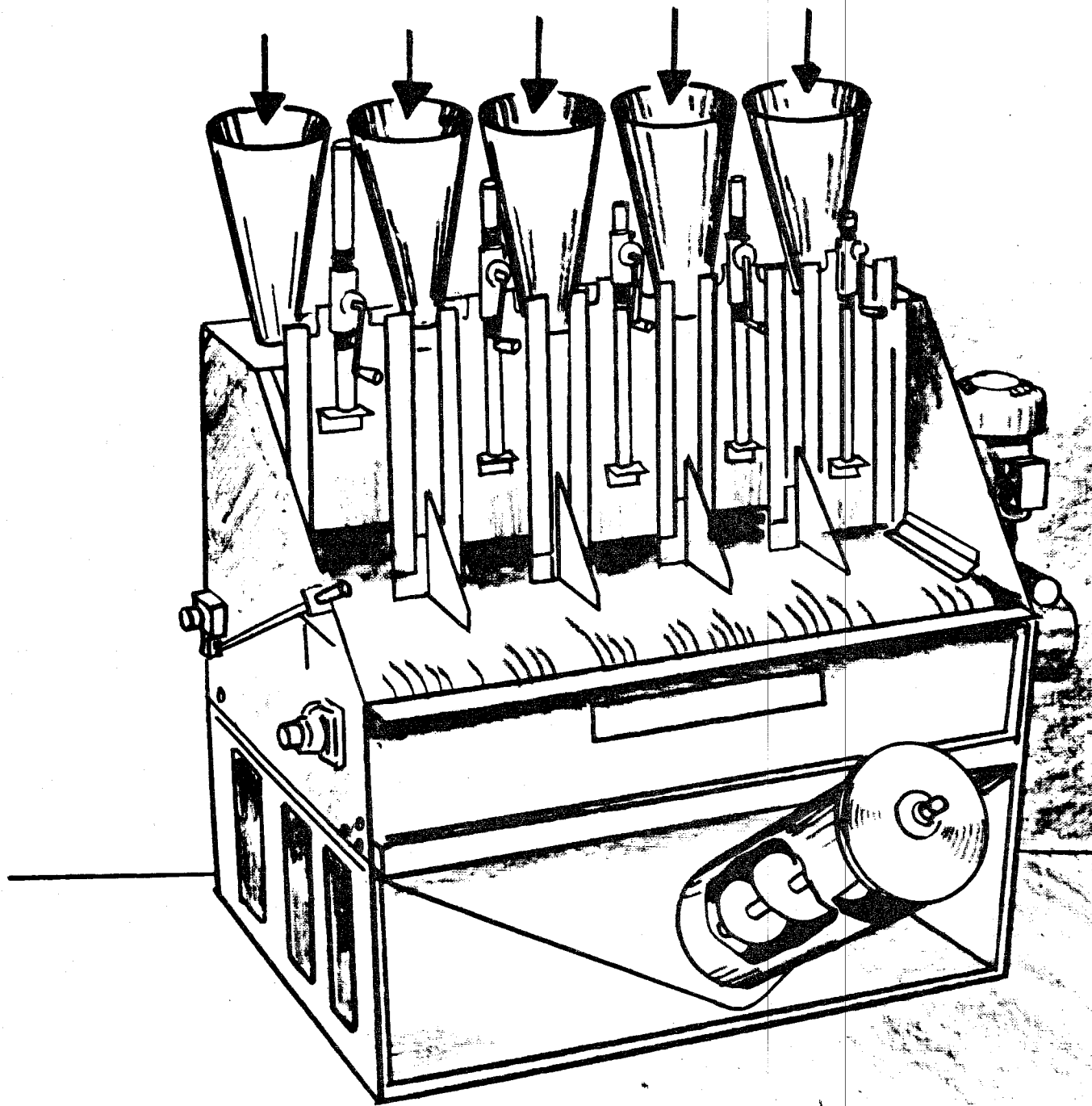


FIGURE 8

