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UNIDO Meeting on the Development of the
Fertiliser and Pesticide Industries in
Latin America
(in collaboration with ECLA and the Government of Brasil)

Rio de Janeiro, Brasil, 16 - 20 November 1970

REPORT AND PROCEEDINGS [1]

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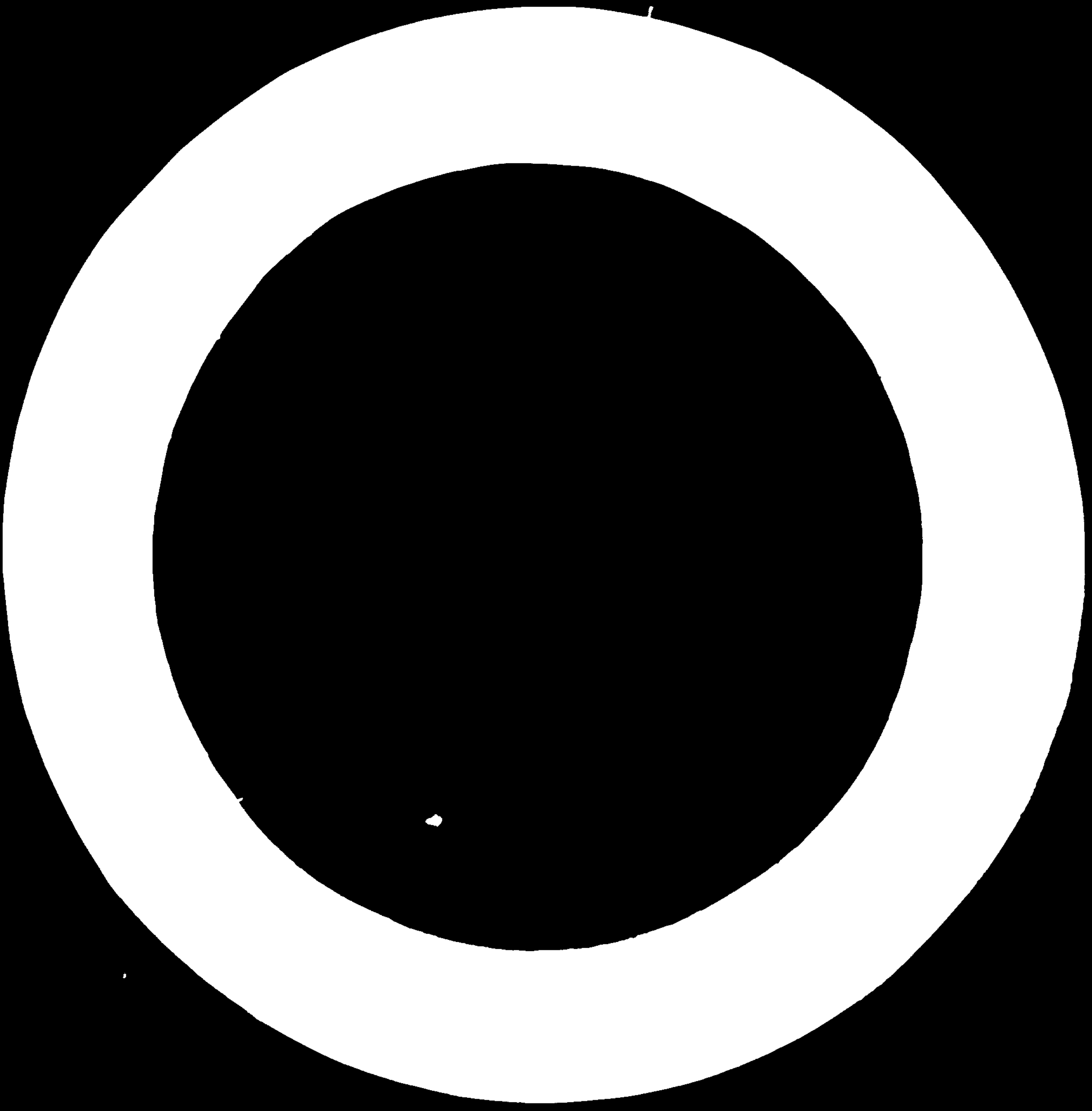

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I. Introduction

The Meeting for the Development of Fertilizer and Pesticide Industries in Latin America was held from 16 to 20 November 1970 in Rio de Janeiro, Brazil. The Meeting was sponsored by UNIDO in co-operation with the Ministry of Agriculture and Commerce and the United Nations Economio Commission for Latin America. It was convened for the purpose of assessing the status of the fertilizer and pesticide industries in Latin America, identifying problems in the development of these industries, and exchanging technological information. There were a total of 90 persons in attendance as participants, consultants, or observers from Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Guyana, Haiti, Honduras, Paraguay, Peru, and Uruguay.

Opening remarks were presented to the Meeting by Mr. Alberto Tangari, General Secretary of the Industrial Development Counoil of the Ministry of Industry and Commerce. The inaugural address was presented by Mr. Luis de Magalhaes Betelho, General Seoretary, Ministry of Industry and Commerce, in the name of His Excellency, Minister Marcus Vinicius Pratini de Moraes.

Mr. José Drummond Goncalves, President, Assoçiacão Nacional para Difusão de Adubos, was elected as Chairman of the Meeting and presented a statement. Mr. Paulo Vieira Belotti and Mr. Paulo Berragat served as rapporteurs. Mr. Roberto Meirelles de Miranda, representing the Minister of Agriculture, His Excellency Mr. Luiz Fernando Cirne Lima, and Mr. Verghese, representing UNIDO, delivered closing remarks on 20 November 1970. The Resident Representative of UNDP Mr. E. Albertal and the Senior UNIDO Industrial Development Field Adviser, Mr. R. Bonini, assisted in the organization of the meeting and participated.

The agenda of the Meeting, list of participants, reports and papers presented are given in the Appendices.

A background paper "Preliminary Survey of the Fertilizer Situation in Selected Countries in Latin America - Availability of Raw Materials, Description of Production Facilities and Historical and Projected Supply and Demand" was presented by Mr. M.C. Verghese, Chief, Fertilizer, Pesticides and Petrochemicals Section, UNIDO.

Country reports on the status of the fertilizer and pesticide industries were presented by representatives of Argentina, Bolivia, Brasil, Chile, Colombia, Costa Rica, Dominican Republic, Guyana, Haiti, Peru, and Uruguay.

Papers presented by UNIDO consultants included the following:

1. Import of New Technology on the Development of the Fertiliser Industry in Latin America - Mr. A.B. Phillips, National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Alabama, USA

2. Review of Pesticides and Their Formulation - Mr. M. Adham, Velsicol Chemical Corporation, Beirut, Lebanon

3. Wet-Process Phosphoric Acid as a Basic Fertilizer Ingredient in International Trade - Mr. Albert M. Close, Fertilisantes Fosfatados Mexicanos, S.A., Sao Paula, Sao Paulo, Brasil

4. The Fertilizer and Pesticide Industries in Latin America - Mr. Roberto Petipas, U.N. Economic Commission for Latin America, Santiago, Chile

5. FAO's Fertilizer Programme - Mr. Juan Ignacio de la Vega, FAO Fertilizer Programme, Rio de Janeiro.

II. Recommendations

1. Taking note of the analysis of the UNIDO document "Preliminary Survey of the Fertiliser Situation in Selected Countries in Latin America - Availability of Raw Materials, Description of Production Facilities and Histrorical and Projected Supply and Demand" from which it was seen that statistical tables contained therein required more detailed information;

Considering that among the Latin American countries there does not exist, as yet uniformity in the criteria used in the compilation of statistics on fertilisers and agricultural chemicals;

Recommended:

That Latin American countries should adopt a uniform system for the preparation of statistics on a calendar year basis.

2. Considering again the above referred UNIDO document, it was recommended that Latin American countries represented at this Meeting be requested to send to UNIDO as soon as possible information concerning fertiliserr in order that the document may be up-dated.

3. Considering the UNIDO document "Preliminary Survey of the Fertiliser Situation in Selected Countries in Latin America - Availability of Raw Materials, Description of Production Facilities and Historical and Projected Supply and Demand" from which it was noted that statistical tables contained therein required more detailed information;

Considering that delegates from Latin American countries attending the Meeting have agreed to take necessary measures for revising the statistical tables contained in this document;

Considering that these delegates understand that identical measures should be taken by Latin American countries which, although invited, were not present at the Meeting;

Recommended:

That UNIDO contact the countries which, although invited, were not represented at the Meeting in order to obtain from them fertiliser statistics that may help in the completion of information contained in the UNIDO document.

4. The detailed exposition made by several delegates present at the Meeting concerned the difficulties existing in their countries relative to establishment of better conditions for the expansion of fertiliser consumption;

Among the more significant impediments to the acquisition of fertilizers at reasonable prices has been the small credit facilities given by suppliers;

It was therefore recommended that Latin American countries and international organizations concerned with the subject colaborate more in order to obtain better financial opportunities that will permit such countries to buy fertilizers at reduced prices.

5. Considering that the Government of the Argentine Republic is seriously concerned about the cancellation of certain exports of agricultural products due to the presence of pesticides residues higher than those established by the importing countries and by the Comissão Codex de Alimentacão;

Cosidering that the delegation from Argentina understands that the factors causing a higher or smaller rate of residue quantities are: climate, evolutionary cycle of pests, quantities applied, number of applications made, length of storage, etc., all of them different, according to the various ecologic zones;

Considering that, consequently, it is most necessary that studies made on pesticides residual effects be made in the same area of application or in consultation with them;

Considering that such effects cause prejudice to human and animal health, affecting the marketing of agricultural products to different countries;

Recommended:

That UNIDO should suggest that the countries producing pesticides study analytically, in their application zones, the residual effects of products recommended by the industries, never losing sight of the possibilities of the users producing their crops within the tolerance limits set by the legislation of importing countries and/or by the Comissão Codes de Alimentacão.

6. The difficulties experienced in exports from Latin American countries, especially of cattle products, that have been caused by the very narrow limits imposed by the importing countries concerning the residue levels of pesticides were considered;

For the economy of the countries affected, the export of such products constitutes an important part of their foreign exchange income;

Considering, as well, that concerning the toxic effect of chemical residues mammalian tissues there is no research accurate enough to determine these losses;

Recommended:

That the governments of Latin American countries take part in international committees dedicated to this subject with a view to make possible at their level, studies of such tolerances, enabling them to reach an understanding with the importing country to stipulate the levels accepted as normal or justifiable of pesticide residues in foods.

7. Considering that in many Latin American countries there is insufficient market for pesticides to justify the installation of production plants;

Considering that although a country may have a market large enough to justify the establishment of an agro-chemical industry, but which in reality would also require products that may not be produced in the same facilities;

Considering that in the pesticide field there exists a great inconsistency in the application of agriculture chemicals either for lack of acceptance or because pests often develop a strong resistance to such products;

Recommended:

That before constructing plants for technical grade products and basic raw materials for the pesticide industry, careful analyses be made of the market in its various aspects, always keeping in mind the experience of organisations which, after having set their positions in the market, have been forced to diversify their production into products other than pesticides.

8. Considering the need for developing fertiliser consumption in Latin American in order to generate a greater economic progress through increased agricultrual productivity;

Considering that in many instances no technical information is available concerning the installation of industries for fertiliser production;

Recommended:

That the international organisations concerned with research in fertiliser technology enlarge their technical assistance to these countries in their field of speciality, as well as in the preparation of programmes designed to increase fertiliser consumption.

9. Some Latin American countries have conditions suitable for the installation of facilities for fertiliser production;

Considering their concern with the fact that these products should be supplied to farmers at low costs;

Recommended:

That upon examination by the international organisations of projects for the installation of a fertilizer industry they should always include a study of raw materials and finished products transportation in order to facilitate reaching better decisions concerning the location of these units.

10. The need to enlarge the information network on the fertiliser industry as a means of improving exchange of information on investment is necessary;

Considering that the institution of a systematic procedure which will make possible the periodic up-dating of statistical data connected with this sector constitutes a measure that may facilitate the implantation of projects in these countries;

Recommended:

That the governments of Latin America try to furnish periodically information to UNIDO on the development of fertilizer projects so that it can maintain a centre of information on the subject.

11. Latin American countries wish to enlarge their economies through the introduction of better prospects for progress in their agricultural and industrial sectors;

Considering that the complete development of a country, either in terms of natural or human resources, constitues a national objective;

Considering that commercial organisations could make their contribution by offering their technical and financial assistance for the development of the country in which they are operating;

Recommended:

That all fertiliser and pesticide manufacturers here represented give special attention to the socio-economic stiuation of the agricultural sector of the developing countries, as well as encourage their associates (directors, managers, executives, and experts) to identify themselves with the agronomic community in order to understand better their problems and aspirations, thus promoting a more versatile interest in industry and agriculture.

12. The need for some Latin American countries for promoting by several means the expansion of fertilizer consumption in order to attain higher rates of productivity in the agriculture sector was emphasised;

Considering that the experience already obtained by FAO in Brazil, as well as in other countries, in setting out programmes of research and demonstration on fertilizer application through the colaboration of private and official organizations and the support of the Advisory Committee of the Indternational Fertilizer Industry;

Recommended:

That the governmente of Latin American countriee study the possibility of creating adequate oonditions for the establiehment of the Fertiliser Programme FAO/FFHC in accordance with their epecial conditions.

13. The great interest demonstrated at this Meeting in the work that is being carried out by the Control of Pestioides Residues established at the Biological Inetitute of Sao Paulo, Braeil, with the co-operation of FAO was noted;

Considering the con ern expressed by delegates of some Latin American countriee ooncerning problems they are facing in the exportation of cattle porducts;

Recommended:

That FAO extend this type of assistance to other Latin American oountries in order to increase the possibilities of installing laboratories for the control of toxic residues.

14. Delegatee from Latin American countrise present at the Meeting appraised the usefulness of the training oourses on pestioides organised by UNIDO and carried out at the University of Syracuse in the United States;

Considering that experte from Latin American oountriss have more training and experience in the pesticide field;

Recommended:

That UNIDO continue in the coming years to support the execution of seminars on pesticides at the University of Syracuse or elsewhere, so as to allow a greater number of Latin American countries to benefit from this training, establishing a continuity, from year to year, in the study of the specific problems of each nation.

15. In this Meeting the courses on fertilisers carr'ed out at Muscle Shoals by the Tennessee Valley Authority, usually sponsored by USAID, were appraised;

Considering that expe.ts from Latin American countries need to obtain more experience in the fertiliser section;

Recommended:

That the governments of Latin American countries exert all efforts in order that these courses may allow a larger number of countries to benefit from them, requesting that TVA continue to render such valuable assistance in the years to come.

16. Considering that through the many convorsations held on fertilizers the delegates from Latin American countries were able to solve some problems that have affected the development of the industrial sector;

Considering that among these problems the need for central and up-to-date information on demand, production, prices, and others are outstanding;

Considering the isolated character of efforts made by some countries regarding:

- exploration of natural reserves
- selection and adaptions of technology for the development of production
- access to the international market of raw materials, finished and intermediate products;

Considering the inadequacy of efforts made up to the present, in terms of complementation and commercialization of such products;

Considering that exports destined for the international market require the intergrated efforts of all countries, and in view of the growing influence of the international producers associations;

Recommended:

That governments of Latin American countries consider the viability of promoting the formation of a group, on a regional basis, in which fertilizer manufacturers participate and that ECLA '(Economic Commission for Latin America) take the necessary initiative to achieve this objective.

17. The fertilizers and pesticides industries developed towards the production of highly concentrated products that may affect the microbiology of the soil;

Considering that, so far, there is not definite technical information on the subject;

Recommended:

That the fertilizer and pesticide industries keep their agronomic experts alert concerning these aspects and report on the effects of intensive use of fertilizers and pesticides on soil life and that FAO undertake studies on the intensive use of fertilizers and pesticides and their effects on the soil life in order to preserve and improve its fertility.

III. AGENDA

<u>16 November</u> Morning Session	Registration Presentation of the meeting Inaugural address Election of Chairman and Vice-Chairman Election of rapporteurs Address of the Chairman Approval of agenda Status of Fertilizer and Pesticide Industries in Latin America U.N. Economic Commission for Latin America (Also Preliminary Survey of the Fertiliser Situation in Selected countries of Latin America - background paper prepared by UNIDO)
Afternoon Session	Report from Argentina Report from Boliva Report from Brazil Addresses of rapporteurs
<u>17 November</u> Morning Session	Report from Chile Paper on Pesticides Report from Colombia Report from Costa Rica
Afternoon Session	Report from Dominican Republic Report from Ecuador (Speaker not present) Report from Guyana Report from Haiti
<u>18 November</u> Morning Session	Import of New Technology on the Development of the Fertilizer Industry in Latin America Report from Peru

Afternoon Session	Report from Uruguay Report from Venezuela (Speaker not present) Summary of country reports
<u>19 November</u>	
Morning Session	Wet-Process Phosphoric Acid as a Basic Fertiliser Ingredient in International Trade
Afternoon Session	Departure for Be fort Roxo Visit to Bayer's factory Lunch at Bayer
<u>20 November</u>	
Morning Session	General review, discussions, recommendations and report
Afternoon Session	Closing remarks. Informal discussions. Closing speech.

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V. ADDRESSES TO THE MEETING

Address by the General Director of the Research and Experiments Office, Mr. Roberto Meirelles de Miranda, representing the Minister of Agriculture in the closing solemnity of the Meeting.

Gentlemen;

I have the honour of representing His Excellency the Minister of Agriculture, Professor Luiz Fernando Cirne Lima, in the closing solemnity of this Meeting. I wish to congratulate the Ministry of Agriculture for the conduct of the Meeting and the importance it represents to the activities connected with agriculture in Brazil and in the countries of Latin America.

The participation of international experts in this meeting suggests some consideration of the remarkable evolution in the Brazilian market for fertilizers and agriculture protective chemicals.

It is valid to say that along with the expansion of financial resources to sell fertilizers to farmers, the Government reinforced the FUNFERTIL operations. This fund is destined to absorb the financial costs of the operations, thus reducing fertilizer prices for consumers.

These measures, along with the policy of securing minimum prices for rural products and grater support by the Government Authorities for a credit policy for agricultrue, either in purchasing or in marketing, were translated into greater confidence of the farmers in the intensified use of modern inputs. Here we remind you that in about three years the Brazilian market has doubled in terms of NPK. In this respect, the importance of the research measures in the Brazilian Agriculture should be stressed. This research indicated the fertilizers and crop production chemicals needed and made available to farmers a prompt analysis of the soil through a network of 20 laboratories. This network analysed, just last year over 300,000 samples across the country.

The fertilizer market outlook in Brazil is improving and the national industry will be able to attend the requirements, producing at competitive levels with foreign products when supported by an infrastructure capable of assuring the distribution of the products.

Regarding input prices for the farmer, it is necessary to mention that a very clear and definite position on the part of the Brazilian Government exists. Apart from the need to intensify,more and more, the modern technology in the field, it is imperative that the costs of agricultural chemicals, as well as fertilizers, be reduced.

What has been observed and attempted to be corrected is that agriculture prices are being raised at a much lower rate than prices in general. And this is a situation that has to be altered, in a country like Brasil, where agriculture absorbs about 50% of the labour, contributes approximately 22% of the bulk domestic products and is responsible for over 70% of the exports.

One way to strengthen the agriculture sector, of such importance to the national economy is, no doubt, to reduce the input costs, in order to make them more accessible to the farmers.

Concerning agricultural chemicals, the Government is attentive to the residue problem, trying to maintain it at permissible levels by adopting practices of correct application in agriculture and in cattle breeding. The Ministry of Agriculture is administering the laws and rules on the subject in order to keep pace with the technical evolution and the Government's agriculture policy.

On the other hand, the Government adopts measures to stimulate the national production of agricultural chemicals by not favouring the importation of products similar to the ones produced locally by Brazilian firms or that contain a low percentage of active igredients.

This picture, gentlemen, demonstrates that Brasil has been encouraging its rural producers to increase their productivity by utilising better technology. At present, the Brazilian Government is engaged in a large campaign of incentives to agricultural productivity and, thanks to prompt acceptance by farmers, can here be said to have had complete success.

This campaign, based on research, rural extension and agriculture credit, will bring, no doubt, a vigorous incentive to the consumption of protective chemicals and fertilizers.

This, gentlemen, is the position that His Excellency, the Minister of Agriculture wished to transmit to all participants of this meeting. For health reasons, he was not able to be present. The honour of representing him, fell on me to express his satisfaction for the presence, in Brazil, of such renowned experts and to extend his wish that the work of this meeting will be fruitful to the Latin American agriculture.

To everyone, my thanks.

Adress by the President-Director of the
Associação Nacional para Difusão de
Adubos (ANDA), José Drummond Gonçalves,
after being elected Chairman of the
Meeting.

Dr. Luiz de Magalhães Botelho, representative of the Minister of Industry and Commerce, Marcus Vinicius Pratini de Moraes, Mr. Eduardo Albertal, permanent delegate of the United Nations in Brazil, Dr. M. C. Verghese of the United Nations Industrial Development Organization, Delegates of the countries represented in this Seminar, Brazilian experts, Gentlemen:

Economic development is the process by which an attempt is made to increase, in a constant way, the "per capita" income of the population.

Along with this process come structural modifications that will affect with more or less intensity all economic sectors.

Although in the majority of the cases known this development has been experienced more spectacularly in the industrial field, it is necessary to say that to agriculture is given a role of importance also and of a fundamental nature.

On the other hand, we know that the countries financial status, in several phases of the development, presents also as a characteristic, the concentration of labour in farming activities and, since these activities are responsible for the formation of a greater part of the income, it is only natural that for their economic improvement better conditions in this most important sector must exist. To this sector is given fundametal work that, once completed, will promote the possibilities of self-generating development.

However, the inability of agriculture, in many instances, to perform its function may cause a halt to the march necessary to economic progress.

Generally the agriculture sector tends to lag behind other sectors, since its products are developed through a slow process of adaptation to the growing demand represented by the requirements of domestic consumption and the generation of foreign currency through export.

The growth rate of domestic consumption tends to expand significatively in initial Development stages, this being a result of demographic expansion and of an elasticity of demand. At the same time, the growing industrial sector begins to depend on growing quantities of raw materials needed, asking from the country a larger importing capacity that depends on the importation of primary products, the demand for which in the international market is rather inelastic.

Progress in the agriculture production may be achieved through the larger utilization of the soil, labour and capital or also through increases in productivity. Increases in productivity depends, above all, on the use of improved seeds, better cultivation techniques, fertilizers, protective chemicals, etc.

The country's awareness of this financial truth turns this work into one of great importance, recognised by all governments and industries, and places this sector in the primary position it deserves.

This meeting is the result of a recommendation made at a Symposium in Athens, when the UNIDO decided to assume the responsibility of promoting periodic meetings, that would study national programmes of supply and demand for fertilisers and insecticides, thus attempting to create better perspectives for the development of the industries producing these inputs.

It was, therefore, with the interest of promoting this analysis in Latin America, that this organisation of the United Nations, in cooperation with the Ministry of Industry and Commerce of Brazil, established the basis for conducting this Seminar, which brought to our country a healthy feeling of patriotism.

The government and private entities have joined forces and the basic conditions for the course of this meeting were immediately established, leaving everybody xpectant with anxiety for the beginning of the work.

Now, we are together here trying to dedicate our enthusiasm, our professional capacity and our goodwill to the examination of papers that will be presented by the delegates, so that at the end will be formulated a résumé of the problems f the Latin America region, reaching, we expect, a formulation of general recommendations for the nations represented here, thus complying with UNIDO's objectives.

I accept, as an imposing responsibility, the office of Chairman of this eminar and will try to act in accordance with the importance of the initiative, doing everything possible to achieve the objectives of the organisations that ave sponsored it.

I conclude by wishing, in the name of the Associação Nacional para Difusão de Adubos, an entity that represents the majority of the fertilizer producers in Brasil, and which I am representing here, to welcome all present with good wishes for a happy stay among us. I hope these words represent the enthusiasm felt in Brazil for being the host to delegates from neighbouring countries that have come to devote attention to the industrial progress of the fertilizer and insecticide sectors and to the agriculture expansion motivated by this development.

Inaugural speech by Mr. Luis Magalhães Botelho, General Officer of the Ministry of Industry and Commerce, representing the Minister, Marcus Vinicius Pratini de Moraes at the International Fertilizer Seminar.

Gentlemen,

It is a great satisfaction for us to open in the name of his Excellency the Minister of Industry and Commerce, Mr. Marcus Vinicius Pratini de Moraes, the work of this Seminar, the objective of which is to discuss the problems relative to the fertilizer and pesticide situation in Latin America.

Our satisfaction is even greater, since the honour was bestowed on Brazil of being the host to this conclave and receiving the delegates of several nations of the Latin America continent, with which our country has always had a fraternal friendship and mutual respect.

At this opportunity, we wish to emphasize the importance given by the Brasilian Government, through its entities, to the subjects that will constitute the themes of the work and discussions that will take place here. From them we will draw conclusions that will, no doubt, be of real value for the solutions searched by our countries in such important sectors of the economic activity.

We consider as a specific point the understanding that the incentive to agriculture productivity is a fundamental instrument of development, through which the equilibrium and integration between the rural and urban activities will be attained. The attainment of this objective depends, in great part, on the intensive utilization of fertilizers in order to be able to achieve maximum return from the soil.

For this reason, among the great objectives of the economic development policy of the country, is included the expansion of our production capacity of basic nutrients, along with protective chemicals and pesticides, with constant attention to procurement at low costs so as to make their application attractive and rewarding in the domestic agriculture.

It was considering this succession of ideas that the Brasilian Government decided, as from 1964, to create an organization specifically in charge of the promotion and development of the chemical industries in the country, including the fertilizer and pesticide industries, by creating fiscal, credit, exchange and tariff incentives that were simultaneously instituted for this purpose.

This work was given to the Executive Group of Chemical Industries - GEIQUIM - of the Ministry of Industry and Commerce, which, since then, has been coordinating the application of such incentives, making possible a radical transformation in the structure of the fertilizer supply to the Brazilian agriculture.

The work carried out by the Associação Nacional para Difusão de Adubos and by the producers and commercial firms to stimulate the growing consumption should also be mentioned. This joint action resulted in an extraordinary expansion of our domestic market.

Ending these brief remarks, we wish to welcome the participants of this meeting and thank UNIDO and the other entities that made possible the realisation of this conclave, the work of which will be of great value to the progress of the industry and agriculture of the country.

VI. CONCLUDING REMARKS

by

M. C. VERGHESE - UNIDO

Mr. Chairman, Ladies and Gentlemen,

At the conclusion of our meeting, it is my privilege to say a few words.

Our thanks are due to Prof. Roberto Meirelles for his presence in this closing meeting.

I wish to, first of all, thank the Government of Brasil and the Ministry of Industry and Commerce for the excellent arrangements made for the meeting. The efforts of Dr. Tangari in this connection is greatly appreciated. To you, Mr. Chairman, to the Vice-Chairman and the Rapporteur, should be given full credit for the successful execution of the meeting. Our special thanks are due to Mr. Petitpas from ECLA, Dr. Yates, Dr. Goodwin and Dr. Prasard from the FAO S.F. project for attending and contributing to this meeting and to the representative of FAO in the FFHC campaigns. To the Consultants to UNIDO, Dr. Philips, Dr. Zweig, Dr. Paul Hoffman and Dr. Close, I say we appreciate your cooperation. Dr. Albertal, UNDP resident representative and Dr. Bonini, assisted us very much in all our efforts. But for Dr. Bonini's efforts, the meeting would not have even taken place.

I hope that the participants to this meeting from the different countries of L.A. and from the host country and all the observers have gained some insight into the problems of the fertiliser and pesticides industries and could learn some lessons from each other's experience. Our thanks are due to each of them. It is hoped that UNIDO and the participants will continue the contacts established here and the countries of L.A. will be able to activate their efforts in getting the required assistance from UNIDO, as and when necessary.

We have seen the excellent work done by all members of Mr. Tangari's team, the interpreters and secretaries. The help and assistance of Dr. Luis to many participants is greatly appreciated.

We have enjoyed the atmosphere of this beautiful city and the hospitality of the Brasilian people and the industry. The visit of participants to the Bayer project was highly appreciated.

I wish all of you now a pleasant return to your home countries and to your responsible duties. Thank you Mr. Chairman.

1. IMPORT OF NEW TECHNOLOGY ON THE DEVELOPMENT OF THE FERTILIZER INDUSTRY IN LATIN AMERICA

by

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It is natural and wise for a country in the early stages of developing a viable fertilizer industry for support of needed expansion in its agricultural base to look around at what the rest of the world has done and profit from this experience. Many Latin American countries are in this position. They have reached the point that the need for higher quality fertilizers in increasing quantities is apparent. They find that the search for the optimum in providing these needs is indeed a complicated process that involves consideration of many factors. Because of vast differences that exist, it is dangerous to assume that the optimum can be achieved by simple transfer of technology from one country to the next without careful consideration of these differences. Yet optimization is essential because even when the resource base is large, capital is usually limited and there is always severe competition for this capital for other phases of development.

Many decisions must be made in structuring projects that will fit into an optimum pattern for a fertilizer industry. Some of them are the scale of the operation, whether the higher analysis fertilizer made possible by newer technology will be advantageous, whether the import of certain intermediates is preferable, and what process routes should be considered. Also, the possible effect of new fertilizers being developed must be taken into consideration in present planning. The task assigned to this paper is to discuss in a general way some of the factors that must be taken into consideration in arriving at these decisions. It cannot make the decisions, of course, because they can be made only after intensive study of local situations.

The Effect of Scale

The question of how large to build a project is foremost in the planning process. Any engineer who is to become involved in chemical processing learns early in the course of his education that the investment cost in processing plants per unit of capacity generally decreases as the capacity of the plant increases. Thus, from the point of view of low unit investment cost there is an incentive to increase the size of plants to the greatest extent possible.

The general rule for the relationship between investment cost and capacity is that the investment cost increases exponentially as the 0.6 power of the capacity. A study by Guthrie (1) attests the validity of this old rule of thumb, giving data that averages 0.64 for 54 different chemical process plants. However, the range varied widely from 0.40 to 0.83, so the average is not very useful. These relationships for specific processes of interest to the fertilizer industry are available. A convenient compilation may be found in a manual published by the United Nations Industrial Development Organization (UNIDO) in 1967 (2). Several of these are reproduced in the charts, figures 1 and 2. They were prepared with the assumption that the plants would be located on the Gulf Coast of the United States of America and cover only "battery limits" costs. Since they were based on costs that prevailed in about 1964, they are subject to an escalation factor of about 1.2.[1/]

The relationship of investment cost to size is subject to influence by new technology and the state of development of the given process. The impact of new technology is seen most often in the availability of larger size units which permit the expansion of capacity in a single train rather than the generally more expensive option of multi-train design. The most dramatic example of this in the fertilizer industry of course is the adaptation of the centrifugal compressor to ammonia synthesis plants put into practice during the past few years. Use of these compressors made possible the design of much larger single-train plants than were possible with compressors of the reciprocating type. They require less floor space and piping and do not introduce oil into the gas stream. The effect on investment cost can be seen clearly in figure 1 in the form of a break in the curve at about 600 tons per day, the size at which centrifugal compressors become feasible. Work is under way to adapt centrifugal compressors to smaller size plants.

Other important technological advances also have been made to reduce the cost and improve the efficiency of ammonia plants. These include improved agents and simpler systems for gas purification and arrangements for a large increase in heat recovery (3).

[1/] Calculated from *Chemical Engineering* Index for Plant Costs.

Technical breakthroughs and process refinements also have permitted large-scale single-train phosphoric acid plants. But their development has taken place over a longer period of time, as shown in the following tabulation.

Period	Type plant	Capacity of largest single-train plant - tons P_2O_5/day
1920 - 1931	Multiple reactor	40
1932 - 1952	Multiple reactor	100
1952 - 1961	Multiple reactor	250
1962 - 1965	Single reactor	850
1966	Single reactor	1,000

The most important developments contributing to the feasibility and resulting economy of large single-train phosphoric acid plants were improved single-unit reactor systems and the very large tilting pan filters. The large number of wet-process acid plants built in recent years speeded these developments and lent the confidence needed to push the maximum size units higher.

Another fertilizer process influenced considerably by better technology that has permitted economy of size is urea manufacture. The most significant advances have been improvements in the design of reactors to give better heat removal and contact between reactants, developments in materials of construction to cope with corrosion problems, and refinements of methods of separation of reactants from product. Designs that feature internal stripping of reactants have made once through processes more attractive. As a consequence, the technology has advanced to the extent that the upper limit of single-train plant size has been pushed rapidly upward to about 1500 tons per day. Investment cost of these very large plants is as much as 50 percent lower per ton of capacity compared to plants of the maximum size available 10 to 20 years ago.

The same general rule holds for more modest projects as for the large complexes. An example that is of interest to many is the continuous ammoniation process for producing granular fertilizers using a rotary drum granulator. This process, which is discussed in more detail later, led to the wide spread of granular fertilizers throughout the United States during the 1950's and early 1960's by providing a route by which small manufacturers could supply the growing demand for high-analysis granular fertilizers in their local area. Since the process was introduced in about 1950, improvements in the design of the granulator and accessory equipment and in techniques for control of the process have led to at least a threefold increase in the maximum capacity of a single-train unit. Increasing the scale has substantially decreased the investment cost per unit of capacity as shown by the following tabulation which gives recent quotations for the f.o.b. price of the equipment only for three sizes of plants using the TVA continuous ammoniation process. The equipment includes a rotary drum ammoniator-granulator, a dryer, a cooler, and all the accessory equipment needed for the plants but does not include freight or erection.

Capacity, tons/hr.	Equipment cost, $	$1,000 per ton/hr.
10	149,000	14.9
20	187,000	9.3
30	237,000	7.8

Similar savings in cost per unit capacity no doubt would be realized in erection costs as the scale of the plant was increased.

The economic advantage of larger plants does not stop, of course, with investment costs. Some of the operating costs are fixed costs in the sense that they do not vary with the scale of the operation. Generally, labor costs do not increase in proportion to the size of a plant. Indeed, increasing the size of a single-train processing unit severalfold may not add any appreciable increment of labor costs. The same may be said in many cases for supervisory and overhead costs. Maintenance and utility costs may not rise in proportion to plant capacity; depreciation costs and the profit per ton of product needed for a given return on investment will decrease because the investment per unit of capacity is less in a large plant.

The magnitude of operating savings that will be accrued as the size of a plant is increased must be studied carefully for each individual case because wide variations in labor and raw material costs from one country to another cause large differences in the ratio of fixed to variable costs. However, charts applicable to the situation in the United States, showing the estimated variation of operating cost with plant size for several processes involved in fertilizer production, are shown in figures 3 and 4 to serve as examples.

As attractive as it may seem to design plants for the highest possible capacity in order to achieve economy of scale in investment and operating costs, extreme caution must be taken. It is most important to make sure that the capacity is supported by a realistic assessment of the market so that the plant can be operated at or near its design capacity. Otherwise, many of the same factors that make it advantageous to increase the size will work in reverse to cause far greater disadvantages when too large a plant is operated significantly below its intended rate.

The magnitude of these relationships can be seen from an illustration from a yet unpublished study made in a Latin American country. The study included estimation of the costs at various levels of operation in two different sizes of ammonia and urea plants.

Ammonia plants having capacities of 1,000 and 600 metric tons per day were compared. The capital costs were estimated to be $29.7 million for the total complex of the larger plant and $19.8 million for the smaller one. The purchase of 400 extra tons of capacity for less than $10 million incremental cost may appear to be economical, but obviously it is a loss if the capacity is not used. Furthermore, the majority of the loss would be in foreign exchange.

The relationship of operating costs to operating levels for the two ammonia plants is shown in figure 5. A study of these curves reveals a startling penalty for low operating levels. For example, the advantage due to scale of producing 1,000 metric tons per day over 600 when both plants are operating at 100 percent of capacity (B - A) is about $4 per ton. However, the disadvantage of producing 600 metric tons per day in the 1,000-ton plant (60% of design) rather than in the 600-ton plant (100% of design) would be about $13 per ton (D - B). If the demand should drop to 540 tons per day (90% of the 600-ton plant capacity), the penalty in operating cost in the smaller plant would be only about $1 per ton (C - B), but if this quantity were produced in the 1,000-ton per day plant (54% of capacity), the cost differential from 100 percent capacity would soar to $25 (E - A) or about $4-1/2 million per year.

Figure 6 shows the same sort of relationships for the urea complex. The operating cost in the 600 metric ton per day plant is about $3 per ton more (P - A) than in the 900-ton per day plant when both are operated at full capacity. However, when only 600 tons per day is made in the larger plant (67% of design), the cost is $5 per ton greater (C - B) than in the smaller plant and $8 per ton greater (C - A) than when the larger plant is operated at full capacity.

The foregoing example serves to illustrate the effect that overbuilding capacity can have on operating budgets. There are other disadvantages. In some cases, operating problems or processing inefficiencies are encountered when facilities are operated below full capacity. The "turndown ratio" of most plants will not permit operation below a certain percentage of design.

In large single-train ammonia plants the minimum turndown is usually about 60 percent of design capacity. In large urea plants it is in the order of 50 percent. Wet-process phosphoric acid plants have little turndown capacity and must be run on a stop and start basis, which is quite undesirable.

Overproduction, whether due to inability to turn down a plant or a desire to hold unit costs down, can be disastrous in a competitive situation when it leads to unrealistic price cutting among competitors as each tries to capture a larger share of the market. It was the root of the disaster that befell the U. S. fertilizer industry in the late 1960's when an overoptimistic projection of the fertilizer market led to gross overbuilding of capacity within the country.

