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T REQUIREMENTS TO SET UP AND OPERATE A PHOSPHATE PROCESSING PLANT

TECHNICAL AIDS BRANCH

INTERNATIONAL COOPERATION ADMINISTRATION

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FOREWORD

This manual is a revision of an earlier report of the same type issued in 1955. This revised version includes current costs of labor, machinery, equipment and supplies, as well as additional information relative to engineering, training, safety, markets, sales, financial and economic factors.

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This manual is designed to provide a general picture of the factors which must be considered in establishing and operating a small-scale factory of this type. It should prove useful in creating interest in the subject, and serve to give enough understanding of the related considerations to help government officials, other leaders and businessmen to determine whether the potential deserves more-detailed attention.

However, it is important to note that in most cases plans for the actual development and installation of a plant will require expert engineering and financial advice in order to meet specific local situations. For further information and assistance, readers should contact their local Productivity Center, Industrial Institute, Servicio, or United States Operations Mission.

Mention of the name of any firm, product, or process in this manual is not to be considered a recommendation or endorsement by the International Cooperation Administration, but merely a citation that is typical in its field.

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PLANT REQUIREMENTS
TO SET UP AND OPERATE
A PHOSPHATE PROCESSING PLANT

INTRODUCTION

Practically all fertilizers used in the United States are prepared on a super-phosphate base. This material is used alone in large tonnages and almost invariably is the component present in large quantities in mixed fertilizer. Since the manufacture of superphosphate consumes much sulphuric acid, the making of this important fertilizer material is often associated with the making of sulphuric acid. In fact, economic considerations are making it necessary that the large scale superphosphate maker be also a sulphuric acid manufacturer.

Successful manufacture of either sulphuric acid or superphosphate is today necessarily a large-scale business. The small manufacturer of these commondities usually is at a great economic disadvantage. The capital required for materials handling and skilled supervision for both superintendence and general management place disproportionately great burdens on any plant of small output. This manual describes a plant which is of adequate size and also capable of considerably increased output without proportionate capital expenditures.

Phosphatic fertilizer materials come from three main sources -- bones, rock desposits, and some special iron ores. Bone and the rock phosphates contain insoluble or tri-calcium phosphate.

Rock phosphate has the chemical formula $3\left[Ca_3\ (PO_4)_2\right].\ CaF_2$ and is recognized to be more or less slowly available to crops, depending on the fineness to which it is ground, the soil conditions, and the crop being grown.

About 100 years ago, both in Germany and in England, chemical methods were described for making the relatively insoluble phosphate carriers more soluble by treating them with sulphuric acid. In the process the three-lime phosphate $\left(3\left[Ca_3\ (PO_4)_2\right]\right)$ is converted to lime phosphates which are easily soluble in soil water and thus become immediately available. Lawes, in England, called the end product of the acidulation "superphosphates." That name has been used ever since.

The chemical symbol for phosphorous is the letter "P" and for phosphoric acid the fertilizer trade uses the symbol "P_2O_5." This symbol means that two parts of phosphorous (P) are combined with five parts of oxygen (O).

The words, "phosphates," "phosphoric acid," and "phosphorous" are used interchangeably in the fertilizer trade.

The manual describes the process and equipment required to process rock phosphate for agricultural fertilizer use as superphosphate. The plant discussed is of minimum economic size and has a capacity for producing approximately 150 tons of superphosphate per working day. The operation is essentially a chemical process and the plant houses this process and facilitates the movement and storage of the large volumes of raw and finished material.

The Acidulation Reactions

Despite the hundred years during which superphosphate has been produced in many countries, the chemistry of the acidulation process is not completely understood. The most generally accepted statement of the reactions is:

$$3\left[Ca_3\ (PO_4)_2\right].CaF_2 + 7\ H_2SO_4 \longrightarrow$$

$$3Ca(H_2PO_4)_2 + CaSO_4 + 2HF$$

Stated in words, this chemical formula means that phosphate rock plus sulphuric acid give monocalcium phosphate plus calcium sulphate plus hydrogen fluoride.

At least this formula is accepted for American phosphate rocks which are of the apatitic form in which fluorine is combined with calcium. The acid causes the fluoride to disrupt. Phosphate rock may vary somewhat in other lands -- the fluoride (CaF_2) may be displaced by calcium hydroxide ($Ca\ (OH)_2$). In any of these compounds the sulphuric acid causes the destruction of the particular molecule which geologists call "the apatite lattice: and in the ensuing reaction, water-soluble monocalcium phosphate and a small amount of dicalcium phosphate are formed.

The mix of pulverized phosphate rock and sulphuric acid varies with the chemical analysis of the rock and the concentration of the acid, but often is in the proportion of 4 to 3 by weight; that is, approximately 1,200 pounds of 77% phosphate rock are mixed with approximately 900 pounds of 60° Baume sulphuric acid at temperatures between 120° and 220°F.

To indicate the prominence of the superphosphate industry in the various parts of the world, see table on pages 3 and 4.

Production or deliveries and consumption of phosphate rock by country for the year 1952

Source: International Superphosphate Manufacturers' Association

Countries	Production or Deliveries (Metric Tons)	Consumption (Metric Tons)
Europe		
Austria	---	80
Belgium - Luxemburg	74,677	377,716
Czechoslovakia	---	112,100
Denmark	---	247,198
Finland	---	218,494
France	24,266	935,566
Germany	---	850,000 (a)
United Kingdom	---	852,370
Eire	---	96,277
Greece	---	82,638
Holland	---	406,980
Hungary	---	31,900
Italy	---	952,161
Yugoslavia	---	22,550
Norway	---	101,462
Poland	---	192,308
Portugal	---	230,000 (b)
Rumania	---	6,000
Russia	2,750,000 (a)	2,300,000 (a)
Spain	19,219	709,272
Sweden	---	281,805
Switzerland	---	8,620
Total Europe	2,868,162	9,015,497
Africa		
Algeria	692,620	68,227
Egypt	527,132	60,000 (a)
Morocco	3,953,067	101,148
South Africa	96,568	455,005
Tunisia	2,264,654	137,856
Various	24,096	11,291
Total Africa	7,558,137	833,527
America		
Brazil	12,500 (a)	61,536
Canada	---	421,782
Chile	26,000	35,853
Mexico	2,500	38,466
United States of America	12,223,712	10,193,101
Various	107,414	38,114
Total America	12,372,126	10,788,852

Production or deliveries and consumption - Continued

Countries	Production or Deliveries (Metric Tons)	Consumption (Metric Tons)
Asia		
Ceylon	---	29,169
Dutch East Indies	---	4,410
Indo-China	---	4,500
India	---	26,926
Japan	---	899,951
Malay	---	15,654
Israel	17,207	14,560
Turkey	---	15,000
Various	487,633	62,440
Total Asia	504,840	1,072,610
Australasia and Pacific		
Australia	---	1,009,997
New Zealand	---	600,000 (a)
Various	1,679,903	---
Total Australasia and Pacific	1,679,903	1,609,997
Grand Total	24,951,168	23,320,483

(a) Estimated; (b) Partly estimated.