BLENDING PLANT WITH SCREW CONVEYOR MIXER

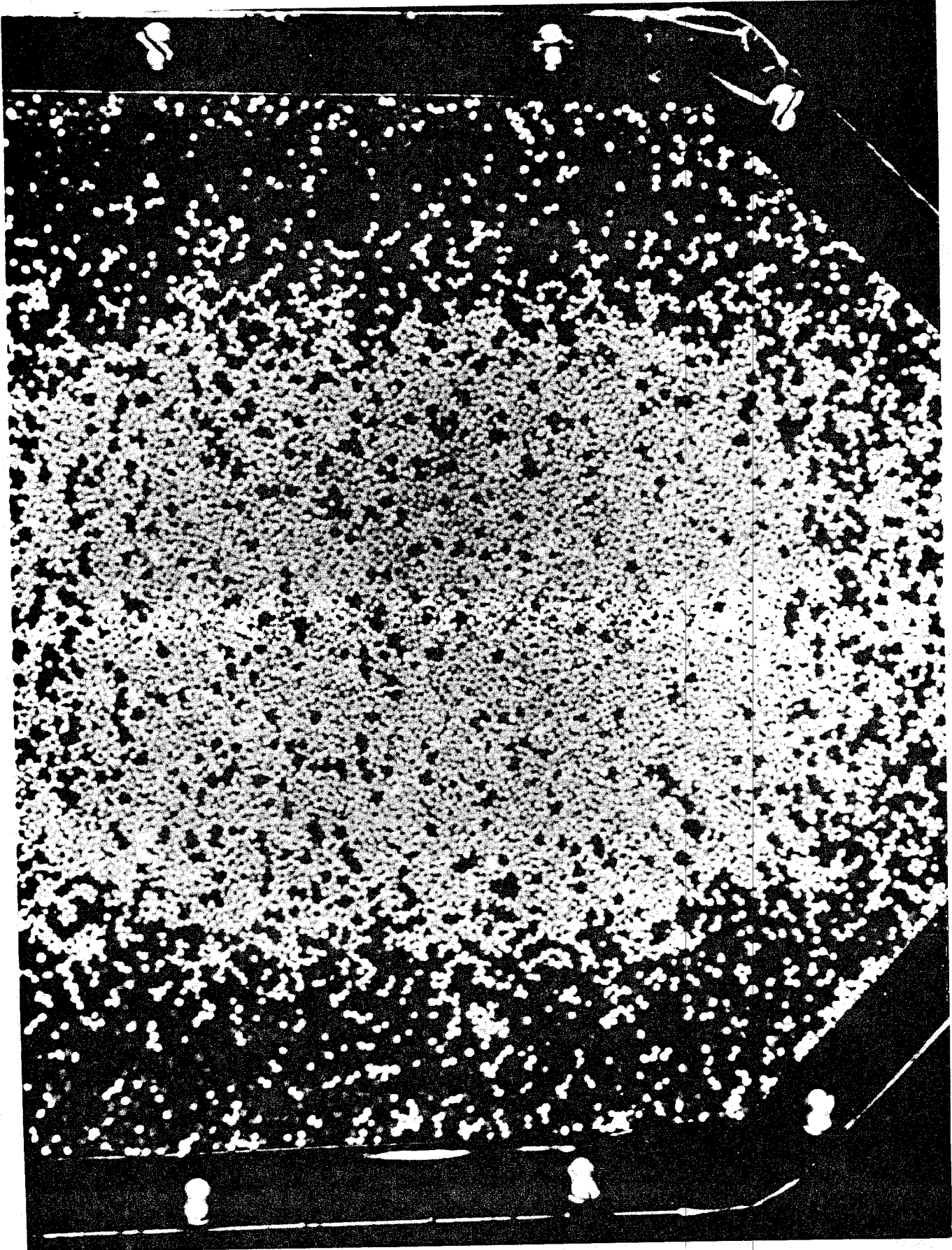
