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RECENT DEVELOPMENTS IN GRANULATION

Presented at the Management Seminar for Indian Fertilizer Executives

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The number of granulation plants in this country and in foreign countries continues to increase. Many companies with small plants which formerly produced pulverized mixtures have converted their batch ammoniators to batch granulators and now produce granular products. Many producers with medium-size granulation plants have installed preneutralizers and scrubbers so that they now produce diammonium phosphate grades. Companies that have plants of the latter type usually have high annual fertilizer production, and many of them are marketing complete grades through bulk handling stations. In recent years there has been a continuing utilization of the TVA ammoniator-granulator for the production of diammonium phosphate grades such as 18-46-0, 16-20-0, 6-24-24, and 15-15-15 by large basic producers of granular products. Some basic producers are using the TVA ammoniator-granulator to produce granular triple superphosphate. The 18-46-0, 16-20-0, and triple superphosphate are usually marketed through blending plants. They are mixed with potash and other materials in these plants to produce mixtures of different nitrogen, P_2O_5, and K_2O ratios.

Producers who have converted their small pulverized-mix plants to granulation have accomplished this conversion by cutting away some of the flights in their batch mixer and installing ammonia and acid distributors below the rolling bed of material in the batch ammoniator. Figure 1 is a sketch of a typical batch mixer that has been converted to a batch granulator. The flights in the first half of the mixer have been removed, and a block or drilled-pipe distributor has been installed in this section. The flights in the latter half of the mixer are usually cut so that they are only about 6 inches deep.

Figure 2 is a flow diagram of a small batch granulation plant or a batch granulation plant that has been changed to a simple continuous plant as explained below. The material from the batch granulator is usually cooled in a rotary cooler. Coolers of this type vary in size from 6 by 12 feet to 7 by 50 feet. Producers with batch granulation plants of this type formerly sold unscreened products, or they removed the oversize only and sold the product as a semigranular fertilizer. However, with the increase in the demand for granular products and the tightening of quality specifications for these granular products, most of these producers have found it advisable to screen the product from the cooler and recirculate the fines from the screen to the batch granulator. Recently some companies have converted their batch ammoniators to continuous granulators by enlarging the discharge openings from the ammoniators and operating on a continuous basis. Their operation is then essentially the same as with the conventional continuous ammoniator-granulator. However, most of these producers that use these small converted granulation plants have found that their production rate is about 10 to 15 tons per hour.

Another disadvantage of the small granulation plant is that it has not been able to produce high-analysis grades which require the addition of merchant-grade phosphoric acid (54 percent P_2O_5). Since the plant does not have a dryer, the high-analysis grades produced in it would have a moisture content too high for satisfactory storage characteristics. Recently we have conducted in the States of Maine and New York plant tests in which superphosphoric acid has been used in small batch and continuous ammoniation-granulation plants which do not have coolers. With the use of superphosphoric acid it is possible to produce high-analysis grades of low moisture content. Since the superphosphoric acid has essentially a negative moisture, its introduction into the formulation has the effect of lowering the moisture content of the product. Usually the product from the granulator has a higher temperature because of the high heat of neutralization of the superphosphoric acid by ammonia. With this high discharge temperature from the granulator, the temperature difference through the cooler is enhanced with the result that there is a high moisture removal by the cooler. With the use of superphosphoric acid in the small granulation plant it is possible to produce high-analysis grades such as 15-15-15, 6-24-24, 12-24-12, and 8-32-16. When superphosphoric acid is used, it is usually sprayed or dribbled on top of the bed in the ammoniator-granulator.

The investment cost of a small granulation plant which could use superphosphoric acid would be about $150,000 which is about one-sixth the cost of the conventional ammoniation-granulation plant which has a large granulator and a cooler. The use of superphosphoric acid in small granulation plants may be of particular value to some foreign countries because:

1. Low investment costs of granulation plant.

2. High-analysis grades of low moisture content and excellent handling characteristics can be produced.

3. Because of the high P_2O_5 concentration of the superphosphoric acid, there should be some economic saving in transporting superphosphoric acid instead of other phosphatic materials.

Many companies have constructed conventional ammoniation-granulation plants. Figure 3 is a sketch of a conventional ammoniation-granulation plant. In this plant superphosphate, potassium chloride, and other solid materials are measured continuously by belt feeders, screened to remove oversize, and discharged into the ammoniator-granulator. The oversize from the screen is crushed and rescreened. Nitrogen solution, anhydrous ammonia, sulfuric acid, and phosphoric acid are metered continuously by means of meters into the ammoniator-granulator through drilled-pipe or block distributors. After granulation takes place, the product is dried in a rotary dryer. The product from the dryer is cooled in a rotary cooler. The cooled product is screened to separate product size from oversize and fines. The oversize is crushed and rescreened for product-size removal. The fines are recycled to the recycle bin and thence to the ammoniator-granulator.

This type of plant is also used by many basic producers to produce granular triple superphosphate. Run-of-pile triple superphosphate is first produced in a cone mixer and cured as usual. The cured triple superphosphate is conveyed to the granulation plant where it is granulated with the addition of phosphate rock and phosphoric acid. Usually 75 percent of the product's P_2O_5 is supplied by cured run-of-pile triple superphosphate. Sometimes steam is added during granulation to promote granulation.

The investment cost in a plant of this type is between $600,000 and $1,000,000.

Figure 4 is a sketch of a typical up-to-date continuous ammoniator-granulator. This ammoniator-granulator operates on a continuous basis. It has an oscillating scraper and a new type of distributors that can be rotated for cleaning. The ammoniator-granulators vary in size from 6 by 6 feet to 12 by 24 feet, depending upon their use. For example, a 6- by 6-foot ammoniator-granulator may produce about 25 tons of a low-recycle grade such as 4-12-12 per hour and have a total throuhgput of only about 35 tons per hour. However, a 12- by 24-foot ammoniator-granulator when fully loaded has a throughput capacity of over 200 tons per hour, but it will have a production rate of only about 40 tons per hour when utilized to produce diammonium phosphate due to the high recycle rate required. The oscillating scraper keeps the material from building upon the walls of the ammoniator-granulator. As it oscillates backward and forward, its teeth dig away the buildup from the walls. The drilled pipe-type ammonia distributor and the acid distributor are below the bed of the material in the ammoniator-granulator. The ammonia distributor has holes that are 1/16 of an inch to 1/8 of an inch in diameter and are spaced on 1-inch centers. The acid distributor is also a drilled pipe. They should be located in the deepest sector of the bed. The center of the bed is relatively inactive and, therefore, is not suitable for the location of the distributors. They should be buried to about three-fourths of the bed depth. For inst ance, if the bed depth is 18 inches, the center line of the distributors should be about 13.5 inches below the surface of the bed or about 4.5 inches from the ammoniator-granulator shell. The holes of the ammonia distributor are oriented so that they face the oncoming material. The holes in the acid distributors are pointed upward.

Most of the ammoniator-granulators are constructed of mild steel. Many have Hastelloy or stainless steel distributor pipes. Most operators have found that the extra cost of stainless steel or Hastelloy is worth the investment. They report that there is considerably less wear of the holes if one of these materials is used. Therefore, the distribution of ammonia and acid remains uniform in the bed of the material in the ammoniator-granulator for longer periods of time. This uniform distribution in turn causes the ammonia loss to be minimized and the granulation efficiency to be good. These operators report that the holes in mild steel distributors quickly become enlarged so that there are wet spots in the ammoniator-granulator that cause overgranulation and high ammonia losses.

Recent observations indicate that many operators are removing the retaining ring inside the ammoniator-granulator, and this eliminates the granulation section. Operators who have removed this ring have found that its removal does not affect their granulation efficiency. They have found also that they can lengthen their distributors and that the longer distributors are better for the production of high-nitrogen grades. Nitrogen losses and the difficulties encountered with overgranulation of the higher nitrogen grades such as 13-13-13 are minimized.

