PROCEEDINGS
OF THE
26th ANNUAL MEETING
FERTILIZER INDUSTRY
ROUND TABLE
1976

October 26, 27, 28, 1976
Sheraton Biltmore Hotel
Atlanta, Georgia

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Fertilizer Industry Round Table
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Glen Arm, Maryland 21057

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Proclamation

CITY OF ATLANTA

Office of the Mayor

WHEREAS the Fertilizer Industry Round Table will hold its Annual Meeting at the Sheraton Biltmore Hotel in Atlanta on October 26 - 28, 1976; and

WHEREAS this is an organization composed of fertilizer producers from the United States, Canada, Mexico, South America, Europe and Japan; and

WHEREAS Atlanta is happy to host the Bicentennial gathering of these people whose industry contributes to our prestigious status as the world's leader in food production:

NOW, THEREFORE, I, Maynard Jackson, Mayor of the City of Atlanta, do hereby proclaim Tuesday, October 26, 1976, as

FERTILIZER INDUSTRY ROUND TABLE DAY

in Atlanta, and urge our citizens to honor this day.

IN WITNESS WHEREOF I have
HEREUNTO SET MY HAND AND
CAUSED THE SEAL OF THE CITY
OF ATLANTA TO BE AFFIXED.

Maynard Jackson

MAYNARD JACKSON
MAYOR

Tuesday, October 26, 1976

Morning Session
Joseph E. Reynolds, Jr., Chairman

Charles M. Grau, Moderator

Introduction of Georgia Lieutenant Governor Zell Miller

Colonel Joe S. Drewery, Jr.

No one in the history of Georgia ever brought to his office a background of experience in public service as broad and rich as that Zell Miller did to the Office of Lieutenant Governor.

He was a sergeant and rifle instructor in the Marine Corps . . . He served as mayor of his hometown of Young Harris . . . He was twice elected State Senator . . . He was a professor of history and political science at Young Harris College and the University of Georgia . . . He has been Executive Secretary to a Governor and a Lieutenant Governor . . . He has been Executive Director of the Democratic Party of Georgia.

He has served in three areas of criminal justice — Director of the State Board of Probation, Assistant Director of the Department of Corrections and a Member of the State Board of Pardons and Paroles.

And he also has been a small businessman, publisher of a county weekly newspaper and coach of a college baseball team.

Therefore, it is not surprising that he has a wide and wise grasp of issues facing our State and that he has proved himself as an official who views matters in terms of how they affect people rather than the government.

In his inaugural address, Zell Miller pledged to "tell the people not merely what they want to hear, but what they need to know" and that he has done. He has not hesitated to discuss the State's problems fully or to propose realistic solutions regardless of their popularity.

Zell Miller is a man who believes government should solve, not create, problems for people. And it is refreshing and encouraging for the future to have a man like him in high office.

I present to you our distinguished young Lieutenant Governor — Zell Miller. *(Applause)*

Welcome to Atlanta

Lieutenant Governor Zell Miller

At this particular time of the year I thought maybe you had heard enough politicians. That's all you read about in the newspapers, all you see on the television or hear on the radio.

I couldn't help but think of the year I got out of the Marine Corps. I then started to college and I was already married and we had two little boys and the GI bill was not enough to feed all four members of the Miller family. So I got a job at the University of Georgia tutoring the Georgia football team. Now this was in the 1950's; and then, like today, they had some great football teams. But they also at that particular time had some of the dumbest football players you've ever seen, and they paid me $2.50 an hour to work with those guys and I earned every cent of it.

I never will forget that I had this one big tackle who made a 58 in English, and it was my job to get that stretched to a 60 so he would be eligible. So I went to see his professor and he happened to be a pretty good Bulldog fan and he wanted to help out. He said, "I'll tell you what we'll do. If you get that guy to memorize a passage from Shakespeare and come up here and repeat it to me, we'll get him eligible." Well, in that English course they had been studying "Macbeth", and I don't know if you remember your "Macbeth" or not or if you've ever read it, but there's a passage in "Macbeth" right before they go into battle when he says, "Lead on, Macduff, and damned be he who cries hold enough." I thought that was pretty simple and so we worked on it for two or three weeks and I thought he had it down just right. I took him up there to perform and he started off great. He said, "Lead on, Macduff." And then he forgot the rest of it and he looked at me over in the corner and he looked up at the ceiling. Finally, he started all over again. He said, "Lead on, Macduff, damn if I ain't had enough."

So I was afraid maybe you've had enough politics and politicians, but I am delighted that you asked me to be here and that you've chosen the State of Georgia and the City of Atlanta as the site of this year's Fertilizer Industry Round Table. On behalf of the citizens of both Georgia and Atlanta, I welcome you.

Atlanta has become noted as a convention center for regional, national and international conferences, but I can think of no group that Georgia is happier to receive than this national and international group of those of you in the fertilizer industry.

Fertilizer is a very vital component of the important business of agriculture, traditionally, very few people have been aware of the fertilizer industry. Most people are very much aware of the final product on their tables and may even give a passing thought to the farmer, but few are aware of all the related industries that are so very, very necessary.

However, in the past few years, with the energy crisis pushing up your production prices, especially for those of you dealing largely in nitrogen fertilizers, and with the farmer feeling the pinch of increased farm expenses, the consumer certainly became aware of your industry when they saw it as one of the factors pushing up food prices.

Unfortunately, life is often like that; whether it is in the fertilizer industry or sports or politics, people often don't notice you until something which directly affects them goes wrong.

But here in Georgia we have always recognized your industry as a vital part of the agri-business that provides support for agriculture. In Georgia where farm receipts last year were over 2.2 billion dollars, you can be sure that we appreciate the importance of agriculture and its related industries.

In fact, last year Georgia consumed 2,239,367 tons of fertilizer. That ranked us as 5th in the nation in fertilizer consumption and the biggest fertilizer consumer in the East. It is pretty hard work not to be aware of and appreciate an industry that is such a big part of our State's largest industry: Agri-business.

Georgia and the South as a whole have witnessed a tremendous surge in economic growth recently, outpacing the rest of the United States on a number of key economic indicators. Though much of the South's recent growth has been nonfarm, agriculture is still a key economic factor in this state. In fact, Georgia, ranking 15th among the states with its farm receipts, was one of the fortunate states last year that didn't show a decline in farm receipts.

Agriculture has become a major factor in the world's economy. It is likely to become even more important in the future, as all of you know.

Only nine nations in the world grow more food than is necessary to feed their own populations. The United States exports more food than the other eight nations combined. It is estimated that an already hungry world will add 3 billion mouths to feed in the next 25 years. American farmers are certain to remain in a position of strength in the foreseeable future because food, unlike oil, is a renewable resource.

Of course, no region stands to benefit more from the prosperity of farmers than does the American South. The Midwest leads the nation with 373 hundred million acres of farm land, but the South is very close with 333 hundred million acres. Even more significant, the largest block of suitable but presently uncultivated land in the world is in the American South; more than 100 million acres.

Our standard of living is dependent upon international trade, and agriculture is one of the few trade accounts where the United States is in the black. Now is the time for agri-business to recognize and meet the challenge of global requirements for its products and services and for the public to recognize and appreciate the importance of agri-business and all its related industries.

I thank you and the fertilizer industry for what you mean to this country and this world. We welcome you to Atlanta and to Georgia. Thank you for being here. *(Applause)*

Introduction Keynote Speaker
D. W. Brooks

Harold Green

Good morning. Jim Gordon was unable to be here this morning so I'm filling in to introduce our keynote speaker.

It is a great pleasure for me to introduce this morning a man I have known for over 30 years. He received his B.S. and M.S. degrees in agriculture from the University of Georgia and later received his Doctor of Law degree from Emory University. He taught agronomy at the University of Georgia for three years.

In 1933 he and a small group of farmers formed the Cotton Producers Association now known as Gold Kist. He was the general manager for 35 years. He began with a $2,100.00 investment and built it into one of the largest farm organizations in the United States with a sales volume now of over 9 hundred million dollars.

He is past vice president of the National Cotton Council of America.

He was named Man of the Year in Agriculture in Georgia and later Man of the Year in the South by *The Progressive Farmer* magazine.

He was delegate to the American Assembly and worked on the proposed changes in the United Nations charter. He has served on seven various advisory boards for five presidents and is currently serving on President Ford's advisory committee for negotiations.

He has served on the National Cotton Board, International Advisory Board for the C & S National Bank and Board of Governors Agricultural Hall of Fame.

He has served as director of Farmers Chemical Association, Chattanooga, Tennessee; Foundation for American Agriculture, Washington, D.C.; Georgia Southern and Florida Railway Company; Agricultural Missions, New York and National Council of Farm Cooperatives, Washington, D.C.

He has served as trustee to five college and universities in the Southeast. He was elected to Agriculture's Hall of Fame, University of Georgia in 1972, the first living person to be so honored.

In addition to his business life he has devoted much of his time to his church having served on practically every board of the United Methodist Church.

He now serves as chairman of the board of Cotton States Mutual Insurance Company, Cotton States Life Insurance Company and Gold Kist Inc., all here in Atlanta.

He is a great outdoorsman and loves to hunt and fish; and I might say is an expert in both. Let's give a warm welcome to one of the leaders in agriculture, Mr. D. W. Brooks. *(Applause)*

Keynote Speaker

D. W. Brooks

You fellows if you want to get a good introduction, what you do is get an employee to introduce you. You learn that as you go along.

I don't know whether you Yankees here fully realize what an important state you are in. You see, it is very unusual for a state to have one fellow running for President. We have two running for President. We even had three governors at one time here in the state. So you are really in an unusual situation.

But I want to say this. We are delighted that you could be here with us. We are delighted that the Yankees showed up. You see, at one time we were very suspicious because when these Yankees came through here once before, you've been seeing all of these big buildings here in Atlanta, but when they got through with Atlanta, there were no buildings left. So we were all suspicious for a long time. Every time we happened to see a lit cigarette or cigar we ran over to put it out. We finally caught on, especially some of us out in the country. I lived on the road where lots of Yankees were coming through going to Florida. We were a little suspicious of the fact that they got to stopping and buying gasoline and eating food, but soon learned that we could pick them a whole lot easier than we could pick cotton. So we just started picking Yankees and we have been doing better ever since.

Now this fertilizer business I guess, that some of you fellows are like myself in that you are 39 and holding, I've been involved in fertilizer all the way back when we called it guano. The introduction reminded me a while ago that I was on the War Mobilization Board with President Truman. He was not too popular in the South at that time; but I was alphabetically first so I sat to his right on the Board all the time, and some of my friends who despised him in a way, they got to saying, "You're not only up there with the blankety-blank; you're his righthand man." Now President Truman knew who to describe fertilizers, see. He did everything direct; he didn't do it indirect.

Now my first training in fertilizer was when I went to the University. I was the youngest member of my family. Now I don't know whether all of you realize it or not, but we had great poverty here in the South for 100 years. You see, after the little war we had with a few of the Yankees, we didn't have any Marshall Plan; and when they got through with us, there wasn't anything left down here and so we had pretty rough going for a long time. Now consequently it is a little hard for most of us to get to college, but my father struggled along and finally got three of my brothers through college and a sister and I was the youngest member. We had such a bad poverty situation on the farms in this area that all my brothers wanted to do was find some way to get off of the farm. That's the last place they wanted to be. That is a little bit like a situation when I was out in one of these farmhouses many years ago and things were so bad that all the farmers had to eat that they could cook was chitlins and poke salad. I said that was the only house I had ever been in where the flies were trying to get out. I think that's the way my brothers were about trying to get off the farm. All they wanted to do was get off. But I felt there was a lot to learn so consequently when I decided to go to the University I would take agriculture. So I began to study, among other things of course, fertilizer; and then I became a professor in the agronomy division in which I had to teach fertilizer.

Now I say to you that things were really bad at that time. In fact, the kind of fertilizer we were using was terrible, it was 8-2-2, 10-2-2, and we finally got a little as high as 9-3-3. The 2 or 3 was not nitrogen; it was ammonia. For example, the 10-2-2 or 8-2-2 is 1.65 nitrogen. So we didn't have anything hardly. Well, the only way you could possible make it that terrible was to put at least 12 to 1400 pounds of sand in each ton.

Now you realize that being a professor of agricultural science, which includes fertilizer, was giving me hemorrages because farmers had a per capita income in the state of Georgia of $72.00 for a year's work. Now you can't get much lower than that and figure you are still here. So consequently what they were doing was buying sand from fertilizer people. You can realize that that was part of our poverty problem, and it was just killing them.

So I finally decided to leave the University against the advice of the president, who must have thought I was crazy. I came to Atlanta and talked to a lot of bankers; and I said, "Farmers are all starving to death, bankers sure can't have any money in the bank with a farmer making $72.00 and all you are going to do is go broke. If you finance farmers they can't pay you back. There's no way. Now we've got to get this thing off the bottom some way.

So consequently the banker said, "O.K., I'll finance you if you leave the University and start this business if you want to start it." He said, "What do you want to do? Do you want to start it as a stock company and you own the stock or do you want to start it as a mutual?" I said, "Well, of course, in many ways I'd rather do a stock company because I know we'll make this thing go. I believe we can because if we can get the right kinds of fertilizer for these farmers, we can get them off of this bottom. We can get the yields up. But on the other hand, I'm afraid to do it that way because I have to change them and they aren't easy to change. They are hard to change. I have to give them some inducement if I get them to change." He said, "Well, I'll finance you either way, whichever way you want to go." So I said, "Well, I'd rather set the thing up mutual, I can then at least give them some inducement to do what we are trying to do."

Now that was a terrible struggle; I don't mind telling you that because it is hard to go out there and tell a farmer he's stupid. I mean that's a little bit difficult to do and do it diplomatically. But anybody that was buying fertilizer with 12-1400 pounds of sand in each ton had to be stupid. So really it was sort of a rough thing.

Now some of the fertilizer industry didn't know what I was trying to do and they got all upset. I finally said, "Why don't we have a meeting of everybody thats in the fertilizer industry here in Georgia. Why don't we get together and see?" They said, "Well, what do you propose to do?" I said, "I propose to take all the sand out of this fertilizer that we are manufacturing and we're going to get a high analysis and it's going to cost more but I think we can sell it." They said, "We've been trying to sell it 50 years, and we haven't sold it yet. Now we don't think you can sell it." "Well,", I said, "I just want to take one shot at it; and if I can't sell it in three years, I'll quit. We'll just walk out." They said, "Well, you go ahead." I said, "You fellows are all hot and bothered that I'm going to compete with you. Let me tell you something. I've been studying your financial statements and not a one of you has as much money as you had 20 years ago. Everyone of you are going broke. Because what's happening is this; farmers going broke and he's making you and the whole industry go broke. Now you better start a little competition and all of us survive rather than doing it that way." They said, "Well, more power to you, but we don't think you can do it."

Well, I had a hard struggle; I don't mind telling you that. I whamed these farmers because I had a reason to wham them. I'd say, "Now this thing is going to make money if you'll do it right. If you don't do it right, I'm going to switch this thing over to a stock company, and I'm still going to make this kind of business go, and I'm going to get rich and keep every dime of it myself. In two or three years I had them turned over; and then, of course, the whole industry got turned. I felt I had a responsibility because I had been a professor of agronomy in which we taught fertilizer, and I had the responsibility to try to make some changes.

Now I had some farmers, of course, that really would wreck me at meetings. I had one old farmer who jumped up and said that he'd tried some of that stuff and went back and got himself some good old 10-2-2 and come again. So it wasn't simple because we had good weather one time and bad weather the other.

I remember I hired an economist. I wanted him to go out and make a survey of our business and to give me an idea of how we ought to go. He came in one night in about a week, and said "You know you've got the greatest group of scientists in the world." I said, "Yeh, hows that?" He said, "They just sit in their house and study geology through the floor in the daytime and astronomy through the roof at night." "So" he said, "thats the kind of group you're dealing with."

Now naturally, you get lots of satisfaction seeing that far back. I was reading some history the other day that said the farther you look back sometime the farther you can look forward. Now looking back and then going out today in this area with the fine homes on the farms is a tremendous improvement. We have greatly increased productivity. For example, the average yield of corn in this state was then bushels per acre and stayed there for 50 years; and it didn't budge until we began to get them better fertilizer. Now it is about 70 bushels per acre.

I've spent over 40 years running from one end of this world to the other because as we got in, we had to market lots of these farm products; and so I put sales offices all over the earth. In doing so I studied agriculture in all of these countries. There have been some basic things that happened to agriculture in the world. Of course, one of them is how you fertilize. Every time we've gotten an increase in productivity we've had to use fertilizer as the basis of doing it. So, consequently I know it; you're in the key industry.

Now you're going to have on this program a little later a talk on the world food situation. Now I've spent lots of time on that from one end of this world to the other. I've worked with lots of agriculture people in the world and worked on their problems, and in trying to get an increase in their productivity. We've even gone to some of these countries and built some plants. Among these we went to India and built a large complex there.

It took a long time; you almost gave out on patience, compassion and everything else before you got through, but we finally built a tremendouse complex trying to feed some Indians.

When, for example, the Green Revolution was started, I was working with some of the scientists who were working on the Green Revolution. The first thing we learned when we go to working with the Green Revolution was that it was no good unless you had fertilizer. We had to push the fertilizer there in order to make the Green Revolution move at all. In other words that was the key. No, of course, we, as you know, had to lower the stalks because heretofore if we fertilized heavy they would fall. We got the low stalks and by doing that we could pour fertilizer on and get the yield and make it go. So everywhere you go in this world wherever you have been able to increase productivity to any extent you've had to do it through fertilizer. That's been the key thing.

For example, I had in my office this week a Chinaman who was a school mate of mine at the University. He was a brilliant student and he went back to China, the mainland, and was in charge of agricultural research on the mainland of China. Now he was an anticommunist, and so when the communists started to take over, he got off the mainland with Chiang Kai-Shek, and he got 12 of his top scientists off with him and so he went to Formosa. Chiang-Kai-Shek put him in charge; he became chairman of the joint commission of rural rehabilitation of Formosa. Now when they came off the mainland soon after they got off I went over there and started working with them and visiting with them, and he started visiting me here. So I've been constantly working with them in that situation. What happend? He, of course, was trained in fertilizer. He started in, and he went to the University of Georgia and then went over to Cornell and got his Ph.D., and so he had all the technical training that anybody could possible have in fertilizer. Now when he got to Formosa he, of course, had millions of people in a very limited area, and he felt like the only chance he had to get the yield up was to do two things. First, get the farms in the hands of the people who would farm them. The tenants bought these farms and then they put in a kind of county agent system, a vocational system, like we have, to train these farmers how to use fertilizer, the right amounts at the right time, and they started increasing yields.

Where are they today? Thats a poor country in many ways, and they have over 16 million people now. But since 1949 when they came off of the mainland of China, they have increased yields so rapidly on these farms until today they have the highest yield per acre on a 12 month basis of any place in the world. Thats the case where one man with the brilliance that he had and the training that he had has been able to bring that about.

For example, he has grown as many as four crops in one year, two crops of rice and two crops of vegetables in a 12 month period. Now you can't do it better than that.

Now what did he do about fertilizer? Theres an Asiatic country thats been starving to death; all that part of the world is starving. The whole area is starving. He has not only turned it back; but he is exporting food out of that nation, and the yield is unbelievable. With 16 million people he's not only feeding them, but he's exporting food. Now what about fertilizer? He's using more fertilizer per acre than anyplace on earth except Holland. Thats the only place that uses more fertilizer per acre than they use on Formosa today. So I'm saying these things to you to say that whatever hope we have of saving the world from complete hunger is through fertilizer. I've been around this world many times and seen the hunger in the world for more than 40 years and its getting worse instead of better and I have the feeling that somehow we're going to finally cross this line and we're going to have mass hunger in this world not a few million but hundreds of millions of people starving to death at one time, but the only hope that I've ever seen is that we can increase productivity not only here but in other parts of the world. Otherwise we've got a starving world thats right ahead of us.

When you look at the population, and I don't want to get into the next speakers subject, but I want to say one thing about population and those of you who spend lots of time overseas like I do sometimes you get to where you can't hardly walk for people in some of these countries. It might get that way all over the world in time. Now over these years what's happened, you've heard these figures, of course, it took from the beginning of mankind to 1830 to add one billion people, 95 years a second one, 35 years a third one and 15 years a fourth billion. Now that is like a snowball rolling against you all the time.

I checked Mexico, for example, and the population is growing faster than we are in this country. By 2020 they'll have 800 million people in Mexico at the current rate. I've been all over Mexico many times. Even with all the most modern methods and all the fertilizer I still don't see how you can feed 800 million people because they don't get much out of the land; it is mostly mountains all over Mexico.

So we've got our work cut out for us. You fellows are the ones sitting on the top of the firing line.

I've said a good many times theres no hope for the communist world. I've been working in the communist world for a long time. Their system is so that they will never feed themselves. They have some ups and downs. Just like in Russia the worst fight I ever had was with the minister of agriculture in Moscow. I kept studying agriculture in Russia, and I came to one definite conclusion that unless they change their whole pattern of agriculture they have no chance in the communist world. None whatsoever, because you have to get enough farmers that have farms that they own, that they have a stake in and they get some return from their production. The government has never been able to do it. No government anywhere in the world has been able to do it and do it successfully. Now I kept saying to the Russian minister of agriculture, "If you don't change your pattern the whole communist world is going to starve to death and you're going to starve too unless we feed you and thats the only chance." He argued vehemently with me. Then I asked him questions. I said, "You fellows are sitting here in Moscow making decisions on how farmers are going to farm all over Russia. Now you don't know that much. You're not that smart." Then I said, "To illustrate what I'm talking about let me ask you just one question." Now all of you've seen all these stories in the papers if you've ever studied agriculture in Russia about opening of the new territories. I said, "O.K., who made the decision to open the new territories?" He said, "Why?" I said, "Well, its crazy. You've got an average rainfall of only six to eight inches, and nowhere you go can you get successful on that average." "Oh," he said, "we're going to use tractors." I said, "I don't care what you use, its stupid. Theres no way you can do it." Well, I kept pestering him. I found out later, he never did answer my question, but Khrushchev, who knew nothing about agriculture, made the decision to open up the new territories. Now to show you how things happen in politics, the year he made them open it up and put all his tractors and everything in there darn if he didn't rain, and they had a good crop. So he lucked out. If you watch them, they'll have one good crop, then have about two or three bad ones because rainfall will go up but then it will go down and it will go out. So I'm trying to illustrate here that nobody can sit in Moscow or Washington and tell any farmer anywhere in any country exactly how to farm. If the government's going to do the farming you're dead. Theres no hope.

So we've got lots of straightening out to do around this world. We might even have a little in this country sometime to straighten out. I say we've got to straighten it out or hundreds of millions of people are going to literally starve on this earth because we don't do it.

It's going to be a little bit like this. In introducing me Harold said that I was on the board of trustees on a bunch of institutions. I'm on the board of trustees, for example, at Emory University which here in Atlanta has a great medical school. So when we go out there to the trustees meeting when we break up for lunch, we have a round table; and the trustees, maybe eight or ten of us or six or eight of us, will sit at this table and maybe two faculty members will sit and we visit. So we get a chance to visit with each other. I was out there two or three years ago, and the two fellows that were at our table were from the med school. They got to telling all these good medical stories, and I thought one of them was pretty good. They said they had a fellow who was seriously ill, and they decided they'd operate. So they'd given him sedation, had him pretty much knocked out; but he wasn't quite out because he could bearly hear what was still going on. So as they wheeled him into the operating room, he heard one of the doctors saying to the other one. He said, "I want to say to you again that I'm in disagreement on the diagnosis of this case." Well, this patient said that nearly got him off the operating table. He could bearly hear. But he said that the thing that finally did it was they wheeled him into the operating room, and in another minute the same doctor said to the other one, "Furthermore, I'm absolutely confident that the autopsy's gonna prove me correct." Now you can't get it any worse than that.

I say to you that maybe the autopsy of the whole world is in the hands of fertilizer, and you fellows have got a very serious and great job to do. You've done a terrific job and you've done a wonderful job and I hope you'll keep it up. Thank you very much. *(Applause)*

CHAIRMAN REYNOLDS: Thank you, Mayor Jackson, Lientenant Governor Miller, D. W. Brooks, Harold Green and Colonel Joe S. Drewery for your kind remarks and welcome. *(Applause)*

We have an excellent program with a variety of subjects covering most of the important phases of our day to day plant operations, viz: Material Supply Availability, Transportation, Environmental, Bulk and Bagged Blending, Granulation, Improvements Covering Existing Processes, New Processes and many more subjects I am sure will be of interest to you.

Sit back and relax. I wish all of you a happy stay. Our registration table will be covered during the meetings for incoming calls and will be prepared to help you with any information you may need.

Our Director Charles M. Grau, will moderate the "Papers" to be discussed this morning. Charles, please.

MODERATOR GRAU: It is my pleasure this morning to serve as moderator for the first session of the 26th Annual Fertilizer Round Table. Mr. Brooks, I sure enjoyed your talk, and I think that's a great endorsement for the free enterprise system. Long may it exist.

Our first speaker this morning, Mr. Belai Abbai, is an Ethiopian by nationality. He is trained as an economist and has degrees from South Hampton University in England and from Harvard University here in the United States. He has worked for six years as an economist with the economic commission for Africa. He has also worked for twelve years with the government of Ethiopia and did serve as minister of land reform and administration. He joined the rural development department of the World Bank earlier this year and specifically to work on the world food problem, which is probably one of the biggest problems the world does have to face. Would you please join me in giving a warm welcome to Mr. Belai Abbai. *(Applause)*

The World Food Situation

Belai Abbai

I. *Introductory Remarks*

Mr. Chairman and distinguished delegates, I have been asked by the organizers of this Conference to address you on the world food situation. I should like to start by making a few preliminary remarks. The world food situation has become one of the most important international issues of the day. The issue came to the forefront after the world food crisis of 1972, which culminated with the 1974 World Food Conference held in Rome under the auspices of the FAO, during which the worst and final food crisis occurred. The World Food Conference came to the view that the food problem will worsen unless appropriate international action is taken in time. Two of its key recommendations were: (i) increasing food production in the developing countries; and (ii) establishing an international system of food security (including a warning system and grain reserves) both to stablize prices of basic foodgrains and to meet emergency needs. Moreever, the Conference proposed the establishment of several institutions to implement its proposed strategy for international action.

Since that date a vast amount of work has been done and is still being done by the international agencies, as well as research institutions throughout the world. The main thrust of this work is, first; to define the magnitude and location of the food problem, and second; to throw some light on the policy and institutional arrangements needed to prevent at least a further deterioration of the food shortage. The international agencies are currently active in various facets of the food problem.

I believe it is fair to say that there is general agreement that the food shortages experienced by the developing countries will worsen by 1985 and even more so by the turn of the century, if things continue as they are. While there are clear signs that the world is moving towards a concensus of views about the nature and magnitude of the food problem, there is, unfortunately, less agreement on the measures to be taken to solve it.

Having made these preliminary remarks, I will now present a bird's eye view of what I perceive to be the world food problem and its causes. In order to get a better perspective of the issue, however, we shall find it convenient to have a quick look at developments during the past few decades before we discuss the prospects for the future. In what follows we shall confine our attention to cereals, which include wheat, rice, millet and coarse grains.

TABLE 1

Trends in World Trade

World Grain Trade: 1934-38 to 1976

(Millions of metric tons + exports, — imports)

	1934-38	1948-54	1960	1970	1976[1]
North America	+5	+23	+39	+56	+94
Latin America	+9	+1	—	+4	—3
W. Europe	—24	—22	—25	—30	—17
E. Europe and USSR	+5	—	—	—	—27
Africa	+1	—	—2	—5	—10
Asia	+2	—6	—17	—37	—47
Austrailia and New Zealand	—3	+3	+6	+12	+8

SOURCE: The World Watch Institute also reproduced in "Lending for Food Grains in the Poorest Countries", World Bank Staff Paper.

[1] Estimates.

II. *Historical Perspective*

In the 1930's Western Europe and to a smaller extent Australia and New Zealand were the only net importers of grains. By contrast, all the other major regions (North america, Latin america, Eastern Europe, Russia, Africa and Asia) were net exporters of grains. It is of interest to note North America's net exports were very modest in those days being on the order of 5 million tons per year.

During the period following the Second World War, a major shift had taken place in the pattern of world grain trade. While Western Europe maintained the volume of the net imports more or less at their prewar levels, three major world regions namely, Latin America, Africa, Russia and Eastern Europe, ceased to be net exporters of grains. It was during this period that Asia had changed from a net exporter into a net importer position on cereals. North America then emerged as the principal supplier of foodgrains. Similarly the position of Australia and New Zealand had altered from a deficit into an export surplus area.

As can be seen from the Table, the same trends continued during the 1950's and the 1960's. The major exception was the Eastern Europe and USSR group which maintained self-sufficiency during this period. However, the most significant development of the early 1970's was that the USSR and the Eastern European countries, as a group, were added to this list of net importers of grains. North America has now become almost the sole supplier of grains to the rest of the world.

III. *The 1972 Food Crisis*

To my knowledge the most plausible account of the 1972 food crisis was presented by F. H. Sanderson, [1] who has argued that the severity of the crisis was due to a series of production short falls both in the USSR and the USA and inadequate levels of stocks held by grain exporting countries.

According to Sanderson, the 1972 Soviet crop was 13 million tons less than the preceding year. The Soviet short falls of the earlier years namely 1963 and 1965 were, in fact, greater than the 1972 short fall. The

Soviet response to the short falls of the earlier years largely took the form of a reduction in the consumption of livestock. In contrast, the Soviet response to the short fall of 1972 was a decision to maintain the level of internal consumption and to make up for the entire deficit by increasing net imports.

Large-scale Soviet purchases came at a time when the level of stocks had been reduced from a peak of 101.5 million tons in 1962-63 to 68 million tons in 1971-72. Then the familiar sequence of events followed. North American stocks declined and prices rose sharply which in turn stimulated farmers to extend their acreages. At a time when prices were expected to come down, it was unfortunate that the US was caught in one of its worst droughts, adding to the severity of the crisis. As a result, grain prices continued to climb upward — reaching an all time peak in 1974.

What should be borne in mind at this point is that, in the absence of an international system of grain reserves, the North American grain stocks had come to play a balancing role in international grain trade. Therefore, while from the US point of view the 1972 stocks may have been regarded as adequate, from the standpoint of international price stability of cereals these stocks were not adequate. This is one of the lessons that we have learned from the 1972 crisis.

IV. *Long Term Factors*

The underlying changes in the volume and pattern of production and consumption of cereals and the consequent shifts in world grain trade has of course, been realized for sometime. During the early 1960's, Lester Brown[2] analyzed past trends and future prospects for cereal production and consumption. He reached the conclusion that developing countries may well have lost their capacity to feed themselves as domestic demand will increase to outstrip domestic supplies. Net imports of cereals from the developed countries would have to increase in future years to meet the expected food deficit.

The tendency for the developing countries to become deficit areas in food production is explained by changes in the demand and supply factors. On the demand side, population growth is the principal factor for an ever increasing food consumption. This was due to the introduction of modern medicine and hygiene which in many instances sharply reduced the death rate. Efforts at reducing the birth rate through birth control measures are continuing, but an appreciable reduction of births is not to be expected, at any rate, within the medium term. Moreover, income per capita in the developing countires being low, the income elasticity for food is relatively high. The modest gains in per capita income are largely spent on food. For these reasons annual incremental consumption of food tends to be high in developing countries.

On the supply side, developing countries production of cereals has barely kept up with consumption requirements. Normally an increase in production comes from two sources: (i) an increase of area under cultivation and (ii) an increase of yields per hectare. Historically the former was an important factor. But in recent years the additional lands that can be brought under cultivation at reasonable costs has considerably diminished. In particular so far as the densily populated areas of Asia are concerned more reliance must be placed on increasing yields per hectare. Average yields/hectare are still low in the greater part of the developing world compared with what conceivably can be achieved as demonstrated by Japanese experience.[3] Average yields of 1 to 2 tons/hectare are typical of India, Philippines, Burma, Bangladesh, etc. Yields of 2 to 3 tons/hectare are obtained in Pakistan, Indonesia and Sri Lanka. Yields of 3 to 4 tons/hectare prevail in Malaysia and China. Taiwan and Korea have reached levels of 4.3 and 5.3 tons/hectare respectively while the average for Japan is close to 6 tons/hectare.

It has been observed that in the countries that attained average yields of 4 tons/hectare or more, a number of sequential changes have been introduced to transform agriculture. These involve: (1) improvement of land productivity mainly through irrigation and drainage; (2) application of science and technology which is now popularly known as the 'Green Revolution' technology, such as the introduction of HYV seeds on iririgated land; and (3) the introduction of a network of institutions to sustain the high level of productivity.

It is true that considerable effort has been made to develop agriculture and to increase food supplies in South and East Asia as evidenced by the Green Revolution in the 1960's, particularly in wheat. It is also evident from the average figures given about that time, resources and government commitment will be needed before the current low yields are raised to adequate levels to meet the food needs of the population in these countries.

In contrast to the persistent deficit of food requirements in the developing countries, North America and to some extent Australia and New Zealand continued to experience a persistent surplus during the past fifty years. United States agriculture played a dominant role and has been the leading exporter of cereals including provider of concessional food transfers. In a recent article,[4] Earl O. Heady has summarized the course of US agricultural development during this period. Briefly, per capita income in the US reached such a high level by the 1920's that the domestic demand for food had become high inelastic. A given increase in output was accompanied by a correspondingly greater decline in price. Any increase in output greater than population growth tended to depress prices which led to a decline in revenue from agriculture. Demand inelasticity in both the domestic and export markets continued to prevail during the post-way period.

In the face of inelastic demand, US agriculture opted for continued application of cost reducing innovations. Considerable resources were devoted to agricultural research, soil conservation and irrigation. The result was a sustained increase in agricultural productivity estimated at 1.5% per annum during the past 50 years. The combination of inelastic demand and high productivity accounted for consistent surplus which could not be sustained unless the government intervened to compensate the deterioration of farmers income from agriculture. Accordingly, the government introduced compensatory programs to stablize farmers incomes. Moreover, according to Heady, "international aid programs were devised to subsidize exports — sometimes in effect giving produce away both to help increase the demand for food and to encourage developing countries to accept it". A similar process was going on in other food exporting countries namely Canada and Australia. Later acerage controls were introduced to keep the surpluses to manageable levels.

V. *The 1974 Assessment of the World Food Situation*[5]

The concern generated by the 1972 food crisis culminated in the World Food Conference organized by the FAO in 1974. In making its assessment the World Food Conference looked into: (a) the long-term trends in consumption and production of cereals by major regions, and (b) the lessons of the 1972-74 crisis.

The FAO established the trend rates of growth for consumption and production by major world regions for the period 1961-73. The FAO results are reproduced in Table 2 below.

TABLE 2

	Volume Growth Rates	
	Demand	**Production**
Developed countries	1.5.	2.8
— Market economies	1.4	2.4
— Eastern Europe and USSR	1.7	3.5
Developing market economies	3.6	2.6
— Africa	3.8	2.5
— Far East	3.4	2.4
— Latin America	3.6	2.9
— Near East	4.0	3.1
Asian Centrally planned economies	3.1	2.6
All developing countries	3.4	2.6
World	2.4	2.7

SOURCE: FAO Assessment of the World Food Situation, November 1974, p. 90 Table 20.

As can be seen from Table 2, for the world as a whole the increase in total production of all cereals has been greater than the increase in population, during the period 1961-73. However, global figures of this sort do not tell us much about the nature of the food problem. Instead we should observe the differences in the long run rates of growth in consumption and production between the developing and the developed countries.

During this period the developing economy countries have experienced an annual rate of increase in consumption of 3.6% compared with an annum rate of increase in production of all cereals of 2.6%. This significant difference between consumption needs and actual production was responsible for the opening of a growing food deficit in the developing countries.

In contrast to this, the developed countries have had a long-term rate of growth in consumption of 1.5% compared to a 2.8% increase in production which accounts for a growing surplus. But as noted earlier, the position of Eastern Europe and the USSR has shown a marked change in that it has tended to become a net deficit area.

In assessing the future food demand and supply situation, the FAO assumed that trend rates of 1961-73 will persist for the coming decade and the conclusion was that by 1985 the developing countries as a group should expect a deficit of 85 million tons.

Subsequent to the FAO study the International Food Policy Research Institute carried out detailed projections. This study[6] is concerned with assessing the location and magnitude of the food deficit in the developing countries. A major contribution of the IFPRI study is that it includes separate projections for major food deficit countries in Asia and Africa. The IFPRI projections have essentially confirmed the FAO assessment of the food situation for 1985. The most difficult area of judgement in these projections concerns the supply side. The IFPRI have analyzed the effect of the Green Revolution which showed dramatic results — especially in wheat during 1965-69 — in many Asian countries. However, the effect of the Green Revolution had tapered off during the early 1970's, but it is too early to judge whether these changes are short-term or long-term phenomena. But should the latter trend persist during the 1970's, then the food gap may even be much greater than 100 million tons which is the IFPRI figure for 1985.

VI. *Proposed Strategy*

The World Food Conference proposed that the solution to the world food problem should comprise the following main elements:

(1) increasing food production in the developing countries themselves (long-term), which would be supplemented by

(2) provision of food aid, particularly for those countries which do not have the foreign exchange to purchase imports (short-term), and

(3) establishing an international food security system (grain reserves) which will have a dual role to:

(a) stablize international prices, and

(b) provide emergency assistance for those in need.

The World Food Conference also recommended the establishment of institutions which were considered necessary to implement the proposed strategy. As a result, the following international institutions were established:

(1) The World Food Council,
(2) The International Fund for Agricultural Development,
(3) The World Food Program, and
(4) The Consultative Group for Food Production and Investment.

The World Food Council, established at plenipotentiary level, is the highest international body which coordinates all matters relating to the world food situation. It has already had two sessions and its third session is scheduled for June 1977. So far the Council has been concerned with:

(1) measures to increase food production in developing countries including the mobilization of greater resource flows from the developed countries;
(2) food aid for the most affected developing countries;
(3) trade in cereals; and
(4) food security.

The World Food Council plans to discuss nutrition and trade issues at its forthcoming session. It is too early to judge how effective the Council is going to be in coordinating this vital area of great international concern. On the positive side, the previous two sessions of the Council have demonstrated that there is general agreement within the Council for an increase in the flow of financial resources and know-how to the production of food. But considerable divergence of opinion still exists within the Council about trade in foodstuffs. It has been agreed by some members that the World Food Council is not the appropriate forum to raise trade issues. According to them, trade issues are better handled within the framework of GATT. On the question of food security, it would be fair to say that everybody agrees on the need for establishing international reserves. But there is serious desagreement on what is considered an adequate level of reserves as well as the management and financing of these reserves. The reserve issue is such a delicate political matter at present that it has scarcely surfaced in the debates of the World Food Council.

The establishment of the International Fund for Agricultural Development within such a relatively short time must be regarded as an important step to help solve the food problem. The Fund will be an UN agency which is in many respects a novel experiment. The Fund will be established with a target of one billion dollars but only $750 million needs to be pledged by governments to make it operative. The new donors (OPEC) have collectively and bilaterally contributed to the Fund about $430 million. The voting structure is also unique in that the three groups: the DAC, the OPEC and the developing countries have equal votes. As now conceived, the Fund will have a small secretariat and will rely on the international agencies for the implementation of its projects. The Fund is expected to commit its current resources in three years. A preparatory commission has been established which is currently working on lending criteria and policies for the Governing Board of the Fund.

The consultative Group for Food Production and Investment (CGFPI), as its title suggests, is a body which was designed to facilitate consultation and exchange of views between donors and recipient countries. As such it has no pledging authority and no formal voting procedures. It is sponsored by the World Bank, the UNDP and the FAO. It has its headquarters in Washington and has already convened several times. It has compiled and analyzed the data on financial resource flows to agriculture of developing countries. It has also started work on the preparation of food plans in selected developing countries. It hopes to demonstrate that food plans can be useful instruments for creating a dialogue between donors and recipients regarding resource requirements as well as policy and institutional changes needed for agricultural development.

VII. *Final Remarks*

I have talked about the food gap but I have not said anything about the amount of resources required to meet this gap. At the World Food Conference it was thought $5 billion would be required annually if the agricultural sector of the developing countries were to increase at 4% per year. This figure would at today's prices be raised to $8 billion. The World Food Council and the international agencies have expressed the desire that a sound assessment of the financial implications of the food gap be made in order to monitor the resource flows to agriculture during the coming decade. This issue was raised at the third meeting of CGFPI held in Manila in September 1976. It was proposed that the International Food Research Institute should undertake the task of assessing the resource requirements of the food gap on behalf of CGFPI and that the sponsoring agencies namely the World Bank, the FAO and UNDP should cooperate by providing the relevant information.

Another critical issue, which in my opinion did not get the emphasis that it deserves at the World Food Conference but which is critical to the success of solving the food problem, is the role of the developing countries themselves. If the governments of developing countries lack the political will to make hard policy decisions to promote agriculture no amount of outside help will by itself provide the solution. One area which deserves special attention is the question of agricultural price policy. It has been observed that in many countries food prices are fixed at levels that do not motivate farmers to expand agricultural production especially in view of increasing cost of inputs experienced in recent years. The problem is however a complex one. If prices are raised as economic rationality would suggest, then the unrest and pressure for price reduction starts in the urban areas. Governments would naturally prefer their own political stability which largely depends on pleasing the urban groups.

If I may be allowed to make one final remark, it is this — the food problem is merely an aspect of the relationship of North and South. Disparities in technological advancement, population growth and per capita income levels have created different conditions for food supply and demand in the two zones. The solution to the food problem would therefore provide a concrete area for a fruitful North-South dialogue.

[1] Fred H. Sanderson: *The Great Food Fumble.* Science, Washington, D.C. May 1975, Volume 188, pp. 503-509.

[2] Sterling, Wortman: *Food and Agriculture.* Scientific American, September 1976, Volume 235, No. 3.

[3] W. David Hopper: *The Development of Agriculture in Developing Countries.* Scientific American, September 1976, Volume 235, No. 3

[4] Earl O. Heady: *The Agriculture of the US.* Scientific American, September 1976.

[5] FAO: *Assessment of the World Food Situation Present and Future. Rome, November 1974.*

[6] IFPRI: *Meeting Food Needs in the Developing World.* Research Paper No. 1, Washington, D. C., February 1976.

MODERATOR GRAU: We would like to take the time after each speaker to open the floor up to some questions. So before Mr. Abbai goes back to his seat are there any questions in the audience? Yes.

QUESTION: I don't mean to be disrespectful or anything, but one of the problems, of course, is the births are continuously increasing; and, of course, agriculture does have some limit. Are there any plans in the future to limit the births or encourage birth control in these undeveloped countries because you'll never solve the problem if you don't control the births?

MR. ABBAI'S ANSWER: On this question of population control I think it can be said that the international agencies are extremely active. They and the World Bank have special programs on it. Many of the governments in developing countries are doing something about it. I think the great problem there is that the developing countries are in the transitional phase. That is to say the immediate impact of modern medicine has been to reduce death. My own impression is that inspite of all efforts that have really made the progress in that area is going to be somewhat slower than some people expect.

MODERATOR GRAU: Any further questions? Mr. Abbai, thank you for taking time from your schedule, which involves a lot of travel I know, to appear in front of this convention.

MR. ABBAI: Thank you. *(Applause)*

MODERATOR GRAU: Rodger Smith was brought up on a farm in Amherst, Massachusetts and is a graduate of the University of Massachusetts. He also served as a naval communications officer and started his job career with Eastern State Farmers Exchange which is now part of Agway. While there he worked on granulation development, high analysis formulation and agronomic services. He currently is manager of technical services for Amax Chemical Corporation. Rodger is a member of the American Chemical Society, a fellow of the American Institute of Chemists and is listed by American Men of Science as well as serving as a director of The Fertilizer Industry Round Table. Rodger, please.

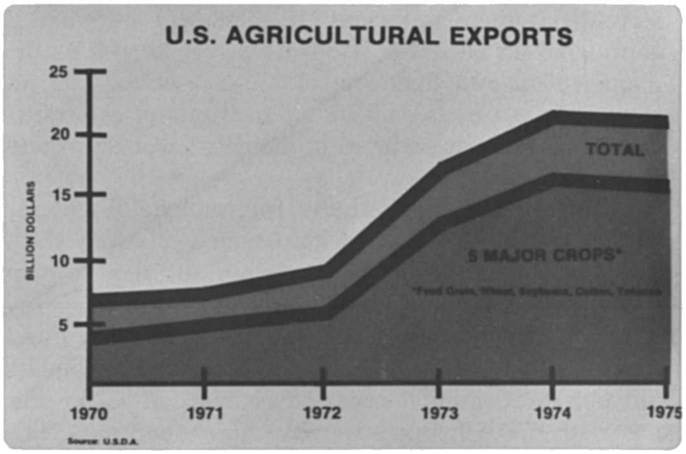
N-P-K Supply Demand to 1980

Rodger C. Smith

Gentlemen: Fertilizer Supply-Demand affects not only purchasing, but formulation, production plans, sales policies and even equipment requirements. currently the industry is attempting to bring supply-demand into near balance after four years of wide swings which disadvantages either or both sellers and buyers.

I appreciate that you are especially interested in the supply situation from now until June, and secondly the long term. However, the industry's projections to 1980 may both assist with immediate decisions and guide forward plans.

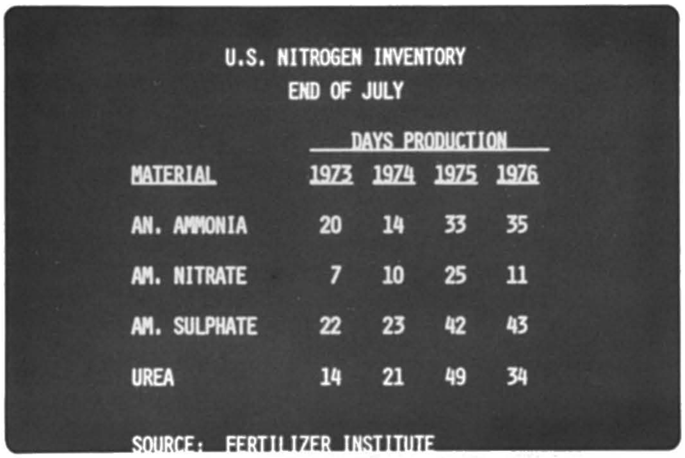
Following a currently good fall fertilizer season in United States, demand should continue strong in response to anticipated plantings and moderated fertilizer prices. Export of fertilizers should continue to improve in response to lower price tags, to the effect of low rainfall on crop yields in some countries and gradual recovery of foreign exchange.



Source: U.S.D.A.

Agricultural exports increased from 7.3 billion dollars in 1970 to 21.9 billion dollars in 1975. Whether President Ford or Governor Carter wins the election next week, I believe that United States Agricultural exports will continue strong for many years having a favorable effect on United States fertilizer consumption.

Nitrogen. Ammonia Producers are concerned about natural gas but are reconciled to paying $2.00 per thousand cubic feet within the next few years, equivalent to about $75.00 natural gas cost per ton of ammonia. African and Middle East countries have large gas reserves, much of which is being flared. Urea in particular will be increasingly produced in these regions.



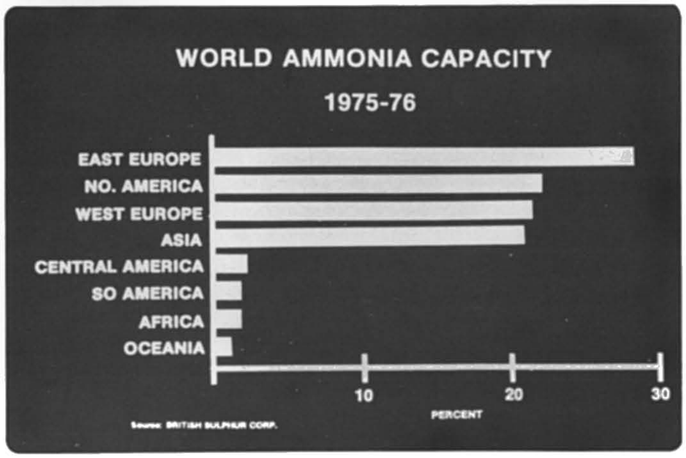
U.S. NITROGEN INVENTORY
END OF JULY

MATERIAL	DAYS PRODUCTION 1973	 1974	 1975	 1976
AN. AMMONIA	20	14	33	35
AM. NITRATE	7	10	25	11
AM. SULPHATE	22	23	42	43
UREA	14	21	49	34

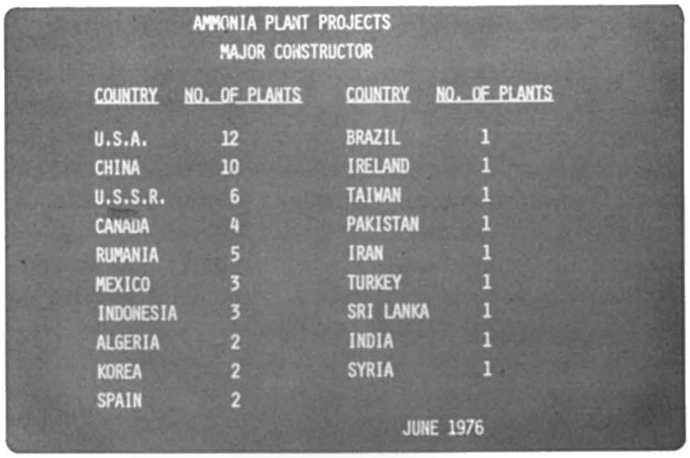
SOURCE: FERTILIZER INSTITUTE

Fertilizer mixers worldwide return to traditional inventory practice during 1975-76 season precipitated lower materials prices, some dropping below costs. Thus producers' inventories levels generally increased. Shown here are U.S. inventories at the end of July in days of production capacity. September end inventories were:

Ammonia	37
Ammonium nitrate	18
Ammonium sulphate	44
Urea	28



Eastern Europe including Russia leads ammonia production with 28%, while North America, Western Europe and Asia each share 21-23% of World capacity. Future expansion of ammonia production in Africa and the Mid-East would modify these percentages.

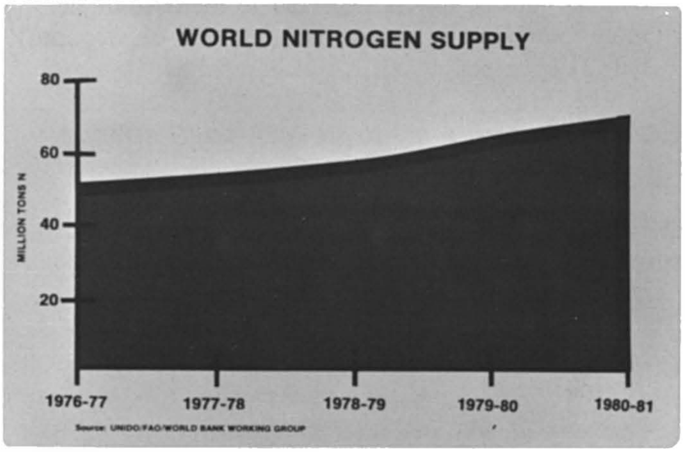


AMMONIA PLANT PROJECTS
MAJOR CONSTRUCTOR

COUNTRY	NO. OF PLANTS	COUNTRY	NO. OF PLANTS
U.S.A.	12	BRAZIL	1
CHINA	10	IRELAND	1
U.S.S.R.	6	TAIWAN	1
CANADA	4	PAKISTAN	1
RUMANIA	5	IRAN	1
MEXICO	3	TURKEY	1
INDONESIA	3	SRI LANKA	1
ALGERIA	2	INDIA	1
KOREA	2	SYRIA	1
SPAIN	2		

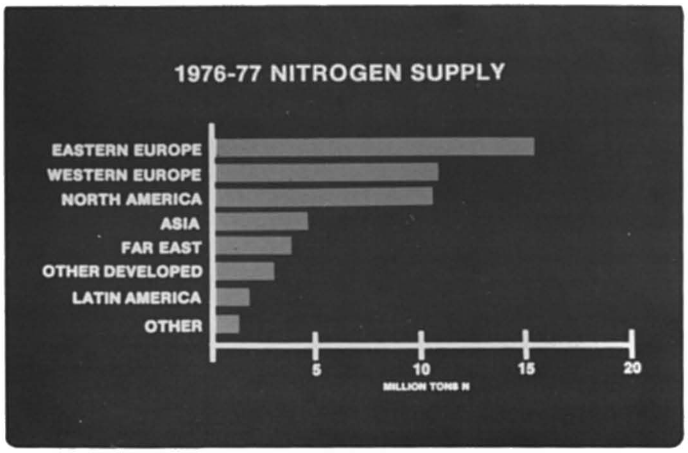
JUNE 1976

The realization in 1973 that expansion of fertilizer capacity had unduly lagged sparked a wave of nitrogen and phosphate expansion. Listed are the countries where one major ammonia plant constructor had active projects in June 1976. United States, China, Eastern Europe and Canada are the major locations, but less industrialized countries are included.

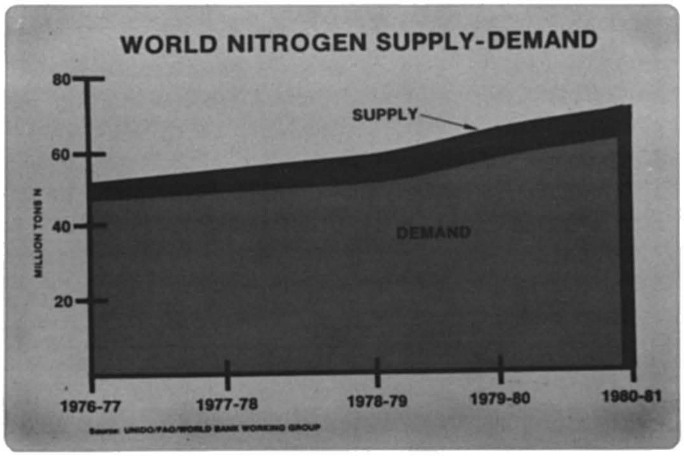


A working group coordinated by United Nations Industrial Development Organization, F.A.O. and the world bank meet regularly to assess fertilizer supply-demand.

World nitrogen supply during this fertilizer year is 50 million tons 'N' and is estimated by the working group to be 68 million tons in 1980-81, or 36% greater than for the current year.

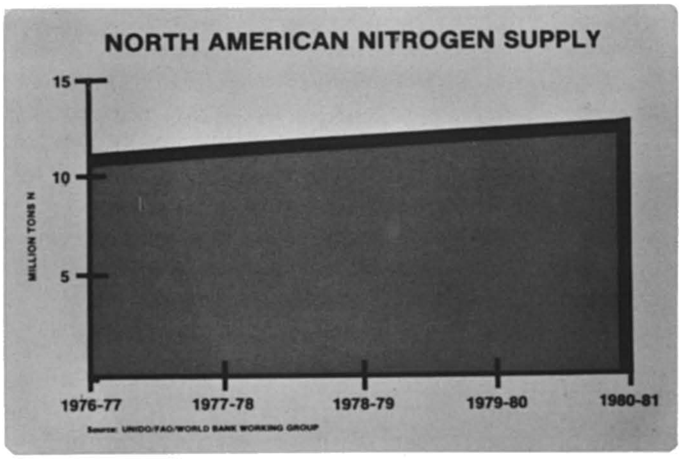


Of the 50 million tons 'N' for the current year supply, nearly 37 million tons are being produced in Eastern and Western Europe and North America, followed by Asia, Far East, Latin America and others.



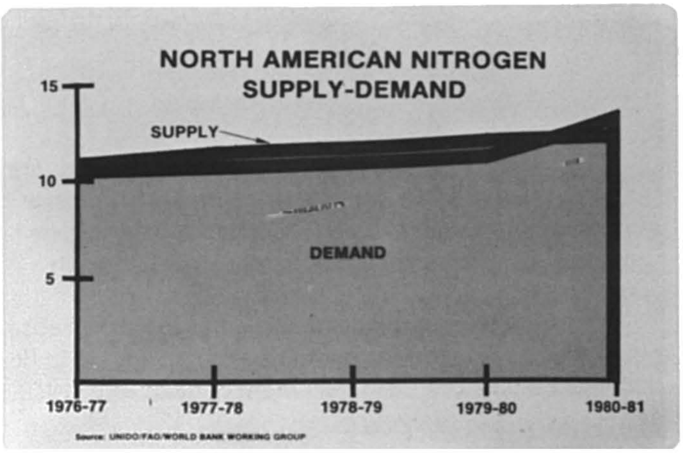
Source: UNIDO/FAO/WORLD BANK WORKING GROUP

1976-77 world nitrogen supply-demand was predicted last April by the working group to be about in balance, but supply is expected to increase moderately more than demand, supply 36% by 1980-81, demand by only 31%.



Source: UNIDO/FAO/WORLD BANK WORKING GROUP

North American nitrogen supply estimated to be 10.6 million tons during the current fertilizer year is projected to increase to 13 million tons in 1980-81, a 21.5% increase



Source: UNIDO/FAO/WORLD BANK WORKING GROUP

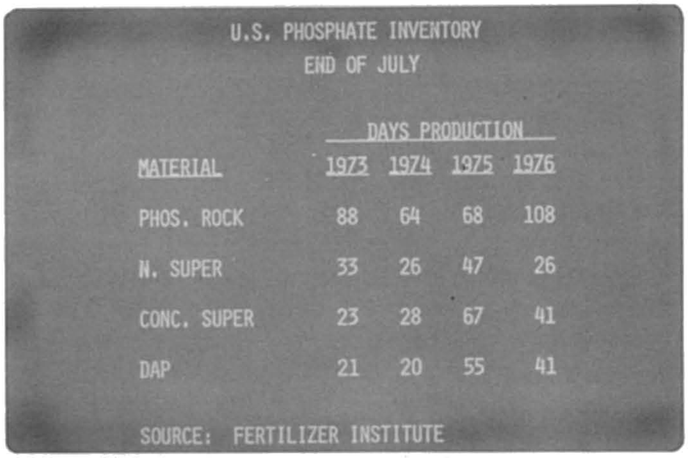
Virtually in balance now, North American nitrogen supply- demand is estimated to remain so to 1980-81. However, droughts, governmental policies, etc., affect demand for fertilizer in any given year and are near impossible to forecast.

World-wide and in North America, Urea supply will increase, but uses for cattle feed and industrial products as well as fertilizers may cause it to be in short supply during this fertilizer year.

In the future, a Urea producer in Pakistan, for example, is certain to seek out the U.S. Market among those having a near balance or deficit nitrogen position.

Phosphates. The markets for phosphate materials have been far more turbulent during the past few years than either nitrogen or potash. Both rock phosphate and concentrated phosphate prices had been unduly low, well below prices necessary to justify new investment.

Rock phosphate mining involves acquiring an economic reserve increasingly difficult to obtain in United States. Some contend that concentrated phosphate capacity in Florida is expanding beyond the long term phosphate rock availability in Florida at competitive costs.


U.S. PHOSPHATE INVENTORY
END OF JULY

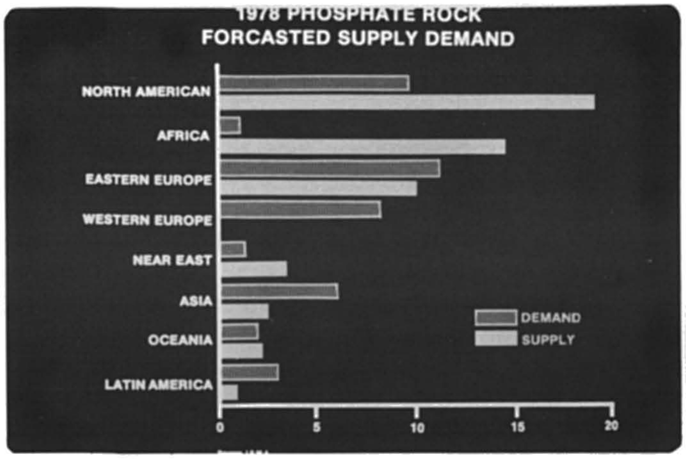
MATERIAL	DAYS PRODUCTION 1973	1974	1975	1976
PHOS. ROCK	88	64	68	108
N. SUPER	33	26	47	26
CONC. SUPER	23	28	67	41
DAP	21	20	55	41

SOURCE: FERTILIZER INSTITUTE

U.S. Phosphate producers' inventories at the end of July were as shown — phosphate rock high, normal super low and triple super and DAP moderate. At September end, inventories represented the following days of production capacity:

Phosphate rock	116
Normal super	50
Concentrated super	35
DAP	23

The U.S. phosphate rock sold or used during the first six months suggests a reduction of 4.0% in 1976, from 1975, largely in exports which decreased 13.5%.

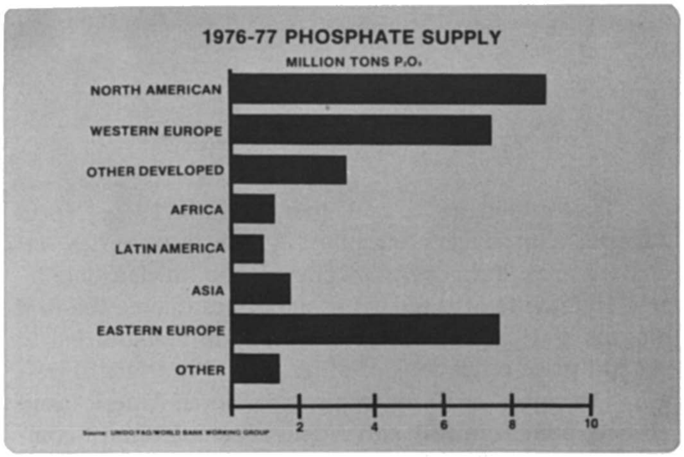

1978 PHOSPHATE ROCK FORCASTED SUPPLY DEMAND

Looking forward two years, world phosphate rock supply capability is projected to be 52 million tons and demand to approximate 42 million tons P_2O_5, or an excess of nearly ten million tons. North America is expected to require about 9 million tons P_2O_5 and have the capability of producing another 9-10 million tons for export.

Africa, the second largest producing region, is by far the largest exporter. Net importing regions are eastern Europe, Western Europe, Asia and Latin America.

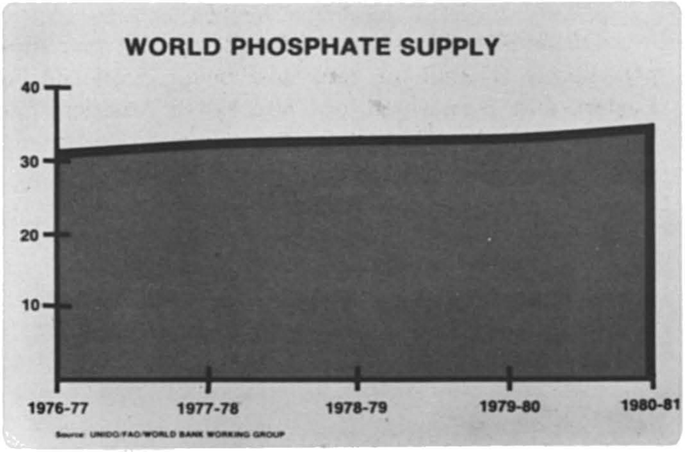
Africa has two-thirds of known world reserves, Morocco over half and certain to be the world's major source of phosphate rock, if not concentrated phosphate, during many future years.

Phosphate rock has well established trade routes from southeastern U.S., Northern Africa and U.S.S.R., to Europe, Japan and other countries.


1976-77 PHOSPHATE SUPPLY

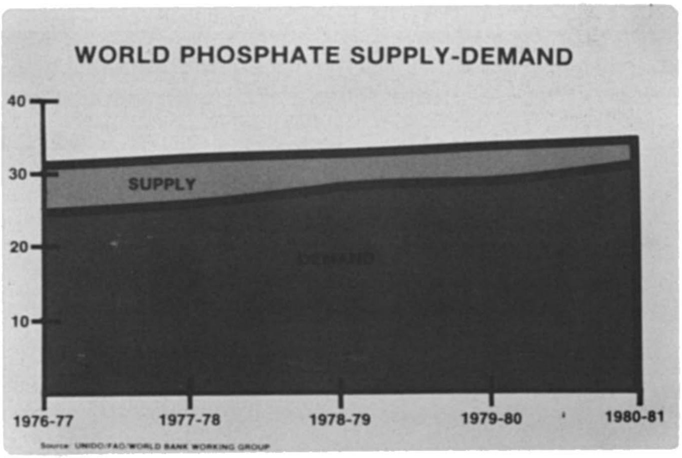
Source: UNIDO/FAO/WORLD BANK WORKING GROUP

For the current year processed phosphates supply in North America is about 9 million tons, Western Europe about 7.5 million tons and Eastern Europe nearly 8 million tons P_2O_5, these three regions totalling three-quarters of the current year world supply.


WORLD PHOSPHATE SUPPLY

Source: UNIDO/FAO/WORLD BANK WORKING GROUP

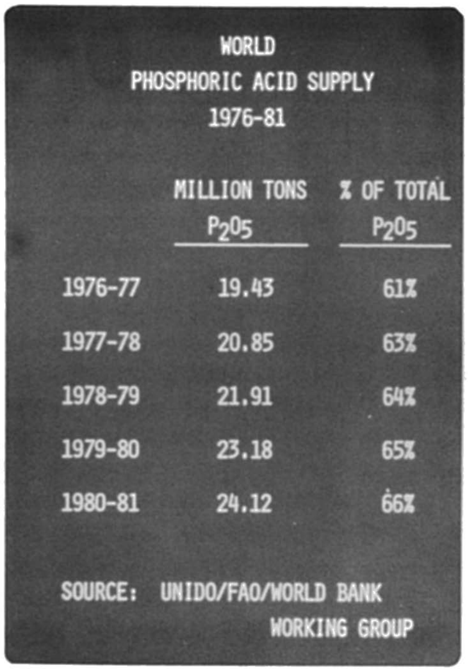
World phosphate capability is projected to increase from about 32 million tons P_2O_5 this year to 36.5 million tons in 1980-81.


WORLD PHOSPHATE SUPPLY-DEMAND

Source: UNIDO/FAO/WORLD BANK WORKING GROUP

While supply capability is projected to increase 15% to 1980-81, largely as result of new plants or expansions planned during the 1973-75 shortage period, world demand for phosphate is estimated to increase about 25%.

Phosphate supply-demand currently is being brought into reasonable balance after hectic 1975-76 and is anticipated to be increasingly in balance to 1980-81.

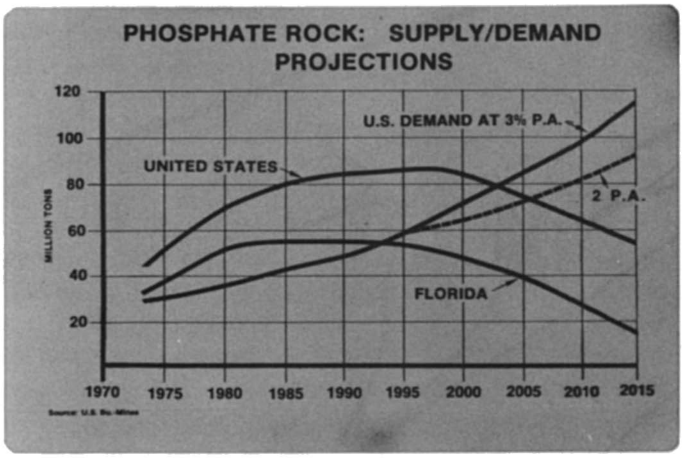


WORLD
PHOSPHORIC ACID SUPPLY
1976-81

	MILLION TONS P_2O_5	% OF TOTAL P_2O_5
1976-77	19.43	61%
1977-78	20.85	63%
1978-79	21.91	64%
1979-80	23.18	65%
1980-81	24.12	66%

SOURCE: UNIDO/FAO/WORLD BANK WORKING GROUP

I mentioned concentrated phosphate expansion in Florida which expansion may signal a trend toward more production of phosphoric acid near the source of rock phosphate and shipping the acid or ammonium phosphates to market rather than rock. F.F.M. in Mexico initiated this trend. In any case, the proportion of the total P_2O_5 supply in the form of phosphoric acid is estimated to continue to increase.



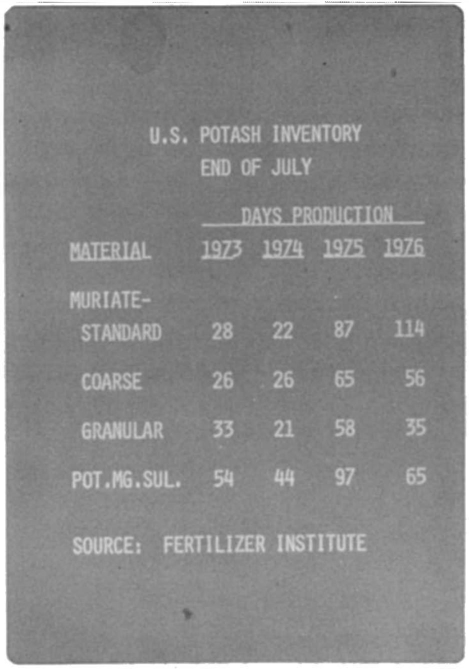
The phosphate mining industry of Florida and North Carolina is expanding following the realization in 1973 that capacity was actually less than anticipated.

Florida phosphate rock capacity is expected to peak within the next five years and then gradually decrease, North Carolina capacity increase to about 20 million tons rock by the end of this century and Western States rock capacity to only gradually increase because of higher costs. Assuming a modest 3% annual growth of U.S. P_2O_5 demand, export of P_2O_5 produced from U.S. rock is projected to peak within the next eight years and then gradually decrease to zero at or shortly after the year 2000.

Escalating rock prices would, of course, make economic certain new reserves. However, with large reserves of quality rock accessible to ocean transport in Morocco and other north African countries, costs will in due time encourage the United States to gradually become a P_2O_5 importer, much as has occurred with Potash.

The price hikes on concentrated phosphates in July restored these materials to approximately break-even levels after several months of depressed prices. Stability of the concentrated phosphate market will depend considerably on international sales activity.

Potash. The potash picture has also come in and out of focus — two years of tight supply, a year of apparent normalcy followed by a fire sale this past summer, and then backlogged orders during the past three months.



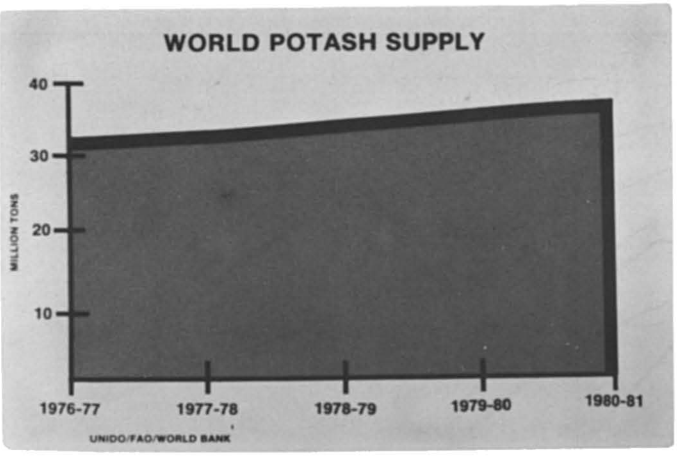
U.S. POTASH INVENTORY
END OF JULY

	DAYS PRODUCTION			
MATERIAL	1973	1974	1975	1976
MURIATE- STANDARD	28	22	87	114
COARSE	26	26	65	56
GRANULAR	33	21	58	35
POT.MG.SUL.	54	44	97	65

SOURCE: FERTILIZER INSTITUTE

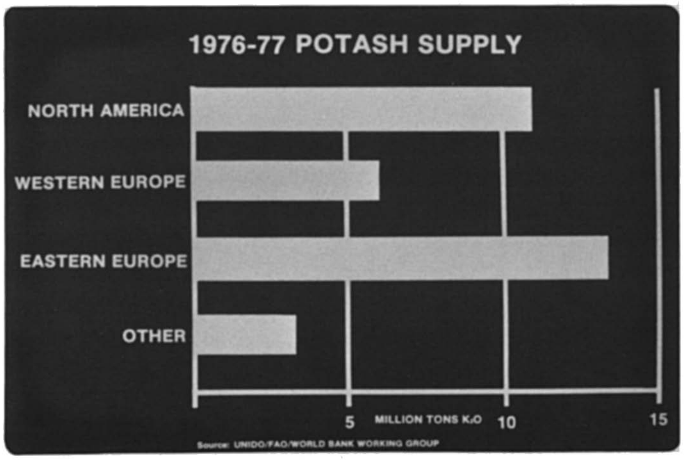
Throughout 1975 and first half of 1976, North American producers standard grade inventories increased more than coarse or granular to burdensome levels. Reduction of standard grade prices during the first months of 1976 in attempt to stimulate demand led to general price reductions of all grades of muriate of potash. The mixed fertilizer industry in North America and abroad, bought in July and August causing almost complete transfer of potash inventories from producers to mixers. The September end inventories in equivalent days of production were:

Standard grade	122
Coarse	43
Granular	15
Pot. Mg. Sul.	95



UNIDO/FAO/WORLD BANK

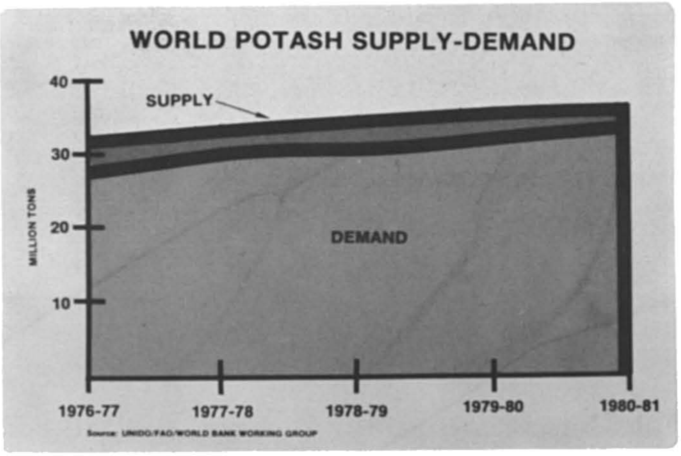
The working group on fertilizers project world potash supply to increase from 31.7 to 34.6 million tons, or an annual increase of only about 2%, which is less than projected demand growth.



Source: UNIDO/FAO/WORLD BANK WORKING GROUP

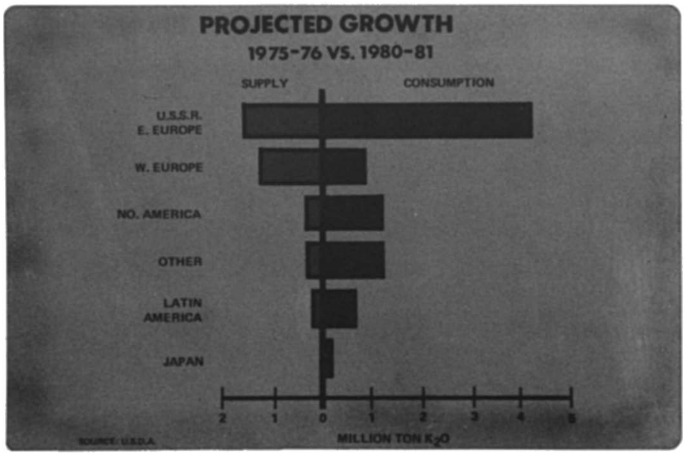
The announced Saskatchewan government acquisition program caused industry to slow major investments. With any reasonable political climate and tax treatment, private industry would have and no doubt still would proceed with expansions to meet forseeable potash demand. The Saskatchewan political leaders stated intent is at least 50% government ownership and operation.

Eastern Europe has the largest supply, Russia having brought about 1.0 million tons potash on stream during each of the last few years. Note that production is greater than demand in only three regions.



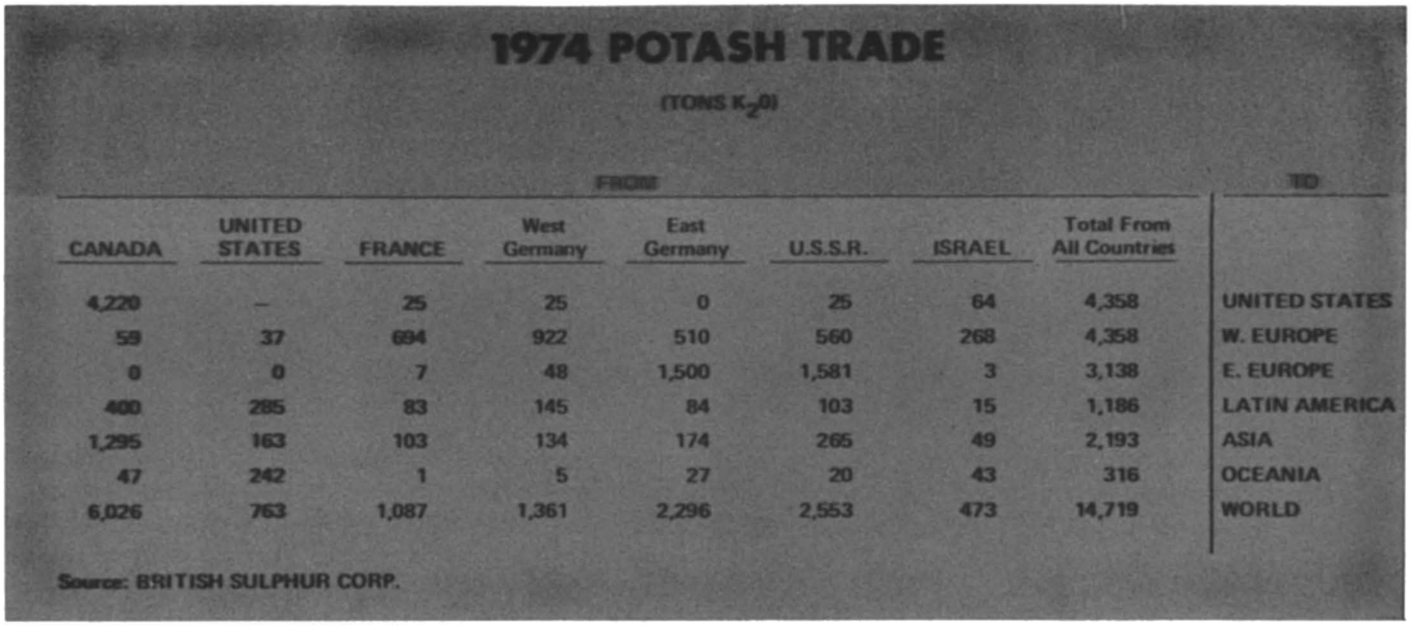
Source: UNIDO/FAO/WORLD BANK WORKING GROUP

While supply is expected to increase only 9% to 1980-81 or about 2% annually, world demand is estimated to increase 26% or over 6% annually. Because any new major potash production in 1980-81 would have to be in at least the planning stage now, it is reasonable to project that supply demand will be in closer balance in 1980-81 than now.



SOURCE: U.S.D.A.

Only in Western Europe is supply expected to increase as much as demand by 1980-81. In all other world regions, demand is expected to increase more than supply. In Eastern Europe supply and consumption are projected to increase most.



1974 POTASH TRADE

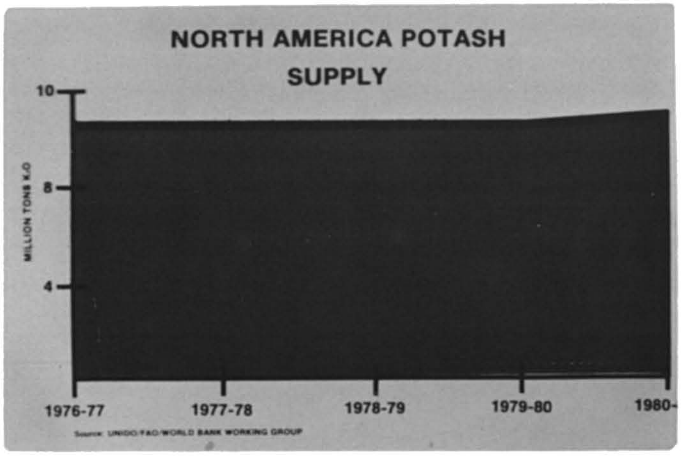
(TONS K_2O)

FROM								TO
CANADA	UNITED STATES	FRANCE	West Germany	East Germany	U.S.S.R.	ISRAEL	Total From All Countries	
4,220	–	25	25	0	25	64	4,358	UNITED STATES
59	37	694	922	510	560	268	4,358	W. EUROPE
0	0	7	48	1,500	1,581	3	3,138	E. EUROPE
400	285	83	145	84	103	15	1,186	LATIN AMERICA
1,295	163	103	134	174	265	49	2,193	ASIA
47	242	1	5	27	20	43	316	OCEANIA
6,026	763	1,087	1,361	2,296	2,553	473	14,719	WORLD

Source: BRITISH SULPHUR CORP.

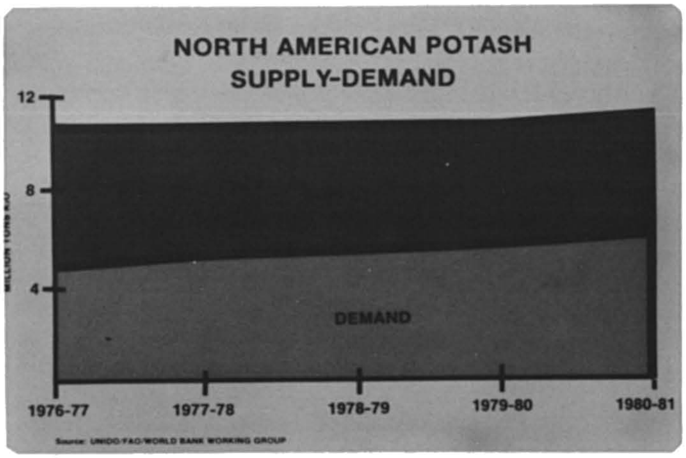
The largest potash sales in 1974 were:
Canada to United States
Russia to Eastern Europe
East Germany to Eastern Europe
Canada to Asia
West Germany to Western Europe

Russia is reported to be probing the U.S. market for future sales of both standard and granular potash.



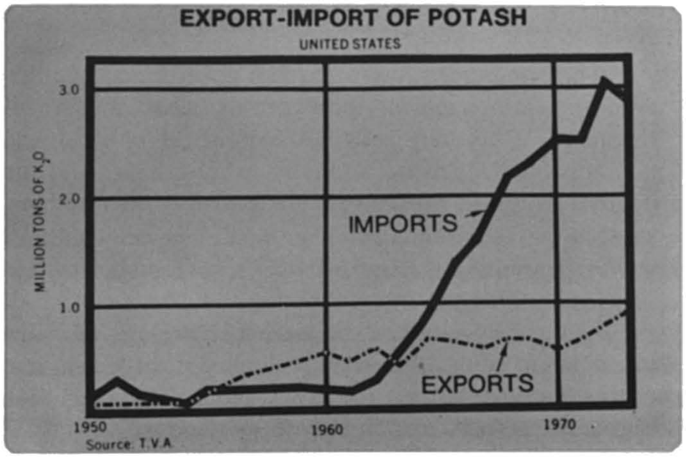
Source: UNIDO/FAO/WORLD BANK WORKING GROUP

North American potash production is blunted by the dwindling reserves in the Carlsbad area, the Saskatchewan situation and limited other economic reserves. In North Dakota, taxes aside, potash production would be more expensive than in Saskatchewan because of ore depth and thinner, less contiguous ore deposits. The potential is not great for very large reserves in New Brunswick.



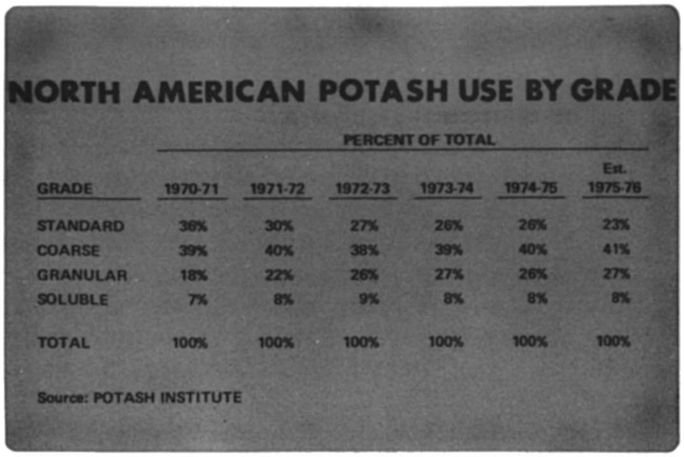
Source: UNIDO/FAO/WORLD BANK WORKING GROUP

North American demand is projected to increase 1.0 million tons while supply remains constant to 1980-81. 5-7 million tons K2O will be available for overseas markets.



Source: T.V.A.

Although North America is a 'have' potash continent, U.S. is a 'have not' potash nation with unlikely prospects otherwise. U.S. can expect increasing supply-price pressures from countries having strategic materials.



NORTH AMERICAN POTASH USE BY GRADE

GRADE	PERCENT OF TOTAL 1970-71	1971-72	1972-73	1973-74	1974-75	Est. 1975-76
STANDARD	36%	30%	27%	26%	26%	23%
COARSE	39%	40%	38%	39%	40%	41%
GRANULAR	18%	22%	26%	27%	26%	27%
SOLUBLE	7%	8%	9%	8%	8%	8%
TOTAL	100%	100%	100%	100%	100%	100%

Source: POTASH INSTITUTE

North American potash use by grade has changed slightly, and may change more. The use of granular potash results in more homogeneous blend mixture than does use of most coarse grade potash: however, many blenders use coarse grade. Farmer and state control officials' pressure for more uniform blend mixtures may cause more blenders to use granular potash as well as granular nitrogen and phosphate materials. The need for uniformity of particle size has been reported many times at the Round Table. So much for potash.

Gentlemen, we are now in the midst of the fall fertilizer season. Soon it will be corn planting time. Contrary to the turbulent past three years, we are entering a period or reasonable supply-demand balance. There may be short duration shortages or occasional bargains.

However, the opportunity to make large inventory profits or the danger of serious inventory losses are not likely. The situation calls for adequate inventories and aggressive salesmanship.

Gentlemen, may the 1976-77 season be a successful one for each of you. Thank you. *(Applause)*

MODERATOR GRAU: Are there any questions for Rodger?

QUESTION: Will you have copies of this paper available?

MR. RODGER SMITH: I don't have any here now. If you want to write me, I will send you one. Of course, it will be printed in the Proceedings at some later time.

MODERATOR GRAU. I would comment that the thing which strikes you from the presentation, and which I agree with, is that the raw material nature of the United States is a little frightening because we do have limited rock reserves in Florida. They will run out and it's going to take a lot of incentive to develop lower grade rock reserves. Natural gas costs are going up and, of course, what gets involved with the energy policy of this country is that we have to utilize the coal reserves that we have. So the balance of power is shifting, if you will, a little bit, and we're not quite as raw material rich as we once were. Rodger, thank you very much.

MODERATOR GRAU: Our next speaker is Anthony J. Skul who is manager of transportation for CF Industries. We've just heard about supply-demand for NPK, specifically for the coming year. I personally believe there will be a transportation nightmare next year so this is a subject that is of special interest to me.

Tony has been associated with the CF system for 18 years. Prior to that he worked for the Illinois Central Railroad in the freight traffic department in Chicago. He attended the College of Advanced Traffic in Chicago and studied interstate commerce law at Bradley University in Peoria, Illinois. He is a member of the executive transportation committee of the National Council of Farmer Cooperatives and chairman of the water subcommittee for The Fertilizer Institute. Tony is married, has three children and resides in Oak Lawn, Illinois. It is a real pleasure to welcome Tony Skul. *(Applaus)*.

Transportation As It Applies To Fertilizer Shipments

A. J. Skul

Transportation equipment plays a vital role in the fertilizer industry. To have a successful year — means to deliver products to the customer when it is needed.

Profits are usually measured by sales volume. Sales volume is directly related to a company's distribution system, with the final link in that system being transportation.

Each year, as industry increases production to meet the market demand, we are faced with increased challenges to deliver the product to our customers in peak seasons.

The use of larger scale farm equipment and changing tillage practices has worked to compress the amount of time available to deliver the ever-increasing quantity of fertilizer materials demanded by the farmer.

Weather, market prices and grain shipments are some very important factors that affect the fertilizer industries' ability to deliver product.

Because of the peak market demands for fertilizer — transportation equipment — or perhaps I should say the shortage of equipment — becomes a rather emotional subject, because of the problems associated with railroads and motor carriers in supplying the required equipment.

I will spend most of my allotted time on the subject of railroads, because they seem to have the most equipment problems and the fertilizer industry relies so much on their performance.

But first, let's briefly review water transportation and trucking.

It has been my experience that the fertilizer industry has had very few periods when there has been a shortage of barge equipment.

The natural flow of grain to the Gulk ports for export, provides our industry with opportunities to avail itself with low-cost barge transportation for northbound fertilizer.

However, if the railroads have their way, taxes in the form of user charges, will increase barging costs substantially.

There has been a long debate about the pros and cons of waterway user charges — and I don't intend to spend any time on this highly controversial subject — but I will say that it is my opinion that the railroads objective in supporting user charges is to create much higher barging costs, so that the railroads can continue to increase freight rates without fear of losing business.

For motor carriers — There are so many carriers throughout the country that it would be very difficult to develop meaningful equipment availability. For dry bulk fertilizer — dump trucks are interchangeable and are used for fertilizer and many other commodities. Usually, the motor carriers do a pretty good job meeting the dry bulk shipping requirements.

Some of the more specialized equipment, such as ammonia trailers, will always be in short supply in the spring, because of the severe market demand for such a short shipping season. Economics dictate that motor carriers cannot supply high cost specialized equipment and perhaps only utilize that equipment for two or three months of the year.

There are opportunities to substitute tank cars for trucks in the spring for the peak demand period, but rail service in most rural areas is poor and many times rail cars end up being used for storage tanks, which effects the utilization of equipment.

There does not appear to be a readily available solution to this problem because of the high costs associated with ammonia storage at the retail level. For the foreseeable future, I am afraid we will all be faced with the transportation crunch for spring ammonia deliveries.

For dry bulk fertilizer, our industry is highly dependent on railroad equipment to move our products.

Potash, for example, is almost entirely dependent on the railroads because of the land-locked location of the potash mines in relation to the market areas.

The railroads serving the potash mines have enough equipment to serve the industry requirements, except in the spring and usually during the fall. The Santa Fe Railroad, who serves the potash mines in Carlsbad, now have enough equipment to meet the car supply demands.

Years ago, before the development of the Canadian Potash Mines — we faced car shortages every spring and fall in Carlsbad.

Because production has been reduced in Carlsbad, railroad car supply can now meet the demand.

In Canada, the potash mines are served by CP Rail and the Canadian National Railroads. There are 10 potash mines competing for equipment at the same time. CP Rail will have about 3,500 covered hopper cars available for spring, while the Canadian National will have about 5,000 cars.

The Canadian railroads will build up their basic potash fleet to 8,500 hopper cars in the spring by diverting cars from other commodity service such as grain. In Canada, because of the low revenue derived from grain — the railroads will not purchase hopper cars for grain. Grain is a heavy volume commodity and hopper cars are generally interchangeable with fertilizer, which provides for better utilization of equipment.

However, in Canada, the railroads rely upon the government to purchase hopper cars for grain and the railroads only use its cars for grain when they are in surplus. Potash is a good source of revenue for the Canadian railroads and ownership of hopper cars is justified on the basis of car utilization.

The Canadian railroads state that they do not make money hauling grain, therefore, potash revenues alone must support the acquisition of equipment.

The Canadian railroads have also stated that they will not purchase any more equipment for potash in order to meet the peak shipping periods. Their studies indicate that additional hopper cars would only generate three moves per car per year.

From this attitude, one can conclude that the potash industry is at its peak shipping capability — under the present marketing system. Car supply is not going to improve — car shortages will continue each spring and fall.

There are some companies that use short-term marketing approaches to help reduce the peaks; such as, private cars — some of which are pre-loaded and stored in transit to provide service to its customers during peak season.

Intermediate storage is also used, but this transfers the car supply problem to another area, although if the storage point is located near the use market, trucking is available.

Turning to phosphates, the largest concentration of shipping facilities are located in the Florida Bone Valley, all of which are served by the Seaboard Coast Line Railroad. There are 13 chemical plants and 17 phosphate rock facilities requiring equipment.

The SCL system has approximately 16,000 covered hopper cars in its fleet. However, these cars are also used for grain and other bulk commodities.

As in potash, it's the peak phosphate shipping periods that give us the car supply problems. The SCL is usually short of equipment each spring and fall.

The SCL philosophy for additional equipment is the same as the Canadian railroads — they will not acquire cars for peak periods.

In addition to the 30 Florida phosphate shipping facilities that compete for covered hoppers, our industry must also compete with the grain industry for these same cars.

This compounds the car supply problem. The SCL now has under its control, the Louisville and Nashville RR, Clinchfield RR, Georgia RR, Atlanta and Westpoint RR and the Western Ry of Alabama railroad, referred to as "the Family Lines."

There is a great amount of grain produced in the regions served by this system and whenever grain begins to move in large quantities — the SCL can expect pressure from the Interstate Commerce Commission to supply cars for grain, because of prior pressure from congressmen.

What this does is to reduce the availability of cars for phosphate — because the ICC says railroads must treat industries equitably in the distribution of equipment.

As you can see, the U.S. philosophy for grain car distribution is different from that in Canada, where the Canadian government owns several thousand grain cars.

It does not appear that the SCL will purchase additional equipment for peak season phosphate movements. So, in my opinion we will continue to have car problems during peak shipping periods in Florida.

I have selected potash and phosphates as examples of our industry's car supply problem.

The same peaking problem exists in all parts of the country — we face car shortages now and will continue, unless some action is taken either by the fertilizer industry or perhaps the government. I don't believe the railroads will ever solve our car problem.

The most obvious solution to the car problem is for the railroads to acquire more cars. But let's look at some facts.

The President of the Association of American Railroads on September 29th, was quoted as saying that the U.S. railroads have added over 50,000 covered hopper cars to their fleets since the Russian grain purchase in 1972.

He also stated that there was no car shortage and that there was a surplus of 10,000 to 12,000 grain cars at all times during the last 2-1/2 years.

The next day a spokesman for the Illinois Central Gulf said, "that statement just is not realistic." In Southern Illinois — a grain terminal reported they are only receiving 11 percent of the cars ordered and that 155,000 bushels of grain were stored on the ground because of a lack of equipment.

We were told by the SCL that they were only able to furnish 50% of the grain car orders and 50% of the phosphate car orders. Other Midwestern railroads also were reporting car shortages.

What about the 50,000 additional hopper cars. No mention was made of the number of hopper cars retired or out of service for repair — a review of the latest statistics on railroad car ownership shows the present railroad owned covered hopper fleet to be about 157,000 cars.

On January 1, 1973, the railroad covered hopper car ownership was 142,000 cars — for a difference of only 15,000 additional hopper cars, and not 50,000.

Let's compare hopper cars awaiting repairs. On January 1, 1973 there were 5,000 bad order cars awaiting repairs, making the serviceable hopper car fleet about 137,000 cars.

The bad order ratio appears to be so bad that the AAR has quit reporting statistics to the public.

The last bad order report that I saw was dated January 1, 1976. At that time there were over 10,000 covered hopper cars awaiting repairs.

Assuming that there are still 10,000 hopper cars out of service, this reflects a present serviceable hopper car fleet of 147,000 cars — only 10,000 more serviceable cars than on January 1, 1973.

During the same period, shipper owned or leased hopper cars increased from 50,000 to almost 71,000 cars, for an increase of 21,000 cars, twice the amount of the railroads' growth.

I believe this is an indication that bulk shippers believe that the railroads are not about to solve our car supply problems.

Enough for car problems — what can we do about it?

1. Our industry can increase its hopper car fleet — but this can be a problem because some railroads will only accept private cars during peak shipping months and cars must be leased for longer periods of time.
2. Under the Railroad Revitalization Act, the railroads can publish seasonal rates. If there are incentives published for off-season shipments, perhaps this will help reduce the peak shipping period.
3. Perhaps a national fleet of government owned hopper cars should be established for use by the railroads during peak periods at some fair rental rate.
4. Another alternative, is a program CF Industries has been involved in for the past five years called our Uniform program. For those of you who are not familiar with this program, it is an attempt to ease peak fertilizer shipping demands by establishing increased warehouse capabilities at the local level, or as close to the farmer as possible.

How can this be accomplished? There's really only one way and that's through incentives and by incentives, I am talking about *DOLLARS.*

This incentive program identifies the cost of local storage at a certain cost per ton, with the realization that if this increased capital investment at the local level is made and written off over a three-to-five year period, there can be some very specific savings for the fertilizer producer.