In summary, advances in technology have created opportunities for substantial increases in the maximum size of plants, giving savings in both investment and operating costs. However, these opportunities can be abused. Severe risks can result from overbuilding capacity before a market for a substantial part of the capacity is assured. This is a lesson that can be learned clearly from experiences in North America during the past few years.

Higher Analysis Fertilizers

Another of the questions that faces planners of fertilizer production is how much emphasis to place on the grade of the product. Over the long range, perhaps the most effective contribution that improved technology has made toward lowering the cost of fertilizer to the farmer has been in increasing the plant food content. Because of the large portion of the total cost that is incurred in handling and transporting fertilizers, there are few greater opportunities to reduce costs than by adding more nutrients per unit of weight. In some countries where facilities for handling and transporting fertilizers are limiting factors, the response to fertilizers is high and the need for greater food production is large. Here, increases in analysis may mean that proportionately greater amounts of nutrients are applied and the total benefits may far exceed the savings in handling costs. In countries depending largely on imports of finished fertilizers, inadequate port facilities sometimes limit the amount of fertilizers used. Obviously, higher analysis can help alleviate this problem.

The average analysis of compound fertilizers produced in countries that are heavy producers of fertilizers has increased sharply. These increases, shown in figure 7, for a 10-year period have averaged 3/4 to 1-1/2 percent per year. The average concentration is now about 40 percent in both the United Kingdom and in the United States. Specific technological improvements that have contributed to these increases in analysis are well known. They began with improvements in processes for making wet-process acid followed by the development of continuous processes suited to large-scale production of triple superphosphate, making available more than a twofold increase in analysis over ordinary superphosphates. The development of the technology for production of diammonium phosphate from the increasing supply of wet-process acid added another 18 percentage points to the analysis. Large basic producers that had been marketing their phosphate as 0-46-0 TSP added 18-46-0 DAP to their line of products. The changes in fertilizer use that resulted can be seen by figure 8, which shows the dramatic increase in the production of more concentrated phosphate materials compared to ordinary superphosphate since 1950.

In nitrogen production and use, the most important technological advances toward higher analysis came first in the development of ammonium nitrate suitable for fertilizer use. This led to improvements in production, such as resulted in the widely used [illegible] method, and in methods for conditioning the material so that it could be readily and safely handled in fertilizer channels. This gave an opportunity to increase the N content to 33.5 percent compared to ammonium sulfate at 20 percent or nitrate of soda at 16 percent.

The next important advance came with a number of improvements in the technology of producing urea. These, over a period of years, have made the cost of urea competitive with that of ammonium nitrate and yielded another substantial increase in the nitrogen content compared to ammonium nitrate. Between 1955 and 1968, ammonium nitrate production in the United States increased by a factor of about 2.5, while ammonium sulfate showed only a modest gain due to increased byproduct production. Between 1957 and 1968, urea production gained by a factor of almost 5.0 (4).

Undoubtedly the greatest technological development influencing the increase in analysis of mixed fertilizers has been granulation. Until satisfactory means for granulating mixed fertilizers were developed, it was not possible to achieve high analysis because the materials needed are too hydroscopic to be used in nongranular fertilizers. The much higher surface area of nongranular forms exposes these materials to rapid absorption of water from the atmosphere, causing caking in storage and many problems in distribution. The effect of the practice of granulation on the grade of compound fertilizer can be seen from examples in the following tabulation.

	Grades before granulation	Grades after granulation
	3-12-12	6-24-24
	5-10-10	10-20-20
	8-8-8	15-15-15
Average concentration	25%	47%

The economic advantage of increasing analysis can be illustrated by data from an unpublished study made at TVA to evaluate prospects for urea - ammonium phosphate, a new material of exceptionally high analysis under development on a pilot-plant scale.

In comparing the costs involved in producing and distributing this material rather than lower analysis materials, the following distribution costs that are independent of the grade of the material were estimated

	$/ton of material
Storage and preparation for shipment	1.50
Bagging	4.00
Transportation	13.00
Retail distribution	4.28
Total	22.78

A simple calculation shows that these costs will vary from about $76 per ton of plant food if the total nutrient content (N and P_2O_5) is 30 percent to $38 per ton of nutrients if the grade is 60 percent. This would leave considerable margin for an increase in production cost to achieve the higher grade. However, in this case the estimated production cost also decreased about $11 per ton of nutrients as the grade was increased.

It must be realized, however, that while as a general rule increasing the analysis of fertilizers decreases their delivered costs, there are exceptions to this rule. In Latin American countries exceptions may occur, for example, where the cost of capital may make production of triple superphosphate exceptionally high and the availability of byproduct sulfuric acid suitable in quantity or quality only for ordinary superphosphate may make it exceptionally cheap. Then the higher cost of distributing the ordinary superphosphate may be more than offset by the lower cost of producing this material. Likewise, the availability of low-cost imported ammonium sulfate in some locations tends to lower the optimum grade of finished fertilizers when all costs are considered. In any case, it is most important to consider the overall system of producing the fertilizers and distributing them in order to be able to select the optimum alternative. Care should be taken to make such evaluation over a sufficiently long time span to allow for variations that often occur in the availability and cost of byproduct materials.

One of the disadvantages of higher analysis fertilizer is that in the process of reducing the impurities that dilute the nitrogen, phosphorus and potassium compounds, other nutrients essential to plant growth may be reduced or eliminated. An obvious example is the elimination of the secondary nutrient, sulfur, when triple superphosphate is used in place of ordinary. In the same manner, addition of a number of the micronutrients[2] might be eliminated by the change to higher analysis

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[2] The elements, B, Cl, Cu, Mn, Fe, Mo, and Zn, are considered micronutrients, Ca, Mg, and S are classified as secondary nutrients.

fertilizers. Unfortunately, the need for addition of these elements is not often well delineated, even where the agriculture is reasonably well developed. It should be recognized, also, that alternative ways of supplying secondary and micronutrients might be a better choice than relying on low-analysis materials.

In some areas where the grade of fertilizers used traditionally is low, farmers are slow to accept fertilizers of increased analysis and, for this reason, manufacturers are reluctant to produce them. However, the benefits of higher analysis usually are so great that it pays to make every effort to educate farmers to their use.

Import of Intermediates

Another question very basic in planning to provide the fertilizer needs of a country is how much emphasis should be placed on importation and how much should be placed on manufacturing in the country itself. Among the many important factors that affect the answer are the availability of indigenous raw materials, the amount of foreign exchange available, and the amount of technical talent that is on hand or can be developed.

In situations where factors do not favor the development of a basic fertilizer industry there may be another alternative that is more attractive than importing finished fertilizers. This alternative is the importing of intermediates that will be used to produce finished fertilizers within the country. It may be the way to utilize limited resources of money and technical manpower to make the earliest strides toward developing an independent fertilizer supply. It can avoid what may be a premature commitment to the use of marginal indigenous materials that would not support a fully developed industry. It can provide a country with a stepwise approach that will permit the development of both the financial and technical ability needed for a fully integrated industry.

During the past few years, advances in technology have made the prospects for world trade in fertilizer intermediates much more feasible. Development of the technology of very large, efficient plants for the production of ammonia, phosphoric acid, and other products, as discussed earlier, has lowered costs because of the economy of scale. Location of such plants near the source of raw materials and water transportation has greatly enhanced the possibilities for world trade in intermediates. Technical advances in shipping, mainly the development of larger vessels and more efficient systems for loading and unloading, have made a contribution. Also, constantly improving technology for the production of finished fertilizers opens, and will continue to open, new possibilities for use of intermediates within the receiving country.

Some of the possibilities for fertilizer intermediates of immediate importance or that may have future potential are:

1. Ammonia (83% N)
2. Phosphoric acid (ortho or super - 54 to 83% P_2O_5)
3. Nitrogen solutions (32 to 37% N)
4. Elemental phosphorus (equivalent to 229% P_2O_5)

5. Ammonium phosphates or polyphosphates (12-50-0 to 15-61-0)
6. Ammonium polyphosphate solutions or suspensions (13-34-0 to 14-47-0)

<u>Ammonia</u>

Liquid anhydrous ammonia is the only fertilizer intermediate that is thoroughly proven in international trade. After some early problems, large plants located at the source of low-cost gas produce ammonia at very low cost. Shipment in ocean vessels is well established and dependable. Innovations are being made in barge and pipeline transport which might help distribution within the importing country. Storage of large quantities of anhydrous ammonia is relatively inexpensive and presents no difficult technical problems. Ammonia is, of course, the primary building block of all nitrogen fertilizers.

The main technical disadvantage of importation rather than local production of ammonia is that carbon dioxide, a byproduct of ammonia production, is not available for the production of urea, a particularly useful product in many instances. While alternative sources of carbon dioxide are possible, they are usually too expensive to be attractive. Imported ammonia would be useful in producing nitric acid, ammonium nitrate, and nitrogen solutions for the production of compound fertilizers or for direct application. It also would be useful for ammoniating phosphoric acid or superphosphate in the production of compound fertilizers.

In a study made last year at TVA for the Agency for International Development, the economics of manufacturing versus importing ammonia were compared for several countries, including one South American country--Uruguay--and at several levels of production (5). The results, summarized in table 1, indicated that in all locations and at all levels, ammonia could be imported at a lower cost than it could be manufactured, although the difference was not great when the capacity was large. However, the study also showed that this situation changes somewhat when the real value of foreign exchange is considered. If foreign exchange is valued at more than about 1.2 to 1.6 times the value of local currency, it becomes more attractive to produce rather than import ammonia when the sizes are from 1,500 to 500 [illegible]/year, respectively, under the conditions assumed in the study.

Nitrogen Solutions

Although there have been no such shipments, nonpressure or low-pressure aqueous solutions of ammonia in combination with urea or ammonium nitrate or both might hold possibilities for ocean shipment. While the nitrogen content ([illegible] 37%) is comparatively low, progress has been made in developing solutions that permit shipping in low-cost containers. Solutions of this type for many years have been shipped widely throughout the United States for use in formulating both solid and liquid mixed fertilizers. They are more useful for this purpose than anhydrous ammonia where the [illegible] content of the finished product requires more nitrogen than can be [illegible] by reacting ammonia with the solid ingredients of the formulation.

Phosphoric Acid

Phosphoric acid is the starting point for all phosphate fertilizers except ordinary superphosphate and some types of nitric phosphate. It may be ammoniated alone to produce ammonium phosphate or used in combination with other fertilizer materials to yield a wide variety of compound fertilizers.

Since phosphoric acid is produced in several different concentrations and degrees of purity, possibilities for import are varied. However, the most economical and prevalent acid production is in the form of 54 percent (P_2O_5) merchant-grade, wet-process acid and this is the only concentration that has thus far found a place in ocean transport. Even this has been rather limited and it must be recognized that there are problems remaining to be solved before it becomes as routine and trouble-free as ocean transport of anhydrous ammonia. Foremost among these problems is the presence of solid impurities in the acid and the further precipitation of solids during shipment. These create a difficult problem of residue deposits in the vessels. They also increase the viscosity of the acid and to some extent limit the uses to which the acid can be put--for example, in liquid fertilizers. The other problem is the corrosiveness of the acid, but this can be solved, of course, by the proper selection of materials of construction.

The problems involved in transport of wet-process acid are reduced by purification of the acid by settling or other means, by selection of the rock used in the manufacture, or by calcination of the rock. All of these tend to increase the cost of the acid, and purification by settling leaves a low-grade sludge that must be utilized by some means. However, much progress was made in techniques for producing cleaner wet-process acid during the last decade to support a greatly expanded commerce in the acid within the U. S. and elsewhere, and progress no doubt will continue with the prospects of expanded overseas shipment. Also, more economical corrosion resisting systems for acid-carrying vessels will be developed as more experience is gained.

The development of wet-process superphosphoric acid (70 to 74% P_2O_5) holds some promise of advantage for ocean shipment of the acid, but none of the schemes for producing it for the world trade have yet materialized. This acid is made by further concentration of merchant-grade acid. Starting at about 68 percent concentration, some combined water is removed forming polyphosphates, mainly pyrophosphate. The polyphosphates tend to sequester the impurities in the acid, preventing precipitation. However, a disadvantage that tends to counteract this benefit is a sharp increase in viscosity of the acid. While the viscosity, like sludge formation, can be controlled somewhat by controlling the impurities in the acid, it probably would be high enough in any event to require heating of the acid to facilitate unloading a vessel at a reasonable rate. Super acid is less corrosive than ortho acid, but the difference probably is not great enough to give it an advantage in ocean shipment since the risk of using anything less than corrosion resistant materials would be too great.

The cost of clarification of 54 percent wet-process acid is about $5 per metric ton of P_2O_5, and concentrating the clarified acid further to about 70 percent P_2O_5 adds at least another \$7 per ton to the cost ([illegible]). Indications are that, with the possible exception of very long hauls, the cost of concentration would offset the shipping advantage gained by the higher concentration. While a considerable amount of wet-process super acid is shipped for long distances overland in the United States, it is used almost exclusively in liquid fertilizer production where the polyphosphate content is an advantage.

Phosphoric acid produced from electrothermally produced elemental phosphorus can be readily made either as ortho acid at a concentration of [illegible] percent P_2O_5 or as [illegible] to [illegible] percent P_2O_5 superphosphoric acid without additional cost. Acid produced in this manner has lower viscosity, does not form sludge, and generally would offer the best prospects for shipment were it not for its high cost of production. Presently, it is competitive with wet-process acid only in the super acid form for the production of high-analysis clear liquid fertilizer. It will not become competitive for general fertilizer use so long as sulfur prices remain as they are and wet-process acid is in such plentiful supply.

Elemental Phosphorus

Somewhat better prospects for electrothermally processed phosphate exist when the possibility of shipping elemental phosphorus as an intermediate for fertilizer production is considered. Equivalent to 229 percent P_2O_5, it is the most concentrated material available. One ton of phosphorus is equivalent to about 7 tons of rock or 5 tons of diammonium phosphate or triple superphosphate. Although there are some hazards in handling it, it has been shipped by rail and stored routinely for years. Recently, two vessels for ocean transport have been constructed to ship phosphorus for industrial use from a large new plant in Newfoundland. Plants to convert phosphorus to phosphoric acid are relatively inexpensive and the investment cost for producing fertilizers could be kept low.

The shipment of elemental phosphorus as an intermediate appeared to be a competitive alternative to manufacturing fertilizer-grade phosphates within the country or importing fertilizers in some circumstances several years ago (7). However, sharply decreasing sulfur prices and an oversupply of wet-process acid have changed this situation. As a result, it is probable that elemental phosphorus will not find a place of any significance in overseas shipment of fertilizers in the next 10 years. It may later, but many factors cloud this picture. Some of these are the uncertain direction of power costs as influenced by increasing fuel costs in contrast to promised cost-reducing improvement in the technology of nuclear generation, and the influence of pollution control on byproduct sulfuric acid supply and on the amount of phosphates used in detergent production.

Other Potential Intermediates

Technological advances during the past few years have resulted in several other materials that may warrant consideration as fertilizer intermediates for overseas shipment. Ammonium polyphosphate solutions or suspensions may have some potential. They are made by ammoniation of superphosphoric acid and are shipped and used extensively in the U. S. as an intermediate in the production of clear liquid and suspension fertilizers. Means of production from ordinary wet-process acid have been developed and will soon be in commercial practice. These materials are of moderate to high concentration (10-34-0 to 14-47-0), can be readily loaded and unloaded by pumps, and can be shipped and stored in mild steel, nonpressure vessels.

Another relatively new material that has more potential as a fertilizer intermediate is powdered monoammonium phosphate (MAP). Several plants for its production are under construction or in operation. With a grade of about 11-53-0, it contains nearly as much P_2O_5 as wet-process acid and likely could be shipped in overseas transport with greater convenience and less cost. Its production is somewhat simpler and therefore should be less costly than granular diammonium phosphate, the ammonium phosphate commonly found in world trade.

Powdered MAP is a versatile material, useful as a major component in the production of granular fertilizers. It can be co-granulated with urea and other commonly used materials to produce a variety of high-grade fertilizers.

The evaluation of the potential for intermediates is highly dependent on a large number of factors including price, shipping distances, import tariffs, the type of fertilizers needed, the quantities needed, and the indigenous materials available. These are so variable within an area such as Latin America that it is impossible to make generalizations. However, studies have been published that evaluate a wide range of

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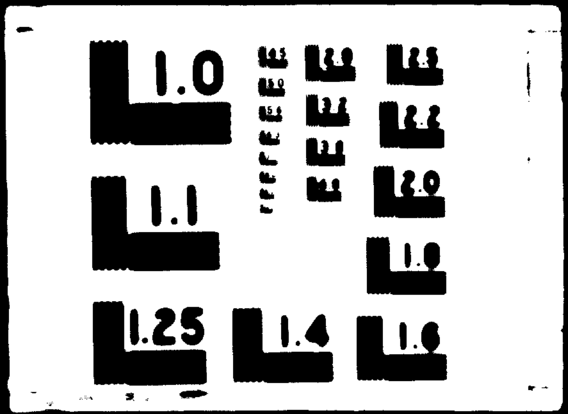

alternatives, including import of intermediates, under specific conditions--even including those found in Latin America (5, 6, 7, 8). These should be useful as a guide to those who wish to make similar evaluations for their own conditions.

Process Review

Over the last two decades, three distinct systems for providing the large variety of mixed fertilizer needed for the farmers have developed in the United States. These systems are quite different from each other in many respects and are more or less in competition with each other. The three systems are:

1. Co-granulation of intermediates in small plants to produce homogeneous granular fertilizer in the grades needed.
2. Production of blends of the various grades by mixing already granulated intermediates.
3. Supplying the needed grades in liquid form blended or manufactured largely from liquid intermediates.

The proponents of each of the three systems claim a distinct advantage, so it is not surprising that there is sometimes some confusion in trying to translate the U. S. experience to help plan developments in other countries.

Granulation

While granular fertilizers have been known and used for a long time, it was not until the early 1950's that granular fertilizers began to replace early pulverized forms in a large and irreversible way. Replacement of the pulverant products took place in a surprisingly short time. The first and probably the most important reason was the improvement granulation makes in the physical properties of fertilizers. It lessens or prevents caking in storage and it facilitates distribution in the field. The second important reason for growth was economic. It lowered the costs by allowing the use of cheaper ingredients and, as discussed earlier, by permitting the production of much higher grades than could be produced with satisfactory physical properties in pulverized form.

Earliest methods for making homogeneous granular fertilizers involved wetting the ingredients to cause them to granulate and then drying the granules to remove the added water. However, a much better method soon evolved in which the liquid phase required for granulation was produced during granulation by highly soluble salts dissolving in a limited amount of water at a high temperature. The heat required was generated by the reaction of ammonia with superphosphate (ordinary or triple) and, in some formulations, sulfuric or phosphoric acid. The chemical transformations and the crystallization on cooling made products that generally were much stronger than were made by the wet and dry method, and less drying usually was required. Furthermore, the raw materials for some formulations were less expensive because a larger portion of the nitrogen could be added as ammonia or ammoniating solutions containing ammonia, ammonium nitrate, and urea or some combination of these.

While several different adaptations of this granulation principle evolved, the most widely used one has been a process developed by TVA (9).

Sketch of a typical TVA-type granulation plant is shown in figure 9. The unique feature of the TVA process is the rotary drum ammoniator-granulator which serves as a mixer and a reactor and also provides a rolling action needed for the formation of granules and disengagement of water vapor. Other equipment in a typical TVA-type plant includes a rotary dryer, usually fired directly by gas or fuel oil; a rotary cooler; screens to separate and remove a product fraction of granules of the desired particle size; a crusher to reduce the size of overly large granules, and conveying equipment to return the undersized product to the ammoniator-granulator.

Phosphate raw materials for the process are ordinary superphosphate, sometimes produced at the site, and usually higher analysis intermediates--triple superphosphate, ammonium phosphates, or phosphoric acid. Nitrogen is supplied by ammonia, ammoniating solutions, and often some solid source--urea or ammonium sulfate. Potassium usually is supplied as the chloride. The ammonia and ammoniating solutions are fed through a perforated pipe under the moving bed of solids in the ammoniator. Acid may be sprayed from above. Sometimes a reaction tank, referred to as a preneutralizer, is added to give more flexibility in formulation. It permits using more liquid ingredients and allows for more dissipation of heat of reaction than could be accommodated in the ammoniator-granulator.

Some commonly used formulations for the TVA continuous ammoniation process are shown in table 2. The formulation for a given grade may vary from plant to plant, depending largely on the cost of ingredients at each location. However, the formulation must provide the proper amount of moisture and heat of reaction for granulation and the free ammonia must not exceed the levels that can be fixed by reaction with the acids and superphosphate present. The amounts of ammonia that can ordinarily be reacted with the phosphate ingredients without excessive loss are as follows.

Material	Lbs. NH_3 per lb. P_2O_5
Ordinary superphosphate	0.30
Triple superphosphate	0.175
Phosphoric acid	0.35
Monoammonium phosphate	0.12

There have been 200 or more granulation plants using the TVA continuous granulator built in the United States. A typical plant would have a capacity of about 15 to 20 tons per hour. It would serve an area in a radius about 150 miles by producing perhaps 50,000 tons per year, operating only a part of the year.

Granulation is practiced in generally similar plants in many parts of the world. However, formulation must be different in countries such as the United Kingdom where it is desired that all of the P_2O_5 be in water-soluble form. Here it is necessary to limit the extent of ammoniation of superphosphate to neutralize only the small amount of free phosphoric acid contained therein. Further ammoniation would form water-insoluble dicalcium phosphate. In such cases, high-analysis grades may be made by co-granulating urea and superphosphate, and adding ammonia and phosphoric (or sulfuric) acid to supply heat of reaction for granulation. Steam or gas flames also might be used for additional heat. The products generally have good physical properties when well dried and coated with a small amount of clay.

Another approach to simplified granulation in the same type of equipment is through the use of a nongranular form of monoammonium phosphate (MAP) now available from several sources. The MAP may be used to upgrade formulations containing ordinary superphosphate or to replace it entirely. Steam or ammoniation or both may be used to supply heat for granulation. The MAP is produced by simple methods (10, 11, 12) at low cost and does not have the problems associated with shipping phosphoric acid.

Bulk Blending

In the late 1950's another system was developed that rivaled and in many areas replaced the small granulation plants. In this system granular intermediates are produced in large plants located near the source of raw materials rather than in the farm areas. These intermediates are then shipped in bulk to relatively small bulk blending plants dispersed throughout the farming areas. Here the materials are stored in bulk, usually for only a short period, and simply mixed together as needed to fill orders from individual farmers. While a small portion of bulk blended material is bagged for delivery, it is usually delivered in bulk. It may be taken to the farm in the blender's truck or in the farmer's truck. In more sophisticated systems it is delivered to the farm in a hopper that is left at the farm temporarily to make it convenient for the farmer to fill his distribution equipment. In many cases the blender may apply the blend on the field for the farmer. He may also take soil samples, have them analyzed, and use the results to recommend a fertilization program for the farmer.

Because bulk blending plants are simple and inexpensive, they need not be large to be profitable. Most plants serve an area having a radius of only 25 to 30 miles and have outputs in the range of 2,000 to 5,000 tons per year. There are well over 3,000 such plants in the U. S. They may be owned by the basic manufacturer that supplies the intermediates or they may be independently owned. It has been estimated that they market about 40 percent of the granular fertilizer produced in the United States. In some local areas the proportion is much higher.

Nitrogen intermediates commonly used in bulk blending are ammonium nitrate, ammonium sulfate, urea, and ammonium phosphate nitrate. Phosphate materials are granular triple superphosphate, ordinary superphosphate, and diammonium phosphate. Nitric phosphate is sometimes used. The usual source of potassium is coarse or granular potassium chloride, although the sulfate sometimes is used. Secondary or micronutrients are added in some areas.

Plants vary in complexity. Some are very simple, providing crude mixing equipment and very little raw material storage. A design fairly typical of the better plants is shown in figure 10.

Incoming materials are unloaded into a conveyor and elevator for transport to several intermediate storage bins. From these they are recovered by a motorized shovel and fed to a weighing device. The materials are weighed batchwise and dropped into a rotary drum mixer. The mixer will handle a batch of 1 to 6 tons, depending on the size of the plant. After a short mixing period, usually not much more than 2 minutes, the batch is elevated to a temporary storage bin or delivered directly to a highway truck. When micronutrients are needed they may be added in granular form also, or preferably as a finely divided dust to coat the granules in the blend.

Simpler plant designs are possible by combining the functions of the elevators, for example. Many different types of mixers are available and are described in the literature (13).

Bulk blending has several advantages. It places most of the manufacturing process in large, efficient plants that can be operated throughout the year. It shortens the marketing channel by combining the functions of the mixer and the dealer. Shipping and handling costs are lowered for this reason and because the raw materials are shipped separately from their various sources to very near their point of use, rather than being detoured through a common manufacturing facility. The mixer-dealer, covering only a small area, is close to and therefore can be more readily responsive to the needs of his customers, the farmers. The flexibility of the system helps him meet these needs.

The most serious technical problem associated with bulk blending is the tendency for materials to become unmixed when they are handled. This segregation may cause wide variations in analysis from one part or sample of the batch to another. It may result in very poor crop responce in some parts of the area fertilized by the batch and thus lead to customer dissatisfaction.

The primary cause of segregation in blends is mismatching of the particle size of the ingredients, rather than differences in the shape or density. Even the variations found in a relatively narrow size range such as 6- to 16-mesh can cause serious segregation unless additional precautions are taken. One precaution that must be taken is to avoid dropping either raw materials or finished product into conical piles because the larger particles tend to roll to the edge of such piles and fine particles accumulate in the center. Therefore, severe nonuniformity can result as the material is recovered from the edge of the pile. Some equipment used in spreading fertilizers also results in segregation on the field according to size. If the carriers of the individual nutrients are not of the same size, there obviously will be nonuniformity in distribution of nutrients. Liquid binders such as oil or water may be helpful in avoiding segregation of micronutrients when they are added in finely divided form.

Chemical incompatibility also can be a problem. Urea and unammoniated superphosphate cannot be used in the same blend because the urea extracts water of hydration from the superphosphate, causing the mixture to become wet and sticky. Mixing ammonium nitrate and urea in the same blend would cause it to be so hydroscopic that the blend would be unmanageable. Ammonium phosphate and triple superphosphate can be used only if they are well granulated and dry and the blend is not to be stored.

Liquid Mixed Fertilizers

It has been said that the most logical solution to the problems of granulation (and bulk blending) is found in liquid fertilizers. While this may be an overstatement, the truth it contains accounts at least in part for the rapid rise in popularity of liquid mixed fertilizers in the U. S. Consumption has grown phenomenally over a short period. While good statistics are not available, it is estimated that use was 1.0 million tons in 1965, 1.6 million in 1966, and 2.5 million in 1967 (14). This quantity in 1967 accounted for about 12 percent of all mixed fertilizers consumed.

The main advantage of liquid fertilizer that has been responsible for this growth is its convenience. It can be handled by pumps and hoses with a minimum of labor. This is an important advantage in the U. S. where farm labor is scarce and expensive. Liquids are not affected by high humidity that sometimes causes problems in storage and application of solid fertilizers.

For the producer, liquid fertilizer has the advantage that it can be made by simpler processes carried out in lower cost equipment. Control of composition and segregation is not a problem as long as the limits of solubility are not exceeded.

The main disadvantage of liquid fertilizer is low analysis compared to solid fertilizers, especially in mixed fertilizers that contain potash. Another disadvantage is that distribution equipment for liquids is not as widely available among farmers as for solids and it tends to be somewhat more complex.

Formulation of liquid mixed fertilizers almost always starts with ammonium phosphate solutions, either purchased by the formulator or manufactured by him during the mixing process from phosphoric acid and ammonia. If he uses an already prepared base solution, his operation is simply one of blending and his plant is known as a "cold mix" plant. If he uses acid and ammonia he operates a "hot mix" plant and he carries out a chemical operation. A sketch of a cold mix plant is shown in figure 11. The main difference between this and a hot mix plant is that the hot mix plant would need storage for acid and a cooling system to remove the heat of neutralization of the acid.

Phosphate solutions used in the preparation of liquid fertilizers usually contain polyphosphate rather than orthophosphate because the former results in greater solubility (hence higher analysis) and has the ability to sequester a certain amount of impurities that would otherwise precipitate and cause handling problems. A base solution having an analysis of 10-34-0 made with wet-process superphosphoric acid or 11-37-0 made with thermal (electric furnace) superphosphoric acid is used by cold mix plants. Solid ammonium polyphosphate (15-62-0) may be used rather than a base solution. It is available from TVA experimentally, but is not yet available from commercial sources.

Hot mix plants usually use superphosphoric acid rather than the ortho form in order to obtain the benefits of polyphosphate in the product. However, the technology is advancing to the point that soon the polyphosphate will be formed directly by the reaction of ortho acid with ammonia.

The usual nitrogen materials for liquid mixed fertilizers are urea-ammonium nitrate (UAN) solutions containing 28 to 32 percent N. Solid urea is sometimes used but it is more expensive. The UAN solutions give greater solubility than solutions that contain only ammonium nitrate. Potash is almost always added as a solid in a refined form that contains 62 to 63 percent K_2O.

The disadvantage of low grade can be overcome somewhat by exceeding solubility limits and making fluid fertilizers in the form of a suspension of solids rather than clear liquids. If this is done in a properly controlled manner, the solids are in the form of finely divided crystals which can be held in suspension for long periods by the addition of a small amount (1 to 3%) of a gelling-type clay. Popular grades of suspension fertilizers in the U. S. are 7-21-21, [illegible], 10-20-20, and 15-15-15. These are close to the maximum grades in granular fertilizers and are about twice as high as can be made in clear liquid form. They are made in the same types of plants as clear liquids. One base suspension for use in cold mix plants has a grade of 12-40-0.

Unfortunately, some of the advantage of liquid fertilizer is lost in substituting suspensions for clear liquids. Storage, handling, and application become more difficult and for that reason suspensions have not gained wide popularity. However, they have an added advantage of being suitable carriers for micronutrients and pesticides in amounts in excess of those that could be dissolved in clear liquids. This advantage, plus their high analyses, gives considerable incentive for continued work with suspensions to overcome some of their shortcomings.

Like bulk blends, liquid fertilizers are usually made in small plants producing, on the average, about 2,000 to [illegible] tons per year. Being small, they serve an area of a relatively small [illegible]. The proprietors often offer custom mixing and custom application to their customers, and perform other services such as soil sampling and testing. Sometimes one hot mix plant will make base solutions for a number of very simple cold mix satellite plants owned by the same company.

The choice among the three routes to mixed fertilizers discussed above can be made only after careful study of the situation in the country involved, and no clear-cut generalizations can be made. Liquid fertilizers probably would not be well suited in many situations where farms are small and labor is cheap. The specialized equipment for handling and distributing liquids would not be widely available and would be difficult to maintain in some countries. The success of both liquid fertilizer production and bulk blending of solids depends heavily on a good transportation system that can be depended upon to supply the materials needed during the busy fertilizer season. Facilities for transporting liquids may present the greatest problem. Successful bulk blending is highly dependent on a source of materials that are well matched with respect to particle size. If the materials all come through a single port, some of the advantage of bulk blending is lost and it may be better to co-granulate them at the port rather than shipping them separately for blending in the field and risking problems of segregation. In considering which alternative is the most advantageous, it is most important to include the whole system, from procurement of raw material down to the final marketing and transport of the product to the farmer.

The Case for Nitric Phosphate

A large number of processes that use nitric acid rather than phosphoric or sulfuric as the primary acidulating agent for phosphate rock have been developed during the past 30 years. The products are known as nitric phosphates (or nitrophosphates). They make up a major part of fertilizer production in Europe but have not been widely used in the Western Hemisphere.

The potential advantage of nitric phosphate production is that the need for sulfur is eliminated or reduced. The nitric acid serves two purposes. It solubilizes the phosphate and provides part of the nitrogen content of that fertilizer. The potential disadvantages of nitric phosphate production are low water solubility of the P_2O_5 in products made by some processes, the problem of dealing with the hydroscopic calcium nitrate formed, and the limited range of ratio of N to P_2O_5 in the product (usually about 1:2 to 2:1). The nitric phosphate process itself is complex compared to some alternatives, but in cases where it replaces a sulfuric acid plant and a phosphoric acid plant, the overall system may be less complex. In most nitric phosphate processes, dissolution of the phosphate rock takes place in a slurry-type operation in accordance with the following reaction:

$$Ca_{10}F_2(PO_4)_6 + 20HNO_3 \dashrightarrow 6H_3PO_4 + 10Ca(NO_3)_2 + 2HF \qquad (1)$$

If the solution obtained is simply ammoniated, the following reaction occurs:

$$6H_3PO_4 + 10Ca(NO_3)_2 + 2HF + 4NH_3 \dashrightarrow 6CaHPO_4 +$$
$$14NH_4NO_3 + 3Ca(NO_3)_2 + CaF_2 \qquad (2)$$

This reaction produces insoluble dicalcium phosphate and hygroscopic calcium nitrate. There are many process variations designed to modify this reaction or cope with the problems it imposes. They may be divided into three main types.

Calcium nitrate removal: A portion of the calcium nitrate may be removed before ammoniation by cooling, crystallization, and centrifuging. This approach is generally known as the Odda process (15). The calcium nitrate may be prilled and sold as a byproduct (15% N) or converted to ammonium nitrate by treatment with CO_2 to precipitate calcium carbonate. The remaining solution is ammoniated and granulated or prilled to produce fertilizers containing ammonium nitrate, dicalcium phosphate, and ammonium phosphate. The ratio of ammonium to dicalcium phosphate depends on the proportion of calcium that was removed as nitrate and determines the water solubility of the P_2O_5 in the product. Commercial products range between 25 and 60 percent water solubility, although 80 percent is feasible. Typical product grades are 20-20-0, 13-13-21, and 15-15-15; or with more complete calcium nitrate removal, 23-23-0 and 18-36-0.

Sulfate salt addition: Other modifications cope with the excess calcium through the addition of soluble sulfate salt to precipitate calcium sulfate. The addition may be made before or during ammoniation of the extraction slurry. The calcium sulfate may be left in the product but this results in low-analysis grades such as 14-14-0 or 17-13-0. Alternatively, it may be removed by filtration, producing a grade such as 25-15-0 with nearly complete water solubility of the P_2O_5 (16). Several different sulfate salts have been used in this type of process but the one most likely to be attractive is ammonium sulfate, since it is a widely available byproduct.

Still another adaptation of this basic approach is the sulfate recycle process (17). In it the calcium sulfate is reacted with ammonia and carbon dioxide to regenerate ammonium sulfate and precipitate calcium carbonate, which is removed as a byproduct or waste.

Mixed acid process: The third basic type of nitric phosphate process is one in which either phosphoric or sulfuric acid is added to the extraction step to react with enough of the calcium to prevent the presence of calcium nitrate in the product. When phosphoric acid is added in sufficient quantity the ammoniation reaction yields ammonium phosphate, and a part of the P_2O_5 in the product is water soluble. The usual practice is to formulate to give 40 to 50 percent water solubility.

The mixed acid process is the only one used in the Western Hemisphere, and there are several of this type in Europe. There are several different designs used but the main variations are the P.E.C. process (18) which in the latest version uses a special granulator-dryer to convert the ammoniated extract to solid form, and the TVA process (19) which uses a rotary drum for the final stage of ammoniation and for granulation. A flowsheet of the TVA mixed acid process is shown in figure 12.

The mixed acid process has the advantage of greater flexibility in the $N:P_2O_5$ ratio than the other processes. Grades such as 26-13-0 and 20-20-0 can be made without the need for producing a nitrogenous co-product.

The phosphonitric process usually is preferred because of the higher grade it produces. However, some of the advantage of nitric phosphate is lost because in effect only part of the P_2O_5 in the finished product is solubilized by nitric acid.

Despite the low price of sulfur there are undoubtedly places in Latin America where the nitric phosphate processes warrant serious consideration in the planning of fertilizer projects. Cost estimates based on somewhat higher sulfur prices than prevail today show an economic advantage for both the mixed acid and the calcium removal processes over processes based entirely on phosphoric acid (20). The Odda process is advantageous even when very low sulfur price is assumed. The sulfate addition process may have good economics where byproduct ammonium sulfate is available.

In evaluating the prospects for nitric phosphate compared to ammonium phosphate based fertilizers, the evaluation should include transportation of the products to the point of use since the analyses of nitric phosphates are generally lower. Also, it should be kept in mind that a part of the nitrogen is in nitrate form which is not desirable for some crops, particularly rice.

New Fertilizers Under Development

As in most industries that are relatively new, there is a constant flow of innovations and new technology generated throughout the world in the fertilizer industry. The question often arises whether a country that is in the early stages of developing its capability for fertilizer production should adopt the very latest, perhaps not fully proven, technology in order to be completely up to date, or whether it is better to choose only well proven products and processes and suffer the penalty of starting with a somewhat old fashioned industry.

While this is partly a matter of philosophy, in general the latter course probably is the most prudent unless the country has an exceptionally large pool of technical skills. The problems involved in building and starting new plants are difficult at best; they are compounded if a strong supporting service industry and ample technical assistance are not available. They should not be compounded further by having an element of experimentation in the project. The penalties for not achieving expected operating levels promptly and having to make extensive changes are too great.

However, it is important for those in the planning function to know what new technology is emerging so they may become prepared to take advantage of it at the proper time. Some of the new products that appear to have potential for the near future are discussed below.

Ammonium Polyphosphate

The term "polyphosphate" is used to describe materials that contain phosphates in a more condensed form than the orthophosphate found in conventional fertilizers. They are formed when sufficient water is removed from orthophosphate to cause linking of molecules into longer chain compounds having more than one atom of phosphorus. Compounds containing many atoms may be formed in this manner, but the shorter chain compounds such as pyro- and tripolyphosphate with two and three atoms are of more practical interest.