There are several new devices in use that are designed to prevent the caking of material on the walls of the ammoniator-granulator. Some companies use rubber-lined ammoniator-granulators to prevent this caking. Figure 5 is a sketch of this type of ammoniator-granulator. Strips of rubber about 3 feet wide are bolted to the walls of the ammoniator-granulator and are held in position with metal strips. As the ammoniator-granulator rotates, the rubber lining flexes and thus causes any buildup on the rubber to fall off. Other companies are now using ammoniator-granulators that have rubber flaps inside. Figure 6 is a sketch of an ammoniator-granulator of this type. These flaps are usually made of 24-inch rubber belting, and they are installed so that the belts overlap each other when they are laid on the walls of the ammoniator-granulator. As the ammoniator-granulator revolves, the loose ends of the flaps drop. Any material that collects on them will drop off, and the flaps will remain relatively clean. Other plant operators prefer to use an oscillating scraper rather than a lining to prevent this caking of material on the walls of the ammoniator-granulator. Figure 7 is a sketch showing a scraper of this type. The scraper oscillates back and forth across the walls of the ammoniator-granulator, and its teeth dig the caked material away from the walls. This type of scraper tends to wear less than a stationary scraper bar. At TVA we have recently installed a spiral scraper in one of our new ammoniator-granulators. Figure 8 is a sketch showing a scraper of this type. This scraper is similar to a German design. It is driven by an electric motor through a speed reducer. As it revolves slowly, its teeth dig away the caked material from the walls of the ammoniator-granulator. Many operators still use mechanical knockers to remove buildup from the walls of the ammoniator-granulator.

Recently a company applied for a patent for a unique method of cleaning and positioning their distributors in the ammoniator-granulator. Figure 9 is a sketch illustrating this device. Many operators have reported difficulty with buildup and with the positioning of the distributors normally used in the ammoniator-granulator. This mechanism will rotate the distributors out of the bed of material in the ammoniator-granulator so that they can be cleaned without shutting down the equipment. It also provides a means of adjusting the position of the distributors for optimum efficiency while the ammoniator-granulator is in operation. The rotating mechanism consists of an electric motor that drives a chain that causes the distributors to be rotated clockwise or counterclockwise. A brake drum is installed on one end of the distributor-support bar, and this drum is used to lock the distributor at a desired position.

Many manufacturers with the larger granulation plants are now installing preneutralizers and scrubbers so that they can use large quantities of phosphoric acid and ammonia to produce diammonium phosphate grades. Most of these companies are using the TVA process for the production of diammonium phosphate grades. Figure 10 is a flow diagram of this process. This is the same process that is being used by most basic producers of diammonium phosphate. Some of these basic producers have plants that produce as much as 1,200 tons of diammonium phosphate per day. The process involves the partial ammoniation of phosphoric acid in a preneutralizer and the complete ammoniation of the resulting slurry to diammonium phosphate in the ammoniator-granulator. The phosphoric acid is ammoniated in the preneutralizer to an ammonia-to-H_3PO_4 mole ratio of 1.4 to 1.5. At this mole ratio there is a maximum solubility of the ammonium phosphate. Therefore, it is possible to make a concentrated slurry in the preneutralizer which has satisfactory fluidity for proper distribution in the ammoniator-granulator. Completing the ammoniation of this slurry to diammonium phosphate in the ammoniator-granulator decreases the solubility of the salts, and this in turn results in a relatively low liquid phase in the ammoniator-granulator. These conditions are conducive to low recycle rates and high production rates.

Many manufacturers have found that by converting their conventional granulation plant to this process they can use over 900 pounds of phosphoric acid per ton of product. This quantity is far in excess of the 200 pounds of phosphoric acid per ton of product that is usually considered about the maximum in the conventional plant. When this process is used, a high degree of ammoniation of the phosphoric acid can be used--9.6 pounds of ammonia per unit of P_2O_5. This degree of ammoniation of phosphoric acid is 33 percent higher than the normal rate of 7.2 pounds of ammonia per unit of P_2O_5 used in a conventional plant with an ammoniator-granulator. Because of this high degree of ammoniation the economics of producing fertilizers in conventional granulation plants can be improved.

The process illustrated in Figure 10 can be altered to permit the production of granular nitric phosphate fertilizers. This alteration is made by utilizing a reaction tank in addition to the preneutralizer. Nitric phosphates can then be produced by reacting phosphate rock with nitric acid or with a mixture of nitric acid and sulfuric or phosphoric acid, followed by partial ammoniation in the preneutralizer and subsequent simultaneous ammoniation and granulation in a TVA continuous ammoniator-granulator. Estimates indicate that the production of nitric phosphates should be more economical than the production of comparable high-analysis nitrogen fertilizers by other processes. Also, in some developing countries where the supply of phosphoric acid may be limited, the process may have other advantages, since less or no phosphoric acid is required. This process as used here at TVA requires about 60 percent of the sulfur required for the diammonium phosphate process.

One of the new methods of marketing granular fertilizers is to market them through bulk-handling stations. Some companies now produce high-analysis grades such as 8-24-24, 10-20-30, 12-24-24, and 20-10-10 by one of the previously mentioned processes and market them through bulk-handling stations. They have found that by producing high-analysis grades they decrease their transportation cost, and they can market their products farther from their plants. A typical granulation plant that uses this handling system produces more than 70,000 tons per year.

A typical bulk-handling station is shown in Figure 11. At this station there is a 6-bin storage building. Each bin is about 12 feet wide and 30 feet long and holds about 75 tons. The total capacity of the bins, therefore, is about 450 tons for all grades. These bins are usually used to store triple superphosphate, ammonium nitrate, potash, and three manufactured mixed fertilizer grades. The mixed grades are usually transported from the manufacturing plant to the bulk-handling station by hopper-bottom railroad cars. A belt conveyor that fits under a hopper-bottom car is used to unload all materials. This belt conveyor empties onto a portable-conveyor that conveys the material to each of the storage bins. Materials are removed from the storage bins by means of a front-end loader. They are weighed in a scale hopper that is mounted above an inclined portable belt conveyor that empties into the bulk truck.

Other types of bulk-handling stations use elevated storage tanks. Figure 12 is a sketch of a typical station of this type. Such a station usually has six tanks, each of which holds about 50 tons. Materials are removed from the railway car by a belt conveyor and are elevated to the storage tanks. The materials from the storage tanks are weighed in a hopper scale that discharges into the same elevator that is used to load the tanks. The material is then discharged by the elevator into a bulk truck.

Cost studies indicate that a bulk-handling station of this type can be constructed for a cost between $10,000 and $15,000. Cost studies indicate also that the high-analysis grades such as 10-20-30 can be manufactured in a granulation plant and marketed through bulk-handling stations at costs that are competitive with the cost of bulk blending. If a granulation plant with a bulk-handling system is to be competitive, it is imperative that the total movement from the granulation plant be high. Previous cost studies have shown that a granulation plant operating in conjunction with bulk-handling stations cannot be competitive with bulk blending when only 30,000 tons of material per year is moved through these stations. Other calculations indicate, however, that with a 70,000-ton movement the economics of this production and marketing system may very closely approximate those of bulk blending.

