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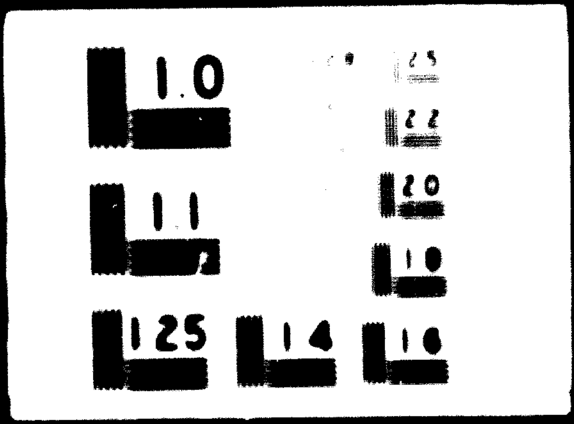

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Second Interregional Fertilizer Symposium

Kiev, USSR, 21 September - 1 October 1971
New Delhi, India, 2 - 13 October 1971

Agenda item IV/7

PRODUCTION OF COMPOUND FERTILIZERS FROM INTERMEDIATES IN LOCAL PLANTS[1]

Ronald D. Young

Tennessee Valley Authority
Muscle Shoals USA

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SUMMARY

PRODUCTION OF COMPOUND FERTILIZERS FROM INTERMEDIATES IN LOCAL PLANTS[1]

by

Ronald D. Young
Tennessee Valley Authority
Muscle Shoals USA

Developing countries with moderate to large anticipated needs for fertilisers usually plan large production complexes for nitrogen, phosphate, and complex fertilisers. Such units usually provide the major initial or early step in fertiliser production. Often not enough attention is given to the types of final fertilisers that may be best suited for use in the country and desired by farmers. There is a growing trend toward greater usage of compound fertilisers that contain all or most of the needed plant food components. This trend is pronounced in most countries with longer experience in production and use of fertilisers and is becoming more apparent in less-developed countries. This trend in preference and usage patterns has resulted in the need for a greater variety of finished fertilisers to provide the primary nutrients as well as some secondary and micronutrients.

Large complexes properly located are well suited to economical and efficient production of nitrogen products such as ammonia, urea, and ammonium nitrate. Likewise, phosphate materials such as phosphoric acid and superphosphates, as well as complex fertilise[rs] of limited grades of ammonium phosphate and nitric phosphate types, are adaptable. Howev[er,] the products that can be readily produced may not be particularly suited as the final fertilisers. Compromises often are made in attempts to produce a variety of finished

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grades in costly and complex facilities actually suitable for only a few grades. Or worse, the mistake may be made of assuming that the large quantities of certain fertilizer materials that can be readily produced somehow will be bought and used by farmers. In short, adequate advance market survey and market development work often are not done.

It seems that sufficient attention frequently has not been directed to local plants of smaller size using fertilizer intermediates. The prospects for such plants in developing and developed countries are discussed, potential advantages outlined, and present patterns of successful use in some countries are described. Production units of this type have provided the main pattern for preparation of the finished fertilizers in the U. S. and some other countries. Small plants located near primary market areas for fertilizers have maximum flexibility for conveniently producing types and grades of compound fertilizers actually needed or desired by farmers. Production can be essentially on a prescription basis to include also secondary and micronutrients. Investment in final production facilities is low, operation can be seasonal without severe economic impact, and ownership can be local with obvious advantages in marketing.

Typical operating practices of such local plants for granular compound fertilisers, for bulk blends, and for liquid mixed fertilizers are reviewed in the paper. Types of intermediates used, grades of fertilizers that can be produced, and integration with production of the main intermediates in a suitably located complex are discussed. Facilities for economical transport of intermediates within a country are a very important consideration. General economics of the total production and marketing system of this pattern are outlined.

CONTENTS

1. INTRODUCTION

1. In recent years, there has been a trend toward installation of very large plants for manufacture of fertilizer intermediates and finished products. Plants have been built throughout the world with production capacities of 1000 to 1500 tons per day of ammonia, urea, ammonium phosphates, nitric phosphates, and the like. Often huge production complexes are built at locations to take advantage of nearness to key raw materials or where low-cost methods of transportation can be used. These complexes may include several large individual plant units together with the necessary auxiliary and support facilities. Investment at a given site may range from 5 or 10 million dollars to more than 100 million. The economy of scale afforded in such units is well established, and the large units making use of the advanced technology of the past few years have greatly lowered the production cost of key fertilizer intermediates and some finished complex fertilizers. The progress in scale, in process technology, and in efficiency and basic economics could well be called spectacular. In contrast, the progress has been less than spectacular in finding out what fertilisers the farmer needs and making them available to him economically.

2. There is a growing trend toward greater usage of compound fertilisers that contain all or most of the needed plant food components. This trend is pronounced in most countries with longer experience in production and use of fertilisers and is becoming more popular in less-developed countries. The trend in preference and usage patterns has resulted in the need for a

greater variety of finished fertilizers to provide the primary nutrients as well as needed secondary and micronutrients.

3. A system whereby the finished fertilizers are prepared in local plants of smaller size offers several advantages. Such a system has been evolving in the United States and some other countries. This system is characterized by (1) production of fertilizer intermediates in large plant complexes located near the source of primary raw materials or where their delivered cost is low, (2) transportation of the intermediates in concentrated form to points near various market areas, and (3) preparation of the final variety of fertilizers in small inexpensive local plants that may combine the functions of manufacturing and retailing. The growth of bulk blending and of liquid fertilizer production to capture a large part of the United States fertilizer market have offered prime examples of this system. Prior to their advent, the production of granular compound fertilizers in plants of small to medium size had followed this general pattern (at least on a regional basis) and this is still being practiced rather widely.

4. The intent of this paper is to review some of the practices in production of compound fertilizers in local plants. It will cover production of granular homogeneous fertilizers, bulk blends, and liquid mixes. Some primary advantages will be pointed out, and the general economics for this system will be evaluated. This full system is not adaptable in all countries, but the main principles are likely to be important in many situations.

II. ROLE OF THE LARGE PRODUCTIONS COMPLEX

5. A large production complex can be a logical starting point in initiating major fertilizer production in a developing country. These complexes also provide the basis for an economical system in developed countries as well.

Progress that has been made in technology now allows efficient and economical production of ammonia, urea, ammonium nitrate, phosphoric acid, refined potash salts, ammonium phosphates, nitric phosphates, and the like in very large plants. Although finished complex fertilizers can be produced, the large plants are not well suited to the production of a wide variety of grades of N-P-K fertilizers that may also contain secondary and micronutrients. Compromises may be made in attempting to produce a variety of finished grades in costly and complex facilities that are actually suitable for only a few grades. In developing countries in particular, adequate advance market survey and market development work often are not done. Sometimes it seems that the assumption is made that the large quantities of fertilizers that can be readily produced in large complexes somehow will be demanded or used. In most cases the large manufacturing complex seems best suited to production of refined materials or intermediates of high concentration that can be shipped economically to outlying locations near the market areas for production of the finished fertilizers.

6. The very large investment and high fixed operating costs in large production units make it essential to operate them a high percentage of the time at near capacity to ensure the potential economy. An example of the effect of operating time factor on production cost of ammonia in a 1000-ton-per-day plant is shown in the following tabulation.

Operating time factor, %	Cost of producing ammonia,[a] $/metric ton
50	67
60	57
70	48
80	44
90	40
100	38

[a] In developing country from natural gas at $0.20/million Btu and with 10% return on investment.

7. Proper integration of a large complex in the total production and marketing system is essential to ensure full utilization. If production can be geared to supplying intermediates to a number of local plants, the prospects for sustained operation are likely to be much better.

8. Primary problems of the large manufacturing complex include providing storage and shipping equipment for adequate amounts of the various materials to meet seasonal and peak shipping demands. The investment for storage facilities for solid and liquid materials at the complex or at regional storage locations is large. Of equal or greater importance is the problem of providing adequate rail and truck equipment for meeting heavy seasonal demands for shipment. This problem has impact on those involved with transportation services (railroads, etc.) as well as on the manufacturer and shipper. Movement by water, such as in river or coastal barges, allows greater flexibility and usually some economy where this mode of transport is practical.

III. INTERMEDIATES THAT ARE OF IMPORTANCE-- THEIR TRADE AND TRANSPORT

9. Most materials that are referred to as fertilizer intermediates also can be used directly as fertilizers. A fertilizer intermediate, therefore, is properly defined in terms of its pattern of use rather than its intrinsic properties. Production and use of intermediates is not a new practice, although it is expanding both in types of materials and in quantities. Refined potassium chloride is a familiar example of a very versatile intermediate that has been important for a long time. Production of potassium chloride in a variety of suitable forms and its economical handling and

transport throughout the world provide one of the best examples of efficiency and economy. Single superphosphate has been produced and used at local plants for more than 100 years. Triple superphosphate (46% P_2O_5) became the first important transported phosphate intermediate, because the grade is substantially higher than for phosphate rock, economy in shipping costs made shipment over long distances practical. Later the shipment of anhydrous liquid ammonia and various nitrogen solutions became important for use both as intermediates and for direct application. In recent years, phosphoric acid, particularly merchant-grade wet-process acid (52-54% P_2O_5), has been shipped quite widely by rail and truck tanks within countries. And, ocean movement of this acid in large quantities has begun (1).

10. Ammonium phosphates, the most rapidly growing type of fertilizer in the United States during the past 10 years, are shipped widely in domestic and world commerce. The granular monoammonium and diammonium products, such as 11-55-0, 13-52-0, and 18-46-0 grades, are quite suitable finished fertilizers for some uses. They also are ideal as intermediates in bulk blending and find some use in granulation processes. These materials are popular because of excellent physical properties, high analysis, high water solubility, and compatibility with other fertilizer materials. Production of ammonium phosphates in the United States reached about 1.8 million metric tons of P_2O_5 in 1970, which was about 37% of the total supply (2).