Ammonium polyphosphate fertilizer may be made by ammoniating superphosphoric acid, or directly from orthophosphoric acid by a process that utilizes the heat of neutralization of the acid with ammonia to drive off water. The resulting melt is then granulated. When made with thermal phosphoric acid, the grade is 15-62-0. When made with wet-process acid, the grade is somewhat lower depending on the amount of impurities in the acid.

There has been no commercial production of granular ammonium polyphosphate as yet, but TVA produces 15-62-0 for experimental use from thermal acid in a demonstration plant. It is expected that commercial production from wet-process acid will be realized soon.

As mentioned earlier, polyphosphate has a special use in formulating higher analysis liquid fertilizers. It also may be used for direct application to the soil and in bulk blends where high analysis and good physical properties make it attractive.

The agronomic properties of polyphosphates have not yet been well defined, and there is much to be learned about their reaction in the soil. Agronomic studies in the United States indicate that ammonium polyphosphate usually is equal or superior to monoammonium phosphates. Experiments in France indicated liquid polyphosphates to be superior to other phosphates. Field studies in Japan showed greater response to ammonium polyphosphate than to ammonium orthophosphate. There was some suggestion that better utilization of micronutrients may have been a factor.

Reaction products of the polyphosphate in the soil are different from those of orthophosphates. There is some indication that formation of insoluble precipitates may be inhibited and that polyphosphates may be able to extract insoluble micronutrients from the soil, possibly by forming soluble metal complexes.

These possibilities, plus the high analysis and versatility of ammonium polyphosphate make it an interesting prospect for the not too distant future.

Urea - Ammonium Phosphates

The production of a series of compound fertilizers containing urea and ammonium ortho- or polyphosphate has been developed on a pilot-plant scale by TVA. They are interesting because of their high analysis--approximately 10 percentage points higher than can be made with ammonium nitrate rather than urea. They not only are excellent general purpose fertilizers, but also have properties particularly well suited for rice fertilization.

Several processes have been studied for the production of urea - ammonium phosphate. The preferred process appears to be co-granulation of nearly anhydrous melts of urea and ammonium phosphates using a pug mill. Granular products having satisfactory storage and handling properties were produced in this manner without drying. Typical grades are 28-28-0, 3[illegible]-17-0, and 19-19-19.

Extensive field tests throughout the world have shown the agronomic value of urea - ammonium phosphate.

Controlled Release Fertilizer

Fertilizers that release their nutrients slowly throughout the growing season or over several seasons would have many advantages. They would increase efficiency of uptake, avoiding luxury consumption by the plants. They would minimize losses by leaching, which might be particularly advantageous in high-rainfall tropical regions, and by decomposition or fixation. They would prevent damage to seedlings and burning of leaves. They would reduce application cost by reducing the number of applications necessary.

Nitrogen fertilization appears to have the most potential for benefit from slow release. Several such nitrogen compounds have been marketed, but none are economical for general agricultural use.

A process developed on a pilot-plant scale by TVA for coating granules to control their solubility seems to have promise of being economical enough to produce material for farm use. In the process, granules of urea are sprayed with molten sulfur in a rotating drum to form a coating of 10 to 25 percent sulfur, depending on the rate of release desired. This is followed by a 3 percent coat of wax to seal the sulfur coating. A small amount of coal tar is added to the wax as a microbicide. Finally, about 1.5 percent of a conditioner such as calcined fuller's earth is added to improve handling.

By varying the amount of coating or by blending the product with uncoated urea, it is possible to produce a wide range of release rates. The rate might be varied from rather quick release such as would be required for corn, for example, to slow release over several years for forest fertilization.

It is estimated that the cost of sulfur-coated urea will be 25 to 50 percent higher per unit of nitrogen than uncoated urea. Hopefully, continued tests will show that this much added cost can be justified by the added benefits for many crops.

In the past decade or so, the advance of technology has brought many new fertilizers to the front at a surprisingly fast rate. A little more than twenty years ago ammonium nitrate was not yet established as a fertilizer, few dreamed that urea would ever be economical enough to find a place in agriculture, diammonium phosphate was barely known, and the most popular phosphate fertilizer contained only 20 percent P_2O_5.

The pace of technology has not diminished, so it is certain that the next decade or two will bring their share of changes. The limit in analysis of fertilizers has by no means been reached. Laboratory and greenhouse tests are being made with compounds that contain twice as much plant food as the highest analysis fertilizers used today. There is much room for improvement in the very limited efficiency of recovery of nutrients by plants that can be realized with today's fertilizers. New compounds that are more readily available to plants or less readily fixed in unavailable form by soil reactions are being sought and will be found. The production of elemental phosphorus is in about the same technological stage as ammonia production was 25 years ago. Possible breakthroughs in the production of elemental phosphorus are under study and could make it more competitive with wet-process acid, broadening the base for the production of new and better fertilizers.

Whatever the fertilizers of tomorrow are, it is certain that they will be better, more convenient, and more economical than those used today. It is hoped that the whole world will be in a position to take advantage of their use.

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Table 1. Estimated Costs of Manufacturing and Importing Anhydrous Ammonia

Location and capacity	Manufacture			Import		
	Capital,[a] million dollars	$/mt		Capital[b] million dollars	$/mt	
		NH$_3$	Foreign exchange		NH$_3$	Foreign exchange
INDIA						
330,000 mt/yr (1,000 mt/day)	29.51	44.87	16.46[c]	6.1	43.73	40.54
SOUTH VIETNAM						
198,000 mt/yr (600 mt/day)	20.82	53.05	23.68[d]	3.38	49.97	45.90
URUGUAY						
49,500 mt/yr (150 mt/day)	5.65	58.65	31.07[d]	1.47	52.88	45.96

[a] Including working capital.

[b] Capital and operating requirements, 15-year plant life.

[c] Assuming use of domestic naphtha; if imported naphtha were used, this figure would be $22.58/mt NH$_3$.

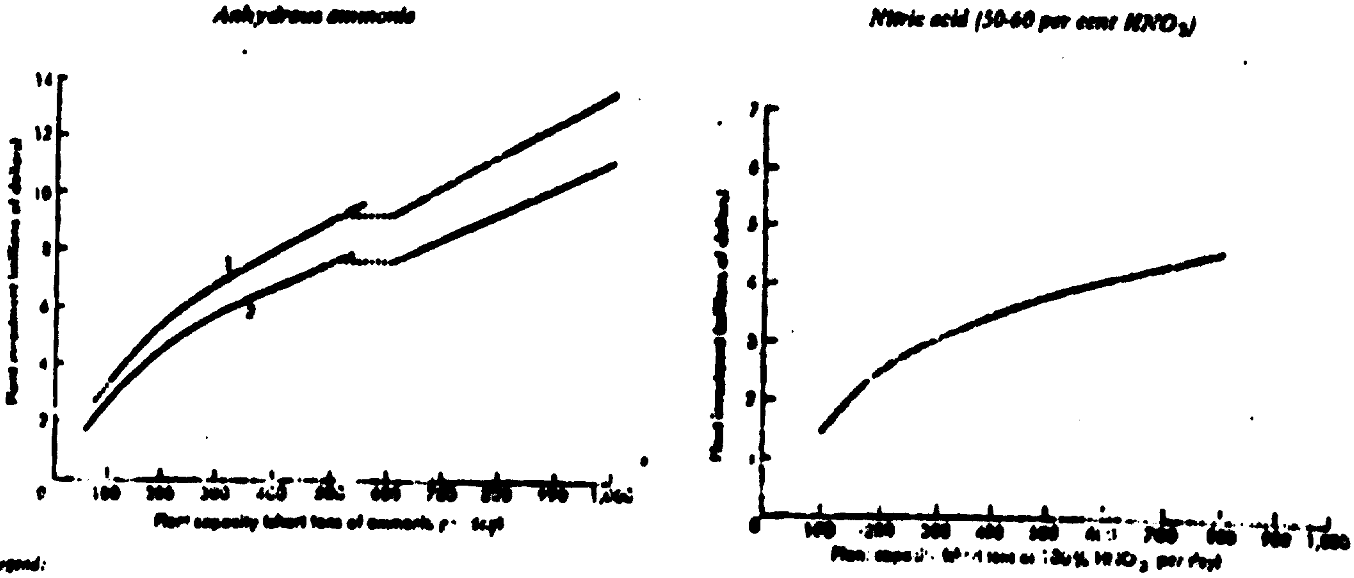
[d] Assuming use of imported naphtha.

Table 2. Some Typical Formulations for the TVA Continuous Ammoniation-Granulation Process

	Lbs. per ton of product					
Grade:	6-12-12	5-20-20	16-8-8	12-12-12	13-13-13	15-15-15[b]
Ammoniating Solution 448[a]	272	-	346	363	392	690
Anhydrous Ammonia	-	125	-	-	-	-
Ordinary Superphosphate	1285	293	5	312	465	350
Triple Superphosphate	-	761	335	394	-	-
Potassium Chloride	400	667	270	400	433	500
Ammonium Sulfate	-	-	881	362	536	-
Sulfuric Acid (93%)	-	140	197	135	-	127
Phosphoric Acid (54%)	-	-	-	-	315	431
Filler	145	-	-	-	-	-

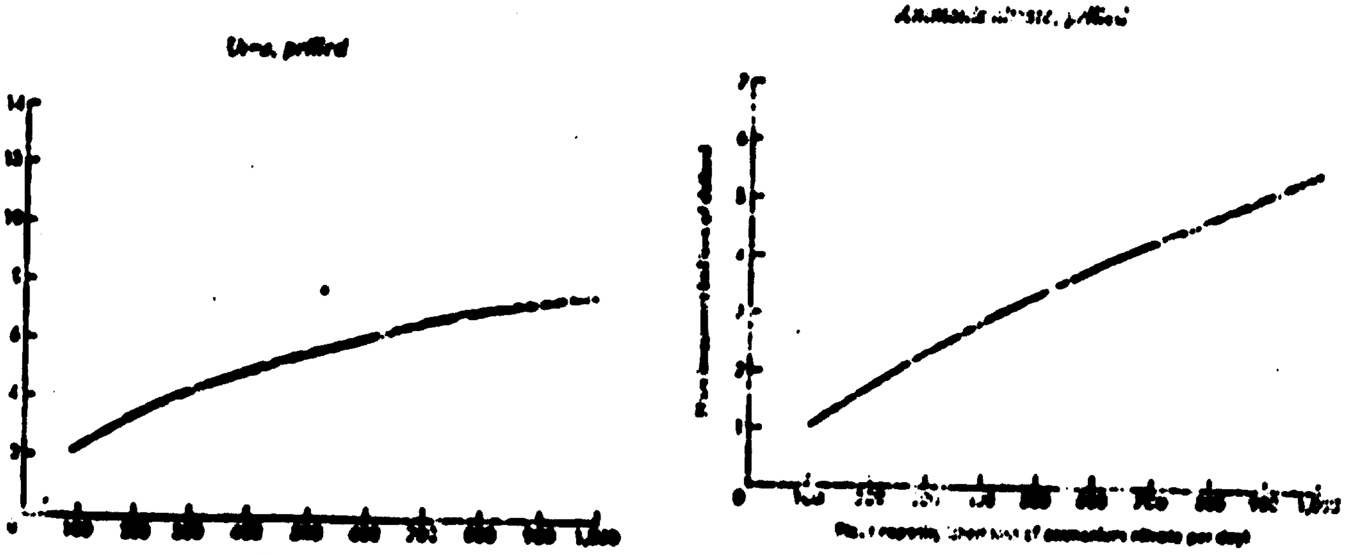
[a] Contains 25% ammonia, 69% ammonium nitrate, 6% water.

[b] Requires preneutralizer tank and scrubber to recover ammonia.



Legend:
1 = Naphtha, steam reforming.
2 = Natural gas, steam reforming.
--- Indicates capacities at which shift to centrifugal compressors becomes feasible.

Note. Takes account of design changes as affected by size. Battery limits plant with storage for 500 tons, but with no [illegible].

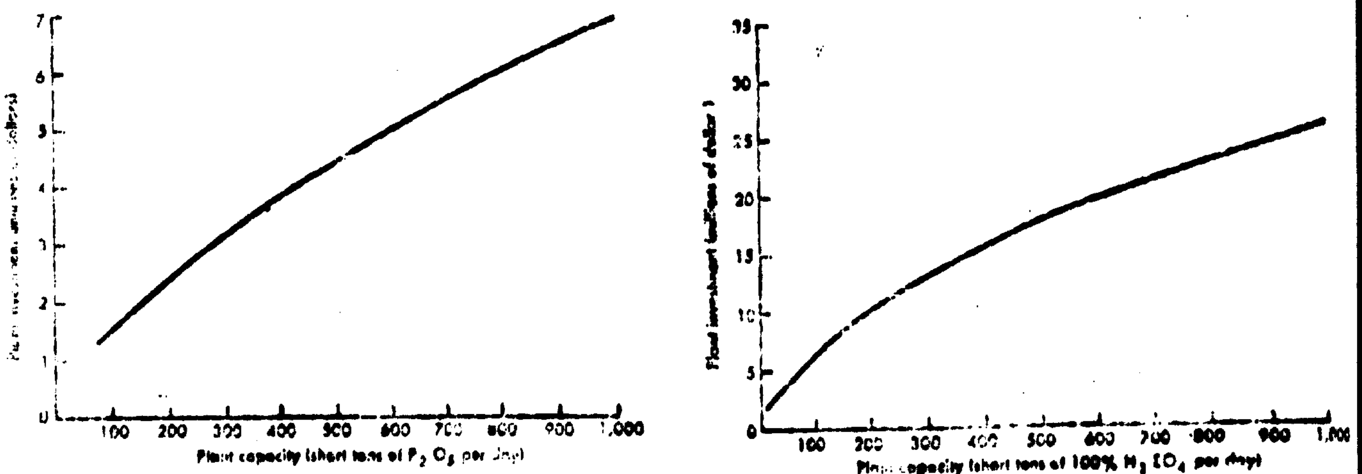


Note: Not including nitric acid plant.

Figure 1. Effect of Plant Capacity on Investment Cost for Various Nitrogen Fertilizer Processes

Wet-process phosphoric acid (54 per cent P_2O_5)

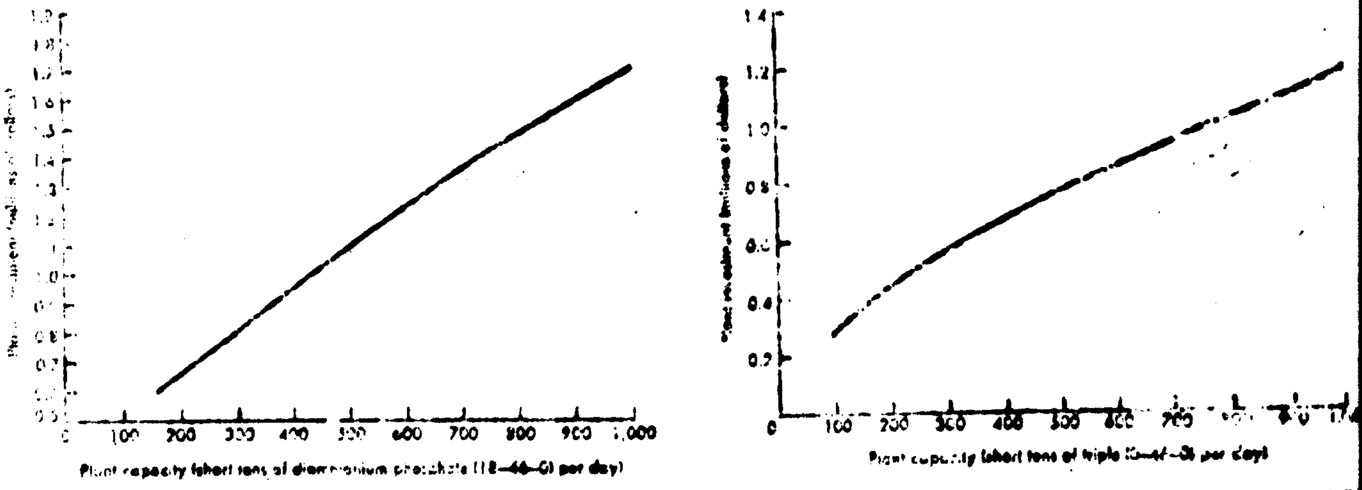
Sulphuric acid



Note: Including rock storage, handling and grinding; and acid clarification and two weeks' storage. Excluding sulphuric acid plant and gypsum disposal.

Diammonium phosphate (18-46-0)

Triple superphosphate (0-46-0)

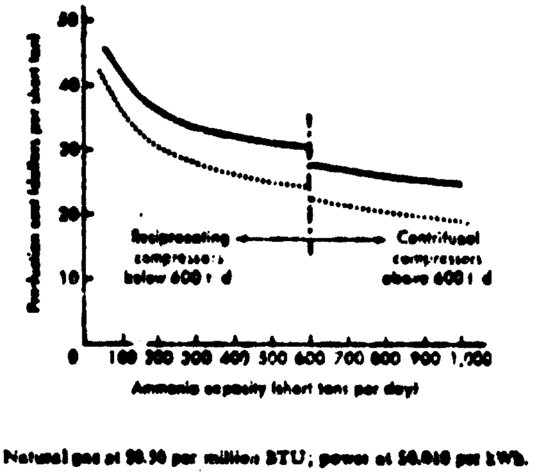


Note: Excluding phosphoric acid or ammonia production units. Including storage for thirty days' production

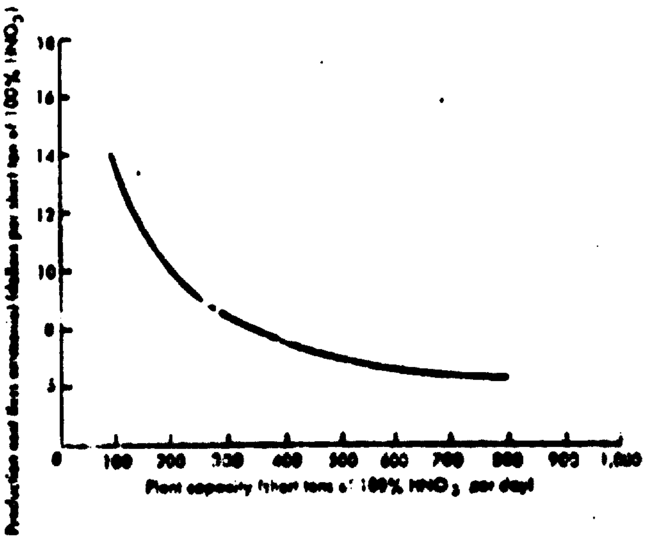
Note: Including storage for one month's production. Excluding rock-grind capacity, for which allowance is made in costs for phosphoric acid plant.

Figure 2. Effect of Plant Capacity on Investment Cost for Various Processes Related to Phosphates

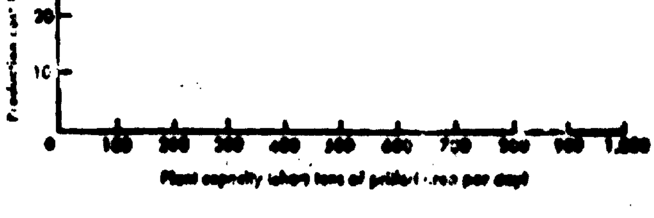
Anhydrous ammonia



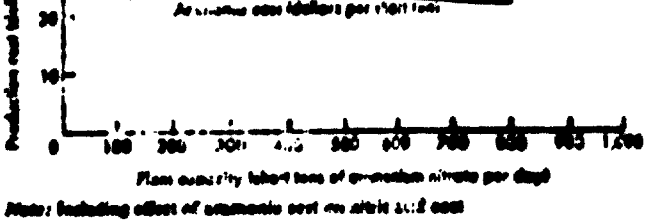
Nitric acid (50-60 per cent HNO$_3$)



Urea, prilled (45 per cent N)

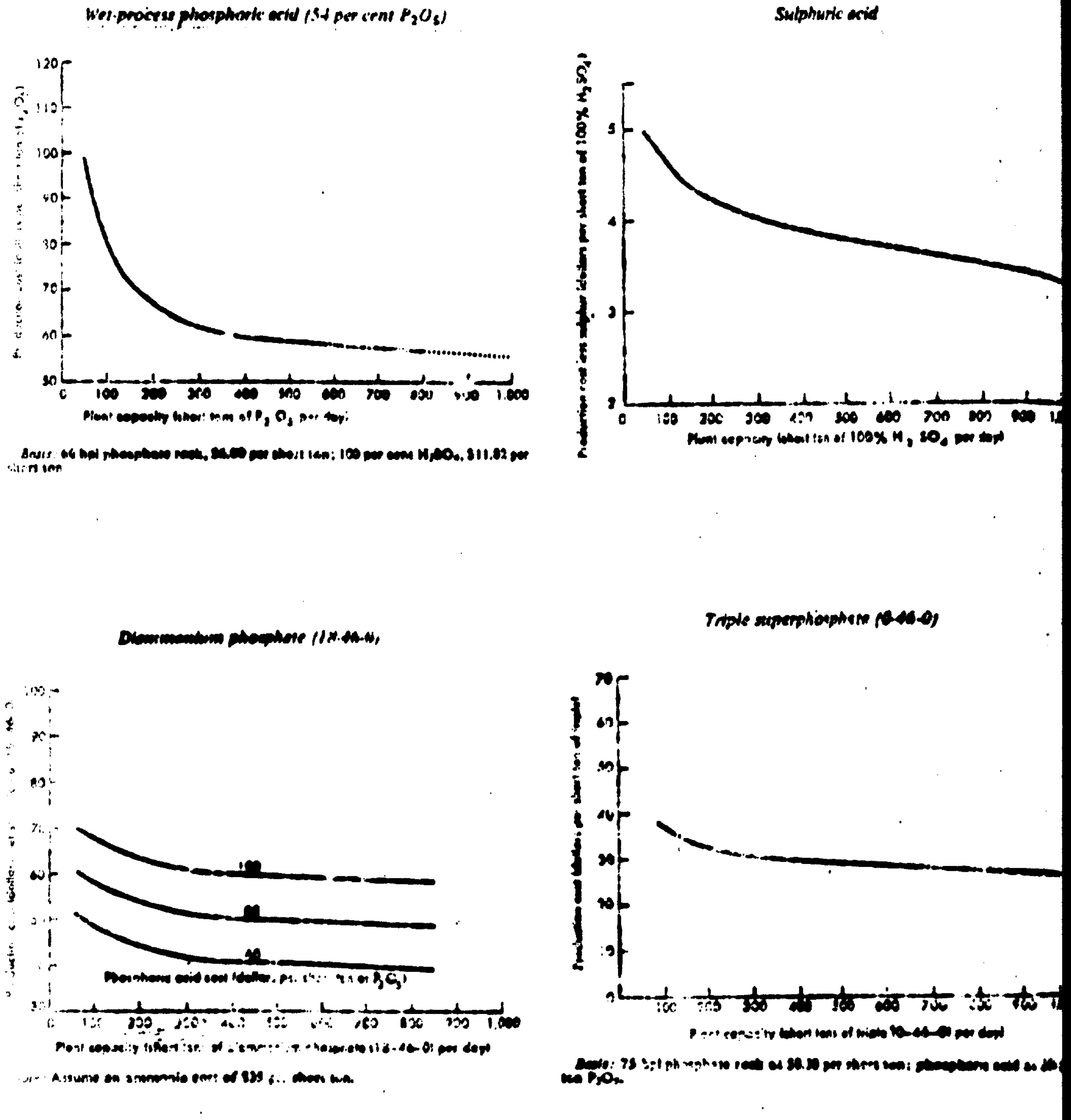


Ammonium nitrate, prilled



Note: Including effect of ammonia cost on nitric acid cost

Figure 3. Effect of Plant Capacity on Operating Costs—Nitrogen Processes



Wet-process phosphoric acid (54 per cent P_2O_5)

Basis: 66 bpl phosphate rock, $6.00 per short ton; 100 per cent H_2SO_4, $11.82 per short ton

Sulphuric acid

Diammonium phosphate (18-46-0)

Assume an ammonia cost of $35 per short ton.

Triple superphosphate (0-46-0)

Basis: 75 bpl phosphate rock at $8.30 per short ton; phosphoric acid as

ton P_2O_5.

Figure 4. Effect of Plant Capacity on Operating Costs—Phosphate Related Processes

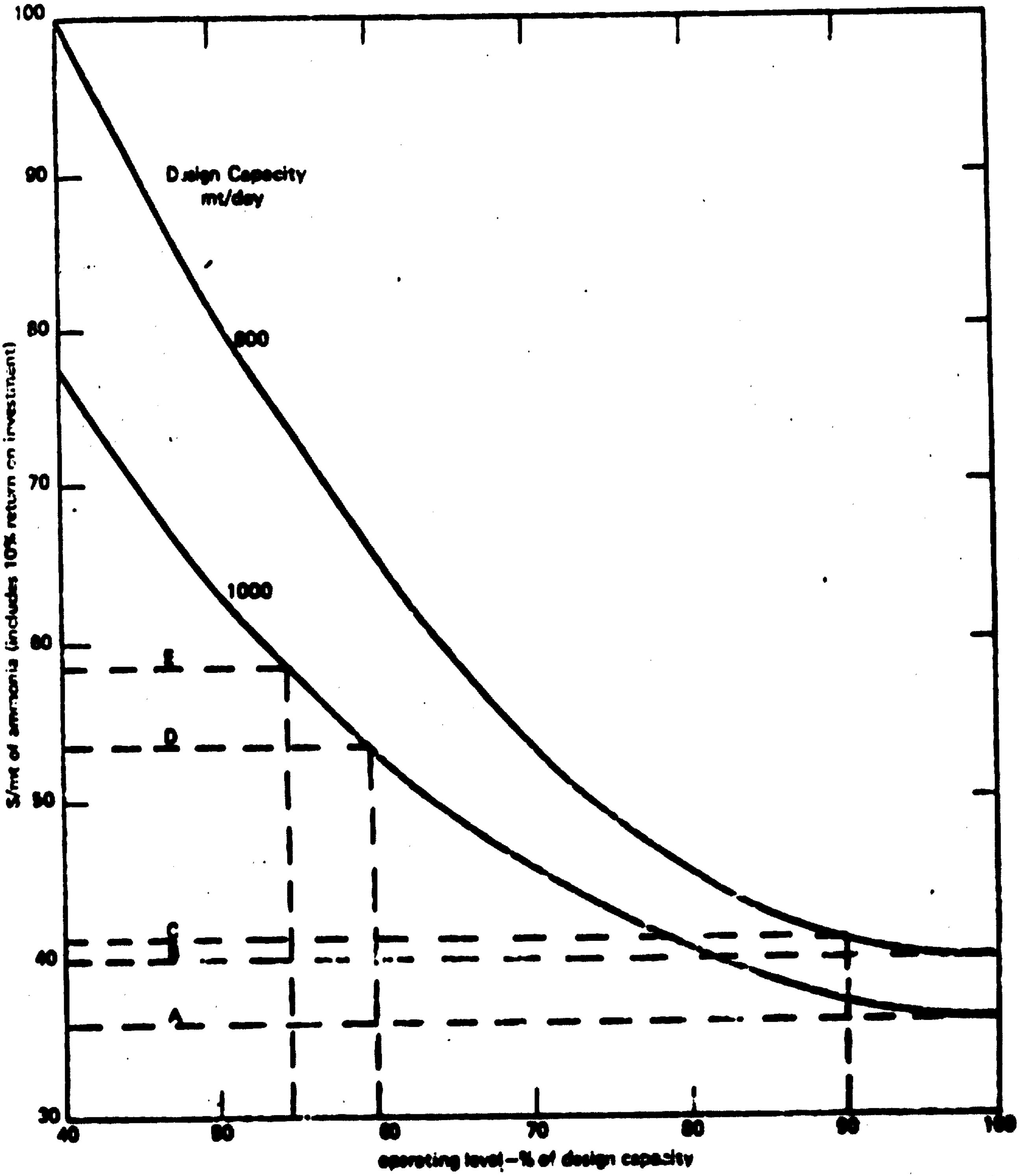


Fig. 5. Effect of Operating Level on Cost of Producing Ammonia (Natural Gas @ $0.10/1000 ft^3)

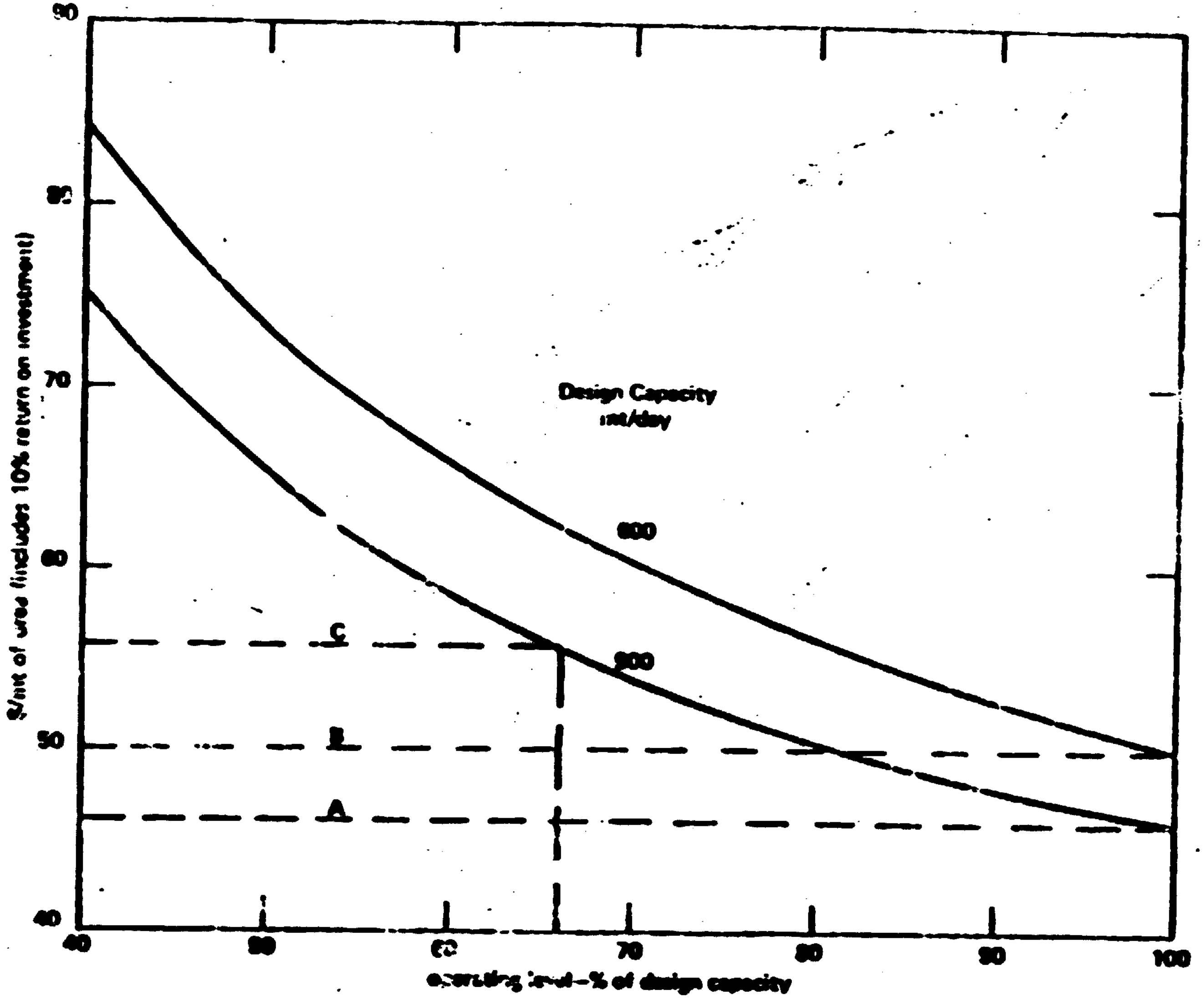


Fig. 6. Effects of Operating Level on Cost of Producing Urea
(Ammonia @ $32.50/mt)