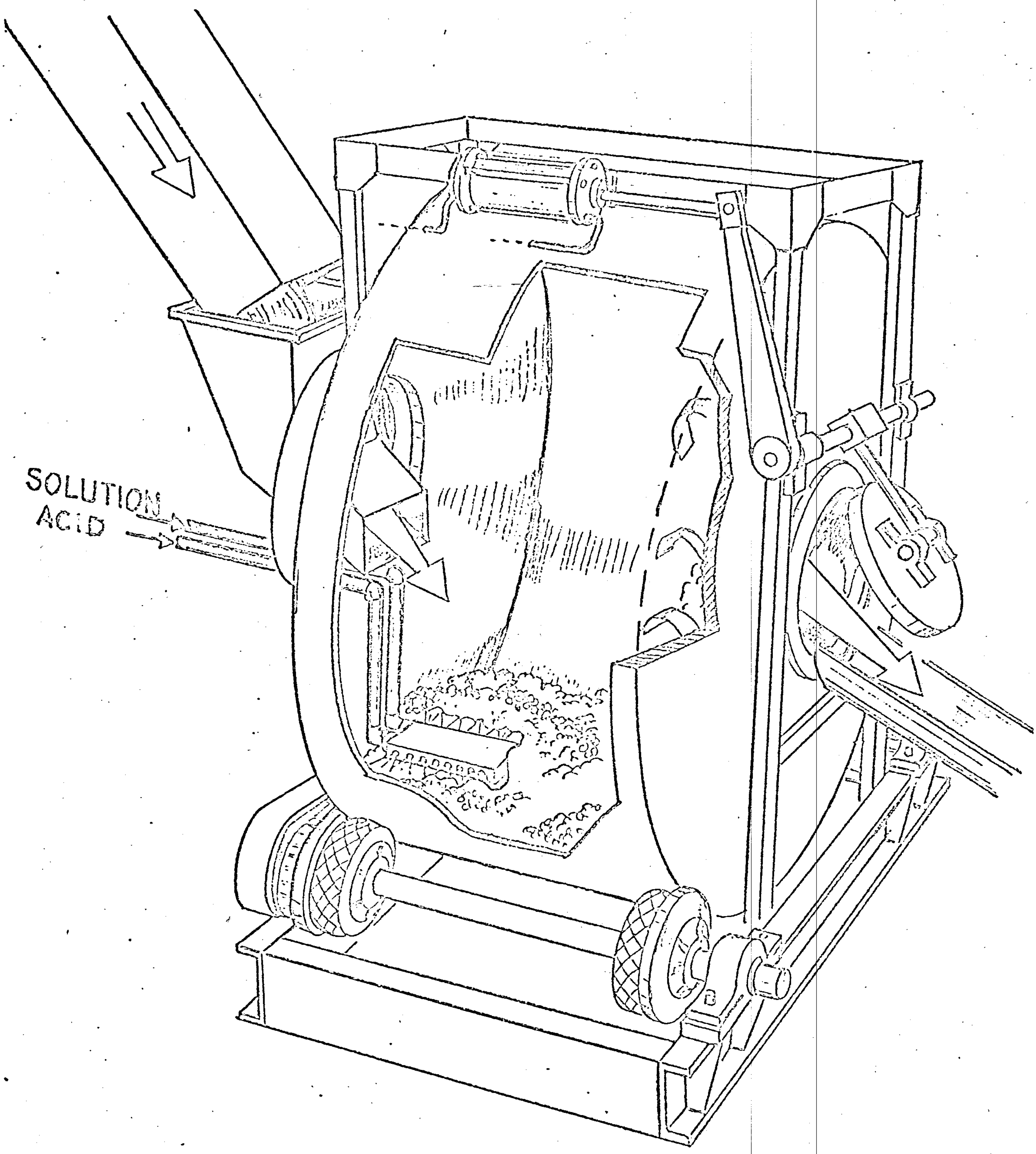

FIG. 1
BATCH GRANULATOR

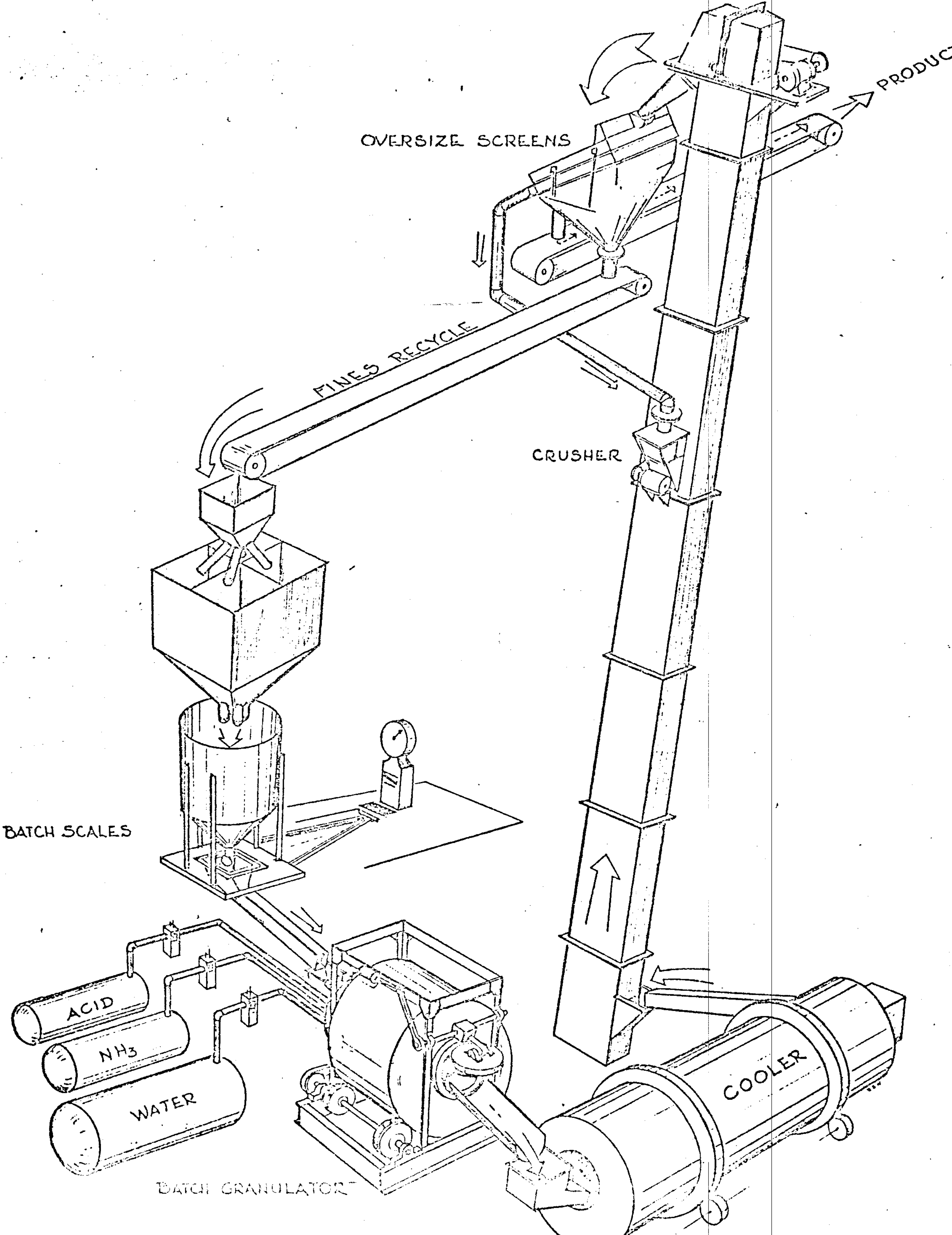

FIG. 2
FLOW DIAGRAM — BATCH GRANULATION PLANT