To facilitate conversion to local figures and costs, columns headed "Actual" are included in the appropriate tables.

GENERAL ASSUMPTIONS

1. The costs of building, equipment, and material necessary are based on United States prices.

2. Labor costs used are the average for the industry and skill described, based on recently published figures of the United States Bureau of Labor Statistics.

3. All other costs, statistics, and figures are based on current United States prices.

4. Adequate heat, light, water, and electricity are available at the plant site.

5. Adequate transportation facilities are available at the plant site.

6. The plant operates on a continuous basis -- 5 days a week for 50 weeks.

7. No special provision is made for the training of ne personnel. It is assumed that learner's rates are p in such cases.

8. The following items cannot be estimated realistically:

   A. Land value
   B. Distribution methods and selling costs
   C. In-freight and out-freight
   D. Taxes, insurance, and interest

   While general assumptions will be made of these items, except taxes, for the purpose of completing cost estimates, adjustments should be made in accordance with actual local costs. In fact, all costs contained in this manual should be adjusted to conform to actual local conditions.

MANUFACTURING OPERATIONS

The process for making superphosphate is relatively simple. Basically, it consists of treating phosphate rock so that it becomes soluble with soil water. The process is shown diagramatically in figure 1. Equipment used and a preliminary plant layout are shown in figures 2 and 3.

Phosphate rock is brought to the plant by rail or water and piled in outside storage by a crane. For convenient movement of the rock, a tractor with a grab bucket is utilized, to move the rock to the first operation station which is the hopper feeding the rock grinder. Here the rock is ground to a coarse powder. Screw or pneumatic conveyors then move the powder to the fine grinders where it is pulverized to a fine powder. Conveyors then move it to the acid mixers where sulphuric acid is sprayed onto it and the mixture is agitated to obtain the proper mix. See figure 4.

Next the mixture is dumped into a den having a capacity of 50 to 75 tons. The active acidulation process is completed here. During this eruption, fluorine gas is given off which by additional capital investment can be collected, purified, and sold as a by-product.

After 6 to 8 hours, the eruption caused by the acid normally has ceased. An overhead crane is then used to move the mixture from the dens to where it is stored for curing. See figures 5 and 6. During curing, acidulation continues slowly and with decreasing activity.

After several weeks of curing and when the material is to be made ready for shipment, it is moved by overhead crane to the bins feeding the rasping and milling machines. Here the mixture, which has become caked, is

broken up by a machine called a rasper, passed through a pulverizer, and then screened. Oversized particles that do not pass through the screens are returned for further milling. Depending on the formula or grade of fertilizer desired, additional materials such as nitrates, potash, or potassium may be added in the mixing machine.

Next the material moves by conveyor to the bins feeding the bagging operation. After being weighed and bagged by an automatic weighing and bagging device, see figure 7, the bags are moved by conveyor to sewing machines. Here the bags are sewed tight. Finally, they are moved by conveyor to the shipping platform, see figure 8, for immediate shipment. Superphosphate should not be bagged until ready for shipment because the bags may rot when they contain superphosphate too long.

MANUFACTURING UNIT

The unit used to measure productive capacity in a plant such as this is the short ton. This plant is capable of producing 150 tons of superphosphate fertilizer per day, or 37,500 tons per year. This quantity is packaged in 100 pound capacity bags.

DIRECT MATERIALS

The only raw materials needed are phosphate rock, sulphuric acid, and the bags in which the fertilizer is sold. For a daily production of 150 tons of superphosphate, the following table lists the quantities needed of these materials and their cost.

Direct materials required for one year's production.

Material	Quantity	Estimated Unit Cost	Estimated Total Cost	Actual Cost
Rock phosphate	30,000 tons	$ 2.50/ton	$ 75,000	_____
Sulphuric acid	22,500 tons	18.00/ton	405,000	_____
Bags	750,000	180.00/thousand	135,000	_____
Total Annual Cost			$ 615,000	_____

Phosphate rock is delivered by rail or water in a rough broken state. The sulphuric acid is delivered by tank car or tank truck and either pumped into storage tanks or used directly fromthe delivery vehicle. It is 93% concentration, 66° Baume. Bags are delivered in freight car or truck load quantities. For domestic use the bags are the six wall paper type. Export would necessitate the use of an eight wall paper bag having a waterproof inter-lining and a burlap cover. The cost for this latter bag would be $400 per thousand.

PRODUCTION TOOLS AND EQUIPMENT

The equipment listed in this table are the major items required to operate the plant efficiently. They are listed in the order in which they are used to produce superphosphate.

Description	Number Required	Estimated Cost	Actual Cost
Crushing			
Mobile 25 foot boom crane	1	$ 55,000	_____
Grab bucket, 2 yard capacity	1	4,000	_____
Rock grinder including hopper, motors, and all accessories Capacity: 200 tons in 24 hours	1	8,000	_____
Pneumatic or screw conveyor from grinder to pulverizer	1	3,100	_____
Fine pulverizer, hopper, motors, and all accessories	1	6,800	_____
Conveyor to acid mixers	1	1,600	_____
Acidulating			
Scale hoppers, acid spray nozzles, hoppers, and mixers mounted on movable platform over dens	1	11,000	_____
Bridge crane, 65 foot span, 30 foot hoist, all motors and floor operated controls Capacity: 300 tons per day	1	80,000	_____
Curing			
Rasper with feed hopper and discharge to pulverizer	1	7,200	_____
Hoppers and mixer	1	5,200	_____
Pneumatic or screw conveyor to bagger	1	3,200	_____
Bagging			
Automatic weighing and bagging machine complete with sewing machine head Capacity: 400 bags per hour	1	6,000	_____
Conveyor to shipping platform	1	3,200	_____
Other tools and equipment	1	32,700	_____
Total		$ 227,000	_____

OTHER TOOLS AND EQUIPMENT

Description	Number Required	Estimated Unit Cost	Estimated Total Cost	Actual Cost
Hand tools			$ 500	
Typewriter	1	$ 150	150	
Adding machine	1	150	150	
Laboratory - Chemical apparatus	set		2,200	
Total			$ 3,000	

FURNITURE AND FIXTURES

Description	Number Required	Estimated Unit Cost	Estimated Total Cost	Actual Cost
Desk and chairs	5	$ 125	$ 625	
Filing cabinets	4	80	320	
Sink and work table	1	300	300	
Total			$ 1,245	

PROVISION FOR EXPANSION

The equipment specified for this plant is not all utilized to its full capacity. If, after the plant is in operation for a time, there is a market for additional production, steps can be taken to utilize this excess equipment capacity. While some new equipment would be required the principal additional expense will be in wages since more direct labor will be necessary. In addition, an extension to the plant to provide additional curing space will probably be needed. These expenditures will be small, however, in comparison to the increased production that will result.

