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ROUND TABLE
1974

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Table of Contents

Tuesday, December 3rd
Morning Session
Joseph E. Reynolds, Jr., Chairman
Rodger C. Smith, Moderator

Page

Opening Remarks: Chairman Reynolds 1

Opening Remarks: Moderator Smith 2

Feeding the World's Hungry
The Challenge to Business
Ambassador Edwin W. Martin
Keynote Speaker 2

Phosphates — Changes In Supply Demands
J. F. Babbitt, Jr. 8

Sufficient Potash At What Price
Everett C. Horne 11

What's Ahead In The Nitrogen Market
John J. Clarke 17

And Address On Transportation
Vernon J. Haan 21

Tuesday, December 3rd
Afternoon Session
L. Dudley George, Moderator

Remarks — Moderator George 24

Personnel Training of Plant
Production Workers
Matthew P. Starcevich 24

John C. Vaaler Award
Gordon H. Weyermuller 26

Accepting John C. Vaaler Award
Samuel V. Houghtaling 27

A Workable Safety Program
For Fertilizer Plants
John L. Medbury 28

Plant Maintenance The Wasted Dollar?
Herman C. Powers 30

Tuesday, December 3rd
Afternoon Session Continued

Page

Environmental Controls Ahead
For The Fertilizer Producers
Gene C. Williams 33

Operation of Pollution Control Equipment
Problems and Solutions In Operations
Of Bag Houses
Edwin Cox III. 42

Question and Answer Session
L. Dudley George, Moderator. 49

Panel: John L. Medbury — Herman G. Powers
Gene C. Williams — Edwin Cox III

Wednesday, December 4th
Morning Session
Bill E. Adams, Moderator

Remarks — Moderator Adams. 53

Production of Granular-Ammonium
Phosphate Sulphate NPK Mixtures
Frank P. Achorn — Hubert L. Balay
Presented By Frank Achorn 53

TVA Pilot Plant Development Work
And Demonstration — Plant Experience
In Pan Granulation of Urea
D. R. Waggoner — I. W. McAmy
G. C. Hicks — J. R. Gahan
Presented By D. R. Waggoner 70

Urea-Ammonium Phosphate Production
Using The TVA Melt-Type Granulation Process
R. G. Lee — M. M. Norton — H. G. Graham
Presented By M. M. Norton 79

The Production and Marketing
Superphosphoric Acid From North Carolina Ore
Brooks M. Whitehurst 86

Wednesday, December 4th
Morning Session Continued

Page

Progress Report On Spherodizer® Granulation
Introduction By E. Pelitti 96

Part One: Granulation of Anhydrous Melts
R. M. Reed — J. C. Reynolds
Presented By J. C. Reynolds 97

Part Two: Hot Spherodizer® Processes and
Complex Fertilizers
Y. Berquin — J. Burko
Read By R. M. Reed 110

Questions and Answers 112
Panel: E. Pelitti — R. M. Reed — J. C. Reynolds
Y. Berquin — J. Burko

Wednesday, December 4th
Afternoon Session
Frank T. Nielsson, Moderator

Remarks: Moderator Nielsson 116

Single Superphosphate — Status and Future
Albert E. Henderson, Jr.. 116

Energy Problems and Challenges
In Fertilizer Production
William C. White 120

Agronomic Effects of supplementing
High Analysis NPK Materials with
Sulphur and Magnesium
Harold D. Blenkhorn 125

Techniques of Adding
Micronutrients To Fertilizer
Carl Schauble 133

Technical Changes Affecting The Supply
Of Sulphuric Acid
David W. Bixby — Jan S. Platou
Presented by Jan S. Platou 135

Outside Bulk Storage Ammonium Nitrate
Jesse C. Z. Ku — Ashley D. Kemila
Presented by Ashley D. Kemila 139

Outside Bulk Storage of Potash
R. M. C. King 150

Wednesday, December 4th
Afternoon Session Continued

Page

Questions and Answers 151
Panel:
Albert E. Henderson — William C. White
Harold D. Blenkhorn — Carl Schauble
Jan S. Platou — Ashley D. Kemila
Jesse C. Z. Ku — R. M. C. King

Thursday, December 5th
Final Morning Session
Moderators: Joseph E. Reynolds, Jr., James C. Brown, Paul J. Prosser, Jr.

Business Meeting

Remarks — Chairman Joseph E. Reynolds, Jr.. 153

Secretary-Treasurer Report
Paul J. Prosser, Jr. 153

Nominating Committee Report
Wayne W. King, Chairman 154

Entertainment Committee Report
Thomas Athey, Chairman. 154

Meeting Place and Dates
for 25th Annual Meeting
Thomas Athey, Chairman. 154

Remarks — James C. Brown, Moderator 155

Materials Handling
Neil S. Whitaker. 155

Designing Quality NPK
Fertilizers and Fertilizer Programs
Henry Plate. 158

Innovations — Selected Questions And Answers 161
Paul J. Prosser, Jr., Moderator
Panel:
Frank Achorn — Hubert Balay
Allen Jackson — A. V. Malone
Frank T. Nielsson — Richard Perkins
Joseph L. Prosser — D. R. Waggoner
Walter J. Sackett, Jr. — James E. Semour

Closing Remarks — Chairman Reynolds 168

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Tuesday, December 3, 1974

Morning Session

Joseph E. Reynolds, Jr.
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Moderator

CHAIRMAN REYNOLDS: It does not seem possible that we are approaching our 25th Anniversary. Let us reminisce just for a moment. In 1951 a small group of nonselfish, dedicated men gathered to probe the "Production Problems" existing in our Industry. Your Round Table has evolved from this and has been largely responsible for taking the initiative to open the doors for "Production Management" to exchange information through the means of an open forum of questions and answers.

The list of participants of the past 24 years, who have contributed to the success of the programing and to our Round Table, reads like a "Who's Who" in Our Industry. The Round Table started with and belongs to the participants. We would like to believe that our Fertilizer Industry has been the beneficiary of these programs.

This 1974 program continues the objectives of bringing pertinent and timely information to our "Forum". Past meetings have been oriented towards themes and general meetings. Some have been very broad with many subjects and some have been more restrictive with considerable detail and penetration into the subjects.

Our programs evolve from your letters, requests and your comments. The Round Table has never been a bashful organization. Our members are free to ask questions and make suggestions. Your questions might provide the answers for other persons who are possibly too concerned to ask. You also receive when you freely give.

It is my pleasure, on behalf of our Directors, to open this 1974 Round Table. During the past two years our Industry has seen a tremendous turn-around in public attitude concerning fertilizer. The depressed period of the late 1960's and the early 1970's will long be remembered. Today we talk in terms of "Plant Food Supply, Shortages, Allocations and Farm Economy". The challenge today is to you, the "Production Man," to increase plant food recovery and efficiency. Our Industry cannot afford to neglect inventory control. This is due to our short supply situation as well as the dollar value of the "Fertilizer Products" we manage.

The United States is again a recognized "Agricultural Nation". Our balance of payment is dependent upon our farm output. The welfare of the Fertilizer Industry is now mews. No longer is our Industry taken for granted.

Our audience today consists of a cross-section of the Fertilizer Industry and of those interested in "Fertilizers". Participants come from many States and from outside the United States. A Special welcome is extended to our "Neighbors and Friends" from near and far Foreign Lands.

Your Various Round Table "Committees", and in particular our "Secretary", have worked very hard, in both thought and action, to bring this program together. My special thanks go to all of those who helped and especially to our "Speakers" who are sharing their "Expertice, time and knowledge" with us.

This 1974 program brings together "Speakers" who will discuss many pertinent and timely topics, evidenced by the opening session with special emphasis directed to feeding the "World's Hungry". We are recognizing the importance of "Plant Food" in meeting these challenges. Insight into the possibilities of improving our "Primary Plant Food Supply" will be an interesting discussion. Transportation will be thoroughly discussed. Without efficient "Transportation" from mine and factory to "Farm" our position would be hopeless.

This (Tuesday) afternoon session pursues "Operational Problems." Safe practices reflect on "Plant Efficiency." Without proper "Plant and Production Supervisors" any invested Capital will not provide a satisfactory return on "Investment". Environmental concerns remain a non-productive item which must be recognized and controlled.

The Wednesday session deals largely with processing both dry and fluid fertilizers. The energy concern entered our vocabulary approximately two years ago and remains in the foreground. Good agronomic practices and micronutrients addition are also topics which contribute to increased crop production. Sulphuric acid has taken some abuse due to accompanying SO_2 emissions. This vital acid is still the barometer, not only of the Fertilizer Industry, but of the entire Chemical Industry. Ours is a materials handling Industry and a prominent spot has been reserved on the program. Outside bulk storage and handling of water soluble materials is also very timely. Product quality tests are still the final exams for our efforts. The customer remembers the quality long after the price has been forgotten.

A new feature has been inserted into our Thursday session "Innovations." The Round Table membership was polled for questions and the response was pleasantly surprising. A panel of experts will be assembled to give the replies.

Without further remarks and comments, I declare this 1974 Round Table in session. It gives me great pleasure to turn the meeting over to the Moderator for the morning session, my friend and colleague, Rodger C. Smith of the Amax Corporation.

MODERATOR RODGER C. SMITH: Thank you, Joe. Good Morning, Ladies and Gentlemen.

Adding just a word to Joe's statement, the 1974 Fertilizer Industry Round Table occurs at a critical time in World History, at a time when there is concern about food unparalleled in modern times in both developed and underdeveloped countries. Logically, there is greater awareness of the cause-effect relationship of fertilizer and food than ever before. The elevated importance of food and fertilizer heightens the responsibility of "This Organization" and that of each of us individually. The challenge to improve "Fertilizer Technology" was never greater.

We are most fortunate to have Ambassador Edwin W. Martin to "Keynote" the 1974 round Table. He is no doubt best equipped to assess food needs, capabilities and priorities. Ambassador Martin is now Senior Advisor to the U.S. Secretary of State and Coordinator of U.S. participation in the "World Food Conference". As you have observed in the press in recent weeks the Conference was a successful meeting of Delegates from 120 nations.

Formerly, our Speaker was Chairman "Development Assistance Committee" of OECD in Paris. Prior to that he was Ambassador to Argentina, Assistant Secretary of State for Inter-American Affairs, Assistant Secretary of State for Economic Affairs, U.S. Representative to NATO and earlier Economic Counselor in London and several other important assignments. He is a graduate of Northwestern University. It is indeed an honor and pleasure to introduce to this 1974 meeting, Ambassador Edwin Martin.

Feeding The World's Hungry The Challenge To Business

Ambassador Edwin W. Martin

Mr. Moderator, gentlemen of the Round Table. It is important to have an opportunity to address a group like this because certainly, as you are keenly aware for the foreseeable future, fertilizer is a critical element in how well we do with respect to feeding the world.

When I came back to take on the assignment with the Secretary of State in preparing for the World Food Conference, I very quickly became aware of the keen interest in the fertilizer problem and what could be done about it. As I looked around the government, I saw a number of agencies with pieces of the operation of the government in relation to fertilizer, but I could find nobody taking an overall look and trying to get a coherent, coordinated policy from an international standpoint. I raised this question with authorities in the White House and got the usual bureaucratic answer. I was named chairman of an interdepartmental committee on the international fertilizer situation. So that I have had, in addition to my conference duties, an active interest over the past eight or nine months in the development of the world fertilizer situation.

My own impression has been that the only thing that could give us an easy situation with respect to fertilizer supply around the world and some moderation of price, the only thing that could have done that, would have been to have the bumper crops in the U.S. that were predicted last spring. They would have reduced the incentive to pile up additional acres and to use additional fertilizer in this country. That didn't happen and I think that one has to forsee a tight situation for some time to come and many complaints about the price and the availability of fertilizers around the world.

The second answer which we have been working on, and I think there has been some success but much more modest in impact, was to increase the output in plants already in existence, in developing countries primarily, in order to get the production out of them that they should be capable of. And our estimate is that instead of operating at something on the average of 60-65% of capacity they may be up around 75 or 80 now, which has helped somewhat.

The third, of course, longer range answer has been the building of new plants. But this, as you all know, is a slow process made particularly slow by certain competition with other energy demands for critical components, particularly of ammonia plants and to some extent of fertilizer rock operations. I think that one of the things that we have been concerned about is that with the high price and the high demand a great many people became interested, particularly in the last six months, in investing in new fertilizer plants and there is some prospect that toward the end of the decade we may again face a somewhat surplus situation with a resulting decline in construction and a tight cycle again in the 80's.

This may or may not take place; forecasting that long ahead is a difficult business particularly difficult on the demand side. But it does seem to us that it is going to be desirable, and the World Food Conference did recognize this, to try to get as much information as possible publicly available on production trend's demand prospects in order that we can avoid or at least soften the boom and bust cycle which has plagued the industry in recent years.

Now, to turn to the World Food Conference, just as a bit of introduction it was, of course, proposed primarily by Secretary Kissinger at the United Nations a year ago September; there had been a suggestion at a meeting of nonallied nations by President Boumedienne of Algeria that something like this be done but it was essentially a U.S. proposal. It was fitting, therefore, that Secretary Kissinger was invited to make what amounted to a keynote speech the opening day, and this was a speech very carefully worked out which combined broad concepts for dealing with the world food problem particularly over the next 10 years but to some extent over a longer period, a number of specific proposals for international cooperation in tackling the problems that we face as well as a number of commitments as to what the U.S. was prepared to do. It was very well received, so well in fact that every one of the proposals which he made in his speech for action by the conference were adopted, often in the identical words which he used. It sets us off with a good start, and one test which I think is a good one of success or failure is the fact that his proposals were all accepted.

Now, there were some obstacles to achieving that result which were not overcome easily and perhaps not wholly even yet. In the first place, subsequent to the proposal for the conference there was a certain rather considerable increase in oil prices which disrupted economies around the world and were particularly difficult for the industrialized economies already suffering from inflationary problems and a certain amount of monetary disorder. This became much more acute, and we feared from the beginning that many of these countries would be so preoccupied with these isssues they would have no attention left over for the problems of longer term food policy. It was a difficulty with respect to a number of countries principally European ones who are much more vulmerable than we to the oil problem, but they did come along in the end and did cooperate in giving us a good result; but we will continue, I think, to face the problem of finding enough attention time for high level people to the food problem given the other distractions with which they must face in the coming years.

A second problem was that is a special session of the United Nations General Assembly held last spring there was the sharpest confrontation yet between developing and developed countries, the developing countries led by the OPEC countries to a very large extent full of vigor and ambition from their successes in raising prices of oil and gaining revenue and with the influence thereby on other members of the developing country group. And there was great fear that this might lap over and that we would have at the Food Conference again the rather bitter debates on a new international economic order which took place last spring. There was a lot of rhetoric of this sort, a good bit of it appeared in the press from the opening speeches; but when we got down to negotiating substantive resolutions, people were concerned about the food problem and addressed the food problem and the rhetoric did not interfere with reaching what we thought were sound and useful results. This was a bonus which we didn't expect and indicates a widespread interest in dealing with the food problem on its own merits.

Thirdly, we did fear back in the early days last January that if there was bad weather again this year with no reserves to fall back upon of grains we would be preoccupied and the countries present would be preoccupied with how to get fed today and not how to plan for the next 10 years, how to avoid the situation in which we are in now. We did have bad weather. The situation is tight, very tight with respect to grains. We have no surpluses in the exporting countries, and the South Asian countries have had a bad season. This did get an enormous amount of press attention alongside the conference, largely focused on what the U.S. was failing to do above the billion dollars of food aid to which we were already committed. But despite the press attention to this, the criticism of the U.S. for not announcing a target, not a criticism I may note for what we're doing or not doing but just for not announcing a target. This did not either lap over and effect the substantive negotiations at the conference. The conference was called to deal with medium and long term problems not to put out fires. You don't call a town meeting, you call the fire department when you have a fire. Alongside the conference, the U.S., the other countries with grain, countries with money were busy, are busy, they met last Friday again to work out the problems of this year's supply. However, there has been a widespread tendency to write off the conference as a failure because it couldn't grow and ship grain or print money to deal with this year's problem. This was not the purpose and this was not allowed by any of the countries, including those suffering, to interfere with the results which we were seeking from the conference.

Now, in any assessment of what needs doing with respect to the food problem, one has to try to make a forecast of what the situation will be if you don't do anything. And the conference spent quite a lot of preparatory time working on this evaluation of the future prospects, particularly over the next ten years feeling that beyond that was too difficult to make any precise judgements. Even over that period one has to make several rather basic assumptions which may or may not be true. One was that the weather will be on the average no worse, perhaps no better than it has been for the last 10 or 12 years. Second, that economic conditions, which affect agricultural productivity in many ways, will be no worse than they have been over the last 10 or 12 years and thirdly, that human beings will behave at least as rationally or irrationally, as you wish, as they have over the last ten years. Making these assumptions, projecting a reasonable rate of growth of population and of income, one comes up with an estimate that we can, we will, following past trends, produce enough grain to feed the world as well perhaps a little better than it has been fed during the past ten years.

However, and this ia the critical problem — the disparity between the demand and supply in the developing world will increase substantially. The estimates range from an increase of from the present level of about 25 million tons of net imports of grain to something between 50 or to 85 to 90 million tons of imports depending upon various assumptions with respect to rate of growth of demand primarily. Now this disparity grows for two reasons. It is not a reflection of lower growth in output of developing countries but of higher rate of growth of population, much higher than in the developed world and of the fact secondly that of their increase in income at their income levels a very high proportion goes to buy more food so that you have a demand increase which outstrips the projected trend in production.

Now this is a problem for two reasons. In the first place it's hard to see how one would find the finance either from their own earnings or from AID flows to handle that much of an increase in grain shipments. Secondly, there would be some very high costs in actually finding the transport for something like 75-80 million tons a year of grain from the few exporters to the developing countries. Therefore, our feeling in developing our program for the conference was that the #1 problem was to see what could be done to increase production in the developing countries themselves. This didn't mean there weren't other problems. There were and I'll go through those as I go through the agenda which we had and the actions which we took. But this was the central problem to which we addressed.

Now, I think the best way to tackle what we did is to take it up under the headings of Secretary Kissinger's speech in which he presented a five point program. The first one was a somewhat new one in terms of conference preparations looking at the situation as he saw it. He felt that there was need to be assured, above all, that there was enough production over the next ten years to meet needs, and, therefore, he proposed that the exporting countries should make a continuing special effort to keep their production up and to expand it. This would be required not only in order to meet the import demands of the developing countries but to increase their nutrition levels, given the estimate that maybe 400 million are now malnourished enough to affect their physical wellbeing noticeably, and to build up the reserves which we do not have now. This was accepted fully by the conference.

The second was the key element to which I referred; namely, the increase of production in developing countries. Here we looked upon the job as twofold, one the priority to be given to agriculture, to food production by the developing countries themselves. As I am sure many of you are aware, there has been a great tendency to emphasize industrialization, to invest in the urban community rather than the rural communities, to hold down food prices for the benefit of the urban consumers, to skim off from export income to the government large amounts of money not allowed to get back to the farmers, to hold up tariffs on the things the farmer buys. There are a range of policy issues of this kind affecting the incentive for the farmer to invest his labor and his capital to acquire new technology and to be willing to borrow for the inputs necessary to use new technology. So that a first emphasis had to be on providing the farmer an incentive to increase the productivity of the land which he was cultivating.

This seemed to us particularly important also over the longer term because as one looks at the world situation and looks ahead say 25 years, the place where the biggest gap exists between output currently and what it might be is in the developing countries. Land and water are going to be increasingly scarce and the more we can use theirs, the better chance we have to be able to feed the 2% increase in population per year which we will have regardless of what else we do at least until the year 2000. But we recognized also that with their efforts when they did give this new priority, and more and more of them in the last several years are doing so, there would be need for additional outside resources and, therefore, we recognized the need for additional flows of AID in technical assistance to help them make their land more productive. This, the U.S. had already committed itself to in our AID budget for this present fiscal year with an increase in the legislation now pending of $350,000,000, more than doubling in the food and nutrition sector alone. Now, others we hoped would move in and help fill the gap, particularly others who are new donors, the OPIC countries in the Arab world particularly, we felt they must be encouraged strongly to participate in this effort.

Now, there were several very important subheads to this effort to increase production in developing countries; two I want to mention here particularly as of interest. One was fertilizer. We went into the conference with one of our eight substantive resolutions, prepared by the Secretariat, after previous discussion on the subject of fertilizer. That resolution was considerably expanded during the conference. I don't think it contains anything essentially new, as this fertilizer problem has been under discussion bilaterally, and in the Food and Agricultural Organization with their new Commission on fertilizers for some time, but it does stress the importance of trying in the next few years, before new capacity can come into production, to do what is possible to meet the needs of the developing countries for fertilizer. This is particularly important in areas whose grain production has been helped materially by the "Green Revolution"' because without fertilizer the "Green Revolution" seeds are often not as good as the old traditional seeds that they were using and when a man can't get fertilizer or finds it's too expensive or he can't get the credit to buy it he tends to go back to the old seeds and it will be very hard to reconvert when fertilizer is available to using the new high yielding varieties.

But there were also a number of resolutions or paragraphs in the resolution, I should say, dealing with investment in fertilizer production. One talked about particularly investment in improving the efficiency of existing plants and their output, balancing them out, insuring that they had adequate power supply, etc.

A second paragraph dealt with the need to find ways to expand production in those countries with raw materials resources — oil, gas, phosphate rock — and locations where it would be most efficient to do so and particularly emphasizing the usefulness of doing so in developing countries where there is often a lack of foreign exchange with which to import fertilizer. This was certainly pointed at the much talked of program to use Middle East flared gas with Middle East capital and Western technology, a program which is, I should say from what I know now, moving rather slowly for some rather well defined reasons.

There was also a substantial emphasis on trying to work out cooperative arrangements by which you produce some of the intermediates in one country and do the final finishing or blending in the actual consuming country. There is some feeling particularly among the developing countries that they don't want to have all the benefits go to the producing country with the raw materials but they want to get some value out of it in the consuming country and they wish to divide up the burden this way. There was emphasis in this resolution and also in the research resolution on research of fertilizer production technology, of fertilizer use, use of existing chemical fertilizers. As you know as a result of a U.S. initiative, an International Fertilizer Institute has been started in connection with the TVA to come later, dealing essentially with the production and efficient use of existing types of chemical fertilizers.

There was also endorsed a further U.S. proposal made initially by Secretary Kissinger in his U.N. speech last spring for a much broader plant nutrient research institute which is now under consideration by the consultant group on agricultural research, which this particular unit would become a part and which would deal with a wide variety of possible measures requiring research for improving availability of plant nutrients. The two principal ones under discussion being the biological fixation of nitrogen with respect to which there are some indications that there are free floating agents both algae and bacteria which can do this to some extent. The question is "Can they be bred to do it more efficiently and be organized so they can be transferred around from field to field?" There are also those who have the idea that perhaps they can, having succeeded with triticale, a cross between wheat and rye. They would like to experiment with putting perhaps a wheat stalk on a legume root and getting the nitrogen fixation that way.

My own impression is that these are programs with possibly a 25 year payoff, if at all, but that the situation looks sufficiently critical that far into the future that we had better try them and put some money and brains into them in case we need them.

I think these were the essential elements in the fertilizer resolution; as you can see, nothing is especially new. There will be, certainly as the normal work is encouraged by the conference of the FAO fertilizer commission, a close watch kept on long term trends of supply and demand to try to provide the information guidance to which I was referring earlier so that the plant investment will take place on a basis which will keep an adequate supply available but not again flood the market as happened a few years ago.

The second main auxiliary element in this production in a developing country is the overall research effort. There is now, as you know, a series of some nine or ten international agricultural research centers which are making very real progress on a good many fronts. We proposed that the resources available to them should be doubled by 1980 in real terms and that in addition there was great need to build up the resources of national research institutions. There are in many countries institutions, but they are not geared into the agricultural system. There tend to be researchers sitting in ivory towers, neither getting the right problems for the farmers nor in a position to transmit their results when they are working on the right problems back to the farmers efficiently and not tied in with sufficient closeness to the international network, so that the U.S. wanted and succeeded in getting an important emphasis placed on building up the national research centers, adapting international output to local conditions whether of soil or climate, local pests, local cultural practices, etc., and this to my mind can be a most important element in increasing food production in developing countries. Even with what we know, if we would get that used it would make an enormous difference. We certainly do need to know more, to find easier, more risk-free methods of production, but what we know now is not used nearly as widely as it should be and the national research institutions have a major function to perform in this respect.

Now, a final major element which we emphasized in our presentation, which was picked up in perhaps the longest resolution of the conference, was that of nutrition. One can do a great deal more with existing production if one concentrates much more attention, than has been given, to what happens to that production after it leaves the farmer's field. In the first instance there is the question of the movement to the consumer's table, the waste, the loss that takes place, the higher the increase in cost which would make our middle man charges seem very small by comparison in many countries, and there will be, I think, resulting from the conference a new emphasis on this.

There will also be a major new emphasis on how to use the food that is produced to increase nutrition. There are a number of new technological advances in this area which should enable us to do much better than we have been able in the past. Food fortification is one element for example which can be of great importance. Education on nutrition is lacking in most countries. Most housewives are uninformed about what to buy and how to prepare it.

There are a number of new developments in connection with some of the most widespread nutritional deficiencies — Vitamin A deficiency, a major cause of blindness, and iron anemia, which can be dealt with by simple injection programs. Secretary Kissinger proposed that major worldwide programs on these two subjects be inaugurated and this was also accepted by the conference. I think that since our real objective in the end is to have people eat enough to be well nourished, we can complement what we do on the production side with a very great increase in the nutrition efficiency of what we produce.

Now the next subject we got into, which is of real importance, is the one of what do we do when, as in 1972 and again in 1974, even though we produce enough over the next 10 years on the average, we have a bad year. And on this, the U.S. proposed that there should be an international system of national reserves. Secretary Kissinger suggested that we ought to plan to try to have as reserves, above working stocks, something like 60 million tons of wheat, coarse grains and rice, this to be held, not just by the exporters or certainly not just by the U.S. as has been the case for 20 years, but by exporters and importers alike. We propose that the principal exporters and importers, and there are not more than a dozen of them if you count the Common Market as one, should get together and work out a firm agreement including a target as to how much should be held whether it is our 60 million or some other figure, some principals for dividing responsibility for holding it among the exporters and importers, a set of guidelines which can be used by countries in making their national decisions about purchase and sale from their reserve stocks and some kind of arrangement to give preference to those who should be participating and are participating as opposed to those who should be but are not. The conference did agree that these countries should meet as soon as possible to try to work out such a system.

Now for it to be effective, it is essential, of course that there be adequate information about existing stocks, about production prospects, about export-import prospects and there was a very good resolution, we think, adopted with respect to improving the information available on the world food situation.

These two resolutions were the only two on which there was reservation, all the other resolutions were adopted without a vote. On these two, the People's Republic of china objected saying information exchange and the reserve system which is eminently tied up with it represent an infringement of national sovereignty. The Soviet Union approved both resolutions which was encouraging to us. We expect that the first meeting of this group of countries will be called by the United States sometime next month to start negotiating a system of reserves.

Now, a final problem which we addressed is that, even though one does one's best to change the trends of production in developing countries, there will undoubtedly still be a substantial gap 10 years from now. It will take time to change farmers' practices, to change the system for providing inputs, the marketing system, getting research results distributed; and we will continue to have a substantial gap.

The problem is how can it be financed, and the U.S. felt that there were clearly two ways to cover that gap. One is by shipping food as we have been doing under our PL 480 program. The other is for the countries, who are able, to pay for the food through commercial channels. The second is the preferable way. In part, this can occur through improved exports of their goods and services. In part, they can get the money through AID programs; and we advocated that there ought to be a very careful consideration of ways and means for providing additional aid for the purchase of food. Money to buy food is just as good as shipping the food itself, and, therefore, we felt that countries who do have money, and there are a number of Arab oil exporters who have quite a lot at the present time, and will have more in the future, should participate in the food aid program.

The conference agreed and called upon countries who had grain surpluses or who had a financial capacity to help buy grain to sit down together ad try to agree on a division of responsibility for providing a minimum of 10 million tons of food aid grain over the next few years, 10 million tons a year. We hope that in the very near future it will be possible for the countries involved, the grain exporters, the countries who have been members of a food aid convention including Europeans, Japan, Argentina as well as some of the newly rich countries, to sit down and be able to reach an agreement to undertake that financing.

Now, from these substantive resolutions we turn to the subject of followup institutions. Many of us were concerned, and I think this was generally shared, with the fate of a good many U.N. resolutions having the best intentions of the world but were filed at Archives and never resulted in action, and we wanted to assign responsibility for follow-up action on all of the resolutions to some responsible body existing or, if necessary, new. I must say we were encouraged to find that, whereas in many past occasions, the developing countries had seemed to feel that a new institution, a new fund was the answer to all problems, they on this occasion shared with us the belief that you create new institutions only if there is a known identifiable gap and that no existing institution can perform that function.

In the end, we came up with a considerably better degree of agreement on this subject that we had expected, even halfway through the conference, and the follow-up resolution provides half a dozen major new initiatives. The first is a food council composed, we hope, of some 20 countries if not more — leading exporters, importers, other countries — to see that the strategy adopted by the conference is carried out. If there are new problems or new opportunities call attention to them and see that the appropriate action is taken. The members will be nominated by the U.N. Economic and Social Council and elected by the General Assembly. It will function at a ministerial similar level under the Economic and Social Council. It will not have a separate staff, but will be serviced within the framework of the Food and Agricultural Organization but it will keep a general watch on what U.N. institutions and governments are doing to carry out the strategy of the World Food Conference. They also provided that there should be set up within the framework a committee on food security and a committee on food aid. These will be in part transformations of existing bodies but will focus attention on these two issues on a global basis.

On the financing side, two things were done. First, a U.S. proposal that there be a consultative group on food production and investment in developing countries be set up essentially under the World Bank auspices, as the agricultural research consultative group is, was approved. This is a place where bilateral donors, multilateral donors, new donors can sit down together and see how they can use their money most effectively in the light of what others are doing and in the light of objective studies of what the requirements are to increase food production in developing countries. It will also take into consideration what the countries are doing themselves and what they need to do in order to make outside investment effective and useful. We have proposed also that this group set up a food aid subcommittee where we would negotiate this 10 million ton commitment that I referred to earlier so that the transfer of resources, whether in the form of money or food or in the form of investment funds, will be integrated together and be able to be combined with the activities of the developing countries on their own initiative both in terms of investment plans and policies.

We agreed that the research program should be turned over to the existing research consultative group, I.B.R.D., for leadership with FAO and UN development program cooperation. We agreed that the FAO fertilizer commission should be responsible for following up on the fertilizer resolution.

In the nutrition field there are a number of organizations in the UN family — The World Health Organization, UNICEF, the FAO — who have interest and responsibilities and we ask the Economic and Social council to take a look and see if there is need for any better coordination than now exists. If there is, to propose how it should be achieved. If not, do nothing.

We had a surprise at the end of the conference. We had been working since the beginning to see if we couldn't tap Arab money for food production. The Secretary General of the conference, Mr. Hussein Enshesei, a very distinguished Egyptian who had just become vice president of Egypt subsequent to the conference, had many friends there and had worked on this.

When we entered the conference itself, the general consensus of all delegations was that this was not going to take place, and we had given up the prospect of this being an outcome of the World Food Conference. However, three or four days before the close of the conference the OPEC countries distributed a draft proposal for setting up an agricultural investment fund. It was modified somewhat and put on a basis which we all found acceptable in the sense that; one, it is voluntary, anybody can c ontribute only if you do so much on some kind of matching obligatory contribution arrangment, but it was made voluntary.

Secondly, in line with the general feeling that we don't want new institutions unless they've got a major contribution to make, it was provided that the fund shall not go into operation until there are assured pledges of enough money to justify a new institution and enough money for a long enough period of time; and the general talk is something like $500 million a year or more must be available before it will justify setting the institution up.

Thirdly, it was agreed that the institution will not operate in the sense of handling projects, implementing projects, dispersing funds but will channel money through existing agencies like the members of the World Bank family, the regional development banks, some of the bilateral agencies could even get allocations of funds from this new body. So that is essentially a collecting arrangement.

Now, I don't want to give a wrong impression; no Arab oil exporter mentioned a figure. One assumes that since they proposed it they're prepared to put money into it. We'll have to keep our fingers crossed, but this could be a very important contribution to the assets of the developing countries whether to invest in agriculture, to purchase food aid, to purchase fertilizers or whatever purpose is directly connected with the food production.

I don't know how soon we will be able to tell if the conference will have made a difference. I think that if in six months these bodies are not set up and are not operating, that it has failed. But it will take us, I think, at least five years to know whether it is suceeding in changing the trend of food production. It takes that long to turn policies around, to spread new technology through the countryside, and to develop investment projects and implement them. And I would think that we should not try to reach too early conclusions.

It will be particularly important to see what happens if we have two or three years of good crops. I think the past history suggests that there will be a great tendency to become complacent again and to downgrade agricultural and food production after a couple of years of good crops. This would be a tragedy because we can't count on that continuing. It will not continue whereas population will keep growing and people will want to eat more.

Unless we can keep up the effort it looks to us as though that somewhere in the future, 25, 35 years, we will face a critical question that if we have not developed the right kinds of technology to use land, water, energy more efficiently, and we have not spread those out so that most people, most farmers are using them, and particularly the farmers in developing countries whose productivity is now so low, that we will face almost inevitably the alternative between massive famines from time to time, and more often tha n not, of paying very high proportion, a much higher proportion than now, of our income just to eat. And that is not a very happy prospect for any of us to face.

I would just add a final point. We cannot succeed just because we have had a good conference even if we just implement its recommendations reasonably well. We cannot succeed over the long term unless we deal with the availability of energy problem on a global basis in a satisfactory way. We cannot succeed over the longer term unless we deal with population growth effectively. The three things are eminently intertwined.

Even the laws of the sea have important implications, both from an energy and a food standpoint, in being able to feed the world properly, and the success of that conference is also important.

We are facing a period of global interdependence of population pressure on limited resources which is going to be a challenge to all of us for many years to come. I think we have gotten a good start in the food field. The polulation conference made a reasonable good start but governments and peoples will have to carry out. We have pointed directions, we haven't grown any wheat yet, and that is for the future.

You with the fertilizer production have a major role to play, but we must not only produce it but use it for the right things in the right places if we are to achieve the result we are all seeking. Thank you.

MODERATOR SMITH: Thank you Ambassador Martin. Your message is most enlightening. It will be of material assistance to all of us as we proceed with the conference. Again our very sincere appreciation to you. We hope you can stay with us as long as you wish in this conference.

Following assessment of the food situation, it is now logical that we take stock of fertilizer supply-demand important to our daily and long term planning. To inform us on the Nitrogen, Phosphate and Potash supply situations we are fortunate to have three leaders in these three key industries.

To address us on "Phosphates" we have the dynamic Leader of a dynamic Company, Agrico. Our Speaker received a degree in chemical engineering at Purdue and was a Captain and Pilot in the U.S. Air Force. Following World War II he gained wide experience in Engineering and Sales with the C&I Girdler Company including Canadian Manager of Operations and with Chemico responsible for North American Sales. In 1958—71 he was President of First Mississippi Corporation. Upon merging of Agrico into the Williams Company, he was named President of Agrico. We welcome to this gathering, Mr. Jack Babbitt. Jack,

Phosphate — Changes In Supply/Demand

J. F. Babbitt, Jr.

It certainly is a pleasure to be here today and participate in the 24th Annual Meeting of the Fertilizer Industry Roundtable.

You know, I had never given it much thought before, but it became rather apparent to me while I was preparing for this discussion on changes in supply and demand in the phosphate industry that our industry as we know it today is actually a very young industry. Of course, the manufacture of commercial fertilizers goes way back in history. Quite frankly, I had not appreciated just how far back it went until I inspected some of the old American Agricultural Chemical plants which were acquired from Conoco by Williams in early 1972. Over a hundred years ago AAC had a number of relatively large. low capacity, fertilizer production facilities scattered in the Eastern half of the United States — usually in area of high population density. Some pretty exotic phosphate products wer made in those days with the principal raw material consisting of animal bones from packing houses. Later, there was the use of phosphate rock from Florida as direct application material and then the movement of acidulation of rock to produce normal superphosphate, as well as phosphoric acid and run-of-pile triple superphosphate. Normal or single superphosphate as it is called, and run-of-pile triple superphosphate, used in conjunction with NPK granulation plants, were well on their way out of style with the successful introduction of direct triple production units on a relatively large scale of throughput. In turn, seemingly almost overnight, granular triple superphosphate was rapidly giving ground to the growth in use of mono and diammonium phosphates, where the latter products were being bulk blended with urea and potash to provide an almost infinite variation in NPK mixtures, tailor made for the particular soil and cropping conditions of any specific area. In fact, it seemed bulk blends were about to sweep homogeneous type NPK granulated products off the face of the earth, receiving a substantial assist from a concurrent movement to liquid fertilizers which could be applied in conjunction with one or more crop protection chemicals; thereby instituting a substantial reduction in application labor. So, about three years ago, it appeared that the transition was well along the way to almost total utilization of high analysis materials — all within the space of just a few years. But with the advent of the shortages in phosphate fertilizers, the transition was slowed down and almost reversed. It was quite easy to put back into operation normal superphosphate units and to expand operation of the NPK granulation plants which had flourished in the past.

My only reason for this recap of the phosphate manufacturing supply situation is so we can understand that from a supply standpoint, at the present time we have the full gambit of phosphatic fertilizers available to the U.S. farmer and to the world. These materials range from a very low to a very high plant food analysis — from granular, bulk blended materials through the homogeneous materials and on into the liquids — wherever there is capacity, it is being utilized.

However, there are significant changes afoot which will have an impact within the next twelve months. Present U.S. capacity of about 6,000,000 tons per year of P_2O_5 (100% basis) is being expanded by approximately 37% through new plant construction which should be onstream in the next two to eighteen months — or which has come into production within the past six months. In addition, there have been announcements of at least an added 1,200,00 tons of P_2O_5 which should be available in 1977 or 1978 at the latest. About 70% of this capacity will be converted to upgraded phosphatic fertilizers in the U.S.; while the balance is largely committed under long term contracts to go offshore as 52/54% phosphoric acid — Occidental's Russian trade notwithstanding. This additional phosphoric acid and phosphate fertilizer production is being achieved without any significant coincidental increase in phosphate rock production in the U.S. for the next two to three years. While there have been any number of announced mining projects for the U.S. which undoubtedly will be built some time in the future and result in additional phosphate rock capacity, very little in the way of actual added capacity is underway. However, I do expect that within the next six months the Florida log jam will break.

As you may know, Florida mine expansions have been held up due to ecological problems as well as some emotional problems from quite well intentioned persons in Florida who frankly do not want industry in their area regardles of the intent or content of such industry. But, because of the disparity of timing, there will be significantly less Florida rock to go into the export market on an interim basis and I do not think we will ever see the amount of Florida rock exported which we have seen in the past two to three years. Similarly, expansions in North Carolina are under way and in the Tennessee and Western Rock Mountain phosphate area. However, in the latter area while such mining is quite difficult at best and somewhat expensive — impact statements and a total land utilization program by the United States is being studied which would indicate that nothing of any substance will get underway within the next two years. And meanwhile, back at the ranch in Florida, we find that large draglines will have deliveries from four to six years, depending upon their size to further agitate the situation.

Outside the United States we find very much the same situation exists with certain unique variations of the basic theme. Phosphate rock producers are planning or undertaking expansions of their mining capacity and facing lengthy delays in actually realizing significant new production. At the same time — almost unanimously — worldwide phosphate rock producers are converting varying amounts of their capacity to upgrading facilities and will produce significant quantities of phosphoric acid and bulk phosphate fertilizers in the future. It would appear that the production of phosphate rock in the world will increase about 45/50% in the next five to six years and the production of phosphoric acid will increase about 190% in this same time span by rock producers. The net availability of phosphate rock to non rock producers will change by about 28%. It goes without saying that this represents a significant departure in considering where the world's phosphate fertilizers will be coming from in the future. The success and the impact of this change in the world's line up of suppliers will, of course, depend to a great extent on the successful operation of rather complex plant facilities in areas where the success ratio has not been too high in the past.

Well what does all this mean? I believe from a supply standpoint that it means within twelve months the United States will have all of the phosphate fertilizer productive capacity operating necessary to supply the total requirements of our domestic market. This is not a remarkable statement, since we had this capability in the last fertilizer year and again in this one with respect to phosphates — assuming zero exports. However, the United States is not an island unto itself and our exports of phosphate fertilizers are essential to the world and to the United States. Throughout the past few years and projecting ahead for the next five years, this country's exports of phosphate fertilizers should maintain about the same percentage of total production. This is somewhat an amazing present phenomenon when you stop to consider that in today's export market, prices are essentially double those of the domestic market for phosphate fertilizers on an equivalent f.o.b. producer's plant basis of comparison. This has occurred, even though the U.S. is one of the few countries in world where we do not have price controls or ceiling prices on fertilizers produced and sold within the country.

So far, I have only talked about phosphate fertilizer supplies. I would now like to talk a little bit about the demand side of the coin.

Without trying to be too academic, I would like to come up with a meaningful definition of demand for our purposes of discussion today. Actually, in my mind there are several types or categories of demand.

First of all, there is what I term the *real demand.* By that, I mean a demand that can be readily and surely translated into firm sales from a commercial standpoint. This is the demand which we would experience under normal conditions where we have no restrictions on supplies, funds, transportation and so forth.

In addition, we have what I feel is the *desired demand.* To me, this represents the amount of phosphate fertilizers which could be used within today's framework of crops, farmer needs, transportation and other requirements to make this a *real demand* with the exception of available funds or supplies.

Lastly, I think there is a *required demand* which takes into account the optimum agronomic use of fertilizer in the world in conjunction with soil conditions, crops, and all interrelated items. Of course, this is only a theoretical number and one to which I will not address myself further today, since it was the main theme for the industry's oversupply problems of the sixties.

When we discuss demand in the fertilizer industry, we should understand one thing, and that is that the demand has risen almost steadily every year — regardless of whether it has been a good year from an economic standpoint, crop standpoint, or whatever, or whether it has been a bad year on any or all of these points. In the late sixties and early seventies when it looked like our industry was forsaken for all time, demand was rising just as surely as it was in the forties and fifties, and as we predict it will the rest of this decade, the eighties, and into the foreseeable future. The major difference in today's demand is that we have these two components I have already defined as *real* and *desired.*

For the first time, we have significant quantities of phosphate fertilizers which could be utilized if they could be produced. At the same time, we have an unknown quantity which could be utilized if it were available but which cannot be paid for due to lack of funds — mostly in devloping countries — but not entirely.

To repeat what I mentioned earlier, most of the nations in the world have price ceilings on the fertilizers sold to the farmers in their respective countries, as well as price ceilings on the farmers' products. As the world prices have increased in fertilizer raw materials and finished good which are traditionally imported into these countries, the countries have subsidized the farmers' fertilizer costs by absorbing some of the price increases.

For the past two years, many countries have been forced by the increasing costs of fertilizers they import to allow the prices of such products to increase to the application of fertilizer to certain high priced commodities such as wheat, corn, soybeans and sugar cane and beets, where the farmer has also been given price relief, this increase in cost of fertilizer has not hampered the use of fertilizer, nor in fact the economy of the country involved. However, there are many row crops and other types of cash crops whose selling prices are controlled at the farm level, and here the farmer has gotten into a crunch with resounding reverberations. The situation I have just described is taking place in most developed countries — principally in Western Europe — as well as most less developed countries on a much less formal basis. Here you have the complex factor of nations which are in a crunch from their balance of payments standpoint — already running sizeable deficits — and trying to hold down additional losses of their reserves and control inflation — while facing an irate and obstinate farmer community on the lower end of the scale, and widespread famine and potential revolution on the upper end of the scale.

In the developed nation, these factors I have referred to have tended to slow down its purchases of fertilizers from outside sources, as well as the purchase of raw materials for other than its own fertilizer requirements. At the same time, within such a country, you have the farmer who is now considering how much fertilizer he should buy due to the price ceilings on his products.

Somewhat similarly, but in an entirely different vein, is the position of the developing country which has farmers in dire need of fertilizers. Such farmers are subsidized to a great extent also with respect to their fertilizer purchases the same as the developed countries, but are not necessarily under the same constraints with respect to ceiling prices on their products. These farmers would utilize all the fertilizers they could get their hands on, except that their country has insufficient funds to buy the quantities required to meet the total *desired demand* level. Accordingly, the *real demand* in such situations is quite a bit below the *desired demand.*

Well what does all this mean? I think it is already obvious that you have a situation where there will be restraints on new phosphatic plant construction due to the lack of a firm supply of phosphate rock on a long term contract basis for the next few years. This conclusion even ignores the rather low kindling point of phosphate ownership disputes in certain area of the world.

Basic phosphate rock producers in all areas, almost without ex ception, are moving to upgrade their rock to phosphate fertilizers or phosphoric acid — at the expense of the traditional non-basic producers of these materials. I believe there will be the usual technical, personnel and associated problems with this new production from developing areas which will be coupled with displacement of traditional expansion production. Thus, I think the effective availability of phosphate fertilizers will be strung out over a projected period — much longer than if construction of these facilities were in the hands of developed nations. These factors will tend to continue the tight supply/demand balance in the world.

Also, it would appear that even under the best of crop conditions, it will take several years of bumper feed and good grain crops to bring a level of safety back into our world's food supply line. A program of building reserves could further prolong attempts to raise maximum yields. Therefore, in the critical food grain commodities, the world price level of such commodities should remain at a relatively high level — allowing the farmer full leverage to maximize his use of fertilizers.

As to the problem of insufficient funds in the hands of the consuming nations, I have already brought out the gap which exists between real and desired demand. As more phosphate fertilizers are brought into the marketplace, the elasticity of demand will be demonstrated and more materials will be moved — but at lower world price levels. I might add here that I believe the extremely high price levels you see in the world market are not in the best interest of our industry. World prices will come down to levels close to those which we will have in this country; while I feel our price levels will creep up a little more with the cost push inflation we are undergoing and then tend to stabilize.

Obviously, there will be short term swings in the next few years. Some brokers will be caught unable to pay the cost of money to hold material for the desired price level. Some producers will have dislocations of material supply/demand and cloud the total picture. Certain areas of our country and the world will be subjected to market changes — where even now fertilization of pastures and certain crops such as citrus is being produced.

However, the industry base today is much broader than it was ten years ago. The industry is different hands, also. I believe we will have a rather orderly transition in this country to the program which was well along the way ten years ago as we phase out low analysis production and again concentrate on the basic cost elements of supply and demand.

MODERATOR SMITH: Thank you, Jack. You have enlightened us greatly on the "Phosphate Outlook". Does anyone have a question that they would like to pose Mr. Babbitt at this time? One of the real keynotes of this Organization has been the give and take. So feel free to ask questions.

It is a special privilege for me to introduce our next speaker because of his "leadership role" in the "Potash Industry" and secondly because it has been my pleasure to work for and closely with him for several years.

Our speaker grew up in Louisville, Ky. and went on to graduate at the University of Georgia. Like our previous speaker he did a tour in the Air Force as a pilot. In civilian life, he excelled early at marketing as manager at a retail store on Fifth Avenue in New York City. Entering the fertilizer field he represented Potash Company of America in several Midwest States. This was followed by ten years as Manager of the Fertilizer Department at Bradley and Baker during its period of rapid expansion in the sale of concentrated phosphates, nitrogen and potash materials. Recognized for his "Marketing Capability" by IMC he was Vice President of domestic raw material sales for nine years during its rapid expansion in "Phosphates and Potash" and also in "Nitrogen." In 1967 he became President of Amax Chemical Company where it is my privilege and pleasure to be associated with him. His activities outside Amax include Director, Potash Institute of America; Director, Campotex; Director, Canadian Potash Producer Association; Director of the Fertilizer Institute. Let me now recognize Bud Horne speaking on the subject, "Sufficient Potash at What Price."

Sufficient Potash — At What Price

Everett C. Horne

Good Morning, Gentlemen —

It is indeed a privilege and pleasure to be addressing the Fertilizer Industry Round Table. I recall quite well the frustrating problems associated with granulation many years ago that really fostered the creation of this technical forum. Its purpose and direction through the years has continued to make great contributions to solving problems associated with fertilizer manufacturing. Let's hope that this endeavor continues.

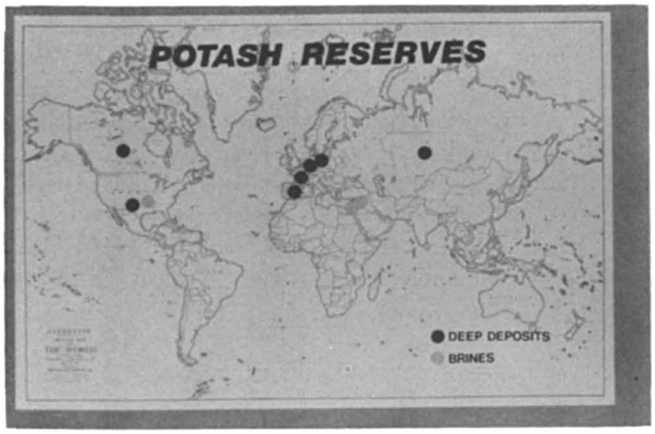
Let me jump right into the subject of potash — my business devotion and affection for the last 26 years.

We sometimes forget there is more muriate of potash. We have sulphate of potash, potassium magnesium sulphate, potassium nitrate and potassium carbonate. Each have their place in this agricultural and industrial world.

MURIATE
KCl
SULPHATE
K_2SO_4
NITRATE
CARBONATE
KNO_3
K_2CO_3
SUL - POT - MAG
K_2SO_4 M_GSO_4

Slide I.

Where do we find potash? — other than at Carlsbad and Saskatchewan — you will note the red dots identifying countries having well defined deeply embedded deposits. The green dots indicate countries with potash bearing brines. In the United States, these brines are located in Utah and Southern California.



Slide II

It may interest you to see where the known potash reserves of the world are located: Mostly in Russia, Canada and the Germanies. This does not say that other commercial deposits will not be found and developed in the future.

Russia and Canada have expanded their potash mining facilities greatly in recent years. They are followed in size by the Germanies, the United States, France, Israel, Africa and China. While Canadian and Russian potash expanded dramatically during the 1960's European production remained about constant, and that of the United States gradually diminished.

POTASH RESERVES

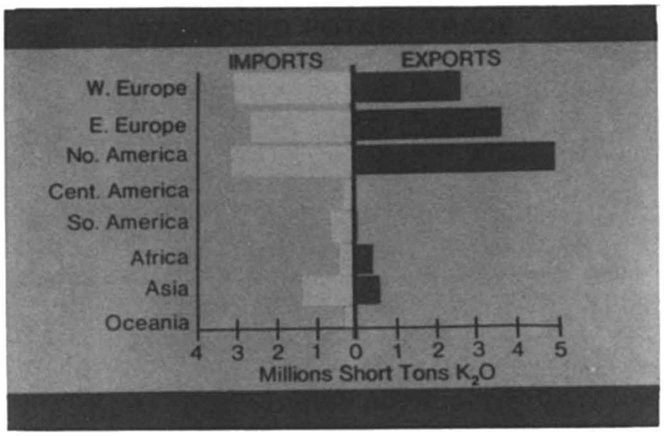
Billion Tons K_2O

COUNTRY	DEEP	BRINES
U.S.S.R.	50	
Canada	50	
East Germany	10	
West Germany	9	
U.S.	0.3	0.1
France	0.3	
Spain	0.3	
Israel-Jordan		2
Others	9	

U.S. Geological Survey

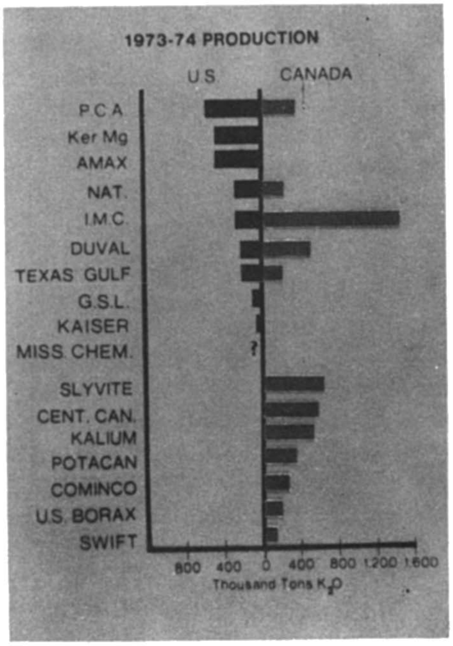
Slide III.

Potash is truly an item of world trade, matching supply and demand between countries or regions of countries. In North America, much potash is imported by the United States from Canada and a little from other countries. Exports from Canada and the United States are quite substantial.



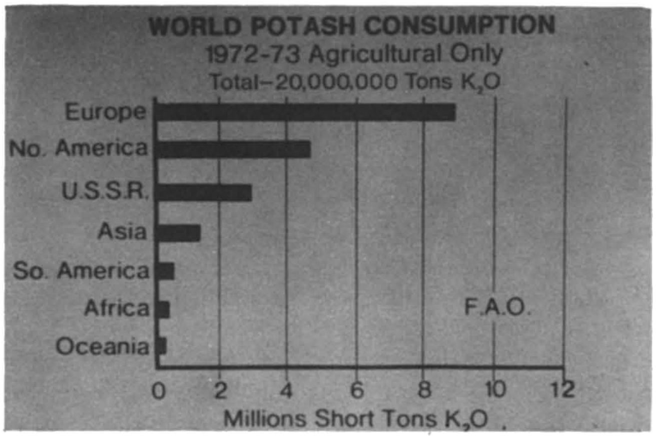
Slide IV.

In the United States, the first company started mining potash in 1931. By 1940, there were three operating in the Carlsbad area and by 1966 there were a total of seven operating. In Canada in 1962, IMC opened theiir first mine and by 1967 were followed by three other operations. By 1969, all companies had commenced operations. Today, there are ten producing companies in the United States and twelve companies operating from Canada, all seeking basically the same business.



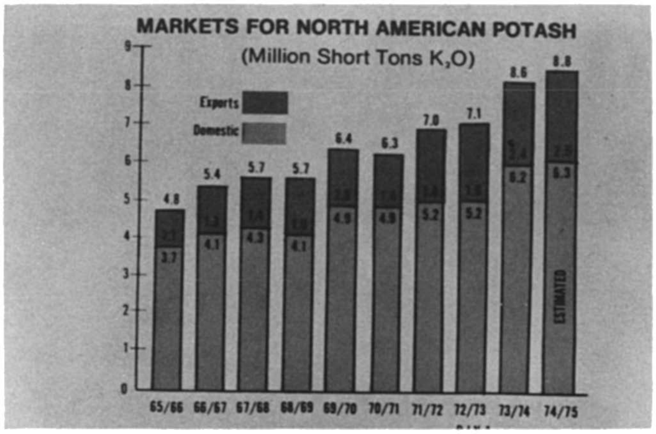
Slide V.

World agricultural potash consumption in 1972/73 was 20 million tons K₂0. Europe, where agriculture is intensive, led with 8.8 million tons, followed by North America with 4.8, Russia with 3.1 and Asia with 1.4. South America, especially Brazil, is making great strides in fertilizer consumption.



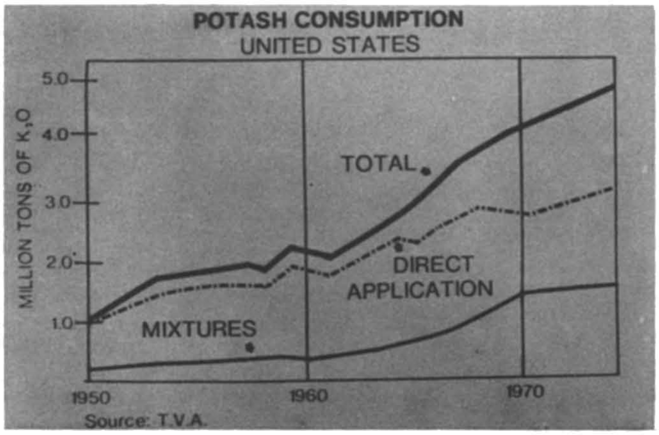
Slide VI.

Viewing North America as a marketing unit, potash consumption in the United States and Canada increased from 3.7 million K₂O tons in 1965/66 to 6.2 million tons in 1973/74. Exports from North America increased in this same period from 1.1 million tons to 2.4 million tons K₂O, with the export market growing a little faster than the onshore market. During the current fertilizer year, North American production is expected to increase 600,000 tons K₂O but sales by only 200,000 tons because of depleted inventories from the previous year's sales.



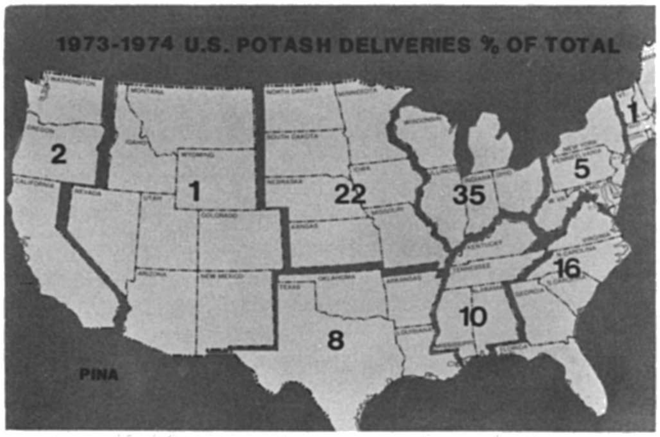
Slide VII.

During this dramatic tonnage growth from 1950 until now, the manner by which potash is applied to the soil has changed. As the concept of fertilizing a crop gives way to programs of soil fertility maintenance, more potash is applied directly to the soil, as opposed to incorporation in complex mixtures.



Slide VIII.

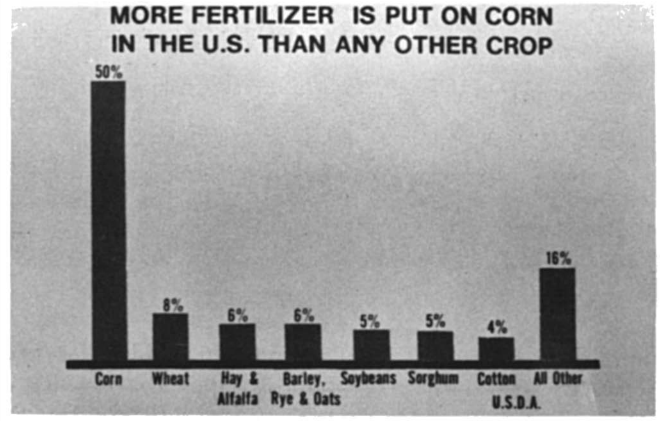
In 1973/74, the East North Central and West North Central States, known as the breadbasket, used 57% of total K₂O consumed in the United States. The South Atlantic region used 16%, whereas the East South Central and West South Central regions jointly used 18% of the total.



Slide IX

The importance of the Midwest to potash sales is apparent. More specifically, the corn crop is the target. Fifty percent of all fertilizer in the United States is applied to corn, wheat uses less than ten percent. While we are currently concerned about the reduction of fertilizers on pasture programs, we are somewhat insulated as it relates to the major potash comsuming crops.

So much for general information on Potash.



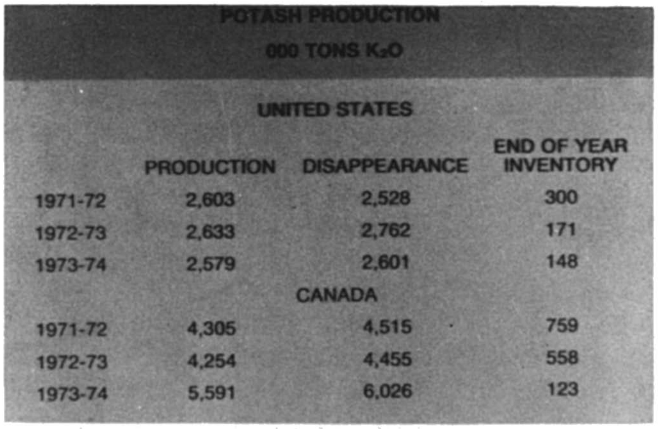
Slide X.

Let's talk about some things that might influence your supply in the next few years. First, let's look back at recent history in the United States and Canada.

From 1971 through 1974, production in the United States remained essentially the same — at 2.6 million tons K_2O. It is important to note that during this period the disappearance in the United States was essentially equal to production, with inventories being reduced to a very low level of 148,000 tons of K_2O at the close of the 1974 Ag Year.

From the sworn capacity of 8,300,000 K_2O tons, you will note that the Canadian Producers were restricted to operating at 4,305,000 tons in 1971/72. In 1972/73, production licenses were reduced to 4,254,000. With production controls essentially released in the Fourth Quarter 1973/74, only 5.6 million tons were produced. Or 1974/75, all producers received licenses matching sworn capacity but only 6.8 — 7.2 million K_2O tons are expected.

The Canadian disappearance remained approximately the same at 4.5 million in 1972/73, and rose sharply to 6 million tons in 1973/74. More important is the fact that these sales or disappearances figures, exceeded production, — and inventories dropped from 750,000 to an extremely low figure of 123,000 K_2O tons. this means that the producers are virtually shipping from the floor. Our experience suggests that a normal working inventory is about 15 to 20 percent of Annual Production. This would require about 1.4 million K_2O tons in Canada and about 500,000 K_2O tons in the United States.



POTASH PRODUCTION

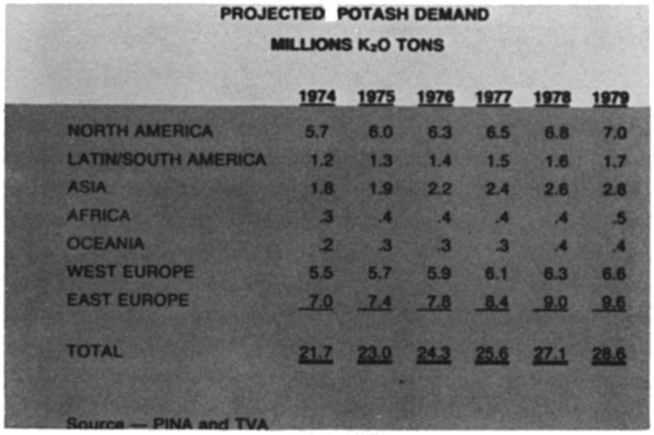
000 TONS K_2O

UNITED STATES

	PRODUCTION	DISAPPEARANCE	END OF YEAR INVENTORY
1971-72	2,603	2,528	300
1972-73	2,633	2,762	171
1973-74	2,579	2,601	148
		CANADA	
1971-72	4,305	4,515	759
1972-73	4,254	4,455	558
1973-74	5,591	6,026	123

Slide XI.

This chart simplifies the expected growth by major areas of the world. Note that demand is expected to increase from 21.7 million tons K_2O in 1974 to 28.6 million tons in 1979. Over-simplified, this reflects a 4% growth rate in the United States and 5.5% growth rate in other areas of the world.



PROJECTED POTASH DEMAND

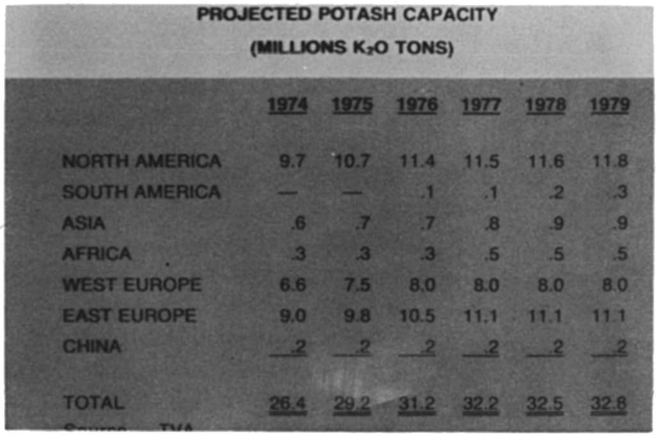
MILLIONS K_2O TONS

	1974	1975	1976	1977	1978	1979
NORTH AMERICA	5.7	6.0	6.3	6.5	6.8	7.0
LATIN/SOUTH AMERICA	1.2	1.3	1.4	1.5	1.6	1.7
ASIA	1.8	1.9	2.2	2.4	2.6	2.8
AFRICA	.3	.4	.4	.4	.4	.5
OCEANIA	.2	.3	.3	.3	.4	.4
WEST EUROPE	5.5	5.7	5.9	6.1	6.3	6.6
EAST EUROPE	7.0	7.4	7.8	8.4	9.0	9.6
TOTAL	21.7	23.0	24.3	25.6	27.1	28.6

Source — PINA and TVA

Slide XII.

Here you will see a simplified version of expected expansions in the world. This information is supplied from the various countries and is summarized by TVA. You will note that capacity is projected to grow from 26.4 million tons K_2O in 1974 to 32.8 million tons in 1979.



PROJECTED POTASH CAPACITY

(MILLIONS K_2O TONS)

	1974	1975	1976	1977	1978	1979
NORTH AMERICA	9.7	10.7	11.4	11.5	11.6	11.8
SOUTH AMERICA	—	—	.1	.1	.2	.3
ASIA	.6	.7	.7	.8	.9	.9
AFRICA	.3	.3	.3	.5	.5	.5
WEST EUROPE	6.6	7.5	8.0	8.0	8.0	8.0
EAST EUROPE	9.0	9.8	10.5	11.1	11.1	11.1
CHINA	.2	.2	.2	.2	.2	.2
TOTAL	26.4	29.2	31.2	32.2	32.5	32.8

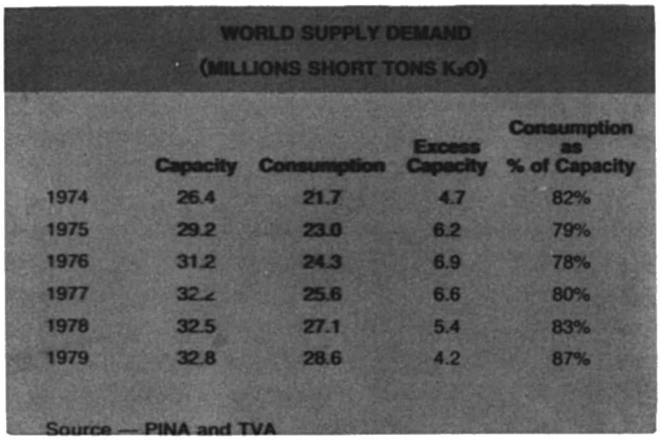
Source — TVA

Slide XIII.

Putting these figures side by side, one is led to believe that in 1974 there is an excess capacity standing idle, — in the amount of 4.7 million K_2O tons, or about 8 million product tons, and that the industry operated at 82% of capacity. Actually, in viewing production as related to nameplate capacity, 80 to 85 percent has been about the operating level throughout history. There is a recognized 5 percent shrinkage between sales tonnages and consumption tonnages. The problems with ore, labor, and other interruptions, seemingly never permit nameplate capacity to occur on a sustained basis.

We know that all potash facilities operated to their best ability in 1974 and that inventories and pipelines supplies are now at an all time low. As a consequence, one must assume that these projected capacity and consumption figures for 1979, which tend to suggest a 4.2 million excess capacity, even if built, will leave us with the same shortage condition that we are now suffering.

My personal opinion is that much of the new capacity that is estimated to be built in the next five years will not happen. The slow delivery time of major capital goods will be one deterrent. The increasing problems of government interference in Canada will undoubtedly bring new productive capacities to a temporary halt. The technology needed to bring the Brazilian deposits into being is still lacking, and the problems of production in England have not been resolved.



WORLD SUPPLY DEMAND

(MILLIONS SHORT TONS K_2O)

	Capacity	Consumption	Excess Capacity	Consumption as % of Capacity
1974	26.4	21.7	4.7	82%
1975	29.2	23.0	6.2	79%
1976	31.2	24.3	6.9	78%
1977	32.2	25.6	6.6	80%
1978	32.5	27.1	5.4	83%
1979	32.8	28.6	4.2	87%

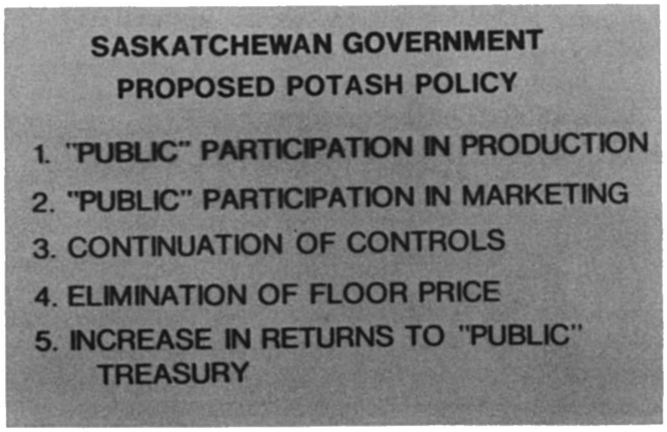
Source — PINA and TVA

Slide XIV.

To describe more fully the confused Canadian situation, let me summarize what the Government of Saskatchewan proposed last April and substantially adopted as their program in late October.

The proposed government potash policy called for participation in marketing and production, the continuation of controls, elimination of the floor price, and an increase in dollars returned to the public treasury.

While the Saskatchewan taxation program that has been introduced is complicated, let me give you just a glimpse of how debilitating it is.



SASKATCHEWAN GOVERNMENT
PROPOSED POTASH POLICY

1. "PUBLIC" PARTICIPATION IN PRODUCTION
2. "PUBLIC" PARTICIPATION IN MARKETING
3. CONTINUATION OF CONTROLS
4. ELIMINATION OF FLOOR PRICE
5. INCREASE IN RETURNS TO "PUBLIC" TREASURY

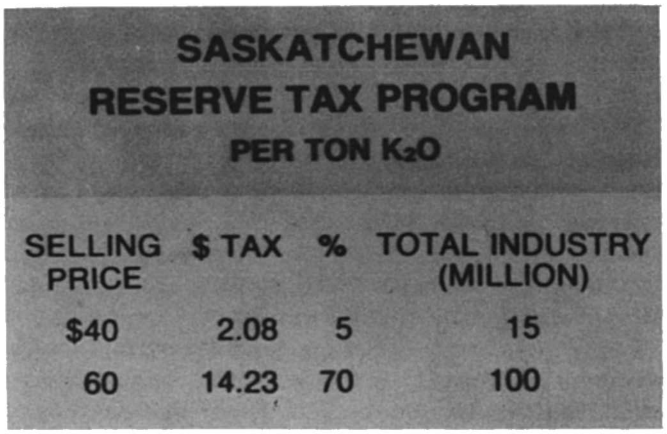
Slide XV.

The Government has introduced a facilities tax, based on several factors, the most important of which is net realized price. At $40 per K_2O ton — or $24 per product ton, they will tax us an additional new tax of approximately $2.08 or another 5%. At this price, Saskatchewan would receive an additional 14 million tax dollars — added to the 18 million they already get.

On this sliding scale tax system, at $60 per K_2O ton, the additional tax would be $14.23 or 70% of the price increase. At this price level, Saskatchewan will receive an additional 100 million dollars. Sixty dollars equates to $40 per product ton which is about the expected price for this Spring.

If this tax is not deductible for Federal tax purposes, conceivably an after tax loss could occur. The impact of this is so fantastic that we still hope that sensibility will evolve.

Amid all this confusion and confiscatory taxing, it is obvious that no new investments will be made. When the people of Saskatchewan begin to understand the impact of this tax program certainly they will not want their hard earned tax dollars invested in potash ownership. Consequently, additional production from Canada in the next five years is highly questionable, with the exception of current procedures bringing their plants to nameplate capacity.

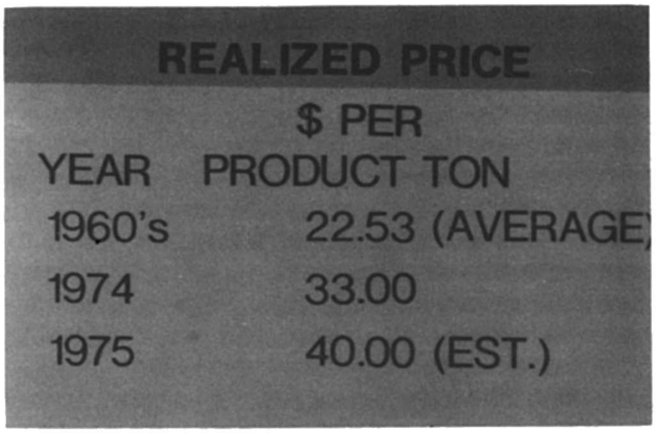


SASKATCHEWAN
RESERVE TAX PROGRAM
PER TON K_2O

SELLING PRICE	$ TAX	%	TOTAL INDUSTRY (MILLION)
$40	2.08	5	15
60	14.23	70	100

Slide XVI.

Another major concern facing the North American Industry is the relatively low price. In the 23 years that Amax has been in the potash business we reached a high in the mid 1960's of net realized prices of approximately $22.50 per product ton from all markets. This year, our net prices will average between 32 and 33 dollars. In 1975, we should see prices approximating $40. This is quite a startling increase, and to many might seem unjustified until you view prices required to initiate new investment in the potash business.

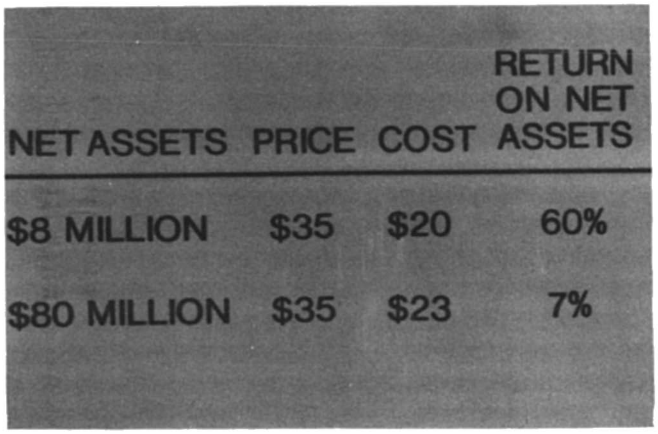


REALIZED PRICE

YEAR	$ PER PRODUCT TON
1960's	22.53 (AVERAGE
1974	33.00
1975	40.00 (EST.)

Slide XVII.

Let's take an example of an older potash company who might have its net assets depreciated to as low as $8 million, and who is selling potash at a price of $35, with a production cost of $20. With the current tax structure, including depletion, these prices would yield a return on current net assets of 60%. However, if these same facilities were built new today, at today's costs, using the same selling prices and slightly increased costs to accommodate depreciation, they would produce an unsatisfactory 7% return on net assets. In the potash world, where 25 to 30 percent new capacity is required in the next five years, we can no longer look at profitability based on investments made 25 years ago. We must look at current and future costs.



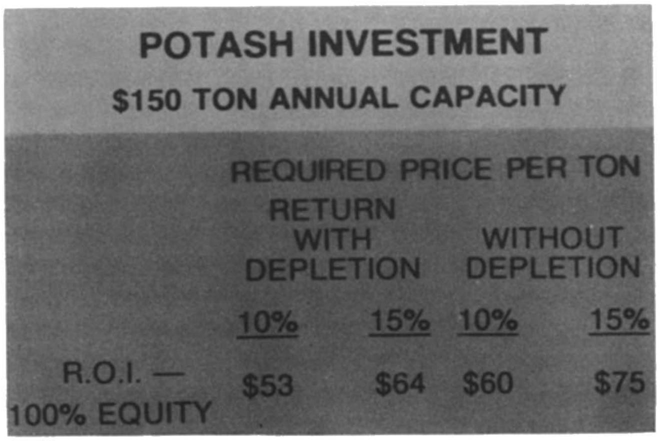
NET ASSETS	PRICE	COST	RETURN ON NET ASSETS
$8 MILLION	$35	$20	60%
$80 MILLION	$35	$23	7%

Slide XVIII.

For example, the only rich ore body in the free world that can currently be exploited is in Saskatchewan. New capacity there will require at least an investment of $150 per product ton of annual capacity. This figure is conservative. On the former tax basis, — before the new Saskatchewan and Canadian income taxes were inproduced, it would take $53 to support a 10 percent return and $64 to support a 15 percent return. If the United States Government eliminates depletion allowance, it would take $60 for a 10 percent return and $75 for a 15 percent return. Even with a compromised tax system by the Federal and Provincial Governments of Canada, it will probably require $80 to $100 per product ton to yield desired ROI.

When Amax goes into a major investment, it must be in a least cost situation. The ore body and capital costs must place the new operation in the bottom quartile of cost, and produce approximately 15 percent return after taxes. This policy is not too unlike that of major mining companies, or of most companies.

All this says to me, and I believe to you, that the price of potash must reach $50 to $60 per product ton in the near future to entice new investment, and that unless the Canadian Government does a substantial turnabout, we shall see no expansion there.