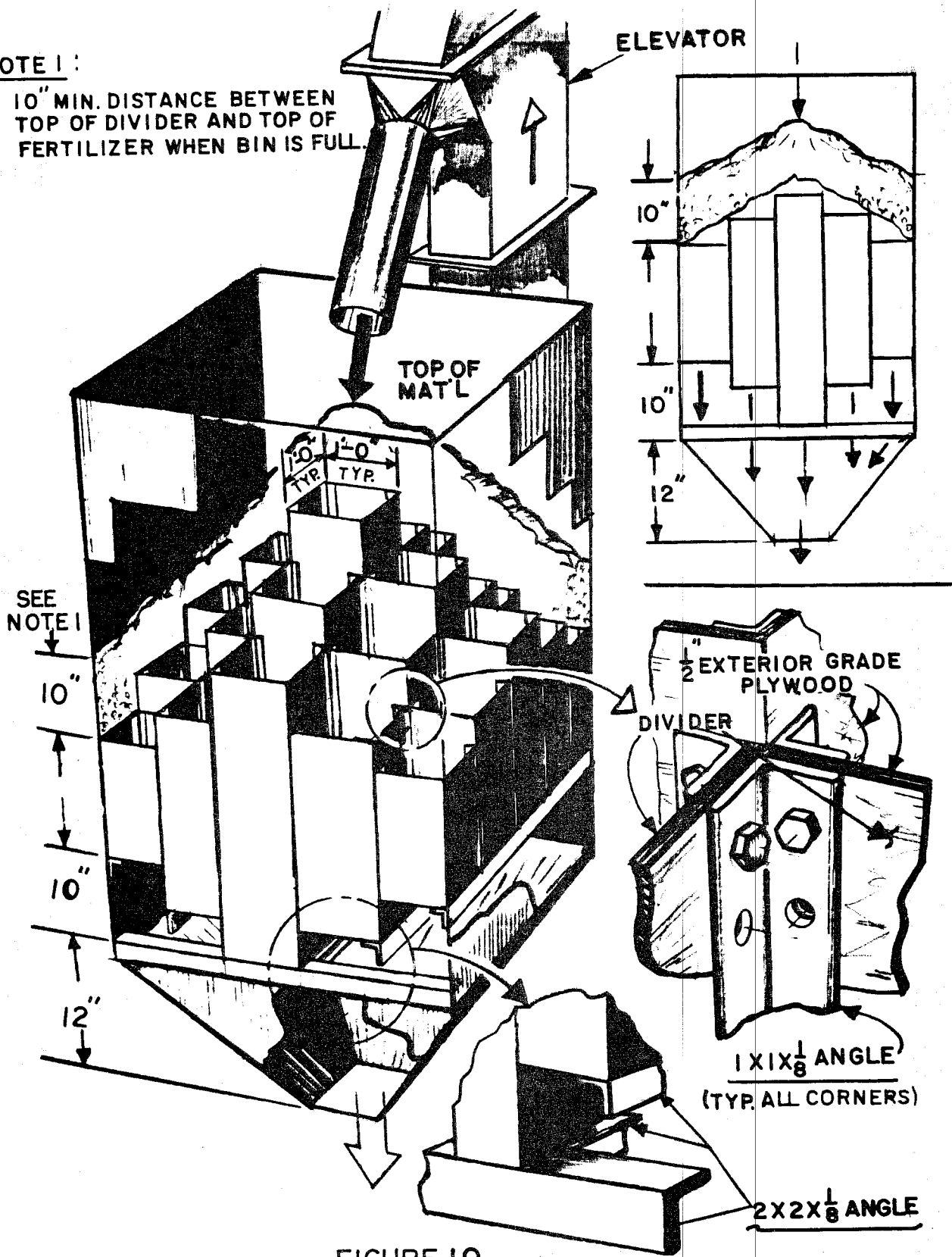