DIRECT LABOR

To carry out the processing of the phosphate rock, the following manpower is needed:

Description	Number Needed	Hourly Rate	Estimated Annual Cost	Actual Cost
Working Foreman	1	$ 2.00	$ 4,000	_____
Shift Boss	2	2.00	8,000	_____
Laborers per shift	13	1.50	39,000	_____
Total			$51,000	_____

Of these, only the working foreman and the shift bosses must be relatively skilled. They will operate the more expensive and complex equipment such as the overhead crane and the grab bucket tractor.

INDIRECT LABOR

Since the preparation of superphosphate is essentially a continuous chemical process, the plant manager should be a chemical engineer. To maintain control of the processing and to carry out such tests as are necessary, a chemical technician should also be available. To furnish supervision during the three-shift operation of the plant, three section managers are required for the crushing, acidulating and curing operations and two section managers for the bagging and shipping operation. Thus, the indirect manpower required in this plant are:

Description	Number Needed	Hourly Rate	Estimated Annual Cost	Actual Cost
Plant Manager	1		$10,000	_____
Chemist	1		8,000	_____
Bookkeeper	1		5,000	_____
Secretary-Clerk	1		3,000	_____
Section Managers - crushing, acidulating and curing	3	$ 2.00	12,000	_____
Section Managers - bagging and shipping	2	2.00	8,000	_____
Maintenance	1	2.00	4,000	_____
Janitor	1	1.50	3,000	_____
Total			$53,000	_____

PLANT LAYOUT

As illustrated by figures 2 and 3, the building required is 70 feet wide and 300 feet long. Most of this area is required for the curing and storage of the superphosphate. This is so since production is continuous but sales are seasonal.

PLANT SITE

To provide for eventual expansion, the land for the plant site should contain about 3 acres. The site should be level, well drained, and should be located as advantageously as possible with respect to transportation, power, water, fuel, sources of markets and labor. The cost of such a site is estimated at $2,000.

BUILDING

Due to the fluorine fumes that are given off during the processing, the building must be well ventilated. A suitable structure consists of a light steel framework with an arched truss roof covered with corrugated galvanized iron sheets. Including the concrete floor, equipment foundations, dens, shipping platform, crane rails, steam boiler, and all plumbing and wiring, such a building can be erected for about $145,000.

POWER

It is assumed that a dependable supply of electric power is available from public power service lines. The total power required, based on the actual capacity of all motors used, is 120 horsepower. The annual cost of power is estimated at $7,300.

WATER

Water requirements for the purpose of production, heat, sanitary facilities, drinking purposes and fire protection is estimated at $525.

FUEL

It is estimated that the cost of fuel for all purposes will amount to $1,800.

SUPPLIES

Item	Estimated Cost	Actual Cost
Maintenance Materials and Machine Parts	$ 3,100	_____
Lubricants	100	_____
Hand and Cutting Tools	500	_____
Office Supplies	300	_____
Total	$ 4,000	_____

DEPRECIATION

Item	Estimated Cost	Years' Life	Estimated Per Year	Actual Per Year
Building	$ 145,000	20	$ 7,250	_____
Production Tools and Equipment	227,000	10	22,700	_____
Other Tools and Equipment	3,000	10	300	_____
Furniture and Fixtures	1,245	10	125	_____
Total			$30,375	_____

MANUFACTURING OVERHEAD

Item	Estimated Cost	Actual Cost
Depreciation	$ 30,375	_____
Supplies	4,000	_____
Indirect Labor	53,000	_____
Power	7,300	_____
Water	525	_____
Fuel	1,800	_____
Total	$ 97,000	_____

MANUFACTURING COST

Direct Materials	$ 615,000	_____
Direct Labor	51,000	_____
Manufacturing Overhead	97,000	_____
Total	$ 763,000	_____

FIXED ASSETS

Item	Estimated Cost	Actual Cost
Land	$ 2,000	
Building	145,000	
Production Tools and Equipment	227,000	
Other Tools and Equipment	3,000	
Furniture and Fixtures	1,245	
Total	$ 378,245	

WORKING CAPITAL

Since fertilizers are used mostly at planting time about 60% of the annual production is usually sold and delivered over a three month's period. For this reason a large amount of working capital is required.

Item		Estimated Cost	Actual Cost
Direct Materials	- 4 months	$ 205,000	
Direct Labor	- 4 months	17,000	
Manufacturing Overhead	- 4 months	32,000	
Reserve for Sales Collections	- 30 days	92,000	
Total		$ 346,000	

CAPITAL REQUIREMENTS

Item	Estimated Cost	Actual Cost
Fixed Assets	$ 378,245	
Working Capital	346,000	
Total	$ 724,245	

SALES REVENUE

The majority of superphosphate fertilizer is sold to wholesalers who, in turn, resell in smaller quantities to individual users. Those farmers or plantation owners near the plant may buy their needs directly from the plant.

The average selling price for superphosphate fertilizer in the United States is $29.50 per ton. On this basis the annual gross sales of this plant would amount to 37,500 x $29.50 or $1,106,250.

RECAPITULATION OF COSTS, SALES AND PROFITS

Item	Estimated Cost		Actual Cost
Direct Materials	$ 615,000		_____
Direct Labor	51,000		_____
Manufacturing Overhead	97,000		_____
Total Manufacturing Cost		$ 763,000	_____
Interest on Loans	$ 18,000		_____
Insurance	5,000		_____
Legal	2,000		_____
Auditing	3,000		_____
Unforeseen Expense	30,250		_____
Total Administrative Cost		58,250	_____
Sales Commissions, Travel Freight Out, Bad Debts, Discounts and Allowances		100,000	_____
Profit before Taxes		185,000	_____
Total Annual Gross Sales		$ 1,106,250	_____

BUDGET CONTROL

A requisition form designed to provide accurate records of procurement and indicate the purpose of procurement with the least amount of time and effort is shown on the following page.

This form has an account number for each type of the various expenditures which the manager will review in detail, monthly or oftener, in order to control his expenses. Some items, such as power and water, are usually under contract and are easily checked by reference to monthly bills. For simplification, items (marked with an asterisk below) are omitted from the purchase requisition. Variations in the labor costs are easily reviewed by examination of the payroll vouchers. The simplified type of control thus provided makes certain that the manager can control expenditures promptly.

Following the requisition form, a sample voucher check is shown. Voucher checks should be used for the payment of all expenditures and the appropriate book account number placed on each voucher.

At the end of each month the manager will receive a statement of all expenditures broken down by budget accounts. If the expenditures exceed the budgeted monthly allowances of any of the accounts, the bookkeeper will furnish the manager with a break-down of all expenditures relative to the budgeted accounts exceeded. All these supporting data can be secured by reference to the purchase requisitions and the check vouchers. This reference will enable the manager to determine what caused the over-expenditure and take corrective action.