POTASH INVESTMENT

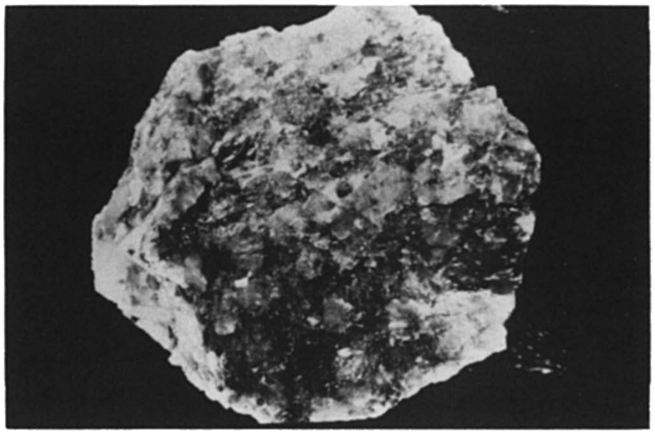
$150 TON ANNUAL CAPACITY

	REQUIRED PRICE PER TON RETURN			
	WITH DEPLETION		WITHOUT DEPLETION	
	10%	15%	10%	15%
R.O.I. — 100% EQUITY	$53	$64	$60	$75

Slide XIX.

There are possible areas for development of new potash from lower analysis ore bodies. There are some higher analysis ore bodies involving many mining complications which will require new techniques and higher costs. Yet this seems to be the approach that will likely occur if North America is to have a healthy potash supply.

This all suggests to me that we are in for several years of world potash shortage. One of the unfortunate by-products of this current shortage is that it is delaying further the identification and possibly the production of the right size product for each method of manufacturing or of application. Unfortunately, customers are taking deliveries of almost any grade of fertilizer material, regardless of whether it matches their specific technical requirements. Constructive thinking about the specifications of the products you buy, and their relative economic values must prevail, to force production of the appropriate products. Slide XX shows mined potash ore before refining.



Slide XX

Let me hope that those of you who constitute the continuing membership of the Fertilizer Industry Round Table will not let the current imbalances in supply/demand sway your intellect from demanding proper solutions to our technical and economic problems. We lack the discipline of a buyer's market to maintain quality of product and service. You are the group who can continue the search for technical excellence through these difficult days. Thank you.

MODERATOR SMITH: Thank you, Bud, that was very informative. Is there a quick question or two on potash, the supply-demand or other aspects of it? Yes sir, Mr. Clare. "I would like to ask Bud why the Saskatchewan Government is eliminating the price floor. To get more taxes?"

MR. HORNE: "It is our opinion that they are eliminating the floor price because it is probably illegal and that they want to defend themselves against the lawsuit that they are already in with the Federal Government."

MODERATOR SMITH: Only occasionally do we have a West Coast speaker. We are, therefore, doubly fortunate with our speaker on "Nitrogen." Not always a Westerner, he received bachelor's and master's degrees in "Chemical Engineering" at Columbia. He has been successively an Engineering Officer in the Navy Amphibious Forces, Manager of several heavy chemical operations for Allied Chemical and has done Management Consulting in the U.S. and abroad. A member of the Collier team since 1959, now manager of Development, he will speak to us on how the Nitrogen Business will change to adapt to future economy. It is with pleasure that we welcome Mr. John Clarke, manager of Development, Collier Carbon and Chemical Company. John.

What's Ahead In The Nitrogen Market?

John J. Clarke

The new centrifugal ammonia plant technology of the 1960's coincided with a wave of enthusiasm for the future growth potential of agriculture and nitrogen fertilizer. The ammonia plant building boom of the late sixties resulted in an unprecedented surge in productive capacity. The overabundant supply of nitrogen fertilizer and intense competition drove prices below the manufacturers' cost. In 1969, 1970 and 1971 United States fertilizer manufacturers operated at a loss.

From Surplus to Shortage

With unexpected rapidity, the nitrogen surfeit has turned into a shortage. Today, countries which do not have adequate production capacity are simply unable to import the quantity of nitrogen fertilizer required by their agricultural industry. In the United States, effective production capacity is now just about equal to the needs of nitrogen consumers. (Exhibit I) Shortages exist in the U.S. today, but they have not yet had a substantial impact on agricultural production.

What caused this sudden turnaround in the supply--demand relationship for nitrogen fertilizers? Worldwide there were two primary factors: First, the extreme depression of nitrogen chemical prices made it impractical to invest the huge sums required for nitrogen plants. New construction virtually ceased.

Second, the "optimists" of the early 1960's who predicted a burgeoning demand for nitrogen fertilizer were fundamentally correct. In the last ten years, world consumption of nitrogen has grown at an average rate of 10% per year. This is a "growth industry" by any standard. In the United States, consumption of nitrogen chemicals increased by over 8% per year from 1964 through 1974. Last year, the U.S.D.A. reported a 9.9% increase in nitrogen fertilizer consumption.

Natural Gas Supply

Within the United States, a third factor has impeded construction of the new capacity required by our agricultural industry and will determine the future of the domestic nitrogen industry — the supply of natural gas. It is horrifying to see how little the general public has been made aware of this shortage and of its very serious potential impact on our nation's economy.

The United States' supply of natural gas is inadequate to meet the requirements of all its consumers. Because of the national system of price controls, this shortage will continue to become more serious as far as anyone can foresee into the future. Currently, the average wholesale price of heavy fuel oil in the United States is $1.56 per million BTU. (Exhibit III) This ia a government controlled domestic price. When crude oil must be imported from foreign sources, its typical cost is over $2.00 per million BTU. The controlled price of interstate natural gas is about 40% of the price of fuel oil. With this cost differential, every consumer of natural gas is competing to obtain the maximum supply of natural gas to avoid converting to fuel oil.

Gas In The Nitrogen Industry

The shortage of natural gas is a more critical problem to the nitrogen fertilizer industry than to most other gas consumers. Over 99% of our nitrogen fertilizers are made from ammonia. In the United States, 4% of the ammonia is manufactured from by-product sources. The remaining 96% is derived from natural gas. When most industrial consumers of natural gas are curtailed, they must switch to an alternate fuel. When natural gas to ammonia plants is curtailed, they must shut-down.

Technologically, it is possible to build ammonia plants which can substitute any carbon or hydrocarbon material for natural gas. But as a practical matter, the cost of building plants using other raw materials is so great that these plants cannot compete with plants using natural gas. Ammonia plants using naphtha, coal or other raw materials are built only in countries where there is no natural gas. These are countries which are willing to pay or subsidize the high cost of these plants because they realize the importance of having their own domestic nitrogen industry. Any attempt to develop a United States industry based on materials other than natural gas would result in an unnecessary penalty to the American consumer.

If those who allocate natural gas within the United States fail to supply the ammonia industry, they will eventually destroy the domestic nitrogen fertilizer supply. Since ammonia manufacturing consumes less than 3% of the nation's natural gas, it would be utter folly to jeopardize this industry by diverting gas to less critical uses.

Future U.S. Supply and Demand

The increased United States demand for nitrogen (Exhibit I) is estimated to average 5.4%/year through 1980. A serious recession could temporarily inhibit this growth. But the national need for expanded agricultural production is expected to dominate future requirements.

This growth will increase U.S. annual ammonia requirements from 17 million to 23 million tons. To meet this demand will require building 15 new ammonia plants. If the required natural gas is made available, these plants can and will be constructed.

Design and construction of new plants requires three years. The new plants which are already underwaay are not adequate to supply the expanded needs for the next few years. We must expect a continued shortage of domestic supply, at least through 1978. This will necessitate a continuation of the recent trend of increasing nitrogen imports.

World Supply and Demand

Our need for increased imports will force a greater dependence on the world market. World prices have fluctuated greatly and are currently about double U.S. prices. Bidding is competitive, and over the long term, supply can depend on the political vagaries of exporting countries.

It is expected that future world consumption will continue to increase more rapidly than in the United States. (Exhibit II) Through 1980, the estimated average annual increase of 6.7% will result in increased ammonia requirements of 35 million tons per year.

Engineering and construction is underway on a multitude of new plants in gas producing areas throughout the world. The estimated demand, however, will require 12 new plants each year. This will strain the technical and financial resources of the world.

It is anticipated that the world nitrogen shortage will continue at least through 1977.

Fertilizer Prices

The U.S. price index for nitrogen fertilizers has climbed from 78% of the 1967 level to 142%. (Exhibit IV) The recent surge in prices has been disappointing to consumers but has not caused a reduction in the increasing rate of consumption.

These price increases are not surprising in view of:

1. The increasing shortage of nitrogen fertilizers.
2. The high return in increased crop yields which results from each dollar the farmer spends on fertilizer.
3. The tremendous inflationary increase which has occurred in the cost of building new plants.
4. The increased cost of natural gas which is the inevitable result of the gas shortage and rising energy costs.

Since the nitrogen building boom of the 1960's, cost of plant construction has increased threefold. If nitrogen prices were to decline markedly from current levels, world wide construction of new plants would be forced to slow down. This could only result in a disastrous long term shortage of nitrogen and the agricultural production of food and fibre.

While nitrogen fertilizer prices have increased 42% over the 1967 base, prices of farm products have increased by 78%. Over the same period, prices of *all* purchases by farmers have increased by 75%. It is evident that the improved farm economy is not simply the result of increased prices, because farm costs have increased along with farm prices. The improved farm economy must be primarily attributed to increased production and efficiencies by the American farmer.

Fertilizer prices have not increased as greatly as farm product prices. The increased value of crop yields for each dollar invested in fertilizer has become even greater than the historical high returns. This indicates that if fertilizer prices remain at current levels, reasonable declines or fluctuations in farm prices will not cause a major reduction in fertilizer consumption.

A temporary over-supply would force nitrogen prices downward. But it is expected that over the long term, prices of nitrogen fertilizers will not decline from 1974 levels.

Exhibit I

U.S. AMMONIA DEMAND AND EFFECTIVE PRODUCTION CAPACITY

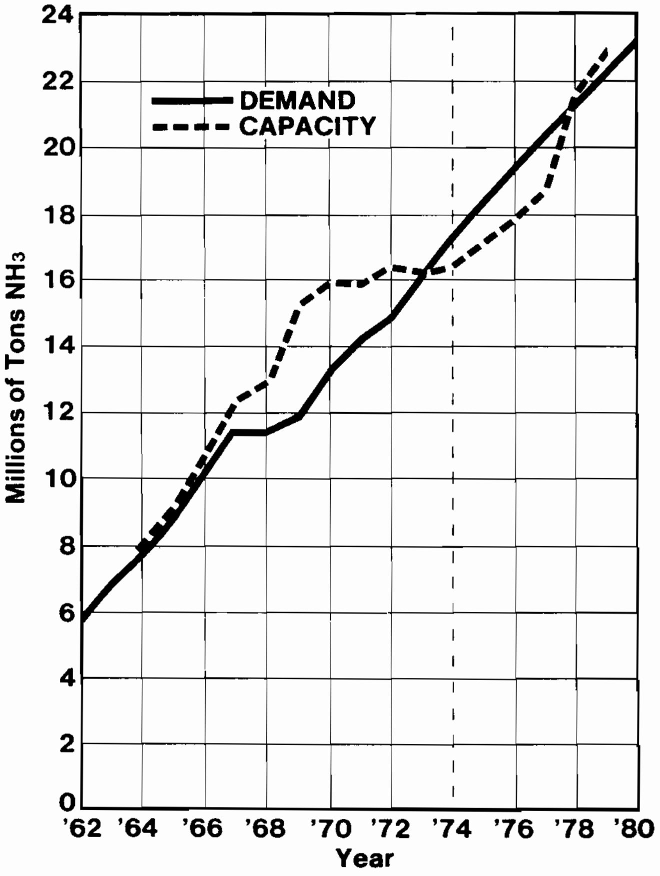


Exhibit II

WORLD AMMONIA DEMAND AND EFFECTIVE PRODUCTION CAPACITY

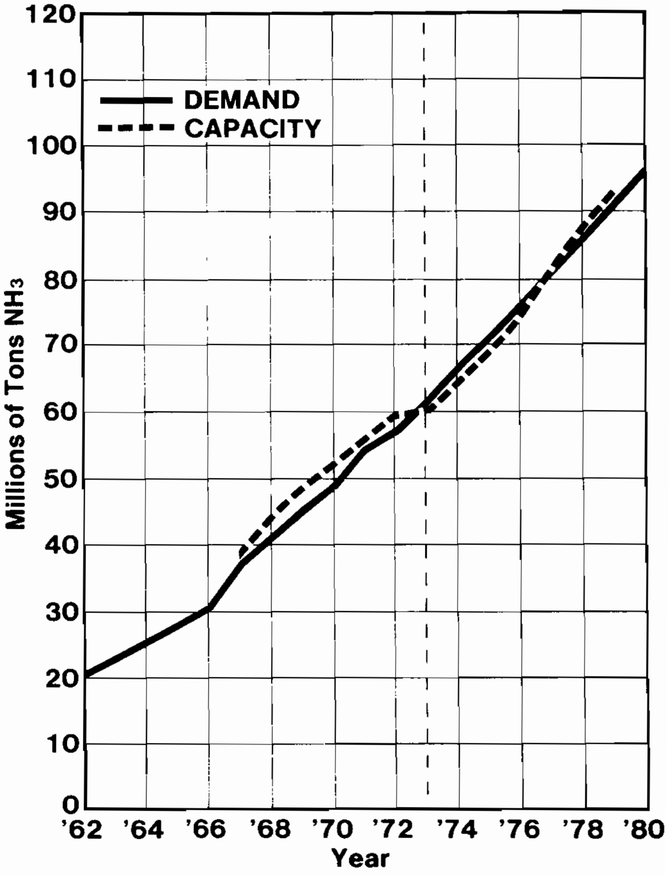


Exhibit III

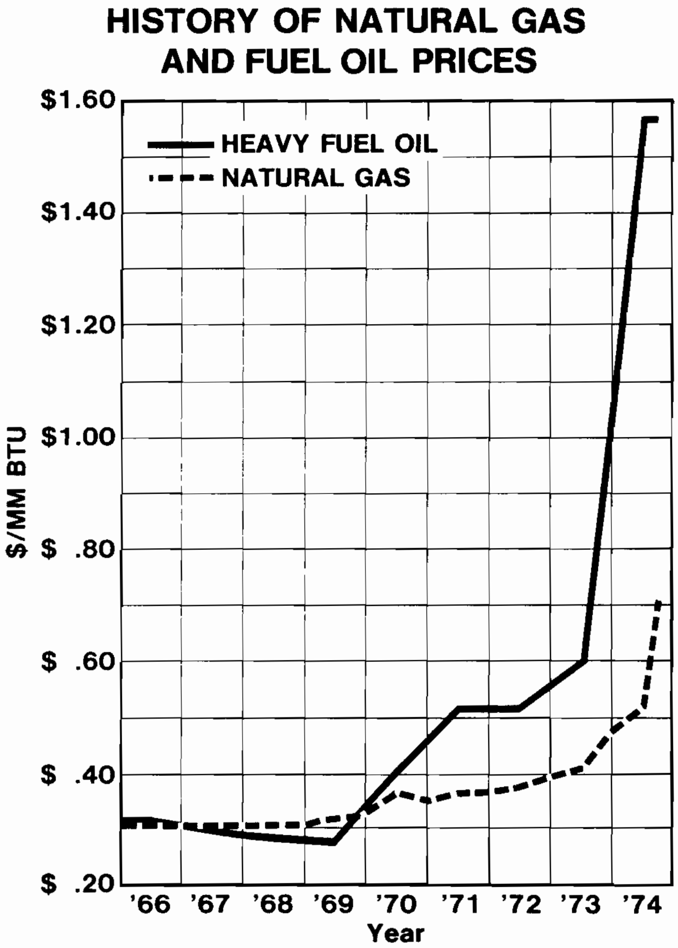
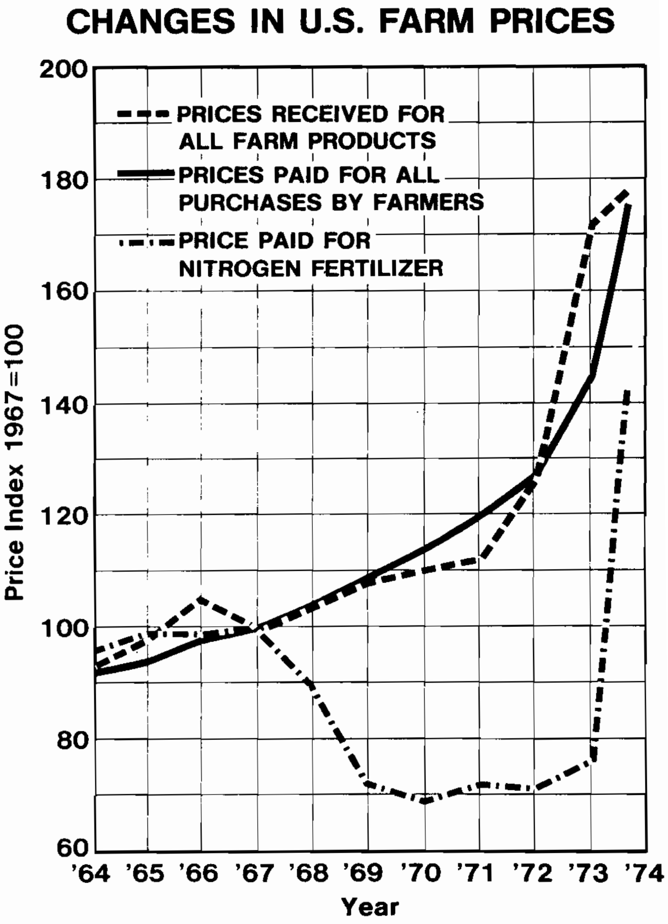


Exhibit IV



MODERATOR SMITH: Thank you, John. We appreciate having your view of the "Ammonia and Nitrogen Industry". That was certainly excellent.

Fertilizer has utility only after being transported to consuming areas. Our transportation speaker is with IMC responsible for many firsts in fertilizer transportation. Our speaker is Director of Traffic and Customer Services for IMC in Libertyville, Ill. He attended Grand Rapids Junior College, The University of Michigan, The University of Baltimore and the Advance Management Institute at Lake Forest College. He holds degrees in Business Administration and Transportation. He is a "Registered Practitioner before the Interstate Commerce Commission. He has been employed in traffic and transportation for 25 years, 13 with the former Pennsylvania railroad and 12 as an Industrial Traffic Manager with Martin-Marietta and IMC. He is the new chairman of the Transportation Committee of the Fertilizer Institute. We are certainly pleased to have Vern Haan to speak to us on the subject of "Transportation", Mr. Vern Haan, please.

An Address On Transportation

Vernon J. Haan

Each year, we take out our cracked crystal ball and try to forecast the future of transportation; and what that will mean to the fertilizer industry. We try to anticipate and define problems, which we lable as opportunities, to assure ourselves and our managments that we have an aggressive optimistic attitude toward the future. We seek out the dragon in his lair, and like knights of old, we rush to engage him in mortal combat. We know we will win because our cause is right, our intentions are pure.

Thus, we have valiantly fought against unreasonable general rate increases that feed an ever excellerating inflationary spiral. However, our common carriers, especially our railroads, plead that they earn less than a reasonable rate of return on their investments and, therefore, can't compete in the money markets for funds necessary to upgrade or maintain their facilities or service. The problem is that no one seems able to really determine what their return on investment really is, or ought to be. No one really knows how much of the railroad facilities are actually obsolete or long-long ago written off in depreciation though still carried on the books. Without accurate knowledge of the investment base, how can we get accurate earnings to investment ratios? What should the R.O.I. be for a franchised industry protected from entry of competitors of the same mode? Should it be as great as other industries who assume greater risk? Can shippers ever pay enough in increased rates to improve carrier earnings if the carriers become subsidiaries of conglomerate holding companies who drain off their earnings, their cash flows, their investments in land and natural resources, their tax credits from lean years, their executive talents? In other words, can a bowl be filled with water by ever increasing the flow from the tap if at the same time the drain at the bottom is reamed bigger and bigger?

Perennially, the dragon of short car supply rears its ugly head. Each year the national carrier car fleet shrinks while the ton-miles increase. The carriers boast of improved car utilization. Actually, the improved utilization results in major proportion from shipper accomplishments in heavier loadings per car, fast cycling of multiple car shipments or unit trains which the rail carriers reluctantly permit to operate, faster loading and unloading. To assist the shippers, the carriers demand more restricted demurrage time for loading, higher demurrage charges; provide longer transit times, more derailments and slow orders, more miles of track severely under-maintained, more greight dollars diverted to manufacturing ladies underwear and recreation vehicles.

Let's look into that crystal ball again to see what transportation opportunities are on the horizon, where we can sally forth and slay the evil dragon by hard work, thoughtful innovation, dedication, applied imagination, determination, never-say-uncle.

What I see is not really another opportunity but a massive overwhelming problem. I sense the meanest, fiercest dragon of them all, the loss of a major part of our rural railroads, first in the Northeast and Midwest, then in the West, then who knows where. However, I clearly see the knight traffic manager stripped of his armor, his righteous weapons taken away by an unbelievably thoughtless Congress. How can the fertilizer industry hope to contend with this monster? You haven't really seen him yet because he has been hidden in his dark cave by his clever creators much as Count Frankenstein concealed his monster.

The problem behind the track abandonment problem is the bankruptcy of eight Class I railroads in the Northeast and Midwest, including the biggest, wealthiest railroad of them all, the giant Penn Central in June of 1970. Penn Central has struggled valiantly to reorganize under Section 77 of the Federal Bankruptcy Act for three years without success. Seven other railroads also collapsed during this period:

> The Ann Arbor; Boston and Maine; Central of New Jersey; Erie Lackawanna, Lehigh Valley, Lehigh and Hudson River; Reading.

These carriers provide service to 17 states and the District of Columbia. In 1972 they handled more than 46 percent of all rail revenue ton-miles North of the Ohio and Potomac Rivers and East of the Mississippi River; and over 13 percent of total ton-miles in the nation. The Penn Central serves an area in which lives over 42% of the nation's population.

The Department of Transportation recommended and the Congress enacted a new approach to the reorganization of bankrupt rail carriers whom the courts had determined could not be successfully reorganized under Section 77. the new *Regional Rail Reorganization Act of 1973* was signed into law on Jamuary 2, 1974. The territorial application was described by D.O.T. as the northeast. Only after passage of the new law did the territorial description become the Northeast and the Midwest, indicating that two district areas were involved, not just one.

Pursuant to the new law, the D.O.T. developed its infamous "Core Rail Service" plan. You may recall this followed the threatened liquidation of Penn Central to satisfy its creditors and prevent the further deterioration and dissipation of the assets of the Penn Central estate. In this Core plan, D.O.T. identified 15,575 miles of light density track — another name for rural branch lines or duplicate track — as being "potentially excess". This was 25 percent of all 61,184 miles of track in the Region and included both solvent and bankrupt lines. D.O.T. didn't say this track was not earning a profit, or that it wasn't required to meet public interest and necessity. D.O.T. said it was "potentially excess", that is, we can get along without it since only rural America needs it.

The shipping public was stunned. Imagine, a proposal suggesting possible abandonment of 25 percent of track in the Northeast and the Midwest. Perhaps the D.O.T. was practicing the political adage when bread is 35 cents a loaf, suggest a plan to increase the price to $1.00; then the public will be glad to pay 70 cents a loaf.

To support its conclusion of 25% of track being potentially excess, the D.O.T. comissioned a study whose conclusions were completely unjustified as a basis for specific branch line abandonment. This was admitted by the authors of the study. However, the study was concealed in a footnote of the D.O.T. "Core" plan. As provided in the Reorganization Act and subsequent to the D.O.T. "Core" plan, the United States Railway Association is studying a plan of abandonment that involves 10,000 miles of the total 30,000 of bankrupt carriers in the Northeast and Midwest; 33 percent of their total trackage. The "Initial" Plan of the U.S.R.A. was to be published by October 29, 1974 as provided by the Reorganization Act. Congress recently extended this deadline to February 26, 1975. It is apparent that U.S.R.A. is blindly following the path blazed by D.O.T. That path is the assumption that wholesale track abandonments will somehow solve all the problems of the bankrupt lines. A study by Penn Central to abandon 50% of its track, from 21,000 to 10,000 miles of right-of-way indicated possible savings up to 20 million dollars per year. However, losses were $236.5 million in 1970; $179.8 million in 1971; and $105.5 million in 1972. What we must keep in mind is that U.S.R.A. and D.O.T. are not merely proposing abandonment of unprofitable branch lines, they are suggesting abandonment of:

1. Break-even lines
2. Marginally profitable lines
3. Medium profitable lines, and
4. Even highly profitable branch lines.

These planners are developing economic criteria that will purport to show profitable lines as being unprofitable. This can be done by overstating expenses for a branch line and understating revenue. The technicalities of this are mind boggling. U.S.R.A. is developing cost based on a Form A fully *allocated* basis. The Reorganization Act required a basis of avoidable costs. A vast difference exists between these two methods.

The avoidable cost basis, simply stated, is the difference between the cost of operating a railroad with a branch line and the cost of operations without that branch line. The President of the railroad involved would still make the same salary. The Superintendent at division headquarters would still earn the same money. Tariff publications, reports to stockholders and the Commission would be undiminished. Nearly all corporate functions and their costs would continue unaffected.

However, the allocated cost basis ascribes to the branch line to be abandoned a pro-ration of executive salaries and other not directly involved headquarter and corporate costs.

Another area of developing inflationary costing by the U.S.R.A. is the method of determining what cost and what revenue contribution to credit the main line with on traffic originating or terminating on a branch to be abandoned. A general rule of thumb has developed from the actual experience of a multiplicity of prior abandonments tried over many many years by the Commission. That rule is to make a mileage pro-rate of the earnings or division of earnings received by the carrier. Fifty percent of the main line pro-rate is attributed to expense, and 50% to revenue. On the branch line, the actual expenses of operations, maintenance, finance, etc. can be determined against pro-rate of this revenue.

However, the U.S.R.A. is not satisfied with this time tried formula, apparently because it does not give the predetermined desired results. The U.S.R.A. insists on using a formula of 80% of Form A fully allocated costs. The sum and substance of this change is a resultant cost that is increased by nearly 50%.

This is terribly important to shippers on lines to be abandoned. They may or their community, county or state may elect to subsidize continued operation of the branch line. What will their cost be? The Reorganization Act provides that a Rail Services Planning Office be established and that it determine the level of subsidy required. The Commission R.S.P.O. has held public hearings on this matter in Ex parte 293 (Sub 2). To assure that an abandonment recommended by U.S.R.A. costing methodology require *no* subsidy payment for its continued operation because of the costing methodogy prescribed by the Reorganization Act (i.e. by the determination of avoidable costs), the R.S.P.O. has ignored recommendations of the shipping public that it:

1. Use the avoidable cost basis.
2. Not permit a carrier to draw down on subsidy funds except to reimburse the carrier for actual expenses incurred.
3. Provide that subsidy funds not used for actual expenses incurred for branch line operations and maintenance be placed in escrow and not flow into the general funds of a carrier, especially one in financial difficulty.

Instead, R.S.P.O. is developing a methodogy more consistent with that of U.S.R.A. This despite the intent of Congress that R.S.P.O. be a watchdog and a judicial arbiter of U.S.R.A. plans in order to protect the public.

If massive abandonment is not the answer, why are the D.O.T., U.S.R.A. and R.S.P.O. planners so aggressively attacking branch line operations, mostly in rural areas?

It seems to me that they:

1. Foresee the least public objection from the farm community because of its relatively smaller number in the general population.
2. Hope that abandoned line rail traffic will be diverted to remaining main lines, thus

tremendously expanding main line profitability.

3. By increasing the cost of transportation to farmers and rural industry not on main lines, and increasing main line profits, less cost for bankrupt railroad rehabilitation will fall on the general taxpayer. In effect, to solve the problem, let rural America, especially in the Midwest and Northeast, bite the bullet; let the farmer and agriculture business pay the piper so that the ills of the Eastern Railroad corridor between Boston and Washington can be maintained to supply the essential passenger service to millions in that area.

IMC has stood *alone* among fertilizer companies in opposition to liquidation of the Penn Central to massive abandonment of rural branch lines where many of its customers are located.

IMC stands alone among agriculturally oriented industries, or even farmer cooperatives or groups, or further, even the State or Federal Department of Agriculture in suggesting a viable, or for that matter, any solution to the bankrupt rail carriers. This solution found its way to the front page of *The Wall Street Journal* on July 10, 1974. This IMC plan was made a part of the public record in Commission hearings following disclosure of the D.O.T. abandonment plan. IMC suggested that the Midwest leased lines of Penn Central be reorganized immediately on a private carrier basis separate from ConRail.

IMC also suggested that a Northeast corridor can be created to handle passenger and freight operations between Washington, D.C. and Boston, Massachusetts. subsidiary terminal companies for freight operations would be created for the New York terminal area, the New Jersey Harbor area, the Philadelphia, Camden--Trenton area and the heavy industrial area south of Philadelphia, including Essington, Eddystone, Marcus Hook; Pennsylvania, Claymont, Wilmington, Newark, New Castle and Delaware.

ConRail would be divided into two systems lying between Penn Central lines west of Pittsburgh, Buffalo and the Northeast corridor company and its terminal subsidiaries. ConRail I would comprise of Penn Central lines, whereas ConRail II would comprise lines of the other bankrupt carriers plus those Penn Central lines necessary to create a viable system. The underlying purposes to IMC's plan is to prevent competition in the Midwest between existing solvent carriers with a ConRail supplemented with Government revenues; to prevent the solvent carriers, because of their service superiority, from weaning away from ConRail I and II the overhead traffic moving to the heavily industrialized Eastern Seaboard areas served by the Northeast corridor terminal companies; to provide an immediate viable reorganizable railroad system in the agricultural Midwest that is Penn Central lines west, and to categorize and isolate those parts of the Northeast railroad in greatest need of federal financing from those portions that can stand on their own two feet. Obviously, if the Midwest section can stand on its own two feet without having its revenues drained to underwrite hopelessly deficient operations in the Northeast corridor, there will be a resulting denunciation of pressure to abandon profitable branch lines of duplicative lines that are required in the public interest to serve railroad areas.

Of interest is the fact that the trustees appointed to the secondary debtor. Midwest leased lines, and the Reorganization Court have found that these lines are indeed reorganizable under Section 77 of the Bankruptcy Act. Mysteriously, the Court found that the public interest would best be served if the reorganization of Midwestern lines occured under ConRail; this in a proceeding which originally had to do with debtors rights in liquidation proceedings and in which the shipping public was not present, did not present any evidence and was not invited to present any evidence.

In Conclusion, IMC feels that the full impact of efforts by the D.O.T., the Congress and the U.S.R.A. have not fully been appreciated by the shipping public, and particularly, the rural public in the Midwestern states. It is significant that in the recent proceedings under Ex Parte 293, Sub 2, to establish the procedure and formula for determining subsidy for lines which may eventually be abandoned, that no public official either state, federal or community from the Midwestern states are parties to the proceedings. When these states, communities and rural industries and farmers become aware of the impact of present plans, we can anticipate a loud wail and cry. At that time, unless an alternate resonable total plan is laid before the Congress, it will have little alternative than to accept a plan which hinges on its hopes on track abandonment even though all studies have indicated that this drastic, unnecessary surgery will not heal the sick patient of our Northeast and Midwest Railroads.

MODERATOR SMITH: Thank you, Vern for so helpfully updating us on transportation which is very vital. I wish at this time to thank all five of the morning speakers who have been most informative and for the time that they have put into the preparation which was very excellent.

One accouncement — will the Board of Directors please check at the registration desk by 4:00 this afternoon for their other announcements.

It is most important that the afternoon session get under way at 1:30, and so unless there are other announcements the meeting is recessed until 1:30 p.m.

Tuesday, December 3, 1974

Afternoon Session

L. Dudley George

Moderator

MODERATOR GEORGE: This is a session that I look forward to with a good deal of interest because it is basically designed to help our "Operation of our present Plants."

Our first speaker, Mr. Matthew P. Starcevich was born and raised on a farm in Iowa. He received his Bachelor's Degree from Iowa and his Master's Degree from Columbia. His career includes teaching, football coach, Navy duty-World War II, in Korea and management consultant with CPC International. Since 1966 he has been with Kerr-McGee. Currently he is "Corporate Manager of Organization Development" located in Oklahoma City. Mr. Starcevich regularly goes out and trains the "Upper Staff" in the Organization. His discussion is titled "Personnel Training of Plant and Production Workers." Glad to have you here Mr. Starcevich.

Personnel Training of Plant and Production Workers

Matthew P. Starcevich

Ladies and Gentlemen: It is good to be with you. I appreciate the invitation and have looked forward to meeting with you. I looked forward to this meeting for two reasons: #1) There is a great deal of personal satisfaction gained from meeting successful people who continue to dedicate effort and energy in further improving their performance, and #2) to share with you some thoughts about an area to which I have dedicated my professional life. So, it is with a great deal of pleasure that I meet with you this afternoon.

So that we may make this time productive and provide you with some useful insights in this broad area of "TRAINING AND DEVELOPMENT," I thought it would be best to address the subject in the following manner: First, a short review of the conditions which you are or may face in your work. Second, look at the anatomy of the supervisor's job. Third, discuss the need for training. Fourth, what should the training be and who will do it. Last, a short summary.

To say that we are living in a complex world with a great deal of uncertainty is an understatement. Our plans and forecasts are influenced by so many things beyond our control. Shortages are with us. Demands for products and services exceed the supply. Confidence and trust in our nation's leadership appears to be waning. Many people look to the future with pessimism, and some have adopted a life style of "take care of today, for who knows what will happen tomorrow." Unemployment is increasing, yet turnover is high. Specifically, your raw material cost is on the increase. This has resulted in doubling the price of your finished product over the last year. Delivery problems have increased. It is difficult to secure truck and rail transportation. Your maintenance problems continue to be with you and are now compounded by shortages and late delivery of replacement parts. These conditions plus long hours, low pay, poor and transient labor force make the work of plant production superintendents and supervisors very tough and demanding. To many of them, management goals and demands for receiving raw material, manufacturing granular and mixed fertilizers and bulk and bagged finished products seem unrealistic and unreasonable.

I am pleased that all of us recognize the need for training. It seems to be a paradox when we talk about training. The supervisor wants and needs training. The company wants to train the supervisor; yet, in most cases, nothing substantive is really done. Research shows that the tremendous emphasis on training following World War II and continuing to date has rarely paid off in terms of results from either the supervisor's or the company's standpoint. My own impression of the causes for this ineffectiveness of training is the low priority assigned to it, and the lack of attention and participation by both company and supervisor.

It seems to me that the foremat for supervisory training is deceptively simple. Simply from the standpoint that the supervisor needs answers to only four basic questions: 1. What is the job? 2. What am I supposed to do? 3. How am I doing? 4. What must I do to improve? The answer, of course, to the last question provides the basis for training and development.

Let's talk briefly about these four questions:

WHAT IS THE JOB? Stated concisely the supervisor's job calls for the production of product or products on time, on spec, within budgeted cost. To do this job the supervisor has a number of people working with him. Therefore, his performance is predicated upon his ability to get work done through the combined efforts and energies of other people.

WHAT AM I SUPPOSED TO DO? I hazzard an opinion that there is a high percentage of supervisors and I might add managers who don't really know that they are supposed to do. The need exists for establishing measurable criteria and standards of performance. This in terms of measurable results. Once these have been established, supervisors need to know how to plan, to organize, to direct, to measure, to control. Probably most of you are familiar with the concept of management which zeros in on results — not activity. It is management by objective. As Dr. G. Odione says "If you don't know where you are going, every road will get you there." Further, "If you don't know where you are going, you don't know when you have arrived!"

HOW AM I DOING? This means the evaluation of progress toward achieving agreed upon goals and objectives. In other words this is performance review. Performance review identifies the incumbent's strengths and also identifies specific areas where performance can be strengthened and improved.

This leads logically to the last question, *WHAT MUST I DO IN ORDER TO IMPROVE?* The answer to this question determines the specific training. Obviously it is the supervisor, if he has evaluated the performance, who determines the need.

WHAT TRAINING? Very simply that which is necessary to improve performance. The goal comes first. Goal of performance rather than goal of increasing knowledge or improving personality. I am sure many of you remember some of the old human relations training which focuses on making the work force happy. The behavioral scientists tell us there is no correlation between happiness and productivity. Let me hasten to add there is a correlation between unhappiness and productivity or lack of it!

The training of production supervisors, if it is to be meaningful and effective, should relate directly to the job and what is needed in order to improve performance in doing that job. Not all of a person's performance can be changed, but important segments of it can be, and very often change in performance can be measured and evaluated. We have learned many things about training and development. Perhaps the most important lesson to remember is that the most fruitful training occurs on the job — 90%. The manner in which a supervisor is treated by his supervisor and the manner in which he treats those reporting to him has an impact on performance. As mentioned previously, the training needs of production supervisors should evolve from fruitful discussion and dialog with the line management of the particular company.

In addition, it will be much more productive if the production supervisor's boss has an active role in planning and conducting the training. It does very little good for example, to have some outsider talk to the supervisor about the importance of self-development for promotion when the production supervisor has never seen anyone get promoted to middle management. What good does it do to conduct training sessions about improving morale, safety, EEO laws, and regulation, when his boss puts pressure only for production. Training must be related to the work the supervisor does. We do not train people so they will die smart. Training must be related to the work and impact positively on improvement.

Up to this point you are probably thinking, and you are right, that we have not really spelled specific training program. We have stayed away from this for a specific reason — that is to emphasize that any training program should center around two factors: 1) the specific nature of the job, and 2) the areas in which performance should be improved.

I do believe, however, that there is a sequence of events or an outline which is basic to a meaningful training program. Let me enumerate them quickly and then we will talk about each.

1) Clear understanding of the job. 2) MBO for incumbent. 3) Performance review/interview. 4) Training commitment — supervisor and company.

Rather than trying to tell you how to go about setting up your own program, let me share our approach in the AgriChem Division of Kerr-McGee.

Initially I met with the Vice-President of our division, Loy Johnson, and the general manager of manufacturing, Gene Black. We talked about the need for specific training and what might be done in order to improve performance. From this discussion evolved this initial program. I say "initial" in that training is not a one-shot affair or something that is finished. It is in continum and specifically our initial program is one upon which we can build. We decided the first session would address the question "WHAT IS THE JOB?" Accordingly, the general manager of manufacturing introduced the session by defining the over all goal of the program and identifying the logistics — time, place, etc. Following this by means of slide presentation he talked about Kerr-McGee Corporation, the parent company, the subsidiaries, and how each is related to the other. He highlighted the AgriChem Division of Kerr-McGee Chemical Corporation. In this he identified each of the production facilities by size, location, and personnel. Again showing the relationship of each AgriChem's facility one to another. Following this the facility superintendent briefly explained the organization of the facility in which the conference was being conducted. Following this the AgriChem's personnel manager conducted a conference on "The Nature of Management." The objective of this session is to develop a better understanding of basic management principles (planning, organizing, controlling) so that managers can effectively utilize such knowledge in application to their jobs and to develop a better understanding of some of the management techniques and how they can be developed and used by managers. The program contains six units, each of which is devoted to a specific area of management. These areas group into four broad categories: 1) The Nature of Management, 2) The Management Cycle (Planning, Organizing, Controlling) 3) Management Skills (Standards and Appraisal, Communications, Motivation) and 4) Goal of management (Improving Managerial Effectiveness).

You may be wondering about time. This entire session takes approximately three hours.

Session #2 focuses on the specific job of the incumbent. A Senior Salary Analysist from the Corporate Office conducted a session on writing job descriptions and during the session had each incumbent develop his own job description. This session identified the specific job in terms of basic accountability, specific duties, and responsibilities. This session turned out to be very productive as in many cases it was the first some of our people had really thought about what their job was and what they were supposed to do. This session took about two hours.

The third session introduced the MBO concept of management. In our case I conducted an initial session and later trained conference leaders. You can see that this session builds on the second session which was to isolate the basic accountability and specific duties. The purpose of this session is to provide direction for the incumbent in doing his job by establishing specific measurable performance criteria. The performance criteria stated positively and in quantifiable terms. This is a work session in which the incumbent identifies the results he is to achieve in a certain time frame. In our case this was in the area of production, quality, maintenance, safety, and personnel.

The fourth session was again a work session on the specific activities the incumbent undertake in order to produce the results identified in the previous session. For example, fruitful discussion centered around the exact measures to be taken in reducing frequency and sererity of accidents.

The fifth and subsequent sessions were tailored in response to querries and needs identified in the first four sessions.

Summary

Ladies and gentlemen, it has been a pleasure meeting with you and hopefully we have been able to give you some thoughts on how you may best approach the training of your production superintendents and supervisors.

MODERATOR GEORGE: Mr. Starcevich we are certainly under a great obligation for you coming here and making this very provocative talk to us. I think everyone in the room, that is involved in production, feels a need of improvement in what training areas we are involved. Mr. Starcevich has to catch a plane right away and will not be able to stay with us. We all wish you a safe trip and thank you very much.

The next item on the afternoon's agenda is the presentation of the John C. Vaaler Award. I will ask Mr. Gordon Weyermuller, Editorial Director of the Putman Publishing Company, to come forward and make the presentation.

John C. Vaaler Award To Davy Powergas

Gordon Weyermuller

I am happy to be here today to present the 1974 "John C. Vaaler Award" to Davy Powergas for an outstanding processing development. The awards are sponsored by Chemical Processing Magazine and are given every two years for outstanding developments in the chemical field. About 12,000 entry blanks are sent to industries and to people interested in submitting entries. When these come in they are judged by a group of people, who are users of chemical equipment, people in plants mainly, from companies such as Dupont, Allied Chemical, Monsanto Chemical and the major chemical companies are all represented.

This award is presented to "Davy Powergas Inc." in recognition of the energy-saving aspects of its newly developed process for "Wet Grinding of Phosphatic Rock."

The wet rock grinding process reduces capital costs, eliminates dust pollution emissions generated by dry rock handling, and saves fuel and power consumption by eliminating the need for drying phosphate rock before processing it.

"This process for handling phosphate rock saves energy through elimination of a costly drying step," commented one of the chief judges in describing the Top Honors winner.

"Since dry rock is not stored, handled or transferred at any point, air pollution control equipment for prevention of dust emissions does not have to be purchased or operated," he said.

The competition was judged by 65 representatives of major U.S. chemical companies. Davy Powergas Inc. was one of 35 Top Honors winners in the Energy Saving Development category of the 6th presentation of the biennial John C. Vaaler Awards.

"Total savings that can be affected by wet rock grinding presently are estimated at $3 to $4.25 per ton of P_2O_5," said Samuel V. Houghtaling, a Davy Powergas senior process engineer, who was instrumental in developing the process. P_2O_5 content is an indication of the purity of the completed phosphoric acid product.

"Rock drying no longer is required, resulting in a saving of about 2.5 gallons of fuel oil per ton of rock or 8-9 gallons of fuel oil per ton of P_2O_5," he said.

"Since there is no dry rock anywhere in the system, all air pollution is eliminated in the drying, transferring, storage, grinding and weighing of dry rock," said Houghtaling. "This reduction of air pollution will eliminate about 1,000 pounds of particulate per day in a large plant."

The new process currently is being installed, or is scheduled for installation, in a number of new plants being designed or built by Davy Powergas in the U.S. It also can be retrofitted into existing plants with plant modifications.

This is Davy Powergas Inc.'s second receipt of a John C. Vaaler Award. The first was in 1968 for its Wellman-Lord SO_2 Recovery Process for cleansing stack gases of sulfur dioxide emissions on fossil-fueled plants.

Davy Powergas Inc. is a major engineering and contracting company providing services ranging from feasibility studies to complete turnkey installations to the fertilizer, gas, fibers, chemical, petrochemical, metallurigical and other process industries. The firm is a subsidiary of Davy International Ltd. of London, England and also has facilities in Houston, Texas.

I would like to present this "Plaque to Mr. Samuel W. Houghtaling, Senior Processing Engineer, at Davy Powergas. He was the prime mover behind "The Wet Phosphate Rock Grinding Process."This is judged as a major contribution toward more efficient and effective operation of plants in the chemical processing industries.

Accepting John C. Vaaler Award

Samuel V. Houghtaling

I would like to thank you personally Mr. Weyermuller and the Putnam Publishing Company, that publishes Chemical Processing Magazine, for this John C. Vaaler biannual award top honors in energy savings. For the emphasis on energy savings throughout the entire world, it is certainly an honor to be selected as the only process to receive the top honors.

To receive top honors of an award requires the efforts of more than one individual. In fact it requires three different distinct groups of people. First, you have to have technical people who can innovate and develop a process that is not only technically sound but commercially feasible. Wet tock grinding, which results in the use of wet rock, produces a rock slurry which is fed in phosphoric acid plants. This eliminates the drying of the rock which is not only energy consuming but a high pollution item. This meets the requirements of being technically sound and commercially feasible. As one of the major contributors to this I would like to thank you personally for the award, also on behalf of the entire Davy Powergas technical group.

Now, there is a second group that is necessary to obtain an award and that has to be your management, a progressive management, that is willing to back the technical group and be willing to offer a new process to industry. Davy Powergas Management, led by Ivan Phillips and Jerry Smith, are these type of leaders in the engineering field that will promote new ideas and encourage us. And they present these processes to solve the problems of industries. In this case it is the energy requirements and pollution problems. Therefore, I would like to thank you on behalf of Davy Powergas management.

No process is of any value, or in other words is meaningless, unless the process can be put into commercial use on a full industrial scale. For this to occur we need a third group. In this case it is the "Management of the Major Phosphate Producers". These people had to demonstrate to their progressive management a willing to accept a new process. In two cases they literally put all the eggs in one basket and went with the whole new complex with a new process. They accepted my motto, which has been my motto from the beginning, that "Wet is Beautiful." Now this took a calculated risk and there are such leaders, that I will mention, Ken Lumberg, Jack Babbitt, Bill Rigby, Barney Baxter, that are all willing to accept this calculated risk to help solve two major problems, that not only plague our industries but the countries and the world. Therefore, it is fitting that this award is given here, because I really feel the Phosphate Industry earned it also. Therefore, I accept this John Vaaler Award and I thank you personally. I thank you for Davy Powergas. I thank you from the whole Fertilizer Industry for your recognition of our effort to solve some of the problems of the world.

MODERATOR GEORGE: Mr. Weyermuller and Mr. Houghtaling: It is an honor to The Fertilizer Industry Round Table having "The John C. Vaaler 1974 Award", to Davy Powergas, presented at this our 24th Annual Meeting. Congratulations.

The next speaker this afternoon is Mr. John L. Medbury of International Minerals and chemicals. Mr. Medbury received his bachelor's degree in Chemical Engineering from the University of Minnesota and spent several active years with the U.S. Navy Engineering Corps. He has been associated with International Minerals and Chemicals from 1952 where he has had wide production experience. He has served as plant superintendent for several years, as production coordinator, as area production manager and as company production manager. Since March, 1974 he has held the position "Director of Operations", for IMC. Mr. Medbury will speak to us on "A Workable Safety Program for Fertilizer Plants."

A Workable Safety Program For Fertilizer Plants

John L. Medbury

By the summer of 1973, the management of the Rainbow Division, the mixed fertilizer production and sales organization of IMC, became aware of the need for a revitalized safety program. The Division operates 6 large granulation plants, one large dry mixing unit in Florida, six secondary plants and a large number of small blending units and warehousing locations. Throughout this system, the accident frequency rate had been rising and the severity rate had taken a substantial jump, with a number of very serious accidents occurring in a short time span.

It was quite apparent that a new and energetic approach to the safety needs of our Division's management and employees was necessary. It was especially important that this new program be relatively easy to administer at the plant level and yet reach, and totally involve each employee.

Previous programs had been good at their inception, but soon became dull and repetitious and eventually were carried out by the Plant managers as a routine exercise completely lacking in zest and impact. They also tended to involve the fewest possible number of employees as this was the most painless way to complete the ritual of lackluster safety committee meetings and cursory safety inspections. Meanwhile, the casuality rates mounted; clearly something had to be done.

Out of this need was conceived the *ACT* program. ACT is an acronym for *A*ccidents *C*ause *T*rouble. The new ACT program was given the kick off in a Division--wide general meeting. The colorful new ACT looseleaf binders were handed out to the management team, and a brief review of the contents was presented to the sales, credit and accounting groups. A more intensive, page by page study was gone into with the production organization and the Plant Managers. These were the people who would carry the football; they were the ones who formed the first line of defense against accidents. The ACT binder would become their *SAFETY BIBLE.*

At this time, I want to emphasize one key point about the ACT program. It involves everybody at the plant, the Plant Managers, the assistant Plant Managers, the foremen and all other salaried and hourly employees. They all participate, they all are made safety conscious thru the activities included in the program.

I will now briefly discuss the key features of the ACT program. These include:

1) *The Supervisor's Home Study Course —*
This is a correspondence course for Plant Managers, assistant Plant Managers and foreman. It is available thru The Continental Insurance Company, one of our insurance carriers. Training materials and twelve home-work assignments are mailed to the employee's home. Upon completion of the required study and submission of the completed worksheets, he is awarded a Certificate of Achievement and the textbook becomes his personal property. The company then will reward the supervisor with gifts valued at $100. These are to be items of lasting usefelness that serve to remind him of his accomplishment whenever used.

2) *Supervisor's First Aid Training Course —*
This is given by the American Red Cross through the Multimedia Training System. This is a scientifically developed instructional system that features filmed demonstrations, guided practice sessions, and programmed work books. All Plant Supervisors are required to take this course. It consists of a solid day-long session of intensive training. At the end of the course, a test will be given. Those who pass the test will be awarded a certificate good for three years. This can only be renewed by taking a refresher course.The local chapters of the Red Cross are very cooperative and are more than willing to accommodate a 10 or 12-man group from our plant either on week days or Saturdays. The only cost is a $5.00 charge per person for materials used.

3) *A Training Program for Payloader and Forklift Operators —*
This is a two-segment basic training course for plant drivers. It involves retraining for all present operators and basic training for new and inexperienced operators. This program had a very special sense of urgency, as several extremely serious accidents involving experience operators seemd to indicate that they had become over-confident about their driving skills and thus were vulnerable to accidents.For experienced operators, a complete check-out on the various mobile units at the plant is required. This is usually carried out on Saturdays when it will not interfere with routine activities and is given the full attention of the management staff.
As well as performing a driving demonstration, the driver is given a lecture based on OSHA rules and regulations for powered industrial trucks as they appeared in the Federal Register on October 18, 1972. Following this a brief written quiz is given. We also use two 15-minute films on safe operation of mobile equipment. Upon completion of the retraining program, the employee driver is given a pocket card listing 14 key safety points entitled, "Powered In-

dustrial Vehicles — Safety Rules". He is issued a "driver's license", a wallet card certifying that he is authorized to operate specified vehicles while on duty on company premises. New drivers are given basic training consisting of the following elements:

a) Preliminary review and demonstration of equipment.
b) Classroom style training on operation covering maintenance, operating techniques, and safety rules. Film strips are usually used as well as lecture.
c) In-Plant training including familiarization, practice driving and loadings, and limited operation with close supervision.

Following this basic training, the new drivers are put thru the same program as the experienced drivers undergoing retraining.

4) *Our Safety Training Film Program —*
This consists of three 16mm color sound films:
"The Color of Danger" — forklift safety.
"Grim Statistics" — heavy equipment safety.
"Don't Push Your Luck" — eye safety.
These films have now been shown at least once at each plant, and we are presently reviewing other films to be integrated into our program.

5) *Our Rainbow Division*
Eye Safety Program —
In this we purchase shatterproof lenses for all employees that wear corrective eye glasses. The employee is required to have these installed in his frames by his own optometrist, we pay the bill.

6) *The Safety Team Award Program —*
At each plant the employees are grouped into teams: shipping, granulation, acidulation, etc. These teams wear identifying colors on their hard hats. A colorful "scoreboard" tells how each team is doing. An accident-free month wins each team member an incentive award.

7) *Safety Signs and Posters —*
We were not satisfied with the usual safety posters and conventional warning signs. We set out to develop our own colorful sign series, based on highway warning signs in a diamond shape and with symbols in black printed on highway orange background. There are twelve signs in this series, and they are posted, as appropriate, in hazardous areas of the plant. We also developed a set of seven large safety posters. These are displayed on in-plant bulletin boards and used as discussion "ice-breakers" at safety meetings.

8) *Specially Prepared Meeting Guides —*
These are group leader's discussion guides similar to lesson plans used by school teachers. Each meeting deals with a specific hazardous situation. Some of the items covered are:
Ammoniator flares and skin burns.
Overhead walkways and falls.
Working under raised bucket of payloader.
Moving shuttle belts with rope winch.
Corrosive liquids and chemical burns.
Dirty or slippery stairways and falls.
Ungrounded electric tools and shock.
Unguarded chain or belt drives.
Cutting and welding risks.
Vehicle collisions.
and there are many others.
A monthly safety meeting is a requirement at all Rainbow locations and these guides serve to keep the discussions in meaningful context and introduce a new topic each month. Group participation is encouraged and the meetings consist of questions by the leader followed by answers from the employees and discussions and amplification by all attendees. A skillful leader can achieve a high degree of involvement and make every man present feel that he, personally, is an active member of the accident prevention team.

9) *The Safety Manual —*
This is a pocket-size booklet, which is issued to each employee. It is required reading, and a portion is read out loud to the employees at each safety meeting. The employee signs a receipt form which is included as the final page and this becomes part of his personnel file. It certifies that he has read and understands the safety rules in the book.

In addition to the ACT program just discussed, we have a number of other on-going safety features. These include:

1) *An Assignment of Responsibility —*
wherein the policy of Rainbow is clearly stated and the responsibility for accident prevention is assigned to the local manager. He has the option to delegate administration of portions of the program to other management personnel, but the ultimate responsibility for carrying out the program is his.

2) *General Safety Rules —*
which are posted prominently in work areas, on bulletin boards and in lunch and change rooms. We also have specific safety rules

which apply to certain jobs.

3) *A Safety Committee —*
which will meet once a month and will carry out the following duties:
   a) Review accidents and close calls.
   b) Update safety rules.
   c) Initiate, implement and supervise plant safety programs.
   d) Make monthly safety inspections.
   e) Plan and conduct monthly safety meetings.
4) *The Monthly Safety Meeting —*
to involve as many employees as possible for the purpose of disseminating training and providing safety education.
5) *Accident Investigations —*
wherein every accident involving lost-time, treatment by a doctor and loss or damage of property is thoroughly investigated and a report of findings is filed.
6) *The Monthly Safety Inspection —*
by the safety committee.
7) *Special Safety Inspections —*
by members of management and the Division's Manager of Safety and Environment. These tend to follow the OSHA manual and are very probing, often uncovering items overlooked by the local plant committee. Unsafe conditions revealed by either inspection require a corrective action within a specified time and assigned action responsibility to a certain person.
8) *A first Aid Treatment Center —*
is provided and fully equipped for proper treatment of minor injuries.
9) *Personal Protective Equipment —*
is issued to employees exposed to hazards. All employees are furnished hard hats and one pair of hard-toe safety shoes per year. In addition, goggles, dust masks and other gear is supplied as needed. Gas masks, oxygen breathing apparatus, acid-proof suits and such items are readily available in case of an emergency.
10) *Physical Examinations —*
New employees must pass physical examinations. Chronic problems are thus discovered and an opportunity is presented for a check on his attitude toward safety. Audiometric tests are frequently given and will become standard when adopted by OSHA.

In conclusion, I wish to state that our frequency rate has shown a steady decline since the ACT program was adopted. The severity rate has also made a distinct improvement with only one high-loss occurrence following adoption of our program. One major plant, which had an excellent record before the summer of 1973, has continued its no lost-time performance and is now at over 1500 consecutive days since the previous lost-time accident.

We feel the key to the success of the ACT program is the involvement of *ALL* employees and the enforced requirement that local management carry out all aspects of the program on a scheduled basis.

MODERATOR GEORGE: Mr. Medbury, that was a very stimulating talk. It shows the interest and dynamic attitude that can be put into safety. We so often tend to think of it as something that has to be put aside until a little later and you are very convincing that that is not the proper attitude.

Our next speaker will be Mr. Herman G. Powers of the Smith-Douglas Division of Borden Chemical. Mr. Powers received his Bachelor's degree in Engineering from Virginia Polytechnic Institute and his Master's degree in business administration from Harvard. Since 1949 Mr. Powers has been active in the fertilizer production area with Smith Douglass. His experience includes "Plant Production manager" of various plants as well as "Chief Engineer" for his company's fertilizer division. He is currently holds the position of "Production Manager," fertilizer division of Smith Douglas, but we know Herman best for the excellent work that he did as Chairman of this Round Table in 1972 and 1973. It is, therefore, doubly appreciated that Mr. Powers agreed to come and speak on our program today on "Plant Maintenance." Herman please.

Plant Maintenance The Wasted Dollar?

Herman G. Powers

This spring when Dudley George called me about speakers for the Round Table's 1974 program, I must have had one of my weaker moments when I volunteered to be his speaker on the subject of plant maintenance. With sky-rocketing costs, shortages, long deliveries on practically every replacement machinery component, and a shrinking labor supply of qualified craftsmen, plant maintenance is certainly one of the most challenging subjects anyone in plant operations has facing him. With inflationary maintenance costs in all operations, whether it be blender, liquid producer, NPK granulation plant, or an ammonia or phosphate complex, no one in management is immune from the impact of maintenance costs. Published maintenance cost indexes indicate that average costs are now running a hefty 19% above a year ago.

In addressing this subject, I feel somewhat like a preacher or should I say like some preachers. I am goin to preach a little, but unfortunately do not practice what I preach as I should. I am sure my company associates in the audience will know what I mean.

In these inflationary times, how do we approach this subject of plant maintenance? There have been hundreds upon hundreds of articles written about the subject along with several texts, and there is no end to the consulting services that are readily available to formulate a maintenance program for your operation. The subject is not new to The Fertilizer Industry Round Table. In fact, I went back to some proceedings of 16 years ago and found that a full half-day was given to the subject of plant maintenance. That day in 1958, in addition to having the maintenance director of DuPont speak, there were such distinguished industry colleagues as Allen Jackson, Robbie Robinson, Wayne King, Joe Prosser, Walter Sackett, Bill Schaffnit and Sam Shelby. With that much expertise, my challenge is all the more to bring you a message in my allowed 20 minutes.

Several years ago, the president of our company sent to the Production Office an article which had the title, "Maintenance — the Wasted Dollar." As one of those responsible for defending our plant expenses, the very title bristled me up a bit as I was pretty certain that one dollar that was not wasted was the maintenance dollar. However, reflecting on the title of the article and its contents, I found it provided a lot of food for thought. If some maintenance fundamentals are not appreciated, miantenance dollars do become wasted dollars. The cost of dollars these days makes it all the more important that we as managers, engineers, operators, contractors, or machinery suppliers make every effort in our industry to exercise control over maintenance dollars.

Where do we start?

First, the original investment: The control of the maintenance dollar tarts in the minds of the men that are responsible for appropriating the funds for a new plant, a process, or a piece of machinery — either new or replacement.

Quoting Walter Sackett from the 1958 proceedings, "Do you want to follow the path of a smaller downpayment in the form of capital investment with loaded carrying and maintenance charges or does it seem more logical to raise the capital investment ante a bit to obtain the best long term value?" Gentlemen, that fundamental is as true today as it was then.

In procuring a new piece of machinery or process, you should first adopt plant standards and specifications along with working toward the interchangability with existing machinery parts. Whether you are a part of the staff of a large complex or the superintendent of a relatively small granulation plant, it is important that this be appreciated. Naturally this takes time and detailed study but it is better to "burn the midnight oil" prior to making the purchase than at 3 o'clock in the morning on a cold winter night.

I fully appreciate you can go overboard on original equipment specifications. Also, I have been around long enough to know there is a limitation on any capital investment, and at times a compromise has to be made to stay or get into the market place. However every engineer or plant operator in the industry must be tough minded on certain standards where he knows there should be no compromise, otherwise maintenance dollars will start to be wasted.

In formulating standards and specifications — *Do not overlook team effort:* If you are in engineering design, be sure to talk with your operating people including your maintenance supervision. It is almost trite to mention this and emphasize team effort when it comes to purchasing a process or new equipment, but I believe we would be amazed how many times this effort is not appreciated.

I have always had a hang-up on so called "jelly fish" specifications such as heavy duty. These type of specifications are often so prevelent in blending plant hardware or field distribution sales brochures. To some people, the term heavy duty means the difference between 14 and 22 gauge plate. One time in our industry we were inumdated with fabricators of blending equipment that was a shade above the erector set class. I wonder how many maintenance dollars were wasted in this area.

Once the original investment is made, what is the next logical step to better control maintenance dollars?

Provide some organized form of record of what is to be maintained:

Depending on the size of your operation and the amount of staff you have available, an equipment record system can be a simple card index file, a log book, or expand into a most complex and detailed equipment record system. Such systems can be purchased from numerous sources but if you do not have the proper clerical staff to administer the system, you are wasting your money.

Let's talk of a simple recording and cost cataloging system that any maintenance supervisor, who is properly motivated, can administer. Such a system can be on cards, indexing each piece of machinery in the plant, and a subindexing of the parts of the machinery on separate cards. Instituting a system of this nature from the start every time a new piece of equipment is installed or replaced will certainly prove most beneficial and a lot better than trying to read from a corroded name plate some day in the future. Each card should contain the description, serial number, etc., all the pertinent data that is needed to maintain the unit. On the same card, cost data can be inserted when replacements or repairs are made so that you start to build a cost record. In turn, the service of an item per dollar becomes apparent along with available cost data for evaluating when a replacement should be made.

Along with this simple cost system, a record can be maintained as to how many tons the machine handles so that eventually this data can be tied in with a scheduled maintenance replacement program.

Right along with what we have to maintain, I noted a paragraph in Mr. Wayne King's paper in the 1958 proceedings on maintenance which is certainly worthy of repeating today:

> "Instruction books are my pet peeve. Who is the gentlemen that gets these books and hides them? Almost every equipment manufacturer takes great pride in the editing, compilation, printing and mailing of these manuals. Please read and reread these, and see that a copy is available to your key personnel of the 'do-it' level."

These are certainly words of wisdom by Mr. King, and are just as prudent today. Equipment instruction manuals should be a part of the "what we have to maintain" file.

Now we have made our investment and implemented some form of record system to tell us what we have to maintain along with cost controls, the next step is:

When to maintain:

This step brings us to the subject of preventative maintenance. If your maintenance force operates as a fire brigage putting out one fire after another, this subject should be of primary interest to you. In short, is the plant running your maintenance force, or is your maintenance force running the plant?

In 1958 Mr. Jensen of DuPont gave the Round Table the following or preventative maintenance:

> "Preventative maintenance consists primarily of doing maintenance when you want to, rather than when the equipment wants to. Equipment left to its own devices seems to have a fiendish ability to do one of the following:
>
> (a) Fail after the regular day shift, thus requiring overtime
> (b) All fail together without warning
> (c) Break down so that maintenance work is required on Christmas or New Year's Day."

To this statement, I do not believe there is an operating man in this audience that will disagree.

To start with any preventative maintenance program, you have to formulate a schedule in your plant for scheduled downtime to perform maintenance work. Once such a schedule is put into practice, it is not uncommon for most plants to schedule more than 60% of the maintenance work in daylight hours with an appreciable decrease in overtime costs.

Basically the start of a preventative maintenance program should be to take the equipment record cards and itemize all major pieces of process machinery on a chart. Opposite each piece should be the frequency of maintenance required daily, weekly, monthly, quarterly, or annually. In turn the time to perform the various preventative maintenance inspections must be determined. Once this is done, you can start to determine the number of manhours required and relate this to the size of the maintenance force required. With this information, the maintenance supervisory force can formulate a chart showing the daily or weekly workload and assign the forces accordingly. No doubt the implementation of scheduling takes time and study, but one of the main points is to get the program started. Adjustments can always be made, but whether it be a small plant or large complex, the scheduling chart is one of the keys to a successful program.

Gentlemen, we now come to the crunch item in any preventative maintenance program — the "people problem". You can invest in the best equipment, set up the most sophisticated maintenance record system and chart a schedule system that ends all, but if your people are not motivated maintenancewise, you are subject to wasting a lot of maintenance dollars. For your preventative maintenance program to work (save dollars), the front end loader driver, the process operator, the shipping foreman, the area supervisor, and the superintendent have to be educated on what you are trying to do, and in short "join church" as a part of the overall plant maintenance effort.

In my judgment, to institute a successful maintenance program, you have to get the operating people involved and become a part of it to make the effort effective. Get the process operators to make equipment inspection reports during the course of their shifts as well as logging downtime and the reasons. These reports reviewed daily by the maintenance supervisor and the plant superintendent or manager can prove to be a useful tool for the plant maintenance program.

The maintenance superintendent or equivalent in your plant has to be sold on preventative maintenance and the fruits that can come from it. If he isn't, it is all too easy for him to become just head of the fire brigade putting out one fire after the other. The inspection frequency and maintenance scheduling has to be determined by him, and those supervising process operations must schedule downtime for these maintenance functions to be accomplished. This is the responsibility of the plant manager or superintendent.

Along these lines I quote again from the proceedings of 1958. Mr. Shelby:

> ". . . In a good preventative maintenance program, the key is the factory or plant manager. It is his responsibility to supervise the preventative maintenance service throughout his organization. The success of such a program depends on how well he fulfills his responsibilities. Some of the most salient essentials of these responsibilities are: educating personnel to perform duties regularly and properly, proper operation of equipment, securing necessary tools, preventing abuse of equipment, and selection of equipment."

Even the small operations in our industry, such as blending or liquid facilities, need maintenance motivation — education, training, and direction to insure their performance and eliminate wasted maintenance dollars.

Maintenance, gentlemen, without motivation becomes the wasted dollar.

Last, but not least — the insurance policy.

A sufficient supply of replacement parts:

In today's climate of long and uncertain deliveries of mill supplies and various process machinery components, an adequate spare parts stock is an absolute must to sustain plant operations. I have just used one of these "jelly fish" words — adequate. How do we define adequate supply? One premise has been to maintain a spare parts stock equal in value to at least 10% of the installed cost of the equipment to be maintained. If you have chosen this approach, you had better check to see if the percentage is in the right perspective with today's inflationary costs and make adjustments accordingly. Plants having equipment record cards or performance logs can use this experience along with replacement data as guidelines to set up parts stocking practices, along with some judgment depending on your type of plant operation and indicated leadtime to procure replacement parts. For multiplant operations, central pooling of spare parts along with attention to standarization can contribute a great deal to providing an adequate supply, and at the same time control the investment in these parts.

To eliminate prolonged production losses, you simply cannot afford to be without spare parts insurance.

Earlier I made mention of a feeling somewhat like a preacher in giving this talk. In that light, I now come to the end of my sermon. In the Bible, there are many fundamental truths that are as valid today as they were over 2,000 years ago. The proceedings of the Round Table could be viewed as one of our industry bibles. Going back some 16 years, we find mention of some maintenance truths which are valid and applicable today as they were then.

Reviewing those truths:

1. The importance of the original investment.
2. Provide some organized form of record to determine what has to be maintained once the investment is made.
3. Institute a program on when to maintain. This is preventative maintenance. For this step to b e a success, motivation of our people is the key.
4. The insurance policy — a sufficient supply of replacement parts.

Gentlemen, all we have to do is to practice these maintenance truths, and in turn plant maintenance will not be the wasted dollar.

MODERATOR GEORGE: Thank you Herman for that stimulating, down to earth discussion "Plant Maintenance — The Wasted Dollar?" I am sure "Our Members" will be reading your "Good Advice" many times and will agree that your philosophy "Properly Scheduled Maintenance" is a must and will prove "A saving dollar in lieu of a wasted dollar".

Our next speaker will be Mr. Gene Williams, "Plant Engineer" Nitram Co., Tampa, Florida. Nitram produces Nitric Acid and Ammonium Nitrate. Mr. Williams received his Bachelor's Degree in Chemical Engineering from Auburn. Following graduation he spent several years as a Chemical Engineer with Dupont and then worked for Geigy for several years as a Production Supervisor and Production Manager. Mr. Williams also was associated with Terra chemicals as Technical Manager in the production of Ammonia, Urea, Nitric-acid and Ammonium-Nitrate. He also handles for Nitram all of their "Environmental Projects". He joined Nitram last June. Mr. Williams has served as Chairman of the manufacturing committee of The Fertilizer Institute. He will speak to us on "Environmental Controls Ahead for Fertilizer Producers." Mr. Williams please.

Environmental Controls Ahead For Fertilizer Producers

Gene C. Williams

I will split this talk into two sections; the first section dealing with air and the second section dealing with water pollution.

In order to look ahead to see what is in store for fertilizer producers in the field of environmental controls, it is first necessary to take a look at the laws under which the environmental controls are being leveled. I will stick to the basics and leave it to the lawyers to give a full interpretation of these laws.

The Clean Air Act can be broken into three parts. Under this Act, the Environmental Protection Agency is required to set national ambient air quality standards, is required to list hazardous air pollutants, and last, is required to establish control standards for certain designate pollutants which they are empowered to designate.

First, let us discuss the ambient air quality standards. Under the Clean Air Act, the EPA was required too promulgate primary and secondary air standards. They were also required to give available technology by which these standards could be met. It was the responsibility of the states to enact laws which would allow the states to meet the primary and secondary standards. It should be clearly understood that the states were under no obligation to require all the technology as given by the EPA but were only required to submit a plan that would allow them to meet the primary and secondary ambient air quality standards. The primary standards were to be met by the states three years after promulgation. The standards were promulgated on November 25, 1971, therefore, all states should have been in compliance November 25, 1974. Secondary standards are to be met at some reasonable period thereafter with no definite date given in the law.

In Table I are shown the national primary and secondary air standards as promulgated by the EPA. With the exception of a few over-crowded areas of the country, most states are already meeting both primary and secondary ambient air quality standards except sulfur oxides and particulate matter.

Next, let us take a look at the available technology published by the EPA as pertains to the fertilizer industry. This is given in Table II. Most states have included this available technology as a requirement of their laws whether it was necessary to meet primary and secondary standards or not. Let me give you an example. Nitric Acid plants in most states are required to meet the 5 lbs. of NO_2 per ton of 100 per cent acid produced even though these states do not have an NO_x problem and nitric acid plants contribute only approximately one half of one per cent of the total NO_x from stationary sources. Most fertilizer plants are spending and have spent money to meet this technology. The one item that is shown here which has been adopted by many states, with no effort to date at enforcement, is the EPA claim that tilling of the soil and fertilizer application can be done by methods which will lead to no airborne dust. Under pressure from environmental groups, we could see some effort in the future being made to enforce the laws regarding fugitive dust.

Another problem that, particularly, the small blending operator faces in the future is the problem of dust from his blending operations . EPA is looking at proposals whereby these operations would have to install ventilation systems with bag-type dust collectors to remove particulates from the air. In most cases, the cost of these collection systems will be greater than the cost the blender has in his total plant. I should point out that the law does provide for small business loans when a small business can show the need for it because of pollution control equipment.

Table III — shows the compounds that EPA has designated as hazardous pollutants to date. Although we have been told many times that one of the methods for removing ammonia from water is to strip it to the atmosphere, I do not believe it would surprise anyone who has worked closely with the EPA to see them designate ammonia as either a hazardous pollutant or one of the so-called designate pollutants. At the present time, there is a high possibility that fluorine will be added to the designated pollutant group leading to considerable cost to the phosphate fertilizer manufacturers.

At this point, let us take a look at water. Basically, the Clean Water Act requires the EPA to set up the National Pollution Discharge Elimination System of permits. This permit system is to be operated so that by July 1, 1977 industry will have reached the level of best practicable control technology currently available; by July 1, 1983, they will have reached the level of best technology economically available. They are also to set standards for performance for new sources. One thing we must never forget is that the law states that the national goal is the elimination of discharge of all pollutants by 1985. Under the law, the EPA is also to list toxic pollutants of water, and they are given control of pesticide application. In Table IV are listed the toxic pollutants that EPA has promulgated. At one point, this list was pages long but was reduced before publication. You will note that the majority of the compounds given are pesticides. We can be usre that additional compounds will be added to this list in the future. The problem encountered in trying to list toxic pollutants is the fact that just about everything is toxic to marine life if present in large enough quantities.

In the following tables, I have listed the effluent guidelines that have been promulgated to date regarding fertilizer manufacture.

In Table V, the guidelines for phosphate plants are given. Basically, except under the conditions as shown in the Table, phosphate plants are not allowed to discharge any water. We have been told verbally that (b) of the 1977 requirements would be added to the 1983 requirements. To date, this had not been done.

In Table VI are given the guidelines for the ammonia plants. These are expressed in pounds per thousand pounds of product. To put it in terms that we are all accustomed to, in 1983 a thousand ton-per-day ammonia plant would be allowed to discharge only 50 pounds per day of ammonia. Although no mention is made of total recycle or no discharge, we all realize that in order to achieve no more than 50 pounds per day this plant must somehow reach essentially total recycle.

Table VII gives the guidelines for ammonium nitrate plants. You will note that in 1977 extra allowance for prilling operations due to fallout from prill towers, but none is made for 1983.

In Table VIII are given guidelines for urea plants. Although I have stated that the asterisk numbers represent changes made by the EPA to the original guidelines, they actually represent proposals made in the federal register which have not been promulgated at this time.

What else can we expect in the future? One thing is increased enforcement and surveillance by both state and federal agencies. Approximately two years ago, efforts were made in Illinois to enact laws that would allow the state agency to control all fertilizer application. Although the need for fertilizer for increased food production to some extent has put this on a back burner, I feel sure that we will see efforts in the future for this type of control. Another point to remember is that in both the air and water laws it is spelled out that although states cannot enact laws that would be less strict than the federal requirement, there is nothing that keeps them from being stricter; we see this in some of our states at the present time. I expect to see even more of it in the future. Even though the EPA has come out with technology that is supposed to be the best, and we in industry have serious reservations as to whether this technology can be achieved, and in fact, some companies have filed law suits; some states are requiring even lower levels than the technology says can be reached. I, personally, have serious reservations as to whether the EPA has really taken into account, as required by law, the age of plants, the differences of processes between plants, the energy requirements or the cost benefit ratio of their technology. Although some plants will probably be able to meet these guidelines due to their own unique situation, there are many others that will not. If a more realistic approach is not taken, there will be a serious economic impact upon the industry.

The question then arises as to what you and I can do to try to reach more realistic standards. I doubt if anyone in this room would question the necessity for controlling pollution. I believe that a lot of the unrealistic numbers that we are seeing today are the results of the impact of so-called envirinmentalists. I use the word "so-called" because I, personally, feel that I am an environmentalist and probably the majority of the people in this room are. To separate us from the so-called environmentalists, I suppose I would have to call us practical environmentalists.

I do not believe that it is reasonable nor desirable to remove everything from water but water. Our industry is a good example of what I am talking about. Although fertilizers are referred to in the rules and regulations as pollutants, in actual fact; they are nutrients. Without some nutrient, no marine life could exist. There has not been enough effort to determine when a nutrient becomes a pollutant, which gets us to the point I am trying to make — the general public does not understand what is and what is not pollution. A water vapor cloud from a cooling tower is often called pollution by people who do not know. Scare tactics are used to rouse the public against so-called pollution. The news media has not done a good job of really informing the public, therefore, what you and I can do both as individuals and companies is to take every opportunity to discuss pollution rather then shy away from it and hope that if we keep our heads in the sand, it will go away.

I thank you for this opportunity of speaking to you today and hope that some of what I have had to say will prove useful to you.