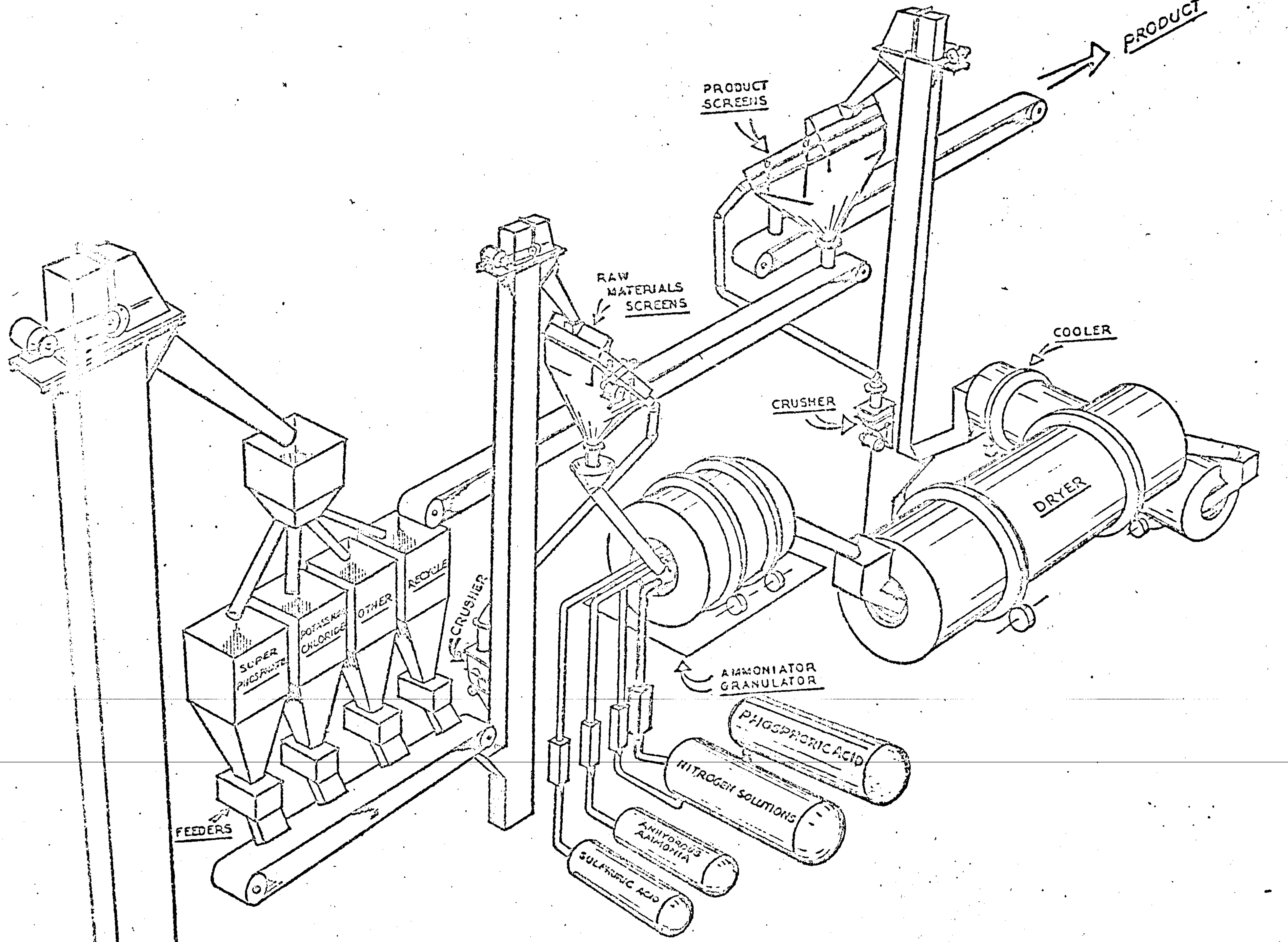

FIGURE #3
TYPICAL GRANULAR FERTILIZER PLANT

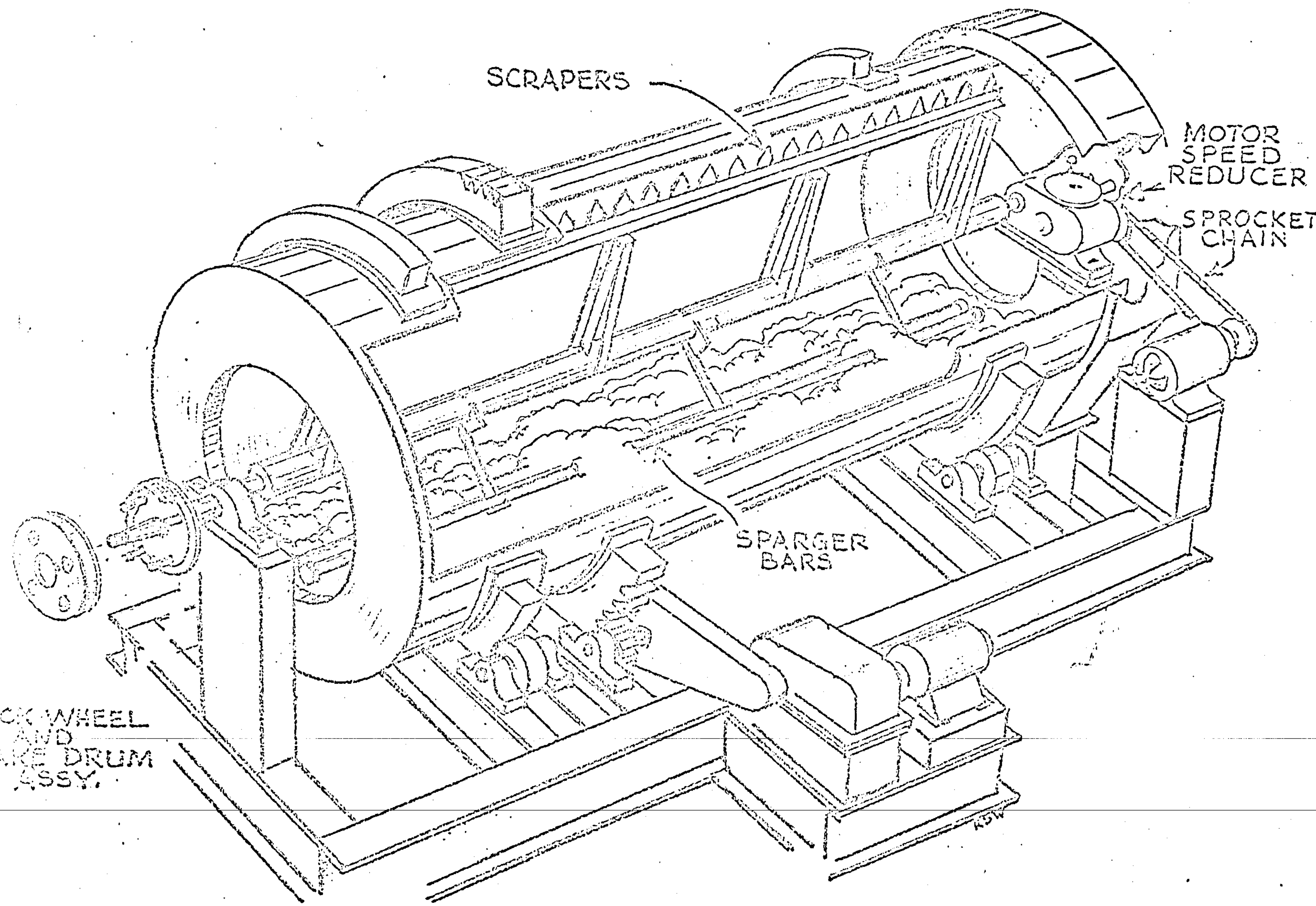

FIG. 34

CONTINUOUS AMMONIATOR-GRANULATOR