If at any time during each month it becomes apparent that expenditures will exceed any of the budget accounts, the bookkeeper will bring this to the attention of the manager for his information and action.

BUDGET CONTROL ACCOUNTS

Account Number		Monthly Expense	Monthly Budget	Annual Budget	Actual
10	Administrative	$_____	$ 2,333	$ 28,000	$_____
20	Sales	_____	8,333	100,000	_____
30	Direct Materials	_____	51,250	615,000	_____
40	Supplies	_____	333	4,000	_____
51	Power*	_____	608	7,300	_____
52	Water*	_____	43	525	_____
53	Fuel	_____	150	1,800	_____
60	Unforeseen Expense (Reserve Account)	_____	2,520	30,250	_____
71	Direct Labor*	_____	4,250	51,000	_____
72	Indirect Labor*	_____	4,416	53,000	_____
80	Depreciation (Reserve Account)	_____	---	30,375	_____

Note: Administrative includes interest on loans, insurance, legal and auditing.

PURCHASE REQUISITION	COMPANY NAME	DATE

- ☐ 10 ADMINISTRATION
- ☐ 20 SALES
- ☐ 30 MATERIALS
- ☐ 40 SUPPLIES
- ☐ 50 UTILITIES
- ☐ 60 UNFORESEEN EXPENSE

INDICATE BELOW THE USE OF MATERIALS

- ☐ DIRECT MATERIALS
- ☐ MAINTENANCE MATERIALS
- ☐ MAINTENANCE SERVICES
- ☐ OPERATING SUPPLIES

	PLEASE ORDER THESE MATERIALS OR SERVICES	DELIVERY WANTED		
QUANTITY	DESCRIPTION	UNIT	TOTAL	

QUOTES FROM		REQUISITIONED BY	
QUOTES FROM		APPROVED BY	
QUOTES FROM		ORDER NO.	ORDER DATE

R. W. MITCHELL MANUFACTURING COMPANY

1422 BOSWORTH STREET, S. E.

65-22
514

ANYWHERE, U. S. A._____19____ No. 10000

PAY _____ DOLLARS $ _____

TO THE ORDER OF

R. W. MITCHELL MANUFACTURING COMPANY

TO FIRST NATIONAL BANK
ANYWHERE, U. S. A.

BY SAMPLE CHECK

VICE PRESIDENT

ACCOUNT NUMBER

Sample voucher check to be used for the payment of all expenditures in connection with Budget Control.

R. W. MITCHELL MANUFACTURING COMPANY

ENGINEERS

The services of professional engineers are desirable in the design of this plant, even though the proposed plant is small.

A correct design is one which provides the greatest economy in the investment of funds and establishes the basis of operation that will be most profitable in the beginning and will also be capable of expansion without expensive alteration.

The addresses of professional engineers who specialize in industrial design, some of whom may be willing to undertake such work on low cost projects overseas, can be secured by reference to the published cards in various engineering magazines. They may also be reached through their national organizations, one of which is the

National Society of Professional Engineers
2029 K Street, Northwest,
Washington 6, D. C.

Manufacturers of industrial equipment employ engineers familiar with the design and installation of their specialized products. These manufacturers are usually willing to give prospective customers the benefit of technical advice by those engineers in determining the suitability of their equipment in any proposed project.

The equipment manufacturers also know, and can recommend, professional engineers in private practice, who are willing and able to provide appropriate consulting services.

TRAINING

Manufacturing an inferior quality of product during the training period could create sales resistance that might be difficult to cope with later. To avoid such possibilities, the quality of the product should be maintained at all times, including the training period.

In some areas skilled operators may be available locally. In other areas all the operators may have to be trained.

If skilled operators are not available, adequate training would be assured by using one or more of the following methods:

A. If the plant is designed and installed by a competent engineering firm, the contract should be negotiated, if possible, on a turn-key basis. On this basis the contractor agrees to operate the plant and produce the quality and quantity of the product stated in the contract for an agreed period of time. Such a contract would assure adequate personnel training, since full quantity and quality could not be produced with an untrained organization.

B. The engineering firm that designs and installs the plant can usually make training arrangements to have key personnel placed, for training purposes, in a foreign industry that produces the same type of product. This would provide training for the key personnel while the plant is being installed.

C. If neither of the above methods is possible, then qualified and experienced individuals should be employed for the key positions, either permanently or temporarily, to perform the key operations and assist in training the organization, even if they must be secured outside the country.

D. The manager should have years of successful experience in this type of business and be fully qualified in all phases of management, including the training of employees.

SAFETY

There is always danger of accident and injury in any industrial plant. Because of this, the manager should take specific action to bring to the attention of each employee the importance of safety precautions and intelligent first aid.

Practically all machines have safety appliances, and the manager should see that these are in good working condition and that the operators are making full use of them.

In addition to constant watchfulness to make sure that all practicable safety precautions are taken, first aid supplies should be readily available. One complete first aid kit should be maintained near the manager's office, and others at appropriate places throughout the plant. Some of the employees should be trained to provide first aid service.

The use of accident posters in the plant have proved to be of value in reducing accidents. It is recommended that such posters be used, and that some direct special action be taken by the manager, at least once each month, to bring to the attention of all personnel the importance of safety precautions.

A fire brigade should be established and each member trained as to his responsibility in case of fire. Fire drills should be conducted periodically.

It is recommended that the employees be encouraged to offer suggestions or recommendations relative to prevention of accidents, removal of fire hazards and maintaining general interest in all safety factors.

SUMMARY

A small plant, built and operated according to the assumptions made in this manual would be a profitable undertaking.

There are some determinations, however, that should be made before a decision is reached to build and operate such a plant. Among the necessary determinations to be made are those with respect to the following items:

MATERIALS AND SUPPLIES

1. Are all materials and supplies available locally?
2. Is the local material market competitive?
3. Are satisfactory delivery of local materials assured at reasonable prices?
4. What materials and supplies must be imported?
5. Are they available in world markets at competitive prices?
6. Would prompt delivery of imported materials and supplies be assured so that large inventories would not be required?

MARKET FACTORS

1. Is there already a demand for the product?
   - A. Who are the principal consumers?
   - B. Who are possible new consumers?

2. How is demand for the product now satisfied?
   - A. By local production? If so, what is the volume of annual production?
   - B. What percentage of consumption is filled by local production?
   - C. By imports? If so, what is the volume of annual imports?
   - D. What percentage of consumption is met by imports?
   - E. From what areas are imports derived?

3. What is the estimated annual increase in local consumption over the next five years?
   - A. How were such estimates made?
   - B. By reference to official figures on population growth, family budgets, imports, etc.?
   - C. By consultation with trade or industry, ministries, associations, bankers, commercial houses, wholesalers, retailers, industrial consumers, etc.?

4. If the product is already being manufactured, can the existing and estimated future local market absorb production of the new plant without price-cutting or other dislocations?