FIGURE 9 SEGREGATION OF UNMATCHED MATERIALS IN HOLDING HOPPER

**NOTE 1 :**

10" MIN. DISTANCE BETWEEN  
TOP OF DIVIDER AND TOP OF  
FERTILIZER WHEN BIN IS FULL.



**FIGURE 10  
ANTI-SEGREGATION DIVIDERS FOR HOLDING HOPPER**

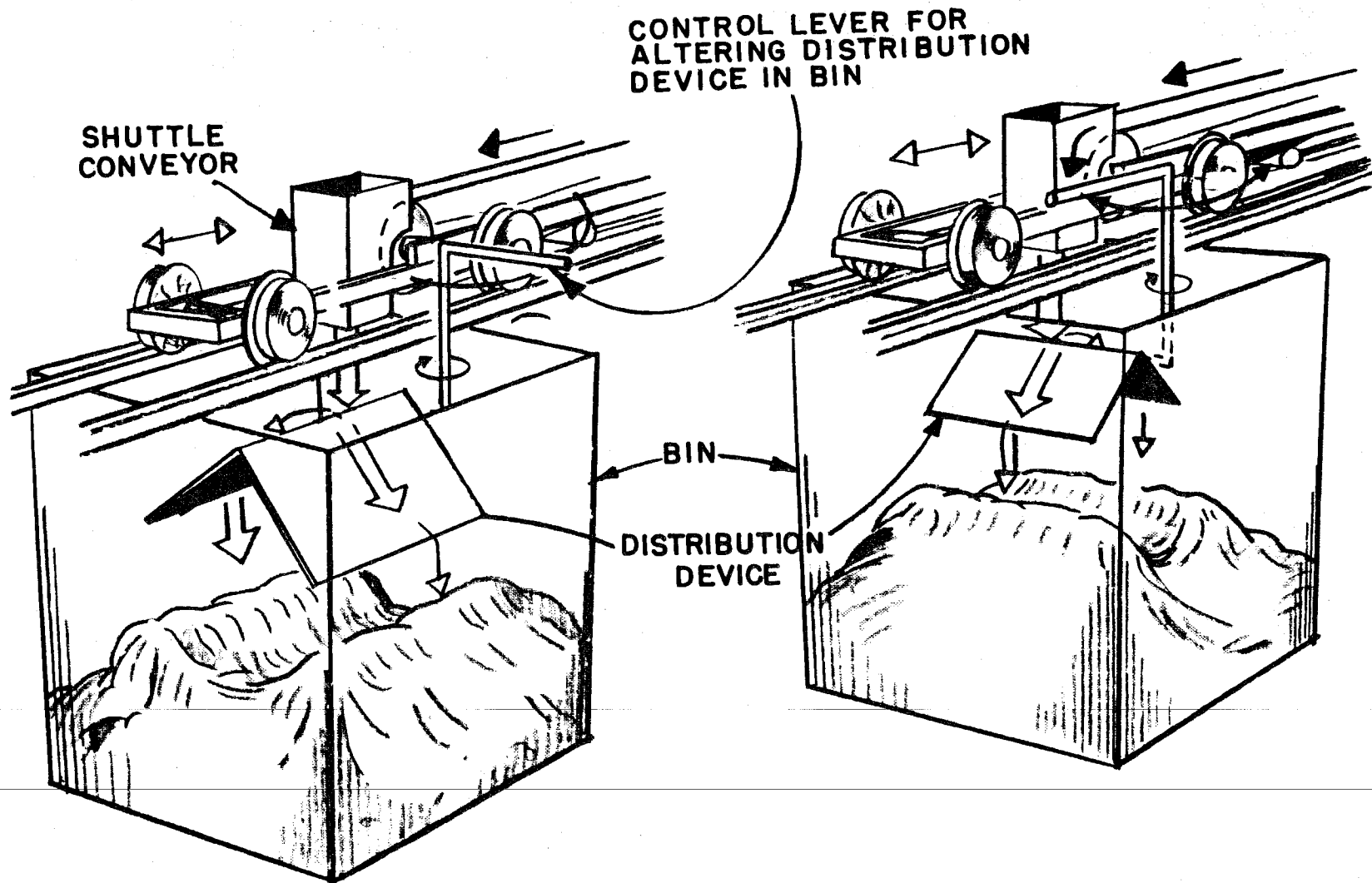


FIGURE II  
DISTRIBUTION DEVICE TO PREVENT  
CONING OF MATERIAL IN BINS

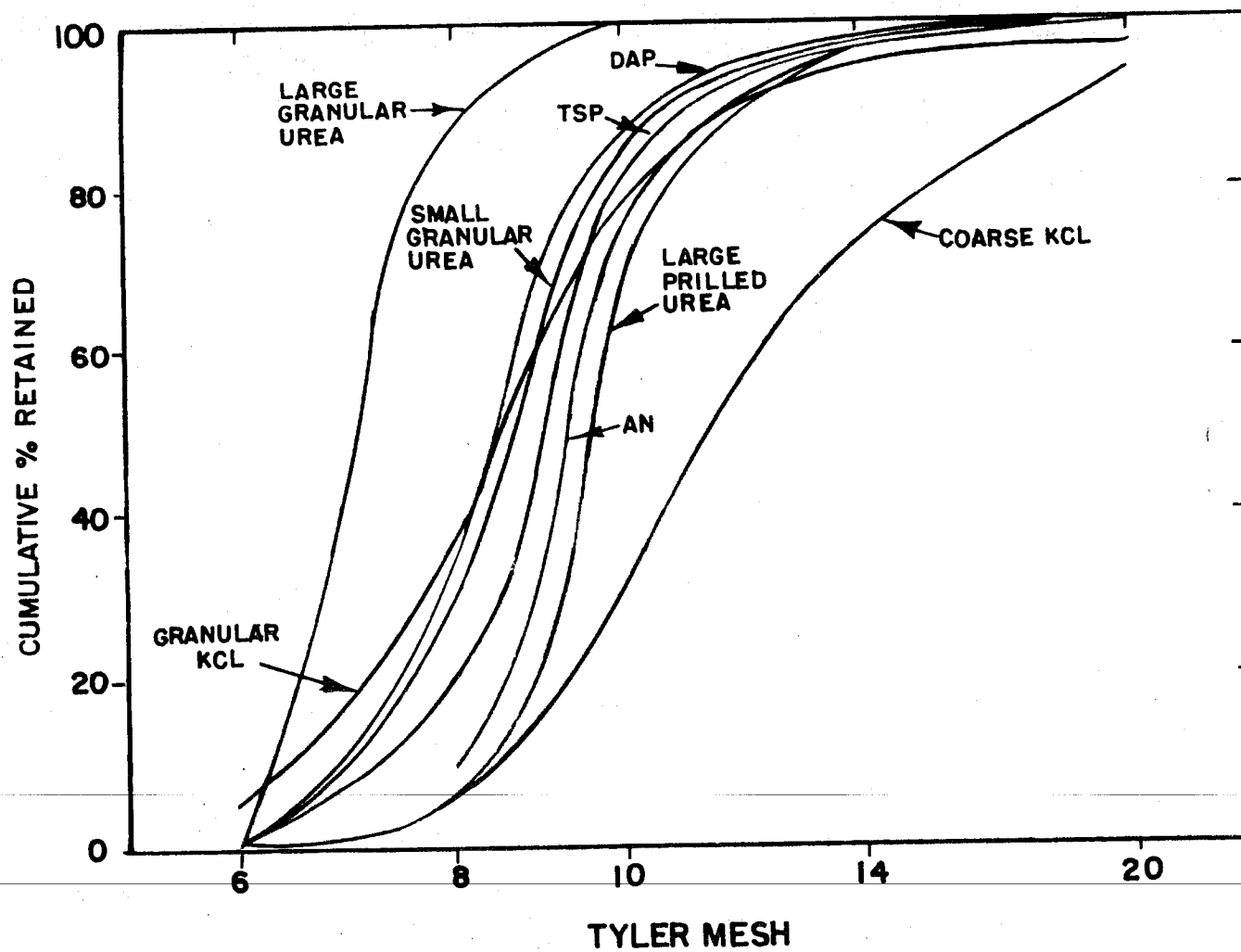