Note: Tables 1 thru 8 on Pages 36 thru 41

TABLE I

NATIONAL PRIMARY AND SECONDARY AMBIENT AIR QUALITY STANDARDS

	PRIMARY	SECONDARY
Sulfur Oxides	80 Ug/M^3 Annual arithmetic mean 365 Ug/M^3 Max. 24 hour conc not to be exceeded more than once/year	1300 Ug/M^3 Max. 3 hour conc. not to be exceeded more than once/year
Particulate Matter	75 Ug/M^3 Annual geometric mean 260 Ug/M^3 Max. 24 hour conc. not to be exceeded more than once/year	60 Ug/M^3 Annual geometric mean 150 Ug/M^3 Max. 24 hour conc. not to be exceeded more than once/year
Carbon Monoxide	10 mg/M^3 Max. 8 hour conc. not to be exceeded more than once/year 40 mg/M^3 Max. one hour conc. not to be exceeded more than once/year	Same as Primary Standard
Photo Chemical Oxidants	160 Ug/M^3 Max. one hour conc. not to be exceeded more than once/year	Same as Primary Standard
Hydrocarbons	160 Ug/M^3 Max. 3 hour conc. not to be exceeded more than once/year	Same as Primary Standard
Nitrogen Dioxide	100 Ug/M^3 Annual arithmetic mean	Same as Primary Standard

TABLE II

AVAILABLE TECHNOLOGY

AIR

VISIBLE EMISSIONS 20% Opacity

FUGITIVE DUST: No Airborne Dust From Tilling Fertilizer Application

PARTICULATES

Process Weight Rate lbs./hr.	Emissions Rate lbs./hr.
50	0.36
1,000	2.25
10,000	9.73
60,000	29.60
120,000	33.26
200,000	36.11
1,000,000	46.72

SULFURIC ACID PLANTS

6.5 lbs. SO_2/Ton 100% Acid Produced (Existing)

4.0 lbs. SO_2/Ton 100% Acid Produced (New)

0.15 lbs. Acid Mist/Ton 100% Acid Produced (New)

NITRIC ACID PLANTS

5.5 lbs. NO_2/Ton 100% Acid Produced (Existing)

3.0 lbs. NO_2/Ton 100% Acid Produced (New)

TABLE III

HAZARDOUS POLLUTANTS

AIR

Asbestos

Beryllium

Mercury

TABLE IV

TOXIC POLLUTANTS

WATER

Aldrin

Dieldrin

Benzidine and its salts

Cadmium and all cadmium compounds

Cyanide and all cyanide compounds

DDDC (TDE)

DDE

DDT

Endrine

Mercury and all mercury compounds

Polychlorinated biphenyls

Toxaphene

TABLE V

EFFLUENT GUIDELINES

PHOSPHATE PLANTS

No Discharge Except

1977

A. Amount Equivalent to Rainfall in Excess of 10 year 24 hour Rainfall

B. Amount Equivalent to Difference Between Monthly Rainfall and Monthly Evaporation Rate. This Discharge Must Meet Following Requirements:

Effluent Characteristic	Max. PPM	30 Day Avg. PPM
Phosphorus	70	35
Fluoride	30	15
TSS	50	25
pH	8.0 - 9.5	Same

1983

Amount Equivalent to Rainfall in Excess of 25 year 24 hour Rainfall

New Source

Same as 1983

TABLE VI

EFFLUENT GUIDELINES

AMMONIA PLANTS

Effluent Characteristic	30 Day Avg. lbs./1000 lb. Product		
	1977	1983	New
Ammonia (As N)	0.0625	0.025	0.055
pH	6.0 to 9.0		

One Day Max. = 2 X 30 Day Avg.

TABLE VII

EFFLUENT GUIDELINES

AMMONIUM NITRATE PLANTS

(NO PRILLING)

Effluent Characteristics	30 Day Avg. lbs./1000 lb. Product		
	1977	1983	New
Ammonia (As N)	0.0375	0.0075	0.025
Nitrate (As N)	0.05	0.012	0.0125
pH	6.0 to 9.0		
(PRILLING)			
Ammonia (As N)	0.1	0.0075	0.25
Nitrate (As N)	0.11	0.012	0.025
pH	6.0 to 9.0		

TABLE VIII

EFFLUENT GUIDELINES

UREA PLANTS

(NO PRILLING)

Effluent Characteristics	30 Day Avg. lbs./1000 lb. Product		
	1977	1983	New
Ammonia (As N)	0.0375	0.015	0.0325
Organic Nitrogen (As N)	0.175*	0.025	0.12*
pH	6.0 to 9.0		
(PRILLING)			
Ammonia (As N)	0.05	0.015	0.0325
Organic Nitrogen (As N)	0.50*	0.0375	0.35*
pH	6.0 to 9.0		

One Day Max. = 2 X 30 Day Avg.

* These numbers represent changes made by EPA to the original Guidelines. One day max. are also greater than 2X.

MODERATOR GEORGE: Thank you Mr. Williams for showing your detailed expertice on "Environmental Control". I am confident your information will be valuable to all of us.

Our next and final paper will be discussed by Edwin Cox, III, Partner, Edwin Cox Associates. Mr. Cox is a Director of Our round Table. He received his Bachelor's Degree in Chemistry from Virginia Military Institute and his Master's Degree in Chemical Engineering from University of Virginia. Mr. Cox is a Registered Professional Engineer in Virginia, Kentucky, Massachusetts, Georgia, North Carolina and south Carolina and is also a Registered Chemist.

Mr. Cox has had wide experience in pollution standards and taking stack tests. His organization is one of the best in our area for it. He is a member of more professional societies than time permits me to enumerate. His topic this afternoon will be "Operation of Pollution Control Equipment Particularly Problems and Solutions in Bag House Operations." Pete, we welcome you.

Operation Of Pollution Control Equipment Problems And Solutions In the Operation of Baghouses

Edwin Cox III

Baghouses, used for dust removal from an exhaust gas, are analogous to other types of filters or screens. Since the dust to be removed consists of fine particles, a tight mesh fabric in lieu of a screen is used.

The physical separation is typical of gas phase reactions. There must be transport of the material to the filter, the filtration itself, the removal of the clean gas stream from the area of the filter, and the removal of the separated dust from the filter.

The fertilizer industry is familiar with one of the problems in baghouses — corrosion is a primary concern. Other special problems are:

1. Moisture in the cake, which causes blinding of the bags.
2. Fire
3. Precipitation of dust in the ducts before filtration.

As with other equipment, the general rule applies — that skid-mounted, shop-assembled units are preferred to field-assembled units for both cost and ease of installation. Seldom can existing plants avoid field erection, however. Larger plants, because of the prohibitive cost of conveying the dust laden air out to a point where the skid-mounted unit can be installed, normally require erection within the existing buildings.

General Description — Baghouses

Before setting forth the results of this study, a brief review of baghouse designs may be helpful. It should be observed that in almost all cases baghouses are of the suction (or negative pressure) type. That is, the impeller fans operate on clean gas streams (the discharge side of the filters).

Figure 1. shows the shaker type baghouse. Dust-laden air enters the lower section, passes up through the bags and out. The bags are hung and are periodically shaken to remove the cake on the filters.

Figure 2. shows a reverse air flow baghouse filter. In this a blast of air, on the clean side of the bags, collapses the cake on the bags, and it falls to the receiving bin below.

A modification of this type of reverse air filter is the reverse jet (or travelling ring) which constantly traverses the length of the bag, breaking the cake incrementally. (Figure 3.)

A pulse jet baghouse (Figure 4.) is another modification of the reverse flow type of baghouse. In contrast to the conventional reverse flow, where a whole section is shut down for cake removal, a pluse of air blasts through the individual bags during operation of the unit.

An envelope type baghouse (Figure 5.) is a conventional unit with different bags. Again, a reverse air cleaning manifold is employed to blast the dust built up as cake. The advantage of the envelopes is greater filter area per cubic foot of space required.

Chart No. 1 depicts the characteristics of the build up of the cake on the bags. Shown here as "drag" on the Y axis, it is analogous to the measure of ΔP, the differential pressure across the filter. Initially there is free flow through the bag, or no drag. As the cake builds up (here called filter dust mass) the drag also increases. After a rapid initial increase in ΔP, there is slower continued increase in ΔP. At the time of shaking (or cake removal) the pressure differential across the cake drops off and the process repeats. You will note that the drag does not drop back to the original point because shaking is not a rigorous and complete removal of dust. Rather, some dust is left in the pores of the bags.

The next four figures are typical baghouse installations. The first (Figure 6) is as we would like to have it— an exterior unit purchased shop-assembled, with final erection and connections only required in the field. The second (Figure 7) is a picture of a conventional skid-mounted unit being prepared for shipment.

The next photograph (Figure 8) shows, however, the all too common type of baghouse installation — interior and occupying what little available space is next to a production unit. These units are more expensive per cubic foot of air filtered because of the increased field assembly. The last (Figure 9) is a smaller unit of the type found in shipping areas and other sources where small amounts of air are filtered. The advantage of this type of unit is that it is shop assembled and arrives intact on the jobsite.

Problems and Solutions

The worst particulate problem of the fertilizer industry is the dust formed during the drying operations.

Of three major companies interviewed, two here in the United States and a third in the United Kingdom, operating over 20 plants, it was found that (with a few exceptions which would be expected because of the differences in available materials in the two countries) common answers were found to most problems.

There are two different types of dust problems in the industry — the gross problem of the dust around the granulators/dryers, and the aggravating but "smaller" problem of dust around mills and shipping facilities. Conveying and handling operations cause varying, local problems, with an often result of much "fugitive" dust.

Dryer Dust Abatement

Air from the cooler is passed through a cyclone and then used as the makeup air for the dryer. This requires modifications of the burner assemblies to the dryers. The dust laden air from the dryer, with the exception of one plant, is passed directly to the baghouse and *not* through a cyclone or prefilter.

The bags used in the United States are acrylic. One company reported that is uses spun acrylic — the other used monofilament. Dacron was reported as breaking in service. Other materials investigated but not used were a French product called Kryolar, spun dacron and orlon. Orlon was reported to shrink in use — a disadvantage. Both major U.S. companies reported that the bag life of the acrylics was eighteen (18) months.

Air to cloth ratios were 1.8 CFM of dust-laden air per square foor of filter area. This is *net* during the time of cake removal, so that the overall availability was in the range 2.0 CFM per square foot.

Shaking frequency was not as specified by the manufacturers. Orginally specified to shake for a minute and a half every hours, one supplier found a preset shaking frequency of one minute every thrity minutes superior.

The baghouses themselves were originally supplied in 14 gauge metal. Because of corrosion problems mentioned earlier, both U.S. manufacturers are going to 10 gauge for new installations.

Pressure differentials across the filter range are from one to twelve inches, with the desired operating range of four to six inches.

Duct velocities are kept between 4000 and 4500 feet per minute, as a minimum, to prevent dust settling out in the ducts prior to filtration.

The cost of baghouses has often been cited as $1.00 per CFM. Fertilizer industry installation experience has been $4.00 per CFM installed and is estimated now to be approximately $6.00. Of this approximately fifty per cent of the cost is in ducting to get the dust to the baghouse, and in hanging the baghouse in whatever space is available.

Insulation, despite the objections of insurance companies is with polyurethane, either preformed or sprayed on. In the event of fire the possibility of toxic fumes *must be considered.*

In order to prevent a moist cake which will blind the filter, a temperature differential (ΔT) of 50 Degree F. is maintained between the dew point and the temperature of the dust-laden air. This temperature is measured by the operators. Measurements are every 15 minutes.

To maintain this temperature differential the baghouse is not heated. Rather, the tonnage of goods processed through the dryer is controlled. To raise the temperature in the baghouse, the production rate is curtailed. Obviously, grade changes are periods requiring great care to prevent too high a temperature being reached in the baghouse, with subsequent attack on the bags. One plant has a set point of 240 Degree F. in the baghouse to control the fuel to the dryer — at this temperature the burner is shur off.

Another difficulty arising from too high a temperature in the dryer is that more dust for a particular grade is formed.

Low ΔT's are experienced as a result of air leaks, particularly at sampling ports and around the dust removal valves.

It is important that nitrates be kept out of the systems.

Bag tension is obviously important. One manufacturer has a device analogous to the old head space adjustment tool for the light machine gun. After the first month of operation, the bags are readjusted. Bag tension is critical — if the bags are too tight they will tear, and if they are too loose poor shaking will result.

Bag lengths have been found to be optimum of 126 inches. In some cases because of the requirement for filter area and the available space, 168 inch bags are used. These are difficult to maintain and require interior scaffolding in the baghouse (when bag service is required).

The question of bag changes raises the question of maintenance. Many baghouses as offered have extremely narrow work areas inside. You are familiar with the safety problems of opperating in closed systems — the baghouse is actually a separate room. Safety must be considered when the operator goes into the baghouse for any purpose. Some baghouses, which tout exterior maintenance by the operator, require head room which is not otherwise used and is thus wasted.

During down time, heating of the baghouse may be required. It is accomplished by either isolation, recycling of warm dry air in a closed loop, strip heaters or in one case by steam radiators. It is important that the bags be shaken well before the unit goes down. Heat lamps in the dust troughs are common.

If the baghouse is cool, it should be preheated before going on stream.

Although many baghouses are field assembled, they have the characteristic of being units which are put together to obtain the required size. These units become separate compartments in the final, installed baghouse. An uneven distribution of dust laden air to the different compartments may result. Dampers to control this are required.

Fugitive Dust

The dust from milling operations or bagging operations is easier to control than from the dryer/cooler operations.

Of greatest advantage is the more favorable air to cloth ratio of 6:1 in lieu of the 1.8:1 experience on the dryer. This significantly reduces the cost of the baghouse since a square foot of filter can do three times the amount of filtration. Reverse pulse air baghouses, shop assembled such as shown in the earlier photograph, are used. Polypropylene, cotton sateen and woven wool have all been employed in this duty without difficulty. Since these units operate under ambient conditions, the problems associated with dryers are not as critical. Indeed, one company reports bag life in this duty of 10 years (in an area that has neither heat nor humidity problems).

Summary

In summary, the baghouse has been used extensively in the fertilizer industry to abate dust emissions. This use will continue.

The plant location, as it fixes conditions of temperature and humidity, is an important consideration in the initial design of the unit. When these factors have been considered baghouses have given satisfactory performance.

I would like to acknowledge my appreciation of the help of the companies visited and state that the errors contained herein are mine. Unfortunately, because of the close attention of regulatory agencies, none can be cited. Thank you.

FIGURE 2
REVERSE FLOW BAGHOUSE

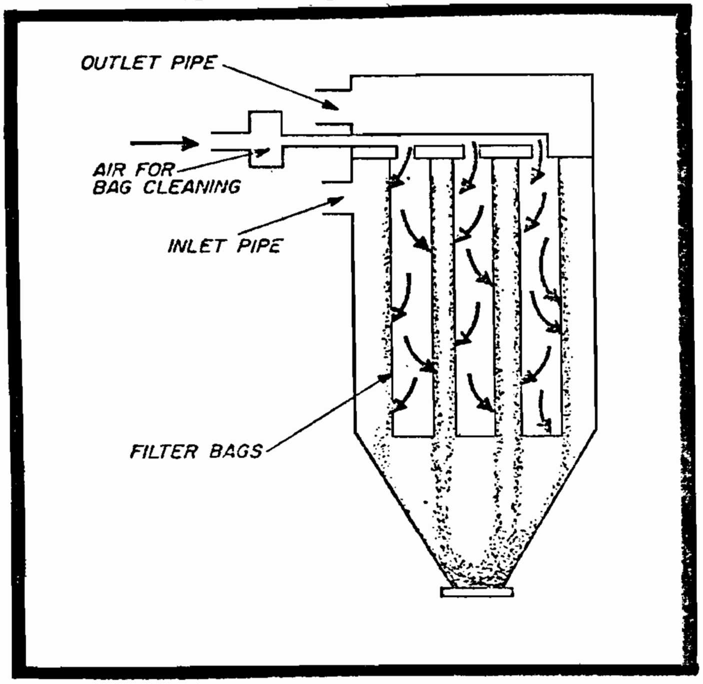


FIGURE 1
SHAKER TYPE BAGHOUSE

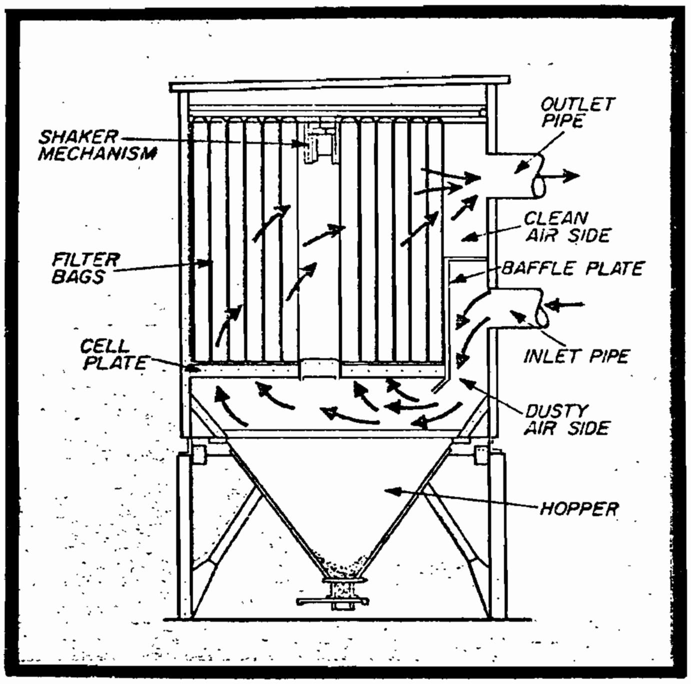


FIGURE 3
REVERSE JET BAGHOUSE

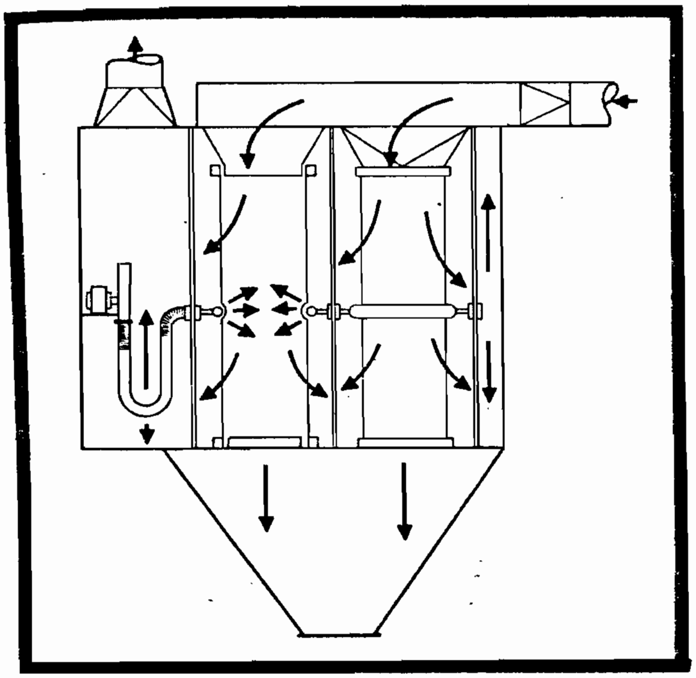


FIGURE 4
PULSE JET BAGHOUSE

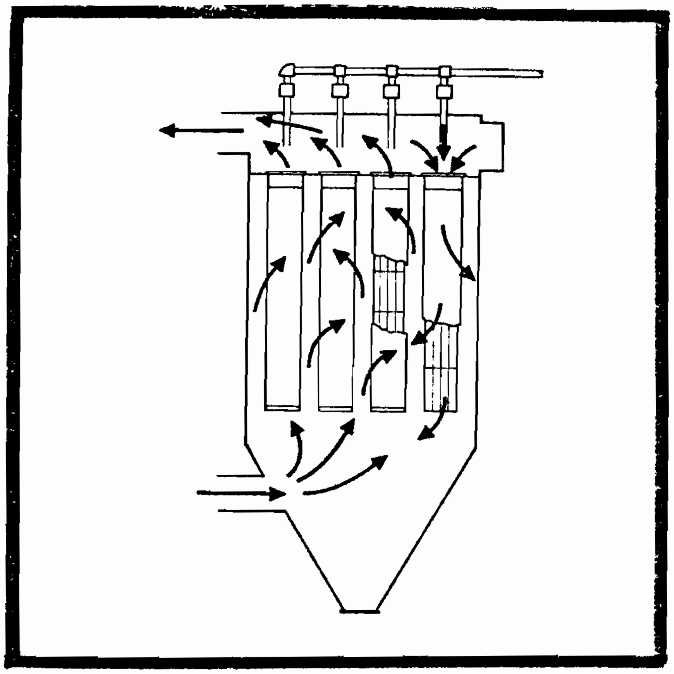


CHART 1
GRAPHIC REPRESENTATION OF CYCLIC OPERATION OF A BAG FILTER

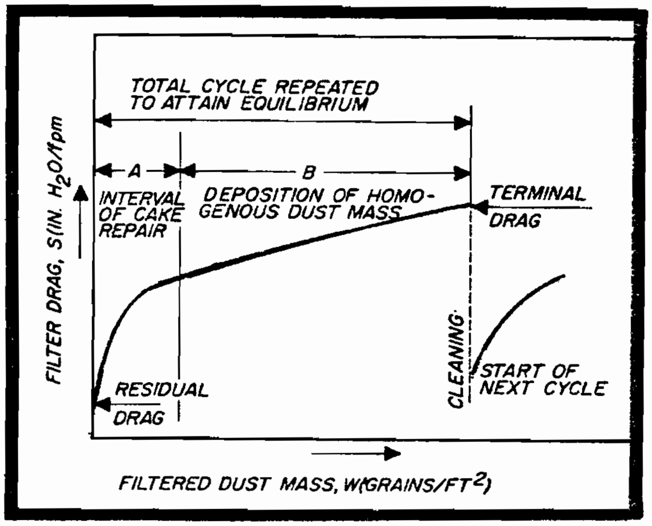


FIGURE 5
ENVELOPE TYPE BAGHOUSE

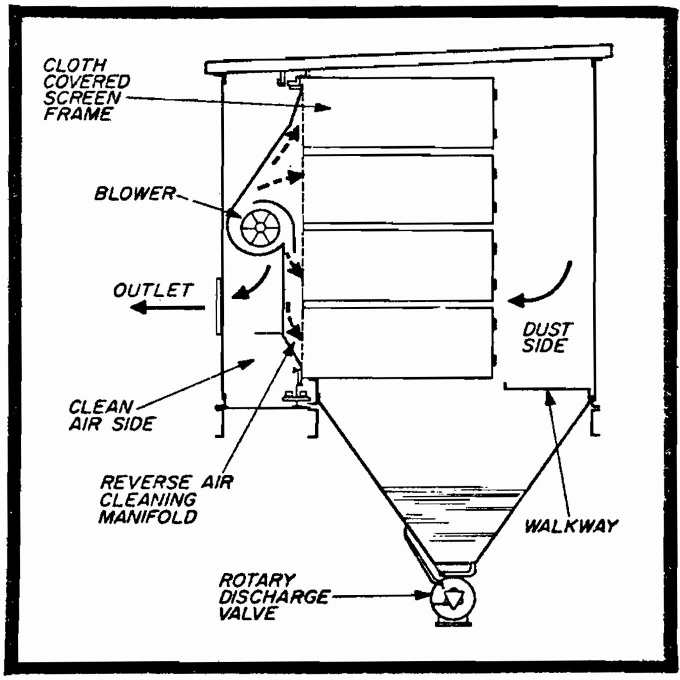
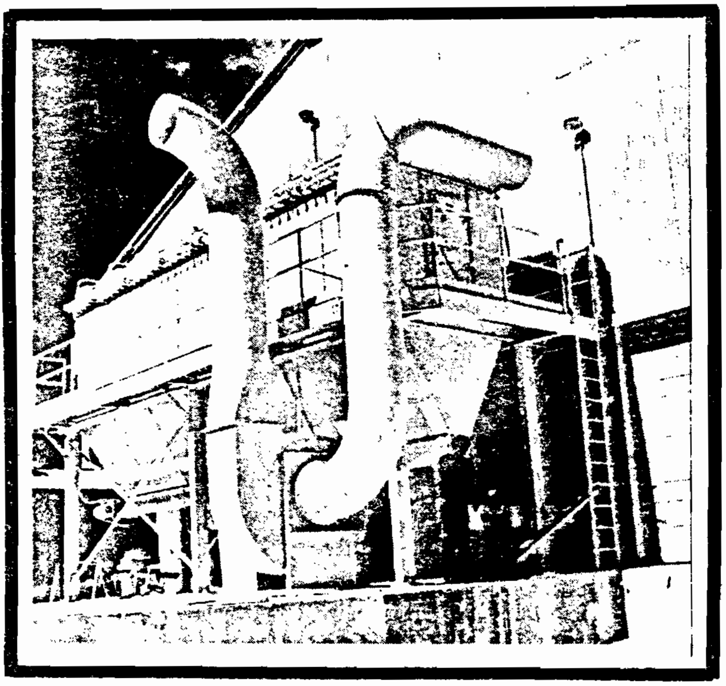


FIGURE 6
MAJOR OUTSIDE BAGHOUSE



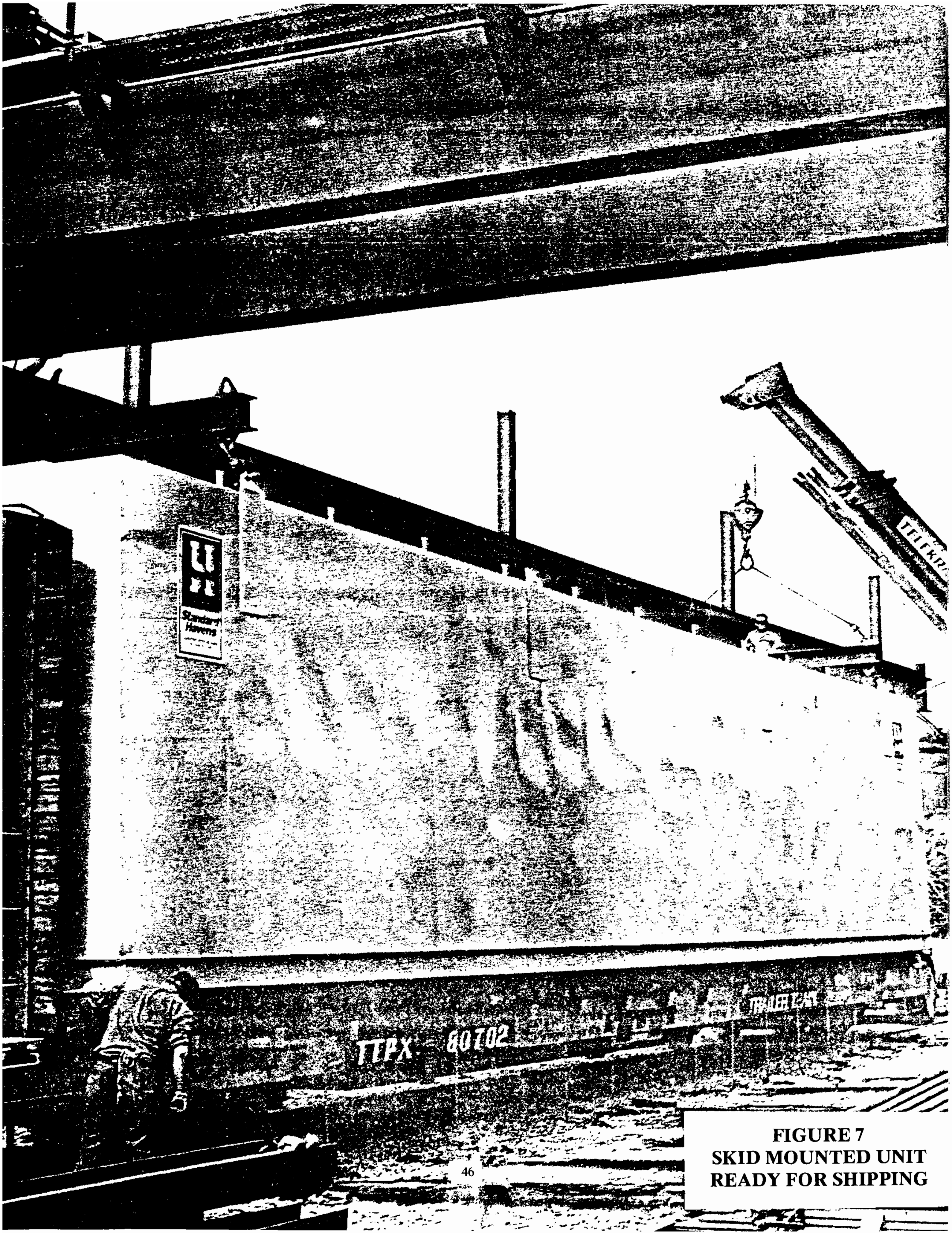


FIGURE 7
SKID MOUNTED UNIT
READY FOR SHIPPING

FIGURE 8
INTERIOR MOUNTED BAGHOUSE

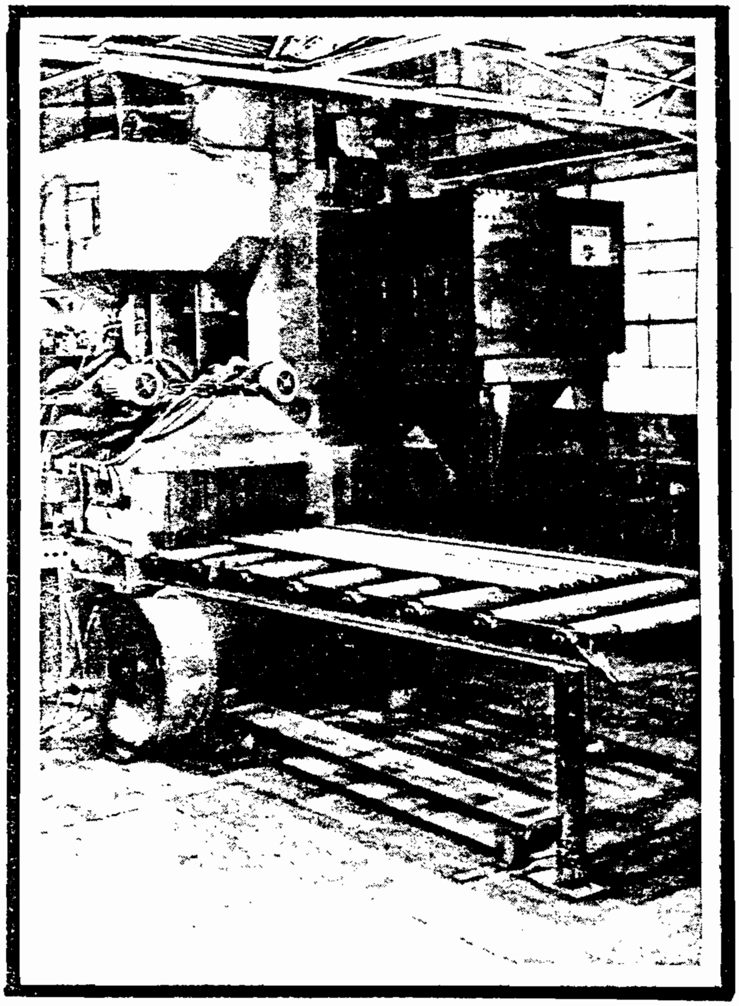
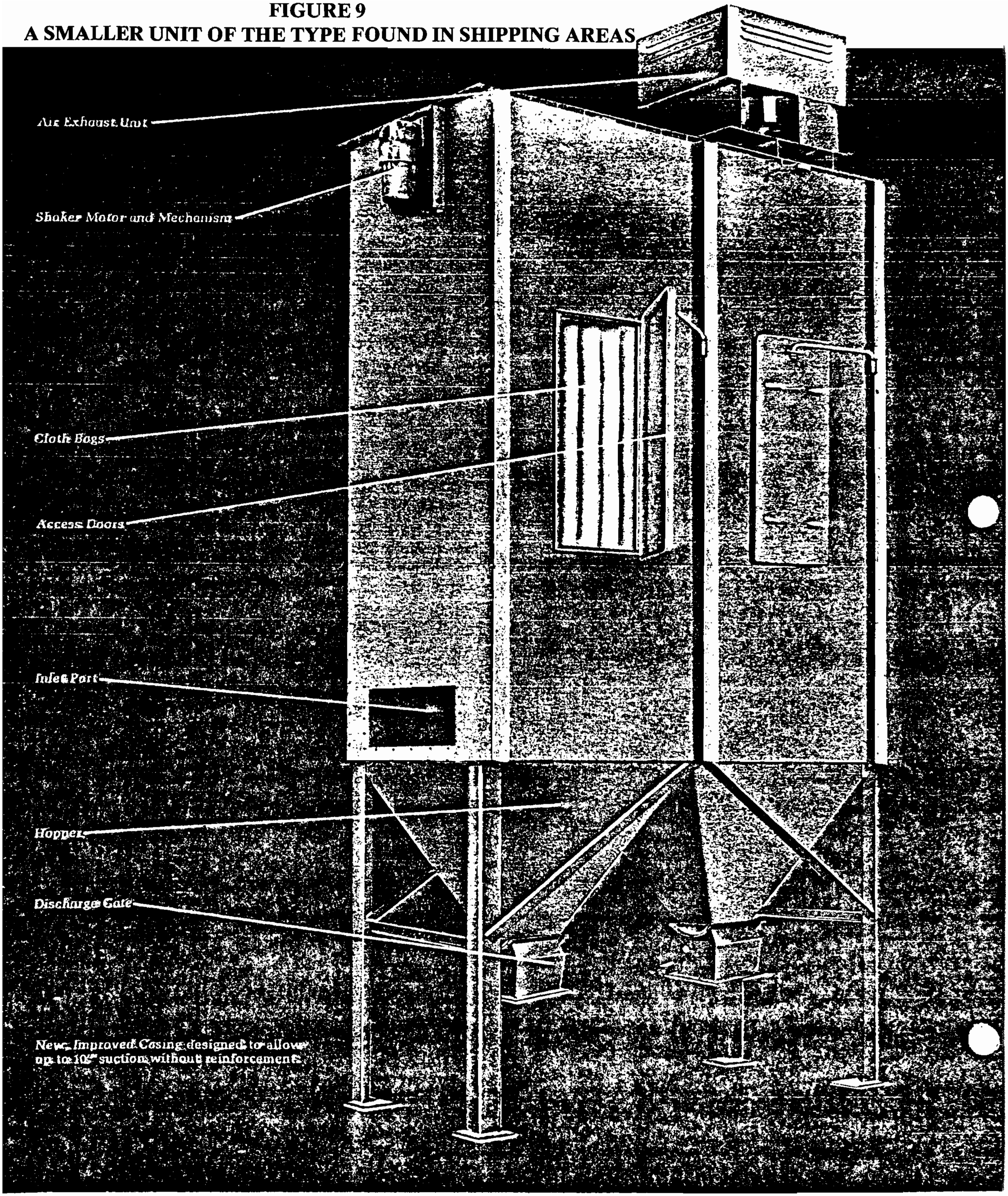


FIGURE 9
A SMALLER UNIT OF THE TYPE FOUND IN SHIPPING AREAS



MODERATOR GEORGE: We will now ask the Speakers to please come up to the table and we will welcome Questions from our Audience. This is where I have always gotton more from the Round Table than any other part of it. I know I speak for the entire group in thanking these Gentlemen for taking the time to prepare these very thoughtful, interesting presentations.

This afternoon we have discussed areas of primary concern to each of us on our Operating Plants. Mr. Medbury spoke to us on "Safety, Mr. Powers on "Plant Maintenance", Mr. Williams on Environmental Control and Mr. Cox on "Operation of Baghouses". We are now ready for your questions.

Questions and Answer Session

L. Dudley George — Moderator

QUESTION FOR MR. MEDBURY: What method of followup did you use and to what degree was it necessary in your "New Safety Program — The Inspection Part?"

MR. MEDBURY: It is a requirement for all Members of our Division Staff, people associated with our headquarters, to visit the plants on a regular basis and try to coincide their visits with a "Safety Meeting", a "Safety Inspection" or some such activity, so that they can be an active part of it. Also, on each occasion when they visit the plant, they review the program. It is a continuous thing. I personally get around to each plant two or three times each year. People who work for me make the same circuit at different times. We review the program continually.

The monthly visit inspections are reported and these reports come to my office. Quite frankly we have check--lists of assigned work in correction of "Safety Hazzards." These are continually being reviewed, old items crossed out and new items put on.

MODERATOR GEORGE: A question to mind along this line. Has it reduced substantially your "Workmen's Compensation?"

MR. MEDBURY: It definitely has. As I indicated, the frequency rate is well on it's way down and the severity rate is kind of a holdover thing. It is definitely on it's way down too. We had one serious accident, since the program was put into effect, at a small plant that had not received the full program yet.

QUESTION: What percentage of the maintenance force would be involved in the planning and record keeping, etc. with the maintenance program, or how many people would be involved in the maintenance program?

MR. POWERS: I don't have any facts as far as numbers go. I think it is something that is easy to sell today depending on the size of the plant, and it doesn't have to be very large to justify a decent clerical type to help the maintenance supervisor to administer the program. Of course, there are those plants that have storerooms. In our organization, the storeroom keepers report to the maintenance superintendent, so there we have the nucleus of two people of a clerical nature.

At two of our plants we have started a data processing program for the various pieces of equipment, various areas of the plant, various types of maintenance, code numbers, and so forth. In turn, the maintenance foremen, as the work is undertaken, code timecards, code materials and services purchased and what have you, so that we have a data processing feedback. The information is sent to us to evaluate areas where there are problems.

We have never had a clerk as such. One plant in particular was completely rebuilt a few years ago, and the man that is now production manager was the maintenance superintendent. On his own, with simple index cards, he made a complete set of records. He had no clerical help, but he just disciplined himself that every week he'd set up his own system with minimum guidance from our staff level. In short order, he can give a pretty good history of his plant.

I have no rule of thumb as far as the number engaged but I think that for the typical granulation plant that we are accustomed to, the services of one clerk with the maintenance supervisor can do a terrific job, and some times that function can be split depending on the size of the staff.

If the program can just get started and follow through with our support at a staff level, it doesn't take a lot. As long as the person is really conscientious and goes after it and he wants to get on top of his preventative maintenance, it works.

QUESTION: How are we investigating the outlook on fluoride emissions?

MR. WILLIAMS: Right now, Terry, it looks like the EPA is going to drop that for a while. Hopefully, they will continue to drop it.

QUESTION: Mr. Powers, would you repeat the figure you gave on the effect of normal maintenance during working hours?

MR. POWERS: Approximately 60%.

QUESTION: Did the point of laundering bags come up in your study at all?

L. DUDLEY GEORGE: The question is did the point of laundering bags in baghouses come up in his survey on baghouses?

MR. COX: Yes sir, it came up in two places. On a smaller unit of using it, let's say in shipping mills where you have your ten year life, yes it's possible to do without. The other bags, the 18 month life that I cited, there is a replacement life. Rather than let the bag run until its burst, take it out at a certain fixed period of time. What you try to do is keep it in service, the individual bags, within the 18 months and then you are content to replace them.

QUESTION: Mr. Cox, what is the best method to measure the tension on the bag in the bag house?

MR. COX: Well, there is no single best method, sir, because each supplier hangs his bags in a different way. The particular unit I was referring to is Wheelabrator-Frye and they have a device, its a very simple device, for measuring. Each of them have a different device for it.

MR. POWERS: Pete, in a Wheelabrator-Frye baghouse depending on the length of the bag, whether it is 126" or 168", I believe the rule of thumb is about 1/2" of slack. The simplest thing is to get a ½" piece of plank or plywood and just cut a slot and put that on the bag and turn it, and that will give you your ½". This is the device we use. We have some foremen that can do it with their fingers. I am not so sure its good.

L. DUDLEY GEORGE: I would like to ask Mr. Williama as to whether or not he thinks fugitive dust from a granulation plant is going to be the subject of very much enforcement in the near future.

MR. WILLIAMS: It looks like now that fugitive dust from granulation plants is going to be quite a problem. In fact there is under proposal regulations, nothing final yet but there have been proposals made on this, and this is where I mention that we can get into some awfully big expenses.

L. DUDLEY GEORGE: Did the group hear that answer. It wasn't what I wanted to hear. Another question please.

MR. COX: I would like to comment on one thing Mr. Williams said when he was talking about either for air or water pollution what you might call a current criteria, and the criteria at some fixed date down the road, and the ultimate criteria. In the case of water, it is 0 discharge. You will notice in his charts that he referred to two things — existing plants and new plants. And there will be a third thing you will have to look for, and these are the so-called envirinmental impact statements that are coming up under an act that is called NEPA or the National Envirinmental Protection Agency Act. And the question is that if you add capacity, is that addition of capacity going to come under the new plant rule or will you simply modify the existing process? And the regulation to which you are subject are remarkably different and the cost which you have to go through to even get approval to whichever you have in mind is remarkable.

I give you this case in point. The plant that we are working on is not in the fertilizer industry. They made overshoes and they are now making golf balls; and I contend that, of course, that was the same plant using the same water with the same people, and all we wanted to do is tell them what we were doing and get any new restrictions. And the reply was "Oh yes, but it is a new plant even though you are using the old building." I just cite that as a possible difficulty you may want to avoid if you can.

MR. WILLIAMS: If I may comment on that a little bit further, under the law an expansion is considered a new plant if its any size whatsoever. So if you are doing any expansion work, you had best clear with EPA just exactly where you stand because you could very easily come under the new plants rule; and that is, as the charts show, an entirely different ball game as far as the numbers are considered.

QUESTION: I would like to aim this to Mr. Powers. I am wondering if anyone has experienced any high degree of flammability with some of the non-corrosive, translucent sidings that are being sold in fertilizer industry. Fiberglass types are something we have experienced that it doesn't meet with the specifications that it is sold under.

MR. POWERS: Thank you, the question was have we experienced any difficulties with the plastic type of siding and the flammability. Well, I think there are types that can be purchased that have a flame spread rating of less than 25. From my own experience, our Loss and Prevention Department and our underwriters vote against even those on account of the smoke situation that develops where you can't get in to fight the fire and the toxic fumes. We have been asked not to use it, or to use it quite limited.

But what you say is very true. There are a lot of materials on the market that are highly questionable. They are wonderful for corrosion but it is highly questionable whether we should use them. We've learned a few things the hard way with some roof panels as far as the expansion and contraction. We bought some good materials one time that we thought would do a real job and everything was checked, but nevertheless they still sagged and we lost the whole works. There are a lot of materials offered, and I think it is most important that all the specifications be checked and see what kind of underwriters' label is available for those materials.

QUESTION: I have a question for Mr. Powers about this initital phase of your maintenance program. When you are considering the investment, how much of the investment's emphasis do you feel is placed on paitning and protective coatings?

MR. POWERS: I am afraid I am a sinner. In my judgment on protective coatings, we've tried them all and we've gone to some pretty fancy painting systems by our standards, but I think that bitumastic paint is better than any epoxy system and seems to hold up better. A black bitumastic paint system is our standard today. We have a plant in Texas City, Texas with very high humidity down there on the Gulf Coast. A truck loading dock that I know for a fact was sandblasted, primed properly, and a professional group put a pretty fancy epoxy paint on the structure. In a year's time if I hadn't known it was done, I wouldn't have believed it. I thought we did the best, but converse to that where we applied the bitumastic paint over primer, it held up a lot longer in those areas. Its somewhat difficult to apply. A lot of painters don't like to use it.

We have been guilty of being in a rush to get something built, and unfortunately there's just a prime coat of paint.

QUESTION: I would like to comment that I came from Alberta, Canada and that the annual precipitation is not less than 15" a year total in our area. We observed that the bitumastic paint coatings dry out and crack. And we've had the problem and still do that it actually is undermining the metal. We have had the best luck in our area with two coats of a vinyl paint. And I imagine this varies with the environmental conditions.

L. DUDLEY GEORGE: Thank you very much, sir. That is a very valuable observation. I imagine most of you heard the comment that in a dry area, the gentlemen was from Alberta, Canada, where the rainfall is less than 15" per year, they have trouble with bitumastic paint drying out, cracking and getting corrosion there, and they don't feel that its as suitable as some of the vinyl paints.

MR. POWERS: Dudley, if I may make one comment along those lines. In the Texas area we have gone to a pretty extensive program on anything that we build of going back to timber, and as far as practical to minimize corrosion. A couple of years ago, we finished revamping the complete shipping facilities and used timber just as far as practical, including conveyor covers. That's been our answer down there as far as I'm concerned to eliminate some of the maintenance costs we have experienced with steel rusting out, regardless of painting systems.

QUESTION: I have a question for Mr. Powers or Mr. Medbury, whomever it pertains to. What are your thoughts on the use of shift maintenance to reduce productive downtime?

MR. POWERS: Well, I think it depends on the type of plant you are operating. From my experience where we have 24 hours operations, we have shift maintenance. It certainly has paid off.

In our larger complex plants, we still have shift maintenance. In some cases there's only one man. In the smaller plants, even though we run two shifts, we have no shift maintenance. I think that we have had pretty good experience with shift maintenance. If they weren't busy, they were always doing something else such as checking or replacing lines, etc. That would take the time away from the day forces. We've always tried to operate our 24 hour operation to definitely schedule maintenance downtime. We take 4 hours for maintenance purposes.

QUESTION: I would like to ask Mr. Powers that of the 24 hours, if you are running 20 and 4 are for maintenance, what do you consider the operating factor?

MR. POWERS: I would say in the neighborhood of 85%.

QUESTION: What is being done to replace impact knockers on your granulators and dryers, Mr. Powers? Is anything being done along that line?

MR. POWERS: I am working on it, is all I can say. I have no answer. The question is what is being done to replace impact knockers on the granulators and dryers. I don't have an answer. Does anyone have one here?

AUDIENCE COMMENT: I just got here 10 minutes before the last speaker ended, and I haven't sort of gotten oriented yet. Some years ago, we switched from knockers on our granulators to the loose rubber panel lining, and we have been using it for about 10 years. I have often dreamed of being able to do the same thing in a dryer, but I haven't come up with any fabric or material that will stand the temperature. But we like the rubber lining in granulators very much better than the knockers. We have had some trouble finding a good rubber material. Right now, we are using a standard fairly light conveyor belt with a high temperature cover.

L. DUDLEY GEORGE: Thank you very much. A question here.

QUESTION: Is the type of rubber liner you use a panel type, or is it a completely sealed rubber lined interior?

REPLY: We have in one granulator, lining two feet wide in strips lengthwise on the drum, and the other one is 30" wide and is held down in the edges with bolted-down stainless steel bars all the way through.

MR. POWERS: Along with the granulator, of course, there is the mechanical hydraulic driven scrpaer or a fixed scraper. We have jydraulic scrappers in most of our plants and we are trying one with the rubber panel, and so far so good.

QUESTION: What was the life expectancy of your rubber liner in your ammoniator-granulator? We have one ammoniator-granulator and one just plain drum granulator, and the ammoniator-granulator was only installed in 1968. We have replaced the panels within the last year for the first time.

MR. MEDBURY: I can add a little something, perhaps. At one of our plants we have a rubber lining that has been in service for about 15 or 16 months, and this plant produced 191,000 tons of NPK mixes last year. So you see, we are in the 230th or 40th thousandth ton on this unit, and it is still in service.

The trick with rubber lining is at the ends of these two feet wide panels. You can fasten the sides rather easily. The gimmick is how to secure the ends so that the corrosive stuff doesn't get under there. This is difficult. You have to make a spacer that fills the void so that you keep a tight seal of the inlet end of the ammoniator drum. this keeps it tightly sealed there. Then if you use a stationary retaining dam you have a similar problem at the discharge end behind the dam, and this was probably the cause of most of our lining failures — an inability to prevent build-up at that point because of the presence of the bolts and what not that hold this all together right behind the dam where you have the wettest and stickiest material. And you have a natural impediment there to the rolling action of the bed, and you get eventually a cake material formed which really destroys a lot of the rolling action of the bed and also sometimes builds up as far back as the spargers. The way to overcome this problem is to eliminate the retaining dam as being part of the drum, but make it instead an individual stationary dam support from the center to a bar support, just a half-moon shaped piece of steel supported by struts, and leave about ½" of clearance on the bottom of this half-moon shaped piece of steel to the surface of the rubber lining. Then you bring your rubber lining all way out to the front lip, and then you can secure it properly.

And this is how we've finally solved that problem, and since that time we have had virtually no failures. Other plants, several of them, have run a year or more. They haven't produced quite as much tonnage as the one I mentioned, but they haven't failed us yet either.

L. DUDLEY GEORGE: Is there another question? Gentlemen, our panel has been most gracious to us. You are a fine audience. On behalf of our group I want to thank our panel.

Wednesday, December 4, 1974

Morning Session
Moderator: Bill E. Adams

MODERATOR ADAMS: This ia our third session. All of the previous papers given have been exceptionally informative. Our attendance has been a real good turn out this morning. Sit back and relax. We have more timely and interesting subjects to be thoroughly discussed.

Our first discussion "Production Of Granular Ammonium Phosphate Sulphate — NPK Mixtures" prepared by Hubert L. Balay and Frank P. Achorn, Chemical Engineers at TVA, will be given by Frank Achorn. Frank and Hubert have given a number of "Papers" at past "Round Table Meetings" and are well known to all of us. They need no further introduction. Frank please.

Production of Granular Ammonium Phosphate Sulfate NPK Mixtures

Frank P. Achorn

and

Hubert L. Balay

In 1973 about 800,000 tons of P_2O_5 as wet-process phosphoric acid (54% P_2O_5) was shipped from producers to conventional ammoniation-granulation plants and used with about 900,000 tons of sulfuric acid to produce about 10 million tons of granular ammonium phosphate sulfate NPK mixtures. Many plants use superphosphates as a source of P_2O_5 in addition to the phosphoric acid.

Plant design has improved through the years and extra equipment has been added. The typical ammoniation-granulation plant shown in Figure 1 has a preneutralizer for partial ammoniation of the phosphoric and sulfuric acids and has a conventional TVA-type rotary granulator (sizes vary from 7 by 14 to 10 by 20 feet). Product from the granulator is usually dried in a rotary cocurrent dryer.

Many companies have found it advisable to screen the product from the dryer for oversize and fines removal. The oversize is crushed and rescreened, and the hot fines are recirculated to the ammoniator-granulator. Only the on-size product is cooled, usually in a rotary cooler. Product from the cooler is again screened on vibrating screens, and the fines are recirculated to the ammoniator-granulator along with fines from the cyclone dust collectors. Exhaust gases from the dust collectors are usually scrubbed in impingement or venturi scrubbers. Water from the scrubbers is recirculated and some of it is used in the ammoniator-granulator or the preneutralizer.

Operations Without Preneutralizer

In plants without a preneutralizer phosphoric acid is usually added to the surface of the bed of material in the ammoniator-granulator and the sulfuric acid is added beneath the bed. The recommended sparger design used in many plants is shown in Figure 2. Companies that formerly added sulfuric acid above the bed of material in the ammoniator-granulator now add it beneath the bed to minimize the formation of ammonium chloride aerosol which is very difficult to remove by scrubbing and is considered an air pollutant.

The ammonia sparger usually runs the full length of the ammoniation section except for 18 inches of clearance between the sparger and retaining rings on both ends of the ammoniation section. The ammoniation section is usually about 85 percent of the total length of the granulator. The granulation section makes up the remaining 15 percent of length and usually does not have a retaining ring on the discharge end. The ammoniation section has a retaining ring which fits closely around the feed chute but with enough clearance so that the ring can rotate freely around the feed chute. The discharge ring of this section usually has a depth between 15 and 20 percent of the diameter of the granulator. The phosphoric and sulfuric acid spargers are about two-thirds as long as the ammonia sparger. The sulfuric sparger is mounted above the ammonia sparger with a clearance of 2 inches between them. Spargers are usually made of stainless steel pipe (type 316L). However, some companies use Hastelloy C pipe for sulfuric acid spargers; some use PVC plastic pipe for phosphoric acid spargers. Formulations that do not require the use of a preneutralizer are shown in Table 1.

One of the main problems encountered in producing ammonium phosphate sulfate in a plant of this type is that the quantity of phosphoric acid that can be used in the formulation is usually limited to 400 pounds per ton and sulfuric acid is usually limited to 200 pounds per ton. Tests have shown that the total heat of neutralization or the chemical heat released in the ammoniator-granulator usually should not exceed 180,000 to 200,000 Btu per ton of product. The total heat of neutralization is calculated from these individual heats of neutralization.

Heats of Neutralization

Materials	*Btu/Pound of Ammonia* [a]
Phosphoric acid (54% P_2O_5)	2220
Sulfuric acid	2696
Normal superphosphate (20% P_2O_5)	1428
Triple superphosphate (46% P_2O_5)	1643

[a] Ammonia assigned for use by the materials shown in first column.

Formerly all companies ammoniated phosphoric acid with 7.2 pounds of ammonia per unit of P_2O_5. At this degree of ammoniation, solubility of salts is high and the amount of liquid phase supplied by the acid in the ammoniator-granulator is high. Figure 3 shows the solubility curve of ammonia and phosphoric acid at the degree of ammoniation of 7.2 pounds of ammonia per unit of P_2O_5 from phosphoric acid. The quantity of salts that will remain in solution in 100 pounds of water is 110 pounds.

Some companies have found it advisable to lower the degree of ammoniation to about 5 pounds of ammonia per unit of P_2O_5. Data in Figure 3 show that at this degree of ammoniation, solubility of salts in solution is much lower (33 versus 110 pounds of salt per 100 pounds of water). At this lower degree of ammoniation, as much as 600 pounds of phosphoric acid per ton of product can be added. Most companies find it preferable to use a preneutralization tank if more than 600 pounds is to be added.

Preneutralizer Operation

Of the several types of preneutralizers, the one shown in Figure 4 is common. It is made of stainless steel, and exhaust from the unit is usually scrubbed in an impingement or cyclone scrubber with the incoming phosphoric acid for the process. This preneutralizer usually operates at an $NH_3:H_3PO_4$ mole ratio in the slurry of 1.5 (pH between 6.0 and 6.5 depending on impurities). At this mole ratio, corrosion of the stainless steel preneutralizer walls is negligible, and solubility of salt in the slurry is high (Figure 3). The slurry usually contains only 20 percent moisture and has a temperature of 240 degrees to 250 degrees F. In this condition it can be pumped and uniformly distributed onto the material in the ammoniator-granulator. There is some loss of ammonia from the preneutralization tank (estimated to be about 2 percent of the total ammonia added to the preneutralizer); this ammonia is usually reclaimed in the scrubber and returned to the granulator or the preneutralizer.

Some companies prefer to operate the preneutralizer at a lower $NH_3:H_3PO_4$ mole ratio to prevent loss of ammonia from the preneutralizer. At the lower ratio, it is not necessary to return scrubber liquor to the ammoniator-granulator where it has a tendency to upset the water balance of the process and to increase the liquid phase in the ammoniator-granulator thereby causing some increase in recycle rate and a reduction in the production rate. These companies usually install a preneutralizer similar to the one shown in Figure 5. This preneutralizer has a mild steel shell with a rubber and acid-proof brick lining. A preneutralizer of this type is usually operated at an $NH_3:H_3PO_4$ mole ratio as low as 0.6 without corrosion problems. At this lower degree of ammoniation, there is no loss of ammonia from the preneutralizer and the solubility of the salts in the slurry is high so that moisture content of the slurry can be as low as 10 percent and it can still be pumped and distributed in the ammoniator-granulator. The preneutralizer (Figure 5) is equipped with a condensing scrubber that consists of a large pipe into which cool water is sprayed. As the exit gas from the preneutralizer is only steam, condensate from the scrubber can be discharged into a drain without introducing pollution problems. As the water rate through the scrubber is high, thermal pollution is low.

In a recent study, operating results were collected in plants with each type of preneutralizer. The flow diagram for the plant in which the first data were collected is shown in Figure 1. Product of a 12-12-12 grade was made. The preneutralizer was made of stainless steel as shown in Figure 4. Usually the exit gases from this preneutralizer are scrubbed to recover ammonia; in these tests, however, the scrubber for the preneutralizer and granulator was inoperative and all the phosphoric and sulfuric acid were added either to the preneutralizer and/or the granulator. This particular preneutralizer is about 7 feet in diameter and 11 feet high and is equipped with a turbine agitator of 26 inches diameter operated at about 100 rpm. Plant results show that therre is much less violent boiling and less tendency for the preneutralizer to overflow when the agitator is in operation.

Liquid anhydrous ammonia is added through two 1-inch, open-end pipe spargers that discharge the ammonia about 6 inches from the tips of the blades of the turbine agitator. Phosphoric and sulfuric acid are added onto the surface of the liquid in the preneutralizer through the open-end pipes. A small quantity of fresh water is added with the liquid anhydrous ammonia to prevent frosting and buildup of solids on the outside walls of the sparger. Large quantities of scrubber water are added to the surface of the liquid in the preneutralizer to control moisture in the slurry and the temperature of the slurry within the preneutralizer. Figure 6 shows a sketch of the slurry distributor for the ammoniator-granulator. It consists of a 2-inch stainless steel pipe 8.9 feet long. It has nineteen 3/8-inch holes with seventeen 1/4-inch holes between the 3/8-inch holes plus three 1/4-inch holes at the beginning of the perforations. No holes are located in the first 40 inches of the pipe. The slurry discharges from the sparger onto the center top surface of the bed of material in the ammoniator-granulator. The slurry streams cover about the first 6 feet of bed length.

The rotary ammoniator-granulator is a conventional TVA type and is 8 feet in diameter and 16 feet long. It is equipped with an exhaust blower with a capacity of 10,000 cfm (30 hp). The ammoniator-granulator has a retaining ring on the feed end about 30 inches deep and another retaining ring on the discharge end about 19 inches deep. The retaining ring at the discharge end is placed about 2 feet from the actual discharge end of the granulator so that there is a small area at the discharge end that does not have a retaining ring but has a shallow bed. The operators report that it is easier to observe the granulation efficiency in a shallow bed than in the deeper bed caused by the retaining rings.

Figure 7 shows the ammoniator-granulator with the slurry sparger and the anhydrous ammonia, sulfuric acid, and phosphoric acid spargers. The sparger arrangement is quite similar to that shown in Figure 2, except that the slurry sparger location is also shown. The ammonia sparger has an overall length of about 12 feet and contains 142 holes. These holes are 1/16 inch in diameter and are placed on 1-inch centers. The ammonia sparger is located at about the 4 o'clock position 6 inches from the granulator shell. Holes of the sparger are directed so that they face the rotating stream of materials in the granulator. The sulfuric acid sparger is 8 feet long and is mounted about 2 inches above the ammonia sparger. It has ninety-four 1/8 inch holes drilled on 1-inch centers, and opening upward.

The phosphoric acid sparger is installed above the bed of material in the ammoniator-granulator. It is a 2-inch stainless steel pipe and is 8.9 feet long. Starting at the feed end of the granulator there are no holes for the first 46 inches, then twelve 3/8-inch holes on 3-inch centers. The next has no holes as the sparger spans a brace in the granulator. Finally there are four 3/8-inch holes on 3-inch centers.

The ammoniator-granulator discharge into a cocurrent dryer 9 feet in diameter and 62 feet long (25 million Btu burner and a 25,000 cfm exhaust blower). Material from the dryer is screened on two series of single-deck screens mounted in steps so that one screen will overflow into the following screen. Fines from the screens are recycled to the ammoniator-granulator. Crushed oversize and on-size product are conveyed to the cooler. The cooler is a rotary cocurrent type 7 feet in diameter and 60 feet long. Product from the cooler is screened on another series of screens also installed in steps so that one screen discharges onto another. Fines from the screen are recycled to the ammoniator-granuulator and product is conveyed to storage or recycled back to the ammoniator-granulator. The amount of product returning to the granulator is controlled by an adjustable baffle, pneumatically operated, in the final product hopper of the screens.

Flow rates of the acid (H_3PO_4 and H_2SO_4) to the preneutralizer and ammoniator-granulator are measured by magnetic flowmeters. Slurry from the preneutralizer to the ammoniator-granulator is also measured by a magnetic flowmeter. Water and liquid anhydrous ammonia are measured by rotameters and solid raw materials are weighed in a batch scale and conveyed by a belt conveyor along with recycled fines to the ammoniator-granulator.

Two tests were conducted for production of the desired 12-12-12 grade. In these tests all the P_2O_5 was supplied by wet-process phosphoric acid as well as part or all of the ammonium sulfate by sulfuric acid and ammonia. Test results are shown in Table 2. Also shown in this table are results obtained when the company's standard formulation was used (no preneutralizer). Some difficulty was encountered with the meters for measuring the feed rates of both acids to the preneutralizer. After the tests these meters were calibrated and it was determined that in test 1 the materials fed into the plant would result in a nominal 13-18-9 grade. In test 2 the nominal grade was a 13-14-10. Formulations actually used in the tests are shown in Table 2.

In the formulation for test 1, about 68 percent of the materials were liquid; in test 2, 77 percent of them were liquid whereas in the standard formulation only about 20 percent of the materials were liquid. Plant operators preferred to use as much liquid as possible because of ease of handling and suppression of dust.

In test 1, only 2.3 units of nitrogen were supplied by ammonium sulfate and about 11 units by anhydrous ammonia. Because large quantities of acids and ammonia were used and to prevent overgranulation in the ammoniator-granulator, some of the acids ammoniated in the preneutralizer. All the phosphoric acid and about 30 percent of the sulfuric was added to the preneutralizer.

In conducting this test, feed rates to the preneutralizer were maintained to give a maximum solubility of salts in the slurry of the preneutralizer. The $NH_3:H_3PO_4$ mole ratio in the slurry was kept at about 1.5 (Figure 3 shows this is the maximum solubility point) and sufficient ammonia was also added to convert the sulfuric acid to ammonium sulfate. At this mole ratio the slurry had good flow and pumping characteristics with a relatively low water content (about 15 to 20%). This high solubility condition is not desirable for operation of the ammoniator-granulator since the liquid phase in the granulator would be high and a very high recycle rate would be required. Therefore, the rates of sulfuric acid, phosphoric acid, and ammonia to the ammoniator-granulator were set so that the phosphoric acid would be ammoniated to an $NH_3:H_3PO_4$ mole ratio of 1.0. As mentioned earlier, the solubility of salts in the granulator at a mole ratio of 1.0 is about one-seventh of that which occurs at a mole ratio of 1.5. This lower solubility in the ammoniator-granulator is desirable so that there will be a low amount of recycle required and a good production rate can be attained.

Results from test 1 show that the plant could be operated well at a production rate of 20 tons per hour. The average $NH_3:H_3PO_4$ mole ratio in the slurry was 1.5 and the slurry temperature was 242 degrees F. The specific gravity was 1.5, and chemical analyses indicate that the moisture content was about 20 percent. At these conditions, the slurry pumped well and there was no difficulty encountered with plugging of lines to the distributor or with holes in the slurry distributor. It was observed that slurry temperature and $NH_3:H_3PO_4$ mole ratio were excellent means of controlling the fluidity of slurry to the ammoniator-granulator. In these tests the mole ratio was determined by first titrating a sample of slurry to a pH of 7.8 with a 0.5 normal sodium hydroxide solution. Next, the solution was titrated with 0.5 normal sulfuric acid solution until the pH of the slurry was lowered to 4.0. The mole ratio was then calculated from the formula

$$2.00 - \frac{\text{ml } 0.5N\ NaOH}{\text{ml } 0.5N\ H_2SO_4}$$

The specific gravity was determined by weighing 100 cc of the slurry. The plant operators stated that the determination of the mole ratio in the preneutralizer slurry and the pH of the product from the granulator are relatively simple determination and assisted in controlling the granulation characteristics in the ammoniator-granulator. In these tests the preneutralizer operated well at an average evaporation rate of 218 pounds of water per hour per square foot of preneutralizer cross section. This is about twice the normal rate in large diamonium phosphate plants. The ammoniation rate per unit of liquid volume was 21.4 pounds of ammonia per cubic foot, which is also about twice the rate in large diammonium phosphate plants.

When the product from the ammoniator-granulator was passed through the dryer, little or no heat was required. Most everyone agreed that probably the burner to the dryer could have been turned off. The product produced during the test had an excellent size distribution with essentially all in the —6 +20-mesh size range. Moisture of content of the product was only 0.5 percent with practically no drying. Since this moisture content is very low, probably no drying at all would be required to produce a satisfactory product. The product from test 1 was stored in bags stacked 12 high for 6 months, and there was no caking of the material during this period.

In test 2 no ammonium sulfate was used; the only source of nitrogen in the formulation (13-14-10 grade) was from liquid anhydrous ammonia. About 70 percent of the phosphoric and 60 percent of the sulfuric acid required by the formulation was added to the preneutralizer. The remaining quantities of these materials were added to the ammoniator-granulator. The average $NH_3:H_3PO_4$ mole ratio was 1.60. At this high mole ratio it was possible to detect some ammonia in the steam plume from the ammoniator-granulator. However, the slurry was adjusted to a lower pH in the granulation by adjusting the amount of ammonia added to the granulator. The average pH of the product was 4.6, which is about the pH of mono-ammonium phosphate. The preneutralizer operated satisfactorily and the evaporation rate was 220 pounds of water per hour per square foot; the ammoniation rate was 22 pounds of ammonia per hour per cubic foot of liquid in the preneutralizer. Plant personnel believed that evaporation rates could have been higher.

The average temperature of the material from the ammoniator-granulator was 226 degrees F. No dryer heat was required, and the dryer was operated as a cooler. The product was 0.8 percent. The product had excellent size distribution and remained free flowing in bulk storage for 6 months.

It was more difficult to operate the plant with the formulation of test 2 than with the formulation of test 1. Larger quantities of recycle were required and the production rate was lower. The granulation required very close attention to avoid overgranulation.

During both tests, a heavy steam plume from the preneutralizer was observed. The plume, which contained a small amount of ammonia, often carried over into surrounding areas and caused some nuisance to neighbors. Management of most plants of this type prefer to scrub the emission to recover the ammonia and partially condense the plume.

Data also were accumulated from a plant with a preneutralizer similar to the design shown in Figure 5. The grade of the product was 8-24-24. All the phosphoric and sulfuric acids are added to the preneutralizer. Sufficient ammonia is added to give an $NH_3:H_3PO_4$ mole ratio of about 0.6. Enough supplemental ammonia is added in a 7- by 14-foot TVA-type ammoniator-granulator to increase the degree of ammoniation of the phosphoric acid to an $NH_3:H_3PO_4$ mole ratio of 1.0. Therefore, all the product P_2O_5 is in the form of monoammonium phosphate.

Potash is also added to the granulator and is the only dry material other than recycle. Preneutralizer slurry is usually added to the ammoniator-granulator through an open-end pipe, although a single commercial spray nozzle or a nozzle made from standard pipe elbow flattened to give a spray effect is sometimes used. Material as it exists the ammoniator-granulator is usually at about 230 degrees F. and is discharged into an 8- by 50-foot rotary dryer and then to a 27- by 40-foot rotary cooler. The production rate for the 8-24-24 usually averages about 40 tons per hour. The average recycle rate is about 1.0 to 1.2 pounds per pound of product.

Part of the phosphoric acid used in the process passes through impingement equipment which scrubs dryer exhaust gases. Usually filter grade phosphoric acid (30% P_2O_5) is used in the scrubber and concentrated acid (50 to 54% P_2O_5) is added to the scrubber liquid prior to its addition to the preneutralizer. The average concentration of phosphoric acid feed to the premeutralizer is 40 to 41 percent P_2O_5; only a small quantity of water needs to be added to the preneutralizer. The water is first added to the scrubber and enough sulfuric acid is added to keep the pH of the liquid at 3.0.

The company also reports good results with this type of operation for production of monoammonium phosphate, 12-24-12 grade. The recycle rate is about 2 pounds per pound of product and the production rate is about 30 tons per hour.

Pipe-Cross Reactor

A few tests were made with a new type of preneutralizer that consists of a pipe cross and a reaction tube mounted inside the ammoniator-granulator. The pipe-cross reactor (Figure 8) consists of a 3-inch stainless steel pipe cross into which liquid ammonia, phosphoric acid, and sulfuric acid are admitted. A small quantity of water is premixed with the liquid ammonia to provide smoother operation of the reactor. Acid and ammonia react in the tube section of the reactor — a 3-inch stainless steel pipe (type 316L) encased by a water cooling jacket (8-inch mild steel pipe).

Two tests were made with the pipe-cross reactor in production of a 12-12-12 grade. The formulation and the results are shown in Table 3.

In the first test the proportion of combined acids (H_3PO_4 + H_2SO_4) was about 1000 pounds per ton of product. This is about three times the normal quantity of acids used in a conventional TVA-type ammoniation-granulation plant without a preneutralizer. The plant was operated at 15 tons per hour and about 50 percent of the phosphoric acid and 70 percent of the sulfuric acid required were added to the pipe-cross reactor. The remaining phosphoric acid was dribbled above the bed in the ammoniator-granulator through a drilled pipe-type sparger and the remaining sulfuric acid was added through another drilled pipe sparger mounted in the bed of materials in the ammoniator-granulator about 2 inches above the ammonia sparger.

In the second test the amount of ammonium sulfate was increased from 300 to 500 pounds per ton of product and acid was decreased to about 800 pounds. With this formulation the production rate was 25 tons per hour.

In both tests the ammoniation rate was adjusted in the ammoniator-granulator so that the sulfuric acid would all be ammoniated to ammonium sulfate and the phosphoric acid ammoniated to an NH_3:H_3PO_4 mole ratio of 1.0. The product in both tests contained well-shaped granules of satisfactory particle size with excellent storage characteristics.

There was significantly less plume from the stack of the dryer and the ammoniator-granulator when the pipe cross was used. Figure 9 compares stack conditions with and without the pipe cross. This improved stack condition was attributed to the spraying of hot ammonium phosphate sulfate slurry over the bed of granular material in the ammoniator-granulator which prevented the escape of ammonium chloride fume from the bed. Plant tests show that when the pipe-cross reactor is used and when the phosphoric acid is ammoniated to monoammonium phosphate, no external heat source is required for drying material from the granulator and hence, there is less plume.

One difficulty encountered with the pipe-cross reactor is corrosion of the stainless steel tube of the reactor. Plant tests show that stainless steel types 304 and 316 are corroded by the hot slurry. Presently tests are being conducted with a stainless steel type 316L tube. Although there has been corrosion at welded joints, this tube has been in operation for several months without excessive corrosion. later a pipe tube made of Hastelloy C metal will be tested. If these corrosion problems can be solved, this type of equipment should have considerable promise for the production of ammonium phosphate sulfate grades. This reactor will be used to replace the preneutralizer, pumps, and other equipment normally associated with a plant having a preneutralizer.

With the pipe-cross reactor it should be possible to use larger quantities of phosphoric and sulfuric acids in the formulation. Also for plants that prefer to use sulfuric acid, the pipe-cross reactor provides a way to preammoniate the sulfuric acid in the formulation so that there will be less tendency for the formation of ammonium chloride in the ammoniator-granulator.

Table 1

Granulation of Ammonium Phosphate-Sulfate in Conventional Ammoniation-Granulation Plant

Grade	13-13-13	8-32-16
Formulation, lb per ton		
Ammonia	120	100
Ammonium sulfate	790	-
Diammonium phosphate (18-46-0)	213	490
Triple superphosphate (46% P_2O_5)	-	500
Phosphoric acid (54% P_2O_5)	300	382
Sulfuric acid	150	62
Filler	35	-
Potash (60% K_2O)	433	540

Table 2

Production of Ammonium Phosphate-Sulfate Using Preneutralizer

Grade	13-18-9	13-14-10	12-12-12[a]
Test No.	1	2	Standard
Duration of tests, hrs	10	7	12
Average production rate, tons/hr	20.3	18.7	25.3
Formulations, lbs/ton of product			
Preneutralizer:			
Anhydrous ammonia	203	226	-
Phosphoric acid (54% P_2O_5)	683	355	-
Sulfuric acid (93% H_2SO_4)	221	473	-
Granulator:			
Anhydrous ammonia	65	97	100
Ammonium sulfate	221	-	861
Sulfuric acid (93% H_2SO_4)	254	316	168
Phosphoric acid (54% P_2O_5)	-	177	124
Potash	294	305	400
Filler	162	178	-
Recycle rate, lbs recycle/lb prod.	2.0	2.5	1.0
Operating results			
Preneutralizer:			
$NH_3:H_3PO_4$ mole ratio in slurry	1.5	1.60	-
pH of slurry	6.6	6.9	-
Slurry temperature, ^{o}F	242	227	-
Slurry moisture	20	30	-
Slurry, sp. gr.	1.5	1.49	-
Evaporation rate, lbs water/hr/sq ft	218	220	-
Ammoniation rate, lbs NH_3/hr/ft^3 liquid	21.4	22.0	-

[continued]

Granulator:			
Material discharge temperature, °F	196	226	190
Material discharge, pH	4.5	4.6	-
Dryer:			
Material discharge temperature, °F	185	190[b]	180
Cooler:			
Material discharge temperature, °F	95	100	95
Product:			
Temperature, °F	95	100	95
Screen analysis			
+6	4	3	1
-6+8	24	25	23
-8+12	48	51	50
-12+14	14	15	15
-14+16	6	5	7
-16+20	4	1	4
-20	1	0	0
Chemical analysis, % of total:			
N	12.5	-	12.2
Available P_2O_5	18.0	-	13.0
K_2O	10.2	-	11.5
H_2O	0.5	0.8	-

---

[a] Standard formulation without preneutralizer.

[b] Dryer heating flame almost off.

Table 3

Production of 12-12-12 Granular Ammonium Phosphate-Sulfate Using Pipe-Cross Reactor

Date	7/11/74	7/12/74
Test Number	1	2
Feed rates, lbs per ton of product		
Pipe Cross		
Ammonia	141	87
Sulfuric acid (93.2% H_2SO_4)	346(369)[a]	180(220)[a]
Phosphoric acid (54% P_2O_5)	232	232
Water	120	79
Ammoniator-Granulator		
Ammonia	79	84
Phosphoric acid (54% P_2O_5)	232	232
Sulfuric acid (93.2% H_2SO_4)	149(155)[a]	124(122)[a]
Potash (60% K_2O)	400	400
Ammonium sulfate (21% N)	300	500
Filler	215	212

[continued]

Production rate, ton/hour	15	25
Operating time, hours	4	3
Operating results		
Pipe Cross		
Cooling water rate, lb/min (jacket)	101	93
Jacket inlet water temperature, °F	92	109
Jacket outlet water temperature, °F	125	139
Pipe cross pressure, psig	33	40
Granulator		
Product temperature, °F	236	202
Product pH	3.2	4.7
Dryer product temperature, °F	209	156
Product to storage temperature, °F	120	116
Product Screen Analysis		
+6		0
-6+8		10.4
-8+12		29.6
-12+14		39.9
-14+16		10.1
-16+20		6.4
-20		3.6
Product Chemical Analysis, %		
Nitrogen	11.3	11.7
P_2O_5	12.6	11.3
K_2O	11.8	12.5
H_2O	-	0.5

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[a] Actual rate shown as first figure; desired rate in parenthesis.