5. Would the estimated sales price and quality of the new product make it competitive with an imported equivalent?
   A. After adjusting cost to local conditions, is the estimated sales price of the product so high that tariff protection is necessary to protect it from imports?

EXPORT MARKETS

1. Could the product compete in export markets on the basis of price, quality and dependability of supply?
2. Can export markets for the product be developed?
3. If so, in what areas and in what annual volume?
4. What procedures would be necessary to develop export markets?
5. What would it cost?

MARKETING PROBLEMS

1. In calculating costs of the product, has adequate allowance been made for the expense of a sales department, advertising and promotion that might be required?

2. Do consumer prejudices against locally manufactured products exist?
   A. If so, why?
   B. Would they apply to the new product?
   C. If so, how could they be overcome and what would it cost to do so?

3. Do marketing and distribution facilities for the product exist?
   A. If not, can they be set up?
   B. What would it cost to do so?

4. Will the product be sold to:
   A. Wholesalers?
   B. Retailers?
   C. Direct to consumer?
   D. Other industries?
   E. Government?

ECONOMIC FACTORS

1. How much foreign exchange (and in what currency) is required to import machinery, equipment and supplies:
   - A. How much foreign exchange (and in what currency) is required for annual interest payments and amortization of any loans contracted to import machinery and equipment, or for payment of royalties and technical services?
   - B. How much foreign exchange (and in what currency) is required for annual import of raw materials and supplies?
   - C. What are estimated annual foreign exchange earnings and in what currencies?
   - D. Has careful consideration been given to the possibility of depreciation in the foreign exchange value of the local currency?
   - E. Has careful consideration been given to the possibility of import controls, or restrictions on availabilities of foreign exchange necessary to operate the business?
   - F. What benefits would the new business bring to the economy in the use of local raw materials: in employment and in technology?
   - G. Do dependable facilities exist for transportation, power, fuel, water and sewage?
     - (1) If not, can existing deficiencies be eliminated satisfactorily?
     - (2) What would be the cost to do so?

PERSONNEL

1. Is there an adequate labor supply near the plant location?
   - A. If not, how can the problem be solved?

2. Can the problem of training competent management and supervisory personnel be solved?
   - A. Also, the training of skilled labor?
   - B. Is technical advice available in the locality?
   - C. If not, where can it be obtained and what will it cost?

LAWS AND REGULATIONS

1. Do existing labor laws, government regulations, laws and taxes favor establishment of new business?
   - A. If not, can existing obstacles be removed?
   - B. If so, how and when?

FINANCIAL FACTORS

1. Technical advice on selection of machinery and equipment.
   A. In selecting the machinery and equipment for the new plant, have reputable and competent engineers and technicians been consulted?
   B. Have they been asked for advice on the most suitable types of machinery and equipment for the process and locality?
   C. Have they carefully compared costs of various suppliers?
   D. Credit terms offered purchasers?

FINANCIAL REQUIREMENTS OF THE PROJECT:

1. In estimating the cost of the project, has careful consideration been given to:
   A. The effect on costs of delays in construction schedules?
   B. In delivery and installation of machinery and equipment?
   C. In import of essential raw materials and supplies?

2. In calculating cash flow and working capital requirements, has careful consideration been given to:
   A. Maintaining adequate inventories of raw materials?
   B. Supplies and spare parts?
   C. Seasonal fluctuations in the business?
   D. The time required to liquidate credit sales to customers and bad debts?
   E. The period necessary to get the plant into production?
   F. Cash required to amortize its principle loans?

3. If the economy is in a period of inflation, has full allowance been made for the influence of rising prices and wages on the cost of the project and on working capital requirements?

SHORT TERM BANK CREDITS

1. Has it been possible to make arrangements with local banks to finance short-time working capital requirements of the business?

FINANCIAL PLAN

1. Has a definite plan to finance the project been worked out?
   A. Is sufficient capital available locally?
   B. If not, what is the plan to obtain the required capital?

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Textbook

Manual on Fertilizer Manufacture — Davison Chemical Company, Baltimore, Maryland

Periodical

Miscellaneous publications — The National Fertilizer Association, Washington 5, D. C.

ABBREVIATIONS

°F	Degree Fahrenheit
%	Percent

APPENDIX IV -- ILLUSTRATIONS:

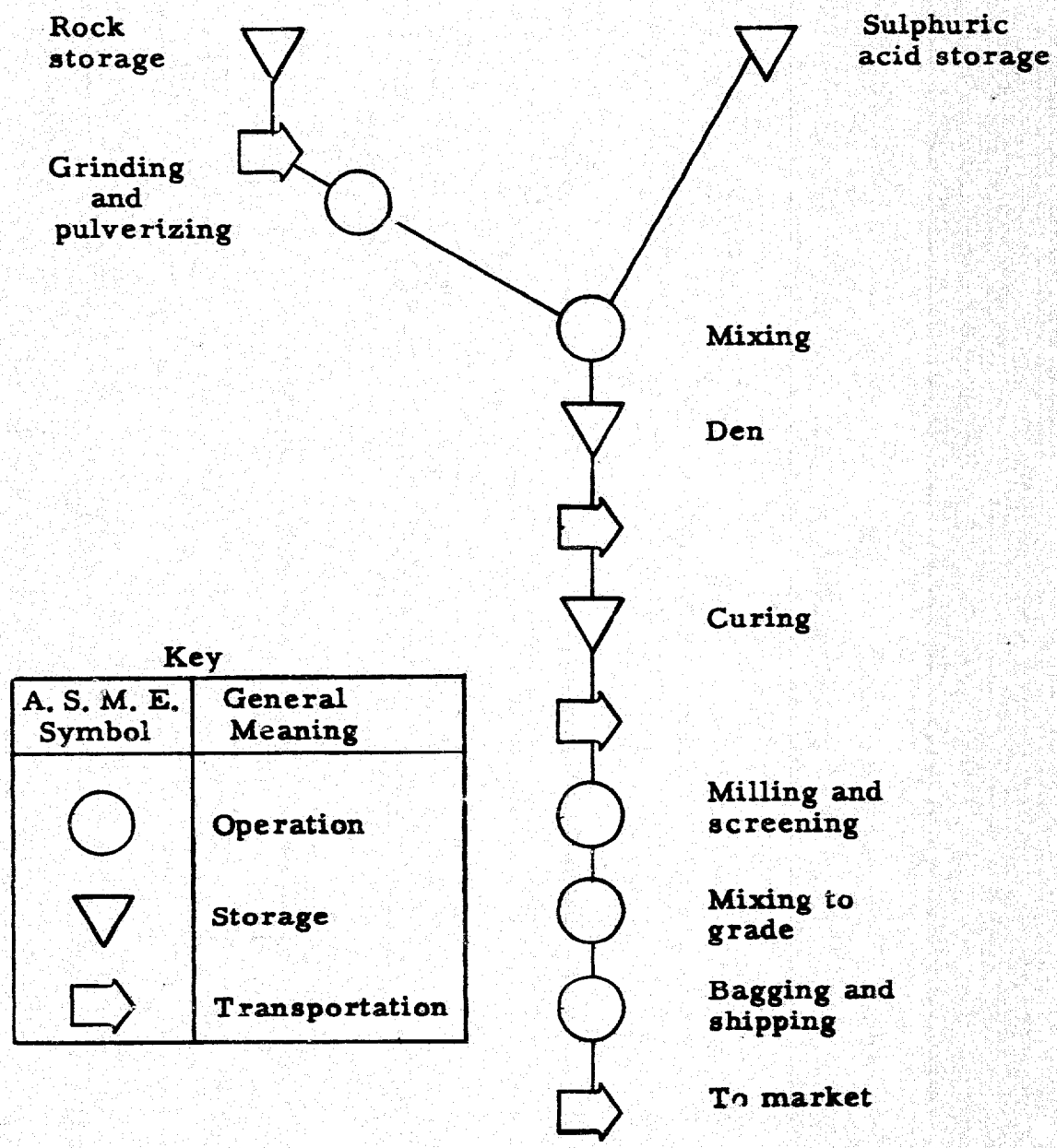
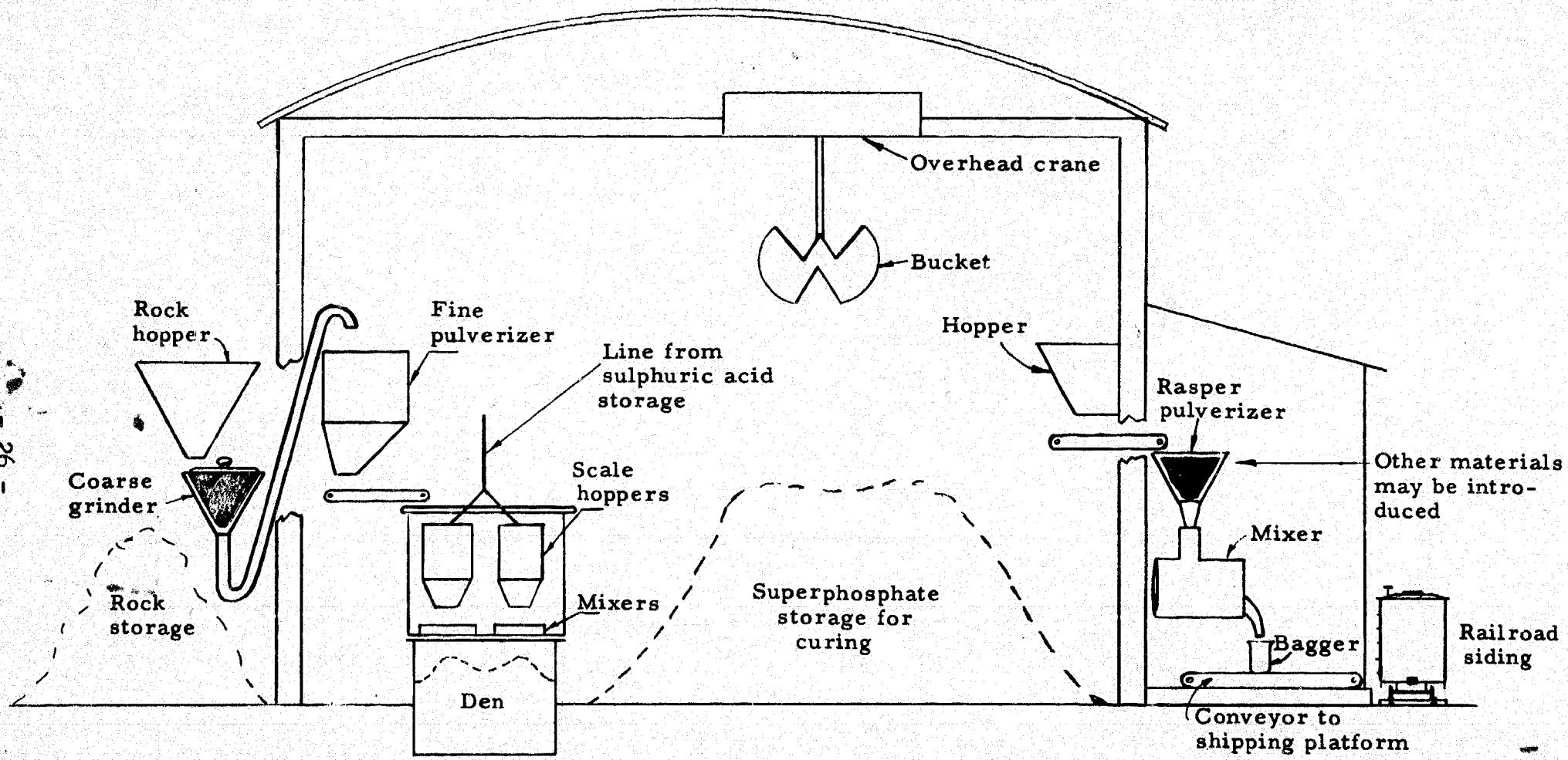


Figure 1 - Diagram showing how phosphate rock is processed to superphosphate



NOTE: Main building 70 feet wide, 300 feet long, 30 feet high at sides.
Storage capacity dependent upon length of building.