FIGURE 12

PARTICLE-SIZE DISTRIBUTION OF FERTILIZER MATERIALS FOR BULK BLENDS

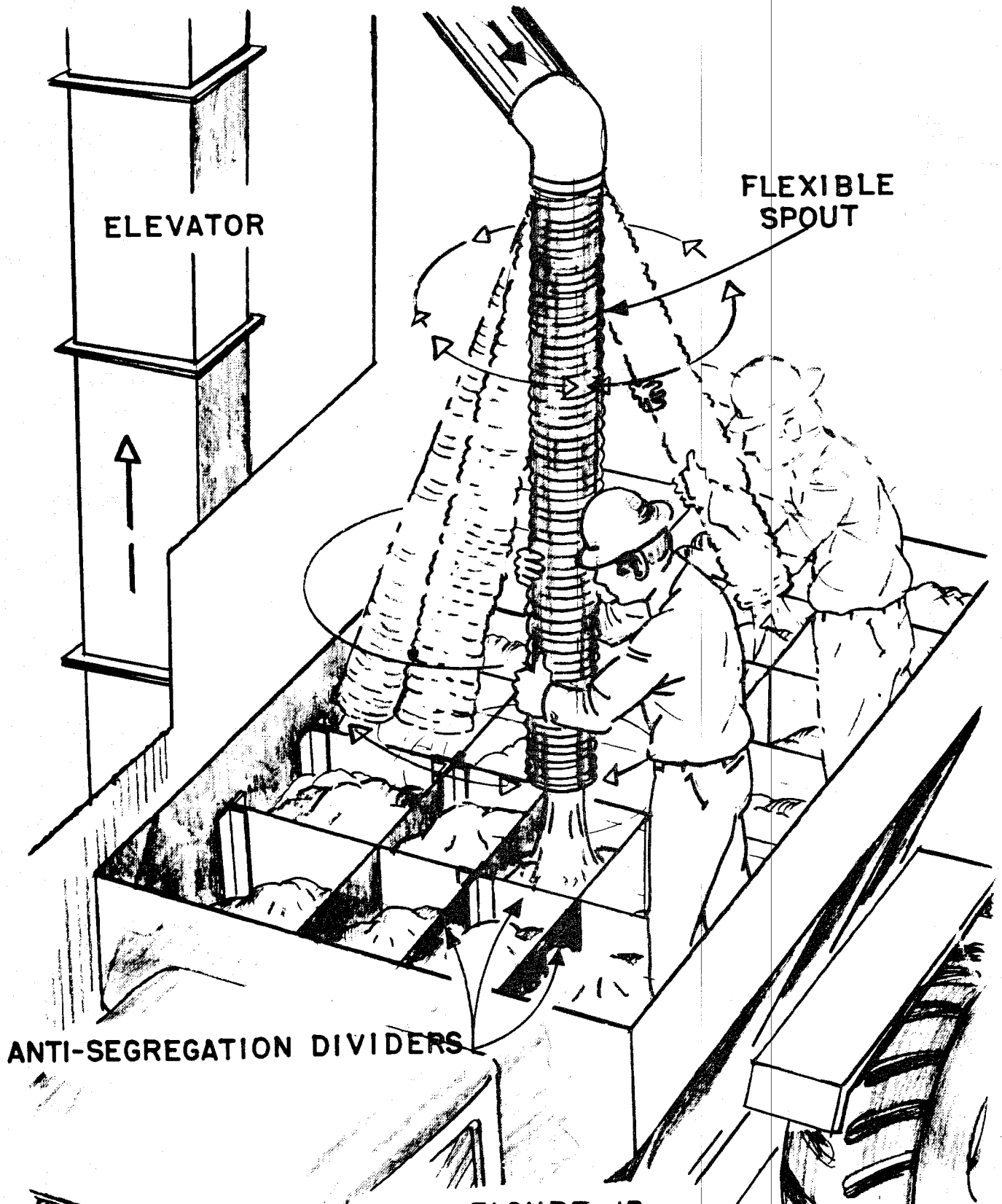


FIGURE 13  
FLEXIBLE SPOUT  