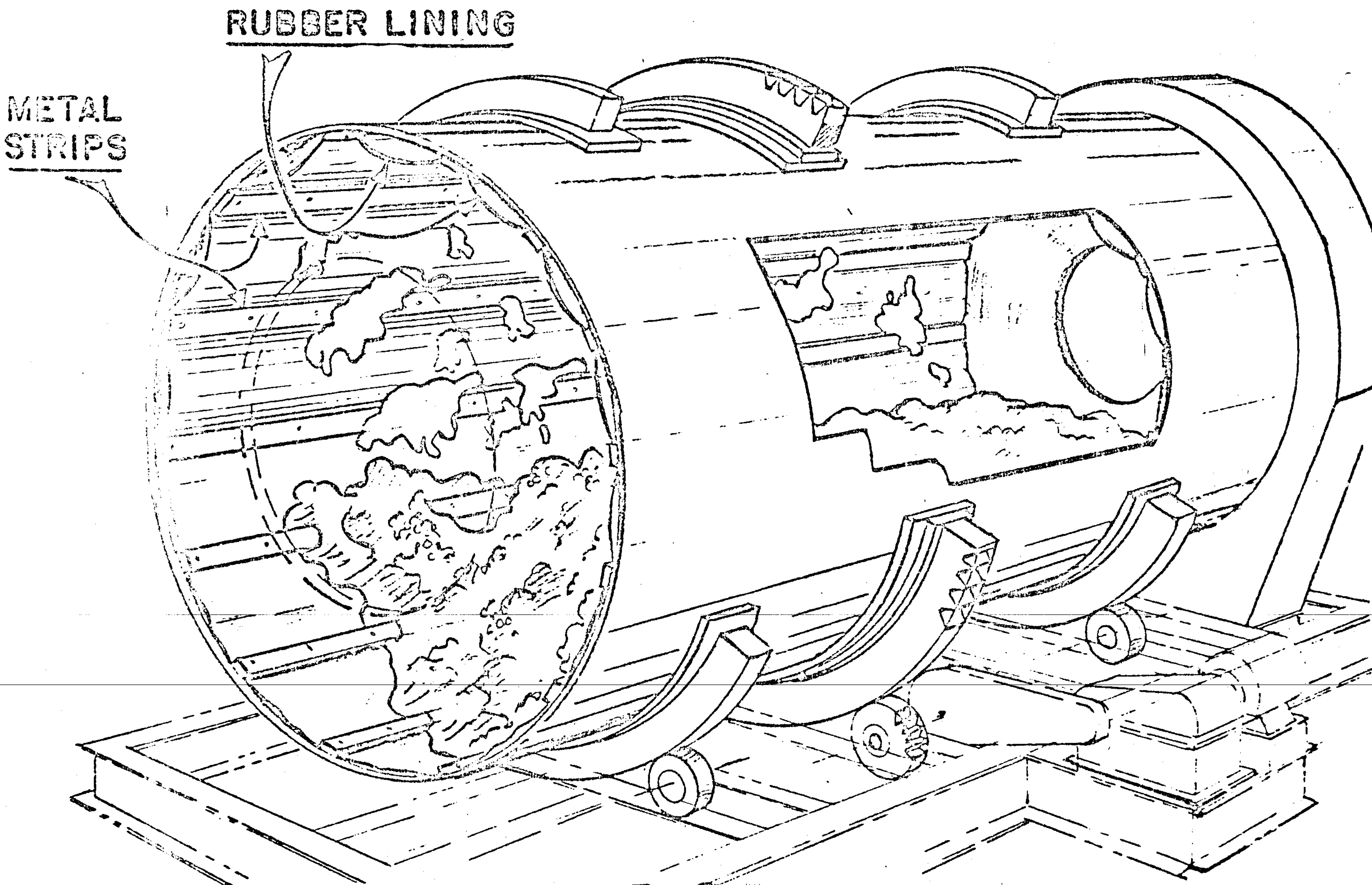

FIG. 2 5

A RUBBER LINED AMMONIATOR GRANULATOR

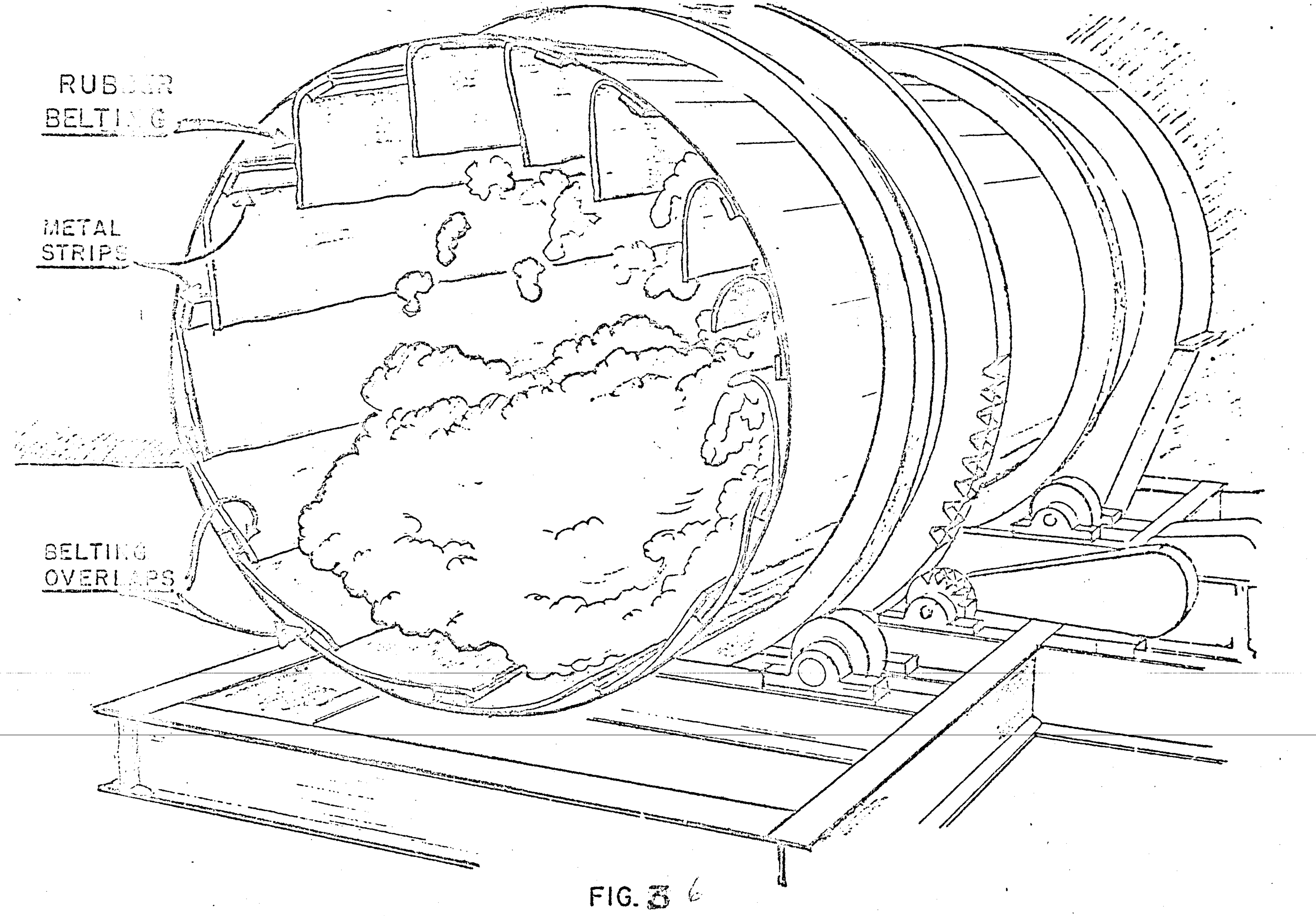

FIG. 3 6