At the same time, obviously, with this increased local storage, there is a great deal more flexibility in handling the large volumes of fertilizer required to meet the service demands of CF Industries' member cooperatives. Also, the local outlet, by buying throughout the year, is able to take advantage of off-season prices for added savings. In the past five years, CF has paid out some $17 million to members. During this same period, our members have added an estimated one million tons of incremental storage at the local level, or approximately double the storage they had available at the start of the Uniflow program.

Pause

In summary then — let me say that I do not see the railroads solving our peak shipping problems. Further, through railroad opposition to the construction of Alton Locks and Dam 26 and support of waterway user charges, they will only compound our shipping problems.

In 1975, the average weight per carload of freight was 61 tons. The average daily movement per car was only 53.6 miles. Faced with this type of operation, plus the fact that rail service has deteriorated in rural areas, the only conclusion I can come to — is that the fertilizer industry will need to control more of the transportation function or we will be faced with more severe equipment problems as the market for fertilizer increases.

Thank you for your kind attention. *(Applaus)*

MODERATOR GRAU: Thank you Tony for your up to date report on "Transportation as it applies to fertilizer shipments."

MODERATOR GRAU: It is a real pleasure for me to introduce our next speaker. Ray Yates has been involved in the potash business for some 20 odd years that I know of. He left the industry briefly for a four year period before coming back. He is currently vice president of sales for Kalium Chemical, headquartered here in Atlanta. Ray is a native of Virginia and has a degree from the University of Virginia. He is very knowledgeable about the current potash situation as it relates to not only supply-demand but the political nightmare that is ever present involving the government of Saskatchewan up in Canada. It is a real pleasure for me to introduce Ray Yates. *(Applause)*

North American Potash Supply

O. Ray Yates

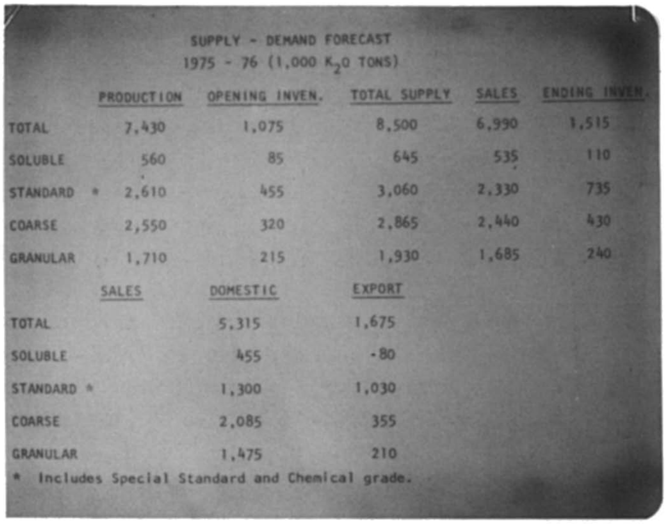
I was originally asked to talk with you today on Canadian potash supply. Feeling that you gentlemen are more interested in the supply picture from *all* North American sources, my remarks will encompass the entire North American potash industry. During the 1975/76 fertilizer year, Canada supplied about 73.5% of the total U.S. demand, but United States sources, principally Carlsbad producers, did supply most of the balance of about 26.5%.

Time today will not allow covering much of the history of our North American industry, so I will confine my remarks to 2 time periods, namely, what has happened during the last 15 months (since the start of the 1975/76 fertilizer year beginning July 1975 *through* the first quarter of the 1976/77 fertilizer year (in other words through September 1976). This recent history brings us to where we are today, and, then I will indicate what we forecast happening October 1976 through June 1977 (the period of roughly 9 months remaining in this fertilizer year). The figures of what has happened are reasonably accurate, but the figures dealing with the next 9 months are "crystal gazing" but they are generally compatible with those of the Potash Institute who historically have been the best of all potash forecasters. The Potash Institute does not forecast grade usage, and the figures to be given later, by grades, are our projections based on historical data and recent trends.

I will indicate to you the opening inventories for each of these periods *plus* production and expected production, known as total supply, *against* sales and expected sales during these periods, thereby arriving at ending inventories and expected ending inventories.

Demand for potash is, as you know, for specific grades of potash, and my illustrations will deal with availability and demand for the most commonly used agricultural *grades* of muriate, namely, soluble or fine grade, standard grade, coarse grade and granular grade. Industries other than agriculture consume muriate of potash, and these usages are included in the total figures.

You will recall the period encompassing 1-1/2 to 2 years ending in early March of 1975 during which producers of primary plant food elements and fertilizer experienced much higher than normal demand, and all were essentially shipping from production. This period was also characterized by fear-of-shortage buying and rapidly rising prices. Prices of notrogens, phosphates and to a lesser extent potash rose sharply during this period, particularly to offshore buyers. In March of 1975 excessive inventories had been accumulated by fertilizer manufacturers, dealers and even farmers, and with the recognition that adequate supplies were available, buying demand in North America and the rest of the world slowed dramatically for the primary plant food elements including potash.



SUPPLY - DEMAND FORECAST
1975 - 76 (1,000 K_2O TONS)

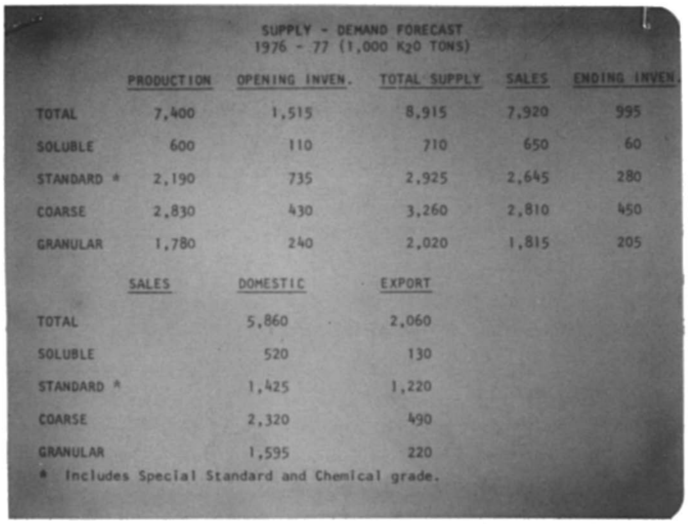
	PRODUCTION	OPENING INVEN.	TOTAL SUPPLY	SALES	ENDING INVEN.
TOTAL	7,430	1,075	8,500	6,990	1,515
SOLUBLE	560	85	645	535	110
STANDARD *	2,610	455	3,060	2,330	735
COARSE	2,550	320	2,865	2,440	430
GRANULAR	1,710	215	1,930	1,685	240

SALES	DOMESTIC	EXPORT
TOTAL	5,315	1,675
SOLUBLE	455	-80
STANDARD *	1,300	1,030
COARSE	2,085	355
GRANULAR	1,475	210

* Includes Special Standard and Chemical grade.

Slide 1
Supply-Demand Forecast
1975-76 (1000 K20 Tons)

Please notice that the total North American producer inventory on July 1, 1975 was about 1,075,000 tons K_2O or 1-3/4 million product tons. Production during 1975/76 totaled 7,430,000 tons K_2O or about 12-1/4 million product tons of which about 35% was standard grade. You will also notice domestic and export sales totaled only 6,990,000 tons K_2O. Thus inventories increased during the year by about 440,000 tons K_2O. Standard grade inventory, somewhat excessive at the start of the 1975/76 fertilizer year, coupled with declining deliveries both domestically and offshore during the year, accounted for 280,000 tons K_2O or roughly 65% of the total 440,000 tons K_2O inventory increase. Standard grade was actually the only grade in significant excess supply as we entered the present fertilizer year. Price declines in all plant food elements characterized the market at beginning and throughout the 1975/76 fertilizer year to the extent that buyers who were caught with excessive and high cost inventories in the spring of 1975 were determined to be void of inventory at the end of the spring movement in 1976. Consequently, the entire buyer "pipeline" was extremely low as we entered the present year.



SUPPLY - DEMAND FORECAST
1976 - 77 (1,000 K_2O TONS)

	PRODUCTION	OPENING INVEN.	TOTAL SUPPLY	SALES	ENDING INVEN.
TOTAL	7,400	1,515	8,915	7,920	995
SOLUBLE	600	110	710	650	60
STANDARD *	2,190	735	2,925	2,645	280
COARSE	2,830	430	3,260	2,810	450
GRANULAR	1,780	240	2,020	1,815	205

SALES	DOMESTIC	EXPORT
TOTAL	5,860	2,060
SOLUBLE	520	130
STANDARD *	1,425	1,220
COARSE	2,320	490
GRANULAR	1,595	220

* Includes Special Standard and Chemical grade.

Slide 2
Supply-Demand Forecast
1976-77 (1000 Ton K20 Tons)

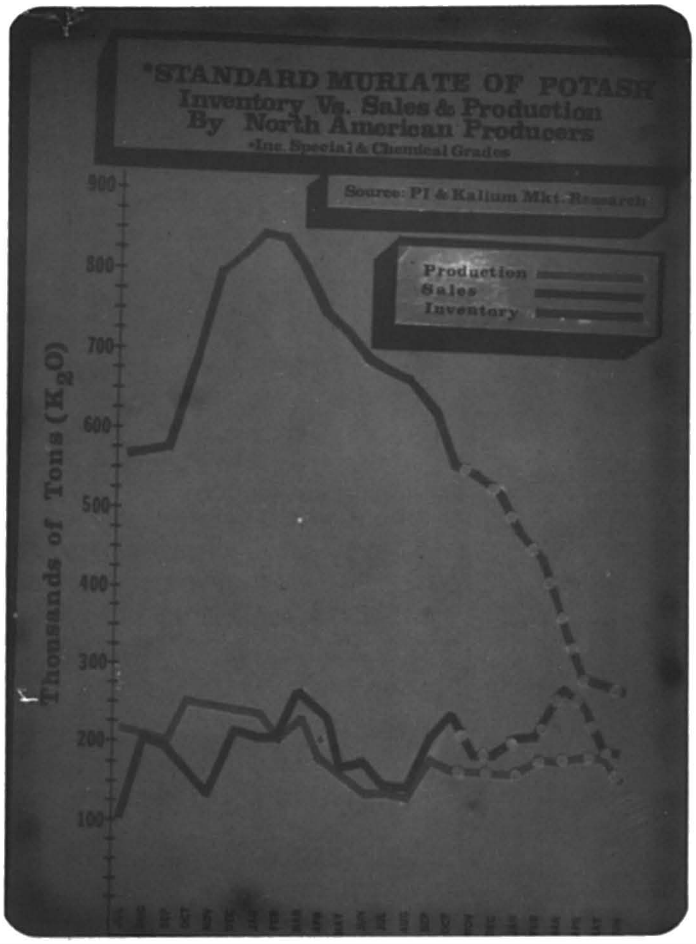
The slide now in view shows the total expected potash availability from North American sources (i.e., opening inventory plus expected production) for the present year.

The expected production figures are derived by using past data and trends. Please notice, however, that if sales and production should coincide with this forecast, sales would exceed production by 520,000 tons K_2O, resulting in a very workable inventory level.

Also please notice the expected sharp drop in standard grade inventory during the year. This is mainly attributable to the return of stronger offshore demand as many foreign countries have worked off their surplus inventories of last year. About 60/65% of North American potash exports are expected to continue to be standard grade.

Also, notice that standard grade production is expected to decline as producers adjust to the larger demand for blending grades.

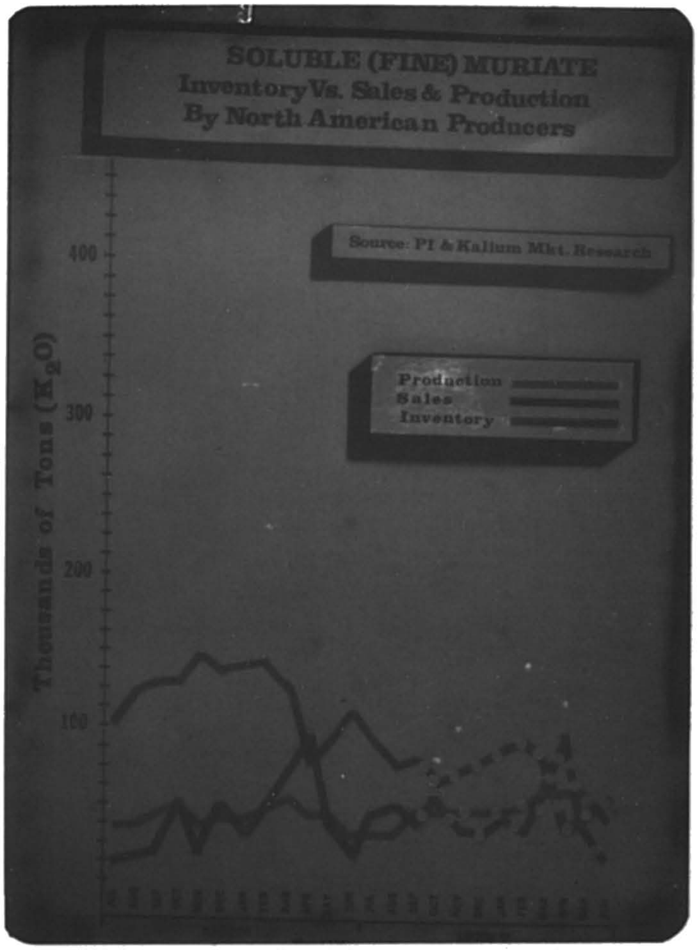
Let's talk now about the individual grades of muriate.



Slide 3
Standard Muriate Potash

The slide now in view shows production, sales and inventory of standard grade muriate beginning July 1975 through June 1977 (2 years).

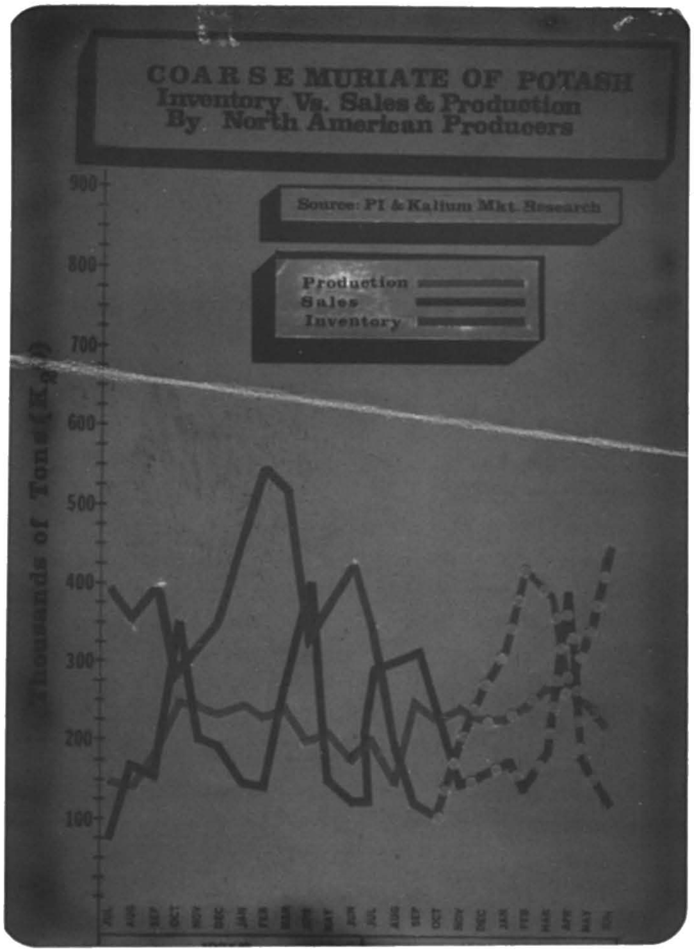
You will notice inventory of this grade peaked in February 1976, and today is actually lower than in July 1975. Standard inventory is falling at an average rate of about 40,000 tons a month and is expected to be only about 280,000 tons K2O at year end.



Slide 4
Soluble (Fine) Muriate

Notice production of soluble or fine grade has been rather constant and is expected to follow this pattern through next June. Demand for soluble this year is expected to increase about 20% over last, dropping the expected July 1977 inventory level to about 60,000 tons K2O. Production can be increased as demand requires.

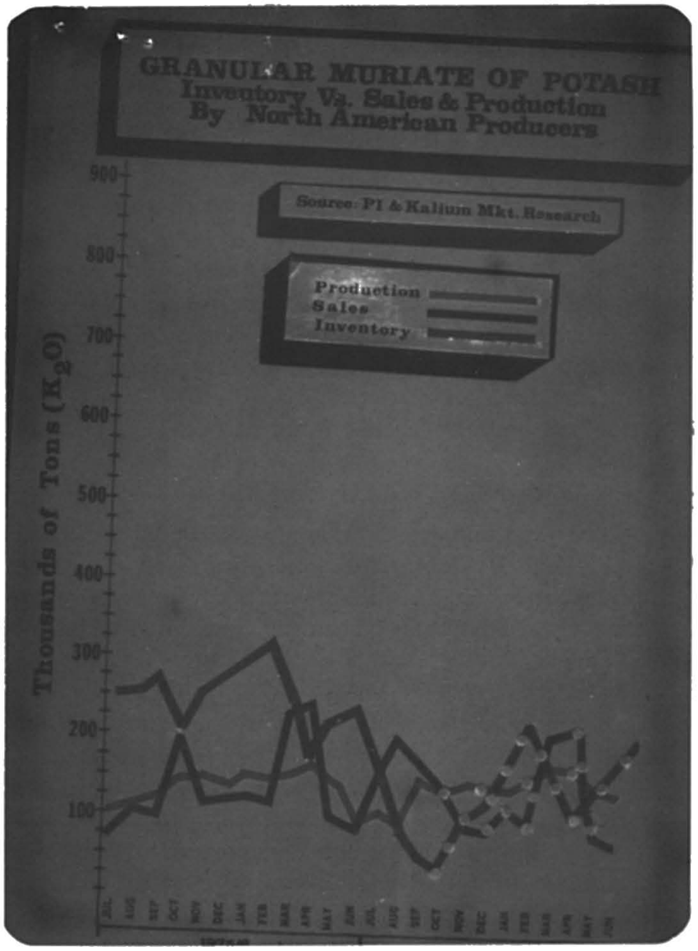
Now to the so-called blending and direct application grades.


COARSE MURIATE OF POTASH
Inventory Vs. Sales & Production
By North American Producers

Source: PI & Kalium Mkt. Research

Slide 5
Coarse Muriate of Potash

This slide indicates the very seasonal demand for coarse grade muriate and a consequent wide variation in inventory level. It further indicates sufficient product availability for the year and that we are now at the lowest expected inventory level of year. Sales are estimated to increase for the year by about 15% but added production capability is expected to more that offset this increased demand.


GRANULAR MURIATE OF POTASH
Inventory Vs. Sales & Production
By North American Producers

Source: PI & Kalium Mkt. Research

Slide 6
Granular Muriate of Potash

This final slide on granular grade muriate shows a pattern very similar to coarse grade — strong seasonable deliveries, with production showing a gradual increase trend. As with coarse grade, we project we are presently at the lowest inventory level of the year. Sales are expected to increase over last year by about 8% — production up about 4%. We expect adequate supply to be available against demand, however, a tight supply situation could develop at times during the spring.

Summarizing, it would appear there will be ample quantities of all grades of muriate of potash to accommodate demand through the spring of 1977. There is however a possibility of limited availability of both granular and coarse during the spring. Standard and soluble grade inventories are expected to be reduced to normal levels.

It would be unfair however, if I did not caution you in 2 vital areas. First, with the expected strong demand for potash next spring, the question as to whether adequate transportation equipment will be available is very pronounced. We encourage you to take potash steadily, whenever your storage facilities allow. Certain studies reveal the Canadian industries that compete with the potash industry for rail cars were noticing below normal activity during last spring, but it is now indicated that these same industries have resumed normal activity, thus leaving the adequacy of potash rail equipment much in question.

Second — the production figures that I have shown you today consider all producers operating at an expected normal rate of production. However, in the last 10 years there have been few if any years that 1 or more sizable North American production was not adversely affected by some unforeseen occurrence. Also, temperatures and excessive rainfall have adverse affects on production of certain U.S. potash companies.

It has been a pleasure to be with you today. *(Applause)*

MODERATOR GRAU: Thank you Ray.

The next subject is "The International Fertilizer Development Center's Data Processing System and Its Role in Supplying Fertilizer Research and Development." Dr. Paul Stangel, who was scheduled to be the next speaker, unfortunately had a conflict. This presentation will be made by Mr. Donald Waggoner who is a chemical engineer by profession in the outreach division of the International Fertilizer Development Center.

There will be a live demonstration showing a data system following the outline of what is presented this morning after the afternoon session. Mr. Waggoner. *(Applause)*

The International Fertilizer Development Center's Data Processing System and the Role in Supplying Fertilizer Research and Development

Prepared by:

D. R. Waggoner - R. L. Booth
M. T. Frederick

Discussion by D. R. Waggoner

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I. *SYSTEM OVERVIEW*

The IFDC World Fertilizer Information System consists of various computer packages (computer programs and databases) developed or planned by the IFDC staff. These programs and datafiles are primarily intended to provide pertinent and timely information to aid companies, government agencies, and financial institutions involved in the supply, consumption and policy aspects of fertilizers as well as meet the internal needs of IFDC research and outreach activities. The system will provide the following data when completed: analysis of fertilizer raw materials reserves; calculation of capital expenditure estimates for fertilizer complexes; and market analysis statistics concerning the production and consumption of fertilizer. These data are first accumulated for IFDC use, but will be available on a fee basis to interested parties from the computer network or by mail from IFDC.

Presently the system is capable of estimating capital investment required and assessing economic feasibility in the early stages of project planning. The raw materials database and market intelligence portions of the system are under development and will be available in the near future.

In addition to those services mentioned, IFDC plans to expand the system to include information packages on material transportation and agronomic-economic data for developing economies (figure 1).

II. *PURPOSE FOR DEVELOPING THE SYSTEM*

During the past decade we have all witnessed the drastic and damaging price fluctuations in the world fertilizer market for final products and raw materials, as well as increases in capital investment requirements (figures 2 and 3). As a result of these cost fluctuations, companies and governments engaged in fertilizer marketing and development have been groping for accurate information on which to base decisions or plan future strategies. Improved data on the movement of fertilizer and fertilizer raw materials in world trade are important for the individual who formulates marketing policies and strategies for his organization.

The need also exists for quickly available and accurate information in planning for new production capabilities. Fertilizer production projects require extensive preinvestment studies to arrive at a project proposal. Management has the option during this planning stage of either making an investment decision based on the limited available information or expending large sums (as high as $200,000 or more) on an in-depth feasibility study. Since the budget allocation at the initial stage of project conceptualization may be insufficient to finance an in-septh project feasibility study, managers often have been faced with the realities of making a preliminary feasibility decision based on the limited information at hand. Because this lack of information has harmed world fertilizer production, IFDC has conceptualized and initiated the World Fertilizer Information System.

III. *FERTILIZER RAW MATERIALS PACKAGE*

The world supply for many fertilizer raw materials is concentrated in a few locations. The world phosphate market is controlled by a relatively small number of countries; 80% of the world potash supply is provided from three locations, and common feedstocks for nitrogen fertilizers come from a relatively small number of locations.

As a result of the monopoly market which exists for certain fertilizer raw materials, many countries have begun to look to the use of indigenous materials to supplement what must be brought from outside (figure 4).

IFDC has begun working on a data package to include information on raw material reserves (particularly phosphate rock) used in production of fertilizers. This package will consist of information on the location of fertilizer mineral resources; detailed mineralogical information including the extent of the deposit and quantity and quality of reserves; current exploitation methods and uses; published literature references; and, where adequate information is available, a technical evaluation of the deposit. Similar natural resource databases are now in existence elsewhere, but none are tailored specifically to fertilizer use.

IV. *INVESTMENT ANALYSIS PACKAGE*

The capital investment analysis package is composed of computer programs and datafiles used to estimate and evaluate capital expenditure requirements for various types of fertilizer installations. This package is intended to assist private and public sector management, financial institutions, research organizations, and government agencies in planning investment strategies (figure 5).

The investment cost estimating program uses a specified country and three location-type categories to identify and calculate the costs of different locations, support facilities, and infrastructure. These categories are defined as follows: location type 1 — the plant is located in a highly industrialized area; location type 2 — the plant is located in an industrial area within a developing economy; location type 3 — the plant is located in a completely undeveloped location within a developing country. In this framework, investment evaluations are modified and escalated using available indices to correspond to each unique situation.

Flexibility and detailed information in the choice of site specific items adds to the usefulness of this program to decisionmakers at various locations. Maintaining current inputs and escalation factors is an ongoing effort in this program. As a result, this information will be constantly revised to ensure that the results stay abreast of economic developments.

Thirty processes dealing with the production of fertilizer with relatively widespread use have been identified for possible inclusion in this subcomponent. Data have been collected (as of October 1976) on eleven of the more common fertilizer processes (see table 1). The procedures for extracting and using the data are quite simple and will be explained later.

Investment appraisal subcomponent of the investment analysis package provides the capability of calculating estimated production costs and the internal rate of return on investment. Specifically, the subcomponent is set up to utilize the results of the capital investment program with the option to input other values for total investment if required.

The production cost program supplies the technical input coefficients which are normal for the process under analysis. Other required inputs include the total required capital expenditure (usually from the investment program) and unit cost of inputs (raw materials, water, electricity, etc.).

The program provides the option of designating a working capital or calculation of standard working capital using the above inputs. The result of this operation yields a total production cost per unit (averaged over estimated plant life), with transfer cost (exclusive of depreciation and interest) if the product is an intermediate for further use. A breakdown of variable and fixed raw material costs is also included; along with the other totals. Inventory costs for raw materials and products, as well as estimates of operating funds required, accounts receivable and accounts payable are given. Ex-factory prices are provided for simple return on investment and return on equity of 5, 10, 15, and 20 percent. The user can use the program for processes not included by IFDC through the option of supplying input coefficients, as well as the unit cost.

The remaining program contained in the investment analysis package is a financial analysis program which provides a three-part profitability analysis. Inputs required for this analysis can be derived from other programs in the system, including such entries as plant capacity, investment requirements, estimated plant life, working capital, construction period, interest payments, and estimated selling price. Using these inputs, the data is arranged in a tabular summary form with calculated values for depreciation, interest expense, and yearly production. The second stage of the program uses tabulated data to calculate yearly cash flows over the life of the plant. Finally, a discounted cash flow is provided with a calculation of internal rate of return.

The mechanism for these calculations is fairly standard and the critical requirement is to insure the practicality and reliability of the input data. The program provides a great deal of flexibility, with four options for calculating depreciation over the life of the plant: (1) straight line; (2) sum-of-digits; (3) and (4) two methods of declining balance.

V. *MARKET INTELLIGENCE PACKAGE*

Another service of the World Fertilizer Information System is the market intelligence subcomponent. This service is projected to be available for general use on a fee basis by mid-1977 and will contain information, generally no more than 90 days old, on the production, consumption, and market movement of fertilizers and fertilizer intermediates on a country by country basis (figure 6).

The information utilized in this system is being compiled from IFDC's contacts in various countries. Updating production/consumption information is to be accomplished on a quarterly basis to provide an unofficial, yet accurate and timely world fertilizer information source on international marketing and production activities.

IFDC's market intelligence package is being developed due to the influence of recent market fluctuations and the lack of availability of accurate, up-to-date information. Previous information on inventories, *et al.,* has been available but is, at times, as much as 15 months old by the time it is made available.

Ultimately most of the responsibility for obtaining market information will rest with the proposed IFDC satellite offices to be established in the developing regions of the world. These offices will serve as regional focal points for monitoring IFDC research and assistance programs and for feedback of statistical information to the international headquarters.

While these data are needed by IFDC for its own programs, this information can be of value to the world fertilizer industry. IFDC intends to prepare a quarterly report on market activities. It will also include short-term market projections.

The market evaluation report will also be available on a fee basis through the time-sharing network. For those who cannot easily access the computer network, the market report will be available in a published report entitled "Outlook" on a quarterly basis. While a fee will be charged to use programs and obtain information, the exact charges have not been determined. Fees will depend to a high degree on the cooperation of the fertilizer industry, various international agencies, and national governments. We can assure potential users, however, that fees will not be structured to make a profit.

VI. *ADVANTAGES TO USERS*

Potential users of the World Fertilizer Information System include companies, government agencies, financial institutions, research organizations and others interested in the fertilizer industry on a global basis. Easily available information on estimated costs, analysis of projects, and market data is important in making decisions. Managers must acquaint themselves with world market conditions affecting their products and supplies. Planners need better information on capital investment and operating costs for fertilizer production facilities when planning agricultural development strategies.

Despite its usefulness, IFDC World Fertilizer Information System cannot be a panacea for every purpose or every organization. The investment data is, by necessity, relatively general in nature. This program can only provide an improved "first-cut" at information needed by the decisionmaker to make a preliminary decision of a project's relative merits. This will enable management to weigh the merits of proposed projects and reach a more informed decision on whether to allocate the substantial funds needed to prepare a detailed project proposal.

The usefulness of the data will depend to some extent on the ease with which it can be accessed. To help ensure worldwide accessibility, IFDC has chosen to utilize a commercial timesharing system (G. E. Mark III® Service). This worldwide computer network utilizes a system of telephone equipment, satellites, and undersea cables to connect more than 500 cities in North America, Europe, the Far East, and Mexico to several large computer centers. With this system, the user in an access city is able to extract information through answering questions asked by the computer. Answers range from simple yes or no responses to providing input coefficients like interest rates, cost of labor, and others.

This system spans 18 of the 24 time zones around the world and may be reached via terminals through ordinary telephones from access cities. Plans for expansion of access cities are under evaluation for areas of South America, the Middle East, and Southeast Asia. With each network expansion, IFDC's database packages will become more accessible to developing countries (see table 2 for access cities).

The data system must be kept current in order to maintain its effectiveness. The Investment analysis and the Market Intelligence Packages include such maintenance plans. Indices used in the Investment model will be updated monthly with the historical base data being updated when IFDC's contacts with manufacturers, engineering companies, trade associations, financial institutions, and government agencies reveal that reported data are materially different from the true situation. Market intelligence data will be updated quarterly through a system of correspondents under agreements with IFDC.

Eventually, we hope this data gathering system can be reinforced through satellite offices. Although other fertilizer and related information is currently available from other agencies and companies, none has focused as directly on fertilizer inputs, outputs, and use in developing countries as IFDC. The purpose of the World Fertilizer Information System is to help fertilizer producers, users, and policymakers working in and for developing countries understand the intricacies of world fertilizer supply and demand.

If successful, this System can help to provide pertinent information to those most vitally concerned with feeding the world's people.

Table 1
Processes Identified for Inclusion in Investment Package

Product Name		Process Description	Raw Material
Ammonia	*	Steam Reforming (C.C.)	Natural Gas
		Steam Reforming (R.C.)	Natural Gas
	*	Steam Reforming (C.C.)	Naphtha
		Steam Reforming (R.C.)	Naphtha
	*	Partial Oxidation	Fuel Oil
	*	Partial Oxidation	Coal
		Coal Gasification	Coal
		Electrolysis	Water
Urea	*	Total Recycle Prill	Ammonia, CO_2
		Pan Granulated	
		Spheridizer	
Nitric Acid		Pressure — UHDE	Ammonia
		C & I Girdler	Ammonia
SCU		Sulfur Coating Drum	Urea, Sulfur, Wax Cond.
Sulfuric Acid	*	Sulfur Burning (High Rec.)	Sulfur
	*	Sulfur Burning (Low Rec.)	Sulfur
		Pyrites Burning	Iron Sulfide
Amm. Nitrate		Prilling	Ammonia Nitric Acid
Amm. Sulfate		Crystallization	Ammonia, H_2SO_4
		Crystallization	40% Amm. Sulfate
Phosphoric Acid	*	Dihydrate, Multi	Phosphate Rock, H_2SO_4
NSP (0-20-0)	*	Run-of-Pile	Phosphate Rock, H_2SO_4
TSP (0-46-0)	*	Direct Granulation	Phosphate Rock, H_3PO_4
		Run-of-Pile	Phosphate Rock, H_3PO_4
DAP X(18-46-0)	*	TVA Pre-Neutralizer	Ammonia, H_3PO_4
MAP (11-54-0)		Non-Granular (Powder)	Ammonia, H_3PO_4
		Pipe Reactor Melt	Ammonia, H_3PO_4, H_2SO_4
APP (11-57-0)		Direct Melt (No Dryer)	Ammonia, H_3PO_4
UAPP (28-28-0)		Direct Melt	APP, Urea
Bulk Blend		Rotary	NP, NPK

* Denotes processes now in the system.

Table 2
Access Cities

Australia

Adelaide
Canberra
Melbourne
Sydney

Austria

Linz
Vienna

Belgium

Antwerp
Brussels

Canada

Calgary
Edmonton
Hamilton
London
Montreal
Ottawa
Peterborough
Saint John
Toronto
Vancouver
Winnipeg

Denmark

Copenhagen

Finland

Helsinki

France

Amiens
Bordeaux
Brest
Caen
Clermont-Fnd.
L'Orient
Le Havre
Lille
Lyon
Marseille
Mauberge
Nancy
Nantes
Nice
Paris
Rennes
Rouen
Strasbourg
Toulouse

Germany

Cologne
Dusseldorf
Frankfurt
Hamburg
Mannheim
Munich
Sttattgart

Holland

Amersfoort
Amsterdam
The Hague

Ireland

Dublin

Italy

Bologna
Brescia
Florence
Genoa
Milan
Naples
Padua
Rome
Turin

Japan

Hiroshima
Nagoya
Osaka
Tokyo
Yokohama

Mexico

Mexico City

Norway

Bergen
Oslo

Puerto Rico

San Juan

Spain

Madrid

Sweden

Goteborg
Malmo
Stockholm

Switzerland

Geneva
Zurich

United Kingdom

Aberdeen
Birmingham
Cardiff
Edinburgh
Glasgow
Leeds
Liverpool
London
Loughborough
Manchester
Middlesborough
Newcastle
Reading
Southhampton

United States

412 Cities

South America,
Middle East,
and Far East

New access cities
are under evaluation

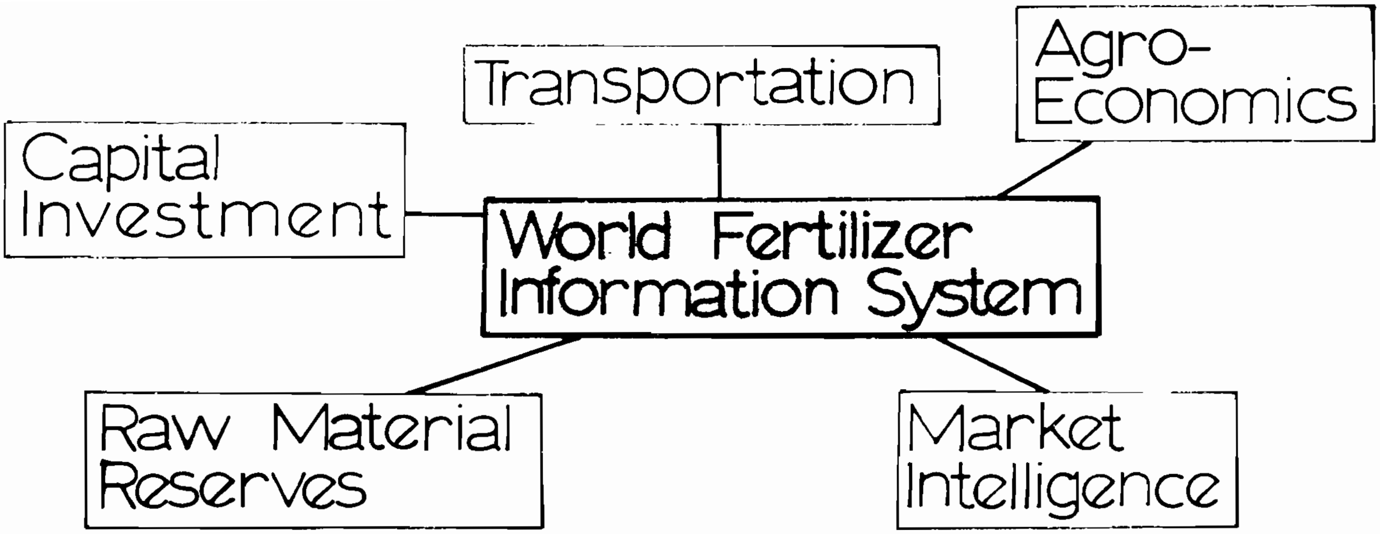


Figure 1.

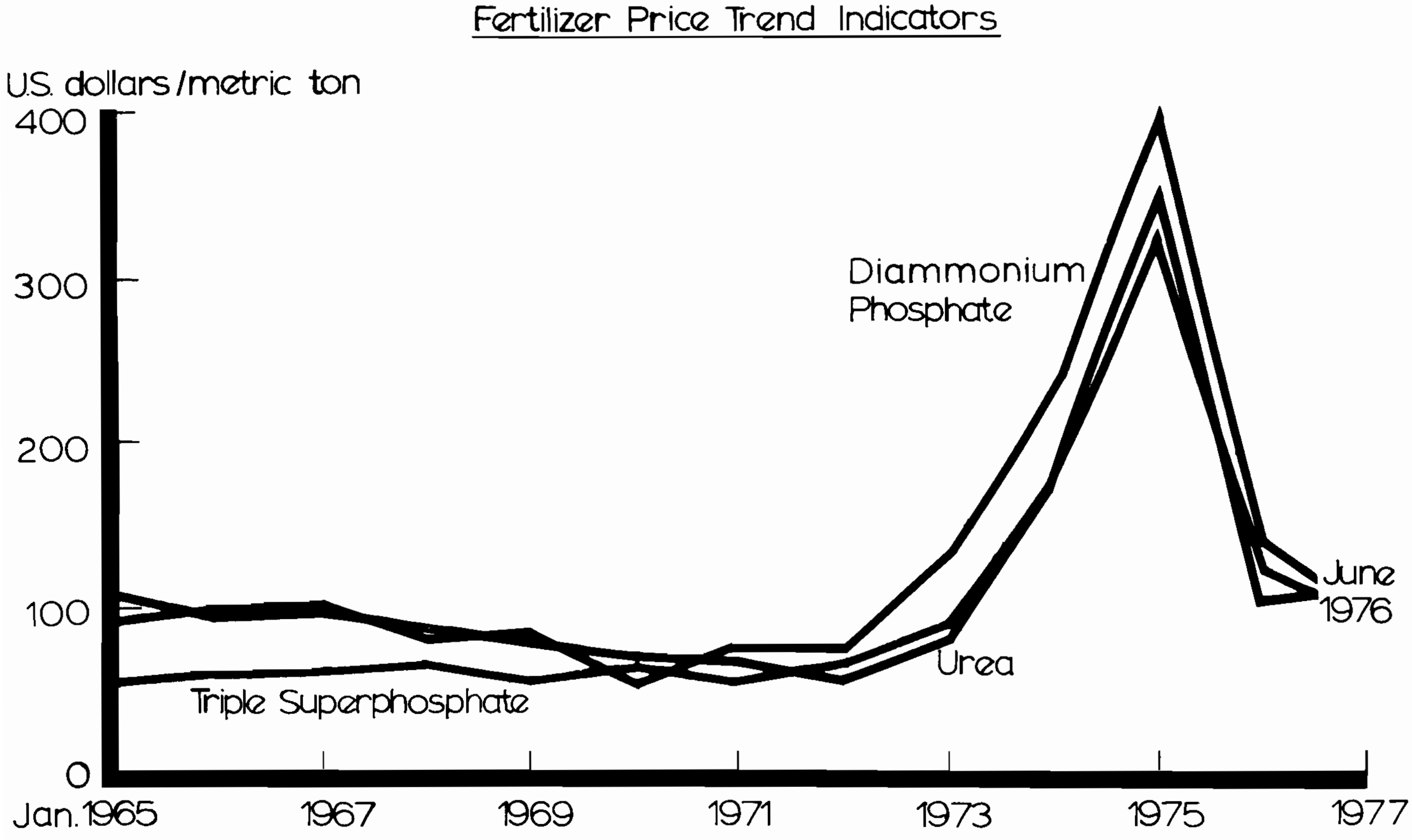


Figure 2.

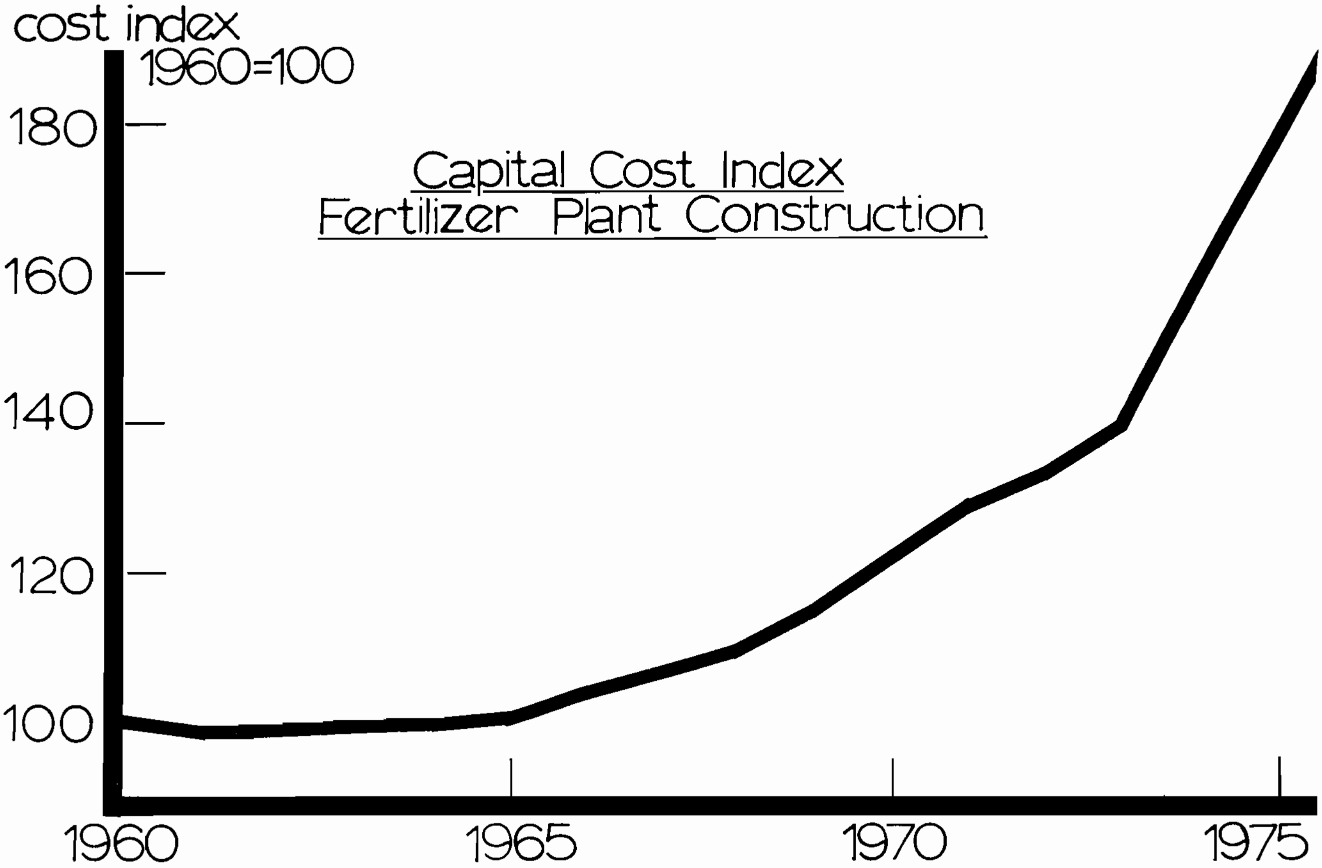


Figure 3.

Figure 4.

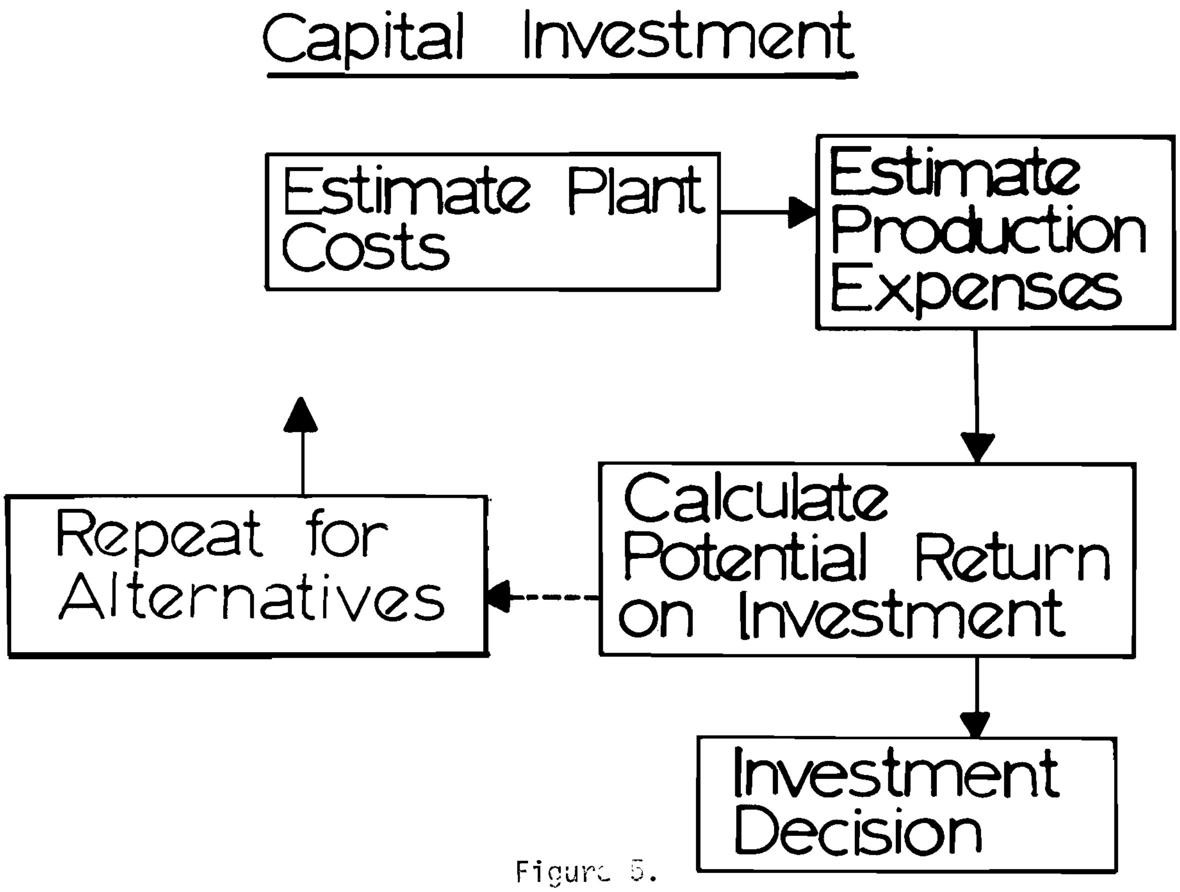


Figure 5.

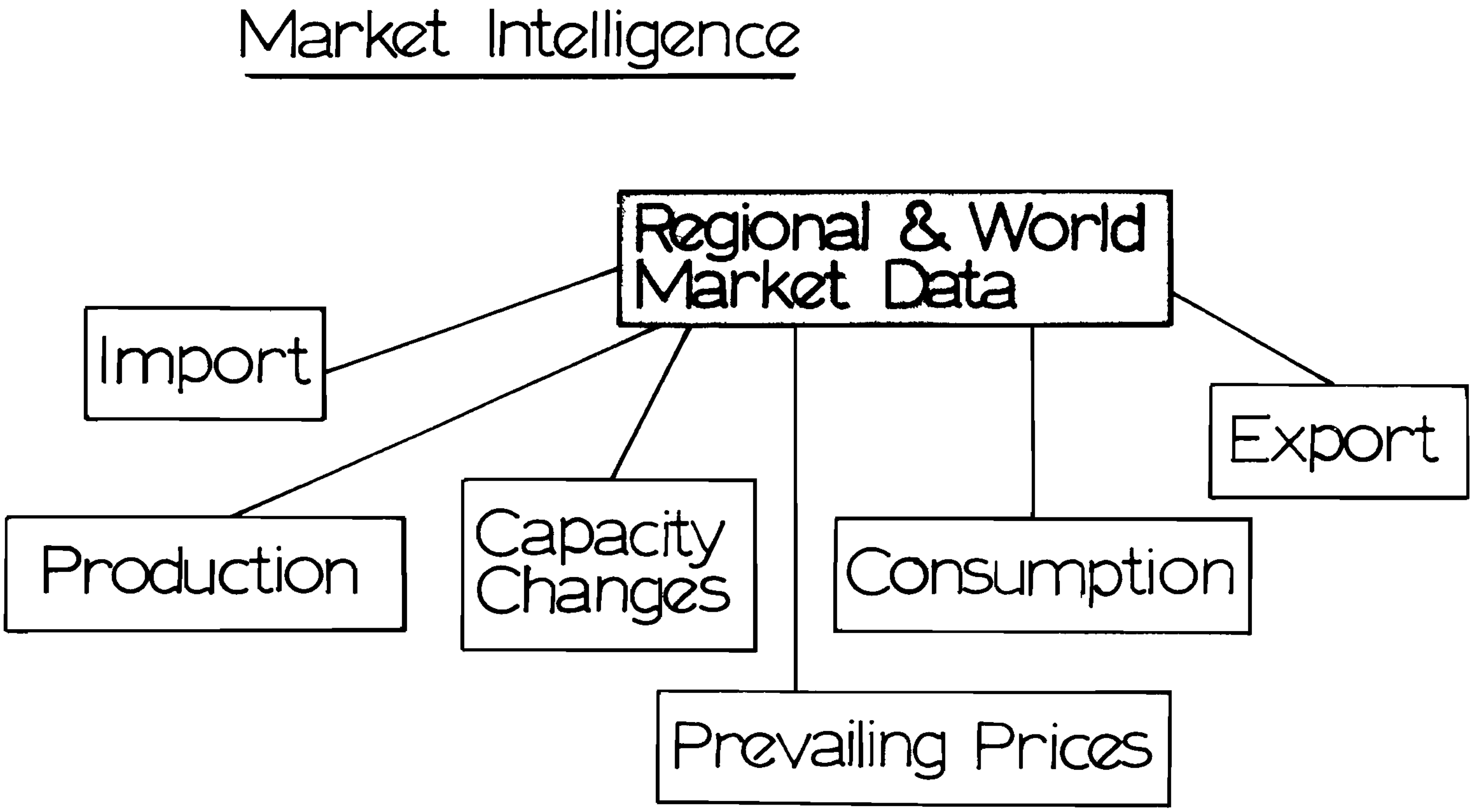


Figure 6.

MODERATOR GRAU: Boy, if they can get that thing down, and forecast the weather and the political situation we would really have something, wouldn't we?

Thank you Mr. Waggoner and Associates R. L. Booth and M. T. Frederick. Your discussion is most interesting. Your detailed "Paper", covering the IFDC Report "In Supplying Fertilizer Research And Development" will be very helpful to all of us in Fertilizer Production, Sales, Research, Users, Marketing, Financing.

Our Morning Session has been completed on schedule, 11:45 a.m. You will note our program for this afternoon session will start at 1:30 p.m. We have an excellent program scheduled including "A Panel Discussion Future Granulation Plants."

Thanks again to all of our speakers this a.m. *(Lots of Applause)*

Tuesday, October 26, 1976

Afternoon Session
Moderators:
Frank T. Nielsson
William E. O'Brien

MODERATOR NIELSSON: I am your moderator for the first part of this afternoon. We are getting down into the meat and potatoes or practical part of the session. Most people come here to see what is going on in a practical way so they learn how to solve some production problems.

The first part of this afternoon's session deals with fluid fertilizers. We are starting off with our main speaker Mr. Frank Achorn whom you all know as Mr. Solutions or Mr. Suspensions. He graduated from the Speed Institute of Technology at Louisville University in 1947. He tells us he was third in the class of three. So we're in good shape there.

He has been with TVA since '47. Years ago I worked at TVA. When I was a project leader on my first pilot plant Frank was one of my project engineers. I had wrestled in school; he had wrestled in school, and on the evening shift we used to make it two out of three. I don't know who won, but at least he's had an operation since then and I haven't, so I think I'm in better shape. Frank Achorn. *(Applause)*

Suspension Fertilizers 1976

Frank P. Achorn and Homer L. Kimbrough

Presented by Frank P. Achorn

During the past five years suspension fertilizers have become important in the fertilizer industry. It has been estimated that between one and two million tons of suspension mixtures (NPK) were produced last year. Suspension fertilizers are popular because of:

1. Relatively high analysis — about twice that of clear liquid fertilizers.
2. Ease of handling when compared to granular or pulverized mixed fertilizers.
3. Uniformity of application as compared to granular fertilizers. Because of this uniformity of application, a popular practice is to incorporate either micronutrients or pesticides in suspension fertilizers, and they can be applied uniformly across the entire swath of the applicator.
4. Fewer problems with air and stream pollution by fluid fertilizer plants than by granular mixed fertilizer plants.

Suspensions are defined as saturated solutions with crystals of plant nutrients and other materials suspended in the solution. Usually the suspending agent is an attapulgite-type gelling clay. Tests have shown that bentonite is also a good suspending agent.

The materials used most frequently in the production of suspensions are:

1. Anhydrous ammonia
2. Phosphoric acid (52-77% P_2O_5)
3. Ammonium polyphosphate solutions (10-34-0 and 11-37-0)
4. Urea-ammonium nitrate solution (28-32% N)
5. Prilled urea (conventional and microprill size, 45-46% N)
6. Crystalline ammonium sulfate (21% N, 24% S)
7. Granular phosphates
    - Diammonium phosphate, 18-46-0
    - Monoammonium phosphate, 11-55-0
    - Ammonium polyphosphate, 12-54-0
8. Solution-grade potassium chloride

Suspensions are made by hot-mix and cold-mix processes. The cold-mix process usually involves mixing a base material such as 10-34-0 solution, urea-ammonium nitrate solution, and potash at atmospheric temperature with no generation of heat. In the hot-mix process the fluid is heated by chemical reactions.

Orthophosphate Base Suspension

Recently TVA developed a process for production of orthophosphate suspension. The suspension is made from wet-process orthophosphoric acid (52-54% P_2O_5) and anhydrous ammonia with an attapulgite gelling clay for a suspending agent.[1] A sketch of the TVA demonstration plant for making 13-38-0 suspension is shown in figure 1. Acid is ammoniated in three stages. Small crystals of diammonium phosphate are formed and suspended in a saturated orthophosphate solution. This is accomplished by ammoniation of the phosphoric acid to a nitrogen: P_2O_5 weight ratio of 0.34 and rapidly cooling the solution in an evaporative-type cooler, followed by a slight ammonia adjustment in the third-stage ammoniation tank which contains cooling pipes. The base suspension has been used in TVA's field development program the past few years and shipped in tank cars as far as 3,000 miles. Recent tests show that the maximum sedimentation of crystals in the suspension during shipment is about 2 percent. The suspension is cold mixed with ureaamonium nitrate solution (28-32% nitrogen), potash, and water to produce various NPK suspension mixtures. A sketch of a typical plant in which these materials are mixed is shown in figure 2.

The plant has a small mix tank mounted on scales in which the materials are weighed. Agitation is provided by a large recirculation pump and a small propeller-type agitator. The large recirculation pump (centrifugal type with 4-inch discharge) is desirable so that materials can be transferred rapidly into and from the mix tank. It is also important to have a large recirculating pump so that if supplemental clay is required in the mixture, the pump can be used to provide the agitation required to completely gel the clay. A "homemade" agitator using a truck transmission and differential as a speed reducer is shown in figure 3. When a large recirculation and transfer pump is used in cold mixing, an agitator often is not required. All the storage tanks are equipped for air sparging and some have cone bottoms.

Some companies do not use a screen and depend on the strainers to remove oversize potash or trash that will not break down to a small size during mixing. they usually connect two of the strainers in parallel. The strainer most frequently used is shown in figure 4. The suspension enters the bottom cone and is strained as it passes through the screen and into the top. This type of strainer can be cleaned by back flushing with water. It usually requires back flushing after every 8 hours of operation.

The base suspension, 13-38-0 grade, has been used without the addition of supplemental clay to produce grades such as 7-21-21 and 15-15-15. When high-nitrogen grades, such as 20-10-10 or 24-8-0 are produced, supplemental clay must be added. This is done usually by gelling the clay in the water of the mixture. When a sufficient quantity of water is not available in the formulation to gel the clay, phosphate solution is added to the mix tank. The optimum clay content during the gelling step is 10 percent. When the clay content is limited to this value, there is a maximum number of passes through the recirculating pump, and the gel does not become too thick for pumping. After the clay has been gelled, the remaining phosphate material and potash and urea-ammonium nitrate solution are added to the mix tank. In most instances it is best to add the urea-ammonium nitrate solution last. Sometimes this is not possible because of the high concentration of salts in suspension and part of the urea-ammonium nitrate solution must be added prior to the addition of the potash.

Liquids most frequently used in cold mixing in the past have been 10-34-0 polyphosphate solution and urea-ammonium nitrate solution. The main disadvantage in mixing these materials is that all the clay required for the suspension must be added at the dealer location. The handling of clay (usually in bags) sometimes causes dust problems, and it is difficult to effectively gel the clay. TVA has tried to avoid these problems by developing products which have gelled clay in them so that little or no clay has to be added at the retail mix plant.

Nitrogen Suspension

Recently TVA has developed a nitrogen suspension that will eliminate the need for the addition of supplemental clay at the cold mix plant when the nitrogen suspension and ammonium phosphate suspension are mixed[2]. The nitrogen suspension contains 31 percent N and 2 percent gelling clay. It is difficult to gel clay in conventional urea-ammonium nitrate solution. In a newly developed procedure the clay is dispersed in urea solution prior to gelling it in urea-ammonium nitrate solution. A sketch of the pilot plant for production of urea-ammonium nitrate suspension is shown in figure 5. Clay is first despersed in a urea solution containing a tetrasodium pyro-phosphate (about 3% of clay weight as TSPP). The resulting suspension contains about 22 percent urea and 30 percent clay[3]. This is an excellent fluid gelling clay that has a freezing temperature of 15 degrees F. which eliminates the problem of freezing now associated with other fluid-type gelling clays that freeze at about 30 degrees F. The fluid clay is then added to a urea-ammonium nitrate solution in which the ammonium nitrate gels the clay, resulting in an excellent suspension. This nitrogen base suspension has been used along with TVA's phosphate base suspension (13-38-0) to produce various $N:P_2O_5:K_2O$ suspensions by the conventional cold-mix process and without supplemental clay. Mixtures that have been produced are 20-10-10, 18-18-0, 13-13-13, 24-12-0, 12-6-0, 21-7-7, 18-6-12, 15-5-15, 15-10-10, and 15-10-15. Tests indicate that the clay that is gelled in the nitrogen suspension is at least 50 percent more effective than conventional dry clay for the production of suspension mixtures. The nitrogen suspension also has been used to produce X-O-X grades without the need for additional supplemental clay at the cold-mix station. Grades such as 20-0-11 and 14-0-28 have been produced. The viscosities of these suspensions are less than 1000 centipoises at 70 degrees F.

These mixtures have stored well for two weeks at 32 degrees and 80 degrees F. However, it is recommended that the mixtures be stored in a tank equipped with an air sparger as the one shown in figure 6, and the mixture should be sparged once a day for about 5 minutes. Nitrogen suspension should be of interest to companies using suspension satellite stations such as the one shown in figure 7. These stations usually receive a potash suspension (3-10-30, 5-15-30, 7-21-21) from another suspension mix plant. The nitrogen suspension and the phosphate suspension can be shipped directly from basic producers. In this satellite station the base materials are weighed in a batch tank. Weighing is necessary because a meter has not been developed that will measure suspension flows accurately.

The investment in a satellite station is about $10,000 to $15,000, and the investment in a conventional cold-mix plant is between $30,000 and $50,000, depending upon the amount of storage available at the plant site. Cold-mix plants usually have the lowest capital investment, and the cold-mixing process is the easiest way to produce suspension mixtures. However, material costs may be higher. The freight rate per ton of fertilizer is usually higher for a fluid than for granular materials. Also, the nutrient concentration of granular material is higher and this results in further freight cost advantage. Table 1 compares delivered costs of 13-38-0 base suspension and 12-54-0 granular ammonium polyphosphate. Considerable advantages are shown for the solid material when shipped distances greater than 350 miles.

Solid Ammonium Phosphates

TVA is demonstrating a high-analysis granular material — 12-54-0 ammonium polyphosphate — in the field development program. Some basic producers are shipping granular monoammonium phosphate and powdered monoammonium phosphate from Florida to the consuming areas for conversion into suspension mixtures. Consequently, some of these materials must be shipped distances greater than 1,000 miles and the lower freight costa make the solids highly desirable to suspension fertilizer producers. However, a mix plant must be equipped with a suitable high-intensity-type agitator and a large recirculation pump.

An obvious question is, "Why convert granular materials to suspensions, when they can be mixed and applied as bulk blends?" Here are some of the answers:

1. Many dealers and farmers want to apply fertilizers and pesticides in one application; however, many state and local governments will not allow these mixtures to be transported across highways and streets without special regulations and marking. This can be easily avoided by mixing the fertilizer and pesticide on the farm. Figure 8 shows an applicator with an eductor or venturi for the addition of pesticides to a suspension after it is delivered to the farm.
2. Uniform application can be accomplished easily with suspensions, making them ideal carriers of mictonutrients and herbicides.
3. Suspensions usually can be handled and transferred more easily than granular mixtures.

Figure 9 is a sketch of three types of mix tanks that are used to produce suspension mixtures from granular materials. The tanks are equipped with large recirculation pumps (usually centrifugal type) and have 5- to 6-inch-diameter piping for recirculating. Some of the mix tanks have a delivery cost as high as $30,000, which includes only the tank, its agitator, recirculating pump, and operating valves. One of the mix tanks (left side) has a high-intensity, high-speed agitator driven by a 60-hp motor and a circulating pump with a 5-inch discharge and a 25-hp motor. The other two mix tanks have recirculating pumps driven by 40- or 50-hp motors and agitators driven by 15- to 25-hp motors. All three arrangements produce violent agitation of the fluid. Violent agitation is required to break up the solid materials.

Most of TVA's experience has been with 12-54-0 granular ammonium poly-phosphate. Mixing tests in which an 11-33-0 suspension was produced showed that a total mixing time of 20 to 30 minutes is required with the ammonium polyphosphate and about 30 to 40 minutes with 11-52-0 granular monoammonium phosphate. Suspension formulations with ammonium phosphate materials are shown in table 2. It should be noted that anhydrous ammonia is required in the formulation to react with the phosphates and generate chemical heat which helps to fluidize the granular materials. In the production of the 11-33-0 suspension from ammonium polyphosphate the maximum temperature rise was 70 degrees F. With 11-52-0 granular monoammonium phosphate the maximum temperature rise was 77 degrees F. The grades shown in table 2 are the highest analysis mixtures that could be produced from the materials shown. The amount of ammonia added to the mixtures is limited so that the N:P_2O_5 weight ratio in the suspension will be 0.3 to 0.33. It is desirable that the viscosity of the mixtures be limited to less than 1,000 centipoises at 70 degrees F. so that it can be pumped, transferred, and applied without problems.

The viscosity of the 11-33-0 suspension produced from ammonium polyphosphate remains below 1,000 centipoises at 70 degrees F. However, the viscosity of 11-33-0 made from some monoammonium phosphates exceeds this viscosity limitation when the product cools to 70 degrees F. When water is added to these highly viscous products to dilute the grade to 10-30-0, the viscosity is less than 1,000 centipoises and the 10-30-0 can be satisfactorily pumped, stored, and applied (by broadcasting). The maximum grade for powdered MAP of 10-50-0 grade, which satisfied these viscosity limitations, was 9-27-0. The reason for the lower grade is the high iron and aluminum content of this MAP, which tends to make the suspension highly viscous.

Some companies cannot always obtain the monoammonium phosphate products and have used 18-46-0 diammonium phosphate in combination with phosphoric acid and a small amount of ammonia. The phosphoric acid is added to adjust the N:P_2O_5 weight ratio to 0.307, the ratio of maximum solubility (figure 10). These data show that at an N:P_2O_5 ratio of 0.39 (for 18-46-0) 35 pounds of ammonium phosphate will dissolve in 100 pounds of water (32 degrees F.); however, if enough phosphoric acid is added to adjust the N:P_2O_5 ratio to 0.307, 110 pounds of ammonium phosphate can be dissolved in the 100 pounds of water. In commercial practice a small quantity of acid is added and is ammoniated to an N:P_2O_5 ratio of 0.307. Sufficient chemical heat is released to assist in degrading the granular 18-46-0 so that a low-cost mix tank equipped with a propeller-type mixer can be used (figure 11). This is the low-cost (about $10,000) type of tank used in cold-mix processes. Formulations which include diammonium phosphate (DAP) for suspensions are shown in table 3. About 30 percent of the P_2O_5 in the product is supplied as phosphoric acid — an amount sufficient to adjust the solubility and provide chemical heat to fluidize the solid materials. Grades such as 18-6-6, 12-12-12, 16-8-8, 8-16-16, 6-18-18, and 8-24-8 have been produced with these materials. The normal mixing procedure is as follows:

1. Water
2. Phosphoric acid
3. Diammonium phosphate (18-46-0)
4. Ammonia
5. Gelling clay
6. Potash
7. Nitrogen solution

The main disadvantage in making suspensions with DAP is the need for phosphoric acid. The acid requires special storage tanks (rubber-lined), and the cost of P_2O_5 in the acid is usually higher than its equivalent cost in monoammonium phosphate.

One company in Hawaii cannot easily obtain phosphoric acid, so it adjusts the DAP with sulfuric acid. The sulfuric acid reacts with some of the ammonia in the DAP to form ammonium sulfate. The quantity of sulfuric acid used is usually limited so that the ammonia combined with the P_2O_5 is at an N:P_2O_5 ratio of 0.307. The grade most frequently produced is an 8-20-0-2S with the following formulations:

Formulation for 8-20-0 Suspension
Using DAP and H_2SO_4

Material	Lbs/Ton
Water	942
Suspending clay	40
DAP, 18-46-0	888
Sulfuric acid (93.2%)	132

For sugarcane the material is applied on both sides of the row and is injected beneath the soil surface with a piston-type pump.

Uses of Phosphoric Acid

Many companies produce suspensions in which wet-process phosphoric acid (50-54% P_2O_5) is the only source of phosphate. Unless the product is of very low grade, such as 2-6-12, a cooler must be used in the plant to avoid boil-over of the mix tank. A typical plant of this type, with mix tank on scales and with meters and separate scales for potash and clay, is shown in figure 12. Formulations in which phosphoric acid is the only source of P_2O_5 are shown in table 4. The mixing sequence is shown at the bottom of table 4.

Many of the standard type evaporative coolers become plugged with impurities in the acid. To avoid this problem, TVA field engineers have designed a cooler, which most plant personnel can easily construct (figure 13). Evaporative surfaces are wood, and the piping is chlorinated PVC that resists softening at temperatures up to 210 degrees F. The sump and most other parts of the cooler are also made of wood. Stainless steel demisting pads are used for each of the cooling sections. This cooler has sufficient capacity for production of 20 tons per hour of most mixtures.

Other Materials

Some companies add prilled urea for supplemental nitrogen in suspensions. The prills, which are too coarse for suspending, are dissolved in the water before addition of other materials. Tabulated below is a typical suspension formulation for an 11-11-11 grade in which standard-size prills are used.

Suspension Formulation for
11-11-11 Grade

Material	Lbs/ton product
Water	733
Clay	20
Urea (46% N)	314
13-38-0	579
Potash	354

Some mixing time is allowed after the urea is added to dissolve the urea.

Some companies use small-size crystalline ammonium sulfate in the manufacture of suspensions containing sulfur. Grades such as 12-12-12-9.3S, 12-6-6-11.5S, and 14-7-7-13.5S are produced. For good results all of the sulfate needs to be less than 20 mesh in size.

In most instances the source of K_2O for suspensions is solution-grade potash with all particles of less than 20 mesh size and 85 percent minus 35 mesh. A few companies have used small-size potassium sulfate and potassium magnesium sulfate as a source of K_2O as well as other plant nutrients. However, problems usually occur when the MgO content of the sus-ension exceeds 3 percent. At a higher magnesium content, magnesium phosphate scale forms in lines and eventually plugs the applicator nozzles.

Normal and triple superphosphate have not been useful in suspensions because of lumps in the material, screening problems, and low analysis of product. Mixtures in suspensions produced from these materials simply become too viscous for application even when they are diluted to very low analysis.

Gelling Clays

TVA has found only two types of clay gelling agents that are low enough in cost for suspension fertilizers. These are attapulgite and sodium bentonite clay. The attapulgite type is found in South Georgia and sodium bentonite is mined in the South Dakota Black Hills area. Attapulgite is most frequently used.

One company offered a fluid clay last year, and some suspension mix operators reported they could decrease the clay content by 50 percent by using the fluid clay. The fluid suspending agent contained about 30 percent clay. Its freezing point is about 30 degrees F. which causes some problems in the Corn Belt and colder regions. TVA developed a fluid clay that contains 10 percent nitrogen (as urea) and 30 percent clay which was described earlier in this paper.

Summary

Production and use of suspensions will grow for several reasons:

1. Low-cost material — comparable to material costs for bulk blends.
2. Ease of application.
3. Uniformity of application.
4. Suspensions are excellent carriers of micronutrients and pesticides.

References

1. 10th Demonstration — "New Developments in Fertilizer Technology," October 1-2, 1974.
2. 11th Demonstration — "New Developments in Fertilizer Technology," October 5-6, 1976.
3. TVA Patent Application, Serial No. 660,055, by J. G. Getsinger, "Fertilizer and Feed Supplement Suspension."

Table 1

Delivered Cost of Plant Nutrients from Muscle Shoals, Alabama
For TVA Base Suspension 13-38-0 and Granular Ammonium Polyphosphate 12-54-0

		Freight Costs, $/Unit Plant Food		
Destination of Shipment	**Freight Miles**	**TVA Base Suspension 13-38-0**	**Granular Ammonium Polyphosphate 12-54-0**	**Difference in Freight Cost**
Memphis, Tennessee	152	0.11	0.08	$0.03
Atlanta, Georgia	294	0.18	0.016	0.02
St. Louis, Missouri	371	0.25	0.15	0.10
Des Moines, Iowa	698	0.31	0.20	0.11
Omaha, Nebraska	787	0.34	$0.20	0.14
Scottsbluff, Nebraska	1,152	0.42	0.26	0.16

Table 2

Formulation Using Ammonium Phosphates

	TVA-APP-12-54-0	Granular MAP 11-52-0	Powdered MAP 10-50-0
Grade	11-33-0	11-33-0	9-27-0
Formulations, lb/ton			
Anhydrous NH_3	89	98	88
12-54-0	1222	—	—
11-52-0	—	1269	—
10-50-0	—	—	1080
Water	659	603	812
Gelling clay	30	30	20
Approximate mix time, min.	23	33	20
Maximum temperature rise during mixing, Degrees F.	70	77	69

Table 3

Formulations With Diammonium Phosphate (18-46-0), Phosphoric Acid, Ammonia, Urea-Ammonium Nitrate Solution, and Potash

	Pounds/Ton Product					
Material	**18-6-6**	**16-8-8**	**12-12-12**	**8-16-16**	**6-18-18**	**8-24-8**
Ammonia	9	11	16	21	26	35
DAP (18-46-0)	183	243	365	487	548	730
Phosphoric acid (54% P_2O_5)	67	89	133	178	200	267
UAN (32% N)	1000	834	503	172	—	—
Potash (62% K_2O)	194	258	387	516	581	258
Clay	40	40	40	40	40	40
Water	507	525	556	586	605	670

Sequence of Addition to Batch Mix Tank

1. Water
2. Phosphoric acid
3. Diammonium phosphate (18-46-0)
4. Anhydrous ammonia
5. Gelling clay
6. Potash
7. Urea-ammonium nitrate solution

Table 4

Formulations With Phosphoric Acid, Amminia, Urea-Ammonium Nitrate Solution, and Potash

Materials	Pounds/Ton of Product 6-18-18	12-12-12	10-30-0	3-10-30	8-16-16	16-8-8
Ammonia (82.3% N)	146	97	244	73	130	66
Phosphoric acid (54% P_2O_5)	667	445	1112	371	593	297
UAN (32% N)	—	500	—	—	166	831
Potash	581	387	—	968	517	258
Clay	40	40	50	30	40	40
Water	566	531	594	558	554	508

Batch Weigh Tank Mixing Sequence

1. Weigh water in mix tank and start recirculation to the cooler.
2. Weigh phosphoric acid in mix tank.
3. Weigh ammonia in mix tank.
4. After mixture cools to 140 degrees F. stop recirculation to cooler and add gelling clay.
5. Add potash.
6. Add urea-ammonium nitrate suspension. Usually final temperature of suspension is about 100 degrees F.

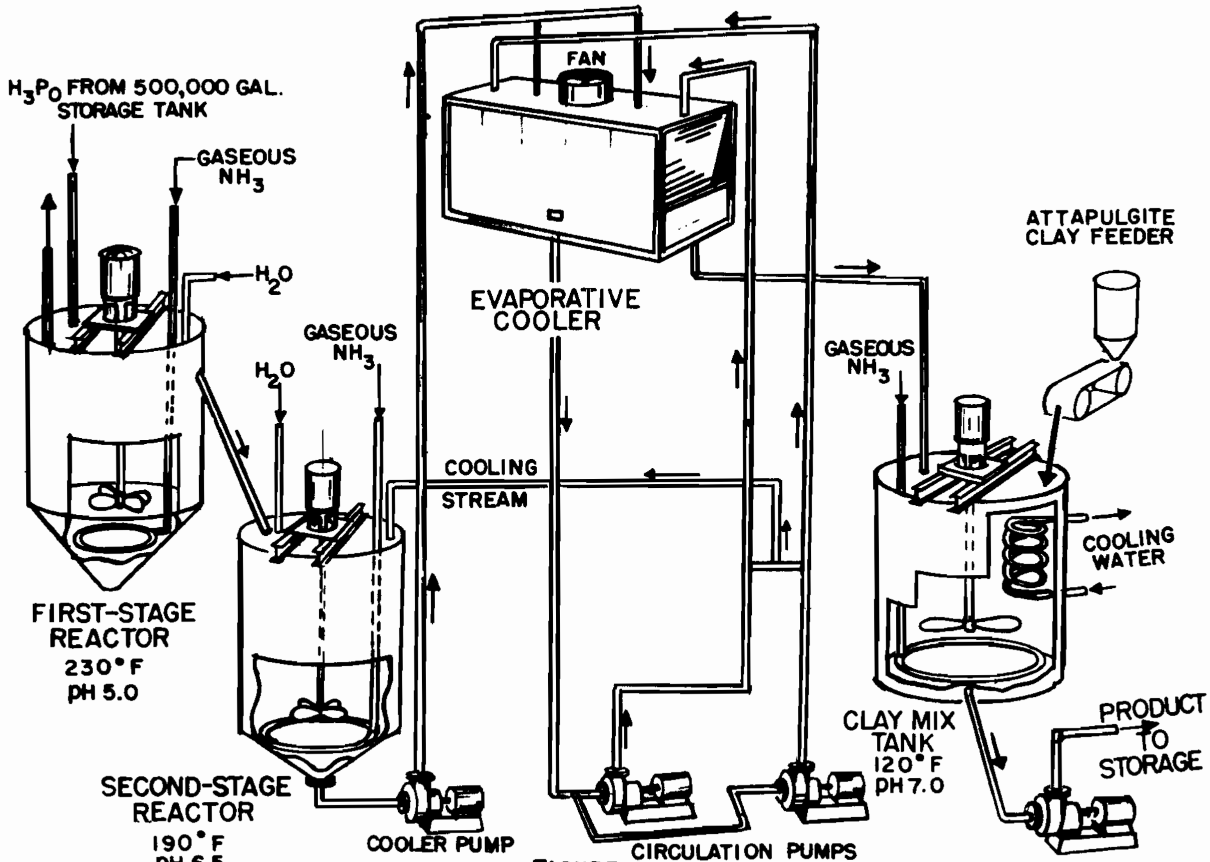


FIGURE I

PRODUCTION OF 13-38-0 ORTHOPHOSPHATE FERTILIZER BY THE THREE-STAGE AMMONIATION PROCESS

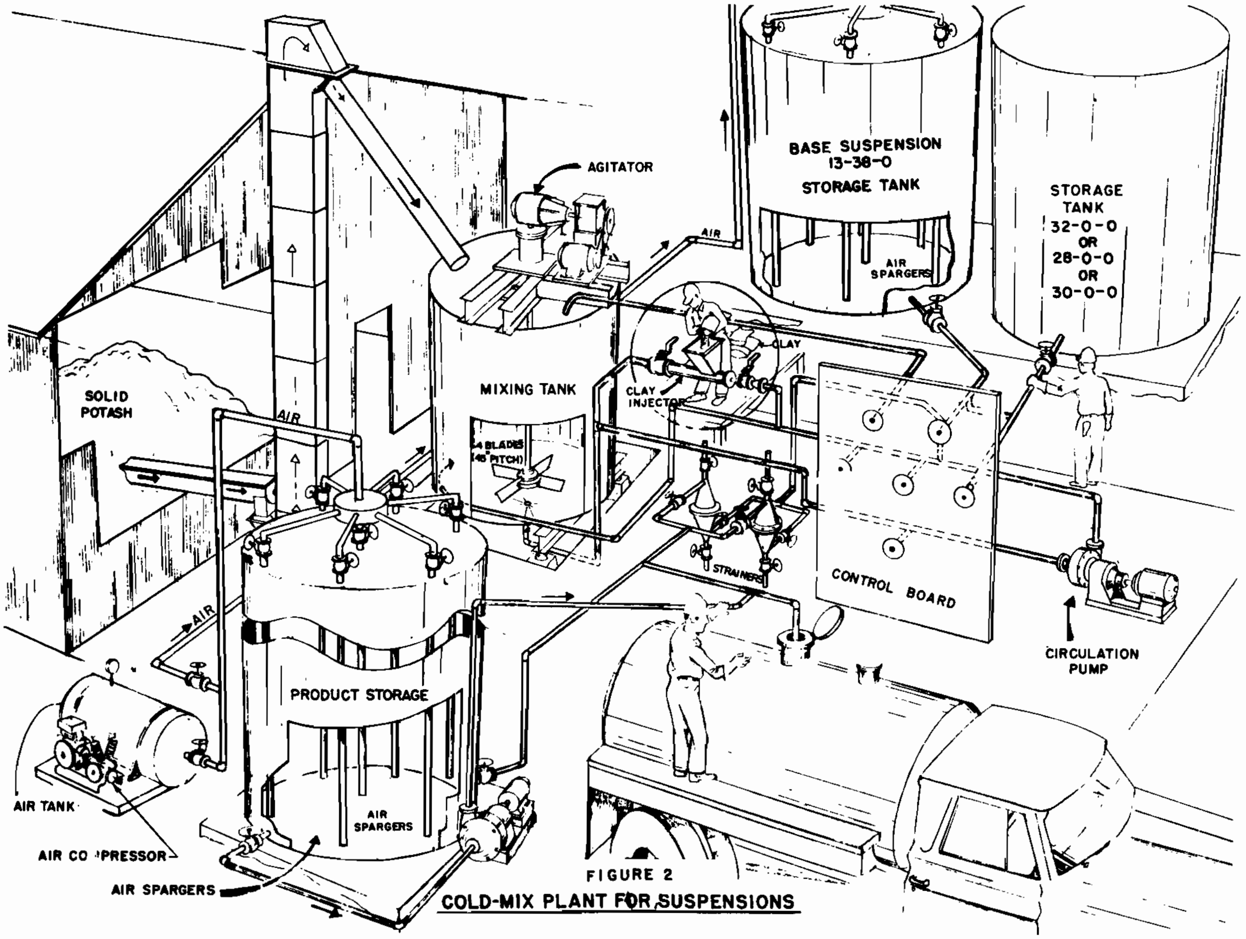
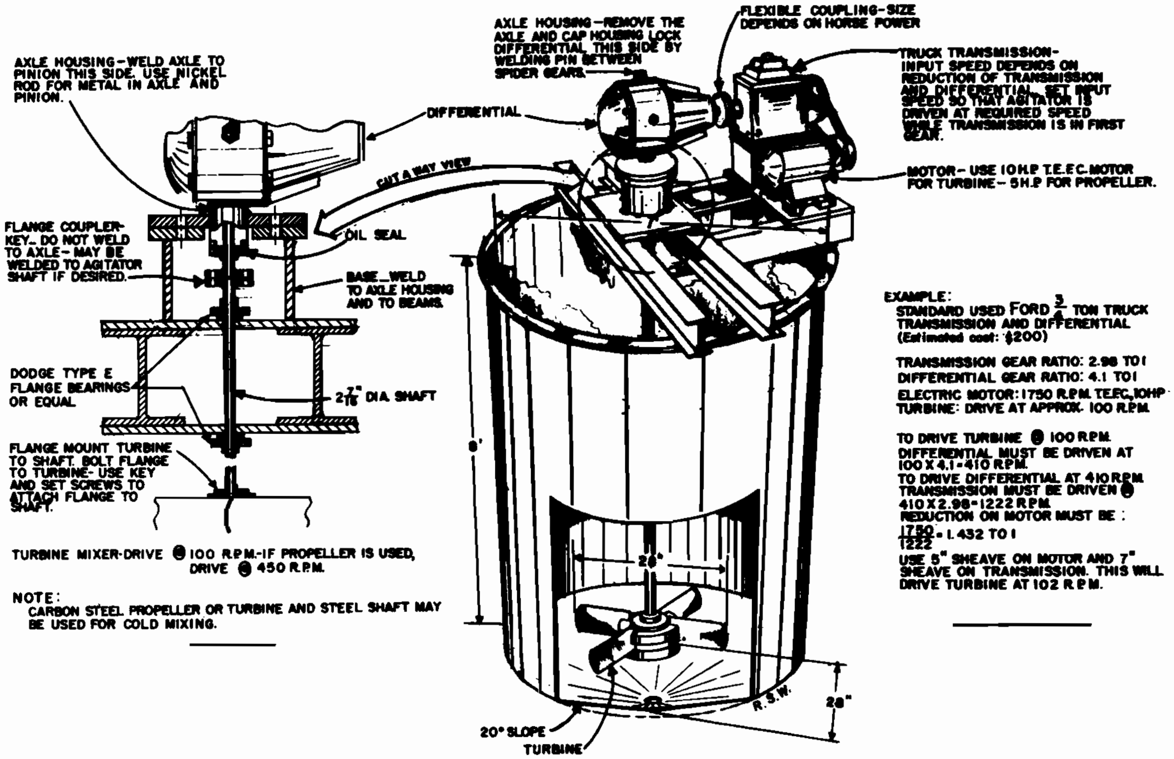


FIGURE 2
COLD-MIX PLANT FOR SUSPENSIONS



TURBINE MIXER-DRIVE @ 100 R.P.M.-IF PROPELLER IS USED, DRIVE @ 450 R.P.M.

NOTE:
CARBON STEEL PROPELLER OR TURBINE AND STEEL SHAFT MAY BE USED FOR COLD MIXING.

EXAMPLE:
STANDARD USED FORD $\frac{3}{4}$ TON TRUCK TRANSMISSION AND DIFFERENTIAL
(Estimated cost: $200)

TRANSMISSION GEAR RATIO: 2.98 TO 1
DIFFERENTIAL GEAR RATIO: 4.1 TO 1
ELECTRIC MOTOR: 1750 R.P.M. T.E.F.C., 10HP
TURBINE: DRIVE AT APPROX. 100 R.P.M.

TO DRIVE TURBINE @ 100 R.P.M.
DIFFERENTIAL MUST BE DRIVEN AT 100 X 4.1 = 410 R.P.M.
TO DRIVE DIFFERENTIAL AT 410 R.P.M. TRANSMISSION MUST BE DRIVEN @ 410 X 2.98 = 1222 R.P.M.
REDUCTION ON MOTOR MUST BE:
$\frac{1750}{1222} = 1.432$ TO 1
USE 5" SHEAVE ON MOTOR AND 7" SHEAVE ON TRANSMISSION. THIS WILL DRIVE TURBINE AT 102 R.P.M.

FIGURE 3
AGITATOR MADE FROM TRUCK DIFFERENTIAL AND TRANSMISSION

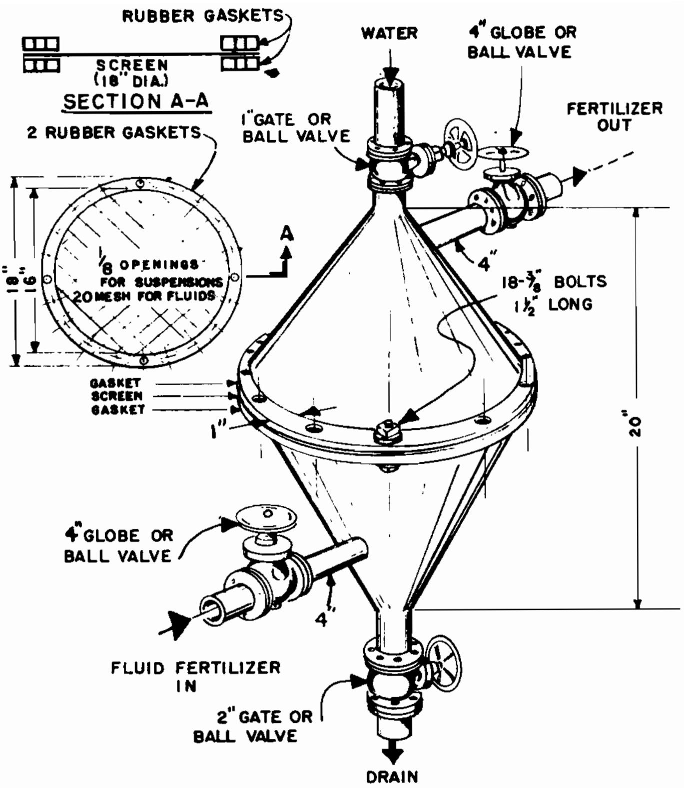


FIGURE 4

PRODUCT STRAINER FOR SUSPENSION FERTILIZER

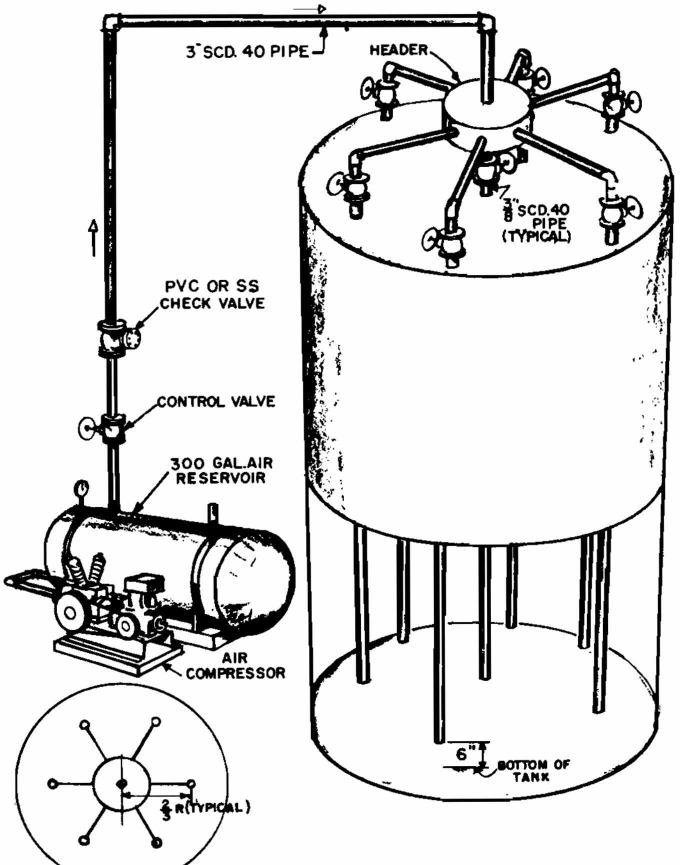


FIGURE 6

PIPE SPARGING SYSTEM FOR SUSPENSIONS

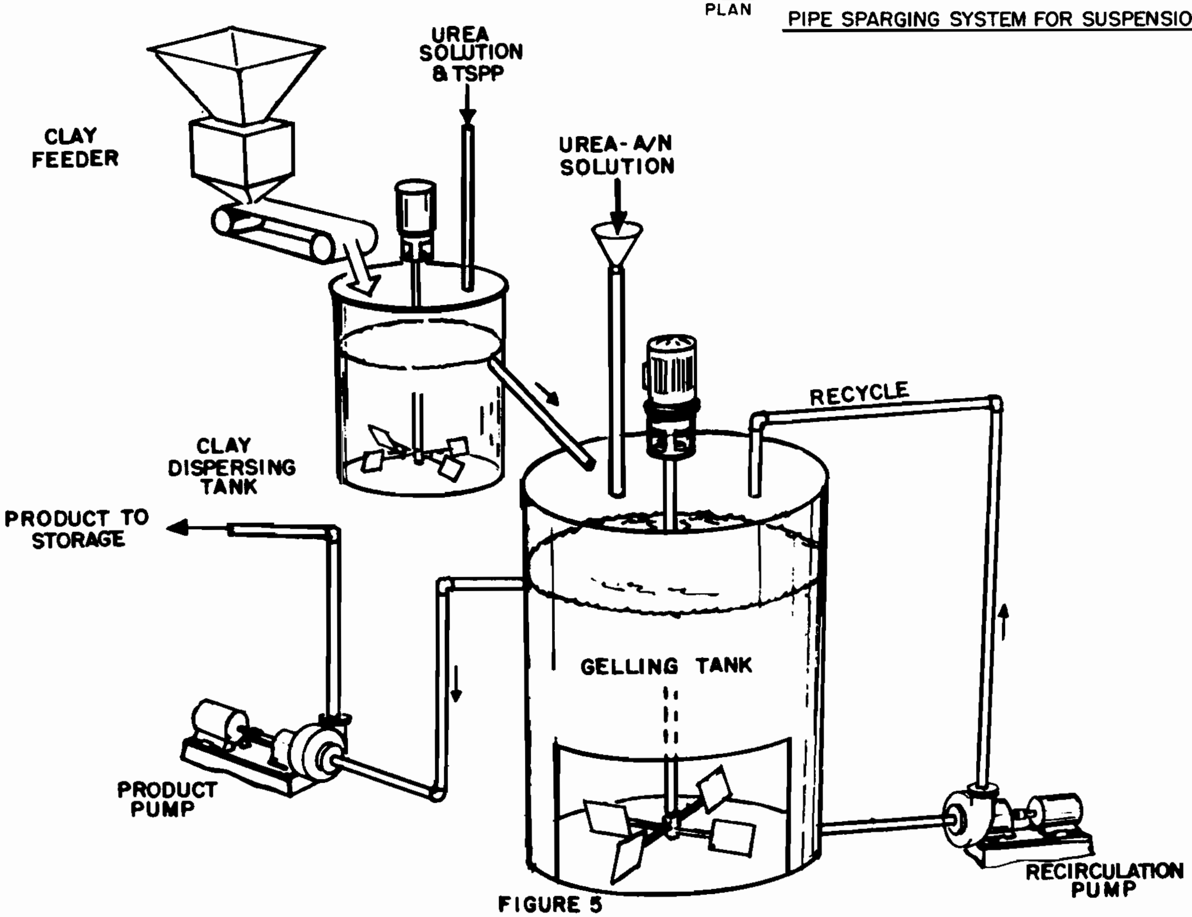


FIGURE 5

PILOT PLANT FOR PRODUCTION OF UREA-AMMONIUM NITRATE SUSPENSION

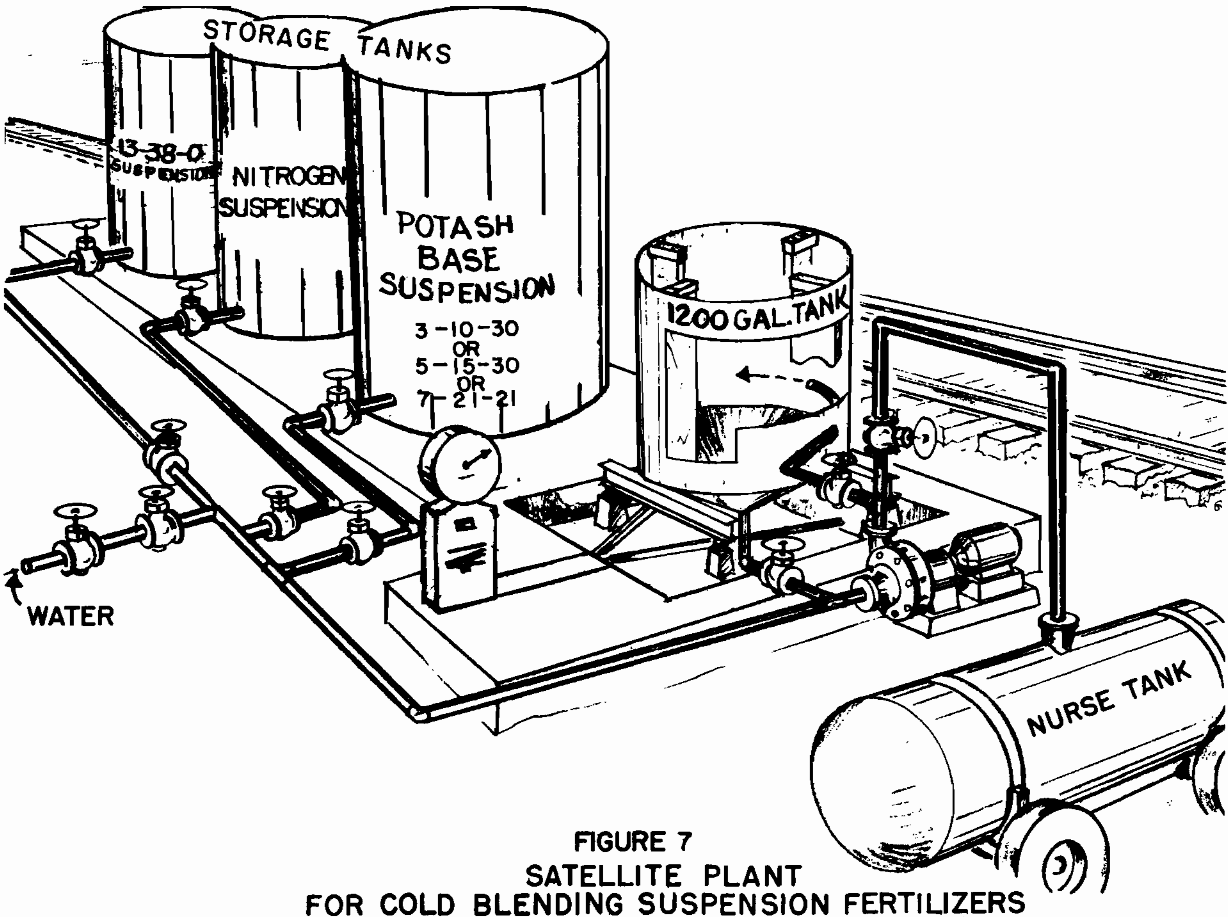


FIGURE 7
SATELLITE PLANT
FOR COLD BLENDING SUSPENSION FERTILIZERS

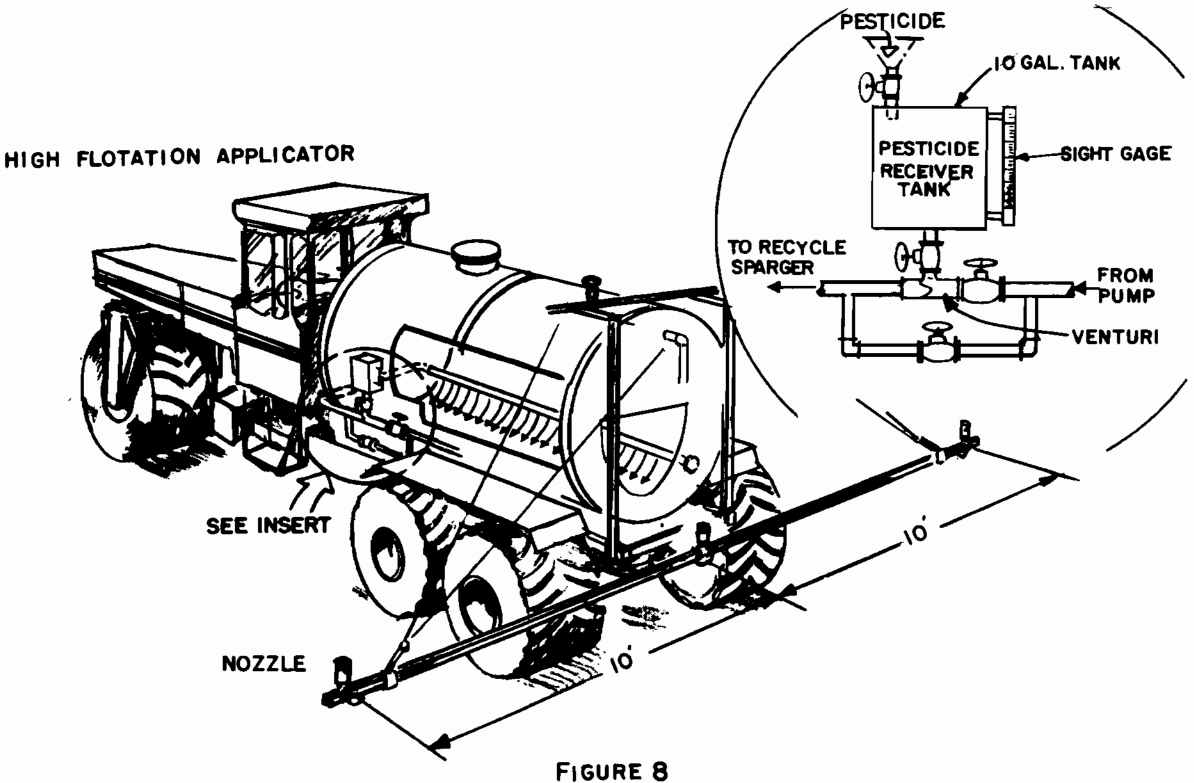


FIGURE 8
SAFE ADDITION OF PESTICIDE TO SUSPENSIONS ON FARM

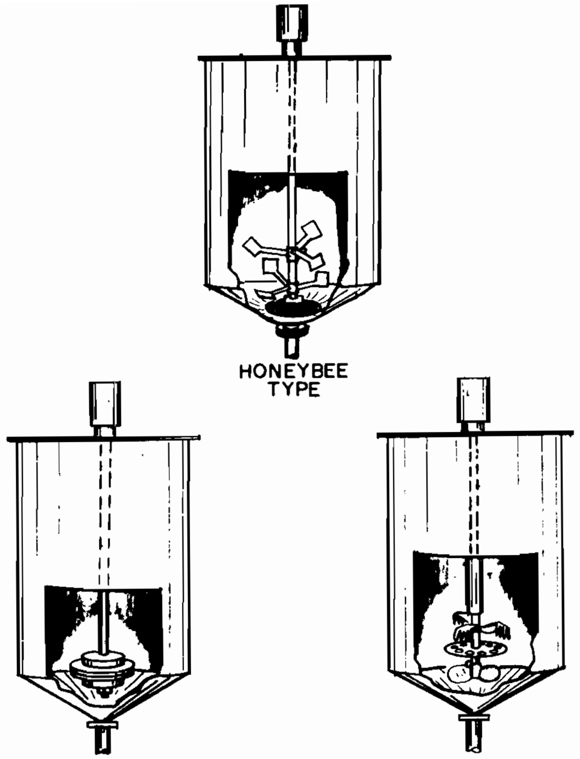


FIGURE 9
MIX TANKS FOR SUSPENSIONS FROM GRANULAR AMMONIUM PHOSPHATES

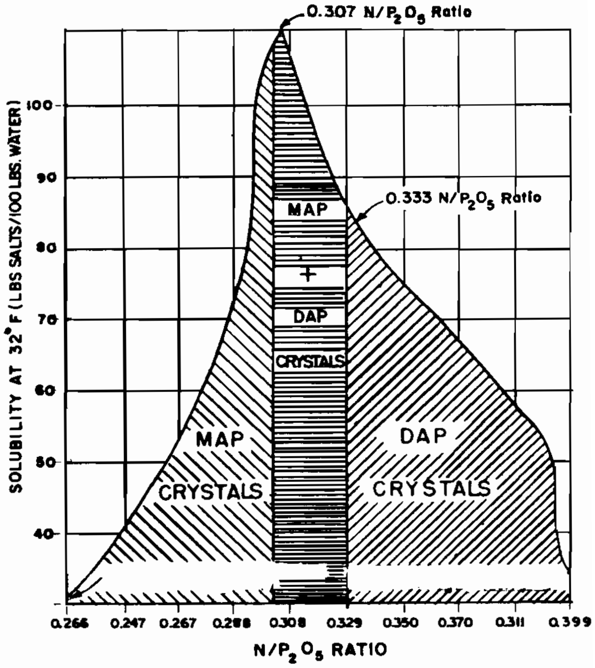


FIGURE 10
SOLUBILITY OF SATURATED AMMONIUM PHOSPHATE SOLUTION

FORMULATION FOR 12-12-12 SUSPENSION

ORDER OF ADDITION	MATERIAL	LBS PER TON OF PRODUCT
1	WATER	556
2	PHOSPHORIC ACID (54% P_2O_5)	133
3	DAP (18-46-0)	365
4	ANHYDROUS AMMONIA	16
5	CLAY	40
6	POTASH (62% K_2O)	387
7	UAN (32% N)	503

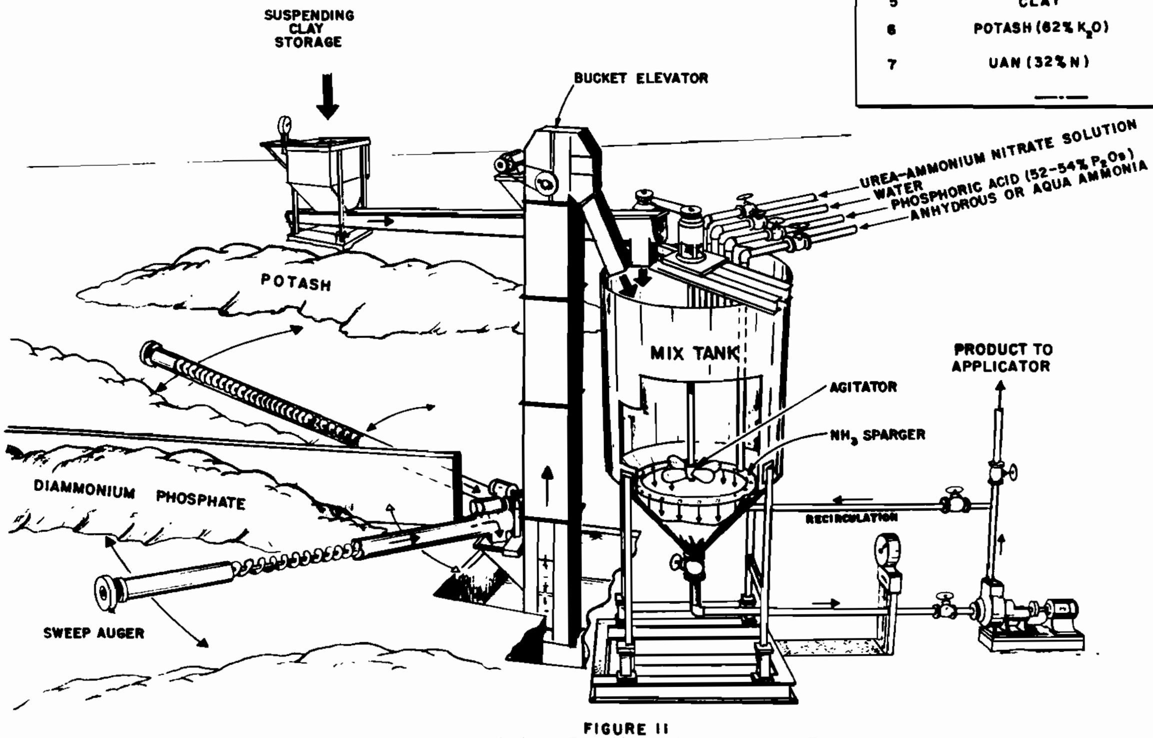


FIGURE 11
USE OF DIAMMONIUM PHOSPHATE IN FLUID FERTILIZERS

FORMULATION FOR 12-12-12 SUSPENSION

ORDER OF ADDITION	MATERIALS	#/TON
1	WATER	531
2	PHOSPHORIC ACID (54% P_2O_5)	445
3	AQUA-AMMONIA (20% N)	97
4	CLAY	40
5	POTASH (62% K_2O)	387
6	UAN (28% N)	500

COOL TO 140°F THEN RECIRCULATE TO MIX TANK WHILE GELLING CLAY.