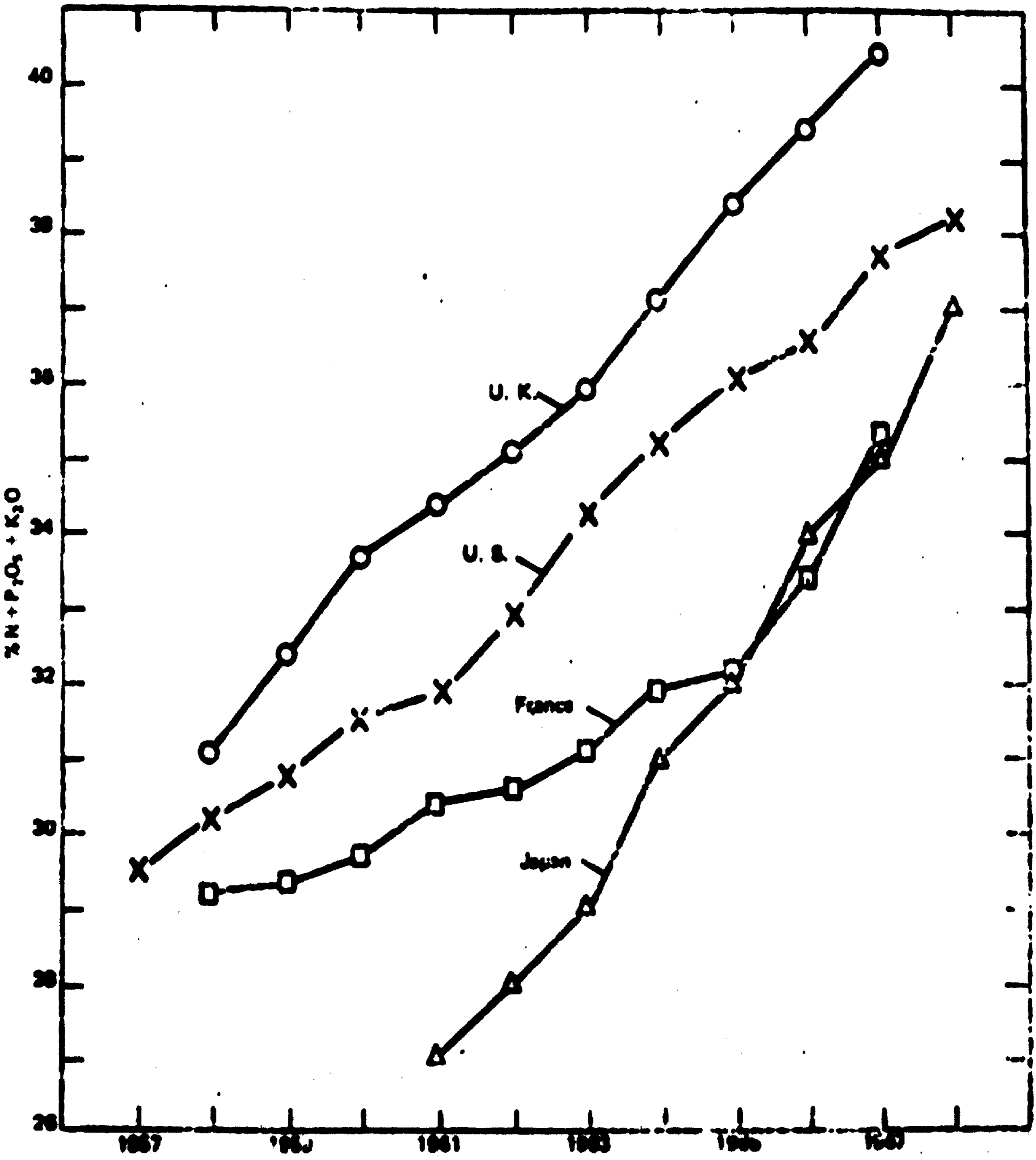


Fig. 7. Trends in Concentration of Compound Fertilizers

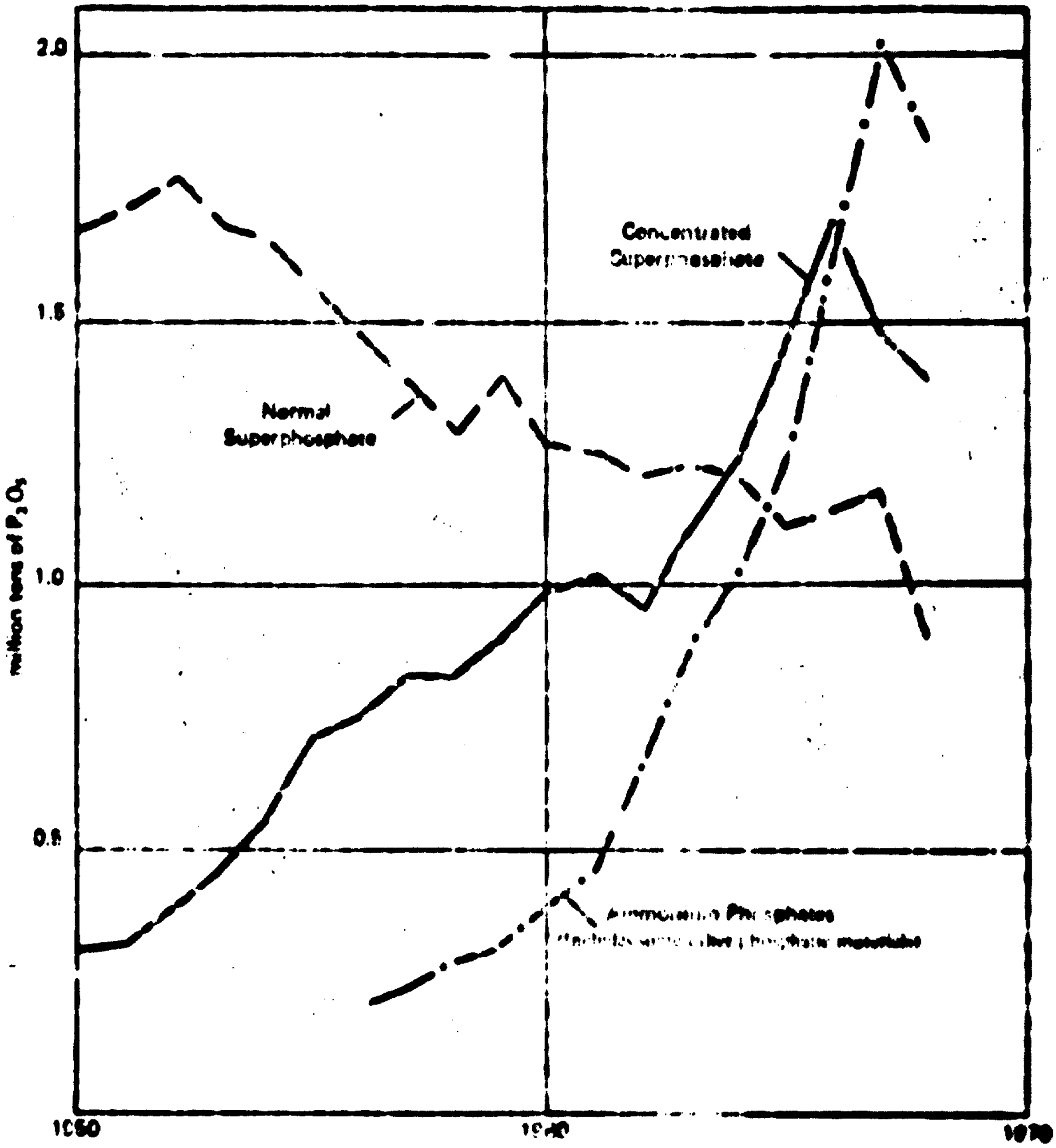


Fig. 8. Production of Phosphate Fertilizers
United States

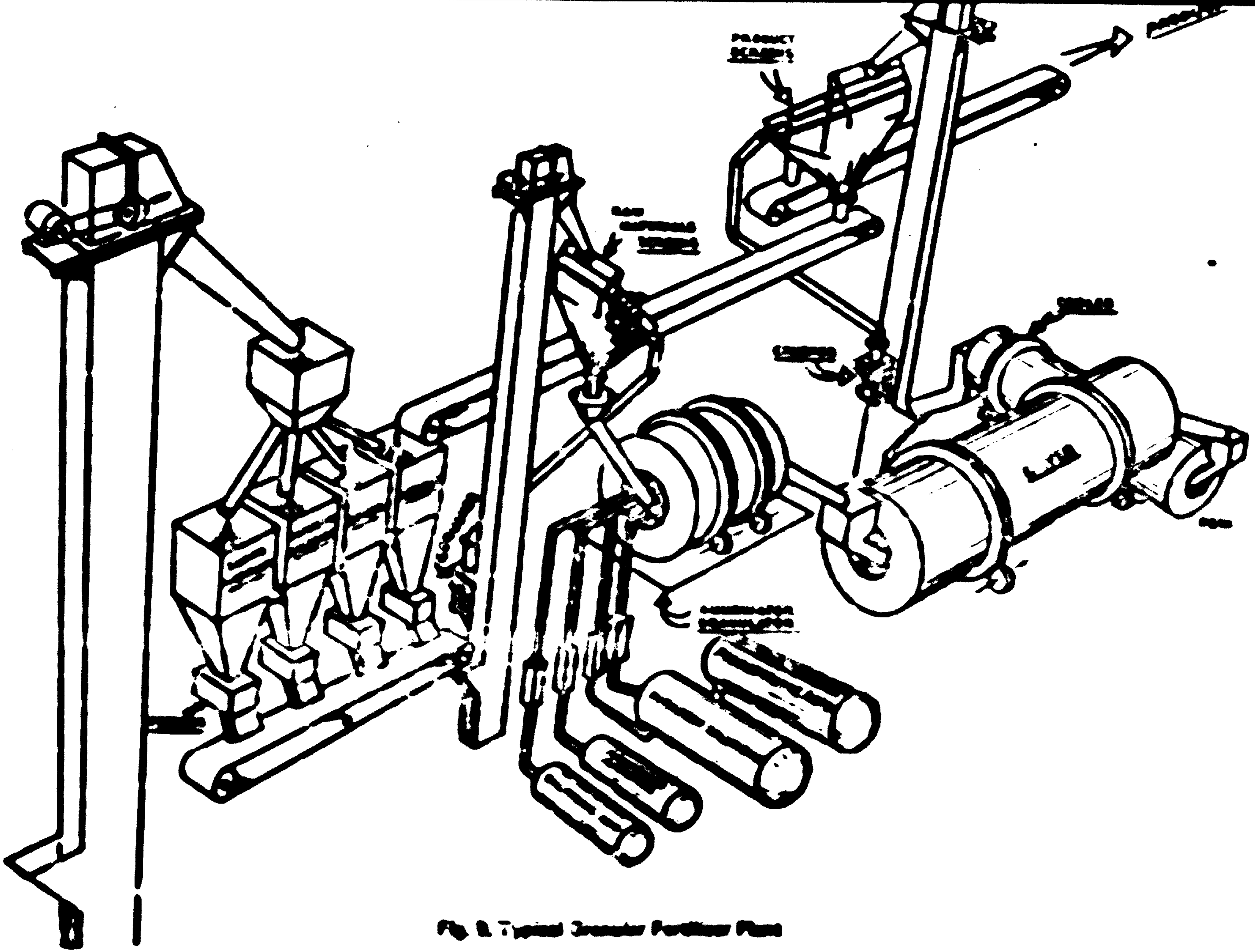
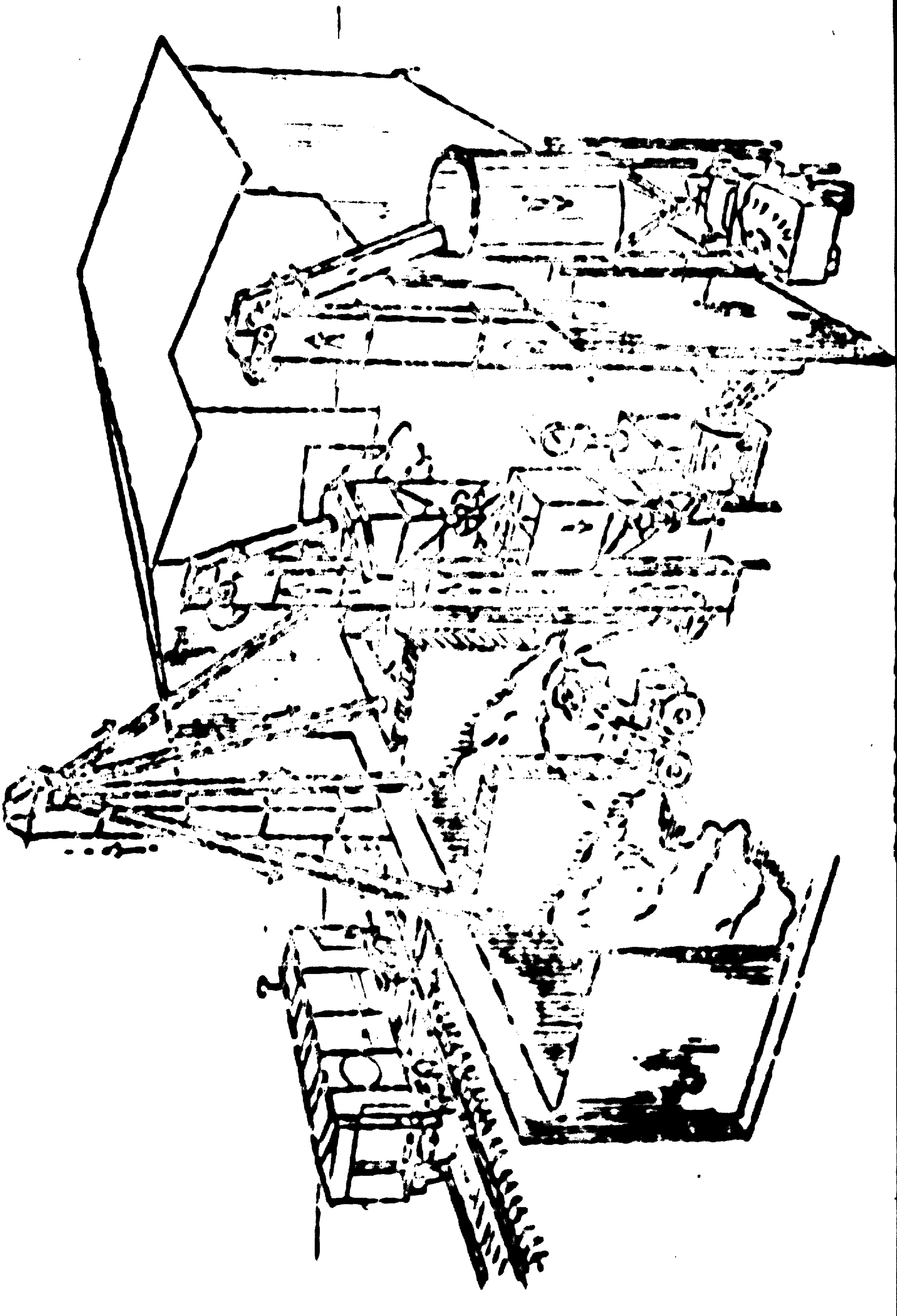


Fig. 8. Typical Granular Fertilizer Plant



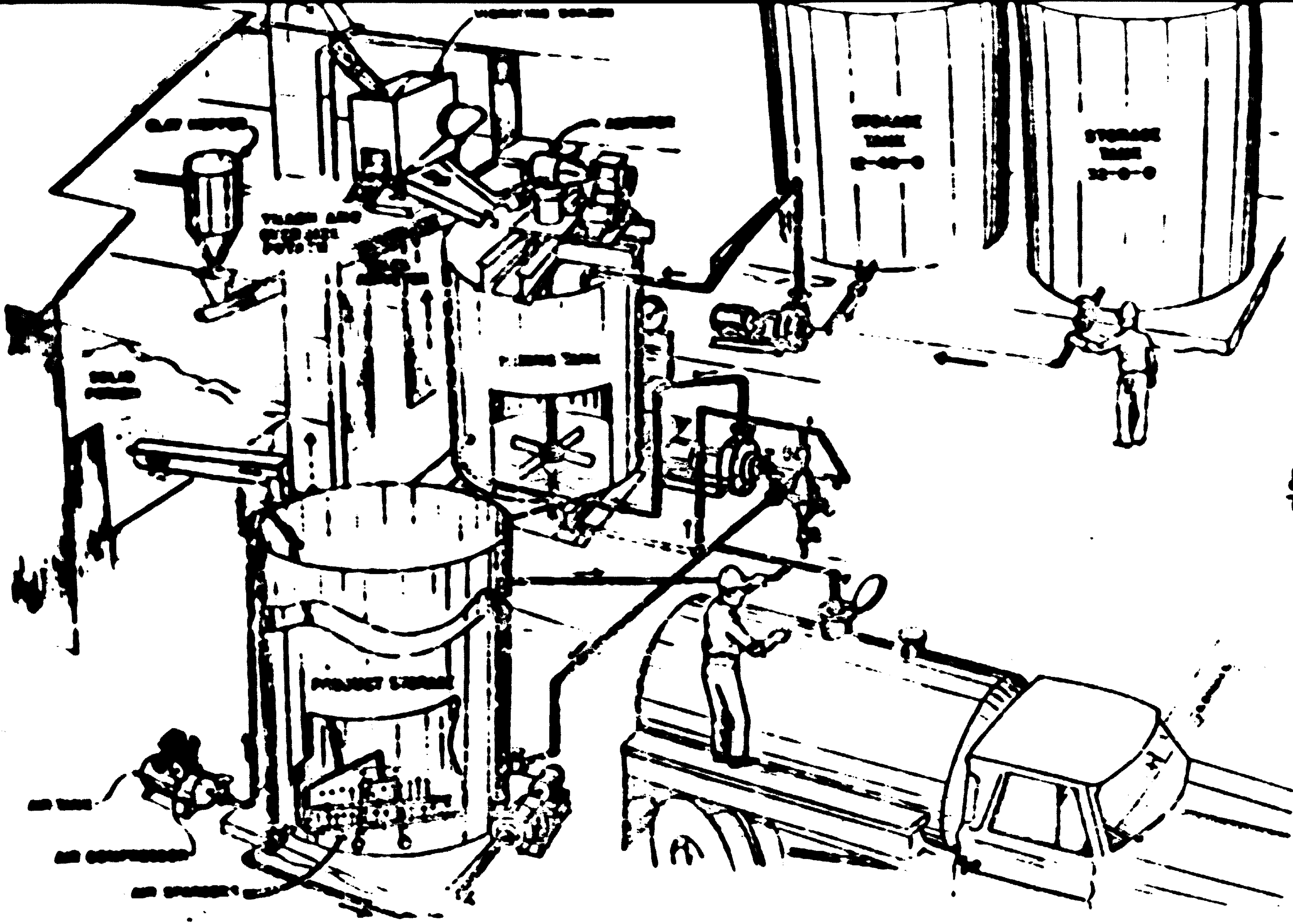


Figure 1[illegible]. Cold Mix Plant for Production of Clear Liquids or Suspensions

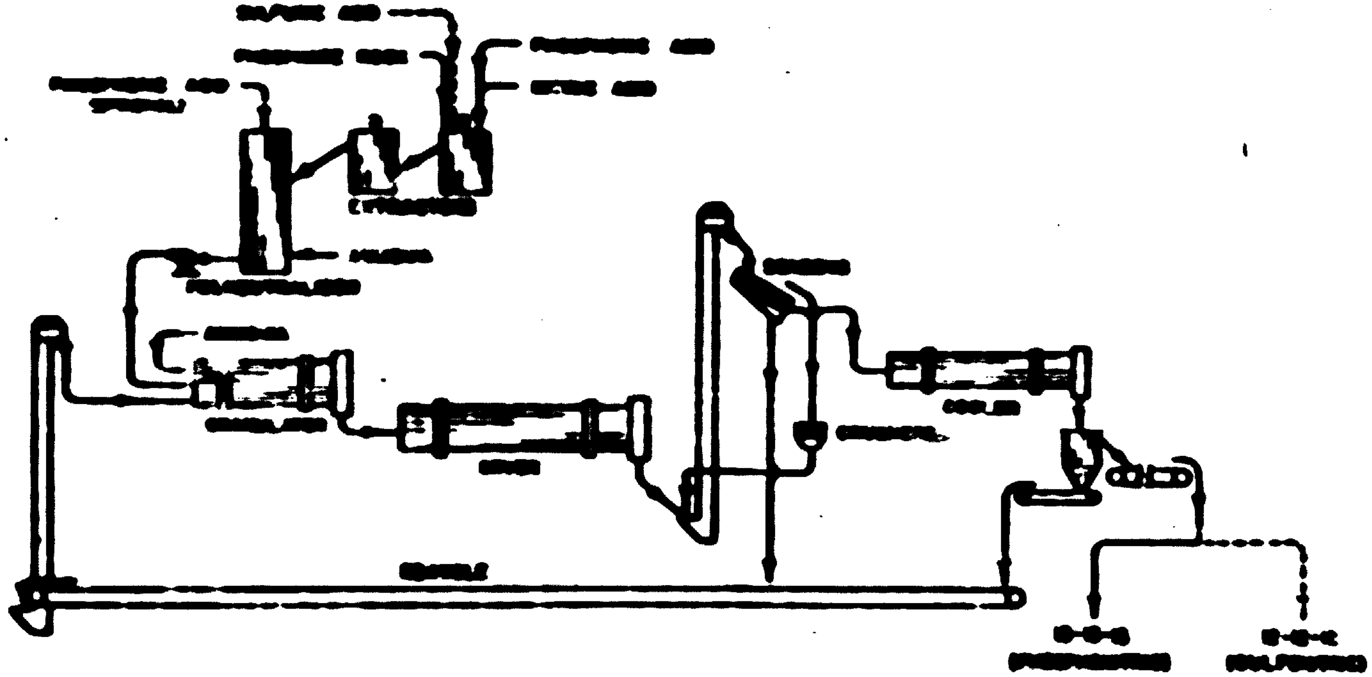


Figure 12. TVA Mixed Acid Nitrophosphate Process

2. REVIEW OF PESTICIDES AND THEIR FORMULATION

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Introduction

Whereas in many sections of chemical industry products are sold subject to compliance with a straightforward specificiation of chemical composition or physical properties, the farmer who purchases agricultural chemicals often expects and receives far-reaching guarantees concerning performance on soils and in weather of different kinds. In particular, the safety of the crop must always be guarded. Marketing of agricultural chemicals, therefore, has to be preceded by patient experimental work in fields situated throughout the main agricultural areas of each country. Such fields trials should preferably be planned in consultation with the chemical manufacturer, but they should be executed and evaluated by field biologists who are familiar with local agriculture and who have close liaison with their own Ministries of Agriculture. Development of an agricultural chemical usually occupies at least three seasons, and at an early stage in the development it is important that the manufacturer should be able to provide data to assist registration of the chemical with the local Ministry. Normally these data will include a summary of chemical and physical properties and a synopsis and interpretation of toxicological studies which themselves may be proceeding for three to five years. It is only by proceeding in this way that the chemical manufacturer can ensure the smooth commercial introduction of a new agricultural chemical.

Reluctance of farmers to buy any agricultural chemical until its performance can be comprehensively guaranteed has sometimes caused a manufacturer to postpone by several years the introduction of a really useful product. For example, the marketing of barban for control of wild oats in cereals was for long held in abeyance because the supplier felt unable to accept alone responsibilities for its performance in the hands of farmers. There are, however, signs that this attitude is just beginning to change as more enlightened people realise that many new and useful chemicals could be made available all the more quickly if suppliers were no longer obliged to bear all risks for performance during an extended period of development.

Ministries of Agriculture, through their registration and approval schemes, ensure that the most urgent public interests are safeguarded. These schemes call for much patient research, for example, by analysis for residues remaining in crops after harvesting, and by pathological studies of toxicity and carcinogenicity of such residues. To be effective these schemes are necessarily complex, but in most countries they are administered competently and are as valuable a guide to the chemical manufacturer as they are a safeguard of the public interest.

For any agricultural chemical the investment in research, development, and technical service is measured in hundreds of thousands of dollars, sometimes in millions, and an adequate return must be built into the retail price of the product. Similar considerations explain why a chemical to be sold for selective weed control is generally more expensive than the same chemical when sold for total weed control. Price cannot be related simply to costs of production and distribution until a chemical has been marketed for many years.

Herbicides

Herbicides are classified in current literature according to several schemes. In this paper it is convenient for the time being to distinguish two classes, viz. those which are applied

(i) to growing plants,

(ii) to soil in order to prevent growth of undesirable plants.

As an example of the first class, the action of MCPA in controlling annual weeds in a grass lawn is well known. MCPA is absorbed in significant amounts by their leaves and moves through the whole plant, often with crippling effect. Such herbicides are "translocatory" and kill by "systemic" action. Another example now becoming increasingly familiar is "Weedol" which is manufactured by I.C.I. and contains quaternary ammonium compounds that kill by "contact" action. The first example introduces the idea of selectivity, for it is easy to apply a dose of MCPA which cripples many weeds without harming grasses. However, "Weedol" would damage most plants and the quaternary ammonium compounds of which it is essentially composed are not regarded as possessing any useful degree of selectivity. Herbicides which are effective after absorption by weeds are generally very soluble in water, but this general rule has its exceptions to some of which we shall refer later.

Herbicides of the second class include highly substituted diazines, triazines, ureas, carbamates, and others. Frequently these are applied to the seed bed soon after the seed has been planted at a depth of at least 3/4 inch; and it is sometimes easy to find by trial a rate of application which, whilst permitting the desirable seed to grow normally, will prevent the growth of indigenous weed seeds for several weeks until such time as the crop is sufficiently strong to enable it on its own to overcome any belated competition from weeds. In these circumstances a sufficient amount of the herbicide continues to reside in the upper layers of the soil for several weeks, and when herbicides are used in this way they are described as "residual" herbicides.

Most residual herbicides now in commercial use have been introduced during the last fifteen years. Still, a great deal remains to be learned about the mode of action of residual herbicides and how to apply such knowledge to practical agriculture.

Of the various residual herbicides that would provide selective control of annual weeds, for example in root crops, rates of application vary from a few ounces to several pounds per acre. Many of the herbicides which are effective and safe when applied at rates within this range are only very slightly soluble in water. For example, diuron, whose action is highly selective after application at 5 ounces per acre to medium loam soils, is soluble in water to the extent of 42 ppm. Thus, the water in a shower of one-thirtieth inch of rain would suffice to dissolve the 5 ounces of diuron per acre if a saturated solution were attainable. During the weeks when residual weed control is commercially valuable, normal rainfall is well over one hundred times greater than would provide a saturated solution of the diuron; yet the phytotoxicity characteristic of diuron remains in the uppermost layers of a seed bed of medium loam soil. Further more, when applied by spraying in bands of width 7 inches over rows 21 inches apart, as in commercial band-spraying practice, effective weed control is restricted to the 7 inch width of the sprayed band with a precision of ± ½ inch. Persistent activity in the uppermost layers of soil, restricted almost precisely to the area of application is the chief characteristic of residual herbicides. This is in contrast to the rapidly diminishing effectiveness of other herbicides, such as dalapon, which are fugitive in a vertical profile by downward leaching and to a lesser extent in a horizontal section of soil by lateral diffusion.

The distribution of a residual herbicide like diuron in the system soil-air-water at normal temperature is difficult to follow in commercial conditions. Laboratory studies are facilitated by ultra-violet spectroscopy (2470 Å) of the aqueous phase. For light sandy soils and medium loams of low organic content the distribution of diuron between the solution and the soil phase follows approximately logarithmic adsorption isotherms of the Freundlich kind, and as the organic content of the soil increases so also does its capacity for adsorption. Five grams of coarse washed sand separated from the other constituents of a medium loam adsorb 6% of the diuron from 20 ml of an aqueous saturated solution, 5 grams of clay adsorb 22%, but 5 grams of any soil containing 5% of organic matter adsorb up to 80% of the diuron, whilst some fen peat soils adsorb virtually the whole.

In these adsorptive processes equilibria are closely approached in 15 minutes; in desorption to a fresh aqueous phase equilibria are much more slowly attained. Although impatience in the laboratory restricts the study of desorption processes, nevertheless it is known that diuron is much more quickly desorbed from light mineral soils than from more organic loams.

At any instant the quantity of residual herbicide which is in solution and available to plants is only a small fraction of that which has been applied to the soil. Whilst plant roots absorb herbicide from the aqueous phase of the soil, whilst the herbicide in solution is partly decomposed by bacterial activity, whilst it partly evaporates, or is slowly leached to become adsorbed again on lower depths of the soil, more of the herbicide is gradually released from the uppermost layers of the soil into the adjacent aqueous phase to provide continuity of herbicidal action, until the adsorbed reserves of herbicide are finally depleted.

This introduces the properties and mode of action of modern residual herbicides which, after application to soil, can prevent the growth of numerous annual weed species. It follows from this theory, and it is confirmed in practice, that their effectiveness against annual weeds depends both upon the adsorption and desorption characteristics of the particular kind of soil. Almost always, to attain equality of herbicidal action the dosage rate upon an organic loam soil must be greater than upon a sandy soil.

The more modern residual herbicides serve a dual purpose; not only do they prevent the germination of indigenous seeds of unwanted plants, but they also have a contact action upon the leaves of emerged weed species. For example, the recently introduced Velsicol Tunic combines the classical residual function against germinating annual weeds; besides, it has destroy perennial weeds, such as Convolvulus arvensis, if directionally sprayed upon their freshly emerged foliage as, for example, in orchards or on vineyards. This dual function may be expected to increase the economic value of residual herbicides which are currently under development.

Insecticides and Miticides

Insecticides include a diverse range of chemical compounds which may be formulated for use as toxicants against the true insect species and against other groups of arthropods such as the red spider mites. Thus, insecticides are generally understood to include miticides or acaricides; similarly, formicides and nematocides are included within the range of modern insecticides.

This whole range may be conveniently classified according to the manner in which toxicant works.

Some insecticides, eg nicotine, are substances whose vapour pressure at the ordinary temperature is small, although methyl bromide is a gaseous substance. Insecticides of this class are absorbed as the insect breathes; consequently, they are fumigants. Their volatility renders them most generally useful in confined spaces. However, many volatile insecticides of this class can be applied in the field beneath the soil surface; then they become physically adsorbed by crumbs of the soil in which they are retained long enough and from which their vapour pressure suffices to be toxic against insect pests. Chlordane, when adsorbed upon soil, exerts a minute vapour pressure which is nevertheless an intoxicant for many insect species.

Other insecticides of much lower vapour pressure are toxic only when digested. These may be applied to the soil if it is desired to protect the roots of plants or otherwise to foliage. In this class many of the most successful insecticides are systemic, so that even when applied to the soil they are quickly translocated to all parts of the plant upon which insects may feed.

However, economically the most important class comprises those chemical substances that are toxic to insects by mere contact with their external parts. Skill devoted to the formulation of these insecticides is then of great importance in ensuring that the toxicant can pass easily through the integument of the insect.

To be effective, insecticides must be located either in the soil or in or upon the plant tissue so that unwanted insect species cannot avoid contact with the toxicant. This is tantamount to saying that the toxicant must have a useful period of chemical stability after it has been applied to the soil or upon the foliage. Another equally important requirement is that when applied at a dosage which is insecticidally effective, the formulation of the toxicant must not itself be phytotoxic to the crop.

It is in these several essential respects that desirable variation and gradation of physical, chemical, and toxicological properties are to be found amongst the members of these important chemical classes, viz.,

organochlorine

organophosphorus

carbamate

compounds. There is practically no limit to the number of members that can be synthesised in each chemical class. From amongst those products that are now already commercial, it is usually easy to find an insecticide that possesses just the right degree of toxicity towards economically important insect species, together with freedom from phytotoxicity, and a limited period of chemical stability which enables edible crops to be harvested without risk of finding them contaminated by residues that would introduce hazard to the consumer or possibility of seizure in international commerce.

Use of insecticides for soil disinfection demands special properties of chemical stability. Often in agriculture it is practicable to introduce insecticides into the soil only in two ways, viz. by incorporating granular or wettable powder formulations prior to drilling the seed or alternatively by dressing the seed with insecticide. In either case the insecticide must protect first the seed, later the roots; and, the required period of protection lasts at least several weeks or even several months. In these circumstances, as for example in the protection of young sugar beet, it is important to select a toxicant which will resist early degradation in, or substantial loss by volatility from, the soil. For use in circumstances of this kind it would seem not yet possible to find insecticides superior to the well-established organochlorines, particularly aldrin, chlordane, dieldrin, heptachlor. At comparatively low doses these insecticides provide long term insurance against damage by soil insects. Besides, the most sensitive analytical methods have facilitated studies of organochlorine residues in crops and in soils. These studies are far more thorough, indeed more reassuring, than have been undertaken on behalf of insecticides of any other chemical class.

As a corollary to the preceding remarks on stability it follows that the chemical class of organochlorine insecticides is by far the best suited for incorporation into compound fertilisers. The point of entry of such insecticides into the manufacturing process is important and will be mentioned in the later section on formulation.

Whereas chemical formicides are seldom necessary even in heavily infested areas, there is a great economic need for a cheap chemical nematocide especially for use in cereals, potatoes, sugar beet, vineyards, and horticulture, where virus diseases may be transmitted by nematodes. Agriculture may eventually solve this problem in its own way by introducing favourable genetic changes into host plants. Meanwhile, some of the chemicals available for use as nematocides are fundamentally soil sterilants and their use is exceedingly unpleasant and expensive. The cheapest of these chemicals, a dichloropropane/dichloropropene mixture, presently costs per hectare about ten times as much as chemical weed control with residual herbicides.

Fungicides

Modern chemical fungicides are applied for two purposes. First, by direct application to exposed surfaces of plants fungicides can act directly upon exposed mycelia. In this way, for example, tetrachloroisophthalonitrile may be applied to kill the powdery mildews. Secondly, fungicides may be applied systemically in order to prevent, or at least to protect against, the possibility of infection in new growth some time later when spores arrive. For example, certain compounds drawn from the chemical classes of benzimidazoles and pyrimidines afford systemic fungicidal protection to fruit and to cereal crops. Any fungicide of the first class, which acts only upon the plant surface where it happens to have been deposited, suffers from the disadvantage that it provides no protection to later new growth, and so the application must be repeated by a series of sprays according to the extent of new growth, whereas a systemic fungicide introduces the possibility that a single spraying may afford a life time's protection against certain specific fungi.

It is a serious disadvantage of several recently introduced systemic fungicides that they are inactive against some common diseases including, for example, those attributable to Phycomycetes; such systemic fungicides are consequently inactive against the economically important potato blight. The directions for future applied research can, therefore, be clearly foreseen.

Rodenticides

Toxicants presently used as rodenticides in agriculture include zinc phosphide and aluminium phosphide. Of these zinc phosphide is the more important, it is an acute poison (LD^{50} to rat 47 mg/kg), it is cheap, and after application in the field it gradually decomposes into the simple hydrates and carbonates of zinc which leave no problem and excite no question concerning residues in soil or crops.

Since the introduction of Warfarin, many other anticoagulant rodenticides have been discovered. Some of the most successful are compounds which are chemically related to the hydroxycoumarins or which are diphenyl acetyl derivatives of 1,3-indandione such as diphacinone or its chlorine substitution products. Such new compounds are being developed particularly for control of rodents in forests. Probably they will eventually be useful in protecting cereal crops against the depredations of mice and rats, but their introduction to edible crops will require patient toxicological, metabolism, and residue studies.

Formulation

Products of the chemical industry for use in agriculture are not usually available in such high purity as is necessary, for example, in [illegible]. It is a fact that some simple chemicals such as [illegible] can be often produced with purity exceeding 97 per cent but [illegible] others, such as the slightly soluble substituted [illegible], or complicated organo-phosphorus compounds [illegible] difficult to synthesise, and their purities as commercial products [illegible] lie within the range 80 - 90 per cent, [illegible] each batch.

Almost always [illegible] industry or for appointed formulators [illegible] products of limited purity into standard [illegible] finished ready for use in agriculture. [illegible] the content of active ingredient, the [illegible] that the finished product

(a) is [illegible] possible for [illegible]

(b) will [illegible] in storage,

(c) [illegible] to the crop [illegible] to be [illegible] use,

(d) [illegible] of the active ingredient [illegible] to the [illegible] provide [illegible] pests [illegible] the lowest [illegible]

To attain these [illegible] converts the substance into one of the following [illegible] formulations -

[illegible] solution
[illegible] concentrate
[illegible] powder
[illegible]
[illegible]
[illegible] organic solvent

in which the content of active ingredient is precisely adjusted to some standard round number.

Formulation is partly an art and partly a science, and in order to be successful the formulator must bring to his task a great deal of experience which will include the following.

Aqueous solutions

It is usually a simple chemical or physical process to manufacture and standardise an aqueous solution, although experience calls a number of precautions that are not always obvious from the start. When it is desired to formulate a phenoxyaliphatic or substituted benzoic acid as an alkali metal salt, since the process of dissolution is exothermic and will yield a highly concentrated solution, it is important to find a reliable means of checking the pH of the finished solution so that long term risk of partial precipitation of the active acid can be avoided. Thus, it is most important to check the pH of a cool aqueous dilution of the finished product.

The potassium salts are frequently more soluble than the sodium salts, whilst the alkylamine or alkylolamine salts are usually still more soluble in water. For economy in packaging and transport the solution must be highly concentrated, although the limiting concentration will be governed by the need to avoid crystallisation during long storage at low temperatures prevailing during winter. Low temperature solubilities of lithium salts are sometimes so much greater as to justify dissolution of certain herbicides, e.g. DNBP, in lithium hydroxide.

The biological activity of certain phenoxyaliphatic acids is dependent upon the cation used to form the salt, and in particular the dimethylamine salt of 2,4-D is a more effective herbicide than the less soluble sodium salt.

For the formulation of aqueous solutions flow sheets of plant show as the central feature a stainless steel or glass-lined steel vessel, cylindrical but with hemispherical bottom and bottom run-off valve, capacity typically 800 gallons, closed except for man-hole opening in lid, with 2 - speed stirring gear and anchor-shaped agitator. This vessel should be jacketed with circulating cooling or heating fluids, and should have metered connections to soft water and alkali metal hydroxide or amine solutions. Solids are charged through man-hole opening. The run-off valve leads to a pump in series with a small filter charged with diatomaceous earth or other filter-aid. The outlet from the filter leads via a by-pass back to the cylindrical vessel and via an alternative line to a large stainless steel or ceramic storage tank. From the storage tank lines lead to automatic drum-filling meters.

Emulsifiable concentrates

Many substances which cannot be formulated as aqueous solutions because of their insolubility are instead readily soluble in cheap aliphatic or heavy aromatic oils. If solubility in these solvents approaches or exceeds 300 grams per litre it is frequently technically possible and economic to formulate emulsifiable concentrates. Toxicants which are not soluble to this extent in hydrocarbons may instead be more soluble in mixtures of xylene with cyclohexanone, isophorone, or dimethylsulphoxide, although the latter are expensive in comparison with hydrocarbons. Then, by incorporating several per cent of a carefully selected and matched emulsifier pair, it is frequently possible to produce a formulation of the toxicant that will spontaneously emulsify when poured into water, even very hard water

In order to formulate the most successful emulsifiable concentrates it is helpful to study according to the phase rule the behaviour of the system pesticide/solvent/atmosphere after tentative formulations have been applied to plant surfaces. At the same time the biologist will study the effects of these tentative formulations on plant life, insects, and fungi.

As solvent evaporates many toxicants crystallise. If the toxicant is intended as a fungicide or insecticide it may be desirable that the dimensions of the crystals be minute and that the maximum possible area of the plant should be protected by their coverage. If the toxicant is to protect the plant systemically, it might be preferable to select a solvent system that can carry it through the leaf surface. The formulator will strive to present the toxicant in such a way that the pest has no opportunity to escape contact with it. On the other hand, when the emulsifiable concentrate is to be used as a herbicide, the solvent/emulsifier system can sometimes be chosen so as to improve the selectivity of herbicidal activity as between crop and weed species by promoting penetration into the leaves of weed species and discouraging penetration of the desirable crop foliage.

It is apparent that the activity of herbicides, insecticides, fungicides can be modified significantly by the physical properties of an emulsifiable formulation. Experience suggests that, once a formulation has been devised which has a satisfactory performance against a specific pest, it is better to permit no departure [illegible] its physical and chemical specification until the possible consequences have been examined biologically in the field.

Plant for the manufacture of emulsifiable concentrates is not fundamentally different from that described for aqueous solutions except that stores are required for a variety of organic solvents and emulsifier pairs. Flame-proof electrical equipment and various [illegible] precautions against fire and explosion are necessary, and various other regulations must be enforced to ensure the health and safety of operators who work with solvents of low flash point or appreciable toxicity.

Wettable powders

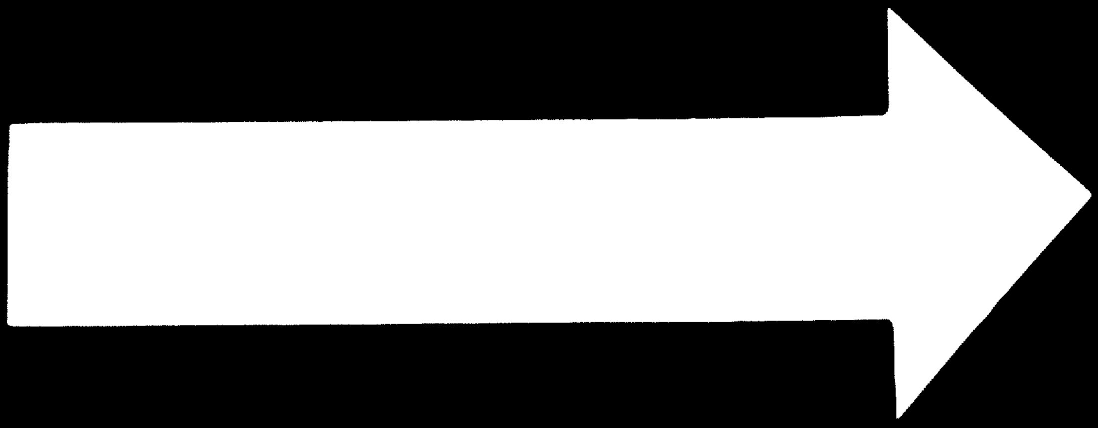
A chemical substance which may not be sufficiently soluble or satisfactorily stable in available cheap solvents may often be formulated instead as a wettable powder. Then the object is to pulverise the substance very finely, to modify its surface properties, and to standardise the formulation so that:

(a) it can be conveniently dispersed in water in the farmer's spraying tank and will remain well suspended to facilitate spraying with almost the same mechanical ease as if it were instead a solution or an emulsion,

(b) after it has been sprayed the particles are so minute and well dispersed that if applied to the soil they dissolve quickly in the soil moisture and become uniformly adsorbed on the soil, or alternatively may provide the greatest possible coverage upon foliage to protect plants adequately against insects or fungal infections or to destroy unwanted weeds,

(c) its content of active ingredient is precisely adjusted to some convenient round number such as 50, 75, or 80 per cent.