AMMONIATOR GRANULATOR LINED WITH RUBBER BELTING

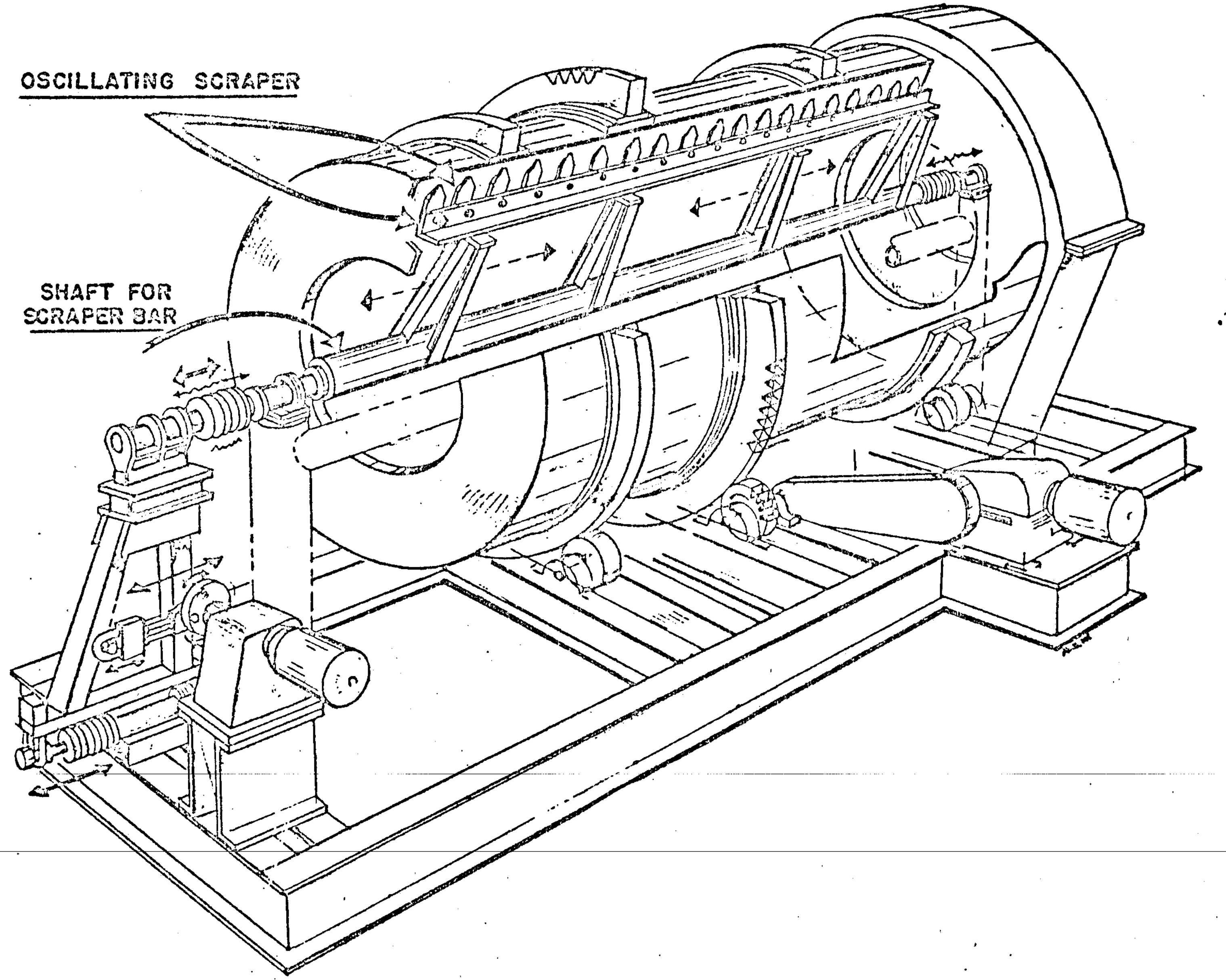

FIG. 3 7
AMMONIATOR GRANULATOR WITH OSCILLATING SCRAPER

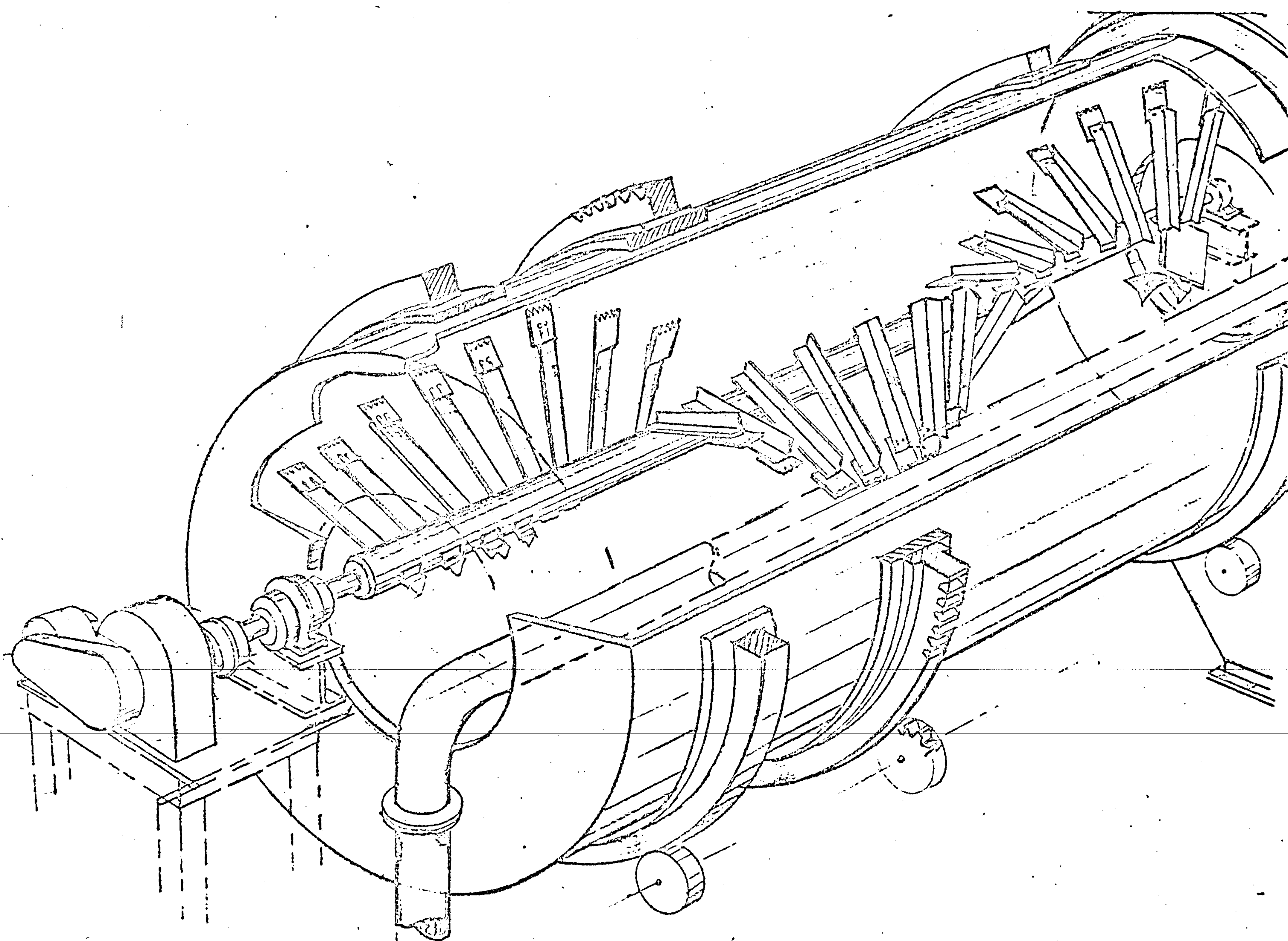