FOR LOADING GRANULAR FERTILIZER IN APPLICATOR

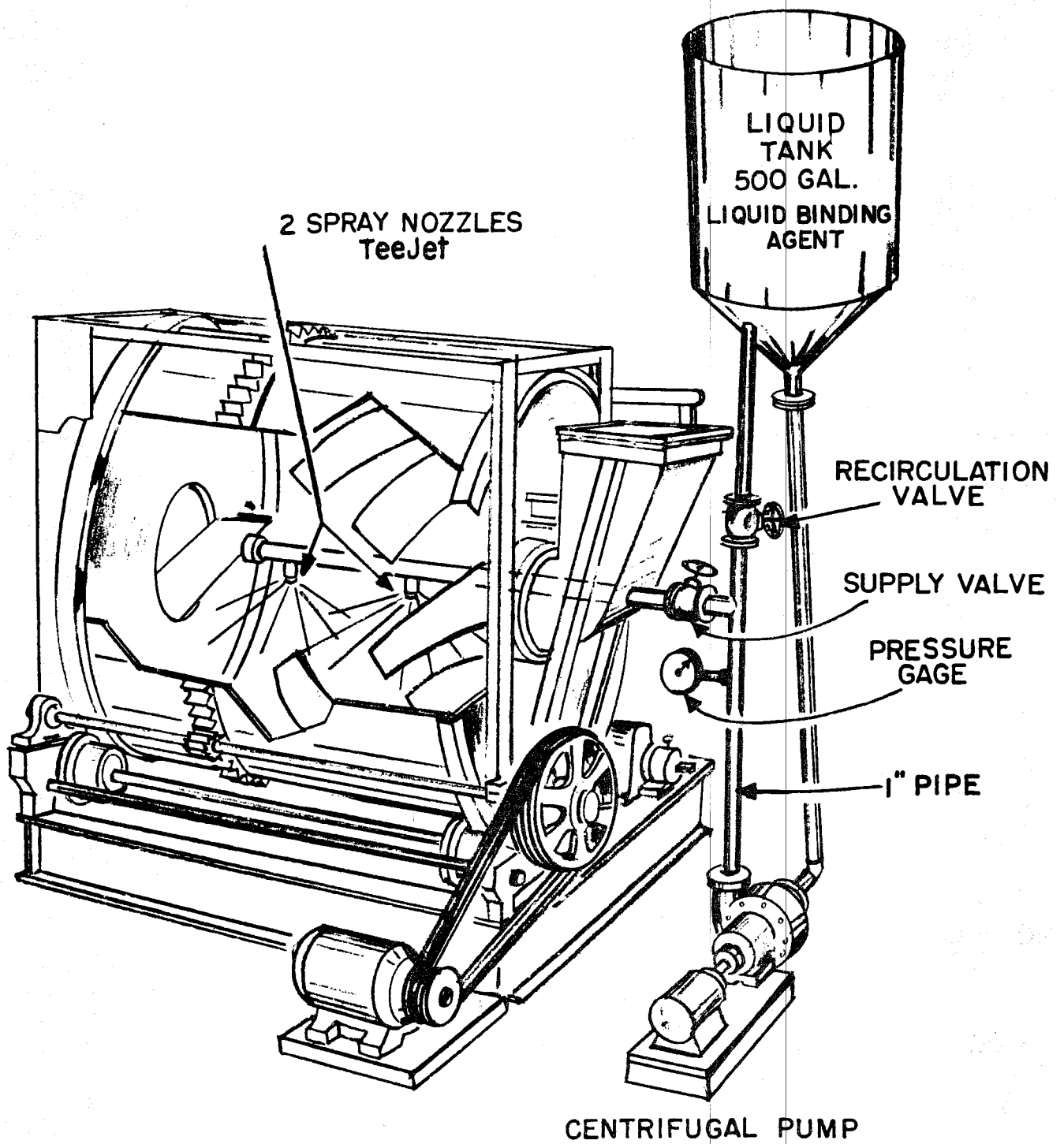


FIGURE 14

ROTARY MIXER EQUIPPED FOR STICKING  
MICRONUTRIENTS TO GRANULAR BLENDS