As a general rule the first step is to mix intimately by ribbon-blender a crystalline toxicant with the carrier of wettable clay, together with surfactant, sequestrant, and deactivator or anti-catalyst where necessary. The blend is then comminuted, for example, in a pin mill. Toxicants of low melting point may sometimes have to be blended little by little into larger weights of wettable clays, and it may be necessary deliberately and continuously to cool the mill into which, by multiple passes, the whole desired proportion of toxicant is



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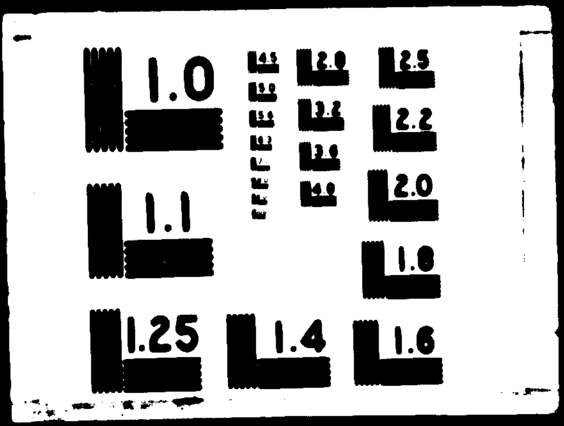


gradually fed. Sometimes it is preferable first to dissolve a low-melting solid, then to spray its solution gradually onto an absorptive clay in the ribbon-blender. Cheap liquid toxicants are frequently sprayed directly upon absorptive clays, and subsequently reduced and standardised to field strength by blending with fresh portions of clay. However, in order to attain the most uniform distribution of and best performance from an expensive insecticide or fungicide it is always better to incorporate a solution of the toxicant with the whole suitable quantity of clay so that no subsequent reduction of strength is necessary. The comminution of particles of toxicant with wettable clay should result in at least 98 per cent passage through 200-mesh, and for the final stage a fluid energy mill may be the most satisfactory. Final blending and standardisation are always necessary.

As integral steps within the blending and milling processes it is generally necessary to incorporate small proportions both of a surfactant and of a sequestrant for calcium and magnesium. The surfactant, of which lignin sulphonate is one of the older examples, is to assist wetting of the powder and to improve the stability of its dispersion in water. The sequestrant, which may be a polyphosphate or a salt of ethylenediaminetetra-acetic acid, is to prevent flocculation of the powder in hard water. Recommendations for use should specify not only maximum hardness but also maximum volume of the water in which 1 lb of the wettable powder is to be suspended in order to prevent inconvenience or failure through flocculation.

The surface properties of some clays may catalyse decomposition of certain insecticides and fungicides. This propensity can be measured in advance by laboratory tests, which consequently become useful criteria in selection and evaluation of clays. Some clays, but not all, can be treated with urea or hexamethylenetetramine which serve as anticatalysts, and it may be necessary at the pre-blending stage to incorporate these substances into formulations of wettable powders.

Dusts

Dust concentrates, standardised to contain for example 25 per cent of the active ingredient, are first manufactured in the manner described for wettable powders. However, it is usually unnecessary to incorporate either surfactant or sequestrant. It is essential that the dust concentrate be very finely divided, and many specifications require at least 95 per cent to pass 200-mesh because no further milling of this ingredient is expected to be necessary.

The dust concentrate must now be converted to a field strength dust whose content of active ingredient is usually within the range 1½ - 5 per cent, and which possesses other desirable properties such as being free-flowing and conformity within reasonable limits to a standard bulk density.

To select diluents most economically, the choice will usually lie among the attapulgites which impart free-flowing properties, kaolinites which are cheap extenders capable of absorbing moisture, talcs and proprietary forms of calcium carbonate whose own high densities are useful in adjusting the bulk density of the finished product within close limits. Some of these materials in the natural or purchased condition would be catalytically active in promoting decomposition of certain insecticides and fungicides, and so must be deactivated by means of urea, hexamethylenetetramine, or with a proprietary deactivator. The desired proportions of the extenders and the requisite quantity of deactivator are mixed in a ribbon-blender, then passed through the mill until at least 95 per cent is minus 200-mesh.

Finally, the prepared dust concentrate is to be diluted with the prepared extender in the pre-calculated proportions. The total quantity of dust concentrate is transferred to the ribbon-blender and with the machine in motion the extender is added gradually over a period of about half an hour. The proportions are pre-calculated so that the active ingredient of the blend at this stage should be slightly greater than specification. The blend is assayed, after which a calculated final adjustment with a little more extender should bring the batch precisely to specification.

Granules

Very toxic insecticides and herbicides formulated as solutions, wettable powders, or dusts may present a hazard to agricultural workers who apply them; besides, air currents may carry dusts and sprays away from the area of application, so impairing effectiveness and perhaps adulterating other crops. It is sometimes practicable to minimise such hazards by formulating the same pesticides as granules, for example, within the size range 30 - 60 mesh.

Attapulgite, vermiculite, bentonite, Fullers earth and other minerals can be manufactured as sorptive granules. Capacity for sorption, and physico-chemical coefficient of adsorption, speed of disintegration in soil, catalytic properties, and cost vary according to the identity of the mineral, its heat treatment, and the size range of the granules. These are the principal factors which must be investigated to ensure the best choice of granule for each particular pesticide application.

For impregnation the granules are tumbled in a drum-blender or ribbon-blender into which a solution of the pesticide and deactivator is sprayed through well placed nozzles. As a general rule, 100 lb of granules would be impregnated with one to two gallons of a pesticide solution in order to assure uniform distribution throughout the structure of each granule. After the solution has been sprayed the granules are tumbled until all has been absorbed, but not for so long as to cause attrition. Afterwards the diffusion of pesticide solution into the innermost interstices continues for a few hours, and when this period of so-called "curing" is complete the granules should be apparently dry, and should flow readily. Finally, the batch is assayed.

The sorptive capacity of granules must be selected in relation to the desired concentration of pesticide in the finished product. For, if the sorptive capacity is too high the pesticide would have to be dissolved in an inordinate volume of solvent to assure even impregnation; to do so would be uneconomic and would introduce the risk during a long period of storage that a significant quantity of this solvent might evaporate, so leading to uncertain content of active ingredient and hence to faulty dosage rates. This kind of risk can be minimised also by choosing solvents of low vapour pressure; in this respect, whenever other considerations are favourable, mineral oils and high aromatic naphtha are admirable solvents.

When granular formulations of insecticides are intended for direct application to the soil it is advantageous to select granules that disintegrate quickly, allowing the insecticide to diffuse into the surrounding soil. But if a granular insecticide is to be broadcast from the air, for example into the whorl of maize to protect against Ostrinia nubilalis, there is an advantage in granules that disintegrate slowly and release the insecticide into the whorl during an extended period.

Certain insecticides of the organochlorine class, such as aldrin and heptachlor, can be introduced into granular compound fertilisers. At stages of manufacture prior to curing the temperature of fertiliser granules might be so high that the insecticide would decompose or volatilise; or the solvent for the insecticide might enter into a temperature exceeding its flash point; or the insecticide would become mixed with a crude form of granules from which fines and oversize granules still have to be separated. Of necessity the point of entry of the insecticide into the manufacturing process must be (a) after curing, (b) at a temperature below the flash point of any hydrocarbon solvent, (c) into a stream of fertiliser granules of the desired finished size range.

Having regard to these practical limiting conditions, procedures based upon two separate principles may then be selected. The principles are as follows:

(i) The insecticide solution may be sprayed upon the compound fertiliser granules in a batch process or in a continuous process. The batch process is the simpler to regulate with precision, but the continuous process is practicable and cheaper for a high output.

(ii) The insecticide may be introduced amongst the compound fertiliser granules in the form of 20% active granules of 30 - 60 mesh. Some variation in this mesh size may be desirable, because it is important to minimise the possibility of segregation or stratification of the insecticide granules within the bulk of the fertiliser granules.

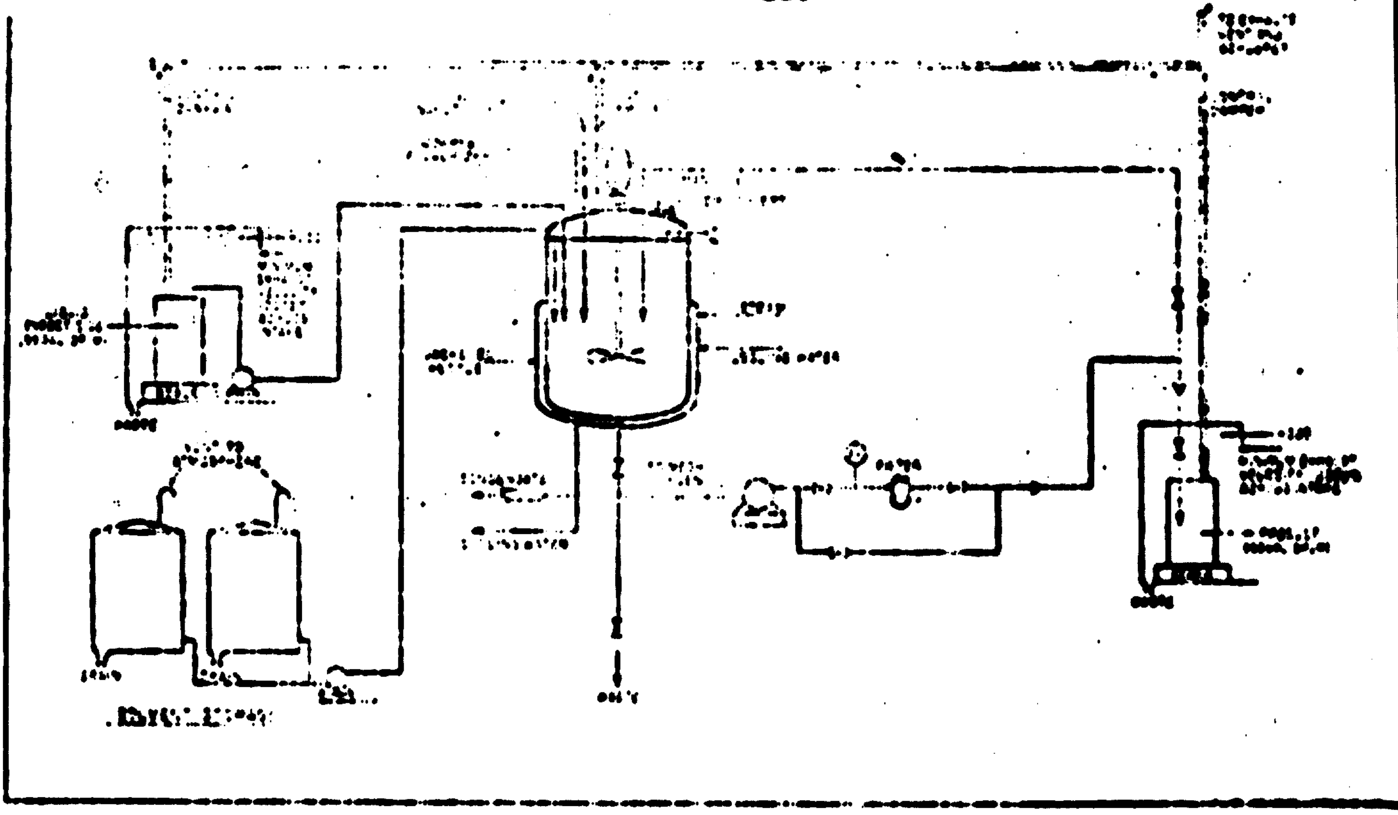
Principle (i) comes nearer the ideal because by its means the risk of segregation can be entirely avoided, and it is also the cheaper method of manufacture. Principle (ii) is the easier course for small scale or occasional production. Which of these principles is to be chosen also depends upon the manufacturing plant available, the expertise with which it can be operated, also upon the period which is expected to elapse between manufacture and use by the farmer.

Solutions in organic liquids

The technique of spraying liquids from spinning discs, without the need for dilution or emulsification by water, challenges in a new way the science and art of formulation. The ability to produce droplets within a very narrow dimensional range of volume mean diameter around 80 microns, enables liquid insecticides to be applied with unprecedented economy to plants and with least contamination of the soil and environment. This technique, sometimes known as ultra low volume spraying, is readily adaptable to the spraying of those organophosphorus insecticides which are themselves liquid at atmospheric temperature; but in order to make the technique more generally applicable, solvents of very low vapour pressure must be found for insecticides that are solids. Mineral oils, high aromatic naptha, and other distinctive liquids of improved solvent power and low vapour pressure are being studied. In certain other respects problems of formulation are simplified; for example, it is unnecessary to devise emulsification systems. Furthermore, insecticides can be packaged by the manufacturer for direct connection to a rotating disc sprayer, so that all hazards of mixing with water (that final step of formulation which is generally left to the farmer) can be eliminated.

Flow sheets

Flow sheets for liquid and solid formulation plants are attached.



Liquid formulation plant

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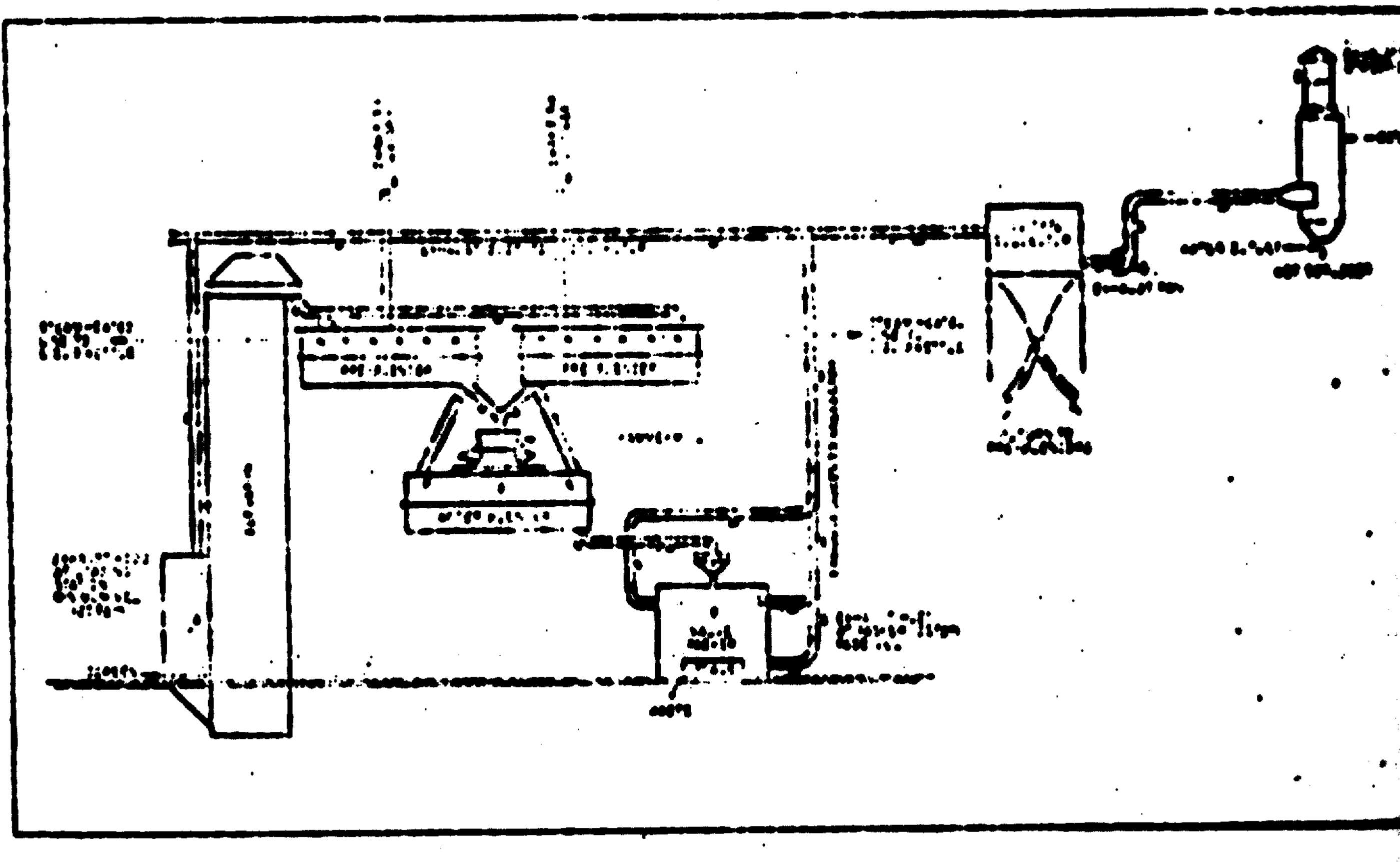


Solid formulation plant

VELSICOL CHEMICAL CORPORATION · 341 EAST OHIO STREET · CHICAGO ILLINOIS 60611

FORMULATION OF PESTICIDES

Investment Captial
- a) Units for Solids
- b) Units for Liquids
- c) Combination units

The following tables list the estimated costs of the major pieces of equipment necessary to set up a formulating plant capable of producing quality liquids, granulars, dusts and wettable powders. The price estimates are US prices and must of necessity be rough approximations. We have not included in these estimates the cost of land, buildings, analytical equipment, safety and pollution control devices, etc.

The estimates of the capacities are also rough, depending upon what products are being formulated and how efficiently the personnel are able to operate.

The production of quality pesticide formulations involves considerable expertise and in the setting up of any formulating facility, experienced people will have to be brought in to assure the equipment is properly installed and to train the local personnel in how to operate the equipment.

GRANULAR, DUST & WETTABLE POWDER CENTER

	Minimal	Typical
Ribbon Blender	$ 2,500	$ 2,500
Bag Weighing Scale	300	300
Bag Loader		1,000
Mikro Pulverizer w/ Dust Collector	2,500	2,500
After Blender		2,500
Small Elevator		2,000
Miscellaneous Equipment	700	1,200
Total Cost	6,000	12,000
Daily Capacity (2 shifts)	4,000 lbs*	8,000 lbs

* applies to wettable powders, for dust formulations, figures can be increase to 16,000 lbs, granular formulations, 10,000 lbs

FORMULATION OF PESTICIDES (2)

LIQUID CENTER

	Minimal	Typical
Melt Kettle 250 gallons	$	$ 5,000
Mix Kettle 500 gallons	4,500	4,500
Hold Tank 500 gallons		4,000
Filter with pump	300	300
Pump		400
Overhead Scale	500	500
Hand Hoist	200	200
Pipe & Fittings Stainless	250	600
Wooden Platform	250	500
Total Cost	6,000	16,000
Daily Capacity (2 shifts)	12,000 lbs	34,000 lbs

MIA:

TOTAL MARKET
PESTICIDES
HISTORY & PROJECTIONS: 1965 - 1974

(M - US Funds)

Market Segments	Actual					Est.	Proj.	% Compound Annual Change
	1965	1966	1967	1968	1969	1970	1974	1970-1974
Mexico	18.7	19.4	20.0	21.5	22.6	24.0	30.0	5.7%
Argentina	12.1	13.4	13.9	14.5	15.0	15.1	17.8	4.2%
Brazil	11.4	13.8	16.8	17.0	24.0	25.0	30.0	4.7%
Colombia	15.0	15.6	16.4	17.2	18.0	18.8	22.3	4.4%
Central America	27.0	28.8	29.8	31.5	32.0	34.4	45.7	7.3%
Total Market:	84.2	91.0	96.9	101.7	111.6	117.3	145.8	5.6%

MLP:

3. WET PROCESS PHOSPHORIC ACID AS A BASIC FERTILIZER INGREDIENT IN INTERNATIONAL TRADE

by

Fertilisantes Fosfatados Mexicanos, S.A.
Mexico 5, D.F. Mexico

1. BACKGROUND

Regular bulk shipments of phosphoric acid by tanker were initiated in 1969 when the FFM Vassijaure carried its first cargo between Coatzacoalcos, Mexico and Rotterdam, Holland. Apart from the technical achievement of its voyage, its importance also lies in the fact that this is the first time that an off-shore supplier of phosphoric acid has ever attempted to penetrate an established and stable market with imports.

The significance of this advance can be seen in many countries today where the larger fertiliser manufacturers are now completing their calculations on whether to "make or buy" intermediate raw materials such as anhydrous ammonia and phosphoric acid, particularly when an increase in present plant capacity is planned or a new venture is envisaged.

Since this first shipment on the M/V FFM Vassijaure, other shipments have been made to Europe and Australia.

Fertilisantes Fosfatados Mexicanos, S.A. (FFM), now has two such ships in regular operation and by early 1971 will have four tankers supplying such countries as Holland, France, Belgium, England, India, Italy, Australia, Brasil, Ecuador and the USA.

This fleet provides added assurance that continuous and dependable deliveries may be expected by FFM phosphoric acid customers.

To be able to take maximum advantage of such shipments, the buyer must have access to a deep water harbour (34 feet) and of course, have built a receiving terminal capable of holding a full shipload (23,000 metric tons of phosphoric acid). Other combinations can be worked out, such as partial shipments into smaller terminals provided that more than one client is on the same shipping route. Or, if a tanker is partially loaded a higher per ton freight rate applies.

The concept of marketing phosphoric acid in ocean going shipments is successful when the above is available and the following premises also hold true for the user of the product.

1. He is obliged to import phosphate rock or to buy expensive locally produced rock. One ton of P2O5 in phosphoric acid corresponds to approximately 3.4 tons of rock.
2. He is obliged to import sulphur. Approximately 0.95 tons of sulphur correspond to one ton of P2O5. Sulphur and rock freight volume is more than twice that for equivalent P2O5 in phosphoric acid.
3. His P2O5 requirements are not large enough to allow him any cost savings by scale of manufacture (approximately 200,000 metric tons P2O5 per year is now generally considered an economic unit).
4. His forecast requirements are such that he cannot justify an installed production facility operating at 100% capacity

within the first several years of operation. Purchased phosphoric acid provides flexibility in quantities received as required. Idle plant capacity is avoided.

FFM with their plant at Coatzacoalcos have an installed capacity of 400,000 metric tons P2O5 per year. The plant is situated on deep water and has a sulphur source with abundant reserves close by. Phosphate rock has to be imported.

One of the inherent problems with fertilizer grade phosphoric acid has been the deposition of solids from the acid upon storing and handling. This is particularly true with acids made from a Florida type rock.

FFM has installed, within its manufacturing facilities, the ability to cool, age and clarify the finished acid before shipment, thereby ensuring that the ships and the future customers have a minimum solids problem upon receipt and subsequent usage.

Experience to date has shown that this "solids" problem has been solved with respect to storing and shipping.

2. MANUFACTURING PROCESS

A. Rock Preparation

Phosphate rock is imported into the plant at Coatzacoalcos by large bulk carriers (30,000 metric tons) equipped with self-discharging gear. The rock is discharged at FFM's privately owned dock and is then conveyed to a large storage building capable of holding 100,000 metric tons.

Generally speaking, the rock that is purchased requires further grinding to obtain the maximum recovery of P_2O_5 and to ensure good production control. Large ball mills are used for the final grind to produce a material which passes 60% through 100 Tyler mesh screen.

A typical flowsheet is shown in Figure I.

(B) Sulphuric Acid Facilities

The company has built two Wellman-Lord contact sulphuric acid plants burning Frasch sulphur.

Each of these plants is rated at 1,500 metric tons per day of 100% H_2SO_4.

A typical flowsheet is shown in Figure II.

Molten sulphur arrives at the plant by road trucks and is discharged into an underground pit.

Special demister devices on the ensuring exhaust stacks ensure that the gases leaving the plant contain a minimum of sulphur trioxide and sulphuric acid emission.

The strenght of acid produced can be either 96% or 98% H_2SO_4 and is passed to intermediate storage. Waste heat boilers produce surplus steam at 500 psig and 35 psig at a rate of one ton of steam per ton of H_2SO_4 produced.

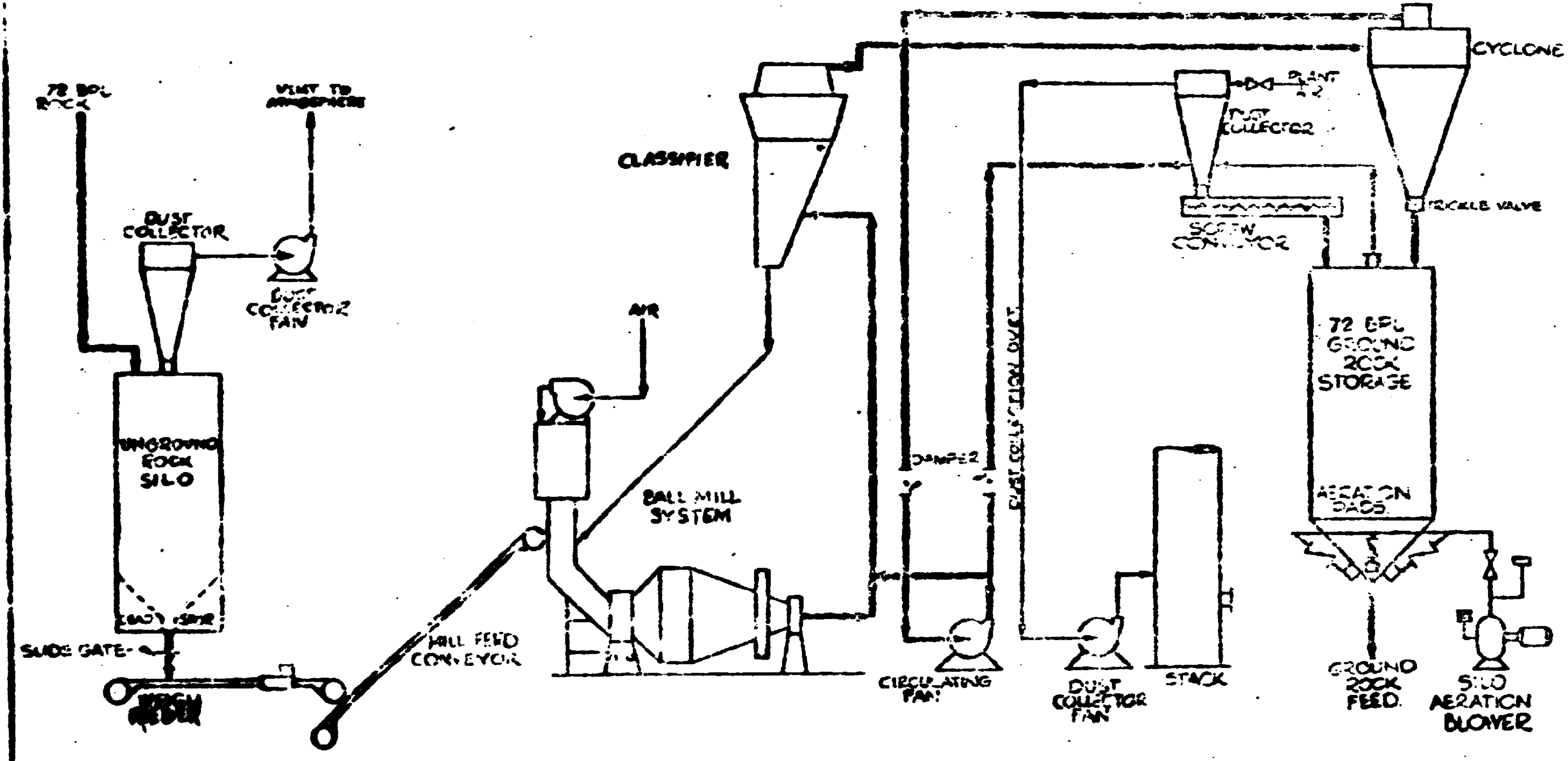


FIG 1

ROCK GRINDING

PROCESS FLOW

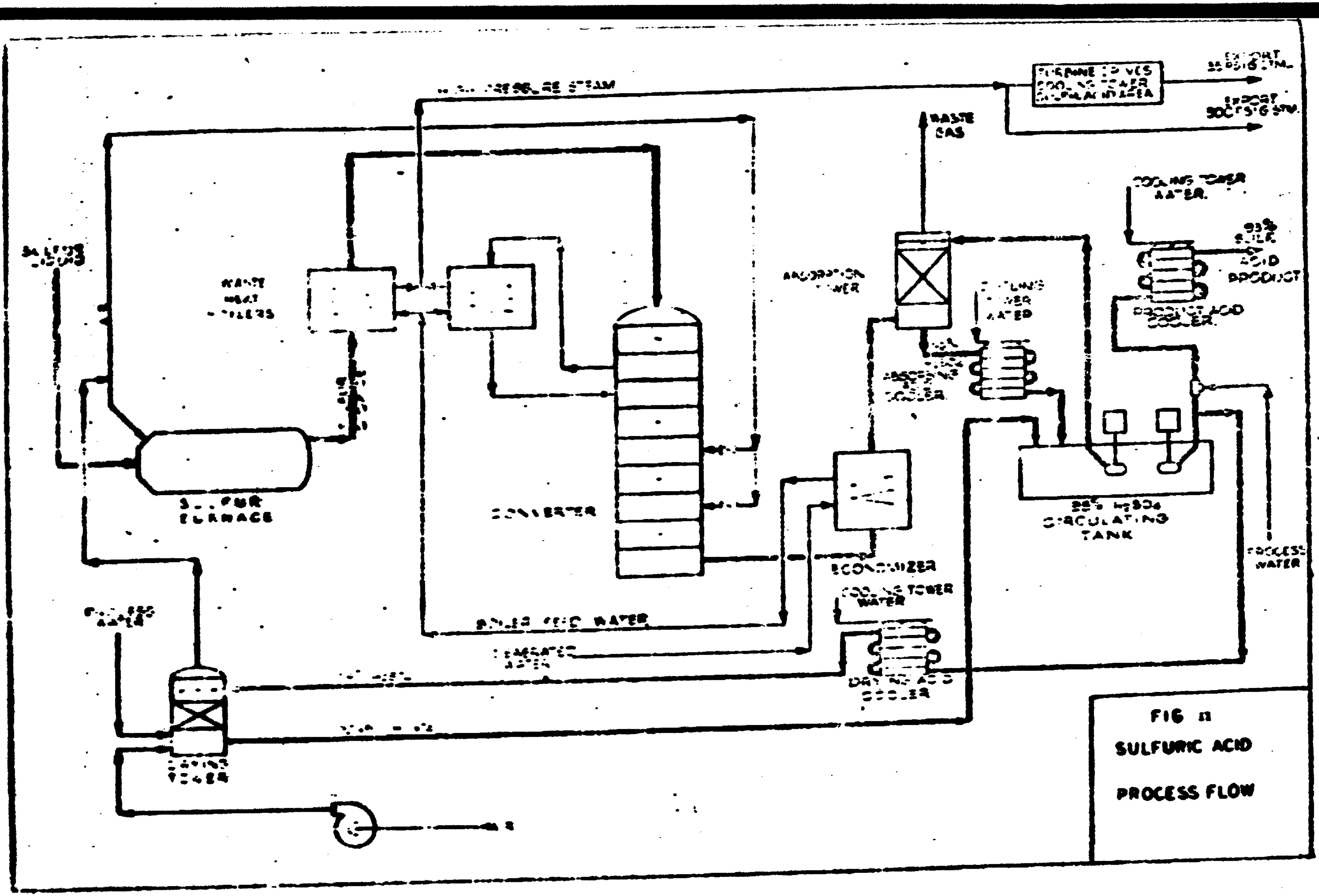


FIG II
SULFURIC ACID
PROCESS FLOW

(C) Digestion and Filtration

The digestion of the ground rock with sulphuric acid is carried out in two trains. Each of these trains is a conventional Prayon dihydrate phosphoric acid plant producing 30% P_2O_5 acid from the filter.

Sulphuric acid is first diluted down to 55% H_2SO_4 and the heat of dilution is removed by a karbate cooler.

A typical flowsheet is shown in Figure III.

This dilute sulphuric acid is then passed to the first and second digestion compartments. The split between the amount going to the first and the second compartment is dependent upon the grade of rock being used.

The ground phosphate rock is weighed on a batch weigher and then sent by a screw conveyor to the first digestion compartment. At the same time weak recycle phosphoric acid from the Prayon tipping pan filter is also introduced into the first digestion compartment.

It is important to control accurately the phosphate rock feed (±0.5%) and the sulphuric acid feed (±0.5%) so that the relative rates can be controlled to maintain the free sulphuric acid in the ensuing reaction slurry between 2% and 2.5% by weight.

Based upon periodic sulphate analysis by the operators, the sulphuric acid feed is adjusted to maintain these desired conditions.

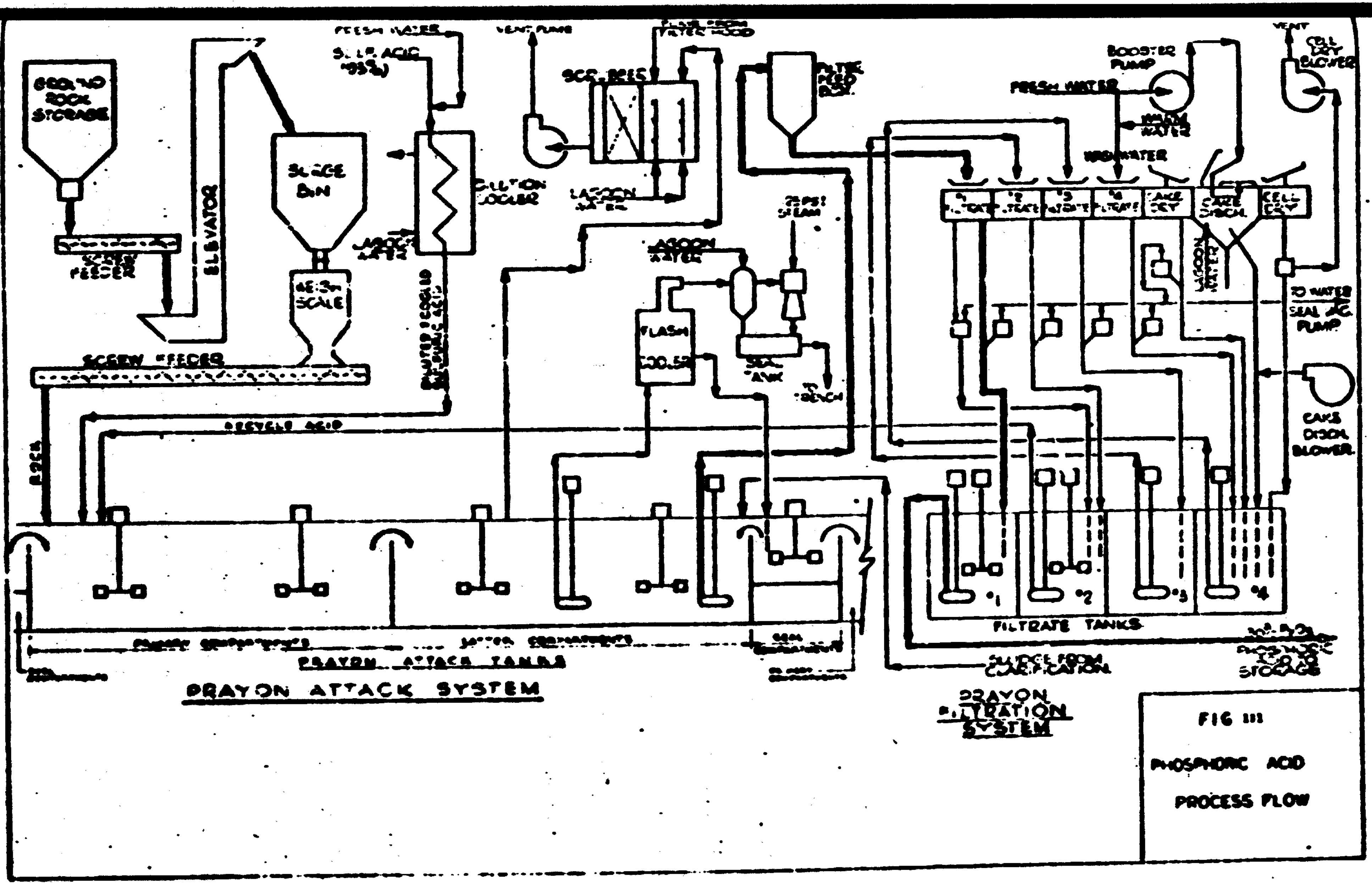


FIG III

PHOSPHORIC ACID PROCESS FLOW

Dilute sulphuric acid is preferred in this process since high concentrations of sulphuric acid result in coating the unreacted rock with gypsum and thereby decreasing the P2O5 recovery.

Since this reaction is exothermic, the heat of reaction has to be removed in order to control the reaction temperature. This is accomplished by pumping the reaction slurry to a vacuum cooler. The cooled slurry drops down a barometric leg and is then split into recycle slurry feeding back into the first digestor and feed slurry to the Prayon filter. The reaction temperature can be controlled by regulating the vacuum to the vacuum cooler.

The prayon filter consists of a Model [illegible] fabricated from 317 ELC stainless steel with a total area of 1,700 square feet.

The filter is comprised of individual horizontal cells, each of which is supported by bearings, which in turn are fastened to a large monolithic rotating frame.

The cells are piped to a central manifold by means of flexible hoses. This head of this central manifold rotates with the cells whilst the underneath valve remains stationary. This allows for the different wash waters to be collected separately.

The cells, moving with the rotating frame, pass successively beneath the slurry feed box and three wash boxes. The feed slurry is allowed to settle briefly in the cell before vacuum is applied. Wash water is fed via the first wash box. The resulting wash is collected and fed to the second wash box. This wash in turn is collected and fed to the third wash box. This wash is collected and pumped back to the first digestion compartment.

The washed cake is rotated round to the cake disposal area, where the cell is inverted, compressed air is blown from the underside of the cloth through the central valve, and the cake is ejected from the cell.

This gypsum cake is then washed down a chute with sea water and pumped to the gypsum disposal system.

An important point in considering a wet process phosphoric acid plant is the large quantities of cooling water required for the various barometric condensors coupled with the disposal of the by-product gypsum.

FFM solved these problems by utilising sea water wherever possible and pumping the gypsum away from the plant by combining it with this sea water as a slurry.