11. Powdered or very small granular monoammonium phosphate of about 12-52-0 or 11-55-0 grade is becoming of considerable importance as an intermediate for shipment within countries and may become useful for shipment in international commerce (3, 4). Handling properties in rail and truck shipment should be at least as good as for nongranular superphosphates. It does not require special ships for handling in bulk, and port handling and storage

facilities may be less expensive than for phosphoric acid. Production and use of powdered monoammonium phosphate as an intermediate is the subject of another paper at this symposium. Reportedly, 20 or more plants have been built for production of the nongranular monoammonium phosphate, most of them in Europe.

12. Ammonium sulfate is available in large quantities as a byproduct from the steel and synthetic fiber industries. It has been a useful intermediate in granulation processes for a long time and will continue to be so, although declining in importance on a percentage basis because of its low analysis.

13. Other finished products that also are used as intermediates include prilled or granular urea and ammonium nitrate. Ammonium nitrate is widely used in the bulk blending in the United States, and urea can be used where it is compatible with the other components. There likely will be growing practice in use of solid urea as an intermediate in granulation throughout the world because of the large number of plants being built. World production capacity reached about 12 million metric tons of nitrogen in 1971 (5).

14. Urea - ammonium nitrate solutions can be prepared, stored, and shipped conveniently and economically. These solutions of 28 to 32% N content are widely used as an intermediate in production of liquid fertilizers in the United States, and their use in other countries is increasing. Other possibilities include low-pressure or nonpressure urea-ammonia solutions that could be used in liquids or in granulation processes. Since they are relatively noncorrosive, low-cost materials of construction can be used for storage and shipping containers.

15. There are some particular intermediates that are of key importance in production of liquid mixed fertilizers. The most important of these contain polyphosphates that are essential for good quality liquids of higher grades.

16. Some intermediates have a present role as commodities moved in international commerce and can be used as key feed materials in large manufacturing complexes to decrease investment and simplify total operations. The most important of these are potassium chloride, anhydrous ammonia, and wet-process phosphoric acid. Studies by TVA (6) indicate significant decrease in investment and good comparative overall economics for import of key intermediates by some developing countries instead of raw materials or finished products.

17. All of the intermediates have potential for movement to local plants for preparation of the finished fertilizers. Several of them can be shipped conveniently without specialized equipment. There have been a great many improvements in methods of transportation and there will be further improvements in the future. Anhydrous ammonia is now transported overseas in specially built ships, through inland waterways and along coastal areas in barges, and overland by pipeline. Liquid fertilizers are now being moved to some extent by pipeline, and we may expect to see other fertilizer materials moved in this logical and convenient manner in the future. The major pipelines also provide substantial storage. Some stretches of pipeline will hold the equivalent of [illegible] months' production from two 1000-ton-per-day ammonia plants. Railroad rolling stock has been improved in size and in design for certain uses. Cars of 100 tons and larger now are common in the United States. Covered hopper-bottom cars are used for solid materials, and heated and insulated tank cars have been developed for hauling superphosphoric acid, elemental phosphorus, and molten sulfur. Entire trainloads ("unit trains") of a single material can be shipped at a substantial saving when there is sufficient volume to warrant this practice. Highway tank vehicles provided with pneumatic loading and unloading are becoming popular for handling some

[illegible] and [illegible]ding of barges, ships and rail cars [illegible] and [illegible].

18. Although most industrialized countries should find little difficulty in moving most intermediates with existing or moderately improved transportation systems, developing countries likely will find considerable restraint until in-country transport systems are more fully developed. Handling of the intermediates in bulk is almost essential for economy, but there may be prospects for moving some solid intermediates in bags if the bags could be reused.

IV. USE OF INTERMEDIATES IN LOCAL GRANULATION PLANTS

19. Use of intermediates in local plants for production of solid compound fertilizers started early in the United States and Europe with use of potash, calcium cyanamide, sodium nitrate, guano or other solid nitrogen materials, and single superphosphate to produce low-grade pulverized mixtures. Ammoniating solutions came on the scene later and gave more versatility in fixing lower cost nitrogen. Ammonium sulfate became available as supplemental nitrogen. With the advent of granulation in the United States in the early 1950's, use of intermediates became more important. Granulation had started as early as the mid-1930's in Europe and was quite popular in 1950 in some countries. Anhydrous ammonia became more economical and practical to transport in the United States. Nitrogen solutions containing free ammonia were used to ammoniate locally produced single superphosphate and shipped-in triple superphosphate that became an important intermediate for upgrading phosphate content. Higher analysis granular products with better handling, storage, and application properties were produced. Sulfuric acid was used

to promote granulation and allow greater fixing of ammonia, and later wet-process phosphoric acid came into [illegible] it was [illegible] as an intermediate to provide higher analysis grades with higher water solubility.

__Equipment and Operating Technique__

20. In the United States, the TVA ammoniation-granulation equipment (rotary cylinder or drum) and process that originated in 1953 were widely adopted. In 1962 there were 164 plants in the United States known to be using this process, and 200 or more local and regional granulation plants of this type were estimated to be in operation by the mid-1960's (7, 8). The rotary drum-type granulation equipment is by far the most widely used because of its versatility in combining mixing, ammoniation or other chemical reactions, and granulation in a single unit. Other types of granulators including pug mills, spray drums, and inclined pan granulators are used to a lesser extent.

21. The ammonium phosphate "boom" in the middle 1960's (9) and growth of bulk blending and liquid fertilizer production slowed the growth in local granulation plants, and they seemed to decline in importance. A present estimate indicates that only about five plants are now being built each year in the United States. Some of these are replacing obsolete facilities. Some granulation plants have been converted to bulk blending and others have been abandoned. No reliable estimate of the number of plants operating in 1970-71 was available.

22. Although they may have declined to some extent in relative importance, these plants of small-to-moderate production capacity still have an effective place in the production and marketing system. They have several advantages including those listed below.

- A variety of N-P-K grades of various ratios can be produced with economical formulations using intermediates. Secondary and micronutrients can be added to produce special grades.
- Recycle ratios usually are low and grades can be changed more easily than in large complex plants. Storage of a large number of grades is more practical.
- Investment in basic production facilities is comparatively low, and fewer costly auxiliary and support facilities are required than for a large complex.
- Operation can be seasonal if desired with use of a small crew of local operating personnel that do not require a high level of training. These people also provide a large part of the routine maintenance and repairs.
- Ownership can be local with obvious advantages in marketing of products due to personal acquaintance with customers and their preferences.

23. Some typical formulations for several grades of granular fertilisers that can be readily produced in local granulation plants are shown in the following tabulation.

Grade	10-10-10	12-12-12	5-20-20	6-24-24	10-20-10
Raw Material	(Kgs./metric ton)				
Ammonia	-	-	63	25	-
N solution, 44.8% N[a]	180	204	-	48	277
Ammonium sulfate, 20.5% N	98	147	-	-	-
Diammonium phosphate (18-46-0)	-	-	-	106	-
Single superphosphate, 20%	510	254	158	-	280
Triple superphosphate, 46%	-	156	377	425	324
Potassium chloride, 60% K_2O	167	200	334	400	167
Sulfuric acid, 93% H_2SO_4	49	70	64	-	38
Filler or conditioner	56	-	-	-	-
Steam	-	-	-	75	-

[a] 25% NH_3, 69% ammonium nitrate, 6% H_2O.