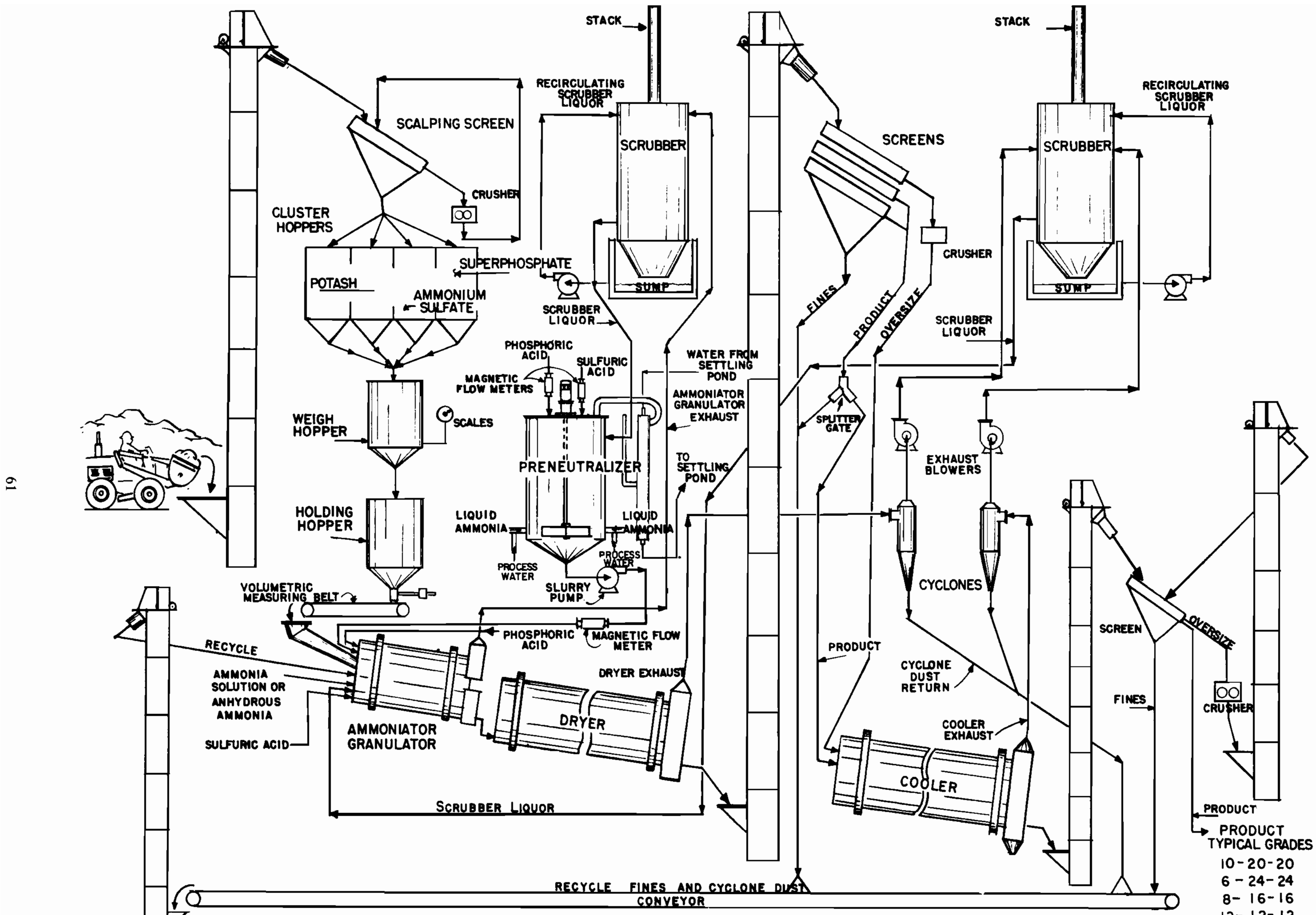
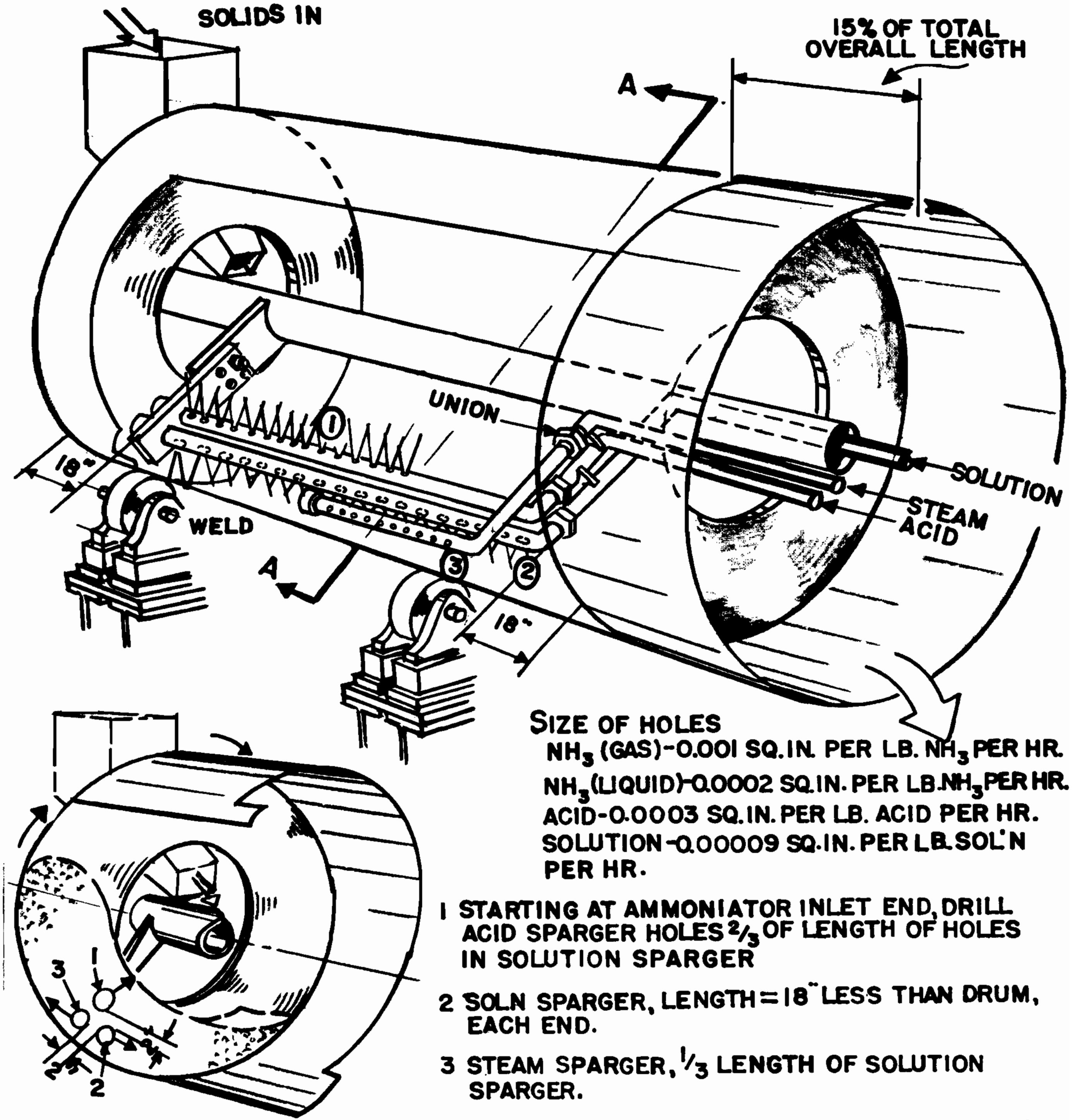


FIGURE I
AMMONIATION GRANULATION PLANT FOR
AMMONIUM PHOSPHATE SULFATE PROCESS



SIZE OF HOLES

NH_3 (GAS)-0.001 SQ.IN. PER LB. NH_3 PER HR.

NH_3(LIQUID)-0.0002 SQ.IN. PER LB.NH_3PER HR.

ACID-0.0003 SQ.IN. PER LB. ACID PER HR.

SOLUTION-0.00009 SQ.IN. PER LB.SOL'N PER HR.

1 STARTING AT AMMONIATOR INLET END, DRILL ACID SPARGER HOLES 2/3 OF LENGTH OF HOLES IN SOLUTION SPARGER

2 SOLN SPARGER, LENGTH = 18" LESS THAN DRUM, EACH END.

3 STEAM SPARGER, 1/3 LENGTH OF SOLUTION SPARGER.

INTERNAL CROSS SECTIONAL AREA OF PIPE > 2X TOTAL CROSS SECTIONAL AREA OF ALL THE HOLES IN THE PIPE.

SPARGER FOR
CONTINUOUS AMMONIATOR GRANULATOR
FIGURE 2

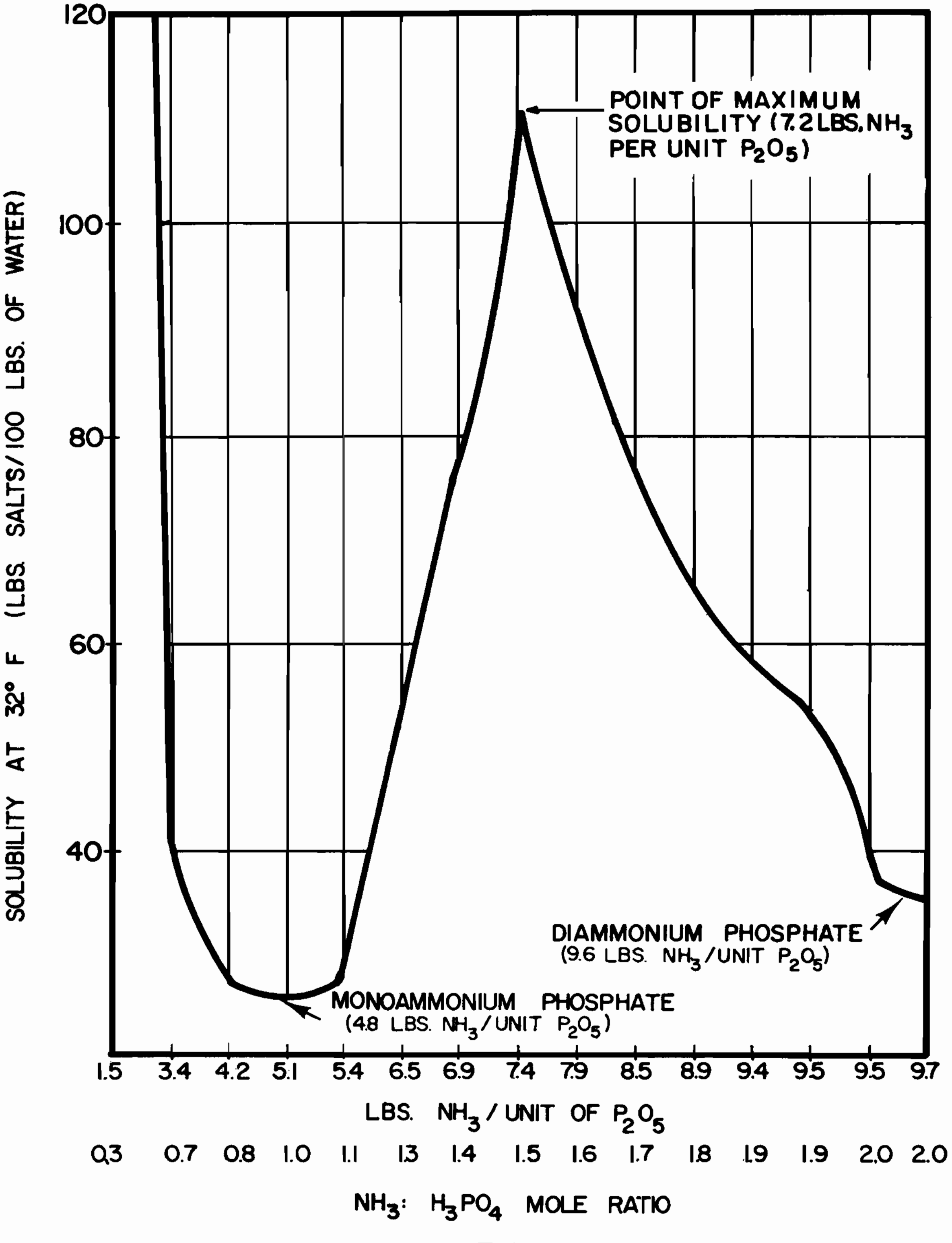
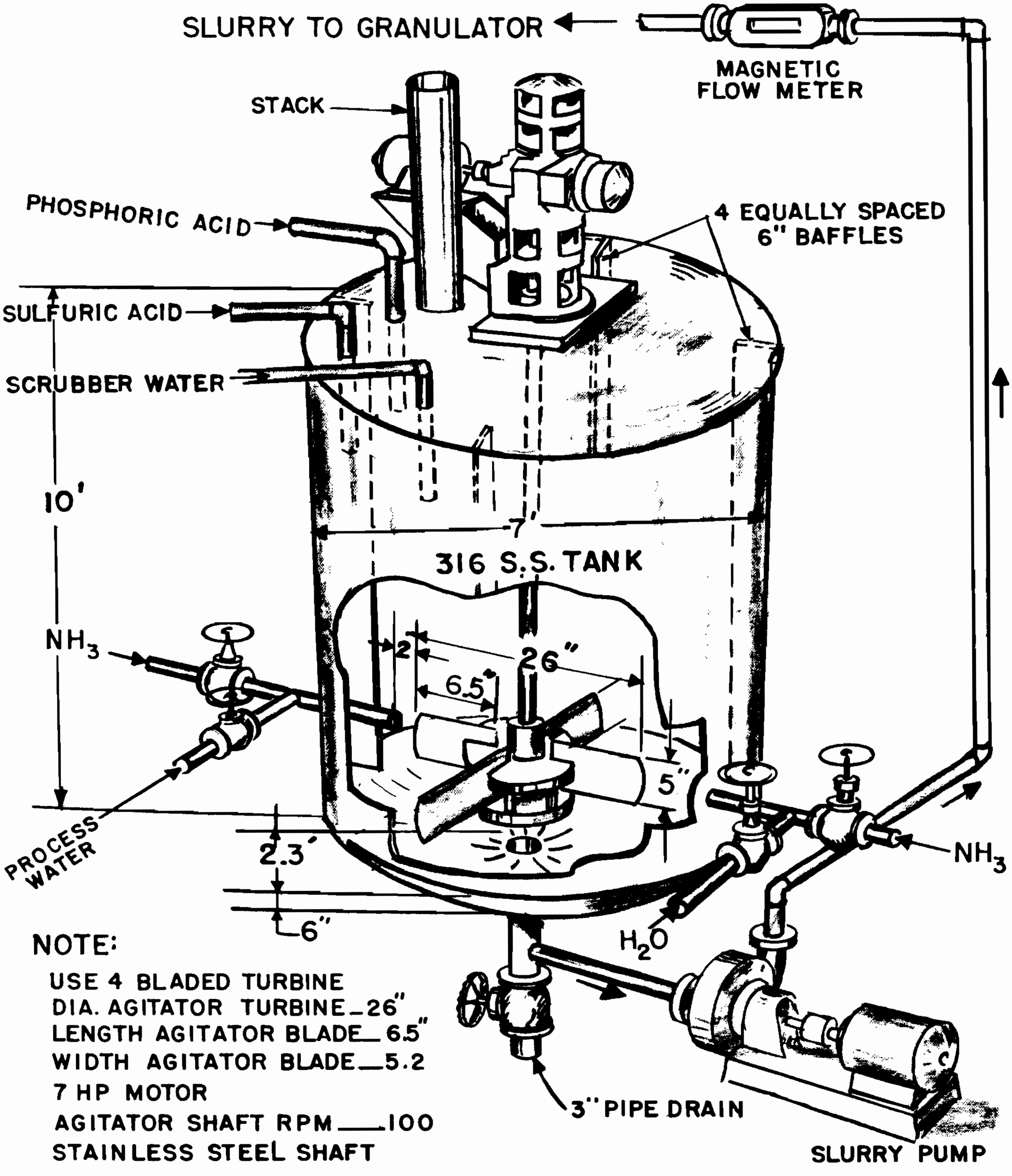


FIG. 3
SOLUBILITY OF SATURATED AMMONIUM PHOSPHATE SOLUTIONS



NOTE:

USE 4 BLADED TURBINE
DIA. AGITATOR TURBINE_26"
LENGTH AGITATOR BLADE_6.5"
WIDTH AGITATOR BLADE_5.2
7 HP MOTOR
AGITATOR SHAFT RPM_100
STAINLESS STEEL SHAFT

FIGURE 4
PRENEUTRALIZATION TANK

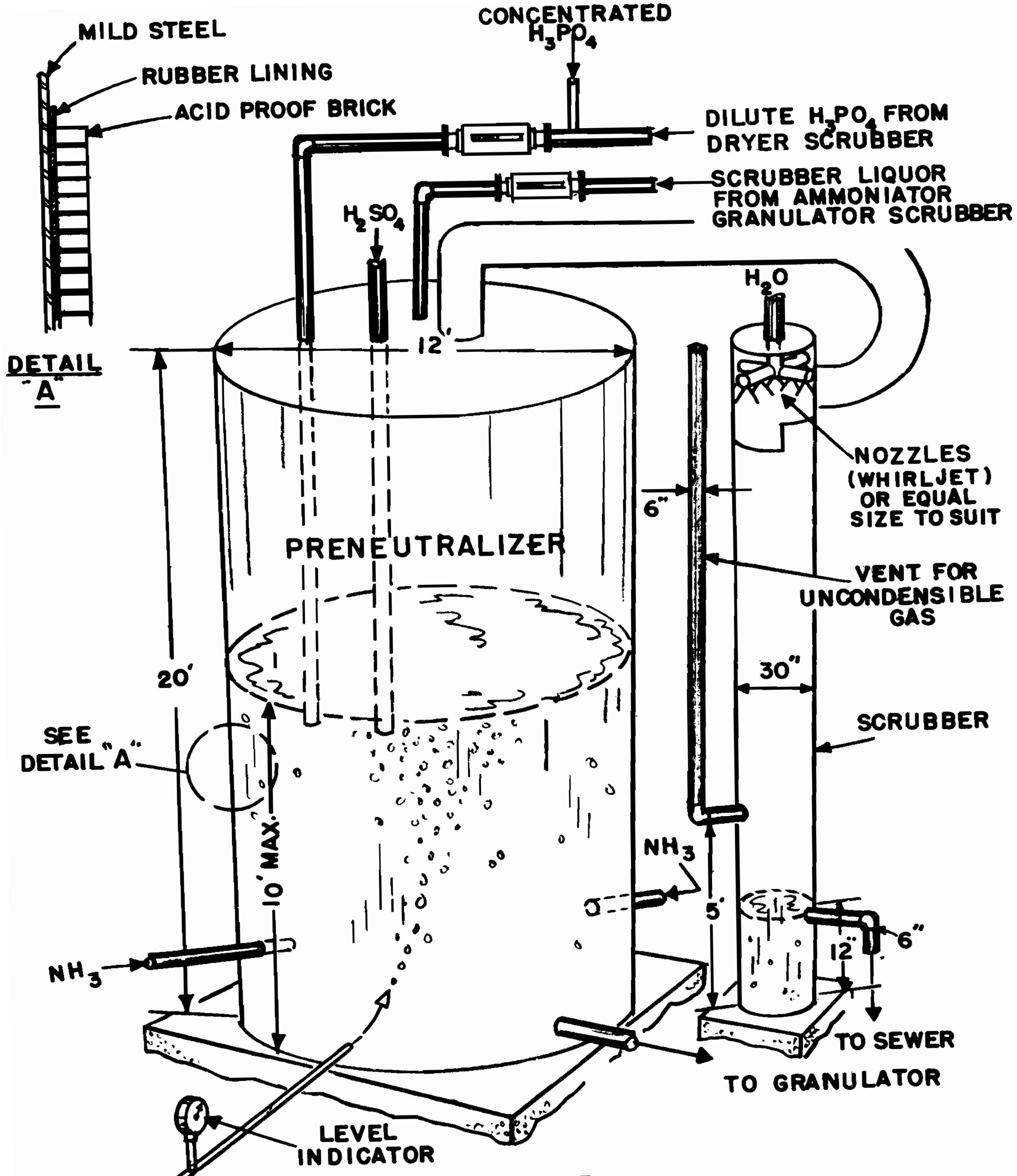
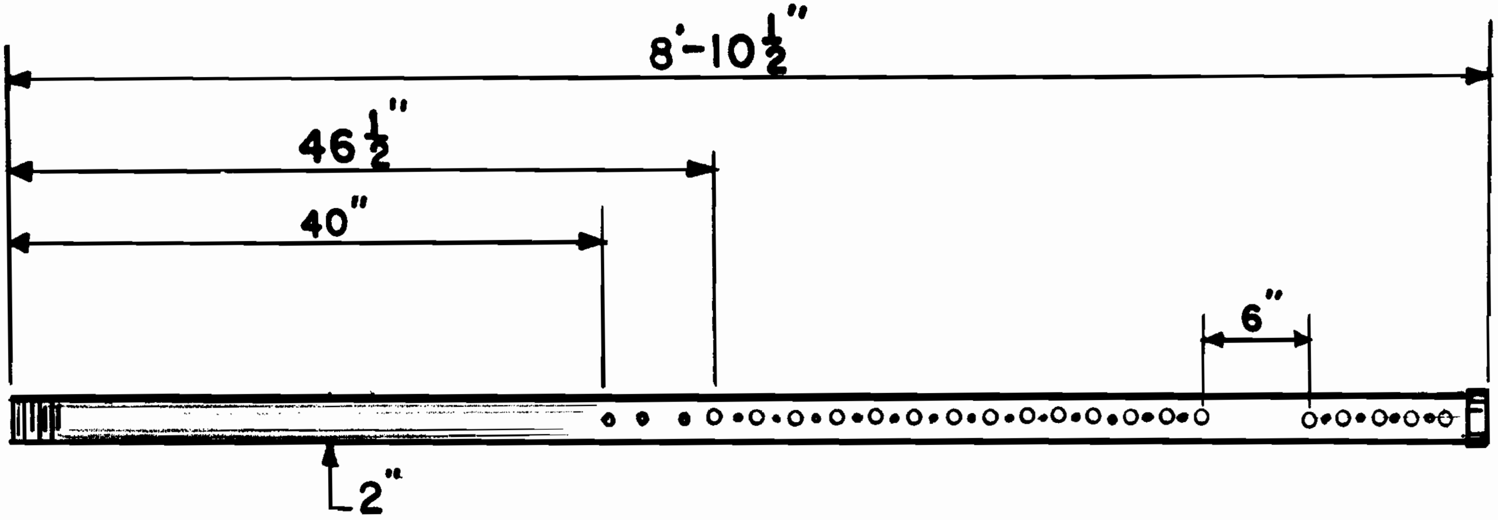


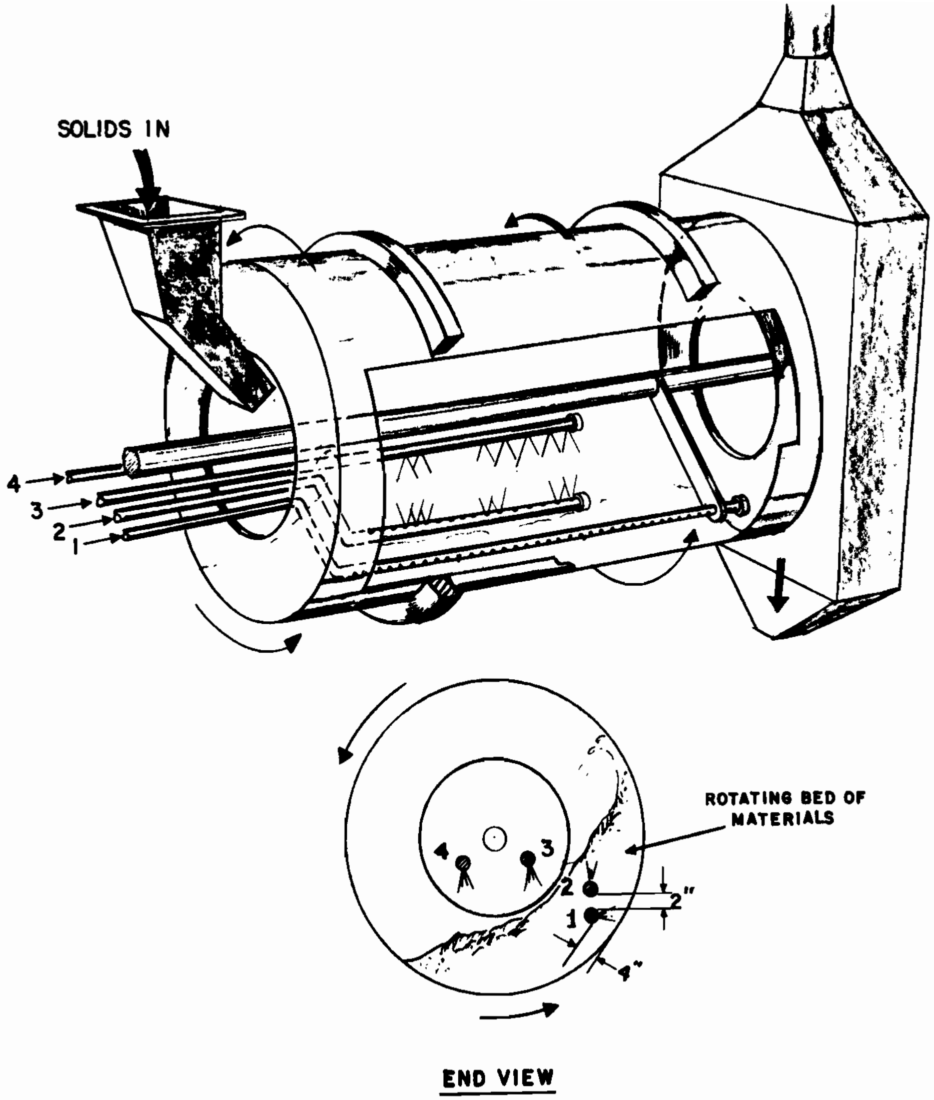
FIGURE 5
BRICK-LINED PRENEUTRALIZER WITH
CONDENSING-TYPE SCRUBBER



1. STARTING AT $46\frac{1}{2}$" —— FOURTEEN $\frac{3}{8}$" HOLES ON 3" CENTERS.
2. SKIP 6" —————— FIVE $\frac{3}{8}$" HOLES ON 3" CENTERS.
3. STARTING AT 40" ———— THREE $\frac{1}{4}$" HOLES ON 2" CENTERS.
4. ONE $\frac{1}{4}$" HOLE HALFWAY BETWEEN EACH $\frac{3}{8}$" HOLE.

FIGURE 6

SLURRY SPARGER
MFA GRANULATION PLANT, PALMYRA, MO.



① **AMMONIA SPARGER**— LOCATED AT THE 4 O'CLOCK POSITION $4\frac{1}{2}$" FROM GRANULATOR SHELL WITH HOLES FACING THE ROTATING STREAM OF MATERIALS. OVERALL LENGTH-12 FEET. ONE HUNDRED AND FORTY-TWO $\frac{1}{16}$" HOLES ON ONE INCH CENTERS.

② **SULFURIC ACID SPARGER** — LOCATED 2 INCHES ABOVE AMMONIA SPARGER WITH HOLES FACING UPWARD. OVERALL LENGTH-8 FEET. NINETY-FOUR $\frac{1}{8}$" HOLES ON ONE INCH CENTERS.

③ **PHOSPHORIC ACID SPARGER** — LOCATED TO DISCHARGE PHOSPHORIC ACID ONTO THE TOP AND NEAR THE CENTER OF THE ROTATING BED OF MATERIALS. OVERALL LENGTH-8.9 FEET. SIXTEEN $\frac{3}{8}$" INCH HOLES ON THREE INCH CENTERS.

④ **SLURRY SPARGER**— LOCATED TO DISCHARGE SLURRY ONTO THE TOP AND NEAR THE CENTER OF THE ROTATING BED OF MATERIALS. SEE FIG. 3 FOR DETAILS OF THIS SPARGER.

FIGURE 7

LOCATION OF SPARGERS IN AMMONIATOR GRANULATOR
MISSOURI FARMERS ASSOCIATION, PALMYRA, MO.

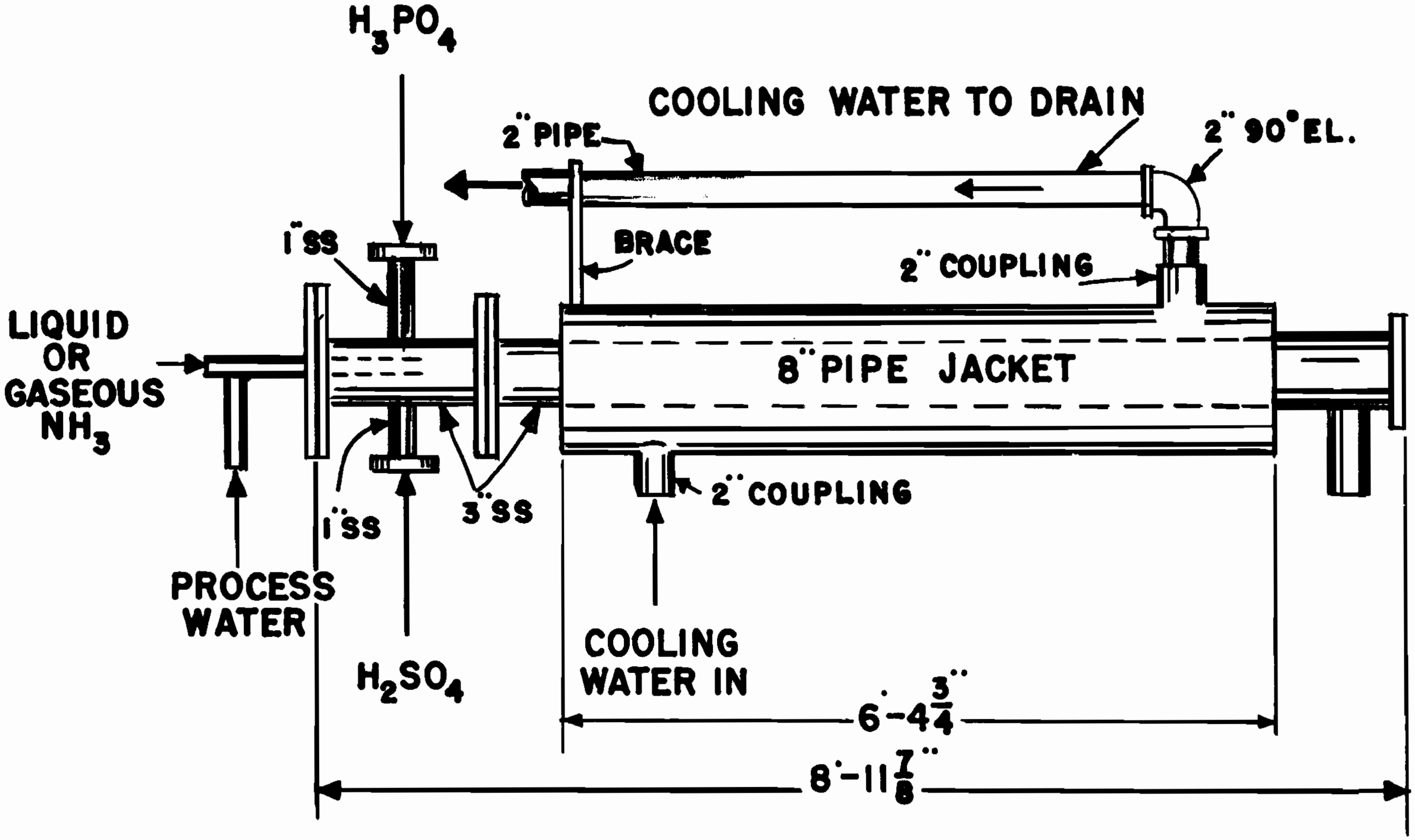
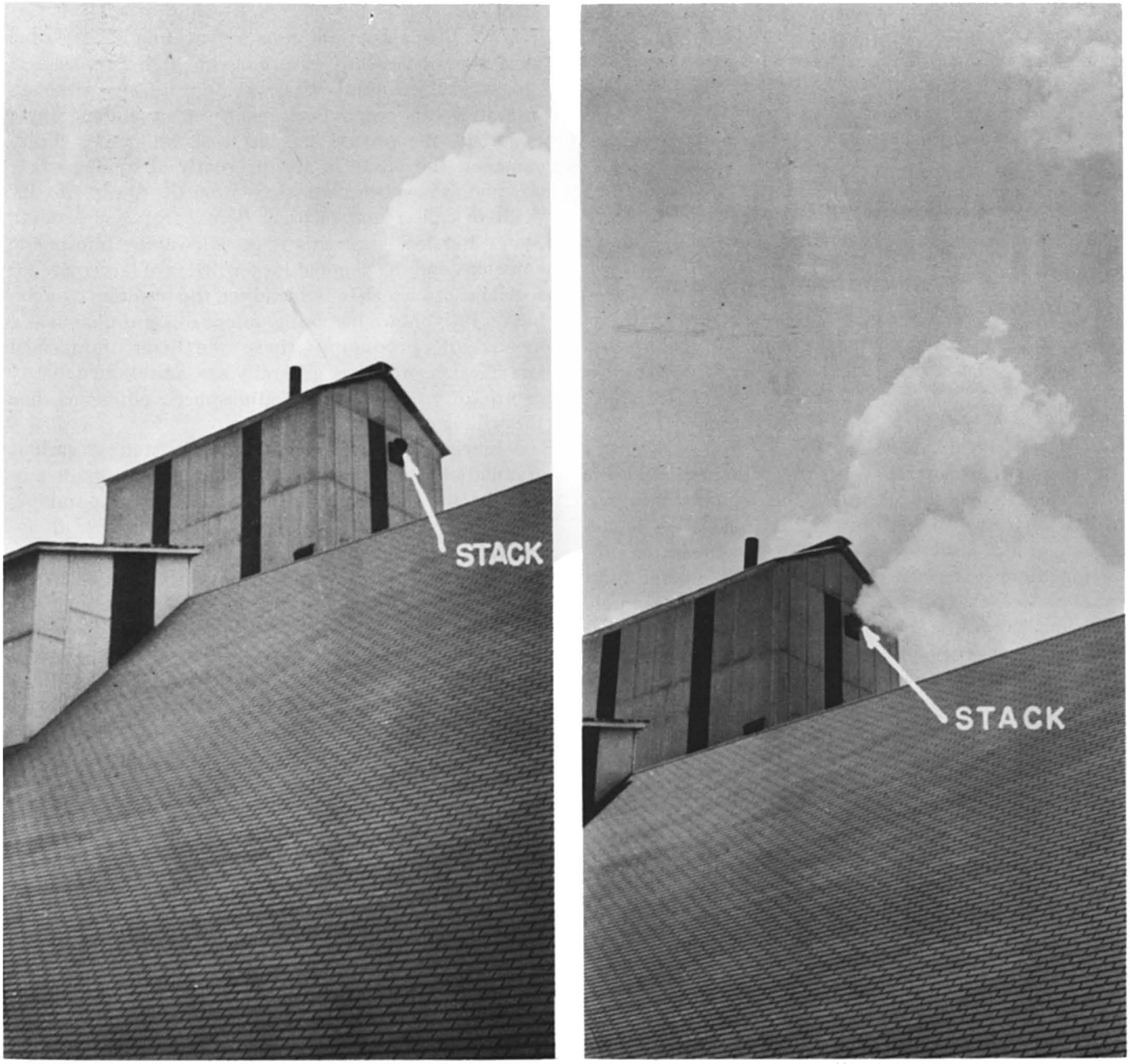


FIGURE 8

PIPE-CROSS REACTOR WITH HOT AQUA AMMONIA

Figure 9
COMPARATIVE
STACK
CONDITIONS



**WITH
PIPE-CROSS**

**WITHOUT
PIPE-CROSS**

MODERATOR ADAMS: Thank you Frank and Hubert. Your discussion and up-to-date information covering Granular Ammonium Phosphate Sulphate NPK Mixtures are most interesting and I am sure will be very helpful to our members.

Our next presentation "TVA Pilot Plant Development Work And Demonstration — Plant Experience in Pan Granulation Of Urea" prepared by D. R. Waggoner, I. W. McCamy, G. C. Hicks and J. R. Gahan will be given by D. R. Waggoner. All of these Gentlemen are TVA Chemical Engineers.

TVA Pilot-Plant Development Work And Demonstration — Plant Experience In Pan Granulation of Urea

D. R. Waggoner, I. W. McCamy,
G. C. Hicks, and J. R. Gahan
Presented by D. R. Waggoner

ABSTRACT

For the past several years, air prilling has been the most common means of producing high-nitrogen fertilizers such as urea and ammonium nitrate. Although prilling is a dependable and economical means of producing these materials, the products are inherently of small particle size, and the high volumes of atmospheric emissions from the prill are difficult to collect and recover. Because of new Federal, State, and local restrictions on allowable atmospheric emissions and the demand for fertilizers of larger granule size (particularly for use in blending), the fertilizer industry has recently shown increasing interest in granulation as a means of producing these fertilizers.

Since the early fifties, TVA has studied various granulation processes for producing fertilizer-grade ammonium nitrate, urea, and mixed fertilizers containing large proportions of these materials. After drum granulators, pugmills, and pan granulators were tested in exploratory studies, TVA concluded that the pan granulator was the most effective for preparing these products. A particularly favorable feature of the pan granulator is the very good classifying action that allows spraying of metls or concentrated solutions specifically on undersize material in an upper quadrant of the pan. Subsequent pilot-plant studies have resulted in the development of processes for pan granulation of both ammonium nitrate- and urea-based products. Both processes have been proved by successful operation of demonstration-scale plants. The pan-granulation process and associated equipment are developed to the point that there are essentially no process losses from the plants. Also, production of granular products with specific physical characteristics required for special uses, such as bulk blending, forest fertilization, and as substrate material for sulfur coating, have been demonstrated. This paper describes TVA development work on pan granulation of high-nitrogen fertilizers with particular emphasis on our latest experience in producing granular urea at a rate of about 9 tons per hour in a demonstration plant.

For the past several years, air prilling has been the most common means of producing high-nitrogen fertilizers, such as urea and ammonium nitrate. Although prilling is an economical means of producing these materials, the process has at least two major disadvantages; the products are ingerently of small particle size and atmospheric emissions from the towers are difficult to collect and recover. Because of new Federal, State, and local restrictions on allowable atmospheric emissions and the demand for fertilizers of larger size for special uses such as bulk blending, the fertilizer industry has recently shown increasing interest in granulation as a means of producing these fertilizer materials. Granulation processes generally are more amenable to control of product size and atmospheric emissions than the prilling process.

Since the early fifties, TVA has studied various granulation processes for producing fertilizer-grade ammonium nitrate, urea, and mixed fertilizers containing large proportions of these materials. The overall objective of this work was to develop processes and equipment that would safely produce fertilizers of better quality and lower costs than could be made with the existing technology. Our mor recent studies have emphasized reduction in process losses and production of granular product with specific physical characteristics required for special uses such as bulk blending, forest fertilization, and substrate material for sulfur coating for controlled release of nitrogen. After evaluating the use of drum granulators, pugmills, and pan granulators, TVA concluded that the pan granulator was more effective than the other types of granulators for making these products. Subsequent pilot-plant studies have resulted in the development of processes for pan granulation of both ammonium nitrate and urea-based products. Both processes have been proven by successful operation of demonstration-scale plants. This paper summarizes TVA development work on pan granulation of high-nitrogen fertilizers and emphasizes our latest experiences in producing granular urea.

Development of Process for Ammonium Nitrate-Based Products

TVA's pilot-plant work on pan granulation of high-nitrogen fertilizers was begun in 1956 when an exploratory test of granulation of ammonium nitrate was made. In this test, a 38-inch pan granulator was used to granulate ammonium nitrate crystals with 95% ammonium nitrate solution. Although the initial test was of short duration, the results were promising; granulation efficiency was high and the product was of good quality. The next pilot-plant studies utilizing the 38-inch pan granulator were made about 2 years later after pilot-plant equipment was installed that permitted operation on a continuous basis. In these studies, 95 to 98% ammonium nitrate solution was fed onto the recycle fines through a drilled-plate distributor located above the deep part of the bed in the pan granulator. The granulator product was dried, screened, and cooled before being coated with a conditioning agent. Good granulation was obtained with granulation temperatures ranging from 200 degrees to 247 degrees F. and recycle ratios that were slightly less than 1. The product had good storage properties when dried to 0.3% moisture and conditioned with 2 to 3% of diatomaceous earth. The conditioned product had good handling properties, but it was not so spherical and smooth as some of the products made during later operation. The solutions used in the tests were prepared by dissolving ammonium nitrate crystals in 83% ammonium nitrate solution and heating the resulting concentrated solution to near the boiling point; about 98% ammonium nitrate was the maximum strength solution that could be made safely in this system. It was visualized that the use of solutions with higher concentrations (99% or above) should have eliminated the need for a drying step.

More extensive pilot-plant studies involving the use of the 38-inch pan granulator were begun in 1961 after TVA decided to build a new demonstration-scale granulation facility for ammonium nitrate products. The earlier studies had shown that the pan is particularly well suited for granulation of ammonium nitrate. The objects of the new work were (1) to develop refinements in all steps of the process; (2) to study production of other products containing ammonium nitrate, and (3) to obtain data that could be used for design of the new plant. These studies resulted in the development of a versatile process in which granular ammonium nitrate and other products containing ammonium nitrate could be safely and cheaply produced with a minimum of process losses[1]. Other grades satisfactorily produced in the pilot plant included 30-10-0 and 25-25-0 ammonium phosphate nitrate, 30-0-0-5S ammonium nitrate sulfate, and NPK grades such as 17-17-17. Process data identifying conditions required for best operation were obtained and critical operating features for the pan granulator were established. After successful operation of the pilot-plant system using the 38-inch pan had been demonstrated, larger pilot plants using 6- and 8-foot pan granulators were built and operated. Operation of the larger units provided the data required for design of the demonstration-scale plant[2].

The process developed for making granulat ammonium nitrate-based products is quite simple. Granulation is accomplished by spraying hot concentrated solutions of the fertilizer salts onto a cascading bed of recycle fines in a pan granulator. The granulator product is dryed, cooled, and screened in conventional equipment. The oversize fraction from the screen is crushed and returned with the undersize for use as recycle material; the onsize product is treated with an appropriate conditioning agent and sent to storage. The heat of reaction from ammoniating the acids is used to concentrate the solution. Some supplemental heat is also required. The nitric acid or mixtures of nitric and phosphoric acids or sulfuric acids are fed to the first-stage neutralizer where most of the required annonia is added. The solution from the first stage is concentrated by evaporation and then ammoniation is completed in the second-stage neutralizer. The solution is concentrated between the two stages of neutralization to minimize ammonia losses. The solution is fed to the pan granulator at a concentration of 95 to 98%. With proper positioning of the spray nozzles which feed the hot solution and with proper distribution of the recycle fines on the pan, the solution solidifies in even layers on the undersize in the upper area of the pan. When the particles reach the proper size, they are discharged by the natural classifying action of the pan before any appreciable amount of oversize is produced. The particle size of the product is influenced by the speed and slope at which the pan is operated. The action in the pan when operated in this manner is illustrated in Figure 1. Cricical features for best operation of the pan granulator include slope, rotational speed, location of sprays, concentration and temperature of the feed solution, and the amount, particle size, and temperature of the recycle material. For best operation there is a definite relationship between the pan diameter, pan depth, slope, and rotational speed. The approximate rotational speed for best results can be calculated from the following relationship

$$\text{Speed of rotation (rpm)} = 1 - \cos\ \theta \left(\frac{76.5}{\sqrt{D}}\right)$$

where θ = slope of pan and
D = diameter of pan in feet

The depth required for a pan granulator of a given diameter can be estimated by the following relationship

$$\text{Depth of pan (in)} = K(\sqrt{D})$$

where K = constant obtained from dimensions of experimental pan and
D = pan diameter, inches

(Fig. 1)

Based on data obtained during the pilot-plant studies with 38-inch, 6-foot, and 8-foot pan granulators, a demonstration-scale plant for production of ammonium nitrate-based products was designed and constructed. This plant [3], with a design capability of 20 tons per hour, was operated from November 1965 until early in 1973. During this period, granular ammonium nitrate (33.5%N), ammonium nitrate sulfate (30-0-0-5S) and ammonium phosphate nitrate (30-10-0 and 25-25-0) were produced at rates up to 23 tons per hour in one 14-foot pan granulator. The process and equipment were developed to the point that essentially no process losses occured in the plant. The TVA pan-granulation process for ammonium nitrate-based products was fully developed and amply demonstrated with 91 to 98% feed soltion and a drying step. Later experiences with pan granulation of urea demonstrated that solutions of higher concentrations (98-99%) could be processed in a pan-granulation system without the need of a drying step.

TVA Pilot-Plant Experience with Pan Granulation of Urea-Based Fertilizers

TVA began pilot-plant studies of pan granulation of urea in 1963. The 38-inch pan granulator, along with other pilot-plant-equipment, was used in the test work. Operating procedures and conditions similar to those used during pan granulation of ammonium nitrate were used as a starting point in the studies; production rates of about 0.5 ton per hour were used. The urea solution used in the tests was prepared by dissolving unconditioned urea prills in hot water. Granulation generally was good when 96 to 98% urea solutions were used as feed to the pan. The granular products were of good quality, but drying was required to obtain moisture levels low enough for satisfactory storage properties. Drying, screening, cooling, and conditioning requirements were about the same as for granular ammonium nitrate.

Urea — ammonium phosphate grades, such as 29-29-0, 33-20-0, and 34-17-0, were readily produced in the pilot-plant pan-granulation system[2]. Concentrated urea solution (96-98%) and ammonium phosphate slurry from a preneutralizer were sprayed as separate streams onto recycle in the pan granulator. The product was dried, cooled, and screened at minus 6 plus 10 mesh. The comparatively high moisture contents of the combined fluid feeds (20-26% for the ammonium phosphate slurry and 2-4% for the urea) required recycle ratios that ranged from 3 to 5. The products had excellent physical properties and stored well when dried to 0.6% moisture and conditioned with 2% of clay or diatomaceous earth. Either wet-process or electric-furnace phosphoric acid can be used as a source of P_2O_5 for the process.

In the 1965 studies of urea pan granulation, the use of solution of 99.3 to 99.8% concentration was tested in the pan. The highly concentrated solution was prepared for the pilot-plant tests by melting prilled urea. The temperature of the solution was maintained at 20 degrees to 30 degrees F. above the melting point to prevent premature crystallization during spraying. Good granulation was obtained and the granules were of good quality and well rounded when the correct operating conditions were maintained. No drying was required, so only a pan granulator, cooler, and screening and crushing equipment were needed.

A few tests of pan granulation of urea — ammonium sulfate were made in the pilot plant. Grades studied included 35-0-0-10S and 40-0-0-4S. This product should be useful as a source of sulfur in sulfur-deficient soils. Two procedures of adding the ammonium sulfate were used in these tests. In one, dry crystalline ammonium sulfate was added to the recycle fines stream; in the other procedure, the solid ammonium sulfate was mixed with the urea solution before the granulation. Satisfactory granulation was obtained by using either procedure. However, operation was simpler where the ammonium sulfate was added as a dry solid with the recycle fines; this method of operation is planned for the new demonstration plant.

We have used both "high-temperature" and "low-temperature" methods for the granulation of urea in our pilot-plant pan granulator. In high-temperature granulation, the temperature and quantity of recycle material were regulated to keep the bed temperature in the granulator only a few degrees below the crystallization temperature of the feed solution. With a recycle temperature of 120 degrees to 135 degrees F., a recycle to feed ratio of 1.0 to 1.5 is required. Best granulation is obtained when the bed temperature is kept at 225 degrees to 250 degrees F. and essentially anhydrous melt is used. In this type of operation, the granules are soft and attain a spherical shape by rolling in the pan. The chief disadvantage of high-temperature granulation is that an upset in recycle temperature or rate may allow the entire bed in the granulator to melt and thereby interrupt operation.

Norsk Hydro now uses a pan granulator for high-temperature granulation of urea in their pilot plant at Porsgrunn, Norway. They report the use of 1.1 or lower recycle ratios when they are spraying essentially anhydrous melts of urea or ammonium nitrate onto the deep part of the bed in a pan granulator. This work was described in a paper delivered at the American Chemical Society meeting in September 1974.

In low-temperature granulation, the temperature and quantity of recycle material are regulated to provide a granulation bed temperature substantially below the crystallization temperaturre of the feed solution. This results in thin layers of solutions crystallizing on the recycle material during each pass under the spray. This method of operation is particularly well suited for producing uniformly large products desired for special uses. With 98.5 to 99.8% urea solution, a recycle ratio of 2.0 to 3.0 is required to control granulation when the temperature of the recycle material is in the range of 120 degrees to 135 degrees F. The granulator bed temperature usually was in the range of 200 degrees to 220 degrees F. One major advantage of low-temperature granulation is that the system is more stable and small upsets in recycle conditions will not greatly affect granulation. Granules suitable for either forest fertilization or use as a substrate material for sulfur coating are easily produced by low-temperature granulation.

Demonstration-Plant Production of Granular Urea

After several plant modifications and installation of some new equipment in 1973, the TVA granular combination fertilizer unit z as converted from production of ammonium nitrate-based fertilizers to urea-based products.

The pan-granulation system, formerly used to produce the ammonium nitrate-based products, was modified to allow production of granular urea (45-0-0) and urea — ammonium sulfate (40-0-0-4S). Production of granular urea was begun in December 1973 and has been continued on an intermittent basis since that time because the urea produced in our plant is also used in other processes. No urea — ammonium sulfate has been produced in the facility. The design capacity of the urea solution plant is about 8.3 tons per hour. Actual production rates in the granulation facility have been in the range of 5 to 11 tons per operating hour. The granular product was conditioned with 0.7% of clay and 0.3% of an oil-wax dust suppressant before going to bulk storage. Some of the unconditioned plant product was used as test material in the sulfur-coating pilot plant to determine its suitability for use in this process.

A flowsheet of the TVA urea pan-granulation process is shown in Figure 2. The flowsheet has been simplified to show only the necessary equipment for a plant designed for this process.

(Fig. 2)

Granulation is accomplished by spraying highly concentrated urea solution (97.5-99%) onto a cascading bed of recycle fines in a pan granulator. The granular product discharges from the granulator into the precooler where it is cooled sufficiently for screening. After being screened, the oversize and undersize fractions are further cooled in the recycle cooler; the oversize fraction is crushed and combined with the undersize fraction for use as recycle material. The onsize fraction (predominantly —6 +10 mesh) is cooled in the product cooler and then treated with about 0.3% oil-wax mixture and 0.7% clay in the conditioning drum. The conditioned product is conveyed to the bulk fertilizer storage building. Raw materials used in the process include 75% urea solution, kaolin-base clay, light lubricating oil, and paraffin wax. Solid crystalline ammonium sulfate will be used when 40-0-0-4S urea — ammonium sulfate is produced.

The concentrated solution used in the pan granulator is prepared from 75% urea solution in an air-swept rotary disk falling-film evaporator. The urea feed solution, along with dilute urea solution recycled from the dust-scrubbing system, is introduced into a steam-heated shell-and-tube preevaporator which discharges tangentially into the top of the evaporator. The evaporator contains eight disks mounted vertically on a rotating shaft and eight Flatecoil sections on the body of the evaporator. As the solution flows down, it is thrown out to the heated surfaces by the rotating disks; a countercurrent stream of dehumidified, preheated air sweeps out the water from the evaporator. The concentrated solution (97.5-99% urea) is pumped from the bottom of the evaporator to the spray nozzles at the pan granulator. The spray nozzles are hollow-cone type mounted on a steam-heated header. Usually, ten spray nozzles are used, but the actual number and combination of sizes used depends on the production rate and the amount of scrubber liquor recycled to the system. The evaporator is made of Type 304 stainless steel. Pipelines, pump, spray header, and sprays are made of Type 316L stainless steel.

The mild steel pan granulator, which was part of the original plant equipment, was 14 feet in diameter and 20 inches deep. It was rotated counterclockwise at about 18 rpm. The photograph in Figure 3 shows the pan granulator in operation. The pan diameter has recently been reduced to 12 feet which is more appropriate for the urea production rate.

(Fig. 3)

The material from the pan discharges into the precooler, which is a conventional countercurrent rotary unit 12 feet in diameter by 80 feet long. Gases from the precooler are scrubbed in a wet scrubber to remove dust. Standard Hum-Mer single-deck screens are used in the product and recycle screening systems. The oversize and undersize fractions from the product screens are recombined and cooled in the recycle cooler. This cooler is also 12 feet in diameter by 80 feet in length and uses countercurrent airflow. The exit gases are scrubbed in a wet scrubber.

The oversize is screened from the recycle cooler discharge material and sent to chain mill crushers which can either be operated in a closed loop with the recycle screens or on a once-through basis. The undersize material, along with the crushed oversize, is returned to the pan granulator as recycle.

Product size material from the screens is cooled in a rotary cooler 8 feet in diameter by 55 feet in length. The airflow is counter-current. The exit gases are scrubbed in a wet scrubber.

Material from the product cooler is coated with about 0.7% of kaolin clay in the original conditioning drum which is 8 feet in diameter by 20 feet long. A wax-oil dust suppressant is sprayed on the material in the conditioning drum at a rate of 0.3% by weight. The suppressant is a mixture of 90% light lubricating oil and 10% paraffin wax which is premixed batchwise and fed to the conditioning drum with a metering pump.

In a plant designed specially for this process, only one large cooler would be required. This would simplify the operation, decrease dust formation, and eliminate two scrubbers. The flowsheet shown is for the simplified system.

All of the dust from the solids-handling system is collected in wet scrubbers that were present in the original plant. Rotoclone-type scrubbers are used to collect that from the pan granulator and miscellaneous dust pickup points. Sly Impinjet scrubbers are used to recover dust from the rotary equipment. All exposed parrts of the scrubber are Type 316L stainless steel. The scrubber solution at about 50% concentration is recycled to the urea evaporator.

The phosphate rock-handling system for the nitric phosphate process was adapted for handling drystalline ammonium sulfate when urea — ammonium sulfate (40-0-0-4S) is produced. The existing unloading, storage, and metering systems did not require major changes; new screw conveyors were installed to convey the ammonium sulfate from the existing bucket elevator discharge to the pan granulator where it will be fed with the recycle material.

Operating procedures were similar to those used in the pilot-plant operation. However, some conditions that were favorable to good performance in the pilot-plant work were difficult to obtain in the plant operation. Most of the existing plant equipment was oversized because it had been designed for production rates of 20 tons per hour while the design rate for the urea plant is only 8.3 tons per hour. The larger equipment allowed greater heat losses and made it difficult to maintain operating temperatures in the preferred range, particularly during periods when the ambient temperature was low. Also, dust generation in the plant equipment has been a problem since operation began. The dust is generated in the crushers, in the pan where the concentrated solution sprays strike the scraper and bottom of the pan, and in those places where there is excessive attrition of the granular product as it passes through the coolers and other equipment. This dust is undesirable because of the increased cost of collecting and reprocessing it in the solution system. Also, it is believed that the presence of the dust in the granulator results in granules with less mechanical strength than those that would be produced if the dust were not present. Reducing the speed of the chain mill from 1200 rpm to 900 rpm significantly decreased the amount of dust formed in the system.

Other equipment and plant changes that are planned include the following:

- A belt conveyor will be installed to bypass the recycle cooler. This change would eliminate the dust presently generated in this cooler and would allow better control of the temperature of the recycle material.
- New screen cloth will be installed in the oversize, product, and recycle screens to provide more efficient screening. This should permit dissolving the oversize instead of crushing it. Also, with better screening, the oversize fraction could be recovered for use as forestry-size product (3-5mesh). The plant has

The plant has operated long enough for operation to become routine. Granulation has been good from the initial operation, but the production rate was limited to about 5 tons per hour because the discharge outlet of the evaporator was undersized. After this condition was corrected, the system operated satisfactorily at rates up to about 11 tons per hour. Several other equipment and instrumentation changes were made that further improved operation. Typical data from a period of good operation are shown in Table 1.

The quality of the granular product is good. The granules are spherical and have a good appearance when granulated at a temperature in the range of 210 degrees to 225 degrees F. The product contained about 0.15% moisture and 1.1% biuret. It had good storage and handling characteristics when coated with about 0.3% of an oil-wax mixture and 0.7% of kaolin clay. The product is dust free in handling, storage, and shipping. The granules have a crushing strength about two and one-half times as great as urea prills, but only about one-half as great as some of the granular product made in the pan granulation pilot plant. Users of the granular urea have been very enthusiastic about its properties, and it has been particularly good for bulk blending. Although the surface of the plant product is more porous than that of the pilot-plant product, tests indicate that it is quite suitable for sulfur coating. TVA plans to use the plant product in a sulfur-coating demonstration plant now being designed.

Except for losses of ammonia and particulate material from the urea evaporator stack, process losses are very low. Tests in the plant indicated that a spray-type condensing scrubber would recover about 90% of the free ammonia fna from 93 to 99% of the particulate material from the evaporator exhaust stream. The urea-scrubbing solution used for collecting process dust was effective as a scrubbing medium. Recommendations were made for the design of the scrubber required for handling the exhaust vapors from the urea evaporator. The scrubber is now being fabricated.

Operation of the demonstration-scale plant has established the feasibility of the TVA pan-granulation process for producing granular urea. Although many operating difficulties were encountered because of the use of missmatched equipment that was already installed, it was evident that most of the difficulties could be eliminated if a completely new plant had been built instead of the original unit being modified. Products suitable for special uses, such as a sulfur coating or forestry use, were produced during the test operation. Also, it was evident that process losses could be kept low enough to meet present emission standards. We fully expect our plant to be in complete compliance with the rigid State of Alabama stack gas emission and environmental standards well before the May 1975 deadline. Our pilot-plant work with pan granulation of urea and demonstration-plant experience show that this process offers an attractive alternative to air prilling, and pollution controls are much easier and less costly.

REFERENCES

1. McCamy, Isaac W., Graham, James L., and Siegal, Milton R., U.S. Patent 3,165,395 (January 12, 1965).
2. Young, R. D., and McCamy, I. W., *Can. J. Chem. Eng. 45,* 50-6 (February 1967).
3. Meline, R. S., McCamy, I. W., Graham, J. L., and Sloan, T. S., *J. Agr. Food Chem. 16,* 235-40 (March-April 1968).

TABLE I

Operating Data - Pan Granulation of Urea

Production rate, tons/hr	8.5
Pan granulator	
Speed, rpm	18
Slope, degrees	66
Number of sprays	10
Urea	
75% solution	
Temperature, °F	200
Feed rate (100% basis), tons/hr	8.5
Concentrated solution to granulator	
Temperature, °F	290
Concentration, %	98.5-99.0
Granulation	
Recycle	
Temperature, °F	115
Ratio, lb/lb product	2.1
Granulator product	
Temperature, °F	210-215
Screen analysis, %	
+6 mesh	7
-6 +10 mesh	59
-10 +16 mesh	28
-16 mesh	6
Rotary coolers	
Temperature, °F	
Precooler	130
Product cooler	110
Recycle cooler	115
Product	
Chemical analysis, %	
Total N	45.5
Biuret	1.1
H_2O (Karl Fischer)	0.1
Conditioner	
Oil-wax mixture	0.3
Clay	0.7
Screen analysis, %	
+6 mesh	0
-6 +8 mesh	30
-8 +10 mesh	55
-10 +12 mesh	10
-12 +16 mesh	5
-16 mesh	0

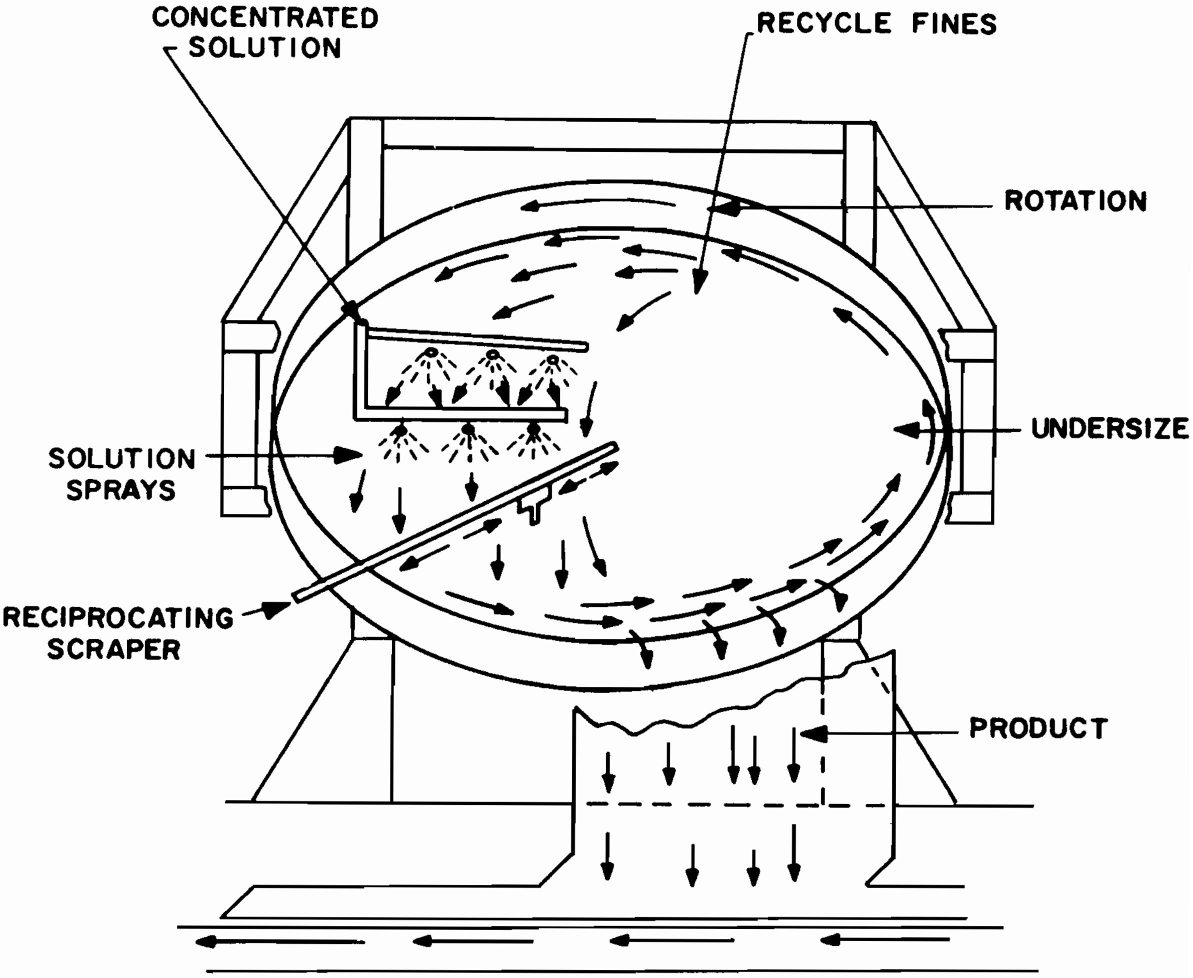


FIGURE 1

Sketch of Pan Operation

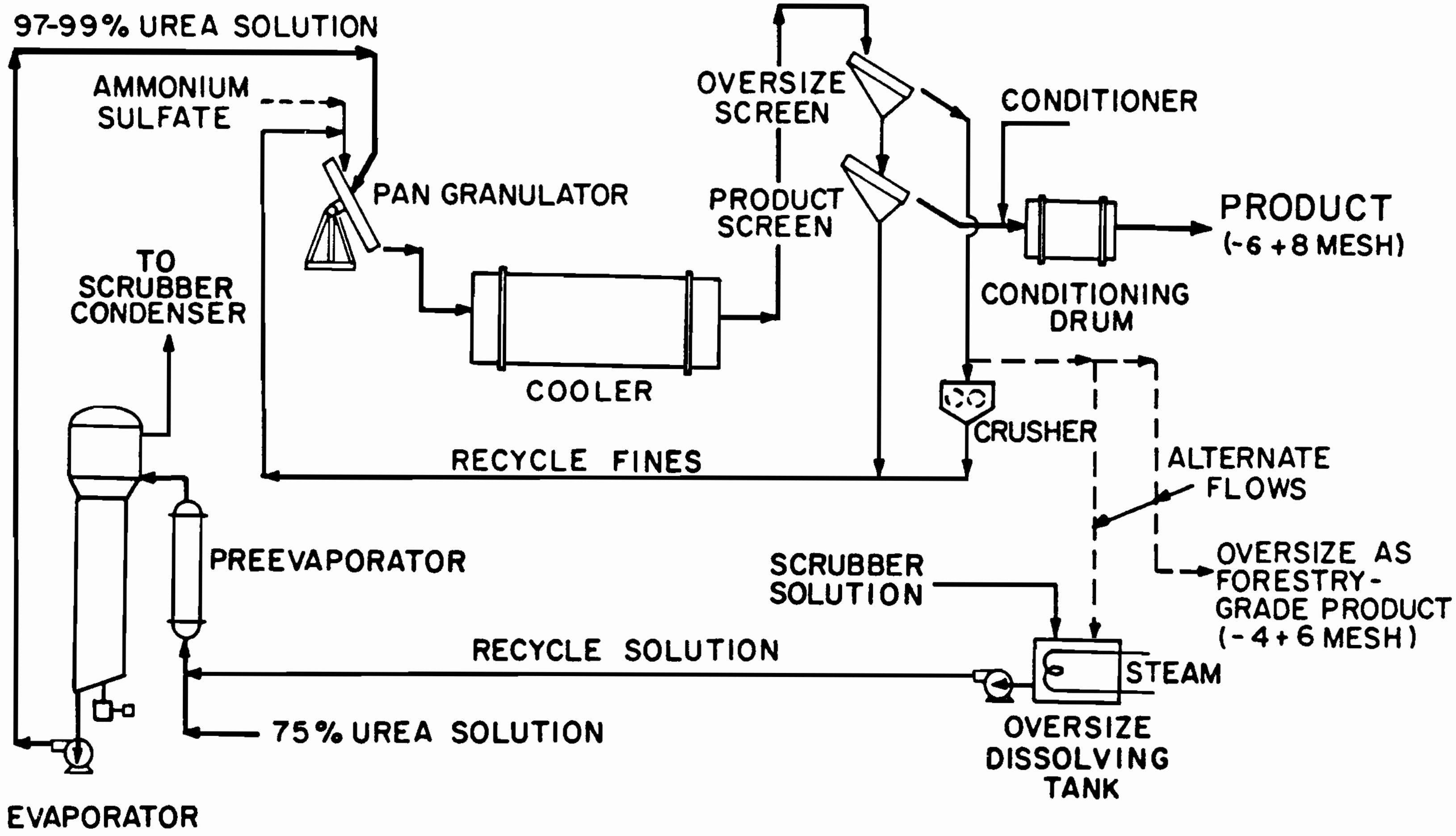


FIGURE 2

Flowsheet - TVA Pan Granulation Process for Production

of Granular Urea and Urea - Ammonium Sulfate

FIGURE 3

Pan Granulator for Urea

MODERATOR ADAMS: Thank you Mr. Waggoner, and your Associates at TVA, Messrs. McCamy, Hicks and Gahan, for discussing to date your "TVA Development and Demonstration Plant" and highlighting your experience in "Pan Granulation Of Urea". Your group, thru the years, have done excellent research on all Phases of Equipment, Formulation and Granulation and have successfully given The Fertilizer Industry much of the know-how now in use in Fertilizer Plant Manufacturing throughout the U.S. and many Countries in the World.

Our next discussion prepared by M. M. Norton, R. G. Lee and H. G. Graham, Chemical Engineers at TVA, "Urea Ammonium Phosphate Production" using "The TVA Melt-Type Granulation Process", will be given by M. M. Norton. Mr. Norton started with TVA 25 years ago and has been exposed to much of the development work done on "Granulation Processes".

Urea — Ammonium Phosphate Production Using the TVA Melt-Type Granulation Process

R. G. Lee, M. M. Norton
and H. G. Graham

ABSTRACT

The production of granular urea — ammonium phosphate (UAP) based fertilizers is a relatively new development in fertilizer process technology. In December 1973 after pilot-plant development work, the Tennessee Valley Authority started up a modified granulation plant with a capacity of 300 tons of 11-57-0 ammonium polyphosphate (APP) or 400 tons per day of 28-28-0 grade UAP to demonstrate the process. APP melt containing about 25% APP is produced in a pipe reactor at 425 degrees F. from gaseous ammonia and wet-process orthophosphoric acid (54% P_2O_5). This melt is fed to a pubmill-type granulator with recycled solids to produce the 11-57-0 product. When the 28-28-0 grade UAP is produced, urea solution concentrated to about 99% by weight at about 280 degrees F. is added to the pugmill. The granulator is cooled, the product-size fraction is separated, and the oversize material is crushed. Entrained dust in the air from cooling and other solids-handling equipment and fluorine evolved from the APP reaction system are recovered in wet scrubbers using recirculated 12-8-0 grade solution which is returned to the pugmill. Problems during startup were corrosion in the reaction system and high power requirements for the pugmill. The process is economically attractive because it eliminates the drying operation normally required for an ammonium phosphate (AP) granulation plant. This decreases investment substantially since the dryer and associated fume — and dust-control equipment are eliminated. Also, enery is saved since no fuel for drying is required. Reports from users of the products particularly in bulk blending have been very good.

In December 1973, TVA started up a 400-ton-per-day granulation plant for production of urea — ammonium phosphate (UAP) fertilizers. The melt-type granulation process installed in this plant represents a major innovation in the field of fertilizer granulation. Because only anhydrous materials (rather than aqueous solutions or slurries) are fed to the pugmill granulator, no drying step is needed in the melt-type granulation process. Eliminating the dryer from the granulation plant in this manner significantly reduces the investment and operating costs, dust and fume abatement problems, and the overall energy requirements.

Development of the melt-type granulation process at TVA covered a 10-year span starting with bench-scale work in 1964 on a reaction system for making ammonium polyphosphate (APP) melt from merchant-grade wet-process phosphoric acid[1]. The reaction system was developed to its present form in the pilot plant by 1969[2,3]. The feasibility of melt-type granulation in a pugmill was established in pilot-plant tests from 1968 to 1970[4,5]. Installation of the process in the existing TVA granulation facilities at Muscle Shoals was begun in July 1972. Granular 28-28-0 grade UAP was successfully produced at the design rate of 17 tons per hour in January 1974. Production of this grade is now routine as well as that of 11-57-0 grade ammonium phosphate (AP) with about 25% of its P_2O_5 as polyphosphate, which is produced alternately in the same equipment without urea addition. The APP melt production system was designed for a rate of 12 tons per hour. It is usually operated at 12 to 15 tons per hour for production of 11-57-0.

Description of Process

The melt-type granulation process consists of cooling and crystallizing anhydrous AP melt along with urea melt and utilizing the recycled fines in a pugmill granulator. Approximately equal amounts of each melt are used for 28-28-0 grade product. A flowsheet of the process is shown in Figure 1. Raw materials fed to the process are urea solution (75% by wt), wet-process phosphoric acid (54% P_2O_5), and gaseous ammonia. The 99% urea melt is prepared by concentrating the 75% solution in an air-swept rotary-disk evaporator. The AP melt reaction system is operated in the same way whether it is producing melt for 28-28-0 or for 11-57-0 granulation. Hot, partially ammoniated phosphoric acid is reacted with gaseous ammonia in a pipe reactor. The heat of reaction is supplemented by preheating the feed acid to about 150 degrees F. to provide the heat necessary to control the polyphosphate level of the resulting melt at approximately 20 to 25%. The amount of preheat varies considerably with the water content of the phosphoric acid. There are provisions for preheating the gaseous ammonia, but they are seldom used.

(Fig. 1)

The feed streams to the pugmill granulator are ammonium phosphate and urea melts, recycle, and a heated solution returned from the wet-scrubbing dust system. The pugmill product is cooled and screened. The onsize portion (—6 +12 mesh) is further cooled and conveyed to bulk storage. No conditioning is required. The undersize and oversize fractions are transferred to the recycle cooler and recycle screens. The oversize is crushed and fed with the recycle fines to the pugmill. The primary granulation controls are the recycle ratio and the polyphosphate content of the APP melt, which governs the readiness with which the melt crystallizes. (It is important to note that solid urea can also be used in this melt-type granulation process[4].)

Description of the Plant

Gaseous ammonia, 75% urea solution, and pressurized steam are received by pipeline from the producing plants within the TVA fertilizer complex. Wet-process phosphoric acid is received by railcar and stored in rubber-lined tanks. The granular products are conveyed to a bulk storage building which was originally used to store nitrate-based products. The original TVA granular conbination fertilizer unit which began operation in 1965 was converted to UAP production in late 1973. The rotary coolers, elevators, conveyors, screens, and wet scrubbers in the existing plant were used. The original chain mill crushers were replaced with new ones. The principal facilities which had to be installed for the UAP process were the urea evaporator, the AP melt production system, and a pugmill.

A large part of the instrumentation came from the original plant. Magnetic flowmeters with pneumatic-type control valves are used for metering phosphoric acid and partially neutralized acid. The ammonia flowmeters are of the orifice and annubar type. Ohmart (nuclear density) meters are used for measurement of product and recycle flows that are recorded; they have given satisficatory accuracy of about plus or minus 5% when calibrated every month or so.

For production of the APP melt, phosphoric acid preheated to approximately 150 degrees F. is introduced into the process through the spray reactor (3½ ft in dia. by 20 ft high). There is an expanded section 5 feet in diameter by 7 feet high on top of the reactor to provide space for entrainment separation. Pumps are used for recirculating the acid from the bottom to three full-come spray nozzles spaced up through the reactor. The preheated feed acid is introduced through a single spray in the bottom portion of the reactor. The circulating acid is partially neutralized to a pH of 1.5 (10% solution) by the off-gases from the pipe reactor. This is equivalent to an $NH_3:H_3PO_4$ mole ratio of about 0.4 which is near the maximum solubility of ammonium phosphate at the temperature (265 degrees F.) and concentration in the spray reactor. Measurement of this pH and adjustments in the ammonia feed rate to hold it very near 1.5 is the main control criterion for the pipe reactor system.

A metered stream of the partially neutralized acid is fed to the 6-inch pipe reactor (10 ft long) where it reacts with gaseous ammonia. (The plant has an ammonia heater which ordinarily is not used.) The foamy melt discharges from the pipe reactor into a vapor disengager 2 feet 9 inches in diameter by 10 feet long for separation of the evolved water vapor and the unreacted ammonia. A photograph of the spray reactor and vapor disengager is shown in Figure 2. The disengager is equipped with a rotary helical blade (similar to a reel-type lawn mower) which turns at 420 rpm. The rotor keeps the melt on the wall of the disengager and conveys it to the discharge end. Its main function, however, is to shear the thixotropic melt to keep it fluid. The gases evolved in the disengager, principally ammonia and steam, are drawn into the spray reactor for ammonia recovery.

(Fig. 2)

The partially neutralized wet-process phosphoric acid is very corrosive at the high temperatures (265 — 430 degrees F.) encountered in the reaction system. The corrosion-resistant materials used for the equipment are described in the listing below.

- Acid heater (mas. exit temp 200 degrees F.)
  - Tubes — Type 317L stainless steel
  - Tube sheets — Type 317L stainless steel
  - Head boxes — Type 317L stainless steel
  - Shell — Carbon steel, SA-53-B seamless (ASME specification)
- Hot acid pipelines (exit heater) — Type 316 stainless steel
- Spray reactor
  - Shell — Fiber glass-reinforced polyester (Hetron 197) with an ultraviolet inhibitor. There is a fluorine protective liner made from Dynal.
  - Recirculating pumps — Tantalum-clad (15 mils) Type 316 stainless steel
  - Recirculating lines — Teflon-lined carbon steel
  - Piping adjacent to spray nozzles — Flanges and internal piping for sprays are Hastelloy G.
  - Spray nozzles — Teflon
  - Outlet vapor duct — Type 316 stainless steel
  - Inlet vapor duct — Type 316 stainless steel
  - Recirculation meter (magnetic) — Teflon linted with tantalum electrodes
  - Drawoff meter (magnetic) — Teflon lined with tantalum electrodes
  - Control valve (drawoff flow) — Tantalum trim, alloy 20 body
- Disengager (420 rpm, 20-hp drive)
  - Shell — Type 317L stainless steel

  - Rotor — Hastelloy C276 or Type 316L stainless steel
- Pipe reactor — Type 316L stainless steel Schedule 40 pipe

Hastelloy C 276 is more resistant to corrosion by the melt in the disengager, but plant experience indicates that Type 316L stainless steel is satisfactory for the rotor if good welding techniques are used in fabrication. The Hetron 197 spray reactor vessel is still in service, although the Dynal lining has cracked and spalled off so that it exposes the fiber glass to fluorine attack. Installation of a new Hastelloy G spray reactor is planned.

The 75% urea solution flows first to a steam-heated preevaporator (a vertical, shell-and-tube heat exchanger) and then to the top of a rotating disk evaporator containing eight sections. As the solution flows down, it is thrown out to the heated Flatecoil surfaces by the rotating disks. The evaporated water is swept out by a countercurrent stream of heated air. The melt at 285 degrees F. contains 1% or less water. It flows by gravity through two spray nozzles into the pugmill. Condensate is recovered from the preevaporator shell and Platecoil outlets and fed to the wet scrubbers for dissolution of recovered dust. Surfaces in contact with the urea are of Type 304L stainless steel throughout the concentration system.

In the granulation step, recycle and crushed oversize enter the feed end of the pugmill at a rate of about 4 pounds per pound of product.The urea melt is sprayed onto the recycle first followed by the APP melt through an open trough. It is necessary to keep the feed points of these hot melts separated by at least 2 feet to minimize decompostion of urea. The 11-57-0 melt is fed after the urea to improve binding of the crystallized urea into the granule and minimize dusting off of urea in the solids-handling equipment. The pugmill is equipped with a 300-hp drive. It is important to keep the polyphosphate content of the 11-57-0 melt below about 25% to prevent overloading the motor. The pugmill trough is 6 feet wide by 4 feet 10 inches deep and 17 feet 6 inches long. Operating experience has shown that this is somewhat larger than needed. The granulator discharges into a conventional countercurrent rotary cooler 12 feet in diameter by 80 feet long. Gases from the cooler are scrubbed in a wet scrubber.

The cooler product is screened on electrically vibrated single-deck screens. Oversize and undersize fractions are recombined and cooled in a second countercurrent cooler 12 feet in diameter by 80 feet in length. Product-size material from the screens is cooled in a rotary unit 8 feet in diameter by 55 feet in length. Both coolers are equipped with wet scrubbers. All of these rotary units were in the previous plant system. One cooler of sufficient size should be suitable in a plant built specifically for this process as indicated in Figure 1.

Oversize is screened from the recycle cooler discharge and sent to a chain mill crusher which can either be operated in a closed loop with the recycle screens or on a once-through basis. The crushed oversize and undersize ar returned to the pugmill granulator as recycle. Product from the cooler is conveyed to storage without further treatment.

All of the dust generated in the solids-handling system is collected by wet scrubbers — Rotoclone type at dust pickup points and Sly Impinjet scrubbers on the rotary coolers. All of these scrubbers were used in the original plant. No mechanical dust cyclones are used. The concentration of the scrubber solution is maintained at about 35% in winter and 45% in warm weather. This results in an average return to the pugmill of about 8 gpm of scrubber solution (typical grade about 16-8-0) which is heated to 200 degrees F. in a steam-jacketed pipe. This amount should be substantially decreased in a new plant with a single large cooler equipped with a heated cyclone preceding the scrubber. Return of the solution increases the product moisture from 0.6 to 1.0% by weight (without affective storage properties) and decreases the polyphosphate content by about 2 percentage points. (Part of the water in the scrubber solution is flashed off as the solution is directed into the 425 degrees F. APP melt stream entering the pugmill.)