The resulting slurry is then pumped a distance of five kilometers to a large gypsum disposal settling area (2,000 acres). Here the gypsum is allowed to settle and the sea water overflows back into the sea.

Disposing of gypsum into the sea or a river is no longer considered feasible by most government agencies.

A. CONCENTRATION

The evaporation system installed uses Swenson evaporators and is designed to concentrate the crude acid from the Prayon filter from 30% to 54% P_2O_5.

Three evaporators are provided for each train and are connected in series. These evaporators are vacuum evaporators using forced circulating and the heat for evaporation is provided by low pressure pass-out steam from the sulphuric acid plant. Vacuum is provided by steam ejectors using high pressure steam from the sulphuric acid plant waste heat boilers.

A typical flowsheet is shown in Figure IV.

The three stages concentrate the acid progressively to 35%, 40% and 54% P_2O_5.

Incorporated at the 40% stage is a clarification stage to remove solids. These removed solids are returned to the phosphoric acid digestion tanks.

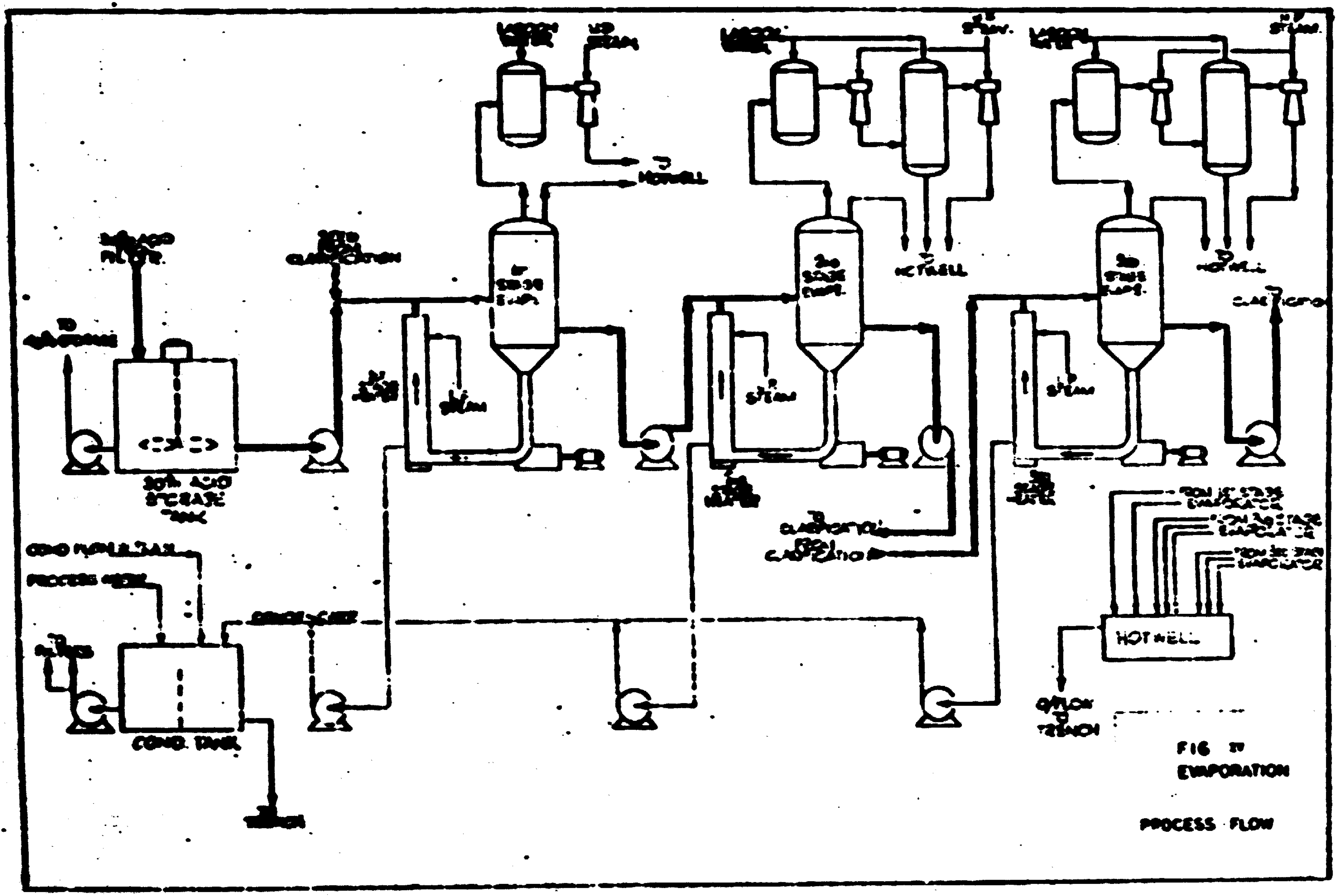


FIG IV
EVAPORATION

PROCESS FLOW

3. CLARIFICATION

Each of the phosphoric acid trains incorporates a separate clarification system. During the clarification of wet process phosphoric acid two general types of solids are encountered.

(a) Initial Solids.- These are the inert solids present in the freshly evaporated acid. These solids precipitate as a result of concentrating phosphoric acid with an excess of sulphuric acid.

This condition is desirable since these solids, largely gypsum, contain little or no P_2O_5 and are immediately available for removal.

(b) Post-precipitated Solids.- These solids mainly iron and aluminum sludge precipitate with time and cooling sometime after evaporation. On concentration, the acid becomes supersaturated with Fe^{+++} and Al^{+++}, F^-, etc. The compounds post-precipitating are about 50% P_2O_5.

This sludge is removed by subjecting the acid to a series of cooling, ageing and centrifuging steps.

A typical flowsheet is shown in Figure V.

The removed sludge is then sent to the Granular Triple Superphosphate plant for further processing.

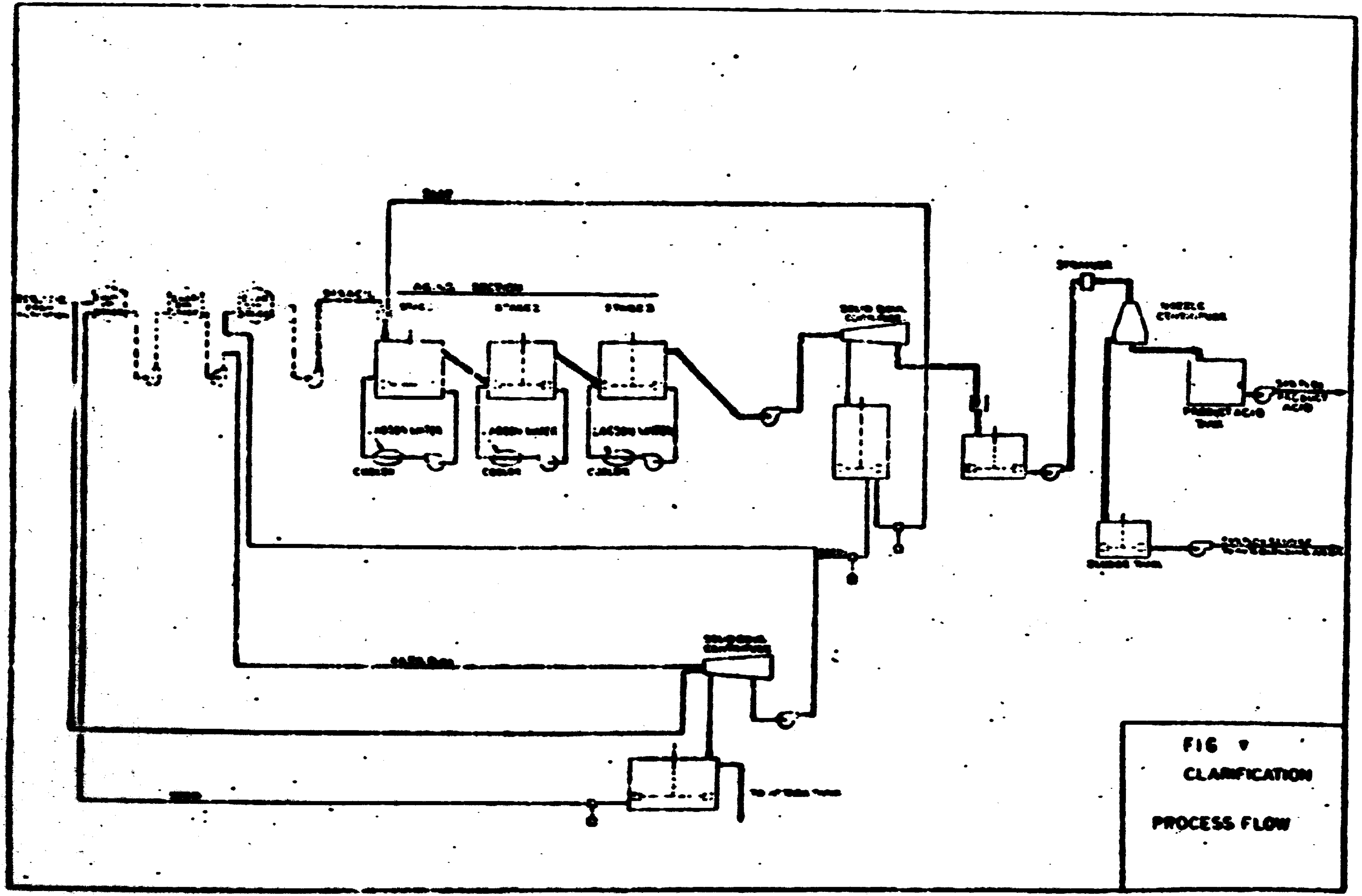


FIG V
CLARIFICATION

PROCESS FLOW

The clarified acid produced usually contains around 1.7 % suspended solids with very little post precipitation. These remaining suspended solids are extremely fine particles and do not present any problems in subsequent handling and storage.

C. STORAGE

The clarified 54 % P_2O_5 merchant grade acid is then sent to final storage.

This consists of large rubber lined tanks (approximately 84 ft. diameter x 40 feet high) which hold up to 10,000 metric tons of acid. These tanks are equipped with slow moving agitators to gently stir the acid to ensure a uniform content and to prevent any subsequent build up of solids on the tank bottom.

FFM currently has four such tanks in operation giving a total storage capacity of 40,000 metric tons of acid. However, three additional tanks are currently under construction, which will provide a total of 70,000 metric tons of acid storage at the plant.

The acid from these tanks is pumped directly by pipeline to the FFM dock and via an unloading arm into the delivery phosphoric acid ships.

3. CAPITAL COSTS AND PRODUCTION COSTS

It is always difficult to generalise on such figures since every location has a different economic position. This can be a question of locating a plant in Florida to take advantage of a relatively low cost source of phosphate rock, or locating in Mexico to take advantage of a relatively low cost source of sulphur. If you consider the production costs presented later you will see that the two basic raw materials represent by far the biggest cost elements.

4. CAPITAL INVESTMENT.

In an attempt to be consistent with other studies, a plant capacity of 200,000 metric tons of P2O5 per year has been chosen on a site in Florida.

This assumes that the molten sulphur will arrive by railcar and that the phosphate rock will also be delivered by rail car. It assumes minimum storage of both raw materials within the plant site.

It assumes a conventional contact sulphuric acid plant, dihydrate phosphoric acid plant with rocking grinding and evaporators to concentrate from 30% to 54 % P2O5, clarification and storage of finished product (one month).

CAPITAL INVESTMENT - WET PROCESS ACID PLANT

Capacity 200,000 metric tons P_2O_5 per year (600 TPD) as 54% P_2O_5 clarified phosphoric acid.

ITEM	X 000 US$	REMARKS
Process Facilities		
Sulphuric acid	3,500	One unit - 1,600 TPD
Phosphoric acid	4,700	One unit - 600 TPD
Raw material handling and storage	1,500	Rock and sulphur
Rock grinding	900	
Phosphoric acid storage, clarification and shipping	1,500	
TOTAL FOR PROCESS FACILITIES	12,100	
Auxiliaries - Off-sites		
Land	500	500 acres Ca. 1,000 $/acre
Water and treatment	600	
Auxiliary steam boiler	250	
Gypsum and water ponds	1,000	
R.R. sidings and scales	150	
Site improvements	500	
Fire protection and security	100	

Office and service buildings	500	
Shop equipment	150	
Piping	300	
Power distribution	500	
Mobile equipment	100	
TOTAL AUXILIARIES	4,650	
TOTAL DIRECT COST	16,750	
Engineering, construction and contractors fees	2,500	15%
Contingency and escalation	2,000	10%
TOTAL FIXED CAPITAL	21,250	
Working Capital	3,000	
TOTAL INVESTMENT	24,250	

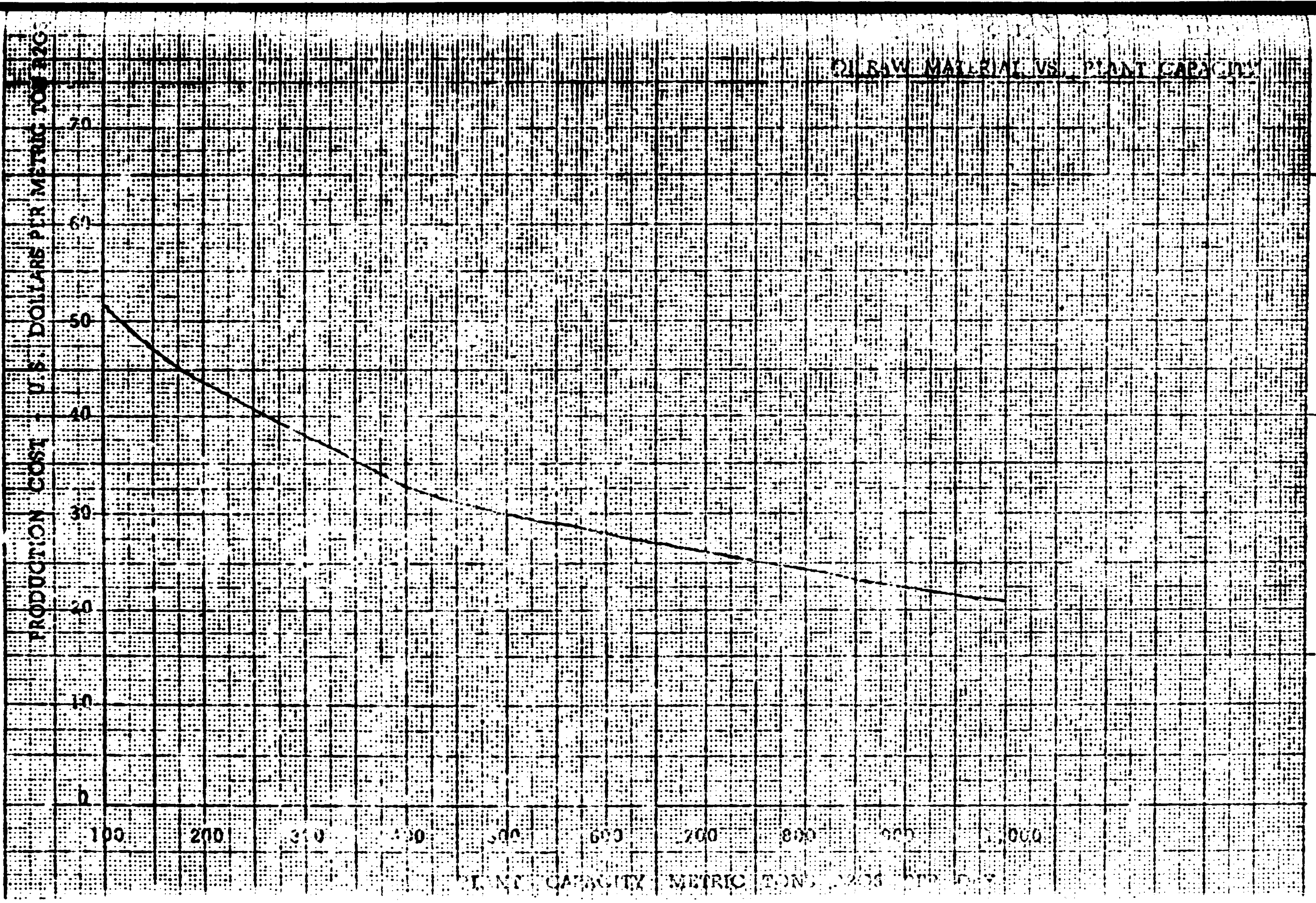
OPERATING COST - WET PROCESS ACID PLANT

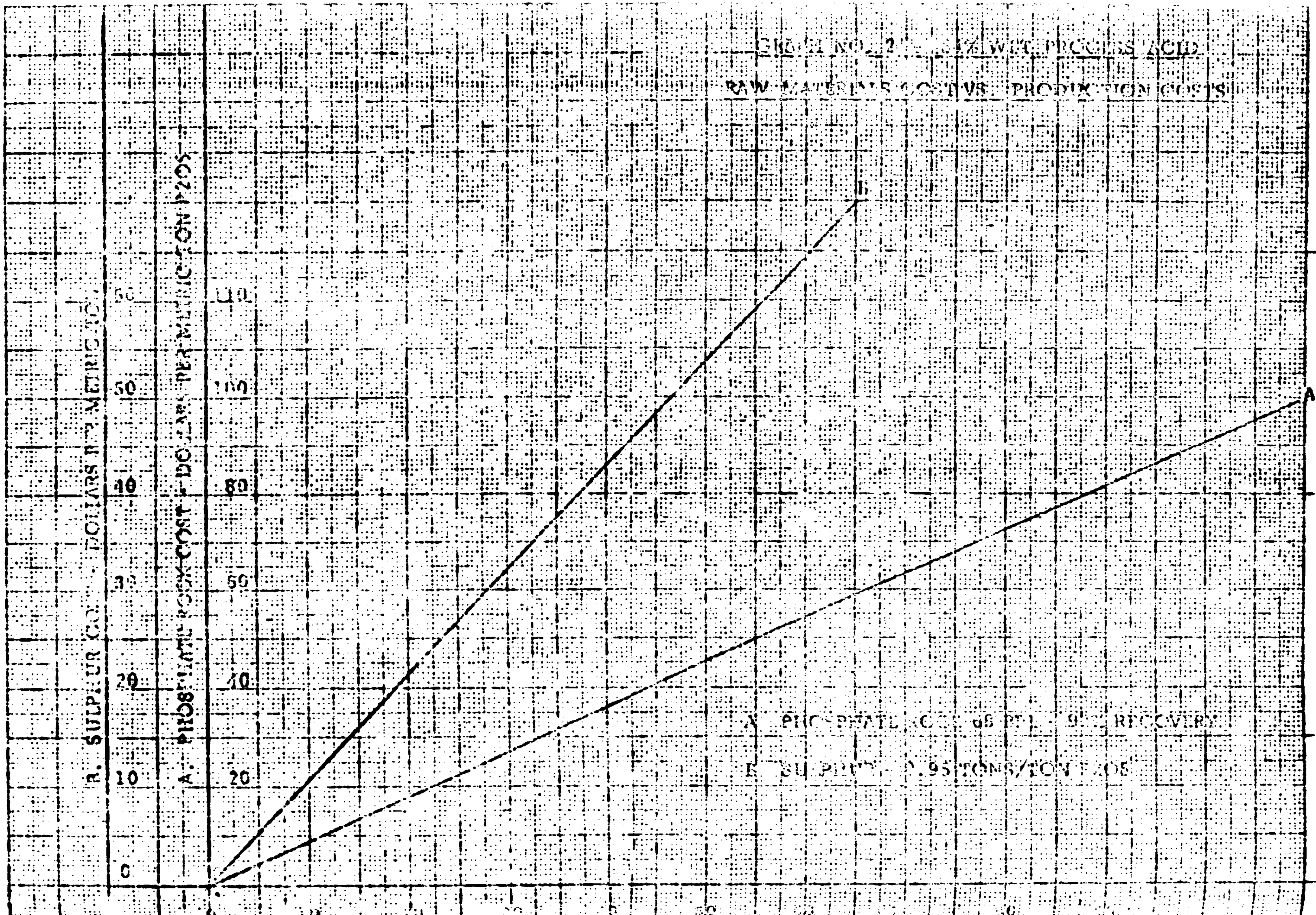
Capacity 200,000 metric tons P2O5 per year. Estimated fixed capital 21,250,000 US$.

	Units	Units /MT P2O5	$/Unit	$/MT P2O5
Raw Materials and Supplies-				
Phosphate rock	M. Tons	3.49	5.50	19.20
Sulphur	M. Tons	0.95	37.00	35.20
Electricity	KWH	275	0.005	1.38
Water - raw	M. gallons	30	0.02	0.60
boiler feed	M. gallons	1.0	0.40	0.40
process	M. gallons	14.0	0.05	0.70
Steam			No charge	-
Operating supplies				0.40
Maintenance supplies	3% of direct cost.			2.50
Mobile equipment				.25
TOTAL RAW MATERIALS				60.63

Operating labour	.47 man hours Ca. 4$	1.88
Maintenance labour	2% of direct cost	1.67
Supervision and overhead salaries	25% of total labour	.89
Fringe benefits	30% of total labour	1.34
TOTAL LABOUR		5.78
Other-		
Taxes and insurance	2% of fixed capital	2.12
Depreciation	10% of fixed capital	10.60
TOTAL FACTORY COST		79.13
General Expenses-		
Administration and selling 1.5 x 10 US$ per year		7.5
TOTAL COST*		86.63

*This cost does not include interest on loans, nor profit


(1) RAW MATERIAL VS. PLANT CAPACITY
PRODUCTION COST - U.S. DOLLARS PER METRIC TON P2O5
0
10
20
30
40
50
60
70
PLANT CAPACITY, METRIC TONS P2O5 PER DAY
100
200
300
400
500
600
700
800
900
1,000


GRAPH NO. 2 — % WET PROCESS ACID
RAW MATERIALS COST VS. PRODUCTION COSTS
B
A
A. PHOSPHATE ROCK 68 BPL - 9 % RECOVERY
B. SULPHUR - 0.95 TONS/TON P2O5
B. SULPHUR COST - DOLLARS PER METRIC TON
A. PHOSPHATE ROCK COST - DOLLARS PER METRIC TON P2O5
0
10
20
30
40
50
60
20
40
60
80
100
120

As you can see from the Graph I that if you consider a plant to manufacture 100 metric tons P2O5 per day with the same raw material costs as assumed for Florida, then the increased production costs would be approximately 20 US$/MT P2O5.

If we now assume a location such as India where both sulphur and rock have to be imported and that the delivered CIF prices for these raw materials are;

Sulphur	35 $/MT FOB
Freight	12
Storage and handling	5
	52.0 $/MT
Phosphate rock	6.0 $/MT FOB Tampa
Freight	12.0
Storage and handling	2.0
Total Cost of rock delivered plant	20.0 $/MT

Equivalent landed P2O5 cost using 68 BPL rock (31.3 % P2O5) = 54.0 $/MT P2O5

Then using Graph II we can see that the total raw material cost would be 107 $/MT P2O5 as compared with 84.40 $/MT P2O5 in our Florida location.

If we now add this additional cost to the additional production cost, we can arrive at a cost advantage of approximately 72 US$/MT P_2O_5 in favour of the Florida producer.

Of course from the margin must be deducted the cost of freight from the plant to the port, the cost of terminalling in Tampa, the ocean freight, and the cost of a terminal in India. These factors will now be discussed.

(1) LOADING-OUT FACILITIES

In the case of FPM, these facilities are an integral part of the plant. FPM possesses its own deep water port facilities adjacent to its pl and the final product storage tanks are the same as the loading out tanks for the ship.

In other cases one would have to consider moving the product from the plant to a terminal alongside a deep water dock.

To consider loading a ship with 23 000 metric tons of phosphoric acid solution one would need three large storage tanks. These tanks could be mild steel, rubber lined and fitted with agitators. Interconnecting pipework and pumps would be needed with sufficient capacity to load a ship within 24 hours. Typical capital investment figures for a terminal in Tampa, Florida would be as follows:

	US Dollars
Three storage tanks	600,000
Agitators	170,000
Dikes	10,000
Foundations	50,000
Pumps	20,000
Piping and valves	100,000
Electrical	25,000
	975,000
Engineering 15%	146,000
Contractors fee 5%	49,000
Contingency	150,000
TOTAL	1,320,000

The contingency has been deliberately inflated to allow for any piling of foundations or for an increase in the length of the loading line from the tanks to the ship.

If we now assume that the whole 200,000 metric tons of P_2O_5 would be exported through such a terminal, then we could expect the following operating costs:

	$/MT P_2O_5
Labour - 4 men/yer Ca. 8,000 $ea.=	0.15
Maintenance- 5% of installed cost	0.33

Electricity - Ca. 0.008 $/KWH	0.03
Leasing land and dock	1.00
Taxes and insurance 2% of installed cost	0.13
Depreciation 10 years	0.65
Overhead 100% operating labour	0.15
Interest 10% on ½ of installed cost	0.33
R.O.I. on ½ installed cost Ca. 20%	0.66
TOTAL	2.49

(2) TRANSPORT FACILITIES

FFM will have by the end of 1970 a fleet of three tankers in operation, and by the end of 1971 a fleet of five tankers.

Each of these ships is capable of carrying a minimum of 23,000 metric tons of acid. Such a cargo will require a port draft of 34 feet.

The ships employed by FFM are on long term charter from the Grangäsberg Company in Stockholm, Sweden. These ships are converted ore carriers.

The cargo tanks are lined with stainless steel and they are equipped with recirculation equipment and heating coils. The overall dimensions of a typical ship are: Lenght: 595 ft. - Breadth: 74 ft. They have six separate compartments and could carry partial loads of phosphoric acid along with other liquid products, or various grades of phosphoric acid. This latter point could be important to smaller customer since FFM will have available next year four different grades of phosphoric acid. These different grades will enable producers to consider the manufacture of dry fertilisers such as triple superphosphate and ammonium phosphate liquid fertilisers such as 11-37-0, sodium tripolyphosphate for detergents or other industrial phosphates and animal feed phosphates.

The capital cost and operating costs for this type of ship has to remain confidential, but it can be stated that this freight cost is sufficiently attractive to FFM to have convinced them that the concept of moving merchant grade phosphoric acid around the world in large tankers out of Mexico is a feasible proposition.

(3) UNLOADING FACILITIES

To obtain maximum economic advantage from this type of business it is necessary for a potential client to be able to receive a full shipload at any one time. This implies that he must have a terminal installation capable of receiving 23,000 metric tons of phosphoric acid which in turn means an investment very similar to the figures shown previously for the loading facilities in Tampa, Florida. (Page 24).

This capital investment of course can be offset against any investment necessary to build phosphate rock handling and storage, sulphur handling and storage, a sulphuric acid plant and a phosphoric acid plant along with the necessary off sites.

FPM believes that with a yearly throughput of four or five times the storage capacity that the investment and the necessary operating costs can be considered to be approximately five to six dollars per metric ton P2O5.

ADVANTAGES OF IMPORTING PHOSPHORIC ACID OVER LOCAL MANUFACTURE

Provided that a prospective client has access to a deep water dock, the following advantages can be cited:

1. The capital investment required for a would-be producer of fertilisers is greatly reduced since, apart from the terminal cost, the only investment is the production unit to manufacture the NPK or NP solid fertilizer materials. This concept becomes even more attractive if one considers the manufacture of liquid fertilisers.

2. In most cases phosphoric acid can be purchased for the same or lower cost price than he could have manufactured phosphoric acid without incurring the capital risk.

3. The phosphoric acid purchaser is not subjected to any of the effluent and pollution problems inherent with sulphuric acid and phosphoric acid plants.

4. Purchase requirements for P2O5 can generally be ordered to suit the local market demands.

5. The buyer has available to him the technical service department of a specialized large company with skills and experience in the manufacture of phosphate fertilizer products.

6. It enables an existing single superphosphate manufacturer to convert production facilities to concentrated superphosphate and/or NPK fertilizers for a modest capital outlay and thereby allows him to compete with high analysis fertilizers producers within his local marketing area.

Probably the most difficult hurdle which still has to be overcome is the problem of import duties, taxes and costly port charges levied in some countries.

Several countries have an import duty on phosphoric acid, while permitting the duty free importation for phosphate rock and sulphur or lower duties on manufactured solid P2O5 products such as MAP, DAP and TSP. The reasoning, of course, is not difficult to understand in countries with existing manufacturing facilities, since the local producer fears competition from the more economical large producer and transporter of phosphoric acid. However, in the interest of supplying agriculture with lower cost fertilizer products PPM believes that this attitude is a luxury which any nation can no longer afford.

Today the financial problem of obtaining capital for investment at attractive interest rates and to a lesser degree the availability of foreign exchange for the purchase of phosphoric acid seems to be a problem in some countries.

FFM believes that the correct approach to this problem is to encourage the developed countries who supply industrial development funds to the developing and underdeveloped countries to make these funds available for the purchase of the intermediate fertilizers raw materials anhydrous ammonium and phosphoric acid from other developing countries. This would permit two developing countries to utilize funds granted by developed countries for trade between themselves. In this way FFM believe that industrial development among developing countries would take place at a more rapid pace.

4. THE FERTILIZER AND PESTICIDE INDUSTRY IN LATIN AMERICA

by

Roberto Petitpas
U.N. Economic Commission for Latin America

The subject which brings us together today has been discussed more than once in recent years. In 1964 a meeting on the development of the chemical industry, sponsored by ECLA, was held in Caracas to examine conclusions on the supply and demand in the first systematic regional study of the chemical sector made by ECLA.

Later, the Interamerican Committee on the Alliance for Progress (CIAP) established, in June 1965, a Working Group on Fertilisers. Representatives of a number of international organisations (FAO, World Bank) and regional organisations (LAFTA, SIECA, Interamerican Development Bank, Interamerican Committee for Agricultural Development, and others) participated. In May 1966 the same group met a second time to examine the conclusions of studies prepared by FAO and ECLA on the use of fertilisers in Latin America and, by ECLA, on the supply, structure of the industry and projections for 1970 and 1975.

The picture of the Latin American industry at this time is known to you and we only need to recall that an appreciable excess of nitrogen was predicted in the short run in the face of imports which amounted to an expenditure of US[illegible]0 million as an average for the decade for all NPK's. The conclusion which the study presented in 1966 is yet today pertinent, and I will refer to this later.

This meeting, convened by UNIDO and organised thanks to the valiant efforts of the Ministry of Industry and Commerce, with the aid of Petroquisa and ANDA, should be an appropriate occasion in which to make an honest balance and evaluate that which still remains to be done based on the conditions existing years before.

I will not present here a similar evaluation since ECLA has not been able to carry out a new detailed study in this sector. I will refer, however, to the changes that seem to us most illustrative, as much with regard to consumption as with regard to production, beginning with nitrogen.

The FAO/ECLA studies predicted a minimum demand for nitrogen in the countries of the region, except for the Caribbean, of 853,000 tons and a maximum that extended to more than 1,100,000 tons. Apparently we have exceeded the minimum level, reaching already in the agricultural year 1968/69 some 850,000 tons of nitrogen. This figure obscures large disparities such as occurred in 1964/65. Thus the average consumption per cultivated hectare present extreme values, with 24 kg. of nitrogen in Central America and less than 1 kg. in the group of countries of the Plate River Valley. Among these is Brasil with 4.8 kg., Uruguay with 5.0 kg., and Mexico with 14.5 kg.; the Andean average about 9 kg/ha. Altogether a growth of consumption at the rate of 11.9% annually took place in the last nine years. Thus it appears very probable that a consumption higher than the minimum forecast for 1975 will take place—that is, 1,175,000 tons—since the present r[illegible] indicates about 1,600,000 tons per year.

Less spectacular has been the increase in the consumption of phosphatic fertilisers. If it is true that in the agricultural year 1968/69 the minimum estimated consumption (for 1970, 614,000 tons of P_2O_5) was reached, we are still far from the figure of 870,000 tons taken as the maximum hypothesis for 1970. Again here the Andean and Central American countries stand out with 9 to 10 kg. of P_2O_5 per hectare; Brasil reached 7.2, Mexico 5.1, and finally Argentina bordered on 1 kg/ha., while Uruguay applied about 13 kg/ha. The global average of these countries does not exceed 5 kg/ha.; that is, between a tenth and a twentieth of the normal dosages in countries of high agricultural productivity.

In respect to potassium, some 300,000 tons (K_2O) were consumed in 1968/69, approaching the maximum figure forecast for 1970—that is, 370,000 tons.

In summary, in 1968/69, our average rate of application of fertilisers was some 16.5 kg. of NPK per hectare and yet in some countries with high fertiliser consumption it does not exceed 40 kg/ha. It is worth remembering that France applies about 200 kg. and Japan about 400 kg/ha.

Production

How have the projects and actual production developed in this period? The projections with respect to production of nitrogen have only been achieved in part by Mexico whose production in 1969 reached 54% of the total, while natural nitrates from Chile supplied 27%. Thus, in 1968/69, the total production can be estimated at 680,000 tons, equivalent to 2/3 of consumption.

If we look at the new units which begin operation near the end of the present year, or during 1971, we find an important jump in capacity, totalling

1,100,000 tons of nitrogen. The new capacities announced by Colombia, Chile, and Peru have not yet materialised, while in Brasil and additional plant has been completed with the annual capacity of 170,000 tons of ammonia from naphtha and another unit of 66,000 tons from natural gas is under construction.

If we now add the projects actually under construction (Venesuala especially) we have 500,000 tons of additional nitrogen, thus having, toward 1971/72, a total capacity of 1,600,000 tons of nitrogen.1/

Summarising the project whose execution is probable before 1975 (Central America, Peru, and Venesuela) the area will have available at least 2,050,000 tons, a figure which would increase to 2,700,000 tons if the other projects in a stage of exploration (Argentina, Chile, and Venesuela are carried out.)

It is necessary to point out that during the period we are considering ammonia prices for important deliveries have experienced a severe decline: from an estimated level of US$ 65 per ton in the first half of the decade to $ 30 to 35 in 1969 and 1970. Many Latin American projects that were studied with the idea of exporting have seen this opportunity lost and they are faced with very different conditions of competition in the world markets.

It is likely that the experience of some small installations whose unsuitable locations or processes caused a paralysis of their activities will be repeated in the next decade with those plants whose capacity or raw material imposes production costs much higher than US$ 30/35 per ton of ammonia.

Before concluding this very superficial review, I wish to refer to the events that mark the evolution of phosphatic fertilisers.

The first in importance is, without doubt, the start of operation of Fertilisantes Fosfatalos Mexicanos with its 550,000 tons per year of phosphoric acid, about which the delegate from Mexico will speak later. At the same time, the efforts developed in Brasil for perfecting the technology of the concentration of phosphate minerals that permit utilisation of her important reserves should be mentioned. At the moment, the exploitation of the large reserves remains to be seen. These, according to plans announced by this country, will be mined at the rate of 2 million tons per year beginning in 1974.

1/ Note: The existing capacity in the Carribean is not included in these figures.

With the exception mentioned, the area is still deficient in processed phosphates and depends heavily on importation.

We will not dwell on potassium since, with minor exceptions (Caliche in Chile) production does not exist in the region. Natural exploitable potassium resources exist in Brasil and in other countries and perhaps this decade will see regional production initiated which will contribute to supplying the demand, which will be about 400,000 tons of K_2O by 1975.

We referred at the beginning to the conclusions extracted from the analysis which ECLA prepared on this branch of the chemical industry[1] in 1966 and we mentioned that this could still be applied to the present situation. Permit me t offer these conclusions to all those in whose hands it is to achieve a better coordination and complementation of the efforts, until now scattered, made in the region.

1. Advisability of accerlerating the use of some important sources of raw materials such as phosphates (Peru and Brasil) and sulphur.

2. Advisability of paying greater attention to the costs of raw materials and manufacturing scale.

3. Interest in improving national and regional transportation, as much for fertilisers as for their raw materials and principal intermediate products: ammonia, phosphoric acid, natural phosphates.

4. Advisability of investigating possible sources of sulphur and potassic salts.

5. Existance of possibilities of obtaining elemental nutrients, especially nitrogen and phosphorus, at costs much lower than the present ones.

6. Advisability of promoting regional interchange to correct the disequilibrium in the development of production that results in excess capacity in some sones while others subsist from importations from outside the area.

7. Advisability of standardising the various types of fertilisers traded in the region.

If there is anything we should add on this occasion, it would be a reference to the urgency of creating a permanent consultive organisation to service

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[1] Document E/CN.12/761, "The Supply of Fertilisers in Latin America"

all the producers of the region, especially with the objective of considering methods of penetrating the world market in nitrogen today and, perhaps, phosphoric acid, potash, and sulphur tomorrow.

5. THE FERTILIZER PROGRAMME OF FAO

by

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FAO Fertiliser Programme
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I should like to take only a few minutes of time left in this meeting to present to the esteemed participants a rapid glance at the Fertiliser Programme of FAO, its objectives, its methods of working, its present state and its future plans. I should like first to express my gratitude for the opportunity for addressing myself to people who in their respective countries live daily the same uncertainties which affect the lines of action of the Fertiliser Programme; that is, to achieve an increase in agricultural production through rational and increasing use of fertilisers. On the other hand, I think that participation in this UNIDO Meeting follows the lines of action established in the agreement signed in Geneva on 9 July 1969 by the Director General of FAO and the Executive Director of UNIDO in which was stipulated the means for harmonising the activities of both organisations in a constructive way, extending and interchanging experiences in a common effort.

The Fertiliser Programme of FAO was started in 1961 in response to the justifiable concern for the possible food deficiency to supply the demand of the constantly increasing population. Nine years later this programme is extending its activities to 5 major regions (the Far East, West Africa, East Africa, the Middle East and Latin America), embracing some 25 countries, to which one must add another 9 more which receive assistance from FAO in work related to the development of the use of fertiliser. Another 9 countries will be incorporated in the Programme in the near future. These countries already are in an advanced state of negotiation with respect to interested governments.