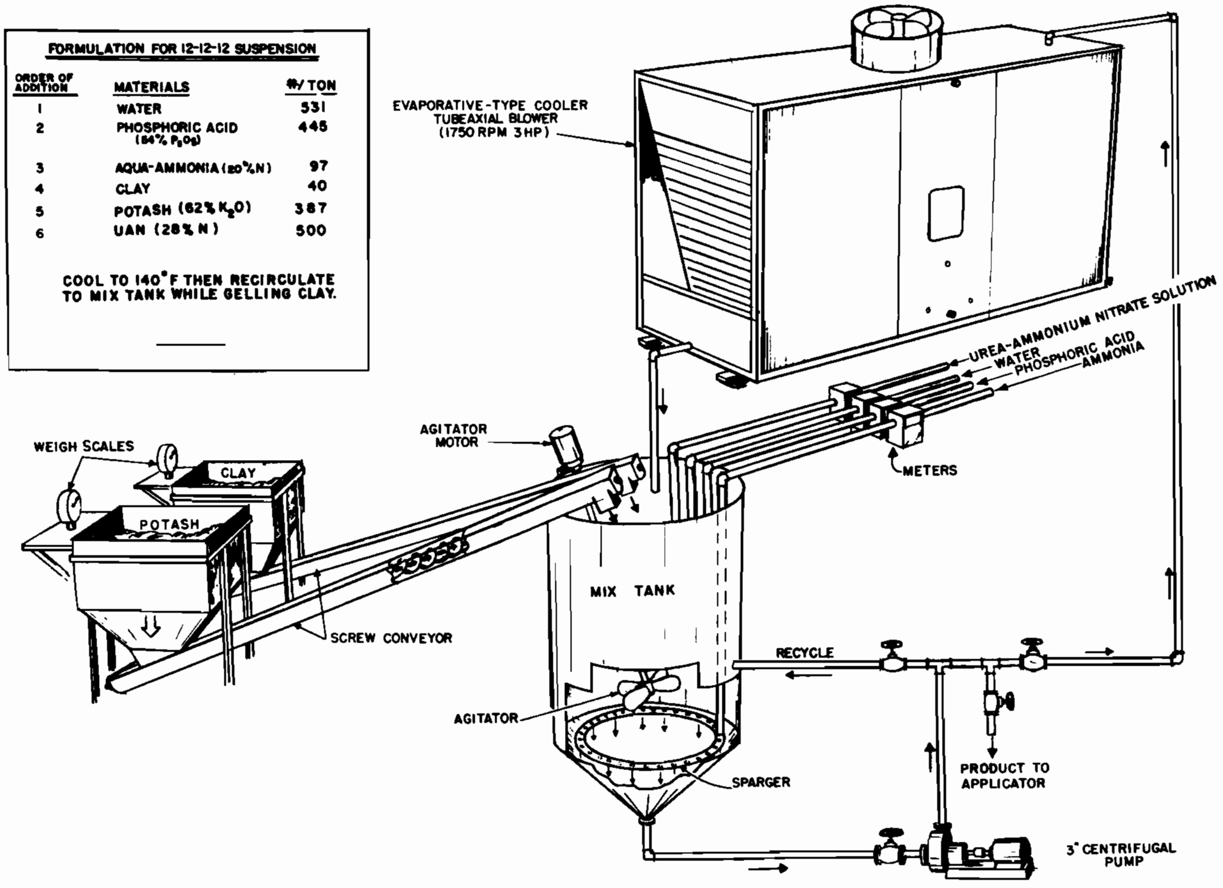


FIGURE 12
USE OF PHOSPHORIC ACID FOR NP AND NPK SUSPENSIONS

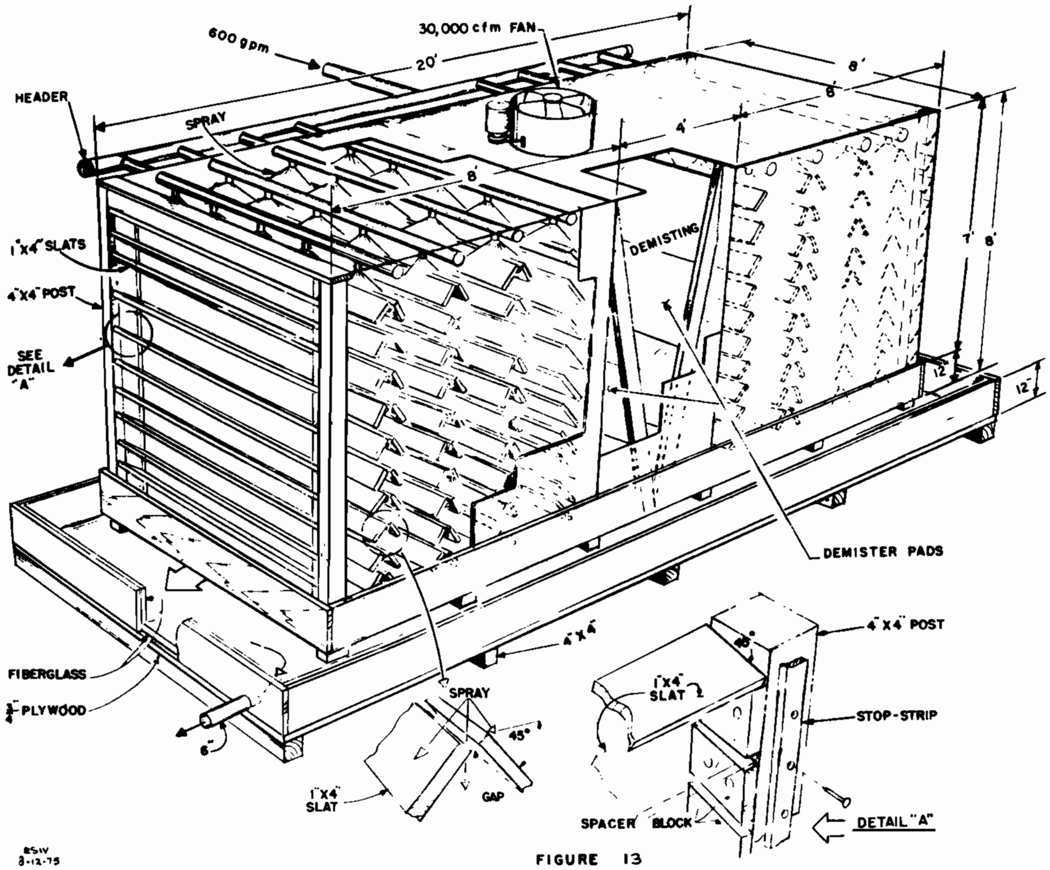


FIGURE 13
SHOP-MADE EVAPORATIVE COOLER FOR SUSPENSIONS

MODERATOR NIELSSON: Thank you Frank Achorn and your Associate Homer L. Kimbraugh. We are just on time. If there are any questions, please contact Frank or discuss your questions at The Question And Answer Session to be held Thursday.

Continuing in this session today about fluid fertilizers, our next speaker will be Pete Shoemaker of Valley Fertilizer Company. Pete is a native of Florida and graduated at The Citadel.

He worked 12 years with Chevron Chemical, was with Florida Gas, became executive vice president and general manager of Valley Fertilizer, and now he is president and general manager of this company. He has been active in the National Fertilizer Solution Association since '72 where he is chairman of the agronomy committee and is on the membership committee.

It gives me great pleasure to present Pete Shoemaker of Valley Fertilizer. *(Applause)*

Manufacture of Fluid Fertilizers At Valley Fertilizer Co.

Pete Shoemaker

I would like to say what a pleasure it is for me to be here with you, Gentlemen.

As many of you know Valley Fertilizer is an old line, dry fertilizer company, dating back in the early 1900's, that straddles both worlds. We still are in the dry business, as you will see in a moment. And we have become heavily involved with the liquid business, both clear liquids, suspensions, and the manufacturing of 10-34-0.

I would like to take a few moments this afternoon; trace our involvement, and our machinery, equipment, and so forth in the liquids as well as the dry. I would like to show you a cross section of what the dealers and the major suppliers to the dealers across the country are using, and I would like to take a few moments on what many of us see as the future of this particular business.

Valley Fertilizer was a Division of Davison Fertilizer Company until 1937. In 1937 George Holtzman bought the existing facility which was a pulverized plant. And then in 1946 he built this particular installation, a newer pulverized plant. In 1968 the old pulverized plant was taken down and a new batch granulator was built and came on stream in 1969.

I joined Valley Fertilizer in 1969 as Executive Vice President in time to get it on stream and started. We have a two ton batch granulator and a 40 foot cooler, I guess you would say a dryer-cooler in it. We normally would run it using 20% superphosphate, 44% mixing solution, and steam. We never used sulphuric acid injection. We ran this successfully for approximately three years until a combination of factors started giving us problems.

The Virginia Air Pollution people used to go up and down the highway and every time I was running a 5-10-10 or one of the high 20% grades then they would come pay me a visit. So it wasn't too hard to see that between OSHA, noise pollution, and dust pollution, and with the Virginia Air folks, the days of our granulation plant were becoming limited.

There was also another factor, 20% superphosphate became expensive. It gave us a finished product cost so much higher that we were having trouble competing with the dry blend people.

In 1970 I put in a Sackett Bulk Blender, 40-ton Mighty Giant Blender, which is still operating very successfully today.

In 1971 and 1972 we worked with TVA, Texas Gulf, and some of the other folks. We developed our plans to get into the liquid fertilizer business. After looking at the many installations we hired Twin State Engineering of Davenport, Iowa, Hover Tinsman, to be our Design Architect. We used both his plans and some of the TVA plans to build our plant.

We built the Liquid Plant at the end of the Granular Plant, and put in bulk storage for potash. We began our construction in January and by September of 1972 we were in the liquid fertilizer business.

We thought we would start right out in both suspensions and 10-34-0 (and you know ignorance is bliss) because we didn't know you weren't supposed to do it this way.

We never went through the clear liquid stage, we never had all these problems that you hear about with solutions crystalizing out and all this type of jazz. I think it is because we listened to all the people that knew what they were talking about, such as Frank. We just have not had these problems.

The most problems we had was with the first batch of 5-15-30 we made. Not knowing any better as the temperature rose, we put it out through the primary cooler and forgot that it was an evaporative cooler. When you evaporate water out of 5-15-30 you leave a pretty solid bunch of material, and that was a lot of digging out. So we learned that one very quickly.

We use Foxboro ratio controllers on the anhydrous ammonia and the water tied in with the 70% super acid flow. Again this comes from the experience that I had as I traveled through the West. A manual plant to make 10-34-0 is great, but the only problem is you cannot have a constant flow of 70% acid. You have layers, evidently, of various densities. Unless you are hooked in with some automated system, you are going to run into off grade material.

I can honestly say that we started in 1972 and as of last week we have never run an off grade batch of 10-34-0. We used both black acid and green acid, too. It takes us approximately 15 minutes to go from scratch on start-up, within 15 minutes we should be on grade and normally are, and then lock in the ratio controllers (we are on a manual system to start off with). As soon as we are on grade we lock in the ratio controllers and from that point on the ratio controllers control the flow.

If we get something in the acid flow that interrupts it and stops it, then the entire system is shut off. If it fluctuates dramatically, so does our flow of ammonia and water; it has been very satisfactory.

We normally operate in the 600 degrees to 660 degrees range with the latest modifications that we have made. We operate and manufacture approximately 200 tons of 10-34-0 in an eight hour shift. We have an hour before hand and an hour afterwards on clean-up and so forth.

In our lab we monitor every 30 minutes during production. We monitor both in the primary cooler and in the line from the promary to the secondary cooler. So we know what is going on at all times. We monitor both pH and specific gravity.

The original T-Reactor we built was water jacketed. We have since built two others, all three are the same size, but the last two are not water jacketed. Quite frankly, we can't see a heck of a lot of difference in them.

We do have scaling and it is a problem of the system. In the horizontal pipe and the vertical down pipe we will build scale enough to stop up at the end of 4 to 7 cars depending on what grade acid we are running. We do have to tear it down and get the scale out. Now there are two very sophisticated ways of doing it. One is by heating, and we keep melting pipes. The other way is even more sophisticated, you get a ten pound sledge hammer and you beat it until the stuff falls out, and you put it back together again. It is hard on the pipe, but it works well.

10-34-0 — We make green and black. As I mentioned earlier, we have had good runs. We have no problems with storability, we take our material to storage at less than 100 degrees. So that we have it stored for as long as a year with no appreciable sludging or precipitants coming out. We emptied a pit that had been in constant use since 1972, a 100,000 gallon pit, this past spring and found less than two inches of sludge in the bottom after four years of continual filling and emptying, and filling and emptying, and so forth. We like our system.

Now for our 5-15-30 manufacture and our retail trade we have a 13-ton batch mixer. The primary agitator is 7½ hp. We pump in all the various ingredients and sparge anhydrous ammonia through a ring sparger in the bottom of it. We also have a steam sparger so that we can make our own urea nitrogen solutions when the economics dictate.

We use air operated valves so that we have two men that operate our entire liquid plant operation as far as the manufacturing. We use Gorham Rupp 4" trash pump with stainless steel insides. We make a great deal of 5-15-30 for our dealer trade, the satellite plants, up and down the Shenandoah Valley.

In 1974 we began an expansion program of storage. We had started out with two 500 ton pits (100,000 gallon). We added four more in 1974. Presently we have a total capacity to store liquids of just under a million gallons. We used the TVA plans with a one to one slope ratio or 45 degrees slope. We put a drain field under it to make sure you can find a leak if you get one. We put 4" of fine sand, we put 9 layers of, I guess, 10 mil of PVC silo cover type material, then put a 30 mil liner from fabric on that.

As I mentioned we have been in operation with the pits since 1972 and we have had no problems with them. Some of the other liquid plants that have used pits with vertical sides have had problems. We have simply a pole shed construction on top which is very inexpensive. The first two pits in 1972 that we put in cost $6.000.00 a piece installed. The last ones that I put in in 1974 cost $9,000.00 a piece installed. I would assume in 1976-1977 we are looking at approximately $11,000.00 to $12,000.00 per 100,000 gallons of storage.

We agree with Frank, we don't like and we never did like to put herbicides in our mix tanks. It is not safe and it is not a good practice. So we have a separate herbicide mix tank that we slurry the various herbicides and pump in through our custom applicators.

As you know each area is different. We began custom applying heavily in 1972 because it has been our philosophy that as we develop services for our farmers we can demand and get a premium for our fertilizer. When we are selling strictly on NPK price and if the bulk blender is in operation (we do that where it is necessary). Then we are very vulnerable to those people who want a shack at it. But where we are providing services that those other fellows can't provide, we have an edge on them and we get the premium. We also give the farmers something in return.

We do have an ammonia cooler that we installed last year and that allowed us to go to from 15 tons an hour up to 20 tons an hour production capacity.

Also in 1974 we began our waste control efforts. This is a 50,000 gallon concrete holding basin, a sloped concrete pad with its own water supply and lighting. The applicator trucks will pull on here and if the next load has a different type of herbicide or if we have a load going out that we don't want to contaminate with the prior load, then the man can flush his tank out of both the fertilizer materials and the herbicide and of course it is held in the holding pond.

Periodically we will stir it up, have it analyzed, and we sell it to the farmers using plowed ground at approximately half the NPK value. This way we control our waste. We have a standing order by half a dozen farmers for all the material that we can provide. The herbicides are diluted so that they have yet to be a factor in plowed ground. We could not do no-till with it, but we can use it on plowed ground.

I had a design engineer come in last summer who designed a complete bi-level control system for our water waste as well as for our fertilizer waste. We will be spending between $50,000.00 to $100,000.00 in the next 12 months to give us a complete self-contained pollution control system.

Nearby our waste control we have a little wet weather stream and unfortunately we drain an eight square mile area down through this part of the plant. We obviously can't contain all of the tremendous amount of water that we get when it does rain, so we will go to a bi-level system; a storm sewer system where we pick-up the rain water before it comes to the plant area. When the water reaches the plant area it is shunted underneath and it goes under the railroad tracks. We use the nearly embankment with 12" of clay which will form a natural embankment. We also will have loading sumps for every loadout place that we presently have.

No matter how careful we are we are going to drop liquid fertilizer every time we load and unload a truck. We do keep 5-15-30 in storage and have stored it for as long as a year. We have the air sparging system designed by TVA (Christmas Tree sparger) in the bottom which we sparge every 12 hours. A 100 gallon bubble of air at 100 pounds pressure regulated by a timer which is automatic.

This summer we took the manhole cover off and had probably two or three inches of potash in the bottom after two years of continuous use. We do store six months to a year.

We will do away with the loading stations, and will go to a complete self-contained concrete lined loading sump with piping directly into the waste ponds, so that as we get these spills periodically they will be shunted back into the holding ponds. These areas will be roofed so that we will eliminate some of the contamination from water with our fertilizer. This will result in a higher analysis and a little bit longer before our holding pond has to be emptied.

The only pollution we have now gentlemen, that the State of Virginia can't cry at us too much about is steam pollution.

We do handle a good quantity of blend fertilizer. We now are bagging a blend and have had excellent results with it, this is our second season. We use 50 pound bags and private label for many companies up and down the Shenandoah Valley. So we are involved very much in the dry business.

Two quick observations that I have on our future — Number One — That is in our estimation, my estimation, those dealers that offer services to the farmers, such as complete soil testing, are going to be the dealers that are here in the future. We think service is extremely important.

In one instance the only thing the soil test called for was 20 pounds of sulfur. The farmer really didn't want to put it on, I gave it to him in order to run the comparison test. Two weeks ago when we ran the yield check there was no visual difference in the field. The county agent didn't know which side had the sulfur and which didn't. When we got back to the office we brought out the files to find 16 bushels yeild increase for less than $7.00 worth of ammonium thio-sulfate.

The other exciting area in suspensions is suspension limestone. Tests run by Auburn many years ago show that only the fines in linestone are effective, not the coarse particles. We bring the material in to be unloaded by air and injected into our 13 ton mixer. We use a 70% limestone solution, with approximately 2% clay, and lignon sulfinate to keep it in suspension. This will form a material that is called (Thixotropic) material. That means that when a material is at rest it has one series of properties, and when it is put under stress or in a pump it flows. I stuck a stick into this material which was approximately 4 feet long and left it. It will sit there forever since the material is almost like a jelly. The minute you put it in a pump it goes out like a 5-15-30 or a 4-12-24 with no problems.

I think this is going to be an exciting new extension of the liquid fertilizer business tomorrow. The air pollution people are going to stop these spreader trucks from these great plumes of lime plus you can add potash or add nitrogen solutions to this material.

Gentlemen I appreciate the opportunity to address you. I would like to say one thing in closing. No matter whether you believe in the peanut farmer from this great State of Georgia, who believes that the greatest problem we have is unemployment, or the Congressman from Michigan, who believes the greatest problem we have is inflation. It doesn't matter, but let's all vote next Tuesday, because that is the only way we or our children are going to be here 100 years from now. Thank you very much. *(Applause)*

MODERATOR NIELSSON: Thank you, Pete. That was a very informative talk.

After the next speaker we'll have a five or ten minute break before we go into the panel discussion because I've always heard that the brain cannot absorb more than the seat can take. So we'll sort of break up.

The next speaker is John McCullogh of TVA. His subject is "Partial Purification of Wet Process Phosphoric Acid." John is a graduate of Auburn University Class of '51 in chemistry.

He has worked for Monsanto, for Kremet-Titanium for Thiocol Chemical Corporation and W. R. Grace. He came to TVA in 1963. He has has a wide variety of experience, and I think you'll appreciate his talk. John please. *(Applause)*

Partial Purification of Phosphoric Acid

John F. McCullough

In the fertilizer industry the major reason for purification of wet-process phosphoric acid is for the production of clear solution fertilizers that can be stored for extended periods without precipitation of solids.

Today's solution fertilizers are prepared either from unpurified wet-process acid or wet-process acid partially purified in respect to magnesium only. A considerable portion of the acid is prepared from calcined phosphate rock and yields clear solution fertilizers. Although today's solution fertilizers are being successfully used, their storage life is shortened markedly by the impurities they contain. They are frequently saturated if not supersaturated with the impurities, and this situation is exacerbated by the fact that the impurities increase the rate of hydrolysis of the polyphosphate needed for stabilization of the solutions. Therefore, it is safe to say that there is a real need for purified acids for the preparation of truly reliable solution fertilizers. This need is expected to become even more pressing in the future because of the general decline in rock quality. In fact, this decline in rock quality presently is making it difficult for some producers to make grade on DAP or to meet shipping specifications on phosphoric acid.

The degree of purification required for solution fertilizers has not been defined precisely because it varies from acid to acid and depends also on the polyphosphate content of the solution. Generally, however, the removal of about 60% of the metallic and fluorine impurities from typical Florida acid should be sufficient. Higher degrees of purification probably are needed for acids prepared from North Carolina and western rocks because of their high Mg content. For direct production of clear solutions, most of the suspended and dissolved organic matter must be removed from acid prepared from uncalcined rock. Removal of only the black suspended matter is not sufficient because the dissolved matter carbonizes during concentration and subsequent ammoniation. However, solutions prepared from black acid can be clarified by a process described later.

A vast amount of research has been conducted throughout the world on phosphoric acid purification. Most of the research, however, has been directed towards industrial-grade acid which commands high prices and requires greater purity than is necessary for fertilizer products. Therefore, I will confine my remarks to purification processes designed specifically for the fertilizer industry.

Different Types of Processes

Most purification processes fall into the following broad categories.

1. *Solvent Extraction:* In these processes a partially miscible solvent is used to extract the major portion of the acid but little of the impurities from the impure aqueous acid. Purified phosphoric acid then is recovered from the solvent by backextraction into water. The acid-depleted solvent then is recycled. Small amounts of solvent enter the aqueous phases and usually are recovered by distillation.
2. *Solvent Precipitation:* In these processes acid is treated with a completely miscible solvent usually in conjunction with alkalies or ammonia to cause impurities to precipitate mostly as phosphate salts. The solids are separated and the solvent distilled from the liquid phase and recycled; the residue is a purified acid.
3. *Indirect Purification:* In these processes acid is not produced, *per se,* but is separated from the impurities as a salt or an organic adduct. The purified salt or adduct then is converted to the end product.
4. *Clarification:* In these processes suspended solid impurities are separated from the phosphate by settling or flotation. Clarification of phosphoric acid by settling has been, of course, routinely practiced by the fertilizer industry for many years.

Israel Mining Industry's Process for Cleaning Phosphoric Acid[1,2]

A flow diagram for a solvent extraction process using isopropyl ether is shown in Slide 1. The process was developed by IMI and has been industrially implemented by FFM of Mexico. Although the process is capable of producing industrial-grade acid, the flow chart is for the less expensive fertilizer modification.

The process is fed with 54% WPA and extraction and phase separation are made at low temperature in mixer-settlers. The clean acid is released from the bulk of the solvent into water at about ambient temperature. Dissolved solvent is recovered from the pure and impure aqueous acid streams by steam stripping under vacuum. Sixty to 70% of the P_2O_5 is recovered as purified acid having a concentration of 48 to 51% P_2O_5.

About 97% or more of the metals and about 88% of the fluorine is removed from the usual Florida acid. Although organic matter is preferentially concentrated in the raffinate, the acid still blackens on concentration. To produce clear acid, a proprietary oxidation method is used.

Purification of Phosphoric Acid With n-Heptanol[3]

The flow chart for a solvent extraction process that uses n-heptanol is shown in Slide 2. The process was developed by USS Agri-Chemicals and has been implemented on a plant scale. One of its most advantageous features is that the low solubility of heptanol in aqueous phosphoric acid makes it unneccessary to recover solvent from the acid. Elimination of solvent recovery and the absence of heating and cooling steps simplifies the process and decreases capital costs. Solvent losses due to solubility and entrainment per ton of P_2O_5 are 7 to 12 pounds with green acid and 12 to 17 pounds with black acid.

The process is fed with 54% acid and uses mixer-settlers for extraction and phase separation. The concentration of the product acid is about 44% P_2O_5 and the product acid typically contains 80% of the input acid. Typical impurity rejections are 80 to 90% Mg. 70 to 80% A1, 50 to 60% Fe, and 75 to 85% F. The process accepts black acid but green acid gives smoother and more economical operation. When balck acid is used a solvent cleanup step must be added to prevent the buildup of tar-like organics. When the process is operated with green acid the product acid is clear; however, information is not available in the literature as to whether or not the dissolved and entrained solvent carbonizes during concentration and subsequent ammoniation is a pipe reactor.

Occidental S-X Process for Phosphoric Acid Purification[4]

A solvent extraction process developed by Garrett Research and successfully tested on a plant scale by Occidental is shown in Slide 3. The process is unique in that it selectively extracts Mg and Ca from the acid by liquid ion exchange. The extractant is sulfonic acid dissolved in kerosene. The objective of the process is to upgrade WPA produced from low-grade rock to about the usual quality without the coproduction of impure byproduct acid.

Crude acid is contacted with the extractant in mixer-settlers to extract the desired amount of Mg and smaller amounts of other metals. Entrained P_2O_5 is scrubbed from the extract with water and returned to the extractor. The extract then is treated with sulfuric acid solution to remove metals and regenerate the extractant. About 94 to 97% of the P_2O_5 is recovered as purified acid. The spent sulfuric acid solution and metal impurities are limed and discarded.

In theory, Mg can be completely extracted by using enough stages but it would be too expensive. Therefore, in practice, only enough stages are used to decrease Mg to meet specifications.

It is reported that purification costs are composed mainly of the costs of sulfuric acid and lime and P_2O_5 losses in the discarded stream.

Purification of Phosphoric Acid With Methanol and Ammonia[5,6]

A solvent precipitation process which uses methanol and ammonia is shown in Slide 4. The process has been developed through the laboratory stage and patented by TVA. Merchant-grade acid is treated with methanol and a small amount of ammonia to precipitate most of the impurities as metal ammonium phosphates and fluorine compounds. The slurry is centrifuged and the filtrate distilled to remove methanol and water to give purified superphosphoric acid. Methonol is separated from water in a fractionating tower and reused. The solids are washed with methanol and dried and the methanol is recovered. Solvent is lost only by mechanical means; chemical losses are negligible.

Purification increases with increase in methanol and/or ammonia; however, filtration rates become rather low when more than about 95% of the impurities is removed. The optimum amounts of methanol and ammonia for good filtration and the removal of about 90% or more of Fe, A1, and F, and up to 70% of the Mg from the usual Florida acid are 3.5 pounds of methanol and 0.04 pounds of ammonia per pound of P_2P_5. Magnesium removal increases with increase in the ratio of F:Mg. Up to 85% of the Mg is removed from acids with high ratios of F:Mg but as little as 20% is removed from acids having exceptionally low ratios. Unfortunately, none of the carbon is removed from the process and the product acid is black.

The solids typically contain 10% of the input P_2O_5 and have a 5-48-0 grade. All of the P_2O_5 is citrate soluble and 50% is water soluble. Therefore, the byproduct is a potential fertilizer.

The most costly part of the process is distillation; however, this is offset by the high concentration of the product acid (% P_2O_5) and the 90/10 split between product and raffinate.

Purification of Phosphoric Acid With Acetone and Ammonia[7, 8]

Another process developed through the laboratory stage by TVA is shown in Slide 5. It is basically a solvent precipitation process in which the acid is treated with acetone and a small amount of ammonia to cause the formation of two liquid phases. The light, acetone-rich phase contains the purified acid and the heavy acetone-poor phase contains most of the impurities and about 25% of the acid. The phases are quickly and cleanly separated in a settler. All of the acetone and part of the water is distilled from the acetone-rich phase to yield concentrated purified acid. The acetone is separated from the water in a fractionation column and reused. The acetone-poor phase is ammoniated and dried to form impure DAP and the acetone is recovered from the vapors. Acetone is lost only by mechanical means; chemical losses are negligible.

The optimum amounts of acetone and ammonia for smooth operation and the removal of 90% or more of the impurities from the usual acid are 3.4 pounds of acetone and 0.037 pounds of ammonia per pound of P_2O_5. Under these conditions about 75% of the acid reports to the purified product. Only part of the carbonaceous matter is removed and the concentrated acid is black. The byproduct DAP has a typical grade of 16-44-0; essentially all of the P_2O_5 is citrate soluble and about 80% is water soluble.

As with the methanol process, the most expensive part of the process is distillation. Compared with the methanol process,, it has the advantages of liquid-liquid separation and lower energy costs for distillation. It has the disadvantages of a lower product to raffinate split and the use of a more expensive solvent.

Urea Phosphate Pyrolysis Process[9, 10, 11, 12, 13, 14]

A process under pilot-plant development by TVA for production of clear solution fertilizer from urea and WPA is shown in Slide 6. Similar processes have been developed by Eugene Kuhlman in France and Badisch Aniline and Soda Fabrik in Germany. This process is an example of indirect acid purification since solution fertilizer is produced without the production of intermediate purified acid.

Urea solution (99%+), 54% WPA, and recycle filtrate are brought together in a reactor to precipitate pure urea phosphate.

$$\text{Urea} + H_3PO_4 \rightarrow \textit{Urea}\bullet H_3PO_4$$

Mother liquor is centrifuged from the crystals; part is recycled to the reactor to fluidize the slurry and the rest is processed into 13-24-0 suspension fertilizer. The urea phosphate cake then is pyrolyzed at temperatures above 250 degrees F. to form a melt of ammonium polyphosphate and undecomposed urea.

$$\text{Urea}\bullet H_3PO_4 \xrightarrow{\Delta H} \text{APP} + (1\text{-}x)\ \text{urea} + {}_xCO_2$$

The melt then is dissolved in water and ammonia is added as needed for pH adjustment to form 15-28-0 solution.

The typical solution is of satisfactory clarity and contains 85% of the phosphate but only 15% of the impurities originally present in the WPA. However, clarity is often a problem when the solutions contain greater proportions of the impurities. Liquids of 50% polyphosphate level that contain more than about 0.03% magnesium oxide (equivalent to about 85 to 90% removal from acid usually received at TVA) unexpectedly contained traces of magnesium precipitate after one to two months storage at 80%F. The reason for this and methods of extending storage life are being studied. Solutions that contain less magnesium have remained free of precipitates, thus far, during four months storage.

The major advantage of the urea phosphate pyrolysis process is the low energy requirement due to the complete dewatering of the urea phosphate and the limited heat needed for pyrolysis. Other advantages are the removal of carbonaceous matter and process simplicity. A disadvantage is the use of relatively expensive urea nitrogen for condensation of phosphate.

Urea Nitrate Purification Process[15, 16]

A process for the preparation of phosphoric acid from purified urea phosphate by treatment with nitric acid is shown in Slide 7. This process has been developed through the laboratory stage and patented by TVA. A similar process has been patented by Azote et Produits Chemiques in France.

Purified urea phosphate prepared as previously described is treated with concentrated nitric acid to form crystalline urea nitrate and phosphoric acid

$$\text{Urea}\bullet H_3PO_4 + HNO_3 = \textit{Urea}\bullet HNO_3 + H_3PO_4$$

The urea nitrate slurry is filtered and the cake washed with the nitric acid needed for reaction with the urea phosphate and the wash delivered to the reactor. The filtrate is purified phosphoric acid; part is recycled to the reactor to fluidize the slurry and the rest is concentrated to superphosphoric acid. The urea nitrate cake is neutralized with aqueous ammonia to form urea ammonium nitrate (UAN) solution

$$\text{Urea}\bullet HNO_3 + NH_3 = \text{Urea} + NH_4NO_3$$

Nitric acid concentrations from 50 to 72% can be used in the process, but as high a concentration as is economically feasible should be used to maximize the phosphoric acid concentration. When prepared with 65% nitric acid, the phosphoric acid contained 51% P_2O_5 and 5% dissolved urea nitrate. Since this acid is too dilute for direct production of APP, it must be concentrated further. If the acid is concentrated at high temperature part of the dissolved nitrate reacts with the urea to form nitrous oxide. However, this can be minimized and the nitric acid distilled and recovered by carrying out the concentration at lower temperatures under vacuum.

Substantially all of the P_2O_5 and impurities in the starting urea phosphate reports to the purified acid product. The product is clear, amber in color and typically contains 85% of the P_2O_5 and 15% of the impurities in the WPA. The trace amounts of phosphate and impurities reporting to the UAN solution do not affect its stability.

The urea nitrate process has higher capital and operating costs than the urea phosphate pyrolysis process. However, this is at least partially offset by production of the more versatile acid and by lower raw material costs since the cost of urea and nitric acid can be charged to UAN production.

Clarification of Solution Fertilizer by Flotation[17]

A process for the clarification of solution fertilizer developed through the pilot plant stage by TVA is shown in Slide 8. Warm, black product from a base solution plant is mixed with long-chain aliphatic amines and quaternary ammonium chlorides and then sent to the separator — a pound of each flotation agent per ton of solution is used. This treatment causes the black suspended matter to float to the surface. The black matter is withdrawn along with 15% of the solution and the mixture cooled and processed to suspension fertilizer. The clarified product containing 85% of the input solution is withdrawn from the bottom of the separator and cooled. The clarification process removes only solid carbonaceous material; other impurities remain in the clarified product in the same proportion as in the original black liquid fertilizer.

TVA has made preliminary estimates based on laboratory data for the cost of solution fertilizers prepared from phosphate purified by the methanol, acetone, and urea phosphate pyrolysis processes. In making the estimates the costs of shipping and clarification of solutions prepared from the methanol and acetone processes and the utilization of the impure byproducts were taken into consideration. Although the results indicated that product from the urea phosphate pyrolysis process was slightly cheaper than the others, the cost of the products from the different processes were essentially the same within the probable error of the estimates.

Since none of the processes had a definite advantage over the others, technical factors such as process complexity, reliability, and energy costs trends were considered in selecting the most promising process. Of the processes compared, urea phosphate pyrolysis is the least complex and has by far the lowest energy requirements, which will become increasingly important in the future. Therefore, TVA has chosen the urea phosphate pyrolysis process for further development in a large-scale pilot plant.

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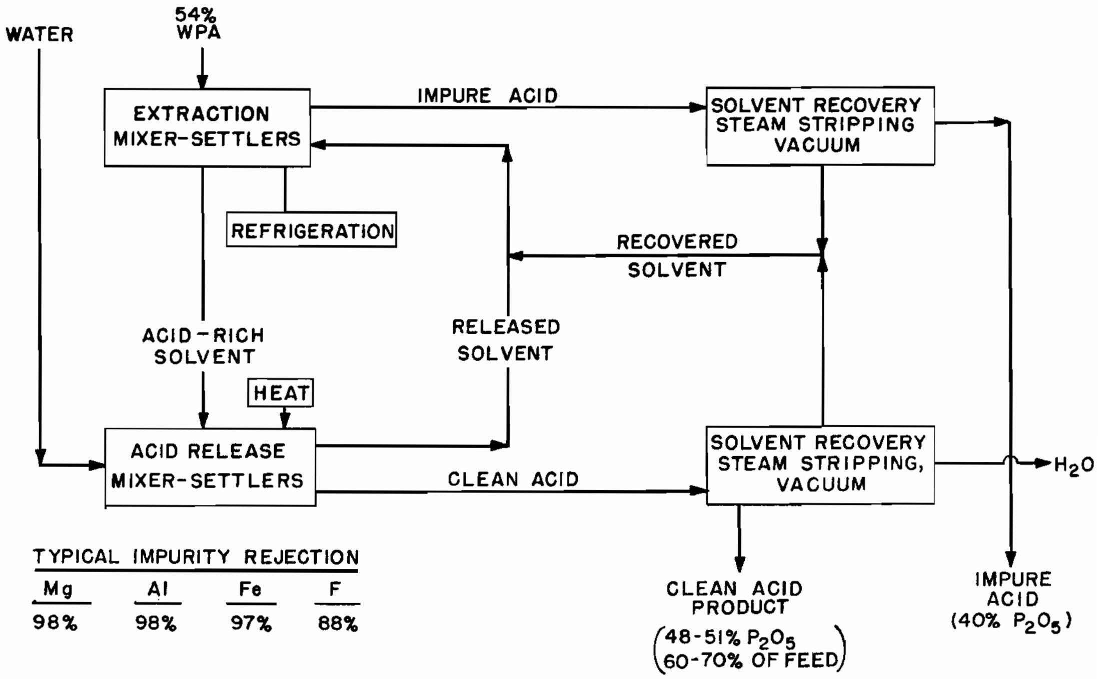
(Applaus) MODERATOR NIELSSON: Thank you John.

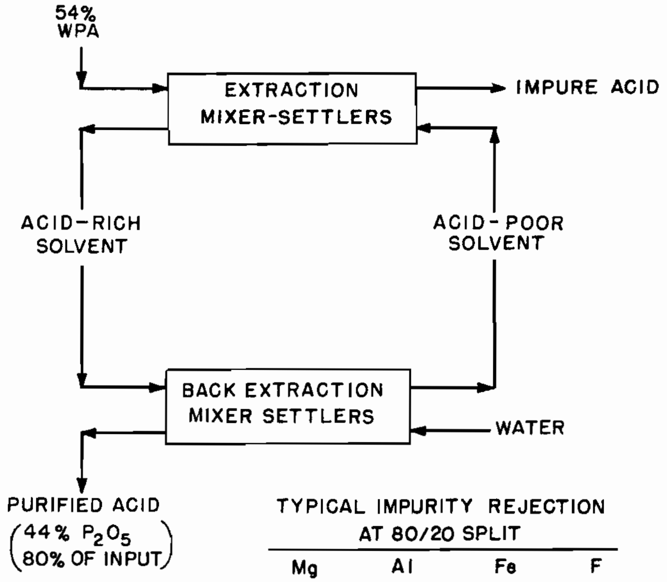
Note: Slides #1 thru #8
Continued on Pages #54 thru #57



TYPICAL IMPURITY REJECTION

Mg	Al	Fe	F
98%	98%	97%	88%

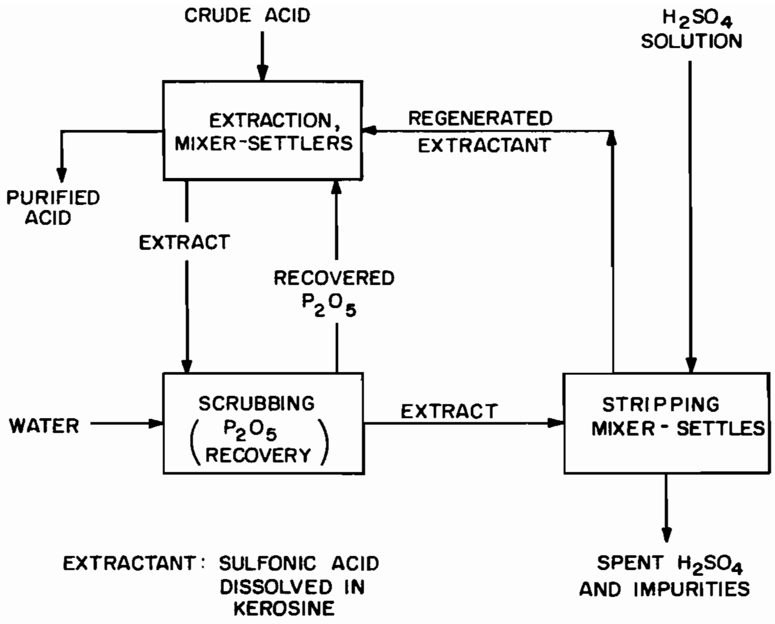
SLIDE 1
ISRAEL MINING INDUSTRIES ISOPROPYL ETHER PURIFICATION PROCESS



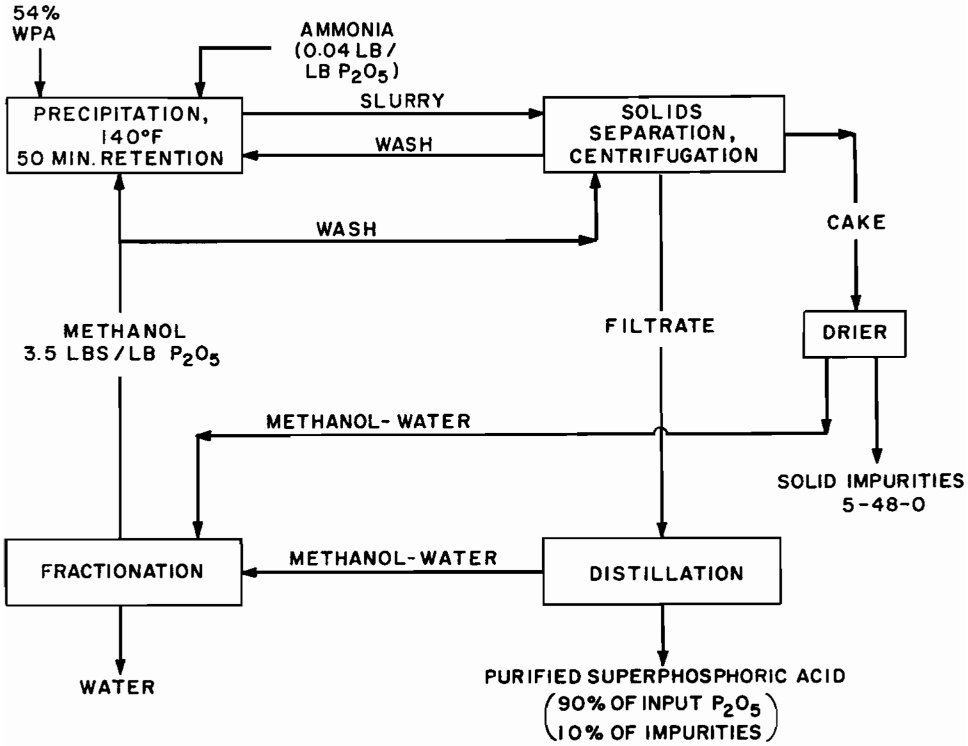
TYPICAL IMPURITY REJECTION
AT 80/20 SPLIT

Mg	Al	Fe	F
80-90%	70-80%	50-60%	75-85%

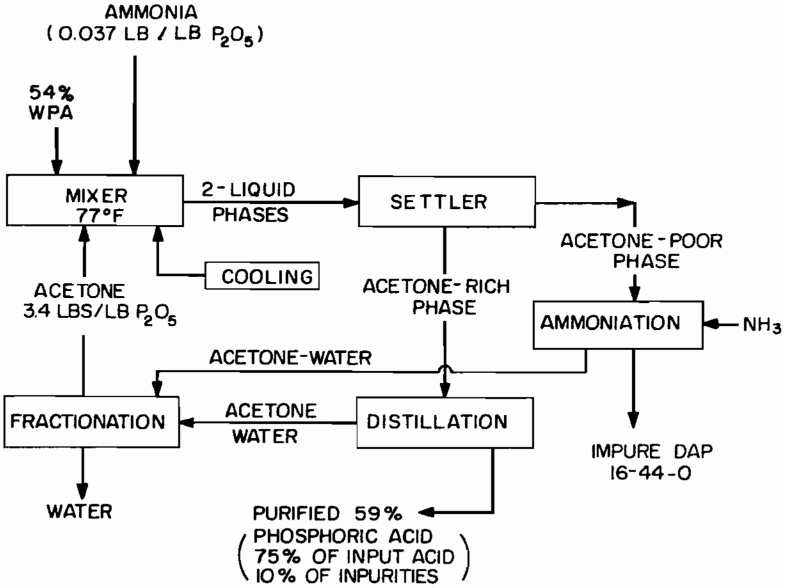
SLIDE 2
USS-AGRI-CHEMICALS' HEPTANOL EXTRACTION PROCESS



SLIDE 3
OCCIDENTAL S-X PROCESS FOR WPA PURIFICATION

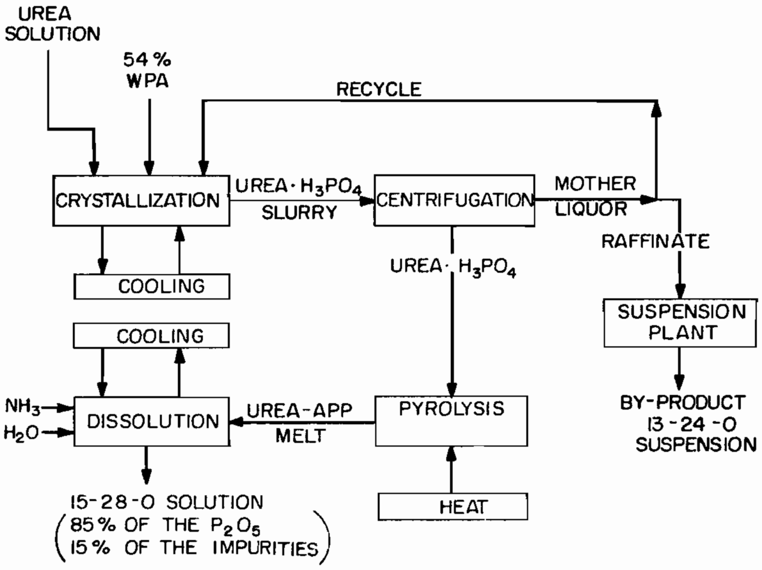


SLIDE 4
PURIFICATION OF WPA WITH METHANOL AND AMMONIA



SLIDE 5

PURIFICATION OF WPA WITH ACETONE AND AMMONIA

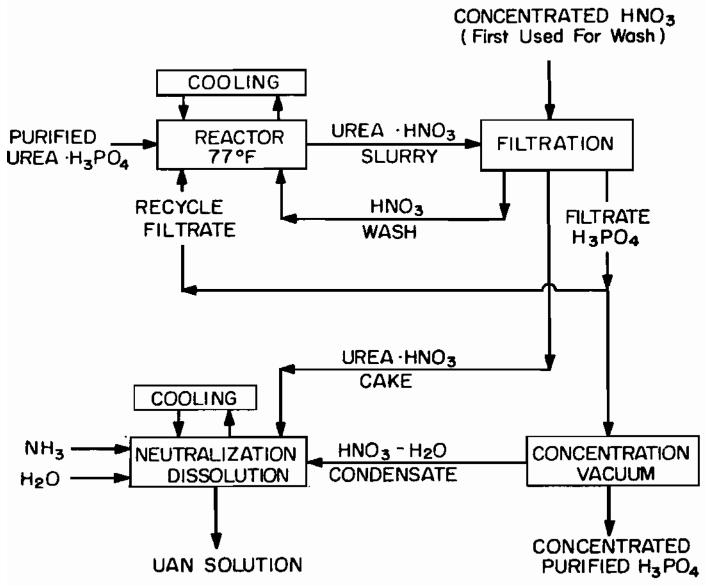


CRYSTALLIZATION: $\text{UREA} + H_3PO_4 = \text{UREA} \cdot H_3PO_4$

PYROLYSIS: $\text{UREA} \cdot H_3PO_4 = \text{APP} + (1-X)\ \text{UREA} + X\ CO_2$

SLIDE 6

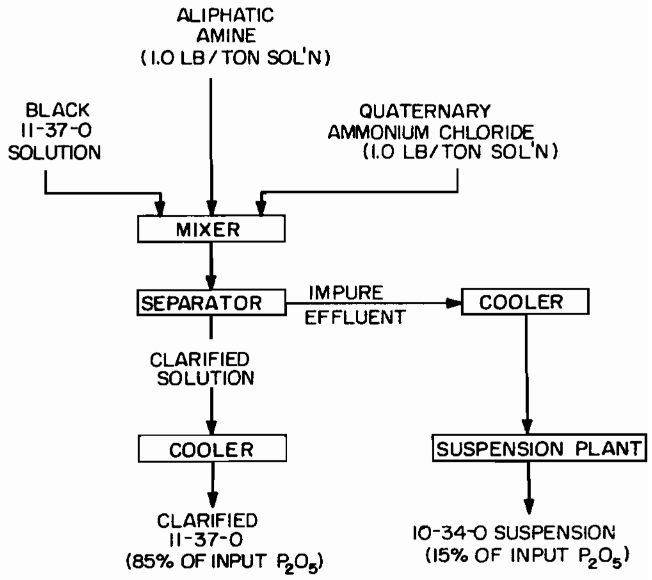
UREA PHOSPHATE PYROLYSIS PROCESS



REACTOR: $\underline{UREA \cdot H_3PO_4}$ + HNO_3 = $UREA \cdot HNO_3$ + H_3PO_4

NEUTRALIZATION: $\underline{UREA \cdot HNO_3}$ + NH_3 = UREA + NH_4NO_3

SLIDE 7
UREA NITRATE PURIFICATION PROCESS



SLIDE 8
CLARIFICATION OF SOLUTION FERTILIZERS BY FLOTATION

MODERATOR NIELSSON: The remainder of this afternoon's program will be moderated by William E. O'Brien. Bill please.

Panel Discussion Future of Granulation Plants

Moderator: William E. O'Brien

Panel: Harry Varnar — Dr. Richard Balser
Barney Tucker — Myron Rushton
Frank P. Achorn

MODERATOR O'BRIEN: For this discussion we have definded "Granulation Plants" as the regional or satellite type plants which receive their raw materials from some other location as opposed to the big Florida complex installations or plants like ours in Pascagoula or others which have phosphoric acid and ammonia production at the granulation plant site.

The makeup of our panel is designed to get different viewpoints on the future of granulation plants. We expect some disagreement and hope for an active discussion. Each speaker will have five to ten minutes for his presentation; and when all have completed their deliveries, we'll open the session up for a discussion and questions from the floor. So please hold your questions until all five panelists have completed their presentations.

Our first panelist is Harry Varner of USS Agri-Chemicals. Harry has been with USS Agri-Chemicals since 1954. He has served as advertising manager, marketing manager of lawn and garden products, manager of marketing communications, director of advertising and public relations, and director of business planning and public affairs, his current position.

His industry activities include membership in and past chairman of the TFI communications committee, chairman of the Florida Phosphate Council public relations committee. He has a marketing degree from Georgia State University. Harry please.

Panelist Harry Varner

Thank you very much. It is obvious, by that introduction, that I probably qualify as the most technically illiterate individual ever to appear before the Fertilizer Round Table. However, a quick perusal of the registration list will make it equally clear that, from USS Agri-Chemicals, I have sufficient technical backup here to get me out of any deep waters in which I might find myself. The introductery remarks also included the fact that the Predecesser Organization, to USS Agri-Chemicals was Armour Agricultural Chemical Co., which many of you recognize as an organization whose history includes heavy involvement in Chemically Mixed Fertilizer Plants, several of which plants are still operating. So, one of the most interesting questions facing the Industry today: "What is the future of granulation plants?" This is more than a passing interest to us.

Many, many factors enter into the process of factoring granulation plants into the long term planning. One of them, of course, is the nature of the markets you serve, from the corn growing areas in the Midwest to the tobacco farms of Eastern Carolina, the Lawn and Garden and Turf Business, and so on down the line. The important question is: "Which of these markets are now and will continue to generate demand for Ammoniated Granulated Fertilizers?" Then, of course, there is the economics situation: "What is the best way to deliver NPX to your market?" I suspect that all of these subjects will be dealt with by all of the other members of The Panel this afternoon.

I would like to deal with a different aspect, which is becoming an increasingly important factor, in deciding the future of an individual granulation plant. If I may back up and make a more general statement which will serve as background to some of my comments. In all the elction Rheteric we hear about inflation these days and in all the news coverage of inflation and the environmental movement. One inflationary factor is never dealt with; the built in inflation, the inevitable inflation which comes with non-productive capital expenditures. A capital expenditure, by and large, and there may be some exceptions, for environmental protection, is nonproductive in that it does not add a unit of production or at a lower cost. I will not make a value judgement this afternoon. It is not in the parview of this presentation to say whether or not what you get out of it is worth it, but I will say, hoping that you will carry it away with you today: "The American Public is not being advised by it's political leaders, nor by it's mass media, of the economic tradeoffs which are inherent in the billions of dollars being invested in Environmental Protection today. I will urge all of you, as influential "Thought Leaders", "Respected People in your Communities", and "Members of an Industry", which is very definitely affected by this, to discuss this when you talk to people, when you discuss politics and the future of this nation, talk about the economic tradeoffs which are involved in the billions of dollars which are required for Environmental Protection.

Now, back to Granulated Fertilizer Plants. There are, of course, as most of you know, Technology and Equipment today, which will qualify most plants to meet quality standards in most parts of the country and also to meet water quality standards. The big question, which your top management has to decide, is whether or not that plant, in a highly competitive market, not only competing with other mixed fertilizers but competing with other forms of plant nutrients, can bear the burden of this increased capital investment, plus the increased operating cost, and still remain economically viable.

When you look at an old fertilizer plant, which has been standing since 1929 and was written off the books in 1949, and you are faced with 3, 4 or $500,000 investment, it has to give pause. Now, that of course is a decision that addresses itself to the top management people of your organization, and mine, who are responsible for allocating available capital resources.

So, let's deal for a moment with something that you, as plant operators or as technical advisors to plant operators, have some control over in keeping a granulating plant going in the light of the pressures we have from the environmentals and the requirements for environmental control. I have mentioned that there are technologies and equipment which will give us control of particulate emmisions, but there are certain facets of control of environmental regulations which are subjective at best. Let's take the opacity test for instance. The time of day it is taken, how much steam is coming our of the stack at a given time, can dictate whether or not that particular inspector decides to cite you for pollution during that given day. Then, of course, there is the eternal problem which also obtains ultimately at a bulk blend plant, fugitive dust emissions, the trucks rolling in over an unpaved yard and the cracks in the building where dust escapes.

Now, when you get into the area of what I would call subjective enforcement of pollution controls, a lot will depend on where your plant is located, what kind of neighbors you have, what kind of pressures the local pollution control officials are coming under by your neighbors.

Again, some of the older granulation plants are in a very difficult position in this respect. I could name cities where we have plants that were originally built out in the boondocks, not a neighbor for miles around, just a nice convenient railroad track or some water transportation and there you were.

What is the story today? Well, I will tell you what has been built close to some of our plants, and I am sure you will relate very quickly: A Mobile Home Development right under the stacks at one location, a school at another, and if you please, an old peoples' home at still another location. A nice clean Industrial Park, where the heaviest industrial activity is warehousing, was built next to one of our plants. Sometimes when there are specks on the chrome of their cars, they will look at you with some little suspicion. The fact that you were there first does not matter. What matters is that the local pollution control official, be he County, City, State or whatever political unit, when he gets pressure from these people, then you are going to get pressure from him and the life of your operation will be threatened.

O.K., How do you avoid this? Let's take a look at some of the operation problems you have, what you can do about them in a nontechnical way and some of the things you can do in the Community to help keep these pressures down as long as you want to keep that plant viable. You know, and I know, that the average granulating plant is a highly seasonal operation. You have got tremendous labor turnover; and even if you make an investment in the sophisticated pollution control equipment, it is down probably four or five months of the year; and the people that come in for spring season, '77 did not learn what you taught them in '76. So, you have some very serious operational problems. Here a heavy responsibility impinges on the plant operator, and his technical advisor, to make sure that plant is operated in such a way to capitalize on the pollution control equipment you have.

Then, from the fugitive dust point of view, you have a very simple matter of housekeeping. I know how difficult housekeeping is in a mixed fertilizer plant, I also know how much difference good housekeeping can make in fugitive dust emissions. For example it is no very simple act of paving a truck yard. It is simple until you try to get your Comptroller to okay the authorization. Just that act alone will cut down tremendously on the fugitive dust emissions.

In addition, to good operations, keeping a pipeline open to the community is very helpful. Wasn't it wonderful in the days of many, many decades ago when all of the plant Manager's responsibilities were bound up in operating that plant efficiently, getting maximum tons per hour, at the lowest cost per ton? That's all he had to worry about and now the poor guy maybe has one day a week to worry about that. He has to be concerned with E.E.O.C., he has to be concerned with D.O.T. regulations, with O.S.H.A. and on through the bureaucratic alphabet. One of the best ways to keep that pressure off you, which can cut the life of the plant, is to know what's going on in the community.

I will give you an example of this which I think illustrates the case. We had a plant in a town about the size of 150,000 — 200,000 people, a very old plant, which we were trying to keep up to date with pollution control equipment. We had a trailer park across the street, and I never will forget, we solved the dust problem, however, the fan had such a high frequency hum we ran into a noise pollution. However, we were fortunate in that, that particular city had an active Chamber of Commerce that really wanted to keep business going. The newspaper was more Pro-Business than Anti-Business which is a rare thing in this day and time. Well, an assistant professor, at the local city college, all of a sudden got an inordinate interest in clean air. He smoked about two packs of cigarettes a day, but he was very concerned about protecting the lungs of other people; and he zeroed in on our plant, harassing the plant manager, going to the City Council, going to the Chamber of Commerce, trying to get the newspaper interested. Fortunately we had a very alert Plant Manager there who knew these things were going on and did not keep them secret.

He let the headquarter's people know what was going on. So, the Production Area Manager and I decided we had to talk with this Professor. We went down and had a chat with him, explained that we recognized we had some problems, but we did feel that we were producing a product which was for the overall well-being of mankind. You know you would hate to see somebody take a last gasp of clean air through starvation. He said "I would like to see your plant and I would like to bring some students through." We said "O.K., it is a small plant; you select a small group of students; bring them over, and we will take you through the plant." He said "We would like to take some pictures." I said "I will bring a camera; I will take pictures; you cannot bring cameras in." The pipeline worked again; the plant manager learned that our friend had been going around the campus trying to recruit people to bring to the plant and urging them all to bring cameras.

Six automobiles, full of students, roared into the yard of the Fertilizer Plant and out they moved. Everyone of them had a camera from a sophisticated Japanese 35mm right down to a Brownie Box Camera. I said "I told you that we could only handle a small group." He said "why, are you trying to hide something" I said "No, we will take them through five at a time, that will take an hour and a half and if the others want to wait, they are welcome." He said "Why can't you take them in all at the same time?" I said "you have to wear a hard hat for safety, there is some dust in there and I am going to give you a nice white coat, we just have enough coats and hats to accommodate five at a time." I said "Check your cameras in with the lady there" He said, "Why can't we take pictures; are you trying to hide something?" I said "No, we have got a group of employees out there who are trying their best to see that the farmers in this area have fertilizer next week, and I don't want them bothered by shutterbugs. I will take pictures." He said "O.K." so we took them through. We explained our problems and how we were dealing with them. The result. We heard nothing further from them.

Now, what is the point of this story? You will have these kinds of people to deal with; and there are certain principals to remember in dealing with them, all of which I think this story represents. One is your local people have to be attuned to what is going on on the community so they can alert headquarters where help is needed. Secondly, you deal with them forthrightly and courteously, but you deal with them firmly. Don't ever think that when you are dealing with an enviromental group, if you are honest with them, that you have to be apologetic and sit down and let them walk over you. They won't respect you if you do.

So, the bottom line of this discussion, of one point of view, on the future of fertilizer granulation plants is this. "Your Top Management, and those of you who represent Top Management, are going to be faced with some extremely difficult decisions, even after you have satisfied yourself of the need for this product in the market place, of whether or not you can meet increasingly stringent pollution control requirements and invest the money in the operating expenses to do so. Once you have made the decision to keep "that plant open" as we have made to keep many of "our's open" your plant operating people have to do an extremely good job of training the people, who operate and maintain the pollution control equipment, to do the kinds of housekeeping things which will help to keep down potential pollution. Then you have to recognize, that even when you have the best technical equipment in the plant, you are still open to community pressures. You then do the kind of things which establish you as a good neighbor in that community. You establish lines of communications with the "Thought Leaders in that community so that you are able to anticipate and to handle situations as they arise. Following those points I think we can extend the life of many of our granulation plants which environmental problems could well threaten otherwise. *(Applause)*

MODERATOR O'BRIEN: Thank you, Harry. I think that environmental factors and public relations are very important in considering the future of granulation plants.

We have a change in our second panelist. Dick Balser is replacing Henry McCarley of Agrico. I think Dick has some comments on the reasons for his replacement. Dr. Balser is manager of marketing communications for Agrico and like our other panelists has been around the fertilizer industry for many, many years. He is widely known for both his agronomic and his marketing knowledge. Dr. Balser, please.

Panelist Dr. Richard Balser

Thank you Bill. All of you have heard the old expression "show me two people who think alike and I can show you one I can do without". I use this illustration to point out that we do not all think alike in our organization. My former associate, Henry McCarley, was selected to present the reasons our company favors the bulk blending-materials approach in the fertilizer market place. Henry left our company about a month ago to join a prominent mixed goods ammoniating organization.

It is safe to observe that all of us in this room are dedicated students in the soil fertility and plant nutrition field. It is a large and diverse field. We seek a common goal yet there are many roads to travel in reaching the end target. It is true that our company is not bullish regarding the future of NPK granulated fertilizer plants scattered over the market place. At the same time, we do see an opportunity and a place for ammoniated mixed goods in the total market picture. We have simply elected to cast our lot in the materials-blends field as our primary approach. I wish to explain some of our reasoning in taking this position. It will not be an attempt to argue that we should all think alike.

There is no question that fertilizer consumption trends over the past 15 years have guided our thinking. Let's look at what has been happening in the U.S. fertilizer market when one studies consumption in a nutrient ton basis by major product type. Dry chemical mixtures held approximately 62 percent of the fertilizer market on a nutrient ton basis in 1961. This percentage dropped to 23 percent of the market in 1971 and fell to 18 percent last year. In contrast, dry straight materials and blends accounted for 25 percent of the total nutrient market in 1961. This percentage increased to some 52 percent of the U.S. nutrient market last year. In other owrds, there has been a pronounced shift from dry chemical mixtures to dry materials and blends over the past 15 years. In addition, three other product types have had large percentage increases in market share. Liquid mixtures increased from 3 percent of the market in 1961 to 9 percent last year; ammonia increased from 4 to 11 percent during the same period and nitrogen solutions from 4 to 10 percent. One cannot ignore these market statistics in assessing what the future may hold.

There are many reasons behind the trend to greater usage of fertilizer materials and fluid or dry blends. We believe that two key factors have led the way. One has been the demand for nutrient programs that have little fit to old fertilizer grades and ratios. The other has been the demand for spreading service along with the fertilizer.

We have become more professional in prescription fitting nutrients to soil and plant needs. We are making more expert use of soil tests, plant analyses and other diagnostic tools in developing a fertilizer recommendation. These programs typically differ field by field and farm by farm. This has led to many ratios of NPK as well as the addition of specific levels of certain secondary and micronutrients. The fertilizer user is much more knowledgeable. They buy very little fertilizer on a brand basis. The old concepts of formulating a corn grower fertilizer or a wheat fertilizer only serves those who sling to the past. A progressive fertilizer user today consults with his dealer and surveys the knowledge at hand to come up with a fertilizer program for corn something like this: 160 lbs. N, 80 lbs. P_2O_5, 100 lbs. K_2O, 15 lbs. sulfur, 5 lbs. magnesium and 1 lb. zinc. Programs of this type can best be served by locally formulated fertilizers. As crop producers shoot for higher yields and as soils become more deficient in varying combinations of nutrients, the need for "on-the-spot" formulation will increase in importance.

A second key factor in the trend from dry chemical mixtures to dry materials and blends has been the change in who applies the fertilizer. The farmer did most of his own fertilizer application 15 years ago. Today, most of the fertilizer is being applied by the dealer or an independent custom applicator. A Doane study in 1975 showed that approximately 60 percent of dry, blended fertilizer was applied by the dealer. Liquid mixed fertilizers exhibited a similar pattern with 62 percent of product sold spread by the dealer.

It is obvious that today's fertilizer application equipment is being built for the dealer-custom applicator, not the farmer. The percentage of fertilizer applied by the farmer continues to drop each year. Since farm labor is difficult to find, since timing in crop production is so critical, and since custom application is often more economical, this trend will continue. The farmer rarely sees the fertilizer he buys. It is a change from the old days when he inspected it in each hopper load on his planter or drill. This trend favors bulk handling and fertilizer formulation in each localized market.

In summary, the fertilizer pie is a big and varied one. There are numerous ways to approach it and all systems must produce results to succeed. Plant food will continue to reach the field in a family of materials and mixtures. Our organization, as one member of the fertilizer fraternity, has chosen a basic producer role. We do not believe the network of granulation plants that was once our pride fits today's market. The trends in usage, distribution economics and application methods just discussed yield the basis for this decision. *(Applause)*

MODERATOR O'BRIEN: Thank you Dick.

Our next panelist is Barney A. Tucker, President and Chief Executive Officer of Burley Belt Chemical Company with Administrative Headquarters in Lexington, Kentucky. Most of you probably know that Burley Belt sometimes will purchase some of Agrico's granulation plants. Barney has a Bachelor of Science degree from The University of Tennessee. He is founding president of the Kentucky Plant Food Council, Past President of the Kentucky Chamber of Commerce and has served in many civic and industrial capacities. He is listed in *Who's Who in World Commerce & Industry* and *Who's Who in the South and Southwest.* Barney, please.

Panelist Barney A. Tucker

Thank you very much, Bill. I wish to apologize for having no formal, prepared paper. My remarks will be made from a few short notes, but I will try to be brief and to the point and not infringe upon the time of the next panelist.

I've always taken the attitude that we are in the fertilizer business. It doesn't necessarily have to be granulated; it doesn't necessarily have to be a blend or liquid; whatever revision the trade demands is what we're going to do. We have had some degree of success in granulation. We have had three plants granulating about 100,000 tons. We also blend. We also custom mix. We also still have three smaller plants that manufacture pulverized tobacco fertilizer, since many burley growers still prefer a homogeneous pulverized product. We supply a number of other companies with their plant bed fertilizer.

In our Kentucky Marketing area we have a high percentage of sulfate of potash grades for tobacco; therefore, a good reason for continuing ammoniation is that there is just not that much granular sulfate of potash on the market, and it's also expensive. I figure that every time one of these ammoniation plants goes out of business over the territory or area, it just leaves us a little more elbow room.

Pollution control is more of a problem in manufacturing plants than in blend or liquid facilities. We are within compliance at the three granulation points; our normal superphosphate plant is also in compliance. We've found that with the sulfur, soluble calcium and minor elements we get from old fashioned run-of-pile normal, we can develop some excellent agronomic formulas by using various amounts with concentrated material; i.e., phosphoric acid and manufacturing grade MAP. It makes a beautiful combination; a combination that drys quickly and stores quite well.

I don't believe anyone can argue that there isn't more segregation in a blend than there is in a good ammoniated fertilizer. Just recently the Kentucky Agricultural Experiment Station's Regulatory Division published their complete report for fiscal '75 - '76. This report revealed deficiencies in blended grades outnumbered those in manufactured ones at a ratio of two to one. The ratio held true in both bulk and bagged finished products. Blended "prescription mixes" for the entire period showed deficiencies in one or more elements of fifty-eight percent.

I would like to point out a few of the qualities that, to me, give a good granular product superiority over a physical blend. In the first place, of course, there is the matter of segregation and uniform distribution. In the granular product we have all the elements tied up in one homogeneous granule, if it's manufactured properly. We can store processed fertilizer in bulk or bags, ready for the market, much better than we can premixed raw materials. We can use pulverized material which is often cheaper. We can use off spec material as long as we adjust the formulas accordingly. As some of the suppliers in here tell you, I'm always on the lookout for a good buy, and we come up with some now and then. Actually, we have two major assets here when we're talking about ammoniation plants; we have the storage space and we have the process. I do know that if we must ever go to blending altogether, we'll have some darn big blenders.

Furthermore, dealers having an ammoniated product do not have as large a capital outlay in order to serve their customers as those who have to put in blending equipment. Also dealers, if they're good merchandisers, can take advantage of brand names the manufacturer has promoted. As many of you know, the growers investment today may be as high as $2,000.00 an acre for corn land or bean land plus all the necessary equipment; so a farmer cannot afford to take anything less than the best to his fields. To me it is a disadvantage, almost a travesty on the farmer, in the way some of these blends go to the field. A small percentage of them rarely are subject to regulatory inspection. These blends are mixed now and spread 30 minutes later; with the inspector never having a chance to get his samples. So he goes to the ammoniator who has a plant full of manufactured product to get his samples, and we're still out performing the blender 2 to 1.

Another point, Dick mentioned that minor elements, when used, should be thoroughly incorporated with the product. I feel we can certainly incorporate these in a manufactured product much more uniformly, and get it where we want it, than you can a blend. You can't put two pounds or three pounds or say ten pounds of dry zinc oxide or zinc sulfate in a ton of blended fertilizer and know what happened to it. These are some of the major benefits that I see for an ammoniated product.

Mr. O'Brien has mentioned the importance of public relations. I could not agree more. Regardless of your type of installation, try too be a good neighbor. Become a part of the community and encourage your staff and other employees to do the same. If you develop a good public image, many *minor* infractions of "pollution regulations" may be overlooked by your neighbors. If you have a poor image, you're in for trouble. Regardless of what really caused a neighbor's automobile paint to peel or problems with the roof, or dust on his furniture, the "fertilizer plant" will often bear the brunt. Just remember it's good to invest in the welfare of your community as well as in your facility and equipment.

I suppose there will be a question and answer period later, and I'll be glad to sit with the rest of the panel and defend the validity of the points set forth. Well operated ammoniation plants will be around for a long time. Thank you. *(Applause)*

MODERATOR O'BRIEN: Thank you, Barney. That was right in the spirit of pro and con we hoped to have from this panel.

Our fourth and next to the last panelist is Myron Rushton of Indiana Farm Bureau. Myron is Manager of the Plant Food Section Crops Division, Indiana Farm Burea Cooperative Association. He started with the Indiana Farm Cooperative in 1939 and spent about three years working in the accounting department. Then World War II came along, and he spent three years in the service. From 1946 to 1957 he was a plant superintendent with Indiana Farm Bureau. From '57 to '74 he was in Production Management, and from '74 to present he has been in his present position of Manager of the Plant Food Section. Myron, please.

Panelist Myron Rushton

I would like to add one word to that topic, "Future of Existing Granulation Plants" as compared to one being built today. We are here today to discuss those existing today. The Indiana Farm Bureau Cooperative Association is operating two granulation plants, one in Indianapolis, Indiana, and one located near Columbia City, Indiana. Both are TVA type ammoniators, 25 tons per hour, Sackett & Sons dryers and coolers, Tyler, triple deck screens, etc. These plants were constructed in early and mid 1950's. Of course, these plants have been modified a number of times since they were constructed.

Since Mr. Bill O'Brien of the Mississippi Chemical Corporation contacted Mel Leach about being on this program, it has been decided to stop operations at one of the granulation plants.

In Indianapolis alone there was five granulation plants and now there is only one. Perhaps, all of these plants were closed for a different reason, tonnage thruput down, did not fit distribution patterns, equipment old and worn out.

We are closing our plant for one reason, thruput tonnage down to a point. It does not warrant $500,000 on EPA air pollution equipment. Perhaps after you spend it, it would not yet pass. Water pollution into a small creek from surface drainage is a continual problem. The best statement to describe it, "EPA helps us make up our minds."

This plant will be utilized as a warehouse and blending facility. This does not mean we will solve our EPA problems by stopping granulation only, but it certainly will be reclassified and less expensive to conform to regulations.

The future of granulation plants has been a topic of discussion for the last fifteen years. I think we have to ask ourselves some questions.

1. What does the farmer of today and the future really want.
2. Is chemically mixed fertilizer or plant food really that much better for the plant growth.
3. Is it the service angle the farmer really wants.
4. Who is going to pay for the more expensive processors.

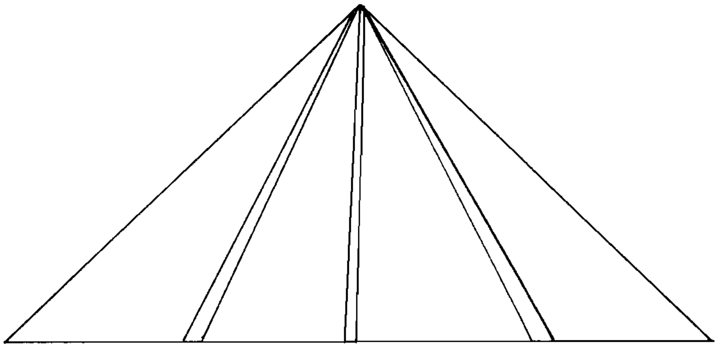
The fertilizer industry lost a lot of credibility these past few years. Better known as the day of the big "rip off." Farmers can read between the lines also. We must service agriculture to its fullest or someone else will be in the act. We have more bureauracy than we can afford now. However, they are a part of our great society and we must learn to compete with it.

It is our opinion that granulation plants of any type is in for a great economic squeeze because of labor rates, $4.50 to $6.00 per hour, equipment replacement cost, repairs and maintenance skyrocketing, productive tons per man hour down, EPA demands costly, installation of water treatment plants, dust collection systems. All of this can only make it tougher to compete with a blender operation or liquid hot mix plants.

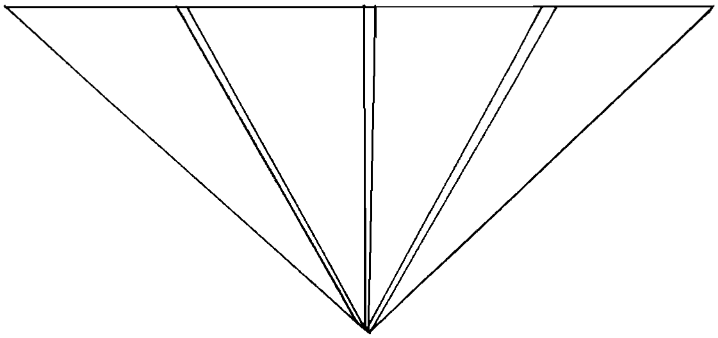
However, we are not ready to give up granulation products. We feel it has its place to furnish us with a complete program in the total supply picture. *(Applause)*

MODERATOR O'BRIEN: Thank you Myron. Our last Panelist is Frank P. Achorn, TVA. I don't think Frank you are entitled to two introductions in an afternoon! Frank, please.

Panelist Frank P. Achorn



The Future of Granulation Plants



When Bill O'Brien asked me to be on this panel, I thought this was an opportunity to discuss one of my favorite subjects — ammoniation-granulation, and I'm glad I came because I'm afraid the previous speakers have implied that it may be time to bury the old girl (ammoniation-granulation) before she completely dies.

Before accepting this opportunity to discuss ammoniation-granulation, H. L. Balay and I reviewed the literature and this review was back to 1966. We discovered that 1966 was the first year there was some discussion relative to the decreasing importance of ammoniation-granulation plants. It is rather difficult to estimate the quantity of NPK mixtures produced by ammoniation-granulation plants;however, the best data we had at that time indicated that in 1966 about 10.6 million tons of NPK mixtures were produced in ammoniation-granulation plants.

In 1975 a similar survey of plant production data indicated that about 10 million tons of NPK mixtures was produced in granulation plants. Data also reveal that the total number of plants in 1966 was considerably higher than the number of plants in 1975. Based on this information, it is safe to assume that each plant is producing considerably more material.

A similar study was made for bulk plants. A result of these studies shows there were less bulk blending plants in 1975 than in 1970. This is contrary in the popular opinion that bulk blending is increasing and replacing all the granulation plants. Therefore, if we were to assume that the number of plants determine the quantity of bulk blends produced, it could easily be assumed that bulk blending is also decreasing, and you know this is contrary to statistical facts. Bulk blending has actually stabilized at about 10 million tons per year.

I personally think that over the next ten years there will be three major production marketing systems. I think ammoniation-granulation plants will be part of one of these three systems, and I do not expect that during the next ten years developments in granulation plants will stop while developments in bulk blending plants and fluid fertilizer plants will improve operations. There are many new inventions for ammoniation-granulation plants that are currently being developed. It is my opinion that the mode of operations and materials used in granulation plants will probably change drastically. It is also my opinion that in the next ten years fluid fertilizer plants will be improving. I wouldn't have presented the paper today on fluid fertilizers if I didn't think they were not going to be a major marketing system. I also think that in the next ten years bulk blending will develop and improve. Therefore, it is my opinion that granulation plants will continue to exist and improve in operation. Currently, I know of a couple of states where they are the dominating production marketing system. For example, in Alabama and Mississippi one company markets about 600,000 tons of NPK mixtures that are produced in ammoniation-granulation plants. Other companies in that area currently have conventional ammoniation-granulation plants that produce in excess of 100,000 tons of NPK mixtures. I am talking about NPK mixtures that come through that granulation plant, and these plants are economical to operate provided the accountants put the numbers and right figures on the right things instead of the accounting procedures being wrong many times.

I have some slides I would like to show that review the reasons I came to these conclusions. Before presenting the slides, I would like to say, "General MacArthur was quoted as saying, 'Old soldiers never die; they just fade away." Well, old granulation plants never die; they just change and go on and on and on . . ."

Now to answer the question relative to the future of granulation plants. My answer to that is the future of granulation plants is good! I don't think they are going to chase all the bulk blending plants out of the marketplace, and they are not going to eliminate all the fluid fertilizer plants; but they are going to be around because we have not lost the need for them.

Slide 1 shows the three marketing systems I reviewed: ammoniation-granulation, fluid fertilizers, and bulk blending. Perhaps somebody may come up with a fourth type of marketing system like putting fertilizer out in a tube. Who can tell?

The slides show the reasons why granulation plants will continue to grow. *Slide 2.* This country will continue to have an ample supply and possible an extreme surplus of spent sulfuric acid. Many steam plants are going to produce sulfuric acid as a byproduct of SO_2 removal. This SO_2 usually ends up as sulfuric acid or fine size ammonium sulfate. In our meetings at the Round Table, we have discussed pollution control and its problems; however, this byproduct of pollution control systems may be of considerable help to the fertilizer industry by supplying us a lower cost raw material. You are now seeing full trainloads of phosphoric acid being shipped to granulation plants. We have cooperating with us in our field program one granulation plant that consumes as much as 1200 pounds of phosphoric acid plus sulfuric acid per ton of product in their own granulation plant. They can do this because of new operating procedures started in the plant, and they don't even use a dryer in the granulation plant any more. Therefore, when a plant has its natural gas cut off, all they have to do is start using more chemical heat through the use of more phosphoric acid and keep on operating without the use of gas or fuel to dry the product.

Slide 3. There is now an ample supply of run-of-pile triple superphosphate. This triple superphosphate has to be produced as a receiver of the sludge phosphoric acid produced in Florida. The producers of phosphoric acid have to do something with the sludge that settles in the acid, and an excellent place for this sludge is for the production of run-of-pile triple superphosphate.

Slide 4. Another ideal material for the disposal of sludge acid is monoammonium phosphate (MAP). It is important we emphasize that for years the granulation plant has been the best phosphoric acid sludge pot the phosphoric acid producer has available. The phosphoric acid basic producer must dispose of his sludge as either run-of-pile triple superphosphate or monoammonium phosphate. He cannot dispose of it in the manufacture of diammonium phosphate because the impurity level of the sludge won't allow him to meet the grade specification of 18-46-0.

Slide 5. This slide shows some information that was published in an article in *Chemical Engineering News* concerning the recovery of SO_2 from 610 steam boilers. The data show that the 610 boilers will produce about 9.7 million tons of sulfuric acid as an impure acid per year. This acid will produce about 13 million tons of impure fine size ammonium sulfate. The materials will be of such particle size that it cannot be applied on the farm without being converted to granular products. This ammonium sulfate will be produced throughout the country at the location of various utilities. It will not be shipped to one location or spot; obviously, it will be shipped to the closest ammoniation-granulation plant to be converted to granular fertilizers. This discussion, therefore, emphasizes the advantage that ammoniation-granulation plants have in utilizing byproducts of pollution systems.

We frequently hear from our politicians that we should use more and more coal as an energy source. However, they also insist that the air remain pure. Therefore, it seems logical that we should expect to recover some of the byproducts from pollution control systems that utilize coal as a source of energy. Obviously, the ammoniation-granulation plant is one of the fertilizer production marketing systems that can utilize these byproducts from pollution control; therefore, there is a strong need for the granulation plant. Let's not bury the old gal yet; the nation still needs her. *(Applause)*

Slide #1
Major Marketing Systems
(Next 10 Years)

1 — Ammoniation - Granulation
2 — Fluid Fertilizers
3 — Bulk Blend Fertilizers

Slide #2
Materials Suited For
Ammoniation Granulation &
Not other Marketing Systems

1. Spent Sulphuric Acid
2. Fine Size Ammonium Sulphate
3. Byproduct Calcium Phosphate
4. Spent Phosphoric Acid
5. Wet Process Phosphoric Acid
6. Run of Pile T.S.P.
7. Powder Size Ammonium Phosphate

Slide #3
Run of Pile T.S.P. For Sludge

Slide #4
Powdered MAP For Sludge

Slide #5
610 Boilers
9.7 Million Tons H_2SO_4
26 Times As Much As
Presently Consumed

MODERATOR O'BRIEN: Thank you Panelists — Varnar, Balson, Tucker, Rushton and Achorn. You have given us many excellent and constructive, varied viewpoints on "The Future of Granulation Plants." You will have an opportunity on Thursday morning to "Submit your questions and suggestions to the Panel" on the question and answer session. We all thank you. *(Lots of applause)*

Meeting adjourned 4:30 P.M.

Wednesday, October 27, 1976

Morning Session
Moderators:
D. O. Walstad - William F. O'Brien

MODERATOR WALSTAD: Good Afternoon. Most of you know him, but for those who don't, Mr. George Hoffmeister is a graduate of Rice University, at Houston, he joined TVA early after leaving Rice. He is now Head of Evaluation Section in TVA's Applied Research Branch. Much of his work has been on this problem of segregation in "Bulk Blending", in fact, he has talked about segregation to this group several times. I still wonder if he has gotten his point across. So we are giving him another try this morning. George Please. *(Applause)*

GEORGE HOFFMEISTER: Thanks a lot Dan. Maybe we can get it across this time.

Designing Bulk Blend Plants To Reduce Segregation

George Hoffmeister

Bulk blenders continue to have considerable difficulty meeting state analysis requirements. For example, in one state where blending is important, the state control official reports that 51% of the bulk blend samples analyzed last year were deficient in one or more nutrient. In that state, and others, TVA now has had the opportunity to work with blenders and control officials in attempt to uncover the causes of the problem and to alleviate it. Out of this work, one predominant cause of the analysis difficulty has been apparent; this is, "the use of blend materials of unmatched particle size in *equipment not designed to handle unmatched blend.*"

It is now well established[2, 3, 5] that the use of blend materials of unmatched particle size results in blend that will segregate, that is, become "unmixed," unless it is handled very carefully. As an illustration, Figure 1 shows a blend (Blend A) of unmatched sizes that was well mixed and homogeneous before it was poured into the small plastic display box, but the simple act of pouring caused severe unmixing of the blend.

Blend that is much more stable can be made by matching particle size of the blend ingredients. For example, Blend B. shown in Figure 1, was made from matched sizes and remained very well mixed when poured, in spite of wide differences in density of the materials.

In our contacts with blenders, therefore, our first approach has been to encourage strongly the use of blend materials of as close a size match as possible. Suppliers of materials for blends have made progress in providing properly sized materials for blenders. Examples of industry efforts are the increase in urea size by granulation or by improved prilling and the installation of increased granulation capacity by the potash industry. Other developments have been the granulation of potassium sulfate and the granulation of micronutrients. However, even with these improvements, we must concede that perfect size matching has not and probably will not be achieved.

However, there is a second approach that we have used successfully to reduce segregation in blend plants; this involves *"speical design or modification of equipment to handle blends of unmatched materials."* There is considerable advantage in using this approach and ending up with a plant that will handle a moderate degree of mismatch in raw materials; it provides more leeway in procurement and handling of blend materials. Having a blend plant of good design is somewhat like having a car that will run well on any kind of gas, not, just on premium grade. The purpose of this presentation is to make some suggestions for design of such a plant.

Figure 2 is a flowsheet of a typical bulk blend plant. The raw materials are moved from storage through weighing equipment and come together in the mixer. Since the blend is first formed in the mixer, it is only the mixer itself and the subsequent handling quipment that need be considered for special design to reduce segregation. In our work, we have found that when materials of unmatched particle size are blended, the likely points of serious segregation are (1) the mixer itself, (2) the holding bin, and (3) the spreader truck bed. Bucket elevators ordinarily are not a source of segregation, so they require no special attention.

A fact that does not seem to be well recognized is that mixers of different types differ considerably in their ability to handle unmatched materials. The problem is not that unmatched materials will not mix well, but rather that they segregate while being removed from some mixers. The result is that mixer discharge is nonuniform. Every mixer is not only a mixer, but is to some extent a conveyor, since the blend must be conveyed out of the mixer; and the method of discharge is particularly important when operating with a blend of materials unmatched in particle size.

The only extensive bulk blend mixer study of which I am aware is the joint TVA-Georgia Tech study of mixers reported to the Round Table by Dr. Leon Bridger in 1968[1]. That series of tests was made with blend materials of unmatched particle size, as shown in Figure 3. These screen analysis curves show that the divergence between the curve for the smallest material, the high-analysis phosphate, and that of the largest material, the granular ammonium nitrate, was about 40 percentage points. This represents a rather large mismatch and is almost equivalent to using coarse grade potash, instead of granular, in a blend with a typical diammonium phosphate [2]. The interesting thing about the results of that study was that only two of the six batch mixers tested gave good or excellent uniformity of discharge with this blend; the other four gave only moderate to very poor uniformity. Both of the satisfactory mixers were of horizontal-drum rotary types, generally similar to the one pictured in Figure 4.

The relatively good performance of this type mixer with materials of poor size match is believed to be due largely to the method of discharge, which gives no chance for segregation. For discharge, a retractable chute is inserted into the drum while mixing continues. Portions of the mix are lifted by flights and dropped onto this chute, which carries them out.

The four mixers that were less satisfactory in the Bridger test series were as follows:

1. Inclined-axis rotary (cement mixer)
2. Ribbon mixer
3. TVA tower mixer
4. Cone mixer

In fairness, it must be pointed out that only one mixer of each of these types was tested, and that none was tested with a closer size match of materials. Also, many other brands and types of mixers were not tested. We do have additional data, however, which confirm that an inclined-axis rotary mixer, a type which now is quite popular, can cause considerable segregation of unmatched blend materials. The results available from the Bridger tests and our own are sufficient to show that in specially designing a blend plant to reduce segregation of unmatched materials, choice of a mixer is of considerable importance, and that in the absence of other information a horizontal-drum type is a good choice.

The second piece of equipment that must be specially designed to handle blends of unmatched particle size is the holding bin. An article in one of the recent TVA publications [6] reported a TVA study specifically directed to this problem and included the photograph that is repeated here as Figure 5. This is a model of a common, unmodified holding bin that has been filled with unmatched blend through a center feed pipe. It is quite obvious that the smaller sized ingredient, the dark material, concentrated in the center while the larger (light colored) material flowed to the outer edges. This action can cause severe segregation in bins. Then, during emptying, as shown in the figure, the center material flows out first and is offgrade. Later, blend rich in the larger material leaves the bin, and it too is offgrade. In the TVA study reported[6], bin models of the type shown in Figure 5 were used to develop a nonsegregating bin design. The blend used in those tests was a 9-23-30 grade made as a 50:50 mix of triple superphosphate and potash of unmatched particle sizes. Screen analyses of the ingredients, given in Table I, show a size divergence of 48 percentage points, which represents a poor match. One test confirmed that use of an unbaffled bin filled from a fixed center pipe resulted in very non-uniform discharge analysis; grade varied from 10-26-26 to 8-20-33, as is shown in Figure 6, test A. Other tests (not illustrated in the figure) showed that changing the fill point from the center to the side of the bin was not helpful; there was still wide variation in analysis. Using a steeper cone bottom (60 degree vs. 45 degree) was not helpful; neither was using a wedge-shaped bin.

One innovation that did work well was level filling of bins; there was very little grade variation during discharge of bins that had been level filled by continually moving the fill spout. In the test work, the level filling was done easily by hand moving of the fill spout; however, in actual bulk blend practice, level filling does not seem to be practical. In the past, we suggested the use of a scattering cone on the end of the fill pipe to promote level filling, but a plant test[6] showed it to be hard to adjust and generally impractical.

A more practical system, which we now recommend for holding bins, is the use of internal baffles. In tests with a small bin model using the 9-23-30 grade unmatched blend, use of four internal baffles to eliminate "coning" of material almost completely prevented segregation, as is shown in Figure 6, test B. Grade variations were all within 1 grade unit when using the baffles, as compared with variations up to plus/minus 4 grade units without baffles.