In addition to the dust scrubbers, there is a small spray scrubber-condenser which is used to remove fluorine from the spray reactor exhaust gas. The scrubbing medium is dust solution which is circulated from one of the Sly Impinjet units. Fluorine evolution from the spray reactor is low, only about 1 to 2 pounds per ton of 11-57-0 melt, and essentially all of this is recovered in the scrubber-condenser. The total amount of fluorine released to the atmosphere from all the wet scrubbers is about 1 pound per hour. An additional spray scrubber condenser is being designed and will be installed to recover particulates and ammonia from the urea evaporator exhaust gas. This is expected to result in all stack effluents meeting the atmospheric emission standards for the State of Alabama.

Operating Data

Formulations for the two product grades are shown below.

Raw material used	11-57-0	28-28-0
Urea (46.6-0-0)	———	Z982
Ammonia (82-0-0)	267	139
Phosphoric acid (54% P_2O_5)	2111(1140)	1059(572)

The actual grade of the UAP is 28.6-28.6-0. Typical plant operating data for both grades are given in Table I.

The ammonium phosphate reactor system is operated at about the same conditions for both the 11-57-0 and the 28-28-0 grades. The feed acid is preheated to 130 degrees to 140 degrees F., and the pipe reactor operates at about 420 degrees F. A recycle ratio of 4 or 5:1 is required. Usually more oversize is produced in the pugmill during 11-57-0 granulation than with 28-28-0. Both products contain about 20% of the P_2O_5 as polyphosphate and 1% moisture. The 28-28-0 contains 0.5% by weight biuret.

The most significant problems encountered in startup of the plant were plugging of the spray reactor vapor outlet duct by buildup of solid monoammonium phosphate (MAP) and formation of scale in the pipe reactor. Acid mist carried over into the outlet duct was ammoniated by trace amounts of ammonia in the gas and frequently plugged the duct. The quantity of acid mist was decreased by adding an enlarged section 5 feet in diameter by 7 feet high on top of the spray reactor. Recovery of ammonia was improved by maintaining good circulation through the sprays and by converting to full-cone-pattern-type spray nozzles. These measures effectively eliminated plugging of the outlet duct.

Formation of acid-insoluble scale is often a problem when wet-process phosphoric acid is used in a pipe reactor. The scale is usually $(Fe, Al)NH_4(HPO_4)_2 . 1/2H_2O$; it forms on the pipe walls and can eventually plug the pipe. This has not been a serious problem. A simple procedure of filling the pipe with water while simultaneously steaming and ammoniating dissolves the scale. Hammering on the pipe to dislodge the scale has also been effective for cleaning it in place.

Conclusions

The viability of the melt-type granulation process has been demonstrated conclusively. The process realizes a net energy savings because the water in the phosphoric acid is evaporated by heat from the reaction of acid with ammonia, rather than by inefficient heating of the solids with hot combustion gases as in a conventional granulation process. The reaction system is dependable and easily controlled; corrosion-resistant materials of construction are required. The process is attractive because eliminting the dryer and accessory dust collector and scrubbing equipment from the granulation plant saves very substantially in both investment and operating costs as well as decreases dust and fume abatement problems. A process without a dryer is especially important in production of mixed fertilizers containing urea because drying is difficult and a long retention time with relatively low temperature air must be used[6]. Either solid urea or urea melt may be used in the process. Other product grades, such as 21-42-0 or 36-18-0, can be produced and potash can be added to the pugmill with the recycle to make NPK grades. Fertilizer consumers who have used 28-28-0 and 11-57-0 in bulk blending and other demonstration applications have been well pleased with it.

REFERENCES

1. Getsinger, J. G., U.S. Patent 3,382,059 (May 7, 1968).
2. Meline, R. S., Davis, C. H., Lee, R. G., *Farm Chem.*, *133* (11), 26 (1970).
3. Meline, R. S., Lee, R. G., U.S. Patent 3,733,191 (May 15, 1973).
4. Lee, R. G., Meline, R. S., Young, R. D., *Ind. Eng. Chem.* Process Design Develop. *11* (1). 90-4 (1972).
5. Lee, R. G., Mitchell, R. D., U.S. Patent 3,825,414 (July 23, 1974).
6. Meline, R. S., Hicks, G. C., Kelso, T. M., Norton, M. M., *Ind. Eng. Chem. Process Design Develop. 7* (1), 124 (1968).

TABLE I

Typical Operating Data for Melt Production and Granulation

Product grade	28-28-0	11-57-0
Production rate, tons/hr	17	14
Urea		
75% solution		
Temp, °F	200	-
Feed rate (100% basis), tons/hr	8.3	-
Melt to pugmill		
Temp, °F	285	-
Concentration, %	99	-
Ammonium polyphosphate		
Melt to pugmill, tons/hr	8.8	14.0
Temp, °F		
Phosphoric acid	130	140
Anhydrous ammonia	100	78
Spray reactor product	266	265
Pipe reactor melt	422	420
pH		
Spray reactor product	1.5	1.4
Pipe reactor melt	3.4	3.5
Granulation		
Recycle		
Temp, °F	140	128
Ratio, lb/lb product	4.5	4.5
Granulator product		
Temp, °F	178	172
Screen analysis, %		
+6 mesh	14	24
-6 +10 mesh	42	28
-10 +16 mesh	29	36
-16 mesh	15	12
Rotary coolers		
Temp, °F		
Precooler	155	147
Recycle cooler	140	128
Product cooler	115	105
Product		
Chemical analysis, %		
Total N	28.7	11.1
Total P_2O_5	28.6	57.2
Available P_2O_5	28.6	57.1
Orthophosphate P_2O_5	28.2	45.6
Polyphosphate, % of total P_2O_5	19.0	20.3
H_2O (Karl Fischer)	1.0	1.1
Biuret	0.5	-
pH	4.9	3.6
Screen analysis, %		
+6 mesh	2	2
-6 +8 mesh	28	33
-8 +10 mesh	52	45
-10 +12 mesh	10	11
-12 +16 mesh	7	8
-16 mesh	1	1

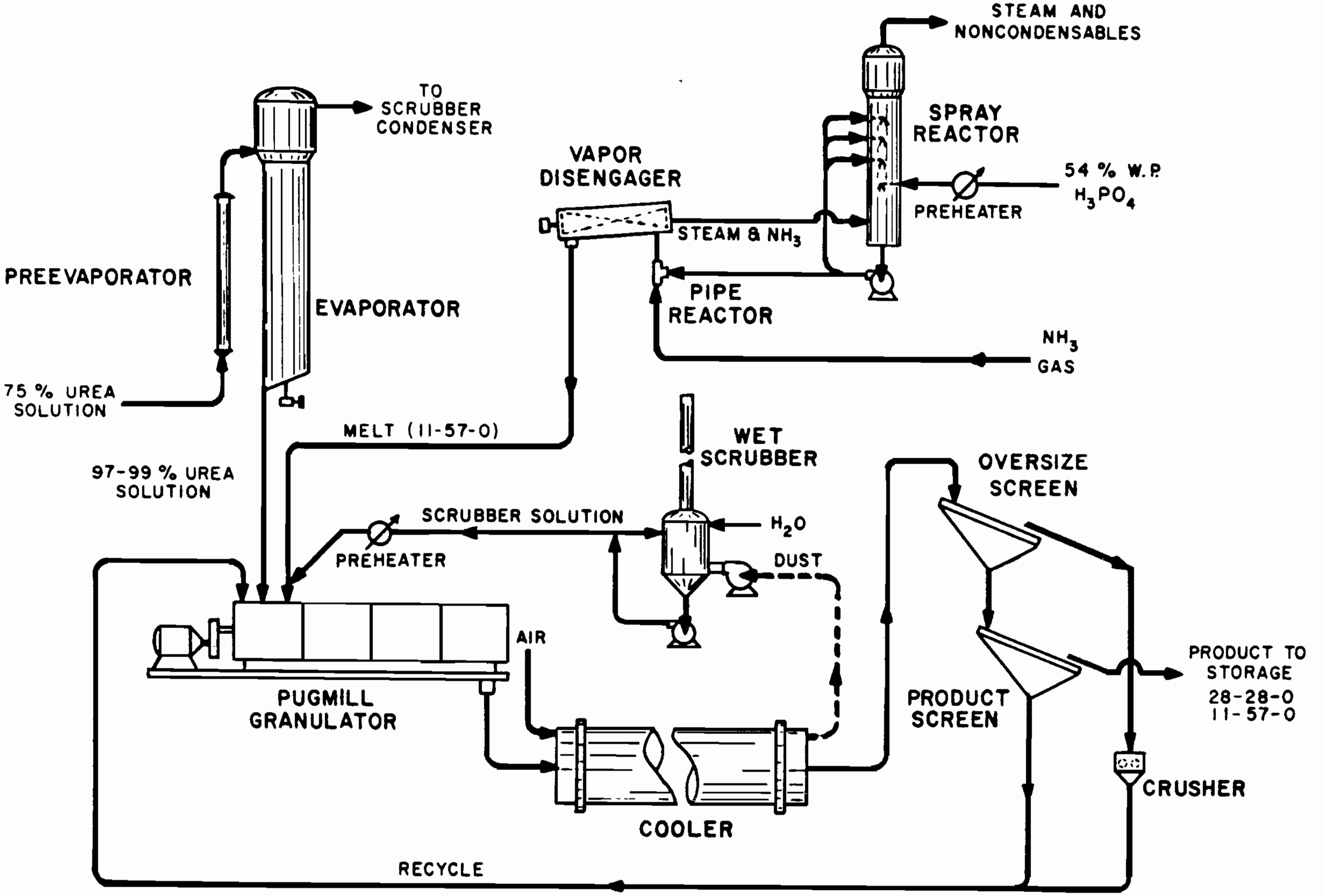


FIGURE 1

TVA Pipe Reactor-Pugmill Process for Production of Granular UAP

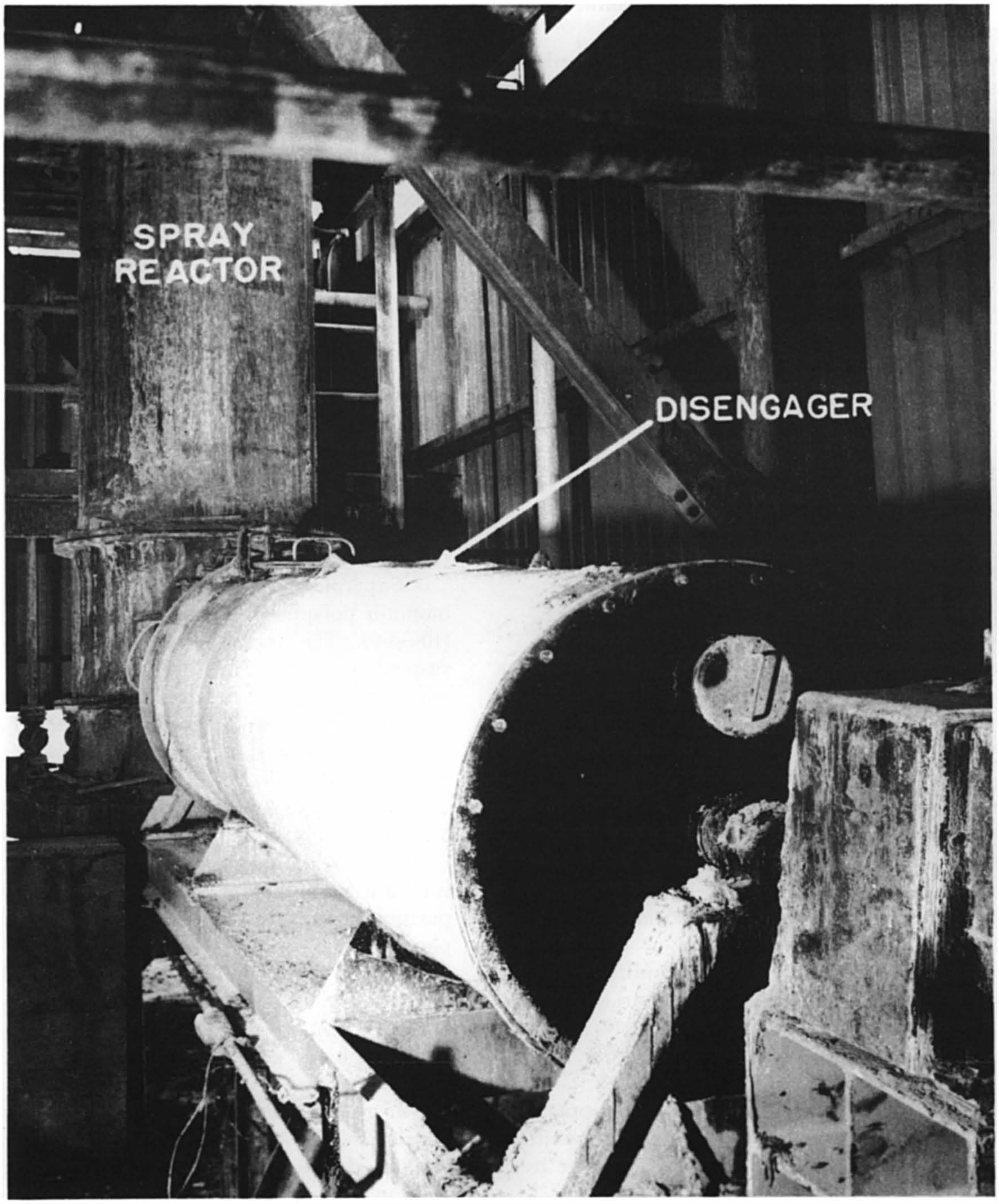


FIGURE 2

Spray Reactor and Foam Disengager for

Low-Polyphosphate Melt Production

MODERATOR ADAMS: Thank you Mr. Norton and Mr. Graham for bringing us your latest information on the "TVA Melt-Type Granulation Process for the past 10 years starting with your bench-scale work in 1964. Our Round Table is most appreciative for the continuous help given to us by TVA and its Personnel during the years.

Our next discussion will be given by Mr. Brooke M. Whitehurst, Technical Service Superintendent for Texas Gulf Sulphur. "Fluid Fertilizers". The title of the Paper "The Production and Marketing of Super Phosphoric Acid From North Carolina Ore".

Mr. Whitehurst is a Chemical Engineer, B.S. Graduate from V.P.I. He is a member of many Professional and Civic Organizations. His Successes and Honors are list in American Man of Science and Dictionary of International Biography. His Industrial Experience has been with American Inca Corporation, Virginia Carolina Chemical, Mobile Oil and Texas. Now with Texas Gulf. Mr. Whitehurst please.

The Production and Marketing of Superphosphoric Acid from North Carolina Ore

B. M. Whitehurst

Introduction

The phosphate deposit in eastern North Carolina was deposited in the Miocene seas about 15 million years ago in an area as seen in Figure 1. The deposit is uniform over large distances (20,000 ha) and flat lying, with an average dip of 1.9 M per kilometer south-easterly. It is estimated that the deposit has an average P_2O_5 content of 12 to 14% and contains about 2 billion tons of ore. Texasgulf has mining rights on more than 12,000 ha in the heart of this reserve.

The phosphorite probably originated in a marine environment in a large shallow lagoon or estuary with restricted circulation under reducing conditions.[1] The phosphate has a composition similar to franocolite or carbonate-apatite. The pellets are about 1 to 3 mm in diameter and contain organic matter throughout. A cross section of the mine area is shown in Figure 2.

Mining is by conventional dragline in an open pit. The ore is from 27 to 40M below sea level. To maintain dry conditions it is necessary to depressure a large fresh water aquifer which underlays the ore.

The sand is removed from the ore by flotation. The beneficiated phosphate pellet is then calcined in a fluid bed calciner to remove the carbonate and organic matter which results in an upgraded product with a grade improvement from 30.6% to 33% P_2O_5. This material has a median particle size of 180 to 200 microns, and range from 420 microns to 70 microns. The unground calcined phosphate is then acidulated in a conventional Prayon dihydrate process plant producing a filtrate of about 27% P_2O_5. Because of the high content and carbonate content, acidulation of the uncalcined phosphate was not possible. The filter cake consists of gypsum crystals about 30 microns wide and 250 microns long which are a textbook example of an orthorhombic gympsum crystal which occurs in nature. The purity of the gypsum is such that it can be converted to wallboard. The 27% P_2O_5 filtrate is concentrated to 54% P_2O_5 acid in Swenson evapoorators.

The evaporator product contains about 2.5% solids which is a mixture of $CaSO_4$ and sodium and potassium siliocrfluorides. These solids are settled quickly to the 0.1 to 0.2 % level in settling tanks. Post preciptation is not a significant problem with this acid. The clarified 54% P_2O_5 acid is then used as a feed stock to the Superacid plant.

Polyphosphates derived from superphosphoric acid play an important role in the manufacture of liquid fertilizer solutions. In 1971-72, 510,000 metric tons of P_2O_5 derived from superphosphoric acid were consumed in the United States in the liquid fertilizer industry[2] Liquid mixed fertilizers account for about 10% of the total fertilizer P_2O_5 consumed in the United States and during the past ten years fluid fertilizer usage has grown at a rate of about 14% per year.

Superphosphoric acid is used to produce an ammonium polyphosphate base solution by the customer (10-34-0). The term "fluid fertilizer" includes both suspensions and clear N-P-K liquids. For the past seven years the Technical Services Department at our North Carolina phosphate facility has conducted development work on superacid manufacture, ammonium polyphosphate base solutions, on N-P-K clear liquid systems, and on suspensions manufactured from Texasgulf super and orthophosphoric acids.

When wet process orthophosphoric acid (54% P_2O_5) is used to manufacture liquid fertilizer solutions, the impurities present in the acid tend to form crystals of phosphate salts that precipitate as bothersome sludges in storage tanks and applicator equipment. Polyphosphates tend to sequester or solubilize these impurities, thus keeping them in solution. The increased solubility of polyphosphates over orthophosphates also allows the production of more concentrated liquids.

In the manufacture of polyphosphates, orthophosphoric acid is polymerized. Polyphosphates are chains of orthophosphate units linked together.[3] Much like making a chain, heat is used to "link" these orthophosphate units, and to give off water from the linking process. This is pictured in Figure 3.

Production of Super Acid

One of the key factors in the production of superacid is the quality of the orthophosphoric 54% P_2O_5 acid feedstock. The aluminum content of super acid is critical to the viscosity of the acid. The North

Carolina ore is characteristically low in aluminum as compared to Florida or some Western US ores. With an Al_2O_3 concentration of 1.4% the viscosity of the super acid for a 30% polyphosphate content would be 600 centipoise at 38 degrees C., whereas a 1% increase to 2.4% Al_2O_3 would increase the viscosity to 1000 centiposise or a 67% increase. The viscosity of a fluid has a major effect on the heat transfer capability of the superacid evaporator. The low viscosity of Tg acid makes it quite simple to concentrate to levels of 50% polyphosphate using a wetted surface heat exchanger. Submerged combustion is often required to attain the necessary poly level in higher alumina acids. An increase in the Fe_2O_3 content has a tendency to lower the viscosity slightly.

Tg has two identical superacid plants which produce about 275/metric tons/day of P_2O_5, and currently a 3rd plant is under construction. When this unit is complete we will have a superacid production capability of 825 metric tons per day of P_2O_5. The first two plants incorporate two stage falling film evaporators. The first stage is heated by steam and the 2nd stage by Dowtherm. The design of the third plant will be based on the use of a forced circulation evaporator.

The reason for the two stages of evaporation was economic rather than process factors. The first stage unit which carries 80% of the evaporation load is heated by waste steam from the sulfuric acid plant, wheras the second stage is heated by vaporized Dowtherm from an oil fired boiler. The absolute pressure in both stages is maintained at 20 to 30 mm of Hg. The tubes in the second stage evaporator are made of Inconel 625, a nickel-moly-chromium alloy which has a higher temperature limit than Carpenter 20. The heat transfer coefficient for our falling film unit varies between 440 and 590 Kg-Cal/Hr/m_2/degrees C. dependent on the cleanliness of the tube wall. Carpenter 20 alloy is very satisfactory for construction of the steam heated first stage evaporator. The tubes have a life in excess of seven years in the first stage unit. The corrosion of the evaporator tubes is significantly less when a thin layer of scale is allowed to form. Some years ago we attempted to concentrate a more purified acid in the 2nd stage evaporator in which a scale did not form on the tube walls. We dissolved the second stage unit in 30 days. Therefore, I must conclude that impurities in the superacid are necessary for plant surivival. Based on our experience, the conversion of a purified acid to polyphosphoric acid with a metal walled heat exchanger is not practical.

Air Purification

The superacid evaporators concentrate the orthophosphoric 54% P_2O_5 acid to about 70% PO_5 and 35% polyphosphate. At this point the acid contains about 7% solids as measured by a methanol extraction. These solids are essentially an iron magnesium pyrophosphate. Thus when they are removed from the superacid, the resultant clarified acid has a lower iron and magnesium content. We are not sure whether this is a single compound or a co-precipitate of ferrous pyrophosphate and magnesium pyrophosphate. We estimate that this solid has a composition similar to $2Fe(H_2PO_4)_2$. $3Mg(H_2 2$ PO_2. Under certain conditions the ratio of Fe to Mg will vary. We are able to remove about 60% of the MgO and 40% of the iron via precipitation followed by clarification. A comparative analysis of the acids before and after purification is shown in Slide 4.

The solids in the acid can be removed by centrifugation and/or filtration. The particle size of the solids ranges from 20 microns to 30 microns. We have a centrifuge and rotary vacuum precoat filters to remove the solids.

One of the factors which affects the amount of precipitation of the iron magnesium pyrophosphate is the amount of free H_2SO_4 in the 54% P_2O_5 feed acid. The control of the phosphoric acid plant is such that the free H_2SO_4 content is essentially zero. If the free sulfate level increases, the amount of precipitate decreases and thus the iron and magnesium removal is reduced.

Marketing

The primary market for superacid is in the liquid fertilizer industry of the middle Western U.S. The acid is shipped in 91 metric ton insulated tank cars. It is loaded at 82 degrees C. and with normal delivery time reaches the customer with a temperature of 52 degrees C. The viscosity of this acid is 175 centipoise at 52 degrees C. which is sufficiently low to use either a simple gear pump or a centrifugal pump for unloading.

The Texasgulf superacid product called Super 49 is typically 69% P_2O_5 with 20-30% conversion of the phosphate to the non-ortho or poly form. Until the concomitant development of Super 49 and the TVA pipe reactor process, the polyphosphate level of our super acid was maintained at bout 50% to insure sufficient sequestering ability when mixed with ammonia.

There are two basic methods for manufacturing ammonium polyphosphate solutions from superphosphoric acid: (1) neutralization of anhydrous or aqua ammonia with superphosphoric acid containing a minimum of 45-55% polyphosphate (conventional process) or (2) reaction of low poly superphosphoric acid containing 20-30% poly P_2O_5 with anhydrous ammonia in the TVA pipe reactor system.

In a conventional liquid fertilizer plant, N-P base solutions such as 10-34-0 are produced by reacting aqua or anhydrous ammonia with superphosphoric acid using a large recycle stream of 10-34-0 liquid. The liquids produced by this method are limited in poly level to the maximum poly level present in the superacid used (typically 45-55%). The temperature of the 10-34-0 product has to be rigidly controlled below 32 degrees C. or hydrolysis of the polyphosphates to orthophosphate will occur at an unacceptably high rate.

The TVA pipe reactor process permits production of

10-34-0/11-37-0 (N-P) solutions with a polyphosphate level of 70 to 80% using an acid containing only 20-30%.[3] Such solutions when stored at temperatures of less than 32 degrees C. have increased storage life as compared to N-P solutions made from superacid with a poly level of 45 to 50%. A typical pipe reactor plant is shown in Figure 5. In the pipe reactor, the heat of reaction of vaporous anhydrous ammonia and superphosphoric acid causes entensive polymerization and yields large quantities of tri, tetra, penta, and higher polyphosphate species. The temperature attained in the pipe reactor is approximatley 340 degrees C., or 120 degrees C. higher than temperatures attainable in a superacid falling film evaporator. Since this process generates polyphosphates, an acid of low poly content is suitable as a feedstock.[3] Some ammonium polyphosphate analyses from commercial production are shown in Figure 6.

A comparison of poly distribution is shown in Figure 7 for conventional, high-poly, and furnace ammonium polyphosphate solutions. It indicates that high-poly wet process 10-34-0 is comparable to furnace grade 11-37-0. As you can see, the conventional 10-34-0 has only 10% of its P_2O_5 above the pyro level.

It is generally accepted that the pyrophosphates do an excellent job of sequestration on valence + 3 metals such as iron and aluminum. However, for valence + 2 metals such as calcium and magnesium, it is generally agreed that polyphosphates above the pyro level are required. The more the better up to about the 81% poly level. Solubility problems can occur above this level. You will note that with the high poly 10-34-0 made from the pipe reactor, 56% of the polyphosphate is above the pyro level.

The first phase of fluid fertilizer manufacture is concerned with the production of superacid and the second phase with the production of the 10-34-0/11-37-0 base solution.

Conclusion

The purity of the North Carolina phosphate makes it uniquely suited for the production of superacid. The magnesium impurity in the ore can be substantially reduced by careful control of process conditions such as the free sulfuric acid content of the feedstock. Because of these factors it has been possible to produce a superacid with a quality comparable or exceeding the quality attainable by some solvent extraction processes. The liquid fertilizer base solution produced from this superacid (10-34-0) has a storage life in excess of 1 year. Because of these unique qualities and techniques, Texasgulf has become a major supplier of phosphoric acids for fluid fertilizer. Further expansion of superacid production capacity is planned. Research and development is continuing on the further development of fluid fertilizers, and on the production of a more highly purified acid for non-agricultural uses.

A thorough description of the pipe reactor process used to produce the base solutions has been given in papers by R. S. Meline, et al,[4] F. P. Achorn, et al,[5] and A. O. Harwell and L. Hopwood.[6] Mr. Meline is presenting a paper on his process before this conference.

Acknowledgments

Acknowledgment is made to co-workers at TVA, Mapco, and Texasgulf for contributions in the development of superacid from a speciality chemical to a product of wide use and utility. Special acknowledgment is made of the work of my Tg associates John Jernigan, John Boyd, Eric Kelder, and Andy Harwell.

REFERENCES

1. Caldwell, A. Blake, "TGS Lee Creek Complex — A New Dimension in Phosphate Mining and Processing," *Engineering and Mining Journal,* January, 1968.
2. (a) Donohoo, H. V. W., "Phosphorus", *Fertilizer Solution, 10* No. 5, 42-46 (1973).

   (b) Blue, Thomas A., "Superphosphoric Acid." *Chemical Economics Handbook,* November (1973).

   (c) Achorn, F. P., and Hubert L. Balay, "Phosphoric Acid: Shipment, Storage, and Use in Fertilizers." *Fertilizer Solution, 17,* No. 5, 54-68 (1973).
3. Boyd, J. B., and J. D. Jernigan, "Use of Superphosphoric Acid in Fluid Fertilizer," Presented to The Fertilizer Institute roundtable, November 6, 1973.
4. Meline, R. S., R. G. Lee, and W. C. Scott, Jr., "Use of A Pipe Reactor In Production of Liquid Fertilizers With Very High Polyphosphate Content." *Fertilizer Solution, 16,* No. 2, 32-45 (1972).
5. Achorn, F. P., H. L. Balay, and H. L. Kimborough, "Commercial Uses Of The Pipe Reactor Process For Production Of High Polyphosphate Liquids." *Fertilizer Solution, 17,* No. 2, 44-54 (1973).
6. Harwell, A. P., and L. Hopwood, "Superphosphoric Acid And The Pipe Reactor." Presented to The American chemical Society national Meeting, Chicago (August 28, 1973).

Figure 1

LOCATION MAP

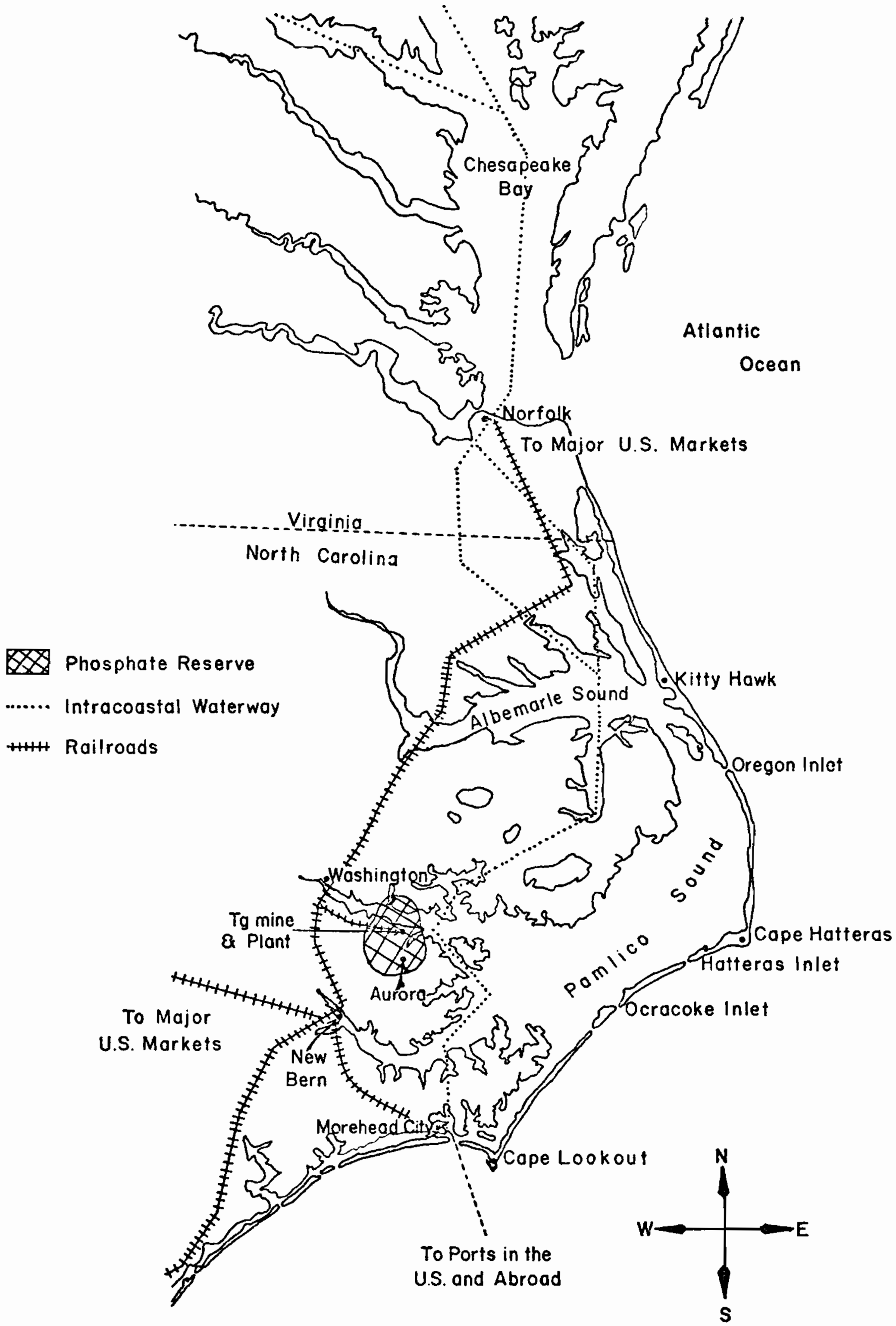


Figure 2

CROSS SECTION OF PHOSPHATE DEPOSIT

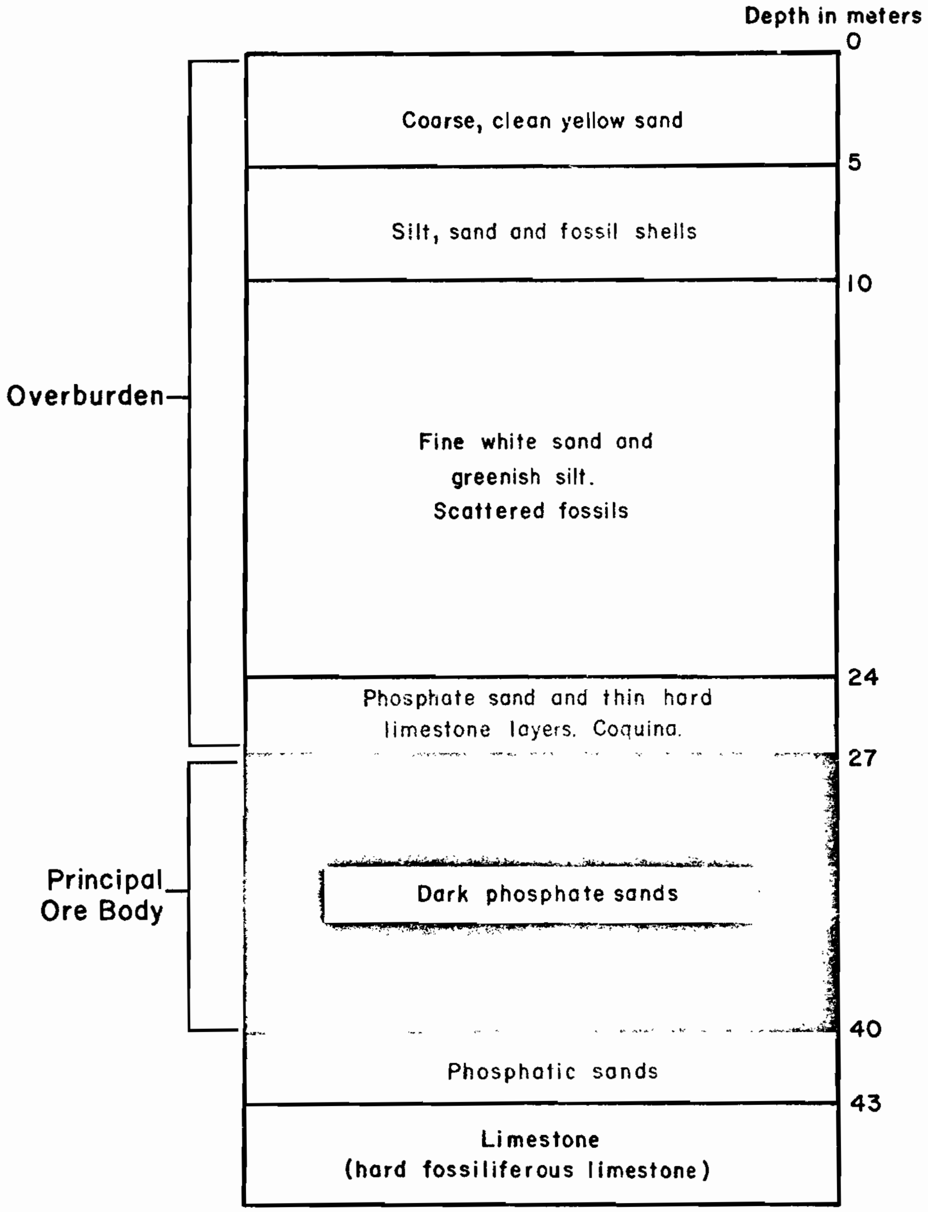
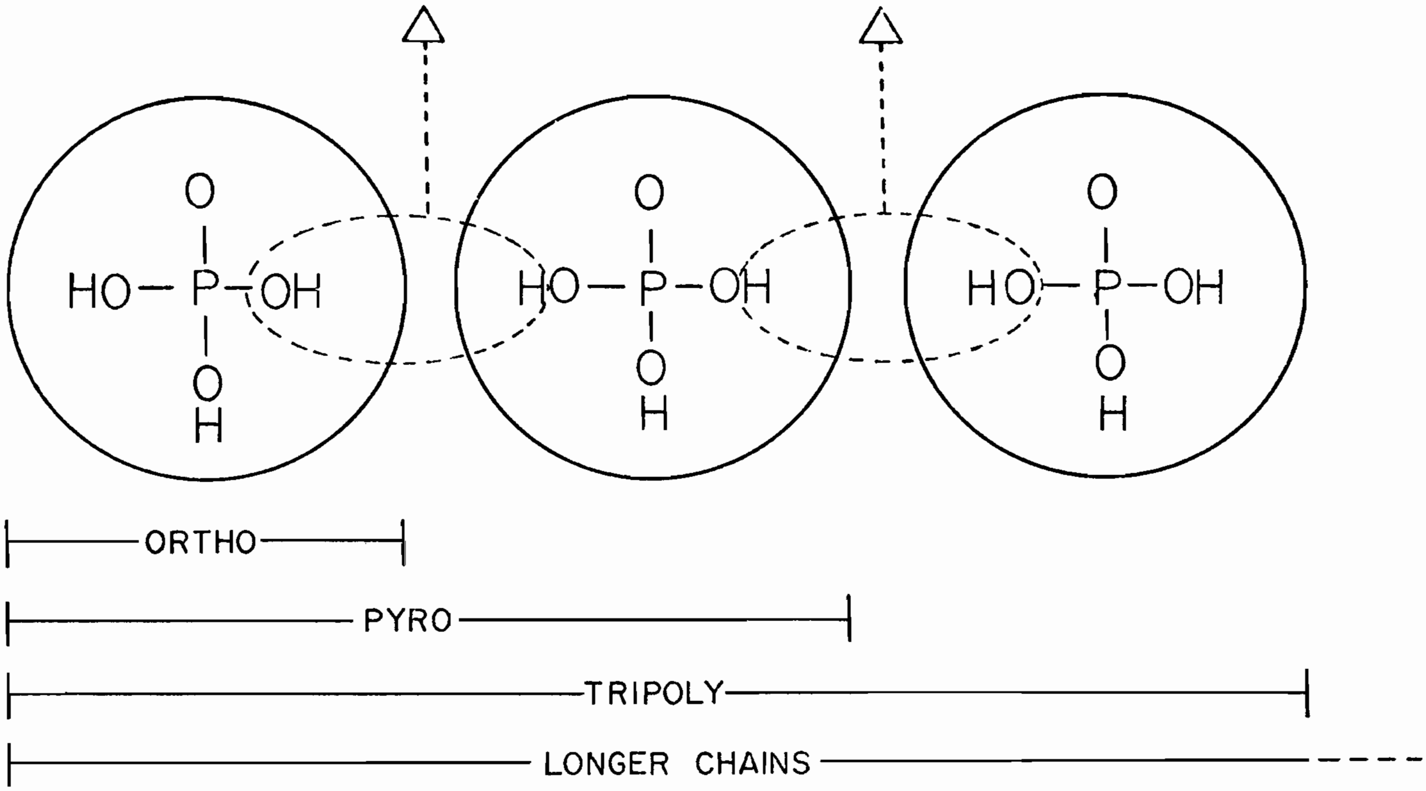
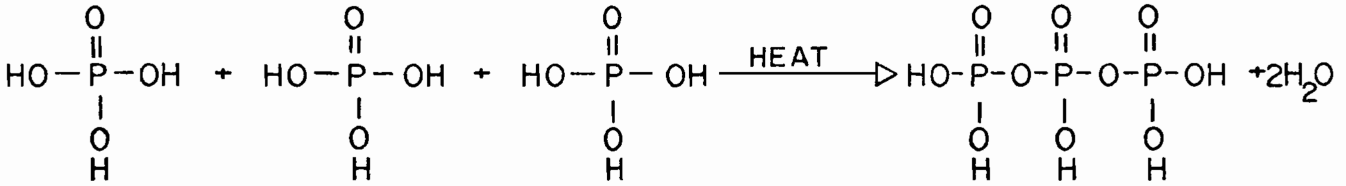


Figure 3

POLYPHOSPHATES(3)



Example of forming Tripolyphosphate



$$\mathrm{HO{-}\underset{\underset{H}{\overset{|}{O}}}{\overset{\overset{O}{\|}}{P}}{-}OH} + \mathrm{HO{-}\underset{\underset{H}{\overset{|}{O}}}{\overset{\overset{O}{\|}}{P}}{-}OH} + \mathrm{HO{-}\underset{\underset{H}{\overset{|}{O}}}{\overset{\overset{O}{\|}}{P}}{-}OH} \xrightarrow{\text{HEAT}} \mathrm{HO{-}\underset{\underset{H}{\overset{|}{O}}}{\overset{\overset{O}{\|}}{P}}{-}O{-}\underset{\underset{H}{\overset{|}{O}}}{\overset{\overset{O}{\|}}{P}}{-}O{-}\underset{\underset{H}{\overset{|}{O}}}{\overset{\overset{O}{\|}}{P}}{-}OH} + 2H_2O$$

Orthophosphate Units

Tripolyphosphate

Water

Figure 4

COMPARATIVE ANALYSIS
Tg Superphosphoric Acid

COMPONENT	PRODUCT NAME SUPER 49 PURIFIED	 SUPER 45 UNPURIFIED
Total P_2O_5	70.0	69.8
% Polyphosphate	30.0	36.8
Sulfate (SO_4)	3.8	3.4
Aluminum (Al_2O_3)	1.1	0.9
Iron (Fe_2O_3)	1.0	1.8
Magnesium (MgO)	0.4	1.3
Fluorine (F)	0.27	0.26
Solids (Insol. in CH_3OH)	0.15	8.0
Solids (Insol. in H_2O)	0.01	0.20
Sp. Gr. at 24°C	1.96	2.00
Viscosity, Centipoise at 52°C	175	450

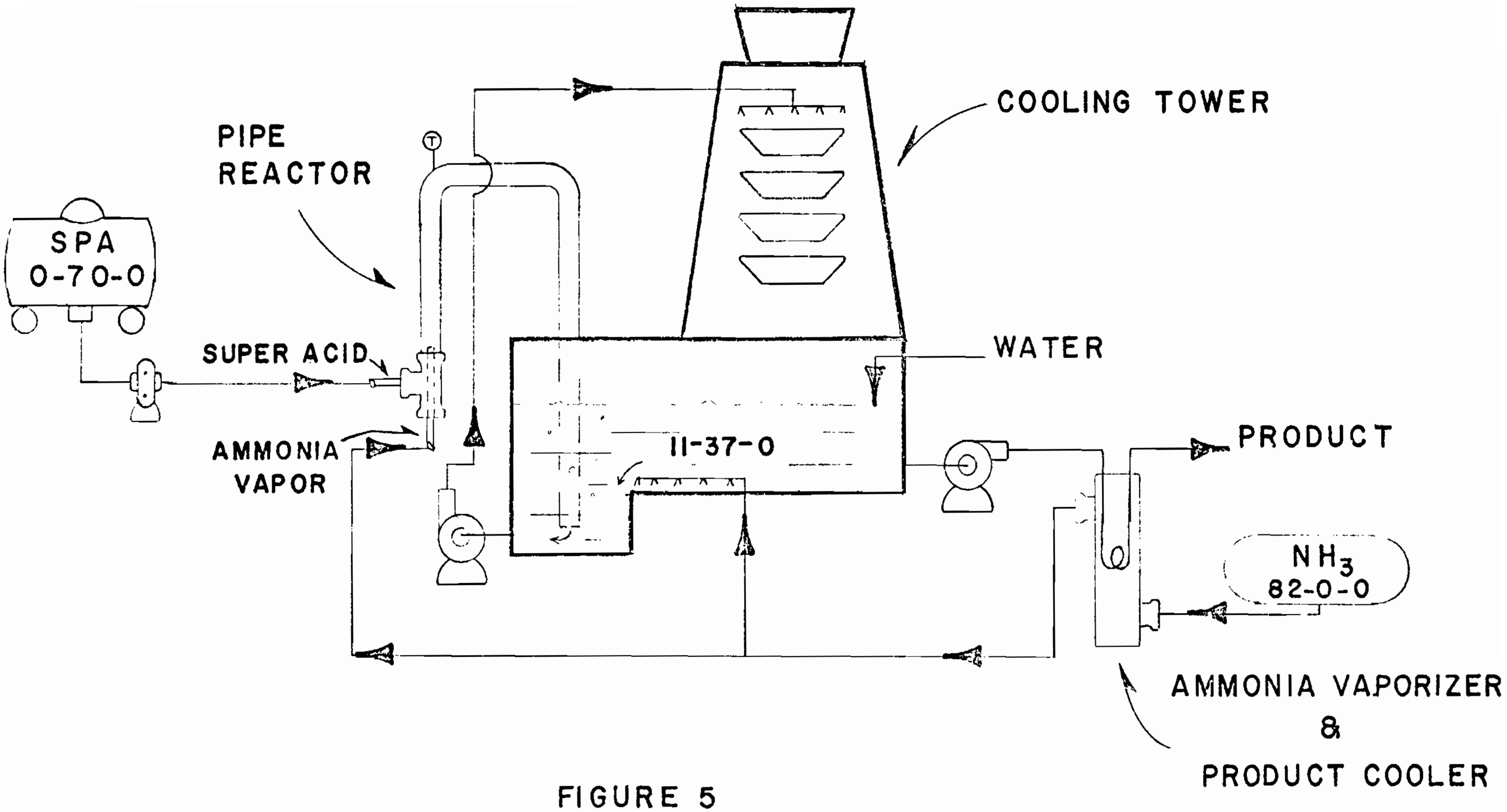


FIGURE 5

DIRECT AMMONIATION PLANT USING A RECYCLE PUMP FOR MIXING AMMONIUM POLYPHOSPHATE MELT

FIGURE 6

COMMERCIAL PRODUCTION OF HIGH-POLY 10-34-0 FROM Tg SUPER 49 SPA

Component, %	Company			
	A	B	C	D
Nitrogen	9.74	10.08	10.09	10.02
P_2O_5	33.95	33.71	33.57	34.08
Poly P_2O_5	75.94	76.02	76.46	74.91
pH	5.85	6.04	5.90	5.97

Figure 7

POLYMER PROFILE 10-34-0/11-37-0

	Conventional	Tg Pilot Plant	Commercial Plant	11-37-0 Electric Furnace
	50% P_2O_5 Feed	TVA Pipe Reactor & Super 49	TVA Pipe Reactor & Super 49	Electric Furnace Acid
% Poly	47	83	79	81
Species, %				
Ortho	53	17	21	19
Pyro	37	27	35	37
Tri	8	21	23	24
Tetra	-	13	11	11
Penta	-	9	6	-
Hexa	-	5	2	-
Hepta	-	3	2	-
Octa	-	3	-	-
Other	2[a]	2	1	9[b]
Above Pyro	10	56	44	43

a. includes tetra

b. includes penta

MODERATOR ADAMS: Thank you Mr. Whitehurst for your detailed history covering "The Phosphate Deposits in Eastern North Carolina" owned and operated by Texas Gulf Sulphur. We also wish to thank you for your thorough explanation covering "The Production and Marketing of Superphosphoric Acid from North Carolina Ore".

Our next discussions cover "A Progress Report on Spherodizer Granulation" The Author will be introduced by Dr. E. Pelitti — C & I Girdler Co. Part I, "Spherodizer Granulation of Anhydrous Melts" was prepared by R. M. Reed and J. C. Reynolds — C & I Girdler Co. and Part II, "Hot Spherodizer Processes And Complex Fertilizers — Recent Developments" was prepared by T. Berguin and J. Burke — PEC — Engineering. Dr. Pelitti is well known to most of us. He has contributed several papers at Round Table Annual Meetings covering Fertilizer Manufacturing Technology. Dr. Pelitti please.

Progress Report On Spherodizer® Granulation

Introduction: E. Pelitti

You have heard this morning several very interesting presentations on granulating processes which, apart from the TVA ammoniator, have been tested on either a pilot or a demonstration scale, and appear very promising. You may now be interested in a progress report on a process which has been in commercial operation for over 15 years, and has already produced several million tons of granular material for the fertilizer industry.

"SPHERODIZER"® is a registered trade name for certain granulating processes, mainly used in the production of fertilizers. The development was first introduced to the Fertilizer Round Table in 1960 by Clem Giles, then with Calspray (presently chevron). It was further discussed at the Round Table meetings of 1961 and 1967 by Smith, Giles, Pelitti and Russo.

The process, which produces granular materials by contacting solid particles with liquid in a rotating drum, has been in commercial use since 1958 producing granular complex fertilizers, and since 1965 producing granular ammonium nitrate and urea.

In its original version, water is removed from the granules by contact with hot air. A modification of it uses cold air to remove heat of crystallization from melt particles. To distinguish the two versions, it has become customary to prefix the term Hot or Cold to the word SPHERODIZER®. The two expressions "Hot SPHERODIZER®" and "Cold SPHERODIZER®" have thus become part of the trade language, even though they may not offer an accurate definition of the respective processes.

Hot SPHERODIZER® granulators were first used in the United States, but most of the subsequent applications occurred in other areas, and principally in Europe. Most of the credit for the European success of the SPHERODIZER® process goes to the C&I/Girdler European licensee, PEC-Engineering.

PEC-Engineering is a company of the E.M.C. group Entreprise Miniere et Chimique, a French state-owned corporation. It was under the name of P.E.C. (Potasse et Engrais Chimiques) that the complex fertilizer processes associated with SPHERODIZER® granulators in so many applications were originally developed.

Cold SPHERODIZER® granulators were first operated by Cominco in Canada, and later expanded into the U.S. market. They have recently captured a predominant share of the whole nitrogen fertilizer granulation market in North America.

The presentation will be in two parts.

The first part is Progress Report on SPHERODIZER® granulation of anhydrous melts. It was prepared by Dr. R. M. Reed and J. C. Reynolds, who are recognized authorities on urea processes. Bob Reed, presently a Process Consultant, is a graduate of Washington University, and was associated with Girdler in various capacities from 1938 to 1970. Carter Reynolds, a graduate of the University of Louisville, joined Girdler in 1951, and is presently Chief Process Engineer of C&I/Girdler.

The second part of the presentation deals with recent developments in Hot SPHERODIZER® Processes and Complex Fertilizers. It was prepared by Y. Berquin and J. Burko, of PEC Engineering. Yves Berquin is a graduate of the University of Lille and has been associated with companies of the EMC group since 1942. He is presently Director of Development for PEC Engineering.

Jacques Burko, a graduate of the Sorbonne, has been with the P.E.C. group for 17 years, the last six as Head of the Commercial Department.

Mr. Berquin and Mr. Burko had originally prepared their presentation in French, but after a quick survey of the proficiency in the French language display by members of the fertilizer industry, they concluded that you may prefer to listen to an English version if it, which will be read to you by Bob Reed.

Messrs. Burko and Berquin, however, are available to answer any of your questions.

We will now proceed with Part I of the Report, presented by Carter Reynolds.

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Part I

Progress Report On Spherodizer® Granulation Of Anhydrous Melts

R. M. Reed and J. C. Reynolds
C&I/Girdler, Inc.

The SPHERODIZER® drum granulation process, which produces granular fertilizers by contacting solid particles with liquid in a rotating drum, has been in commercial use since 1958 producing granular complex fertilizers, and since 1965 producing granular ammonium nitrate and urea.

This progress report will list recent commercial application for manufacturing granular ammonium nitrate and urea, with photographs of operating units, and typical operating data.

The historical background of the development of the SPHERODIZER® drum granulation process was given in a paper, "Recent Developments in the Granulation of Nitrogenous Fertilizers" by G. C. Hildred, E. Pelitti, and R. M. Reed, presented at the September, 1969 American Chemical Society Meeting in New York City, and the specific application of the process to the manufacture of granular ammonium nitrate was discussed in a paper, "The SPHERODIZER® granulation process" presented by the present authors at the August, 1972 meeting of the American Institute of Chemical engineers in Minneapolis, Minnesota.

A simplified flow sheet of the process, as applied to the production of granular ammonium nitrate and urea, is shown in Figure 1.

Substantially anhydrous (preferably 99% or higher) molten ammonium nitrate or urea is sprayed inside a rotating drum onto a rolling bed of solid particles. As the particles roll, they become coated with the molten ammonium nitrate or urea, and gradually build up to product size by being coated repeatedly with thin layers of liquid, which solidify to give the granule an onion-skin structure. Such granules have greater strength, and are more nearly spherical than granules produced by mixing solid particles with liquid to form granules by agglomeration.

The granules flow from the granulation section through a cooling section to a screen where oversized and undersized granules are separated. The undersized granules, plus crushed oversized material, are returned to the granulation section for further coating with liquid.

Air flows through the granulation drum countercurrent to the flow of granules, and serves to cool the granules and remove dust from them. The exit air from the granulation drum flows through an impingement type wet scrubber to an exhauster which discharges through a stack.

Condensate fed to the wet scrubber dissolves the ammonium nitrate or urea dust to form an aqueous solution that is returned to the evaporator for reconcentration.

In addition to the three original SPHERODIZER® granulation plants built by Cominco Ltd. in Canada, and two later plants built by C&I/Girdler in the United States, that were described in the previous papers, there have recently been announcements of six new SPHERODIZER® plants for manufacturing urea and one for ammonium nitrate, with a total daily capacity of 6220 tons, utilizing 20 granulation drums.

A listing of these seven new projects, four of which are already in operation, is given in Figure 2.

In addition to the above projects, four others that will utilize 14 granulation drums to produce 4500 T/D are being engineered at present.

Figure 3 is a view of the SPHERODIZER® building in the Agrico plant at Donaldsonville, Louisiana. All the equipment is housed except for the refrigeration unit for air cooling, the wet scrubbers and pumps, and the exhaust air blowers and stacks.

Figure 4 shows a SPHERODIZER® drum and the outlet belt conveyor which transfers the material leaving the drum to the bucket elevator feeding the screen.

A SPHERODIZER® motor drive and speed reducer are shown in Figure 5.

The urea melt inlet piping manifold, the undersized recycle line, the motor control panel, and the air exit breeching are shown in Figure 6.

The bucket elevator feeling the screen is shown in Figure 7.

The rotating screen, which separates the output from the drum into oversize product, and undersize, is shown in Figure 8.

The urea product belt conveyor, transferring product from the screen outlet pipe to the warehouse belt conveyor is hown in Figure 9.

The crusher, which crushes the oversized urea before it is returned to the drum, is shown in Figure 10. This is a rigid arm hammer mill crusher.

The cooling air required to solidify the melt in the SPHERODIZER® drum and cool the product is drawn through the drum and the wet scrubber by an exhaust blower. In warm climates, such as Louisiana, refrigeration is used to cool the air entering the drum. A package refrigeration unit is shown in Figure 11.

The air intake screens and ait chiller coils are shown in Figure 12.

The air duct leading from the SPHERODIZER® drum to the wet scrubber is shown in Figure 13.

The wet scrubber, which removes urea dust from the cooling air stream, is shown in Figure 14.

The exhaust air blower, which draws air through the drum and the wet scrubber, and discharges into a stack, is shown in Figure 15.

The air exhaust stack, with a sampling platform, is shown in Figure 16.

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ADVANTAGES IN SPHERODIZER GRANULATION

As has been pointed out in previous papers, there are three principal advantages in SPHERODIZER® granulation of ammonium nitrate and urea, as compared with prilling. These are:

1. Any desired product size range, from small agricultural grade granules, to large forestry grade, can be manufactured by a suitable choice of screen sizes.
2. The SPHERODIZER® product has a higher crushing strength than prills, and has been found to resist breakdown better in air conveying equipment, when reclaimed from bulk storage, the breakage rate is less than 1%.
3. Pollution control, meeting all present standards, is being attained in the effluent air stream by the use of wet scrubbers. The smaller air volume required (about one-third that used in prilling), and the ground level location of equipment, simplifies the pollution control problem in the SPHERODIZER® plant. Four of the presently operating SPHERODIZER® plants were originally prilling plants.

PRODUCT SIZE DISTRIBUTION

The granular product size distribution is determined by the screen sizes selected for rejecting oversized and undersized granules. The screen choice will also affect the ratio of recycle to product. A narrow product cut will result in a higher recycle ratio. This is illustrated by the following screen analyses, made on urea samples from two units, unit A using 6 and 8 Tyler mesh screens, and unit B using 6 and 9 Tyler mesh screens.

The unscreened urea granules at the outlet of the drums had the screen analyses shown in Table 1.

As will be noted from Table 1, all the urea leaving the drum at the product outlet is larger than 28 mesh, and only a small fraction (3.5% in A, 0.7% in B) is in the size range of —14 +20 mesh.

The A unit, with the 6 and 8 mesh screens, was producing less +6 mesh oversize than the B unit, but had a larger fraction (58.7% vs. 40.7%) in the —8 +14 size range, as well as in the —14 +20 size range (3.5% vs. 0.7%). The B unit, with the 6 and 9 mesh screens, was returning less undersize material as recycle, and was depending more on crushed oversize to provide nuclei for forming product size granules.

The screened urea product screen analyses are shown in Table 2. As would be expected, the product from the B unit contained a higher percentage of —8 +10 granules than the product from the A unit.

CRUSHING STRENGTH OF SPHERODIZER® GRANULES

As mentioned earlier, one advantage of the granular ammonium nitrate and urea products is their higher crushing strength as compared with prills. The relative crushing strengths of urea granules and urea prills are shown in Table 3, which gives the mean crushing strength in pounds, as measured by a chatillon compression tester, in which a single granule or prill is placed between flat plates, and the loading in pounds needed to crush it is determined. Ten samples of each size size were tested, and the mean crushing strength, the standard deviation, and the standard error of the mean were calculated.

The crushing strength of the urea granules is 1.8 to 2.8 times as high as that of the urea prills. The higher strength of the urea granules greatly reduces the amount of fines that must be recycled from bulk storage as compared with prills.

Similar data for ammonium nitrate granules and prills are given in Table 4, with the granules having crushing strengths 2.3 to 3.2 times as high as the prills. The higher strength greatly reduces the number of complaints about hopper cars that do not unload freely, by eliminating breakdown to fines that cake easily.

POLLUTION CONTROL

The cooling air stream from the granulation drum flows into an impingement type wet scrubber, in which the ammonium nitrate or urea dust is scrubbed out by an aqueous solution of ammonium nitrate or urea. Condensate is added to the scrubber to dissolve the dust to produce solutions that are recycled to the plant evaporators for reconcentration. The air from the scrubber flows to an exhaust blower, which discharges to a stack. The stack exit air temperature will be about 110 to 120 degrees F. when producing urea and 130 to 140 degrees F. for ammonium nitrate. Measurements of urea losses from the stacks have consistently shown amounts of less than 10 pounds per hour from a stack on a SPHERODIZER® unit producing 335 tons per day of urea granules. Comparable dust losses from a conventional urea prilling tower have been reported as about 40 pounds per hour, or more than 4 times as great as is being obtained with granulation.

TYPICAL OPERATING DATA

Although the equipment used in the SPHERODIZER® plants for producing urea or ammonium nitrate granules is similar, operating conditions are somewhat different, due to the higher melting point (337 degrees F.) of ammonium nitrate as compared with urea (271 degrees F.) and the higher heat of crystallization of urea (104 BTU./LB.) as compared with ammonium nitrate (30.6 BTU./LB.). Typical operating data for ammonium nitrate and urea granulation are given in Table 5.

The ammonium nitrate granules are cooled in a separate rotary cooler after screening, while the urea granules go directly to storage from the screen.

The ammonium nitrate granules are ordinarily coated with 1.2 to 2.0% of clay, while urea granules are usually uncoated.

C&I/GIRDLER
UREA OR AMMONIUM NITRATE GRANULATION
SPHERODIZER® PROCESS

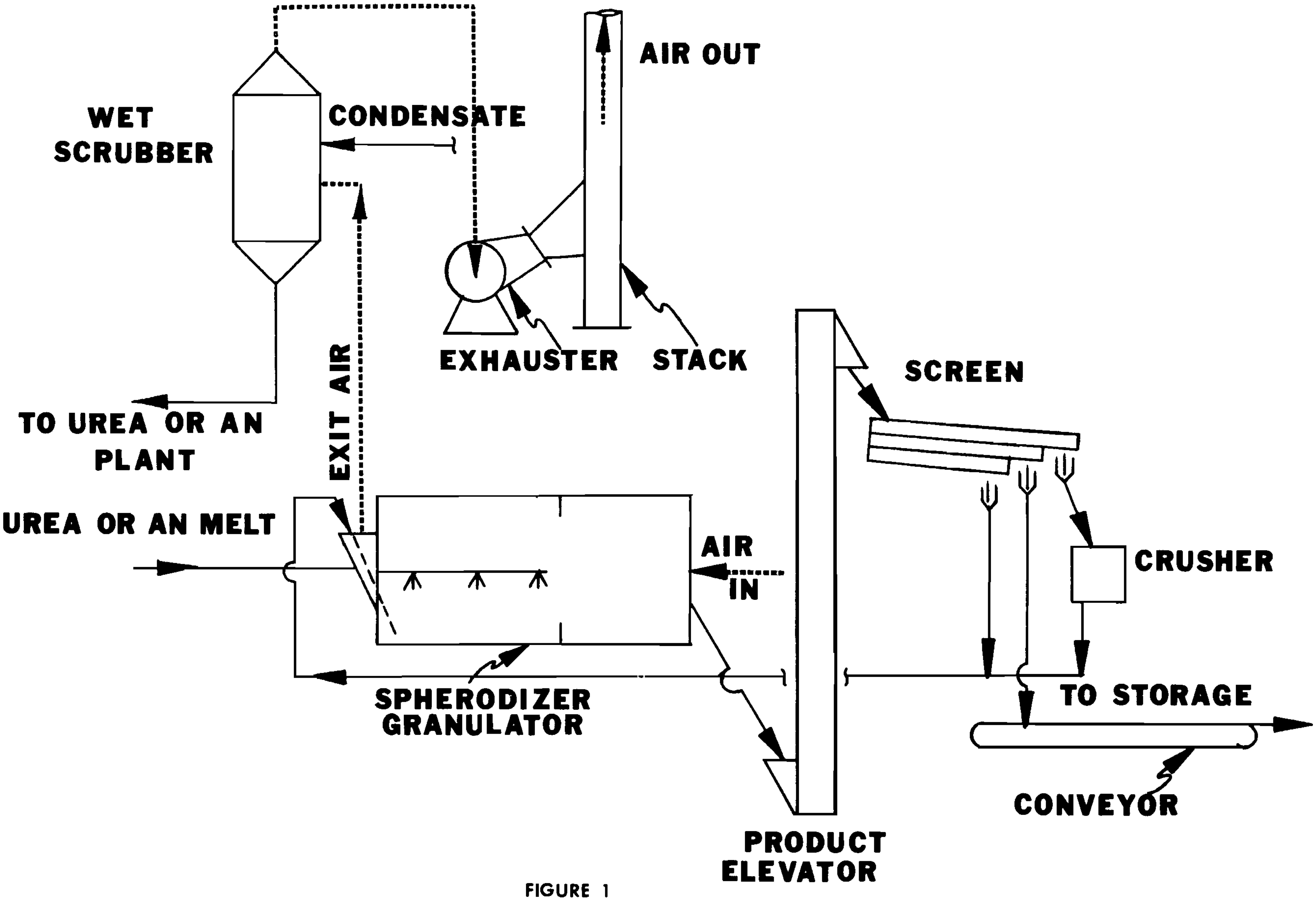


FIGURE 1

SPHERODIZER® GRANULATOR PLANTS

CLIENT	PRODUCT	CAPACITY ST/D	NO. OF DRUMS	LOCATION
Agrico Chemical Co.	Urea	600	2	Donaldsonville, La.
Agrico Chemical Co.	Urea	1000	3	Blytheville, Ark.
CF Industries Inc.	Urea	1000	3	Donaldsonville, La.
Canadian Fertilizers Ltd.	Urea	1500	5	Medicine Hat, Alta.
Chevron Chemical Co.	Amm. Nitrate	320	1	Ft. Madison, Iowa
Collier Carbon & Chemical Co.	Urea	1200	4	Kenai, Alaska
Cooperative Farm Chemicals Assn.	Urea	600	2	Lawrence, Kansas
	TOTAL	6220	20	