24. A schematic diagram of a typical local granulation plant of the type used in the United States is shown in Figure 1.

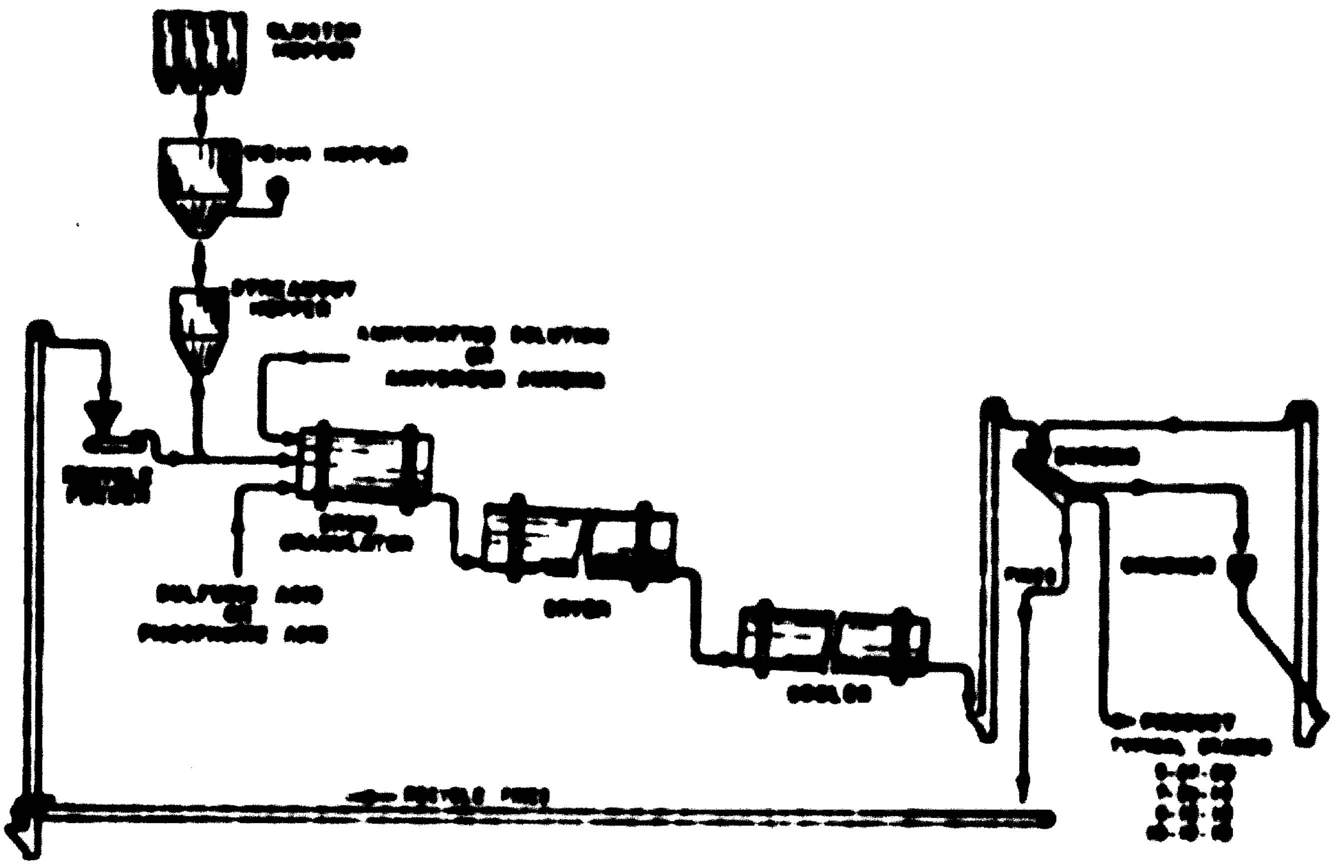


FIGURE 1
TYPICAL LOCAL GRANULATION PLANT
USED IN UNITED STATES

Such plants include storage bins for several solid intermediate materials and tanks for ammonia, nitrogen solution, and acids. In most plants, the solid materials are batch weighed in the proportions required in the formulation and fed collectively at a fairly steady rate to the ammoniator-granulator. Other plants use individual gravimetric feeders for the solid components. Ammonia or nitrogen solution and sulfuric acid are sparged beneath the bed in the rotary drum. When phosphoric acid is used, it is sprayed onto the bed in the granulator. Magnetic flowmeters and automatic potash salts are commonly used [illegible] controlling the rate of feed of the liquids. The formulations are designed to provide the proper balance of heat, moisture, and total fluid phase to allow good granulation. They are balanced to ammoniate properly and to produce the desired grade. In the United States, ammoniation is a key procedure in [illegible] formulation and in providing heat for granulation.

25. Material from the granulator flows into a direct fuel-fired rotary dryer and then into a rotary countercurrent cooler. The cooled material is screened to separate the desired product size (usually about -6 +12 mesh), oversize is crushed, and undersize is recycled to the granulator. The amount of recycle usually is only that portion obtained as fines from the screening operation. The product may be treated with a surface conditioner to minimize caking. Products usually are stored in bulk prior to bagging and shipment.

26. There are some variations in equipment and operating technique such as elimination of the dryer by use of special and limited formulations that granulate at low moisture content.

27. Granulation plants usually produce from 10 to 30 tons per hour. Recycle ratio usually is 1:1 or less allowing smaller size process and conveying equipment than in plants producing complex granular fertilizers where recycle ratios are likely to be 6:1 or higher. They are comparatively simple and flexible in operation. Starting up and shutting down operations are not particularly difficult, and grades can be changed frequently without great difficulty. Investment cost in the United States ranges from about $500,000 to $1,000,000, although very simple plants reportedly have been built for less.

28. In the early y[illegible] [illegible] In the United States, essentially all of the output was bagged for shipment. After bulk blending became popular, bulk handling of granular fertilizers directly from the granulation plant in spreader trucks and "[illegible]" became fairly important. At present, this practice is quite common in the southeastern, lower Atlantic coast, and southwestern parts of the United States. Some plants report moving 50 to 70% of their production in bulk. This practice was an apparent effort to incorporate some of the advantages and economy of bulk blending in moving granular fertilizers to customers.

Pollution Problems

29. One of the biggest problems at present facing local granulation plants is meeting required regulations to avoid atmospheric and stream pollution. The earlier plants were usually located in rural or suburban areas, but neighborhoods eventually grew up nearby. Dust and fume removal from stack effluents became more important to control, and the need to avoid dumping liquid wastes into streams increased. With present increase interest in environmental factors, good control of all effluents is becoming essential. Addition of scrubbers to existing plants is costly and difficult, return of liquid effluents to the process may be impractical, and technical personnel may not be available to fully plan for and deal with these problems.

30. Pollution problems have resulted in some plants being shut down and production consolidated at other more favorable locations. Some changes in formulation and in operating technique can greatly decrease dust and fume problems. TVA and industry have shown that use of furnace or wet-process superphosphoric acid ([illegible] % P_2O_5) in formulation ([illegible] kg./metric ton of product) greatly decreases fume and dust ([illegible], 11). Fuming is less because

ammonium chloride [illegible] is not formed with this acid. When sulfuric acid is used, it reacts with potassium [illegible] in the [illegible] to produce troublesome fumes. Drying is decreased or eliminated, and this decreases both dust and fumes. The granules are harder and less subject to surface degradation to form dust. Cost of the more expensive superphosphoric acid appears to be justified in some situations. In a later section a granulation scheme, using mostly lower cost solid intermediates, that greatly decreases fume and dust problems is described.

31. Engineering firms and equipment manufacturers are devising simpler and more effective dust and fume control equipment, so prospects for effectively dealing with environmental problems are improving. Use of selective intermediates in local granulation plants could shift the major responsibilities for pollution problems to the large complex where investments in capital and engineering personnel can be better afforded.

Changes in Formulation Practices and Favorable Patterns

32. The early granulation plants had a primary economic advantage in producing low-cost single superphosphate in simple facilities at the plant site and using this component to the maximum extent practical in all grades. In grades such as 10-10-10 (tabulation on page 14), all of the phosphate was derived from the low-cost, locally produced single superphosphate intermediate. As triple superphosphate became available, it was purchased as a shipped-in intermediate to use with single superphosphate to allow higher analysis grades such as [illegible]-12-12 or [illegible]-16-16. Then wet-process phosphoric acid and ammonium phosphates became available to produce still higher analysis and increased water solubility. With use of the higher analysis intermediates, formulation

and operation became to some extent more [illegible]. [illegible] ratios increased and production rates [illegible] decreased.

33. Statistics listing phosphate supply in the United States for 1970-71 are tabulated below (2).

	1970-71	
	1000 metric tons	% of total
Normal and enriched superphosphate	[illegible]50	10.[illegible]
Concentrated superphosphate	1,[illegible]00	24.0
Ammonium phosphate[a]	1[illegible]0	[illegible]7.0
All other[b]	1[illegible]	[illegible]8.[illegible]
Total	[illegible]00[illegible]	

[a] Liquid and solid ammonium phosphates excluding those combined with potash salts in the process of manufacture.

[b] Includes nitric phosphates, sodium phosphate, wet base goods, natural organics, phosphate rock, colloidal phosphate, basic slag, estimates of wet and furnace phosphoric acid for liquid and solid mixed fertilizers and direct application, and ammonium phosphates combined with potash salts in process of manufacture.

These data show that single superphosphate accounted for only 10 to 11% of all phosphate for fertilizer purposes in the United States in 1970-71. This was a substantial decrease from the level of 15% in 1969-70. The extent of the decline is remarkable in light of estimates that showed single superphosphate supplying nearly 70% of all fertilizer phosphates in the United States in 1954. Figures for world production show a decline from about 64% of total P_2O_5 in 1955 to about 35% in 1969 although annual tonnage stayed about the same (12). This percentage decline is the result of much larger amounts of higher analysis phosphate intermediates becoming available.

34. The extreme move away from single superphosphate, particularly in the United States, may not be wise since formulation [illegible] using substitute

intermediates may be increased when prices stabilize. Sulfur present as a secondary nutrient in products is decreased or eliminated, and a comparatively simple granulation operation may become more difficult. It seems that in many cases the existing single superphosphate plants should be used and perhaps construction of others considered in the future. The problem of controlling pollution in local single superphosphate production units is a major factor. Availability of spent sulfuric acid and pollution problems related to its use apparently are other factors affecting the decline in production and use of single superphosphate.

35. For the first several years in the United States and in some other countries, many of the granulation plants were locally owned. These people with substantial personal investment of money, interest, and pride of ownership contributed very significantly. With a greater intimate knowledge of local customers and their whims or needs, marketing on a personal and mutual confidence basis was possible. As larger organizations including major oil companies gained control of these facilities through merger and acquisition some of these advantages appear to have been lost. Recently there is an indication of some moves away from centralization of ownership. The cooperative organizations, although centralized in overall activities, retain some advantages of local ownership and intimate liaison with customers who are actually shareholders. Cooperatives seem to be generally faring quite well, and the practice is growing in other countries. Some large cooperatives have a classical setup of the pattern of production of intermediates in a large complex and shipping them to local plants for producing and marketing the final fertilizers for a fairly well established market.

Local Granulation Practices in Countries Other Than the United States

56. Most of [illegible] and references have been concerned with practice in the United States. Some comments concerning local granulation plant practices in other countries obtained from available references, visits, and personal contacts follow.

57. In continental Europe there has been less practice of local granulation plant operation than in the United States, although several plants of this general type that are at least regional in nature are utilized in France, Germany, and Spain. In other countries, such as The Netherlands, Italy, and Belgium, the local plant concept does not appear to be very prevalent; production of several grades of finished N-P-K fertilizers of complex types in larger centralized plants is more common. Nitric phosphate plants of comparatively large size have been used rather extensively and ammonium phosphate-based systems are now coming into use. In the Scandinavian countries, the production seems to be centered in large facilities producing several grades of fertilizers of complex types by nitric phosphate or ammonium phosphate-based processes.

58. In the United Kingdom, there is substantial practice of the regional or local granulation plant concept although there are large major producers. One of the major producers ships intermediates from large production centers to company-owned regional granulation plants of fairly large capacity for a large part of final fertilizer production. In addition to the usual key intermediates, the shipment, storage, and use of ammonium nitrate solution as an intermediate is a common practice. At present, there is considerable practice by this company of blending granular intermediates in preparation of final varieties of grades in large granulation plants. Equipment is

provided for blending immediately before bagging or bulk loading. Granular intermediates used include ammonium phosphates and ammonium nitrate - potash cogranulated material. Most of the intermediates are produced by the parent company. This practice of blending in a granulation plant for preparation of a variety of finished N-P-K grades and for special grades containing secondary and micronutrients is said to comprise 60 to 70% of production output in some plants. High production rates (30-50 tons/hr.) of different grades are said to be practical, whereas, full granulation would be difficult and low production rates would result for some grades. The writer has seen a list of at least 50 formulations for a variety of grades that can be prepared in this manner to suit local demands.