Figure 7 is a sketch of a large bin with baffles installed in the manner that we recommend. These baffles, in effect, divide the bin into a number of bin sections each of small cross section. Each section fills separately either from the fill pipe or by spillage from an adjacent filled section. Because of the limited cross section of each segment, there is very little lateral flow or coning of material, thus segregation is essentially eliminated. In the baffle systems of this type that have been installed, 18 inches square has been taken as the maximum cross section for each segment; larger segments would not reduce the lateral flow of material as effectively. Exterior-grade plywood of 1/2-inch thickness with angle-iron corner pieces was used in one installation. Steel baffles with welded or bolted corners also should be satisfactory. Clearance of about 10 inches is recommended between the lower edge of the baffles and the bin bottom, to permit free drainage. The heights of the upper ends of the baffle sections should, as shown, be staggered to correspond approximately to the angle of repose (about 30 degrees) of blends; this staggering can be omitted, however, with some loss in efficiency.

Results with baffled bins have been very encouraging. In plants so equipped, tests have shown significantly more uniform bin discharge, and state analysis violation records have improved markedly.

In one notable case, a blend plant with the usual unbaffled holding bin had been bagging a considerable proportion of its output but getting so many citations that they had almost decided to abandon bagging. Their mixer was of the horizontal-drum rotary type and appeared to be doing a good job, but segregation in the holding bin could be observed by looking into the top. We took a series of bag samples from the bagging machine during the bagging of about 5 yons ogg 16-16-16, then had the plant install the series of baffles shown in Figure 8. Siince the bin was of a somewhat unusual shape, the baffles required a little special designing. Plywood was used with angle iron corners, sections were 18 by 18 inches, and the tops were sloped away from the feed opening. After installation was complete, we took another set off sambple while bagging 16-16-16 blend. Screen analyses of the blend materials used in the tests are shown in Figure 9. This blend represented a very poor size match. The granular urea was excessively large, with about 85% larger than 8 mesh, while the potash was excessively fine, with only about 10% larger than 8 mesh. The maximmum divergence between the urea and potash was 76 points.

Results of the tests before and after baffling are shown in Figure 10. Without baffles, definite segregation cycles between the urea and the potash are evident; nitrogen analysis cycled by 4 to 5 units of plant food and this was accompanied by opposing cycles of K_2O content.

Results of the test installation of baffles are shown also in Figure 10. The composition was considerably more uniform; almost all the variations were within 1 unit of plant food. Furthermore, the variations were generally not cyclic, but instead were random, such as would be expected from sampling and analytical errors.

Even more impressive than the test resultss, though, has been the plant experience since the change. Analysis deficiency citations have been reduced to almost zero, and marketing in bags is proceeding.

We are convinced that good blend plant design should not include holding bins without internal baffles. We know of some six or eight plants that now are equipped with baffled bins and there is general satisfaction with them.

It is an interesting sidelight to note that the idea of internal bin baffles to reduce segregation is a qquite old one, not limited to fertilizer work. For example, Peacock in a 1938 article in the British *Journnal of the Institute of Fuel*[4] gave very convincing data on the use of "egg-crate" bin baffles to prevent segregation of coal in bunkers. He indicated them that the idea was not a new one.

Going back to the flowsheet of a bulk blending plant (Figure 2), the final point of possible segregation is the spreader truck bed. Simple filling from a fixed pipe results in coning and can cause segregation of unmatched materials, as in holding bins.

One solution that we have recommended[2] is the use of a flexible discharge pipe that can be moved around to give level filling. This is effective but requires a man, who often is not available. A more recent innovation is the use of egg-crate baffles in the spreader truck. F.igure 11 shows both a flexible hose and egg-crate baffles, but I believe either item alone would be sufficient.

In summary, the main points that I have tried to make are:

1. A large number of the analysis difficulties encountered by blenders are due to the use of materials of unmatched size in equipment that will work well only with well-matched material.
2. A plant that will handle a surprising degree of particle size mismatch can be designed by:
    a. Choosing a mixer that is not sensitive to particle-size differences.
    b. Using egg-crate baffles in the holding bin.
    c. Using similar baffles or a flexible fill pipe in filling the spreader truck.

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2. Hoffmeister, George. "Quality Control in a Bulk Blending Plant." Proceedings of the TVA Fertilizer Bulk Blending Conference, Louisville, Kentucky, August 1-2, 1973.
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4. Peacock, H. M. "The Design or Adaptation of Storage Bunkers To Prevent Size Segregation of Solids." *The Institute of Fuel 11,* 230-39 (February 1938).
5. Russel, C. "Quality of a Blend Can Be Determined." *Farm Chem. 128* (3), 86-8, 90, 92 (1965).
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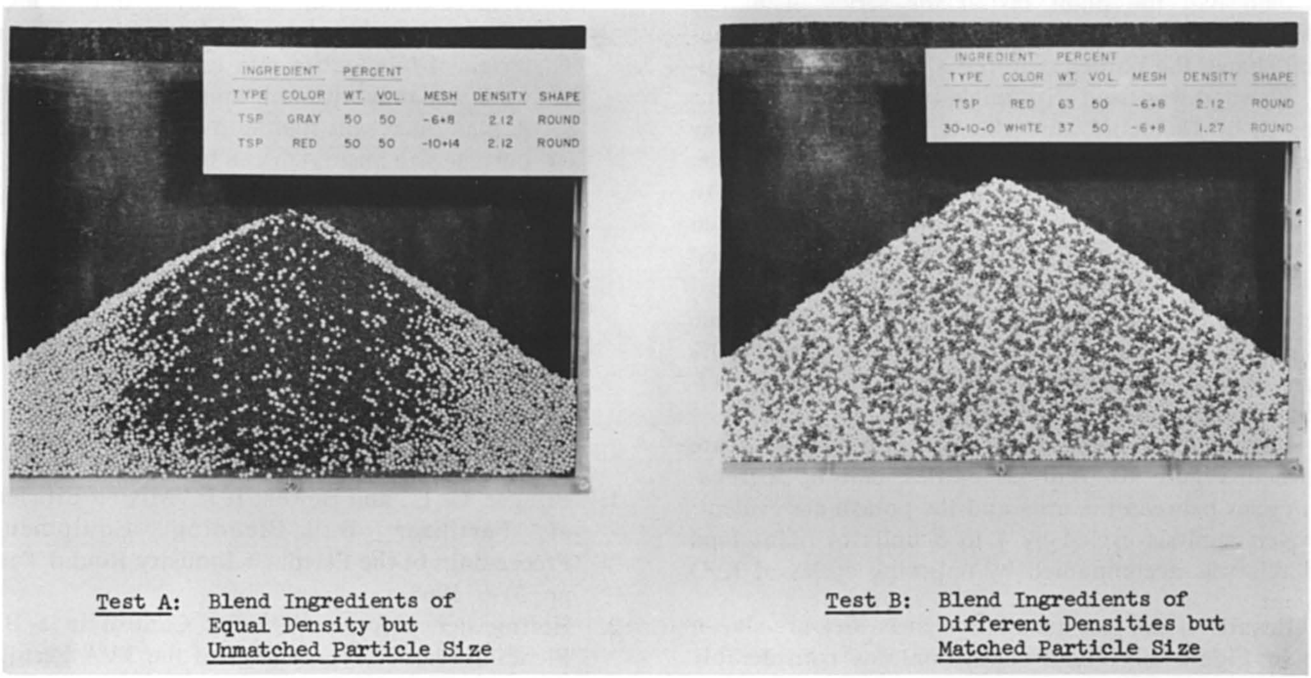
TABLE I

Screen Analyses
of Ingredients of
9-23-30 Bulk Blend
Used in Laboratory-Scale Bin Tests

	% retained on indicated Tyler screen				
	6	8	9	12	14
DAP (18-46-0) . .	2.7	24.5	43.2	77.8	92.4
KC1 (0-0-60) . . .	13.1	72.5	86.2	96.1	98.4
Divergence.	—10.4	—48.0	—43.0	—18.3	—6.0



Test A: Blend Ingredients of
Equal Density but
Unmatched Particle Size

Test B: Blend Ingredients of
Different Densities but
Matched Particle Size

Figure 1
Effectiveness of Particle-Size Matching
in Reducing Segregation

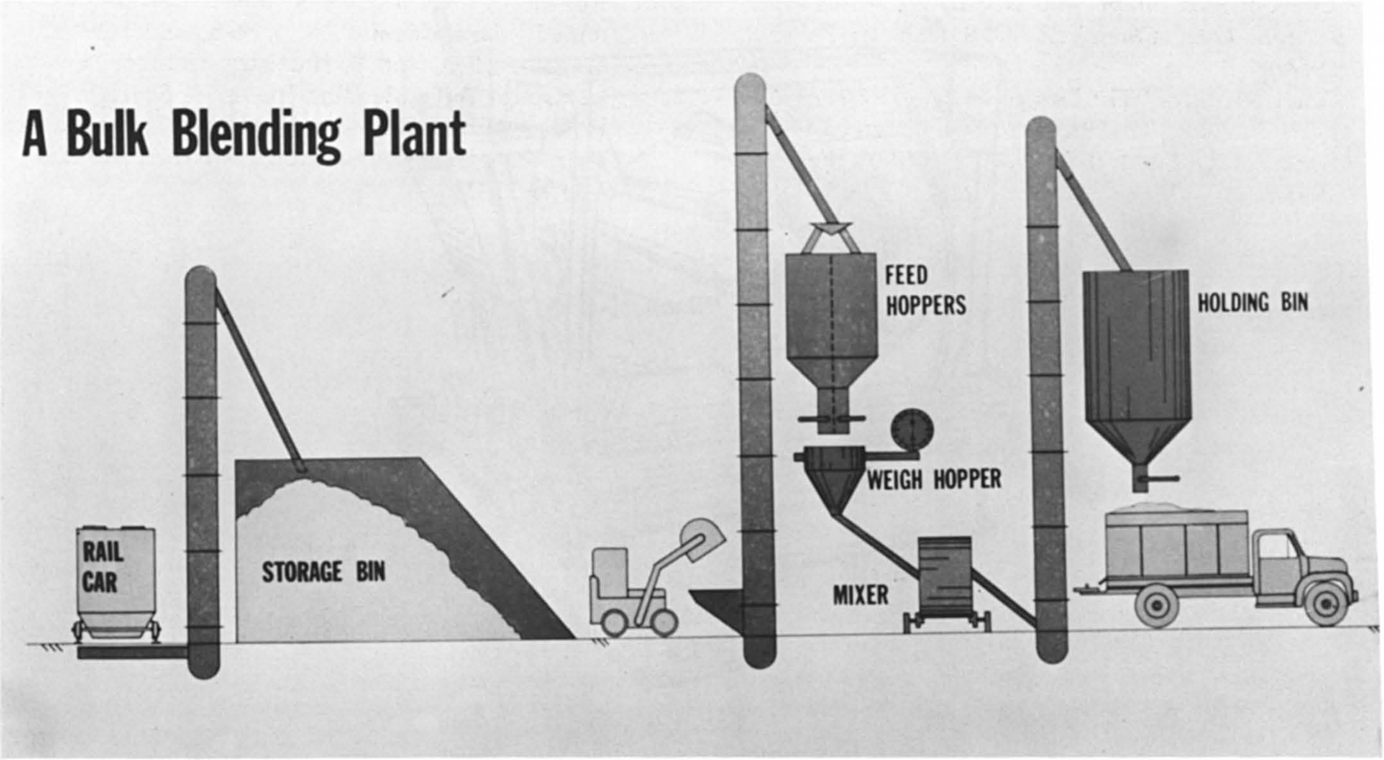


Figure 2

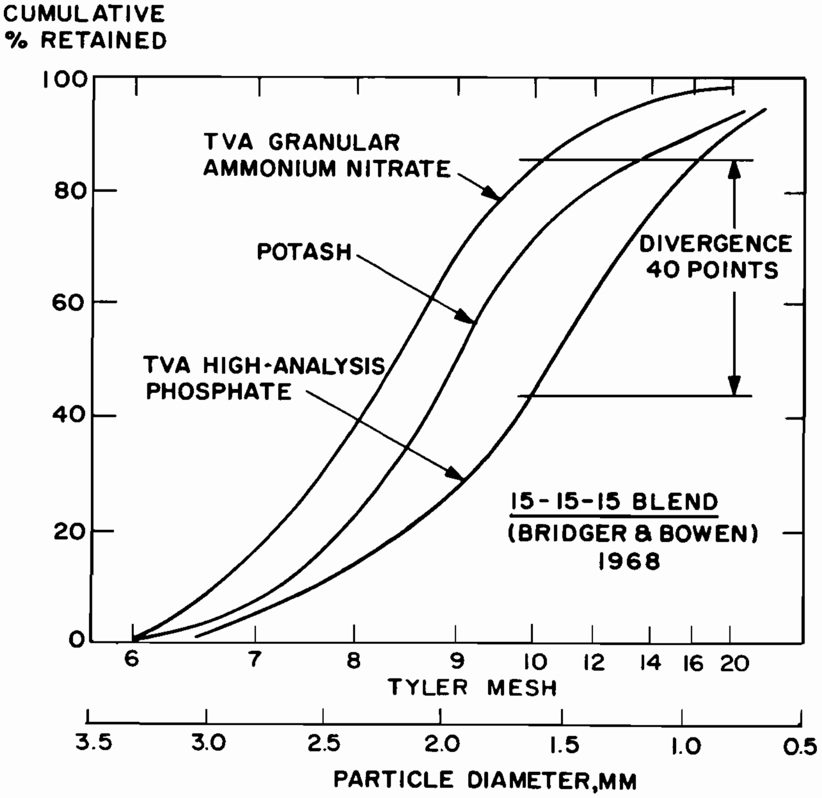


Figure 3
Particle Size of Blend Ingredients
Used in Mixer Tests [1]

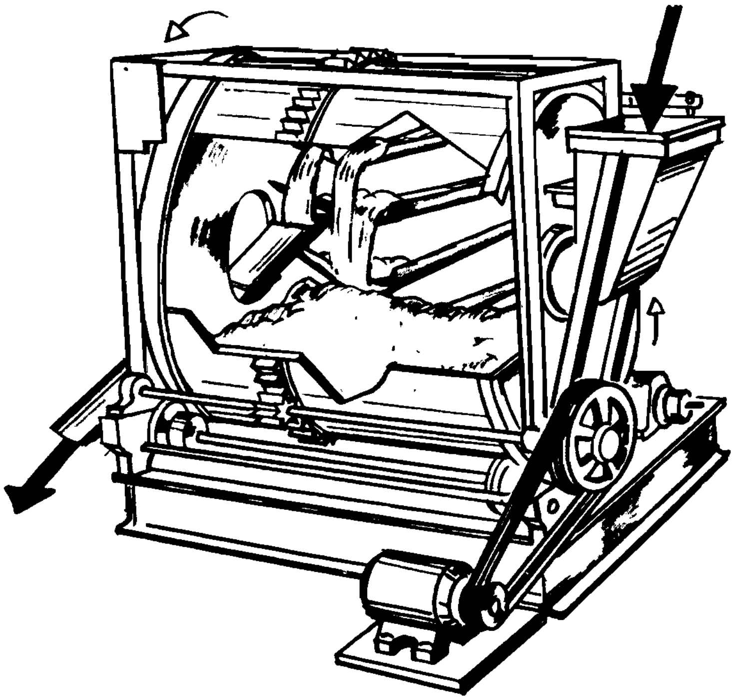
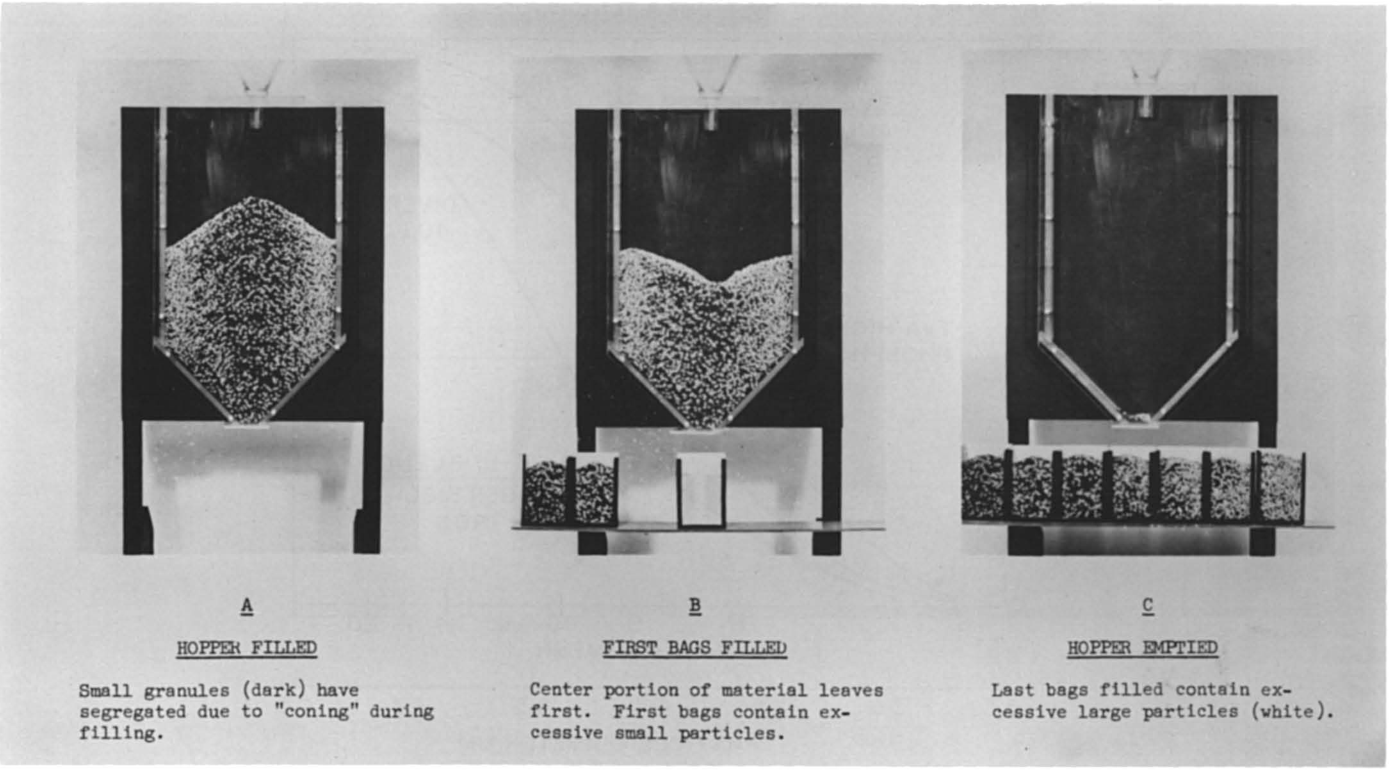


Figure 4
Typical Horizontal-Axis Rotary Drum Mixer



A

HOPPER FILLED

Small granules (dark) have segregated due to "coning" during filling.

B

FIRST BAGS FILLED

Center portion of material leaves first. First bags contain excessive small particles.

C

HOPPER EMPTIED

Last bags filled contain excessive large particles (white).

Figure 5
Segregation of Bulk Blend in bagging Hopper
as a Result of Particle-Size Mismatch

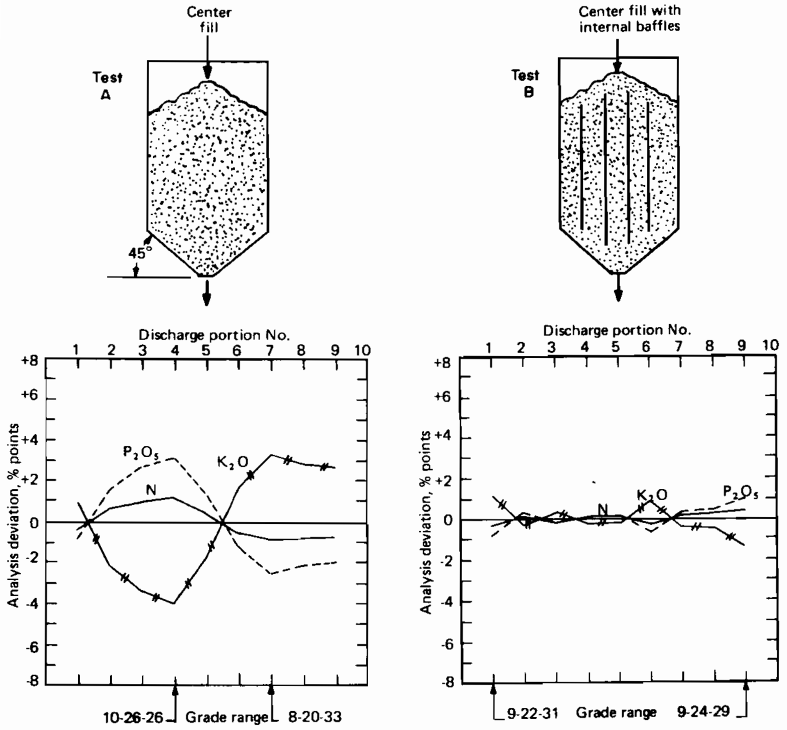


Figure 6
Effect of "Egg-crate" Type Bin Baffles in Reducing Segregation of Bulk Blend of Unmatched Particle Sizes

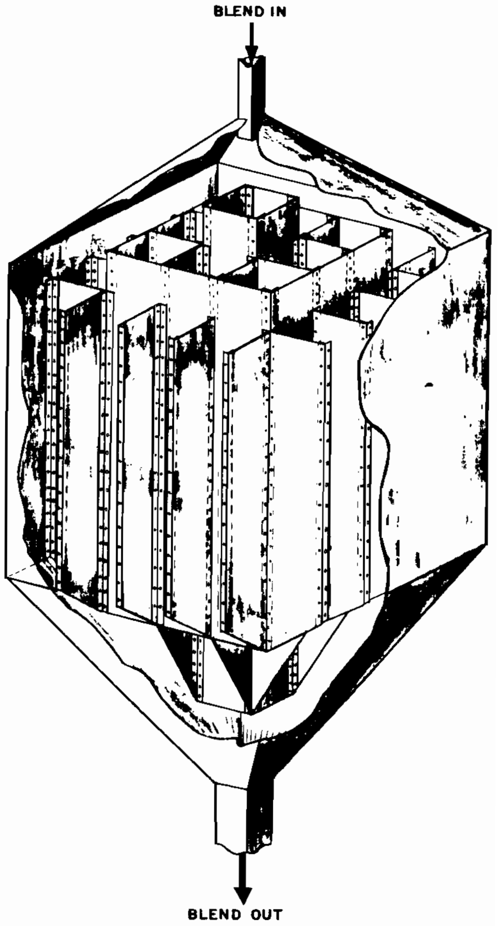


Figure 7
Bulk Blend Holding Bin with Antisegregation Baffles

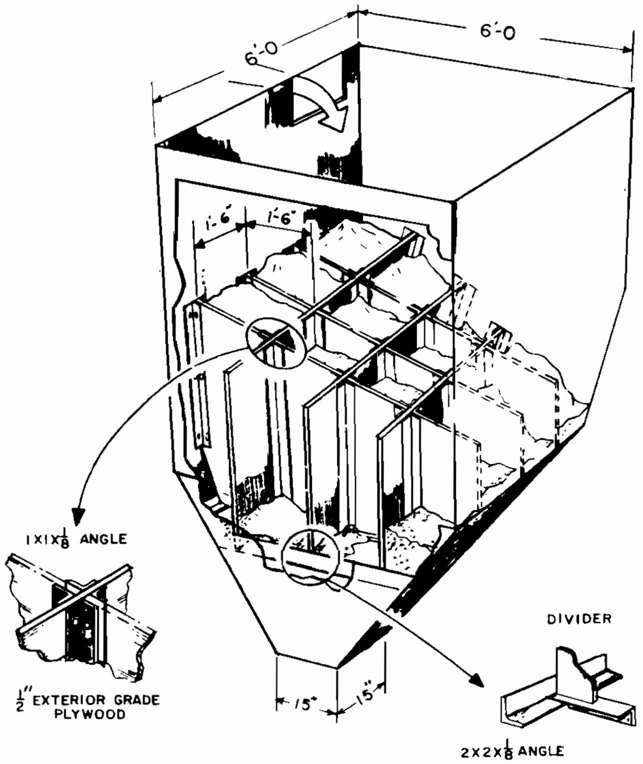


Figure 8
Antisegregation Dividers Adapted to Existing Holding Hopper with Side Entry

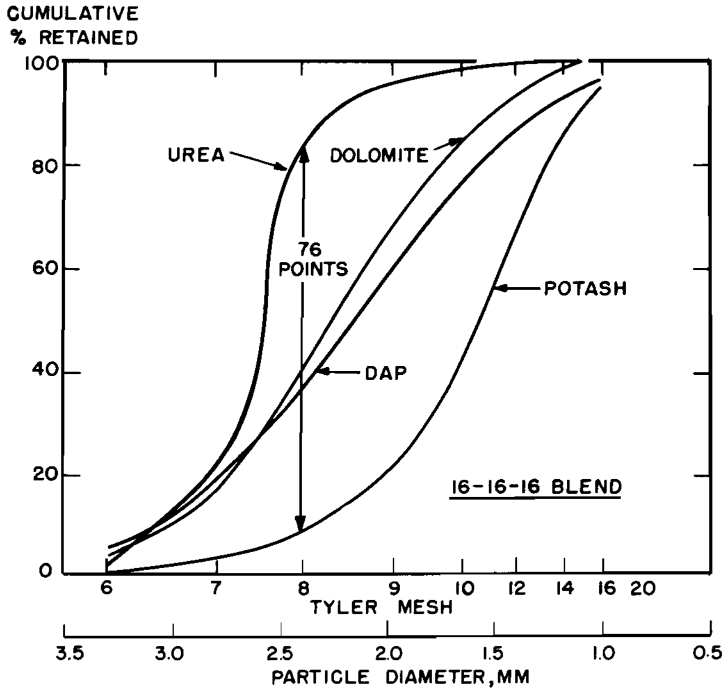


Figure 9
Particle Size of Ingredients in 16-16-16 Blend
Used for Plant Test of Bin
with and without Egg-Crate Baffles

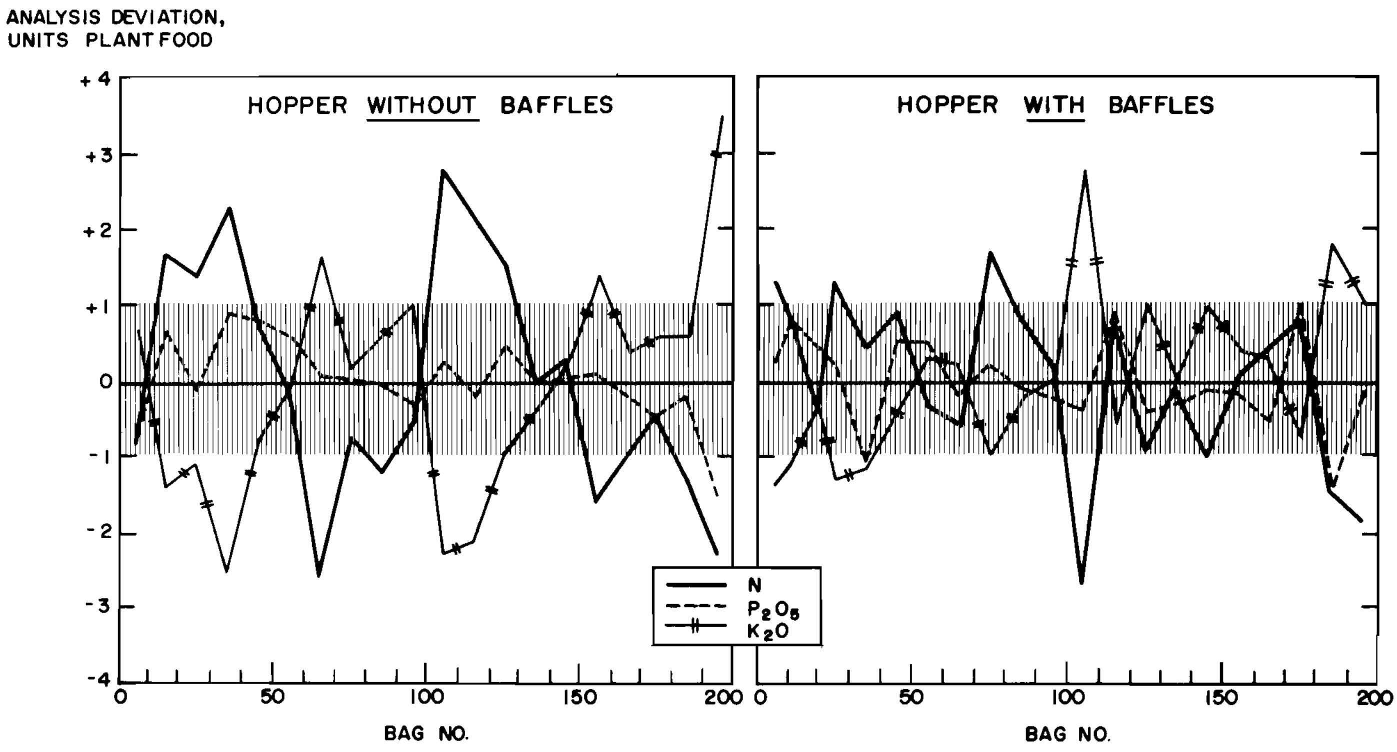


Figure 10
Effect of Egg-Crate Bin Baffles on Uniformity of
16-16-16 Bulk blend Bagged from Plant Hopper

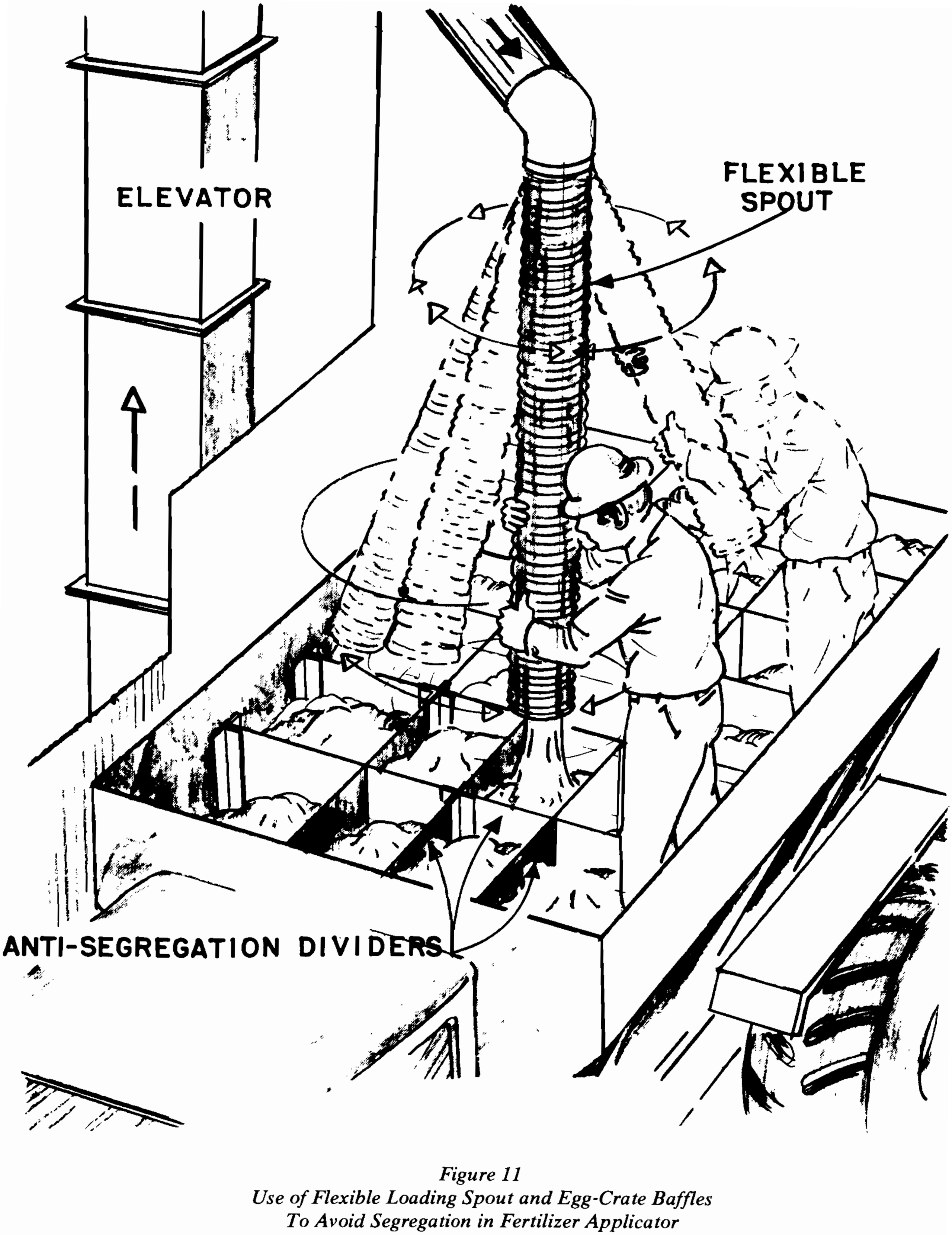


Figure 11
Use of Flexible Loading Spout and Egg-Crate Baffles
To Avoid Segregation in Fertilizer Applicator

MODERATOR WALSTAD: Thank you George. Are there any questions that you would like to ask on this subject. Apparently you have succeeded at doing a very fine job, George. At the end of the Session tomorrow morning you will have a chance to question a Panel of experts about any subject related to the fertilizer business. We would like you to submit your questions before the Panel meets, to give the experts a chance to consider their answers. Your questions can be brought up here or given to Paul Prosser. *(Applause)*

A friend recently told me about a Doctor who had the unpleasant experience of informing one of his patients that he had a terminal illness. In order to make the patient feel better, the Doctor said: "I want you to go home, think about your life and the time you have left, and do the things that you really like to do, surround yourself with beautiful girls if that is your pleasure, or go out and play every good golf course if you are a golfer. This will take your mind off your problems. But the patient, a shrewed Scotsman, said, "I don't want any of these things, what I want now is a second opinion." So tomorrow morning is your chance to have that second opinion.

Our next speaker this morning, is also a fellow moderator, Mr. William F. O'Brien of Royster, and obviously he could not introduce himself, so he have me a little bit of his background. He went to the University of Wisconsin, took a Degree in Animal Husbandry, and he joined Royster at their Granulation Plant in Madison. He came to his present positionn in Norfolk as Manager of Plant Operations in 1971. He has a good background in what he is about to tell us this morning. Mr. O'Brien please.

Thank you kindly Dan.

I've got to tell you a little something on Paul Prosser. I was out in Ohio last week and when I am out I always make a habit of calling my secretary to see if she has any notes for me so when I got back into Washington I gave her a call and she said yes I have one that sounds real urgent. Mr. Paul Prosser is trying desperately to get a hold of you. Well I had an hour and a half to wait at the airport, so I called Paul and he said, "Oh Bill, I am so glad to get a hold of you.". "I want to thank you for volunteering to be one of our Moderators." I said "I don't recall that I volunteered." He said, "Yes you did, I volunteered for you."

Royster is indeed delighted to participate in the Round Table. What I want to do is walk through our Blend Operations from days back and show you what we are now kind of fixed on, our High Speed 8-Ton Mixing Operations. I will go through my presentation and we will have a group of slides later if we could. I want to thank you all kindly.

Blend Equipment Developments

William F. O'Brien

The Royster Company has, over the last decade, installed and is now operating in excess of 30 bulk blenders. Most of these bulk blenders were expansions of existing facilities. Many have limitations due to the plant layout, property size, or market location. The blend market has changed considerably in many areas and most often has increased in product demand far in excess of the original plant's design. Over the last few years it has been observed that the plants with the greatest growth have been those with the best ability to serve the customer with the lowest amount of manpower. Prompt, efficient service is one key to developing a subtantial profitable business in areas where the fertilizer market is prevalent.

STORAGE FACILITIES

A. *Bulk Storage* — For new facilities, the minimum seasonal tonnage throughput to storage ratio should be no more than 3 to 1. We presently operate blenders with a ratio slightly higher; however, for new facilities which we expect to grow, we should not start with anything more than the 3 to 1 ratio. Blend materials are not as easily replenished as complete product mix as has been true from our factories in the past. Due to rail delays and potentially long periods of bad weather, scheduling of raw materials will become a problem with more that the 3 to 1 storage ratio. Higher ratios generally mean additional expense in car demurrage or loss og business due to the absence of essential raw materials when needed.

B. *Bag Storage* — Where the bag tonnage is provided by another facility, the warehouse capacity should be determined by evaluating the following factors: cost and time involved with both truck and rail shipment, length of season, largest day, and largest weekly movement. As a general rule, use a ratio of 4 to 1 for warehouses whose tonnage is to be supplied by some distant factory. This evaluation must include consideration for rail over truck savings and proximity of bagged supplying facilities.

Plant facilities whose volume is in excess of 10,000 tons per season should have the ability to receive 5 or more cars per day. Plants in excess of 20,000 tons per season should be able to receive and handle a minimum of 6 cars per day of 600 feet of properly located, usable siding. This will allow for 600 tons of raw materials to be unloaded into a plant per day or 3,000 tons per week.

Inloading equipment would be 60 tons per hour for plants up to 10,000 tons per season and 90 tons per hour for plants up to 20,000 tons per season. Plants with tonnage in excess of 20,000 tons per year should have a 120 TPH inloading system.

The labor force to operate any of the above systems should never exceed 2 persons and generally can be handled with 1 full-time person.

MOBILE EQUIPMENT

Blend plants will require a front-end loader to handle basic raw materials. The samll (1,000 lb. per trip) "hi-lift" loaders have proven to be satisfactory for blenders up to 24 TPH. For larger systems with 25 - 40 TPH equipmment, a 2,000 lb. loader should be considered. Large 6 and 8 ton vertical blenders with ratings up to 100 TPH require 3,000 and 4,000 lb. units, often articulated and with diesel power.

BLENDING EQUIPMENT — SIZING AND ARRANGEMENT

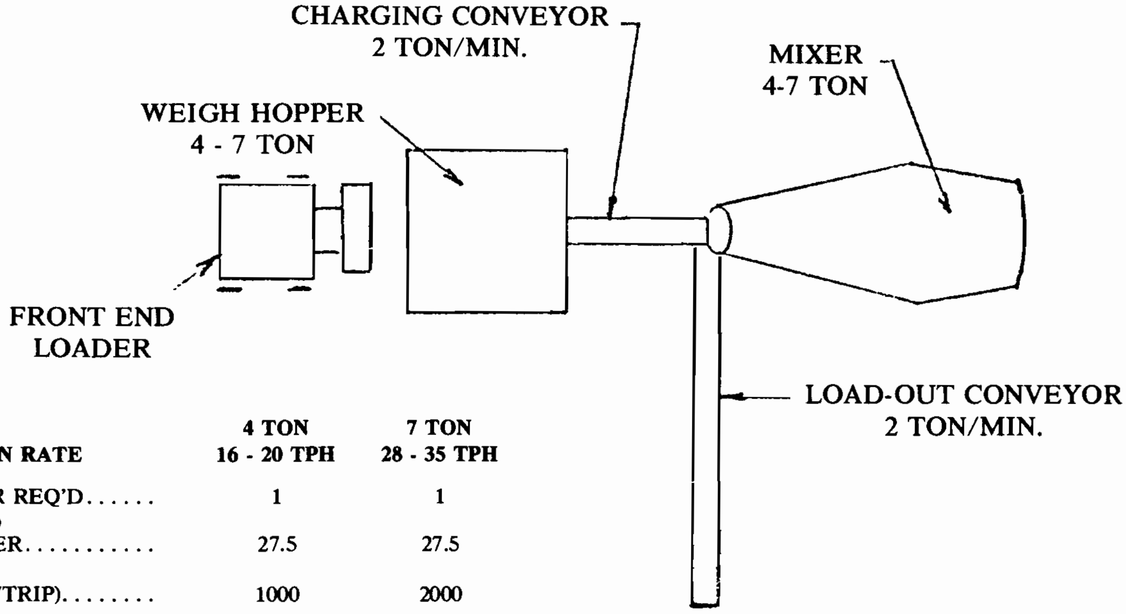
There are of course many factors which enter into the problem of selecting the equipment to be used for any particular location. The schematic diagrams illustrate some of the arrangements that have proven practical.

ARRANGEMENT 1

This is the basic horizontal system. It is offered by a number of manufacturers in various batch sizes from 4 to 10 tons, and uses a weigh hopper and concrete-type mixer. The payloader operator feeds the weigh hopper and observes the scale reading. When the batch is complete, he presses the start button. The weigh hopper belt fills the mixer, the mixer will mix the load for a pre-set time and then automatically discharges to the load-out conveyor. As soon as the weigh-hopper has been emptied, the payloader operator can start to make the next batch. Depending on the skill of the payloader operator and the number of ingredients, these units can produce 4 - 5 batches per hour. This gives theoretical production rate of 16 - 20 tons per hour for 4-ton units, up to 28 - 35 tons per hour for 7-ton units with the lower figures being the ones most often experienced. Consideration should be given to the type of load to be supplied. For instance, if all loads are to 4-ton spreaders or smaller, there is no advantage in having the larger unit because it will only be making partial batches. If, however, it is certain that most loads will go to 6 and 7-ton spreader trucks, the 4-ton unit is at a distinct disadvantage because the spreader must wait until a second batch has been made.

	4-Ton Batch
Advantages	Low initial cost for equipment. Minimal installation cost.
Disadvantages	Not particularly well suited for trace element addition in "stick-on" form. Requires a relatively skilled tractor operator for accurate batching and good production rate.
Suited For	Small outlets where maximum annual tonnage will be *3000* or less. Maximum daily tonnage is on the order of *100* tons. Almost all spreader loads are *4* tons or less. Straight NPK blends.

ARRANGEMENT 1
HORIZONTAL SYSTEM
4 - 7 TON BATCH & LARGER



PRODUCTION RATE	**4 TON** **16 - 20 TPH**	**7 TON** **28 - 35 TPH**
MAN POWER REQ'D......	1	1
CONNECTED HORSEPOWER...........	27.5	27.5
FRON END LOADER (16/TRIP)........	1000	2000

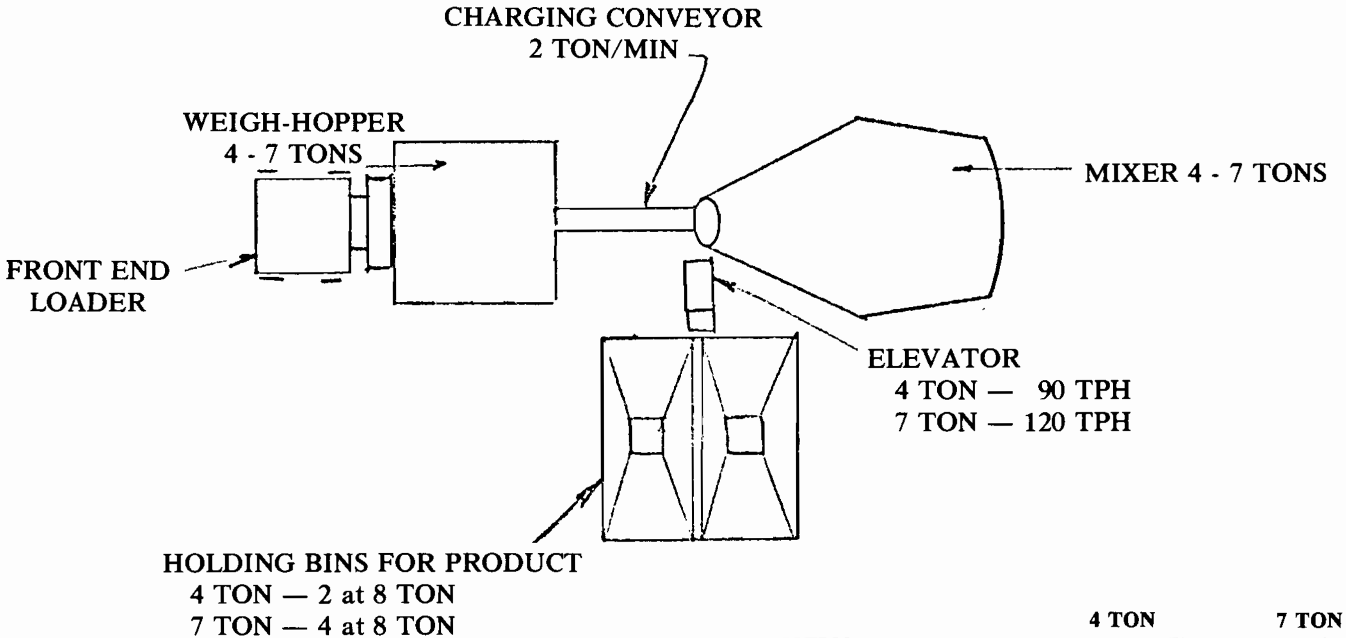
	7-Ton Batch
Advantages	Low initial cost for equipment. Minimal installation cost.
Disadvantages	Not particularly well suited for trace element addition in "stick-on" form. Requires a relatively skilled tractor operator for accurate batching and good production rate.
Suited For	Small outlets where maximum annual tonnage will be *5000* or less. Maximum daily tonnage up to *200* tons. Almost all spreaders or trucks are *5 - 7* tons. Straight NPK blends.

ARRANGEMENT 2

This arrangement is essentially an Arrangement 1 with holding bins. These bins are fed by a bucket elevator and are mounted off the ground to discharge into trucks or spreaders by gravity. They are generally sized to hold about one hour's production capacity. Typical would be two 8-ton pockets for a 4-ton system or four 8-ton pockets for a 6 or 7 ton system. They greatly enhance the ability of the dealer to give fast service and also allow the mixer to operate more efficiently.

	4-Ton Batch
Advantages	Increased flexibility with loadout bins. Mixer runs instead of waiting for trucks. Better service to customers. Customer does not wait for mixer if he calls ahead.
Suited For	small outlets where maximum annual tonnage will be *3000* tons and daily tonnage *100* tons. Mixed loads of 2 - 6 tons. Straight NPK blends.

ARRANGEMENT 2
HORIZONTAL SYSTEM
WITH PRODUCT HOLDING BINS
4 - 7 TON BATCH AND LARGER



PRODUCTION RATE	4 TON 16 - 20 TON/HR	7 TON 28 - 35 TON/HR
MAN POWER REQ'D......	1	1
CONNECTED HORSEPOWER...........	25	25
FRONT END LOADER LB./TRIP........	1000	2000

7-Ton Batch

Advantages	Increased flexibility with loadout bins. Mixer runs instead of waiting for trucks. Better service to customers. Customer does not wait for mixer if he calls ahead.
Suited For	Outlets where annual tonnage will run from *2000 - 5000* tons maximum and daily tonnage will be *200* ton maximum.

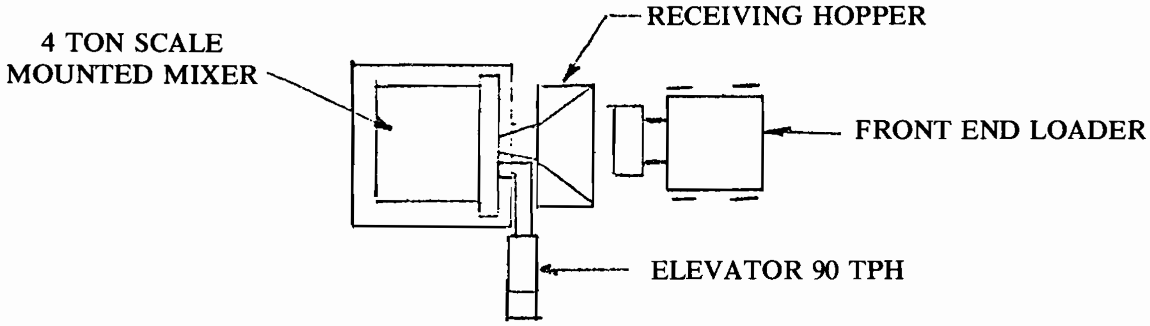
ARRANGEMENT 3 and 4

This variation of the basic horizontal system uses a 4-ton rotary drum mixer mounted directly on a scale and fed by the payloader operator. Its main advantages are small space requirements and the ability to "stick on" trace elements in the powdered form. The concrete-type mixer is not particularly desirable for the "stick on" type of trace element addition.

4-Ton Scale Mounted Mixer

Advantages	Small space requirements. Simple, easy to maintain. Able to mix any blend including "stick-on" type trace elements. Easily installed. Easily expanded to vertical system.
Disadvantages	Higher initial cost. Requires relatively skilled tractor operator.
Suited For	Small outlet with *3000* tons annual tonnage, *100* tons per day. Trace element mixtures with "stick-on" system.

ARRANGEMENT 3
4 TON SCALE-AMOUNTED



PRODUCTION RATE	16-20 TON/HR
MANPOWER REQ'D......................	1
CONNECTED HORSEPOWER...............	25
FRONT END LOADER lb/TRIP..............	1000

ARRANGEMENT 4
AS ABOVE WITH 2 - 8 TON HOLDING BINS

ARRANGEMENT 5

This is the basic vertical system as installed by Royster. A payloader operator feeds the charging elevator which elevates the materials and fills the overhead bins through a swivel spout (turnhead) positioned by the tractor driver. The blender operator makes the batch and controls the loadout operation. These systems have been installed in 2, 4, 6, and 8 ton batch sizes.

2, 4, 6, and 8-Ton Vertical Systems

Advantages	Highest production rate for a given batch size.

	Good flexibility in planning operation.
	Most accurate batching and mixing.
	Ability to incorporate any trace elements accurately.
	Best service to custommer.
	Efficient use of tractor — hauls a full load every trip.
	Easy to operate — less operator fatigue.
Disadvantages	Usually relatively high in initial cost.

Applications:

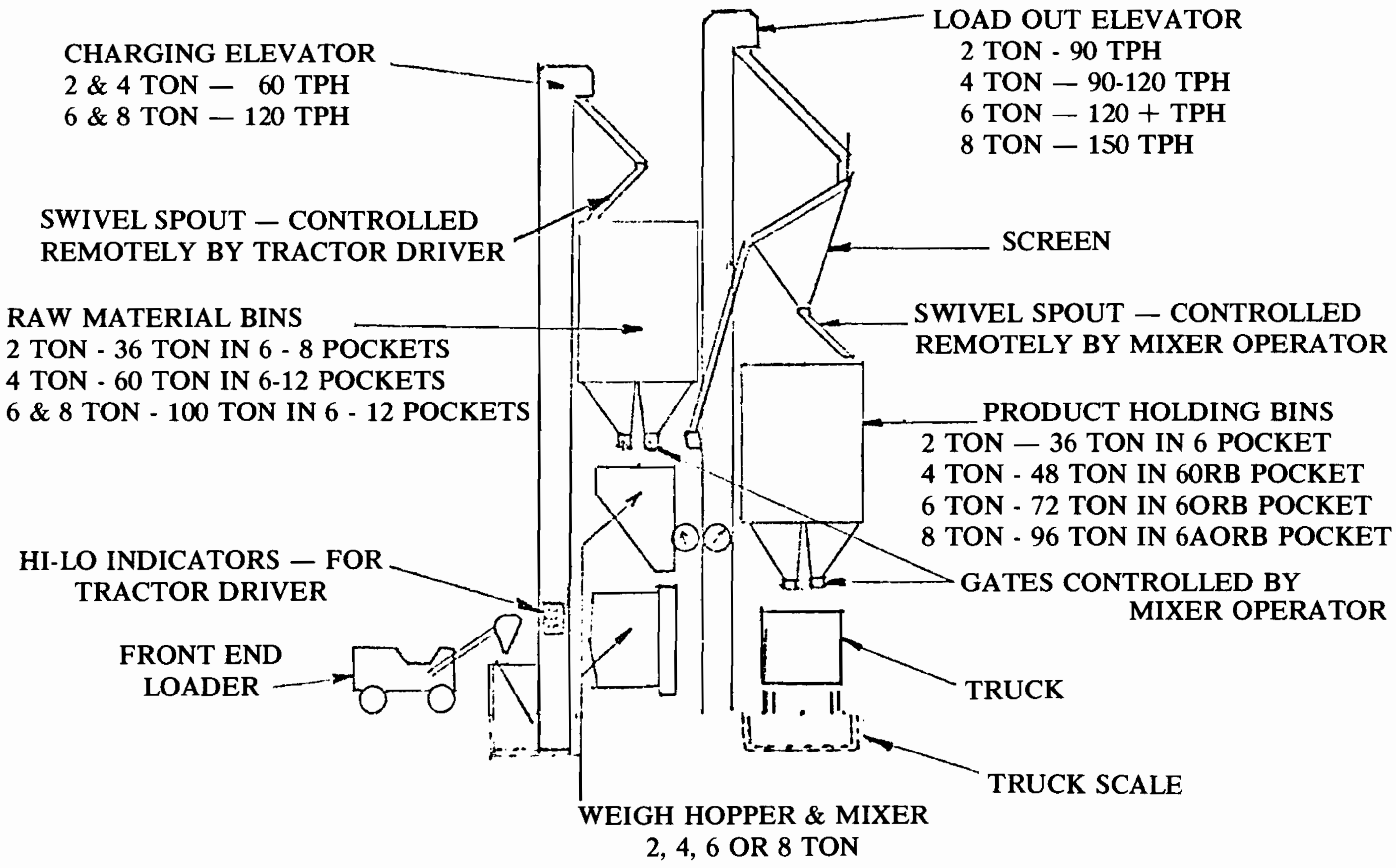
2-Ton	Retail Outlets	2 - 6000 ton/year	200 ton/day
4-Ton	Retail Outlets	4 - 12000 ton/year	300 ton/day
6-Ton	Large Outlet	10 - 30000 ton/year	400 ton/day
8-Ton	Central Facility	25000 + ton/year	500+ ton/day

TRUCK SCALES

Generally, blend plants will not require truck scales to weigh the blend product mix. The weigh scales which are an integral part of the blender are the best money can buy and provide exact weights to trucks as they are blended. Truck scales may be required to weigh liquid nitrogen. Larger blend plants should have 10 ft. x 60 ft. truck scales to weigh out blend mix from overhead live storage and as a check on incoming raw material which may be purchased during peak season. Most large transport carriers prefer a printed ticket when running fully loaded.

ARRANGEMENT 5 VERTICAL SYSTEM

2, 4, 6, 8 TON BATCH SIZES



	2 TON	4 TON	6 TON	8 TON
PRODUCTION RATE (VARIES WITH TRACE ELEMENT MIXES)	**20-32 TPH**	**36-51 TPH**	**48-75 TPH**	**60-100 TPH**
MANPOWER REQUIRED	2	2	2	2
CONNECTED HORSEPOWER	23	40	66	38
FRONT END LOADER SIZE (16/TRIP)	1,000	2,000	3,000	4,000

LIVE PRODUCT STORAGE

This is storage of blended fertilizer for quick loading of customers. We have in the past furnished 4 - 6 ton bins, 6 - 6 ton bins, 4 - 8 ton bins, and 8 - 10 ton bins. These bins are located overhead and trucks drive under for loading. A 22-ton bulk hauler can easily be loaded within five minutes. This live storage has proved to be of great assistance in providing the service which is essential to a successful medium to large operation. The number of bins and compartment size would be in proportion to the volume and load size for each facility. With high speed blenders, it is essential that these systems be operated continuously and the live product storage gives the storage for excess production during a given period of time. Some facilities have educated their customers to call and order a load before leaving to pick it up. The operator can then have his order ready and waiting. this way a customer can pick up his order in just a few minutes instead of waiting.

BAGGING FACILITY

Baggers in small blenders have generally not been successful. They are not highly production oriented and have a capacity of only about 15 tons per hour of 50 lb. bags. To provide the capacity necessary to render good service, the investment in equipment becomes prohibitive. Generally, to support a production oriented bagging line, a plant should have 8,000 tons to bag. About 15,000 tons would support a semi-automatic palletizer and around 20,000 tons a fully automatic palletizer should be considered. All bagging operations are dependent upon adequate warehouse space. Experience has shown that no bag operation can be successful where bagging is done directly to trucks. This is true due to grade changes which are normally required. The most practical method of loading out bags is to have them palletized in a warehouse. This allows a bagging line to set up on one grade and run until a sufficient amount of each grade has been bagged to keep the warehouse replenished.

SHOP

This has probably been one of the most often overlooked provisions for any new facility. The shop is an essential part of any new facility which will operate with spreader trucks, liquid applicators, and tow-type spreaders. Also periodic maintenance must be performed on plant mobile equipment.

CHEMICAL STORAGE

Chemical storage buildings are sized to suit each plant's need. Most often these buildings double as seed storage and overflow palletized bag storage. The cost of these facilities will vary depending on local fire codes, truck height, or grade elevation, heated or unheated, wood or steel construction. Contamination from chemicals stored is an important consideration from the water and air pollution standpoint and future sites will almost certainly require paved impoundment areas and fireproof construction.

PROPERTY SIZE AND LOCATION

The minimum size property for any future Royster investment in plant facilities should be no less than two acres. This would be for a typical small 2,000-ton to 5,000-ton facility. For medium (5,000 to 10,000 ton) plants, you would need three to five acres. For larger (10,000 to 50,000 ton) plants to serve greater geographic areas, the initial property considerations should be five to ten acres. This may seem more than adequate but we have vvery few company-owned locations where adequate room to expand is available. Obviously, these minimum requirements must take into consideration the property configuration and topography of the land. Good access to major highways is absolutely necessary. The land should be fairly level with adequate drainage to some convenient location. Consideration should also be given to the availability of water, sewer, and electrical service. While not mentioned above, the single most important consideration for any future property is that it must be located properly on an existing rail siding or have room to build an adequate siding of our own.

ADDITIONAL PRODUCT LINES

Mixed Fertilizer

Earlier in this outline, certain criteria were established as guidelines to determine ratios of storage to total seasonal movements. Additional consideration should also be given to the movement of mixed ammoniated fertilizer and materials for direct application. The ammoniated fertilizer will generally be stored in smaller quantities and special bays must be provided for their storage. The seasonal movement for each grade should be considered.

Chemicals

No Company standards have to date been established to determine the size of warehouses required. This, of course, would vary considerably depending upon proximity of existing Royster regional chemical warehouses, pre-season discounts, dollar volume, and seasonal movement patterns.

Feed, Seed, Hardware, Lime, and Sundries

As in the previous section, local conditions and market demands will dictate the storage allowance for these items.

Much of the material presented was developed by Mr. H. Lynn Gaskins, Jr., Royster Company's Manager - Maintenance, and Mr. William H. Paulson, royster Company's Senior Project Engineer.

RECOMMENDED READING

There are many good sources for obtaining information on blending. Two very good ones which also contain information on other sources available are:

1. TVA — *Fertilizer bulk Blending Conference*
   August 1-2, 1973

   National Fertilizer Development Center
   Tennessee Valley Authority
   Muscle Shoals, Alabama 35660

2. *Bulk Blend Quality Control Manual*

   The Fertilizer Institute
   1015 18th Street, N.W.
   Washington, D.C. 20036

I want to thank you all. *(Applause)*

MODERATOR WALSTAD: Thank you Bill for sharing a wealth of experience with us and here's a man you can really ask questions if you have been faced with some of the problems that the royster people apparently have already solved.

Do we have questions?

QUESTION: What are the additives you are using and what is the stick-on binder?

MR. WILLIAM F. O'BRIEN — ANSWER: Presently we are using two stick-ons, 28% Urea Solution and 10-34-0 and quite frankly we are getting the best results wwith 10-34-0. We think we get more adhesiveness with the 10-34-0. We get pretty uniform distribution with it. I think it is fair to say after it has been in storage there is no question about the fact that it doesn't stay there all that long. We don't know a better way to do it and we are certainly always open to thoughts on that. I was certainnly interested to hear the first presentation today because I will be quite frank about it, we're frustrated as all get out on segregation and the question I was going to bring up on that was — What do you do out in the warehouse and in the retail outlets? In these big facilities that we have now, we converted some of our old granular plants to these High Speed Bulk blending Units, then we transfer that product out into the field, and that's difficult and I don't know if anybody has got an answer to that.

QUESTION: I was wondering if you could give a little discussion on the scale location. I noticed from your slides that you have a scale located under the spout and the argument comes up from time to time whether the scale should be under the spout in a fertilizer plant or whether it should be out in another location. What would you do in the future?

ANSWER: Well, I would do exactly what we have done. I think the operation that we presented here is a very efficient one. These 10' x 60' scales are right under the holding hoppers. We belt along the edge of the scale so if we have a spillage, we don't have to clean out underneath. I don't know of any of our operators that have reported any problems in that regard. I would much rather have it just that way. The mixer operator stands right inside where he is mixing and discharging; he has got the whole control right there and he does the weighing of the truck also. You have seen three scales in that operation, one is for weighing the N K & P, the other for weighing out the micro-nutrients, and the other was the truck scale. I don't think we would do it any other way.

QUESTION: How much difference do you get between the blender scales and the weight of the truck when you bring it in?

ANSWER: As reported from the field I say it is very negligible. The one thing we do encounter every now and then with this type of scale is the larger the scale, the more wind drift on it.

I think it is important, probably the most important thing on accurate weights, is to have the scales inspected. We are talking about our scales in the mixing process and the truck scales.

QUESTION: What percentage are you willing to accept as good analysis?

ANSWER: That's a very interesting question. Let me say this, we have set up at many of our plants, quality control labs and we have our computer print-outs back in the home office. Where we have these quality control labs, the boys run all the samples right at the local plant; however, all of our blenders do not have labs. Our record on the production plant is excellent. That is why I made reference to the receiving plant. There is a different correlation if you talk with the state officials. We think maybe at this point in time that it might be fair to say that we must get a lot of segregation, I am not just talking about Royster; I talked with a group of people who believe this. That is why I say this is a very frusstrating part of our operation and I don't know how you correct it. Usually the plant food is there.

QUESTION: What are you getting at the plant?

ANSWER: The plant is excelllentt.

QUESTION: What do you ean by excellent?

ANSWER: I say 85% to 90% in that range. Here again like we said earlier, we have found that the sizing of the material is probably the most important thing and if we can keep our sizing good, we have excellent results. The next most important, probably it might be fair to say the most important thing, is the employees you have running the mixer. We feel very fortunate in that we have got some fellows that I think can do as good a job as any one of us people in management, maybe better. I have seen some real concerned people and they are hard to come by now a days. We feel very fortunate and we stress strongly that we want a qualified man running the mixer.

MODERATOR WALSTAD: We have another question.

QUESTION: I have one more question. We have two arguments. In the hhopper systems everything is up in the air and drops directly into the trucks. Other systems call for putting the mixer on the ground and having the elevators load the trucks. I would like you to express your ideas on that.

ANSWER: Well, really what we have is the system you talked about first. We mix then we come out with the mixer into the elevator into the large storage bins and then draw out of the large storage bins into the truck. Like I said we put these 20-22 toners out maybe in five minutes, something like that. I am not that familiar with the other operation. Most of them are little outlets and lots of them are done that way. I don't have responsibility in that area and I can't talk about their experience.

MODERATOR WALSTAD: Another question?

QUESTION: I have a question on the use of the stick-on system with a liquid binder. Do you do this where you are going to bag and palletize? Some people have had experience with bag set where you would use liquid additives.

ANSWER: A very good question. You are exactly right. Yes, we do that in our premium grades and our special grades. We use the stick-on to put the additives on and yes indeed we do bag and it is fair to say that in a lot of the higher analysis we can get some bag set. To say we don't have bag set, I would just be plain lying to you because we do.

QUESTION: What are you going to do with the materials you collect in the bag collectors?

ANSWER: In the blend plants, we don't have any other alternative but to feed it right back through the system.

Now in our granular plants, I have a little different theory on that. I like to take it back to the granular plant and work it back in again but in the blenders we don't have any alternative.

We have a dust collector on our additives also because as most of you know a lot of your additives are tremendously dusty and we have cleaned up all of these plants.

MR. O'BRIEN: Any other questions fellows. Thank you again *(Applause)*

MODERATOR WALSTAD: That was great Bill. We appreciate your sharing a wealth of experience with us.

Our next speaker is Russ Grom, who is a Technical Service Consultant for I.M.C. and lives in Libertyville, Illinois. He is a graduate of the University of Arkansas with a Degree in Electrical Engineering, and worked for Westinghouse for a few years, joined I.M.C. in 1955, and has been trouble-shooting with I.M.C. on problems in their plants all over the world. He told me that today I.M.C. has absolutely no problems with any of their plants or else he would not be here.

Russ Crom: Thank you Dan.

Electrical Problems In Fertilizer Plants

R. C. W. Crom — J. B. Madsen

Presented by R. C. W. Crom

Normally, round Table meetings are most usually covered by sales executives, production people, and process engineers. It is hard for someone like me to justify an invitation. It appears that the best way for an EE to be assured of having an opportunntiy to attend is to be on the program, *so* I am pleased to be here.

In the fertilizer industry electricity is a necessary evil. The objective is to produce fertilizer and while doing it use as little electricity as possible. In spite of the objective to minimize energy consumption, the use of electricity in fertilizer plants continues to grow. There is sound reason behind this. Electricity is an extremely convenient form of energy. Even though the price is high and continues to climb, compared to doing equivalent jobs with manpower and internal combustion engines, electricity is still the best buy. Consequently, electrical loads continue to increase and there are correspondingly more electrical problems in fertilizer plants.

At this point let me zero in on the type of plants that we are talking about. Certainly, the large chemiccal complexes with sulfuric acid, ammonia, phosphoric acid, DAP and MAP production are fertilizer plants; but this is not the type of operation that I have in mind in this talk. To be sure, these large plants have problems. They may have a 2,000 HP synchronous motor on a large grinding mill that continues to throw its windings or a new 1250 HP air compressor may knock out other essential equipment every time they try to start it. Their switch gear may have realy coordination problems. But, these large complexes have a full-time resident electrical enginneer and an electrical maintenance department to solve their problems.

The plants we are primarily concerned with in this session are those with connected loads up to 1500 KVA. In these operations the plant manager has all of the responsibility. He must see to it that at the plant is safe, that the products meet state specifications, that production costs are right and in addition he must deal with his own electrical problems without assistance of an on-sight electrical engineer. In many cases he does not have a journeyman electrician but he must fall back on a local contractor for electrical maintenance.

Working for Technical Service I travel a great deal and from time-to-time I am called on to assist the smaller plants in correcting their electrical problems. Usually, these trips are short and cover a specific problem. Because of the nature of our operation, I have never kept records for the purpose of giving a paper. So, in order to prepare for this presentation, I decided to telephone a number of plant superintendents and inquire: "If you were to attend a round

Table discussion and were to listen to a session entitled 'Electrical Problems in Fertilizer Plants', what would you like to hear about?" The response to my first call was so terrific that I only made one call. Mr. Wallace Thorne, superintendent of our Florence Alabama fertilizer plant, raised a number of questions — including the following:

"How do you eliminate shock hazards?"

"Discuss grounding."

"What is a GFI?"

"What is a GFCI?"

"What is the best way to handle corrosion?"

"Explain power factor?"

"How does a capacitor correct power factor?"

"After capacitors are installed, how do you know that they are working before the power bill arrives at the end of the month?"

"What makes a circuit breaker blow up?"

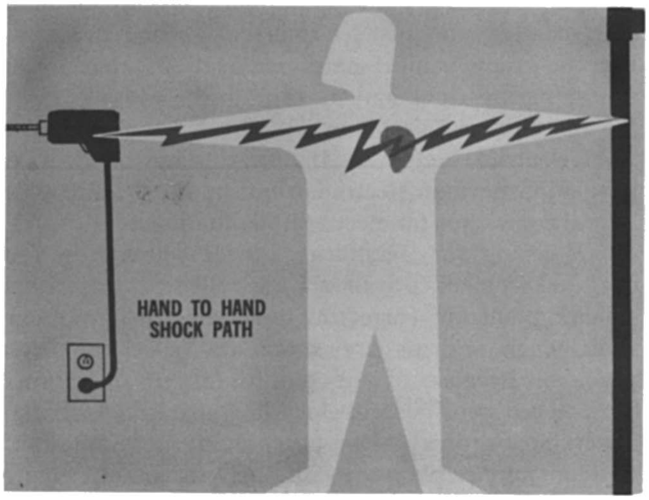
"How should mobile equipment be grounded?"

"How should one minimize power bills?"

After the conversation with Wally, it was not necessary to make additional calls because it was apparent that I already had more than could be covered in the time alotted.

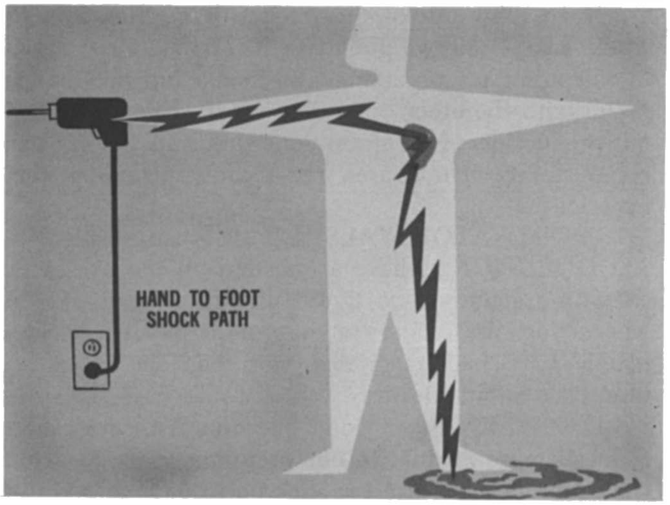
By the way, you have all heard various definitions of an expert. Here is one that I picked up from the paper the other day: *An expert is a guy who knows about as much about the subject as you do except his information is perhaps better organized and he has a bunch of slides.* Combing Wally's list of questions, I selected a few which would match my slides. As to whether or not the information will be better organized, this will be determined in the next few minutes. Besides, I am a little uncomfortable with the expert handle. Even after 25 years in the business, I continue to learn new things about electrical problems.

To start, let's look at shock hazards. This will naturally lead into grounding, GFI's and GFCI's. In order to understand shock hazard a little better, let's review the eletrical characteristics of a man.



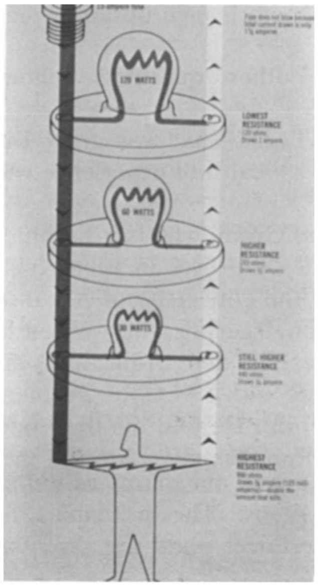
Slide 1

Slide 1 shows the worst possible type of shock for a man. An arm-to-arm electrical shock causes current to directly go through the heart and this stray signal upsets the rythmic action of the heart and will cause it to go into a vibrating state. It is interesting that many lives could be saved if everyone understood resuscitation procedures. We cannot go into resuscitation because it would justify a full half-hour paper.



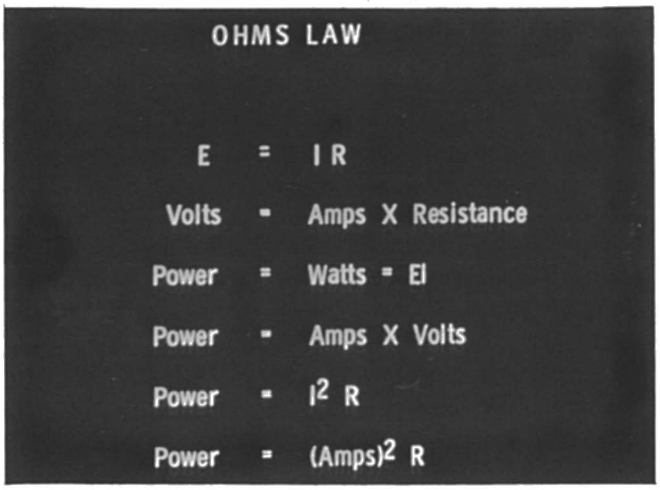
Slide 2

Here is the next worse type of fault. This would be from left arm to right leg. Here again the fault current goes through the heart. Other types of shocks, leg-to-leg, hand-to-elbow, can result in severe burns but the victim will live. The amazing thing about a shock through the heart is that it takes a surprisingly small amount of current to kill. The exact figure is somewhat arbitrary: some authorities say that it is between 50 and 100 miliamperes and still others contend that even 25 miliamperes can kill. When comparing this small figure to the available power from any power system, we can see why precautions must be taken to prevent shock hazards. Even the conventional 100 ampere 120/240 volt service used in residences can be lethal.



Slide 3

A 30 watt, 120 volt light bulb has 480 ohms resistance and the average resistance of the human body will be about 960 ohms. Callouses and moisture content can cause skin resistance to be considerably above this, but once the electrical shock punctures skin insulation, resistance of a man is relatively low.



OHMS LAW

E = I R

Volts = Amps X Resistance

Power = Watts = EI

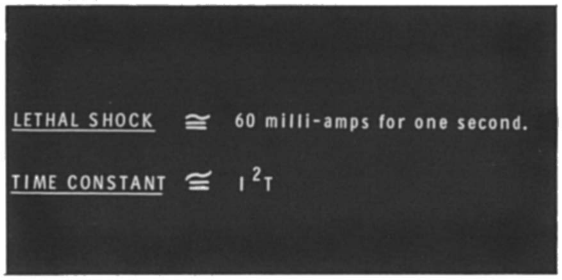
Power = Amps X Volts

Power = $I^2 R$

Power = $(\text{Amps})^2 R$

Slide #4

At this point recall Ohm's law, the most basic formula in electricity: $E = IR$, or expressed in words, volts = amperes X resistance. Applying Ohm's law to the man: if a 960 ohm man touches 120 volts he will draw 130 miliamperes. This is more than enough to kill him, and he only draws 15 watts. This will not trip a circuit breaker.



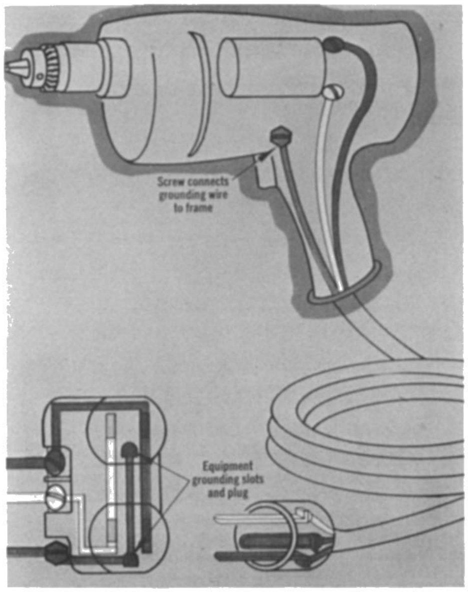
LETHAL SHOCK ≅ 60 milli-amps for one second.

TIME CONSTANT ≅ I^2T

Slide #5

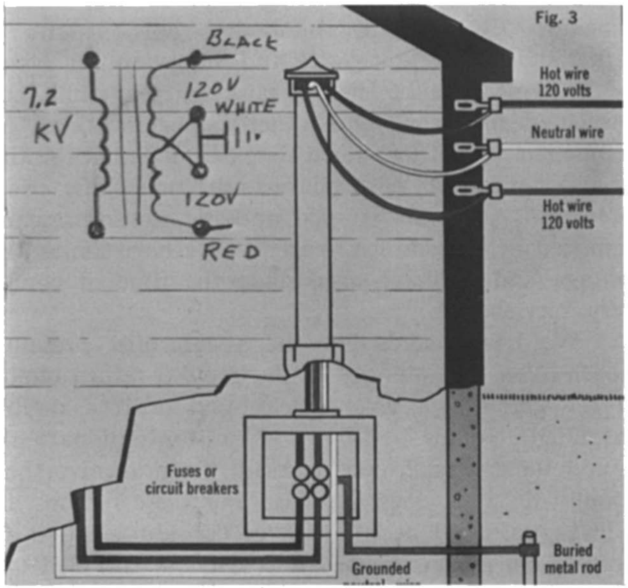
There is one other important factor in the shock hazard, and this is time. An authority has expressed the general case in this way. Lethal shock approximates 60 miliamperes for one second. A man, like a fuse, appears to have a time constant that is proportional to the current squared times the time. Knowing this basic information about the electrical shock gives us a clue as to what can be done to avoid electrocutions. Two things are suggested: first, limit the current; second, shorten the duration of the time.

In the next few illustrations portable tools will be used as examples because they are common to everyone in this room. They are in our plants as well as in our home and hobby shops. The principles for protecting equipment in a fertilizer plant are the same as those which are applicable to portable tools. To protect the man from being shocked we must find a means to limit the electrical potential of anything that he might touch, be it a portable drill, a shuttle conveyor, a pump or a mixer.



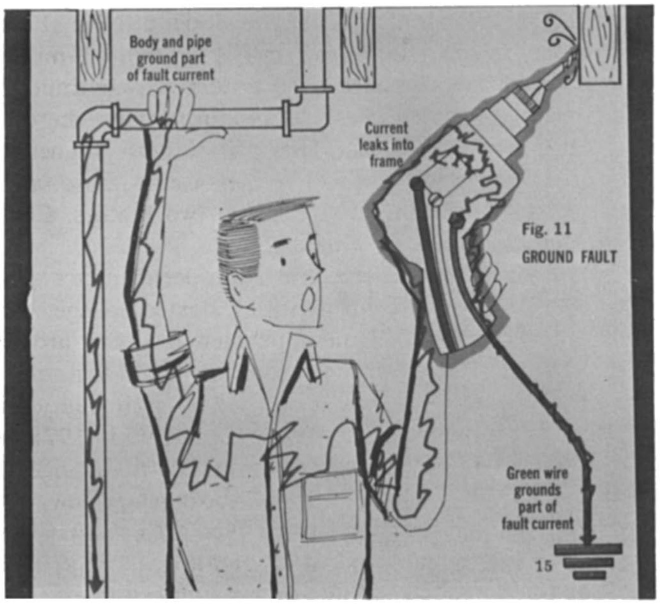
Slide #6

Here is the portable drill. The most important feature of this slide is the green wire. Note that this green wire is connected to the frame of the drill. It uses a three wire cord andd the green wire is plugged into the grounding system of the building. This grounding system goes back to the service entrance equipment where it is connected to the neutral of the power system. This discussion assumes that the plant or the house is wired in accordance with the National Electric Code.



Slide #7

In this example the conventional 120/240 volt single phase system with a center tap ground is used. The white conductor is known as the neutral conductor or the grounded conductor with 120 volts available between either line and ground. Normal 240 volt loads are connected line-to-line and the neutral does not enter the circuit. The grounding system consists of the green wire, electrical conduits, piping, building steel and so forth. It should not carry current except when there is a ground fault.



Slide #8

Here is what happens when a man is using a defective portable tool and is also touching ground. The line conductor faults to the drill frame and the fault current is carried by the grounding system. The man only sees the voltage drop in the ground return. The ground return resistance is kept low and thereby limits the voltage that can appear on the frame of the machine. Consequently, man does not encounter a lethal shock. The green wire and the grounding system have by-passed the heavy fault current and have protected the man. One other important thing has happened. Recall that for a shock to be lethal the time is also important. With heavy fault current the circuit breaker is promptly tripped and the shock hazard is removed in a fraction of second. We have limited the voltage and we have also made the time of contact very, very short.

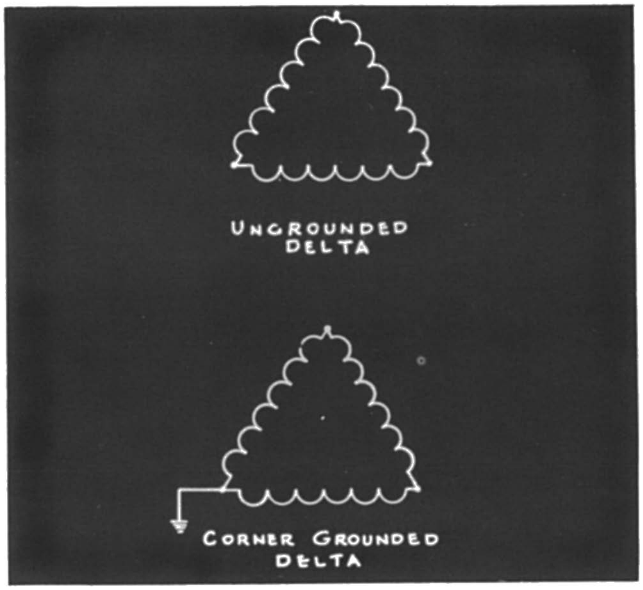
We have noted that the system just presented depends on the integrity of the ground return circuit. If the green wire is open circuited or if a double-insulated tool is used or if a conventional two-conductor extension cord is used, the protective shunt around the man does not exist. For these reasons, the GFCI was developed. GFCI is the abbreviation for ground fault current interrupters. These and GFI's, or ground fault interrupters, will be discussed in greater detail later.

The grounding system just described can be applied to everything in a fertilizer plant to make it safe from shock. Equipment such as rubber tired portable conveyors, welding machines, shuttle conveyors, bucket elevators and mixers can all be lethal unless they are adequately grounded. All equipment in a plant can be made as electrically safe as the home drill if proper grounding is applied and if correct circuit breaker protection is used.

This discussion emphasizes that the grounding system must be a good one. Time does not permit going into details of a good grounding system. In a nutshell, a good grounding system provides a low resistance path for ground fault currents. This means that all metal components such as pipes, pumps, building steel and shuttle conveyor rails should be bonded together with a good electrical conductor that will not corrode beyond usefulness. If this is done, a man standing on a metal staircase will be safe even though he might be touching a metal bucket elevator with his hands at the instant the 480 volt drive developed a short circuit to ground. The low resistance path of a good grounding grid would limit voltage between the staircase and the elevator and at the same time the circuit breaker would trip within 16 miliseconds or less. As plant operators and people working in fertilizer plants, it is our responsibility to make sure that good grounding grids are installed and that the equipment is grounded. The IEEE Green Book on grounding is one of many excellent references on the subject.

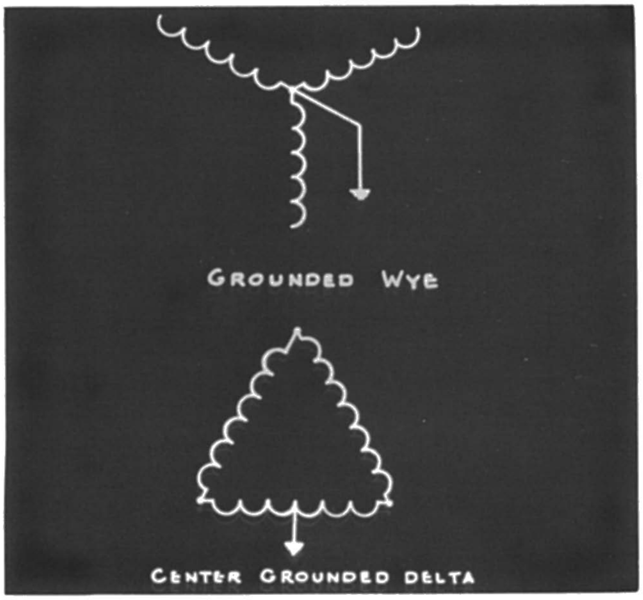
During the last five years you have been hearing a lot of talk about ground fault protection. The subject became popular after the OSHA legislation went into effect making the National electric Code law of the land. The revision in 1971 requires GFI's on grounded power systems for each service disconnecting means rated 1,000 amperes and above. In addition, GFCI's became mandatory for all 120 volt single-phase construction power and certain other 120 volt circuits. As mentioned earlier, GFI stands for ground fault interrupter and GFCI stands for ground fault current interrupter. GFI's are normally for power circuits and operate at several amperes. The GFCI is more commonly known as a "people protector" and the goal with the GFCI is to detect ground fault currents that are below the lethal currents and to trip the circuit breaker before damage can be done. The GFI's are concerned with amperes while the GFCI's are concerned with miliamperes. To understand how these devices work, we need to take a look at the power system. Power systems can be either grounded or ungrounded.

The residential system of the previous example was a grounded system. Recall that the center tap of the secondary winding of the transformer was grounded. Some power systems supplying energy to fertilizer plants are ungrounded. With these systems there is no deliberate connection to ground. The transformer insulation isolates the electrical system from ground.



Slide #9

The upper illustration in this slide shows a three phase ungrounded delta system. The lower schematic is a delta system with one leg grounded.



Slide #10

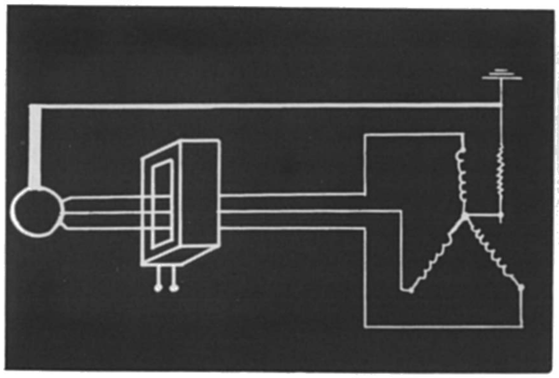
In the next illustration the upper section shows a three phase grounded wye system. There will be 277 volts between phase conductors and ground with 480 volts between line conductors. The lower illustration is typical of the power source for smaller plants which use 240 volts, three phase and need a small amount of 120/240 volt single phase power. Three single phase transformers are used with the third being somewhat larger than the other two. The third transformer will have its center tap grounded. The grounding grid and the main circuit breakers on all of the grounded individual systems function very similar to the residential power system discussed earlier.

In the 50's and 60's the wye connected 277/480 volt grounded wye became popular in all industries. Becaus of abuse and neglect there had been some bad experiences with the 480 volt three-phase ungrounded sysem. The problem with an ungrounded system is that one leg can become inadvertantly grounded. At this instant the system becomes a grounded system. Then, if becase of neglect or ignorance, the operator continues tooperate until the second ground occurs he has double troble; and then there is a big myster as to why two motors can blow up at once. If one stops to think about it, it is easy to solve the mysterym For example, if motor A goes to ground on phase I the system will continue to operate as a grounded eletrical system because there is no ground fault curent. However, if motor B goes to ground on phase II there will be a phase-to-phase fault through the grounding grid and the two motors. Consequently, two motos blow up at once.

In early days with the wye syste performance was good. But, when these installations started to age, the industry encountered a new problem — the arcing ground fault. After insurance companies paid fr a number of electrical burn downs caused by arcing ground faults, the National Electric Code was revised in 1971 to require ground fault interrupters on all main circuit breakers rated 1,000 amperes and above when power is supplied from a grounded source. The GFI detects the difference between a ground fault and a heavy load current. For example, a circuit breaker could have a 1,000 amp rating but a ground current flow caused by an arcing ground fault could be as low as 200 amperes, then the breaaker would not trp. It would not recognize the ground fault, so the systm would burn down. However, a GFI would open the circui breaker. It is a good system except that it has the incovenience of causing a shut down without warning. Fo example, you could have a ground fault in a non essential ventilating fan in the change house which would tip out the main circuit breaker. Needless to say, this would not be very popular in many plants. As a result vendors and equipment suppliers have had a field day selling coordinated ground fault GFI's so that the whole plant does not go down but just isolated sections of the plant.

Slide #11

The intelligence for the ground fault detection comes from a donut transformer. Here is a slide that shows a prominent vendor's current line. The principle behind this is that all current carrying conductors are brought through the donut. Each conductor will have a corresponding electromagnetic field and with a three-phase circuit. These must vectorally add up to zero.

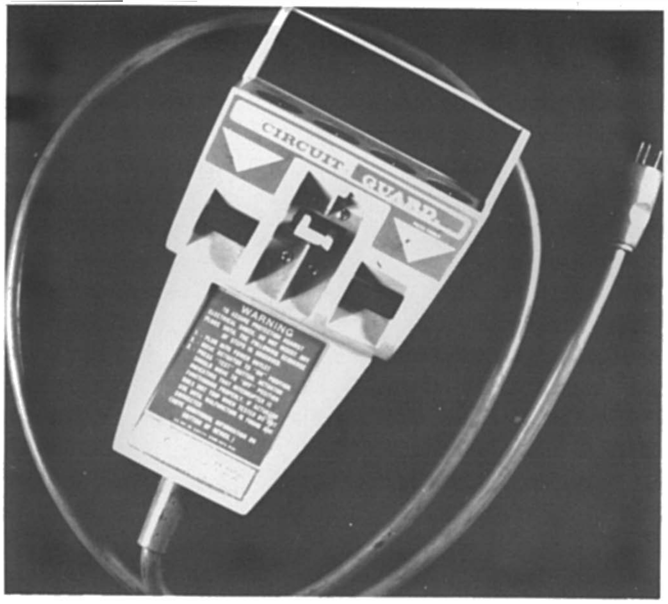


Slide #12

Regardless of the unbalance, this will be true. Note, however, that if there is a ground fault that part of the current will return over the green wire outside the donut and this will unbalance the flux in the donut transformer. A resulting signal is fed to a relay or a trip unit which in turn trips the circuit breaker. Complete coordination of feeders and main breakers is possible with proper application. Only the faulted section of theplant will shut down. This system will do a good job but it is expensive.

Personally, when a plant has responsible managemet and a good maintenance program and if the installation is proper with a good grounding system I prefer the 480 volt, three ungrounded system with ground indicator lights. It permits the plant to plan an outage. However, if here is any question whatsoever about the plant superintendent being responsible enough to insist that a ground fault be located and eliminated or if the process is suc that a sudden power outage is not a severe handicap, I will install a gounded wye system. In this way the plant superintendent does not have to make a decision. The circuit breakers and fuses make the decision for him and there is a power outage. The fault must be located then and there. I am always reluctant to do this because I know that power outages cost production; and as mentioned at the beginning of my talk, our game is to produce fertilizer.

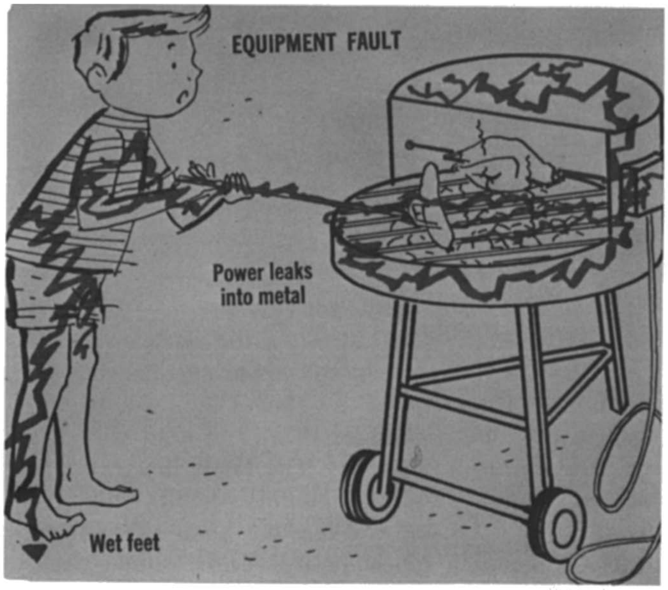
Now, let us move to GFCI's. This is the one that was made mandatory by the OSHA legislation and the 1971 Nationa Electric Code. It applies to all constructin power and various single phase circuits. It is similar to a GFI except that the trip current is at a much lower level. Another name for the GFCI is the "people protector." The attempt here is to make the ground detecting system so sensitive and so fast that the person can come into contact with a live conductor and *not* be electrocuted. Many manufacturers are making reliable GFCI's.



Slide #13

Here is a slide of a portable unit. You may find that these devices are unpopular with some contractors because of nuisance trips. Nevertheless, if the contractor will do a first class job of maintaining his equipment, nuisance outages can be prevented and so will electrical shocks.

In passing, it is interesting to note that GFCI's are even applicable in the home. The present electrical code calls for GFCI's to be applied in the bathroom, basement and outside receptacles.

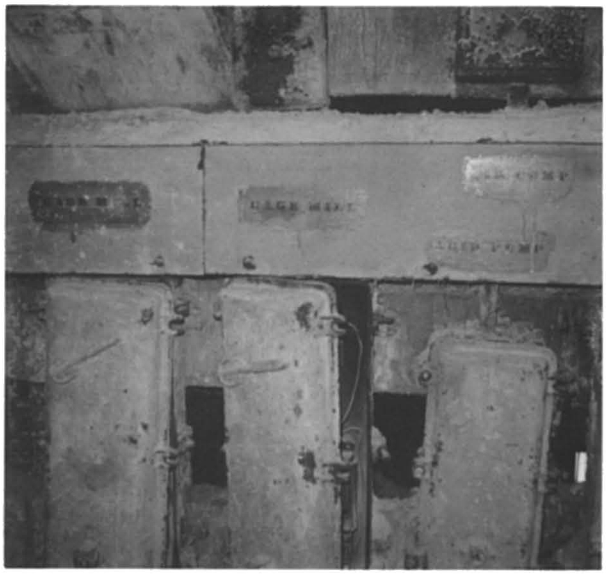


Slide #14

It is not a bad idea because you could have a barefooted chap handling the rotisserie on the back patio.

With a GFCI he is protected. In addition, even you are protected if you are using your two conductor, or a defective so-called double insulated power tool. The code is permitting the use of the double insulated system but it should be recognized that there are still hazards with the double insulated system. We have had one near miss where the bit and chuck became electrified by an internal fault and became welded to the work it was drilling. A man attempting to change bits on such a defective drill could have been electrocuted.

So much for shocks, grounding, GFI's and GFCI's. These subjects naturally lead into corrosion. If there is any one electrical problem in fertilizer plants that is more difficult than in comparable industries, it is corrosion.

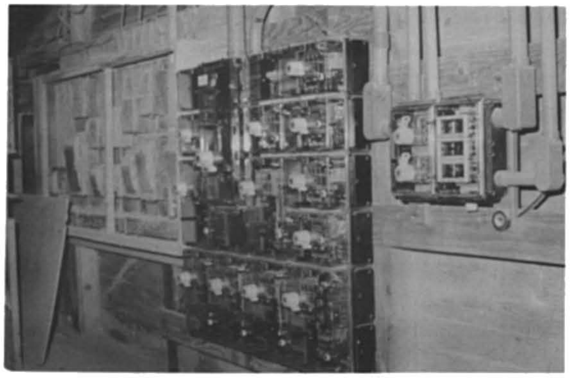


Slide #15

Corrosion can nulify a good grounding system and destroy control equipment and motors.

Slide #16

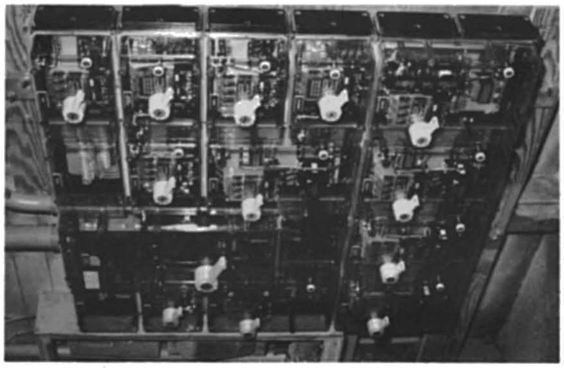
Here is an example of where a three inch aluminum conduit has corroded away from its wireway nulifying the protective grounding system. Not only has the grounding system been nulified but it has become a severe shock hazard.



Slide #17

A short in the wireway could cause a lethal potential to form between the wireway and the corroded service entrance conduit. In IMC plants we are trying to move away from metals wherever possible. Here is a typical shot of an old installation with a side-by-side example showing the replacement installation. Here are close ups of the same thing.

Slide #18



Slide #19

We are going to plastic starters and plastic conduit. This is not a new thing with us, we have had installations for several years and are convinced that this is a safe way to go. An acceptable alternative is to use steel enclosures but to put them in a room that is pressurized with clean air to keep out corrosive fertilizer contaminants. Previously we depended upon the conduit system for the grounding grid. Now we are putting in grounding conductors for all circuits regardless of whether or not they are in plastic or metallic conduit.

I do not have a slide to show this but there are tricks to installing plastic conduit. Periodic hot and cold cycles will cause plastic conduit to pull away from the end terminations and split. In addition, unless it is supported quite frequently, at least every four feet, it will sag and soon become unsightly and unreliable. When applying plastic conduit one should be sensitive to vibration and heat. If you want a successful installation, follow the manufacturers instructions and pay attention to expansion joints, vibration, terminators, bends and supports.