Figure 2 - Schematic diagram of superphosphate plant

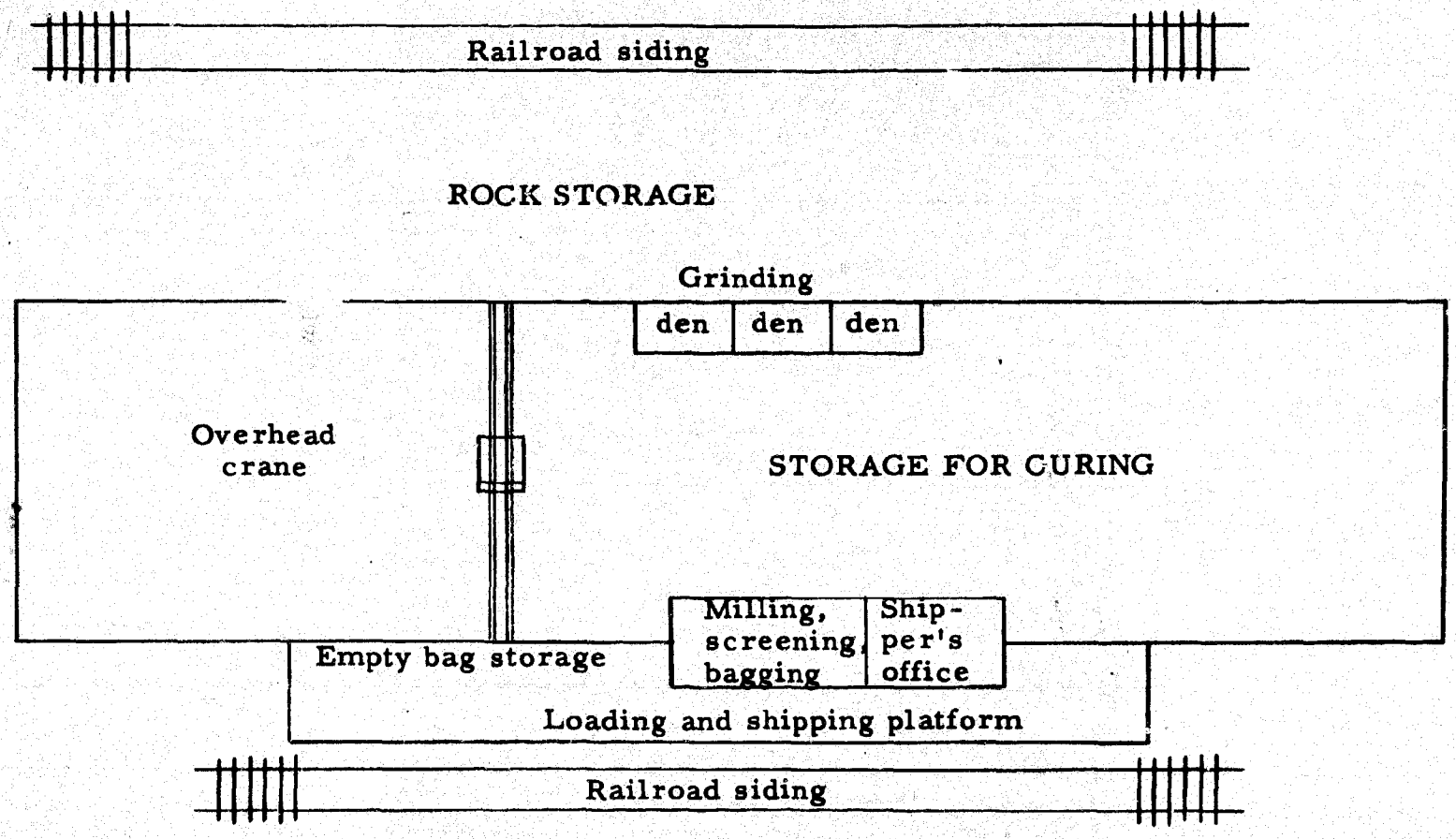


Figure 3 - Preliminary plant layout

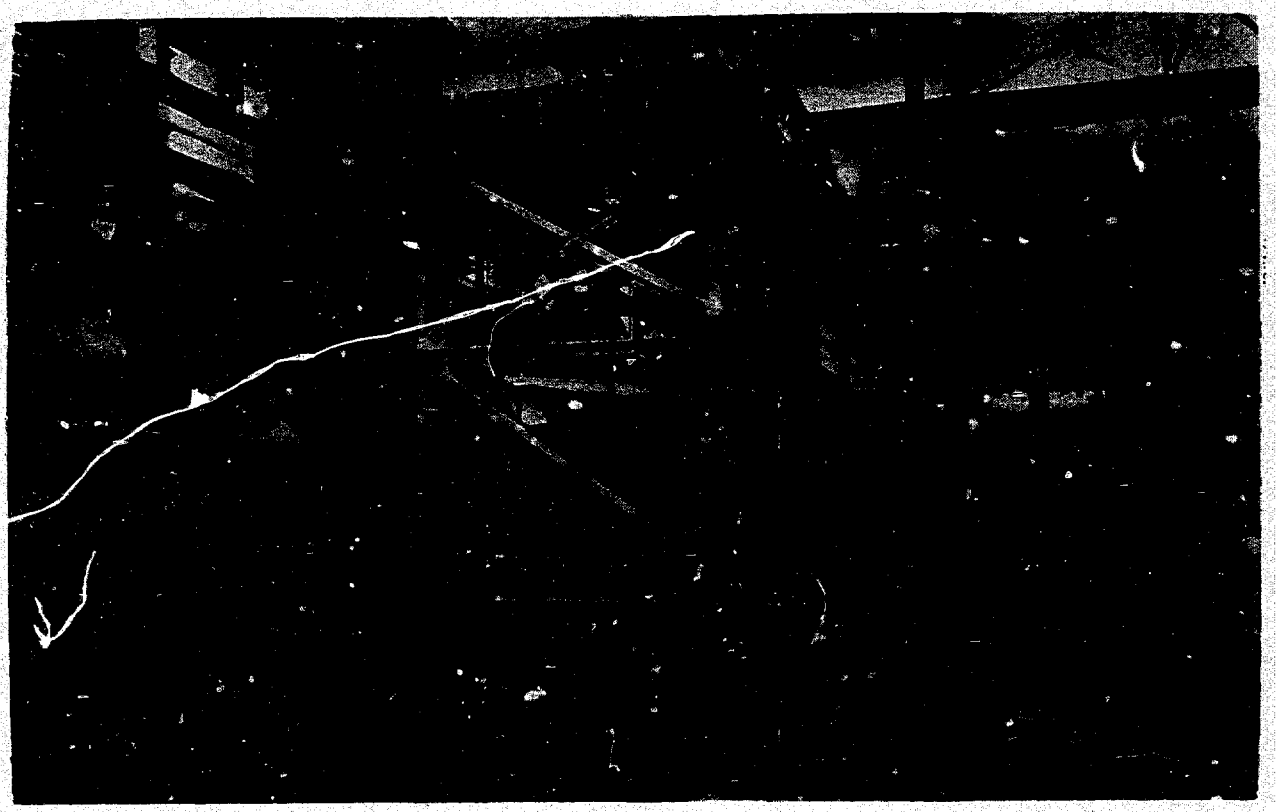


Figure 4 - A mechanical mixing platform where rock dust and sulphuric acid are mixed and dropped into a den beneath