39. Another of the major producers in the United Kingdom has acquired about 50% interest in several small, previously independent, local granulation plants. These local plants produce a variety of grades using intermediates supplied by the major production facilities of the large affiliate. Advantages in flexibility of producing grades referred to as "specials" are obtained, and local marketing advantages are achieved.

40. A few small independent granulation plants of a particular type seem to be prospering in Great Britain (13). Formulations have been worked out that permit use of substantial amounts of single superphosphate and ammonium sulfate--usually low-cost materials. Low-analysis granular grades, such as 7-7-7 and 6-8-9, are readily produced with routine formulations. The mixtures are upgraded by use of urea and ammonium phosphate as intermediates. The urea may comprise about 25% of the weight of the formulation, and grades of medium-high analysis, such as 14-14-14 and 10-20-10, have been produced.

41. Production in these small plants is usually only 8 to 10 tons per hour which is considered marginal at best in economics. However, they reportedly

have been more successful in recent years than larger, more sophisticated plants. Some have reported substantial profits in a generally depressed fertilizer industry. Because of interest in highest practical water solubility of phosphate (about 90%), ammoniation by use of ammonia or diammonium phosphate in the formulations is restricted to neutralizing any acid fed and the free acid in superphosphate. Heat for granulation sometimes is supplied or supplemented by use of a direct flame in the granulator and by use of steam. TVA has conducted pilot-plant studies of this method of granulation. An impressive feature is the essential absence of fumes from the granulator and dryer. Typical formulations for two grades are given below.

	Kilograms/metric ton of product	
	14-14-14	10-20-10
Ammonium sulfate, 20.5% N	72	-
Urea, 45% N	230	130
Ammonium phosphate (18-46-0)	-	228
Ammonium phosphate (13-52-0)	147	-
Single superphosphate, 20% P_2O_5	320	480
Potassium chloride, 60% K_2O	234	168

42. The Committee of Fertiliser Association of India, at the meeting in December 1969, recommended an all-out effort to use existing single superphosphate plants more effectively. The following detailed recommendation was made.

It is in the national interest that the single superphosphate industry, whose numerous units are dispersed over the country and in which a substantial amount of capital has been invested, should be enabled to hold its own and make a full contribution to the total supply of phosphatic fertiliser in the country. For this purpose the industry should be helped to upgrade its basic products by compounding them with high analysis intermediates and fertilisers such as ammonia, phosphoric acid, monoammonium phosphate, diammonium phosphate, urea, and potash salts. Indigenous research and experience abroad have shown the technical feasibility of producing granulated high analysis compounds based on phosphate. To make such products economically competitive, it is essential that the materials required should be supplied (if necessary, by importing them) to superphosphate manufacturers at bulk rates.

43. Use of locally produced single superphosphate to the fullest extent practical and upgrading by use of urea and ammonium phosphates may be good practice for an interim or longer period in India (14).

44. India has two major farming seasons, "Rabi" (dry or winter season) and "Kharif" (wet or monsoon season). Cropping and tillage practices for the two seasons are different as are those of fertilisation. Also, there are a variety of soil types, different climatic conditions, and likely widely different needs for complete fertilisers. The local granulation plant concept should help meet these specific needs in India if properly implemented. A major necessity for full implementation will be improvement of inland transportation systems and use of coastal barges for handling intermediates in bulk.

45. Doshi gave a good detailed account of the mixed fertiliser industry in India in his book published in 1969 (15). He pointed out that in the late 1960's there was a total of more than 500 mixed fertiliser plants of all types in the private and cooperative sectors. Location of most of the plants did not appear to be related to any overall planning of production or receipt of materials and accessibility to the market. His survey indicated that 66% of the plants produced less than 2,000 tons per year, [illegible]% from 2,000 to

10,000, and only 5% in excess of [illegible],000. He further pointed out that the equipment and processes in the small plants were cut in designing along the lines of practices in the United Kingdom and United States in the late 19th century. He stated that about [illegible]% of the plants used simple manual processes using entirely [illegible] hand methods, [illegible]% a semi-mechanical process, and only about 2% a truly mechanical process. Mr. [illegible] seemed to make a good case for more emphasis in planning for better equipped and more efficient local granulation plants using local single superphosphate and intermediates manufactured in some of the large complexes now being planned, built, or operated. He estimated substantially higher operating costs for production of chemically granulated or mechanically granulated fertilizers over the crude hand-mixing operations. However, taking into account higher analysis and more appropriate grades, better handling, application, etc., he assumed final savings to the farmer and better assurance of good fertilization practices by use of the well-granulated fertilizer. His studies appear to establish a good case for proper application of local compound fertilizer plants in India using indigenous and imported intermediates.

46. Dr. [illegible], in his comprehensive description at the United States Fertilizer Industry Round Table in 1966, of practices in granulation of compound fertilizers in Japan, pointed out many interesting facets (16). He reported that use of straight fertilizers has essentially ceased the past 10 years in Japan and that at least [illegible]% of all fertilizers are now granular compound fertilizers. He indicated production of granular fertilizers totaling above 4.5 million metric tons in 1968. High-analysis grades (35% or more total plant food) have increased markedly since 1960 and now predominate.

47. Materials commonly used include the usual ones--ammonia, ammonium sulfate, single superphosphate, small amounts of triple superphosphate, and potassium chloride. One other special intermediate is ammonium chloride that is used in substantial quantities. Large amounts of phosphoric acid now are being used especially in larger plants to produce fertilizers based on ammonium phosphates. Special controlled-release organic nitrogen materials are being used in mixtures to some extent. Most popular low-analysis grades are 8-8-8 and 8-8-5, but they are declining in importance. Higher analysis grades that are taking over are based on ammonium phosphates, ammonium sulfate, and potassium chloride; popular ones are 14-14-14, 14-10-13, and still higher grades of 16-16-16, 18-18-18, etc., using some urea in the ammonium phosphate formulations. Although a number of plants for complex fertilizers of ammonium phosphate and nitric phosphate types are operated and being built for production of 60,000 to 200,000 tons per year of the higher analysis grades, several small local granulation plants using intermediates still are quite widely used. The smaller plants produce grades such as 8-8-8, 8-8-5, and 6-9-6 using single superphosphate, ammonium sulfate, and potassium chloride. Several producers substitute ammonium chloride for ammonium sulfate and increase grades to 9-9-9, 10-7-9, etc. A step further in higher analysis by use of moderate amounts of urea allows production of grades, such as 10-10-7, 12-8-7, and 10-10-10, by accepting 10 to 30% lower production rates in the comparatively small regional or local granulation plants using recycle ratios of less than 1. It is apparent that, in general, the concept of small-to-medium sized local or regional granulation plants producing a variety of needed grades of final fertilizers is an important part of the total pattern in Japan.

48. Production of granular compound fertilizers is practiced quite widely in several Central and South American countries, such as Colombia, Ecuador, Peru, Brazil, Venezuela, and Costa Rica. Several years ago, the Eirich pan granulator was introduced, and this system proliferated for mechanical granulation with moisture. In modernization programs and new plants, rotary drum-type granulators, in some cases utilizing ammoniation, are being installed. In larger complex plants, the spray drum granulator is used quite extensively.

49. TVA visitors to South American countries on assignments have reported some of the present practices and plans for the future in internal reports.

V. BULK BLENDING

History and Growth

50. A blended fertilizer may be simply described as one consisting of a mechanical mixture of fertilizer materials. Bulk blending as referred to in this paper is defined as a mixing process for granular fertilizers (simple or binary) in small plants, that usually receive their intermediates in bulk and are located very near the point of use of the blended products. The practice of bulk blending of granular fertilizers has grown rapidly in the United States, particularly in the past decade. The first known practice of blending granular fertilizers was at Davison Chemical Company plant near Baltimore, Maryland, in 1936. A few grades were produced in granular form and other varieties were prepared by blending base grades such as 7-7-7 and 0-13-20 (17).

51. The practice of bulk blending as it is known today in the United States is believed to have originated in Illinois. Pulverized phosphate rock for autumn "plowing-in" was distributed in vehicles equipped with limestone spreaders. In the late 1940's, some operators started including potassium

chloride mixed with the phosphate rock; later ammonium sulfate was added to provide N-P-K grades. Four blenders were operating this way in Illinois in 1947. From this crude start with nongranular materials, a practice of blending granular materials that has proliferated spectacularly has developed. The very rapid growth of this practice in the United States is pointed out in Figure 2 that shows the total of bulk-blending plants for years 1959 through 1970 (<u>18</u>).

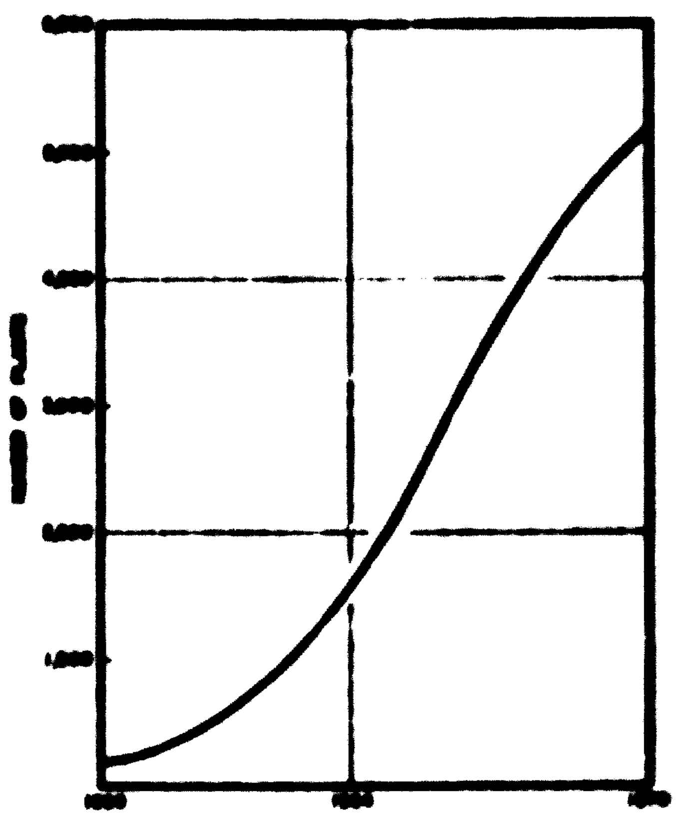


FIGURE 2
ESTIMATED NUMBER OF BULK BLENDING
PLANTS IN UNITED STATES

52. Information concerning the actual production from various bulk-blending plants is difficult to obtain. However, most of them have comparatively small annual production and serve a small area. Production may range from less than 1000 tons to 6000 tons per year, but the average is likely to be

no more than about 2,500 tons. They [illegible] and usually the operators now support [illegible] or provide additional farm services. Many people have attributed the success of bulk blending in the United States largely to the additional services commonly provided by the entrepreneur. These include a range of activities from soil sampling to establish a basis for fertilizer needs to the service of applying the fertilizers to the soil. Farmers generally are willing to pay for the service of application since there are many other demands for available farm labor at the time.