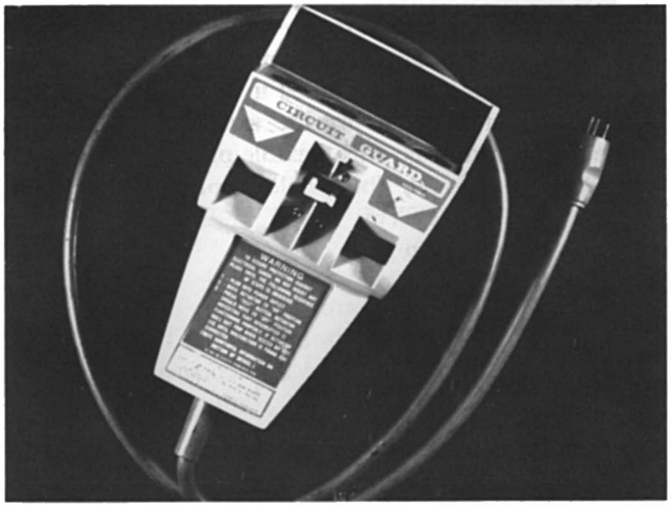
At times it is essential to use steel. In these cases some form of plastic coated steel should be used. There are a number of manufacturers supplying steel conduit with good plastic coatings.

Mr. Jim Madsen, co-author of this paper, is in our Rainbow Division. He and his associates have been doing some excellent work in preparing standards to readily communicate to plant superintendents and their electrical contractors how various electrical things should be done. He has made up a number of samples to give a 3-D explanation of how things should be. If a picture is as good as 1,000 words, a 3-D example should be as good as 10,000 words. The next sequence of slides is going to show some of this work. comment here will be short. This is a sequence of nine slides called from about 30. If we were to do justice to the work that Jim is doing, we would need a full 30 minutes for standards alone.

There are four criteria that a product should meet before it can become one of Jim's standards. These are:

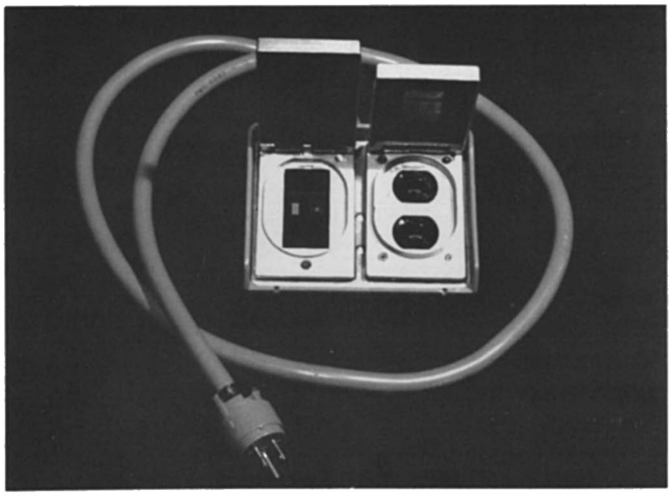
1) It must prevent, eliminate or minimize corrosion.
2) It must prevent entrance of dust and moisture.
3) The product must prevent or eliminate any possibility of electrical shock hazard to an employee.
4) The product must meet the minimum requirements of the National Electric Code and OSHA standard 1910.309.

Here is another shot of the portable Hubble GFCI that was shown previously.



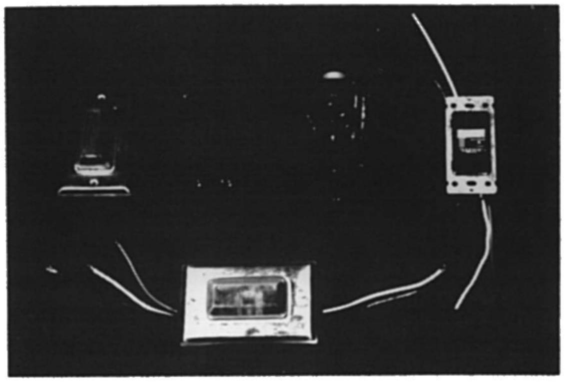
Slide #20 Slide #21

This is another type of "people protector." The Pass & Seymor catalog #4516 with the weather-proof cover. It is a 15 amp unit.



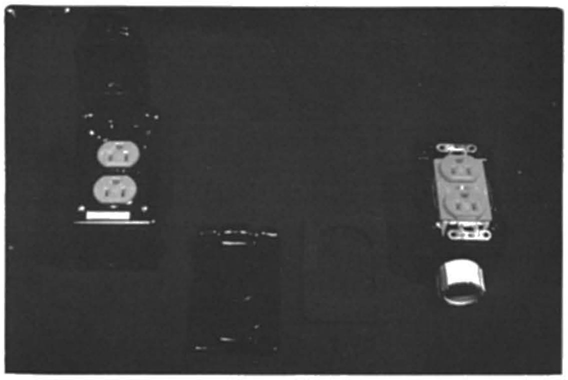
Slide #22

Here is another illustration of a GFCI, "people protector," which has been installed in our own maintenance shops and production areas.



Slide #23

This unit is a feed-through type capable of serving several wall recepticals. Take particular note of how the unit is protected and is installed in a plastic box with a plastic adapter plate to provide wiring clearance. The entire unit is protected with flexible plastic. At the right note the "see through" boot held in place with a stainless steel wall plate. This is a Pass & Seymor catalog #1591-F. Rated 15 Amps.

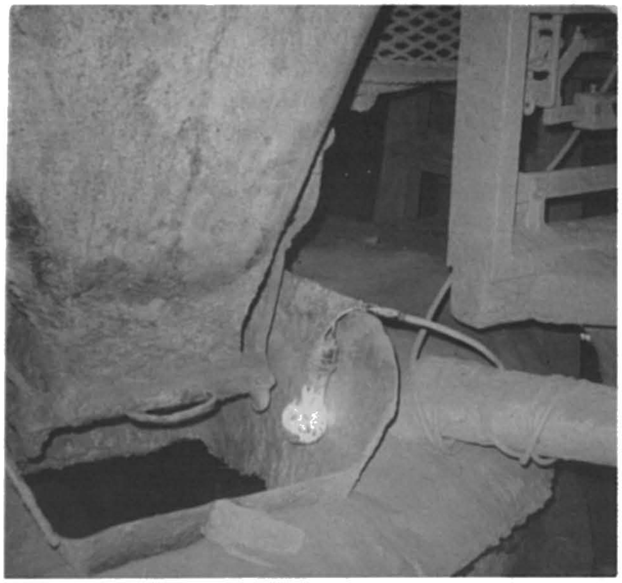


Slide #24

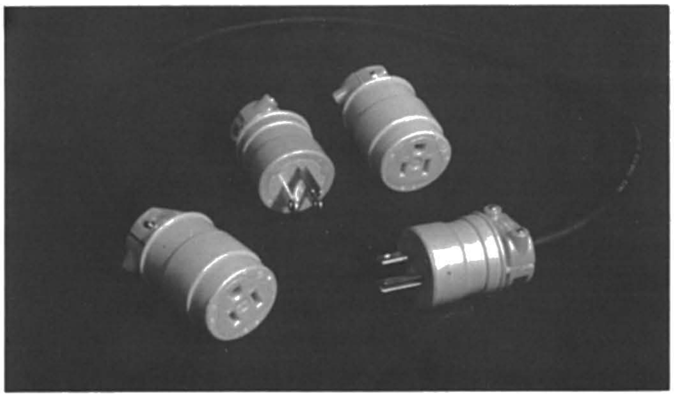
This is a standard wall receptical mounted in a plastic box with a gasketed plate. Note that it has a hinged gasket cover. The box, an FS type, is Hubbel catalog #6080. The weather-proof duplex receptical cover is Sylvania catalog #FSC-53. The duplex receptical is a Daniel Woodhead catalog #860 CR, rated 15 amp, 120 volt. This is a heavy duty corrosion resistant unit.

Slide #25

Extension cords are important safety items. This UL approved Daniel Woodhead unit provides a dependable extension light.

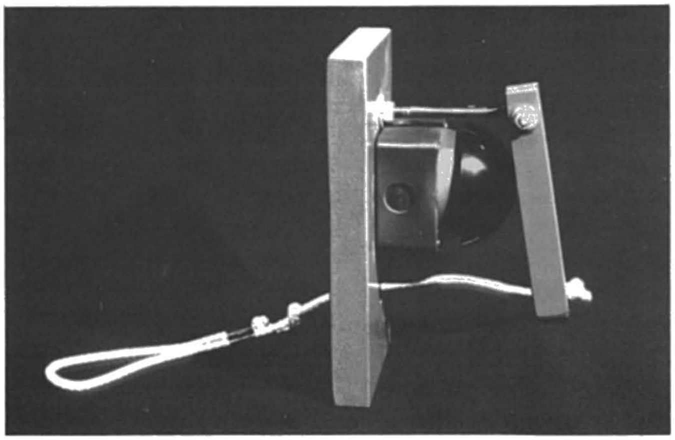


Slide #26
This is what not to do.



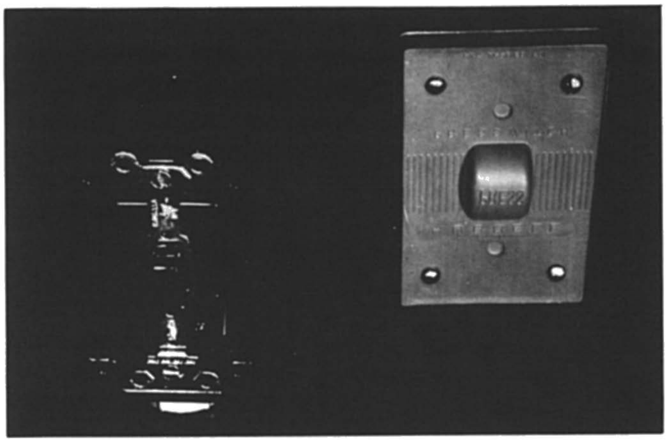
Slide #27

These Woodhead attachment plugs and connectors for extension cords provide dependable power for portable tools. Note that we still use the three wire grounding system even though we have "people protectors." The third wire prevents even a low level shock.



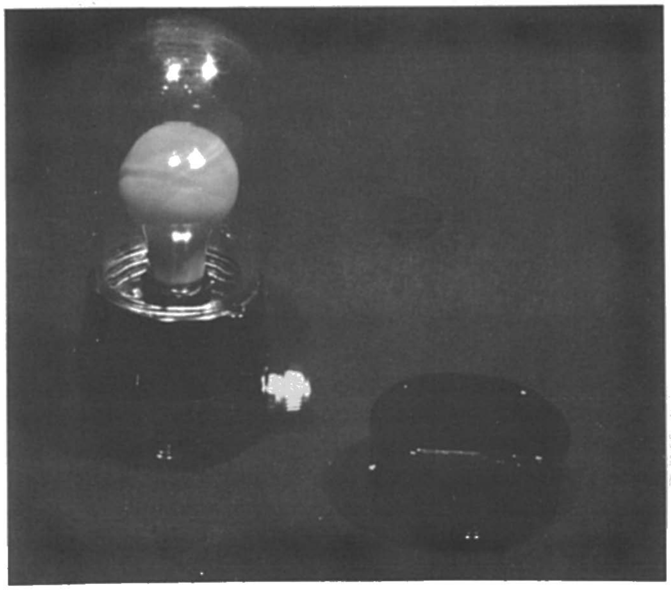
Slide #28

Here is an all plastic emergency stop switch with a manual reset. This is used for conveyor belts and screw conveyors and can b e conveniently operated by a rope along the conveyor. The switch is a Klockner Moeller.



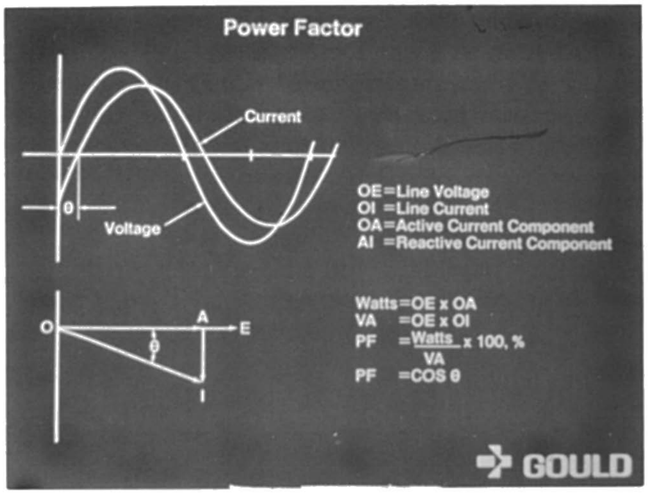
Slide 29

This is a press type of wall switch mounted in a plastic box with a dust tight flexible boot. It is a Hubbel catalog #17CM51 with weather-proof plate and pressure switch.



Slide 30

This is a plastic lighting fixture with a plastic junction box and a glass cover. It is used primarily in the smaller bulk blending plants.



Power Factor

OE=Line Voltage
OI =Line Current
OA=Active Current Component
AI =Reactive Current Component

Watts=OE x OA
VA =OE x OI
PF $=\frac{\text{Watts}}{\text{VA}} \times 100, \%$
PF =COS θ

Slide #31

This has partially covered Wally's list of questions. We have discussed shock hazards, grounding, ground fault interrupters, people protectors, corrosion and have briefly touched on standards that have been started in the IMC plants. I wish that there were time to discuss power factor. You get me started on this slide and I can go on for another 15 minutes. It would also be interesting to talk about some of the reasons why circuit breakers blow up. Also, I am sure that many of you would like to know more about how to minimize power bills. If you are interested in hearing more on the subjects, let your program chairman know about it and perhaps some other fortunate electrical engineer will be invited to go to the Round Table. In the meantime, I am looking forward to joining you in the audience so that I can listen to the rest of the presentations.

Thank you for your attention. *(Applause)*

MODERATOR WALSTAD: Thank you Mr. Crom for a very informative and illustrated discussion on how to keep from damaging equipment and from killing our selves. I am sure there must be some questions on this subject.

QUESTION: Are there other plastic boxes available besides those you mentioned.

ANSWER: Many. Everybody is drawing that line pretty close and if you are having trouble I would suggest that you look at the so called heavy duty.

MODERATOR WALSTAD: More questions? We have been sitting patiently. Let's take a 2 minute break.

Thank you George Hoffmeister, Round Table Director William F. O'Brien and Mr. R. C. W. Crom and Associate J. R. Madsen for your most interesting, timely and valuable discussions. We had a good, attentive, interesting audience.

The remainder of this morning's schedule will be moderated by Round Table Director William F. O'Brien. Thank you all. *(Applause)*

MODERATOR WILLIAM F. O'BRIEN: Thank you Dan. Continuing with our morning session. Herman

L. Kimbrough, TVA Chemical Engineer, will present the discussion "Recent Developments In Production and Use of Monoammonium Phosphates" prepared by TVA Chemical Engineers Hubert L. Balay and David G. Sallabay. Mr. Ballay is ill today and is very sorry he could not be present. Homer please.

Recent Developments In the Production and Use of Monoammonium Phosphate

Herbert L. Balay - David G. Salladay
Presented by Homer L. Kimbrough

Introduction

The popularity of monoammonium phosphate (MAP) is growing rapidly because of its versatility. The granular product is becoming a popular bulk blend material and the powdered product is finding use as a replacement for superphosphates in granulation plants. Interest in producing suspension fertilizers from granular and powdered MAP is widespread because of its low delivered cost compared with other ammonium phosphate bases.

MAP production is also becoming popular with basic producers of ammonium phosphate products. As the BPL content of rock declines in some of the major phosphate deposits in the United States, it is becoming more difficult for diammonium phosphate producers to reach the established analysis for diammonium phosphate (18-46-0). Some diammonium phosphate producers are reaching the accepted analysis by removing solids from the phosphoric acid to increase its concentration. This presents a problem of disposal of the solids. There is no such problem in the production of monoammonium phosphate. So far, no single grade has been established for monoammonium phosphate. Several grades ranging from 10-50-0 are being produced. The grade produced depends upon the purity of the feed acid.

Processes for Production of MAP

Several processes are being used to produce MAP. Basically they are:

1. Ammoniating acid to NH_3:H_3PO_4 mole ratio of 1.3 in a preneutralizer and adding acid in a TVA ammoniator-granulator or a blunger to return the mole ratio to 1.
2. Two-step neutralization under pressure followed by flash ejection of hot concentrated slurry into a receiving tower.
3. Direct reaction of ammonia and phosphoric acid followed by flash ejection into a receiving tower.
4. Reaction of phosphoric acid and ammonia in a pipe-cross reactor in the presence of a small amount of sulfuric acid with subsequent flash ejection onto a rolling bed of solids in a TVA ammoniator-granulator.

Since all these processes were covered in previous Round Table meetings, they will not be covered in detail here.

Use of MAP in Bulk Blending

A major use of granular MAP is expected to be in bulk blending. Monoammonium phosphate has the advantage over diammonium phosphate in that all the popular ratios, even 1:4:X and 1:3:X, can be blended without the need for an additional phosphate material. If ratios below 1:2·56:X are blended from 18-46-0, granular triple or some other phosphate material must be available. More nitrogen is required with monoammonium phosphate (except in the 1:5:X ratio), but plants must usually have the nitrogen available anyway to produce higher nitrogen ratios. This eliminates the need to store and ship one more material.

All ratios, even a 1:5:X, can be blended from triple superphosphate and nitrogen; however, monoammonium phosphate has an advantage over these materials in that it contains from 60 to 66 units of plant food per ton rather than the usual 45 for triple. This results in lower freight rates and less required storage space. The higher nitrogen ratios (above 1:2.56:X) can be blended from diammonium phosphate without a second phosphate source; however, some nitrogen source other than that supplied by the DAP is required. In these grades diammonium phosphate requires less supplementary nitrogen than MAP, but nitrogen frequently can be obtained more economically from local suppliers than from either diammonium or monoammonium phosphate. If this is the case, the less nitrogen shipped with the phosphate the better. Several formulas for common grades blended from MAP and DAP are shown in table 1.

A 12-48-0 mixture of monoammonium phosphate and ammonium sulfate has been produced by the TVA pipe-cross reactor process especially for blending the popular 1:4:X ratios. This cuts down the number of materials required in these ratios and helps alleviate segregation problems that still plague blenders. A 1:4:4 ratio using this product is also shown in table 1.

MAP In Granulation

Monoammonium phosphate, especially the powdered variety, should become a popular material in granulation plants. It is expected to replace normal superphosphate and sometimes triple superphosphate in the granulation process. Because of the increasing cost of shipping phosphate rock and the pollution difficulties encountered in producing normal superphosphate, NSP is disappearing from the market. It continues to be available to producers who are basic in phosphate rock and who make their own normal super; however, it is now essentially unavailable to the independent granulator. The logical replacement for normal superphosphate is triple superphosphate; however, many granulators prefer monoammonium phosphate because of its high concentration and comparatively low storage and shipping cost. MAP is also preferred over phosphoric acid because it is more convenient to ship, especially by water. Also, it can usually be stored and used without changes in the existing equipment.

Monoammonium phosphate is especially useful in granulating high nitrogen grades. The amount of ammonia can be used as a nitrogen source in these grades is limited because of the increased heat and liquid phase generated when the ammonia reacts with acids and superphosphate. Usually as much nitrogen as possible is obtained from ammonia and the balance is obtained from ammonium nitrate or ammonium sulfate. Both of these materials, if used in any quantity, degrade storage and handling properties of the product. Also, use of ammonium nitrate and ammonium sulfate will sometimes increase raw material cost of the product. If monoammonium phosphate is used as a phosphate source, the requirement for ammonium nitrate and ammonium sulfate is reduced because of additional nitrogen in the monoammonium phosphate.

Usually, fume evolution is decreased because there is no need to exceed the optimum amount of ammonia in a high nitrogen grade. Also, the amount of dust in the plant is reduced because there is less oversize to be crushed and, hence, less dusting.

One plant in the South has used monoammonium phosphate for about a year in its granulation process. Many of the reasons for adopting monoammonium phosphate were those given above; however, the main consideration in this case is economics. After a year's experience, the plant has had fairly good success with the monoammonium phosphate; however, all of the anticipated advantages have not developed. Specifications of the product used in this plant are listed in table 2. The general conclusion after one year's operation was that MAP handles and granulates about like triple super-phosphate, although in most cases the MAP, as received, is dustier than triple and has more of a tendency to cake in storage.

When the plant began using monoammonium phosphate, it was assumed that MAP could be ammoniated from about 4.7 pounds of ammonia per unit of P_2O_5 (the amount in MAP) to 7.2 pounds of ammonia per unit of P_2O_5, or an increase of about 2.5 pounds of ammonia per unit of P_2O_5. Up to 2.4 pounds of ammonia per unit of P_2O_5 had been successfully added in the TVA pilot plant to MAP (11-55-0) made from a relatively pure wet-process acid. It was found in the plant operation that this amount of ammonia could not be added to powdered MAP made with less pure acid. Through trial and error it was found that the maximum ammoniation was 1.9 pounds of ammonia per unit of P_2O_5 and that best results were obtained if the ammoniation rate was limited to about 1.5 pounds of ammonia per unit of P_2O_5.

Difficulty was also encountered in making the pellets as large as those produced when all of the P_2O_5 was obtained from normal and triple superphosphate. In grades where all the P_2O_5 could not be obtained from MAP, triple was used as the supplementary phosphate source because it cost less than normal superphosphate. Experimentally it was found that larger granules could be produced if some normal superphosphate was used as the supplementary source.

A problem also developed with filler. Because of the high analysis of the monoammonium phosphate filler was required in established grades which had previously been formulated without filler.. A suitable granular filler could not be obtained, and a fine dolomitic limestone was used as filler during the first trials with monoammonium phosphate. Later a satisfactory granular filler was obtained that appeared to improve the granulation characteristics of the mixtures. Successful formulations are shown in table 3. eighty-three percent ammonium nitrate liquor was available and was used as supplementary nitrogen in a number of the formulations. Products containing less than 2 percent moisture stored fairly well and seemed to be similar to products produced without monoammonium phosphate. Hardness of the pellets was about the same regardless of what materials were mixed.

TVA uses granulation factors to determine how much a material will contribute to granulation. The granulation factor used for monoammonium phosphate in this plant was 0.2 as compared to 0.5 for anhydrous ammonia, 1.0 for ammonia-ammonium nitrate solutions, 0.10 for ammonium sulfate, 0.20 for normal superphosphate, and 0.2 for triple superphosphate (see first reference for explanation of granulation factors).

A brazilian company reported results with monoammonium phosphate produced by two European companies. These results are similar to those reported above except that one of the products handled in bulk was not as dusty and did not cake as badly as the powdered material described earlier. This company also reported that granulation was similar to that obtained with well-cured and disintegrated run-of-pile triple superphosphate. Ammoniation rates were not given. However, it is believed that they were similar to those obtained in the U.S. granulation plant because the authors of that paper reported that some sulfuric acid had to be added to provide heat and to hold ammonia. It is of interest that this company added the acid at the feed end of the ammoniator-granulator so that the monoammonium phosphate was wetted with sulfuric acid before it entered the ammoniation section.

It has been reported in previous Round Table proceedings that excellent granulation has been obtained with a monoammonium phosphate produced in Europe which contains 6+ percent water. The proceedings state that further drying of the product could impair granulation properties of the product because amorphous gels formed by impurities in acids used to manufacture the

MAP became dehydrated. All granulation tests reported in this paper have been made with MAP containing 3 percent or less of water. Further tests with monoammonium phosphate containing more water seem warranted.

Use of MAP in Fluid Fertilizers

As mentioned previously, there is considerable variation in inpurity content of monoammonium phosphate produced in the United States. Very satisfactory 11-33-0 base suspensions have been produced from 11-55-0 grades of monoammonium phosphate which contain fairly low quantities of impurities. However, as impurity content of the monoammonium phosphate increases, the grade produced from it must be reduced because of thickening (or gelling) properties of the impurities. Grades as low as 9-27-0 must be produced from monoammonium phosphate made from sludge acid. Most of the grades produced contain about 1 percent clay. It hass been found inadvisable to store any of the products except those produced from very pure monoammonium phosphate.

It is common practice to add enough ammonia to the monoammonium phosphate to bring the mixture to a mole ratio of 1.7 (about 8.1 pounds of ammonia per unit of P_2O_5 or 1:3 $N:P_2O_5$ ratio). Maximum solubility for mixtures of mono- and diammonium phosphate is obtained at mole ratio 1.45 and more salts are in solution than at any other mole ratio, but salts that precipitate at 1.45 mole ratio are usually monoammonium phosphate. At mole ratio 1.7, salts precipitate as diammonium phosphate. Diammonium phosphate crystals are smaller and suspend better than monoammonium phosphate crystals. The reaction between ammonia and MAP also provides heat for disintegrating franular monoammonium phosphate (when granules are used).

High intensity mixing equipment is usually required to produce suspension fertilizers from monoammonium phosphate, especially where granulated material must be disintegrated. High shear mixers driven at 1800 rpm's by 60-hp motors are common in the industry. Investment in this kind of mixing equipment is high; however, savings in using monoammonium phosphate over other phosphate sources available to the fluid fertilizer industry usually makes purchasing this equipment profitable. It is expected that more and more monoammonium phosphate will be used for this purpose because it is about the only way that fluid fertilizers can be produced at prices competitive with bulk blends.

Ammonium Polyphosphate

TVA started producing solid ammonium polyphosphate in 1966 from electric furnace phosphoric acid. In the early 1970's the cost of energy for producing electric furnace phosphoric acid rose sharply making the production of ammonium polyphosphate from this acid economically infeasible.

In 1974, TVA introduced ammonium polyphosphate (12-54-0) made from merchant grade wet-process phosphoric acid. The product is granular and contains ammonium ortho- and polyphosphates. The polyphosphate content varies from 15 to 25% of the total P_2O_5. The orthophosphate is mainly monoammonium phosphate.

Ammonia and wet-process orthophosphoric acid are reacted in a pipe reactor to produce an anhydrous ammonium phosphate melt. Heat of reaction converts part of the phosphate to polyphosphate. In this respect, the operation is similar to that in the production of powdered monoammonium phosphate. Gaseous ammonia is charged to the reactor. The acid usually is not heated since this will produce a product with high polyphosphate content. It is desirable to limit polyphosphate content of the product to less than 30 percent to facilitate granulation because high-polyphosphate melt will not solidify and granulate well.

TVA granular ammonium polyphosphate has excellent storage and handling characteristics. It is believed that the polyphosphate in the product contributes to these characteristics. Specifications for the product are shown in table 4.

The product has been used in bulk blending and for production of suspension fertilizers. It is especially suited to producing suspension grades since the polyphosphates are more soluble than orthophosphate and will sequester a portion of the impurities from the wet process phosphoric acid used to produce the ammonium polyphosphate. The product is ammoniated to the 1.7 mole ratio for the same reasons the monoammonium phosphate is ammoniated to that ratio. Granules tend to disintegrate rapidly in water because polyphosphate in the product goes quickly into solution helping to disintegrate the granules so that the orthophosphate portion suspends easily. An 11-33-0 base suspension that will store well for up to 60 days can be produced from this material.

Ammonium polyphosphate can be blended in the same manner as monoammonium phosphate. Its higher analysis is of some benefit in producing higher grade blends. Also, it has been reported that sinc oxide coated onto the surface of the granules reacts with the polyphosphate and is sequested into a more available form.

Summary

Monoammonium phosphate is a versatile product which can be used in every phase of fertilizer production. Its $N:P_2O_5$ ratio is more suitable to bulk blending than that of diammonium phosphate. It serves well in granulation as a replacement for some of the more familiar phosphate forms. It is economical to ship and store because of its high analysis. It is easily made and granulated from impure phosphoric acid. This will be an important factor in future decisions to produce monoammonium phosphates rather than diammonium as the BPL content of phosphate rock decreases. Take a good look at monoammonium phosphate. We can expect to see more of it in the future.

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Table 1
Bulk Blend Formula Using MAP & DAP

Grade	5-25-25	5-25-25	8-24-24	8-24-24	8-24-24
Ratio	1:5:5	1:5:5	1:3:3	1:3:3	1:3:3
Raw Material	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**
MAP (11-55-0)[a]	—	910	873	—	873
MAP (12-48-0)[b]	—	—	—	—	—
DAP (18-46-0)[c]	556	—	—	889	—
Triple super (0-46-0)	531	—	—	155	—
Urea (46-0-0)	—	—	140	—	—
Ammonium sulfate (21-0-0)	—	—	—	—	305
Potash (0-0-60)	834	834	800	800	800
Filler	79	256	187	156	22

Grade	6-24-24	6-24-24	6-24-24	6-24-24
Ratio	1:4:4	1:4:4	1:4:4	1:4:4
Raw Materials	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**
MAP (11-55-0)[a]	—	873	—	873
MAP (12-48-0)[b]	1000	—	—	—
DAP (18-46-0)[c]	—	—	667	—
Triple super (0-46-0)	—	—	377	—
Urea (46-0-0)	—	53	—	—
Ammonium sulfate (21-0-0)	—	—	—	115
Potash (0-0-60)	800	800	800	800
Filler	200	274	156	212

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[a] Monoammonium phosphate

[b] Monoammonium phosphate-sulfate made by pipe-cross process

[c] Diammonium phosphate

Table 2

Specifications of Powdered Monoammonium Phosphate (MAP)

Moisture	2-3%
P_2O_5	50-51%
N	10%

Table 3

Granulation Formulas Using MAP

Grade	a 5-10-15	b 5-10-15	c 5-10-15	d 8-16-24	e 8-16-24	f 8-16-24
Ratio	1:2:3	1:2:3	1:2:3	1:2:3	1:2:3	1:2:3
Raw Material	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**
NH_3 (82.2-0-0)	61	49	80	80	70	80
NH_4NO_3 (liquor) (29-0-0)	104	104	87	135	182	135
Ammonium sulfate (21-0-0)	—	—	—	—	—	—
Normal super (0-18-0)	534	245	823	267	397	190
Triple super (0-46-0)	—	—	—	—	—	—
Monoammonium phosphate (10-52-0)	200	312	100	544	497	590
Sulfate of potash-magnesia	—	—	—	100	—	—
Potash (0-0-60)	492	492	492	751	787	787
H_2SO_4 (93%)	100	145	125	120	134	125
Filler	614	694	370	—	—	153
Micronutrient mix	—	—	—	50	—	—
Steam	116	100	68	37	—	—
Ammoniation rate of MAP (No. NH_3/unit P_2O_5)	0.2	0	0	1.9	0.5	1.9

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[a] Granulated well with granular filler; recycle build up with fine filler

[b] Amount of NH_3 increased over original amount formulated; granulated well with granular filler

[c] Granulated well with granular filler

[d] Granulated well; some trouble holding ammonia

[e] Granulated well

[f] Granulated well; some trouble holding ammonia

Table 3

(Continued)

Grade	g 5-15-30	h 5-15-30	i 8-24-24	j 8-24-24	k 14-14-14
Ratio	1:3:6	1:3:6	1:3:3	1:3:3	1:1:1
Raw Material	**No./Ton Prod.**	**No./Ton Prod.**	**No./Ton Prod.**		**No./Ton Prod.**
NH_3 (82.2-0-0)	60	70	70	89	63
NH_4NO_3 (liquor) (29-0-0)	55	—	75	—	166
Ammonium sulfate (21-0-0)	—	—	—	—	591
Normal super (0-18-0)	—	412	—	150	—
Triple super (0-46-0)	275	—	169	—	—
Monoammonium phosphate (10-52-0)	350	448	809	871	560
Sulfate of potash-magnesia	—	—	—	—	—
Potash (0-0-60)	984	484	787	787	460
H_2SO_4 (93%)	100	111	125	130	130
Filler	207	—	—	—	65
Micronutrient mix	—	—	—	—	—
Steam	—	95	—	—	—
Ammoniation rate of MAP (No. NH_3/unit P_2O_5)	0.4	1.1	0.7	1.7	1.8

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g Granulated well with granular filler

h Did not granulate well

i Some over granulation

j Would not hold ammonia

k Granulated well; some oversize; product hygroscopic; MAP only source of P_2O_5

Table 4

Specifications of Granular Ammonium Polyphosphate (APP)

Moisture	2.0%
P_2O_5	54%
Polyphosphate, % of total P_2O_5	15-25%
N	12%

MR. KIMBROUGH: It has been my pleasure to discuss Monoammonium Phosphate with you. I thank you all for your kind attention. *(Applause)*

MODERATOR O'BRIEN: Thank you ever so much Homer and thanks to Mr. Balley and Mr. Salladay for preparing this excellent and interesting "Paper". Do we have any questions?

QUESTION: Mr. Kimbrough you made reference to a more suitable filler for MAP. Please elaborate.

ANSWER: This Company used MAP in granulation. They used a powdered filler first and changed to a granular filler and had better results.

Any more questions? Way in back.

I am John Surber with IMC Chemicals. I wish to make several comments that you folks might be interested in. The present powdered MAP that we are making we are shipping thru ports. I think, as most of you are aware, EPA is pretty strict on dust. Our port facility manager, in Tampa, tells us that the product is less dusty than DAP. That is a good comparison. The second comment, as far as ammoniation, we have found in some limited work that we have done that you can ammoniate up to 7.2 lbs. of NH_3 per unit of P_2O_5 from your starting point of about 4.8 lbs. per unit, or approximately 2½ lbs. per unit. However, to do that you have to add water.

MR. KIMBROUGH: How much moisture do you have with MAP?

MR. SURBER: How much does ours have? It has in the range of 1 to 1½% as shipped. In order to effectively ammoniate to higher rates you have to put water back in as if it were a Phos Acid. We have added MAP as a recycle in a DAP Plant and taken it all the way to DAP. So it can be done, but you have to get the moisture back. That is really the point. So I say to anybody that experiences trouble, if you can stand to put, more water in the bed you can get an additional bonus of picking up some ammonia.

MR. KIMBROUGH: I will say this, if you don't have a reasonable pure acid, it will not hold enough ammonia to make DAP. Perhaps a pure acid was used in your case.

I am Bob Pendergrast with U.S.S. Agri-Chemicals. We have a MAP, made from Sludge Acid. It only analyzed 9-45-0 because of all the impurities in it. The maximum ammonniation rate we could use was about one pound per unit. I would like to ask Homer if you were formulating a grade where you had not only MAP in there, but some run of pile triple, would there be any danger of over-ammoniating your triple if you were going for broke to ammoniate the MAP?

MR. KIMBROUGH: I would think you could.

MR. PENDERGRAST: How would you go about calculating that?

MR. FRANK NIELSSON — IMC: In all of the tests, that we have made we have assumed an ammoniation rato of 1 to 2½ — sometimes as high as 2. We assume a standard degree of ammoniation for triple superphosphate of 3.8%. As long as we stayed at around 1.5% I do not believe we ran into a reversion problem.

There is no argument that the first MAP that we made was a little bit dusty. One of my jobs is to see what a Customer complains about and then come back and see if the Boys in the plant can do something about it. Dust was one of the early complaints; and I must say that the Boys in the plant have gotten this problem licked. They changed processes, changed the nozzle sizes. Now they have a product if you take it in your hand and throw it up in the air, comes back like sand. This is 10-50-0 or higher generally.

Part of my job also is to run tests with our products in various parts of the world. One of the interesting tests was made in India. There is a big Cooperative Plant there just north of Bombay. This plant was built to handle imported Phos Acids. Imported Phos Acids handled better for him unloaded at his pier than the bringing in of MAP thru a government port a few miles from the plant. However, he was able to replace 75% of this Phos Acid with MAP in the DAP operation. When I say DAP type operation, I mean they make either 18-46-0 or 28-28-0 or 22-22-11 where they add UREA to DAP formulation. The only thing that this man used Phos Acid for was the scrubbers in the DAP operation. And no problems with formulation.

Also :IMC) have a plant in Korea where we ran a test to take MAP and replace a big portion of the Phos Acid and just use Phos Acid for scrubbing. This man in India was talking also, if worse came to worse, he indicated that he might even start running experiments to see if he could take MAP and use it in a scrubbing system and to do without Phos Acid completely. When you are talking about the 6% moisture product that the originators of MAP first came up with, it is probably a product that granulates better than what is being made now-a-days. The only thing wrong with that is that it was developed for somebody that was making MAP for local consumption but with moisture contents like that caking occurs.

When the MAP is put into a boat and pounded up and down for 30 days or shipped 3 or 4 weeks in a boxcar.

One of the things we discount was that you have to get down below 2% moisture if you want to have a product that will store for a long period of time. And of course, once you do that you get to the point where you have got to add some water if you want the MAP to granulate.

This is a little bit like the same problems in clear liquids using white potash that has an anti-caking agent on it. You may complain about the fact that it gives you a film on your clear liquid. So then you go ahead and try technical potesh which has no additives in it. After one month you have to use a jack-hammer to get that potash out of storage because it cakes too badly. So finally you just put up with the fact that it is better to have something which handles easily, which does not cake and with which you have a minor proplem compared to something that you cannot handle.

The same way with MAP. If you make it so it will ammoniate and granulate quickly then it cakes in storage. If you make it where it does not cake then you will have to add a little bit of water when you granulate and that is a more simple way to solve the problem.

QUESTION: What grade of ammoniation do you get.

ANSWER: I call MAP particpartially ammoniated dried phosphoric acid. If you look at it that way, whatever you do with phos acid you can do with MAP. Because MAP has become a sort of specialty item to handle certain problems in phos acid operations, each company's product will be different. Each company will have to find out what can be done witt their product. I know what ours can do. I do not know about somebody elses.

MODERATOR O'BRIEN: Thank you Frank Nielsson for your most interesting anaysis concerning your experiences with Phos Acid and MAP.

Thank you Homer for discussing developments and use of Monoammonium Phosphate. *(Applause)*

MODERATOR O'BRIEN: Our final discussion this morning will be given by Fred J. Hurst. Fred is a graduate of Mississippi College. He has worked at Oak Ridge National Laboratory for over 30 years. Much of his time has been concerned with Process Development involving recovery of uranium "Thorium" and "Vanadium" from western sandstone ores, phosphate lignites and granits. Fred please.

MR. HURST: Thank you Bill. I appreciate the invitation to participte in your "Round Table" discussions and I see you have a large, enthusiastic group here.

Progress and Problems of Recovering Uranium Form Wet Process Phosphoric Acid*

Fred J. Hurst, Wesley A. Arnold
Allen D. Ryon

Presented by Fred J. Hurst

Increasing uranium prices offer the phosphate industry an attractive economic opportunity to recover uranium as a byproduct of fertilizer manufacture. At the same time, an important natural resource is conserved that can be used to increase the nation's future power supply and a radioactive contaminant is removed. It has been estimated that about 3000 tons of U_3O_8 could be recovered from the wet-process phosphoric acid this year, with even greater amounts potentially recoverable in future years. At current talking prices of $40/lb U_3O_8, the value of the uranium dissolved in the acid this year is more than 240 million dollars. An attractive solvent extraction process (DEPA-TOPO process) for recovering this uranium, developed several years ago at Oak Ridge National Laboratory (ORNL), has now been demonstrated successfully in pilot plant operations at several phosphate plants, and full-scale plants based on this process are presently being designed by several engineering firms. More recently, an alternative process (OPAP process) for recovering the uranium has been reported by ORNL. This process, which offers several potential advantages over the DEPA-TOPO process, requires additional testing, some of which is currently being carried out at ORNL. Since the technical aspects of these processes are well documented, this paper deals more with the commercial and management areas of uranium recovery. Our primary purpose is to describe how a phosphate producer can get started in the uranium recovery business, and some of the problem areas with which he must cope. This is done in the context of an existing 1000 tons P_2O_5 per day plant operation.

Since we published our first of four reports on the recovery of uranium from wet-process phosphoric acid in 1969, we have been visited by representatives of over 30 companies seeking information and advice on our recovery processes. The questions most frequently asked are:

1. How much uranium is in our acid?
2. How complex is the recovery operation?
3. Will these processes harm our acid?
4. How much will recovery cost and how much profit can we expect?
5. What are the future trends in uranium prices?
6. How do we get started — Should we go it alone or contract with a uranium recovery company?
7. What is the patent situation?

I would like to emphasize that we do not know all the answers but we are anxious to do all we can to help you find them.

The major drawbacks to our process development has been the lack of detailed knowledge of the phosacid industry, much of which is proprietary, and in the fact that our tests were made with aged rather than fresh acid. As we have emphasized from the start, final testing must be made with fresh acid at the plant site. Interfacing a successful uranium recovery process to a phosphate plant is a complex problem and one that will require a cooperative effort from everyone involved.

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However, for those who are successdul, the pay-off could be large. Our main purpose today is to try and give you an overview of the problem, as we see it, after talking to many of you in the industry.

The first question I would like to address is:

How much uranium are we talking about?

Tremendous reserves of phosphate rock are known and well documented. On the other hand, information on the uranium content of the rock is not as well known, but is sufficient to indicate that phosphate rock is a significant potential source of uranium.

An order of magnitude estimate of the uranium contained in the three major phosphate areas in this country (Florida, North Carolina and the Western States) is about 1 million tons. Moroccan deposits could contain ten times this amount. According to a recent article in the Wall Street Journal (Aug. 16, 1976), Morocco is interested in developing a joint venture with American interests for extracting uranium as a by-product from their rock. Slide #1.

At the present time and for the foreseeable future, economics dictate that the uranium can be recovered only as a by-product of wet-process acid production. Thus, the most important number is the ratio of ∿1 lb U_3O_8 per ton P_2O_5 for most of the deposits. Based on present acid production rates ∿3,000 tons U_3O_8 will be dissolved this year and this is projected to increase to ∿8,000 tons/yr by the end of the century. Incidently, our current annual domestic production of uranium from sandstone ores is ∿13,000 tons, so we are talking about a significant amount of uranium.

As we see it, there are three major incentives for recovering this uranium. First, to supplement the nation's future power supply. You might expect to recover ∿150 tons U_3O_8 per year for each 1000 ton P_2O_5/day train that you operate. If you can recover this much uranium annually for the next 30 years, you can supply the fuel requirement of a 1000 MWe light water reactor for its projected lifetime.

A major advantage that you have over the uranium mining industry is that your uranium is already dissolved, with no additional mining, leaching, or tailings disposal required. Once your plant is built and operating, recovery costs should remain relatively constant. This means that your profits should inrease if the price of uranium increases as anticipated when the higher grade uranium ore deposits become depleted and lower grade deposits are developed.

Secondly, removing the uranium improves the environment by preventing the spread of a radioactive contaminant to the soil. This should give you a big plus from the environmentalists.

Thirdly, you can do this at a profit. Lets look at a few numbers for illustration. An independent research organization recently estimated the cost of recovering uranium from phosphoric acid at about $15 per pound. If the uranium can be recovered at this cost and sold at the current spot pric of $40/lb, then the indicated profit is $25 per pound of uranium or ton of P_2O_5. For a year's operation of a 1000 ton P_2O_5/day train, this amounts to between 7 and 8 million dollars. Slide #2.

This slide shows some of the areas that need to be considered in designing a uranium recovery operation. For convenience, we have chosen a 1000 ton P_2O_5/day operation and have assumed that the uranium (∿1000 lbs U_3O_8/day) will be recovered from 32% P_2O_5 filter acid by a two cycle solvent extraction process. The first or concentration cycle is by far the most cost sensitive part of the process and involves three unit operations; (1) pretreatment to prepare the acid, (2) solvent extraction to concentrate the uranium, e.g., as shown here from ∿1.7 lb to ∿90 lb/1000 gal of acid, and (3) post treatment, to insure that the acid returning to the acid plant will not be harmful downstream.

As you can see, concentrating the uranium by a factor of ∿50, reduced the volume of acid to be processed in the second or purification cycle from ∿400 to 8 gal/min. This cycle can be carried out in a very small scale operation at the plant site or the first cycle product solution can be shipped to a central refinery for processing to a high grade U_3O_8 concentrate. I plan to discuss each of these operations in as much detail as possible in the time allotted. Slide #3.

First, I would like todescribe the two solvent extraction processes that we have developed at ORNL for recovering uranium from the 32% acid. (1) The DEPA-TOPO or reductive stripping process which uses the synergistic combination of di(2-ethylhexl) phosphoric acid and trioctyl phosphine oxide to extract oxidized uranium from the acid, and (2) The OPAP or oxidative process which uses a mixture of mono and dioctylphenyl phosphoric acid to extract reduced uranium from the acid. Both processes are covered by ERDA patents. However, the DEPA-TOPO process is in litigation. Slide #4.

We feel strongly that the success of a uranium recovery operation hinges on proper pretreatment of the acid. As you well know, "black" acid contains a lot of organic matter or humus in addition to being supersaturated with gypsum. A significant fraction of the organic matter is soluble or in a colloidal state and cannot be removed by filtration. Some of this material coagulates upon contact with our extractants to form a crud that collects at the organic/aqueous interface and will eventually flood the system. Thus, provision must be made to remove the organic matter either before it enters the extraction system or to periodically remove the crud after it has formed. The crud contains substantial amounts of the valuable extractant, which must be recovered. In addition, some of the organic matter can be extracted irreversibly by the extractant and reduce uranium extraction. We believe it is preferable to remove the organic matter in a pretreatment process prior to the solvent extraction process, but we have not studied this problem and cannot tell you how to do it at this time.

Potential pretreatment methods that have been investigated by others include oxidation, flocculation-clarification, treatment with activated carbon, and calcination. Slide #5.

At this point, I should mention that we have used the Pittsburgh activated carbon process to produce green acid for some of our laboratory tests. On the basis of these tests and information from the Pittsburgh people, we feel that this process could solve the pretreatment problem if the economics can be proved to be satisfactory. This process has the added advantage that the carbon can act as a two way catalyst; e.g., as an oxidation catalyst for iron and uranium using air as the oxidant or as a reduction catalyst for these materials when using SO_2 as the reductant. However, we feel that a considerable amount of work remains to be done in this area before the best choice can be made. In addition, the effect on both extraction and phase separation of defoamers added during digestion of the rock needs to be determined. To be meaningful, these tests need to be made with fresh acid.

Once the organic matter has been removed the uranium valence can be readily adjusted to the desired state, depending on the extraction process used if this has not already been done during the clean-up step.

Acid cooling is another important consideration. Variation of the temperature can be used to control gypsum precipitation and has a significant effect on uranium extraction and phase separation. Uranium extraction efficiency can be improved significantly by reducing the temperature but this is done at the expense of poorer phase separation and higher entrainment. A temperature of ∿40 degrees - 50 degrees C (105-120 degrees F.) is probably about optimum.

This slide shows simplified flowsheets for the first cycle of our two processes. They have been adequately described in the literature and I will not take the time to detail them here, but will discuss some problem areas. You will note that the two processes are very similar; in fact they can be operated in the same equipment. This could be advantageous if later testing proves that one process is superior to the other or if one of the extractants falls in short supply or becomes too expensive.

On the basis of present information, one would almost have to select the DEPA-TOPO process if the choice were made today. This process has been successfully tested in pilot plants operated at several phosphate plants by several companies. Although most of the information gained in these tests is proprietary, the general consensus seems to be that acid clean-up before solvent extraction is necessary for efficient operation and that this is one of the major problem areas.

While not as fully developed, the OPAP process has several potential advantages over the DEPA-TOPO process. OPAP extracts U^{4+}, the prevailing oxidation state in fresh acid (although this could change in pretreatment), it is a stronger uranium extractant, and is less expensive (∿$2/gal compared to $6/gal for the concentrations shown in this slide.) A minor disadvantage is that the uranium is more difficult to strip and requires the use of a more concentrated (54% P_2O_5 instead of 32% P_2O_5) acid. In addition, phase separation and crud formation have been more of a problem with OPAP than with DEPA-TOPO. We are presently making tests to measure the long-term stability and uranium extraction performance of the OPAP reagent. Slide #6.

There are a number of design decisions to be made in interfacing a solvent extraction plant to an acid plant. These include extraction temperature, type of contactor, materials of construction, number of stages, phase ratios, recycle rates, extractant concentration, choice of diluent for the extractant, bleed streams, stripping temperature, inert blanket over strippers, etc. We feel the advice of a competent engineering firm will be a good investment when you are making these decisions.

Regardless of how well the solvent extration system operates, the Uranium barren acid or raffinate contains entrained solvent. Most of this material must be removed from the acid before it is returned to the acid plant in order to prevent damage to the rubber lining of the evaporators and to recover the solvent for reuse.

We feel that additional work is needed in this area, to determine the level of solvent that can be tolerated and to develop a simple and reliable method for continuously monitoring the entrainment. Potential removal methods include hold-up tanks, packed columns and air flotation units. Slide #7.

Other potential problem areas that need investigation include the effect of added oxidants or reductants on acid processing equipment and the effect of small amounts of dissolved extractants in the acid. For example, small-scale tests have shown that mono-octylphenylphosphoric acid has a small but measurable solubility (∿15 ppm) in the acid. The effect of this material on fertilizer end-products and on acid processing equipment is not known.

Now lets take a brief look at the second or purification cycle which is the same for both processes. For a 1000 ton P_2O_5/day plant operation, this will be a very small scale or pilot size operation. If you remember from slide 3, the acid feed rate from the first cycle is only about 8 gal/min. This section consists of extraction, scrubbing and stripping units. With the phosphoric acid solution highly concentrated in uranium (10-12 g/liter), it is now possible to extract under conditions that will load the DEPA-TOPO solvent with uranium and minimize the extraction of impurities such as iron and aluminum. The loaded solvent is further cleaned by scrubbing with water and the uranium is stripped with a solution of ammonium carbonate under conditions that allow direct precipitation of the uranium in the stripping system as relatively pure ammonium uranyl tricarbonate. This precipitate is continuously removed from the stripping system and calcined to U_3O_8. The product is sufficiently pure to be fed directly to refineries that produce UF_6 for enrichment. Incidently, the only part of the entire process that requires special care to avoid radioactive contamination is the filtration, calcination and packaging area. Slide #8.

Special problems or hazards are minimal in this plant compared to those already present in the acid plant. Probably the major problem is the fire hazard and personnel exposure from handling kerosene type solvents. Since it will be necessary to enclose most of the equipment to minimize evaporation losses, this should pose no significant problem.

With respect to radioactivity, most of the hazardous radionuclides, radium and its daughters, are removed from the process in the acid plant with the gypsum. The only problem in the uranium recovery plant is from dusting in the calcination and packaging operations. Thus, methods to prevent the inhalation of dust by the workers and dust collectors to prevent its spread to outlying areas must be installed. Health monitoring procedures must be set up according to conditions and limitations specified by the appropriate state government. (Agreement State licenses are discussed in 10CFR150.20.) This type of operation is carried out routinely on a much bigger scale in processing western uranium ores. Slide #9.

Recently the EPA has taken an interest in this operation and are trying to set standards. If you are interested, I can give you the names of those who should be contacted for information in this area.

Open communications between the acid plant and the uranium recovery plant are necessary for efficient operation. For example, changes in the rock being processed can cause changes in the concentrations of acid and uranium as well as the amount of organic matter in the acid, all of which could cause problems in the solvent extraction plant. A sudden change in the type or amount of defoamer used could also cause problems downstream. Personnel in the solvent extraction plant should be notified as soon as possible of any situation that could effect their operation. Likewise, personnel in the acid plant should be notified of any problem that occurs in the solvent extraction plant, such as excessive entrainment or unusual concentrations of oxidants or reductants. The solvent extraction plant should be designed so that it can be by-passed when necessary. Slide #10.

In closing, we want ot emphasize that the phosphate industry has a tremendous opportunity to increase their profits and at the same time recover a valuable resource that is now being lost. However, uranium recovery from phosphoric acid is not a venture to be intered lightly. Wet-process phosphoric acid is a difficult material to handle in a solvent extraction plant, and the removal of uranium from it is one of the more difficult separations problems we have encountered. There are many decisions to be made and additional tests to be performed. We believe it can be done and that the potential pay off is worth the effort. We plan to maintain a program in this area and will be glad to talk to any of you who are interested.

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ORNL DWG. 76-16769

URANIUM IN MAJOR PHOSPHATE DEPOSITS

Location	Phosphate rock	P_2O_5 equivalent	Total U_3O_8	Average U_3O_8 concentration (%)	U_3O_8 / P_2O_5 ratio (lb/ton)
	(millions of tons)				
Florida	2,000	660	0.380	0.019	1.15
North Carolina	2,000	660	0.180	0.009	0.55
Western States (Montana, Idaho, Wyoming, Utah)	3,000	870	0.510	0.017	1.17
Morocco	60,000	16,650	10.200	0.017	1.22

Slide 1

ORNL DWG. 76-16775

INCENTIVES FOR RECOVERING URANIUM

1. Supplement the Nation's Future Power Supply

   1000 MWe Nuclear Reactor Requires:

   500 tons U_3O_8 for initial inventory
   150 tons U_3O_8 each year to operate

2. Reduction of Environmental Pollution

   Uranium diverted to productive use rather than dispersed to soil in fertilizer.

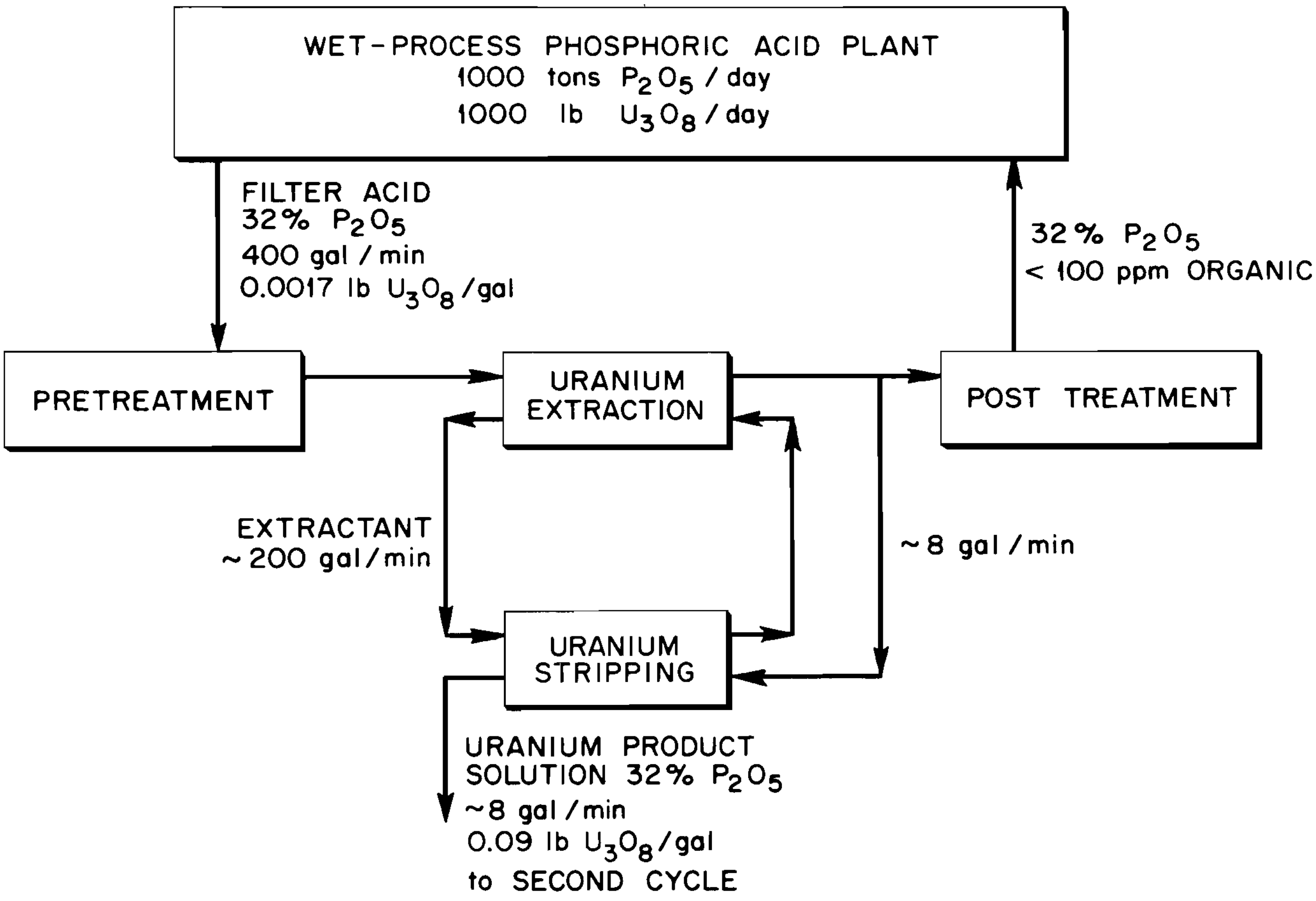
3. Economic

   Rapid escalation of U_3O_8 price from $6 to $40 per pound provides an opportunity to increase operating profits.

Slide 2

ORNL DWG 76-14733

FIRST OR CONCENTRATION CYCLE



WET-PROCESS PHOSPHORIC ACID PLANT
1000 tons P_2O_5 / day
1000 lb U_3O_8 / day

FILTER ACID
32% P_2O_5
400 gal / min
0.0017 lb U_3O_8/gal

32% P_2O_5
< 100 ppm ORGANIC

PRETREATMENT

URANIUM EXTRACTION

POST TREATMENT

EXTRACTANT
~200 gal/min

~8 gal / min

URANIUM STRIPPING

URANIUM PRODUCT
SOLUTION 32% P_2O_5
~8 gal / min
0.09 lb U_3O_8/gal
to SECOND CYCLE

Slide 3

ORNL DWG 76-16771

ORNL PROCESSES

1. DEPA-TOPO (Reductive Strip) Process
   Di(2-ethylhexyl) phosphoric acid
   Trioctyl phosphine oxide
   Extracts oxidized uranium
   Patent Status – U.S. Patent 3,711,591 (in litigation)

2. OPAP (Oxidative Strip) Process
   Mono and dioctyl phenyl acid phosphate
   Extracts reduced uranium
   Patent Status – U.S. Patent 3,835,214 (licensing available from ERDA)

Slide 4

ORNL DWG. 76 16772

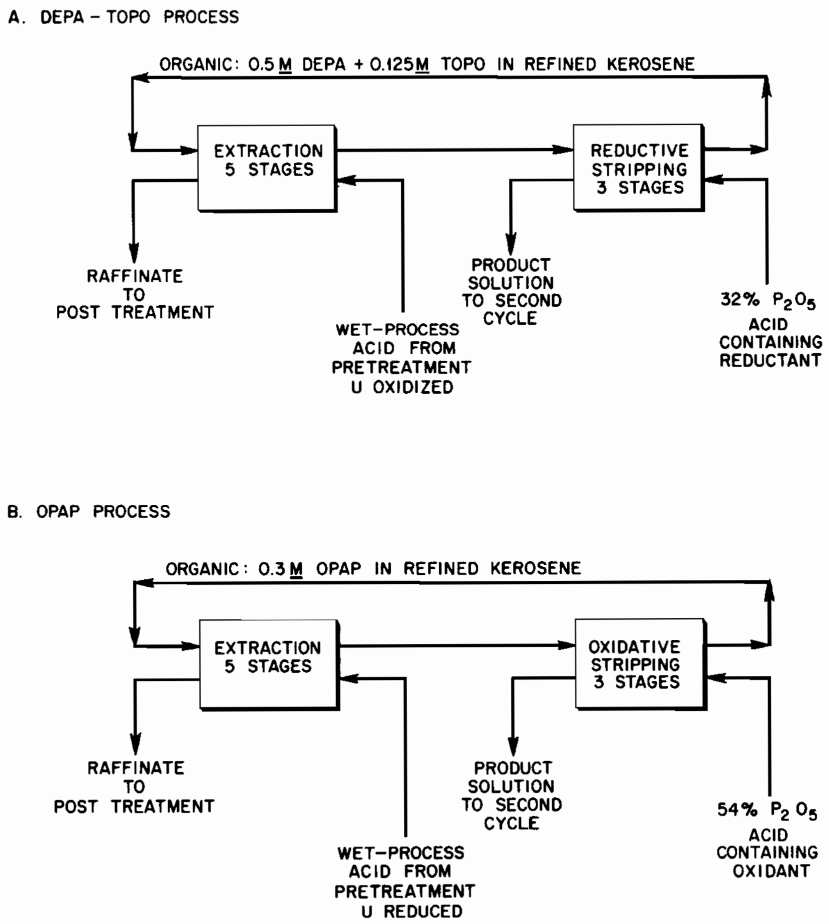
PRETREATMENT

1. Removal of Crud-Forming Humus
   a. Filtration
   b. Oxidation
   c. Flocculation-clarification
   d. Activated carbon
   e. Calcination
2. Uranium Valence Adjustment
   DEPA–TOPO: Oxidize – H_2O_2, $NaClO_3$, $Na_2S_2O_8$
   OPAP: Reduce – Fe metal.
3. Acid cooling

Slide 5

ORNL DWG 76-14728

SOLVENT EXTRACTION OF URANIUM



A. DEPA – TOPO PROCESS

ORGANIC: 0.5 M DEPA + 0.125M TOPO IN REFINED KEROSENE

EXTRACTION 5 STAGES

REDUCTIVE STRIPPING 3 STAGES

RAFFINATE TO POST TREATMENT

WET–PROCESS ACID FROM PRETREATMENT U OXIDIZED

PRODUCT SOLUTION TO SECOND CYCLE

32% P_2O_5 ACID CONTAINING REDUCTANT

B. OPAP PROCESS

ORGANIC: 0.3 M OPAP IN REFINED KEROSENE

EXTRACTION 5 STAGES

OXIDATIVE STRIPPING 3 STAGES

RAFFINATE TO POST TREATMENT

WET–PROCESS ACID FROM PRETREATMENT U REDUCED

PRODUCT SOLUTION TO SECOND CYCLE

54% P_2O_5 ACID CONTAINING OXIDANT

Slide 6

ORNL DWG. 76-16773

POST TREATMENT

1. Removal of Entrained Solvent
   a. To recover solvent for reuse
   b. To prevent damage to rubber lined evaporators
      – hold-up tanks
      – packed columns
      – air flotation

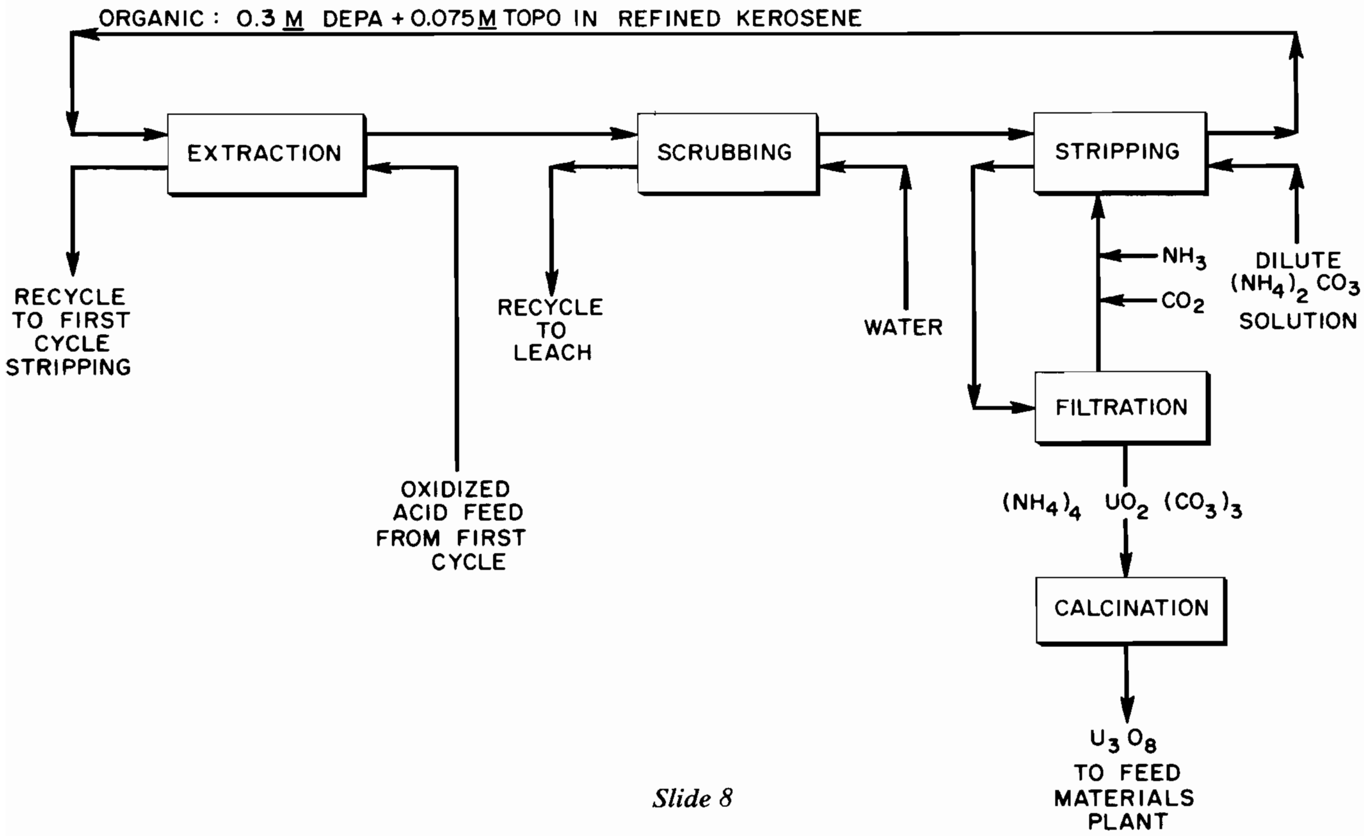
2. DEPA–TOPO Process
   a. Returns oxidized acid to acid plant
   b. Extractant insoluble in the acid

3. OPAP Process
   a. Returns reduced acid to acid plant
   b. MOPPA has slight solubility in the acid

Slide 7

ORNL DWG 76-14727

SECOND OR PURIFICATION CYCLE



ORGANIC : 0.3 M DEPA + 0.075 M TOPO IN REFINED KEROSENE

EXTRACTION

SCRUBBING

STRIPPING

RECYCLE TO FIRST CYCLE STRIPPING

OXIDIZED ACID FEED FROM FIRST CYCLE

RECYCLE TO LEACH

WATER

NH_3

CO_2

DILUTE $(NH_4)_2CO_3$ SOLUTION

FILTRATION

$(NH_4)_4UO_2(CO_3)_3$

CALCINATION

U_3O_8 TO FEED MATERIALS PLANT

Slide 8

ORNL DWG. 76-16776

SPECIAL PROBLEMS

1. Solvent Handling

   Fire hazard
   Personnel exposure

2. Radioactivity

   Licensing requirements
   Personnel exposure

Slide 9

ORNL DWG. 76-16774

COMMUNICATION

1. Acid Plant – Notify SX Plant of Changes in
   - a. Rock type
   - b. Uranium concentration
   - c. Acid concentration
   - d. Acid temperature
   - e. Defoamers used
   - f. Acid flow rates
2. SX Plant – Notify Acid Plant of
   - a. Excessive organic entrainment in acid
   - b. Solids or crud in acid
   - c. SX plant by-pass

Slide 10

MODERATOR O'BRIEN: Thank you kindly Fred, and Associates Allen D. Ryon and Wesley D. Arnold, for a most interesting discussion. Do we have any questions? Looks like you have done a superb job. *(Applause).*

Gentlemen we have completed this morning session. on behalf of Dan and myself we certainly appreciate being part of the program and being your co-moderators and our thnaks to all of our Speakers and to a very attentive audience. We have another excellent session this P.M. Thank you. *(Applause)*

Wednesday, October 27, 1976

Afternoon Session
Moderators:
Elmer J. Leister
Harry L. Cook

MODERATOR LEISTER: Good afternoon. I am happy to be your Moderator for the first part of this Session.

Our first paper "On-Site Water Management", will be discussed by D. H. Stassford, a graduate chemical engineer form Virginia (VPI). He has a number of patents related to the fertilizer industry. He has been in the Swift Organization for 30 years advancing from Superintendent, Research and Development, Technical Supervisor Plant Operations Manager and presently is Regional Operations Coordinator, Swift Eastern Division. *(Applause)*

On-Site Water Management for Fertilizer Plants

D. H. Stassford

Thank you Mr. Chairman and good morning to all members and friends of this twenty-sixth annual meeting of the Fertilizer Industry Round Table. It is an honor and privilege to be here this morning.

For the past decade the fertilizer industry has put forth and used all technical knowledge to overcome air pollution and to bring our plants into compliance with the E.P.A. standards both Federal and State. Every type of scrubber, such as venturi, cyclone, impingment, bubble cup towers and numerous others too many to mention were employed to remove gases and particulate matter generated in our processes. Little attention was ever given to the one most important raw material necessary to make these scrubbers work. That material is water. Most plants located on rivers, streams or had deep wells and city water supply, with the cost of this water being relatively economical. Very few plants worried about the disposal problem of the discharge water from these scrubbers. Any creek, river or ditch was usually the source to dispose of this water. Some plants found it necessary to design recycle systems and to construct holding ponds as a means of collecting the polluted or hazardous chemical discharge water.

Since the enactment of the Federal Clean Water Act and some state laws, the control and collection of discharge water is mandatory. The big problem today is what to do with all the water being used and how to dispose of the hazardous compounds collected by the scrubbing processes. As previously stated, you can not put in ditches, rivers or streams; and in most cases, it must be retained on the plant property. Even the solids collected cannot be removed to land fill dumps unless special permits are obtained from the Federal and State government agencies.

All plants operating today are running under the conditions set forth in the NPDES permits and those of the various State Clean Water Acts. Some of these permits were originally applied for some years back through the U.S. Corp. of Engineers prior to the E.P.A. assuming this responsibility and before the standard of the water pollution act. Today these permits regulate the discharge of all water coming from the plant property. No water is allowed to leave if the pH is not between the range of pH 6 to pH 9 and no hazardous chemicals are contained in this water.

The big question today is, What can we do to solve this compounding polluted water accumulations?

Lets take the case of a fertilizer plant having a continuous superphosphate unit, a continuous ammoniation-granulation unit and a contact sulfuric acid plant.

Refer to Slide #1.

I am sure that most of us are familiar with the process of manufacturing superphosphate. In this process, ground phosphate rock dust is mixed with sulfuric acid causing florine gas to be released. This florine gas is usually scrubbed by a two or three stage scrubber using water as the scrubbing medium. Past experience has proven this as an effective method of collecting the florine emissions and keeping the plants in compliance with E.P.A. standards on air pollution. The hydrofloric acid generated in the scrubber must now be recycled for concentration and resale or be discharged to a holding pond on the property.

In the plant I am about to describe, this low pH water or hydrofloric acid begins to attack the silica in the pond walls and causes seepage through the banks of the pond. This acid water then flows off the property creating a violation of the NPDES permit and the State Clean Water Laws. The quantity of water can be nil, two or three gallons per minute, but this is still a violation.

To rectify this low pH condition, calcium hydroxide or lime is now added to the discharge water through a mixing tank prior to going to the holding pond. This process takes an enormous quantity of neutralizing material, especially if the existing pond is ten years old. The cost of the calcium hydroxide increases the cost per ton of superphosphate manufactured by twenty-five to forty cents per ton, depending on the delivered cost of calcium hydroxide.

It was determined that it was not necessary to raise the pH of the superphosphate pond to pH 6.0 as originally thought to correct the seepage problem. By controlling the pH in the pond to a pH 1.5 to 2.0, we could reduce the cost of neutralizing the pond and still recycle the water to the superphosphate scrubbers. This pH gives an effective scrubber medium and prevents air pollution.

The seepage problem had to be solved by digging interceptor ditches completely around the ponds. (See Slides A-B-C) These ditches were dug below bottom grade and then lined with plastic on the bottom of the outer wall. River gravel was dumped in over a perforated plastic drain pipe which in turn went to a concrete sump. Five to six feet of river gravel filled the ditch, then plastic covers were added one foot below normal ground level and covered with dirt. This was done to pre-vent excessive water in the ditch due to rainfall.

Another problem was soon encountered when the holding pond began filling with calcium floride due to the neutralization process. This we will discuss in a moment. The amount of water going to the pond was reduced as was the fresh water make up used before the recycle process was incorporated. It was found that agitating the calcium hydroxide in the holding pond with compressed air would hold the pH at 1.5 to 1.8 for a relatively constant long period of time.

Refer to Slide #1.

Lets now go to the ammoniation-granulation scrubbing system for a moment. In this process, like the superphosphate, the scrubbing system usually consists of two and three stage scrubbers using water as the scrubbing medium. The gases and particulate matter are removed by these scrubbers to comply with the E.P.A. air standards. The discharge water from these scrubbers can be recycled to some extent; but as the temperature and pH rises, it must be discharged to a holding pond. This holding pond usually runs in the range of pH 4.0 to pH 8.0 and contains valuable fertilizer ingredients, such as ammonium salts, potash salts and phosphates. Because of Federal and State regulations, this water cannot be discharged from the plant property.

The discharge water from the contact sulfuric acid plant is usually cooling water and does not present any large-scale problem, if the pH is between 6.0 and 9.0 and the temperature is not excessive. The quantity of discharge is controlled by the NPDES permit issued. This water can be recycled and used in the various processes or as make up water in the ammoniation scrubbers, if necessary.

Refer to Slide #1.

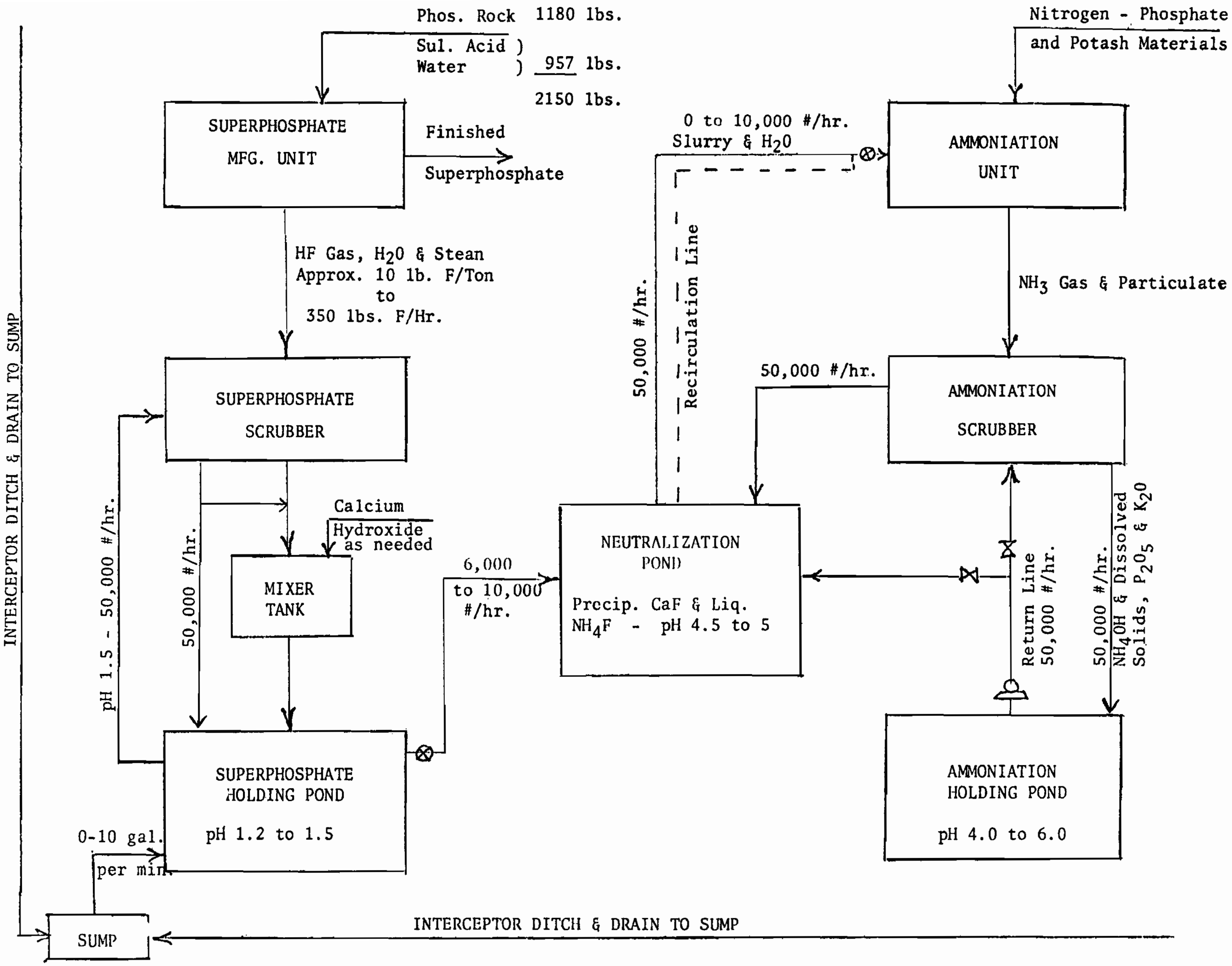
Now that we have seen the superphosphate pond and the ammoniation-granulation pond system, what do we do to eliminate the ever accumulation of water and materials in these ponds?

First, we must have the third pond which we shall call the silt or neutralization pond. In this pond, we must be sure that we control the pH between pH 4.5 and 5.0. This is necessary to prevent the release of florine gas as we recycle this slurry and water to the ammoniation unit. A slurry type pump continuously pumps in a cycle from the silt pond to the ammoniation unit. At the ammoniator, a take-off line is installed to feed this slurry and water back into the process as make up water in the granulator. It is here that we capture back the fertilizer ingredients once lost to the ammoniation pond; and at the same time, we are constantly removing the water and precipitated materials from the ponds. Again, it is important to point out that the pH of the slurry be controlled to pH 4.5 to 5.0. To control this pH range in the silt pond, we must now connect the superphosphate holding pond water with the granulation pond water. This requires pH checks of all ponds to know exactly what ranges we are working. The water and precipitate from the superphosphate pond and granulation pond come together in the silt pond. Reaction between the two ponds causes the precipitates to drop out and the balances of the pH occurs. The water soluble ammonium floride and other soluble fertilizer salts are incorporated in the calcium floride slurry recycling to the granulation unit.

If the pH in the superphosphate pond should drop below pH 1.5, it can be raised by adding high pH water from the granulation pond and vice-versa.

Again, it is important to control the pH in all ponds

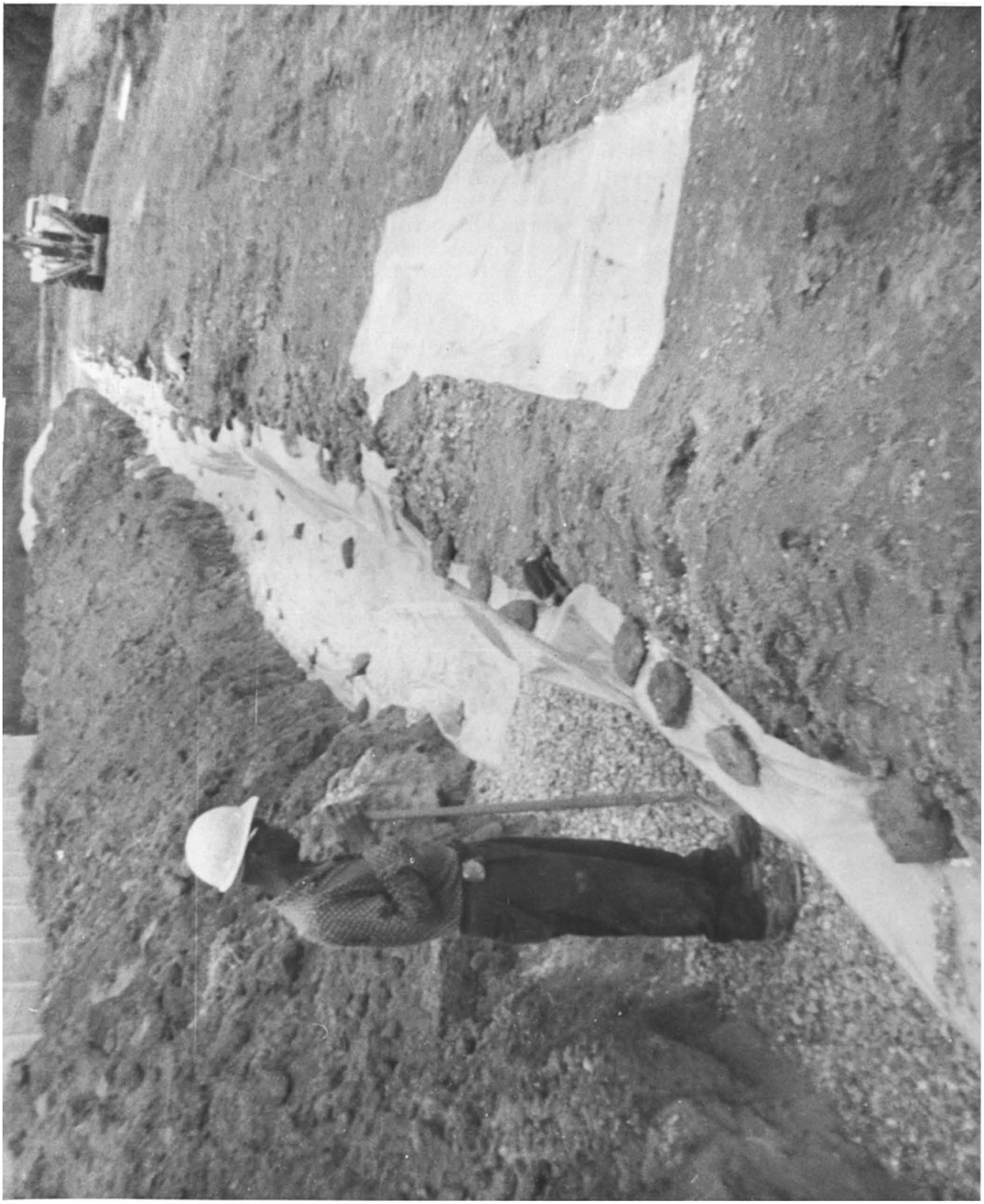
(Continued on page 115)


Phos. Rock 1180 lbs.
Sul. Acid) Water) 957 lbs.
2150 lbs.
SUPERPHOSPHATE MFG. UNIT
Finished Superphosphate
HF Gas, H_2O & Stean
Approx. 10 lb. F/Ton to 350 lbs. F/Hr.
SUPERPHOSPHATE SCRUBBER
pH 1.5 - 50,000 #/hr.
50,000 #/hr.
Calcium Hydroxide as needed
MIXER TANK
SUPERPHOSPHATE HOLDING POND
pH 1.2 to 1.5
0-10 gal. per min.
SUMP
INTERCEPTOR DITCH & DRAIN TO SUMP
INTERCEPTOR DITCH & DRAIN TO SUMP
6,000 to 10,000 #/hr.
NEUTRALIZATION POND
Precip. CaF & Liq. NH_4F - pH 4.5 to 5
50,000 #/hr.
Recirculation Line
0 to 10,000 #/hr. Slurry & H_2O
Nitrogen - Phosphate and Potash Materials
AMMONIATION UNIT
NH_3 Gas & Particulate
50,000 #/hr.
AMMONIATION SCRUBBER
Return Line 50,000 #/hr.
50,000 #/hr. NH_4OH & Dissolved Solids, P_2O_5 & K_2O
AMMONIATION HOLDING POND
pH 4.0 to 6.0

Slide #1

Slide A Ditch Construction

Slide B Ditch Construction



Slide C Ditch Construction

so that effective scrubbing can be obtained and that no gases are generated that were once scrubbed.

At present there is still a lot of data that must be obtained before a complete water balance can be 100 percent attained. We must know the evaporation lost in the ponds, the annual or average rainfall, and the seepage lost, if any. New ponds will have to be plastic lined or constructed of concrete. The older ponds will have to have seepage interceptor ditches.

The process discussed does work and is now in operation at Dothan, Alabama, and Savannah, Georgia. Thank you. *(Applause)*

MODERATOR LEISTER: Thank you Stass for a very fine paper.

MODERATOR LEISTER: I am very sorry to advise you our next two scheduled Speakers will not be with us to discuss their assigned subjects.

Mr. Robert Koch, President, National Limestone Institute, is ill in the hospital since yesterday. We wish him a speedy recovery. Wayne King has been in touch with Mr. Koch's office. They advised that Mr. Koch is doing well and should be OK very soon. Wayne will try to have Mr. Koch, at an early date present an updateed report to our Round Table on the subject: "Importance of Agricultural Limestone Availability".

Mr. Adolf Sisto, Operations Manager, Guanomex, Mexico, was out of the country and could not get back in time to present his paper: "Production of Inverse Ratio Fertilizers". Mr. Sisto, thru his home office, advised his secretary to forward his assigned completed paper with instructions to us to please have one of our people read his discussion. The information was forwarded as requested by Mr. Sisto, however, it did not reach The Roundtable in time. Mr. Sisto (By Editor) at a subsequent Board Directors' Meeting in Baltimore, accepted an invitation to present an updated discussion on "Inverse Ratio Fertilizers" at The Round Table 27th Annual Meeting in Washington, October 25-27, 1977.

Our next paper will be discussed by a genuine native of the good state of Maryland. He was born in Harford County, Maryland, has a degree in Agronomy from the University of Maryland, has had 23 years of fertilizer experience and was promoted by Southern States Cooperative from Production Manager, of the Baltimore Plant to his present job as Baltimore Plant Manager. This fine Gentlemen, Mr. W. Chase Coale, Jr. will discuss "A successful Pollution Control Program". Mr. Coale please.

A Successful Pollution Control Program For Granulation Plants

W. Chase Coale, Jr.

Good afternoon ladies and gentlemen of the Fertilizer Round Table. Our discussion this afternoon is entitled "A SUCCESSFUL POLLUTION CONTROL PROGRAM FOR GRANULATION PLANTS". We know that our program can not be adapted by all granulation plants but maybe our experience can be of help to many of you all that are in the granulation business.

We are talking of a plant that is operated by Southern States Cooperative Inc. of Richmond, Virginia. Southern States is a Regional Cooperative that operates in the State of Maryland, Delaware, Virginia, West Virginia, and Kentucky. We operate six manufacturing plants and three of them are continuous granulation plants. In the fiscal year 1975-1976 we marketed over six hundred, thirty five thousand (635,000) tons of fertilizer materials.

I have the responsibility of our Baltimore, Maryland plant, which is the largest and oldest in our system. Our plant itself is over fifty (50) years old and our continuous ammoniation system is ten (10) years old. Our system was designed and installed by the Prosser Company and consists of a 8 x 50 foot dryer, a 8 x 50 foot cooler and a 8 x 16 ammoniator. I personally have been in this business close to twenty three (23) years and I feel that this is the best equipment of its type I have operated. We operate at rates of 25 to 40 TPH with an average of 35 TPH. Our Baltimore Plant is located just off the Baltimore Beltway in the Curtis Bay Section of the metropolitan area, near the new outer harbor bridge.

We had fairly efficient cyclones on our manufacturing and shipping equipment and we felt that we did a fairly respectable job of dust collection. During September 1969 we received notice from our County Department of Health that we must register, quote "all installations causing emissions to the atmosphere". This started the ball rolling and we received an inspection on December 11, 1969 by the State of Maryland and the County. Our plan of Compliance of the Air Pollution Code of the State of Maryland was submitted and finally approved in August 1970. Many of you all are very familiar with what we went through — red tape — requests for permits — permits to construct — progress reports — permits to operate — more governmental red tape — meetings — more meetings — and a resultant file a foot thick and the expenditure of over a quarter of a million dollars.

We employed a small local consulting engineering firm to assist us and a local contractor for duct work fabrication and installation. We established an approved phase method of compliance in which we would control emission from our shipping area in the first phase and the manufacturing area in the second phase.

Our shipping area consists of a St. Regis four (4) tube force flow packer and a St. Regis three (3) tube force flow valve packer and also a bulk loading mill. During the Winter of 1971 we installed a Wheelabrator-

Frye Model 108, Size 112 single compartment ultra-jet bag house on each shipping mill. Each unit is powered by a 50 HP fan of approximately 11,000 C.F.M. each and each compartment contains 144 polypropylene felt dust-tubes 108 inches long and 6 inches in diameter on wire cages, with an air to cloth ratio of 7.25 - 1. In this system we collect the dust in a common bin, mix it with floor sweepings, and reformulate it through our manufacturing.

We have operated this sytem for five (5) years this January and we have yet to remove or replace a dust-tube and maintenance has been minimal. The work area is dust free and we do not have plant emissions. However, we must do our housekeeping and all duct work must be dismantled and cleaned annually and critical areas more often. We do not use auxilary heat on these ultra-jet units and pressure drop varies from 1.5 to 4.0 inches depending upon relative humidity, duct restriction and cleanliness of the bags. Our timing impulse is set at 30 seconds and we vary this as required. We use pulse air at 80 p.s.i.g. This air is cooled by a locally designed coil located at the fan discharge.

Now let's move to our manufacturing area. We only have pollution control equipment on our stock emissions. We still have a in-plant dust problem in this area and we must tackle this problem next. On November 17, 1972 we completed installation of a Wheelabrator-Frye Model 168 D, six compartment continuous automatic dust-tube, shaker type dust collector on our manufacturing dryer, cooler and ammoniator. This unit is powered by a Clariage 133 x L fan which is driven by a 150 HP motor. Our bag house is of plenum design and each compartment contains 156 bags that are 168 inches long and 5 inches in diameter. These are Criswell #212-52 Arcrylic dust-tubes and we have only 936 of them in the unit. We pull 32,000 C.F.M. of air through this bag house and have an air to cloth ratio of 2.12 to 1.

During our four (4) years of operation we have manufactured approximately two hundred, eighty thousand (280,000) tons and have washed the bags only three (3) times. We have replaced, for repairs only, about an average of seventy (70) bags per year. Our bags in this unit are now beginning to show some signs of wear but we feel we have had excellent service. We know that this is not good news to you suppliers of filter bags that are present, but we have not actually destroyed one bag. Let me show you how we repair our bags. We have it done by a filter bag manufacturer. We have a couple of repaired bags here to show you and a couple of slides to show you where and how the repairs are made. We use a "wollen" weave fabric to repair because we think it is a little more flexible and cake release is not as critical in this area of the bag.

You will notice (Figure #1) that we have a common plenum in our bag house and a by-pass line. We know that all of you will not agree with the by-pass, but we feel it is necessary for the successful operation of a bag house. We only use the by-pass for a couple of minutes during start-up and then only until the temperature of the dryer exit gases reach the temperature of the bag house and of course the dryer is not in operation, not rotating, during this period. We also have a high temperature cut-out control in our dryer exist stack ahead of the by-pass. This automatically throws the unit on by-pass and although fortunately this feature has never operated for cause, we feel it is good insurance for ten thousand dollars ($10,000) worth of filter bags.

You will also notice that our cooler air passes through two (2) high efficiency cyclones, then through the cooler fan and then to the combustion chamber of the furnace as secondary combustion air. We have drastically lowered our cooling capacity in order to accommodate all the cooler air into our combustion chamber without blow-back from the combustion chamber. We go into storage with product as high as 140-150 degrees F. during hot weather, which is too high, but we have been able to live with it.

Through a process of trial and error, time and sweat, we have developed a start-up and shut-down procedure that has contributed to a successful operation. We have previously discussed start-up. On shut-down we do not allow the bag house to cool off. We have a gas fired auxilary furnace and we recirculate warm air to 200 degrees F. during the down time period. This is accomplished by this method.

We have (Figure #2) a thermostat at the intake of the plenum which we normally maintain at 200 degrees F. This will give a maintenance temperature of 160 degrees F. at the coolest place in the bag house.

A major key to the operation is that we keep the automatic shaker system in operation during non-operating periods. We shake the bags for thirty (30) seconds every seventy (70) minutes at *all times.*

The cleaning cycle appears to be somewhat critical. We operate ours on a seventy (70) minute cycle. Each seventy (70) minutes we close a bag house exit door, idle the house for sixty (60) seconds, then shake the house for thirty (30) seconds, and then idle the house for sixty (60) seconds before slowly opening the exit door. This cycle has proven satisfactory and we have been operating in this manner for sometime. We have numerous micro-switches, indicator lights and buzzers to keep the operator asvised as to what is taking place. These are of local design and developed through trial and error.

We think another key to the operation is that we manufacture a maximum of sixteen (16) hours a day and our bag houses have a chance to dry and clean eight (8) hours out of each twenty four (24).

We have had our operating problems as many of you all have, but the system is performing well after four (4) years of service. The State of Maryland tested our stacks in January of this year, after over three (3) years of operation and here are the results.

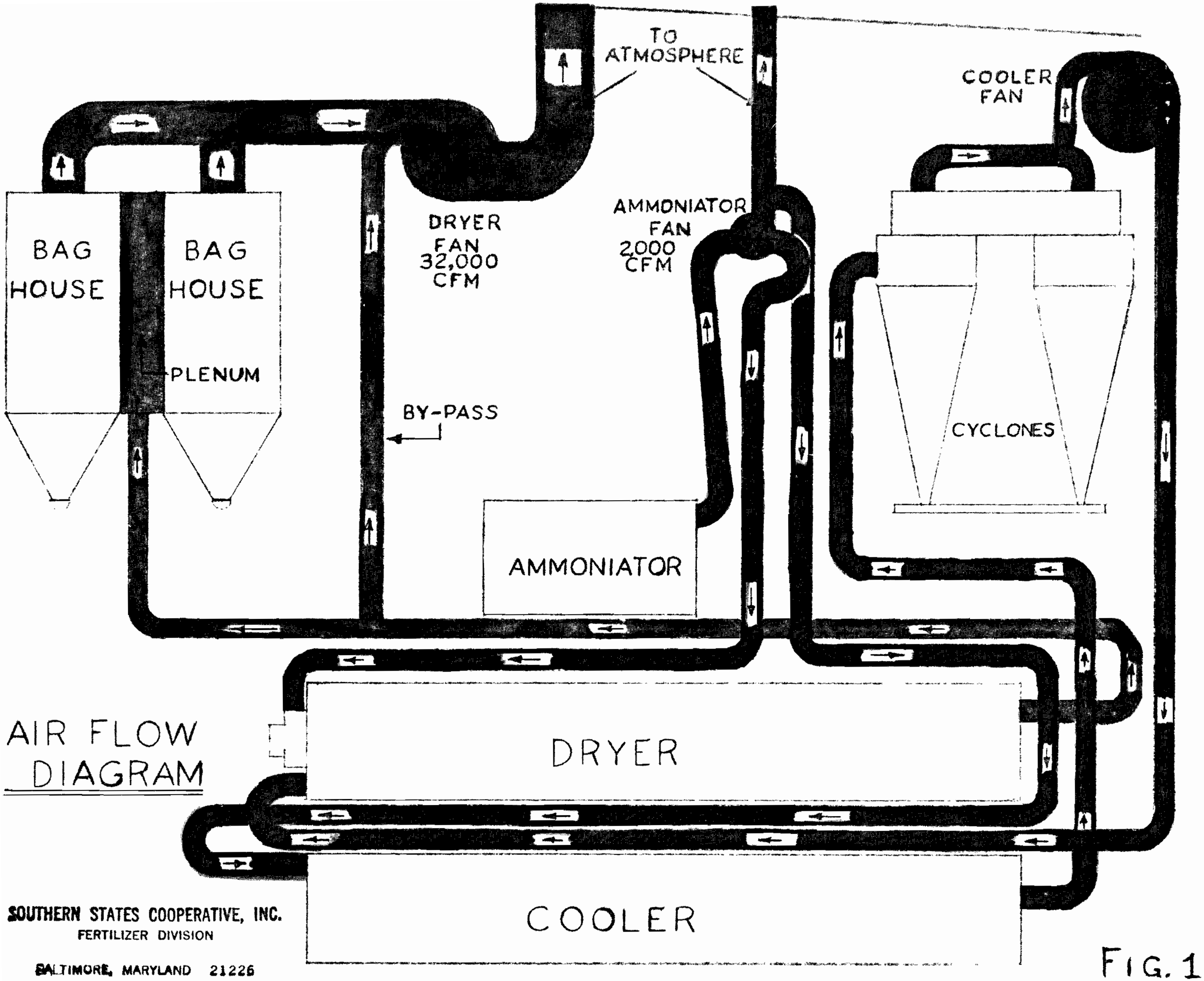
You will notice that we had a loading of .005 grains per s.c.f.d. and an emission rate of 1.4 lbs. particulate per hour, compared to a permited emission of .03 grains and a rate of 45.6 lbs. per hour at a production rate of 35 TPH. We are also in compliance as far as zero visible emission is concerned.

We have several slides of our system which may interest you. You will notice that our bag house is insulated with polyurethane and over-sprayed with a fire retardant coating. The maintenance and repair of this insulation is important to satisfactory operation.

I have showed you some slides of our plant, our pollution control equipment, our locker rooms and our office building. You all who have been in the granulation business for years, have all heard the old statement that the granulation of fertilizer is an *art,* not a science. We feel the same applies to the operation of a bag house. A Vice-president or engineer behind a desk in Atlanta or Chicago will not successfully operate a pollution control operation in Smalltown, U.S.A. Successful operation rests purely on the shoulders of local personnel and local management. There is much more to it than air to cloth ratios, dew points, CFM and the like. It is the *desire* to make the system work. It is clean showers and locker rooms and good housekeeping. It is good personel management and human relations. It is many tangibles and intangibles. Of course, you must first have the correct engineering and design but that is only where it starts. Thank you. *(Applause)*

MODERATOR LEISTER: Thank you for a most interesting and valuable discussion.