FIG.5 8

AMMONIATOR GRANULATOR WITH SPIRIAL TYPE SCRAPER

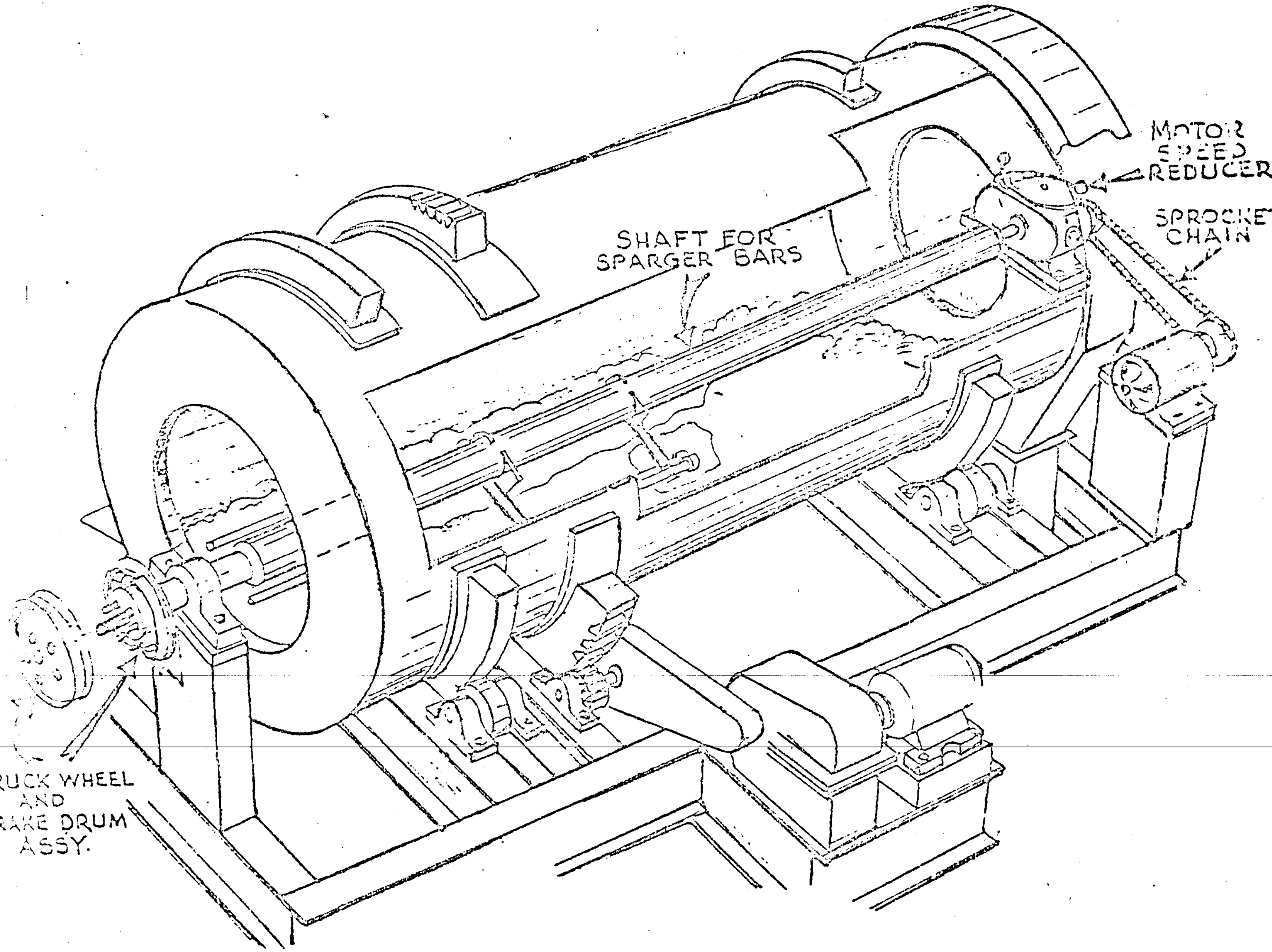

FIG.6 ?

AMONIATOR GRANULATOR WITH ROTATING SPARGER BARS.