Equipment and Procedures

53. Investment in the actual blending plant usually is quite small, ranging from $50,000 to $70,000 (17). Some plants with more sophisticated mixing equipment may cost as much as $100,000. Additional investment in bulk spreaders and other application equipment usually is substantial. Most of the key equipment is prefabricated by a number of equipment manufacturers in a variety of types. The total system is quite simple as indicated by the diagram in Figure 3. Typically, it involves receipt of the intermediate granular components in bulk by railroad car or highway vehicle, storage of a few or several of the intermediates separately in bins, weighing of the granular components in desired proportions, and mixing to obtain essential uniformity. The weighing and mixing operations are combined in some types of equipment such as the ribbon mixer mounted on weigh scales. The rotary mixer that is quite popular usually receives preweighed batches of the granular intermediate components. Weigh hoppers are used in some plants while other plants weigh front-end loaders with the scoop load of material. Some plants simply use volumetric measurement of components. The mixing or blending step usually

is a batchwise operation, but the total equipment arrangement and operating practice gives a high rate of production in essentially a continuous sequence.

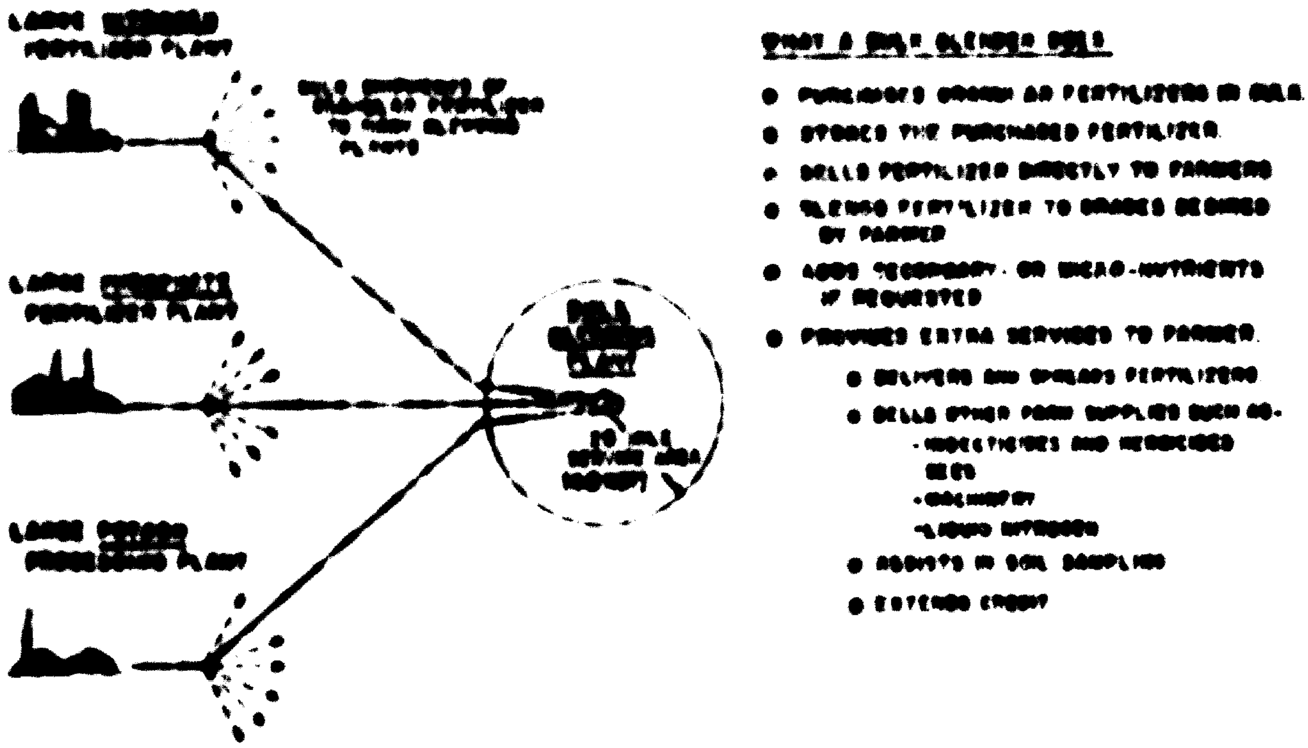


FIGURE 3
PATTERN OF BULK BLENDING

54. There are many varied arrangements of equipment in the thousands of plants throughout the United States. Two popular types of blending plant layouts are shown in Figures 4 and 5. The first (Fig. 4) has a horizontal rotary mixer at ground level. In a variation of this general type, the rotary mixer is in an elevated position that allows discharge directly into spreader trucks. Figure 5 shows a ribbon weigh-mixer in an unusual but apparently convenient hexagonal layout.

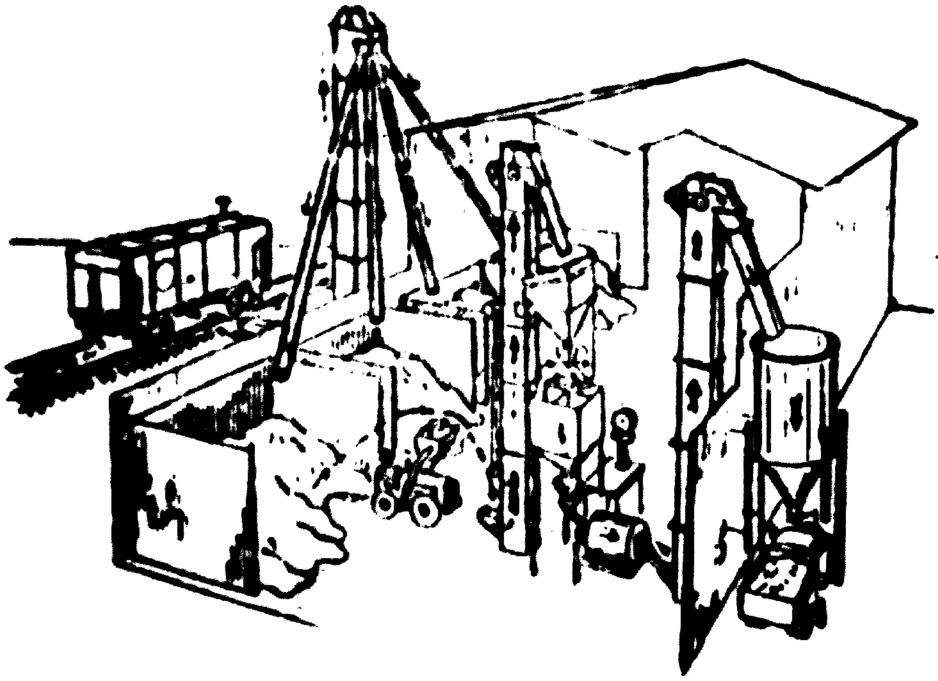


FIGURE 4
BULK BLENDING PLANT USING ROTARY BLENDER

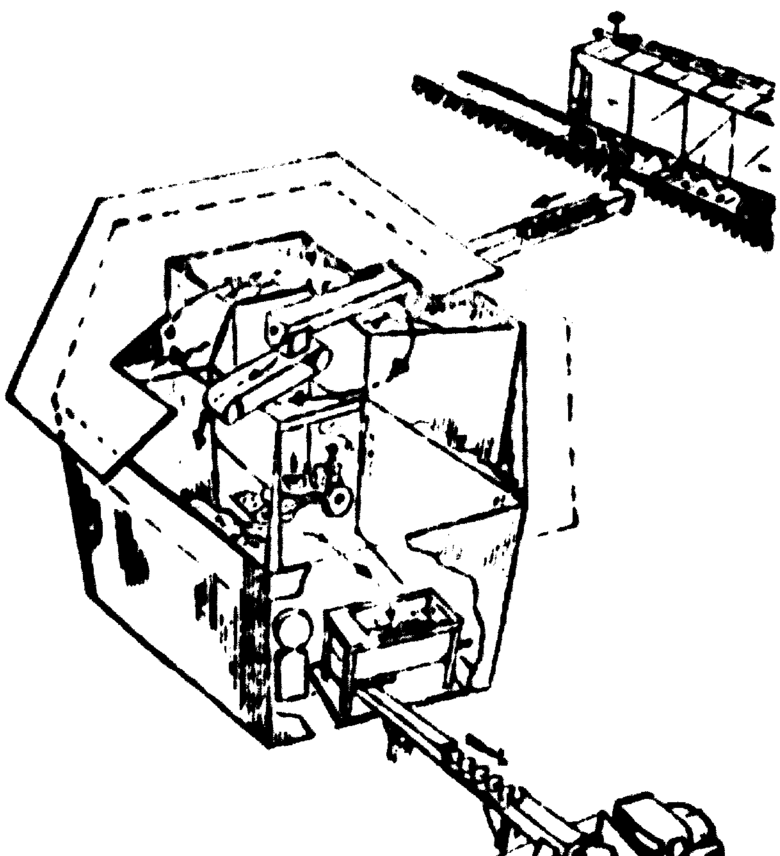


FIGURE 5
BULK BLENDING PLANT USING RIBBON MIXER

55. The entire cycle of weighing, mixing, and discharging may be automated (20). The weight of each component of the blend is punched on a card which is fed into a control mechanism that is set to repeat the cycle for the desired number of batches. Once started by a push button, operation continues until the entire consignment has been prepared. Timing of the various operations is overlapped, and the output, even with a 1-ton mixer, may be 15 to 20 tons per hour.