The objective of the Programme can be summarised as follows:

1. To promote greater use of fertilisers in rural areas, demonstrating the efficiency of their use as well as the introduction of other improved practices.

2. To collaborate with the experiment and research services on fertilisers, establishing appropriately designed trials which permit the establishment of profitable fertiliser use.

3. To collaborate in efforts undertaken by the countries to creat a body of agronomists fully qualified in the use of fertilisers, especially at the farm level.

4. To promote the utilisation of existing credit systems in the countries through implementation of specific projects of distribution and credit for fertilisers.

5. To offer these countries suggestions and recommendations in respect to the policy to follow in the development of the use of fertilisers and concrete data on the possibilities for fertilisers consumption in the country or specific areas.

In respect to the Latin American Region, the Programme was started in 1962 in El Salvador, Costa Rica and Honduras. In 1963 the Programme was extended to Ecuador and Guatemala, and in 1964 to Panama and Columbia. Lastly, in 1969, Brasil and Paraguay were incorporated. There are other countries in the Region which have shown interest in the Programme and these are currently under negotiation.

The way in which the Fertiliser Programme is established and functions.

For this I will follow briefly the chronological order of events which begin with preliminary discussions through four operating phases of development.

In the preliminary discussions, motivated by a request from a government, the contribution of the country (personnel and equipment) as counterpart is evaluated, through FAO, by the Consultative Committee of the Fertiliser Industry. The personnel is comprised of high level technical officials as counterparts to FAO experts and sufficient technical personnel at the farm level whose number should be related to the work to be undertaken.

After this phase the Programme, which comprises four different phases, is initiated;

1) Search for the most advantague fertiliser recommendations for each crop in each of the major zones,
2) Demonstrations of these formulae to the greatest possible number of farmers.
3) Pilot projects of distribution and credit for fertilisers.
4) Institutionalising of the operation of the Programme in all of the country.

With respect to the first point one may find that there is sufficient information available in the country, in which case a Programme can begin from a demonstration phase. If this is not the case, the Programme begins with the establishment of simple trials on the farmers' land. In this case, these tria play an important part and complement that which the experiment stations can play. The scheme which is generally used is the factorial with three different levels of each of the principal elements - N,P, and K.

The demonstration phase is the basis of the Programme; that is, the phase which best develops the final objectives. It consists in establishing the greatest possible number of simple demonstrations, also in farmers fields, in which with a very simple design the economic effect of the formula recommended the zone can be demonstrated and compared with the test without fertilisers or with the formula that was usually used in the past. The organisation of frequent visits to the fields—that is to say, the holding of "Field Days"—make it possible to demonstrate to farmers the differences in each crop and, what is more important, at the time of harvesting the differences in production transla to a simple economic language which allows the farmer to compare clearly the economic advantages of correct fertilisations.

The conclusions derived from the demonstrations are expressed in terms of the relation value/cost; that is, the ratio of the increased value obtained fro the harvest per unit cost of fertiliser used to obtain it. Experience shows th if this value is maintained permanently at around 2 the farmer will feel motiv to use in the future the formula which has been recommended.

In the final demonstration phase (2/3 year), if the value/cost ratio has been maintained at attractive levels, the farmer attempts to purchase the fertilisers which were used in the demonstration. In the majority of cases he try to obtain credit. Perhaps the credit systems available in the country are sufficiently available in the zone or there are restrictions. In this case a pilot project attempts to make available to a small farm community or to some 10 farmers a quantity of fertiliser on credit under a guarantee of some community responsibility for repayment. Agreement with two organisations is required: The Rural Extension Service, which promotes the formation of interested groups and the farmers applying for loans and an institution which is able to manage the loans and their repayment. A pilot object establishes the automatic renewal of individual loans after their repayment, thus establishing a rotating fund whi can be reinvested in the purchase of fertilisers.

After two to three years of operation one is able to create a community strongly interested in the increased use of fertilisers, a community which earlier was dependent directly on suppliers and credit institutions.

After 5 or 6 years from the beginning of the Programme the country is able to continue, without direct assistance from the Fertiliser Programme, the aspects of demonstaration, distribution and credit. The Programme thus acts as an irreversible catalyser whose continuity becomes a property of the country.

Another important facet of the programme is the realisation of frequent training courses of technicians at a local level on the use of fertilisers, such as a publication of booklets and manuals which serve as training material on the technique of fertilisation.

Very significant also is a collaboration that is maintained with other similar programmes operating in the respective countries or programmes which are supported by other organisations within or outside the influence of the United Nations.

In this brief talk about the fundamentals of the Fertiliser Programme I should not wish to tire you with the presentation of numbers and statistics which, on the other hand and in greater detail than I could give you here, are contained in documents and summaries which are published annually. More than 35,000 trials and demonstrations have been carried out and some 2 million farmers have had access to the test farms and have been enabled to realise the economic advantage of fertilisation. Ninety-five per cent of the demonstrations carried out gave clearly positive results from the economic view-point. The average of the highest value/cost ratio in these was 4.9.

Having already passed through the different phases in the other countries, today the Programme is active in Brasil, Paraguay, Ecuador and Colombia with a total of 729 trials and 2,598 demonstrations, numbers of which are being rapidly increased if we take into account in the two first countries mentioned where the Programme was initiated last year.

Finally, and as an addition to this general information, I should like to show to the gentlemen present a small collection of slides which show some of the trials and demonstrations in the various countries where the Programme is now operating.

VII. PRELIMINARY SURVEY OF THE FERTILIZER SITUATION IN SELECTED COUNTRIES OF LATIN AMERICA - AVAILABILITY OF RAW MATERIALS, DESCRIPTION OF PRODUCTION FACILITIES AND HISTORICAL AND PROJECTED SUPPLY AND DEMAND IN

Argentina

Brasil

Central America

Chile

Colombia

Mexico

Peru

Venezuela

Prepared by the secretariat of UNIDO

Availability of fertilizer raw material and fuel

	Location	Total proven and probable reserves	Production	Grade	Future planning
Natural gas	Jujuy, Salta, Mendoza, Neuquén, Rio Negro, Chubut, Tierra del Fuego	180 billion m^3 (1968)	7,065 million m^3 (1968)	Analysis: CH_4 85.6–88.6% N_2 2.0– 6.2% CO_2 2.0– 6.2% Rest C_2H_6 and higher	-
Crude oil	Santa Cruz Norte, Santa Cruz Sur, Pampa, Tierra del Fuego	250 million m^3 (1968)	19.9 million m^3 (1968) 20.7 million m^3 (1969) provisional	-	-
Coal	n.a.	n.a.	942,400 tons (1969)	-	-
Potash	-	-	-	-	-
Phosphate rock	n.a.	n.a.	n.a.	-	-
Sulphur	n.a.	n.a.	27,000 tons (1967)	-	-

Petroleum refineries

Company	Location	Crude oil capacity m^3 per day	Main source of crude
Y.P.F.(Yacimientos Petroliferos Fiscales)	La Plata	22,250	National, imports from Bolivia, Abu Dhabi
"	Luján de Cuyo	7,300	"
"	San Lorenzo	6,050	"

Company	Location	Crude oil capacity m³ per day	Main source of crude
Y.P.F.	Campo Duran	4,500	National, imports from Bolivia, Abu Dhabi
"	Dock Sud	1,000	"
"	Plaza Huincul	750	"
"	El Centenario	30	"
ESSO	Campana.	9,520	National, imports from Venezuela and S. Arabia
"	Galvan	2,500	"
SHELL	Dock Sud	14,500	National, imports from Quatar, Venezuela and Iraq
Petroquimica S.A.	Comodoro,Rivadavia	700	National
LA ISAURA	Bahia Blanca	650	"
CONDOR	Lomas de Zamora	210	Imports from Ecuador and Peru
LOTTERO PAPINI	Avellaneda	160	"
BAKER	Quilmes	60	"
SOL	Francisco Solano	120	n.a.

Fertiliser plants in operation

Company	Location	Date of commissioning	Rated capacity tons per year		Production	Feedstock and fuel used
Electro Clorus	Santa Fe	very old plant	NH_3	3,000	NH_3 2,500 (no production of fertilisers -- NH_3 for refrigeration)	electrolytic hydrogen
Direccion General de Fabricaciones,	Rio Tercero, Cordoba	20 years old	NH_3	6,000	for explosives, no fertiliser production	coal gasification
Petrosur S.A.	Campana, Buenos Aires	May 1968	NH_3 urea amm.sulph NPK	68,000 95,000 50,000 30,000	48,000 40,000 (1969) 35,000 21,000	natural gas from province of Salta
Sociedad Mixta Siderúrgica Argentina (SOMISA)	San Nicolás, Buenos Aires	-	amm.sulph	6,000	3,000	by-product

Fertiliser plants in construction or planned

Company	Location	Status	Probable date of commissioning	Type of product	Rated capacity tons per year	Feedstock to be used
Y.P.F.	San Lorenzo (Santa Fe)	in planning	1974/75	NH_3 urea calcium amm.nitrat complex	300,000 200,000 160,000 200,000	natural gas (local) phosphate rock, and potash (to be imported)

[illegible] preliminary planning (indefinite)

Company	Location	Status	Probable date of commissioning	Type of product	Rated capacity tons per year	Feedstock to be used
Duperial (subsidiary of ICI)	all proposals dropped					
Cordenmed S.A. (caprolactam plant)	San Lorenzo	in planning	1974/75	amm.sulphate	43,000	NH_3 from YPF – sulphur to be imported

note: preliminary planning (indefinite)

Consumption and production of fertilizers

		1959/1960	1964/1965	1968/1969	1975	1980
N	Consumption	8,104	29,548	30,705	67,000	117,000
	Production	-	-	24,400	35,000	n.a.
P_2O_5	Consumption	3,266	10,610	20,812	35,400	66,000
	Production	-	-	4,000	4,000	n.a.
K_2O	Consumption	1,280	5,846	7,516	13,500	22,000
	Production	-	-	-	-	-
NPK	Consumption	12,650	46,004	59,033	115,900	205,000
	Production	-	-	28,400	39,000	-

[illegible] 1959/1960
1964/1965 - consumption, "Projection and Marketing of Fertilizers by Rubén O. Meninato", ([illegible])

1968/1969 - IFPA - Jorge I. Ballati

1975/1980 - [illegible] (according to IFPA, increase in demand is very slow).

1975 - projection - [illegible]

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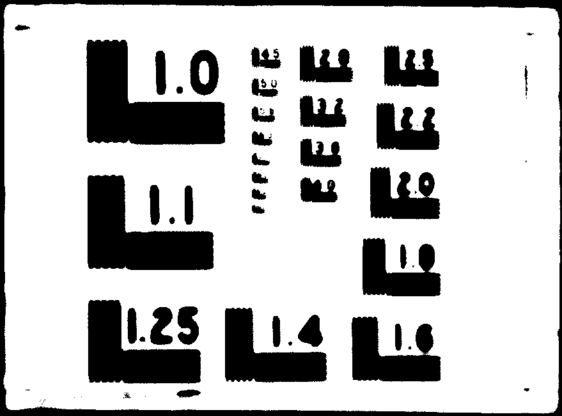


BRAZIL

Availability of fertiliser raw material and fuel

	Location	Total proven and probable reserves	Production	Future planning
Natural gas (associated)	Bahia	26.8 billion m^3	964 x $10^6 m^3$	-
Crude oil	Sergipe Alagoas	128 x $10^6 m^3$	9.51 x $10^6 m^3$	-
Coal	Rio Grande Do Sul Santa Catarina Parana, Sao Paulo	2.91 billion tons	5.1 x 10^6 tons	-
Lignite	Amazonas	n.a.	no commercial exploitation	
Phosphate rock	Pernambuco Sao Paulo Minas Gerais	250 x 10^6 tons (5%-22% P_2O_5)	105,000 tons P_2O_5 (1968)	-
Potash	State of Sergipe	silvinite - 25% K_2O 350 x 10^6 tons 24% K_2O 100 x 10^6 tons carnallite - 14% K_2O 60 billion tons	no production to date, mining to start in 1978 with 500,000 t/y production.	
Sulphur	-	-	-	-
Pyrites	-	-	-	-

Petroleum refineries

Company	Location	Main source of crude	Capacity m³ per day	Additional capacity m³/day Future planning
Petrobras				
Refineria Landulpho Alves	Mataripe	local	12,800	7,150 (1972)
" Duque de Caxias	Rio	local and import	24,000	7,150 (1972)
" Presidente Bernardes	Cubatao	local and import	19,100	7,150 (1972)
" Gabriel Passos	Belem	import	7,150	-
" Alberto Pasqualini	Canoas	"	7,150	-
Fabrica de Asfalto de Fortaleza	Fortaleza	"	480	-
Petrobras	Campinas (Sao Paulo)	"	under construction	20,000 (1972)
Others				
Refineria Manaus (COPAM)	Manaus (Amazonas)	"	1,100	-
UNIAO	Capuava (Sao Paulo)	"	4,930	-
Refineria de Manguinhos	Guanabara (Rio)	"	1,590	-
" Matarazzo	Sao Paulo	"	140	-
" Ipiranga	Rio Grande do Sul	"	1,510	-
" Uruguaiana	"	"	60	-

Principle fertilizer plants in operation

Company	Location	Date of commissioning	Rated capacity tons/year		Production tons/year	Feedstock or fuel used
Petrobras	Cubatao	1969	NH_3	36,000	6,081	refinery gases
			amm.nitrate	12,000	8,917	
			nitric acid	68,000	18,381	
			cal.amm.nitrate	n.a.	17,759	
Copebras	Cubatao	1968	H_2SO_4	46,200	n.a.	imported sulphur & rock phosphate
			TSP	100,000	no production	
			SSP	22,775	n.a.	
Fertilizantes MITSUI Industria e Comercio Ltd.	Pocos de Caldas, Minas Gerais	n.a.	thermophos to be expanded to	20,000 60,000	n.a.	electric furnaces, local rock.
Quimbrasil S.A.	Jacupiranga	25 year old plant	36% P_2O_5	142,500		local rock

Fertilizer plants in construction or planned

Company	Location	Status	Date of commissioning	Type of product	Rated capacity tons/year	Feedstock
Conjunto Petroquímica da Bahia (subsidiary of Petrobras)	Camacari (Bahia)	in construction	Sept/Oct 1970	NH_3	66,000	natural gas
				urea	66,900	
Ultrafértil S.A.	Piacaguera (Sao Paulo)	just completed	May/June 1970	NH_3	170,000	naphtha
				nitric acid	200,000	
				ammonium nitrate	250,000	
				some DAP		

contd.

Company	Location	Status	Date of commissioning	Type of product	Rated capacity tons/year	Feed-stock
Fertilizantes do Sul S.A.	Rio Grande	just approved	1971	NPK mixed	300,000	imported NH_3, phosphoric acid and potash
Petroquisa	Bahia	preliminary planning	1973/74	NH_3	1,000 t/day	natural gas
Prefertil	Recife	very preliminary project	1973	mono amm.phosphate	n.a.	imported NH_3 and phosphoric acid

Consumption and production of fertilizers (source: 10 year plan of Brazil)

		1960	1964	1967/68	1968/69	1971	1976
N	Consumption	66,700	50,800	106,400	144,200	181,700	397,000
	Production	15,700	7,000	7,600	9,300	n.a.	n.a.
P_2O_5	Consumption	131,600	135,100	165,800	214,100	290,800	595,400
	Production	77,400	70,987	92,300	109,400	n.a.	n.a.
K_2O	Consumption	106,100	69,600	137,000	184,300	218,100	397,000
	Production	-	-	-	-	-	-
NPK	Consumption	304,400	255,500	409,200	542,600	690,600	1,389,400
	Production	93,100	77,987	99,900	118,700	-	-

Fertilizer plants in Central America

Company	Location	Date of commissioning	Rated capacity tons/year		Production tons/year	Feedstock and fuel used
Fertilizantes de Centro America (FERTICA) S.A.	Puntarenas, Costa Rica	1963	nitric acid	75,000	41,000 (1967) to be extended to 83,000 (1971)	ammonia and rock phosphate
			amm. nitrate	50,000	25,000 (1967) 46,000 (1971)	potash (import)
			complex (nitric phosphates)	120,000	60,000 (1967) 133,000 (1971)	
"	Acajutla, El Salvador	n.a.	H_2SO_4	16,500	16,500 (1967) 33,100 (1971)	sulphur rock phosphate
			complex	85,000	58,000 (1967) 117,000 (1971)	potash DAP (import)
Fertilizantes del Istmo Centralamericano	Tecún Umán	in construction end 1970	complex	45,000		NH_3, amm.nitrate, phosphoric acid, sulphuric acid, KCL, SSP.

Other mixing plants in Central America

Company	Location	Rated capacity tons/year
Interero	Corinto, Nicaragua	11,793
Abonos Superior	"	27,216
Fenisa	"	9,072
J.H. Baker & Bro., Inc.	Puntarenas, Costa Rica	29,200

Company	Location	Rated capacity tons/year
Abonos Superior	Limon and Puntarenas, (Costa Rica)	43,800
Abonos Agro	San Jose, Costa Rica	29,200
		150,281
Fertica (Acajutla and Puntarenas)		205,000
		355,281

Capacity of mixing plants in terms of average NPK mixtures

N	(14 %)	49,039 tons of N
P_2O_5	(17 %)	59,548 tons of P_2O_5
K_2O	(15 %)	52,542 tons of K_2O
Production capacity NPK		161,129 tons

Future plans

Several ammonia projects for Central America are under consideration, one of the most recent proposes a 600 t.p.d. ammonia plant and a 500 t.p.d. urea plant to serve the whole Central American market.

[illegible] : World Nitrogen plants (1968 - 1973), Stanford Research Institute (May 1969)

Consumption and demand of fertilizers in Central America (in metric tons)

Country		1960	1961	1965	1969 •	1970 •	1975
Guatemala	N	6,377	7,805	8,595	10,700	10,900	34,000
	P_2O_5	2,876	3,828	5,952	9,000	9,700	16,500
	K_2O	2,257	2,678	2,823	2,700	2,800	1,200
	NPK	11,510	14,311	17,370	22,400	23,400	51,700
El Salvador	N	12,466	13,134	24,224	48,300	52,700	60,000
	P_2O_5	3,700	3,917	8,233	19,800	21,900	33,500
	K_2O	4,953	5,161	6,056	11,800	12,600	10,300
	NPK	21,119	22,212	38,513	79,900	87,200	103,800
Honduras	N	7,391	5,905	10,027	15,000	16,400	17,000
	P_2O_5	264	300	688	1,400	1,600	4,200
	K_2O	437	743	4,980	10,800	12,200	7,500
	NPK	8,092	6,948	15,695	27,200	30,200	28,700
Nicaragua	N	2,346	3,752	15,183	26,300	29,200	40,000
	P_2O_5	1,686	1,947	6,836	12,400	13,700	15,500
	K_2O	1,007	1,294	2,890	4,300	4,600	6,500
	NPK	5,039	6,993	24,909	43,000	47,500	62,000

Consumption of fertilizers contd.

Costa Rica	N	8,098	6,387	17,905	29,000	31,600	51,000
	P_2O_5	5,098	4,754	8,047	11,400	12,100	22,000
	K_2O	4,621	4,525	7,061	10,600	11,300	18,200
	NPK	17,817	15,666	33,013	51,000	55,000	91,000
Total Central America							
	N	36,678	36,983	75,974	129,300	140,800	200,000
	P_2O_5	13,624	14,746	29,753	54,000	58,900	91,700
	K_2O	13,275	14,401	23,773	40,200	43,600	45,500
	NPK	63,577	66,130	129,500	223,500	243,300	337,200

1969, 1970 * : Extrapolation of the lineal tendency of the historic series which covers the period 1960-1965.
Source: Report of the ICAITI on the Fertilizer Industry in Central America.

1975 : Estimates of [illegible], UNIDO expert with SIECA. These estimates could be low if the producers and governments make a special effort to introduce fertilizers.

1960, 1961 and 1965 : **Source**: Report of the ICAITI on the Fertilizer Industry in Central America.

Petroleum refineries (all imported crude)

Country	Company	Location	Crude capacity 1,000 bbl/day
Costa Rica	Refineria Costa-rricense de Petroleo S.A.	Moin (Distrito de Limon)	8.0
El Salvador	Refineria de Acajutla S.A. (RASA)	Acajutla	13.2
Guatemala	Refineria del Atlantico (GUATCAL Atlantico)	Puerto Sto. Tomás de Castilla, Depto. de Izabal	12.0
	Refineria del Pacifico (TEXACO)	Escuintla	9.0
Honduras	Refineria TEXACO	Puerto Cortes	10.3
Nicaragua	Refineria de Managua (ESSO Standard Oil S.A.)	Managua "	12.0 8.0 (not in operation)
Panama	Refineria Panama S.A.	Bahia Las Minas Provincia de Colón	55.0

CHILE

Availability of fertilizer raw material and fuel

	Location	Total proven and probable reserves	Production	Future planning
Natural gas	Magallanes	100,000 million m^3	3,300 million m^3	–
Crude oil	–	150 million barrels (1967)	12 million barrels (1967) 11.6 million barrels (1968)	–
Coal and lignite	–	–	–	–
Rock phosphate	–	–	–	–
Potash	only in the form of sodium and potassium nitrates (Caliche)			
Sulphur	northern part of the country (volcanic)	n.a.	42,000 tons (1967)	potential for producing H_2SO_4 as byproduct from copper smelting

Petroleum refineries

Company	Location	Crude oil capacity b/d	Main sources of crude
ENAP	Concon	44,000 bbl/day to be expanded to 120,000 bbl/day	local
ENAP	Concepcion	35,000 bbl/day to be expanded to 72,000 bbl/day	local

Fertilizer plants in operation

Company	Location	Date of commissioning	Rated capacity t/y		Production t/y	Feedstock & fuel used
S.Q.M. (Sociedad Quimica & Minera)	Antofagasta province	very old plant	sodium nit potassium nitrate	900,000	700,000 900,000 (1963-68)	-
COSAF (Compania Sudamericana de Fosfatos)	Penco	late 1968 early 1969	SSP TSP	40,000 100,000	full capacity full capacity in 1970	rock phos. (Florida and Morocco) sulphur partly imp.
SOCHIF (Sociedad Chilena de Fertilizantes)	Tarapaca province and Antofagasta province	[illegible]	Grade 5-20-6-11,000		full capacity	N_2 (local), P_2O_5 and K_2O imports

Fertilizer plants in construction or planned

Company	Location	Status	Probable date of commissioning	Type of product	Rated capacity tons/day	Feedstock and fuel
Petroquimica Chilena	Punta Arenas	planning	1974	NH_3 urea	1,000 900	natural gas (local)
CORFO (Corporacion de Fomento)	also has plans to produce fertilizers. Exact information on their plans will be known in three months' time (September). No other data available so far.					

Consumption and production of fertilizers

		1960	1963	1968	1970	1975	1980
N	Consumption	14,700	27,300	48,000	55,153	90,000	117,000
	Production	190,503 (1959/60)	176,823 (1962/63)	181,400 (1968)	probably same as in 1969	n.a.	n.a.
P_2O_5	Consumption	30,000	77,100	114,000	126,850	165,250	191,000
	Production	n.a.	10,730	• 17,000 (1968)	• 37,000	-	-
K_2O	Consumption	6,800	12,000	11,500	14,090	49,670	61,500
	Production	-	-	-	-	-	-
NPK	Consumption	50,500	116,400	173,500	196,290	304,920	369,500
	Production	190,503	187,553	198,400	218,400	-	-

Source : Ministry of Agriculture, and Report prepared by A.T. Kearney & Company Inc. for Banco del Estado de Chile "Chilean Fertilizer Distribution", January 9, 1970
• estimated figures

COLOMBIA

Availability of fertilizer raw material and fuel

	Location	Total proven and probable reserves	Production	Future planning
Natural gas	Yondo, San Pablo, Cantagallo, La-cristalina Barco, Cicuco, Demares, Payoa, PF. Guaguaqui	495,200 x 10^6 SCF	82,389 x 10^6 SCF (1969)	-
Crude oil	Pelagua, Tetuan, Ermitano, Rionegro, Sogamoso, Cocorna, Tisquirama, Tetumal, Orito, Acaz, Zulia, Roble-Limon, Neiva, Violo, Yondó, el Dificil, La Nocha, Los Alpes Sampues, Jobo-Tablón	n.a.	76 x 10^6 barrels	-
Sulphur (Volacino)	Purace (Cauca)	8.5 x 10^6 tons (32% S)	174,736 tons (1969)	-
	New deposit at Chiles (Nariñó)	700,000 tons (20% S)	-	-
Coal	Valle, Cauca, Boyacá, Cundinamarca, Guajira, Antioquia, Santander	18,000 x 10^6 tons **Analysis:** Humidity - 1-2.7% volatiles - 8.8-17.9% fixed carbon - 74.1-84.1% ash - 2-7% S - 0.7-1.1%	3.1 x 10^6 tons (1968)	-
Phosphate rock	Santander, Boyacá Huila	463,722,000 tons or 200 t/d (20-25% P_2O_5)	about 200 t/day	-
Potash	-	-	-	-

Petroleum refineries

Company	Location	1970 crude oil capacity b/y
Intercol	Cartagena	16.5×10^6
Ecopetrol	Barranca	27.42×10^6 (to be increased to 37×10^6 in 1971)
Colpet	Tibu	1.2×10^6
Texas	Guamo	0.8×10^6
Intarcol	Dorada	1.7×10^6
Antex	Plato	0.5×10^6
Ecopetrol	Neiva (under construction)	- estimated to be 1×10^6 by 1972
Ecopetrol	Occidente (in planning)	- estimated to be 17.5×10^6 by 1974

Fertiliser plants in operation

Company	Location	Date of commissioning	Rated capacity		Production	Feedstock and fuel used
AMOCAR	Cartagena	1962/1963	100,000 t/y		100,000 t/y	natural gas
ABOCOL	Cartagena	1963	urea complex	75,000 t/y 125,000 t/y	about 50%	NH_3 and CO_2 from AMOCAR, phos.rock and potash (imports)
FERTICOL	Barranca, Bermeva	1963	NH_3 urea amm.nitrate	65 t/d 50 t/d 120 t/d	about 70% in 1969	natural gas

Fertiliser plants contd.

Company	Location	Date of commissioning	Rated capacity		Production	Feedstock & fuel used
FERTICOL	Barranca	(planning to increase NH_3 capacity to 115 tons/day)				
SULFACIDOS	Barranca, Bermeva	1964	NPK	300,000 t/y	60,000 (1967)	DAP (import) TSP " potash "
QUIN S.A.	Cali	n.a.	SSP	25,000 t/y	n.a.	

(apart from the last two plants mentioned above, there are a number of mixing plants).

Fertiliser plants in construction or planned

Company	Location	Status	Probable date of commissioning	Type of product	Capacity ton/day	Feedstock and fuel used
Monomeros (caprolactam plant and ammonium sulphate)	Barranquilla	under constr.	October 1970 ..	amm. sulphate to be increased to planned : complex fertilisers-	75,000 t/y 110,000 t/y 175,000 t/y	NH_3 (import) H_2SO_4 local manufacture (with local and import sulphur), rock-phosphate and potash, phosphor. acid (import)
Colminas Ltd.	Bogota	-	end of 1970	SSP to be increased to	8,000 t/y 60,000 t/y	rock phosphate (import)

Consumption and production of fertilisers

		1963	1966	1969	1970	1975	1979
N	Consumption	22,500	40,200	44,000	47,500	60,100	73,900
	Production	17,485	44,658	53,700	58,200	98,500	109,200
P_2O_5	Consumption	45,300	47,400	53,500	57,500	81,900	106,300
	Production	22,477	48,343	58,600	64,700	82,700	89,600
K_2O	Consumption	24,600	31,500	29,000	30,000	37,100	43,400
	Production	15,056	29,345	31,200	33,400	49,100	57,900
NPK	Consumption	92,400	119,100	126,500	135,000	179,100	223,600
	Production	55,018	122,346	143,700	156,300	230,300	256,700

Sources : 1969,1970,1975,1979 - Estimates from Monomeros.

1963, 1966 consumption and production figures :"From a Study of Fertilisers in Colombia (under preparation) by Ministerio de Agricultura Officina Planeamento del Sector Agropecuario and 2) ECLA study E/CN/12/76.

Other remarks : Production includes all the mixed fertilisers from the mixing plants.

Availability of fertilizer raw material and fuel

	Location	Total proven and probable reserves	Production	Future planning
Natural gas (and associated)	Zona Norte Angostura	328,400 million m^3 (1967)	16,335 million m^3 (1968)	-
Crude oil	Pola Rica Zona Sur	3,166 million barrels (1968)	160 million barrels (1968)	-
Coal	Coahuila, Oaxaca, Sonora	182.2 million tons	2.6 million tons (1968)	-
Phosphate rock	San Luis Potosi, Oaxaca, Nuevo Leon, Mexico	46 million tons (18% P_2O_5)	43,138 tons (1968)	-
Potash	Only indications	-	-	-
Sulphur	Coahuila, San Luis Potosi, Huascama, San Felipe, B.C., Sierra Banderas	58 to 17.4 million tons	1,684,948 tons (1968)	-

Petroleum refineries

Company	Location	Crude oil capacity b/d
PEMEX	Ascapotzalco	90,000
"	Salamanca	75,000
"	Minatitlan	175,500
"	Madero	160,000

Refineries contd.

Company	Location	Crude oil capacity b/d
PEMEX	Posa Rica	24,000
"	Rey Nosa	18,700

Installed capacity of production of NH_3 by PEMEX

Location	Nominal capacity tons/year
Unit Minatitlan	60,000 (1966)
Unit Salamanca	90,750 (1966)
Unit Ciudad Camargo	132,000 (1969)
Unit Cosoleacaque	363,000 (1968)
Total	645,750

Total production	1969	390,658 tons/year
"	1968	163,170 tons/year

Fertiliser plants in operation

Company	Location	Date of commissioning	Installed capacity t/y		Production tons/year	Feedstock and fuel used
Guanos y Fertilizantes de Mexico S.A.	San Luis Potosi (SLP)	1947 1950	SSP mixed	55,000 5,000	62,227 (1967/68) 2,498	H_2SO_4 (local) phos.rock (import)

Fertilizer plants contd.

Company	Location	Date of commissioning	Installed capacity t/y		t/y Production	Feedstock & fuel used
Guanos y Fertilizantes de Mexico S.A.	Cuautitlan Mexico	1951	$(NH_4)_2SO_4$	150,000	132,241	natural gas, sulphur, rock phosphate, potash
		1953	SSP	120,000	110,098	
		1961	mixed	60,000	46,261	
"	Monclova Coah.	1959	am. nitrate	68,000	69,590	coke oven gas, ammonia from PEMEX, H_2SO_4 rock phos., potash
		1963	complex	32,000	50,112	
"	Coatzacoalcos Veracruz	1962	TSP	50,000	17,573	ammonia from PEMEX, rock phosphate, potash, sulphur
		1966	phosphoric acid	17,000	17,117	
		1966	$(NH_4)_2SO_4$	50,000	5,509	
"	Bajio, Salamanca	1963	urea	56,000	50,176	CO_2 and NH_3 from PEMEX
"	Torreon Coah.	1966	$(NH_4)_2SO_4$	100,000	41,940	am. from PEMEX H_2SO_4
			mixed	5,000	5,029	
"	Camargo Chih.	1968	urea	75,000	55,000	ammonia and CO_2 from PEMEX
"	Minatitlan Veracruz	1962	$(NH_4)_2SO_4$	110,000	97,089 (1968/69)	CO_2 and NH_3 from PEMEX, sulphur, rock phosphate, potash
			urea	55,000	45,252	
			complex	190,000	76,486	
			phosphoric acid	41,000	20,785	

Fertilizer plants contd.

Company	Location	Date of commissioning	Installed capacity t/y		Production tons/year	Feedstock and fuel used
Guanos y Fertilizantes de Mexico S.A.	Guadalajara	1968	$(NH_4)_2SO_4$	120,000	109,282 (1968/69)	NH_3 from PEMEX, sulphur, rock phosphate
			SSP	120,000	106,265 "	
			mixed	160,000	50,000 "	
"	S. Cristobalecatepec	1960	SSP	10,000	10,000 "	H_2SO_4, rock phosphate
Fertilizantes Fosfatados Mexicanos S.A. (F.F.M.)	Pajaritos (Veracruz)	1969	phosphoric acid	550,000	50% capacity (1969)	rock phosphate (import) sulphur (local)
			TSP	204,000		
			H_2SO_4	1,065,000		

Fertilizer plants in construction or planned

Company	Location	Status	Probable date of commissioning	Type of product	Capacity	Feedstock and fuel used
UNIDEK S.A. (caprolactam and amm. sulphate plants)	Salamanca	planned	1972	$(NH_4)_2SO_4$	140,000 t/y	ammonia and sulphuric acid
Guanos y Fertilizantes de Mexico S.A.	Coatzacoalcos	under const.	June 1970	$(NH_4)_2SO_4$	expansion to 82,000 t/y	ammonia from PEMEX, sulphur
Expansion of plant at Cuautitlan		under const.	end 1971	H_2SO_4	600 t/d	natural gas, sulphur, rock phosphate
				$(NH_4)_2SO_4$	[illegible] t/d	
				SSP	[illegible] t/d	

Fertiliser plants contd.

Company	Location	Status	Probable date of commissioning	Type of product		Capacity	Feedstock & fuel used
Expansion of plant at Minatitlan	Minatitlan	planning	1975/76	urea		200,000 t/y	NH_3 and CO_2 from PEMEX
"	"	"	1973/74	DAP		200,000 t/y	phosphoric acid (FFM)
Expansion of plant at	Guadalajara	"	1975	$(NH_4)_2SO_4$	from to	100,000 t/y 170,000 t/y	NH_3 from PEMEX, sulphur.

Consumption and production of fertilisers

Note 1) Estimated production Guanos Fertilizantes and FFM prod.
2) Estimates from Guanos Fertilizantes de Mexico S.A.

		1960	1965	1968	1969	1970/71	1973/74	1976/77
N	Consumption	128,259	243,719	352,073	374,178	450,000	565,000	695,000
	Production	48,206	134,769	209,383	366,339	2) 450,000	2) 565,000	2) 695,000
P_2O_5	Consumption	34,038	76,795	115,953	125,327	2) 145,000	2) 202,000	2) 274,000
	Production	18,647	83,821	117,602	120,239	1) 515,239	1) 715,000	1) 910,000
K_2O	Consumption	6,479	22,755	35,517	22,801	2) 41,000	2) 50,000 (1975)	-
	Production	-	-	-	-	-	-	-
NPK	Consumption	168,776	343,269	503,543	522,306	636,000	817,000	969,000
	Production	66,853	218,590	326,985	486,578	965,239	1,280,000	1,605,000

Availability of Fertilizer Raw Material in Peru

	Location	Total proven and probable reserves	Grade	Production	Future planning
Natural gas	Nor-Oeste, Brea and Pariñas, Lima Los Organos	1,250,150 million ft^3	70-85% CH_4	75,750 million ft3	-
	Aguaytia	700,000 million ft^3		no exploitation	-
Crude oil	Brea and Pariñas, Lima, Litoral and [illegible], Los Organos, Humboldt, [illegible]	150 million barrels (1967)	-	46 million barrels	-
Phosphate rock	Piura	2,762 million MT	9-30% P_2O_5	nil	to produce 2.0 million tons by 1976
Potash	Piura	6.43 million MT	60-62% K_2O	nil	200,000 tons by 1976
Coal	Chicama Valley S. Ana " Oyon " [illegible]	50 million MT 100 " 20 " 10 "	fixed carbon- 80-85% ash 5-15% volatiles 10%	3,000 (1968) 2,000 (1969) - 10,000 (1969)	plans to increase prod. up to 450,000 tons/year in Santa Valley
Sulphur	[illegible] (volcanic) [illegible]	20 million MT	30% S	400 tons/year	-

Petroleum refineries

Company	Location	Crude oil capacity barrels per day
Petro Peru	La Pampilla (Lima)	20,000
"	Talara (Lima)	57,000
"	Luis F-Dias (Loreto)	1,200
Chevron	Conchan (Lima)	10,000
Ganso Azul	Pucallpa (Loreto)	2,500

Fertilizer plants in operation

Company	Location	Date of commissioning	Rated capacity tons/year		Production	Feedstock and fuel used
FERTISA (Fertilizantes Sinteticos S.A.)	Callao	1954	NH amm. nitrate amm. sulphate	26,500 44,000 37,000	17,112 22,116 15,750	fuel oil, H2SO4 (by-product from copper smelting), nitric acid-local manufacture
Fabrica de Fertilizantes del Cuzco	Cachimayo	1963	ammonia amm. nitrate	15,000 46,500	6,000 19,200	electrolytic hydrogen
[illegible]	Callao	n.a.	SSP TSP	30,000 72,000	17,152 n.a.	rock phosphate (Florida), H2SO4 (Bayovar)

Fertilizer plants in construction or planned

Company	Location	Status	Probable date of commissioning	Type of product	Capacity ton/day	Feedstock and fuel used
Project prepared by the Ministry of Mines and Energy of	Callao or Talara	in planning	1976	NH_3 urea amm. nitrate nitric acid	544 500 526 417	natural gas
Project prepared by Petro Peru	Talara	in planning	no date given	ammonia urea	300 530	natural gas

Consumption and production of fertilizers

		1963	1964	1965	1970	1975	1977
N	Consumption	66,000	65,796	67,151	115,000 (87,880)	170,000 (137,680)	189,000 (187,480) in 1980
	Production	13,772	17,069	n.a.	35,300	180,000	180,000
P_2O_5	Consumption	19,800	19,940	21,668	37,010	63,000	78,000
	Production	3,590	3,430	n.a.	n.a.	n.a.	n.a.
K_2O	Consumption	4,900	2,782	6,356	23,000	49,000	63,500
	Production	-	-	-	-	-	-
NPK	Consumption	90,700	88,518	95,175	175,000	282,000	330,500
	Production	17,362	20,499	-	35,000	110,000	180,000

Ref: - 1963 CEPAL (ECLA)study
1964 consumption TVA - Peru's Fertilizer Distribution and Marketing System (1968), production - ECLA study.
1965 consumption - study made by Latin American Free Trade Association (ALALC)
1970/75/77 - demand projections - TVA study figures in brackets - Techno/Economic study by a Nitrogen Fertilizer Plant in Peru (1969).