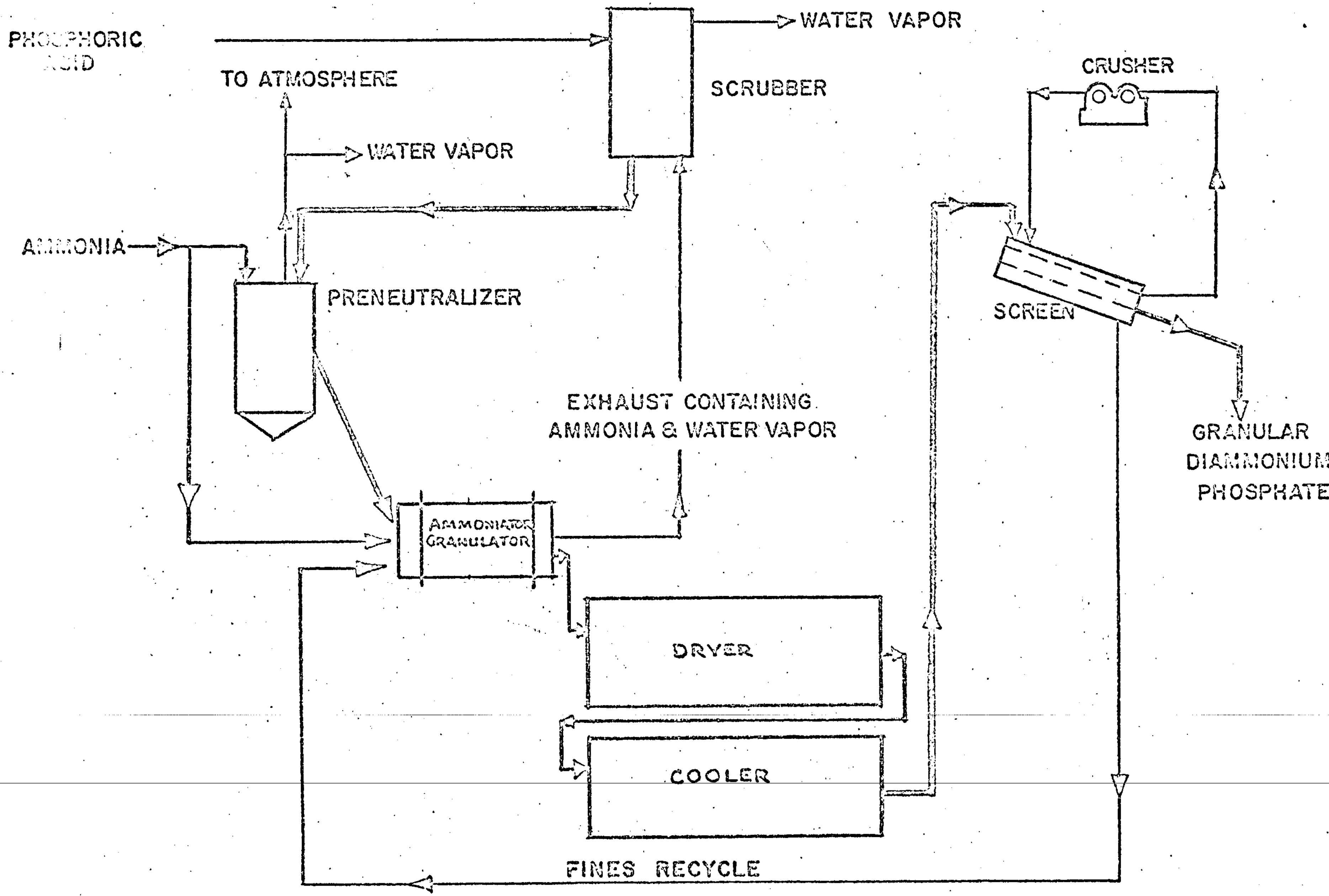

FIG. 6 10

FLOW SHEET OF TVA PROCESS FOR PRODUCTION OF GRANULAR DIAMMONIUM PHOSPHATE

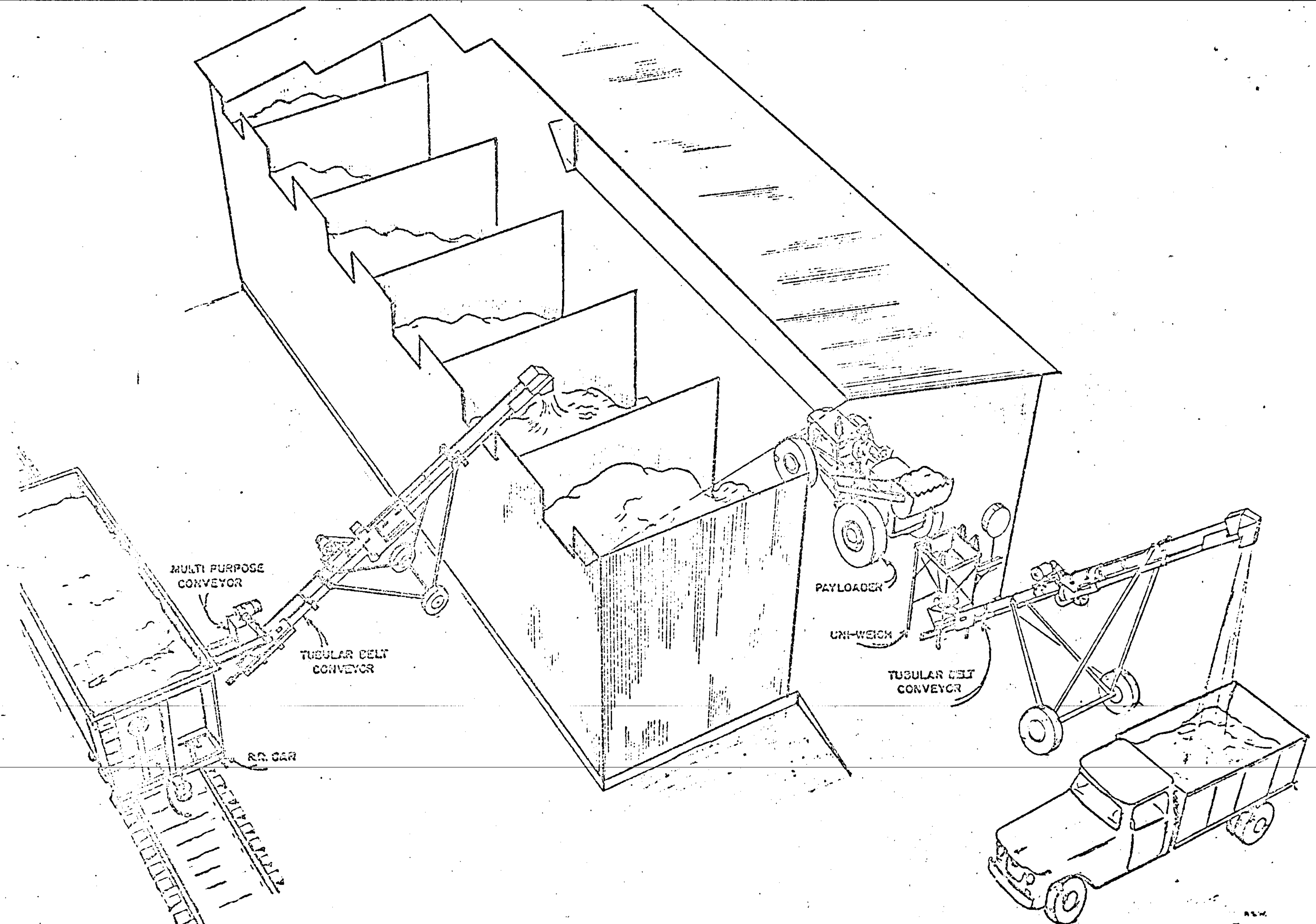

FIG. 11
GROUND STORAGE BULK HANDLING STATION

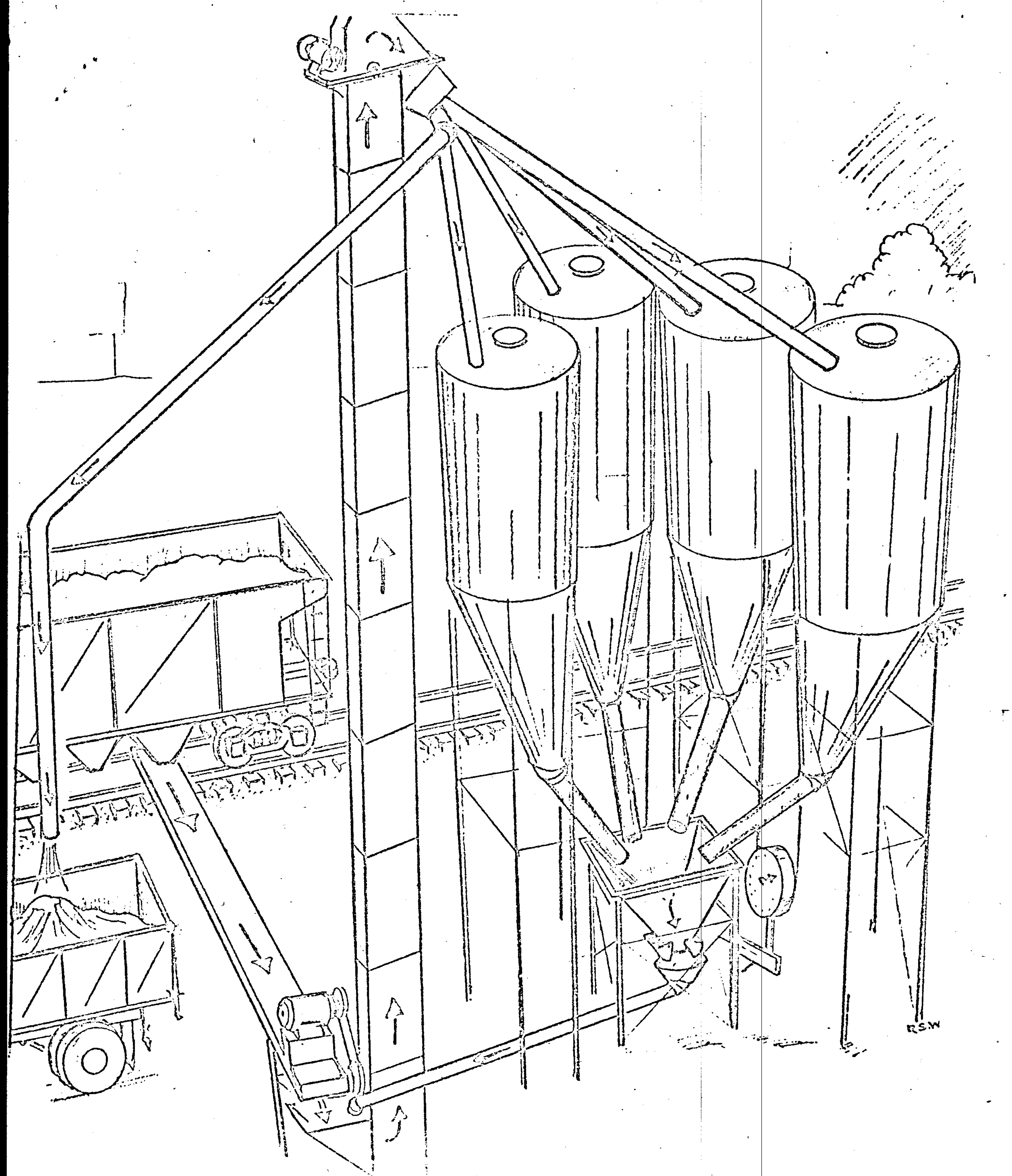

FIG.

BULK HANDLING STATION WITH ELEVATED STORAGE