56. Rotary mixers are available with capacity of 1 to 6 tons per batch and ribbon blenders 1 to 4 tons, so quite high hourly capacity can be obtained with simple but ingenious arrangements.

57. Storage bins for the intermediate granular components used in the blend may provide storage of 100 to 150 tons each, and six or more often are included. Cost of a simply constructed storage building with six bins of this size range is reported to be only about $10,000 (19).

58. Most product blends are handled in bulk to the farm in spreader trucks or other conveyances, but the practice of bagging the finished blends apparently is increasing in some parts of the country.

59. The entire blending plant operation usually requires only one or two men who need to be only semiskilled. Operation is highly seasonal.

Problems in Bulk Blending

60. Bulk blending is a simple type of practice and can provide uniform mixtures in almost any desired proportions. Blends can be prepared to provide a given weight of N, P, and K rather than specific grades. However, unless proper materials are used and certain practices are followed, segregation can occur and nonuniform blends would be delivered and applied to the farm. The factors involved and precautions that are necessary have been

thoroughly described by Hoffmeister et al., of TVA (21). The main requirements are use of granular materials of well-matched range of particle size and handling the mixture after blending in ways to minimise segregation. It is quite easy to obtain a uniform blend by use of proper materials, but maintaining this uniformity to the farm and onto the soil involves precautions. Shape and density of the granules are much less important factors than particle size matching in obtaining uniformity in blending. Handling procedures that may cause segregation include coning (as occurs when the blend is allowed to drop onto sloping piles), vibration in hauling vehicles, and ballistic action imparted by some types of spreaders. The TVA researches give data to show the effect of several variables that emphasises the importance of particle size matching. Simple procedures that can decrease segregation in handling subsequent to blending are pointed out.

61. Seguin (22) has given an interesting account of a Frenchman's first acquaintance with the surprising practice of bulk blending in the United States of America. In visiting the United States in 1964 to study liquid fertiliser practice, he was surprised to find such a prevalence of blending of granular materials. He said in part:

> The progress of bulk blending in that country, where such great importance is given to the question, is particularly due to the fact that it is the means for the farmers to lower the net price of their fertiliser without any involved manipulation. A saving on the order of 10% is realised.

62. T. P. Hignett of TVA has given a thorough description of the practices and problems of bulk blending in his paper to The Fertiliser Society of London (17). He also gave some cost comparisons that at the time indicated 10 to 20% cost advantage for blends over granular compound fertilizers delivered

to the farm. Bulk blending was pointed out as perhaps the major factor in promoting increased fertilizer usage in the United States in the 1960's.

Intermediates Used in Bulk Blending

65. The intermediates most commonly used in bulk-blending plants in the United States are ammonium nitrate, diammonium phosphate (18-46-0), triple superphosphate, and potassium chloride. Lesser amounts of urea, ammonium sulfate, granular ordinary superphosphates, and nonchloride potash materials are used. Some nitric phosphate grades, such as 20-20-0 and 26-13-0, and ammonium nitrate sulfate are used. Operating experience and TVA studies (23) have pointed out some combinations of materials that are incompatible and should be avoided. These include urea with unammoniated superphosphate and, of course, urea with ammonium nitrate. Secondary and micronutrients can be provided suitably in bulk blends, but there are some problems that have been outlined by Silverberg et al. (24). Equipment used for transport of the intermediates in bulk must keep the material dry and avoid spillage.

Practice in Other Countries

66. Although bulk blending has increased spectacularly in the United States and now accounts for a large part of the total finished fertilizers, this practice has not been very widely adopted so far in other countries. Canada uses this system quite extensively (25). There is limited practice of this concept in the United Kingdom and in Brazil and other South American countries. Several blending plants were built in the Caribbean area. Other developing countries including India and Thailand apparently are evaluating prospects for blending and some are experimenting with it in at least a limited way. In Korea, ammonium phosphate and potash are cogranulated and additional nitrogen is provided by blending with prilled urea.

65. In one bulk-blending operation in England, an annual output of about 15,000 tons was reached in the second year of operation of a single well-located plant. Plans and hopes are for increasing the output for this single plant to 40,000 to 50,000 tons per year. The single location with shipment of finished blends over somewhat longer distances than the usual 25 miles (40 km) maximum in the United States was decided upon after a logistical study of an alternative of three locations. The manager indicated that ability to prepare plant food mixtures in any proportions, and particularly special grades containing secondary and micronutrients, are primary reasons for his success. Output of 15,000 tons gives a quite favorable economic outlook, and 50,000 tons or more certainly would be a prime example of low capital investment and operating costs. The future of this venture certainly will be followed with interest.

66. It is doubtful that a combination of factors that led to the popularity and rapid growth of bulk blending in the United States will be repeated to this extent in other countries. However, this system with its classical adaptability to the concept of concentrating the chemical processing in the hands of prime producers, and simplifying the final fertilizer preparation with attendant flexibility and economy of blending plants, certainly will be taken into account. The blending operation using intermediates eliminates one step in the marketing system and the expense of bagging usually is avoided.

VI. LIQUID MIXED FERTILIZER PRODUCTION

History and Patterns of Production

67. Perhaps the best example of the classic concept of use of intermediates in simple local plants for preparation of the final mixed fertilizers is

that of production of liquids. The liquid fertiliser segment of the industry in the United States is based almost entirely on production of intermediates by large producers and shipment of these to small plants for the final compounding of mixed grades. Like bulk-blending plants, these outlets serve a limited area. There are different patterns of ownership. In some cases the small plants are owned by a large private or cooperative organisation that produces a large part of the intermediates used. In other cases the small liquid plants are independently owned and depend on purchase of all their materials from nonaffiliated companies. The liquid manufacturer usually combines manufacture and retail sales, and in many cases provides the equipment for and service of application of the fertiliser for the farmers.

68. The production of liquid mixed fertilisers in the United States has increased quite rapidly. The estimate of 2.5 million metric tons of liquid mixed grades in 1969-70 (that likely is conservative) was about 12% of all compound fertilisers. Figure 6 shows the rapid growth in number of liquid fertiliser plants during the past decade (10). The approximately 2700 plants operating in 1970 represent an active, aggressive, and dynamic segment of the fertiliser industry. Some have said that the atmosphere at a national meeting of liquid fertiliser manufacturers is somewhat like that at an evangelistic religious crusade. During the past 2 to 3 years, the liquid industry has remained quite viable, and manufacturers appear to have prospered well in a generally depressed situation for the industry as a whole.

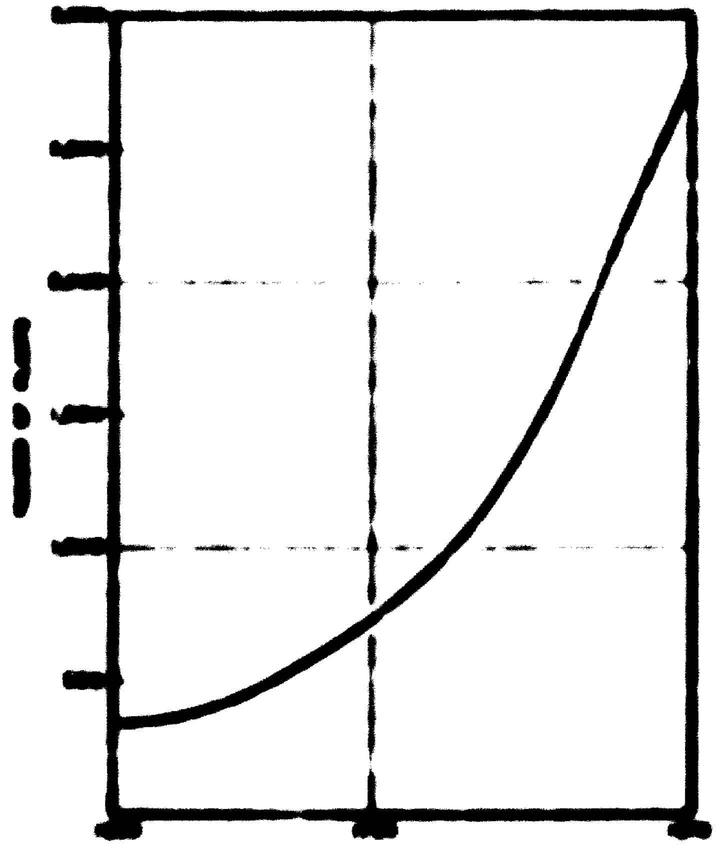


FIGURE 6
ESTIMATED NUMBER OF LIQUID FERTILIZER
PLANTS IN UNITED STATES

69. Liquid fertilisers actually have been around throughout the entire history of the industry. The use of liquid organic wastes as nutrient for crops goes far back into earliest history. Some of the first prepared fertilisers were actually liquids or slurries. In 1840 Liebig ([illegible]) wrote:

> The most easy and practical mode of effecting their division is to pour over the bones, in a state of fine powder, half their weight of sulphuric acid diluted with 3 or 4 parts of water, and after they have digested for sometime, to add 100 parts of water, and sprinkle the mixture over the field before the plough.

70. In modern times, liquid fertiliser manufacture in the United States started as early as 1923 in California (27). The practice grew slowly until

the middle 1950's when it spread into the Midwest and Southwest. Now production of liquids is significant in essentially all parts of the country.

71. Methods and equipment are simple, plant investment is low, and it is comparatively easy to get into the business. A large-scale operation is not necessary for a successful venture. Annual production from a single plant may range from less than 1000 tons to as much as 25,000 tons in a few large plants. The average plant likely will produce 2000 to 4000 tons per year. As is the case with bulk blenders, the liquid manufacturer often has supplementary sideline business activities in farm service.