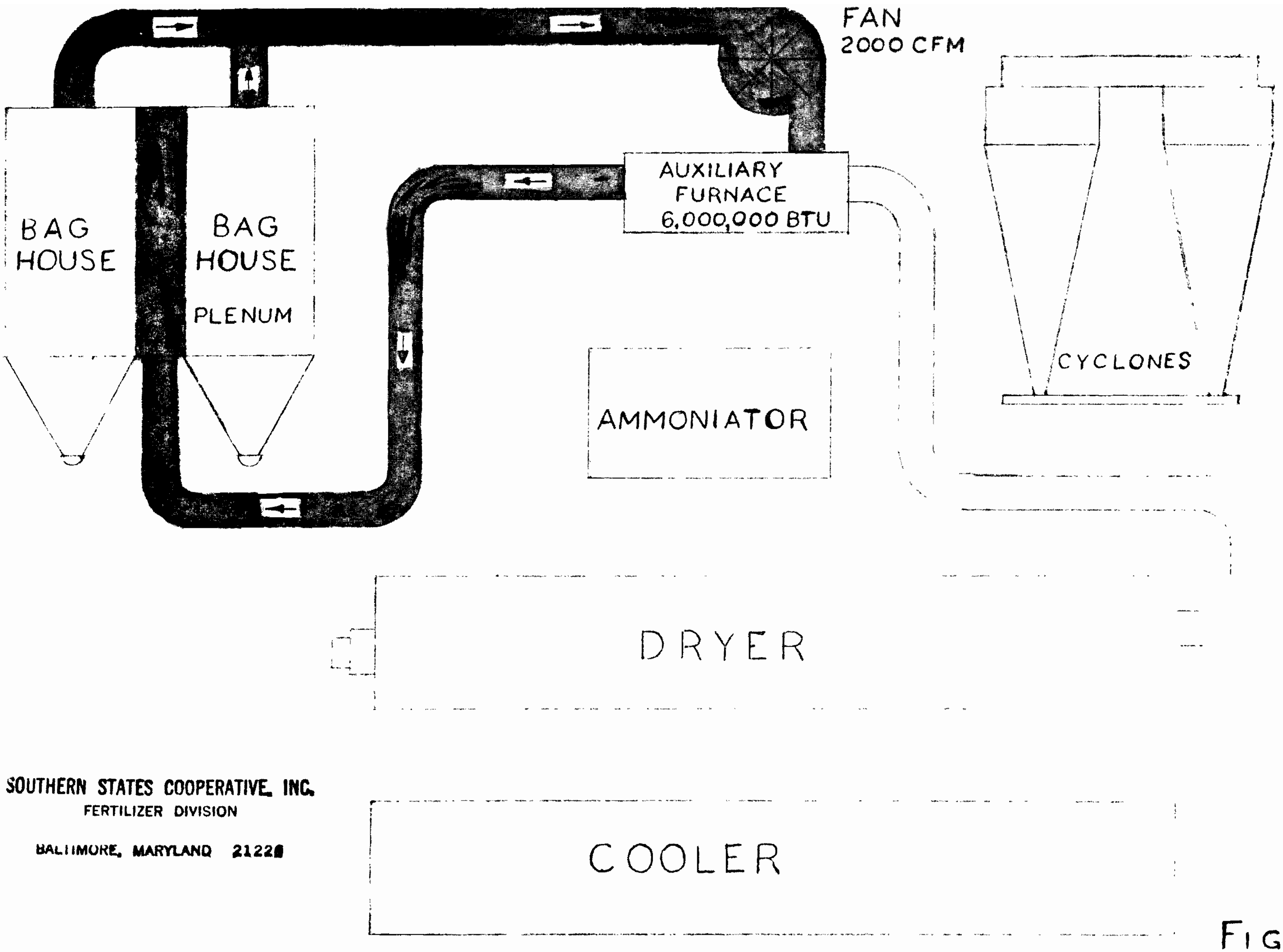
Note: Figure #1 - Page 118
Figure #2 - Page 119



AIR FLOW DIAGRAM

SOUTHERN STATES COOPERATIVE, INC.
FERTILIZER DIVISION
BALTIMORE, MARYLAND 21226

FIG. 1



SOUTHERN STATES COOPERATIVE, INC.
FERTILIZER DIVISION

BALTIMORE, MARYLAND 21228

FIG. 2

MODERATOR LEISTER: The next paper, "Use Of Phosphoric Acid In Granulation", prepared by William and Tom Howe, will be discussed by Tom Howe. Tom is 26 years old, a graduate from Augsburg College, Minneapolis, and the third generation in the family business, Howe-Inc. Agricultural Chemicals, Minneapolis, Minn. Tom is not only a rookie in the fertilizer business; I also think he is the rookie of the speakers at our Round Table at this meeting. Let's give young Tom a nice welcome. *(Applause)*

Use of Superphosphoric Acid In Granulation

William and Tom Howe

Presented by Tom Howe

Introduction

The primary purpose of this presentation is to discuss our experiences with superphosphoric acid in our ammoniation-granulation plant. However, before I begin to discuss some of the problems and their solutions, I feel it necessary to give some background data on our plant and how we became involved in granulation with superphosphoric acid.

Howe, Incorporated, is an independent fertilizer manufacturer located in the northwest corner of Minneapolis, Minnesota. Our present plant is shown in figure 1. We are basically a wholesale distributor of our manufactured products. We still have a close tie with farmers in an irrigated vegetable area just north of us who were the primary users of our product in the 1940's when my grandfather organized our company.

In the 1940's, Howe mixed dry materials and bagged the products in 125 burlap bags. The grades we produced were low analysis (3-12-12, 3-9-18, and 0-9-27). Because we are a long way from raw material sources, we now use all high analysis materials with the exception of single superphosphate, which we feel gives us better granulation and supplies calcium and sulfur.

In 1946 and 1947 we started ammoniation of materials to produce pulverized fertilizer. Nitrogen solution was metered into the batch mixer and we relied on conveyors and rehandling for cooling. The products were conditioned with rice hulls or tobacco stems at bagging time. The grades were of higher analyses; 5-20-20, 8-16-16, 6-24-12, and 10-10-10.

This was during the post World War II housing sprawl and many new homes were built around the plant. Along with the houses came complaints from the new residents of dust and odor coming from the plant.

In 1955 and 1956, with the help of TVA and the Spencer Chemical Company, we installed a modified TVA ammoniator-granulator and a sulfuric acid tank.

The ammoniator-granulator was seven feet in diameter and eight feet long. Two 4-foot sections were formed by dividing the drum in the middle with a dam. Drying and cooling were done with one vessel by pulling ambient air cocurrently with the product. Early formulations (table 1) resulted in fertilizers that set up in the bags. The dryer cooler fan exhausted directly into the atmosphere, and with no scrubber and only one cyclone collector, the plant emissions were heavy and the complaints increased.

Our neighbors continued to build until they were only 300 feet from the plant, which is in Brooklyn Center — a suburb of Minneapolis. It came to the point where the city of Brooklyn Center took us to court asking for a permanent injunction to close the plant down. We won the case but were given a time limit to correct the plant emissions.

That summer we installed a dryer, a series of cyclone collectors, and a small inefficient wet scrubber on the exhaust fan from the ammoniator.

The following year we installed a Raschig ring packed scrubber on the dryer and cooler cyclone exhausts. This worked satisfactorily for several years, producing only an occasional complaint from our neighbors.

Reasons for Using Superphosphoric Acid

Eventually the Minnesota Pollution Control Agency became fully funded. At this point complaints became numerous, because the neighbors knew they could call the Pollution Control Agency and get recognition.

As in other times of trouble, we contacted Frank Achorn and Bud Balay from TVA to assist us in complying with the Minnesota Pollution Control Agency to stay in business.

Collectively, we became convinced that with the use of superphosphoric acid we could comply with the standards set down by the MPCA. The advantages expected with superphosphoric acid were:

1. Lower drying temperatures and less particulate emission from the dryer and cooler.
2. No formation of ammonium chloride fumes in the ammoniator.
3. Harder and more durable pellets.

Tests of Existing Equipment

Since 1971 we have made many changes in the production system. In that year the MPCA put the burden on Howe, Incorporated, to prove it was within the set standards. We hired an independent firm, Pollution Curbs, Inc., to make tests for us, both before and after the use of superphosphoric acid.

We applied and received permits for installing the necessary equipment. We installed a 30,000 gallon rubber lined tank lined with Goodyear chlorobutyl lining number L5582 for superphosphoric acid. A sparger was installed at the bottom of the tank to blow air through the acid to keep sludge from settling. An Ulrich pump and a Fischer and Porter mag meter were installed to deliver acid to the ammoniator in a controlled flow. A heated and insulated room was built around the tank to keep the acid above 90 degrees F. at all times. A sketch of the system is shown in figure 2.

The original tests conducted by Pollution Curbs were designed to determine compliance with existing state emission standards, to determine the sources of pollution, and to determine a course of action to correct violations.

The Pollution Curbs engineers made measurements and collected samples and other data necessary to evaluate:

1. Particulate emissions from the existing scrubber.
2. Odor emissions from the existing scrubber.
3. Property lines for settlable acids and alkalies.
4. Other sources of dust.

The scrubber effluents were sampled during production of two formulations at the usual rates: 12-12-12 produced at 15 tons/hour and 6-24-24 produced at 25 tons/hour. Formulations and results are shown in tables 2 and 3.

Several potential sources of dusting were observed: (1) handling of dry raw materials by conveyor or truck; (2) transportation of finished products to storage areas by conveyor; and (3) bag filling operation. In each of the above cases, the source of the dust was enclosed by a building.

The Minnesota standards on particulate emissions limits source gas volumes of 33,000 scfm to a maximum particulate concentration of 0.6 gr/scf.

The samples obtained while 12-12-12 was produced at 15 tons per hour were within these limitations. However, the samples from the 6-24-24 operation (25 t/u) were in excess of maximum allowed. It was concluded that the scrubber system in its present form was inadequate.

The average odor emission rate from the scrubber during 12-12-12 production was 640,000 odor units per minute. The average odor emission from 6-24-24 production was 3,695,000 odor units per minute, both as determined by ASTM method D 1391-47 (reaffirmed, 1967).

Generally speaking, odor emission in excess of one million odor units per minute will not be sufficiently diluted in the atmosphere to allow them to go undetected. Under certain weather conditions, odor emission rates as low as 500,000 can bring neighborhood complaints.

The conclusion was that the existing scrubber system was also unable to reduce odor to an acceptable level.

Equipment and Operating Revisions and Results Obtained

The packed tower wet scrubber had been used successfully over the years to collect particulates and absorb gases emitted in the production of NPK fertilizer. However, it appeared to be inadequate for further needs.

Pollution Curbs engineers made five suggestions for improvement of the scrubber. The first was to increase the retention time to a minimum of 0.50 second. The retention time during tests was only 0.065 second. To attain a retention time of 0.50 second, it was necessary to increase the depth of packing.

The second suggestion was to change the existing water spray system from "perforated pipe" to a type which would give better coverage of the packing. Scrubber performance depends upon good coverage of the packing by the spray. The existing "perforated pipe" type spray bar was replaced by Bete spiral fog nozzles. These nozzles give good coverage with fine spray and have large non-plugging orifices.

The third suggestion was that scrubber water pressure be increased from 10 to 20 psig at the nozzles.

The fourth suggestion was that the scrubber stack height be increased.

The fifth was that 1 percent sulfuric acid solution be used as the collecting medium. A sketch of the revised scrubber is shown in figure 3.

It was also recommended that superphosphoric acid be used to replace sulfuric acid and to supply a portion of the phosphate requirement for granulation.

Most of the recommended equipment changes were made (stack height was not increased) and a car of superphosphoric acid was obtained from Texasgulf. We again ran the worst grade (6-24-24) and Pollution Curbs collected samples. Acid was moved from the car to the ammoniator by air pressure and metered volumetrically in equipment supplied by Texasgulf. Results of the test are shown in table 4.

The emission of particulate matter from industrial processes in the State of Minnesota is limited for source gas volumes of 41,000 scfm to a maximum particulate concentration of 0.06 gr/scf. The results show our average of .006 gr/scf is well within limitations.

A comparison of the average mass emission rate of particulate matter before and after system and process modifications is as follows:

Before	22.2 lb/h (0.078 gr/scf)
After	2.3 lb/h (0.006 gr/scf)
Reduction	89.6%

The Minnesota regulation governing the emission of odorous air contaminants of less than 50 feet above ground is limited to a maximum odor concentration of 25 ou/ft3. All odor sources are limited to a maximum odor emission rate of 1,000,000 ou/min.

The results after the modifications show the average odor emissions to be within the limit.

The differences in the values reported for samples 1, 2, and 3 are attributed to adjustments in the sparger arrangements, manufacturing temperatures, and operating procedure variations.

Following is a comparison of odor emission rates from the scrubber discharge before and after system and process modifications:

	Range	Average
Before	4,739,000 - 2,651,000 ou/min	3,695,000 cu/min
After	1,402,000 - 281,000 ou/min	754,000 ou/min
Reduction		79.6%

These tests showed that with the use of superphosphoric acid and the additional equipment and modifications, we were within the standards set by the Minnesota Pollution Control Agency. We were granted an operating permit to continue production.

Removal of 100 percent of the odor and fume is not a requirement (fortunately) and we still receive an occasional complaint. Our experience has shown that odor problems persist long after the odors are gone.

After the tests were made in 1971, we lengthened our ammoniation section to 10 feet to provide longer retention time. Our spargers are constructed entirely of Hastelloy C, which is highly corrosion-resistant. The sulfuric acid pipe is under the bed and the phosphoric acid pipe is on top of the bed. We also installed a second 30,000 gallon tank made from 316L stainless steel.

The liquid phase in the bed of the ammoniator is controlled by the use of recycle, steam, and/or water. Hot recycle is continuous from 16-mesh screens at the end of the dryer. The steam plant has a capacity of 100 hp. Steam along with hot recycle gives great flexibility in production.

Experience with Superphosphoric Acid

At first operation with superphosphoric acid resulted in small granules. This has improved with operational experience and modification of the superphosphoric acid sparger on certain grades, size of the product is controlled by varying the size of added potash.

We found some maintenance advantages in using superphosphoric acid. There is less buildup in the cyclone collectors and they are now cleaned only 3 or 4 times a year. There is no buildup in our hammermills. We now have to change the hammers 5 or 6 times a year because of excessive wear. Also, the screens stay clean. There is no blinding as with sulfuric acid.

The tanks for storage of phosphoric acid have accumulated sludge on the bottom. There is about 2 feet of sludge in the older rubber lined tank and 1 foot in the newer stainless steel tank. Sparging with air to avoid this settling has not been entirely successful.

The use of superphosphoric acid in the operation has presented a few formulation problems. There is less flexibility within the formula. The liquid phase, the heat of ammoniation, and the ammoniation rate have to be much more exact. Ten pounds of superphosphoric acid in certain formulas can make a difference between running or not. With sulfuric acid we were able to granulate even with very high liquid-solid ratios. Differences in material size, moisture or (during the material shortage period) substitution of materials had effects on formulating.

We have had some major equipment problems with superphosphoric acid. Sticky material leaving the ammoniator caused buildup at the feed end of the dryer and lumps at the discharge end, resulting in a buildup of oversize to the point of overloading the elevators. We did not have this problem with sulfuric acid. We found that the solution to this problem was to maintain a good stream of recycle with a formulation giving the current solution-acid ratio and adding 50 to 100 pounds of single superphosphate to aid in granulation.

A second problem was encountered in the production of lower phosphate grades such as 4-12-36. With superphosphoric acid we were not able to make as good a product as with sulfuric acid. We did not get a good wrap and the potash was not covered. To manufacture good low phosphate grades we had to use less super acid and, at times, add single superphosphate.

During the spring of 1975 we had a new problem. Our finished product was caking. We had bin set, hardening in the bags, and a product which flowed unevenly from applicator hopper boxes.

Here again, we needed help from the people at TVA. From discussion with Bud Balay and Frank Achorn, we found our problem to be a combination of three interacting causes. The first two were simple: too many fines and excessive moisture in the product (from 1 to 2%).

The third problem arose from the dolomitic limestone filler we were using at this time. Because of the high analysis of the superphosphoric acid, large amounts of limestone filler were required. All or part of the filler could have been eliminated if the analysis of the grades could have been increased, but changing long established grades was undesirable. We found that the ammoniation rates on certain grades were too low. The pH of the product was low and there was reaction in the pile between acid and limestone. There also seemed to be a reaction with ammonium sulfate and the dolomitic limestone. The various reactions indicated that dolomitic limestone was a poor filler. The original idea for using dolomitic limestone was that it was less reactive than calcitic. Such large quantities were used, however, that some reaction with the acid was unavoidable.

Each of these three problems were attacked separately. To eliminate the fines we made a larger pellet by closer formulation and screening. This reduced the surface contact area and caused less "knitting" of the pellets.

To eliminate the excess moisture, the ammoniating temperature was increased to 200 degrees - 220 degrees F. by using higher free ammonia solution or more solution on certain grades. This was allowed by the greater proportion of recycle from closer screening.

The third problem was solved by finding a substitute filler for dolomitic limestone. We looked for a material uniform in size and around 8 mesh. The substitute filler had to be a material which would not react with the superphosphoric acid or the ammonium sulfate.

The first substitute tested was a coarse cement sand, but a problem arose in finding a uniform coarse sand.

A byproduct from the Northern States Power Plant was found to be satisfactory. It is called boiler slag and results from burning a blend of Illinois and Western coal. The composition given us on this material is:

Silica, aluminum and iron oxides	80%
Calcium oxide	8.7%
Magnesium oxide	10.4%

The material is shown in figures 4 and 5. This black material is about the right screen size and has the appearance of a cinder. It gives our product an attractive, dark appearance. On some grades such as 10-10-10 we are using as much as 480 pounds per ton of this material.

Conclusion

We have learned to formulate using superphosphoric acid and have overcome most of the problems encountered. However, we now face a problem in the cost of superphosphoric acid.

At the time we first used superphosphoric acid (1971), its cost was $1.38 per unit of P_2O_5 delivered to our plant. The difference in cost between using sulfuric acid or superphosphoric acid was nominal. On two formulations of 12-12-12 with either phosphoric acid or sulfuric acid, the per ton cost differential was $2.98. On 6-24-24, depending on the formulation, the difference was about $.52.

Today the difference is much greater. The per ton differential ranges from $2.00 per ton on low phosphate grades to $6.00 per ton on high phosphate grades. In the highly competitive market, these figures make the use of superphosphoric acid restrictive on many grades.

Our original thoughts in 1971 were we would rather upgrade our existing scrubber and use superphosphoric acid at a minimal increase cost per ton than install an expensive venturi system.

We felt that we made the correct decision in 1971; however, since that time we have installed a venturi scrubber as well as upgrading our old scrubber. The venturi is connected to our ammoniator and uses fresh water. The water from the venturi is then channeled to our packed scrubber where it is reused. Recent improvements made on our packed scrubber have been the addition of a mist eliminator pad and a stainless steel casing to replace an old wooden one.

We feel these changes give us more flexibility and we can now formulate with both superphosphoric and sulfuric acids. We also plan to use orthophosphoric acid and will probably discontinue buying superphosphoric acid unless the delivered price again becomes favorable.

Table 1

Original Granulation Formulas

	Lbs/Ton of Product		
	6-24-24	5-20-20	12-12-12
Solution 530 (49-36-0)	164	113	-
Solution 448 (25-69-0)	-	-	420
Sulfuric acid (66° Be'.)	100	75	175
Triple superphosphate (0-46-0)	684	162	311
MAP (11-55-0)	300	370	-
Ammonium sulfate (21-0-0)	-	-	250
Single (normal) superphosphate (0-20-0)	-	624	481
Potash (0-0-60)	800	667	400

Table 2

Scrubber Emission - Grade 12-12-12
Using Sulfuric Acid

Item	Sample 1	Sample 2
Volumetric gas flow rate (scfm)	33,141	33,141
Effluent gas temperature Average (°F)	83	83
Particulate concentration (gr/scf)	.0361	.0278
Particulate emission rate (lb/h)	10.3	7.9
Odor strength (ou/cu ft)	15	24
Odor emission rate (ou/min)	486,000	795,000

Formula Used

Raw Materials	Lb/Ton Produced
Solution 448 (25-69-0)	420
Sulfuric acid (66° Be.')	175
Ammonium sulfate (21-0-0)	250
Triple superphosphate (0-46-0)	311
Potash (0-0-60)	400
Single (normal) superphosphate (0-20-0)	481

Table 3

Scrubber Emission - Grade 6-24-24
Using Sulfuric Acid

Item	Sample 1	Sample 2
Volumetric gas flow rate (scfm)	33,141	33,141
Effluent gas temperature Average (°F)	98	98
Particulate concentration (g/scf)	0.0659	0.0907
Particulate emission rate (lb/h)	18.7	25.8
Odor strength (ou/cu ft)	143	80
Odor emission rate (ou/min)	4,739,000	2,651,000

Formula Used

Raw Materials	Lb/Ton Produced
Solution 530 (49-36-0)	164
Sulfuric acid (66° Be'.)	100
Triple superphosphate (0-46-0)	684
Monoammonium phosphate (11-55-0)	300
Potash (0-0-60)	800

Table 4

Scrubber Emissions - Grade 6-24-24
Using Superphosphoric Acid

Item	Sample 1	Sample 2	Sample 3	Average
Formulation	6-24-24	6-24-24	6-24-24	6-24-24
Production rate (ton/h)	25	25	25	25
Volumetric gas flow rate (scfm)	40,620	41,750	41,332	41,234
Particulate concentration (gr/scf)	.006	.007	———	.006
Particulate emission rate (lb/h)	2.1	2.5	———	2.3
Inlet odor emission rate (ou/min) ammoniator, dryer, cooler	9,192,000	2,680,000	1,521,000	4,464,000
Exhaust odor strength (ou/ft^3)	35	14	6.8	19
Exhaust odor emission rate (ou/min)	1,402,000	580,000	281,000	754,000
Odor reduction efficiency (%)	84.8	78.4	81.5	81.6

Formula Used

Raw Materials	Lb/Ton Product
Solution 490 (34-60-0)	258
Superphosphoric acid (0-69.6-0)	185
Triple super (0-46.5-0)	755
Potash (0-0-60)	805

This concludes my discussion. I will be glad to answer any questions.

Thank you Elmer. I wish to thank the Committees of The Fertilizer Industry Round Table for asking me to present this paper. *(Applause)*

MODERATOR LEISTER: Thank you Tom for that most excellent, valuable discussion. Any questions?

QUESTION: All during the time of your discussion, I take it, regular phosphoric acid is still a little bit cheaper than the type you are using. Can you give me your reason why?

ANSWER: The question is why we are using superphosphoric acid opposed to ortho-phosphoric acid. The super acid was recommended to us by our condulting firm and TVA people. The main reason for this recommendation was pollution control factors. We were told we would have less ommissions from our stack using superphosphoric acid.

QUESTION: The delivered price was also about the same. Wasn't it?

ANSWER: The price for ortho acid and super acid at the time was essentially the same. However, at the time we started formulating with super acid our primary concern was not price but pollution control.

There being no further questions, thank you.

For more information see Slides and Figures - 1 thru 5.

Note:
Figures 1 thru 5
Pages 128 thru 132

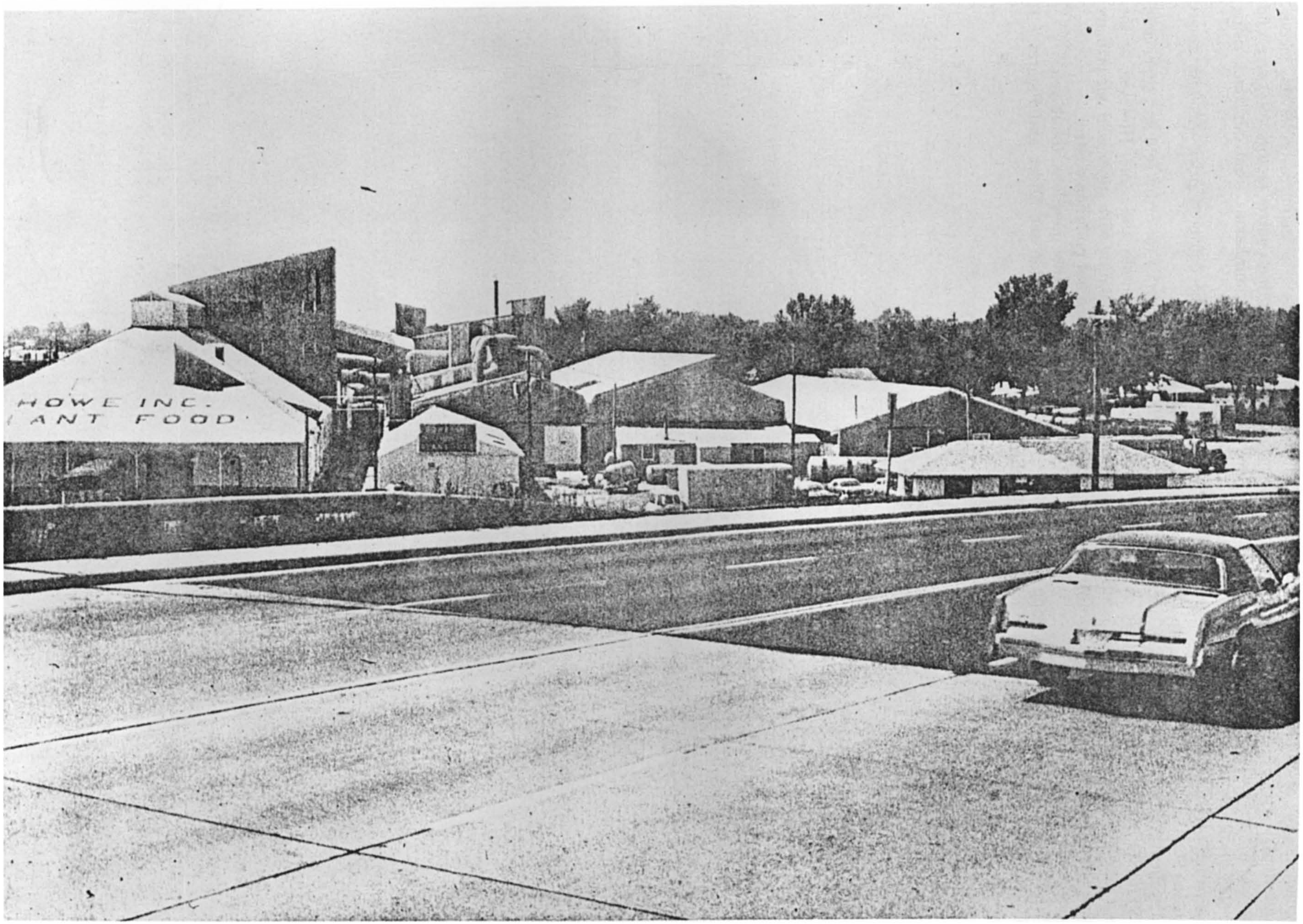


FIGURE 1
HOWE INC. GRANULATION PLANT

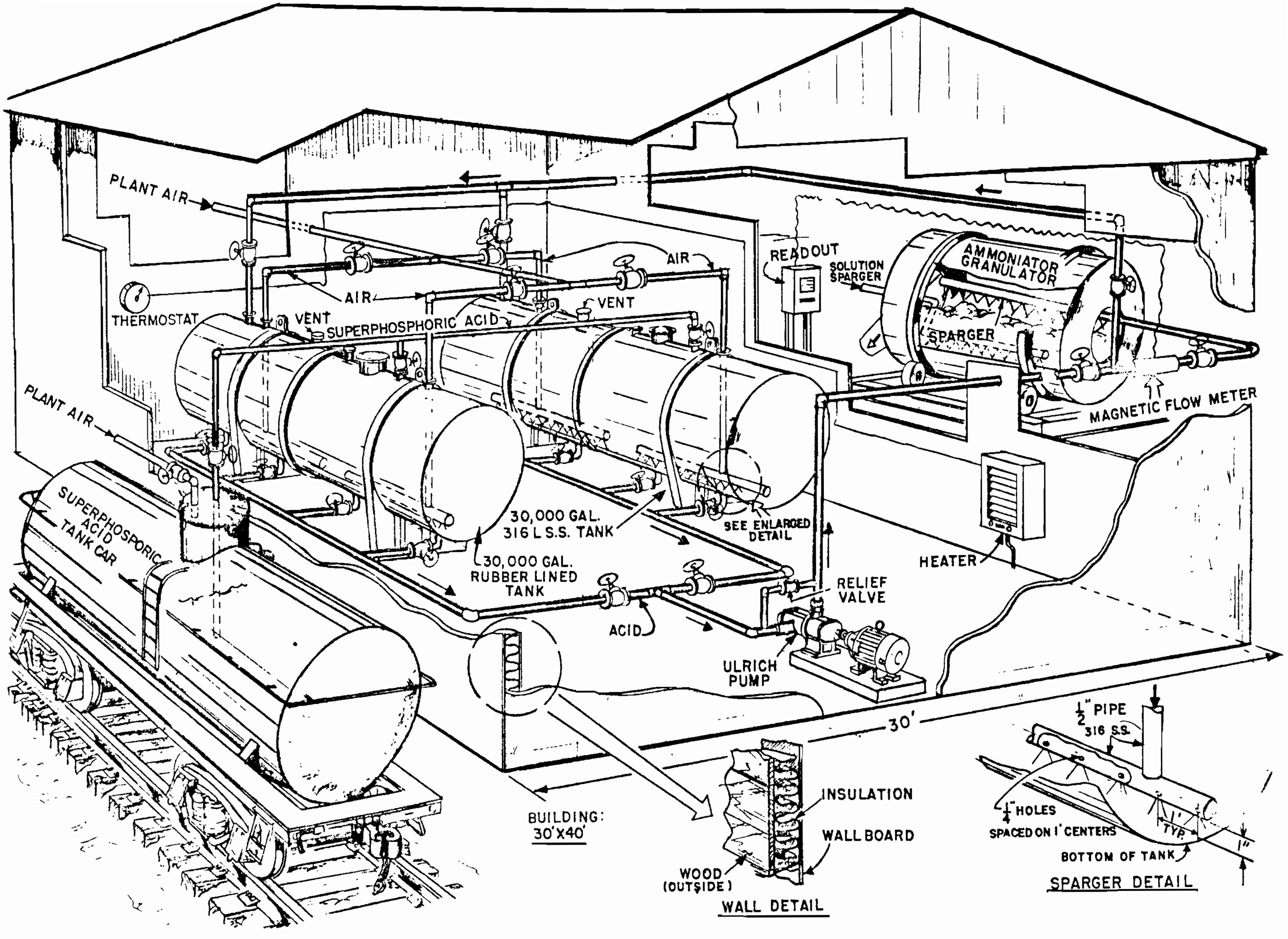


FIGURE 2
SUPERPHOSPHORIC ACID STORAGE

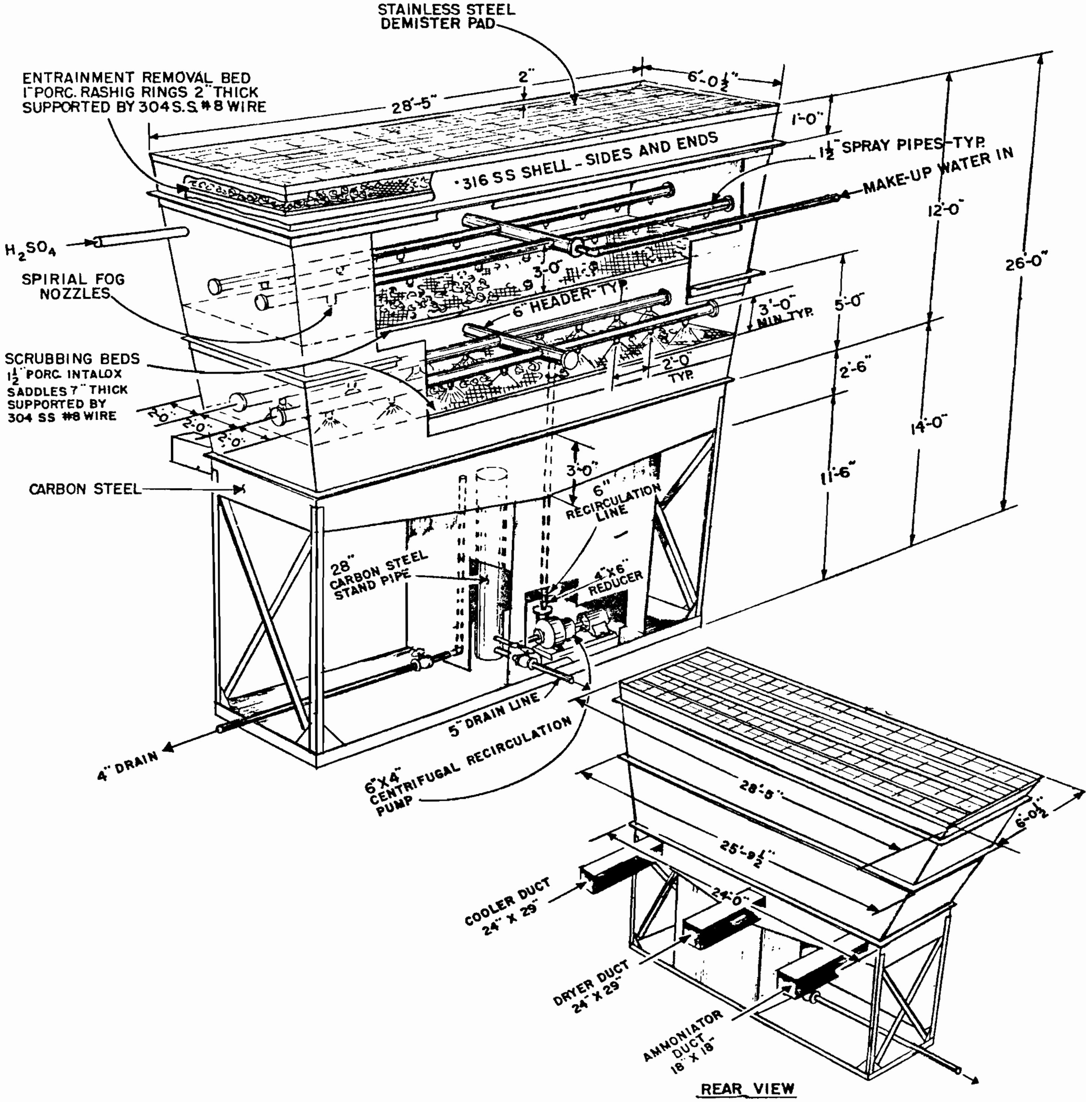


FIGURE 3
GRANULATION PLANT FUME SCRUBBER

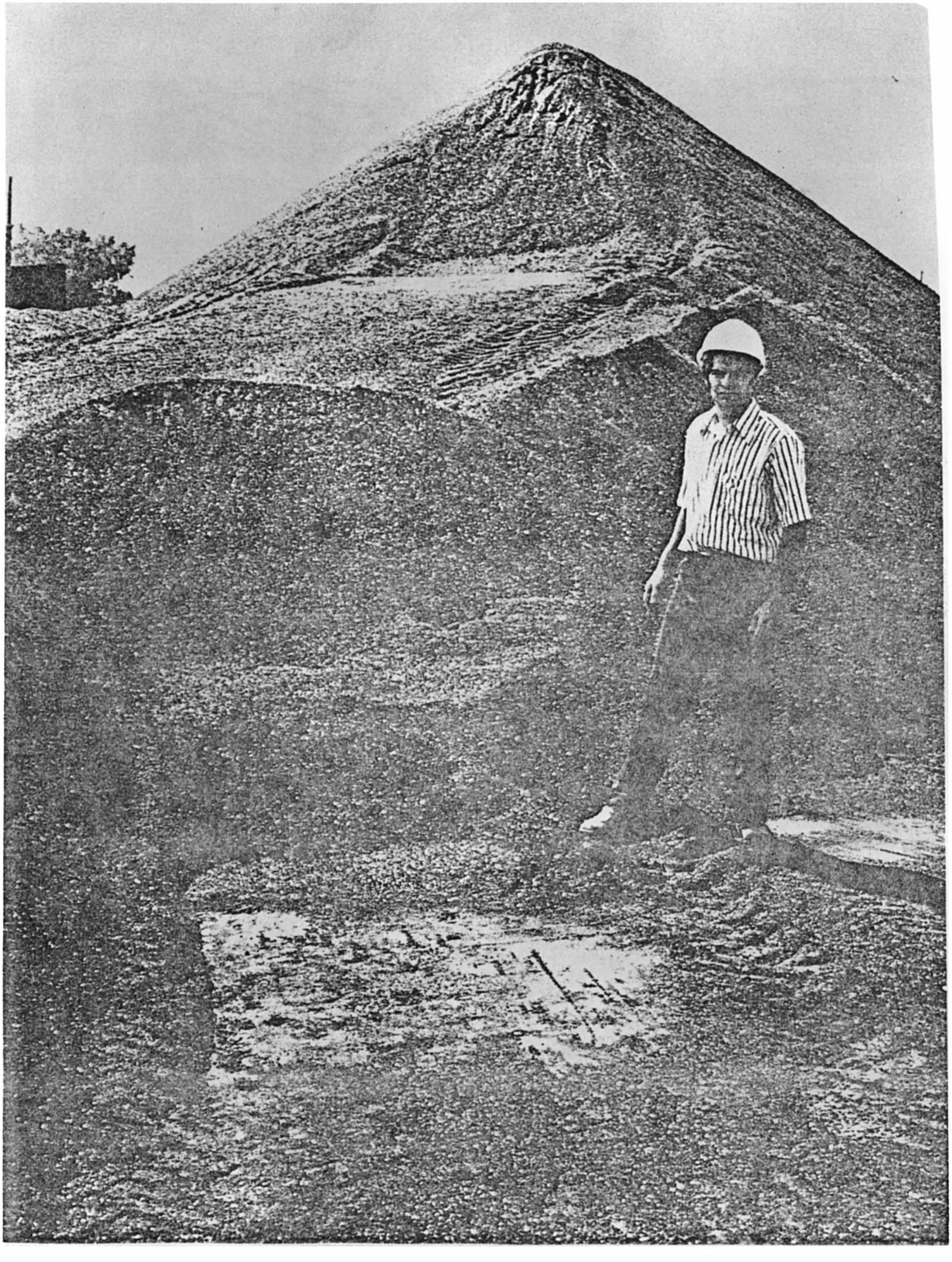


FIGURE 4 BOILER SLAG FILLER

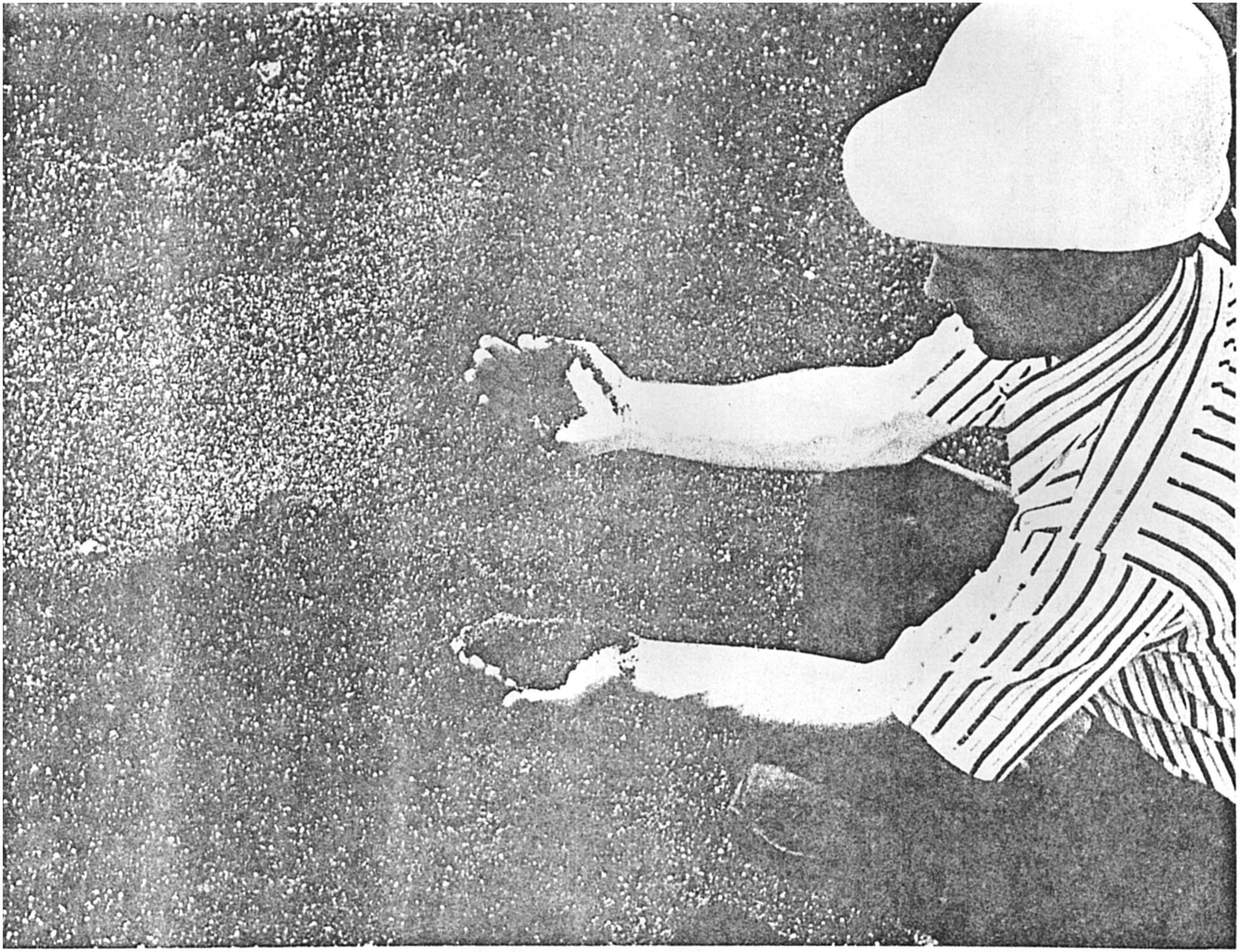


FIGURE 5 BOILER SLAG FILLER

MODERATOR LEISTER: Harry L. Cook will now take over the remainder of this afternoon session. My sincere thanks to our Speakers for their splendid discussions and to our audience for their kind attention. *(Applause)*

Information Seminar for Plant Level Management

Moderator: Harry L. Cook
Panel:
Warren E. Ware
F. F. Edmondson
Myron Rushton
Glen A. Feagan

MODERATOR COOK: Thank you Elmer. You did a very good job.

We can only do things through "People" and with "People". If we cannot keep a plant running it is not of much value to us. We have to level with some of these government agencies that we have today. We have the problem of how to sell a "Quality Control and Housekeeping Program" to your employees.

We brought to this program Warren E. Ware, Manager, Personnel and Training, Landmark, Inc. Warren came to Landmark in 1946 from the Army. He graduated from Ohio State University in Agriculture, Agricultural Economics and Agricultural Education; also took courses in Accounting and Business Administration. Warren started with Landmark as Supervisor of Office Services and has moved through our Company to his present responsibilities "Manager of Personnel and Training Administration and has a few side issues such as the "Big Brothers" he devotes time to. I shall now ask Warren to talk about "Personnel Management". *(Applause)*

Personnel Management

Warren E. Ware

Two words that put a label on a job function that all of you have that no doubt sometimes gets to be confounding, perplexing, and nerve-wracking.

At other times I am sure you really do get some self-satisfaction and a sense of accomplishment from working with your employees.

There has never been a text book written on Personnel Management that would indicate it was a simple and natural process.

Writers tend to make a natural process appear complicated and difficult.

If we can make a couple of observations and keep them in mind during the remainder of my comments, I think you will better relate to the process of Personnel Management.

O.K. — Keep in mind this one very important fact — All People operate according to the same basic principles, and *all have individual personalities.*

In managing people always keep in mind the old adage of "Doing unto others as you would have them do unto You".

Don't let your stubborn human desire take over and rewrite the principle so it reads "Do unto other what *we* think ought to be done".

This version causes us to hold tenaciously to pet prejucices, outworn traditions and practices, leads to duplication of effort, fosters misunderstandings and jealousies and makes for friction and lost time.

It makes a simple job difficult.

When our prejudices and selfishness enter, reason, justice and simplicity exit.

Personnel Management involves *Leadership.* Leadership is a perfectly natural status in life.

The world divides itself casually into leaders and followers.

In any work situation the same division takes place.

The situation gets complicated because some of us feel the whole future of the company depends on us — That if we don't get perfection from all our employees the company is doomed.

Let's each make his own contribution with as little fuss as possible in a simple and natural way. This does not mean we should work any less hard, but it does mean that there is little merit in being busy just for the sake of being busy.

Activity is of Value only in terms of *Attainment.*

The success of your operation depends on having an adequate number of people in the right jobs at the right time, all producing at their *individual highest capacity.*

Let's talk about leadership for a few minutes —
Leadership is the ability to handle people in a manner that commands confidence, respect, and loyal cooperation, and gets people to want to do things the leader wants done.

The good leader infuses his subordinates with the desire to support the company policies.

The supervisor's ability to use the talents of his subordinates efficiently is also a measure of his leadership skill.

The successful leader learns as much as possible about human nature. He respects the dignity of the individual and understands that each person is important to himself. He gains their confidence and respect by looking out for their interests and giving them credit when due.

— *Styles of Leadership*
Some managers and supervisors practice a man-to-man approach in getting work done; other use a group method, supervising workers as a team to accomplish the function of the unit. The group method usually yields higher productivity and greater job satisfaction inn those work situations that call for everyone to work together.

If employees are kept informed about their work and how it should be performed, the actions they take are likely to be those management wants.

To secure effective and efficient performance, the manager, and in turn the supervisor, must delegate some authority to act and make decisions in particular types of situations.

In delegating authority provide for accountability. An employee given authority to perform a task needs an opportunity to report on his performance.
Reporting serves two functions:

1. It makes the employee conscious of the importance of the job he is performing and . . .
2. It helps you assess any need for additional training, for redefinition of procedures or organizational responsibilities.

Remember, final responsibility for employees acts or decisions can never be passed on. The buck passing stops with you.

I'll bet some of you in the audience expect effective intelligent human relations practices and high morale within the work group will develop spontaneously while you spend most of your time and effort worrying about production schedules, transportation, facilities, raw materials, prices, and markets.

We all have a tendency to place a greater degree of importance on material things than on *people* things.

Management has often been defined as "Getting Things Done Through the Efforts of Other People".

That function breaks down into two major responsibilities — Planning and Control.

In Planning You Decide what Your Employees are to accomplish. This involves the careful determination of the job needs, the establishment of objectives, outlining of procedures to attain the objectives and the assignment of responsibilities to individuals or groups.

You can't expect your manufacturing plant to turn out a product efficiently without careful planning going into the production process.

Control requires you to use media which will *motivate* the people in your work groups to follow your plan.

There are many control factors that require attention, but let's consider two of the more important ones — *Organization Structure* and *Supervision.*

Keep the organization structure as simple as possible. Make sure all are a part of it and understand it.

If there is misunderstanding of authority and responsibility or about inter-relationships between individuals and organization units, people cannot work effectively.

Why do we have *Supervision?*

The major function of supervision is to close the gaps between desired performance and actual human performance.

Now you can begin to see that one of your primary functions as a plant manager is to determine *what you want your people to accomplish, to check periodically on how well they are doing it, and to develop methods to get your employees to perform more efficiently.*

Now let's spend a few minutes discussing your responsibilities as a plant manager in developing a favorable working climate through the use of effective human relations practices.

If you are to build sound employee relations in your work force, your dealings with your supervisors and your supervisors dealings with their employees, you must take into account the simple motives and desires of human beings.

You begin to build an image of your human relations practices even before you hire an employee.

When an individual is seeking employment he likes to be treated courteously and made to feel at home and at ease.

Under these conditions he can present himself to the best advantage.

Establish for yourself some practices and procedures to be followed in interviewing and selecting your employees so that you arrive at a decision that will indicate you are interested in *his* future.

The average person likes to be welcomed to his new job rather than "thrown into it . . ."

Let the new employee's supervisor do the first day's introduction and training necessary so the new employee will at least feel he is an entity of some value and not a non-productive nuisance.

Have a planned indoctrination program that will acquaint your new worker with all plant rules — operating rules, safety rules, personnel policies, etc.

Instructions to the new employee are most important. His supervisor should give simple and intelligent instructions in what is expected, how it can be done, and what constitutes a job well done.

In your operations, agreement on what constitutes a job well done would include meeting production schedules that were *fairly* established, production of a quality product, proper maintenance of equipment, etc.

Try to instill into the new employee the feeling that he will make a valuable contribution to the overall success of your plant operation.

Any employee likes to work for someone whom he can respect and in whom he can have confidence.

To foster this working climate capable supervision is necessary.

You can help to develop intelligent and capable supervision through a continuous training program with your supervisors.

Your training programs should certainly zero in on how you can maintain morale within the work group since most of the employees are in jobs that certainly don't lend themselves to being highly motivational or morale builders.

Morale is a state of mind with reference to confidence, zeal, spirit, esprit de corps, among a number of persons who are working together in an enterprise.

Remember morale is peculiar to each individual; it can change overnight; it doesn't depend on technical knowledge or skill — it is best described in terms of feelings and attitudes.

What is it that you can do to help attain high morale within your work group?

Before we talk about sone of the things you can do to help attain a state of high morale within your plant, let's think a while about what makes people behave like they do.

Behavior is caused by an attempt to satisfy basic needs.

Needs have been grouped into five basic categories:

1. *Physical* — the things we need to stay alive — food, shelter, clothes, heat, etc.
2. *Security* — self preservation, job security, security of loved ones, etc.
3. *Belonging* — family, church, social, civic organizations.
4. *Self-Esteem* — Think well of ourselves; need for self worth and self-respect.
5. *Self-Fulfillment* — need to attain the highest level or purpose in life for which we were destined.

Satisfaction of these needs is like climbing a ladder. We usually aren't interested in the higher level needs until we have the lower level needs. The lower level needs are more powerful.

People are motivated by only the unsatisfied needs.

In your plant operation remember that the behavior of your employees is caused by each employee's reaction to stimuli that are influencing them.

Stimuli From The Superior

There are many types of managers. No single managerial style will be the most productive with every individual in every work situation. The method must be adapted to fit the person and the situation.

For example "selling" a person on a certain production standard might be more effective than telling him.

Stimuli From the Fellow Workers

Social forces operating within a work group can be very important in influencing production. An employee's fellow workers can limit his production through personal talk, group standards and ostracism. Production can be increased through teamwork, high morale and establishing group goals.

Stimuli From Job Duties

The kind of work a person does, his authority, and his responsibilities influence the interest he feels, the satisfaction he receives, and his level of production. Changes in job duties can affect his production.

Every worker is subject to forces on his job; some push him toward high production, some toward lower production. His rate of production will be the net result of the interaction of the stimuli.

By now you are all probably getting tired of the psychological aspect of personnel management; however, just another couple of minutes to point out that there are other psychological forces at work that are definitiely influencing your operation.

For lack of a better handle — Let's call them *Motivators* and *Satisfiers.*

Motivators are defined as forces that can increase production.

Satisfiers are conditions which prevent dissatisfaction.

An increased use of "motivators" can increase the productivity; however, a decrease of satisfiers can decrease productivity.

Some examples of "Satisfiers" would be paid vacations, retirement benefits, job security, fair policies, friendly supervision, working conditions, wages, etc.

Some examples of "motivators" are challenge on the job, chance for self development, chance to obtain status, excitement, chance to advance, chance to be creative.

Now in summary — some of the things your employees do really want out of a job — some of their motivators and satisfiers would be:

1. The possible prospects of a promising future with security to advance.
2. Fair treatment and square deals on grievances.
3. Recognition of and credit for constructive suggestions offered. Listen to your young people.
4. Friendly and helpful criticism of work or correction of errors. Make it your goal that the person feel grateful for the correction rather than resentful.
   - A. Start with the right attitude.
   - B. Look behind the mistake and find out what causes it.
   - C. Adapt your methods to the individual. Know your Supervisor.
   - D. Prevent reoccurence by making it easy for him to come to you for help; give him achievable goals; conduct group meetings on the most common mistake; use experienced personnel to train.
5. Pay increases when deserved.
6. Recognition and praise for unusually good work.

   To obtain the best use of your personnel, requires a continuing program for appraising each job and evaluating the performance of the person filling it.

An evaluation program has some very important purposes:

- — To determine how well the employee performs the various aspects of the job.
- — To encourage the employee to develop his skills and abilities.
- — To insure proper placement — the right man in the right job.

The discussion with the employee should start with a review of the job description. This gives him an opportunity to make suggestions about his work and its relation to overall operations.

It offers you an opportunity to establish goals — goals the employee will help set. People always work harder to reach company goals they help establish.

Your discussion of the job functions will naturally lead to an evaluation of the employee's performance. Are the most efficient work methods used? What are the employee's characteristic ways of tackling programs, dealing with people and handling tools and knowledge? Other evaluation factors could include quantity and quality of work produced, ability to adjust to changing work situations, dependability, initiative, judgment, ability to accept responsibility, ability to make decisions, care and maintenance of equipment furnished the employee and many, many more.

But, always remember *you* or the employee's *supervisor* (depending on who is doing the evaluation) should be able to give the employee some suggestions as to how he or she can improve the areas of less than satisfactory performance and again periodically follow-up to indicate you are interested in their development and improvement.

7. Selection of best qualified employee for promotion when vacancies arise — fair treatment.
8. A reasonable work load.
9. Pay at least equal to or higher than the going rate for the same type of work.
10. Freedom to seek help when difficult problems arise at work.
11. Good working conditions and satisfactory daily working hours. Don't be unreasonable in asking employees to work lots of overtime or long hours.
12. Employee Benefit programs that provide for insurance, vacation, sick leave, etc.

Each individual within the group must be made to feel that his job offers him a chance to gain or avoid the loss of something of value to him.

Since this must be done through relationship with other people on the job, his values must be in basic agreement with those of the group.

You and your supervisors should explain the necessity for taking certain action, changing policies, insisting on new production standards and/or schedules.

You can maintain morale if the group can see that the change affects them equally and is fair.

One of your most important responsibilities is to have your supervisors or foremen knowledgeable in supervisory practices that help to build good morale.

1. They should be sure that in group discussions the opinions of the employees are recognized, respected and encouraged.
2. They strive to create employee initiative, which in turn breeds responsibility and greater job satisfaction.
3. They spend very little time in production work themselves, they are more "employee-centered".
4. They have a strong sense of security in their own job. They know where they stand with you, and the company.
5. They instill a feeling of security. The workers feel their supervisor goes to bat for them and is reasonable in what he expects from them. He lets them know where they stand, what he thinks of their work, and how they are doing it.
6. They like dealing with people and have an honest, genuine interest in employee problems.
7. They praise their people more than they criticize.
8. They know the job, and can explain it clearly to the worker, yet they will listen to constructive suggestions or criticisms.
9. They are skilled in handling people.

By now you are probably thinking that I have "hammered" pretty hard on the importance of maintaining high morale in your work group.

I have — since I feel it probably is the one most important factor contributing to any company's success or failure and to any manager's own personal success or failure.

Perfection in any activity only occurs after practice. Remember the old adage, "He who makes no mistakes makes no progress. He who make progress without mistakes is not human".

Most everyone reacts quickly to understanding, fairness, and consideration.

The greatest single reward which any manager, supervisor, foreman, or lead man can receive is to have those who have been under his direction say they are better workers, better citizens, and better individuals as a whole because of his leadership.

This is your role in Personnel Management.

MODERATOR COOK: Thank you Warren. I am sorry we do not have time to explore those things unlimited. We will hold questions when we get through.

The next Speaker in our "Seminar" is F. F. Edmondson who will discuss "Maintenance Management".

Born and educated in Memphis, Tenn.

Present Employer — USS Agri-Chemicals — Atlanta, Ga.

Received a B.S. Degree from Memphis State University in 1968 Major — Mfg. Technology; Minor — Industrial Management.

Active member of the American Institute of Plant Enginners. Have been in this organization for the last 6 years. Held all local offices in the Kentuckiana Chapter in Louisville, Ky. Presently a member of the Altanta Chapter.

Worked as a full time employee while taking a full college curriculum. Was able to obtain several years of on the job experience prior to graduation.

1962-1965 wmployeed by the Tennessee Department of Hwy. Engineering. Worked in various areas of civil engineering. This included surveying as well as general office duties related to estimates and civil engineering.

1965-1969 employed by Coyne Cyclinder Company (a leading manufacturer of acetylene cyls).

1965-1967 worked in Quality Control Lab. Included inspection and testing of incoming raw materials, general lab work and finall inspection of the finished product.

1967-1969 Maint. Supt. reporting to Plant Engineer — Responsible for maint. of total Mfg. Facility.

1969-1973 employed by USSAC, Jeffersonville, Indiana Plant. Plant Engineer for Mfg. Plant.

1973-1974 left USSAC for 1½ years employment as Sales Engineer for a small machine tool operation in Southern Indiana. Served as Plant Engineer, Safety Co-ordinator, Engineer and Salesman.

1974-Present — In 1974 he rejoined USSAC in Atlanta, Ga. as Northern Region Plant Engineer. This entailed Maint. and Plant Engineer responsibility for (5) Mfg. Plants. In Jan. 1976 a reorganization in the Atlanta General Office left me as Plant Engineer Fertilizer Operations for our eleven (11) Fertilizer Manufacturing Plant. Reporting to Mgr. Maint. and Plant Engineering.

In the past few week another organizational change left him with total responsibility for the eleven Manufacturing Plants in the area of Maintenance and Plant Engineering, and he now reports to D. W. Brochstein, Manager of Fertilizer Operations for USSAC.

Maintenance Management

F. F. Edmondson

When I was asked to speak for the Round Table's 1976 Program, I must say I was pleased to accept. I sincerely hope that I am able to meet this challenge and offer a presentation that will have meaning to you, the participants of this Round Table. As each of you knows, managing a maintenance program in an era of skyrocketing costs, long deliveries and an unstable labor market is most challenging. However, meeting this challenge with a successful program is most satisfying and rewarding. This satisfaction and reward is available to you the individual and also to the Company and its Stockholders.

As you know, a maintenance program is initially established to maintain and protect the original investment. However, a successfaul program is also necessary if you are to operate your plant on a continuous basis, as necessary to make a profit.

Additionally, it chould be mentioned that this service group has become a very expensive overhead item. It exists solely to serve production. It has no purpose other than to maintain and keep the plant running efficiently and effectively with minimum manpower. This becomes a great challenge, as the equipment and labor available to our plants today is far more expensive when compared to that of a few years ago. Everyone involved in managing or supervising a maintenance program must be aware of his role in production. He must be aware of the cost that maintenance adds to production, as well as his responsibility in reducing maintenance costs to the bare minimum.

Operating as well as maintenance personnel must be motivated in order to establish a successful program.

These opening comments have been made in order to emphasize the importance and need for establishing and utilizing a good maintenance program.

In addressing this important subject, I would like to make my presentation to you from the plant level. This choice has been made as this level of Maintenance Management is of utmost importance. It is important to each of you, whether you are located at a plant or have a staff position at an offsite location.

At this time I will introduce and briefly discuss areas or topics that are considered to be of utmost importance to any successful maintenance program. The degree to which each of these items is utilized can be adjusted in magnitude in order to meet the needs of each individual operation.

Planning and Scheduling is considered to be a very important factor in increasing the output of your Maintenance Department.

It lets you, the Manager, plan when the maintenance task should be done and allows scheduling a portion of your work load.

This planning and scheduling should be done at a regularly scheduled meeting involving maintenance and production personnel. This meeting should be held on either a daily or weekly basis. If daily it should be in the mid-afternoon of each day. If done on a weekly basis it should be held on each Thursday afternoon.

Remember planning and scheduling of immediate plant needs as well as long-range planning and scheduling is necessary if you wish to establish an effective maintenance program.

Planning and scheduling should cover all individual normal maintenance jobs. It is not intended to be used for emergency jobs or routine proventive maintenance work.

The jobs should be selected from a backlog of work orders which are a necessary part of a planning and scheduling program. Only jobs that are ready for immediate action should be selected to schedule. In selecting jobs to be performed, you should consider the impact of the job on the plant operation, the availability of manpower and materials and the age of the work order. As you plan the jobs, a work schedule should be made up for the selected jobs. On this schedule you should list the job to be performed, the mechanics to be assigned, the estimated time and any pertinent comments. A good program, once it is established, should allow scheduling approximately 75% of the available work load. However, when initiating a new program you should only schedule approximately 25% of the work load. You should strive to complete everything as scheduled.

Do not overschedule as people will lose faith in this system and the purpose for which it is designed will be defeated. Remember that planning and scheduling saves valuable time and money. When a mechanic goes to perform a job he will have materials and tools as needed to properly perform the job as scheduled.

A Work Order System is also a most important part of any maintenance program. It also goes hand in hand with a planning and scheduling program. It must be fully supported by production and maintenance personnel. There are several basic rules that must be understood and used if the system is to be successful. These rules are as follows:

(1) All maintenance work must be performed on a properly filled out work order.
(2) Work Orders should come from supervisors in the department for which the work is done.
(3) Work Orders need not be issued for emergency or routine preventive maintenance work.
(4) Work Orders should not be allowed to become excessively old.

Remember work orders provide an efficient method for notifying maintenance supervision of jobs that need to be done. They also establish controls to assure that all necessary work is performed. They allow the maintenance superintendent to plan and get his manpower and materials together before trying to perform a job. A typical work order should be compact in size and brief. It should have designated space for the originator to describe the work requested, the date of the request and the name of the originator. In addition this card should have another section to be utilized by the Maintenance Department. This section should have designated spaces to allow brief notes about the job, the estimated or actual man-hours required, the name of the mechanic assigned to the job, the completion date and the location or area of the plant where the work is to be performed.

Upon completion of the job the work order should be removed from the active file and either discarded, returned to the originator or placed in a departmental file. Remember work orders for major items should be filed to establish a history of problem areas in the plant. This can also be an aid in making decisions for future maintenance or replacements.

As we all know, cost control and budgeting plays a most important role in optimizing maintenance spending. This does not necessarily mean that we spend a bare minimum for maintenance. We merely optimize maintenance spending and plan how and when the money is to be spent. The reason for doing this is merely to get the maximum benefit from every maintenance dollar.

The two main areas that must be controlled are labor and materials. In controlling these costs we must first relate to the annual amount assigned to us for our maintenance budget. This should then be broken down into either weekly or monthly amounts available to be spent for maintenance. Now it becomes necessary to establish the average labor rate for your department. Once this has been done, you should budget a percentage of the available amount for labor and materials. After this is done you should set up logs to record daily itemized amounts spent for labor and for materials. This should be reviewed at least once a week in order to establish what your position is, in relation to your available budget amount. Cost control should also be established for any capital or expense project that is being handled at a plant level. Generally the responsibility of upkeep and control falls in the hands of the Project Engineer or Manager. However, I am sure that most companies have cases where the project is handled by the Maintenance Superintendent or Engineer at a plant level. In this case a log should be maintained in your project file. This log should have the same data as required for your maintenance cost control. However, unless this project was budgeted and included in your maintenance budget, you should isolate these costs from normal maintenance spending.

Enough emphasis cannot be placed on the need for each of you to establish a means for budgeting and controlling costs. Whatever method is used, it should be monitored for effectiveness and changed as necessary to insure adequate cost control.

I know each of you is aware that a preventive maintenance program is necessary. However, enough emphasis cannot be placed upon the importance of a good Preventive Maintenance Program. In establishing this program, you set up a systematic inspection; cleaning, lubricating and servicing for your plant equipment. This program helps in evaluating problems and problem areas. It can be used to reduce or eliminate repetitive problems. It can aid in eliminating problems before they cause equipment outages. When properly used, P.M. definitely is a tool to aid in planning and scheduling of your work load.

Charts or cards should be established for inspection and lubrication of your plant equipment. They should be used religiously in making routine checks and inspections. A legend of symbols should be established to record the frequency required, the task to be performed, the type of lubricant and the amount required. These P.M. charts should be monitored in order to pick up problem areas in your plant.

You must also establish and provide an organized record of what is to be maintained. This should be in the form of an equipment file. This file should cover major equipment and its major components.

Each file should have a card with pertinent data such as description, serial number, model number, purchase price, and current lead time for delivery. This file can save much valuable time when replacement parts or components are needed. It eliminates the need for useless tasks of measuring and searching for data at a time of need. This file or card should be kept current and should list any changes or alterations that are made to your equipment. If the cards are not kept current, then you are defeating the purpose for which it was designed. Remember it is important that the pertinent data section of the card list dates, prices and lead times of the items when purchased. This can be a definite tool to be used in helping establish what constitutes an adequate supply of spare parts.

Another area that is very important to a successful plant operation is having an adequate supply of replacement parts. As all of you know many items that are used in our industry have exceptionally long deliveries. Therefore, an adequate supply of replacement units or parts must be decided upon and purchased as spare parts stock. In addition you should continually review your stores of spare parts in an effort to assure having adequate spares necessary for a continuous operation. Remember, if you are to eliminate production losses, you must have what is felt to be an adequate supply of spares. However, we all know with the money situation as it is we cannot afford to stock useless parts and waste money for unneeded spare parts inventories. Therefore, much thought and research should go into establishing what you call an adequate inventory of spare parts.

In closing, several important factors need to be mentioned. As you are fully aware our equipment types have generally changed. They have become more sophisticated and automated and require better educated maintenance personnel. We must strive to educate and improve our maintenance personnel. This must be done if we expect to establish a good, sound maintenance program. We can't live in the past, we must change with the world we live in.

Remember a successful maintenance program can personally benefit everyone whether you are involved in production or maintenance.

Also, the sole objective of these programs is to improve the efficiency of your maintenance effort at a minimum cost.

You should not let excessive details or paperwork be detrimental to your establishing a good program.

Also, remember that the effectiveness of your program is dependent upon you, the initiators and users of it. Many people profess the desire for the kind of system we have discussed, but they are not willing to sacrifice or totally support the program.

I thank all of you for letting me present this program. I wish I could have been able to talk a little bit better. I too have a cold like everyone else and I did not know whether I would be able to present this talk at all. *(Applause)*

MODERATOR COOK: Thank you Fred for a most thorough, valuable to all of us, on that important item "Maintenance". *(Applause)*

The next discussion will be by Myron Rushton, Manager Plant Food Section, Indiana F. B. Cooperative Association. Myron has been with Indiana F.B.A. close to 40 years. He started our in Accounting and moved to Plant Superintendent and to his present job "Manager Plant Food Section". Myron please. *(Applause)*

Living With OSHA and EPA

Myron Ruston

OSHA — Occupational Safety and Health Administration

I am not going to try and convince anyone that we have anymore of the answers to this topic than anyone else present in this room. I would like to discuss some of the procedures we did apply in our company in Indianapolis. We do operate two Granulation Plants; one in Indianapolis and one located just South of Columbia City, Indiana. We operate a leased Nitrogen and Distribution Section which includes approximately 100 NH_3 tanks and 400 tanks for Liquid Nitrogen non pressure and liquid NPK grades. All of these are scattered throughout the state of Indiana. Therefore, we are subjected to OSHA inspectors quite frequently.

When we got our first OSHA copies of the laws, we decided we needed one man appointed to be responsible to keep us all informed as changes were made or deleted. We appointed a company OSHA committee, our safety director, and one man knowledgeable about equipment and one man from each granulation plant.

These men were to pull unannounced inspections and in writing list all defects they found. Then turn in to us at the office and leave a copy at the facility they inspected. This was not too popular at first, but soon became a procedure to follow and they were given only a period of time to correct their problem. Maintenance men particularly did not like this because they were the biggest offenders. We did have this going for approximately three years before we actually had a state inspector in our plants. We are spending at least two days a week with some type of inspectors. We presently have an engineer heading up our EPA Program, who is assisted by a person that we employed from the State Board of Health to constantly run air, and water samples both from stacks, windows, and various places surrounding these plants. We are in an industrial area and the water is constantly being checked by control officials. They have driven wells to a 100 ft. depth and sample these periodically. No process water is allowed to go to the lagoons. Surface water from around the plants is being questioned. We do not know that the outcome may be dwon the road. We hope it can be handled properly and to everybody's satisfaction. All it takes is money and more time.

Air pollution is a bit different. We have added bag collectors in the plant.

Shipping Area — Bag collector — Wheelabrator — Frye Model 108 — 17,500 CFM — 180 Bags, Poly-Propaleen — good for up to 200 degree F.

Granulation Plants — Buell Cyclones backed up by Doyle wet acid. scrubbers on both dryer and cooler. Screens are equipped with Flex Kleen Bag Collector 12,000 CFM, 136 Poly Propaleen Bags

We have proposed in our budget to add another $150,000 Bag Collector on Inbound Raw Material Unloading system.

After all equipment is installed, we may be closed down, but we feel every effort must be made to stay within the law.

It must be understood that these are older plants and they are difficult and most expensive to convert or update to a modern dust-free plant.

We maintained these records at our office and at the facilities. When the OSHA inspector called at our plant, our company OSHA director was notified and he went to the facility and escorted the State OSHA official around on his inspection. Certainly he found some things not to his satisfaction and probably he always will.

We feel the greatest thing we accomplished was the training and the way our people accepted those officials. The procedures we has established the State OSHA officials seemed to like and approved readily. Since that time we have extended these inspections out to other facilities. Refinery, feed mills, blenders, storage warehouses, etc. We feel it has become part of our great society and you can not fight it and win.

Frankly, the State OSHA inspectors were not as severe in their inspections as our own company inspections. Perhaps, we were just fortunate, but it certainly has been easier than we had anticipated.

Environmental Protection Agency:
EPA and Granulation Plants.

We have four major agencies in Indiana controlling air and water pollution.

Corp of Engineers
Federal EPA Officials
State Board of Health
County Unigov Control Officials

In Indiana we do not stand short of control officials. We have different officials for all categories:

Landfill Dumps
Hazard Material Dumps
Water Pollution (Lagoons, Sewer Run Off)
Air Pollution — Stacks, Fugitive Dust

MODERATOR COOK: Thank you Myron.

The last part of the program, but certainly not the least, as you will well see, is by Glenn Feagin.

We have got a lot of years up here this afternoon.

Glenn has been with IMC for some 27 years, a Chemical Engineer from Georgia Tech (it seems to me that I have heard that expressed in a different way!) Part of his present job responsibility is in the General Supervision of Plant Operations and Processes; and in this capacity he became involved with a program of housekeeping and quality control. As Warren says, "How do you educate people along this area?" Glenn is going to bring us their program on that. Glenn please. *(Applause)*

MR. FEAGIN: One thing he failed to mention is that I am originally from a small town in South Georgia — Americus. I don't have too much of a problem today telling people where it is located. It is 10 miles from Plains. It used to be that Plains was 10 miles from Americus. Thank you very much Mr. Cook.

Housekeeping and Quality Control As Presented To Plant Workers

Glenn A. Feagin

A review in 1974 of our 72/73 Quality Control Data indicated that improvements were possible and in some places needed.

With the help of Mr. J. R. Archer, who until retirement was in charge of the Rainbow Division analytical Laboratory and Quality Control Program, we made a survey of the opinions of our Plant Foreman as to the causes of poor analyses.

To make this survey, we visited a number of our locations and invited all of the foremen to dinner. After dinner, we had each individual list his ideas on why our quality control was not better. These lists were collected, tabulated and then discussed.

Almost every foreman felt that poor attitudes and lack of knowledge was a major factor. Housekeeping was also frequently mentioned.

We could handle the housekeeping problem. We had already begun a paint-up, fix-up program. Part of this was to meet the Government Regulations on protection of oil storage tanks, prevention of chemical spills, water pollution elimination and air pollution elimination.

We intensified this effort. Committing money and time as needed. We also gave the housekeeping factor more weight in supervisory personnel performance reviews. It worked! Our plants look good.

The problem we had to solve was how to explain to the hourly workers, in a way they could understand and appreciate, the importance of doing the job right.

Most of them have less than a high school education. Some really care — others do not. Could we get their interest?

It was decided to develop a cartoon program pointing up problem areas and why each man's job was important.

After the program was developed, we had to decide on how to present it. For the first presentation, we selected only the key hourly employees at one location and took them to dinner. Also attending the dinner were the Production Foremen, Sales and Production Managers, the Zone Manager and myself. We did this to impress on the employees the importance of this subject.

The cartoons were on large charts. About 45 minutes were spent presenting the program and another 15 to 20 minutes answering questions.

The feed-back from this dinner meeting indicated that the other hourly workers, who were not invited, resented being left out.

To correct this, we changed to a luncheon format. We selected a confortable location at the plant, had a local catering service provide a good lunch, and invited all plant, sales and office personnel to attend. This proved very satisfactory.

It was amusing to see how the men identified the various characters in the cartoons with people at the plant.

This was not a cheap program but it was not really expensive. Art work, photography, and presentation was done by IMC personnel.

Meetings were scheduled to fit with existing travel plans as much as possible. Cost of lunches was usually about $3.50 per person.

Was it worth it? We think so. For the 1974/75 fertilizer year, we were below the industry average for penalties in most areas where we operate.

Our penalty dollar amount fell almost 50%.

I would not give this program all the credit. We also had other programs going. But it was a big help and it did do the job it was designed to do.

We have put this program on slides — So let's take a look.

I will give a very brief description of the points we were trying to make:

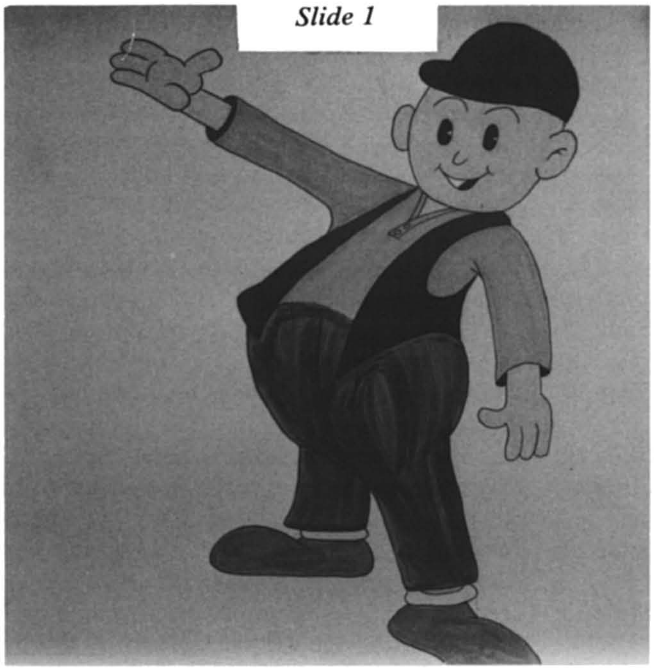
Slide 1: Introduction of Fred — Typical Employee showing Attitude we desired.
Slide 2: Description of Plant Operations for general knowledge.
Slide 3: Description of Acidulation Unit for general knowledge.
Slide 4: Importance of Correct Acid Strength.
Slide 5: Importance of Correct Weighing.
Slide 6: Importance of Correct Acid Measurement.
Slide 7: Storage of Raw Materials — Safety Violations — Usually give cash awards to employees who can identify errors.
Slide 8: Weighing System Description for general knowledge.
Slide 9: Problems caused by Incorrect Hopper Selection.
Slide 10: Importance of Use of Correct Materials.
Slide 11: Importance of Correct Weighing and Reporting any errors made.
Slide 12: Importance of Correct Feeding of Dry Materials.
Slide 13: Description of Granulation Process for general knowledge.
Slide 14: Importance of Meter Settings.
Slide 15: Why Sulfuric Acid is used in Ammoniation.
Slide 16: Purpose of Spargers — Why they must work correctly.
Slide 17: Dryer Operation — items to watch.
Slide 18: Dust Collector Operation.
Slide 19: Operation of Screens.
Slide 20: Correct Storage of Finished Product.
Slide 21: Sampling and Sample Preparation.
Slide 22: Importance of Housekeeping.
Slide 23: Cost of Incorrect Bag Weights.
Slide 24: Shipment Identification Problems.
Slide 25: State Inspection and Penalty System.

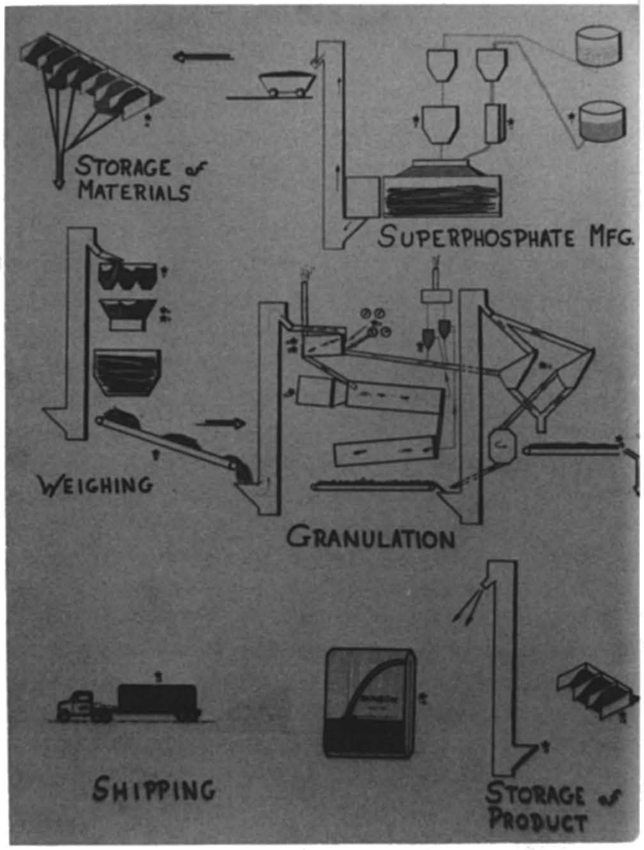
You can easily see that we can use these as a quick over-all view or as a lead-in for detailed discussion.

In fact, we are developing a series similar to this on each operation. It was a pleasure to present this idea to you. Thank you veru much.

Slides #1 thru #25
Pages #142 thru #145

Slide 1





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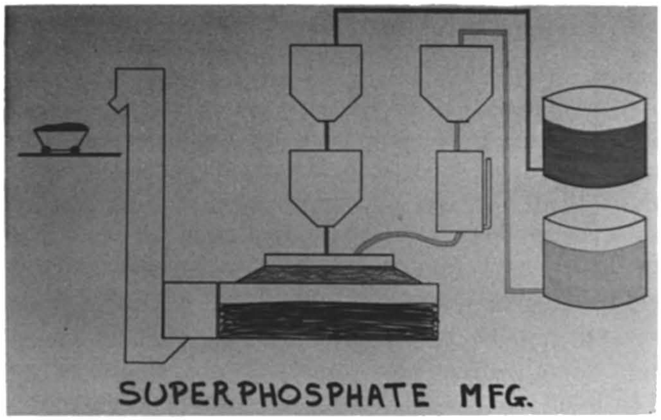

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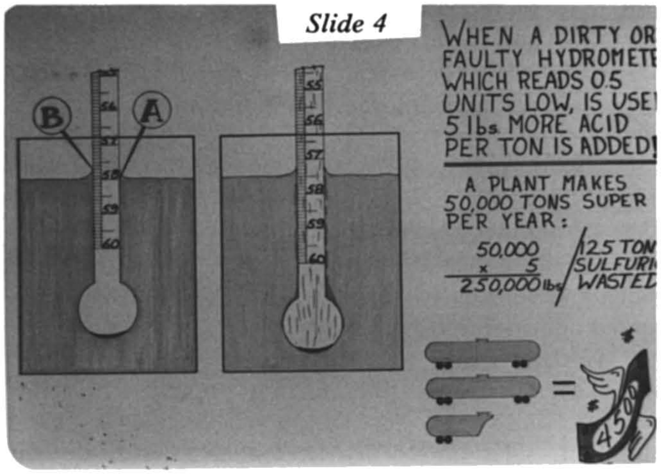
Slide 4

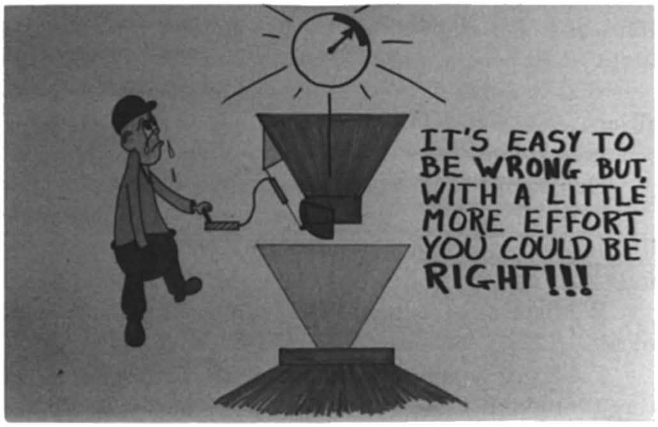


WHEN A DIRTY OR
FAULTY HYDROMETE
WHICH READS 0.5
UNITS LOW, IS USE
5 lbs. MORE ACID
PER TON IS ADDED!

A PLANT MAKES
50,000 TONS SUPER
PER YEAR:

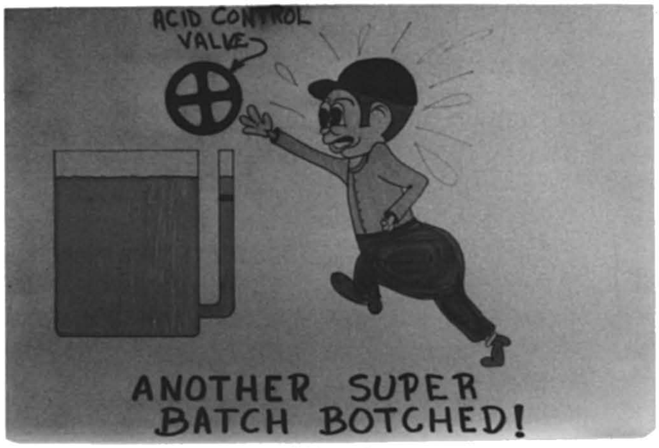
$$\begin{array}{r} 50{,}000 \\ \times\ 5 \\ \hline 250{,}000\text{ lbs} \end{array}$$

125 TON
SULFURI
WASTED



IT'S EASY TO
BE WRONG BUT,
WITH A LITTLE
MORE EFFORT
YOU COULD BE
RIGHT!!!

Slide 5



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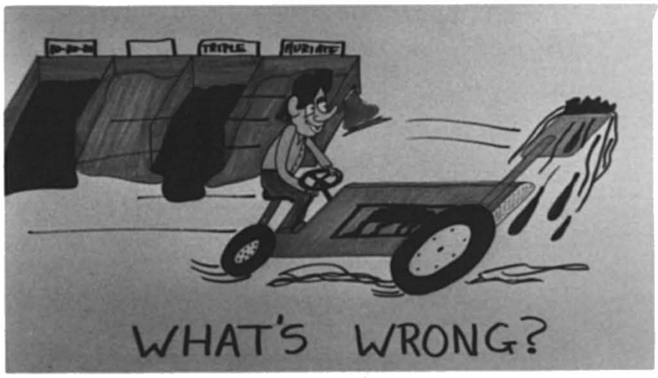

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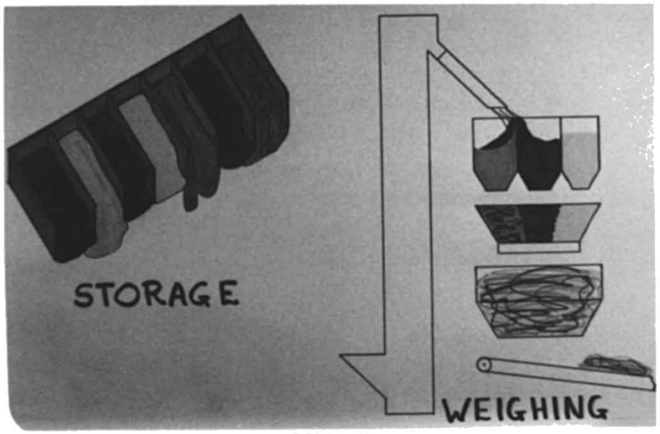

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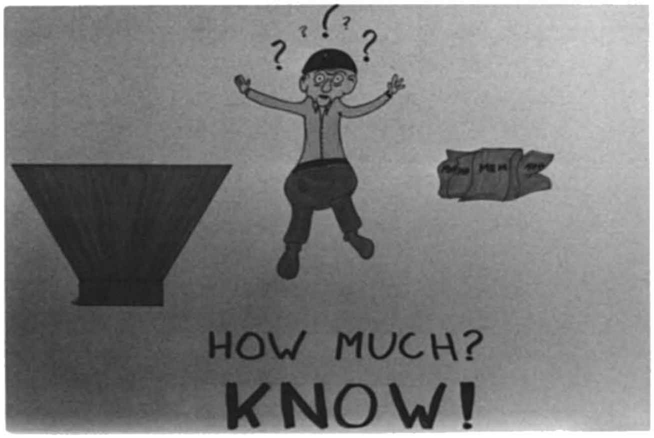

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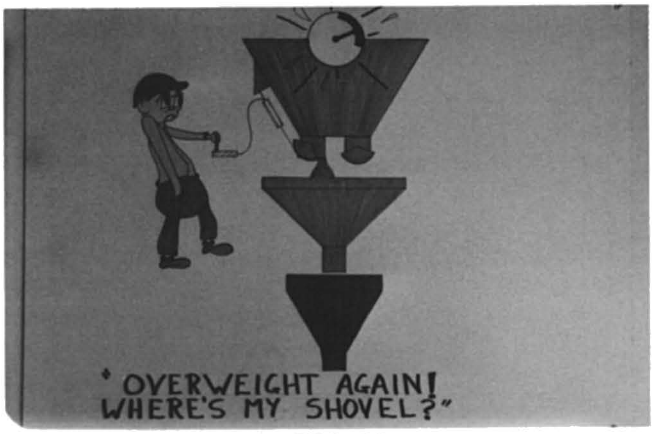

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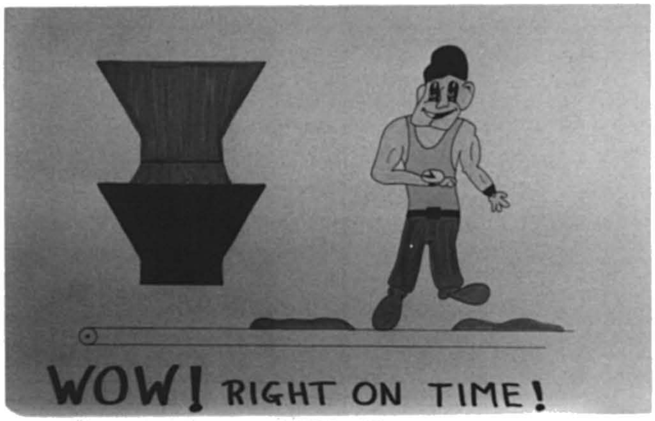

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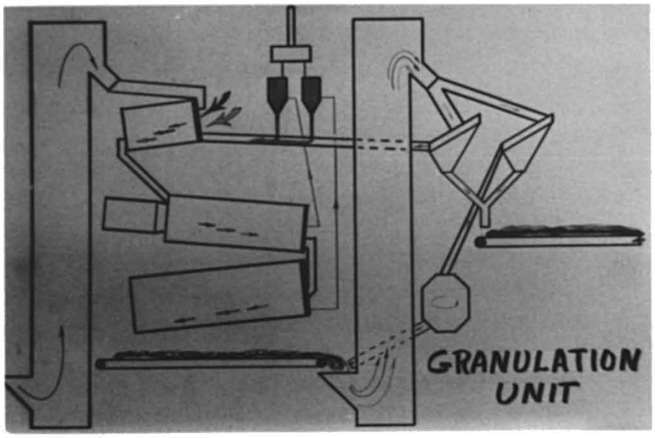

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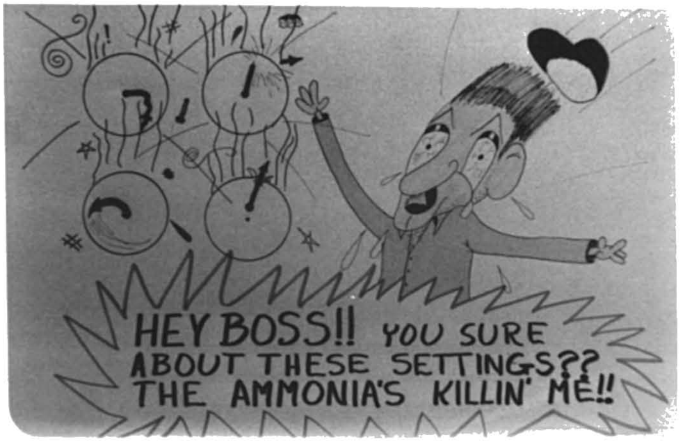

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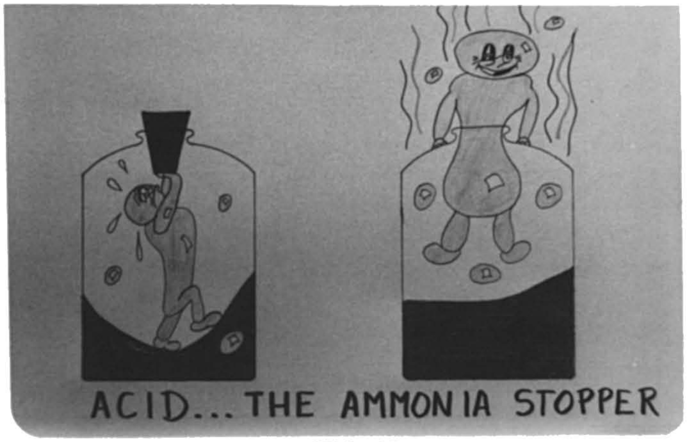

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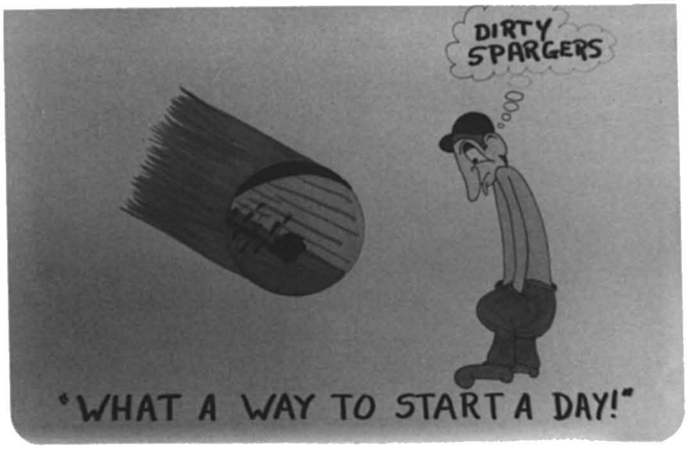

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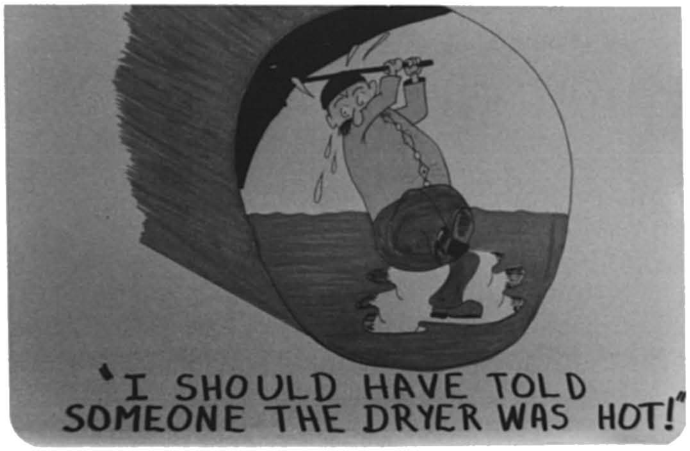

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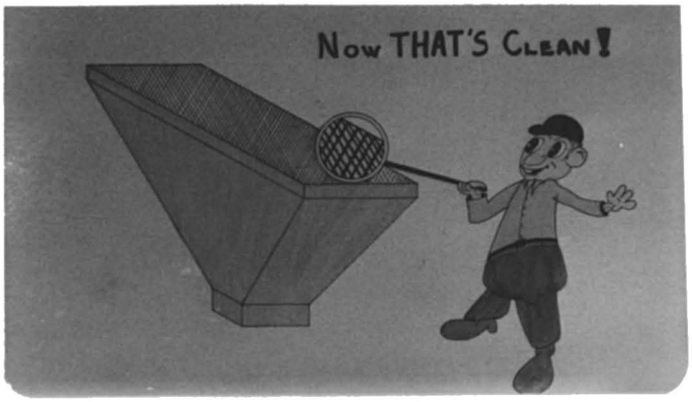

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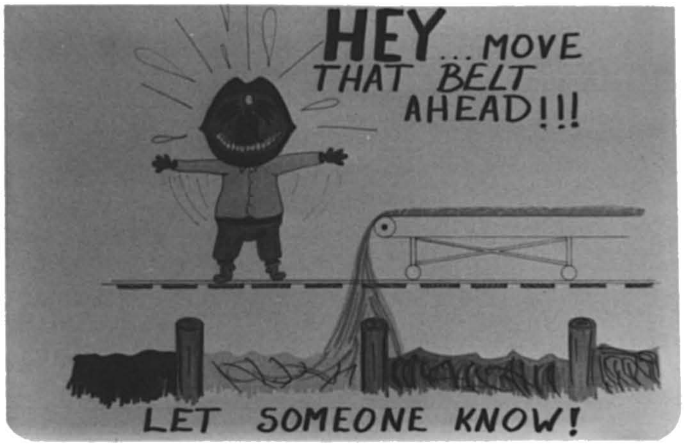

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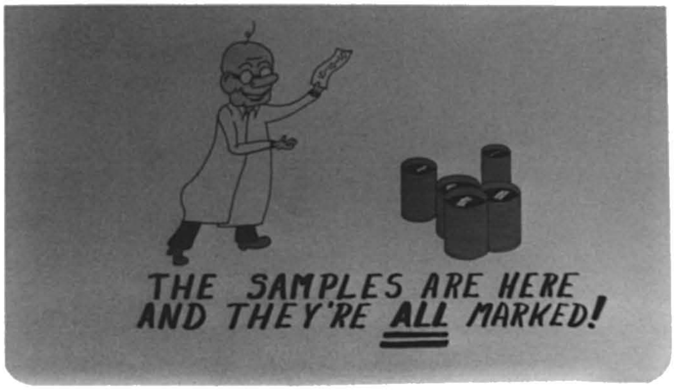

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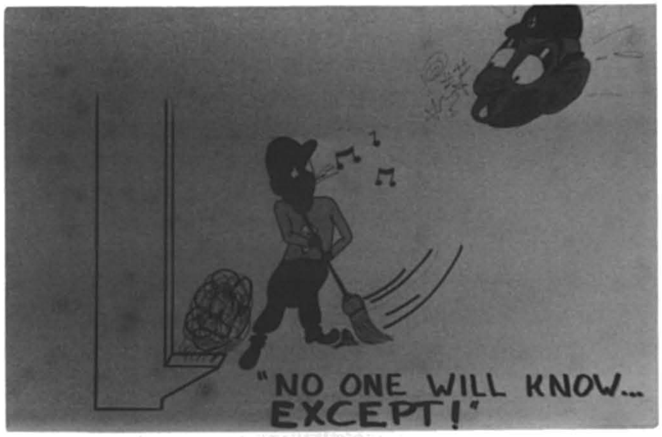

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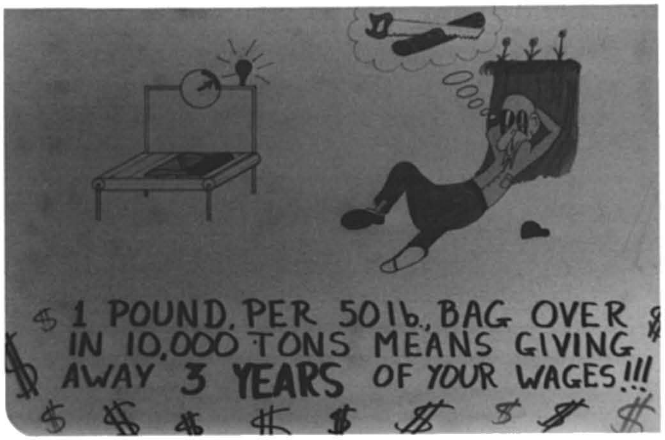

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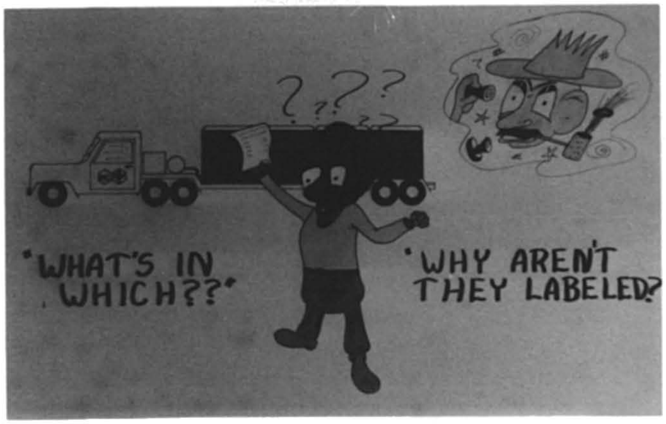

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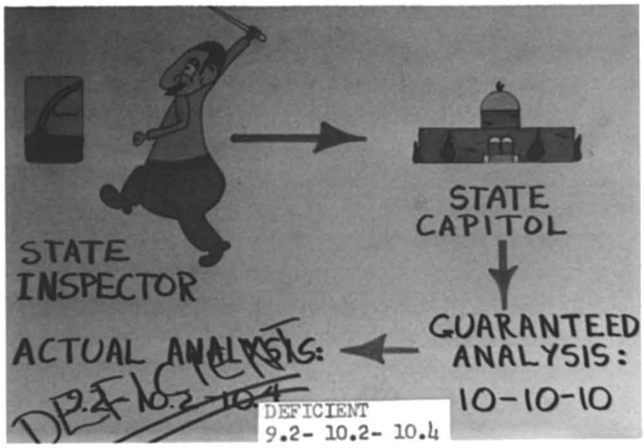


Slide 25

MODERATOR COOK: Thank you Glenn Feagan, Warren Ware, Fred Edmondson and Myron Rushton, for your most interesting and valuable discussions covering — Personnel, Maintenance, OSHA, Housekeeping and Quality Control. See you at 6:00 P.M. in "The Ball Room". Meeting adjourned 4:45 P.M. *(Lots of Applause)*

Thursday, October 28, 1976

Final Session
Moderators
Joseph E. Reynolds, Jr.
John S. Neild
Paul J. Prasser, Jr.