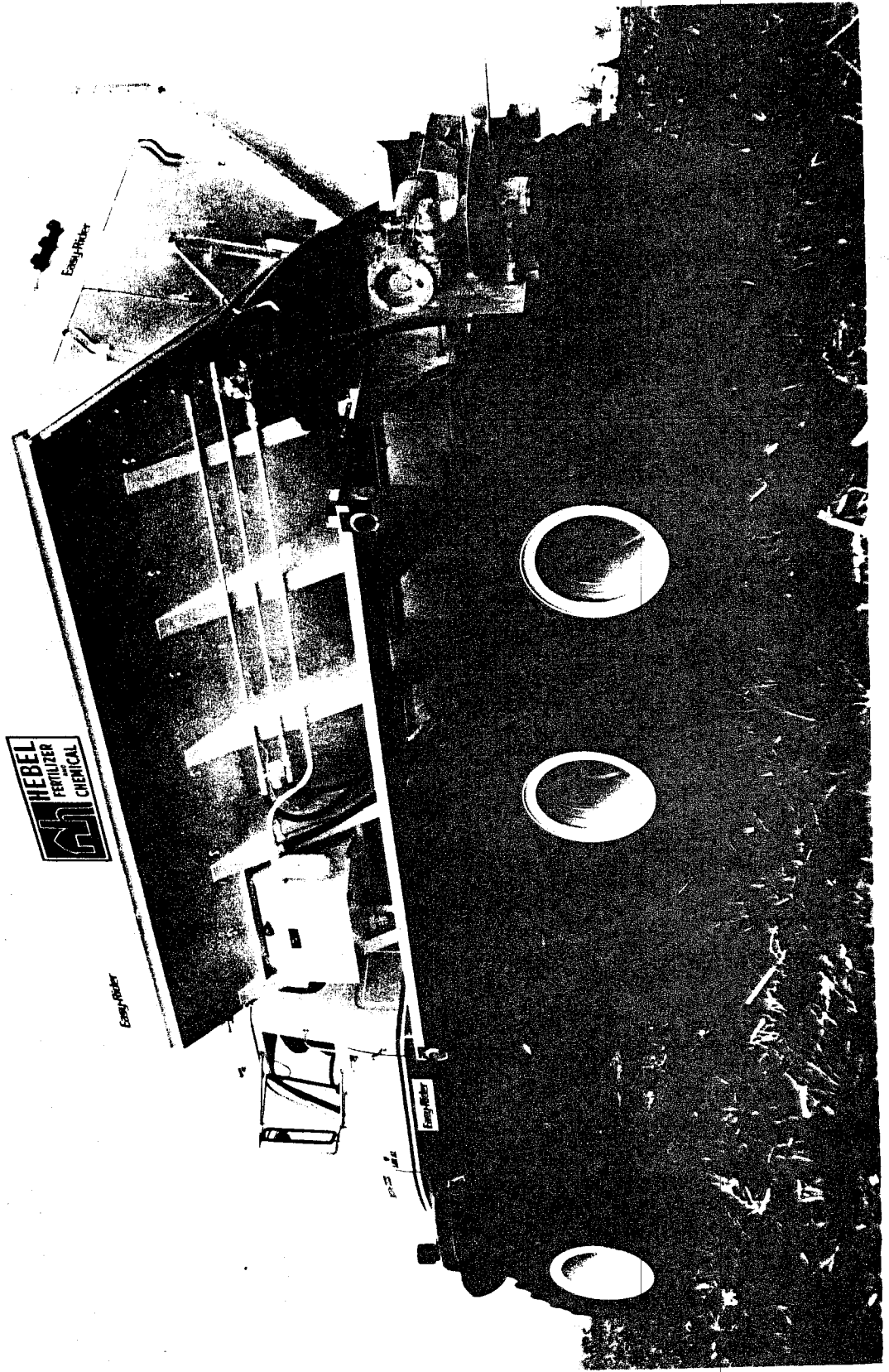


FIGURE 15 HIGH FLOTATION APPLICATOR 17 TON CAPACITY

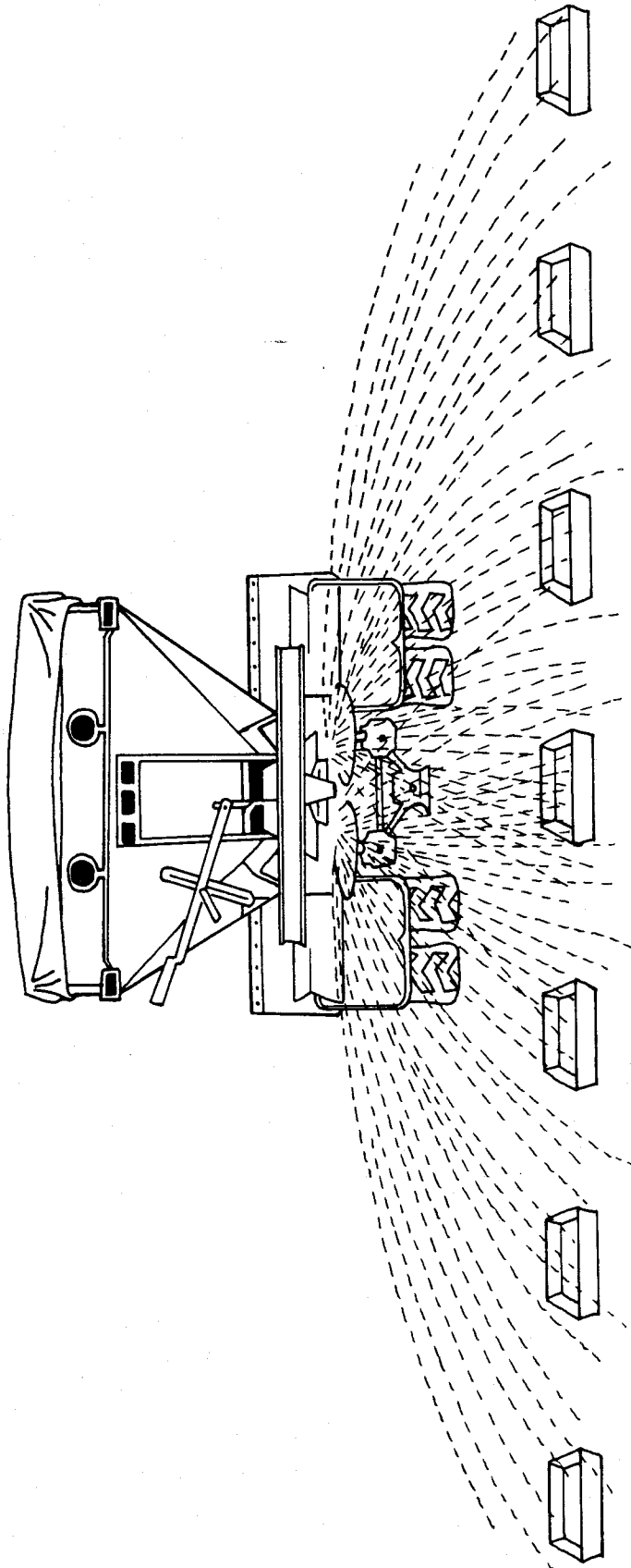


FIGURE 16 - COLLECTING SAMPLES ACROSS SWATH TO DETERMINE PATTERNS