72. T. P. Hignett, in his Sixth Francis New Memorial Lecture (28), gave a good assessment of advantages for liquids.

> Liquid fertilizers are dependably free-flowing. They are well adapted to handling and application by mechanized, labor-saving methods. Precise metering and placement and uniform distribution are easier with liquids than with solids. Liquids are homogeneous, free from dustiness or caking, and unaffected by hygroscopicity. They are fully water soluble. With liquids, there are no sacks to lift, open, and dispose of; there is little delay in refilling applicators. Liquid fertilization may be combined with irrigation or with application of herbicides or pesticides.

In addition, the manufacture of liquids involves little or no problems of pollution of air or water as far as the final production units are concerned. Most of these problems are shifted to the basic production complexes where the intermediates are produced and where such problems can be more adequately coped with. As has been pointed out earlier, dust and fume problems are major concerns in most granulation plants. Losses can be essentially nonexistent in liquid manufacture. Control of chemical composition is easier--in N-P liquids such as 10-34-0 or 11-37-0, simply through measurements of specific gravity, temperature, and pH. Pumps, piping, storage tanks, and feed tanks usually are less costly and more convenient than equipment for handling, conveying, and storing of solids.

73. This is an impressive list of advantages, and it is quite easy to accept another statement of Mr. Hignett in his Sixth Francis New Memorial Lecture (28).

> In my opinion, liquids will become an important, perhaps a dominant form of fertiliser in many countries in the future. However, there are reasons why the growth is likely to be slow.

He goes on to point out that the nature and established patterns of production in some countries will tend to deter liquids as will lack of supply of some key intermediates.

74. The main disadvantages of liquids are the lower analysis of N-P-K grades than for granular fertilizers or bulk blends, and the usually higher price for the phosphate and potash components. Maximum clear liquid grades are 9-9-9 and 8-16-8 due largely to limited solubility of potassium chloride, the lowest cost and most widely used source of potash. The problem of lower grade of N-P-K compound liquids is being overcome by production of suspensions (29, 30) that can be prepared in grades as high as 15-15-15 and 12-24-12. A large part of the plant food is held in the fluid as small suspended crystals; therefore, solubility is not a controlling factor. Special types of clay are used as suspending agents. Production of suspensions is growing steadily despite some greater precautions required in handling, storage, and application. Increased production of suitable phosphatic intermediates is tending to lower formulation cost for clear liquids and suspensions.

Intermediates Used in Liquid Fertilizer Manufacture

75. The principal intermediates used in production of mixed liquid fertilizers are phosphoric acids and ammonium phosphates (ortho and polyphosphates), urea - ammonium nitrate solution, fully soluble (white) potassium chloride, and solid urea. The phosphate materials may be supplied as 10-34-0 or 11-37-0 ammonium polyphosphate solution or as merchant-grade (54% P_2O_5) ortho and superphosphoric acids (72-76% P_2O_5). TVA has developed and made available a granular ammonium polyphosphate (15-62-0) that has been well received as an intermediate in demonstration programs with the industry (31).

76. In the past, there has not been a fully adequate supply of good quality phosphatic materials. This situation is being remedied by improved technology and increased production capacity, particularly for wet-process superphosphoric acid and 10-34-0 solution. Polyphosphates, developed and pioneered by TVA and carried to commercial importance by the industry, have been a key factor in growth of liquids (32).

Liquid Fertilizer Plant Equipment and Operating Practices

77. The principal types of liquid or suspension fertilizer plants are the cold-mix and hot-mix operations. Another hybrid variety sometimes is referred to as the "semi hot-mix" type. F. P. Achorn has given a rather comprehensive description of these types of plants and their operating practices (33).

78. The hot-mix type plant ammoniates superphosphoric acid or mixtures of superphosphoric acid and lower cost merchant-grade orthophosphoric wet-process acid. Such plants may prepare finished N-P-K grades or 10-34-0

for shipment to the [illegible] for [illegible] mixing with other materials to prepare the final grades.

79. Cold-mix plants compound mixed grades in a simple fashion by physical mixing of liquid intermediates and dissolution or suspension of solids. They are simpler and equipment investment is lower since the comparatively large requirement of cooling equipment of hot-mix plants is not needed. A diagram of a typical cold-mix plant is shown in Figure 7.

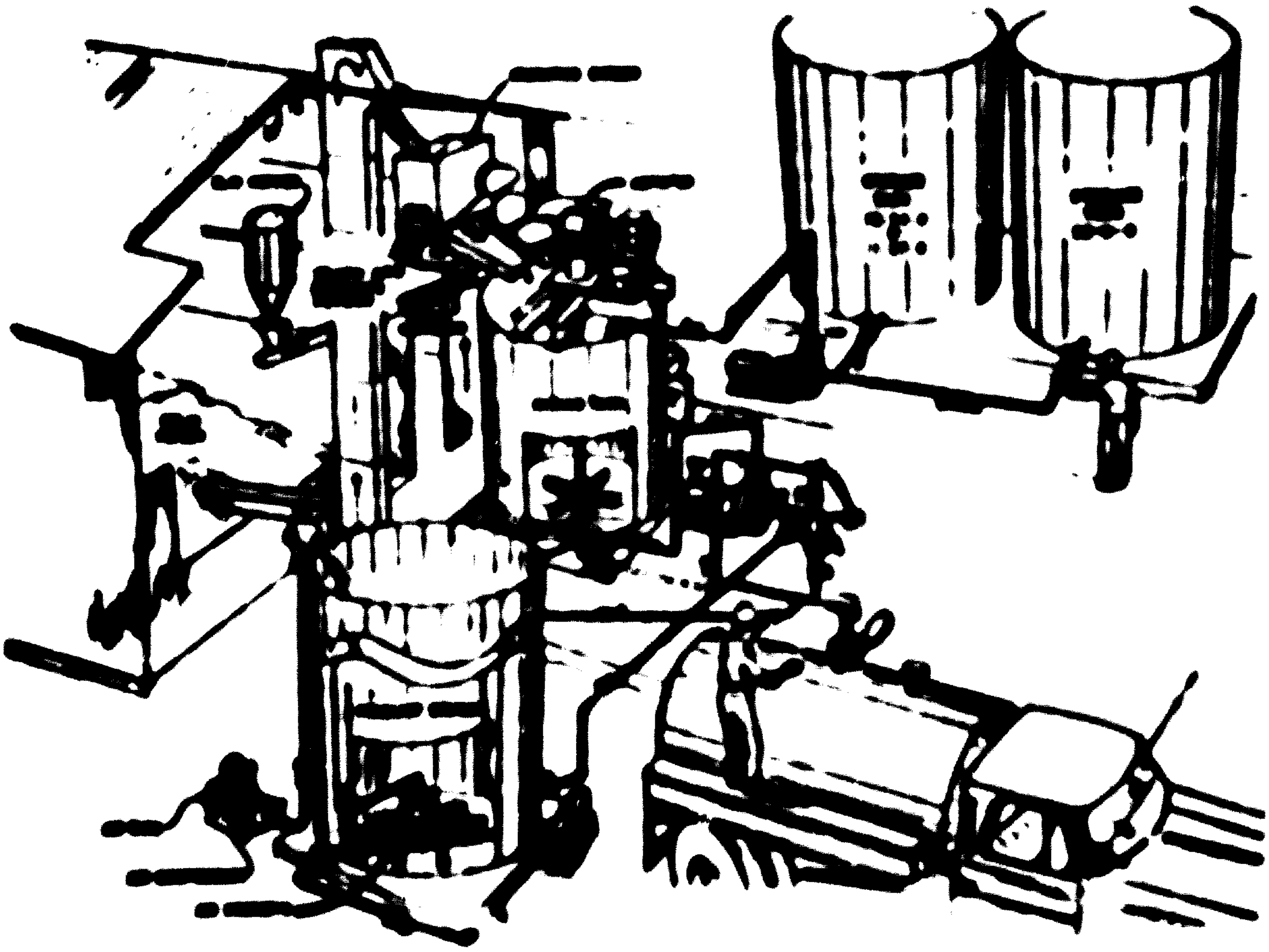


FIGURE 7
COLD-MIX PLANT FOR LIQUID FERTILIZERS

80. Total investment of an average liquid fertilizer manufacturer has been reported as about $[illegible],000. This total investment is about equally divided among buildings and plant equipment, storage tanks for intermediates and

products, and nurse tanks and application equipment (24). Investment for the manufacturing plant alone may range from $[illegible]0,000 to $[illegible]0,000 for cold-mix and $[illegible]0,000 to $[illegible]0,000 for hot-mix operations.

81. The simplest method of arrangement that has been referred to as the "fertilizer filling-station" concept since operation is somewhat like gasoline retail outlet stations. In a typical operation for suspensions, the equipment as shown in Figure 6 consists simply of storage tanks of moderate capacity for intermediates such as 12-40-0 polyphosphate and 5-15-30 potash-base suspensions, and urea - ammonium nitrate solution.