FIGURE 2

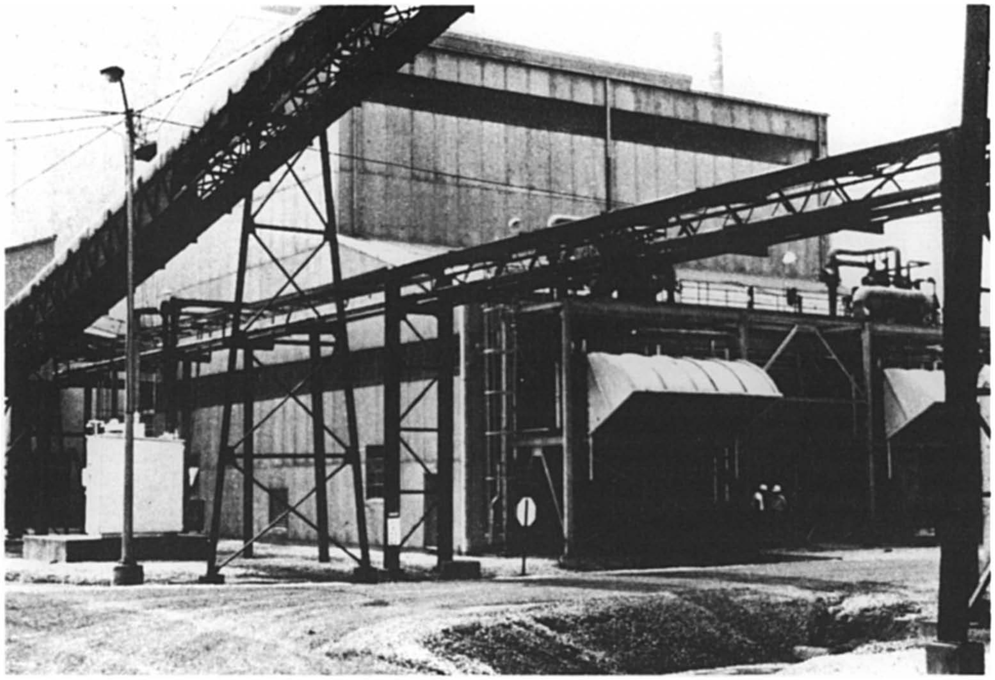


Figure 3

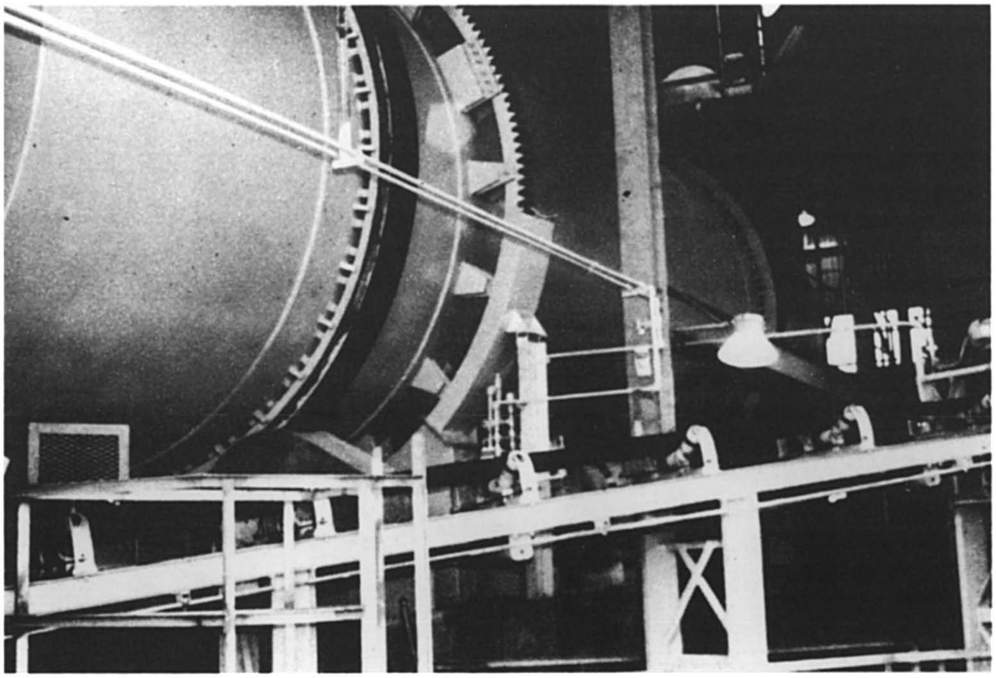


Figure 4

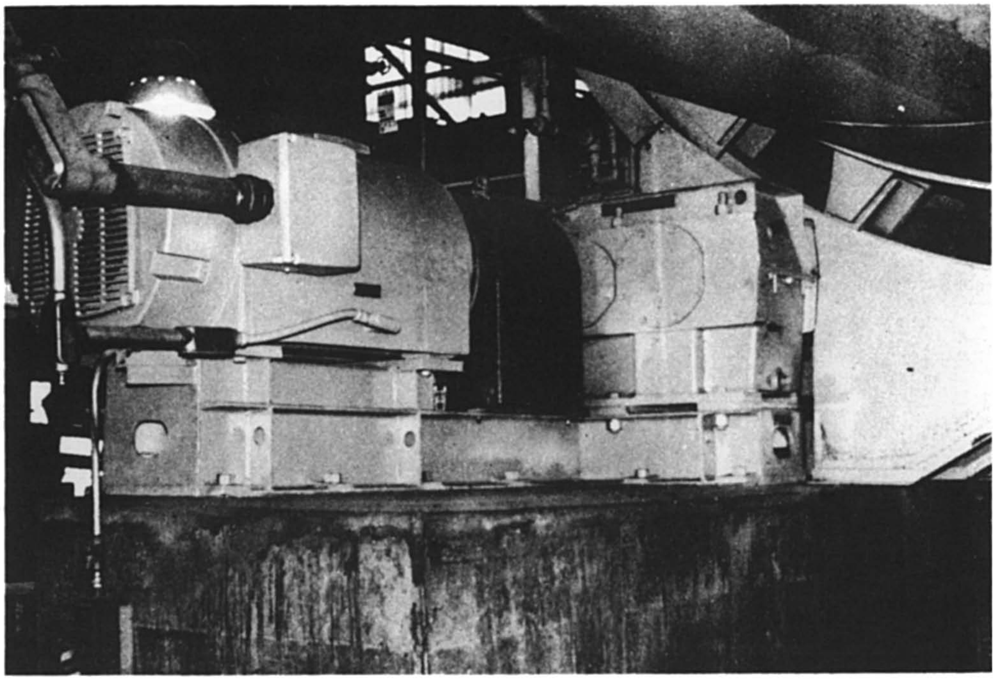


Figure 5

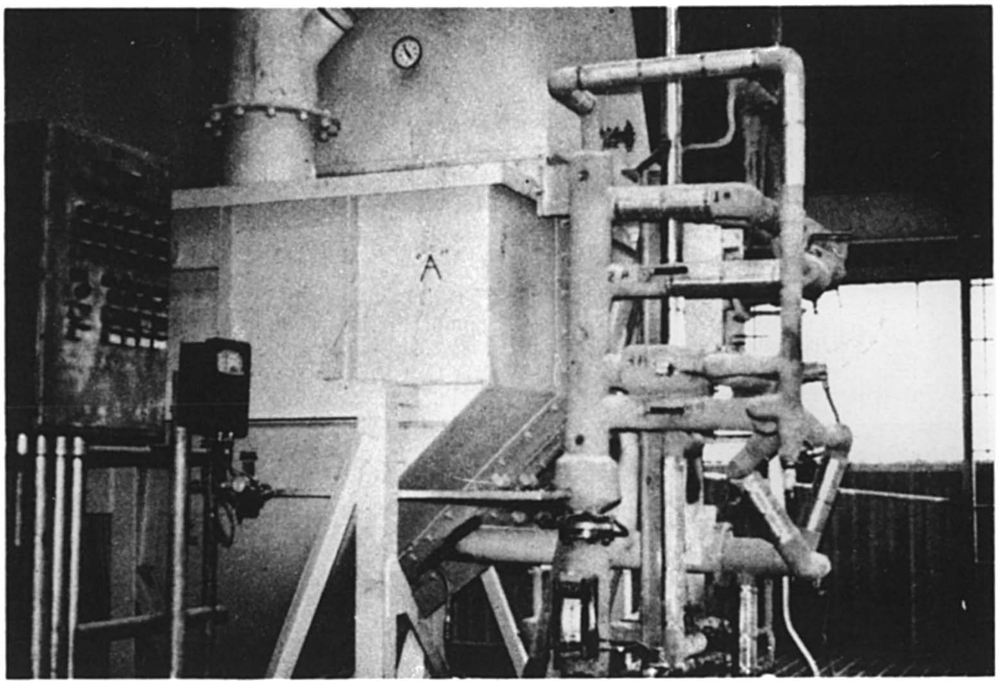


Figure 6

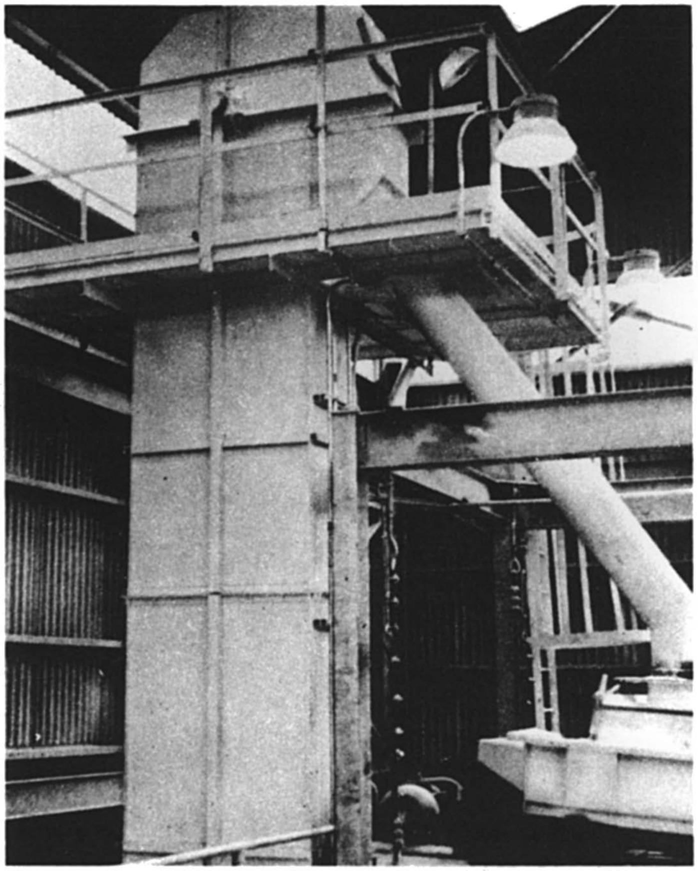


Figure 7

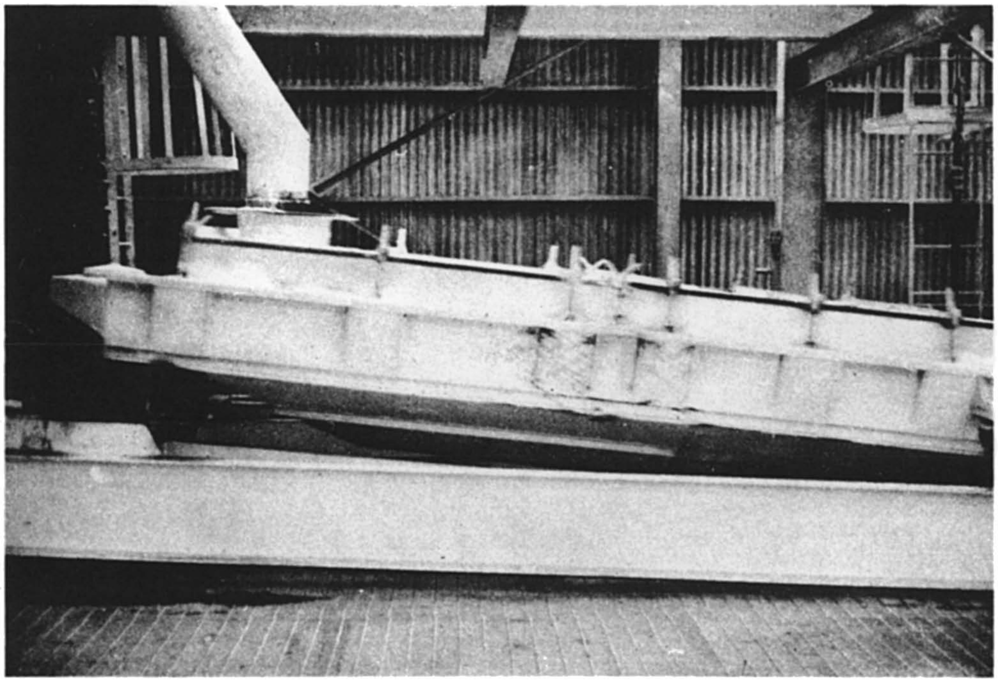


Figure 8

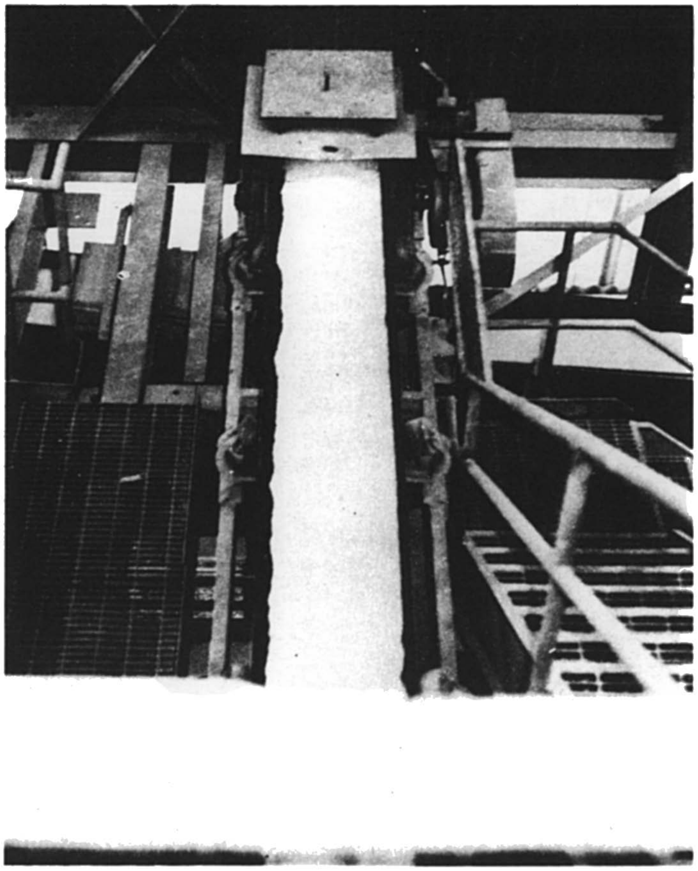


Figure 9

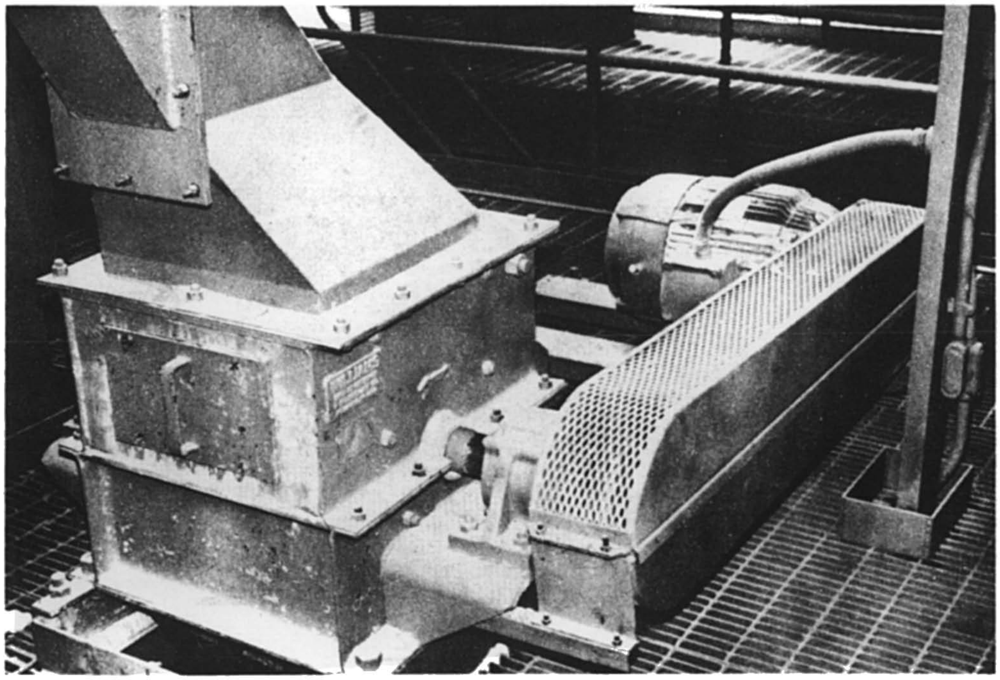


Figure 10

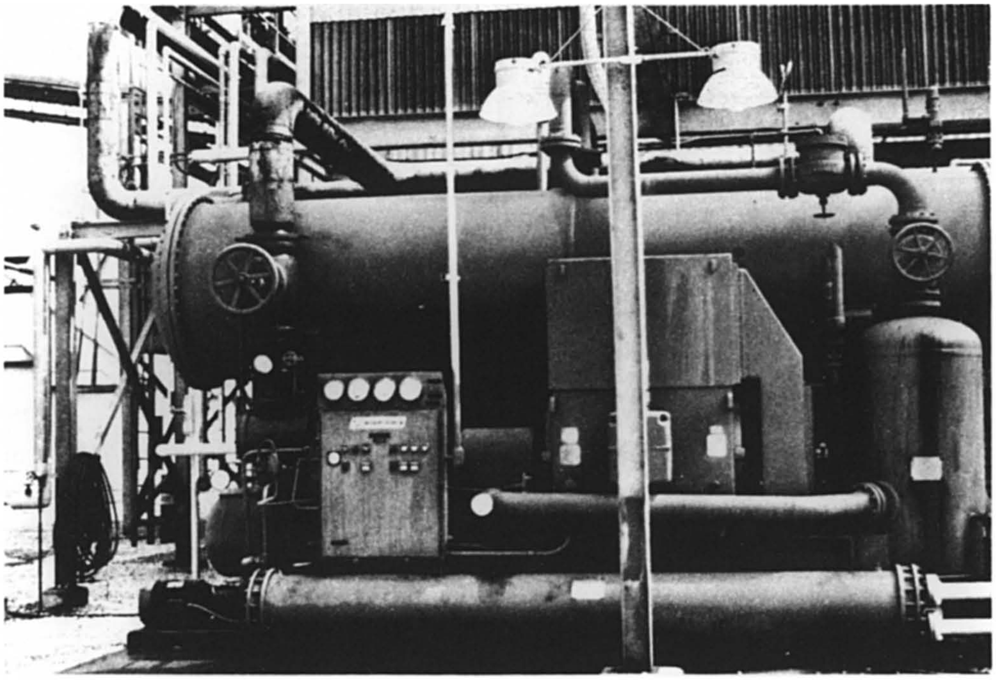


Figure 11

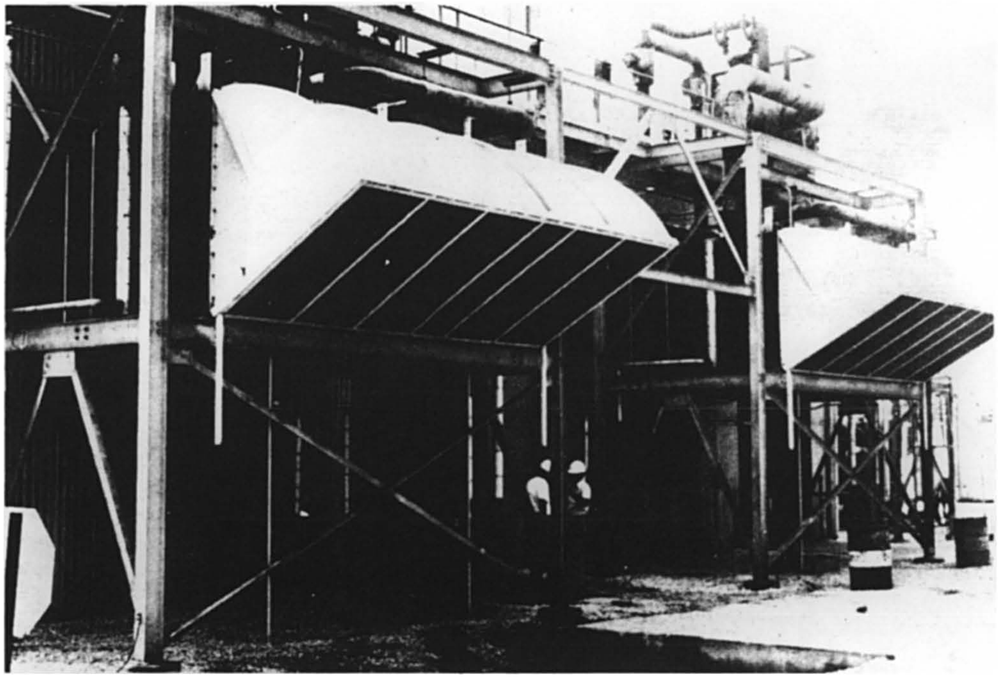


Figure 12

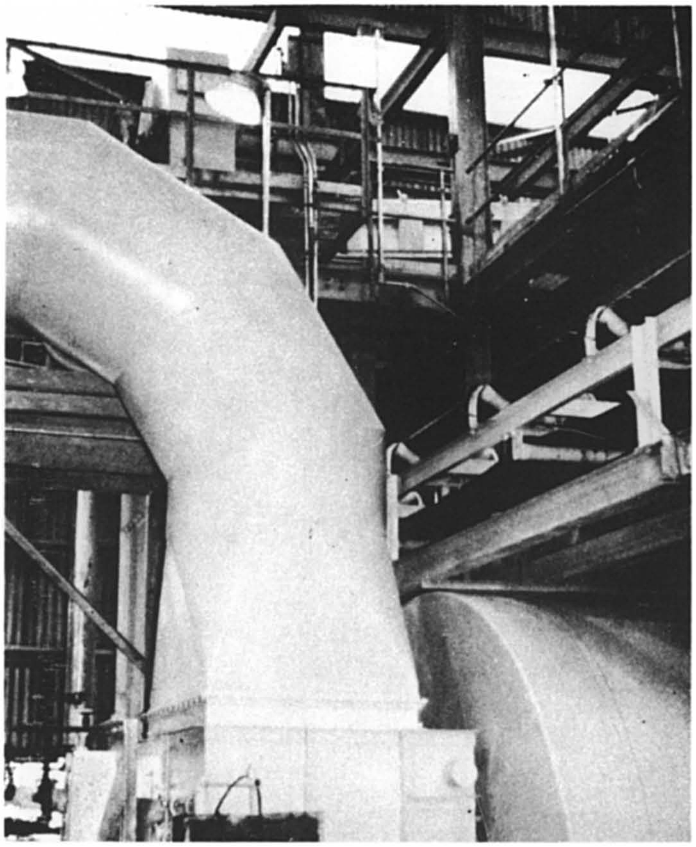


Figure 13

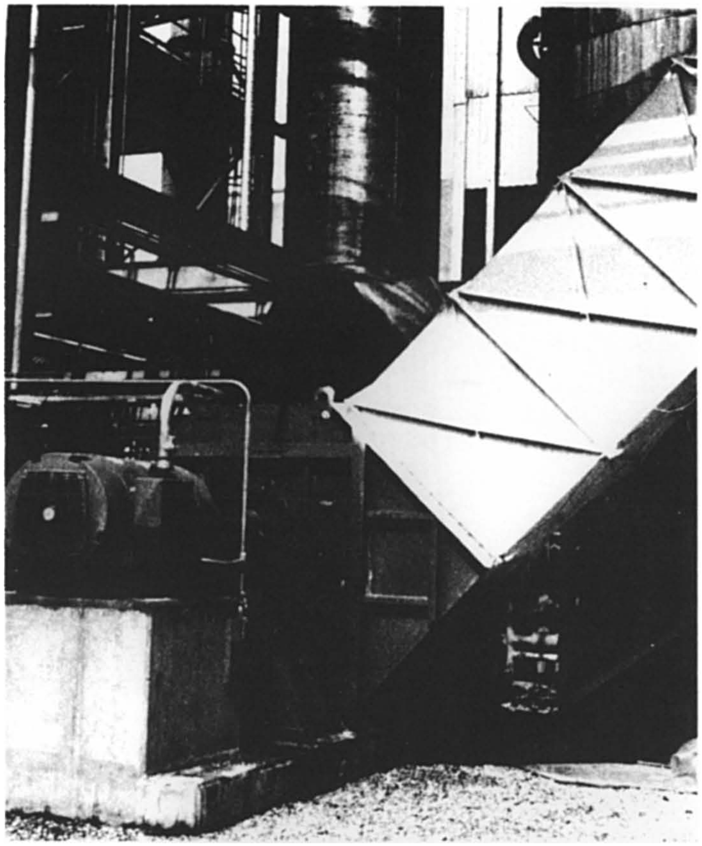


Figure 15

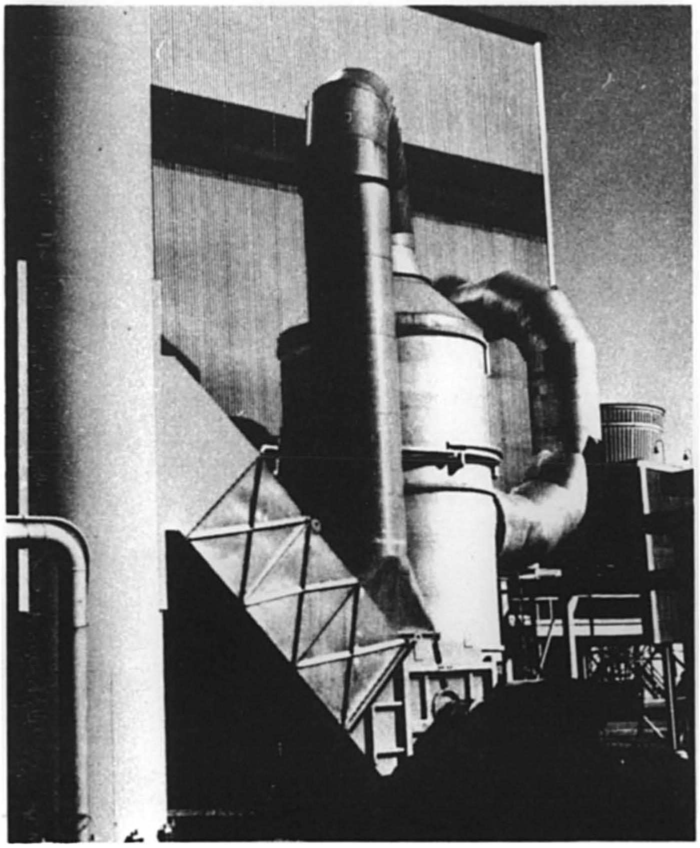


Figure 14

Figure 16

Table 1

UNSCREENED UREA GRANULES

TYLER	UNIT A %	UNIT A CUM. %	UNIT B %	UNIT B CUM. %
+6	11.7	11.7	27.4	27.4
+8	25.9	37.6	31.2	58.6
+14	58.7	96.3	40.7	99.3
+20	3.5	99.8	0.7	100.0
+28	0.1	99.9	0.0	100.0
Pan	0.1	100.0	0.0	100.0

Table 2

SCREENED UREA PRODUCT

TYLER	UNIT A %	UNIT A CUM. %	UNIT B %	UNIT B CUM. %
+6	1.5	1.5	2.7	2.7
+8	89.6	91.1	80.1	82.8
+10	8.8	99.9	17.1	99.9
+14	0.1	100.0	0.1	100.0
Pan	0.0	100.0	0.0	100.0

Table 3

CRUSHING STRENGTH OF UREA GRANULES AND PRILLS

TYLER MESH	UREA GRANULES MEAN CRUSHING STRENGTH, LBS.	UREA GRANULES STANDARD ERROR	UREA PRILLS MEAN CRUSHING STRENGTH, LBS.	UREA PRILLS STANDARD ERROR
−6+7	9.5	0.4	3.5	0.5
−7+8	7.7	0.2	2.8	0.4
−8+9	5.6	0.2	2.3	0.4
−9+10	4.4	0.1	2.4	0.1

Table 4

CRUSHING STRENGTH OF AMMONIUM NITRATE GRANULES AND PRILLS

TYLER MESH	AN GRANULES MEAN CRUSHING STRENGTH, LBS.	AN GRANULES STANDARD ERROR	AN PRILLS MEAN CRUSHING STRENGTH, LBS.	AN PRILLS STANDARD ERROR
−6+7	12.6	0.7	4.5	0.3
−7+8	11.7	1.2	3.9	0.3
−8+9	11.5	0.8	3.6	0.3
−9+10	6.3	0.7	2.8	0.2

Table 5

SPHERODIZER GRANULATOR OPERATING DATA

	AN	UREA
Melt temperature, °F	365	280
Melt concentration, %	99.0	99.3
Moisture in product, %	0.1	0.06
Air inlet, °F	50	50
Production rate, ST/D, 14′ dia.	400	335
Recycle ratio (recycle/product)	2	2
Product temperature, °F	90 to 95	110

Part II
Hot SPHERODIZER® Processes And Complex Fertilizers Recent Developments

Y. Berquin and J. Burko,
PEC—Engineering
Read by R. M. Reed

You have just heard a progress report on SPHERODIZER® granulation in the United States. The two main points that should be clear from it are: SPHERODIZER® applications have gone through a period of very rapid expansion, and the report covers mainly the "cold" version of this equipment, used for the granulation of products entering it as a liquid melt.

In this respect, it should be of interest to review the differences between the situation in the United States and that in other areas and more specifically in the European sector. In Europe, the development of this technique has followed a somewhat different pattern, though it is to be expected that even their applications of the Cold SPHERODIZER® process will soon begin to occur, for reasons similar to those that were responsible for its expansion in the United States.

Interest in this technique is only now beginning to develop on the continent. The reasons for this delay are many. On the one hand, concern about atmospheric pollution has lagged, and in many cases is not yet as serious as in the United States. On the other hand, the average unit size of European installations is larger, and the producing companies tend to favor equipment such as prill towers, which can produce in a single line tonnages that would require multiple SPHERODIZER® lines. Finally, production of urea in Europe is represented by tonnages relatively smaller, and the requirements are to a great extent satisfied by units already in operation.

However, both for ammonium nitrate and for urea, new units have already been announced, and to the extent that this trend will continue there will undoubtedly be a demand for the Cold SPHERODIZER® Frocess.

It is in the field of the so-callled "Hot" version, used in the granulation and drying of complex fertilizers from aqueous suspensions instead of melts that the most impressive applications of the SPHERODIZER® process are found today in Europe and other non-U.S. areas.

Complex fertilizer processes, in which NP or NPK products are obtained by nitric acid acidulation of phosphate rock, have been in wide use in Europe since World War II. The savings they allow in sulphur constitute a greater advantage in that part of the world than in North America. It is not surprising, therefore, that SPHERODIZER® applications in connection with complex fertilizer plants should be more numerous in Europe than in other areas.

Among complex fertilizer processes, those developed by P.E.C., including some original ones like the carbonitric process, have attracted much interest. Combining the wet section of these processes with SPHERODIZER® granulators for drying and granulating the product has resulted in plants extremely flexible and economical, in which a wide range of raw materials can be used. The granules produced have superior characteristics: homogeneity, sphericity, hardness, uniformity of screen size, absence of dust.

This explains why PEC plants equipped with SPHERODIZER® granulators are used to produce fertilizers in most of the countries of both Western and Eastern Europe. However, plants of this type have also been widely used outside Europe, and applications are found in the U.S., Latin America, and Asia.

In general, early SPHERODIZER® installations had a capacity of 250 to 300 MT/D per unit. A limiting-factor in many cases had been the size of drum that could be easily transported to the site.

In this respect, however, conditions in Europe are frequently different than in North America. For instance, the shorter shipping distances and the availability of waterways serving the shole continent make it easier to handle heavy and bulky loads. In addition, fertilizer plants are more integrated than in the States, which means that the capacity of downstream units must match the scale of production of materials used as intermediates such as ammonia (600 to 1000 MT/D NH_3) and phosphoric acid (500 to 600 MT/D P_2O_5). Under these conditions, sizes such as used for earlier SPHERODIZER® applications (10 and 12 ft. dia.) would have resulted in the multiplication of parallel production lines, with the attending increase in investment and operating costs. Consequently, they were no longer satisfactory for European requirements. This is why PEC developed and installed the first 14 foot SPHERODIZER® granulators (4.25 m), which are those still in use in most European plants. With a production capacity between 500 and 700 MT/D per unit, they have been the standard for several years.

However, pressure for increasing the unit size of process plants does continue. The latest trends call for production of up to 1000 MT/D in a single line. To satisfy these new requirements, PEC-Engineering has decided to increase gradually the size of the SPHERODIZER® granulators offered as part of their complex fertilizer plants.

In line with this decision, a first step was taken on the occasion of the construction of the Grande Paroisse plant in Montoir, France. This time, the size of the SPHERODIZER® drum was brought to 4,50 m in diameter (about 15 ft.) by 12 m of length. The results were excellent: 600 MT/D of 17-17-17 were easily produced, whereas a 14 ft. diameter SPHERODIZER® granulator operating under the same feed conditions would only reach 500 MT/D. As a matter of fact, the upper limit could not be determined, as the capacity was limited by the ancillary equipment, sized in accordance with contractual guarantees.

On the basis of these results, PEC-Engineering decided to pursue this line further. A study has been made of a 5.25 m diameter SPHERODIZER® granulator (about 17 ft.). It should allow the production of 1000 MT/D of 17-17-17 or alternately over 1300 MT/D of 15-15-15.

This will remove the only serious objection which could be raised in the past to the SPHERODIZER® process for having a unit capacity of less than a prilling tower, for instance, when the latter can be used.

On the other hand, two other important characteristics give the SPHERODIZER® process a definite advantage over prilling techniques:

- The lower dust content of the exhaust gases and the relative ease by which they can be treated,
- The size of the granules can be easily adjusted to meet practically any market requirements.

It should also be noted that the evolution in the manufacturing of fertilizer does not concern only the trend to giant units, but also changes in the very nature of the fertilizers produced. Presently, along with the production of nitric complex fertilizers of conventional type on an intensive scale (70% of total fertilizer production in France), we are witnessing considerable efforts to develop products of a higher concentration.

Schematically, evolution in this field can be summarized in this manner:

- The first processes for the production of complex fertilizers using phosphate rock as the only source of P_2O_5 resulted in grades such as 12-12-12 (1-1-1) — 1.e. 36% plant nutrient content — or 16-14-0 (1-1-0). Substantially, all the P_2O_5 in these products was in citrate soluble form.
- Later, addition of a certain amount of phosphoric acid brought the grade to 15-15-15 — i.e. 45% plant nutrient content — (or 20-20-0 with a 1-1-0 nutrient ratio). This grade has been very popular; it is still in great demand. It supplies 25% of the P_2O_5 in water soluble form, with the remainder citrate soluble.
- The most recent formulations are based solely on phosphoric acid. The 17-17-17 grade — i.e. 51% plant nutrient content (or 23-23-0 with a 1-1-0 ratio) contains substantially all of the P_2O_5 in water soluble form.

PEC units equipped with SPHERODIZER® granulators display extreme flexibility, and can produce with no difficulty all the above grades. Thus, they can adjust to the trends of the industry by simply changing raw materials, without requiring any major plant modification. Most of them produce, in the same plant and in separate production campaigns, various grups of formulas, so as to take advantage to the extent allowed by the market of the considerable savings provided by nitric acid acidulation of phosphate rock, as used in the first two groups of formulas.

This is why several plants still use the carbonitric process for a significant fraction of their total production, which is good evidence of their flexibility and of the economic advantages they provide.

However, the production of NPK fertilizers has just about reached the maximum concentration which is possible with the raw materials presently in use: NH_3, HNO_3, H_3PO_4 plus KC1 (or K_2SO_4).

At the present stage of technological development, only a modification in the form of the nitrogen content can offer a further increase in plant nutrient concentration at economic conditions. Actually, it is possible to replace ammonium nitrate, analyzing 34%N, — which along with ammonium phosphates, is the main nitrogen component of complex fertilizers — with urea, analyzing 46%N. Grades of the 20-20-20 type, with 60% plant nutrient content, become a possibility.

In view of the intrinsic characteristics and advantages mentioned earlier for the SPHERODIZER® process, it was desirable to adapt its use to the production of the new urea-based fertilizers.

Initial tests on an industrial scale were based on adding a small quantity of urea to conventional nitric complex fertilizers. However, it was quickly determined that, whenever the proportion of urea in products containing nitrate passed the 5 or 6% level, production rates would drop drastically. this approach, therefore, could only be used when urea requirements are rather small, for instance to adjust the grade in case of underformulation.

Replacement of all the ammonium nitrate with urea was then investigated, and in this case the flexibility and effectiveness of the SPHERODIZER® process, once again, were demonstrated.

The main problem was to avoid hydrolysis of urea into NH_3 and CO_2, which could occur during the preparation of the slurry or the granulation and drying step. Temperature and pH were found to be the main factors; best conditions for the preparation of urea-based fertilizers were found to be:

- temperature under 104 degrees C. (practically between 90 and 100 degrees C.)
- pH : 5.6,
- Water content = 18%

Generally, evolution of gases was observed in the last reactor of the PEC reaction section, but did not cause loss of ammonia, because of its re-absorption into the slurry, still sufficiently acid. 7 to 8% of the urea is thus decomposed, with conversion of nitrogen from the urea to the ammoniacal form.

In the granulation step in the Spherodizer section, the time required for crystallization of the salts is relatively long, and the presence of urea makes it necessary to hold temperatures to a lower level than required for complex fertilizers based on ammonium nitrate, resulting in higher air flows.

In practice, air temperature at the granulator inlet will be between 180 and 200 degrees C., preferably 190 degrees C. (374 degrees F.). Outlet temperature is between 68 and 75 degrees C., preferably 70 degrees C. (158 degrees F.). Cooling ahead of the screens is required.

Maximum water content of the commercial product is 1%. The average grain size of the ungraded product is quite satisfactory:

- — Oversize (above 4 mm) 10%
- — Product size 2-4 mm 73%
  of which :
  - . 48% between 2.5 and 4 mm,
  - . 25% between 2 and 2.5 mm.
- — Fines 17%

The granules are well rounded, similar in appearance to other complex fertilizers produced in a Spherodizer granulator, and they have excellent storage properties. Storage tests without anti-caking agents have been successful. However, use of coating agents is still preferred, especially since very small quantities are required : the cost is small and dust generation insignificant.

In the production of 1-1-1 fertilizers, grades well in excess of 19-19-19 can be obtained; even a 20-20-20 grade is possible by using a desulphated acid. As an example, the results of one test run in Toulose, France, are given below:

- Ammoniacal N 4.3%
- Urea N 15.3%

TOTAL N 19.6%

- P_2O_5 . . . . 21.1%
- K_2O 20.3%

Using one 4.25 m (14 ft) Spherodizer granulator capacity was of the order of 10 MT/H, i.e. 240 MT/D. Fuel consumption under these conditions was 300 thermies per metric ton of finished product.

The shortage of urea in the present market made it necessary to limit the duration of the test runs. It is expected that future tests will make it possible to improve on the above results.

In summary:

Spherodizer granulators associated with PEC complex fertilzer plants have been shown to have the following advantages:

- Great flexibility both in the nature of the formulations produced (NP or NPK, various N/P ratios) and in the choice of raw materials : phosphate rock, nitric acid, phosporic acid, sulphuric acid, ammonium phosphate, ammonia, urea potassium chloride or sulphate, or even carbon dioxide.
- Large unit capacity : current developments indicate the feasibility of production well in excess of 1,000 MT/D per unit for certain grades.
- Easy operation, little maintenance, high on-stream factor (the Spherodizer granulator itself, which from a mechanical viewpoint is only a rotating drum, has been in service without major problems in several plants for more than 10 years).
- Exceptional quality of the granules obtained : dense, spherical, smooth, hard, free of dust, uniform grain size.
- Easy cleaning of gaseous effluents, with a double advantage : first, efficient control of pollution, but also better efficiencies, especially for NH_3. (It is expected that addition of a scrubbing tower on the effluent of the Spherodizer granulator in one of the most recent plants will result in an overall nitrogen efficiency higher than 98%).

The Spherodizer process in the form known as "Hot Spherodizer", developed by C&I/Girdler about 15 years ago, has found and kept a prominent place in the granulation of complex fertilizers.

As indicated in the previous paper, it is also being very successfully applied in the form known as "Cold Spherodizer". The inherent flexibility of this equipment gives it an even greater field of application, and undoubtedly all of its possibilities have not yet been explored. It has already made, however, a substantial contribution to the chemical industry.

MODERATOR ADAMS: Thank you Dr. Pelitti and your Associates for bringing us up-to-date information on "Spherodizing". The papers presented will be of great interest to us and we thank you very much for coming to this meeting.

We have completed our discussions scheduled for this morning and we have time for Questions. Will all of our Speakers please come up to the front table for quizzing by our audience.

Questions and Answers

QUESTION FOR MR. ACHORN: First of all, in your preneutralizer, with the various proportions of acids and ammonia going into the different stages in the process, you must have multiple meters?

MR. ACHORN: That is right. We use Magnetic Flow Meters in each instance to measure liquid stream.

SAME QUESTIONER: Okay, obviously, you will have the typical meter problems as evidenced by your inability to get on grade?

MR. ACHORN: I do not know whether that was the meter or myself and the operators. I suppose since I do not know how to correct a magnetic flow meter correctly you better put it on me.

SAME QUESTIONER: I think what you have is certainly typical of our usual experience with meters. That brings up a point. Control of mole-ratio in the preneutralizer is obviously critical, and with meter problems being rather chronic in the industry, are we not running serious risks of going into an insoluble phase in the preneutralizer with these associated problems?

MR. ACHORN: If you are using the stainless steel preneutralizer you need to be able to take that mole-ratio rather accurately, but we have a simple procedure setup that uses a pH meter and a citration system that has worked well in numerous plants. In fact, this is what is used in most diammonium phosphate plants in the country. So it is an old system that has worked in other places.

Now if you are somewhat disturbed about maintaining a good mole-ratio and you would prefer to operate at a low pH, I suggest you put in a brick-lined preneutralizer. Operate the preneutralizer at the low mole ratio of 0.6. At this ratio the slope of the pH curve is steep enough that you can use pH's for control instead of mole ratio. We showed the mole ratio in this instance because this was what our curve showed. But in actually operating the brick lined preneutralizer pH is used rather than mole ratio.

SAME QUESTIONER: Have you considered putting a lining in the Pipe Cross Reactor rather than using an exotic alloy?

MR. ACHORN: We used a Hastelloy C Pipe Cross about six months ago, and we tried to get some Teflon line pipe; however, we could not get delivery of it. We could get delivery of the Hastelloy C. The people that are cooperating with us in this project are MFA, at Palmyra. They plan to test out some Teflon line material.

QUESTION: What is the right temperature after you pass through the Cross and go into the Jacketed Section?

MR. ACHORN: Frankly we have not been able to measure these temperatures. I hope that we will be able to get additional data out of the pipe-cross and later on give a more detailed paper. We just introduced it here today as a new way to possibly eliminate the use of preneutralizers. We think it gets up to around 300 degrees F. but we do not known.

QUESTION: Why is the cooling jacket used?

MR. ACHORN: We used stainless steel for the reaction tube, and we know that at those temperatures we would probably have corrosion of the stainless steel. So, we hope that by cooling the walls of the reaction tube we can prevent corrosion. However, I would like to give you something else we did. We tried to use vaporous ammonia first, and we had hoped that we could pass the liquid ammonia through the manifold and vaporize it by the heat liberated in the reactor and then pass the partially vaporized ammonia into the pipe cross. We wwere not successful. It got a little hairy around there for a while, and that is when we came up with using a little bit of water with the liquid ammonia. These pipe-cross reactors won't operate on liquid ammonia at all. It is violent reaction and the pipe-cross reactor vibrates violently when the water is not combined with the ammonia prior to its addition to the reactor.

QUESTIONER: I do not have a question. I wish to advise that if you are interested in the cross-reactor the C.R.O.S. People in Spain, instead of vapor, are using what they call their ammoniator.

MR. ACHORN: We thoroughly investigated the literature before we conducted our tests and applied for our patent. We reviewed the pipe cross information that C.R.O.S. company in Spain uses and this cross has a special design of nozzles inside. Our design does not have these nozzles. TVA's pipe cross is a simple standard pipe cross with another piece of pipe sticking through it. The C.R.O.S. system has spray nozzles and uses vaporous amonia in the reactor.

With the cost of energy today and the availability of energy of the process, we thought it was important that these regional plants use liquid ammonia. So we designed a system in which we add water to the liquid ammonia prior to its use in the reactor. Our pipe-cross reactor doesn't use vaporous ammonia.

QUESTION: I wonder if Mr. Waggoner, T.V.A. and perhaps one of the Gentlemen from C&I/Girdler would care to hazard a guess on the relative costs of the Pan Granulator or the Spherodizer or the Spherodizer granulation of Urea and Ammonia Nitrate versus Prilling?

MR. WAGGONER: You might say we are doing a study on that now at TVA. Preliminary indications are that if you include a prilling operation it is more economical in a standard prilling plant but if you consider the pollution abatement equipment then it is a standoff.

MR. REYNOLDS: We would partly agree with that. It would depend on the size of the Plant. A real large plant probably would favor prilling and it would depend on the exact size whether it happened to fit the capacity of the maximum drum size we can produce. If it happened to be just too big for one drum and way too big for two drums, of course, it would not match up very well.

I would hazard to guess that a Spherodizer Granulation Plant is somewhat more expensive than prilling even including the dust removal equipment. However, we feel it is worth it because of the better quality product, and there are not too many systems around where they scrub all of the air.

QUESTIONER: There are two types of Ammonium Nitrate Prills that we are usually interested in. One is the fertilizer grade and the other is an explosive grade. Will either of you care to comment on your prossess for the explosive grade ammonium nitrate?

CARTER REYNOLDS: Spherodizer granulation does not make explosive grade ammonium Nitrate.

MR. WAGGONER: Our answer to that would be the same.

QUESTIONER AGAIN: What you are saying then is that for the explosive grade it is necessary to go to a prilling system.

MR. WAGGONER: Yes.

QUESTIONER: I want to ask the Urea Experts. One of the major uses for Urea today is in feed supplements due to the high cost of soy-beans and corn and all of the other items you feed to cattle. Liquid feed supplements which contain Micro-prills have become a very big market. I visited the Feed Convention this year and much discussion was the use of Microprills to make feed supplements with. The Microprills carry a premium price over the fertilizer grade urea. I would like to know if these processes cn be adopted to make Microprills or should we stick to using Prilling Towers for Microprills?

CARTER REYNOLDS: Well, as you know, in South Africa they quit making Microprills for feed grade. You do not need to have Microprills for feed grade. It is more of a convenience than anything else. For solution materials you do not need to have any particular size. It is just a question of how fast they will dissolve. As far as the drum granulation process, we have not made what you would consider an equivalent product to Microprills in the Spherodizer Drum Granulator.

MR. WAGGONER: The Pan Granulator also does not produce very well with small sizes. Microprills usually run —14 +30. Our suggestions also is to use liquids in the feed grade.

QUESTIONER: A Comment. I know that Microprills work much better in a feed business than do granulator prills. We have tried both. You can put Microprills into solution faster. The cows like that size better.

QUESTIONER — DAVIS, TVA: I have a question for Mr. Reynolds. What do you consider the maximum granulation output of Urea Spherodization and also what the labor requirements are.

CARTER REYNOLDS: The last slide I gave. Capacity of a 14 foot drum as being 335 tons per day. Actually we have exceeded that by at least 10%. The labor requirements are no different than Prilling. One man. Just like you would look after a Prilling Tower.

QUESTION FROM THE PANEL — NO IDENTIFICATION: I think comments have been made earlier this morning of increasing the drum size much more than 14 feet in diameter to satisfy some of the large unit requirements. Theoretically there is no limit just a question of somebody having the guts of trying to build a granulator drum as large as 20 feet in diameter if required.

CARTER REYNOLDS: We were speaking of those in existence. We have not built one for Urea bigger than 14 feet up to the present time. It is mainly a shipping problem.

If you were to locate a plant near a place where you could fabricate the drum easily we could make a size 15' or 16' and increase the capacity.

QUESTIONER: For a 14 feet diameter drum is the capacity about 380 short tons per day.

CARTER REYNOLDS: Something in that range. Yes.

QUESTIONER: In my opinion granulated urea is not necessary from a mixed fertilizer point of view. I somehow think that the Suppliers of this equipment are making an excuse to give us a higher priced product.

CARTER REYNOLDS: Are you saying that you do not feel that granulated material is necessary for bulk blending? O.K. my only comment to that would be that you do have more flexibility in the size range and that you can produce whatever size you wish to match up and to blend well with your other materials.

QUESTIONER CONTINUES: Even with that I somehow think that it could make a much harder prill than you are talking about theoretically, but is this necessary? Prilled material of 3 or 4 is quite sufficient in large piles?

CARTER REYNOLDS: Yes, that is true, it will store, however, I think the quantity that you crush up under the Payloader would probably be greater. Maybe you do not agree.

MR. ACHORN: Can I offer an explanation? We have conducted tests with pan granulated urea, and I am sure that you would probably get the same results with spherodized urea. We found that in taking dust samples in a bulk blend plant that 18-46-0 or diamonium phosphate, triple superphosphate, potash and all the conventional materials that are used liberate more dust in handling than is maximum allowable as recommended by OSHA, the labor department people. The Granular material fell within the range; it only caused 10 milligrams of dust per cubic meter, which is what is suggested as the maximum. The 18-46-0 caused 186 milligrams per cubic meter of dust. The other problem with prilled urea is its use in a herbicide-fertilizer mixture, which is now becoming popular. The bulk blender used to be able to get by with some segregation and nonuniform application; however, segregation of blends are definitely out now. With fertilizer pesticide blends you must have a uniform blanket so that you have a uniform kill of your weeds; and unless you match the particle size of the materials used in the blend, it is almost impossible to get uniform application.

QUESTIONER: Even with that I somehow think that it could make a much harder prill than you are talking about, theoretically, but is this necessary?

CARTER REYNOLDS: Is not Potash the bad actor and not Urea?

MR. ACHORN: Actually granular urea matched potash better than prilled urea. It also matched 18-46-0 better than prilled urea. It matched everything that was used in the blend. Are you saying that we ought to ask all the Potash Companies to change their size specifications and all the Triple Superphosphate Producers to match the size of granular urea. I do not believe that is practical. In the first place it will lower the production rate of many of these plants if the particle size is decreased. So there's no question that in this country we are going to have to get a practical size urea if we are going to continue to put herbicides on blends. We are going to have to get a particle size urea that will match the other materials or probably we will use much less urea.

QUESTIONER: I would like to Ask Mr. Whitehurst. What do you do with the material that either filters or centrifuges out of your Super-Acid and what percentage of loss of P_2O_5.

MR. WHITEHURST: In terms of loss; there is none. The P_2O_5 is consumed in making granular triple.

QUESTION: I would like to address TVA on the question of Biuret formation in prilling versus granulation. I imagine that you would run a higher Biuret with granulation of high recycle and reheating of the urea.

MR. WAGGONER: We find no increase in Biuret caused by granulation. None. The increase in the Biuret in our product comes from a recycle of an excessive amount of solution. Without that solution we can give you data to show that the Biuret out of the evaporator is essentially the same as the Biuret content in the granular product.

CARTER REYNOLDS: I would say that I agree with that. We have made Biuret profiles too and the increase in Biuret between the melt pump and the product is less than a tenth of a percent. It is within analytical accuracy, in other words, it might show .04, .07 and sometimes it is negative. Essentially it is a very minimal contribution. You have to keep in mind that in both processes you are spraying a melt onto a cold particle and that particle chills the melt down very rapidly. From that standpoint it is probably no different than prilling.

QUESTIONER: I have a question for Mr. Waggoner. In regard to the coating on the urea product. You showd 7/10 of a percent of Kaolin Clay and 3/10 of a percent of a mixture of oil and parraffin. First, in what sequence are those materials added and why use clay for an anti-caking material if you put a parrafin wax over it? Would not parrafin also do the same thing?

MR. WAGGONER: No. We had hoped it would get some moisture resistance from the was-oil mixture originally. The reason we do this now is as a dust suppressant. The clay goes into the coating drum first along with your granular urea and then we have a ring about 4 feet down the coating drum with a spray for the wax-oil mixture and that is pumped through a hydraulic spray.

QUESTIONER: Is the wax-oil mixture heated?

MR. WAGGONER: Yes. We maintain it at about 150 degrees.

QUESTIONER: Before you changed over to urea you were making ammonium nitrate products. Did you use a dust suppressant on those products.

MR. WAGGONER. No.

MODERATOR ADAMS: If there are no more questions we will adjourn for Lunch.

Thank you Gentlemen of the Panel and to all of you in the room for your excellent and most interesting, valuable discussions. The Question and Answer Period was superb and again I thank all of you.

Wednesday, December 4, 1974

Afternoon Session
Frank T. Nielsson, Moderator

MODERATOR NIELSSON: This afternoon we will have discussions on: Single Superphosphate, Energy Problems and Challenges, Agronomic Effects Supplementing Sulphur and Magnesium Techniques of adding Michronutrients To Fertilizer, Technical Changes Affecting Supply of Sulphuric Acid, Outside Bulk Storage of Ammonium Nitrate and Muriate of Potash. I am pleased to see the room filled up and more are coming in. The papers to be discussed are timely and should be extremely important information because they effect our day to day decisions how best to operate our plants.

Our first discussion, "Normal Superphosphate," will be given by Albert E. Henderson. Al is one of the old-timers in the business. He is a graduate of Emory College, has worked for Wilson and Toomer and now has his own business — Technical Services, Inc. I would like to welcome you Al.

Single Superphosphate Status & Future

Albert E. Henderson, Jr.

I What is the status of the technology of single superphosphate?

II Have there been any significant changes in manufacturing since the early 1960's?

III What are some of the current problems regarding the manufacturing of single superphosphate?

IV What is the future of single superphosphate?

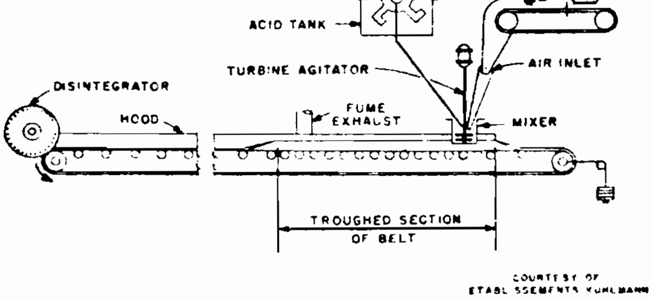
The literature relating to the technology of single superphosphate is excellent, and it is doubtful if I could make a worthwhile contribution in this area, other than some comments, which will follow. For those who are newcomers to this subject, and others who wish to review, I suggest the following references which more than adequately cover the subject:

1. "Fertilizer Technology & Resources in the U.S.", edited by K. D. Jacob, 1953 Academic Press, Inc., Publisher, New York, N.Y.
2. "Phosphoric Acid, Phosphates and Phosphatic Fertilizer", by Wm. H. Waggamon. Second Edition 1952, Reinhold Publishing Corp., New York, N.Y.
3. "Phosphorus and its Compounds", Vol. I & II 1961, Interscience Publishers, Inc., New York, N.Y.
4. "Superphosphate — History, Chemistry & Manufacture" U.S. Dept of Agriculture, Tennessee Valley Authority, 1964.

Probably the most significant change in manufacturing single superphosphate has been the continuing adaptation of the TVA cone mixer for that purpose. Slack (1) in 1959, concluded that "the trend to mixer simplification is exemplified by the cone mixer (2). Slack (1) and jackson (3, 4) have both described the advantages of the cone:

1. No moving parts, therefore, no power requirements.
2. Low space requirements.
3. Low maintenance cost.
4. Low investment cost. The cost of a cone mixer installation is much less than that for an equivalent installation with a standard pan mixer, or for that part, most other continuous mixers that I am familiar with.
5. Part of the low investment cost is due to reduced structural support requirements.

Some earlier problems with the cone have been improved or eliminated. Initially, it was necessary to run the cone full, thus limiting its capacity; however, both TVA and Jackson solved this problem. Jackson by adding an elbow to the discharge spout, and TVA by adding a small turbine mixer to the discharge spout.



COURTESY OF ETABLISSEMENTS KUHLMANN

Typical Cone Mixer Installation with Belt Den

Phosphate rock is fed continuously to the center of the mixer through a pipe. The rock impinges on an inverted cone which serves as spreader for better rock distribution. The acid and water enter the mixer from small diameter pipes set at an angle to provide tangential flow for those fluids. Extremely rapid mixing occurs (about 2 seconds) and the mixture is then discharged to a den for conditioning.

A cone as small as 24 inches in diameter by 24 inches tall can produce up to 40 tons per hour of single superphosphate.

Cones have been constructed from various materials, cast iron, black iron, stainless steel and lead. One method consists of a lead liner over an existing steel cone and is good for about 50,000 tons of production.

Problems

(a) If a cone mixer is used, failure to thoroughly clean the cone, the spout, and the inverted cone speaker, will cause start-up problems.

(b) Short supply of phosphate rock & declining rock quality. A few years ago when phosphate rock was plentiful, and single superphosphate manufacturers were having various problems, such as:

  1. High moisture content.
  2. Low conversion ratios.
  3. Poor physical condition (even when the free acid-rock ratio was correct) one common practice among independent producers was to change rock suppliers. More often than not, this eliminated the problem, and I can personally attest to this fact from over 3,000,000 tons of single superphosphate experience. I don't mean to imply that we permanently changed supplier, but only for a month or so. We purchased rock over a period of several years from at least seven suppliers, and to my knowledge, this problem occured with all suppliers.

One of our plants was producing approximately 100,000 tons of single superphosphate per year and had very large storage capacity for unground rock. This was a one to two shift operation (usually 10 hours per shift), in which daily analyses were made for each shift; TPA, moisture, and screen tests for rock (60, 100, 200 mesh) and TAP, IPA, moisture, and free acid for the superphosphate. Screen tests were made in the A.M., and if the 60 mesh analysis was under 99.0%, or the 100 mesh less than 93%, the raymond mills were adjusted until these conditions were met.

After approximately seven years of experiencing above noted problems, it was decided to change rock receiving procedures. It was our practice to order rock from one supplier for a certain period of time, and then switch to another supplier. We changed this so that we were receiving rock from at least two, and frequently three suppliers at one time, thus insuring a mixture of rock most of the time. While this was not a 100% solution, it never the less reduced the problem to one of little significance.

At another smaller plant operating during the same time period, this system could not be adopted, because of limited rock storage and plant location. Condition problems continued at this location on a periodic basis and were usually corrected by changing rock supplier when trouble was experienced.

I have recently discussed problems in single superphosphate production with eight plant managers and various friends who are presently involved in single superphosphate manufacturing. More than half of these men considered declining rock quality as their most significant manufacturing problem in single superphosphate production. Today, however, most of them no longer have the option of switching suppliers, because of rock short supply.

According to TVA (5) the phosphate rock supply/demand situation should be in balance by 1978, and surpluses could occur. This would not, however, necessarily solve the problem, since the quality of rock could continue to decline. In my opinion, we must learn to produce single superphosphate from poorer and poorer grades of rock. Ultimately, this may have a strong influence on the type process used and could represent a further reduction in the amount of single superphosphate production.

(c) There are other factors which cause poor condition in single superphosphate, such as failure to provide adequate amounts of air in the dennning process, incorrect free acid-rock ratios, high moisture, high acid concentration, and when a cone mixer is used, a leaking cone. This usually occurs at the seam of the cone and discharge spout. Contanination of phosphate rock with muriate of potash causes a very hygroscopic superphosphate. This condition can likewise occur in the curing pile from contamination at that point.

Failure to provide adequate air in the denning process may also causse the den to "fall". Apparently, a slightly negative pressure in the ben aids gas evolution and helps produce the desirable "honey-comb" condition characteristic of good quality superphosphate. The same condition can result when acidulating with rock that contains low CO_2 content.

Obviously, any phosphatic material which is available to plants and can be adequately incorporated into mixed fertilizers, is assured of a future over the next three to five years.

Single superphosphate granulates well, it reacts with more NH_3 per unit of P_2O_5 than triple super, and it supplies large amounts of sulfur, whereas triple superphosphate and DAP do not.

Independents and small operators cannot manufacture DAP or triple superphosphate competitively with larger chemical complexes, however, they can produce single superphosphate, and at less overhead.

By-product H_2SiF_6 currently enjoys a reasonably good market. The single super-phosphate plant lends itself to recovery of this by-product more readily than a triple superphosphate operation.

Capital outlays for other phosphate processes are significantly higher. It seems reasonable that single superphosphate will never again be the dominant source of fertilizer P_2O_5 in the U.S., still it does have many merits which probably will keep it around for years to come.

NOTE: Continued on Page 119. "World Fertilizer market Review 1974 Outlook." Normal Superphosphate Production.

References

(1) "Developments in Superphosphate Production" by A. V. Slack. Reprinted from "Farm Chemicals" April and May issues, 1959.

(2) rvan, P. B., Langguth, R. P., Eckstein, R. R. V., "Agricultural Food Chem., 131-5 (1955).

(3) Jackson, Allen S. "Advantages and Disadvantages of TVA Cone Mixer, Proceedings of 6th Fertilizer Industry Round Table, p. 92-5, Washington, D.C. (1957).

(4) Jackson, Allen S., "Farm Chemicals" 121, No. 4, 10-11, 18 (1958)

(5) "World Fertilizer Market Review and Outlook", TVA, 1974 by E. A. Harre of TVA.

THE FUTURE OF SINGLE SUPERPHOSPHATE

In a publication by TWA and financed by AID, "World Fertilizer Market Review and Outlook," 1974, the following information and projections were made:

TABLE A-13: NORMAL SUPERPHOSPHATE PRODUCTION

(Thousand Metric Tons of Nutrient)

Year	No. Amer	West Europe	E.Eur. USSR	Japan	Israel	South Af.	Oce- ania	Latin Amer.	Dev'g Af.	Dev'g Asia	Other Asia	Dev'd Regions	Dev'g Regions	Free World	Dev'd Fr Wld	World
1967	1092	1387	2580	219	12	194	1264	94	95	154	636	6748	343	4511	4165	7727
1966	985	1215	2605	211	19	186	1241	118	91	183	660	6462	392	4249	3857	7514
1969	789	1203	2666	191	12	179	1190	161	109	140	696	6230	410	3974	3564	7338
1970	715	1112	2926	165	14	160	1134	160	111	135	796	6226	406	3706	3300	7428
1971	588	1001	2997	132	14	150	1010	133	127	145	933	5892	455	3350	2895	7280
1972	635	1079	3155	126	15	140	1010	226	200	173	1110	6160	599	3604	3005	7869
1973	580	020	3150	105	15	130	1100	250	200	180	1150	6100	630	3580	2950	7880
1974	560	1000	3150	92	15	120	1150	250	200	200	1200	6067	650	3587	2937	7937
1975	520	980	3100	86	15	110	1200	250	200	200	1250	6011	650	3561	2911	7911
1976	460	940	3000	80	15	105	1250	250	200	200	1250	5850	650	3500	2850	7750
1977	400	900	2900	80	15	100	1300	250	200	200	1250	5695	650	3445	2795	7595
1978	360	800	2800	78	15	95	1350	250	200	200	1250	5498	650	3348	2698	7398

TABLE A-14: CONC. SUPERPHOSPHATE PRODUCTION

(Thousand Metric Tons of Nutrient)

Year	No. Amer	West Europe	E.Eur. USSR	Japan	Israel	South Af.	Oce- ania	Latin Amer.	Dev'g Af.	Dev'g Asia	Other Asia	Dev'd Regions	Dev'g Regions	Free World	Dev'd Fr Wld	World
1967	1423	385	433	28	0	54	0	0	210	28	0	2323	238	2128	1890	2561
1968	1330	458	521	31	0	76	0	0	184	32	0	2416	216	2111	1895	2632
1969	1314	625	688	42	0	100	0	40	319	73	0	2769	432	2513	2081	3281
1970	1208	634	791	33	0	100	0	44	295	69	0	2766	408	2333	1975	3174
1971	1326	669	956	29	0	100	0	55	594	79	0	3080	728	2652	2124	3808
1972	1512	686	1234	32	0	100	0	94	597	98	0	3564	789	3119	2330	4353
1973	1525	690	1300	30	0	100	0	100	600	100	0	3645	800	3145	2345	4445
1974	1580	710	1413	30	0	100	0	100	600	100	0	3813	800	3250	2400	4613
1975	1560	730	1541	30	0	100	0	100	600	100	0	3961	800	3220	2420	4761
1976	1550	750	1550	30	0	100	0	100	600	100	0	3980	800	3230	2430	4780
1977	1530	750	1550	30	0	100	0	100	600	100	0	3960	800	3210	2410	4760
1978	1500	750	1550	30	0	100	0	100	600	100	0	3930	800	3180	2380	4730

This data clearly indicates that in 1978 Single Superphosphate will still be the dominant source of P_2O_5 on a world wide basis; however, in N. America its decline is significant (1967 was 1,092,000 tons of Nutrient) while 1978 is projected to be 360,000 tons of Nutrient. During the same period, concentrated superphosphate gained from 1,423,000 tons of Nutrient to 1,500,000 tons.

MODERATOR NIELSSON: Thank you, Mr. Henderson. Out next speaker, Dr. William C. White of The Fertilizer Institute, will talk to us about the "Energy Problems and challenges in Fertilizer Production." Dr. White grew up on a Virginia farm and went to V.P.I. and florida State University. He has been with the Fertilizer Institute and its predecessor, N.P.F.I., since 1953. Currently he is Vice President, Member Services of The Fertilizer Institute. Let's welcome Dr. White.

Energy Problems and Challenges in Fertilizer Production

William C. White

From the extraction of sulfur and potash thousands of feet below the earth's surface to transportation of nearly 50 million tons of finished products annually to U.S. customers, the fertilizer industry is inexorably enmeshed in energy crises.

The "plural" tense is used here because fertilizer production focuses on all forms of available energy today — natural gas, oil, electricity and coal. All steps in fertilizer production, except for those few exothermic reactions, consume energy. One ton of anhydrous ammonia contains 19.3 million Btu, and this energy has to come from some cource. A law of thermodynamics dictates that energy cannot be created, it only can be converted.

The fact that such fertilizer-producing processes are intensive energy consumers is the root problem as we face increasing energy shortages. Furthermore, the fact that fertilizers are nutrient bearing materials makes them unique among the variety of energy uses because they are the only end-use of energy that enters directly in the food production chain.

Closer examination of the problem identifies three points of focus in dissecting the over-all problem of energy shortages and also identifies their challenges in fertilizer production. One is *curtailment* of energy deliveries from suppliers and public utilities, a clear manifestation of supply falling short of demand. Curtailments, in turn, have reduced ammonia production and, in severe cases, temporarily closed plants.

A high energy-using industry such as the fertilizer industry, when faced with curtailments or inaccessible supplies for expansion, seeks *conversion* to alternates. But, such options for the fertilizer producer are quite limited.

Thirdly, fertilizer producers as large energy consumers have a responsibility for energy *conservation.* Closer examination of energy discarded as waste heat and development of more efficient energy conversion processes are long overdue by producers and design engineers.

Curtailment Problems

Natural gas shortages and electrical outages are the two major energy curtailment problems. Estimates of ammonia losses, which have nearly tripled since 1970, due to natural gas curtailments are in the following table:

Tons of Ammonia Lost	Source of Estimates
CY 1970 - 117,000	TFI
CY 1971 - 164,000	TFI
CY 1972 - 188,000	TFI
FY 1973 - 315,000	USDC
FY 1974 - 231,000	TFI
FY 1975 - 337,000	TFI

The basic cause of such curtailments is that supply has fallen short of demand. Several facts are useful in examining this demand.

Sixteen million tons of ammonia annually require about 640 billion cubic feet of gas for feedstock and process use (about two-thirds feedstock and one-third process). This use is about three per cent of the U.S. total annual use of about 22 trillion cubic feet. In terms of coal equivalent this energy demand is equivalent to:

22.4 million tons of coal (1.4 tons per ton of ammonia on a Btu equivalent basis).

6.1 trains of coal per day (100 cars per train with 100 tons per car).

Other estimated annual natural gas uses, based on figures in the next table are:

43 mill tons of phosphate rock and downstream products —

4.4 mill tons of potash — 23 bill, cu. ft., 9 bill, cu ft.

8.5 mill tons of Frasch sulfur — 51 bill, cu. ft.

Thus, there is presently used a total of about 723 billion cubic feet of gas annually in producing basic fertilizer products. At 50 cents per 1,000 cubic feet, this use presents an annual natural gas bill of about $361 million dollars, nearly 10 per cent of current sales value.

Much of the natural gas curtailment problem is part and parcel of current federal regulations over interstate gas. According to a TFI survey, about half of the U.S. ammonia capacity in 1972 was on interstate gas and half in intrastate. Yet, TFI's survey of anticipated curtailments in FY 1975 shows that 88 per cent (298,000, tons of 337,000) of them will be with interstate gas supplies.

Such a situation clearly explains why all new ammonia plants under construction and most of those in the contract stage in the U.S. are on intrastate gas. Federal regulations pertaining to extent of jurisdiction, type of contracts and priorities for end-use constitute a lengthy discussion inappropriate in this paper, in addition to procedures for filing for extraordinary relief. There is no easy solution to these problems, but deregulation of new wellhead gas offers the most practical solution for the foreseeable long range term.

For electricity-related problems, it is worthy to recall that the draglines that do the mining and most of the pumps and motors required for the beneficiation of phosphate rock are electrical. It has been estimated that the phosphate mines in Florida consume close to 10 per cent of the power generated in the state. These compete directly with air conditioners and other consumer uses of electricity, and in periods of shortages phosphate plants and mines with interruptible contracts are the first to receive "curtailment notices." The result of such notices is loss of production.

During CY 1973, phosphate producers in Florida had 319 curtailment "experiences," according to a report of the Florida Phosphate council. These resulted in a loss of at least a million tons of phosphate rock production. further compounding the electrical shortages have been price increases pushing the cost for some producers to over a cent per kwh.

In the case of fuel oil, the Federal Energy Office (now the Federal Energy Administration) published May 6, 1974, a revised list of "activities directly related to agricultural production." Included in this list is production of fertilizers. The result of this provision, under the Mandatory Petroleum Products Allocation Program, is that fertilizer production is provided 100 per cent of fuel oil needs during periods of allocation. Hence, curtailments of oil supplies thus far have not been an "energy shortage" problem for the industry.

Problems of Converting to Alternate Fuels

Difficulties in switching fuel sources center on two hang-ups — economics and technology.

A comparison of fuels solely on the basis of cost per unit of energy illustrates the pressure for natural gas at present prices.

	Cost per unit of product	Btu per unit of product	$/million Btu
Natural gas	50¢/1000 cu.ft.	1,012,000 (per 1,000 cu ft.)	0.49
Fuel oil (No.4)	25¢/gal	144,000 (per gal)	1.74
Coal	$25/ton	28,000,000 (per ton)	0.89

	Plant Investment		Production Cost[1/]	
	$Million	Index	$/Ton	Index
Natural gas	54.5	100	63	100
Naphtha	60.8	112	70	111
Heavy fuel or crude oil	69.3	127	73	116
Coal	97.6	179	108	171

[1/] Interpolated from TVA data at the 80¢/mcf gas cost level, with $37/T naphtha, $33/T oil and $22/T coal.

The above prices are what may be considered typical at present, and other values within current ranges will show a similar relationship. However, prices for intrastate gas of $1.25 to $2.50 are ahead and represent (using 1 x 10_6 Btu/1000 cu. ft.) costs of $1.25 to $2.50 per million (1 x 10_6) Btu. Such a price level could push coal ahead with a cost advantage, provided coal is available at $25/ton. But, look for it to jump forward too, especially with the recent 40 per cent increase in the miners' settlement.

The point of the above is that the per unit cost of energy is one of the first considerations in converting from one form to another. At present, interstate natural gas (when you can get it) is strongly advantageous costwise, with intrastate prices being much less so. Only computers with a program of permutations can predict the price relationships should deregulation of new wellhead gas occur, an event that seems extremely remote with the current Congress.

There are other cost differences associated with using different fuels — storage, handling, environmental controls, etc. Information in the following table calculated rom TVA data* illustrates these differences for a 1,000-ton-per-day ammonia plant with various energy sources:

Largely for reasons of technology, including costs for different processes, ammonia plants using natural gas are strongly favored over other fuels when considering plant investment and per unit production costs. The data further illustrates that although technology presents a feasible set of options, economics are the final determinant in choosing the preferred form of energy as well as the order of converting from one to another.

But, other factors of technology influence suitability of energy sources. Flame characteristics, degree of temperature control, levels of contaminants that affect catalysts and environmental emissions, and specific process requirements, are some of the critical characteristics of different fuels. One or more of these may make conversion from one to another technically impossible as well as reducing operating rates.

Conservation of Energy in Fertilizer Production

With industrial uses accounting for nearly half of the total energy consumed in the U.S., it is obvious that there is a heavy responsibility or conservation by industry, including the fertilizer producer. Some industries may be able to achieve 5-15 per cent savings in energy usage per unit of product. Just what the fertilizer industry can achieve is yet to be determined.

Obviously, the sooner fertilizer producers identify ECO's (Energy Conservation Opportunities) and set conservation goals the better off they will be. The day will come, and much sooner than some expect, when all major users of public energy utilities will be held responsible publicly for energy conservation. At present, government policy calls for *voluntary* energy conservation, and should it prove ineffective, compulsary conservation by means of government regulation is right around the corner.

The Federal Energy Administration has recently begun laying plans for "coordinating" voluntary energy conservation plans. Ammonia production is one of five major industries it has targeted in these plans. During recent weeks, TFI has been working with FEA in this effort, and several firm requirements are taking shape. They call for six-month reports from producers showing use of energy per unit of product. Calendar year 1972 is proposed as a reference "base period" for energy consumption per unit of product.

Strong leadership by the fertilizer industry in this conservation program will be critically important if mandatory requirements are to be avoided, and if the industry is to continue its justification for priority of allocation of energy sources. In other words, we must soon show progress in getting better "mileage" in terms of increasing production per unit of energy, or, conversely, decreasing energy per unit of product, just as the auto industry must produce cars for better mileage. Such questions as how much energy is discarded as waste heat in cooling towers must be anawered by our industry and losses cut to absolute minimum levels. Even basic processes such as vacuum evaporation vs. submerged combustion for superphosphoric acid and formulations in granulation plants will come under closer energy cost analysis in the future.

While examing ECO's in fertilizer production, it is also appropriate to cite opposing forces. Environmental controls for ammonia, urea and nitric acid, are heavy energy users. TFI reported to FEA iin October, 1974, that steam stripping of ammonia waste water is estimated to cost nearly $200,000 annually for *energy alone* for a 1,000-ton-ammonia/day plant, and about $150,000 annually for a 1,000 ton/day urea plant for urea hydrolysis and subsequent ammonia stripping. Additionally, capital costs for these two "treatment technologies" of EPA are presently about $218,000 and $231,000 respectively. And, I'll leave up to the engineers to calculate what "catalytic combustion" of NO_x for nitric acid plants will run.

Regardless of obstacles such as the above to energy conservation, there are strong reasons why it deserves positive action by management. Economics stand out among the motives. As cited earlier, the annual bill for natural gas is on he order of $360 million, based on 50 cents/Mcf and 723 billion Mcf total use. A five per cent savings on this would amount to $18 million, a sizable figure even in periods of prosperity. With energy costs constituting higher and higher percentages of cost analysis figures, it is logical that saving energy for the sake of saving will be a stronger motive when profit margins start pinching again. But, conservation for the sake of conservation also will have its pressures.

Whether industry is to lead or to be pushed in this vital area is squarely up to industry.

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* **World Fertilizer Market Review and Outlook.**

Summary

Energy shortage problems are some of the most important facing the industry, for without energy there is no fertilizer production. This applies to producing superheated water to extract Frasch sulfur to providing a hydrogen feedstock and thermal energy to create ammonia. By the principle of "challenge and response," each energy shortage presents a challenge to fertilizer producers and, hence, opportnities for developing improved, more efficient processes.

Challenges lie ahead in each of the areas of energy curtailments, conversion, and conservation. Curtailments of natural gas and electrical power are increasing and are cutting production. Additionally, lower operating rates with partial curtailments push up per unit production costs and push down efficiency on a per unit of product basis. Curtailments not only are critical to existing facilities, but also portend inadequate energy supplies for additional plants.

Conversion to alternate energy sources will result from balancing economics and technology. Either of these alone cannot dictate conversion; both must be balanced. Scarcity and depletion of energy sources such as natural gas ultimately will be manifested in costs, and increases beyond certain levels will tilt the balance to conversion. Only keen managers constantly reviewing relative costs will be prepared to make the conversion at the opportune time. Others, unaware or failing to heed the rapidly changing energy economics will be caught with overbearing cost disadvantages.

Conservation will be a responsibility of everyone within a plant. Much of the responsibility for future conservation rests with the design and process engineers. Bold action and progress towards producing a pound of nitrogen with less Btu's from natural gas or other feedstocks, a pound of P_2O_5 with less kwh's, etc., will be the best means of warding off governmental regulations in this important area.

Note: Appendix — Page 124

Energy Units (Representative Values)

1 Btu (British thermal unit) = quantity of heat to raise the temperature of one lb. of water 1° F.

1 kcal = quantity of heat to raise the temperature of 1,000 grams of water 1° C.

1 therm = 100,000 Btu

1 Btu = 0.252 kcal

1 kwh - 3,412 Btu

(10,000 Btu generates 1 kwh electricity)

1 cu ft gas (methane) = 1,012 Btu

1 cu ft gas (methane) weighs 0.0425 lb.

40,000 cu ft gas weighs 1700 lb.

1 lb. NH_3 = 9,667 Btu

1 ton NH_3 = 19.3×10^6 Btu

40,000 cu ft gas = 40.5×10^6 Btu

1 ton coal = 28×10^6 Btu

1 gal No. 4 fuel oil = 144,000 Btu

267.5 gal No. 4 fuel oil = 1 ton

1 ton No. 4 fuel oil = 38.5×10^6 Btu

1 barrel (U.S.) = 42 U.S. gal

1 barrel crude oil = 5.8×10^6 Btu

MODERATOR NIELSSON: Thank you Dr. White. I just want to assure you that IMC is having an intercompany energy conference for two days starting tomorrow, bringing in people from Florida, Canada, Carlsbad. We lost some of IMC people attending this meeting here because they had to leave for the energy conference. There are other people worried beside you.

Our next paper "Agronomic Effects of Supplementing High Analysis NPK Materials with Sulphur and Magnesium" by Harold D. Blenkhorn — Manager Technical Services — Brockville Chemical Co. — Montreal, Canada. Harold is a graduate of McGill University. He has worked with the Canadian Department of Agriculture before joining Brockville.

Agronomical Effects of Supplementing High Analysis NPK Materials with Sulfur and Magnesium

Harold D. Blenkhorn

Recent trends in fertilizer consumption in the Canadian Province of Ontario are typical of what has been taking place in all major agricultural areas of Canada and the U.S.A. There was almost a five-fold increase in plant food consumption ($N + P_2O_5 + K_2O$) in Ontario during the twenty year period 1950-1970. During this same period, the average plant food content of fertilizers sold in this Province increased from 23% to 44% (1). This increase in concentration is a reflection of the changes which have been taking place in fertilizer materials, and shows the influence of high analysis plant food sources which, during recent years, have gradually come into use and now dominate the market.

The effect of plant nutrient sources on the chemical make up of mixed fertilizers is shown in Table 1. The pulverized and granulated products which prevailed successively through the nineteen fifties and into the early sixties contained, in addition to NPK, substantial amounts of sulphur. On an elemental basis, the sulphur content of these fertilizers was often greater than N, P, or K. Sulphur was supplied as an incidental component of ammonium sulphate (21-0-0-24S) and single superphosphate (20-0-0-11S) which were the traditional sources of N and P in mixed fertilizers.

The growing demand for fertilizer which became evident during the late nineteen fifties led to the large scale production of synthetic ammonia and wet-process phosphoric acid. These two key products are the building blocks of ammonium nitrate, urea, ammonium phosphates, and triple superphosphate, which are now the main sources of N and P in the North American fertilizer industry. These are relatively pure compounds which contain little or no sulphur. Along with muriate of potash, they are extensively used as direct application fertilizers and as components of the high analysis blends exemplified in Table 1. The growth of these materials in the market has been parallel to an ever-decreasing amount of sulphur applied to our crops.

There has been a tendency to overlook the agronomic importance of sulphur. Like nitrogen, phosphorous, potassium, calcium and magnesium, sulphur is a macronutrient, all of which are required in relatively large amounts for plant growth. Sulphur is a component of protein. It is essential for the synthesis of chlorophyll, and plays various roles in the physiological development of the plant. It is perhaps not generally known that most plants contain approximately the same amount of sulphur (S) as phosphorous (P). The trend toward increased use of fertilizers has gone hand in hand with the development of higher yielding crop varieties, crop protection chemicals, and improved cultural techniques which have induced high yields and hence an accelerated rate of plant food removal from the soil. Since applied fertility now consists almost entirely of NPK, plant nutrition or nutrient imbalance problems may be developing due to the absence of other macronutrients which are not routinely applied. As already pointed out, sulphur is a prime example. Another macronutrient which may be of equal importance is magnesium. This presentation reviews the findings of a field trial program undertaken by Brockville Chemical Industries Limited to compare the effects of NPK, NPKS and NPKSMg. fertilizer applications on the yield and protein content of silage corn.

In 1971, a randomized block experiment consisting of three replications of eight treatments was established at nine separate sites with co-operating farmers located in major silage corn producing areas in Ontario. Fertilizer treatments are shown in Table 2. A second set of treatments, shown in Table 3 was put down in 1972 and 1973 at fifteen sites. Sources of plant nutrients were ammonium nitrate, diammonium phosphate, muriate of potash, sulphate of potash, and potassium-magnesium sulphate.

The experimental site was selected from a corner of a field on which corn was to be grown. Treatments were broadcast by hand during the first two weeks of May and worked into the soil by the co-operator in the course of routine tillage. Plots were thirty-four feet long by four rows wide (exact width determined by row width used by co-operator). Corn was planted on the experimental area by the co-operator in a routine manner except that no additional fertilizer was applied. The variety grown, plant population, and herbicide treatment were determined by the practices of the cooperator.

The soils on which these experiments were carried out may be broadly classified as medium texture calcarious soils with a PH range of 6.8 to 7.2 Fertility levels in terms of P and K were generally high. Sulphur content of leaf tissue (ear leaf at time of silking) representing the experimental sites ranged from .12 to .34%. It is to be noted that fields which showed S levels of .25% or above were located in populous industrial areas.

Yield checks were taken during the last week of August. Green weight was determined from 26 feet of the two middle rows of each plot. Sample stalks were drawn from each plot to give a composite sample representing each of the eight treatments. Samples were chopped on the site, sealed in plastic bags, placed in deep-freeze storage, and subsequently analysed for dry matter and crude protein. Yields are expressed in terms of tons of silage per acre on a 35% dry matter basis, and pounds of protein per acre. The latter is based on: —

Pounds of green weight/acre x % dry matter x % crude protein. A combined analysis of variance was carried out on the silage and protein yield data.

RESULTS

Yield results of experiments carried out at 9 locations in 1971 are shown in Table 1. Figure 1 shows the pattern of response to three levels of N with and without sulphur as reflected by yeilds of silage and crude protein. The three treatments N_1PK, N_2PK, and N_3PK show a response to nitrogen which may be regarded as typical for silage corn when a response curve is based on average of trials conducted over a range of field conditions. 150 pounds of N per acre produces a significantly higher vegetative yield than 100 pounds per acre. N at 200 pounds per acre produces a further yield increase which is non-significant. When yields are expressed as pounds of protein per acre, the yeild from 200 pounds of N becomes significantly higher than the 150 pound rate. This is due to the influence of increased protein content, which causes the response to levels of N to take on a linear relationship. The nitrogen responses found in this set of treatments are in agreement with other reported results (2, 3).

Treatment data fro rates of N with S versus N with no S show a significant yield increase due to sulphur at the lowest rate of N, but only slight increases at the higher N rates. A similar nitrogen-sulphur relationship has been reported by research workers in Nebraska, (4) who observed that yeild response of sweet corn to applied S was highest with low rates of N and that sulphur applications tended to lower the amount of N required for maximum yield. The significant response to S is also shown in the protein yield a the N_1 level, but unlike the response of the silage yields, a favourable effect from sulphur is shown with the N_2 and N_3 levels when the yield is measured in terms of protein production. The slight increases in silage yield due to S with N_2 and N_3 shown in the lower graph of Figure 1 become magnified in the upper graph due to the increases in protein content which occur with the sulphur treatments.

The highest silage yield and protein content were produced by the five-nutrient treatment N_3PKSMg. The silage yield from this treatment is significantly higher than the comparable three nutrient treatment N_3PK. The soils on which these experiments were carried out are not usually regarded as magnesium deficient. The magnesium response may be due to the fact that high levels of potassium in the soil, plus high rates of applied potash are known to depress plant uptake of magnesium. The application of soluble magnesium in such a situation may counteract this effect. Also, it has been reported (5) that a favourable interaction can exist between S and Mg in which the combination of these two elements is more effective than either one used singly.

The 1972 —73 experimental design and yield data are shown in Table 3. In this design, two levels of N were compared, each with 0, 25, and 50 pounds per acre S, with 20 pounds per acre Mg added to the 50 pound S rate at both levels of N. Growth conditions and general experience with this set of experiments were less favourable than with these of 1971. However, the analysis of the combined data of 15 locations over two years revealed significent effects which are closely in line with the findings of 1971. They are as follows:—

1. S added to the N_1 PK treatment showed a significant yield increase in silage and protein yield. These yield increases were achieved with the 25 pound per acre rate rate of S.
2. Yield of silage was not increased by adding S to N_2PK.
3. Magnesium added to N_2PKS showed a significant increase in silage yield over N_2PK.
4. Increases in protein content are associated with: N_2 over N_1, S added to N_1 and N_2, Mg added to N_2PKS.

SUMMARY

Comparing the experimental designs used in 1971 and 1972-73, there are five treatments in each which are essentially the same. These treatments are: low N with and without S, high N with and without S, and high N with S + Mg. Table 4 shows the overall yield and protein content data obtained from these treatments from 24 locations over a three year period. Figure 2 shows a graphic summary of the silage yield and protein level increases due to S, N_2, and SMg, and the cumulative effect of these increases on the yield of protein. The response shown by S is partly due to the influence of data from locations where S content of the leaf tissue was in the range of .12 to .19%. These levels are below optimum, indicating borderline S deficiencies (6). The response to Mg should be regarded as S-Mg effect, which in turn, was probably influenced by levels of N and K.

In general, the fertilizer manufacturer and the farmer are not aware of the agronomic significance of sulphur. Also, implications of the changing technology which introduced sulphur-free fertilizers have largely escaped the attention of the research community. For this reason, there is a woeful lack of research information on sulphur as a plant nutrient. Some suggested areas of research are:

1. Investigation of the sulphur status of our soils — identification of existing or potential sulphur

deficient areas.

2. Sulphur requirements of major crops, and effect of sulphur on the availability and utilization of other essential elements.
3. Effect of all macro and micronutrients on the nutritional value of crops — content and composition of protein, content of vitamins and related compounds, content of essential minerals, etc. Use of these and other quality factors as a criterion for evaluating fertilizer effects.

Research along these lines offers the prospect of greater efficiency of fertilizer utilization and crops with higher nutritional value. There are indications that sulphur fertilization may reduce the amount of applied nitrogen required to obtain maximum crop yield. If the routine inclusion of sulphur in our fertilizers has the effect of "stretching" our nitrogen supply, this could be of inestimable significance. Food crops such as cereals and legumes for direct human consumption will assume tremendous importance in the years ahead. The use of multinutrient fertilizers containing sulphur and magnesium can play a significant role in achieving the full genetic potential of the yeild and protein content of these crops.

References

(1) Fertilizer Trade, Annual. Catalogue 46-207. Statistics Canada.

(2) Bishop, R. J., G. G. Smeltzer, and C. R. MacEachern. 1971.
Response of corn to nitrogen, phosphorous, and Potassium. Can. J. Soil Sci. 52:27-42.

(3) Stevenson, C. K. 1970. More nitrogen increases corn's protein content. Soils and Crops. Dec. 1970. p. 70. Am. Soc. Agron.

(4) Daigger, L. A. and R. L. Fox. 1971. Nitrogen and sulphur nutrition of sweet corn in relation to fertilization and water composition. Agron. J. 63 (5) 729-730.

(5) Matocha, J. E. 1971. Influence of sulphur sources and magnesium on forage yields of coastal bermudagrass. Agron. J. 63 (3) 493-496.

(6) Stewart, J. A. Personal Communication 1973.

(7) Blenkhorn, H. D. Effect of Sulphur and Magnesium on silage corn in Ontario, 1974 Sulphur Inst. J. 10 (1): 12-14.