CHAIRMAN REYNOLDS: We are eagerly awaiting some of the reports from my gentlemen friends up here to the left.

We've had a real fine meeting. As we indicated in the beginning we had subjects that were of interest to many people, a very broad spectrum of subjects. The attendance confirms the interest. In fact as far as the powers that be, in making plans for next year and later years, the Directors are trying to figure out what kind of attendance to anticipate for 1977 and '78, but this type of problem is welcomed.

We've had an excellent representation from our friends overseas. Many people worked very hard on putting the program together, and I want to express a personal thanks to them for their efforts and also for the speakers who have prepared the information for these presentations.

Many things make this program go together. It is really you as a group out there, a feeling of belonging, a feeling of responsibility. So from my personal standpoint you made it extremely easy for me, and I really thank you.

So without a lot of other commentary I'm going to get right on into the agenda. Probably the first and one of the most important persons to call on here is my friend, Paul. Paul has really done a tremendous job. He keeps everything intact. He is the pulse of the whole organization. He also has the money. So, Paul. *(Applause)*

Secretary-Treasury Report

Paul J. Prosser, Jr.

That is not a bad pulse, is it? I came prepared to read the "Financial Report" for the period November 1, 1975 through October 25, 1976. We cut the fiscal year off this year right before this meeting.

When I came into the meeting this morning we had registered 362 people. We have 11 registrants who did not appear but fortunately we have their money! Thank you. *(Applause)*

CHAIRMAN REYNOLDS: Thank you, Paul. Are there any questions? I tell you that's detail when he gets down to that $2.00. He has indicated we are solvent. The 362 registrants represents another increase in attendance. Any other questions or anything else you would like to ask Paul? You have him here right now in front of you. Paul, thanks again for your effort. It is really great.

The next gentlemen here needs no introduction. He has been with us many years. He's the one who keeps behind the scenes, keeps the ship going right down the channel. He's a good friend of all of us. So, Wayne, how about coming up and making a report.

FINANCIAL STATEMENT

November 1, 1975 to October 25, 1976

CASH BALANCE - November 1, 1975		$ 2,052.93
Income November 1, 1975 - October 25, 1976		
Registration Fees-1975 Meeting (321 @$40.00 less $2.70 exchange)	$12,837.30	
Sale of Proceedings	1,510.81	
Sale of Souvenirs	30.00	
Total Income November 1, 1975 to October 25, 1976		14,378.11
Total Funds Available November 1, 1975 to October 25, 1976		$16,431.04
Disbursements November 1, 1975 - October 25, 1976		
1975 Meeting Expenses	$ 1,269.17	
1975 Proceedings, including postage, printing, etc. (including mailing of invoices)	8,487.76	
Membership letters including postage	560.36	
Miscellaneous expenses including office supplies, postage for mailing back issues, etc.	206.29	
Directors Meetings including mail notices, postage, etc.	847.34	
1976 Meeting - preliminary expenses	270.97	
Bank charge	2.00	
Total Disbursements November 1, 1975 - October 25, 1976		11,643.89
CASH BALANCE - October 25, 1976		$ 4,787.15

Nominating Committee Report

Wayne W. King, Chairman

I am very happy to be here in "Iowa" with you *(Applause)*

Now we get into the nominations. Each of you will note, on the program you have received a complete list of our Board of Directors. I would like to place the names of those people in nomination for a two year tenure. In April we will have a small revision and in a year from now we will add some names.

CHAIRMAN REYNOLDS: I think you have heard the report of the Nominating Committee. Wayne is making a motion that the present Board of Directors be placed in nomination for a two year term. Do I hear a second?

PERSON IN AUDIENCE: Joe, I second it.

CHAIRMAN REYNOLDS: All in favor of the motion as made please say "Aye". Opposed. Silence. Motion passed unanimous.

WAYNE KING: Now it's time to have an incoming and outgoing potentate for the chairmen. I'd like to explain that. This is not a one man nominating committee. I've talked to everybody here that would listen to me and some that wouldn't! So here is what we propose. Obviously, the incumbent chairman will become chairman ex officio, and the new chairman and vice chairman are the names I am going to read to you. Rodger C. Smith as chairman and Frank T. Nielsson as vice chairman, and I'd like to place those names in nomination.

CHAIRMAN REYNOLDS: You have heard the nominations. Do I hear second? Person in audience. I second it. All in favor of the nomination of Roger C. Smith and Frank T. Nielsson, as made by Wayne, please say "Aye". Opposed. Silence. Motion passed unanimous. So we have a new slate.

WAYNE KING: Thank you Joe and congratulations for an excellent job "Chairing our Round Table for the years 1974 - 1976". I think everyone is in accord with what we have attempted to do. I will see you all a year from now, the Good Lord willing. *(Applause)*

CHAIRMAN REYNOLDS: At some point I'm supposed to turn the gavel over to Rodger. Perhaps we'll go on through with this part of it, and I'll fade out or whatever you do. We have had few chairmen of this organization when you look back over the historical pattern so we don't really know what to do in passing the gavel. Rodger, why don't you come forward. *(Applause)*

Tom Athey is Chairman of our Entertainment Committee and also chairman of our Meeting Place and Dates Committee. He has done a real good job. Come to the platform Tom. *(Applause)*

Meeting Place and Dates Committee

Tom Athey

These meetings have to be planned about two years in advance. Last year we decided that we would go back to Washington for our 27th Annual Meeting in 1977. Arrangements have been made with the Shoreham Americana Hotel to check in on arrival date, Monday, October 24, 1977. Meeting starts Tuesday morning, October 25, and will end Thursday, October 27, 1977. Please record this in your F.I.R.T. Book. Thank you.

CHAIRMAN REYNOLDS: All right, be sure and jot those dates down. Any questions or any suggestions for Tom in his preparation for next year? Everything has been well handled here. It has been excellent. The cocktail party last evening was also a real highlight. It was tremendous.

Entertainment Committee Report

Tom Athey, Chairman

We had a delightful "Cocktail Party" last night. Thanks to the Management of our hotel for a job well done. On behalf of our "Members" our "Board of Directors" and our "Officers" I wish to thank our "Hosts" for that beautiful "Cocktail Party". Needless to tell you that we enjoyed all of it.

ATLANTA UTILITY WORKS
BIRD MACHINE COMPANY, INC.
C&I/GIRDLER INDORPORATED
COMMONWEALTH LABORATORY INC.
DAVY POWERGAS, INC.
FEECO INTERNATIONAL INC.
FESCO, INC.
FLEX-KLEEN CORP.
HOWE RICHARDSON SCALE COMPANY
J&H EQUIPMENT, INC.
JACOBS-DORRCO DIVISION
  JACOBS ENGINEERING CO.
KIERNAN-GREGORY CORP.
THE PROSSER COMPANY, INC.
EDW. RENNEBURG & SONS CO.
ST. REGIS PAPER COMPANY
  BAG PACKAGING DIVISION
THE A. J. SACKETT & SONS CO.
SOUTHEASTERN CONSTRUCTION
  & MAINTENANCE, INC.
STEDMAN FOUNDRY AND
  MACHINE CO., INC.
WEBSTER INDUSTRIES, INC.

CHAIRMAN REYNOLDS: Walt, we move on to you. Please give us a report on your activities this past year. Walt has done a tremendous job this year on our Public Relations. We have had more coverage in trade journals and magazines than, I think, we have had in many years. Walt please. *(Applause)*

Public Relations Chairman

Walter J. Sackett, Jr.

As Joe said, we have had considerable increase in coverage as far as the trade journals are concerned, both domestic and foreign; and I have some folks that I would like to thank for their assistance in that regard. Joe himself, Rodger Smith, Frank Nielsson and particularly Bud Davis gave me a lot of help. I really appreciate it, gentlemen.

I think over the years the Round Table has been very fortunate to have some real selfless and dedicated men to chair the organization. We have had Vince Sauchelli, Al Spillman, Herman Powers and Joe Reynolds. I know that everybody here knows Rodger Smith, knows that he'll carry on in the same tradition of excellence. *(Applause)*

Now, today, it is my distinct honor to try to thank Joe Reynolds in some small way for the three years of dedicated service that he has given to this organization. Joe, I would like to present you this plaque from the Round Table Membership. *(Much Applause)*

FERTILIZER INDUSTRY ROUND TABLE
JOSEPH E. REYNOLDS, JR.
CHAIRMAN
1974 — 1976

CHAIRMAN REYNOLDS: Thank you very much, and I can assure you that it has been a real privilege and a pleasure to work with this group in this capacity. As many of you, I too, have been associated with this group for many, many years. It is a real rewarding experience. My job was the easiest of anyone's because everybody pitched in an everybody helped. I think we had a good program, and I'm sure we'll continue right along. So I'm going to turn the meeting over to Rodger.

At this point I do really appreciate your support and help. It's been great. Thank you. *(Applause)*

CHAIRMAN ELECT RODGER C. SMITH: Thank you, Joe, and my appreciation to all of you for this confidence.

I well remember 26 years ago when I was directly involved in mixed fertilizer production and development Vince Sauchelli then of Davison Chemical Company invited me to join a group that developed into this Fertilizer Industry Round Table. We met one evening over at Atlantic City during the American Chemical Society meetings. The purpose then was to share information on Process and operating problems, and that is the precise purpose today. There have been some shifts of the emphasis in tune with industry changes. For example, moving on further into environmental control, more on bulk blending and fluid fertilizers, more on production of materials as well as mixtures, a greater understanding of problems and the possibilities in production of both materials and mixtures; and I believe this is useful to everyone concerned.

Again, thank you. As has already been expressed and I am sure all of you share, the strength of this organization is you and having a program that serves your needs. I ask each of you for your ideas and encourage even more to attend. In that connection there have been on occasion a few companies who have held production planning meetings in association with the Round Table meeting, and this would serve a dual purpose for the particular company and their personnel who attend.

Is there any further business that would come before this meeting before we move into the speaking program for the morning? Are there any announcements. I would just like to add to what Joe has said regarding our overseas participation. This is a genuine strength, and we are certainly pleased to have them and hope that they will continue.

If there's nothing further, let me turn the meeting over to Pat Neild for our morning program. Pat. *(Applause).*

MODERATOR NEILD: I kind of feel like the ship's being abandoned up here - all these fellows leaving. It's quite a testimony to the Directors and the Committee Chairmen that on the last day of the session when everybody's getting ready to go home that we should have such a good turnout to our meeting this early in the morning. After three nights in Atlanta there must be some pretty hearty people in the fertilizer business.

We're going to try to go on with our program in such a fashion this morning that we can wind up on time. So we'll begin with our first speaker of the morning who is Mr. Douglas Caine of Swift Agricultural chemicals Corporation. Douglas is a native of the black hills of South Dakota, who somehow found his way over to Great Britain for his education. I think this explains a slight accent that makes us feel that he might have been a native of that country. He attended grade school and high school in Britain and was graduated from the University of Manchester with degrees in both chemistry and pharmacy.

He is a "Fellow" of the Pharmaceutical Society of Great Britain, a member of the Royal Society of Health in London, the American Chemical Society, the American Society for Quality Control and is also a member of the Board of Directors of The Fertilizer Industry Round Table.

Doug began work with Swift in 1951 as chemist, and he was appointed in charge of quality assurance for the Agricultural Chemical Division of Swift in 1966.

He serves as an industry advisory member of several committees of the Association of American Plant Food Control Officials including fertilizer terms and definitions, inspection and sampling, soil amendments and elemental guarantees.

He is a member of TFI Product Quality Committee, and this morning Doug will give us a talk on "Correct Bag Weights to Reduce shrinkage.

Correct Bag Weights To Reduce Shrinkage

Douglas Caine

We have all discovered, at one time or another, that recognition and acknowledgement of the existence of a problem is often far easier than finding its solution. This brings to mind the situation of the professional troubleshooter whose task is not merely learning that there is a problem, of which everyone on the location is also aware, but the additional challenge and responsibility of fixing it.

Shrinkage, for example, is a problem which has plagued our industry from the beginning. We use the term "Shrinkage" as a euphemism for the disappearance or loss of product, when what goes in is compared with what goes out.

This seems simple enough as a reference. We have even quite studiously determined where this shrinkage occurs and in this age of "accountability" have assigned an estimated percentage for more accurate cost accounting.

Thinking over this procedure for a moment brings us to the realization that this type of "solution" for the problem of shrinkage is not a solution at all. It is, in reality, a system which compensates for, rather than one which resolves the problem. It is an acceptance of an apparently unchangeable situation.

The inevitability of the occurrence of shrinkage is undeniable, but its magnitude can be reduced. The assignment of a factor for product accountability should not permit the development of an apathetic attitude towards resolution of the problem. A compensation factor for shrinkage may be nothing more than an attempt to compensate for our own short-comings in seeking to alleviate the problem.

At Swift, we recognized one critical area where the benefits of reducing shrinkage would lead to additional benefits. This was in packaging. Our bagging systems were adequate to provide the needed production rates, but it was soon determined that accuracy was being sacrificed for speed.

The rising costs of product and processing coupled with possible pressure from state agencies and consumer groups made it even more imperative that we should become concerned about package weight control.

Even today, there are probably some manufacturers who may not be aware of the tremendous package weight variations they are sustaining, most of which are probably overweights, due to lack of essential controls and misleading checkweight reports. They are likely to be concerned with consequences of violating weights and measures regulations and with the need for satisfying consumer interests. They may not however, recognize the economic consequences of "too little, too late" in the purchase of equipment or in the proper maintenance and running of the equipment.

Our company initiated a survey of our bagging systems with the intention of documenting actual weighing accuracy under the then current production conditions. The problem of inconsistent weighings with consistent product giveaway was readily recognized. It was also evident that a solution to the problem would not be developed within the framework of the existing equipment and practices.

Union Camp Corporation was consulted for assistance in developing a program to correct the existing conditions and make recommendations.

It may be appropriate at this time to show what may not be an unfamiliar piece of equipment. This is probably representative of a fertilizer bagging machine after several years of service. This particular model well served the purposes for which it was designed, but did not have the versatility to meet today's changing market place and associated pressures on production. See Slide #1.

It is probably not necessary to dwell on the changes we have all experienced in designing our packaging to meet the demands of the consumer market, particularly for garden products. While we were quick to adapt to the 50 lb., the 25 lb. and the 20 lb. bag we did not recognize the corresponding need to review our weighing systems.

With reduction in unit package weights, shrinkage of material may actually have been increasing. Bagging systems which were designed to produce up to twenty 100 lb. bags per minute during peak operation, and hold at a reasonable accuracy, were not giving the same results on smaller unit weight bags. Increased shrinkage was occuring without an increase in total tonnage.

Although Union Camp Corporation was able to demonstrate the capability of the existing magnetic switch dial scale to operate efficiently at its designed function, it was evident that there were limitations which could not adapt to our changing needs.

When considering weights of unit packages, a myriad of elements arises, including the monitoring of products by the regulatory agencies. Shifting target weight and overfilling to a large degree so that no underweight packages enter the market is rarely satisfactory. Compensation which decrees no under-weights in these circumstances will result in an alarming giveaway of product and an attendant shrinkage.

Our customers, whether they be the individual farmer, garden hobbyist or large retail organization, demand and expect a commitment to accuracy. Shrinkage remains our problem. Our customer does not expect to see it in his purchase. As we become more sophisticated in our processing and marketing, it is imperative that packaging, which is a critical link between these two functions, maintainss a corresponding pace.

The Packaging Systems Division of Union Camp Corporation presented our company with a two-pronged approach to increased weighing accuracy.

The first was to refurbish all existing equipment and enter into a program of regular maintenance and service. It was anticipated that such a plan would reduce the bagging shrinkage by 50%. A detailed study of one installation showed a consistent variance of from 4 to 8 ounces above the target weights, prior to refurbishing of the bagger, and only 2 to 4 ounces after servicing was complete.

The second phase was to replace existing equipment with electronic scales designed for modular installation. Union Camp further proposed to install Duplex electronic baggers with built-in versatility to meet current needs and future growth.

This slide illustrates where once a bagger similar to the one previously shown stood, now stands a Duplex Scale system. See Slide #2.

Designed with as few exposed moving parts as possible, so essentially necessary in the fertilizer industry, the new 7300 system will eliminate many troublesome maintenance problems. The modular scale concept provides increased production rates with vastly improved accuracy. Where once a single scale was required to produce 20 or more bags per minute now two scales are cycling at 10 bags per minute. Discharge is made through a single spout, thus requiring no increase in labor, while the two scale system provides for greater accuracy.

This next slide is indicative of recent samples taken at one of our southern facilities. A direct comparison is shown between the performance of the new electronic bagging equipment represented by curve A and that of the old equipment represented by curve B. See Slide 3.

Curve A, with its extremely narrow confines, is completely typical of the daily activity of this machine. A considerable number of bags have to be weighed to find any which do not show the target weight of 50 pounds 4 ounces. The required net weight for the package is 50 pounds 3 ounces. Our average excess of product per bag is actually less than 1 ounce. The calculated shrinkage factor from the use of this equipment is only 12/100 of a per cent.

Curve B is representative of the daily activity of the old equipment still likely to be found in a number of installations. The fairly gross standard deviation does not illustrate a system under good control. There is evidence that the system has been tilted to assure no underweights being produced. This assurance, however also carries the penalty of excessive bag fill with an increased shrinkage factor, respectively amounting to 6 ozs. per 50 pound bag or 3/4 of 1%.

The penalty in shrinkage from using the old equipment as opposed to the new amounts to a giveaway of 5 fifty pound bags per 20 ton truckload. This saving, however, does not represent the complete picture in every case. We can anticipate less product waste and less bag waste at the shipping mills made by on-site supervisory decisions. This is due entirely to the machine's capability of consistently producing the targeted weight.

The use of load cell sensors, which are illustrated on this slide, provides the needed versatility to permit greater control of bag weights. The load cell permits the transformation of a weight in the weigh hopper to a directly proportional voltage output from the cell. Our new Duplex baggers are equipped to automatically checkweigh each weighing prior to discharge. If the checked quantity is found to be under our target minimum, the scale will not discharge. If the checked quantity is over the target maximum, an alarm will sound alerting the operator while the scale continues to cycle. This could happen if a change in bulk density of the product is encountered. A simple adjustment at the control panel will remedy the situation. See Slide #4.

Our goals for this program are to produce twenty-five 50 lb. bags per minute with an accuracy of plus or minus 2 ounces, 2 sigma. As yet, it is a little early to tell if we will reach this goal, but indications to date are positive.

To avoid as many problems of the past as possible, new featuress have been included such as remote mounting of the dust tight control panel. This isolates the electronics from corrosion.

Indicator lights and externally controlled timers permit the operator to adjust the scales to compensate for trends that may develop during operation. Digital display meters, located at the top of the panel, provide a read-out of every weighing. See Slide #5.

The controls are all solid state, plug in type, and are easily replaced. There should rarely be a necessity to open this dust-free control panel. These weighing systems are designed to permit adaption to plug-in data recorders which will record all weights and even calculate the standard deviation. See Slide #6.

The means therefore exist, not only to reduce shrinkage, but also calculate the actual reduction. As far as the bagging operation is concerned, we can get away from arbitrary percentages and reflect actual shrinkages in our profit accountability reporting.

With regulatory agencies monitoring weights, consumer groups demanding accuracy and management calling for a reduction in shrinkage, correction of bag weights becomes a high priority. If the correct policies and practicies are instituted, under-weights can become a thing of the past and the profit drain from a constant flow of overweights can be dramatically reduced. *Slide #7*

It is certain that shrinkage will be with us as long as materials and products are transferred from one point to another. There are, however, positive means of reducing its impact on our business.

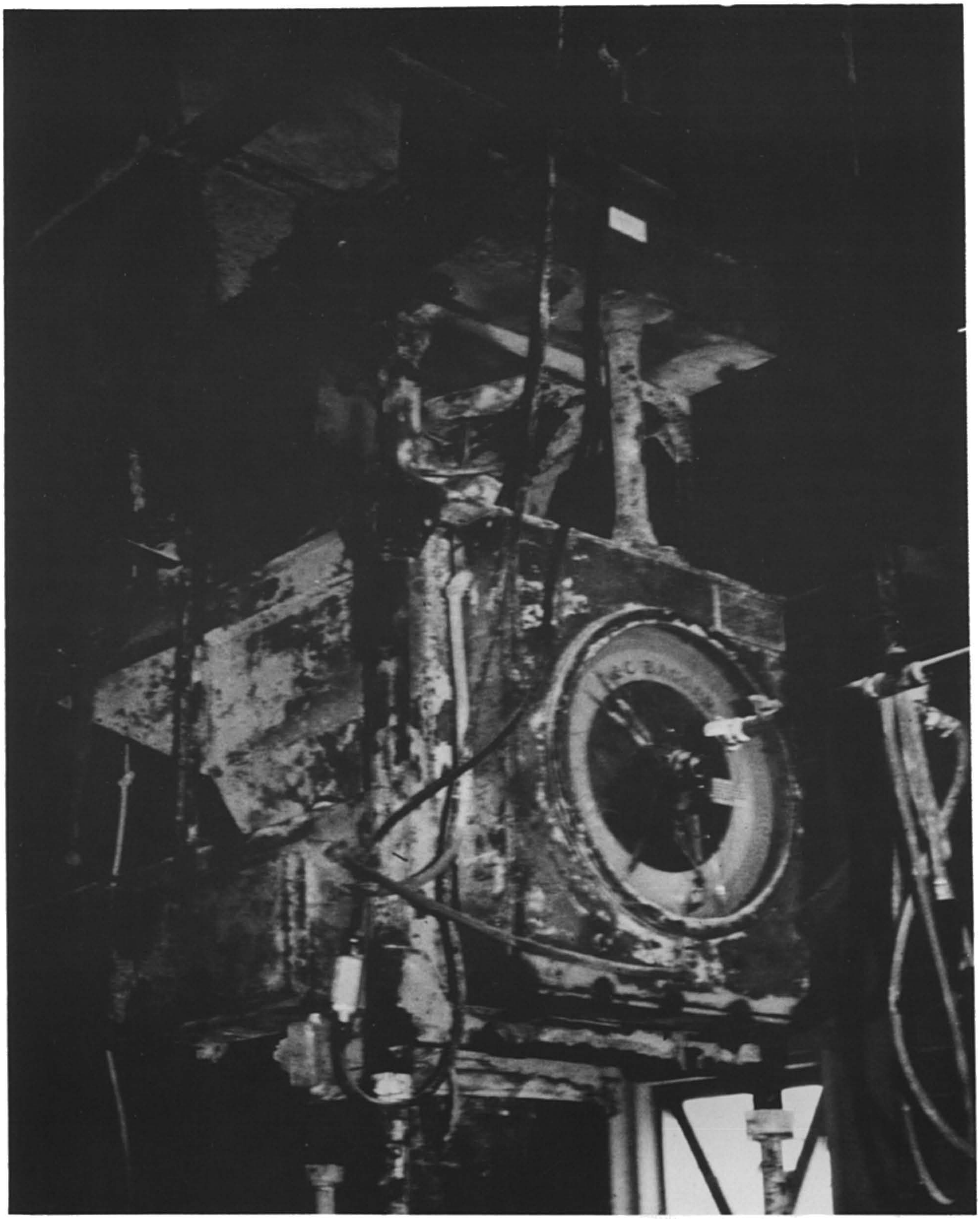
Early in this presentation, the term "shrinkage" was described as a euphemism. In this context, it would be an agreeable term for waste. We cannot afford waste, nor should we tolerate it.

Fertilizer is a valuable product in a world with increasing demand for food. Fertilizer production requires energy. There is no necessity to enlarge upon this. Correcting bag weights may be only one step, but it is a step in the right direction. At Swift, we feel it is a valuable one.

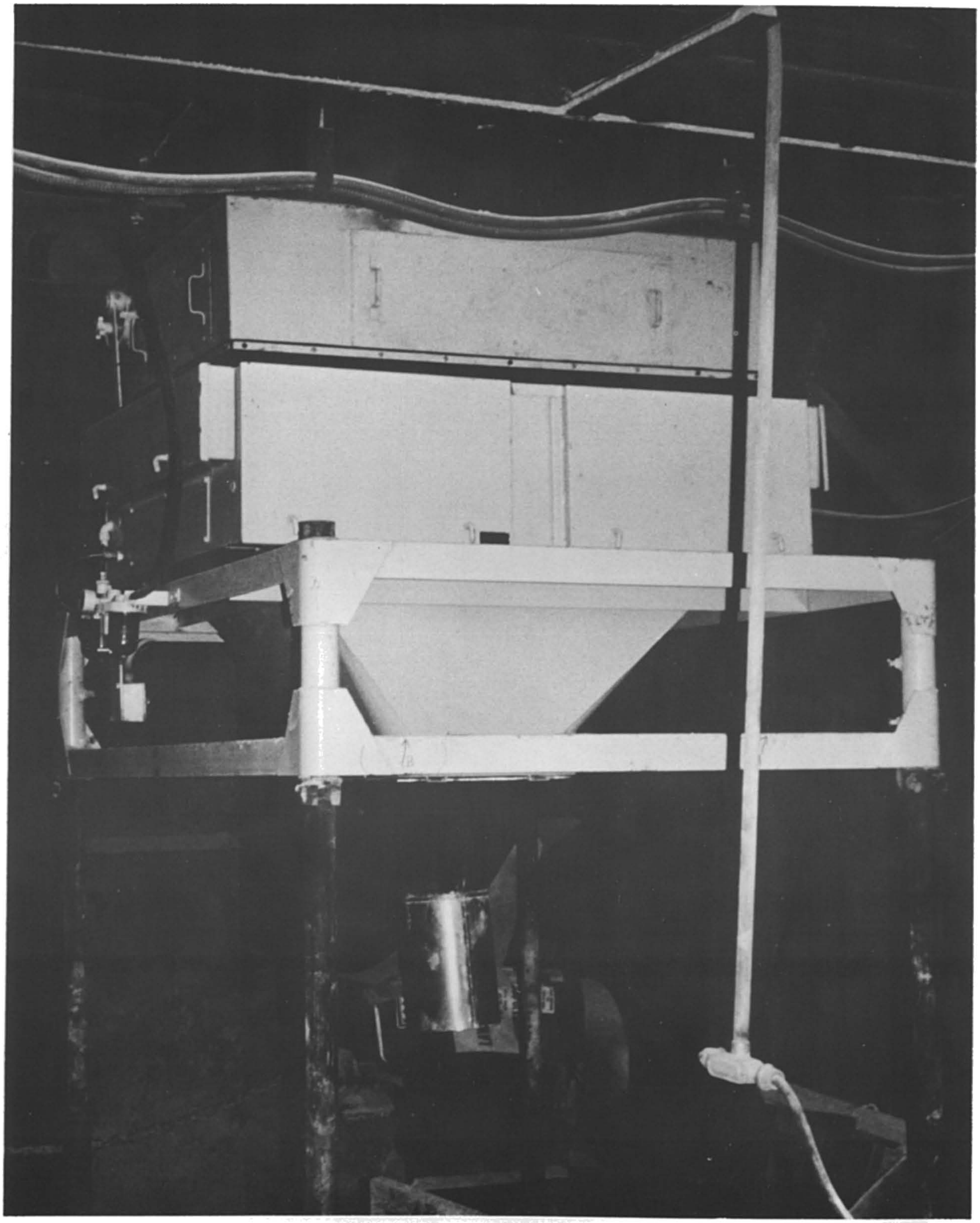
Please check Slides 1 thru 7 for additional visual information. Thank you. *(Applause)*

MODERATOR NEILD: Thank you Doug. That gets us right down to the very important factor of how to make a little extra money in the plant by reducing shrinkage.

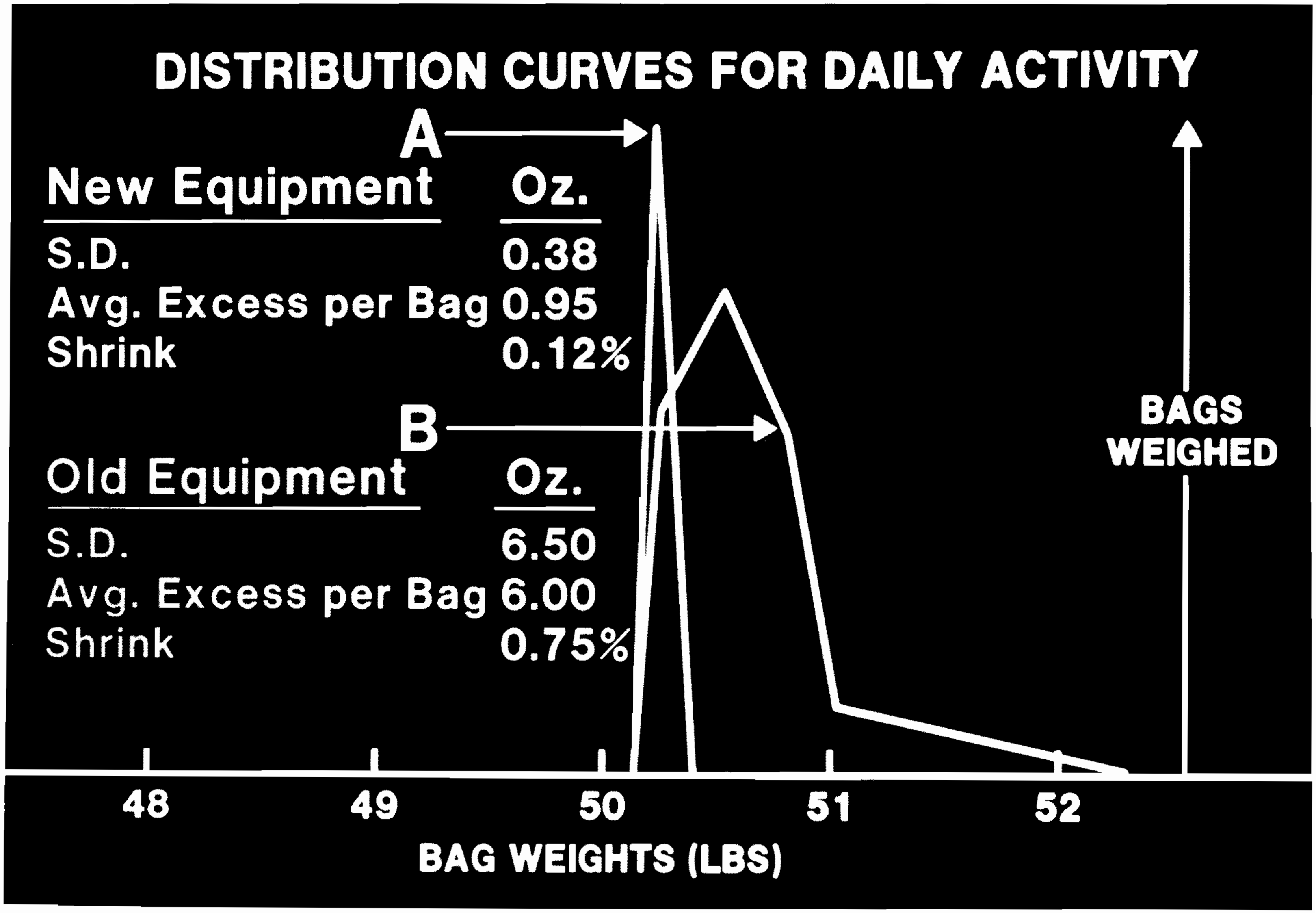
Note: Slides #1 thru #7
Pages #152 thru #158



Slide 1 - OLD WEIGHING EQUIPMENT



Slide 2 - DUPLEX SCALE 7300

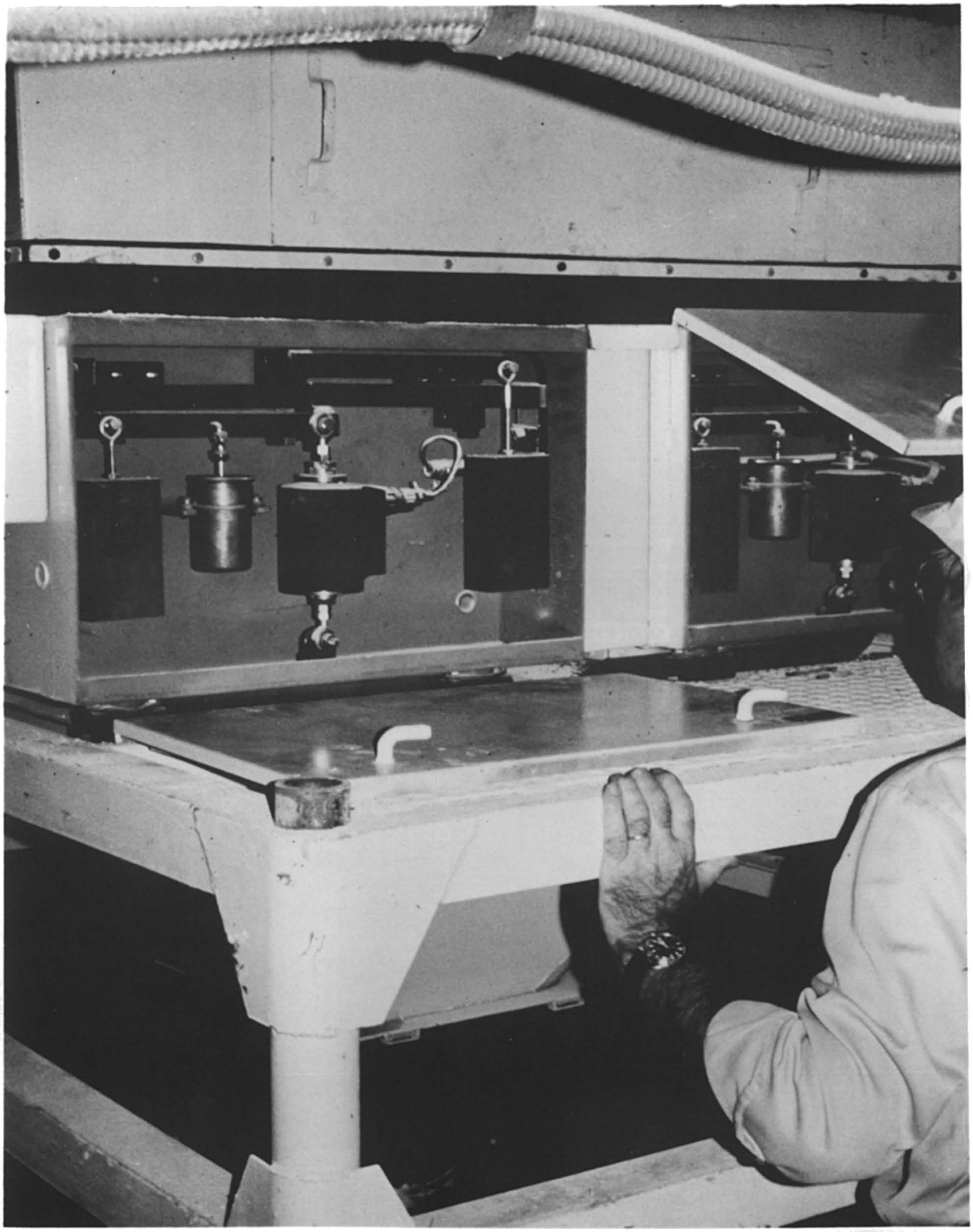


DISTRIBUTION CURVES FOR DAILY ACTIVITY

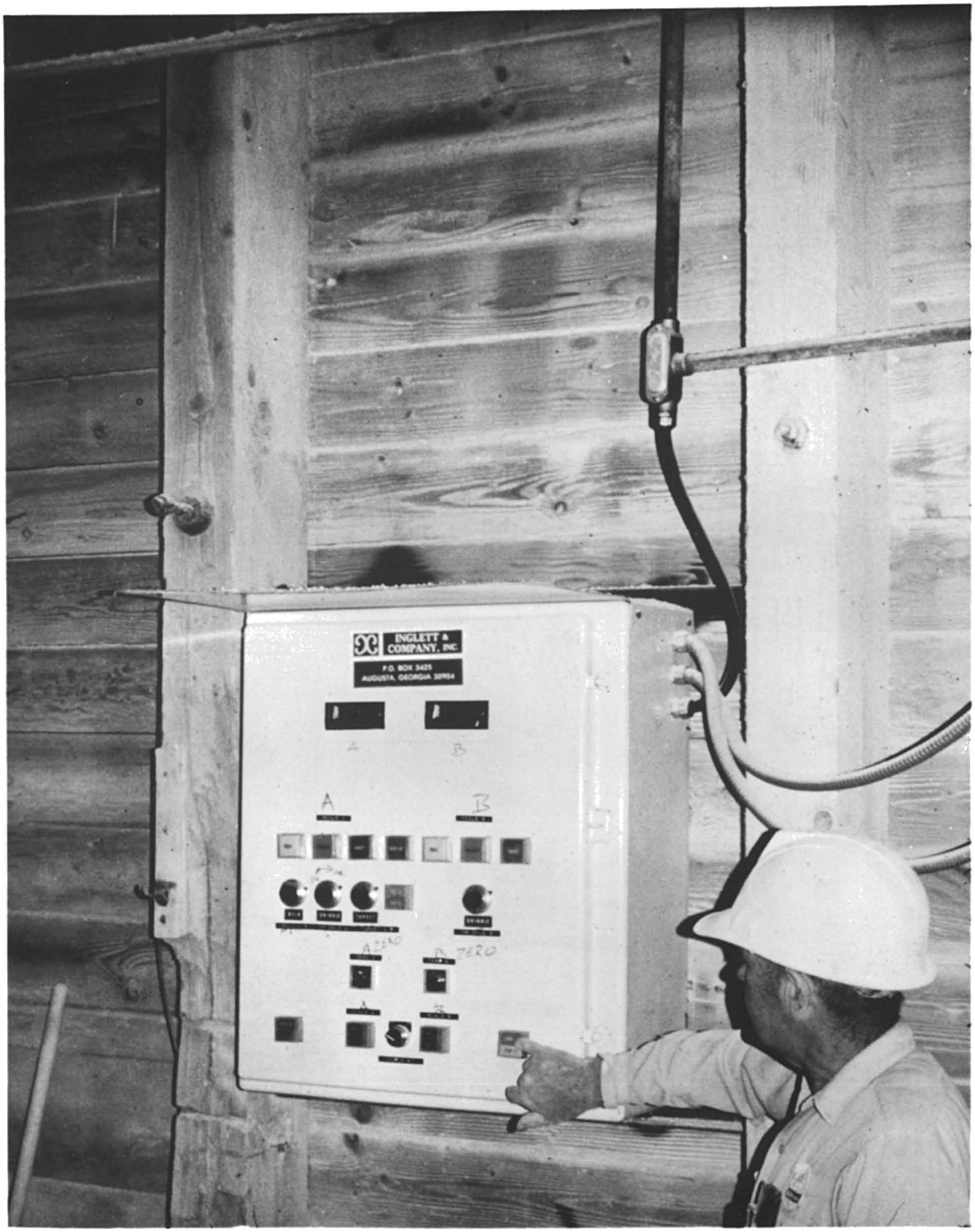
New Equipment	Oz.
S.D.	0.38
Avg. Excess per Bag	0.95
Shrink	0.12%

Old Equipment	Oz.
S.D.	6.50
Avg. Excess per Bag	6.00
Shrink	0.75%

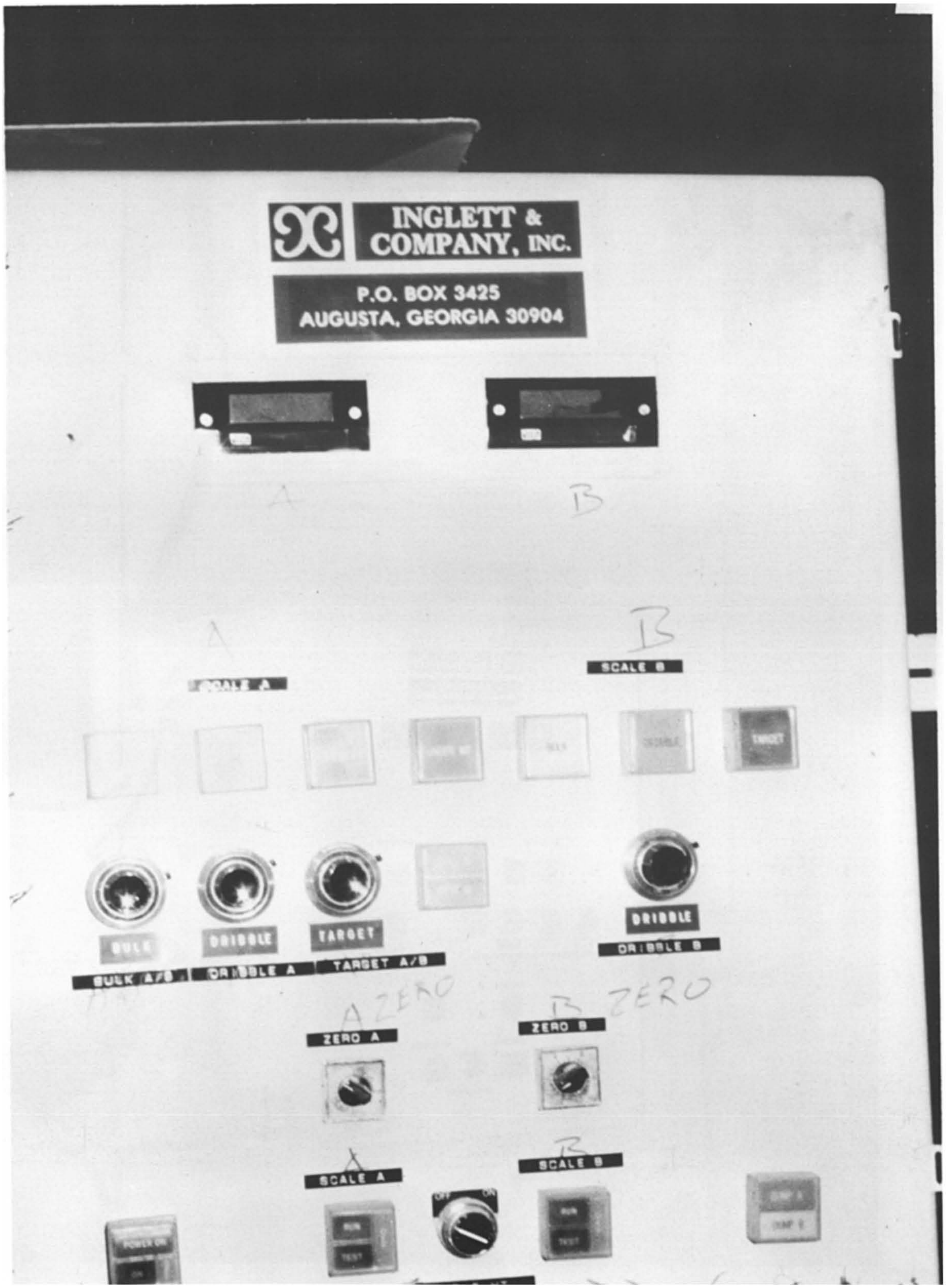
Slide 3 - COMPARISON OF NEW (A) and OLD (B) WEIGHING SYSTEMS



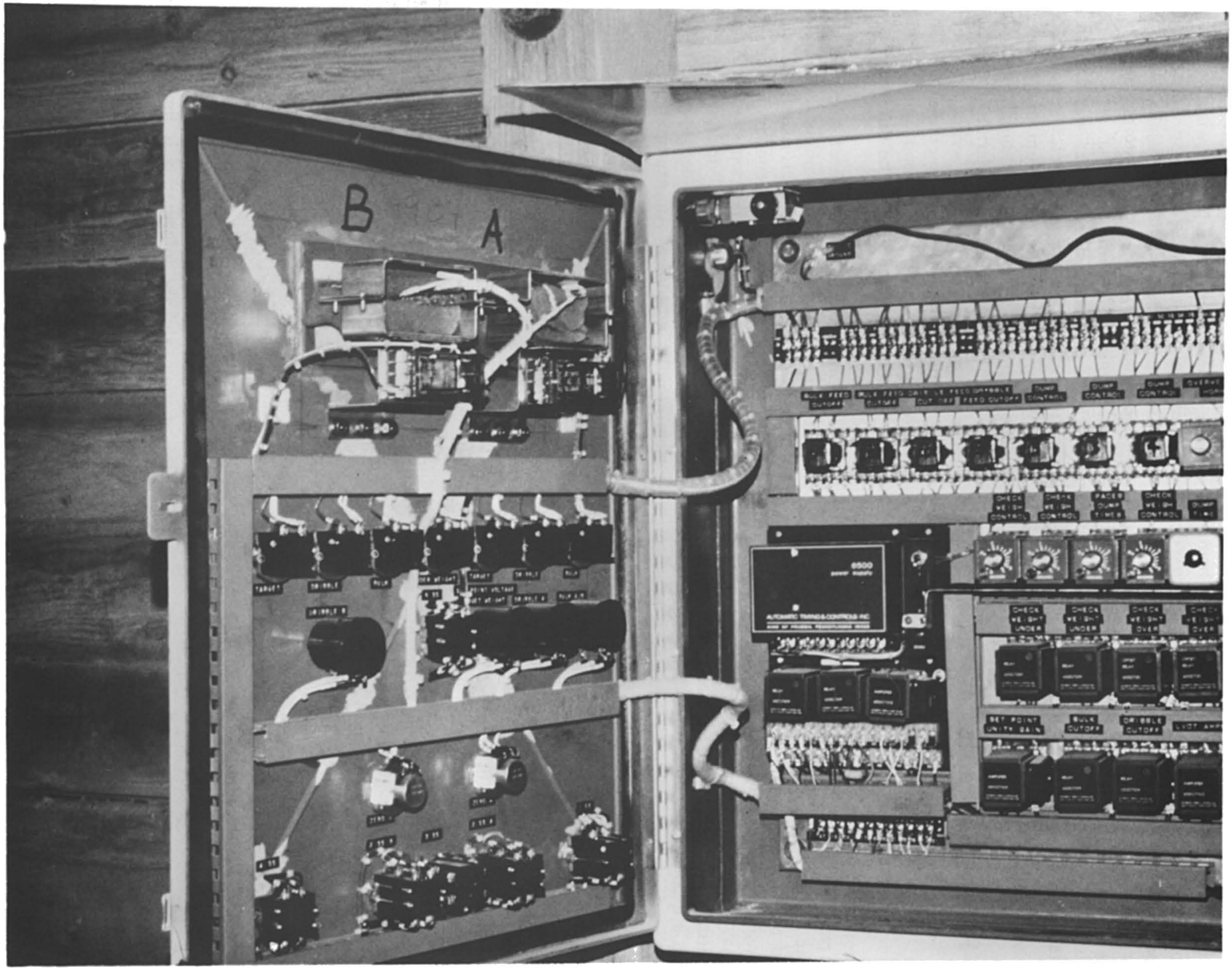
Slide 4 – LOAD CELL SENSORS DISPLAYED



Slide 5 - DUST TIGHT CONTROL PANEL



Slide 6 - CLOSE-UP OF CONTROL PANEL



Slide 7 - INTERIOR OF CONTROL PANEL

MODERATOR NIELD: Our next speaker is William Whatley of USS Agri-Chemicals. Bill has spent all of his fertilizer industry career with USS Agri-Chem, and the predecessor company, Armour. He has served as fertilizer plant manager, general office area production manager, and he is currently working as manager of materials useage and control. Bill is going to talk to us this morning on "Review of Quality Control in Granulation Plants." Bill. *(Applause)*

Review of Quality Control in Granulation Plants

W. D. Whatley

Introduction

The real significance of the expression "Quality Control" in a granulation plant is rarely ever fully comprehended by management or even by those to whom this responsibility is assigned. Customer satisfaction and promotional claims are fruits of a controlled process, but the primordial motivation for providing the customer with a quality product is financial. Quality Control in its broadest connotation is an economic business requirement, because the cost of materials bears such a high percentage of the cost of goods. A fertilizer manufacturer cannot afford the "luxury" of a process without controls. Nobody in production or selling has a greater product cost impact on fertilizer than the personnel involved with the activity of so-called quality control. This term is inseparably allied with process control, material selection in formulas, and yield control. In providing a controlled quality product, the operator has served well the interests of the customer, the governmental regulatory agencies, and his management.

It isn't difficult to comprehend the philosophy of quality control, understand the need for quality and accept the cost for providing it, but the challenge is to have a viable program. There are at least four basic elements of such a program:

(1) A definition of quality requirement, a predetermined expectation from the program;
(2) In-process disciplines to assure process control;
(3) A clear and understandable performance measurement mechanism;
(4) Decision criteria for acceptance or rejection of the product as made.

Even though each of these is a vital part of the program, only the second one, in-process disciplines, is strictly control. Strangely, production people themselves often view good control of quality as taking a large number of samples. Neither taking nor analyzing a sample is quality control, no matter how well done. Indeed, the function is necessary as a measurement of performance and in some cases as an aid to control. Therefore, before proceeding, let everyone understand what Quality Control is. Stated in layman's terms, Quality Control is the activity engaged in guiding a process in such a way as to result in a product with the desired attributes. Guiding a process means to change inputs or conditions as needed for desired results. A product is not "controlled" *after* it gets to its storage bin.

I. *General Quality Requirements*

The establishment of a product specification sheet, sometimes called product data sheet, is normally a function of a marketing group and not of production or sales personnel. Because of the commodity aspect of fertilizer and the behavior of the materials in process, production people have a vital role in writing product specifications. In addition to the product specification sheet provided for the customer, a good operator will also have "process specifications". The difference is in the purposes of the two.

The product specification sheet gives the customer a statement of the chemical and physical characteristics of his purchase. The guarantee is usually restricted to plant nutrient, primary, secondary, and minor. However, the product specification sheet also normally includes "Typical" and "Range" for nutrient content as well as particle size, moisture, density, and other data useful to the customer. An example of a "Product Specification Sheet" is shown as Exhibit A.

Process specifications give production criteria for meeting the product specification. The degree of proficiency in control of quality is almost entirely dependent upon how well the operator responds to in-process measurements to meet the process specifications.

The materials used in the process must be subjected to the same general criteria as listed under the product specification sheet, whether the material is received from an outside vendor or from another part of the Company's operation. Product analytical tolerances are usually the same as those listed by the Association of American Plant Food Control officials. It is good practice to use these same tolerances as upper limits as well. An example of Process Specifications is shown as Exhibit B.

II. *Quality Measurement*

Making a chemical or physical determination of the characteristics of a material or product only gives information; and the information is limited to the lot represented by the sample thus analyzed. It does not control quality. However, the need for this information is essential in five categories and for as many purposes. [Note: Detailed sampling and analytical procedures are beyond the scope of this paper.]

1. Assurance of raw material specification.

   The two purposes included in analyzing raw materials are to verify vendor's claim and provide basis for product formula calculation.

2. In-Process Analytical Service.

   This is the only category of assay related directly with *control.* The primary purpose of the local process lab is to provide promptly to the operational supervisor the analysis of what he is *currently* producing. This provides the opportunity to alter the material input and/or the process conditions. A product sample is normally taken about two hours after production on a shift has started and as often thereafter as required to assure compliance with process specification. A shift composite sample of the product is analyzed for purposes of formalizing the record of analysis for a given product or bin. This record also provides a means for performance reporting that will bee discussed later.

3. Product Quality Assurance.

   This inplies confirmation of a controlled process, proving to management that the product complies with the product specification. However, in the vernacular, it more often represents a record of the actual production and shipping analysis. In spite of this modified use, there is still merit in the expanded use of the term. It provides an expression of quality control performance as mentioned above. The quality assurance is in two parts: the record of the shift production assay by grade as analyzed by the local process lab and the record of the shipping assay by grade as analyzed by a central laboratory remote from the process lab. However, if the local lab is equipped with sufficient capacity and manpower, the assurance function can and often is handled in the same laboratory. The frequency of sampling production has already been mentioned as minimum. The frequency of shipment sampling can be determined by Table A, (military standards 105D for random sampling) or by the sampling of "Nth ton" without regard to grade. This "N" factor is determined by the analytical service available. However, the validity of the summarized data declines with the increase in the number of tons shipped between samples.

4. Confirmation of state analytical results.

   This is a minor consideration in providing analytical service, but it serves two purposes: it checks for errors that may be reported by the state lab and it collaborates its results with the state lab.

5. Laboratory collaboration, reliability check.

   There are several check samples used throughout the industry in collaborative work among participating labs, but there has to be a more timely collaboration between the local process lab of a company and its assurance lab. This is provided by a monthly check sample analyzed by each participating lab. The results and remedial action is coordinated by the assurance laboratory manager. Another collaborative check is the periodic (at least twice each week) duplication of assay by the process and assurance labs of production samples.

III. *In-Process Controls*

It should again be emphasized that the only point at which quality can be controlled is *while* product is being made. The fundamental consideration is to prepare for quality control by first using materials of known analysis and behavior in the process through measuring devices (meters, scales and feeders) of predetermined calibration. Additionally, provision must be made for the appropriate sparging arrangement and screening equipment. The second consideration is to provide in-process measuring devices and to provide procedures for responding to the measurement. There are four categories for in-process controls that require attention simultaneously:

1. Chemistry of Formulation and Material Compatibility.

   The formula must recognize ammoniation rates, critical humidity of material combinations, liquid phase and heat requirement. These criteria on formulation have been published by T.V.A., and they need not be repeated here. Additionally, various material solubilities must be taken into consideration in the heat and liquid phase requirement.

2. Metering and Weighing.

   Any proportioning device must have some means for monitoring its compliance with required input. For example, each liquid meter must have a chart recorder so that the operator can change flow as needed. The supervisor can also note any deviation in flow during a previous time.

3. Mixing and Sparging-Process.

   The attainment of homogeneity of materials in the ammoniator is vital to product quality. The distribution of the liquids in the mass is particularly critical. Here again, Frank Acorn and his associates at T.V.A. have published some useful criteria for sparger arrangements; the repitition here would serve no useful purpose.

4. Process Sampling.

   Frequent assay of process samples as described earlier is essential in guiding supervision in the required process changes.

IV. *Economics of Quality Considerations.*

The cost to maintain an effective quality control program is not easily isolated, nor is it the intention of this section to attempt any specificity. In the introduction to this paper, it was observed that the materials selection, yields, and process controls are all associated with the term "quality" because of common usage as well as its allied relationship. No company can expect to "save" money by elimination of state penalties, for the money spent on the program is more than *all* the state penalties. The purpose of having the program is to provide the customer with the expected value of the product at the lowest cost to the producer.

The program can be divided into three activity areas with their attendant costs:

1. Man Power Responsibilities.

   Control supervision (Chemical Services Supervisor, Quality Control Supervisor, etc.) are generally responsible to the plant manager for formulation, QUALITY CONTROL AND YIELDS. The plant personnel required also include laboratory technicians and samplers.

2. Training.

   The general principles of quality control are out lined in this paper, but each company needs a manual or formalized published program for its personnel. Periodically, small group seminars or work shops are useful in providing on-the-job training for new people as well as to serve as a refresher for established personnel.

3. Laboratory

   The equipment and reagents for the process laboratories as well as the assuranc e lab represent another function and cost in the program.

V. *Summary*

1. For an effective program of quality control, the first order of business is to set objectives and goals. One objective is defined in writing product specifications along with the establishment of a performance expectation expressed in terms that are measurable and attainable. Attainment can be measured in several ways. One is by comparing state penalties last year with the objective or goal for next year. This is good enough for a start, but for statistical reliability of a process, the measurement must be deviation against the guarantee and not the tolerance provided by a state law, which is often statistically quite arbitrary. A good control program measures performance in three categories: percent deviation from grade (actual analysis as percent of guarantee), average deviation (plus/minus) from grade expressed as percent, and coefficient of variation. These terms are defined in the TFI *Fertilizer Sampling* and *Analytical Methods,* Third Edition Method 702.
2. In the production, sale and use of commercial fertilizers, there are five basic points at which a chemical assay must be made, and others as needed by circumstance:
   a. Materials into process
   b. In-process, to control nutrient content of product
   c. Production, to record analysis of inventory
   d. Shipments, to assure compliance with specification
   e. State inspector, the final check point.

   Evaluation of the production assay whether the product is acceptable for sale or requires alteration or reformulation before shipment. If the shipping sample does not pass the minimum specification dicated by the program, the product can be recalled if able to identify it.
3. During production, the various input material recorders are carefully watched and values adjusted as required to keep them at target setting. Process samples of product are frequently taken, and the rate of material input is regularly changed in response to such information. The effectiveness of the control program is determined at this point.
4. The final judge of quality performance per se, however arbitrary the judgement, is the buyer of the product. This does not define the absolute performance soon enough or in quantitative terms. Performance can be quantified by the state regulatory agency but it too is not timely or statistically representative of the absolute performance.

   USS Agri-Chemicals makes a statistical summary of analytical performance, reporting each month separately for production (samples of composite shift analysis) and for shipping (as analyzed by the assurance lab). The summaries reported for each grade as well as the plant summary each month represent accumulated data for the calendar year. The statistical report for each grade provides information as follows: Average actual analysis, standard deviation, percent of grade (mean of the actual divided by the grade), the coefficient of variation (degree of control, or standard deviation as percent of actual mean). The report also indicates the results of the individual samples and a graphical pattern of those results. The plant summary lists Goal, Mean, S.D., A.D., C.V.%, and M/G% as described above. For an illustration of this "plant report card," Exhibits C & D show shipping analysis for one of the USS Agri-Chemicals plants on 08-24-24 and the plant summary, respectively. The summary in Exhibit D includes all grades shipped and indicates the following data on which the quality control performance was measured:

1. The coefficient of variation (C.V.%) as 5.0% 3.3% and 4.4% for nitrogen, P_2O_5 and K_2O respectively, which is a measure of how close the actual analysis is to the average.
2. The average deviation (A.D.) of 3.9%, 3.5% and 4.1% which is the average percent deviation each analysis was to the guarantee.
3. The percent of guarantee shipped (M/G%) as 101.5%, 100.6% and 101.5% respectively. Example, if 10-10-10 were shipped, the analysis would be 10.15-10.06-10.15.

EXHIBIT A

14-14-14 POWR PRILS

CHEMICAL ANALYSIS (WEIGHT PERCENT)

	Guarantee	Typical	Range
Total Nitrogen (N)	14.0	14.1	14.0-14.4
Ammonical		14.1	
Total Phosphate (P_2O_5)		14.1	
Citrate Insoluble P_2O_5		0.1	
Available P_2O_5	14.0	14.0	14.0-14.7
Water Soluble P_2O_5		13.0	
Potash (K_2O)	14.0	14.1	14.0-14.7
Sulfur (S)	10.0	10.0	
Coating Agent		0.5	
Moisture		1.5	

TYPICAL SCREEN ANALYSIS (WEIGHT PERCENT, TYLER)

+6	1.2
-6+14	96.8
-14	2.0

BULK DENSITY

Loose Bulk Density, lbs. per cu. ft.	59	58-64
Packed Bulk Density, lbs. per cu. ft.	65	

ANGLE OF REPOSE 32°

ACID FORMING EQUIVALENT

1365 lbs. Calcium Carbonate ($CaCO_3$)

SALT INDEX 67

DERIVED FROM

Phosphoric Acid, Ammonia, Sulfuric Acid, and Muriate of Potash

MANUFACTURED AND STORED

Manufactured: Cherokee, Alabama
Stored: Cherokee, Alabama

Exhibit A — Continued

14-14-14 POWR PRILS

This is a good general purpose topdress or preplant fertilizer for use where all three nutrients must be added.

(a) Its excellent physical condition makes calibration easy for accurate application.

(b) This is a popular topdressing where additional nitrogen applications are planned.

(c) This grade can be used as the basic plowdown material to meet soil requirements.

(d) Contains sulfur, a secondary element often found deficient in cotton and corn fields.

EXHIBIT B

Process Specifications for Granular Fertilizer

Grade:

All grades on approved standard grade list.

Analysis:

Minimum analysis is same as state requirements in area where fertilizer is marketed, or equivalent to AAFCO tolerances, whichever is closer to grade.

Product Moisture:

Maximum shall be:

Group I

1%	10-10-10, 10-10-20, 10-20-20, 12-04-08, 12-12-18, 13-13-13

Group II

1 1/2%	8-10-15, 08-16-16, 08-32-16, 10-06-04

Group III

2%	05-10-05, 05-10-15, 05-20-20, 06-12-12, 06-12-18 06-24-24

Group IV

3%	0-25-25

Particle Size:

U. S. Standard mesh sieve analysis shall not exceed:

Mesh	Group I & II	Group III	Group IV
+6	3%	5%	5%
-16	7%	8%	10%
-20	1%	2%	3%

EXHIBIT C

FERTILIZER - CHEMICAL - ANALYSIS - VARIATION

```
8-24-24                    SHIP. SAMPLES FOR PERIOD FROM  1/ 1/76 TO  9/24/76

NO. SIEVE  H2O    N     P     K

  30  0.0  0.0  8.21 24.37 23.39
  43  0.0  0.0  8.10 23.87 24.98
 270  0.0  0.0  8.08 24.51 24.16
 304  0.0  0.0  8.11 23.82 24.96
 360  0.0  0.0  8.06 24.99 23.19
 485  0.0  0.0  8.05 23.20 25.55
 498  0.0  0.0  8.12 24.52 24.42
 503  0.0  0.0  7.90 25.22 23.76
 576  0.0  0.0  7.88 24.27 24.61
 680  0.0  0.0  8.14 24.96 23.37
 698  0.0  0.0  8.57 22.32 22.41
 733  0.0  0.0  8.19 23.62 25.05
 821  0.0  0.0  8.06 23.71 25.16
1065  0.0  0.0  8.19 23.88 25.49
1086  0.0  0.0  8.68 25.15 23.21
1111  0.0  0.0  7.67 23.31 26.03
1258  0.0  0.0  8.08 24.52 24.07
1321  0.0  0.0  7.95 23.54 24.30
1493  0.0  0.0  8.42 23.31 25.12
1642  0.0  0.0  7.98 23.62 23.99
2037  0.0  0.0  8.52 24.05 23.69
2048  0.0  0.0  8.46 24.82 24.14

AVER.  0.0   0.0   8.16 24.07 24.32
S. D. 0.0    0.0   0.244 0.737 0.914
A. D.14.000 1.000 0.212 0.599 0.774
M/G%    0.0    0.0 101.9 100.3 101.3
C.V.%   0.0    0.0   3.0   3.1   3.8
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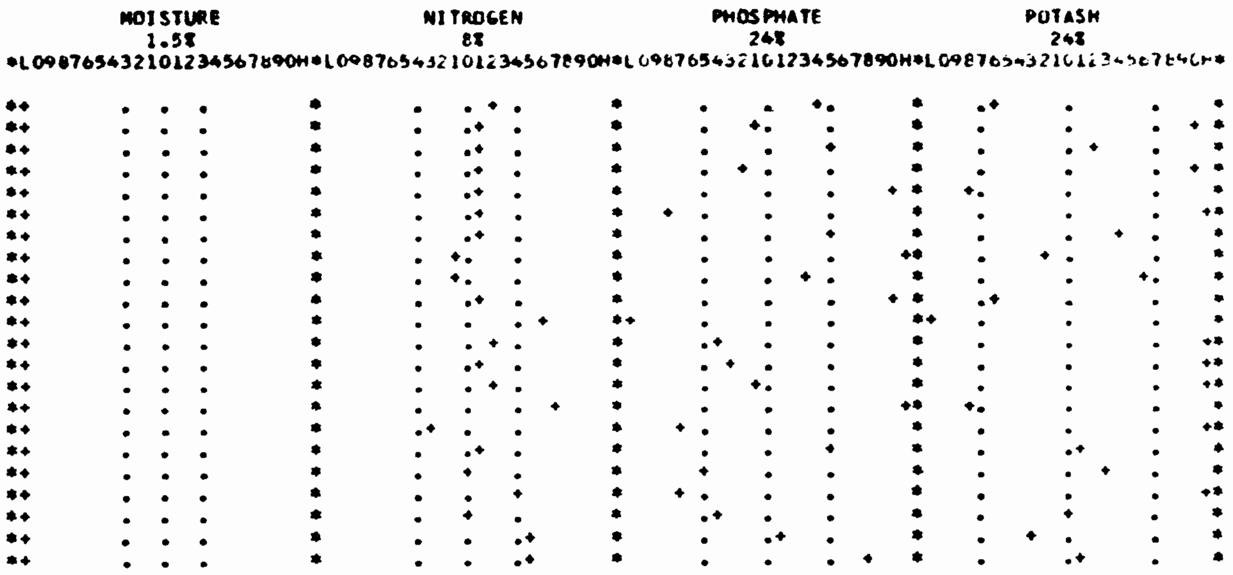

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MIN  0.0   MAX  0.0      MIN  7.67  MAX  8.68     MIN 22.32  MAX 25.22     MIN 22.41  MAX 26.03
    RANGE  0.0               RANGE  1.01              RANGE  2.90              RANGE  3.62
LO 22, OK  0, HI  0.     LO  0, OK 18, HI  4.     LO  4, OK 13, HI  5.     LO  3, OK 11, HI  8.
```

EXHIBIT D

PERIOD FROM 1/1/76 TO 7/23/76	N	P	K
GOAL	7.374	13.725	14.817
MEAN	7.481	13.802	15.033
S.D.	0.376	0.458	0.670
A.D.%	3.906	3.534	4.103
C.V.%	5.029	3.320	4.457
M/G%	101.46	100.56	101.46

<u>Free Acid</u>: Minimum Free Alkalinity shall be 0.2%

Analytical determinations in terms of percent sulfuric acid by the water-wash method, with methyl orange indicator.

<u>Curing Time</u>: Minimum time between production and shipment shall be:

All Specialty Grades 3 Days
All Organic Grades 3 Days
All Other Ammoniated Grades - 1 Day

<u>Physical Appearance</u>:
All particles shall be homogeneous. No unagglomerated materials shall be present.

<u>Sampling</u>: Production sampling shall be by automatic sampler in proper operating condition, cleaned between grades. The automatic sampler's cycle should not be even multiple of production time per ton.

Production and shipping sampling frequency shall be by established standards.

<u>Laboratory Analysis</u>: Shall be made by NPFI methods.

Suggested Process Specifications and Operating Conditions for Granulation Unit

Weighing and Metering Equipment shall be maintained to an accuracy of 1%. Dry material feeder shall be operated within this limit by checking as often as necessary (about every 2 hours).

Ammoniator spargers shall be replaced when hole enlargement reaches 50%. All holes shall be kept open for proper distribution of liquids. Ammoniator discharge temperature shall be a minimum of 200 degrees F.

Dryer and *Cooler* flights, fan, ducts and cyclones shall be kept clean. Product temperature at dryer discharge shall be a minimum of 200 degrees F., but as low as possible (above 200 degrees F.) to meet product moisture specifications. Cyclone discharge closure shall be maintained with a tight air seal.

Screens shall be kept clean and free of enlarged openings. Flow of material on the screens shall be evenly distributed. Raw material screen shall not be a coarser mesh than the largest particle size in product specifications.

Belt Conveyors SHALL BE CONSTRUCTED AND MAINTAINED SO THAT THERE WILL BE NO PRODUCT OR MATERIAL SPILLAGE THAT WILL RESULT IN CONTAMINATION AND POOR YIELDS. Any spillage shall be promptly picked up and returned to process or storage, whichever is appropriate.

Recap of Discussion

Introduction

I. *General Quality Requirements*
    1. Material & Product Specifications, chemical & Physical
    2. Process Specifications

II. *Quality Measurement*
    1. Assurance of Raw Materials Specifications
    2. In-Process Analytical Service
    3. Product Quality Assurance
    4. Confirmation of State Analytical Results
    5. Laboratory Collaboration, Reliability Check

III. *In-Process Controls*
    1. Chemistry of Formulation & Material Compatibility
    2. Metering & Weighing
    3. Mixing & Sparging — Process
    4. Process Sampling

IV. *Economics of Quality Considerations*
    1. Manpower & Responsibilities
    2. Training
    3. Laboratory

V. *Summary*
    1. Objectives Determined at Outset
    2. Quality Measured at Various Stages
    3. Suitable Responses to In-Process Measurement
    4. The Quality Report Card

Thank you. *(Applause)*

MR. JOHN S. NEILD — MODERATOR: Are there any questions now for Bill? Anyone have any questions you would like to ask about this program? Looks like you could make a little bit of money on selling those copies there, Bill. Everyone would like to have a copy. I realize one of the disadvantages now of being a moderator. You don't get a chance to see the slides.

Thank you Bill Whatley for a most magnificent detailed interesting and valuable discussion "Reviewing Your Recommendations For A Quality Control Program In Granulation Plants".

O.K. Gentlemen, let's move on with our program. We're just about on time; let's try to keep it that way. Our next speaker I. W. McCamy from TVA, will be talking to us in just a minute on "The Use of Urea in Granulation Plants World Wide." He is a native of Alabama. He received his degree in chemical engineering from Auburn University in 1941.

He joined TVA at Muscle Shoals, Alabama, in 1945 and worked with their process development and process engineering branches. His fertilizer experience includes working with the crystallization process with ammonium nitrate and DAP, granulation processes utilizing drum, pan and pug mill type granulators, and most of his experience involved work with ammonium nitrate and urea based products. He has also worked with sulfur coating of urea, use of pipe reactors in production of fluid fertilizers and is currently involved in pilot plant and plant scale granulation work with the melt granulation process. I would like to present to you I. W. McCamy. *(Applause)*

Worldwide Use of Urea in Granulation Plants

By

I. W. McCamy and G. C. Hicks

Presented by I. W. McCamy

Worldwide urea production capability was increased rapidly in the last decade, and production of urea in the United States has nearly tripled during the same period. However, relatively little urea is used in granulation plants to produce compound fertilizers, and most of the urea-based granulation facilities are located outside the United States. The object of this paper is to review and summarize work that has been reported on this subject. It is hoped that this information will serve as a guide in the use of greater quantities of urea in compound fertilizers.

Successful granulation has been accomplished with superphosphate-based formulations and with ammonium phosphate-based formulations in conventional drum or blunger granulation systems. Also, pilot-plant studies have indicated that urea-ammonium phosphate (UAP) grades can be produced in a pan granulator. Products made by these processes require a drying step to reduce the moisture level in the products sufficiently for good storage characteristics. Several urea-ammonium phosphate grades have been produced by melt-type processes that do not require a drying step. Incorporation of potash lowers the critical relative humidity of the urea-based products, and the NPK grades should not be exposed to humid conditions.

Urea-Superphosphate System

When urea and unammoniated superphosphate are mixed, the urea and the monocalcium phosphate monohydrate in the superphosphate react to form an adduct[1] releasing the water of crystallization. Some moisture must be present for the reaction to start; this moisture plus that released in the reaction forms a saturated solution that causes a sticky condition and excessive agglomeration. Granulation is very difficult to control because the reaction apparently is relatively slow. As a result, granulation has been noted to continue throughout the dryer and part way through the cooler. Hemsley and Ward[2] reported that sticky conditions can be avoided by raising the pH to at least 4.5. They added chalk (calcium carbonate) to increase the pH. Young and Davis[3] reported in 1973 on the use of partial ammoniation to prevent the sticky condition. Results of pilot-plant tests in which ordinary superphosphate (OSP), diammonium phosphate (DAP), urea, potassium chloride (KC1), and ammonia were used to produce 14-14-14 grade showed that granulation was satisfactory in all tests in which the degree of ammoniation of the OSP was between about 0.8 and 3.5 pounds of ammonia per unit of P_2O_5 in the OSP. Degrees of ammoniation below 0.8 pound of ammonia per unit of P_2O_5 from OSP resulted in unsatisfactory operation because of persistent stickness of the material. Degrees of ammoniation above 3.5 resulted in a sandy-like product containing insufficient onsize material. In tests of 10-20-20 and 16-16-16 in which triple superphosphate (TSP) and DAP supplied all the P_2O_5, data indicated that a degree of ammoniation of about 1 pound per unit of P_2O_5 in the TSP would give satisfactory granulation. Granulation was promoted in most tests by the use of steam to provide heat and liquid phase above that supplied by the ammoniation reaction. In some tests, small to moderate amounts of sulfuric acid were added for supplemental heat and liquid phase. With sulfuric acid added at a rate of 125 pounds per ton, no steam was required for granulation.

Clur et al.[4] reported in 1961 on plant-scale tests of the use of urea in compound fertilizer based on OSP (5-15-5 grade). Their studies showed that there was an upper ammoniation limit beyond which granulation decreased and the granules became very small and had a gritty feel and appearance. The recycle would then increase until it became impossible to continue operation. Usually, the limitation was about 3.8 pounds of ammonia per unit of P_2O_5.

In 1956, Jensen[5] reported work done at DuPont using a urea-ammonia-water solution first on a pilot-plant scale and then on a plant scale. On both scales of work, the equipment used and the process tested resembled that of the TVA process. In the pilot-plant studies, the production rate was about 0.5 ton per hour. four formulations were tested, 8-16-16, 10-10-10, 5-20-20 with all the nitrogen from solution 455 (31-0-43)[1], and a 10-10-10 with about 7-1/4 units of nitrogen from the same solution and 2-3/8 units from ammonium sulfate. The formulated pounds of ammonia per unit of P_2O_5 was five for the OSP and three for TSP. Sulfuric acid (60 degrees Be) was added to neutralize the excess ammonia. In the 5-20-20, the acid was necessary only for increasing the temperature. Granulation efficiency was increased by the addition of water, about 8 to 9% for the 5-20-20 and 2 to 4% for the other grades. Satisfactory granulation was achieved for all grades and no great technical difficulties were encountered. The form and the strength of the granules were satisfactory.

In the plant-scale tests, only a formula for 6-24-12 with solution 455 (31-0-43) was tested. In the early phase of operation, difficulty was experienced with the product going to fines and a progressively lower and lower yield of granular product. After adjustments were made, granulation proceeded satisfactorily and granulation yield was greater than 76% minus 4 plus 20 mesh when considering the plus 4-mesh granules would be two-thirds in the range of minus 4 to plus 20 mesh after crushing.

Phillips et al.[6] reported in 1957 on pilot-plant studies made to compare ammoniating solutions containing ammonia and urea with ammonia-ammonium nitrate solutions for use in the production of granular fertilizer. The widely used ammonia-ammonium nitrate solution 406 (22-65-0) and 408 (26-56-0) were used as the standard for comparison. Ammonia-urea solution 453 (31-0-43) and ammonia-urea — ammonium nitrate

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[1] United States designation in which the value in front of the parenthesis is 10 times the nitrogen content; the values within the parenthesis are percent ammonia, ammonium nitrate, and urea, respectively.

solution 444 (25-56-10) as well as an ammonia-urea solution 455 (24-0-43) containing 15% ammonium carbonate, were tested in production of 5-20-20, 6-12-12, 8-16-16, 10-20-20, and 12-12-12 grades of fertilizer. In the 12-12-12 studies, two or four units of nitrogen were supplied as either crystalline ammonium sulfate or crystalline urea. The tests were made in the TVA ammoniation-granulation pilot plant.

Operation with solutions containing ammonia, ammonium nitrate, and 10% urea was about the same as with solutions containing only ammonia and ammonium nitrate. With solutions containing urea but no ammonium nitrate, granulation usually occurred at a higher input moisture content, temperatures were lower, and the products contained more moisture before drying. The urea solutions containing ammonium carbonate (15%) usually gave lower temperatures in the granulator than those without the carbonate for the low-nitrogen grades (5-6%), and granulation efficiency was slightly higher with the solutions containing urea. For the products containing 8 to 12% nitrogen, granulation efficiency was about the same with the solutions containing urea as with the nonurea solutions. The storage properties of the products were about the same except that those products made with urea solutions had a harder bag set. In most cases, the moisture content of the undried products made with the ammonia-urea solutions was higher because of the greater proportion of water in this solution. Data indicate that ammonia loss and loss of P_2O_5 availability (less than 1.5%) were not influenced by the type of solution.

Kuwabara and Hatakeyama[7] reported that Mitsui Toatsu Chemicals, Incorporated, started production of urea-based compound fertilizers in Japan in 1950. At that time, OSP was the source of the P_2O_5. The OSP, urea, ammonia, and KC1 were the main raw materials, and typical product grades were 18-11-0, 11-12-7, and 10-10-10. The production plant was small-scale and the operation was partly batchwise. In recent practice, the OSP has been largely replaced with ammonium phosphate; plants produce 50,000 to 100,000 tons per year of high-analysis fertilizers, such as 28-28-0, 18-18-18, 17-22-17, and 20-12-21.

Hignett[8] described three plants in Great Britain that use urea and superphosphate in formulations. In one of the plants, high-analysis grades, such as 20-10-10, 13-13-20, and 15-15-15 were produced at 7 to 8 tons per hour using urea, ammonium sulfate, monoammonium phosphate (MAP), DAP, OSP, and KC1. Gas flames were used in this plant along with steam to supply heat and liquid phase for control of granulation; two gas flames were used near the feed end of the granulator. Quoting Hignett's conclusion:

> *Use of urea and superphosphate in formulations for compound fertilizers is feasible and techniques are fairly well developed. Upgrading the products by addition of ammonium phosphate or phosphoric acid and ammonia is a common practice (in United Kingdom). The water solubility of the P_2O_5 in the products is maintained at or above 90% by limiting the amount of ammonia or diammonium phosphate to that which will reactt with the free acid in the superphosphate to form monoammonium phosphate. When acid is added, ammonia addition is similarly limited to that needed to neutralize the acid, including free acid in superphosphate. Means of supplying heat for granulation include heat of reaction of sulfuric or phosphoric acid with ammonia, steam injection, and gas flames. Sometimes, a combination of these is employed. Means for securing better inforporation of urea into the granules may need further study.*

Sharples[9] described granulation experience in 22 plants during development of urea-based compound fertilizers. It was found that granulation was difficult when urea was in the range of 10 to 18% by weight. Granulation became progressively easier as urea was increased from 18 to 30%. The use of prilled urea instead of crystalline urea was advantageous because of the larger size of the prills. This gave less tendency to solubilize the urea in the granulator and in the dryer where granulation was completed. Granulation results were better when TSP was used than when OSP was used because of the lower water content and lower free acid in the TSP. It was advantageous to keep the proportion of superphosphate and ammonium phosphate above 40% of the formulation weight and the weight ratio of ammonium sulfate (crystals) to urea at 1:1. Drying in co-current dryers is the key operation in making good urea fertilizers. The temperature should be controlled to plus or minus 2 degree F. as the very outside limits. It is recommended that the product be dried to 0.3% moisture content and that bulk storage areas have controlled humidity.

In 1972, Achorn and Livingston[10] described preliminary operation of a commercial plant in Brazil using a low-pressure, high-water-content urea-ammonia solution (UAL). Grades containing 100 to 350 pounds of UAL solution per ton of product were produced at rates of about 30 tons per hour. Steam was used to give a granulation temperature of about 160 degrees to 180 degrees F.

Hydrolysis of Urea — Processing and Storage

Hydrolysis of urea forms ammonia and CO_2. Clur et al.[4] state that hydrolysis of urea in the dryer resulted in continued and further ammoniation of the OSP and increased the reversion of water-soluble phosphate to citrate-soluble P_2O_5. Figure 1 shows the effect of product temperature and retention time in the dryer on hydrolysis.

Jewell[11] studied decomposition of urea and decrease of water-soluble P_2O_5 during storage of laboratory-scale mixtures containing urea and OSP. The urea content of the mixtures was from 2 to 15%. The OSP was about 45% of the mixture which had a normal grade of 10-10-18. There was very little decrease in the urea content of mixtures containing 1% moisture during storage for as long as 100 days at a temperature of 95 degrees F. When stored at 140 degrees F. for 80 days, the urea content decreased from about 2.0 to 4.5 pounds per 100 pounds of mixtures as the initial urea content was increased from 2 to 15 pounds. The ammonia formed during hydrolysis ammoniated the OSP and decreased the proportion of water-soluble P_2O_5. The water-insoluble P_2O_5 formed was soluble in neutral ammonium citrate solution.

Phillips et al. [6] reported that no appreciable amount of urea was hycrolyzed during processing of several grades of mixed fertilizer containing urea and superphosphate. Ammonia was added to the superphosphate during granulation. Hydrolysis of urea during storage was determined on two 12-12-12 products formulated with eight units of nitrogen from a solution containing urea and four units from solid urea. Moisture content of products was 1 and 3%. Hydrolysis of urea during 60 days of storage ranged from about 5% at 100 degrees F. to about 30% at 180 degrees F. Hydrolysis was slightly less in the product with 1% moisture than in the product with 3% moisture (Fig. 2).

Urea-Ammonium Phosphate System

Meline et al. [12] described pilot-plant studies of cogranulation of urea and DAP in a drum-granulation process. Except for the addition of urea, the process is essentially the same as that developed by TVA for the production of granular DAP [13]. The urea was introduced as a concentrated solution (83-98%), prills, or crystals. The phosphoric acid was fed to the preneutralizer where about two-thirds of the ammonia was introduced to give an ammonia-phosphoric acid mole ratio of about 1.4:1 which is near the point of maximum solubility. This ratio, therefore, allows the use of the maximum concentration of the ammonium phosphate slurry. The preneutralized slurry was fed to the rotary drum granulator where the urea and the remainder of the ammonia were added. Granulation was controlled by adjusting the proportions of material recycled to the rotary drum. The product was dried and then cooled in conventional rotary equipment. Drying was the most difficult and critical step in the process because of the low melting point of the urea (271 degrees F.). The form in which the urea was introduced affected the recycle requirement. The use of prilled or crystalline urea required less recycle than the use of urea solutions. When urea solutions were used, the proportion of recycle required decreased as the concentration of the urea solution increased and ranged from about 3 to 5 pounds per pound of product. When a 1:1:0 ratio material (29-29-0) was produced using urea prills, the recycle ratio was only about 2.5.

The Coromandel plant in India [14, 15, 16] was the first of several commercial-scale plants based on the use of the DAP slurry process with the addition of urea to produce grades such as 28-28-0. When the plant was first started, it was demonstrated that straight DAP could be made without serious granulation problems. When urea was added, small variations in slurry feed and recycle rates or in slurry distribution pattern resulted in either large, wet lumps or in a dry granulator product with large proportions of uncoated urea prills. A significant improvement in granulation was made by modifying the slurry distribution system. A spray nozzle pattern was developed that was far superior to the saw-tooth distributor. Ammoniation in the granulator usually had a beneficial effect on granulation. It was found advantageous to use gaseous ammonia instead of liquid ammonia. Drying is a critical step and the temperature must be controlled to maintain a dryer product temperature around 160 degrees to 170 degrees F. The dryer inlet air (cocurrent) is limited to 392 degrees F. In 1975, it was reported by Krishnaiah et al. [17] that the manufacturing facilities, including the UAP plant, are to be revamped to obtain greater capacity. Prior to revamping, the plant, which was designed for 42 tons per hour, has consistently operated well above 150% of the design capacity without many problems.

Two other large complexes have started operation in India since the Coromandel complex. The construction of the Madras Fertilizers Limited urea-diammonium phosphate plant was completed in July 1970 [18]. There are two trains, each capable of producing in excess of 35 tons per hour of grades 17-17-17, 14-28-14, 28-28-0, and 24-12-12. The plant design is that of a typical DAP plant (see Fig. 3). One train has a TVA-type drum that is 10-feet in diameter and 20 feet long. The other train uses a blunger that is 5 feet wide and 12 feet long.

The NPK plant at Indian Farmers Fertilizer Cooperative Limited (IFFCO), Kandla, went into production in November 1974 [19]. It has two trains, each train being capable of production rates in excess of 50 metric tons per hour of product when making 10-26-26 grade. One train of the plant is equipped with a drum granulator and the other with two blungers. The recycle ratios vary between 3:1 and 7:1, depending upon grade. For high urea grades, the air to the cooler is slightly heated.

Young and McCamy [20] reported in 1967 that UAP grades 29-29-0, 33-20-0, and 34-17-0 were granulated satisfactorily in the TVA pilot-plant pan-granulation system. In this work, concentrated urea solution (96-98%) and ammonium phosphate slurry from a preneutralizer were sprayed separately onto recycle material in the pan granulator. Phosphoric acid was preneutralized in a reaction tank with gaseous ammonia to an

NH_3:H_3PO_4 mole ratio of about 1.35:1 in the production of the ammonium phosphate compound. The granular product was dried, cooled, and sized at minus 6 to plus 10 mesh. Granulation efficiency was high, but the compartively high moisture content of the combined fluid feed (20-26% for the ammonium phosphate slurry and 2% for the urea) required recycle ratios that ranged from 3:1 to 5:1. The products that dried to a moisture content of about 0.6% stored satisfactorily when conditioned with 2% clay or diatomaceous earth. Production of UAP products in a pan-granulation system appears to be feasible, and the pan may have advantages over the rotary drum or pugmill for N:P_2O_5 ratios of 2:1 or higher.

Melt-Type Granulation Processes

In recent years, TVA has developed simple melt-type processes that may be utilized for producing urea-based compound fertilizers. Lee et al. [21, 22, 23] described a process involving the use of a pipe reactor and pugmill for production of ammonium polyphosphate (APP) or UAP. After successful pilot-plant operation was established, a demonstration plant was built. This plant, which had a capacity of 400 tons per day of 28-28-0 or 300 tons per day of 35-17-0 product, had logged almost 3 years of successful operation by the fall of 1976. (A process flowsheet is shown in Figure 4.)

In the TVA demonstration plant, APP melt containing about 25% of the P_2O_5 as polyphosphate is produced in a pipe reactor at about 425 degrees F. This melt is fed to a pugmill-type granulator with recycled solids to produce the 11-55-0 product. When the 28-28-0 or 35-17-0 grades of UAP are produced, urea solution concentrated to about 99% by weight at about 280 degrees F. is also fed to the pugmill. The granular material is cooled, the product-size fraction is separated, and the oversize material is crushed. Entrained dust in the air from the cooling and other solids-handling equipment and fluorine evolved from the APP reaction system are recovered in wet scrubbers using recirculated water solution which is fed to the pugmill. Problems during startup were corrosion in the reaction system and high power requirements for the pugmill.

In other pilot-plant work at TVA [24], a pipe reactor and a drum granulator were used to produce granular UAP and NPK products. The ammonium phosphate component was produced from phosphoric acid and ammonia, and the urea was introduced either as a melt or as solid urea and potassium chloride supplied the K_2O component. Grades such as 19-19-19, 12-24-24, and 15-30-15 were produced; usually between 20 and 30% of the P_2O_5 was in the polyphosphate form.

A few pilot-plant tests were made in which a pipe-cross reactor and a drum granulator were used to make granular 33-11-0 product [25]. The pipe-cross reactor is a variation of the TVA pipe reactor in which an additional side branch is used to feed sulfuric acid into the reactor. The sulfuric acid mixes with the phosphoric acid in the pipe-cross reactor before reacting with ammonia in the reaction tube. Provisions also were made to add controlled quantities of water with the ammonia to control the reaction temperature and thereby control the polyphosphate content of the reaction product. The urea component was in the form of melt sprayed onto the bed in the drum granulator.

The melt-type processes offer significant reductions in energy consumption, in investment and operating costs, and in dust and fume abatement problems. Because anhydrous melts or a combination of melts and solid materials are fed to the granulator, no drying is needed. Eliminating the dryer, its accessory dust collector, and scrubbing equipment reduces plant investment and operating cost by about 20% and greatly reduces dust and fume abatement problems. Also, energy is saved because no fuel is required for drying. Thank you. *(Applause)*

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Note:
Figures #1, #2, #3, #4
Pages #174 — #175 — #176

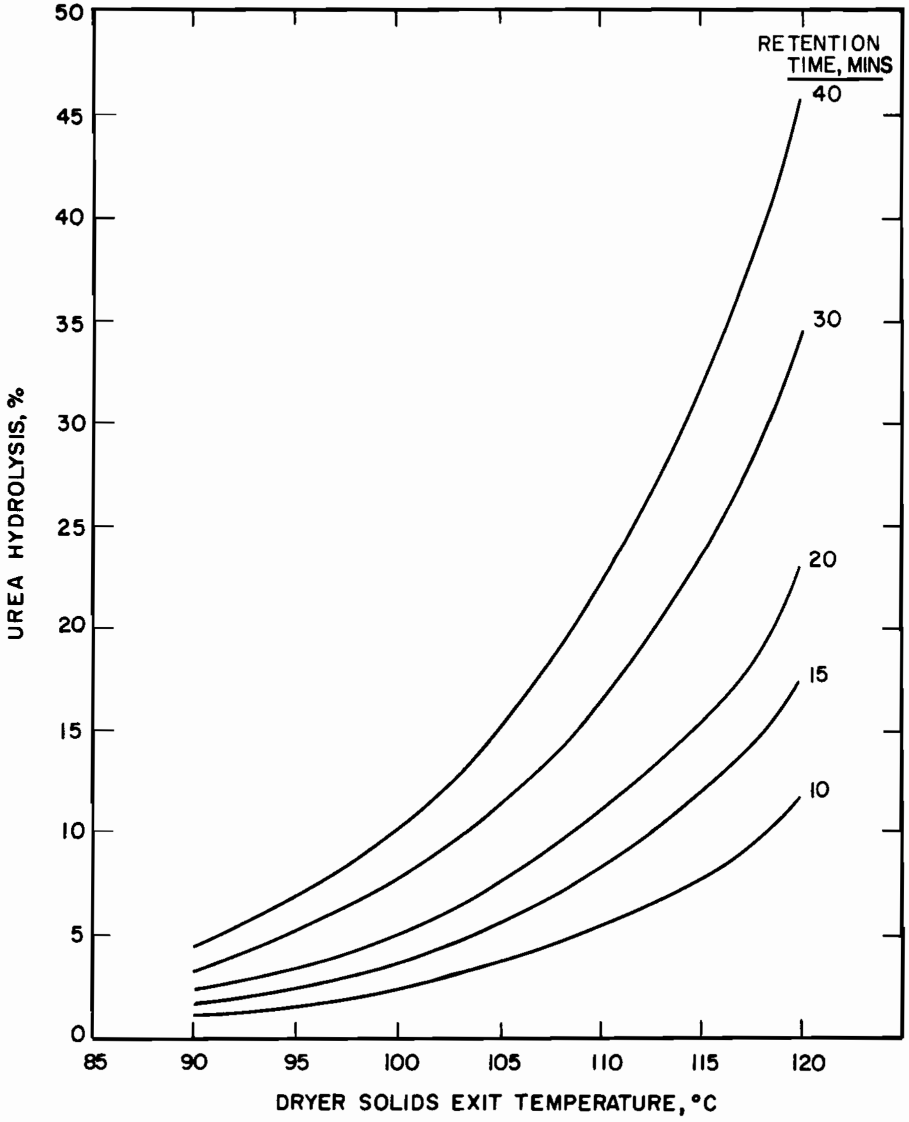

FIGURE 1

Effect of Drying Time and Temperature on Hydrolysis of Urea in Compound Fertilizers

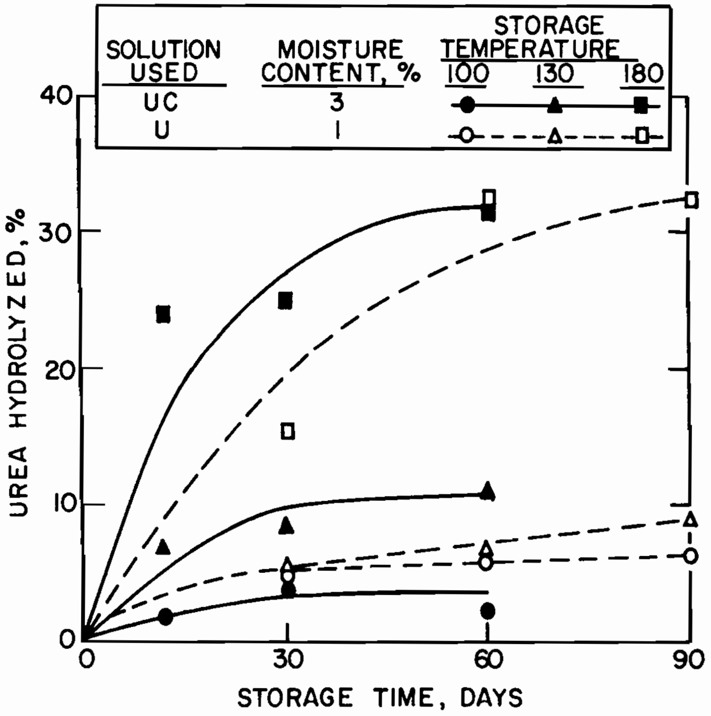

FIGURE 2

Effect of Storage Time and Temperature on Hydrolysis of Urea in 12-12-12 Fertilizer

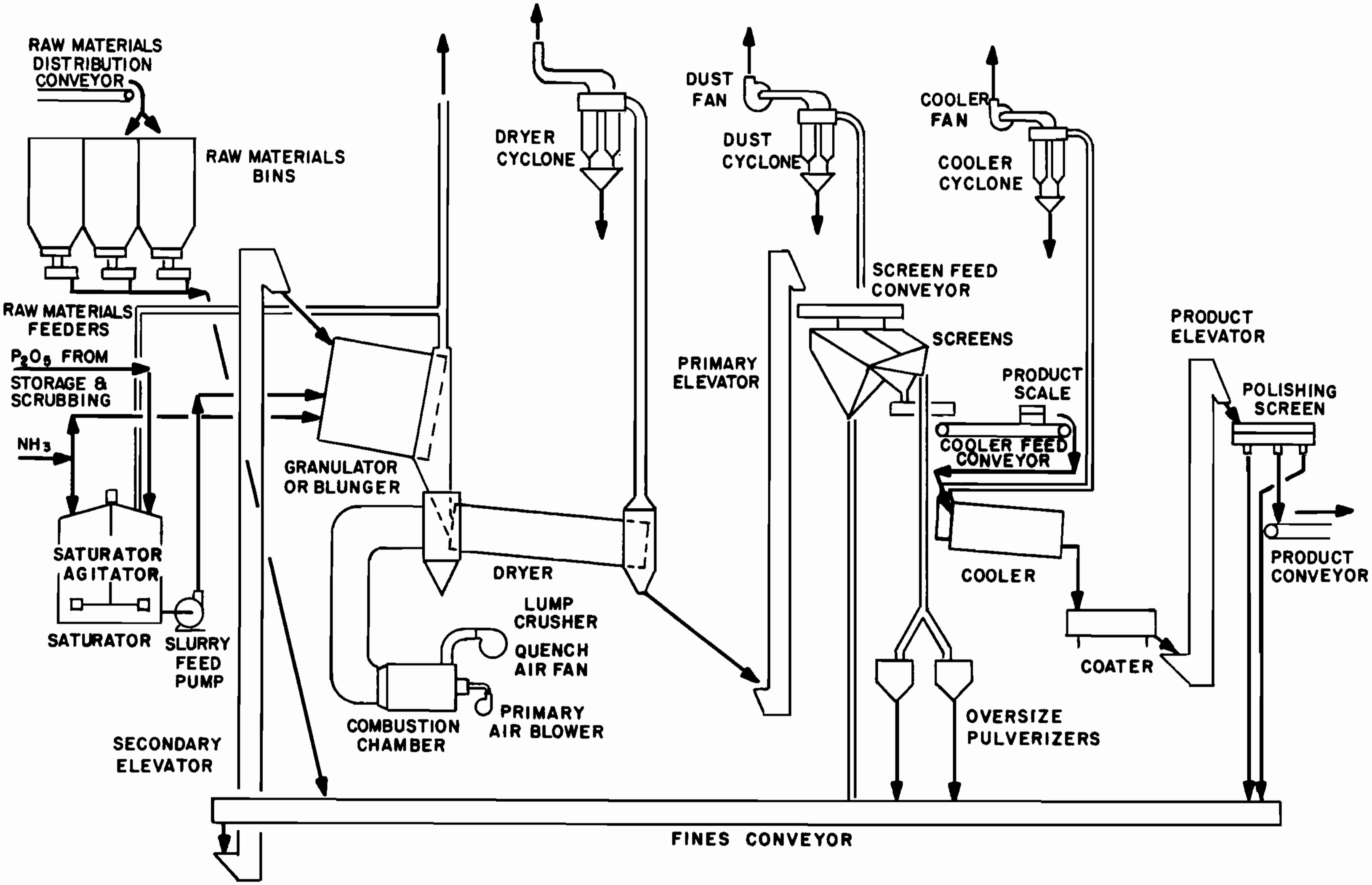

FIGURE 3

Equipment Flowsheet of Granulation Section of MFL Complex

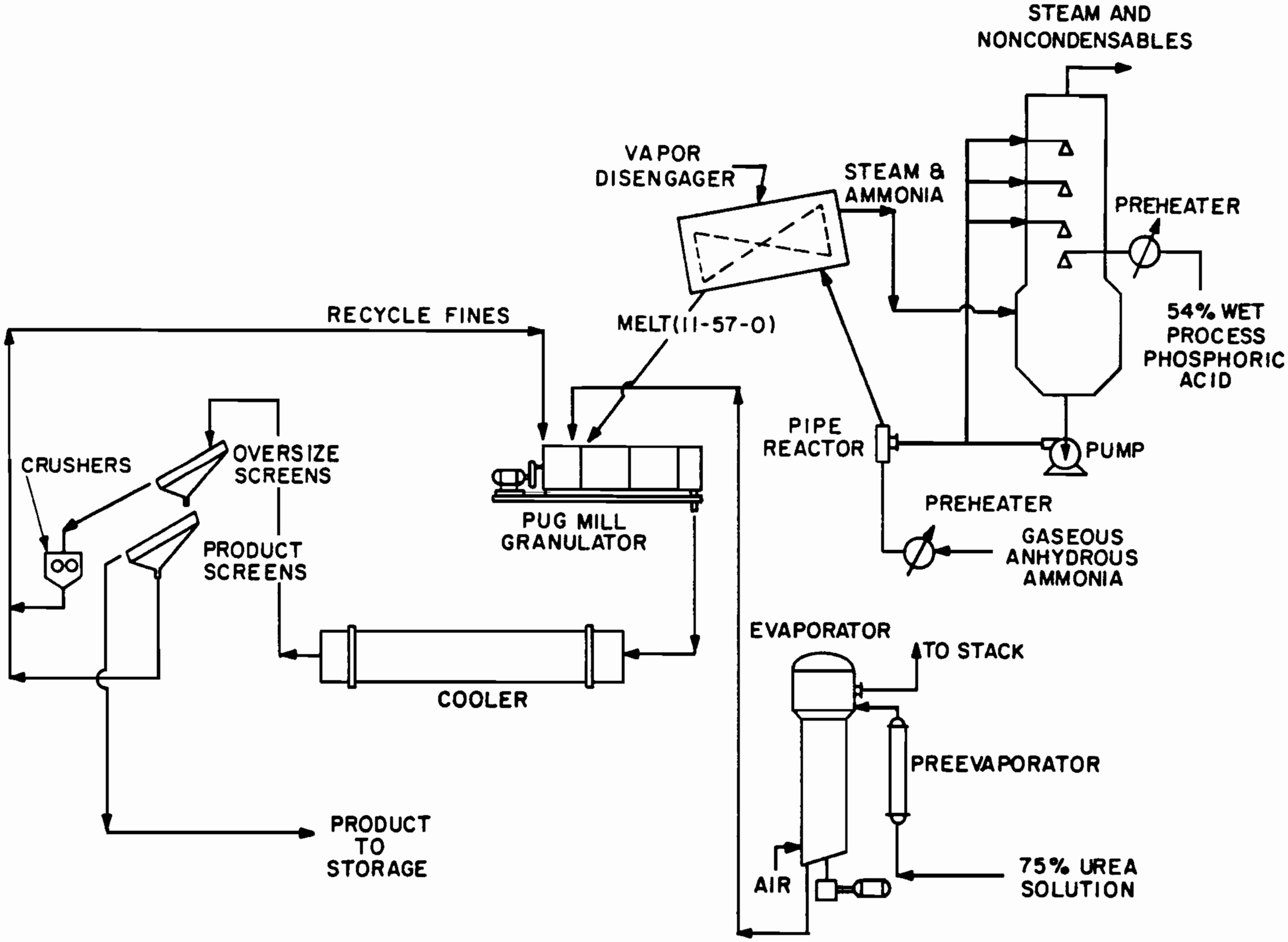

FIGURE 4

Flowsheet for Granulation of Urea-Ammonium Phosphate

MODERATOR NEILD: We'll hold any questions until the discussion period a little later and move on with our program. I was coming right along with that Mr. McCamy until you mentioned controlling humidity in the plant, and I know down in our plant it gets pretty wet sometimes so I don't know whether that would work down there or not.