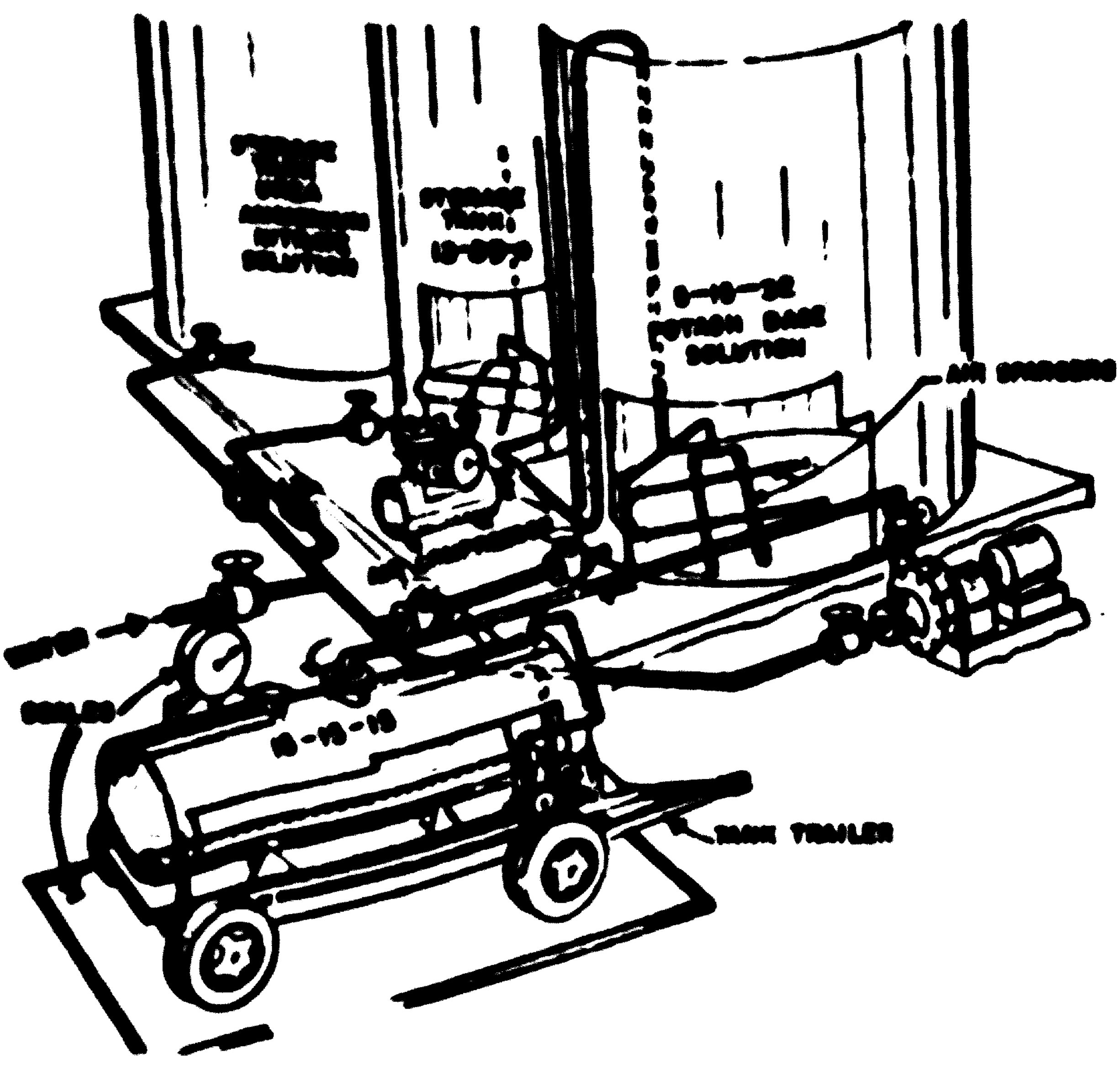


FIGURE 6
SATELLITE COLD BLENDING STATION

The same type of operation is suitable for clear liquids. In the very simple operation, the ingredients are metered to and mixed directly in the farmer's nurse tank. Simple air sparging is used for mixing. Herbicides and micronutrients have been included in suspension mixtures prepared in this way.

Practice in Countries Other Than the United States

82. Reports the past few years show that liquid fertilizers are becoming quite popular in the United Kingdom. Production by about 15 companies is reported to have totaled about 200,000 metric tons of nutrients, or slightly more than 3% of the total plant food consumption in 1970. Somewhat different materials and technique are used and some unique and economical expedients for storage have been employed.

83. Liquid fertilizer production also is a growing practice in France and Belgium. Polyphosphate materials are used considerably in both countries. It is estimated that more than 400,000 metric tons of liquid fertilizers was consumed in France in 1970.

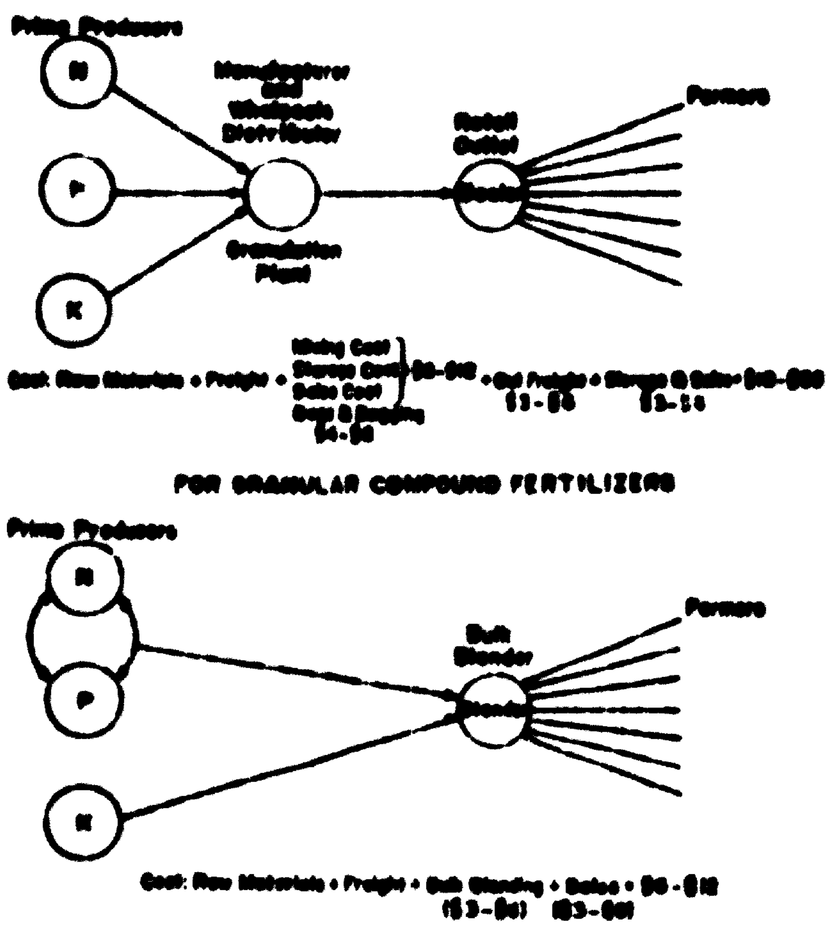
84. T. P. Hignett in his paper, "Liquid Fertilizer Production and Distribution," at this meeting points out that future prospects for liquids in developing countries should not be underestimated. He stresses the many potential advantages that may be expected to compel the industry to overcome problems in use of this system in the longer term. He predicts that ultimately liquids likely will become a major part of total compound fertilizers for the world.

VII. ADVANTAGES IN LOGISTICS AND ECONOMICS

FOR THE SMALL LOCAL PLANT CONCEPT

85. The previous discussion has outlined a number of potential advantages for preparation of final compound fertilizers in local plants. These advantages have been demonstrated in the United States and some other countries. There should be potential for greater application of this type system at other locations, including developing countries in which the fertilizer industry is being planned or emerging.

86. The diagrams in Figure 9 show a comparison of patterns of the production, distribution, and marketing system for granular compound fertilizers



FOR BULK-BLENDED FERTILIZERS

FIGURE 9
COMPARISON OF PRODUCTION AND DISTRIBUTION CHANNELS

and bulk blends. One step generally is eliminated, with potential savings for the bulk-blending practice. Liquid fertilizers follow a similar pattern to that of bulk blending. The convenience, flexibility, and economy that are afforded have been major factors in the rapid growth of these practices in the United States and some other countries.

87. Although granular compound fertilizer production is not so ideally suited to the system of small local plants, the at-least regional plant concept using intermediates is widely used. It has been shown that very simple and inexpensive local granulation plants, by using certain formulations, could function quite effectively and economically. They would serve a limited area and could eliminate a full step in the production and marketing pattern (35). This is shown in the diagram of Figure 10.

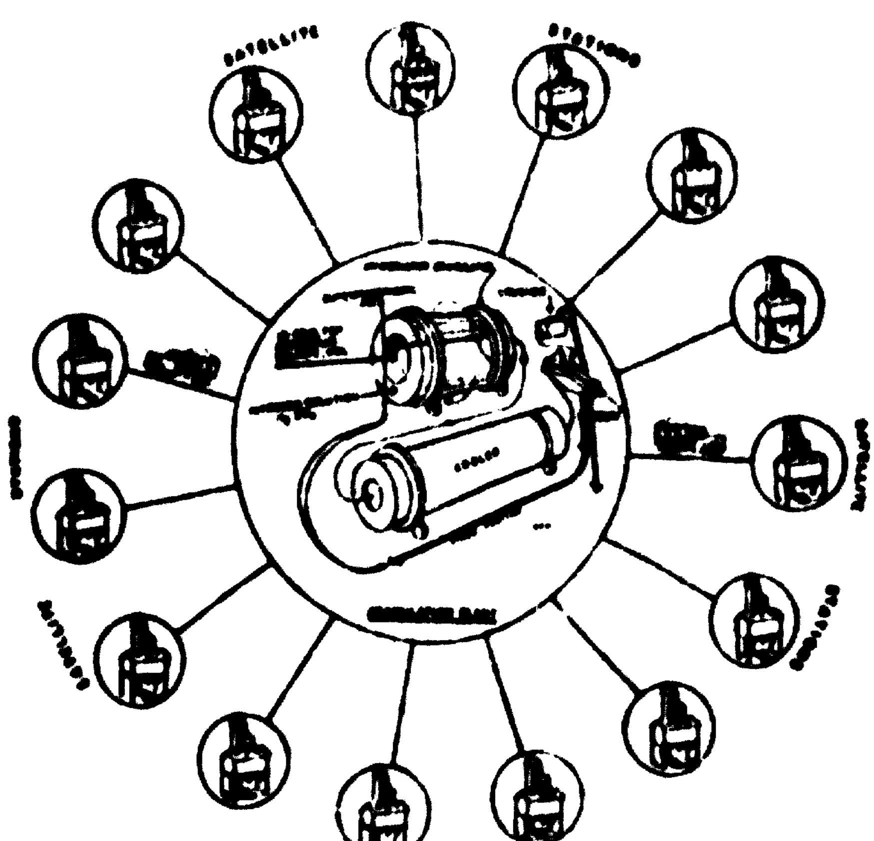


FIGURE 10
GRANULATION - BULK HANDLING MARKETING SYSTEM

88. Perhaps we shall see more practice of the concept of local plants using suitable and economical intermediates. This system appears to offer best prospects for providing farmers the varieties of fertilizers likely to be needed for effective and economical fertilization practices.

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