[TABLES CONTINUED ON PAGE 128]

[Footnote] — This presentation is based partly on an article which appeared in the spring 1974 issue of The Sulphur Institute Journal.(7)

TABLE 1

Elemental nitrogen, phosphorous, potassium, and sulphur content of mixed fertilizers.

GRADE		% (Typical) N	P	K	S
2-12-10	Pulverized	2.0	5.2	8.3	9.5
5-10-10	"	5.0	4.4	8.3	11.7
5-20-10	Granulated	5.0	8.8	8.3	8.7
10-10-10	"	10.0	4.4	8.3	10.4
6-24-24	Blended	6.0	10.5	19.9	Trace
8-32-16	"	8.0	14.0	13.3	Trace
12-24-24	"	12.0	10.5	19.9	Nil.
19-19-19	"	19.0	8.3	15.8	Nil.

TABLE 2

Treatments, yields, crude protein contained in whole plant corn silage at time of harvest. Averages of 9 experiments -1971.

Treatment	Tons Silage per acre 35% dry matter basis	Pounds Crude Protein per acre	% Crude Protein*
Check	10.91 e	667 e	8.61
N_1PK	13.08 d	982 d	10.50
N_2PK	14.27 bc	1051 c	10.31
N_3PK	14.58 b	1119 ab	10.87
N_1PKS	13.89 c	1052 c	10.79
N_2PKS	14.34 bc	1101 bc	10.64
N_3PKS	14.75 ab	1167 a	11.17
N_3PKSMg	15.25 a	1176 a	11.22

[continued]

Values within a column not followed by the same letter are significantly different at the 5% level.

N_1 = 100 lb/acre

N_2 = 150 "

N_3 = 200 "

P = 100 lb/acre (P_2O_5)

K = 160 " (K_2O)

S = 60 "

Mg = 25 "

* Determined at a dry matter content of approximately 20%.

TABLE 3

Treatments, yields, crude protein contained in whole plant corn silage at time of harvest. Averages of 15 experiments -1972-73.

Treatment	Tons Silage per acre 35% dry matter basis	Pounds Crude Protein per acre	% Crude Protein*
N_1PK	11.28 g	789 e	9.97
N_1PKS	11.63 f	878 d	10.69
N_1PKS_2	11.78 ef	874 d	10.44
N_1PKS_2Mg	12.00 bcde	887 cd	10.45
N_2PK	12.15 bcd	890 cd	10.35
N_2PKS	12.34 ab	915 bc	10.58
N_2PKS_2	12.29 abc	925 ab	10.67
N_2PKS_2Mg	12.50 a	958 a	10.89

Values within a column not followed by the same letter are significantly different at the 5% level.

N_1 = 100 lb/acre

N_2 = 180 "

P = 100 (P_2O_5)

K = 160 (K_2O)

S_1 = 25 lb/acre

S_2 = 50 "

Mg = 20 "

* Determined at a dry matter content of approximately 20%.

TABLE 4

Data Summary of 24 Corn Silage Fertility Experiments 1971 - 73.

Treatments	Tons Silage Per acre	Pounds Crude Protein per acre	% Protein
N_1	11.96	853	10.13
N_1S	12.58	936	10.55
N_2	13.06	966	10.63
N_2S	13.24	1001	10.84
N_2SMg	13.53	1031	11.00

Average Application Rates

N_1	100 lb/acre
N_2	188 "
S	54 "
Mg	22 "

P_2O_5 at 100 lb/acre and K_2O at 160 lb/acre are common to all treatments.

FIGURE 1
Effects of Rates of N with and without S on Silage and Protein
Yield of Corn - 1971 data.

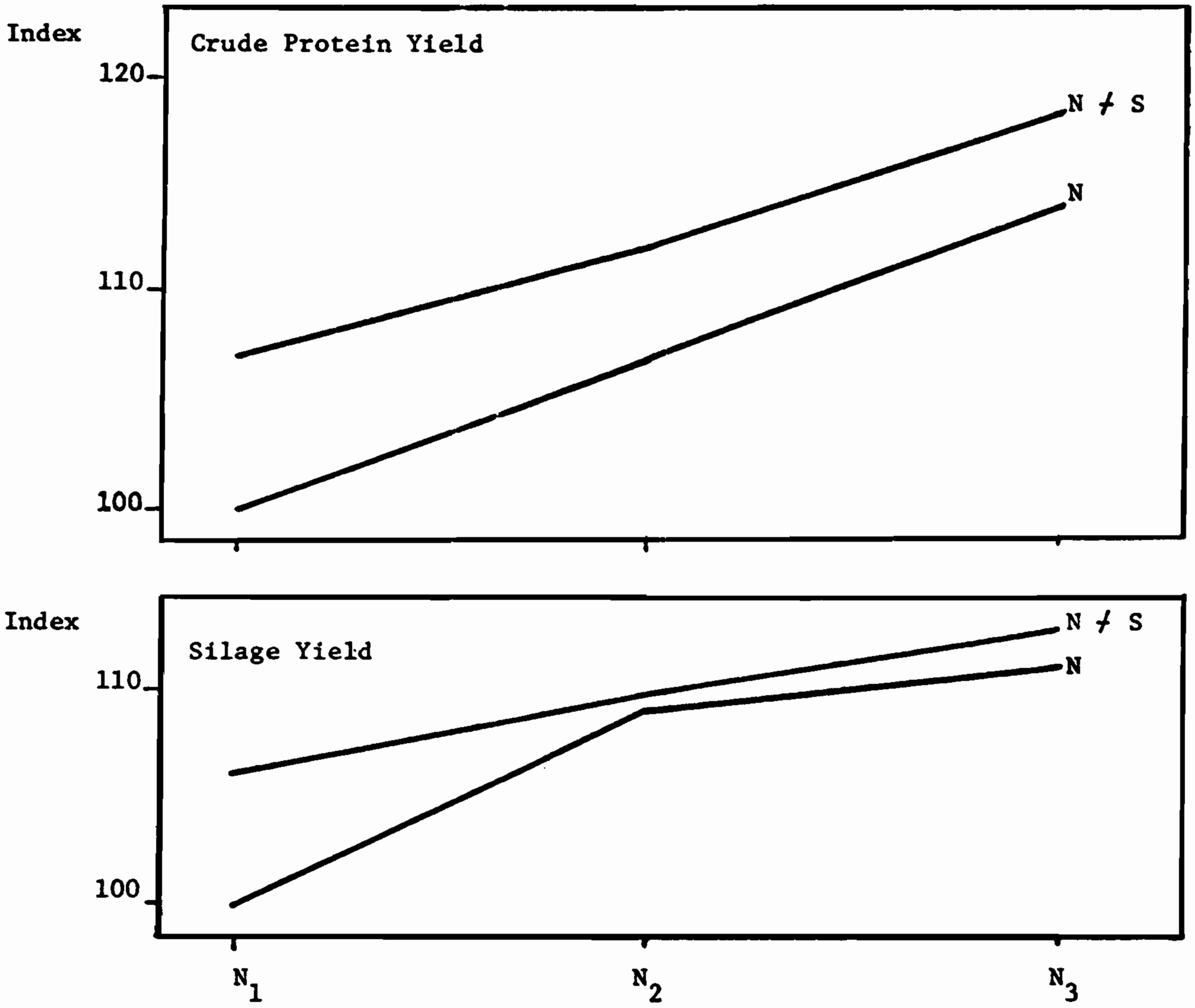
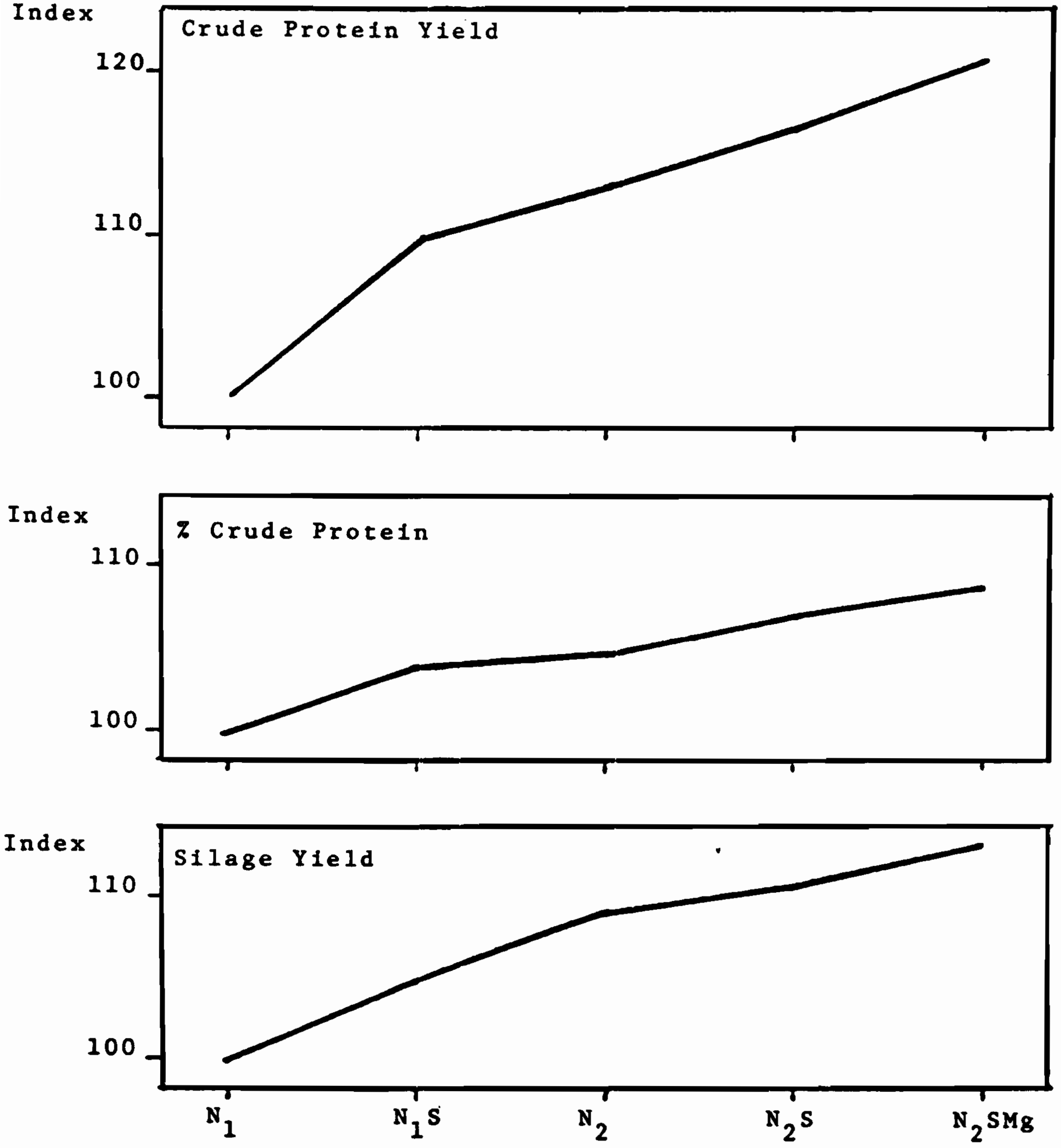


FIGURE 2

Effects of Rates of N with S and SMg on Protein Content, Silage and Protein Yield of Corn - 3 Years data.



MODERATOR NIELSSON: Thank you, Harold. We need more agronomists who talk fertilizer language. The next paper is the "Technique of Adding Micronutrients to Fertilizers" by Dr. Carl Schauble of Frit Industries. Carl is one of these wandering boys. He's been to the University of Illinois for his B.S., Purdue for his M.S., North Carolina State for his Ph.D. He has been with the Frit Industries for 14 years. He has worked with Dupont, N.P.F.I., North Carolina Department of Agriculture, TVA, I.M.C., and now is with Frit Industries.

Techniques of Adding Micronutrients to Fertilizers

Carl Schauble

During the past decade, and particularly the last few years, the need for micronutrients in crop production has increased dramatically. As farmers strive for maximum yields, greater demands are placed on the soil's ability to supply nutrients. As yields are increased, nutrient removal from the soil is also increased and we know these nutrients must be replaced somehow. Diagnostic techniques have also been improved. With refined soil testing techniques and plant tissue analysis, we can now isolate areas of hidden hunger that heretofore would have gone undetected. The result has been that the need for secondary and trace elements is being recognized in more and more areas of the country each year and recommendations for trace elements are becoming as commonplace as for N P, and K over wide areas for many crops.

Although they are just as essential for plant growth, trace elements are needed in relatively small amounts compared to the primary nutrients, so they are seldom applied alone. Instead they are usually mixed with or incorporated, in some fashion, with the macronutrient fertilizers. There are various methods by which this can be accomplished; each method has its advantages and disadvantages. These methods or techniques are the subject of this discussion.

There are three basic methods of adding micronutrients to dry fertilizers. They are: a(physical blending, b) coating, c) incorporation in granules.

Let us consider physical blending first. What I am referring to here, of course, is the blending of granular micronutrient materials with granular N, P, and K materials or granular chemically combined fertilizers. With the large growth of bulk blends as a system for supplying fertilizers, this method of adding micronutrients to fertilizers has shown the most rapid growth and is now the most widely used. It is popular because it is simple; it does not require extra equipment, and it offers maximum flexability in adding standard or prescription amounts of one or more micronutrients. A wide variety of micronutrient carriers are available in the granular form (e.g. oxides, sulfates, frits and organic complexes) as individual elements or as multinutrient formulations.

The major disadvantages of this method of addition is segregation and the possibility of poor distribution. Particle size and to a lesser extent, particle shape and density of the various materials, should be comparable in order to have maximum segregation in a blend. Micronutrients tend to have a higher bulk density than NPK fertilizers. Segregation and/or uneven spreading patterns can be critical in the case of boron and copper because of the relatively narrow range between deficiency and toxicity of these elements.

Aside from potential segregation and uneven spreading problems, this method of addition has additional shortcomings from an agronomic standpoint. If small amounts of a trace element are added using a concentrated source, only a relatively small number of granules are needed. Particularly if the fertilizer is bulk spread, distances between micronutrient containing granules on the soil would be excessive. For example, if one pound of micronutrient granules are required per acre there will be less than one granule per square foot of soil on the average (6). Band application in the row would, of course, present less of a distribution problem (4). One way of overcoming or minimizing this problem is the use of lower analysis granular micronutrient materials. There is a definite trend in this direction. Since micronutrients do not tend to move readily in the soil, the use of water degradable granules which are made up of finely divided particles will also help to improve distribution of the micronutrients in the soil.

Let us now consider coating as a method of applying micronutrients to fertilizers. The technique of applying powdered micronutrients as a coating on the surface of granules is well suited to the practice of and equipment used in bulk blending. It can readily be seen that this method of addition when properly carried out can overcome the potential problems of segregation and poor distribution inherent in blending of granular micronutrient materials.

This method of addition offers great flexibility in formation and is quite simple, although some additional equipment is needed such as spray nozzles in the mixer, and a suitable pump and storage container for the binder.

The main limitation to this method of adding micronutrients to fertilizers is the amount that can be added and effectively retained on the granules. Small amounts of powdered micronutrients have been added as a coating successfully without the use of a binder; however, the use of fluid binder, such as 1 to 3% of oil, water or a fertilizer solution greatly improves adference and minimizes segregation (2). Used motor oil is favored over diesel oil since it does not impart a foul odor and discolor bags. A comparatively simple coating procedure has been worked out. It consists of weighing in and charging a batch mixer with a granular fertilizer or granular mixture and pulverized micronutrients. They are mixed about a minute, then binder is added in an amount equal to 1 to 3% of the charge and mixing is continued for another minute before the batch is discharged (6).

This procedure is applicable to granular fertilizers at the time of shipment as well as the bulk blends. All types of micronutrient carriers can be added in this manner so long as they are finely divided. Richards found that when water soluble micronutrient sources were added in this manner, there was some reduction in water solubility probably as a result of chemical reactions at the surface of the granule. This was particularly apparent with zinc when ammonia and phosphourus were present in the granules. Chelated micronutrient sources can be added in this manner and retain a high degree of water solubility when sprayed on as a coating (5). This method of addition offers one additional advantage in that it helps to control dust in the finished product.

Micronutrients have been incorporated into fertilizer granules by adding them during the granulation process longer than any other method of addition. They can be added in a slurry or solution system, or fed in with the other solid materials. This method is relatively simple, provides distribution throughout the fertilizer mass, and should eliminate problems of segregation. This method has several inferent disadvantages, however. It offers limited flexability for prescription formulation. It is not a convenient method of addition unless large amounts of fertilizer containing a given amount of micronutrients are being produced. Inventory and storage problems can become severe if small lots of special grades containing various types and amounts of micronutrients are needed.

There are also some potential problems resulting from chemical reactions between the micronutrients and other fertilizer components. Soluble micronutrient sources often become largely insoluble when added prior to the granulation process. Chelates can be greatly reduced in effectiveness if subjected to low pH or high temperatures in the granulation process (5) (6). Fritted materials and compounds of low water solubility tend to be effected little by granulation.

Generally, when water soluble forms of micronutrients are added prior to the ammoniation granulation step, the water solubility is greatly reduced. In one test, over 90% of the zinc from five water soluble sources was converted to a non-water soluble form (4). Zinc solubility has been found to decrease as the rate of ammoniation is increased (3). This is likely due to the formation of zinc phosphate or zinc ammonium phosphates (1). While the water solubility of chelated micronutrients is also reduced by the ammoniation-granulation process, the magnitude of reduction is not generally as great as with inorganic source (5). This would indicate that there is little or no advantage in using water soluble micronutrient sources at premium prices if they are to be added in a granulation system. Solubility of micronutrients is normally higher if they are incorporated after ammoniation, however, even then there can be some reduction in solubility from surface reaction of water soluble products.

So far, we have discussed only dry fertilizers. Liquid and suspension fertilizers also are important vehicles for adding micronutrients to soil.

In adding micronutrients to clear liquids, the primary problem is solubility. When inorganic water soluble micronutrient carriers are needed to orthophosphate solutions, precipitates form. Thus, chelates are about the only source by which micronutrients can be added to these systems. Chelates are relatively expensive and the amount of micronutrients that can be added through orthophosphate based liquids is limited.

Polyphosphate solutions, on the other hand, sequester most micronutrient elements and can hold substantial concentrations in solution. There is still a limitation as to the amounts of various inorganic micronutrient compounds that can be held in solution however, even in polyphosphate based solution. Complete NPK polyphosphate based solutions are capable of sequestering sufficient micronutrient concentrations to correct moderate deficiencies of zinc, copper and iron, slight manganese deficiencies and severe boron and molybdenun deficiencies (6).

Suspensions offer greater potential for carrying micronutrients than do clear liquids because the solubility problem is not inherent. The main restrictions on the type or amounts of micronutrient materials added are that the particle size of the suspended materials be smaller than 20 mesh and that the final viscosity of the suspension in not excessive. Eventhough solubility is not of the importance it is in clear liquids, reaction products do form with some materials which tend to increase viscosity of the suspension particularly during storage, thus limiting the amounts of some micronutrients, such as manganese, which can be added.

While all of the various methods of adding micronutrients to fertilizers we have touched on are being used to some extent, some are more popular than others. The technology of adding micronutrients to liquid and suspension fertilizers has been adopted quite widely. The coating technique is only being used to a limited extent by bulk blenders in spite of the advantages it offers, probably because of the additional care, attention, and equipment it requires. Blending of granular micronutrient materials with other granular components is the practice used most widely and growing most rapidly in spite of the shortcomings already pointed out. In some cases, several methods of addition are used in combination e.g. coating and blending of granular micronutrient carriers thereby overcoming some of the shortcomings of the individual methods. Incorporation of micronutrients in the fertilizer granules continues to be popular where granular plants are in operation. Perhaps as specific micronutrient needs become more uniform and wide spread, we will see micronutrients added to certain raw material components or granular bases that can be used to make up a significant portion of a blend. Thus, allowing some freedom in formulation but overcoming the potential problems of segregation and poor distribution.

BIOLIOGRAPHY

1. Frazier, A. William, James P. Smith, and James R. Lehr. Precipitated Impurities in Fertilizers Prepared from Wet Process Phosphoric Acid. J. Agr. Food chem. 14: 522-529, 1966.
2. Hignett, Travis P., Supplying Micronutrients in Solid Bulk-Blending Fertilizers. Commercial Fertilizer. 108 (1) 23-25, 1964.
3. Mortvedt, J. J. Crop Response to Applied Zinc in Ammoniated Phosphate Fertilizers. J. Agr. Food chem. 16: 241-245, 1968.
4. Mortvedt, J. J. and Paul Giordano, Effectiveness of zinc Applied with Micronutrient Fertilizers. Commercial Fert. Dec., 1967.
5. Richards, G. E. Water Solubility of Zinc in a Granular Mixed Fertilizer as Affected by Zinc Source and Method of Addition. Soil, Ser. Svc. of America. Proc. 33: 310-313, 1969.
6. Young, R. D. Providing Micronutrients in Granular bulk-Blended Liquid and Suspension Fertilizers. National Plant Foods Inst. Meeting October 1968.

MODERATOR NIELSSON: Thank you Dr. Schauble.

Our next Paper, "Technological Changes Affecting The Supply Of Sulphuric Acid", was prepared by David W. Bixby and Jan. S. Platou.

David is a Graduate Chemical Engineer of "my school — Syracuse University". He is Director of Research for the Sulphur Institute. Jan was born in Norway, graduated from Heriot-Watt College in Edinburg, Scotland. He joined the Sulphur Institute in 1961 in London and since 1967 has been with them here in Washington. This paper will be given by Jan.

Technological Changes Affecting the Supply of Sulphuric Acid

David W. Bixby — J. S. Platou

Future production and supply of sulphuric acid in the U.S. will undoubtedly be influenced by technological changes — but these technological changes will, more often than not, in turn be the result of decisions made by politicians rather than technologists. Given the somewhat inexact nature of political science, the future supply of sulphuric acid is fraught with uncertainties.

The discussion that follows represents an attempt by the Sulphur Institute staff to evaluate the likely developments in the sulphur and sulphuric acid situation to 1980.

In 1973, the U.S. consumed about 9 million tons sulphur equivalent of sulphuric acid (Table 1), and fertilizers accounted for 61% of this. It is estimated that in 1980, consumption will have increased to 12.4 million tons, and that the fertilizer industry will have increased its share slightly, to 63%. Thus, this industry will need another 2.3 million tons sulphur annually by 1980. All of this increase will be accounted for by phosphoric acid. Single superphosphate is shown declining — the current increase in production of this material being regarded as a result of a temporary shortage of other forms of P_2O_5, expected to be reversed when new phosphoric acid plants come on stream. Ammonium sulphate tonnage is expected to remain constant.

It is apparent from Table 1 that presently announced new sulphuric acid capacity will be more than adequate to supply the projected requirements. Some of the new capacity will replace older plants which are being phased out for reasons of obsolesence or inability to meet emission regulations.

Actual 1980 production levels of the announced new capacity depend on several factors, among them completion on time, raw material supply, and market for the acid produced. Certain aspects relating to the last two of these factors will be discussed in the following.

Raw Materials

The principal raw materials are elemental sulphur and metallic sulphides (for plants associated with smelters). The elemental sulphur situation is shown in Table 2. If all announced and existing acid capacity is to produce at design capacity, it appears that imports of 2.3 million tons of sulphur will be needed in 1980, assuming that U.S. exports continue at the 1973 level. However, several factors may alter this situation: some older existing acid capacity may be shut down; Frasch sulphur production is flexible to some degree; recovered sulphur production will depend to a considerable extent on the crude oil import situation, and sulphur exports may go up or down.

The smelter acid situation is shown in Table 3. The question of discontinued capacity applies to smelter acid as well. Announced closures, including several zinc smelters, have been subtracted from the 1980 figures. Additional closures are possible, but it appears that about 1.8 million additional tons of S as smelter acid will be produced in 1980 compared with 1973, assuming 70% of announced capacity.

The combined elemental sulphur and smelter situation is shown in Table 4, together with the supply/demand situation for 1980. From U.S. raw materials, an additional 1.9 million tons of S as acid might be available in 1980. to meet the projected need for an additional 3.3 million tons of acid in that year, it appears that 1.4 million tons of sulphur must be imported. However, announced new acid capacity totals 4.7 million tons of sulphur equivalant, more than enough to produce the acid needed. Given this situation, several scenarios are possible. Some of these will be referred to in the remainder of this paper, which deal with the technological changes affecting the industry.

Technology

A number of technological changes affecting the supply of elemental sulphur are pending, but most of them are not expected to have a significant effect until after 1980. Oil and gas desulphurization uses existing technology which is not expected to change markedly, although attempts to make it more efficient continue. The same applies to Frasch sulphur technology.

Sulphur recovery from coal offers the greatest potential sulphur production but at the same time the greatest technology challenge. Several methods are being investigated, some on a very large scale, but none have as yet been completely successful. Direct cleaning, which removes only about 50% of the sulphur in coal (the pyritic portion) is least attractive because of its inefficiency and the difficulty of marketing the byproduct. Coal gasification or liquefaction is more attractive, although technology has not yet reached the commercial stage. These processes have the advantage of converting combined sulphur to hydrogen sulfide which in turn can be converted to readily marketable elemental sulphur.

Another way of recovering sulphur from coal or oil is by treatment of stack gases after the fuel is burned. Many processes which yield sulphur, sulphuric acid, or other compounds are in various stages of development. None of them are expected to have a significant effect on the sulphur market before 1980. Some 68 flue gas desulphurization units are scheduled to have started up by 1980, but 64 of them are scheduled to use line or limestone and to make a throwaway byproduct.

Some time after 1980, large quantities of sulphur or sulphuric acid derived from fossil fuels, either before or after burning of these fuels, will inevitably make an appearance. The potential exists — some 9 million tons of sulphur from utility fuels alone by 1980, rising to 13 million tons by the year 2000. However, at this time any prediction of how much will actually be removed in useful forms is pure guesswork.

In the long term, elemental sulphur will probably by the primary byproduct from fossil fuels. It already is for oil and gas and is expected to be for coal, even though a great deal of stack gas sulphur dioxide from coal burning will be converted to sulphuric acid.

Most of the copper, zinc and lead smelter operations will continue to produce sulphuric acid rather than sulphur as their primary byproduct. In 1973, about 0.6 million tons of sulphur as acid were recovered by smelters West of the Mississippi, representing perhaps 25% of their emissions. As shown in Table 1, some 1.7 million tons of sulphur in new acid capacity has been announced for 1974 and beyond, which, assuming 70% utilization, means that 1.2 million tons will be produced. Some of this is at remote locations and will, after neutralization by limestone, be discarded as gypsum. Some acid will find its way to the chemical and/or fertilizer industries if the delivered price is right.

In addition, some of this byproduct acid will be used captively to leach low-grade copper ores or tailings previously uneconomical to process. Some evolved SO_2 will be converted to elemental sulphur rather than aicd, assuming that one or more of the several pilot plant programs now under way are successful. In these areas, many avenues of new technology are being developed with obvious potential effects upon the supply picture. If a process for converting SO_2 to elemental S looks promising, a product which can be shipped some distance at minimum cost will become available in the sulphur market. On the other hand, if large amounts of sulphuric acid can be used captively for leaching or hydrometallurgical processes, some potentially low-cost material will no longer be available for use by the fertilizer industry.

The term "technology," of course, is not limited to processes only. Computor technology is being used to enable utilities, smelters, and other companies to ascertain what their revenues might be were they to produce byproduct sulphur or sulphuric acid and adopt this or that marketing strategy. One example is a preliminary study entitled "Marketing H_2SO4 from SO_2 Abatement Sources — The TVA Hypotheses," published in December 1973. TVA plants alone could produce 2 million tons of acid in 1975 if acid plants could be built by then. The study concluded that such an amount could be absorbed by the 11-state market adjacent to the TVA power system, if there were no other competition from abatement sources. A versatile computer program was developed for the study, which is now in the process of being extended to the U.S., East of the Rocky Mountains.

Decisions made as the result of such computer programs could affect the sulphur-sulphuric acid supply situation in either direction. New technology of information gathering and utilization will certainly play an important part in helping organizations decide if, how, and when they should enter the sulphur-sulphuric acid market.

Existing technology will probably be applied to a greater extent to the matter of sulphur-sulphuric acid transportation, thus helping to increase the supply at point where it is needed. Unit trains for both liquid and solid sulphur are one example. Pipelines for sulphur have received considerable attention and may one day become commercial. Barge transportation of acid will extend the range of marketability for this potential utility byproduct.

Another area in which technology may affect the sulphur supply/demand situation is that of new and expanded uses for this element. One of the functions of The Sulphur Institute is to develop and promote these new uses, so as to assist the sulphur industry in times of oversupply and reduce its dependence on the cyclic phosphate industry. Well along in various stages of development are such industrial programs as sulphur-asphalt paving, sulphur concrete, sulphur in construction, and foamed sulphur, as well as promotion of sulphur as an essential plant nutrient in agriculture. Although the demand likely to be created in these areas cannot be forecast precisely, it does provide another example of how technology may affect the supply of sulphur to other consuming industries.

In summary, largely as a result of political decisions, technology will provide a number of previously untapped sources of sulphur-sulphuric acid supply derived from fossil fuels and smelting operations. The impact from oil, sour gas and smelters is already being felt. After 1980, sulphur from coal, oil shale, and stack gases is expected to enter the market. In the long term, should additional sulphur be needed, technology can provide it in quantity, although at greater cost, from pyrites, gypsum and other sources. Technology will also provide the information on how to make the best use of new and existing sources, and, by creating new markets, will affect the distribution pattern among consuming industries.

Table 1

U. S. Consumption of Sulphuric Acid
(Million long tons S equivalent)

	1973	1980
Fertilizer Acid		
Phosphoric Acid	4.45	6.96
Single Super	0.36	0.16
Ammonium Sulphate	0.66	0.64
Total	5.47	7.76
Industrial Acid	3.55	4.59
Total Sulphuric Acid	9.02	12.35
New Capacity Needed 1973-1980		3.33
New Announced Capacity to 1980		
Brimstone		3.00
Smelter		1.67
Total		4.67
Apparent Excess Acid Capacity in 1980		1.34

Table 2

U. S. Elemental Sulphur Supply/Demand
(Million long tons S)

	1973	1980
U. S. Production		
Frasch	7.6	7.5
Recovered-Refinery	1.5	2.9
Recovered-Natural Gas	0.9	1.7
Total	10.0	12.1
U. S. Consumption		
Non-acid	1.1	1.4
Acid	8.2	11.2[1]
Total	9.3	12.6

[continued]

Imports	1.2	2.3[2]
Exports	1.8	1.8
Net	(0.6)	0.5

1. Assuming 100% utilization of new acid capacity.
2. Apparent requirements, assuming exports at 1973 level.

Table 3

U. S. Smelter and Other Sulphur Supply/Demand
(Million long tons S equivalent)

	1973	1980
U. S. Production		
Smelters and Other Byproduct Acid	0.6	1.8[1]
Pyrites	0.2	0.2
Other	0.1	0.1
Total	0.9	2.1
U. S. Consumption	0.9	?

1. Assuming 70% utilization of new (1974-1980) capacity.

Table 4

U. S. Sulphuric Acid Situation
(Million long tons S equivalent)

	1973	1980	Change
U. S. Elemental S Available for Acid	8.2	8.9[1]	+0.7
U. S. Produced Smelters and Other	0.9	2.1[2]	+1.2
Total	9.1	11.0	+1.9
Additional Acid Needed in 1980		3.33	
Additional Acid Achievable with U. S. Supply		1.9	
Imports Required to Meet U. S. Needs		1.43[3]	

1. Estimated U. S. sulphur production, less 1973-level exports, less non-acid use, no imports.

2. Estimated available U. S. production.

3. Assuming full utilization of that new "Smelter and Other" acid which will be produced by operation at 70% of announced capacity. Compare with figure of 2.3 million tons of sulphur as brimstone in Table 2, required for 100% utilization of announced brimstone using acid capacity.

MODERATOR NIELSSON: Thank you, Jan. Now, we have an interesting development being discussed by our colleagues from Canada from the Brockville Chemical Industries, Ltd. We will have two papers on the outside storage of water soluble materials. The first is on the "Outside Storage of Ammonium Nitrate" by Jesse Ku and Ashley Kemila.

Now, Mr. Ku was born in Republic of china, graduated in Chemical Engineering and worked in Taiwan. Now he lives in Canada, is a member of the Chemical Institute of Canada and a member of the Canadian Society of Chemical Engineering. Mr. Ku is Process and Development Engineer for Brockville Chemical Company at Maitland, Ontario. Mr. Kemila is a production manager of Brockville Chemical Industries. He has worked for Union Carbide, Ogilvie flour Mills, and he's a graduate of chemical engineering from University of Saskatchewan in Saskatoon. The paper will be delivered by Mr. Kemila. Let's welcome him.

Outside Bulk Storage of Ammonium Nitrate

J. Ku and A. D. Kimila

1. *Need For and Advantages of Outside Bulk Storage from B.C.I.L.'s Standpoint*

The need for fertilizer grade ammonium nitrate prills is seasonal, and so is its shipment from B.C.I.L. More than 50 percent of the annual shipments are between March and early June. During these months, plant production cannot match Sales' requirements, therefore, starting in the fall, the prills have to be stored in order to match the demand during the coming spring.

In 1973 and 1974, spring shipments of bulk product were 66 percent and 75 percent respectively of the total shipments of bulk and bagged product during that period. The trend toward bulk shipment is increasing.

Before B.C.I.L. made the decision to store bulk ammonium nitrate outside, some small scale bulk storage tests and economic studies were carried out.

(a) *Indoor Bulk Storage Study*

In 1972, B.C.I.L. had a plan to convert the existing 6,000 ton bag warehouse into a 12,000 ton bulk warehouse. Concrete retaining walls, a conveyor belt and tripper, and a heating system would have cost an estimated $200,000, or $17 per ton of ammonium nitrate stored.

(b) *Outside Storage Study*

A small scale outside storage test was conducted in the winter of 1971. The prills were stored in an 8' x 8' x 1' deep wooden box with a polyethylene sheet lining. On top of the prills were placed two layers of polyethylene sheet, one layer of cardboard, and one layer of tarpaulin. The box was tightly sealed to protect against precipitation. This two and one half ton test pile was covered in September. When it was opened the following May, the prills were found to be free-flowing.

During the summer of 1972, another test was conducted iin a humid warehouse. About one ton of ammonium nitrate prills was placed in a poly sheet-lined wooden box. The prills were then covered with a single layer of polyethylene sheet and tightly sealed. After the heat and humidty had passed, the prills were found to be as free-flowing as when they were placed. This test proved that the prills could be protected against humid air by sealing with a polyethylene sheet.

The cost of building outside bulk storage facilities was estimated to be much less then indoor bulk storage. The investment for the outside bulk storage was about $9.50 per ton. The cost of labor in handling the prills would be a little higher, however the overall storage cost justified this approach.

B.C.I.L. started outside bulk storage of ammonium nitrate prills in November of 1972. The two experimental 350 ton outside bulk piles proved very successful, and outside storage was continued in the winter of 1973 with three 900 ton piles. After two years' experience in bulk storage, the prills have been found to cake very little, and have been easy to handle. This method of storage has proven to be economical.

2. *Description of Ammonium Nitrate Prills*

Low density ammonium nitrate prills were stored. The prills from production were cooled to below the 32.3 degrees C. crystal transition point, screened, coated with about 1.5 percent of diatomaceous earth, and temporarily stored in bulk hoppers (1972) or hopper cars (1973). After an accumulation of prills, bulk storage piling was started.

The quality of the prills stored was:

Water Content : Less than 0.15%

Sieve Analysis:

	Tyler Standard Sieve	**Weight %**
Retained on	No. 10	Greater than 60%
Passing	No. 20	Less than 0.5%
Prill Temperature:	Less than 32 de. C.	

3. *Outside Bulk Storage Bin construction*

(a) *Bin Design and Arrangement*

The outside storage bin consists of an asphalt pad surrounded by a four foot high retaining wall. The bulk pile may look like a cottage roof or pyramid, depending on the dimensions of the pad. Following are data on the storage bins:

Year	**Winter 1972**	**Winter 1973**
Capacity of the bin	350 tons	900 tons
Number of bins built	2	3
Pad size of one bin	32 ft x 64 ft	64 ft x 64 ft
Retaining wall height	4 ft	4 ft
Pile height	12 ft	20 ft
Shape of bulk pile	Cottage Roof	Pyramid

(b) *Pad and Side Wall Design*

The pad is paved with 3 inch thick asphalt over a bedding of 6 inches of pit gravel, 6 inches of crushed stone, and 2 inches of stone dust.

The side wall is built with 3/4 inch thick, 4 ft x 8 ft plywood boards which are nailed to 2 x 4's which in turn are fastened to 6 inch diameter x 8 foot long posts. A movable wall design could also be used, but protection of the prills by sealing with polyethylene sheeting is not as good as with the fixed wall design. The wall is painted with ammonium nitrate-resistant epoxy paint or silicone liquor.

A concrete floor pad was considered, but the construction cost was almost double the cost of the asphalt pad.

4. *Covering the Outside Bulk Pile*

Ammonium nitrate is a hygroscopic material, thus for bulk storage, it must be protected from damp surfaces and humid air. In the storage bin, a layer of 4 mil clear polyethylene sheet is used as a water barrier on the asphalt floor, and as a lining on the inside of the walls for protection from melting snow and heavy rainfall. In order to protect the prills against exposure to rain and humid air, 2 layers of 6 mil clear polyethylene sheet are used to cover the pile. A reinforced clear woven poly sheet is laid on top of the 6 mil poly sheeting to provide wind and heavy snow protection.

In order to secure the plastic sheets on the bulk pile, a 2 inch x 1 inch wooden strip is nailed over the sheets around the side walls. Furthermore, sand bags are laid on top to prevent lifting by the wind.

In the winter of 1972, the two 350 ton piles were covered slightly differently.

	Number of Layers	
Covering Layers	**Pile A**	**Pile B**
6 mil clear polyethylene sheet	1	2
Cardboard layer	1	1
Woven poly sheet	2	1

In the winter of 1973, each of the 900 ton pads were covered with two layers of 6 mil clear poly sheet and one woven poly sheet, however, only two of them were provided with the cardboard layer.

From this experience, B.C.I.L. have found that two layers of 6 mil poly sheet and one layer of woven poly sheet are able to protect the prills in the outdoor bulk piles.

5. *Physical Handling of Ammonium Nitrate Prills*

In the fall of 1972, prills were taken from two production storage hoppers in two open dump trucks to the outside storage bin site. A portable inclined tubular conveyor piled the prills in the bin to a height of 12 to 18 feet after which the bin was covered with polyethylene and cardboard sheets and left over the winter.

During the operation, one man loaded prills into the truck, two men drive the trucks and one man fed prills into the bin.

In the fall of 1973, because 900 ton bins were being filled as against 350 ton ones in 1972, a different method was used to minimize the bin filling time. A number of 80 ton hopper cars were filled directly from production, and then unloaded from the tracks into the adjacent bins via an undercar conveyor and inclined tubular conveyor. Under normal conditions, one man can handle each of the preceding operations. An additional expense with this approach, was the demurrage incurred on rail hopper cars due to their delayed turn-around.

In the spring, the bulk storage pile was opened. With a front end loader, screened hopper and inclined tabular conveyor, the prills were loaded back into hopper cars by two operators.

The equipment used in 1972 were two 8½ ton tandem open dump trucks; a 50-ft inclined tubular conveyor with a 12 inch belt, a 30 degree rise, and a capacity of 60 tons per hour; a front end loader with a one cubic yard bucket and a 9 ft x 5 ft x 4 ft deep hopper with screen. In 1973, the only new piece of equipment used was the undercar conveyor which received prills directly from the hopper car chutes. The two dump trucks were not required.

6. *Efficiency of Operation*

Ten hours are required to make a 350 ton pile. The making of a 900 ton pile requires about 25 hours provided that the operation is continuous. Due to mechanical problems with the inclined tubular conveyor and the unavailability of prills, generally more than 25 hours were required to make a pile. Because of difficulties in unloading the hopper cars such as establishing consistent flows of prills out of the hoppers, more time was required to fill the pile than to empty it.

The placing of the polyethylene sheets on the pile, requires five men — one at each corner and one at the top of the pile.

B.C.I.L.'s experience revealed that in making the 350 ton piles, 0.21 manhours per ton were required to make and cover the pile, and 0.13 manhours per ton were required to move the prills by truck for a total of 0.34 manhours per ton. Emptying the pile into the hopper cars required 0.17 manhours per ton.

The weather conditions during the operations in 1972 were as follows:

	Making pile	**Emptying Pile**
Month	November 1972	April 1973
Weather	Sunny and dry	Dry
Air Temperature, Deg. F.	35 — 50	58 — 63
Water, grains per lb dry air	24 — 33	24 — 56
Dewpoint of air, Deg. F.	30 — 37	24 — 50

Following is a comparison of the prill analysis before and after storing:

	Before	After	
		Pile A	Pile B
Prill temperature, Deg. F.	50 — 60		
Water, %	0.14	0.13	0.11
Coating agent, %	1.46 — 1.71	1.14	1.44
Tyler Standard Sieve Anal.			
Retained on 10 mesh, %	60 — 75	75.4	57.3
Passing 20 mesh, %	0.3 — 0.5	0.7	0.2

The prills were in excellent condition with little caking and no indication of breakage. There were a few caked spots on one pile due to water leaking through holes in the 6 mil clear poly sheet next to the prills and through the seams of the woven poly sheet.

Of the 700 tons of prills stored in 1972-73, only 4 tons were lost for a 0.6 percent shrinkage. The loss was traced to water leaking through holes in the 6 mil poly sheet. About 80 tons of prills were lost of the 2,700 tons stored in 1973-74 for a 3 percent shrinkage. This loss was caused by a heavy dew one night during which prills were being added to a pile, and by rain getting into another pile while emptying it.

7. *Capital Investment of Outside Bulk Storage*

Piles	2 x 350 tons	3 x 900 tons
Bin size	32 ft x 64 ft	64 ft x 64 ft
Asphalt pad size	74 ft x 80 ft	100 ft x 210 ft
Pad cost	$ 4,600	$ 19,000
Side wall cost	$ 1,200	$ 5,000
Covering material cost	$ 750	$ 2,300
Total material cost	$ 6,550 (1972)	$ 26,300 (1973)
Cost per ton	$ 9.36	$ 9.74

The woven polyethylene sheet is reusable.

8. *General*

Outside bulk storage has many advantages over indoor bulk storage, such as less capital investment, increased safety and better product protection. The prills stored in the outside bin are completely enclosed by the polyethylene sheets and are less affected by atmospheric humidity. Piles should not be filled or emptied when the air is near its saturation point.

The storage bin is sized to the rate of filling and emptying of the pile desired. A storage bin holding 500 tons is the optimum size. The size of pile can be filled or emptied in a 12 to 15 hours continuous operation, thus avoiding a temporary covering and the extra labor cost and lack of prill protection associated with it. The coverings can be put over a 500 ton pile without too much difficulty.

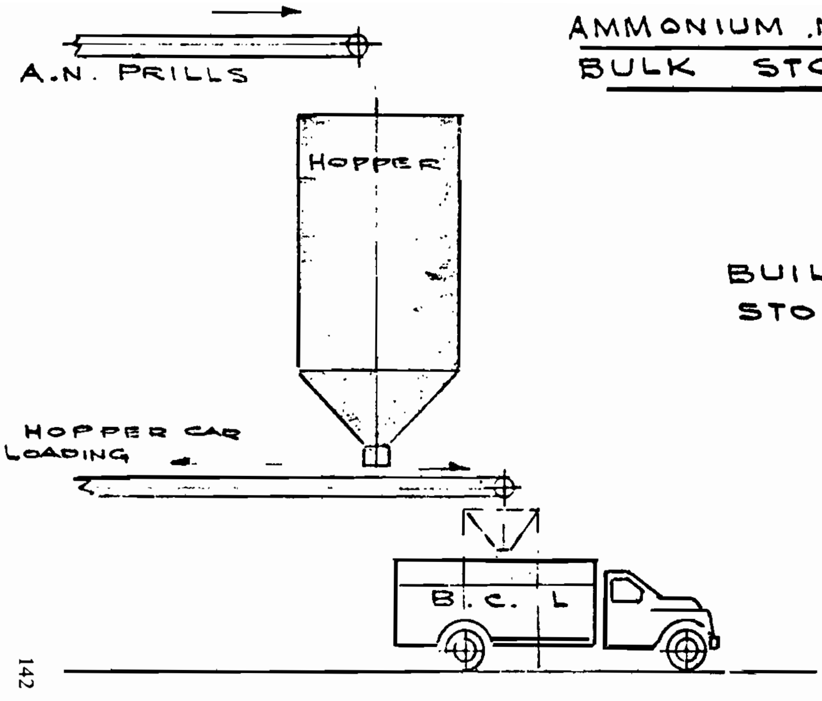
The desired shape of the storage bin is round. This will eliminate the "pockets" that are present in the four corners of a rectangular pile. A 500-ton pile is about 60 feet in diameter, and 16 feet high.

The ideal arrangement of an outside bulk storage system should consist of a small bulk warehouse with a capacity of one week's production built next to the outside bins and along the railway tracks to serve as surge capacity while preparing the bulk pile and to serve as a load-out point for rail car and truck shipments. A front end loader can move the prills from the warehouse to an inclined tubular conveyor for subsequent conveying into ht outside bins. In the spring, the prills in the bin can be moved out by a front end loader and loaded into hopper cars for shipment via an inclined tubular conveyor.

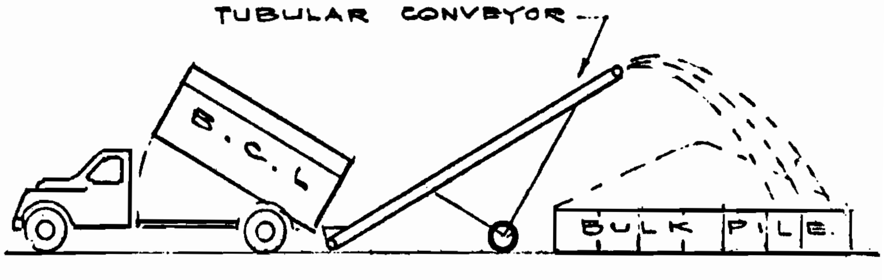
To fill 500 ton pads in the manner described above will require two men for fifteen hours on the front end loader and tubular conveyor, and five men for three hours in placing the covers. This is equivalent to about 0.09 man-hours per ton of prills stored. The manpower requirements for unloading the pile into hopper cars will be similar for a total of 0.18 manhours per ton, compared to 0.34 manhours per ton (filling, moving and dumping trucks into pad plus covering), plus 0.17 manhours per ton (emptying pad into hopper cars) for a total of 0.51 manhours per ton in the case of B.C.I.L.'s original 350 ton pads.

Page 142 — Slide #1 Ammonium Nitrate Outside Bulk Storage Operation.
Page 143 — Slide #2 Views of Bulk Storage Pile with Wooden Wall.
Page 144 — Slide #3 Outside Storage Bin of Ammonium Nitrate Prills.
Page 145 — Slide #4 Details of Pan And Walls Construction.
Page 146 — Slide #5 Corner Design Of The Wall
Page 147 — Slide #6 Method of Covering Bulk Storage Pile.
Page 148 — Slide #7 Movable Wall Design Of The Bulk Storage Bin.
Page 149 — Slide #8 Crystal Transitions And Volume Changes In Ammonium Nitrate As A Function Of Temperature.

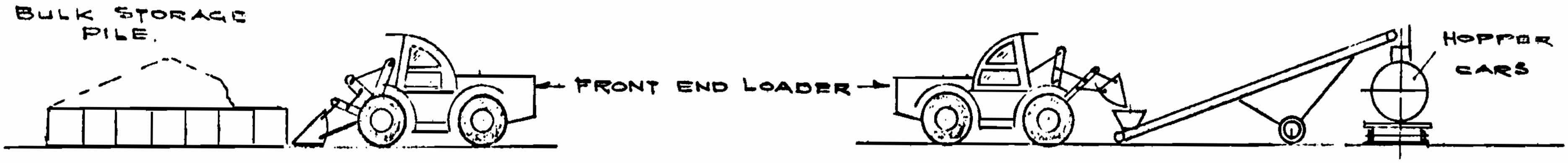
AMMONIUM NITRATE OUTSIDE BULK STORAGE OPERATION.



BUILDING THE BULK STORAGE PILES

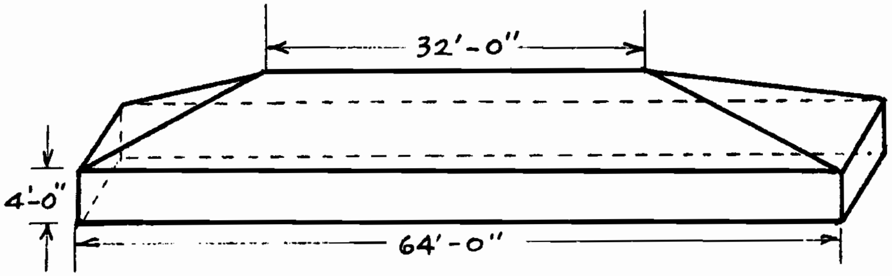


EMPTYING THE PILES & LOADING HOPPER CARS.

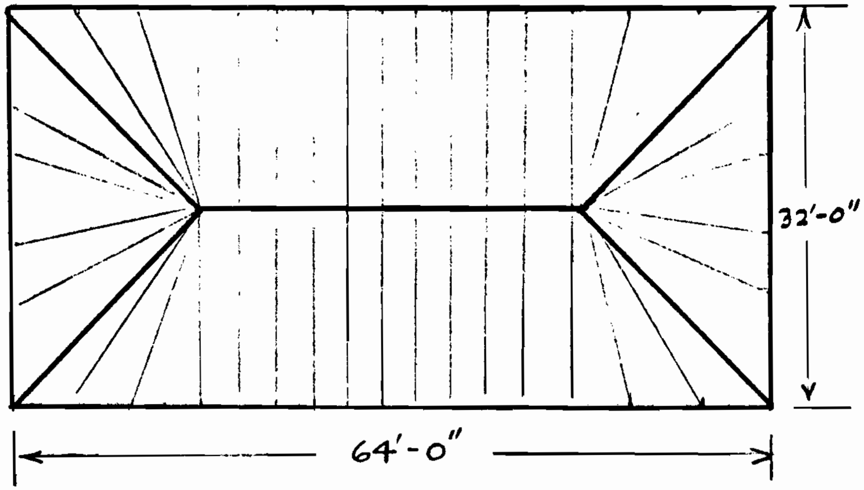


O.E.H. AUG. 1974.

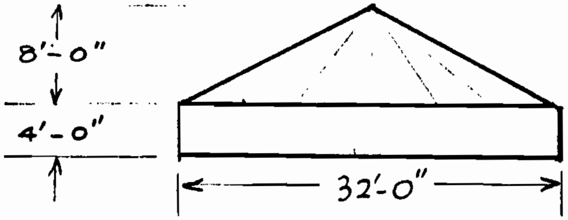
Slide 1



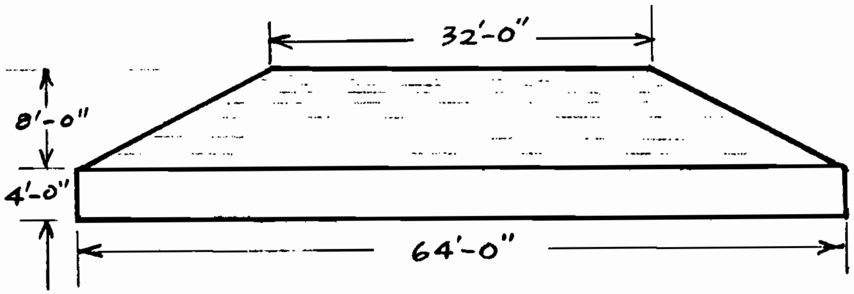
COTTAGE ROOF SHAPE PILE



PLAN VIEW



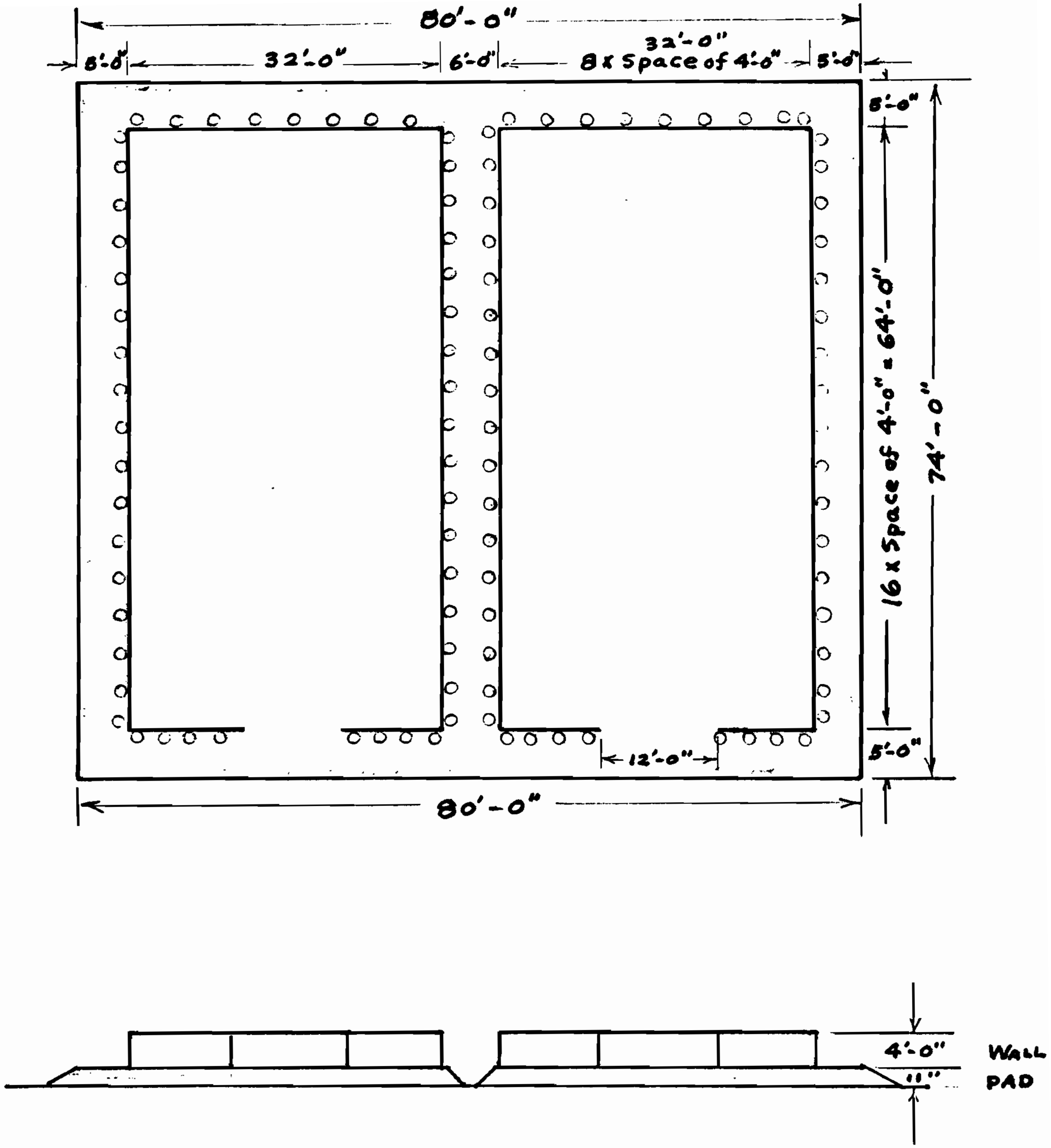
EAST ELEVATION



SOUTH ELEVATION

VIEWS OF BULK STORAGE PILE WITH WOODEN WALL

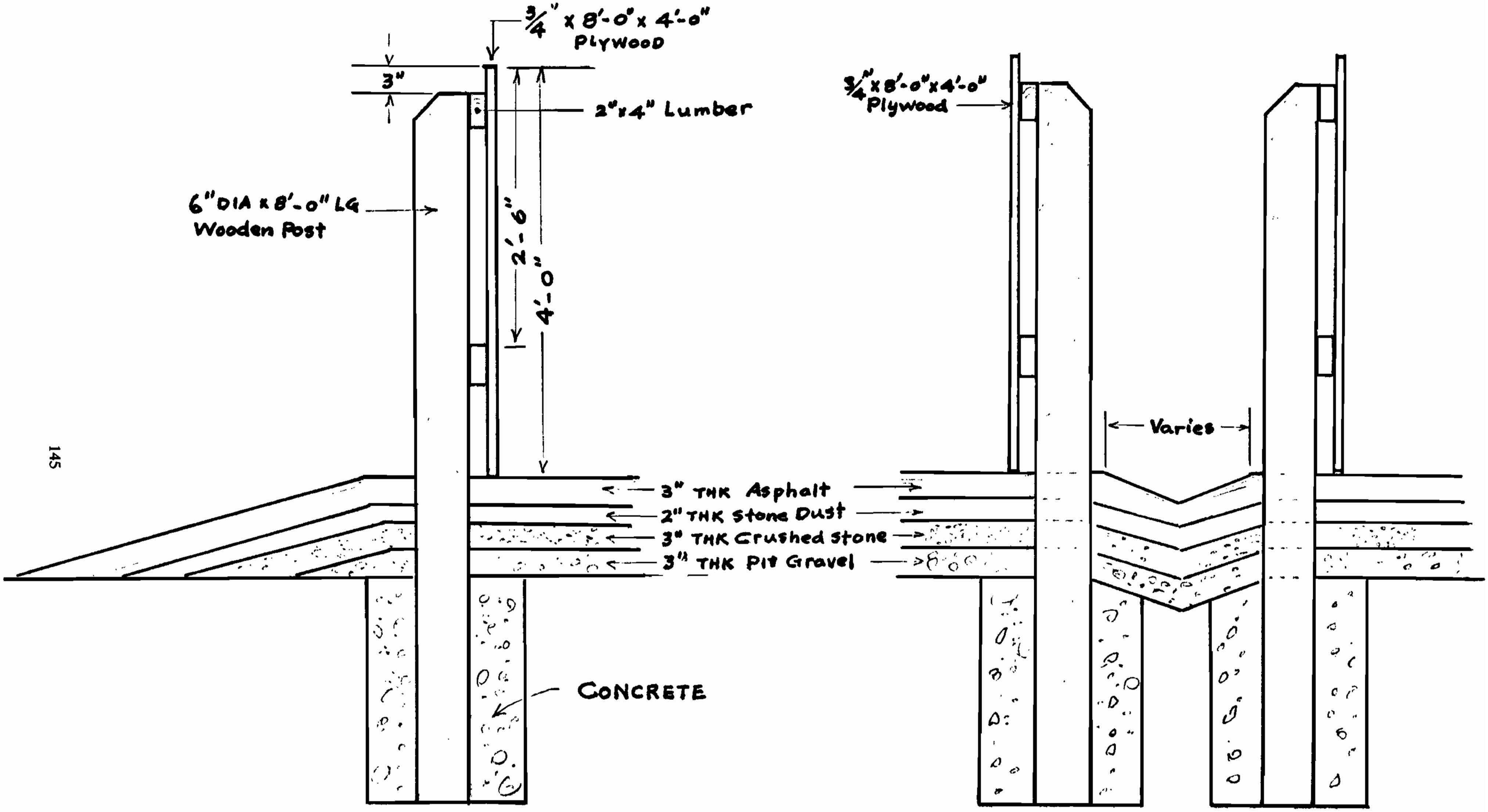
C. Z. Ku



OUTSIDE BULK STORAGE BIN OF AMMONIUM NITRATE Prills

CAPACITY: 350 Tons PER BIN

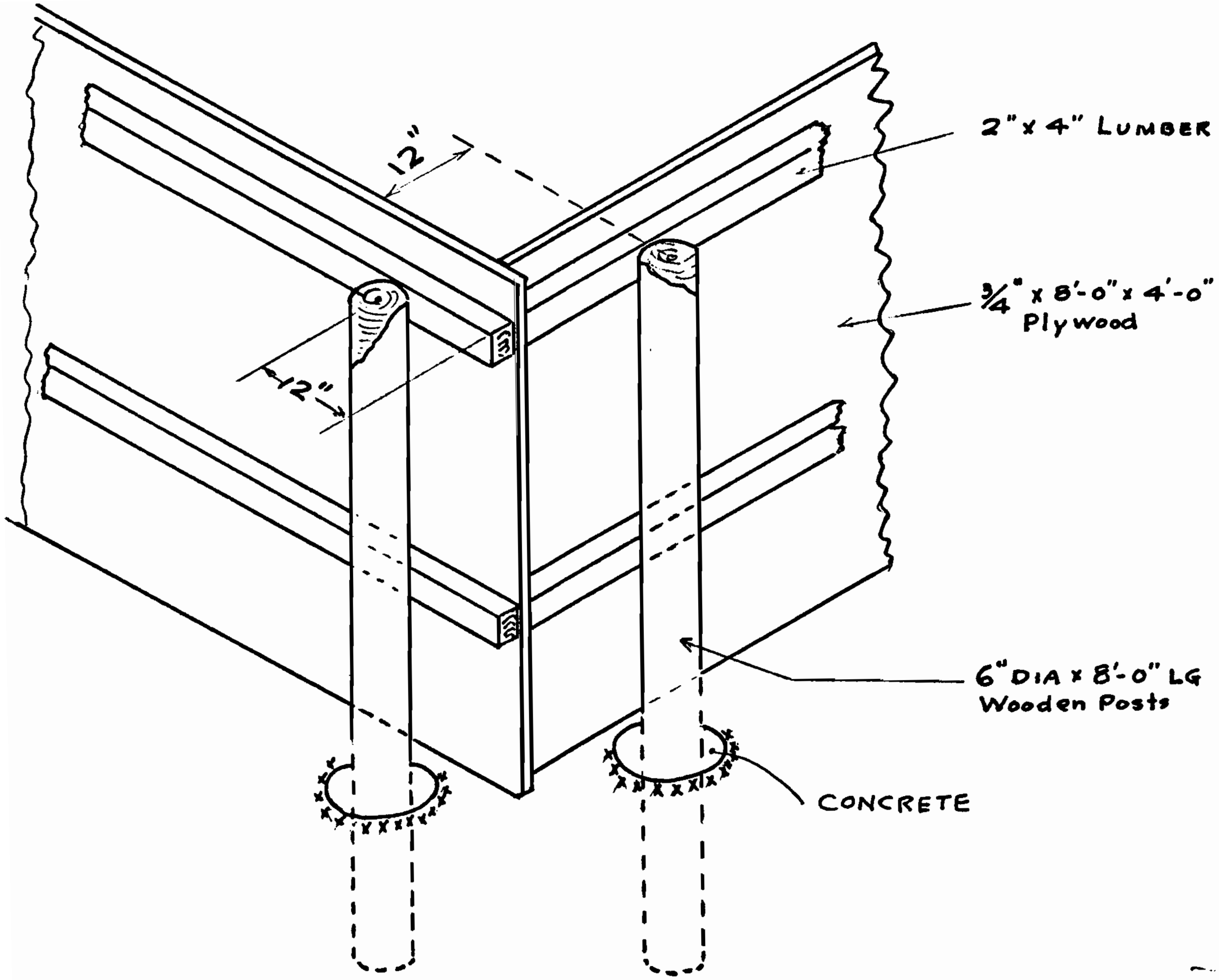
Slide 3



DETAILS OF PAD AND WALLS CONSTRUCTION

C.Z. Ku

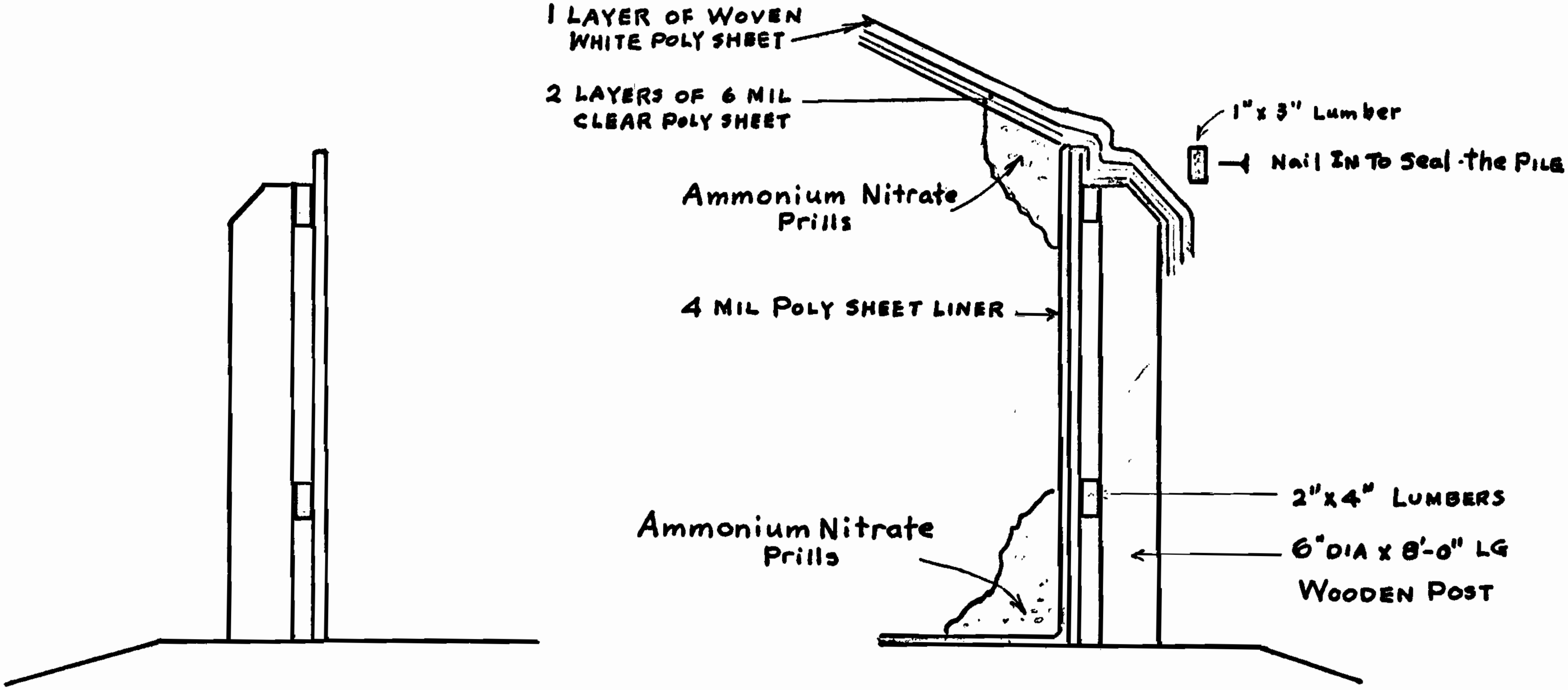
Slide 4



C. Z. Ku

CORNER DESIGN OF THE WALL

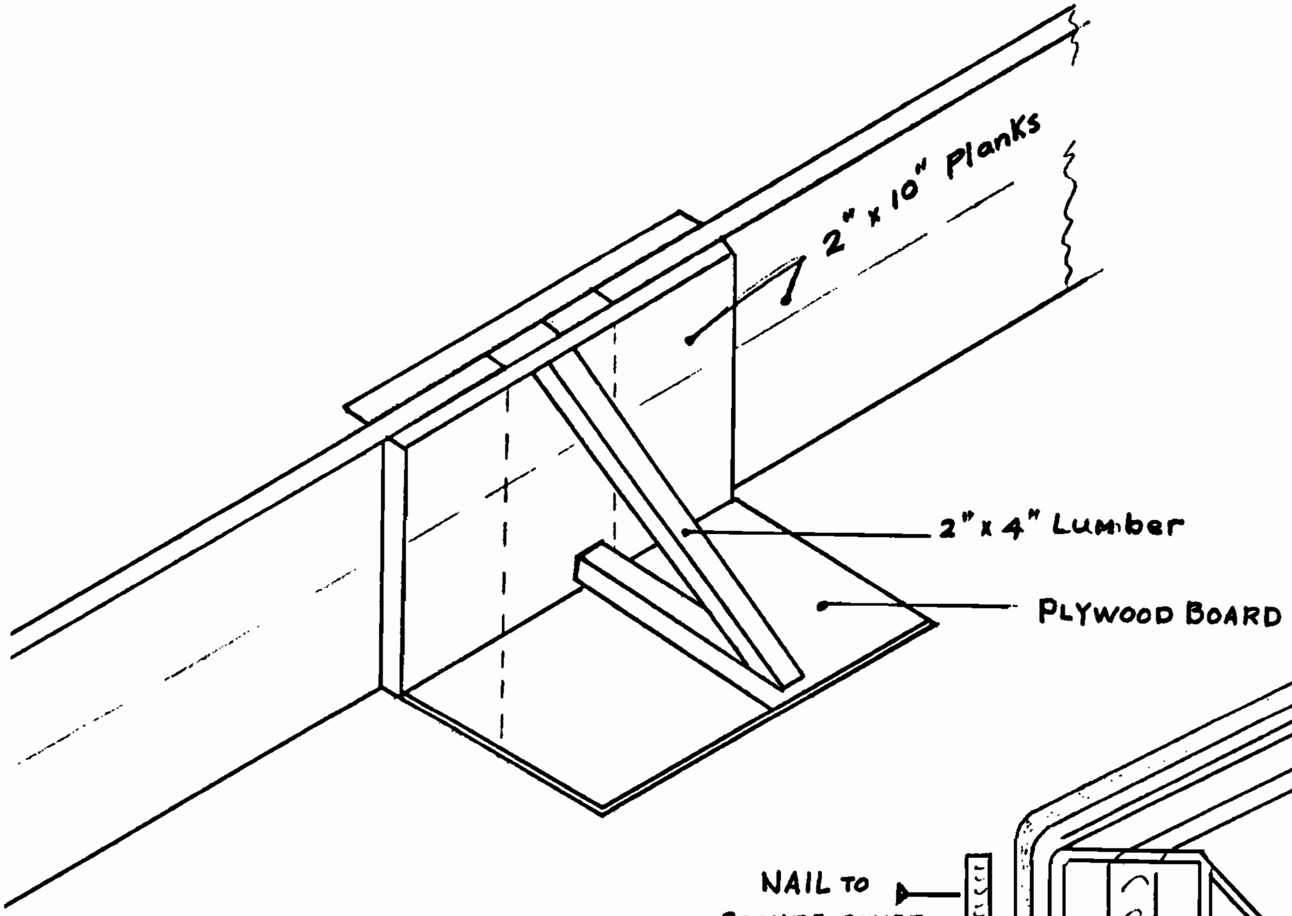
Slide 5

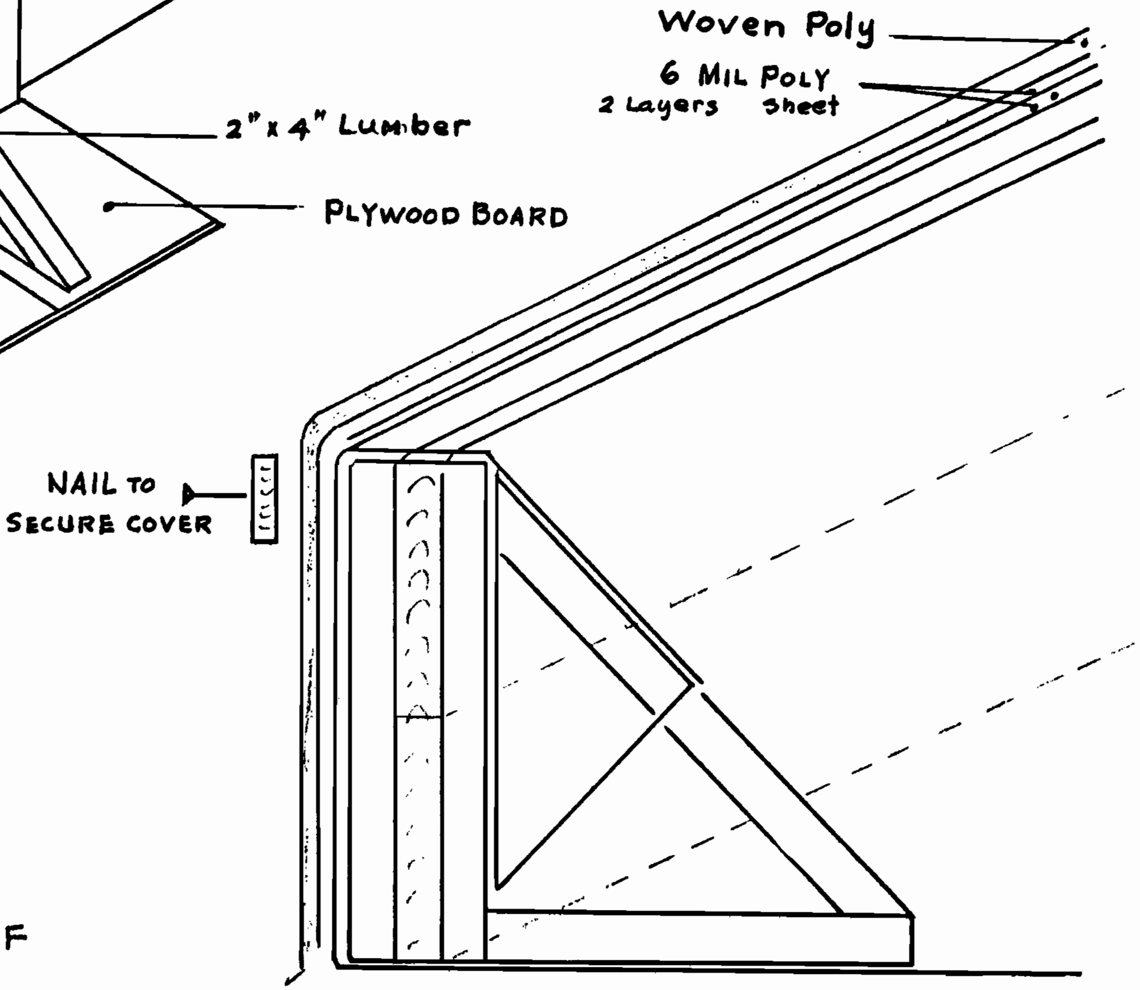


METHOD OF COVERING THE BULK STORAGE PILE

C. Z. Ku

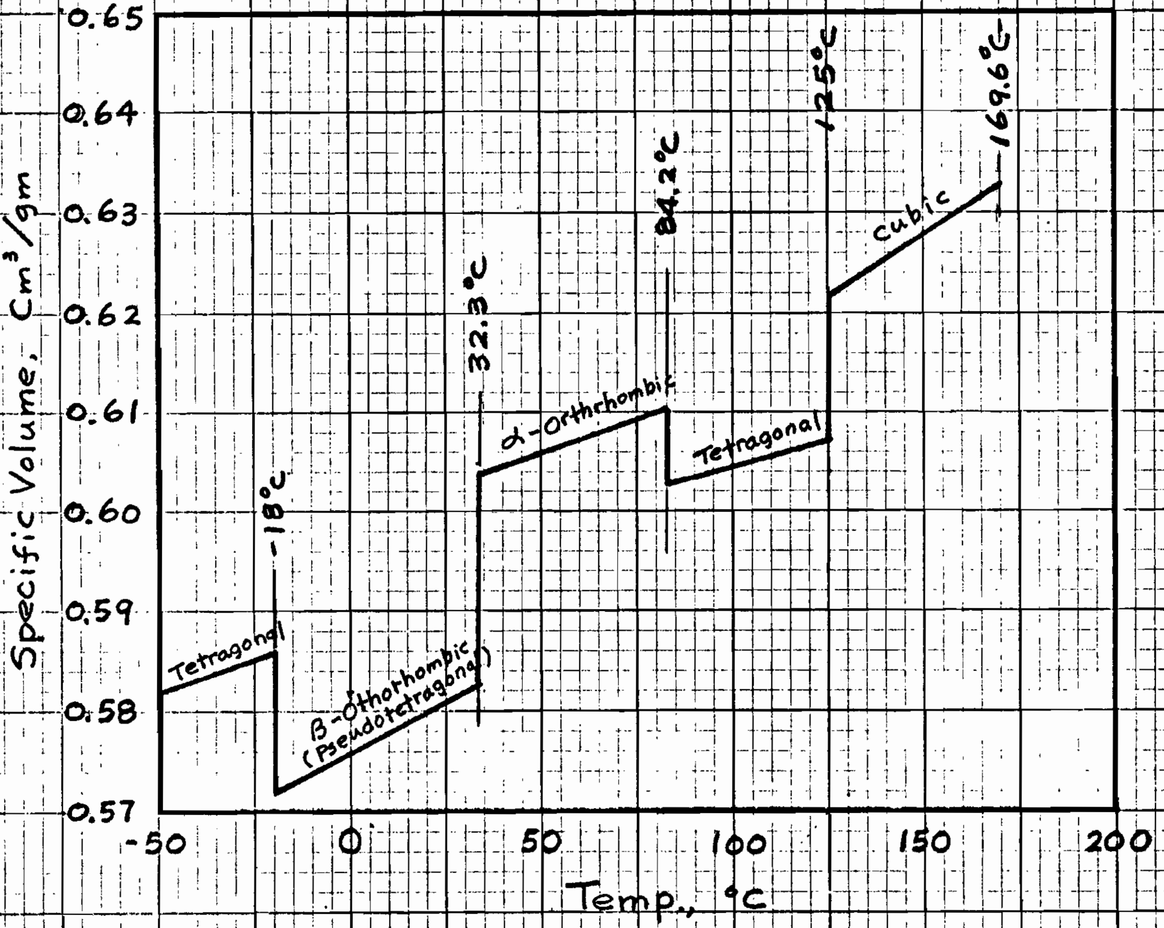
Slide 6





MOVABLE WALL DESIGN OF THE BULK STORAGE BIN

C. Z. Xu



Crystal Transitions and Volume Changes in Ammonium Nitrate as a function of Temperature

Slide 8

MODERATOR NEILSSON: Thank you, Ashley. Our last paper, again by our friends from Brockville, "Experience in Outside bulk Potash Storage" by R.M.C. King. Bob King started with Canada Packers and stayed on when Brockville took them over. He is now Technical Manager of Brookville's mixed fertilizer operations. Let's welcome Bob King.