Figure 5 - Overhead crane servicing storage bins

Figure 6 - A superphosphate storage bin

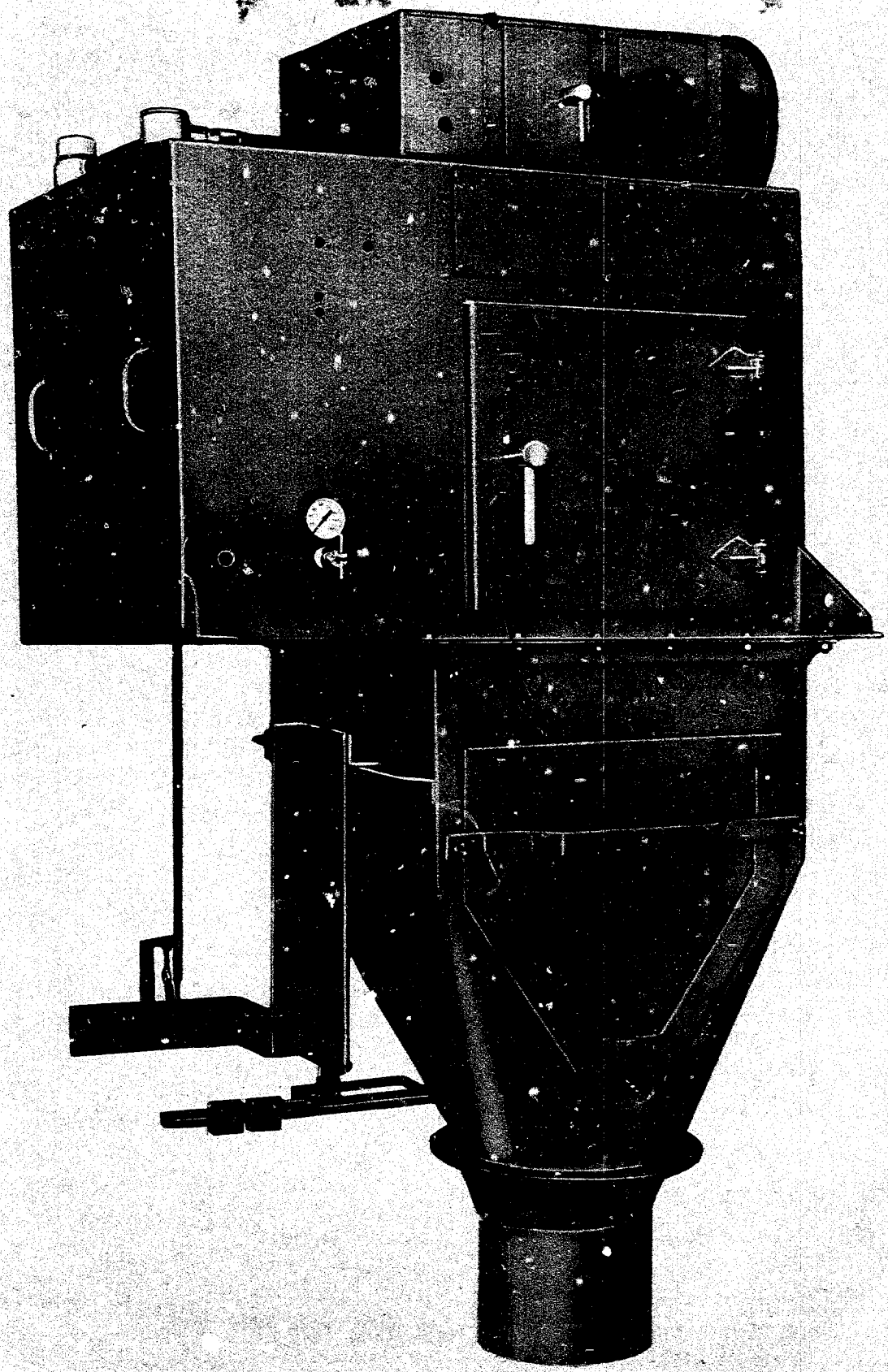


Figure 7 - Automatic bagging scale.

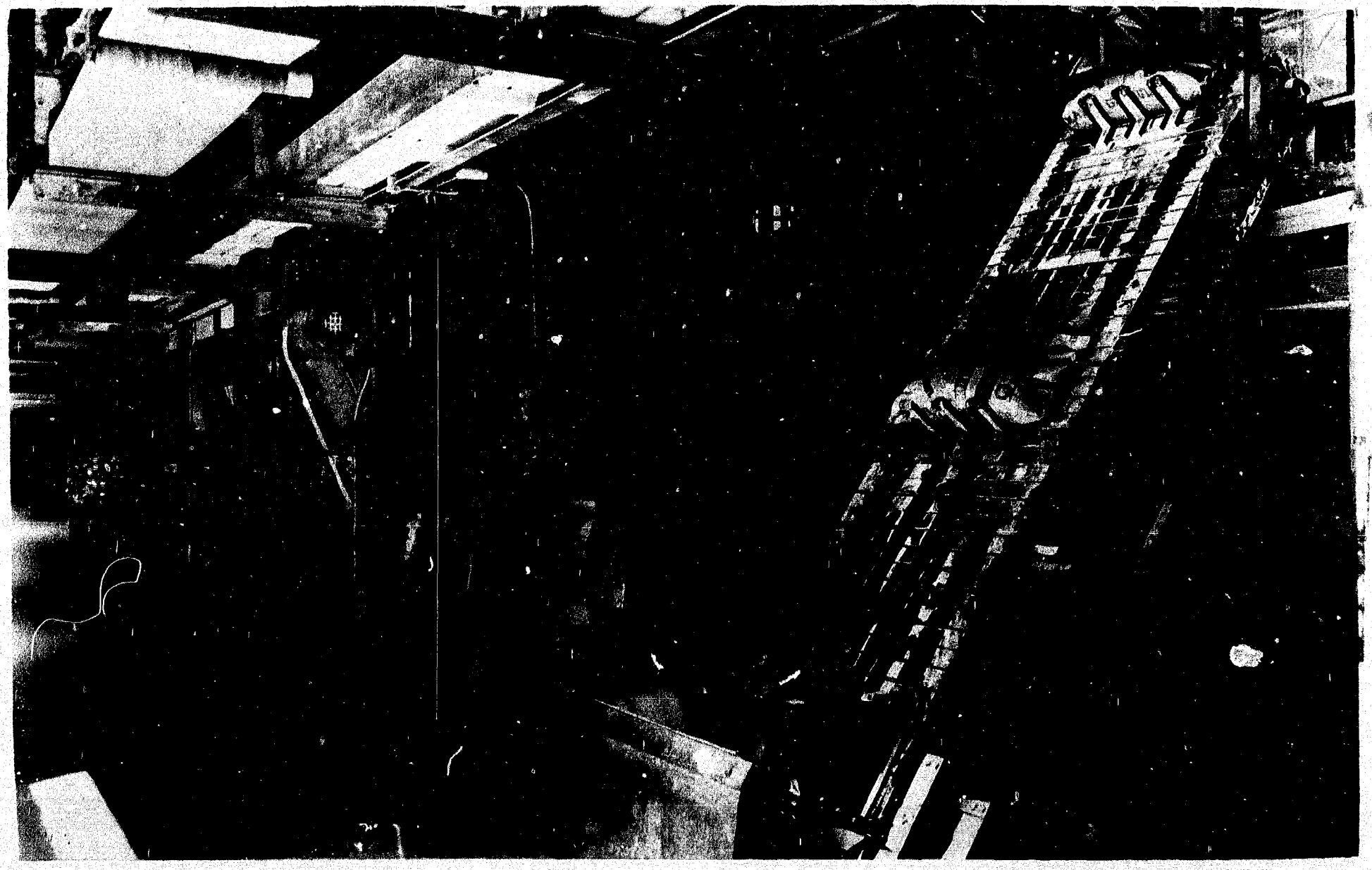


Figure 8 - Conveyor for elevating bagged superphosphate

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