VENEZUELA

Availability of fertilizer raw material and fuel

	Location	Total proven and probable reserves	Production	Future planning
Crude oil	States of Zulia, Falcon, Apure, Monagas, Guarico	$15,676 \times 10^6$ barrels (1968)	$1,319 \times 10^6$ barrels (1968)	-
Natural gas, associated and non-associated	States of Zulia, Anzoa-Tegui, Monagas, Barinas	$752,781 \times 10^6 m^3$ (1968)	$25,384 \times 10^6 m^3$ (1968)	-
Coal	States of Zulia, Tachira, Anzoategui	100×10^6, 2×10^6, 50×10^6	30,815 (1968)	-
Sulphur	State of Sucre	n.a.	300 tons	-
Rock phosphate	States of Falcon Tachira	15×10^6 500,000 tons	31,550 (1967) - 26% P_2O_5 36,000 - 22.5% P_2O_5	-
Potash	-	-	-	-
Pyrites	-	-	-	-

Petroleum refineries

Company	Location	Crude oil capacity b/day	Main sources of crude
Creole	Amuay	470,000	local
SHELL	Cardon	379,000	"
Ven. Gulf	Pto. La Cruz	159,000	"
Mobil	El Palito	96,500	"

Refineries contd.

Company	Location	Crude oil capacity b/day	Main sources of crude
Creole	Caripito	74,200	local
Chevron	Bajo Grande	61,500	"
Sinclair	El Chaure	38,000	"
SHELL	Sanlorenzo	35,000	"
C.V.P.	Moron	16,300	"
Texas	Tucupita	10,000	"
Sinclair	Barinas	5,400	"
Phillips	Sanboque	4,300	"

Fertiliser plants in operation

Company	Location	Date of commissioning	Rated capacity tons/day		Production	Feedstock and fuel used
I.V.P. Complex	Moron	1962	1. H_2SO_4 (98%)	600		sulphur imports from Poland,
			oleum	50		
			phosphoric acid	100	average 60-70%	rock (local)
			TSP	120		
			SSP	360		
			2. NH_3	100		natural gas
			urea	50		(local), potash
			$(NH_4)_2SO$	240		imported
			HNO_3	185		
			ammonium nitrate	150		
			NPK mix.	300		

Fertilizer plants in construction or planned

Company	Location	Status	Probable date of commissioning	Type of product	Capacity ton/day	Feedstock and fuel used
I.V.P.	Moron	under const.	whole complex by 1972 NH_3 end of 1970 urea " 1971 others " 1972	NH_3 urea DAP TSP NPK	600 750 1146,000 t.p.a. 100,000 t.p.a. 115,000 t.p.a.	natural gas
Nitro Lara	Bajo Grande (El Tablazo)	in planning	1973	NH_3	1,500 for export	natural gas
Nitroven	El Tablazo	I stage in construction II stage in engineering	end of 1971 end of 1972	2 x NH_3 plants 2 x urea plants	900 each 1,200 each	natural gas

Consumption and production of fertilizers

		1963	1965	1967	1967/68	1968/69	1970	1975
N	Consumption	4,200	13,900	18,500	26,000	26,000	25,800	38,500
	Production	10,400	22,000	23,000	15,000	21,000	856,000	1,243,000
P_2O_5	Consumption	3,000	7,200	108,000	12,000	15,000	16,400	26,700
	Production	6,300	15,600	16,300	12,000	15,000	18,000	75,000
K_2O	Consumption	3,500	8,200	13,700	13,000	15,000	19,900	31,500
	Production	-	-	-	-	-	-	-
NPK	Consumption	10,700	29,300	140,200	51,000	56,000	62,100	96,700
	Production	16,700	37,600	39,300	27,000	36,000	874,000	1,318,000

VIII. COUNTRY REPORT

Summary

ARGENTINA (by Maria A. Lew de Lerer)

PRELIMINARY FOCUS ON THE SUPPLY AND DEMAND FOR AGRICULTURAL CHEMICALS

The paper stresses the fact that since the major part of the foreign exchange earned by the country is derived from agriculture and cattle raising, it has become necessary to increase exports and improve technology for the rural sector.

The paper points out the significance of agriculture chemicals in the improvement of production, considering that the losses caused by insects, pests, weeds, etc. represent from 35% to 40% of the production potential. Losses suffered by several crops of importance to the Argentine were described.

In the decade 1950/1960, there was a rapid increase in the use of agricultural chemicals. For example, the consumption of 2,4D increased from 150.000 lbs. in 1951 to 700.000 lbs. during 1954/55. The tables attached to the paper register this intensive development of the national production and consumption of chemicals for the agriculture.

With respect to raw materials and intermediate products, the paper points out the existence of national products that satisfy the domestic demand for pesticides. Several raw materials are also mentioned and prices are given of several pesticides locally produced.

The work indicates that the idle capacity is still very high. For example, the utilisation rate of Pentachlorofenol is only 10%. On the other hand, in the case of 2,4D, the rate increases up to 90%.

As far as the importation of chemicals for agriculture is concerned, the study points out that the products are very diversified. Furthermore, there has been registered a considerable increase in imports, especially during 1964, when the amount of nearly 8 million dollars was registered.

The apparent consumption of chemicals for agriculture was US$7 million in 1960, jumping to US$21 million in 1968. It indicates also that if there existed the possibility of producing, a greater number of products in Argentinia in order to substitute for importation, the above consumption would double.

When commenting on the change experienced in the products applied the paper explains that Law 18073/69 prohibited the use of traditional chlorinated hydrocarbons due to complaints received from main foreign buyers of agriculture products, in view of the presence of residue levels above the ones permitted.

Concerning pesticides, the paper ends by stressing the significance of the studies on residue levels, in order to avoid that the agriculture and cattle product-exports be affected by CODEX limits on pesticides residues of the Joint Programme of FAO/OMS on food rules.

FERTILIZERS

Fertilizer consumption in Argentina has shown little progress during the last 10 years. At present consumption is approximately of 70,000 tons per year, including nitrogen, phosphates, compounds and organics. Among nitrogen urea stands out with 25,000 tons. Phosphates total approximately 8,000 tons/year and include triple superphosphate, Thomas slag and hyperphosphate. NPK compound is about 38,000 tons and the consumption of the NP group is about 22,000 tons.

The paper suggests that development of fertilizer consumption will take place when the farmer and cattle breeder apply it in the intensive zones of culture, such as cereals, forage, and oil seeds.

With respect to the national production, in 1968 the first nitrogen fertilizer complex started operating. Production of this industry is as follows:

Anhydrous Ammonia	68,000	tons/year
Urea	55,000	" "
Ammonium Sulphate	50,000	" "
NPK	40,000	" "

In view of Argentina's restricted consumption of these products, they are being exported in part to the neighbouring countries.

COUNTRY REPORT

Summary

BOLIVIA

ANALYSIS OF THE FERTILIZER AND PESTICIDE MARKET IN BOLIVIA

by
Maria Llanos Cáceres

FERTILIZERS

Presently, Bolivia has no fertiliser plants and is worried about the fact that it has to import over US$23 million per year of agricultual products.

Based on a study made by TVA (with the financial assistance from USAID), Bolivia decided not to erect a plant for phosphate fertilisers, but to consider the installation of a plant to produce nitrogen fertilisers in the Santa Crus de la Sierra region.

Bolivia is presently studying the possibilities of financing an industrial complex, to produce:

Ammonia	39,000 m.t./year
Nitric Acid	9,900 " "
Ammonium nitrate	11,550 " "
Urea (46%)	49,500 " "

The country's fertiliser requirements are as follows:

Year	1970/71	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79	79/80
N	2,385	3,160	4,054	6,102	7,936	10,289	13,100	14,165	14,901	15,542
P_2O_5	2,384	3,158	4,051	5,298	6,833	8,917	11,467	12,354	12,921	13,443
K_2O	1,232	1,654	2,195	2,900	4,769	5,769	7,933	8,480	8,881	9,287
Total	6,001	7,972	10,301	14,300	19,538	24,975	32,500	34,999	36,703	38,272

PESTICIDES

Considering the fact that Bolivia participates in the Complementation Agreement No. 6 of the Petrochemicals Industry of LAFTA and in order to be able to supply pesticides to the other countries, has requested from Syracuse University Research Corp. the preparation of a study on the technical/economic possibilities. This study is being made.

RESUME OF NITROGEN REQUIREMENTS
(BY CULTURE) ACCORDING TO TVA
M.T./YEAR

Products	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Wheat	200	600	1,000	2,400	3,300	3,900	6,000	6,400	6,800	7,000
Potatoes	2,100	2,400	2,400	3,000	3,300	3,600	3,900	4,200	4,200	4,200
Quinoa	3	6	9	12	15	36	45	90	120	150
Rice	-	-	-	-	-	120	240	350	480	600
Cotton	22	34	45	90	120	150	270	315	315	420
Peanut	-	-	-	-	1	3	5	8	10	12
Sugar Cane	60	120	300	600	1,200	2,400	2,020	2,592	2,676	2,760
Corn	-	-	-	-	-	40	60	100	150	200
Forage	-	-	-	-	-	40	60	100	150	200
T O T A L	2,385	3,160	4,054	6,102	7,936	10,289	13,100	14,165	14,901	15,542

DEMAND OF PHOSPHATE (P_2O_5) REQUIREMENTS

(BY CULTURE) ACCORDING TO TVA

M.T./YEAR

Products	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Wheat	200	600	1,000	1,600	2,200	2,600	4,500	4,800	5,100	5,290
Potatoes	2,100	2,400	2,700	3,000	3,300	3,600	3,900	4,200	4,200	4,200
Quinoa	2	4	6	8	10	18	22	45	60	75
Rice	-	-	-	-	-	60	120	180	240	300
Cotton	22	34	45	90	120	150	270	315	315	420
Peanut	-	-	-	-	3	9	15	22	30	38
Sugar Cane	60	120	300	600	1,200	2,400	2,520	2,592	2,676	2,760
Corn	-	-	-	-	-	40	60	100	150	200
Forage	-	-	-	-	-	40	60	100	150	200
T O T A L	2,384	3,158	4,051	5,298	6,833	8,917	11,467	12,354	12,921	13,443

COUNTRY REPORT

Summary

BRAZIL (continued) by Paulo Barragat

BRAZILIAN MARKET FOR CROP PROTECTIVE PRODUCTS

The paper points out that, in order that food production in Brasil satisfy the population needs, which increases at a yearly rate of 3.2% the agricultural production should have as a goal, an increase of 12% per year. In order to meet this value it is necessary that, apart from the use of fertilisers, crop protective products for several cultures also be applied.

It stresses that presently, agricultural production loses approximately 16% due to the action of insects and rats, estimating the minimum annual loss at US$400 million in Brasil.

Average importation of crop protective products has been nearly US$14 million, taking as a basis the table relative to 1958/67, which would represent 85% of the apparent consumption during this same period, the majority of these products being imported in concentrated form, especially the case specified as "technical grade".

The paper indicates that due to agricultural development, imporation should increase in the near future, even though a larger participation of domestic production will be registered.

One may reach the conclusion that just 15% of the products consumed are formulated with products of technical grade originating in the country. Then, the paper examines by category, the actual situation of this basic industry and also the processing industry that operates with technical grade products, either domestic or imported, formulating the mixtures.

The paper ends by indicating that present increase in consumption of these products in Brasil is from 8% to 10% per year, and that in 1969 the total value of these protective products (imported and national) was of Cr$[illegible] million (approximately US$130 million).

The size of the market along with the increase that should be registered, demonstrates the necessity of producing in the country, these products today being imported.

[illegible]

SUMMARY

BRAZIL (by Joao Drummond Gonçalves)

SOME ASPECTS OF THE BRAZILIAN AGRICULTURE POLICY - RURAL CREDIT

The strategy of the present governmental policy is to expand exports of manufactured products and increase agriculture income, so that [illegible]% of the population may join the market for consumer goods produced by the industrial sector.

In the slides shown, the good results of the campaign designed to increase exports of manufactured goods are demonstrated.

In order to reach this goal, the following were some of the main measures taken: develop the seed production sector; encourage consumption fertilizers; enlarge consumption of crop protective products, establish rural credit conditions adequate to the rural enterprise and on efficient basis.

The paper goes on detailing how the rural credit policy is applied, emphasizing that the economic situation of the enterprises and market organization should be especially considered.

The paper also reviews the development of storage facilities, development - of applications from the Banco Nacional de Crédito Cooperativo, the Government policy concerning maintenance of minimum prices for agriculture products, introduction of compulsory rural insurance in the State of São Paulo and extension of agriculture mechanization possibilities.

With reference to the fertilizer industry's work in increasing the application of fertilizers, this industry has played a relevant role in the process of enlarging agriculture productivity.

COUNTRY REPORT

SUMMARY

Paulo Vieira Boletti

BRAZIL

FERTILIZER INDUSTRY OUTLOOK IN BRAZIL

The paper presents a picture of the main aspects of the Brasilian consumption and production of fertilisers, also of the aspects of the Brasilian agriculture production, comments on the Brasilian Government policy on fertilisers and mentions the country's outlook for the development of domestic production of basic nutrients.

At the beginning, it states that agriculture in Brasil is divided in two sectors; "traditional" and "modern". In the first, fertiliser consumption is practically nil and in the "modern" all new technique are applied, such as mechanisation, use of selected seeds, combat against pests, fertiliser application adequate treatment for crops and, finally, obtaining of minimum prices guaranteed by the Government.

According to the paper, apparent consumption of fertilisers during 1968, was the following:

Zones	Nutrients ($N+P_2O_5+K_2O$) Tons
North/northeast	38,420
Center/South	439,880
South	121,400
Brasil	601,700

During 1969, the apparent consumption of nutrients for all Brasil, was 530,365 tons, which indicates a considerable increase. For 1970, a larger increase was forecasted and has been registered.

The study indicates that the comparison between domestic fertiliser production and apparent consumption covers 22% of the total, just in 1969. This comparison when made in 1964, was 42%. The paper includes an analysis of the main fertilisers used in 1969, nitrogen, phosphate, and potassium.

With reference to consumption, the paper states that in 1971 the country should consume 934,000 tons of NPK nutrients, reaching 1,553,000 tons in 1975 and 2,387,000 tons in 1980. Furthermore, it is foreseen that the increase of use by hectare, which in 1968 was 6.7 k, will be 13.0 k in 1975 and 18.6 k in 1980. For 1971 is forecasted a radical alteration in Brasil, on the production structure, mainly where nitrogen is concerned, considering that today most of

K is imported. It will be produced locally with the possibility of attaining around 70% of the Brasilian consumption.

The study reveals that the opinion prevailing in the governmental and industrial circles is that all future projects for basic nutrients for Brasil should start from utilising national natural resources and produce on a scale that will make possible competition with the products imported under normal price conditions, without customs protection. Within this policy, all large projects are being planned for the Brasilian fertiliser industry.

In continuation, the paper refers to the basic fertiliser projects existing in Brasil, making specific mention of projects in the phosphate and nitrogen fields. Where potassium is concerned, reference is made to carnalite and silvinite mines discovered in Sergipe, which will permit Brasil to fulfill completely its demand with Sergipe's potassium and may also have extra quantities for exports.

At the final part of the paper, is mentioned the significant party played by the fertiliser mixing industry concerning the development of fertiliser application in the country and emphasises the work effected by ANDA towards popularising use of fertilisers, especially in the Center/South region.

COUNTRY REPORT

Summary

CHILE (Rodrigo Donoso M.)

THE CHILEAN FERTILIZER INDUSTRY

The paper points out that in recent years, the Chilean agricultural production has turned from a surplus to a deficit position. This is due, among other things, to the fact that only 7% of the soil can be ploughed and out of this total, only 1,6 million hectares are adequate for intensive cultivation.

In order to effect a more efficient distribution of the fertilisers imported by Chile, the Bank of the State has made a study of future consumption of fertilisers. The result of this study indicates that Chilean consumption of NPK fertilisers could double by 1975. Consumption in 1975 could be the following: 90,000 tons of nitrogen fertilisers; 165,000 tons of phosphates and 49,700 tons of potassium fertilisers. In order to achieve this consumption, it will be necessary to effect an intensive program of market development.

Regarding raw materials, Chile has natural gas, nitrates, phosphatic minerals, volcanic sulphur and although deposits of potassium minerals have not been found, there are "caliches" which are the raw material for the production of nitrate and these contain potassium.

The plants operating in Chile have production capacity for 170,000 tons of nitrogen, 50,000 tons of P_2O_5 and 24,000 tons of potassium oxide. The paper mentions the most important organisations in the fertiliser sector.

In order to satisfy the estimated consumption for 1975, Chile would need 40,000 tons of N, 107 tons of P_2O_5, 38,000 tons of K_2O, apart from the nutrients that may be produced by the existing plants. The paper points out that it will be very important that the estimated consumption be attained, in order to obtain a greater productivity of the soil and prevent the growing deficit prevailing today in agriculture production.

The Corporación de Fomento (CORFO) has asked TVA to make a study, in order to know the alternatives necessary to satisfy the demand by producing domestic fertilisers. The paper presented by TVA is being studied by CORFO and a decision is expected for very soon concerning the general plan for fertilisers.

One of the problems discussed is the production of ammonia and urea. Results show that a production of 600 tons of ammonia and 600 tons of urea/day in plants located in Magallanes (using natural gas) will compete favourably with international prices.

COUNTRY REPORT

Summary

COLOMBIA by R. Donoso Moderra

THE COLOMBIAN FERTILIZER AND PESTICIDE INDUSTRY

The paper presented is divided into two parts: Fertilisers and Pesticides.

FERTILISERS

The source of raw material for the manufacture of fertiliser by the 40 existing firms in Colombia, is imported.

With reference to nitrogen, there are two plants with a total installed capacity of 120,000 tons of N per year. However, 60,000 tons of N is used yearly. These plants produce urea, ammonia, nitric acid, ammonium nitrate, and granulated fertilisers.

It is estimated that in 1971 the Empresa Monómeros Colombo-Venezolanos will start production, with the capacity of 300,000 tons/year of compound fertiliser.

Potassium is imported, considering that presently there are no sources of supply in the country.

Sales of fertilisers enjoy a banking credit supported by Law No. 26 of 1959, which force the banks to designate 14% of the deposits to agricultural development. The majority of producing firms extend their credit conditions up to 180 days, for 40% of each sale.

Apparently, the transportation cost from the interior adds to the cost of the product, as much as 20%, which can be compared to existing costs in the United States. However, transport presents a bottleneck when the demand is great.

Fertiliser consumption in Colombia is considered to be low, since it is 100 kg hectare. It is to the greatest extent in the cultivation of potatoes.

Producers have prepared a programme to increase fertiliser application, in which is included field demonstrations.

Briefly, the paper indicates that by 1975 Colombia will have the capacity for producing all fertiliser needed, permitting the farmer to use more fertilisers and increase agricultural production and exportation.

PESTICIDES

In the commercial formulations made in the country, are employed today 30% of the Colombian raw materials are used for 30%. It is expected that in the coming years it will reach 50%. Furthermore, the installed capacity of the formulating firms is employed up to 75%.

There are some products of the bisdithiocarbamates that are being made in the country and sold at prices 50% lower than in the North American market.

In order to facilitate distribution of fertiliser to small consumers in distant regions, the State sells pesticides through the Caja de Credito Agrario. Those sales are made to approximately 450 firms that are part of the 10,000 retailers that sell pesticides.

The Colombian market for pesticides in Latin America countries is low, but has a constant tendency to expand. Local producers receive the incentive through a Certificate of Tributary Bonus (CAT).

Application of pesticides in Colombia is effected, in great part, under the supervision of experts who keep close contact with agricultural credit. This way, the Government supervises the assistance given by experts from private enterprises.

The alterations effected in the agriculture and cattle raising sector, gave a considerable impulse in Colombia, where pesticides and fertiliser industries are being developed. This reform authorised the Instituto Colombiano Agropecuario (ICA) to control the quality of such inputs either in production or distribution, and application of same.

COUNTRY REPORT

Summary

COSTA RICA by Rodrigo Lopez Aguero

THE FERTILIZER INDUSTRY IN COSTA RICA

The paper informs that Costa Rica has one plant producing NH_4NO_3 ammonium nitrate to supply all Central American countries. It has a capacity of 50,000 tons of NH_4NO_3 and 120,000 tons of nitrophosphates. By 1971 it is estimated that this plant will operate at full capacity, selling all the production to the Central-American area.

Costa Rica has sulphur mines with estimated reserves of 200 million tons. Up to now no interest in the installation of a plant able to use this mineral in the production of sulphuric acid has been evident.

There are only mixing plants using the only national raw material, i.e., diatomite. All other products are imported. Fertiliser consumption in 1971 is estimated to be around 34,000 tons of N, 15,000 tons of P_2O_5, and 13,000 tons of K_2O.

The farmer in Costa Rica is aware of the necessity of using fertilisers. This results from the work done over many years by the Agriculture and Cattle Breeding Ministry (Ministerio de Agricultura y Ganaderia) which offers continuous assistance to the farmers.

Regarding the crop protection products, considering that it is a small country, Costa Rica cannot afford the installation of a chemical plant for productio of these products. That is the reason why all pesticides are imported ready to be used by the farmer in Costa Rica.

COUNTRY REPORT

Summary

DOMINICAN REPUBLIC by Gustavo Tirado A.

SITUATION OF THE FERTILIZER AND PESTICIDE INDUSTRY IN THE DOMINICAN REPUBLIC

FERTILIZERS

The Dominican Republic just recently started to develop fertiliser consu tion, this development being hindered by the lack of agronomists, which in 1962 were only 2 and in 1970 are 100.

There are two mixing firms, but all raw materials are imported, and granulated fertilisers are still being imported ready to be applied in agriculture.

The largest fertiliser consumer is the sugar industry, followed by the rice, tobacco, corn, and coffee plantations. A new law, presently being formulated, is expected to benefit the use of fertilisers on a large scale.

PESTICIDES

In the Dominican Republic, there is no domestic pesticides industry, and they are wholly imported for the animal and plant application, ready to be us

A new law, still to be put into force, will cover the use and control of pesticides. There are problems with chlorinated products residues that have restricted tobacco exports especially.

COUNTRY REPORT

Summary

GUYANA by Bernard Wylde Carter

THE FERTILIZER INDUSTRY IN GUYANA

Guyana has 200,000 hectares being cultivated, out of which 120,000 are in rice and 50,000 in sugar cane. Approximately 80% - 90% of the fertilisers consumed in the country are applied to the sugar cane plantations. For rice little fertiliser is used in the Guyana. There are also 18,400 hectares planted with cocoa-nut trees.

Regarding pesticides, their main use is to combat the rice sucker and destructive ants (MIREX is utilised).

Importation of fertilisers were as follows, last year:

	Long tons
Nitrogen	28,004
Phosphate	3,559
Potassium	3,018
Others	1,459
Total	36,040

Presently the prices in the country are:

	US$ per Long ton
Urea	97.50
TSP	110.00
Potassium (Muriate)	68.50

The main problem is the high cost of maritime transport, due to the need of importing the products in small ships, because of the banks of sand that bloch the ports for the traffic of boats of greater draught.

Evidently, larger quantities of fertilisers and pesticides could be consumed if prices were more reasonable, since besides rice there are new crops like, for example, corn, peanut, soya bean, and sorghum. There are also the savannahs which also require fertilisers and pesticides.

The Government is presently giving great attention to agriculture and is especially encouraging the expansion of rice culture. It is interesting to point out that the paper indicates that in some cases, during the period of 3 years, there have been 9 rice crops.

The large organizations that contract the rice and sugar trading, give credit to producers, in goods.

COUNTRY REPORT

Summary

REPUBLIC OF HAITI by Joseph Adrien

FERTILIZER INDUSTRY IN HAITI

The paper pointed out some serious agricultural problems of that country, which could be summarised as follows:

1. Erosion caused by heavy rains characteristic of the country and which is diminishing, year by year, the area devoted to agriculture.
2. Difficulties in the preparation and education of farmers.
3. The system in practice until recently, concerning rural property.
4. Lack of foreign financial assistance.
5. Extremely high fertiliser prices.

The paper emphasises the need to take measures, as urgently as possible concerning nutrition which is presently defficient and runs the risk of causing hunger at large-scale hunger.

Recently cooperatives and agronomic schools were created, and modifications were in the conditions needed to improve the rural properties. The Government is now carrying out an advertising campaign to promote better farming practices.

Mention is made of a large hydroelectric project that should supply plenty and cheap electric power over all the country.

It is also mentioned that importation of finished fertiliser was around 3,000 m.t./year and that it could go up to 20,000 m.t./year or more, if the above defficiencies were corrected, especially with the reduction of costs to reasonable levels.

The paper ends by requesting the colaboration of the other nations of the continent to help Haiti financially and technologically, in order that all serious problems may be solved.

COUNTRY REPORT

Summary

PERU (by J. Garcia Castillo)

THE FERTILIZER AND PESTICIDE INDUSTRIES IN PERU

1. Present situation of the Fertilizer Industry.

(a) Guano of the Island

The national fertiliser consumption has depended for many years on Guano of the Island. Prior to 1957, most nutrients consumed (NPK) were provided from this product. In 1969 the participation in the market decreased noticeably, because a phenomenon of mortality reduced the population from 36 to 4.5 million birds. This created the need for importing fertilisers, especially nitrogen, in order to cover the deficit. The possibilities of industrialising guano is important because of its high content of uric acid (around 12% to 15%). It is the world's only natural source of this product, from which are derived drugs of high price and high demand in the international market. SENAFER has a pilot plant for the production of uric acid, which is exported at US$4.00/kg.

(b) Synthetic Fertiliser Plant

A private organisation is producing the synthetic fertilisers, ammonium nitrate and ammonium sulphate, beginning with ammonia that is made from Bunker and fuel oil. The plant capacity is 18.000m.t./year of N (approx. 22.000 m.t./year of ammonia) that is used to produce 43.000 m.t./year of ammonium nitrate (33.5% N) and 15.000 m.t./year of ammonium sulphate (21% N).

The ammonia synthesis is expensive because of the use of fuel oil as a raw material and because of the small installed capacity that does not permit the economies of plants of large capacity and which utilise methane from natural gas.

The ammonium sulphate plant is modern and was designed to absorb the ammonia surplus not converted into ammonium nitrate because of the limited installed capacity and because part of the concentrated nitric acid is required by the local explosives industry.

(c) Cachimayo is a plant owned by the State for the production of nitrogen fertilisers. It produces ammonium nitrate of agriculture grade (33.5% N). The installed capacity is 38.940 m.t./year. The production is limited due to insufficient power to 31.142 m.t./year. The 1964 production was 26.240 m.t. (84% of designed capacity). The electrolitic process for producing hydrogen is one of the reasons why production costs are relatively high, as compared to the process based on natural gas.

Presently, because of technological advancements in this industry, the size of the plant is considered economically obsolete.

One aspect that benefits the plant is the strategic location, with a market separated by a barrier of high freight rates, making possible the inclusion of the market in the south when the supplies of fertilisers like urea are not imported at prices artificially reduced or at dumping prices.

2. Production Statistics

Tables on national production and demand projections are given.

3. Evaluation and recommendations

(a) Recommendations under the legal considerations:

It is necessary to centralise all activities of extraction, production and marketing of fertilisers at a commercial rate in the country. For this, it is recommended to follow the Empresa de Fertilizantes created by Law Decree n° 17.525, within the Industry and Commerce Sector. When appropriate conditions have been created, the organisation will assume the responsibility of operating the nitrogen complex in northern Peru. The financing, equipment and construction are under the jurisdiction of the Ministry of Energy and Mines, through Petro Per

(b) Technical Recommendations:

The fertiliser industry is considered to be basic, strategic and of social interest, according to the General Law of Industries n° 18.350; therefore, the State has the responsibility for planning its activities.

Install, as soon as possible, a complex of nitrogen fertilisers in the northern part of the country, taking into consideration the urgent need the country has of easing the yearly deficit of urea, which is imported in great quantities.

The participation of the nitrogen fertiliser plant at Cachimayo in the domestic market should be the production of technical ammonium nitrate for explosives.

Since the present FERTISA production is not economical, its installations could have a better use by buying ammonia from the projected complex in northern Peru.

With reference to Guano of the Island, due to the economic significance of its use in the production of uric acid, a product that could be transformed into organic chemicals of high value, it is believed that there is a need for basic research which would indicate its economical possibilities.

Promotion

1. The Empresa de Fertilizantes, in close coordination with the Ministry of Agriculture and other technical organizations, will coordinate all information on soil fertility and the need for [illegible] for the domestic agriculture.

2. The Ministers of Agriculture and Education reorganized the system of farmer education in the country in order to respond to the needs, objectives, and goals for development.

3. The Ministry of Agriculture will increase technical assistance to farmers, especially through the Agrarian Reform Law.

Infrastructure

1. The Empresa de Fertilizantes will direct its efforts to acquire the means, necessary to plan, organize and build a structure of marketing, thus providing a good situation for fertilizers produced locally or imported.

2. The Ministry of Agriculture will look into problems relevant to the expansion of agriculture production by larger fertilizer applications.

Credit

1. Credit will be supervised through programmes such as the Costa Plan, Sierra Plan and the Community Plan that presently operate in the country in order to provide the financing necessary to cover the goals of the fertilizer projects, closely connecting production with credit.

2. Restructure a new credit system for fertilizers, in order that they may be channeled, in a better way through the Empresa de Fertilizantes, the Ministry of Agriculture, Banco de Fomento Agropecuario of Peru and other State or private credit organizations.

3. This new system must be considered as one of the principal measures to facilitate the aquisition of fertilizers by the farmers.

4. The development programme of the Ammonia Industry, according to the estimated demand for nitrogen, for both agriculture and mining uses, is expected to have, in 1973, a deficit of [illegible]0.000 tons, which, in terms of urea, represents

130.000 m.t./year. Production of ammonia from natural gas is the most economic. Consequently the logical material for the production of nitrogen is natural gas of the Peruvian Northwest, which is rich in methane. Talara, near the producing wells of natural gas and the installations for collection and canalization of gas, was chosen as the site for a nitrogen plant. This will permit production at a low cost, particularly since [illegible] facilities of [illegible] tion at Petro Peru can be used

[illegible]

Nitrogen projections, estimated at [illegible] per year, between 1970-197[illegible], justified the installation of a plant for [illegible] tons/day of ammonia to cover the deficit of approximately [illegible]0.000 tons/year of nitrogen estimated for 197[illegible].

[illegible] - Sechura Project

The Ministry of Energy and Mines have formed a commission to promote the Sechura project. The commission should present their final study by December of this year.

The reserves which are confirmed and economically available are:

Phosphates : 2.762.000.000 m.t. with [illegible].00% of P_2O_5 (67% BPL)

314.453.000 m.t. with 30.[illegible]% of P_2O_5

Marketing will be directed toward Latin America, Japan, Australia, West of the United States and the other countries of the Pacific coast. Minera Bayovar, through its main shareholder, Kaiser Aluminium, expects to effect sales to India and East Pakistan in view of the eventual construction of fertilizer plants that are presently being studied by Kaiser Aluminium for these countries.

With reference to the price and freight costs to these markets, the medium average would be US$37.65 per ton for phosphates with 57% B.P.L. and US$ [illegible]0 per ton for calcined phosphate with 72% B.P.L. (FOB Bayovar).

The production capacity will be as follows:

Phosphate	57% B.P.L.	550.000 T./year
"	72% B.P.L.	1.550.000 T./year
Potash	60-62% K_2	[illegible]00.000 T./year

Significance of the project for the national economy

Production of new products in the domestic mining sector will be established: phosphate and potash.

Details of the project

During the construction stage, it is estimated that $43 million will be invested in internal expenses.

In the erection period the maximum labour engaged will be 1.[illegible] persons.

The permanent employment during production will be 700 persons.

Taxes estimated for the exploitation of the project will reach [illegible] million per year during the first ten years of production and later [illegible] million per year.

COUNTRY REPORT

Summary

URUGUAY (Nicolas Herrera Mac-Lean)

FERTILIZERS - IMPORTATION, CONSUMPTION, STATISTICS

1961-1968

The paper analyses the statistics covering the period 1961-1968. These were attached to the paper.

The analysis indicates that fertiliser imports amounted to US$10 million in 1968. In view of the significant volume this represents, it becomes necessary that the country develop research and policies that will maintain a continuity and allow a selection of the products to be imported.

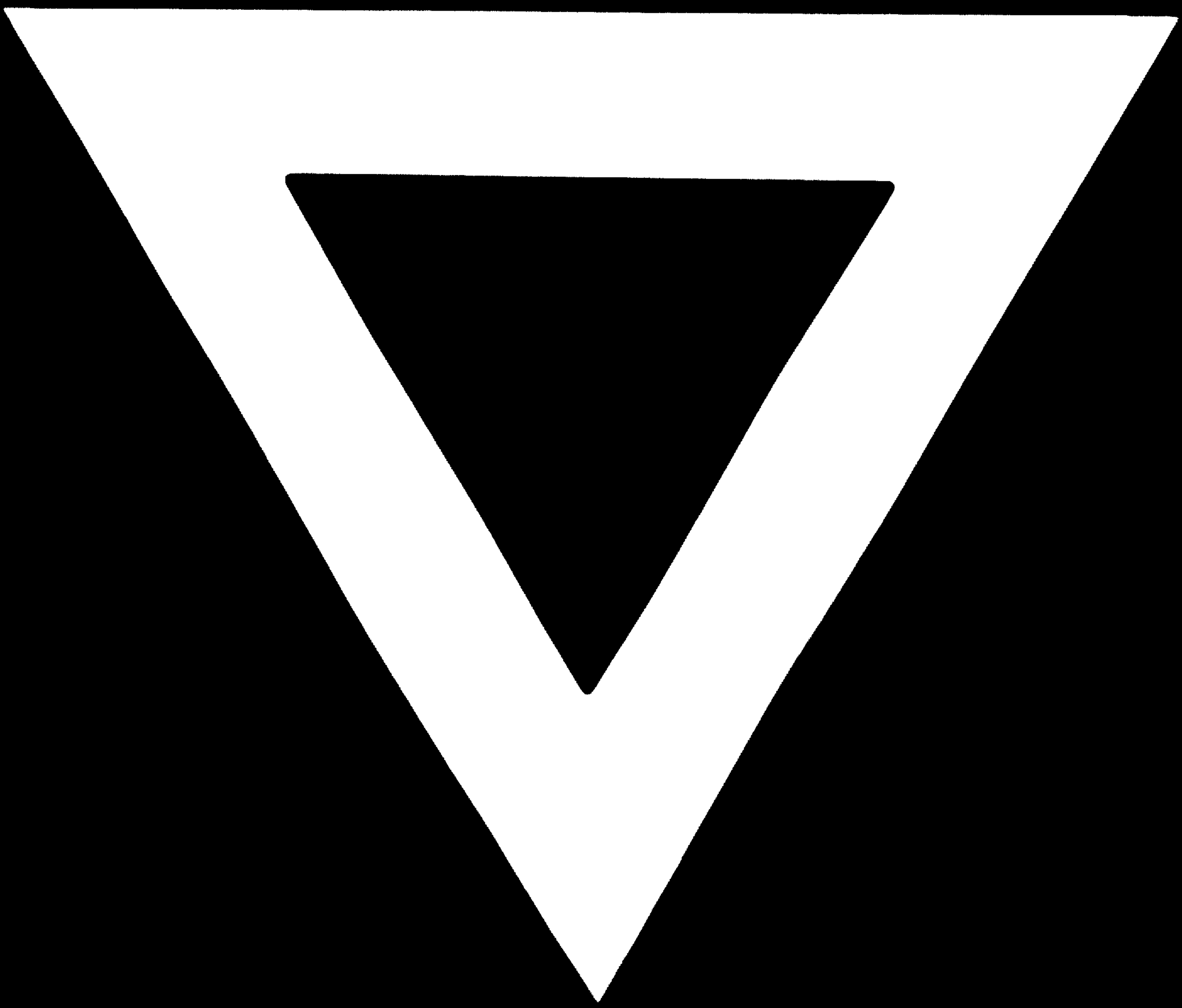
During the above period, consumption of NPK fertiliser increased 454% (from 15,000 tons to 68,100 tons). The concentration increased from 27% to [illegible]% of plant food. Furthermore, there was an expansion in the area fertilised from 110,000 hectares in 1960 to 704,000 hectares in 1968. Higher concentrations and more extensive application should be intensified in the future.

Expansion in the years to come should basically be effected in pastures in order to multiply the cattle breeding. The consumption of phosphates should be increased by 20 times. Potassium consumption has been kept stable due to its reduced effectiveness on the country's soil.

The progress of the fertiliser industry has accompanied the increase in consumption and, in the coming years, granulation will be applied in general. The installation of a triple superphosphate plant will be studied. The size of the market does not make production of synthetic nitrogen economically feasible.

Fertiliser imports effected through AID loans, will permit the establishment of a sizeable rotating fund for credits in the coming years.

The important economic effort made by the Uruguay Government in subsidising the fertiliser selling price was emphasised. Thus the resulting consumption increase indicates the need of maintaining this policy.



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