Outside Storage of Potash

R. M. C. King

You have already heard from our Company with respect to the outside storage of Ammonium Nitrate.

We felt that this has been an unqualified success. However, we have had another program in which coarse potash has been stored outside as well. This program we consider successful also, but with some negative aspects.

Our negative experience has concerned the wear and tear on the tarps employed. This has not occurred at the Maitland plant as they are still using the original tarp.

The astonishing difference is increased if you consider that the Maitland plant invariably has some nitrogen oxides in the air pollution, whereas the two blend plants which stored the potash were in rural environments with very minor air pollution.

I will begin by describing the pads and the construction details for the blend plants.

There are two plants involved; one at Hanover, Ontario and one at Elmira, Ontario.

The Hanover storage pad is actually made from a 4" thick asphalt layer on a 1′ gravel base. Its dimensions are 65′ x 95′, and its storage capacity is 2,000 tons of coarse Muriate of Potash.

This creates a pile of Muriate with the highest point being 16′.

Although the tarps which were ordered for this pile have been 125′ x 125′, there has been excessive material left over. Our initial experience indicated that this was necessary for protecting of the product, but we now feel that a smaller tarp can be used in the future.

Surrounding the pad is, in effect, a board fence. The fence is constructed from 4" x 4" cedar posts which are 3 feet above the ground, and 2 feet below the ground, spaced 6 feet apart.

The cribbing on the inside of these posts is 3/4" lumber, with the whole fence being approximately 3 feet high.

The original cost of this asphalt pad including the fence posts, lumber, excavation, etc. was approximately $4,300.00. This cost did not include the subsequent tarps.

The Elmira storage pad was slightly different, as it was a modification of an old superphosphate storage building. Consequently, the foundations and footings were intact with the foundations being approximately 12 inches above the floor level.

The beams used in Elmira are standard 8" H beams, tied into each other with 1/2" rods, with the entrances to the pad being a 10′ section of planking removed for access by a small payloader.

If a large payloader were to be used then a removable post is possible.

The Elmira pad measures 60′ x 80′, with the height in the center being 20′. The cribbing around the sides are approximately 6 feet high.

This higher cribbing and greater height permits storage of 2,500 tons of coarse potash.

At both plants identical tarps were purchased.

The tarp is actually two tarps. The inner tarp, that is, the one adjacent to the product, must be made of a waterproof material. The outer tarp is simply present to protect the inner tarp from damage.

The inner tarp is made from "Tuffex" which is a woven polyolefin with a moisture barrier impregnated upon it. The weave consists of 10 strands per square inch. By this XI mean there are 10 strands woven in one direction, with 10 strands cross woven in the other direction per each square inch. These fibres are then impregnated with Sclair polyethylene resin to complete the water proofing.

The outside tarp is made of conventional "Fabrene", but without the water proofing. Its purpose is protection only.

The combined cost of both tarps is approximately $1,600. (per plant).

At both plants the tarp is actually nailed to the planks with wooden strips. the strips are 4" wide lumber with a thickness of 3/4".

The sides of the tarp are actually tied down with large ropes which are fastened to the foundation posts with metal eyes inserted in the posts.

The usage of this storage is the most important aspect. The product will suffer from weather exposure once the pile is opened. Consequently, since most is used during the spring rush, it is necessary to keep these storage piles completely covered and untouched until the rush begins.

Removal of product will start from one end or one corner permitting the tarp to be rolled back gradually as product removal takes place.

At the end of each working day the exposed face of the pile is again covered and the tarp re-anchored.

If more than half of the pile has been removed, it is convenient simply to lay this tarp on the concrete pad, and anchor it with old truck tires.

It is quite important to keep wind from causing a slapping motion in the tarps. If wind is allowed to lift the tarp, trouble will quickly start at the sewn seams.

In spite of these precautions, we have had to replace the hanover and Elmira tarps every year.

One theory which has been presented to us by the tarp supplier is that these plants are exposed to the effects of ultra-violet light. It presumably originates in the

Lake Huron area and has been reflected by an atmospheric layer to the inland areas.

Our outer tarp is black rather than clear, but this has not prevented the deterioration in the seam stitching in the inner one.

This year a nylon thread was ordered instead of the cotton thread in the original tarps, but in spite of this we see some evidence already of deterioration in the seams.

Our next efforts will be to have a wax coating applied over these threads if the nylon material will not stand up this coming spring.

One other technique that is used by our plants is a rigorous inspection on a daily basis of these storage pads. This inspection takes place even when the product is not being used, as it will prevent any slight deterioration from setting in unnoticed.

In conclusion, may I state that the product quality underneath these tarps has been excellent. In fact, our plant superintendents have both commented that they have had fewer product losses (shrinks) than in their in-plant storage experiences.

Because of their close attention to the condition of the tarp and keeping the product covered at all times, there has been no losses due to wet product.

MODERATOR NIELSSON: We have concluded our discussions. We have time for questions. Our speakers please come up front.

QUESTIONER: My name is Elliott Dorman, Alcan Rubber and Chemical co., Inc. I have a question for Mr. Henderson. Do you know of any process additives that can be used to improve the acidulation ratio of Phosphate rock?

MR. HENDERSON: I do not, however, I have tried an awful ot.

MR. DORMAN: Do you know of any additive for Moroccan Rock?

MR. NIELSSON: You do not need additions for this. What is the problem? Is it too slow reacting when mixing not fast enough in the storage pile?

MR. DORMAN: No. the problem is that we have developed such a material and I wanted to know if there is anything like it available?

MR. NIELSSON: As far as I know noone uses any.

MR. DORMAN: Thank you.

QUESTION—ROGER SMITH: I would like to ask Bob King what grade of Potash was stored?

This was actually coarse, Rodger. That brings up a little comment I would like to make concerning some of the things mentioned this morning. Our Canadian Fertilizer Institute did a little particle size survey of all basic producing plants in Canada similar to The Fertilizer Institute did here in the states. And the point was made this morning that granulated Urea matches more closely in size to the Diammomium Phosphate and Granular Potash that is prevalent in the States. Our biggest Diammonium Phosphate Plant in attempting to size their DAP decided to match their own Urea which was prilled and Ammonium Nitrate which was also prilled. So we tend to have finer DAP in Canada. Consequently, we use in Eastern Canada, Coarse Potash instead of Granular Potash. So this is Coarse Potash which I think would magnify the problem of moisture compared to granular, Rodger, but the storage was not a problem.

QUESTIONER: I would like to ask the gentlemen what the average rainfall is in the area where they stored ammonium nitrate in these bulk bins. The reason I am asking the question is I was wondering how many days it could be impossible to operate?

MR. KU: Well, in that part of Canada, I am familiar with this statistic. We have 2200 to 2400 hours of sunlight in a year compared to about 3800 in Tuscon, Arizona. Now, as far as annual precipitation goes, I believe that's in the order of 35" per year.

QUESTION—MARTIN WEAKLEY OF NIPAK: My question is relative to the needs of Sulphur. On some tests, that we have dome with Bermuda Grass, we have found that sulphur deficiency occurred only when nitrogen rates were up around 200 pounds per acre or greater. I was surprised to learn from Mr. Blenkhorn's discussion that Sulphur gave better results at the lower nitrogen rate. I was wondering if you could discuss that with a little more information?

MR. BLENKHORN: I am not surprised at your question as it would seem logical that the higher yields from high rates of nitrogen would induce a greater need and hence a greater response from sulphur. In fact, this appeared to be the case at one or two locations, but the overall results showed that the best response to sulphur was at the low rate of nitrogen. In reviewing literature on this subject, I came across a reference on work done in Nebraska which somewhat substantiates my own findings. An experiment on sweet corn using increments of nitrogen with and without sulphur showed that the best response to sulphur was associated with a moderate rate of nitrogen. Would you like to make any comments, Dr. Schauble?

DR. SCHAUBLE: Yes, I would not be surprised to see that you get greater response from Sulphur at a high nitrogen rate than you would at a lower one because, of course, both nitrogen and sulphur are constituents of proteins. I would suspect, as you would, that you would get a greater response to Sulphur at a high nitrogen rate, particularly with something like Bermuda Grass. I have not seen results like Harold was finding very often, rather the other way around.

MR. BLENKHORN: Perhaps the particular circumstances of my experiments have an important bearing on the results. The farmers I worked with were mostly beef and dairy operators, and many of my locations were on fields which had a history of manure applications. In such cases, there would have been a considerable amount of nitrogen available in the soil. It could well be that 100 pounds of applied nitrogen, plus the amount in the soil provided a more favourable nitrogen-sulphur ratio than 200 pounds of applied nitrogen.

MR. WEAKLEY: I would like to ask one other question concerning the pH. If I remember correctly you mentioned the pH was around 7. Would you expect the same results from the added Sulphur at somewhat lower rates in the neighborhood of 6 or 6½ or even 5½ to 6½ pH?

MR. BLENKHORN: I think you might have Sulphur problems at extreme alkalinity. You might have them if you go down into the acidity range. I simply pointed out the median pH of the soil to sort of characterize the type of soils that i was working on. I am really not sure what bearing that might have had.

MODERATOR NIELSSON: I wish to take this opportunity to thank Our Speakers and our very attentive Audience for a splendid well done job.

Our cocktail Party is scheduled for 6:00 P.M. After this hard working afternoon session you are entitled to some relaxation and I hope all of you can attend promptly at 6:00 P.M. Thank you.

Thursday, December 5, 1974

Moderators
Joseph E. Reynolds, Jr.
Paul J. Prosser, Jr.
James C. Brown

CHAIRMAN REYNOLDS: This is our final session of our 24th Annual Meeting. First we will have the Business Meeting — Secretary-Treasurer Report; Various Committee Reports; Two Technical Papers, Viz: "Materials Handling" and "Designing Quality NPK Fertilizers and Fertilizer Programs." Our final discussion will cover "Innovations Selected Questions and Answers". We have a good attendance this morning. Each of our five Sessions were well attended and we thank you for coming.

I will call on our able Secretary-Treasurer to give us "Financial Report and Status of Our Round Table".

Secretary-Treasurer Report

Paul J. Prosser, Jr.

FINANCIAL STATEMENT

November 1, 1973 to October 31, 1974

CASH BALANCE — November 1, 1973		$1,523.60
Income — 1973 — 1974		
Registration — 1973 meeting	$7,470.00	
Sales of Proceedings	930.50	
Total Income November 1, 1973 to October 31, 1974		8,400.50
Total Funds Available November 1, 1973 to October 31, 1974		$9,924.10
DISBURSEMENTS 1973 — 1974		
1973 Meeting Expenses	$915.97	
Directors Meetings	723.03	
Membership letters including postage	448.79	
Miscellaneous Expenses including office supplies, postage for mailing	143.05	
back issues, etc., 1974 Meeting — Preliminary expenses including advertising	374.08	
Total Disbursements		$2,604.92
CASH BALANCE — October 31, 1974		$7,319.18

As you have noted, from my financial report, we have not paid for the printing of the 1973 Proceedings. The Proceedings are now being mailed. We had budgeted $4000.00 for the 1973 Proceedings and it would appear, from what Mr. Spillman has told me, that we have a much larger volume for 1973 than previously. We are estimating the costs at around $6000.00 or approximately $2000.00 more. At this meeting we have registered, until this morning, 271 People. We have a registration fee of approximately $9,300.00. We have eight paid registrations that did not show. I believe that several of these people may still be trying to get here.

CHAIRMAN REYNOLDS: Thank you Paul for your excellent report covering the business of our Round Table, November 1, 1973 thru October 31, 1974. You summed it up very well. I too believe that our attendance for this meeting would have been many more if it were not for the heavy snow storms in Michigan, Ohio, New York and Canada. Your announced attendance of 271 registered is very, very good when considering the adversities of the weather. Are there any questions that Paul can answer. Paul, you and your helpers have done an outstanding job and we all thank you.

Our Good Friend Wayne W. King will now give us his report covering The Nominating Committee.

Nominating Committee Report

Wayne W. King, Chairman

Hello everybody. Relax. I will not keep you too long. There will be no Officers or Committee Chairmen to nominate here today.

We are recommending 3 Members for Our Board of Directors'. Most of you know these fine Gentlemen and they know us. Here are the names:

Travis Barham, Sales Manager,
St. Regis Paper Co.,
762 Fairmount Ave.
Towson, Maryland 21204

Joseph S. Drewry, Jr.
Vice President
Kiernan-Gregory Corp.
173 ½Wieuca Road, N.E.
Atlanta, Georgia 30342

Douglas Caine, Director
Quality Assurance
Swift Chemical co.
111 W. Jackson Blvd.
Chicago, Ill. 60604

Everybody in favor of these Gentlemen going on our Board please say "Aye". The Audience unanimously "Aye". We thank you Messrs Barham-Drewry-Caine for joining our Board.

Tom Athey now has the floor.

Entertainment Committee Report

Tom Athey, Chairman

On behalf of our Members, Our Board of Directors and Our Officers, I wish to thank our "Hosts" for that beautiful "Cocktail Party" last night. Needless to tell you that we enjoyed all of it.

HOSTS

ATLANTIC UTILITY WORKS
C&I/GIRDLER INCORPORATED
COMMONWEALTH LABORATORY INCORPORATED
DAVEY POWERGAS INC.
FEECO INTERNATIONAL, INC.
JACOBS ENGINEERING CO.
DORRCO FERTILIZER PLANTS DIVISION
KIERNAN-GREGORY CORP.
THE PROSSER COMPANY, INC.
EDW. RENNEBURG & SONS CO.
ST. REGIS PAPER CO.
THE A. J. SACKETT & SONS CO.
STEDMAN FOUNDRY
AND MACHINE CO., INC.
WEBSTER INDUSTRIES, INC.
WHEELABRATOR-FRYE, INC.

CHAIRMAN REYNOLDS: Thank you Wayne King and Tom Athey for your reports on Nominations and Entertainment Committees.

Moving along, we need to talk about our meeting (25th Annual) to be held next year. Place and Dates. I will turn this over to Chairman, Tom Athey.

Meeting Place and Dates

Tom Athey, Chairman

CHAIRMAN ATHEY: Arrangements have been completed with this "Hotel" for our 25th Annual **Meeting Dates** are: Tuesday, November 4, Wednesday November 5 and Thursday, November 6, 1975. Please make a note in your "Appointment Book". Make your reservations early and we promise you another good program. Place:

The Shoreham-American Hotel
Washington, D.C.

We have not decided where to meet in 1976 and 1977 and this information will be given to you at a later date.

CHAIRMAN REYNOLDS: Thank you Tom. Gentlemen, do you have those dates and place? I repeat: The Shoreham-American Hotel, Washington, D.C., November 4-5 and 6, 1975.

Our committee has been discussing the question and the possibilities of where to go in 1976 and 1977. Tom has talked to several of you and he has looked at some "Hotels and Locations". If you have any ideas or thoughts I know Tom would welcome to hear from you as soon as possible. At one of our "Committee Meetings" the consensus of opinion was "Our Meetings should be rotated around." We are a National Organization and hopefully we can come up with recommendations for Hotels that can accomodate our "Group", locations easily accessable by "Good Transportation" and "Dates" suitable to our Membership.

The Floor is open to any information or business you wish to discuss before we adjourn the "Business Meeting." The Round Table really belongs to you, the "Participants". We will be starting our next year's meeting in the planning stage very soon and, hopefully, we will be able to come up with a program that will be timely and pertinent. We think that this year's program has covered many interesting subjects that we are concerned with in our day to day "Operations".

You have been a very attentive "Audience" which is further support to the fine work the "Speakers" have done.

I wish to recognize all of Our "Foreign Friends" and the "People" who have joined us from "Across the Water" and to "Our Neighbors North and South". We really appreciate everyone pitching in. Last night at the "Cocktail Party" it was very evident that there was a lot of elbow rubbing. Everyone had a fine time and we are really indebted to "Our Hosts" and to the "Group" that put that together. It was very, very fine.

Our Director Jim Brown, Potash Company of America, will now take over as Moderator. We have kind of moved pieces of his program around to Previous Sessions of this meeting. He still has a portion to Moderate. Jim, please come forward.

MODERATOR BROWN: Thank you Joe. Our first "Speaker", Neil S. Whitaker, is a "Chemical Engineer" from the University of Michigan, former Vice President of Southern Nitrogen Company, Former Vice President of Agricultural Chemicals Division of Kaiser Aluminum and Chemical Corporation and currently he is President of Systems Services and Industrial Corporation, dealing primarily with Industrial Engineering and Consulting. Neil will talk to us on "Materials Handling."

Materials Handling

Neil S. Whitaker

Thank you, Mr. Chairman, and good morning gentlemen!

As indicated in your program, our chore this morning is to talk on the very broad subject of "Material Handling." All facets of this important topic — the basic belt conveyors, bucket elevators, screw conveyors, drag conveyors, pneumatic conveyors, palletizers, payloaders, forklifts, etc., and the related hardware such as dust control and collecting systems — are all in need of, and most worthy of, careful examination. It is most prudent and timely to diligently seek economies in each of these areas, with the possible exception of dust collection and control where we must rise to comply with OSHA and EPA guidelines and not to the challenge of the attractive payout.

In the few minutes that are available for this presentation, we, obviously, cannot cover more than a very few facets of this broad topic; so, consequently, we have chosen to limit our comments to the handling of bulk materials, in volume, with the more common types of equipment — belt conveyors, screw conveyors, drag conveyors and bucket elevators.

We will look at and comment on some typical rail car unloading installations, some in-house systems and some bulk product load-out arrangements. Further, we will discuss the all-important matter of efficting economies within the limits that we have previously mentioned.

To create a proper environment for this discussion, and to make you feel at home, let's look at some hardware:

I. Slides — Unloading
Advantages and Disadvantages
Belt (unloading)
- Initial Cost
  Hardware — Low
  Pit — Low
- Shrinkage Exp. — High
- Maintenance
  Hardware — Moderate
  Clean-up — High
- Power Req. — Low
- Product Degradation — Low
- Dust Level — High

Screw (unloading)
- Initial Cost
  Hardware — Moderate
  Pit — Moderate
- Shrinkage Exp. — Low (if closed)
- Maintenance — Moderate (if short)
- Power Req. — Mod. to High
- Product Degradation — Can be high
- Dust Level — Low (if closed)

Drag (unloading)
- Initial Cost
  Hardware — High
  Pit — Nil to Low
- Shrinkage Exp. — Low
- Maintenance — Moderate
- Power Req. — High
- Product Degradation — Low to Mod.
- Dust level — Low

II. Slides — In-House
Advantages and Disadvantages
Belt (in-house)
- Initial Cost — Low
- Shrinkage Exp. — High
- Maintenance — Low
- Power Req. — Low
- Product Degradation — Low
- Dust Level — High

Screw (in-house)
- Initial Cost — Moderate
- Shrinkage Exp. — Low (if closed)
- Maintenance — Mod. (if short) — High (if long)
- Power Req. — Mod. to High
- Product Degradation — Can be High
- Dust Level — Low (if closed)

Drag (in-house)
- Initial Cost — High
- Shrinkage Exp. — Low
- Maintenance — Moderate
- Power Req. — High
- Product Degradation — Low to Mod.
- Dust Level — Low

III. Slides — Load Out
Advantages and Disadvantages
Belt (load-out)
- Initial Cost
  Hardware — Low
  Cover — Mod. to High
- Shrinkage Exp. — High
- Maintenance
  - Hardware — Moderate
  - Clean-Up — High
- Power Req. — Low
- Product Degradation — Low
- Dust Level — High

Screw (load-out)
- Initial Cost — Moderate
- Shrinkage Exp. — Low (if covered)
- Maintenance — Mod. (if short)
  — High (if long)
- Power Req. — Mod. to High
- Product Degradation — Can be High
- Dust Level — Low (if covered)

Drag (load-out)
- Initial Cost — High
- Shrinkage Exp. — Low
- Maintenance — Moderate
- Power Req. — High
- Product Degradation — Low to Mod.
- Dust Level — Low

Let's now move on to the subject of economies. In this connection, we will be addressing most of our comments to those of you who are involved directly in plant operations.

In virtually every fertilizer plant, we believe that substantial economies can be effected. Even today, with all of the material shortage problems that we are encountering, and with much higher material costs, we have noted little real intensification of plant management effort to reduce material shrinkage. Gentlemen, we are in a changing ball game — one which is in need of rule modefications and changes. If you will forgive me, I might observe that most of you have played the game long enough to be more than eligible to modify and change these rules.

Let me ask this question. Is it now consistent and prudent to place the responsibility of unloading a rail car shipment of material having a value, in many cases, of $20,000.00, or more, in the hands of your least experienced, your least intelligent and your least dependable operator? Consider for a moment, if you will, that a 2% unloading shrinkage, which is not uncommon, on a single rail car of one of your more common materials, can result in a loss of $300.00 to $400.00, when both material and freight costs are included. It is not uncommon for a fertilizer blend plant to experience shrinkage losses of $80,000.00 to $100,000.00 in a single year. Many such plants are operating continuously, year after year, with overall shrinkage experience in the 4-5% range, and complacently ignore this fact until eventually hit with the zero inventory moment of truth. The common contention that recovery of spillage from pits, floors and ground areas is an effective shrinkage control procedure must be strongly challenged or, at least, kept in proper perspective. Such materials, even though worked off by-way-of the shovel-full in each batch method, have only filler value less the recovery labor cost involved. The effectiveness of this procedure is further reduced in situations where surface drainage and high water table conditions create water accumulations in pit installations, and through various fringe benefit and goodwill arrangements for the disposal of so-called floor sweepings.

The problems of shrinkage control, as it relates to pit maintenance and recovery from pit installations, is by no means limited to the physical design of the installation. The cost of clean-up labor is most significant, and frequently, overtime rates are involved since pit clean-out work, in many cases, can only be done when adjacent equipment is idle. Beyond the actual cost of clean-out labor, an even more difficult situation may be involved — the actual availability of manpower to do the work — either in the local labor market or within the plant organization. Often the mere suggestion that pit cleaning is on the schedule will create cases of "hole sickness" as well as sudden and severe family emergencies requiring immediate attention of the employee. Shrinkage, further, creates pollution, and may represent lost and unrecoverable sales volume in this period of limited material supplies.

We continue to note complacency in the area of rail car demurrage cost control. Consider that one rail car held for two weeks can incur demurrage charges in excess of $250.00, and that many plants incur demurrage expense of $10,000.00 to $20,000.00, or even more, in a single year.

Shrinkage, demurrage, maintenance and labor costs are all directly related to the design and performance of materials handling equipment and systems. Somewhat unlike death, taxes and the price of sugar, they are controllable; and prompt, continuous and effective attention can generate substantial returns.

Calculate the dollar value of a 1-2% shrinkage reduction in your plant. Add to this a number representing a 50% reduction in demurrage expense and a number representing a 50% reduction in clean-up labor expense. Using this, or some similar formula that you may consider to be more realistic for your own plant, you can get a quick and general idea of the savings potential in your plant. This figure, then, can serve as a general guide for considering the economics of equipment and system upgrading and/or replacement.

Now, how do we establish a program to attain these improved results?

You, as fertilizer plant management and operating people, are in position to effect short range, intermediate range and long range economies in materials handling, an activity to which much of a plant's shrinkage, demurrage, maintenance and labor expense can be charged.

Looking first at short range objectives, we recommend an immediate analysis of existing conveyong equipment and systems pursuant to identifying units operating out of proper and efficient range and systems of two or more conveying components out of sequential balance. Quite often, simply changing a sheave combination can increase an entire system's capacity by 10-20%, and in so doing, canoften eliminate controlled hand feeding of an upstream component and transition spillage. One should also be alert to the possibilities of slowing down units that are running faster than necessary with resulting increased maintenance and product spillage.

A short term analysis of your unloading, in-house and load-out conveying systems can be made very quickly and very inexpensively by simply running an electrical current draw survey and making a few very simple calculations.

Collection of the current draw data will require only a few minutes for each motor by an electrician or any other person capable of using a simple snap-around ammeter. By working with the resulting amp data and to what we choose to call a "Plus 10 System Sequence," many of you will be surprised to find that much improvement can be made at virtually no expense. The "Plus 10 System Sequence," incidentally, simply means stepping up capacity by 10% as you progress through a conveying system so that each component is discharging to a component having a 10% greater capacity.

A short range program should include, further, the general improvement of and repairs to all chutes and transitions. This equipment is the source of much spillage. In chute and transition modifications, drop distances should be minimized and chute angles held to 60 degrees or greater.

Another short range consideration that is currently of utmost importance is that of spare parts coverage. Carefully analyze your vulnerability in this connection, and take immediate steps to provide adequate converage. If you have been caught recently without replacement elevator chain and have attempted to buy same from your regular supplier, you know the problem. Another very important point in this regard is that the equipment manufacturer's ability to supply spare parts and components has been severely weakened by recent market changes. The manufacturer, of necessity, has diverted a much greater percentage of his reduced and extended material and component allotments into new equipment manufacture and away from spare and replacement parts. Many manufacturers no longer solicit spare parts business — they would prefer not to have it! On the other hand, the established and reputable equipment manufacturer still accepts and respects the fact that he has a permanent and a continuing spare parts obligation to the customer who has purchased his equipment — but not necessarily a responsibility to provide off-the-shelf spare coverage.

All of this means that it is currently prudent for the fertilizer manufacturing plant to carefully study spare requirements, order as quickly as possible to avoid further price and delivery erosions, and accept the fact that a somewhat higher percentage of plant investment dollar should be dedicated to spare parts inventory.

Intermediate range economies can result through a continuation and expansion of the short range effort. With the same objectives in mind, the effort can be expanded into an upgrading program involving the replacement of worn out and/or obsolete components, and de-bottlenecking by installing larger motors, etc. In the latter case, however, gear unit compatibility, etc., must be carefully considered.

In upgrading material handling systems of the general type and design being considered in this presentation, we strongly favor moving away from the belt for outside applications and out of the pit for all possible equipment installations.

Wind and weather losses from outside belts can be substantial, and spillage recovery, in most cases, cannot be efficiently effected.

The somewhat higher power requirement for totally enclosed unloading and load-out equipment should be considered but kept in reasonable perspective. These are generally intermittent operations, as opposed to a continuous in-house application. The difference in power cost for unloading a rail car with a 3 H.P. belt system *vs* the same unloading with a 10 H.P. drag system is only a matter of pennies even at today's higher power costs.

In regard to the second point (staying out of the pit), we simply do not subscribe to the old industry standard, which is still slive and respected in many design quarters, that an integral part of any and all bucket elevators is a 7' hole in the ground.

The potential for effecting intermediate range economies in most fertilizer plants is tremendous. New equipment, capable of reducing shrinkage and demurrage expense by 50% in numerous existing plants, can pay for itself in a matter of months.

Long range economies involve major equipment replacement and new plant design and erection. In this category, we again favor the use of belt conveyors for inside applications only, and equipment erection at floor or ground level for ease of maintenance, clean-up, etc.

Systems should be designed to the "Plus 10 System Sequence." In selecting new equipment, there is much to be said for a conservative approach of oversizing the components and gearing them down to meet capacity requirements. Oversizing and conservatism in providing materials unloading systems is especially wise since material in the house incurs no demurrage expense.

In designing materials handling systems for the new plant, we favor simplicity. Actually, there are few new design concepts in this regard. Be consefvative in selecting system components and insist on 60 degrees, or greater, transition and chute angles. Provide adequate electrical overload protection and system component interlocking. The latter is most important for the closed system with closed transitions.

In summary and in conclusion, we urge that you immediately launch a simple, very basic, and potentially very profitable program in your plant:

I. Carefully evaluate your existing plant conveying systems. Bring the equipment into range and into balance. Repair and improve chutes and transitions. Carefully analyze your spare parts position and cover your requirements promptly.
   You should be able to complete this activity in 30-60 days.

II. Examine the feasibility of upgrading components and systems by replacement in kind or with more modern and efficient equipment. Work toward getting the belt in the house and the hardware out of the hole.
   In this effort, look for and move out on upgrading steps that can pay out in 12 months or less.

III. Evaluate your plant materials handling capabilities with long range improvements and economies in mind.
   Move ahead in this area as good economic payout is evident and, of course, as capital improvement funds are available.

Gentlemen, I thank you for your very kind attention and I sincerely hope that some of our suggestions will have profitable application in your plant.

MODERATOR BROWN: Thank you Neil for that effective illustration and discussion on "Materials Handling". You demonstrated much food for thought giving us a number of excellent ideas and studies one must make when deciding a change of facilities for effective "Materials Handling Equipment" to give the "Most Economical Performance."

Our next "Speaker" is known to most of us, therefore, needs very little introduction. He is Manager of "Agronomic and Technical Services" for Agway, Inc., Syracuse, N.Y. He will discuss "Quality Fertilizers and Fertilizer Programs". I give you Henry Plate. Henry, Please.

Designing Quality N-P-K Fertilizers and Fertilizer Programs

Henry Plate

Ladies and gentlemen, as I looked at the preliminary title of my talk for today, "Quality Aspects of N-P-K Fertilizers," I had serious question on how to approach the subject. A straight listing of quality aspects in terms of chemical analysis, meeting guarantees, etc. is redundant on many excellent talks that have been given previously.

Therefore, let's look at this topic from the standpoint of how one designs the specifications for a quality N-P-K fertilizer and the fertilizer program for its use on a crop. Let us be frank — the ultimate consumer of food and fiber in the U.S. really doesn't care very much about quality of N-P-K fertilizer, and in reality the farmer doesn't care either. Fertilizers are a necessity to the farmers' ultimate purpose of producing food or fiber for a profit. In these days, the farmer thinks of fertilizer as the high price spread. All he really wants from fertilizer is productive ability in terms of growing the crop. We must design each fertilizer to the total cropping program.

We must also deal with the overall environment — maximizing beneficial environmental effects of growing crops and these are many.

Use — First, consider *the use* to which the fertilizer is to be put. What is the crop on which it is to be used? Corn and alfalfa have markedly different nutrient requirements. How is the fertilizer to be placed? Row, broadcast, side-dressed? What are the physical requirements of the fertilizer? What chemical considerations must be given? How about the acidity of the fertilizer? What effect does it have on the soil? What is the salt index?

We can consider three types of fertilizer. These include the so-called general fertilizers such as the 10-20-20 and triple 15 grades which are designed for a multitude of uses. These have been made for a long period of time and are generally regarded as relatively safe under most normal application methods. With some limitations, the 1-2-2 ratio can be used to grow vegetables, corn, potatoes, fruit and many other crops. It may not be exactly the right analysis but it can be used. Similarly, higher nitrogen materials such as 15-15-15 can be used for corn, turf, pasture fertilization, etc. Again, though not right in every aspect, they will do and have done a reasonable job.

USE

GENERAL	SPECIFIC	SPECIALTY
10-20-20 15-15-15	SNAP BEAN ALFALFA	TURF ROSES
GENERALLY SAFE	SAFE FOR SPECIFIC CROP	ADDED PREMIUM FOR CONVENIENCE OR SALES PROMOTION

For most situations, we have progressed well beyond general fertilizers (although some farmers don't seem aware of it) to the second category of fertilizers specifically oriented to a given crop and a given method of use. For instance, we may have a snapbeam fertilizer high in phosphate and low in nitrogen and potash to avoid possible injury when used in the planter. A fertilizer for this purpose may contain additional micronutrients such as manganes and zinc, dependent upon the area where it is to be used. Or we can design a fertilizer for topdressing alfalfa, which is completely different from the snapbeam fertilizer. Usually, it would be a no nitrogen, high potash fertilizer. Dependent upon soil conditions of a given area, it might contain a considerable quantity of boron — enough that, if used on snapbeams, would cause chlorosis and death of the crop.

The third group, specialty fertilizers, is designed for turf, roses, homeowner use, etc. where an added premium is built in for convenience of application, and safety or even for sales promotion. Specifications become more critical as we move into these last two areas.

Physical Specifications come next. Is this to be an ammoniated or a blend fertilizer? Let's defer discussion of this choice for a short period of time, until we have run through some other factors. Does the product have to be granular or can it be pulverized? What are the alternatives? We see very little powdered fertilizer now, but really, what is wrong with it, provided it maintains good physical condition? What is the water solubility of the fertilizer? Does it need to be totally soluble for use through irrigation equipment or as a starter solution in transplanting? Or is the water solubility of an individual item such as phosphate important?

Obviously, the particle size must be uniform to eliminate segregation. We have been through this many times. TVA and many others have done a tremendous amount of work on particle size and yet it is still far from satisfactory on many raw materials. Particle size of the finished product must be large enough for the spinner spreader, but small enough for a planter application. A finished product size of —7 +16 mesh is about where the industry is, be it blended or ammoniated material.

Chemical Quality of a finished product is concerned with compatible sizing, material analysis, ammoniation procedures, and granulation of the product — all of which enter into the handling quality and the adherence to the chemical guarantee. Many papers have been presented on this at earlier meetings.

Placement of Fertilizer — Is it to be broadcast preplant type fertilizer? In that case we have different quality specifications than the fertilizer to be used through the planter. Is the product to be sidedressed? Is it to be applied with irrigation equipment? All of these enter into the design.

Nitrogen Structure — One of the most important phases is the nitrogen structure of the product. Basically, there are four choices of the types of nitrogen that can be incorporated into the fertilizer. These are: nitrate nitrogen, amminia, urea or one of the controlled release types of nitrogen. The choice must tie in with the use. Is it broadcast or planter applied? Some research shows that urea-DAP mixtures are not totally compatible with close placement to the seed.

Temperature may influence the selection. For early spring planter application, some nitrate nitrogen is needed. For later season, warm planter application, all ammonia may be fully satisfactory. Urea is probably undesirable as a topdressed application on soil covered with organic matter in the summer months, yet proves fully satisfactory at other times of the year, when volitalization is not a major problem.

The possibility of denitrification or loss as N_2 directly into the air under waterlogged conditions must be considered. Can this be avoided by the use of a controlled release nitrogen? You'll note here that I use the term "controlled release" to include the wide gamut of ureaforms and other formaldehyde combinations, sulfure coated ureas, various coated and coating products, nitrification inhibitors and any others that come along.

Urea-DAP mixtures are an enigma as far as their adaptability to planter type application. Several experiment stations have given warning — Mississippi, Purdue, Ontatio, New York — that ammonia may be released too rapidly from either the urea or from the second molecule of ammonia in the diammonium phosphate, and cause ammonia toxicity to the crop. We don't have the full answer on this one. We, personally, have done work for two years with all sorts of combinations, several planting dates, several crops, in a attempt to hit the right weather conditions that might induce this injury. We have not found injury. Yet look at the information published by New York in 1968. The yield reduction in 1966 amounted to 20 bushels of corn when an 80-40-40 was banded two inches to the side and two inches below the seed. Apparently, although not replicated, a significant decrease. The year following, at another location, there was only a 5 bushel difference and this would be highly questionable whether there was any significant difference.

CORN YIELDS
BU/A

YEAR	LOCATION	BANDED	AN-CSP-KCL	U-DAP-KCL
1966	GENEVA	80-40-40	112	92
1967	CORTLAND	80-40-40	131	126

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Based on this type of data, it appears one should avoid a urea-DAP mix applied through the planter. Yield reductions, even if they occur only once in five years, are significant enough to cause farmers real problems. It might even be better to skip a row application and apply the same amount of nutrients broadcast when using urea-DAP. This problem can be avoided by using an An-TS-MP mix when it is to be applied through the planter.

Under cold soil condition, at least 10 and up to 25% of the nitrogen should be in the form of nitrate nitrogen for quick start. For broadcast pre-plant applications, the nitrogen source probably makes little difference. However, if broadcast and topdressed in the summer in presence of organic matter as on a pasture, urea should be avoided from the possibility of volitalization loss. For sidedressing on corn, nitrate or ammonia forms of nitrogen are satisfactory and urea can be used on conventional corn. Avoid the use of urea on no-till due to the possibility of volitalization. On turf, cane and rice, certain controlled release products have merit. Ureaforms and IBDU have been used for a considerable period of time on turf. Sulfur-coated urea appears to have considerable merit on cane and rice, but very little merit on corn. These controlled release nitrogens will give much more uniform production on some of the prennial grasses instead of the great flush in the spring of the year. Usually, they do not give any more total yield for the year when the same amount of N is applied.

Phosphate Structure — In the case of planter type applications, 40% water soluble phosphorus should be a minimum. It may have to go as high as 60% on certain special crops, particularly those grown under acid soil conditions. It is relatively less critical for broadcast. When diammonium phosphate is used in a planter, don't exceed a maximum of 75 pounds DAP per acre. This is true whether this be a blend or a highly ammoniated product with DAP formed in place. Urea-DAP guidelines have been published by New York for planter applications where the fertilizer is two inches away and two inches below the seed, as in the corn planter. A maximum of 30 pounds of urea-nitrogen is recommended with P and K. A maximum of 30 pounds of P_2O_5 as DAP. A maximum of 15 pounds of urea-nitrogen and 15 pounds of P_2O_5 from DAP where these are combined. And where no urea or DAP is included, a maximum of 80-100 pounds of nitrogen plus K_2O.

U-DAP GUIDELINES

PLANTER APPLICATOR

2" x 2"

1. MAX. 30# UREA N WITH P & K.
2. MAX. 30# P_2O_5 AS DAP.
3. MAX 15# UREA N AND 15# P_2O_5.
4. MAX. 80-100# N PLUS K_2O. (NO U OR DAP)

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Potash Sources include those where all muriate is used, and those with low chlorine for crops such as tobacco and potatoes. Where low salt level is desired as in greenhouse use, give consideration to dual element products such as potassium nitrate to maintain as low a salt level as possible.

Other speakers have reviewed the *secondary elements* — calcium, sulfur, magnesium and the eight *micronutrient elements* which must be considered in formulating a complete fertilizer program. Micronutrients of course, are related to the soil conditions with specific areas of the U.S. being short of boron, short of zinc, organic soils low in copper, etc. This must be tied in with specific crops being grown. Some need a high level of boron, others zinc, etc. The form of the micronutrients must be considered as to whether water soluble, oxide or a controlled release form of one sort or another.

How acid are these fertilizers going to leave the soil? High N grades such as the 15-15-15 are highly acid. Is it going to pay to go to a low analysis with a limestone filler? Probably not because the limestone filler used is too coarse to be effective in our lifetime on the soil, although it may appear to show up in laboratory tests due to the fact that it is ground before the tests are made. But where 100 and 200 pounds of nitrogen are applied to a crop a year, we'd better consider the effect on the soil acidity. When we get into some of the more acid products such as ammonium sulfate, we can get three times the acidity developed that we get with ammonium nitrate, urea and anhydrous. Between the nitrogen residual acid effect, leaching and crop removals we may require 1000# limestone a year per acre to maintain pH.

Salt Index for greenhouse crops or under potting soil conditions is a real factor. Reducing the salt index requires certain premium type materials. Salt index per unit of plant food from some of the more common fertilizer materials based upon John Hardesty's summary in Farm Chemicals is shown in Table IV. For example, potassium sulfate is the lowest of the common potassium carriers. Potassium nitrate, slightly higher, and potassium chloride, quite a bit higher. But the potassium nitrate shows up even better when you figure that the nitrate must be obtained, if not from potassium nitrate, then from products such as ammonium nitrate, urea or ammonium sulfate. Proper selection can give a much lower salt index.

SALT INDEX

Material	Index Unit of Plant Food
Dolomite	0.04
Triple Superphosphate	0.22
Superphosphate	0.39
Mono Ammonium Phosphate	0.41
Di-Ammonium Phosphate	0.46
Ammonia	0.52
Potassium Sulfate	0.85
Potassium Nitrate	1.22
Urea (C.P.)	1.62
Potassium Chloride	1.81
Epsom Salts (C.P.)	2.69
Ammonium Nitrate	2.99
Ammonium Sulfate	3.25
Calcium Nitrate	4.41
Sodium Nitrate	6.06

Farm Chemicals Oct. 1967
John O. Hardesty

In conclusion, top quality N-P-K fertilizers are going to result from full utilization of the refinements coming in agronomic research. We must remember that no longer are we dealing in a gross chemical. We are getting more and more specific with more valuable fertilizer materials. Our soil nutrient levels are increasing in many soils and this requires a change in our fertilization practices. Production of the world food supply must be considered because this effects all of us. We must conserve resources and energy. We must maintain the environment.

We — the U.S. — are still responsible for much of the world food supply — we export more than any other country. We must utilize all our fertilizer products to their ultimate maximum productive efficiency.

MODERATOR BROWN: Thank you Henry. I can see the importance of "Agronomical and Technical Services required out on the farm and you have done your usual, excellent job bringing this valuable information to our attention.

Our final subject "Innovations" will be moderated by our "Hard Working" Secretary-Treasurer Paul Prosser.

Innovations — Selected Questions and Answers

Paul J. Prosser, Jr.
Moderator

MODERATOR PROSSER: As you know, The Round Table Membership was submitted a list of suggested questions and asked to vote on those questions which they preferred to hear discussed. Our Board of Directors selected the "Outstanding Panel" that you see on exhibition. I will introduce each of these fine Gentlemen and ask them to stand as I read their name.

Frank Achorn, TVA, Hubert Balay, TVA, Allen Jackson, J&H Machinery, A. V. Malone, Agway, Inc., Frank Nielsson, IMC, Dick Perkins, W. R. Grace, Joe Prosser, the Prosser Co., Walter Sackett, Jr., The Sackett Co., James Seymour, Royster Guana Co. and D. R. Waggoner, TVA. Much Applause.

MODERATOR PROSSER: I believe, in the interest of being fair, we will ask the questions in the order in which they are preferred. We have a number of additional questions that we may intersperce if time permits. I believe we will have to make some time limitations to any given subject and I think we should judge that from the interest of the "Audience".

Question #1 — Do you recommend the use of dust suppressants at solid transfer points in granulation plants? If so, which suppressants?

Panel responses to Question #1 can be summarized as follows:

A. Some of the depressants presently used are oil, liquid fertilizer, either urea, ammonium nitrate solution or 10-34-0.
B. Granular products are more dusty than powdered fertilizers.
C. The best corrective measure is to eliminate the problem before a suppressant is required, that is to close up conveying systems, transfer points, etc., including continuous elevators in lieu of contrifugal elevators, putting seals on elevators, etc.
D. In lieu of trying suppressants, install a complete fugitive dust collecting system, preferably a baghouse.

Comments on Question #1 by Mr. John Medbery:

A. They first used diesel oil as a suppressant, but they found it deleterious to rubber belting and that it did not persist for a long period of time and the odor is objectionable. Further, it is dangerous when used with nitrate containing fertilizers.
B. Next they tried DCA 410, which persisted longer than diesel oil, but this came on allocation, supply became unreliable.
C. Next they used lignin from the paper industry; they also found it to be not persistant and having an objectionable odor. Further, it was more difficult to apply than oil.
D. His organization is still looking for a satisfactory material.

Question #2 — When production is pushed beyond designed rates, the fines are greatly increased. Are there any suggestions to reduce the fines at high rates of production? Have any additives materially reduced fines?

Panel responses to Question #2 can be summarized as follows:

A. In granulating low nitrogen materials adjust the sparger arrangement in the granulator and concentrate liquid phase on the smaller area to decrease the fines generation.
B. There are few additives known that will help reduce fines.
C. Do not generate fines with the equipment itself, that is, have proper mills, elevators, etc.

Question #3 — What is the best system for controlling recycle rate in ammoniation-granulation plants?

Panel responses to Question #3 can be summarized as follows:

A. Questions #2 and #3 tie closely together.
B. Formulation is the key thing to the whole regeneration cycle of fines.
C. Panel was divided on the question of changing the finished product size, that is making a product 8 x 26 instead of 7 x 14.
D. It was generally agreed that if increased production is required, larger sized equipment is required.

E. Need emphasized for a well trained operator, alerted to adjust formulations to control recycle.

Question #4 — How can ammonium nitrate and urea be protected from hyroscopic breakdown in the plant during humid weather?

Panel responses to Question #4 can be summarized as follows:

A. Install a simplified system for dehumidifying the storage area.

B. There is some experience indicating that ten tons of air conditioning for 20,000 tons of storage would adequately dehumidify the storage area.

C. Heating the storage area was believed not to be as satisfactory as air conditioning.

Question #5 — Describe latest techniques in instrumentation for fertilizer plants.

Panel responses to Question #5 can be summarized as follows:

A. There are no known new techniques in instrumentation for fertilizer plants.

B. Magnetic flow meters are still believed to be the best devices for phosphoric acid and sulphuric acid.

C. TVA reported using an anubar type flow meter on vapor ammonia, gaseous ammonia systems.

D. Because of increased fuel costs it was emphasized that accurate measurements of temperatures at both inlet and outlet ends of the dryer and of product moisture are absolutely essential, since there is a tendency to overdry thereby using more fuel than necessary. The control systems on the dryer should control heat input and not have a manual firing rate on the dryer. The panel agreed that most plants are behind in dryer instrumentation and need to update their equipment.

E. The opinion was expressed that turbine meters do give more accurate results on anhydrous ammonia liquid flows but must be properly installed to prevent overranging by use of inner coolers for the ammonia flow.

F. Mention was made that magnetic flow meters are used in some places for ammonia, a small quantity of water being added to the ammonia to increase its conductivity.

Question #6 — Discuss methods of reducing fertilizer build-ups on floors, wood and concrete, because of wet hydroscopic conditions.

Panel response to Question #6 can be summarized as follows:

A. Close the storage bins in the plant while they are being filled.

B. Prevent spillage from front end loader buckets by more careful operating or by using buckets with hydraulically closed front gates.

Question #7 — Can a pipe reactor be substituted for a preneutralizer tank for production of high analysis NPK grades containing large amounts of anhydrous ammonia and wet process 54‘% phosphoric acid in a conventional 60,000 ton per year granulation plant?

Frank Achorn — That's what we are trying to do with the pipe cross reactor. I think we have shown that we can produce a fairly high analysis NPK mixture with about 800 pounds of acid per ton of product. We are just in the initial stages and I think we are going to have to make a bigger one of slightly larger diameter. The purpose of it was to replace the preneutralizer.

D. R. Waggoner — I think with a conventional pipe reactor, because of the temperature of the reactor, you are limited to low mole ratio grades in the neighborhood of 1 and sometimes you can ammoniate some more in the granulator, maybe to a 1.3 mole ratio. Scaling of the pipe reactor increases significantly if you don't have a preneutralizer.

Frank T. Nielsson — The C.R.O.S. Company of Spain is pushing a process where that have pipe reactors inside the ammoniator. they use a battery of them, maybe three or four. I couldn't understand how they were using sulphuric acid in a pipe reactor. they use either sulphuric or phosphoric with ammonia; but they've got their sulphuric acid down to 67%. Apparently you have to provide enough water to keep your heat load down and provide flashing ability. But it shows the people in Europe are using pipe reactors internally within ammoniators, and the same thing can be done here. The other thing is the Davison people, W. R. Grace now, back in ‘56 or ‘57, I guess, at the Round Table had a couple of papers on using prereactors, they called them then, inside of pug mills. they were Teflon lined and they were using slugs of ammoniating solution and sulphuric, phosphoric acid. And the tricky thing they had was that on a regular cycle they had a little burst of compressed air that would shoot out. If they were using nothing but anhydrous and sulphuric acid, it tended to build up with ammonium sulfate and the controlled time cycle would just flush it out. I don't know if Grace is still using that.

Frank Achorn — On the pipe cross, the important thing is adding water with the liquid ammonia. We had quite the opposite problem that C.R.O.S. and other experimenters in this area had. We didn't have a scale problem; we had a corrosion problem. We kept it well cleaned. We put in a Hastelloy C tube because we could get Hastelloy C before Teflon lined pipe. It's preliminary work; but it looks real good to me. I don't think you could make diammonium phosphate with it because of the high mole ratios required.

Question #8 — Are baghouses practiccal in making NPK grades? The word practical encompasses original cost, operating cost and trouble-free operation.

Joe Prosser — I think it's probably a problem of how individual people and companies formulate and how they operate. Control of dew point is the name of the game and maintaining warm temperatures during periods of shutdown. Some people replace their bags maybe as infrequently as every 18 months. Some people replacing bags on a shorter period. Some people consistently have difficulty of clogging bags. Most of these things can be worked out. If you really need to use a bag filter, it may be a nuisance; but you can work with it. It's in competition with wet scrubbers, and there are places where it's difficult to use wet scrubbers. The bag flter will normally let you bring back your raw materials. The wet scrubber is more difficult in that area. When it comes down to cost of operation, I can argue either way about how much it costs to operate either. The wet scrubber is almost always a bigger energy hog than the bag filter because the pressure drops to get the job done are a lot higher. I think that the answer to the question is they are practical. They are a nuisance, but they are practical.

[Note: Not sure, however, we think Herman Powers made this comment.] I think we could say they are practi cal. We have five in operation on dryer exhausts, and are installing another. There's an awful lot we don't know, and you may be interested in some of the history of our operation. We have gotten bag life ranging from 30,000 tons per change up to 125,000 tons. In fact, we have one unit that has been operating about four years that happens to be one of the smaller producing units, 30-35,000 tons per year, whose bags have never been changed. We believe that the grade formulation has considerable bearing on the life of bags. We have not used anything extensively except the acrylic continuous filament or monfilament type weave bags. All of these units have the exhaust, the drying air medium from the dryer, the cooler exhaust through the combustion chamber to the dryer.

Joe Prosser — I was asked the cost of installing a bag filter. It ranges from as little as $3.00 a CFM to as much as $5.00 a CFM. That's changing all the time because the cost of the bag filter is going up rapidly.

Al Malone — One other point — these are only for the control of particulates so we do have to control the ammoniation and drying operation to minimize the ammonia or other gases which might come out through this exhaust.

Joe Prosser — We do have two bag filters operating at the present time that include the ammoniator air stream. They are not any more difficult. One of them has been operating about 2-1/2 or 3 years and they don't believe they are experiencing any different kind of bag life.

Dick Perkins — With the energy problem that we have and shortages of natural gas has anybody had any experiences using fuel oil in a bag filter on a dryer operation? I thought there might be some problem with shortened bag life due to the sulphur in the oil.

Al Malone — We do, Dick. We have two units using #2 fuel oil for the fuel. We don't know whether there is increase attack because of this or not.

Question #9 — How can oversize crushing equipment be designed for greater crushing efficiency and reduced dust generation?

Allen, do you want to take a shot? Or Walter?

Allen Jackson — The dust generation from the crushing equipment is not going to be a function of the mill. It's going to be a function of the hardness of the particle and how it fractures. I think the design of the crushing loop is more important than the mill in this case. You have to have two factors to make floating dust. You have to have the motive power to blow the dust, and you have to have the dust. If you can eliminate either the motive power or the floating dust, you won't have the problem. This whole question would be answered by the system that you install. It's not necessary in a granular plant system to have any dust at all coming out of crushing equipment.

Walt Sackett — The question confused me. Two things are together here — greater crushing efficiency and reduced dust generation. I wasn't sure whether this was floating dust or fines. As far as the floating dust generation, all that you can do is try to cap it closely and possibly vent it to the cooler. Quite a few people vent the mill into the cooler air stream. As far as fines generation, the type of mill is very important. Naturally, you don't want to go to a double cage if you are trying to cut down on your fines. We find that a double opposing rotor type of mill, chain, open cage, or combination, is most effective.

Question #10 — What steps can a granulator take to get a harder particle that will resist breakdown in storage?

Jim Seymour — One way to do it is to use more concentrated liquid phase. It's probably hotter.

Dick Perkins — I think the key to it is formulation depending on grade. I think the last answer is pretty vital too. On some grades the use of larger amounts of anhydrous ammonia and phosphoric acid can generate harder granules.

Hubert Balay — I want to say one thing. Based on experience it appears that granules are always harder when they're produced by chemical heat rather than by water or steam. It's a different kind of bond.

Frank Achorn — We used to make a nitrogen fertilizer in which we added a little bit of iron ore to promote granulation. It did help to form a stronger granule. But I agree the best way to do it is to have more heat or liquid phase in the granulator.

Question #11 — Discuss causes and preventions of buildup in dryer and cooler cyclones in granulation plants.

James Seymour — Granulate before you get to the dryer.

Joe Prosser — Insulation of cyclones helps. It's the same old problem of dew point. If you don't have any moisture present, you won't have any buildup.

Walt Sackett — Well that's true, and there are still a lot of old plants that have air systems that were not properly designed in the first place. You don't have the proper speed of air going through the ducts, and it'll buildup the ducts, the cyclones, etc., until it reaches the proper velocity.

Hubert Balay — Again, harder pellets. You don't have the dust being produced to buildup in the ducts and the cyclones.

D. R. Waggoner — Depending on the material, heating cyclones will help sometimes. One other thing, with a metal cyclone, never hit it with a hammer.

Hubert Balay — I would like to say one more thing about buildup in dryers. Know the melting point of the materials you are using to make the grade, and don't run the dryer temperature up higher than this melting point, or you will have trouble.

D. R. Waggoner — For the boot of the conical section of the cyclone there are now available plastic materials that are flexible, that you can hit.

Person in Audience — What is the panel's opinion of chains in a cyclone?

Joe Prosser — Good !

Hubert Balay — It helps, but the chain builds up too sometimes.

Question #12 — What is the relative efficiency of fluidized coolers and dryers versus conventional rotary equipment? A discussion of square footage required for fluid bed coolers and dryers versus rotary equipment would also be of interest.

Frank Achorn — We have operated some fluid bed coolers. The trouble is the recycle load varies in particle size so much that it's difficult to maintain a good fluid bed. Some plants are using fluid bed coolers to cool their product fluid, which is a good idea. But as far as cooling recycle load, it wasn't practical. The efficiency of a fluid bed cooler is much better than a rotary cooler. But it's the practicability of using it in the type of recycle system that is in a conventional granulation plant that is questionable, because there's such a wide range in particle size. It didn't look practical for the recycle load but was practical for cooling the product.

John Medbery — I think what is referred to as a fluid bed cooler is nothing more than a vertical box with perforated trays in it. The fertilizer spills down through these openings, and the air enters through the bottom and flows countercurrent. You have to keep a dancing bed of material or pellets on the trays to get the maximum surface contact with the air. So put a flexiglass panel in the side so you can see what's going on in each tray. If you don't have enough activity because of air flow or either too much or too little fertilizer, then you close off part of the holes with removable steel plates. And each time you change your production rate you have to vary the number of openings in the plates that you are passing air through.

Frank Achorn — That's what I meant about it being practical. You have to change it so much.

John Medbery — Well, it takes about half an hour to make the adjustment.

Question #13 — What is the ratio of square feet of screening surface versus tons per hour to be screened?

Joe Prosser — We find that depending on how much is going to the screen we are talking about product screening of a granulation plant needing between 3 and 5 square feet per ton produced, settling at about 4 usually if it's 100% recycle.

Allen Jackson — I would put it a little different from Joe. On the six mesh product I would say that you need about 1 square foot or a little better per ton per hour throughout. And for the fines you would want 1-1/2 to 2 square feet per ton per hour thruput.

Walter Sackett — Well, I'll let you fellows argue about that; but naturally if you screen after drying, you are going to have to increase your ratio whatever it is.

Person in Audience — How about distributing to the screen? Does it make a difference?

Allen Jackson — When we are talking about covered square feet, yes, it makes a difference. It's trial and error and get it straightened out, I guess.

Walt Sackett — Try to get an effective feed first of all. You don't want to come on to your screens at an angle for one thing. A spout that is coming in at a 60 degree angle, will throw the feed to one side of the screen. A left and right hand screw at the top will help spread the materials across the face. There's quite a number of ways to go. But try to get the feed in your design square so that you're getting an effective spread to the screen.

Allen Jackson — And the initial design is most important. If you miss that, it becomes trial and error.

Hubert Balay — You ought to check the screen occasionally to be sure that part of the chute hasn't stopped up. Because if half of it is stopped, you are overloading one side of the screen. It doesn't make any difference how good your original design is if you don't keep the chute clean.

Joe Prosser — One other point is the use of retarding curtains which when used properly gets the spread right in the beginning.

Paul J. Prosser, Jr. — Moderator. Mr. King, would you like to comment on this screen question?

Mr. Wayne King — Some of these questions don't have a simple answer. It's like how much air do you need to clean the screen and keep the dust controlled properly. We have formulas for that — like 50 cubic foot of air per square foot. But you are talking about tons. For a four foot of width, if you get beyond 75 tons an hour you have got one hell of a load.

Question #14 — Describe a preventative maintenance program for rotary trunnion equipment — granulators, dryers and coolers.

Al Malone — I don't think we have any out of the ordinary preventative maintenance program for this type of equipment other than what might be considered good mechanical maintenance inspection and checking of your drives and trunnions and seeing that they are in alignment.

Joe Prosser — I think the most important single thing is the proper alignment of the trunnions because it can cause wear on tires and trunnions which get to be almost impossible to realign. If not properly aligned, you put undue stress on bearings and on tires causing failures trying to carry thrust load which is supposed to be carried by the thrust rolls. If you don't line the trunnions properly, you are transferring that load onto the trunnions, and putting unusual loads on the tires and the trunnions.

Frank T. Nielsson — I think it's got to float. When you go to a plant where the people have put in perfectly parallel trunnion rollers and the whole thrust is carried by beautifully designed thrust rollers, after two years you notice that the trunnion and the tires have een going in one place. The next thing you know you've got a spool piece. Once you start making that spool piece you won't have to worry about thrust rollers anymore. That thing stays there, but that trunnion goes in a hurry after that. If you have a system that is properly designed and floats, you are getting complete wear across your trunnion, across your trunnion roller; and the life of those is really extended.

Allen Jackson — I disagree with you, Frank. I think if you take part of the thrust of the dryer by cocking one of your trunnions you have added to the wear far more than you will save by running it in one space. I think one of the critical things in dryer operation is don't let tires develop ripples. Tires that are not allowed to rotate on a drum where they catch a repeating force from a sprocket or a chain at the same place every time will pick up that pitch and develop ripples in the tire. As ripples develop, you can be sure that foundations will go out shortly. That's the toughest thing you can have on the dryer. Rings around the tire or lines are, except for appearances, fairly meaningless; but ripples will be very destructive. Now, there are techniques of taking the ripples out very easily. I mean in the terms of hundreds not thousands of dollars. And it's done by plant people. If anybody has the problem, I can show you how to do it. But it's important that tires on big vessels are allowed to rotate so they don't receive a repeating vibration. But I would not cock a trunnion.

Frank Achorn — Can't you let a dryer float between the two thrust bearings with the trunnions parallel? I don't see why you have to tow them in the first place.

Allen Jackson — It'll always run against the bottom thrust bearing if everything is true.

Frank Achorn — The two trunnions can be parallel to each other, right?

Allen Jackson — Yes, they should be.

Question #15 — Which is the best conveyor to use — screw conveyor, belt conveyor, or cleated conveyor?

D. R. Waggoner — I've got one answer to that. I think that depends on what the application is. And I suggest that everybody's got their own pet peeve, and I might as well state mine. the best application that I know of for a screw conveyor is handling dry free flowing material mounted in a vertical position discharging downwardly, it can be installed at a cheaper cost than a duct of the same capacity.

Paul J. Prosser, Jr., Moderator — Maybe we ought to comment for example about the equipment for receiving material from a hopper car. It sounds to me like this is the way this question was intended.

Walt Sackett — I definitely have an opinion on that. I think that, as it was pointed out in a paper this morning, with belts and screws, you are going to have pit problems, and need at least two pieces of equipment. Everybody here knows what kinds of problems you get into with pits. I definitely am for drag unloading. One piece of equipment will take it right out from under that rail and up into the bin with no pit or a minimum pit required.

Paul J. Presser, Jr. — Anybody else have an opinion? Want to disagree?

Joe Presser — In large capacities, I think that the better application is a belt conveyor under the track properly installed with pits. It's more expensive but perhaps a better installation, where people can get down there and maintain the equipment. For larger capacities only, I emphasize; not for small operations because the initial cost is too high.

Walt Sackett — You can get into higher capacities. Are you talking in terms of 3-400 tons an hour? This can be done with a drag with less of a pit than with a belt installation. You don't need the surge, and you don't need as much of a pit. And you don't have the dust problem that you have with the belt.

Paul J. Prosser, Jr. — Anybody else want to disagree with both of them? All right, let's take another question.

Question #16 — With increased pressure on fertilizer plants to produce more, is it likely to see EPA requirements relax somewhat?

D. R. Waggoner — No!

Joe Prosser — No!

Frank Achorn — No!

Dick Perkins — We've got a number of no's here, and I concur with that. Our problems aren't going to influence EPA at all so far as their standards are concerned.

Question #17 — Discuss the use of fiberglass resin and cloth in plant repairs. What type of materials should be used and where can they be used to advantages to replace wood or metal?

Joe Prosser — We have been using FRP for a long time for ducts and hoods. We are using it also for cyclones, elevator casings, drag conveyor housings and most any place that is corrosive. The only disadvantage is the stuff is not very good in abrasion. For instance, if you have high velocity ducts that are heavy with material, you'll experience wear on the elbows. there are ways of getting around that. If you know where to put the stuff, you can put plastic liners in these elbows. I think FRP is becoming competitive with steel. We're not going to start making dryer shells out of it. But it's much easier to install in stacks as an example. What extra cost is involved is overcome by the installation cost. I think that there are almost as many applications for FRP in a plant as people can dream up.

Paul J. Prosser, Jr. — Anybody else have an opinion?

Frank Achorn — We just worked with a plant in Birmingham that had fiberglass roofing on their plant, and I was surprised to see how much more light was in the plant and how much easier it was for them to operate during the daylight hours. The people at that plant seemed to be well satisfied with fiberglass roofing and thought that it was actually more economical than the normal roof on a plant. I don't know how it would hold up after a long period of time. I was surprised how much light it put into that plant and helped the front end loader operators in moving material.

Joe Prosser — This translucent material has been used for years, and some people who used it 10 or 12 years ago have experienced some degradation of the resin. In the early days nobody knew how to avoid that; but the manufacturers have now developed some material that they add to the resin that kills the ultraviolet light. Today it's possible to buy corrugated sheets that should last a long time. The same thing is with stacks. If you look at old stacks, you will see that the glass has been exposed because the resin has disappeared.

Paul J. Prosser, Jr. — Anybody else?

Al Malone — We have a fair amount of plastic siding; but we seem to have more wind losses with the plastic siding that we do with some of the other materials. Perhaps we haven't learned the best way of installing.

Joe Presser — A lot of this siding will support combustion. Some is underwriters rated. You have to be careful what you are buying; and if you are going to put big expanses of siding on, you'd better talk with your insurance people. You can hurt your insurance rate.

Question #18 — How can concrete be protected and repaired around acid pumps?

Joe Prosser — In new construction you can use grade 5 concrete, acid resistant grade. Where you have an old installation, there are epoxy based coating materials that can be added to finished concrete that greatly improve the life.

Paul J. Prosser, Jr. — Anybody else want to say something about that?

Person In Audience — You can use an acid proof grip, half grip or whole size. It does an excellent job.

Question #19 — What are the effects of impurities in phosphoric acid on production of DAP in a rotary granulator?

Frank Nielsson — If you go back to old TVA experience, when they first started using furnace acid in making DAP, it wouldn't granulate so they put iron oxide in it. You don't have to do that with wet process acid because it has plenty of iron and aluminum. This acts as a seed and you improve granulation. But then if you have too many impurities, you are not going to make grade. I was in Japan and people were asking me why they couldn't make 18-46-0. they were using 77 rock which means a pretty good acid. But over there they use a hemihydrate dihydrate process. they go from the hemihydrate to the dihydrate stage. they add extra sulphuric acid to promote gypsum formation so they use about 10 percent free acid. As a result, the best they can do is a 17-45-0 grade because they've got DAP plus ammonium sulfate. Too many impurities and you are not going to make grade.

Dick Perkins — That's what I was going to say, Frank. Essentially, it serves as a diluent so far as making analysis.

Frank Achorn — There is one thing it does do. It shifts that solubility curve from about 1.4 over to 1.5 and if you don't get further on that solubility curve in that preneutralizer, the reason you may not be making 18-46-0 is you've thrown a lot of MAP crystals into the granulator. So the more impurities you have the more you've got to run that ratio higher in the preneutralizer. Now to get those MAP crystals back to where they can be ammoniated you have to go in solution again. Keep checking your mole ratio to determine that your major crystals are diammonium phosphate. that can be with microscopic analysis, but it's not difficult to tell the difference between a DAP crystal and a MAP crystal even with a magnifying glass. This is one thing that has been underrated as we go to 64 and 68 BPL rocks, and we end up with a lot of iron and aluminum phosphate in our acid. We are ending up with a lot of MAP in a DAP grade because we're not running that mole ratio high enough in the preneutralizer.

Dick Perkins — I don't think the aluminum does much to promote granulation. Some of the other diluents do. With wet acid I don't think that having enough is the problem, it's having too much.

Hubert Balay — I don't have any scientific data on this, but I do know that plant operators do have preferences for acids from various locations. this is because of the variation in impurities. Because of economics, they can't get all their preferences. But a lot of them do have definite preferences, which tells me that the impurities do affect granulation.

Frank achorn — Haven't they added iron ore to granulate with? We've granulated ammonium nitrate with iron ore for years, and it was a granulation promoter. We claim that these impurities hurt us, but they also help us. Because when you dry the diammonium phosphate, the iron aluminum phosphate does dehydrate itself; and I think aluminum will take on 10 moles of water and iron will take on 6. somebody can correct me if I'm wrong. It seems to help in the storage of a product. The dirtier the acid, the better the product storage. You can probably run at a little higher moisture content in making diammonium phosphate with the dirtier acids. Calcium salts will hydrate too. Impurities do really help in the storage of the product.

Question #20 — Stormwater runoff control for existing units and treatment. Discuss.

Dick Perkins — It's a problem that most of us are faced with in the fairly near future with the EPA regulations. A number of states are attempting to set standards now that will require that we attempt to control the storm runoff water that may be contaminated from our plant areas. It's going to be extremely difficult to comply with. A couple of positive steps that you can take are to consider using a sump and curb arrangement, paving an area around your liquid tank car receiving areas, and pumping stations, so that you won't get any runoff from this area that would contaminate storm runoff. Around receiving areas try to have as good and prompt housekeeping as possible to keep from conteminating any rainwater. Beyond that, I am looking for answers I'm not trying to give any.

Hubert Balay — I visualized a plant with an evaporative receiving pond, and the rain being channeled into the pond and the pond running over. I think one answer if this is a problem would be to keep the runoff water out of the pond.

Paul J. Prosser — I think that what they are talking about here is carrying the dust and acid materials that have escaped into the stormwater and running it into the storm system.

Dick Perkins — I think that most of the states would like to have this put into a pond that would hold all the runoff water from the plant area. I can't see that this is really a solution because in areas where we get that much rain there's no way of ponding that large an area.

Joe Prosser — Around North Carolina you can get a pond that just about balances. As much rain falls into it as evaporates out of it. If you go further north, the pond's not going to work very well. There's going to be more rainwater coming in than is evaporating out. We do know of two or three people who are getting their plant makeup water out of such a pond.

Question #21 — With increasing pressure from EPA recently to clean up the air and water around our fertilizer plants do the pollution control equipment manufacturers admit this equipment reduces efficiency and ultimately increase cost of production?

Allen Jackson — I don't say it reduces efficiency, I say it does increase cost.

James Seymour — Where can we get one of these free devices with no operating costs?

D. R. Waggoner — Several of these questions revolve around this point. We've had several questions about dust and buildup of materials on the floor and that sort of thing. do we have any elixirs that we can add to our materials to prevent this dust, any magic solutions? We are going to be required to control fugitive dust, and we might just as well be prepared to add money to our budgets to do that job.

Hubert Balay — Part of our problem has been low profitability of fertilizer and low cost of materials. this is a cost we are going to have to consider.
There's engineering practices used in other industries that we don't even consider because of thie cost.

Question #22 — Do you consider bag filter dust collection systems to be suitable in existing granulation plants? If so, on which process streams can they be satisfactorily utilized? Now, I think that we touched on that earlier. Does anybody want to summarize for the record?

Joe Presser — Well, they have been and are being used obviously on dryer streams, cooler streams or combined dryer and cooler streams. And in a few cases on combined dryer, cooler and ammoniator streams. They also can be used in the fugitive dust control system in the plant as well.

Dick Perkins — I doubt that anybody would recommend one purely for an ammoniation air stream.

Joe Prosser — In combination if there's enough air from the dryer and the cooler, you can sneak a little bit from your ammoniator without causing any trouble.

Al Malone — I think that's right, until the officials get around to setting some standards on ammonia.

Question #24 — What methods can be used to open hopper bottom doors on railroad cars when the door does not open by normal means?

Hubert Balay — You see advertisements in magazines all the time for rachet type devices for opening doors.

Paul J. Prosser, Jr. — Yes, pneumatically operated.

Question #25 — In fertilizer granulation plants that have preneutralizers and wet scrubbers can the scrubber liquor be returned to the preneutralizer without inducing excessive corrosion?

Dick Perkins — Generally speaking I think that the scrubber water could be used without experiencing too much corrosion. The one thing that I would be concerned about a little bit would be the potash content of your scrubber water. Most preneutralizers are stainless steel without a lining, but generally I don't believe it's a problem.

Allen Jackson — You're not talking about fluorides in super water, are you?

Frank Achorn — No, he's just talking about scrubber water for the dryer and granulator. Most plants I've seen operate use scrubber water for the preneutralizer; if they have a separate scrubber for the granulator and preneutralizer, they recirculate that water back to the preneutralizer. The scrubber water from the dryer also goes into the preneutralizer.

Paul J. Prosser, Jr. — So, the answer's yes.

Frank Achorn — that's been going on for a long while. These are even with stainless steel preneutralizers. I think at the high pH that they are, 6, 6-1/2, they are probably all right.

Question #26 — What alterations would you suggest for modification of an existing granulation plant so that solid urea can be used for feed material? Should the prilled or granular urea be crushed prior to feeding it to the granulator‘? Can the plant also produce products that contain nitrate?

D. R. Waggoner — The first thing to do is to clean all the ammonium nitrate out. Then crushing of the urea is not really necessary. The cosmetic effect on the product may be of some concern. If you don't crush your urea, you will find in the final product some particles of urea uncoated or evidence of the urea in the product. You can overcrush the urea very easily. In the general crushing operation you will more hide the appearance of the urea in the final product.

Frank Achorn — It's been the experience of people that use urea in granulation that they usually don't exceed 500 pounds per ton, and preferably down around 200 pounds a ton. they also find that it's better to use larger quantities of urea when you use low degrees of ammoniation in normal superphosphate. There was some pilot plant work that describes this. It has been pretty well confirmed by tests in plants that are using urea. We found that when you do lower the degree of ammoniation of normal superphosphate to about a pound and a half per unit of P_2O_5, product quality becomes better. If you use the standard degree, the product is soft and deteriorates in storage.

D. R. Waggoner — Small amounts of ammonium nitrate in a granulation plant, that then uses urea, and it's disasterous.The critical relative humidity of a mixture of ammonium nitrate and urea in the solid form is about 18 percent.

Question #27 — How can prilled urea be used in 60,000 ton per year conventional NPK granulation plants to produce high analysis 2-1-1 and 1-1-1 grades without the severe problems in processing equipment and plant housekeeping resulting from the bygroscopity of the urea?

Frank Achorn — I wouldn't try to exceed 500 pounds and more like 200 pounds.

Question #28 — What is the possibility for energy reduction and/or conservation programs in granulator production plants?

Joe Prosser — If you don't make the product so good, you don't have so much recycle, and you don't put so much through the dryer, and you don't use so much fuel.

D. R. Waggoner — Another good point is moving to melt processes for producing ammonium phosphates.

Frank Achorn — By using large quantities of phosphoric acid and only ammoniating to five pounds per unit of P_2O_5 you can have a temperature coming out of the granulator of around 230 degrees; and then you can operate your dryer as a cooler. M.F.A. has a particular problem because they had a drastic cut in their natural gas. By using this procedure they are able to save substantially on their requirements for natural gas. What they are doing is using chemical heat to dry the product. In the past we've got a pretty poor record of efficiently using the chemical heat in the process. We are going to have to watch that closer. If they remove all that water down in florida and ship it up to Missouri, then we ought to use it the best way so that we don't have to add all the water back and dry it out again. Operating at lower degrees of ammoniation requires you to use additional quantities of ammonium sulfate or urea or ammonium nitrate in your formulation, but it will allow you to run without a dryer. You can consistently make a 6-24-24, and they never dry the product. they just cool it.

James Seymour — I think it depends to a great extent on where you want to take your lumps on energy, whether it's in florida or some granulation plant.

Frank Achorn — I certainly agree. But I don't think we ought to compound that by once we get it up here, not using the energy efficiency that's been given to us. In the past we've used so much water in operating at wrong degrees of ammoniation. We've had overgranulation and drying problems. If we watch ourselves, I think we can utilize this energy that is given to us by the Florida producers.

Paul J. Prosser, Jr. — Gentlemen, it is now about 12:17. I think we'd welcome questions from you people in the audience who might have something that is bugging them and hasn't had an opportunity to hear it. If you have some, let's try to do that right now. does anybody out there have a question?

Hubert Balay — I've been asked what's happening to shrink. We've had several papers given and Mr. Whitaker gave a paper this morning on what's happening to shrink in fertilizer plants. I guess what people who have asked me this want to know is, how are other people doing on shrink. does anybody have any thoughts on that and what it costs to reduce shrink?

Dick Perkins — I think that all of use are worried about shrinkage as the dollar value of our raw materials goes up. I don't have anything constructive. I know that we're all concerned about it.

Paul J. Prosser, Jr. — Mr. Reynolds is mentioning that shrinkage will be a topic for discussion at our next round Table meeting in more detail.

Hubert Balay — It seems to be of very much interest at this time. I think our standards are changing, and that's the reason I asked the question.

Paul J. Prosser, Jr. — We had a question similar to this someplace in this pile when people were asking about preserving raw materials and so forth. Does anybody want to comment? Mr. Young,

R. D. Young — I would like to comment on the way that the Round Table's been run this year. I think we've gone back a great deal toward the old times, and all committees did a very good job.

Paul J. Prosser, Jr. — Thank you.

(Applause)

Person In Audience — I'd like to comment just a little bit about shrinkage. I think that we are inclined to think of it in terms of dollars lost, but really it's a double headache because it also means pollution. That's where it's going, because what we lose in processing is going to pollute somebody else, and the answer to this is really in housekeeping, in preventing spills, so that we minimize our loss either through stack or through spillage.

Paul J. Prosser, Jr. — Any other comments from the floor? If there aren't, I am going to suggest that we give the panel a round of applause for their big effort.

(Applause)

And I'll turn this podium over to Mr. Joe Reynolds and thank you.

CHAIRMAN JOSEPH E. REYNOLDS, JR.: Thank you, Paul, Thank you, panel, I think we've had a real good session again this morning.

One of the things I want to mention again is please drop us your comments, your suggestions and any information you have on how this program can be improved. As you recognize, it has been mentioned before, this is your meeting; and if you look back through the Proceedings, very seldom do we repeat the same type of a program two years in a row. We try to give where the action is and what the interests are.

I think this shrink factor that was mentioned this morning was picked up by several people and I think that it will definitely be on the program for next year.

But let's hear from you, and thanks again to everyone who came and contributed. We are most sppreciative of those who came considerable distances, our hosts for the cocktail party last evening, Paul, and different committee members who worked so hard on this program.

We really appreciate everything, and thanks for coming, and we'll see you next year. *Lots of Applause!* Adjourned 12:40 P.M.

Appreciation and Thanks
Albert Spillman
Editing Chairman

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