Our next speaker will be talking to us about "Flotation chemistry Phosphate and Potash." He is a native of Georgia. I understand he studied at the University of Alaska. He graduated from the University of Georgia. He has his Ph.D. from Johns Hopkins University, and at present he is a research professor of geology at the University of Georgia.

I would like to present to you Dr. Vernon J. Hurst. *(Applause)*

Flotation Chemistry — Phosphate and Potash

Dr. Vernon J. Hurst

INTRODUCTION

Flotation is perhaps the No. 1 beneficiation process. Currently it is being applied to more than a half billion tons of ore per year. While sulphide ores still account for most of this tonnage, other ores each year account for a greater proportion. The application of flotation in industrial minerals is increasing notably.

About 90% of U. S. potash production, which was about 2.3 million tons in 1975 , (USBM, 1975, p. 128), is from sylvinite, of which about 65% is processed by flotation. thus about 8 million tons of sylvinite ore were processed by flotation in the U.S. last year.

Phosphate rock production in the U.S. in 1975 was about 49 million tons (USBM, 1976, p. 124). This entailed the mining of nearly 200 million tons of matrix, of which slightly more than half was put through flotation.

REVIEW OF THE FLOTATION PROCESS

Flotation is essentially a physical separation process utilizing specific gravity differences to separate suspended phases. In a sense, it is similar to the sink-float separation process. Whereas sink-float utilizes differences that are intrinsic to the suspended phases, flotation utilizes differences that are generated, by attaching small gas bubbles, usually air, to the phase or phases to be separated. These are solid particles in the case of mineral beneficiation. In the flotation cell, the particles with attached bubbles float to the top of the pulp column and are scraped off. The flotation cell is fitted with a stirring mechanism to counteract the settling of suspended particles and to mix air or other gas introduced near the bottom of the cell for bubble generation. Decades of development have brought changes in the shape and size of the cell, improvements in the stirring-mixing mechanism, and more specialized modifications. An example of the latter is the generation of very fine bubbles by electrolysis within the cell, for the flotation of ultrafine particles (Goldverger et al, 1973). Cell size has increased greatly. In the phosphate industry, cells with a capacity of 300 cu. ft. and even 500 cu. ft. are in use (E/MJ, 1976). The greater developments, though, have been in chemicals for selective particle-bubble attachment and bubble generation.

Preparation of Ore for Flotation

Prior to flotation, most ores require comminution and sizing.

Comminution may be necessary to liberate the ore mineral or minerals from the gangue (waste) minerals, and to reduce particle size to or below the maximum size that can be floated within a given system.

The amount of grinding necessary for liberation depends upon the grain size and texture of the ore and the physical properties of the individual minerals.

The maximum size that can be floated depends upon the difference in specific gravity of the solid and the suspending liquid and on the nature of the particle surface. For example, a 20 mesh (0.8 mm) phosphate particle with a specific gravity of 3.2 is about the largest that can be satisfactorily floated in aqueous slurry, while 8 mesh (2.38 mm) and even coarser sylvite with a specific gravity of 1.99 can be floated in brine. In practice, the upper size limit of food sent to flotation circuits is generally 6-8 mesh (3.36-2.38 mm) for potash and 14-20 mesh fractions of the flotation feed are processed separately.

The lower size cut-off is generally 200-250 mesh (75-60 microns) for potash and 150-200 mesh (100-75 microns) for phosphate. There are several reasons for a lower size cut-off. With decreasing size, the surface/mass ratio of the particle increases very rapidly, causing an increasing rate of reagent consumption and a change in the hydrologic behavior of particles. Additionally, a diffusio-phoretic force may come into play with decreasing particle size. This force is negligible for coarse particles but it may become decisive in the flotation of particles which are much smaller than the thickness of the diffusional boundary layer of the bubble (Deryaguin and Dukhin, 1961).

Review of some Surface Porces involved in Flotation

Particle separation by flotation depends upon how readily and how securely a bubble attaches to the particle, i.e., upon how well the particle's surface is "wetted" by air rather than water. Minerals with naturally hydrophobic surfaces are flotable in an aquenous medium without prior chemical treatment. Examples are stibnite, graphite, molybdenite, and talc. Particles with hydrophilic surfaces — most natural minerals are in this category — must be conditioned so as to render their surfaces hydrophobic before they can be successfully floated. Reagents that can induce this change generally are called *collectors*.

Flotation may be viewed in terms of two main sets of interactions: (1) Those involved in collector mechanisms, reflected by the hydrophobiscity of particle surfaces, and (3) those relating to particle bubble attachment (Rao, 1974, p. 45). Actually, the surface forces responsible for both sets of interactions are the same:

1. Van der Waals attraction, a weak force operating between all atoms and molecures.
2. Electric forces arising from overlapping electric double-layers in the liquid around particles, causing repulsion between double-layers of the same sign and attraction between those of opposite sign. Electric forces may arise also from diffusio-phoresis (Deryaguin and Dukhin, 1963): an electric field is generated when bubble movement disturbs the equilibrium distribution of absorbed ions in the outer, diffusional boundary layer of a bubble.
3. Repulsion due to adsorption.
4. Hydrogen bonding and dipole interactions.

Van der Waals attraction is due mainly to the interaction of temporary dipoles arising from instantaneous fluctuations in electron density; these induce additional dipoles by temporary polarization of the electron clouds of neighboring atoms. For two individual atoms the van de Waals force is inversely proportional to the 7th power of the distance separating them (to the 6th power of the attractive energy). For two colloids the force is approximately the sum of the attractive forces between every atom of one particle and every atom of the other; for two spherical particles it is inversely proportional to the third power of the distance between the surfaces (van Olphen, 1963, p. 38).

A much-used approach to the approximation of van der Waals forces is through evaluation of Hamaker constants. In 1937 Hanaker showed that London-van de Waals forces can be split into a purely geometric part and a constant, the Hamaker constant, which depends only on the materials involved. More recently Lifshitz and coworkers have developed a theory for the interaction of condensed bodies based on accurately measurable optical properties, throughout the electromagnetic spectrum. The Lifshitz-van der Waas constant depends only on the material and is independent of geometry. It can be related to the Hamaker constant after multiplication by 3/4II because the geometrical terms of both theories are the same. Visser (1972) compared Hamaker constants as initially calculated with Lifshitz-van der Waals/Hamaker constants based on optical data and with the Hamaker constants obtained from flocculation experiments, surface tension measurements and rheological data. He concluded that Lifshitz-van der Waals/Hamaker constants are more correct because they involve only minor assumptions in their derivation, but he found that they differ substantially, in many cases, from the Hamaker constants obtained from flocculation experiments and surface tension measurements. Neglect of the viscous effect and the fact that hydrogen bonding as well as dispersion forces are important in surface tension measurements might account for some of the differences. At any rate, Hamaker constants in the literature are approximations, most of which differ according to the manner in which they were calculated or measured. Errors in Hamaker constants based on measurements in vacuum can lead to 25-fold errors in evaluating interactions involving water. For application to flotation systems, Hamaker constants based on contact angle between bubble and attached solid probably are more practicable than more accurate values obtained by measurements in systems not involving water, because of non-dispersive interactions and the as yet unevaluated effect of the medium through which electromagnetic forces are transmitted. There is not a single mineral, at present, for which the van der Waals component of surface forces can be stated with condifence, according to Kitchener (1974). Nevertheless, the approximations that are available do provide many qualitative answers and allow a much clearer insight into flotation phenomena that would be possible without them.

As two colloids of the same kind approach, their diffuse counter-ion atmospheres begin to interfere. The resulting changes in the distribution of ions in the double-layers of approaching particles increase the free energy of the system. Work must be done to bring the particles together. Thus a repulsion between the surfaces is generated. Increasing the electrolyte concentration of the fluid between the surfaces compresses their electric double-layers, and considerably reduces the range of the repulsion between them.

The surface charge which engenders an electric double-layer on particles or bubbles can be measured by electrophoresis.

Bubble surfaces as well as particle surfaces may be charged. When the charges of bubble and particle have the same sign — the usual case in flotation systems — particle and bubble repel one another. Their repulsion can be significant when a strong zeta potential is present (Blake and Kitchener, 1972). This is a reason for better flotation at low zeta potentials. It also supports the empirical observation that weakly hydrophobic solids are more readily floated in brine than in water. When the charges of particle and bubble have unlike signs, they attract one another. On contact, the bubble's wetting film collapses quickly (Schulze and Cochos, 1972).

Solvation of any lyophilic groups on the surfaces of particles or films generates a repulsion. Hydration of surficial hydrophilic groups is an example. In order for the distance between hydrated surfaces to become less than the thickness of the adsorbed water layers, the water must be desorbed. The work required for desorption manifests itself as a short-range repulsion. Another example of repulsion due to adsorption is steric hindrance due to the adsorption of a monionic polymer.

For a molecule possessing a permanent dipole, as the strongly polar water molecule, its total van der Waals attraction can be much greater than that of a monpolar molecule (Evans, 1964, p. 115). Still, van der Waals forces might not be the most important determinant of whether a solid is hydrophilic or hydropholic. According to Fowkes (1964), hydrogen bonding is the major term responsible for the high work of cohesion of water to a surface. About 70% of the total surface free energy of water derives from hydrogen bonding and dipole interactions (Fowles, 1964b), so both of these forces are important in the interaction of water with minerals.

Particle-bubble Attachment

As a mineral particle and a bubble appraoch, during agitation in a flotation cell, the disjoining film between them is subjected to an interplay of forces which may allow the wetting films to remain intact, or may cause them to thin and finally rupture as a firm solid-to-bubble adhesion is established.

The concept of a disjoining pressure was introduced by Deryaguin and his coworkers (Deryaguin and Zorin, 1957; Deryaguin and Shukakidse, 1960) to explain the stability of thin liquid films in terms of surface forces.

The concept is applicable also to particle-bubble interactions. The disjoining pressure is the sum of all the surface forces:

$$DP = P_{\text{van der Waals}} + P_{\text{electric}} + P_{\text{Hydration}} + \ldots\ldots$$

Other components may be needed for special cases. A term for diffusion-phoretic force, for example, may be needed when ultra-fine particles are involved.

If absolute values for the disjoining force components were available for all constituents of flotation systems, empirically obtained results could be understood better, and the effects of new reagents better predicted. Only approximate values, however, are generally available; some anomalies still exist between theory and results, and the behavior of new flotation systems is not always predictable. The ranges and qualitative relations of the surface forces still are very useful for flotation practitioners.

The van der Waals component of the disjoining pressure diminishes rapidly with increasing separation. It also diminishes with decreasing particle size and with decreasing specific gravity. It is generally negligible for separations greater than 0.02 μ, and for even smaller separations when particles are very fine. It is always a negative term in the disjoining pressure equasion above.

The distance at which the electric double-layers of approaching surfaces begin to interact may be greater or less than the separation at which van der Waals attraction becomes effective, because the thickness of the double-layers varies considerably with electrolyte concentration. At low concentration, the thickness of the double-layer usually exceeds the range of van der Waals attraction, and may greatly exceed it, may be as thick as 0.1 μ (Kitchener, 1974, p. 246). Thus at low electrolyte concentrations, when a moderate or high zeta potential is present, the electric component of the disjoining pressure is the most important component. At high electrolyte concentrations, on the other hand, the electric double-layers may be compressed so much that their thickness becomes considerably less than the effective range of van der Waals attraction, at which time the van der Waals component may dominate. P_{electric} usually is positive in flotation systems.

The sign of $P_{\text{Diffusio-phoretic}}$ may be positive or negative, depending upon which ions diffuse toward the outer surface of the bubble. The range of the electric field generated by diffusion may be up to several microns (Laskowski, 1974, p. 225).

The adsorption term is positive. Its range is the thickness of the adsorbed layer.

The total disjoining force of a particle-bubble interface or particle-particle interface varies in magnitude and sometimes changes sign with the thickness (and chemistry) of the disjoining liquid film. When the liquid is relatively thick, the principal components of the disjoining force are P_{electric}, arising from compression of diffuse double-layers, and perhaps $P_{\text{diffusio-phoretic}}$. On thinning of the liquid film, dispersion forces, hydrogen bonding and dipole-dipole interactions become more important (Lankowski, 1974, p. 229). The manner in which the total disjoining pressure between a particle and a bubble may vary with the thickness of the liquid film between them is illustrated schematically in Figure 1. When $\frac{\Delta DP}{\Delta h} < 0$ (curve A of Figure 1), the films are stable and the particle is unfloatable. When $\frac{\Delta DP}{\Delta h} > 0$ (curve B), the films are unstable. Curve C displays a minimum and maximum: the disjoining force changes sign with changing film thickness; the film will spontaneously begin to rupture when the bubble reaches ht.

Even though none of its terms can be precisely evaluated at present, the concept of disjoining pressure and the approximate values that can be derived for its components are very helpful in understanding hydrophobiscity, collector mechanisms, frother-collector interactions and flotation kinetics.

Natural Hydrophobiscity

Mineral particles that are bounded mostly by cleavage surfaces across which there are no broken interatomic bonds exhibit hydrophobicity, and are naturally flotable when there is also no lattice charge imbalance.

Tabular graphite and molybdenite particles bounded largely by perfect cleavage planes are hydrophobic. Platelets of montmorillonite also bounded largely by good cleavage planes but displaying a lattice charge imbalance, on the other hand, are hydrophilic.

Most mineral surfaces offer broken bonds for ready hydrolysis and are hydrophilic. Some, like montmorillonite, have a built-in charge deficiency which renders them strongly hydrophilic.

POTASH FLOTATION

The two basic processes used to recover KC1 from sylvinite ore are flotation beneficiation and dissolution-recrystallization. Flotation produces fertilizer grade KC1, 95-97% KC1, for use in solid fertilizers, while dissolution-recrystallization usually produces a higher grade, 92% or above KC1, for liquid fertilizers and industrial chemicals.

Sylvinite accounts for 90% of U.S. potash production, of which about 80% is taken from the Carlsbad area OF New Mexico. About 63% of U.S. sylvinite production is processed by flotation.

Sylvinite ores currently mined contain 20-25% K_2O and 2% or less clay slimes.

In the typical operation, the ore is supplied by traditional shaft mining. It is crushed and screened to yield a -6 mesh fraction, which is pulped with saturated brine of KC1 and NaC1 and deslimed, after which KC1 is separated by flotation. Current practice favors floating sylvite away from halite. Several good descriptions of KC1 flotation are in the literature (Baarson et al, 1962; Agar, 1967, p. 459A; Fullam and Faulkner, 1971, pp. 80-82; Browning, et al, 1975, p. 4-14).

A generalized flowsheet is reporoduced as Figure 2. The sylvinite ore, 6"-8" or less as hoisted from the mine, is crushed by impact mill of flextooth crusher, ground in a rod mill and screened. Oversize is returned for further grinding. The —6 or —8 mesh fraction is pulped with saturated brime. An anionic dispersant, as marasperse C-21, may be added to the high-solids pulp to facilitate removal of clay, which constitutes about 1% of the feed. Desliming is accomplished by screens or scrubbers and classifiers or Dorrclones. After desliming, the ore may be split into two size fractions for separate reagentizing.

The plus 20 mesh fraction at about 60% solids may be conditioned with a depressant, as starch or guar, to prevent later adsorption of collector by any clay not removed during desliming. A cationic collector such as tallow amine acetate is added, and an extender, as petroleum oil, to increase the lifting power of the amine. The conditioned pulp is then diluted to about 20% solids. A frother, as methylisobutyl carbinol, is added before the coarse pulp is sent to rougher flotation.

The finer fraction at high solids is conditioned with a depressant, then a cationic collector, diluted, and after addition of a frother is sent to rougher flotation. The coarse and fine fractions, after reagentizing, may be recombined before being sent to rougher flotation.

The KC1-rich froth collected during rougher flotation entraps appreciable halite and other impurities. The rougher overflow is therefore sent to a second set of flotation cells (cleaner cells) where the KC1 is again floated off. Overflow from the cleaner cells is centrifuged to eliminate brine, dried and screened.

The KC1 product usually is light pink due to very fine included hematite. It assays 96-97% KC1, with sodium chloride the major contaminant. The product generally is made available in the following size grades:

Grade	**Size Range**
Standard	100% —20 mesh 95% +65 mesh
Coarse	100% —14 mesh 95% +28 mesh
Granular	100% —6 mesh 98% +20 mesh

Increased demand for KC1 particles coarser than those usually obtained by regular production practices has led to the use of two methods for increasing the particle size of fertilizer grade KC1: fusion and compaction. In the fusion process, fine KC1 is melted and then solidified in thin layers which are crushed and screened to the desired particle size. In the compaction process, fine KC1 is compacted into thin sheets with heated high pressure rolls, after which the KC1 sheets are crushed and screened.

Carnallite ($KC1.MgC1_2.6H_20$) and kainite ($MgSO_4.KC1.3H_20$) can be floated like sylvite. Langbeinite ($K_2SO_4.MgSO_4$) requires an anionic collector.

The slimes removed from the sylvinite slurry contain some KC1. These usually are leached with a minimum of water to remove KC1, centrifuged and discharged as waste. The KC1-rich leachate is added to the process brine system.

Underflow from the primary flotation cells contains mostly NaC1, but also some KC1. Because the solubility of KC1 is much greater in hot than in cold water, while the solubility of NaC1 is only slightly greater in hot water, the underflow may be heated to dissolve the KC1 (mainly), centrifuged and the NaC1 waste discarded. The KC1-rich brine is added to the process brine system.

Water is used at the rate of 20,000-40,000 gallons per ton of KC1 product. By careful control, more than 80% of this water is recycled. Major losses are in the clay slimes tailings and halite waste. The water content of these wastes is kept to a minimum by settling, filtering or centrifuging them before they are discharged. An additional smaller water loss arises from the necessity of bleeding the brine to remove dissolved impurities which, if their concentrations were allowed to build, could interfere with the process. Bleeding is held to a minimum because of the attendant KC1 loss, which is about a half pound per gallon of brine.

On a dry weight basis, clay slimes accoumulate at the rate of 30-80 lbs./ton of KC1 product, NaC1 at the rate of as much as 1.5 tons/ton of KC1 product.

Potash Slimes

The aconomics of sylvinite processing relate directly to how well clay slimes can be eliminated prior to the flotation of sylvite, and on how efficiently slimes can be debrined. These cost factors become increasingly important as high-grade sylvinite ores are depleted and potash producers are forced to process lower-grade, high-slime ores.

The behavior of the slimes with respect to desliming and debrining stems primarily from their mineralogy, particle size and shape, and manner of occurrence in the ore.

The principal slimes mineral is Na-montmorilonite. It is found in the intergranular spaces of much coarser salts (Fig. 3) and as fine inclusions and along fractures within the salts (Figs. 3 & 4). When sylvinite ore is ground, much of its montmorillonite is exposed at salt particle surfaces because breakage is somewhat preferential through clay-rich masses. Figure 5 is a scanning electronmicrograph of a portion of the surface of a freshly broken sylvite grain, showing adhering clay. The break which made this furface went through a clay pocket rather than between the clay pocket and the underlying sylvite grain. Surficial clay like this is readily removed from sylvinite particles during the scrubber stage, especially in the presence of a suitable dispersant. Any handling of the ore feed, however, after as well as during scrubbing, entails attrition which exposes some clay at new surfaces.

The Na-montmorillonite readily disaggregates during scrubbing to submicron particles, as in Figure 6.

Other slimes minerals are magnesite, kaolinite, hematite and quartz. These are authigenic minor accessory constitutents of the ore (Jones, 1968, p. 1312-13). All are insoluble in brine and tend to concentrate in the slimes, where their proportions are quite variable.

Magnesite sometimes is a major component. Its mode of occurrence in the ore is shown in Figure 7. What happens to the coarser magnesite at the processing plant has not been traced. Finer magnesite is diverted to the slimes.

Poorly crystallized kaolinite is a minor component (see Figure 6), typically in the form of submicron booklets.

Quartz occurs in the ore mostly in silt-size grains (Figure 8). Due to its hardness, it undergoes very little cominution during grinding and scrubbing. What happens to the coarser grains has not been traced. Most of the finer quartz is diverted to the slimes.

The hermatite in the ore is very fine. It occurs typically as a stain in sylvite and halite grains and as a coating on microfractures and cleavage surfaces. Electronmicrographs reveal that the hematite is in the form of subhedral to euhedral crystals, with pseudohexagonal outlines (Figure 6). This fine hematite is responsible for the reddish color of the ore.

Grinding of the ore and its subsequent attrition at every handling step produces very fine particles of halite and sylvite. The same is true, but on a minor scale, of other minor minerals in the ore. By preferential leaching. much of the fine sylvite is dissolved and recovered from the brine, but much fine halite remains in the slimes.

Each mineral component of the slimes has its own set of physical characteristics. Most of the components behave differently when treated with dispersing or floccing agents.

Inherent in the manner of occurrence of the slime minerals, any high-slime ore must yield a higher proportion of slime during processing and also must leave a higher proportion of remnant slime in the finished products. The only way to achieve the altimate slime-free product would be to dissolve the ore, floc and separate the slimes, then crystallize sylvite from solution. A close approximation might be achieved by finer-than-usual comminution of the ore to expose nearly all the slimes minerals at particle surfaces, followed by thorough scrubbing. Flotation could be made to work as well on the finer feed; the main disadvantage would be the fineness of the finished product.

Efforts to rapidly flocculate potash slimes, to facilitate the separation of brine and solids, have not been completely successful. The reasons are the different responses of slime components to surfactants, the very fine size of some of the colloids, particularly the montmorillonite, and the complexities of the suspending brine.

Problematics

The sylvinite ores currently mined are low-slime and mostly coarse. Their minor slimes can be eliminated with relative ease by scrubbing. The volume of slimes being produced is not great enough to pose a major disposal problem. Reagent consumption is low. Collectors currently used are very specific and give good recovery. The finished product is largely coarse.

The crushing, scrubbing and flotation practices of the potash industry are well proven. They are well adjusted to and relatively efficient for currently mined ores. Thus cost-cutting innovations at a "breakthrough" level are hardly expectable at this time.

Lesser, but still significant, cost improvements probably can be made. They appear most likely in the compaction of KC1 fines, possibly by fine particle agglomeration, and the reduction of brine losses of potash, perhaps by more efficient dewatering of slimes and more sophisticated control of brine composition.

The eventual treatment of higher-slime ores necessarily will:

(1) require finer crushing of the ore to free potash minerals,
(2) generate a higher proportion of slimes and a higher proportion of slime-size potash minerals,
(3) require more costly multistage scrubbing and separation of slime-size potash minerals from other slime components,
(4) increase reagent consumption, not only for flotation but also for ante-scrubbing dispersant and for flocculants to aid slimes dewatering, and
(3) yield a higher proportion of fine product requiring compaction.

The plant procedures that now appear most amenable to significant cost improvement, in current practice, are the same procedure that will require major improvement before economic treatment of high-slime ores can be undertaken.

PHOSPHATE FLOTATION

Phosphate rock is produced in the U.S. in eight States: Florida (which produces about 80% of the total), Tennessee, North Carolina, Idaho, Montana, Utah, Wyoming and California. All of the Florida, Tennessee, and North Carolina phosphate and part of the western phosphate is mined by open pit methods. The underground deposits of western phosphate generally are mined by room-and-pillar methods. The following treatment pertains to Florida phosphate.

Well over 100 million tons of ore are mined annually in central Florida (BM 1C-8668, 1975), yielding about 38 million tons of phosphate. More than 95% of it is used in fertilizer.

The average thickness of overburden, principally sand and clay, is 25 feet. The general practice is to strip the overburden with draglines, mine the phosphate rock, called matrix, and slurry it at about 40% solids, after which the slurry is pumped up to 6 miles to a washer plant. The slurried ore typically is about one-third silica sand, one-third clay, and one-third phosphate. Its bone phosphate of lime (BPL) ranges from 15-40%, equivalent to 7-18% P_2O_5.

Beneficiation methods differ somewhat from place to place, depending upon the size distribution of the feed, the proportions of sand, clay and phosphate, the ratio of washer rock to flotation feed and equipment preferences. Good descriptions of beneficiation practice are in Baarson et al. (1962), Agar (1967), Fullam et al (1971), and Hoppe (1976).

At the washer plant, the matrix slurry is processed by screens, hammer mills and log washers to break up clay lumps, free and clean the phosphate modules and classify the material (Figure 9). The minus 1 inch plus 14-mesh fraction is a clean phosphate pebble concentrate ready for market. The —14 mesh fraction is deslimed in hydroseparators or cyclones. The —150 mesh slimes are pumped to waste. The —14+150 mesh fraction is fed to the flotation plant. The primary functions of the washer plant, then, are to reduce the feed to —1", disperse the clay, scrub the phosphatic particles, split off a coarse phosphate pebble concentrate, and deslime the finer flotation feed.

At the flotation plant, primary classification units split the —14+150 mesh feed from the washer plant into two size fractions for separate treatment (Figure 10). The coarser fraction, usually —14+35 mesh, is concentrated by gravity and skin flotation. The reagents used for it are the same as those used for flotation of the finer fraction. The —35+150 mesh fraction is dewatered to 60-75% solids. With addition of a reagent to adjust pH, an anionic collector and an extender, the high-solids slurry is subjected to high-energy, short-term conditioning. The pH adjuster usually is sodium hydroxide or ammonia. The collector is fatty acid, usually a low-grade tall oil. The extender is a heavy oil fraction or a mixture of Bunker C and kerosene. Conditioning is short-term to minimize the generation of slimes from friable phosphate. The conditioned pulp then goes to rougher flotation cells. Underflow from rougher flotation is pumped directly to waste. The concentrate (froth product) is scrubbed with sulfuric acid to remove the collector and oil films, washed, diluted to about 25% solids, and pH adjusted to about 7.5. The cleaned concentrate is than reagentized with an amine to float silica away from phosphate. Delamine 80 in pine oil or kerosene may be used, or a variety of similar reagents. Kerosene serves not only as an extender but also as a froth-control agent. Overflow from the amine flotation, mainly silica, is pumped to waste. The underflow is the final product, assaying 2-3% insoluble and 75-78% BPL.

Phosphate Slimes

About one-third of the mined matrix eventually is discharged from the washer and flotation plants as slimes. This discharge, generally 2-6% solids, is pumped into extensive settling ponds in mined-out areas. The rate at which the ponded slimes settle is very slow (Figure 11). Many years after impoundment the slimes a few feet beneath the surface generally have concentrated to only 20-25 solids. If the proportion of solids could be raised to 50%, economically, then all of the wastes from washer and flotation plants could be redeposited into the same pits from which the matrix was mined. This possibility has prompted a great amount of research during the last 20 years. Virtually every imaginable method for dewatering the slimes has been investigated. So far, a method has not been found that is entirely acceptable.

The most recent slimes disposal method tried on a large scale consists of spraying fine-grained quartz sand over slimes, after they have settled to about 12% solids.

The sands penetrate and mix with the clay slimes, liberating water and producing a thick sand-clay mixture of 40-45% solids. After decantation of the supernatant water, windrow overburden is spread over the sand-slime material, after which the area is ready for agricultural use. As a somewhat less successful variant of the method, a common-line mixing of sand and slimes is pumped to a disposal area. Another variant consists of depositing alternating layers of tailing sand and slimes (Hoppe, 1976, p. 89).

Quartz, apatite, and clay minerals are the main mineralogical components (Table 1). Their proportions vary, even more than indicated in the Table. Variation relates to the depositional environment of the matrix and the extent to which it has been weathered.

Most of the slimes particles are submicron (Table 2). Both electron micrographs and chemical analyses of various size fractions show that apatite is a principle component of all. Its proportion remains relatively constant with decreasing particle size down to one micron, then decreases. Apatite is still a common constituent of the submicron size fraction (Figure 12). The proportion of quartz decreases rapidly with decreasing particle size; the proportion of silica decreases more slowly. As quartz diminishes, the proportion of clay minerals increases. They account for most of the alumina and silica of finer fractions.

Roughly a third of the phosphate in the mined matrix is lost during processing, most of it lost in the slimes. The BPL content of the matrix ranges from 15 to 40 percent, corresponding to 7-18% P_2O_5. The BPL content of the slimes is roughly the same (BM 1C 8668, p. 9, 11). Thus in terms of phosphate content alone, the slimes are as good a source of phosphate as the original matrix. Hopes of recovering this phosphate have led to a great amount of research, recently summarized in BM 1C-8668, pp. 12-41. So far, no economical recovery method has been found.

The problems encountered in efforts to dewater the slimes or recover their contained phosphate relate directly to the slimes' mineralogy and very fine particle size.

The high surface area of the fine slimes particles and the porous felt-like matte that develops during settling account for the high retention of adsorbed and trapped water, and resistance to dewatering by simple flocculation and settling. The addition to the slime of coarser, heavier particles, as quartz sand or fly ash, somewhat reduces the steric hindrance of fibrous attapulgite through a weighting, compacting effect. This reduces the proportion of trapped water and yields a firmer sediment than a straight slimes sediment, but has little effect on the surface-bound water. Accordingly, the proportion of water in the settled or compacted slimes remains high.

Recovery of Phosphate from the Slimes

Flotation, ultraflotation or carrier flotation, chemical recovery involving digestion of slimes, preferential flocculation and several other methods have been tried, so far with limited success. Despite much effort, there are possibilities still to be explored. In particular, the possibilities for recovery by flotation have not been fully explored.

The particle size range of the slimes is greater than the size range of the presently treated matrix fraction: The —1"+200 mesh fraction spans 3 size classes, while the slimes span 4. Variation of hydraulic and colloid behavior within a span of 4 size classes is too great for any satisfactory *en masse* flotation treatment of the slimes.

A size split around 2-5µ readily can be made. The +5µ slimes fraction can be treated by more or less conventional flotation. The —5µ fraction will require modified treatment.

Several factors bear importantly on modifications that probably must be devised for satisfactory flotation of fine and ultrafine phosphate.

(1) The proportion of phosphate in the slimes is fairly constant in the various size fractions down to 1µ. Below 1 µ, the proporation declines.

(2) The proportion of quartz, which is a major component of the coarser fractions, decreases very rapidly below 75 µ. Thus the mineralogical composition of the submicron slimes is principally montmorillonite, attapulgite and apatite, in verying proportions.

(3) The clay minerals are coated by a layer of bound (adsorbed) water up to about 65 angstroms thick. Van der Waals attraction generally is negligible for particle separation greater than about 200 angstroms, and for smaller separations when the particles are very fine, as in these slimes. For the fine particles of montmorillonite, then, agglomeration is *very* slow due to the adsorbed water layers which prevent closer approach than about 130 angstroms and thus keep the particles beyond the effective range of van der Wasls attraction.

(4) The clay minerals, especially the montmorillonite, are strongly hydrophilic, hence a depressant for them probably will be unnecessary if the fine apatite can be rendered flotable with a reagent preferrential for apatite.

(5) For satisfactory flotation of the finer phosphate, diffusiophoretic forces generated by diffusion of ions within the bubble wall probably will have to be taken into account.

As reviewed in the early part of this paper, the hydrophobicity of a particle and its floatability can be viewed as a consequence of a disjoining force which is the algebraic sum of several surface force terms.

The term for van der Waals attraction is always a negative term in the disjoining force equasion, and can be approximated from Hanaker constants. The force term for the interaction of electric double layers is nearly always positive in flotation systems, and can be approximated from zeta potential measurements. The term for hydration is positive and hard to measure. The diffusiophoretic force can be either positive or negative.

When total disjoining force, the algebraic sum of all the surface force terms, is negative, the wetting films on particle and bubble in a flotation cell rupture on contact, allowing a firm solid-to-bubble adhesion to be established. When the disjoining force is positive, the wetting films remain intact and attachment of particle to bubble does not take place.

Two additional considerations bear on the conditions necessary for flotation of fine apatite.

One is that the separation of small bubbles with attached apatite particles from other fine particles sheathed by water films in the flotation liquid still depends on specific gravity differences, but because surface areas are so much greater than in coarser flotation systems, the viscosity of the slurry becomes a much more important factor.

The other consideration is the reduced momentum of fine particles sheathed by adsorbed layers as compared to coarser, heavier particles. If the variation of total disjoining force with distance from the apatite particle surface (see Figure 1) is such that a force barrier must be overcome before bubble and particle can attach, flotation may be hindered because impacts due to agitation within the flotation cell will be less effective in overcoming this force barrier than when coarser particles are involved.

Table 1 - Mineralogical composition of Florida phosphate slimes.

Mineral	Weight Percent
Carbonate-fluorapatite	20-25
Quartz	30-35
Montmorillonite	20-25
Attapulgite	5-10
Wavellite	4-6
Feldspar	2-3
Heavy Minerals	2-3
Dolomite	1-2
Miscellaneous (Kaolinite, crandallite, hydrous Fe-oxide, organic)	0-1

(From BM IC 8668, p. 10)

Table 2 - Size distribution of particles in a Florida phosphate slime, and chemical composition of various size fractions.

Diameter, Microns	Weight percent	P_2O_5	SiO_2	Al_2O_3	Fe_2O_3	CaO
Plus 20	4.8	15.6	31.1	10.3	7.3	11.6
-20+10	5.6	17.1	24.3	12.1	8.4	11.8
-10+6	5.2	17.1	22.7	12.5	8.7	11.1
-6+4	3.8	16.5	23.2	14.1	9.0	11.8
-4+2	3.8	18.7	20.5	15.0	9.1	11.1
-2+1	4.3	16.6	22.5	13.5	8.8	10.6
Minus 1	72.5	12.1	27.9	17.8	6.7	12.5
Composite	100.0	13.4	26.9	16.4	7.2	12.2

(From BM IC 8668, p. 11)

Figure 1 —
Schematic representation of ways in which total disjoining pressure may vary with film thickness, h. (after Laskowski, 1974, p. 228).

Figure 2 —
Generalized flowsheet for recovery of KC1 from sylvinite ore by flotation.

Figure 3 —
Photomicrograph of thin section of clay-rich sylvinite, plain light. White grams are principally halite and sylvite. The black areas are clay, mainly montmorillonite. Print was over-developed to darken the clay images and thus to emphasize its distribution in intergranular pockets and crystal inclusions.

Figure 4 —
Photomicrograph of thin section of clay-poor sylvinite, plain light. Sylvite grains are white, halite grains are gray from fine inclusions. Black areas are mostly hematite, lesser montmorillonite. Print was overdeveloped to better show the distribution of very fine slimes minerals.

Figure 5 —
Scanning electron micrograph of fracture surface, showing clay-coated sylvite grain.

Figure 6 —
Transmission electron micrograph of potash slimes from AMAX plant, N.M. The filamentous masses are Na-montmorillonite. The dark platelets are kaolinite. The black grains with pseudohexagonal outlines are hematite crystals.

Figure 7 —
Photomicrograph of thin section of a magnesite-rich fragment of sylvinite ore, x-nicols. The light colored areas are magnesite. The dark areas are coarse sylvite and halite enclosing the magnesite.

Figure 8 —
Photomicrograph of thin section of a quartz-rich fragment of sylvinite ore showing the occurrence of silt-size quartz grains (white) in salt, plain light.

Figure 9 —
Generalized flowsheet of a washer plant for recovering Florida pebble phosphate.

Figure 10 —
Generalized flowsheet of a flotation plant for recovering Florida phosphate.

Figure 11 —
Typical rate of consolidation of Florida phosphate slimes (from BM 1C-8668, p. 7).

Figure 12 —
Electromicrograph of Florida phosphate slime from Agrico chemical Company. The black masses are apatite. The fibers are attapulgite. The gray masses, usually with indistinct boundaries, are montmorillonite.

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Thank you for inviting me. *(Applause)*

MODERATOR NEILD: Thank you Dr. Hurst.

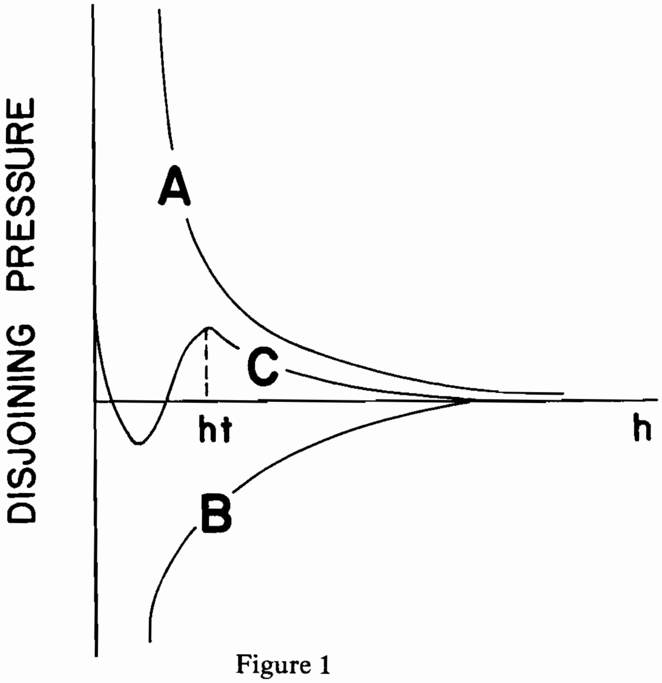


Figure 1

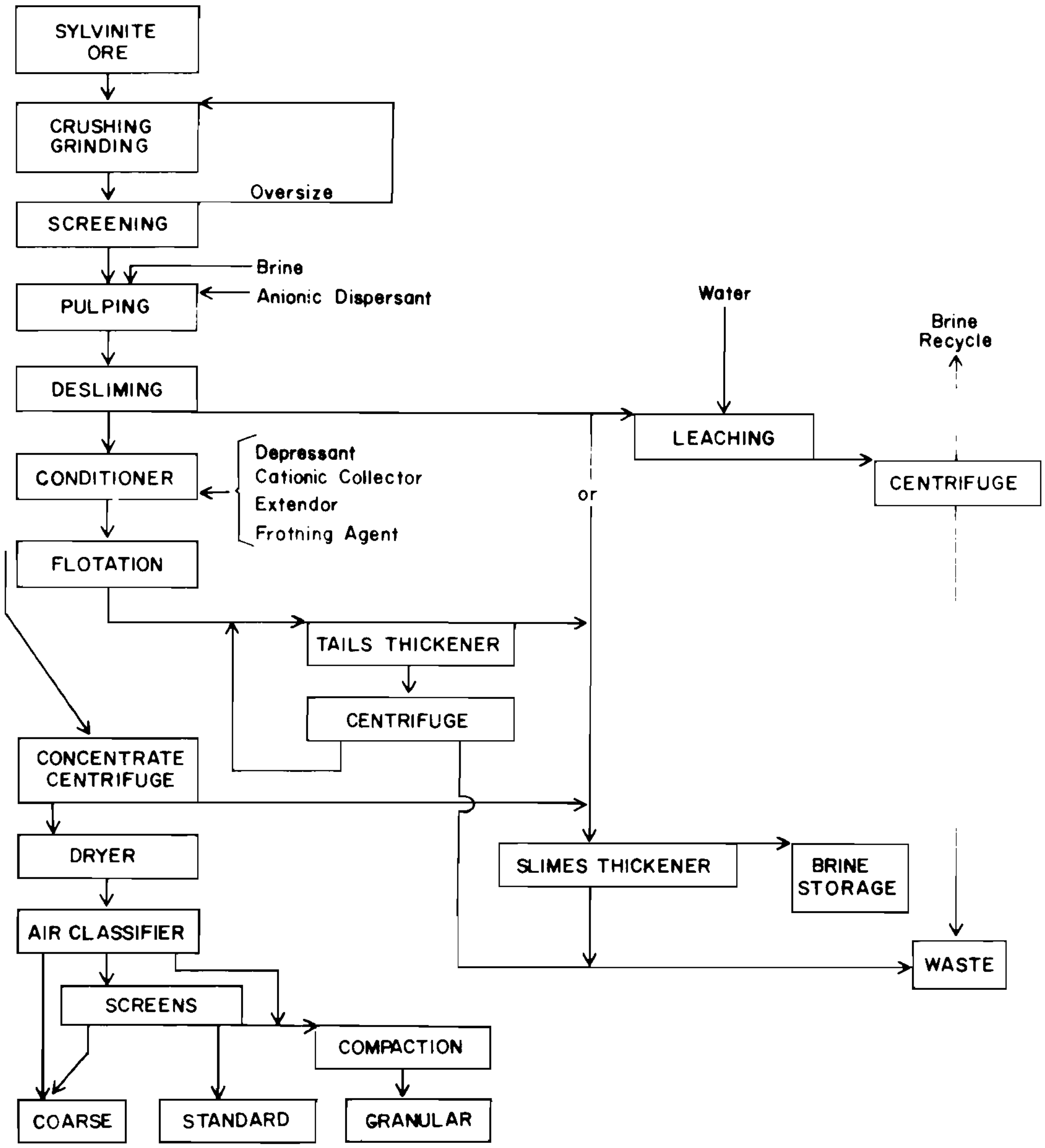

SYLVINITE ORE
CRUSHING GRINDING
Oversize
SCREENING
Brine
Anionic Dispersant
PULPING
DESLIMING
Water
Brine Recycle
LEACHING
CENTRIFUGE
CONDITIONER
Depressant
Cationic Collector
Extendor
Frotning Agent
or
FLOTATION
TAILS THICKENER
CENTRIFUGE
CONCENTRATE CENTRIFUGE
DRYER
SLIMES THICKENER
BRINE STORAGE
AIR CLASSIFIER
WASTE
SCREENS
COMPACTION
COARSE
STANDARD
GRANULAR

Figure 2

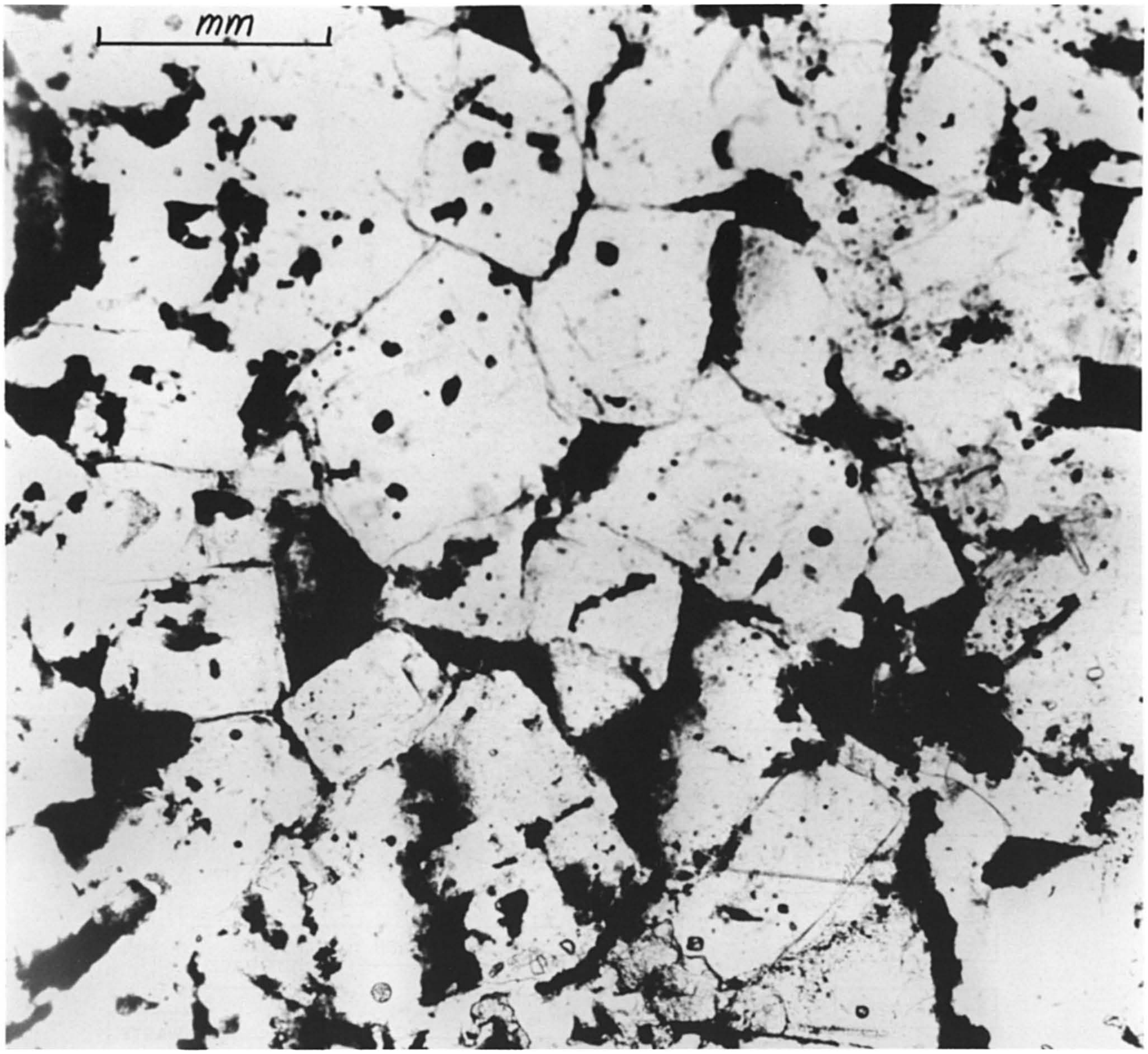
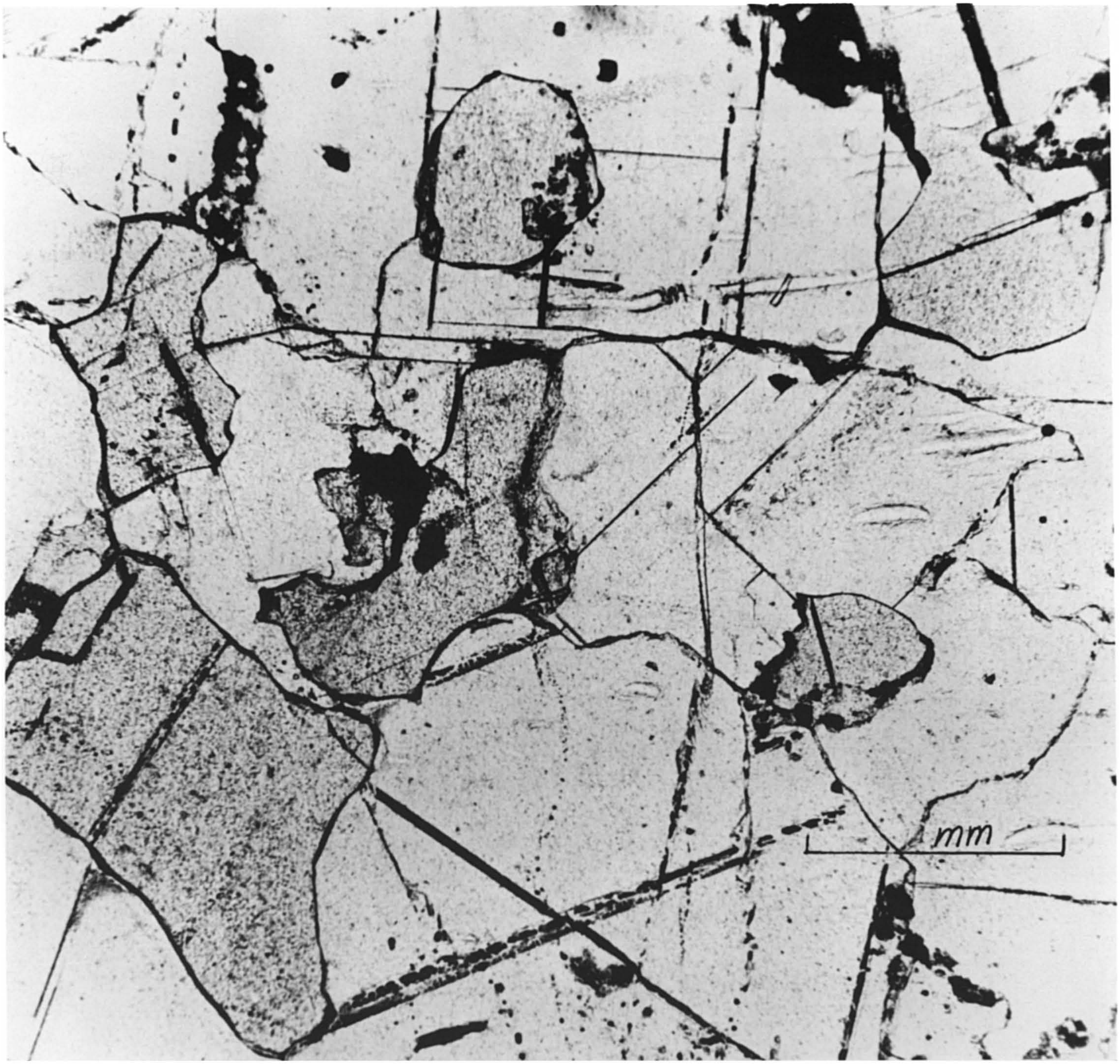


Figure 3



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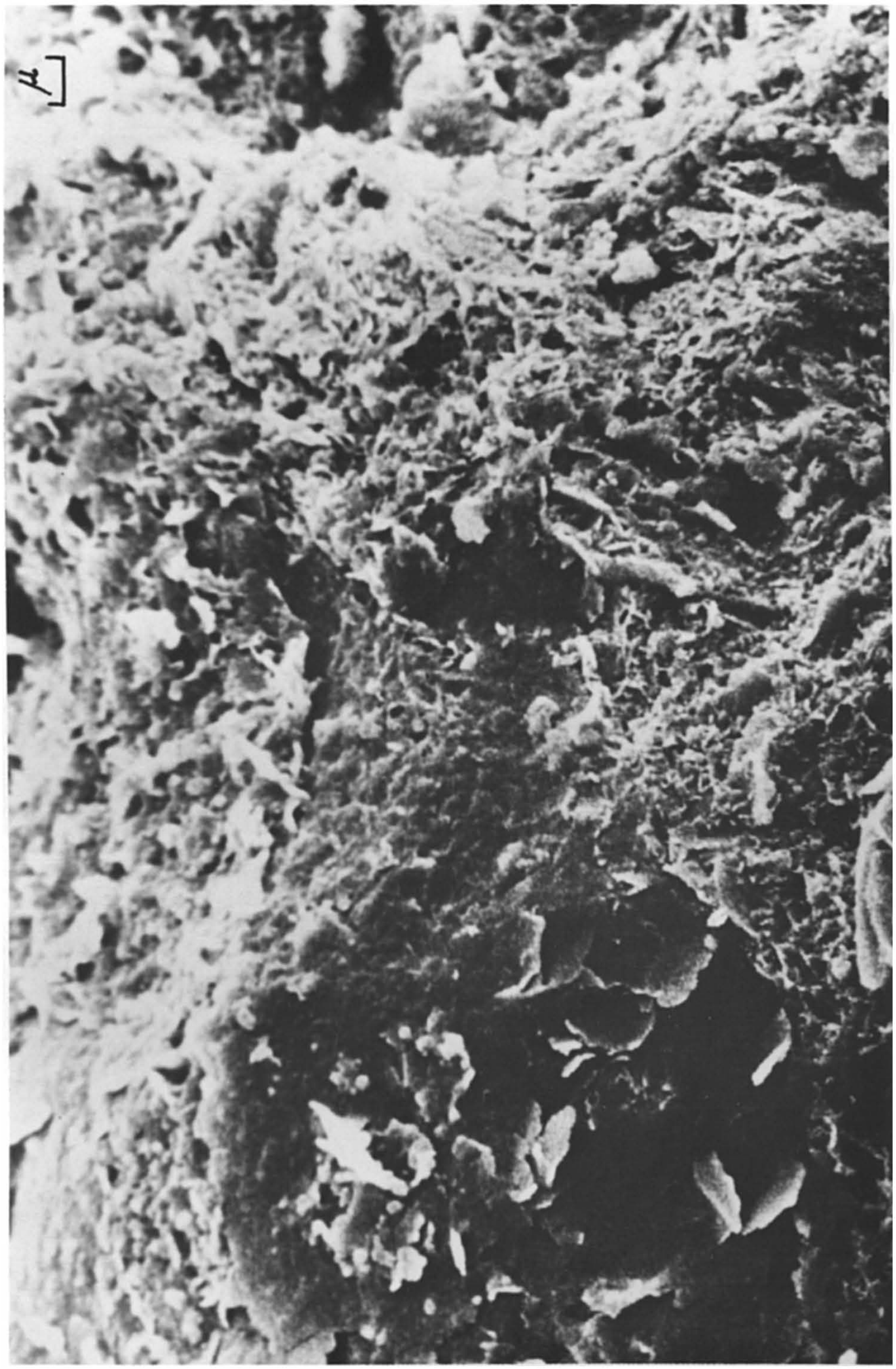


Figure 5

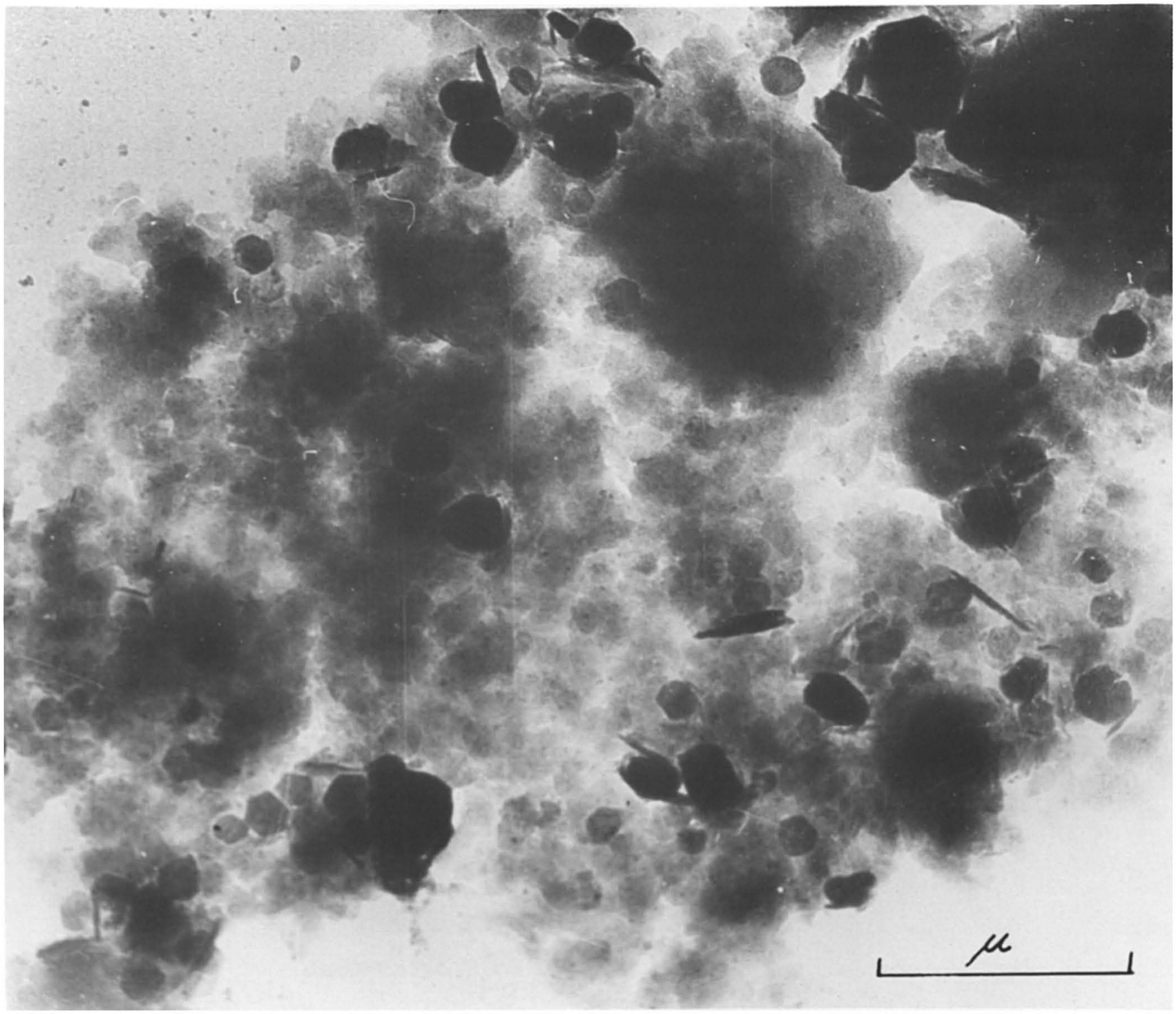
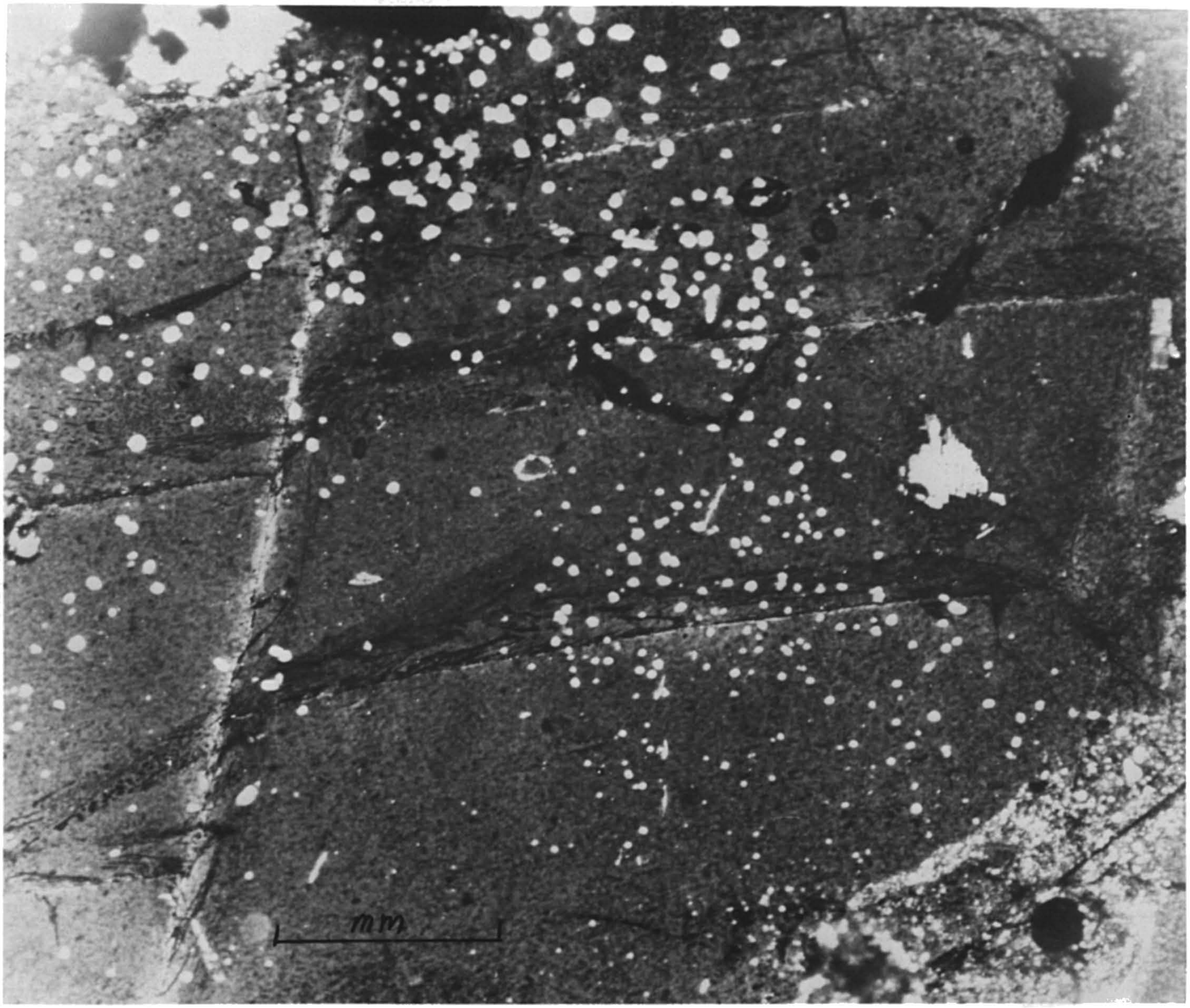


Figure 6

Figure 7



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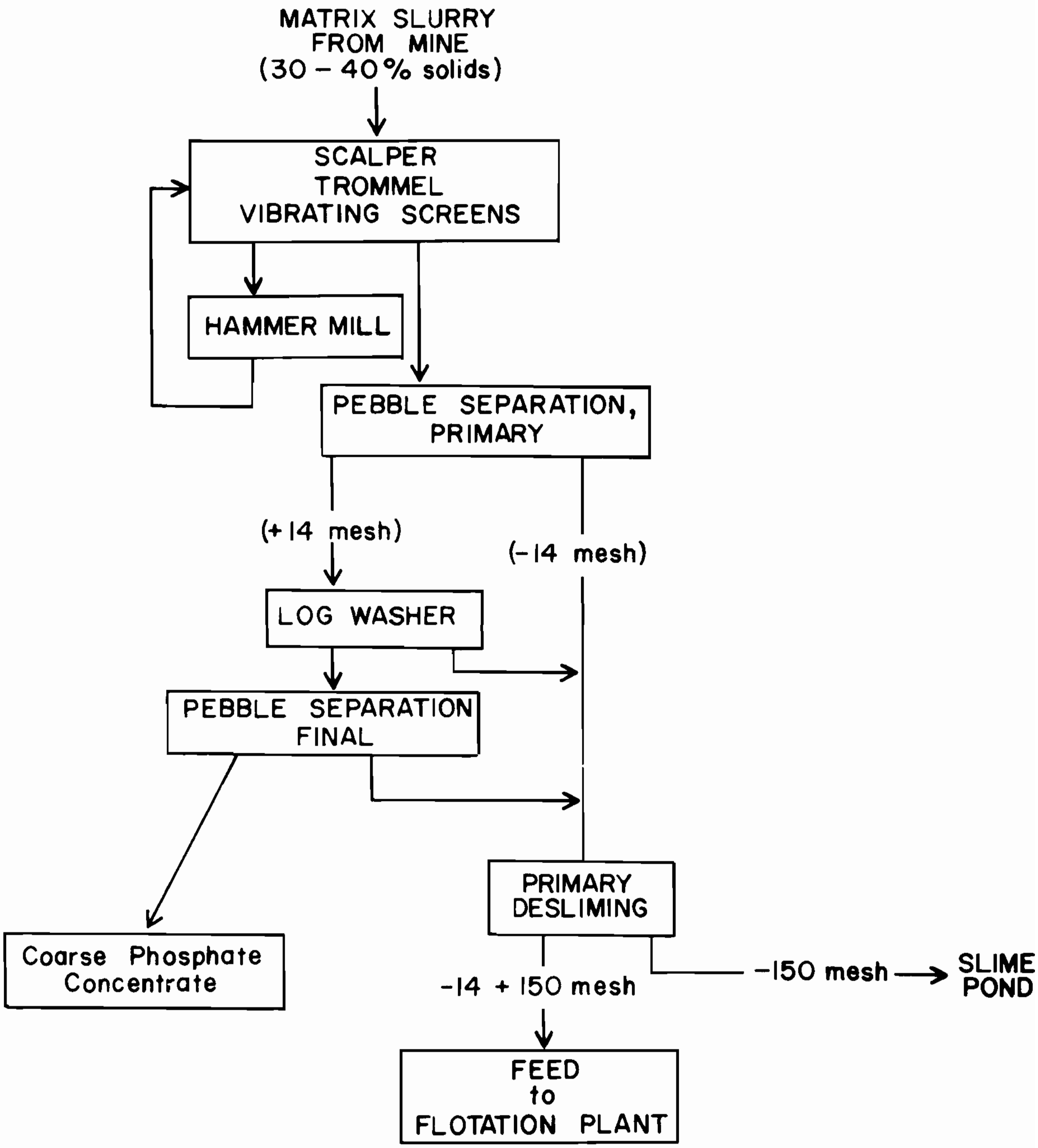
MATRIX SLURRY
FROM MINE
(30 – 40% solids)
SCALPER
TROMMEL
VIBRATING SCREENS
HAMMER MILL
PEBBLE SEPARATION, PRIMARY
(+14 mesh)
(-14 mesh)
LOG WASHER
PEBBLE SEPARATION FINAL
Coarse Phosphate Concentrate
PRIMARY DESLIMING
-14 + 150 mesh
–150 mesh
SLIME POND
FEED
to
FLOTATION PLANT

Figure 9

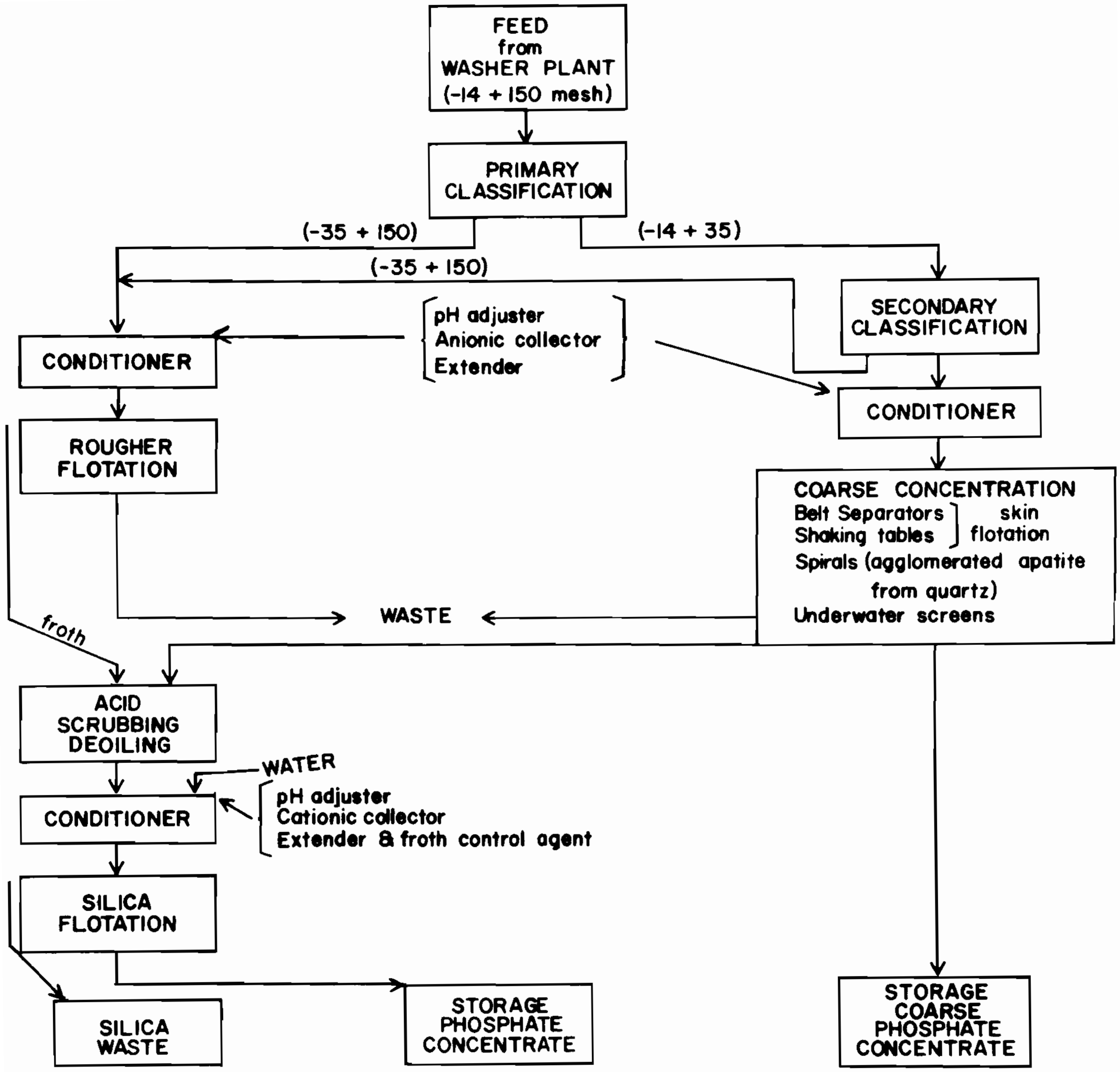
FEED
from
WASHER PLANT
(-14 + 150 mesh)
PRIMARY
CLASSIFICATION
(-35 + 150)
(-14 + 35)
(-35 + 150)
SECONDARY
CLASSIFICATION
pH adjuster
Anionic collector
Extender
CONDITIONER
CONDITIONER
ROUGHER
FLOTATION
COARSE CONCENTRATION
Belt Separators
Shaking tables
skin
flotation
Spirals (agglomerated apatite from quartz)
Underwater screens
froth
WASTE
ACID
SCRUBBING
DEOILING
WATER
CONDITIONER
pH adjuster
Cationic collector
Extender & froth control agent
SILICA
FLOTATION
SILICA
WASTE
STORAGE
PHOSPHATE
CONCENTRATE
STORAGE
COARSE
PHOSPHATE
CONCENTRATE

Figure 10

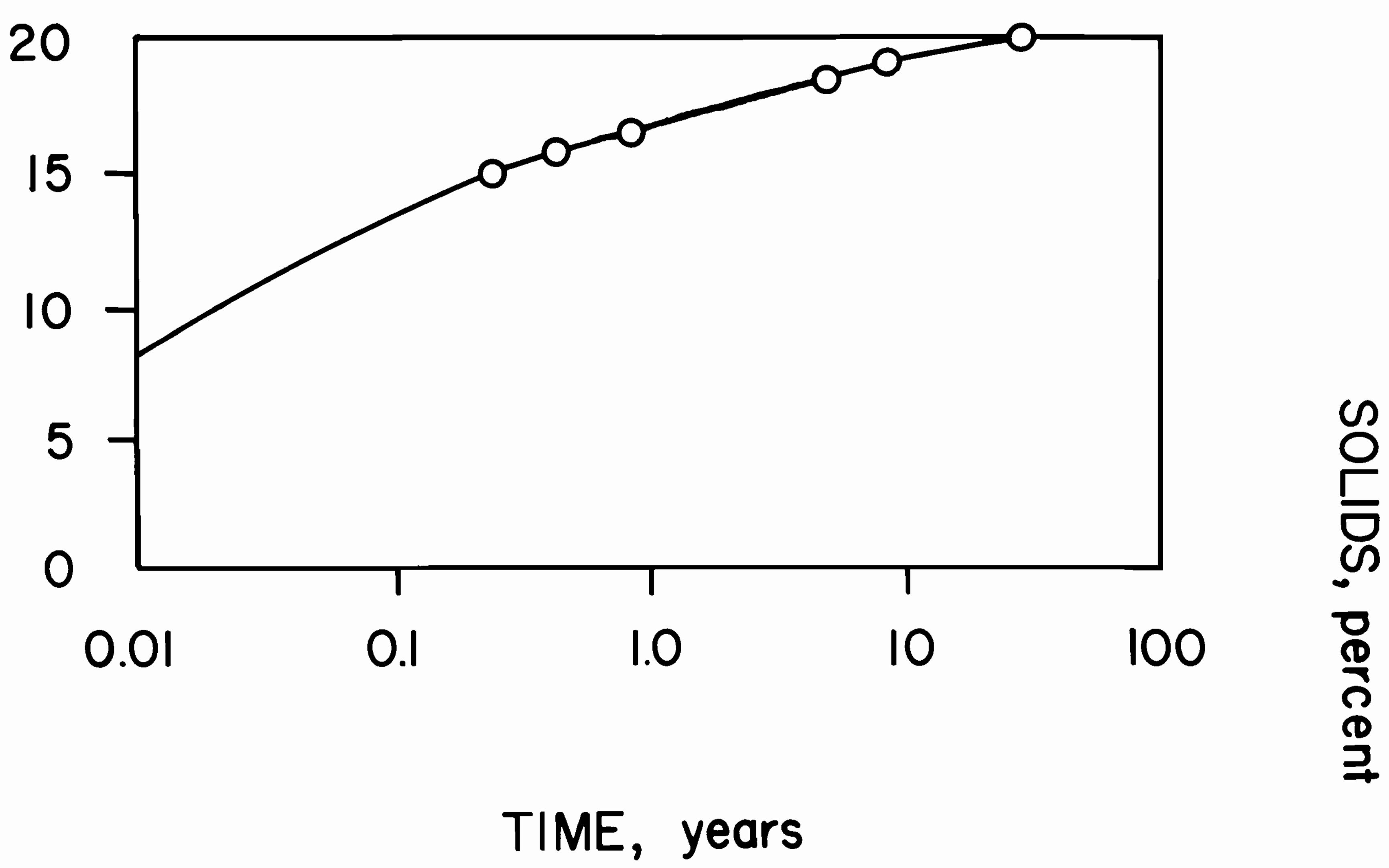

Figure 11

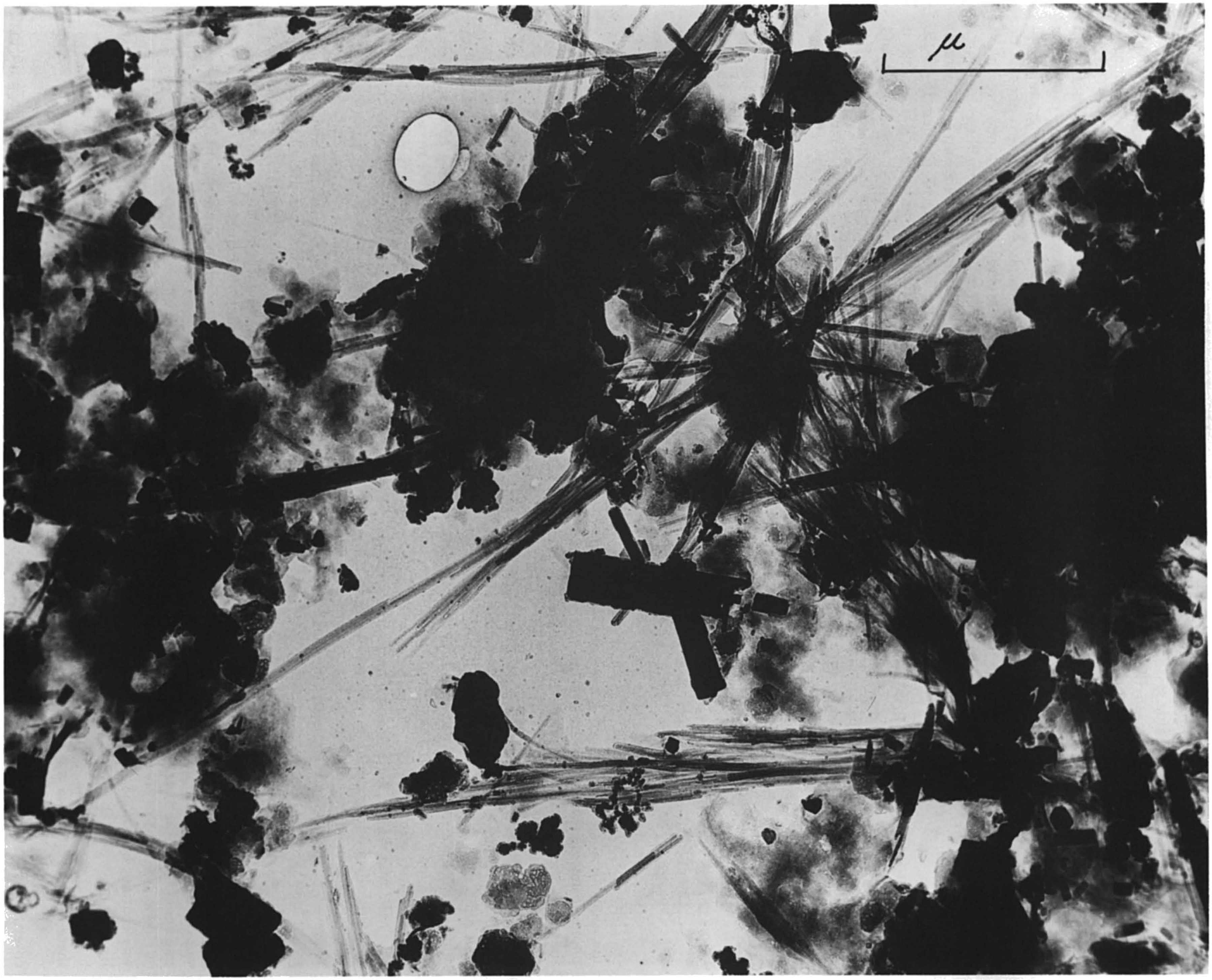

Figure 12

MODERATOR NEILD: At this time I would like to thank our speakers of the morning for their valuable contribution to our Round Table session. I would like to thank you for your attention to these speakers. *(Applause)*

Now we'll let Paul Prosser bring his troops on up here and wrap up the program for you. *(Applause)*

Panel Discussion Question and Answer Session

Paul J. Prosser, Jr., Moderator

MODERATOR PROSSER: As you may know, the purpose of this session is to give all of you an opportunity to ask questions of this distinguished "Panel".

For purposes of facilitating the recording and transscribing, we will ask the "Panel" to identify themselves beginning at the left side, that is my left. Introductions:

> I. W. McCamy, TVA; Allen Jackson, J & H Equipment; Joe Prosser, The Prosser Company; Frank Achorn, TVA; Bob Flagg, USS Agri-Chemicals; Al Malone Agway, Inc.; Dick Perkins, W. R. Grace; John Medbery, IMC; George Hebbard, The Sackett Co.

MODERATOR PROSSER: We'll begin by inviting questions from the audience. I believe that this microphone to my right has been turned on, but we do have these two microphones here. Now do we have any questions from the audience? Yes, sir.

QUESTION: Alan Longacre of Fluor Engineers and Constructors. I think I'll direct this question to Mr. McCamy. In regard to urea granulation with high analysis I believe you would use a melt for that purpose. What has been experience with biuret in the products made by that technique?

MR. McCAMY: Well, I don't recall any analyses, but typically from granulation of urea we didn't have any increase in biuret content in the granulation step. However, in the presence of these other materials there might have possibly been some increase.

QUESTION: Alan Longacre. I have a second question in regard to urea formulations and that is you do have hygroscopic conditions. Has TVA considered using a coating on such granules? I know you've done a lot of work with sulfur coating of urea. Perhaps such a technique could be useful there.

MR. McCAMY: Some work has been done with oil wax coatings with hopes that they would protect it. I believe in lab work, this type coating appeared effective, but in field work it was not proved as effective. Perhaps there can be additional work directed in that direction.

QUESTION: Alan Lonquacre: Is there a bulletin covering that subject? Has TVA generated such a bulletin?

MR. McCAMY: I'm not sure on that. Perhaps there is along with their other coating publications.

ALAN LONGACRE: Thank you.

QUESTION— CARL WEIL — Coppee-Rust Belgium: We're licensing some Spanish technology which may be interesting on urea, Mac. C.R.O.S. in Spain, which is a large fertilizer producer, is running in Malaga, Spain, a 400 ton per day NPK production using prilled urea; and they have in the granulator a pipe reactor using ammonia and wet process phosphoric acid. On the site in Malaga they have a new urea plant so for about a year they've been using these high urea formulations. The content of urea goes up to 35 percent for 28-10-10, and they're making all of their 15-15-15. They have particular problems in handling urea; but it is, I think, one of the most advanced commercial and industrial uses of urea. I just want to report that to you in connection with your paper.

MODERATOR PROSSER: Thank you, sir. Anybody else?

SAM HOUGHTALING OF DAVY GAS: We built the Coromandel plant, and the Coromandel plant produced 28-28-0 while I was there. We used no coating on materials at all. It went into storage; it was a closed building. It did have some humidity control, but only fair humidity control. Then it was bagged direct on site, but we used no coating. Just to correct one thing, it was reported in the literature — there is no pug mill in the Coromandel plant; it is just a granulator.

MODERATOR PROSSER: Thank you. anybody else? All right, here's one that was sent in. What are you doing about fugitive dust control?

ANSWER: JOE PROSSER: We're controlling it. Seriously, we have in a lot of plants, and everybody has, made pickups. There's a lot of literature published on this thing. We usually put it into a bag filter and feed the dust back into the system. We're able to get granulation plants as an example pretty nearly dustfree this way. It doesn't take a whole lot of energy — 50 hp, 60 hp, something like that, does it with a normal granulation unit.

MR. JIM HEBBARD: One of the obvious things, and, of course, Joe's done this, is to use all the air to the maximum advantage. Now, of course, there's quite a push now for recycling cooler air through the dryers where possible. I think that an obvious thing is that you have to take air into your equipment. Make sure that the air you take in does as much good as possible. Take your air out of the mills which are dusty; it's not hot usually; throw it in the cooler. Take your air out of any area in the plant that is sitting there and move it out of the personnel area into the equipment; or, as Joe said, put it in a collector and clean it up and use it in the plant. Don't exhaust it to the atmosphere; it's just another stack.

MODERATOR PROSSER: Anybody else want to comment?

COMMENT, DICK PERKINS: I think each plant has to look at the particular problem. Bag collectors, of course, can do the job. Taking it into coolers will do the job in many cases. Sometimes you can solve the problem with application of a light oil or organic material. In a large blend plant, where a bag collector won't solve much of a problem because what you do with the dust, application of an oil on incoming materials has helped a great deal on dust control.

MODERATOR PROSSER: Allen.

MR. ALLEN JACKSON: To have floating dust in the air you've got to have obviously the floating dust and the motive power to blow it there. If you can eliminate either one of these features, you will not have the floating dust. One example would be where a conventional plant may take the oversize, crush it, put it back in the elevator and come right back over a screen. You will have the floating dust generated by this mill. You have the motive power of the material moving down the screen. Unless the screen is tightly covered you can have a lot of dust. If this material, after it were crushed, could be passed back through the cooler, the cooler would strip the dust and there would be no floating dust at the screen.

In many cases you cannot go into an old plant and do something like that, but you could simply turn the discharge of your breakers right back up into the discharge end of your cooler and let the cooler strip most of the dust. A typical floating dust example may be a cyclone trying to return the cyclone materials to the process. If you bring the cyclones dust back to an elevator with an open intake and you discharge the fines into that elevator from your sizing screen you will have a problem. Obviously, the cyclone dust is floating dust. The fines falling down a chute will drag air and generate motive power. You can blow the dust around with that arrangement. You can't put both together in an open elevator. If you can eliminate from your system the floating dust paired with the motive power to blow it, it's quite easy to eliminate dusty areas. My feeling is it's much easier in a plant to eliminate all of the dusty areas than it is to go to supplementary equipment such as a bag collector to pick it up.

MODERATOR PROSSER: Any other comments?

JIM HEBBARD: I think that most of the challenge is where there's not enough money to do the job. Everyone wants a dust collector if they have a dusty area or they want better equipment if they can get it not to make dust. But there is one area that we all walk by and close our eyes as much as we can and that is a problem for the guy that doesn't have the money. That's the man who is charging his system with a front end loader while he's trying to make product. The front end loader has a problem in that it is dumping a tremendous volume of material all at once and this makes it extremely expensive to get that dust, and this is a problem that is being worked on. I think there is an answer coming up, but it is one point that is an inexpensive part of the operation that is usually put in because of lack of budgeting for automatic materials handling or because the plant is a small bulk blend, etc. It's a serious area and we should not overlook it.

MODERATOR PROSSER: Anybody else? In this connection what is the best material to use in a bag filter?

BOB FLAG: I'll take a try at that. It will depend upon the application, what you are handling, and the temperature involved. On fugitive dust the cheapest bag material will be cotton sateen. It doesn't hold up too long. You might get at best two years of life out of it, probably one year. Better materials are Dacron, but you can't use that where any heat is involved because Dacron breaks down, sort of disintegrates, hydrolyzes in the presence of heat and moisture. So Dacron is all right on fugitive dust where there is no heat involved. Polypropylene is a material being used quite extensively now that is good on fugutive dust. It is available in felted materials as well as woven facric. On our bag collectors serving our dryer coolers we use acrylic woven bags. They will withstand the heat; they will withstand the corrosion. I say they will withstand heat; they will take up to about 260 degrees F. continuous temperature. Above that they will burn and fail. Teflon bags have been used to a very limited extent. Some manufacturers have gone to a teflon cuff on the bag. The bottom 12 inches of the bag that takes a lot of the wear, the abrasion, the flexing there. So there are a lot of materials that can be used, and it depends upon the application. Most of your bag collector people if they have had any experience in the fertilizer industry can give you good recommendations on what to use.

MODERATOR PROSSER: Anybody else want to comment?

AL MALONE: Our basic specification for fabric in our multicompartmented collectors on our dryers which I think is of major interest to some of you is an acrylic fiber of continuous filament type. There are variations in weights and weaves of these fabrics and some other characteristics which we in our experience don't yet know how to specify just what the most reliable characteristics are, but we are sticking with that type filament as a standard at this time. However, we are trying some polyester fiber of continuous filament type material in one of these type collectors. We should have better information within a year as to the applicability of that type fiber. Certainly, if it will work, the polyester type fabrics such as the tradenamed "Dacron" are less expensive than the Acrylic clothes. Dacron are less expensive types of cloths.

MODERATOR PROSSER: If you were putting a new or replacement elevator into a granulation plant, which type would you install, one with the conventional malleable combination chain or one with a belt?

ALLEN JACKSON: I'd use chain in a granulation plant.

JOE PROSSER: We would also. There may be some exceptions when you get way downstream on the final product; but as long as it's for anything like raw materials or it's coming out of an ammoniator or between a dryer and a cooler, chain.

QUESTION FROM AUDIENCE: Single or double?

JOE PROSSER: Single, if at all possible.

QUESTION FROM AUDIENCE: Why?

JOE PROSSER: Because I haven't been able to find two chains that don't stretch differentially. Now understand that when you get up over about 250 tons per hour, you might be talking about a double chain elevator; but certainly up to 200 tons an hour we would go with a single chain because we think a single chain is easier to maintain and easier to keep in proper adjustment. You only use a double chain when you can't do it any other way.

FRANK ACHORN: We have observed several plants are thinking about and a couple have changed to positive discharge elevators as a raw materials handling elevator. There appears to be less reflux down the elevators from what is normally received with a centrifugal type elevator. Those companies that have used these elevators have been able to eliminate a lot of their problems with dust in the areas we were talking about earlier. We took some dust measurements in one plant several years ago, and they have since improved their operation; but they were atrocious. They had dust measurements that were 150 times the recommended limit. So I think I would certainly look at positive discharge elevators. They cost a lot more than the centrifugal type elevator, but they certainly have less dust around them and cause less problems with dusting.

JOE PROSSER: I would recommend on that if it's not too great a capacity you need, a continuous elevator again on a single chain at about the same cost or slightly more cost than the centrifugal discharge elevator will improve the dust generation problem quite a bit so long as the raw materials or whatever you are handling is dry and not sticky, which is the same problem with the positive discharge elevator.

MODERATOR PROSSER: Anybody else? A question from South America. Discuss the type design and manufacturer of a continuous fertilizer sampler.

ALLEN JACKSON: The continuous sampler obviously is some type of mechanical device to pass the cup through the stream at some fixed interval of time. The problems that you get into with any continuous sampler are how do you close the cup off for floating dust in between the sample periods. If you try to cover it, as you move the cover on and off you guarantee that you will contaminate and pressurize the sample slightly and cause enough air flow to come out of the sample tube not to destroy the accuracy of the sample and prevent entry of dust.

MODERATOR PROSSER: Does anybody want to put in a plug for a brand name?

JOHN MEDBERY: I'll take a try at that. We've used the Denver Equipment Company automatic samplers for years. They are probably better for our industry than some of the other types. There are less expensive ones around that are made for sampling grain and this sort of thing, but they are not quite rugged enough perhaps for fertilizer. Our experience has been just as Allen pointed out it's difficult to protect the cup from contamination. We have built little shelters or you might call it a little parking place for the cup at either end of the traverse where it goes underneath a little hood and is covered from fugitive dust. This cover doesn't touch the lip of the cup, Allen, it clears it by a fraction of an inch. This seems to be a practical answer. One problem with any of these samplers is they take a certain amount of vertical space underneath the discharge from a belt conveyor at the head pulley. If you get the "Denver Bulletin" they will show different configurations, and some of these work better for a particular setup than others. You would have to kind of choose which configuration fits best, but you still have to have about two feet, maybe as much as 30" of space between one belt and whatever it is transferring into. They also can be built into a hopper of course.

PAUL PROSSER: Thank you. Anybody else?

DICK PERKINS: We use some Denver samplers. We also have several samplers made by Allen Jackson that fit pretty easily into a chute if you can't get it under a belt discharge. There are several vendors of samplers, I think. Most of them will do a pretty good job if you install them properly and if you can keep the dust out.

MODERATOR PROSSER: Anybody else? Anybody in the audience? We have had our natural gas shut off at times during the winter. Give suggestions how a granulation plant can be operated without a dryer.

FRANK ACHORN: A lot of granulation plants have had a lot of luck by using larger quantities of sulfuric acid and phosphoric acid in their formulations to have enough chemical heat to dry the product. There's one operation in which we have worked that hasn't used a dryer for almost two years now. I think that with the technology of a prereactor whether it be a preneutralizer or pipe cross reactor or any prereactor, I think, that you can use a lot of sulfuric acid. With neutralized sulfuric acid, when it comes in as a melt, primarily has a lot of sensible heat in it which will allow the granulator product discharge temperatures to be as high as 220 degrees. When you operate at these high temperatures, you can dry by cooling; and you are also granulating at a very low moisture. So I think the time will come when many of us will be operating without dryers. It's been practical in the two places we've worked it.

ALLEN JACKSON: Let's go back to 20 odd years ago when we used to granulate without dryers. I can think of several plants that ran many years without any dryers at all, but they were faced with a lack of flexibility in formulation. They were certainly faced with a lack of flexibility in grades that they could make. The operation totally without a dryer is going to be very, very difficult unless you limit grades to, as Frank said, certain grades that have enough heat to operate with. By and large the average plant though can reduce gas cost by formulating to get the highest liquid phase with the minimum of water. Keep ammoniation rates down below the point you make superphosphate or triple work against you instead of for you. Keep the product in the ammoniator wet enough when you run so that your recycle doesn't build up so high that you are actually wetting and drying a whole lot more material than you need to.

JOE PROSSER: I may make another comment, and I do this every year. It doesn't make any difference; nobody pays attention. We could save a lot of fuel if that's what we're supposed to do by stop drying the stuff to 1 percent because when we first started granulating, as Allen said, we sold an awful lot of granular fertilizer at 3 percent and 4 percent. There are still two or three people that I know in this country selling fertilizer at 4 percent. Now, obviously, it doesn't take as much heat to get it to 4 percent as it does to get it to 1 percent. I'm not so sure that just because the sales persons tell us that we have to have a 1 percent because somebody else says it has to be a 1 percent does not necessarily make it true. I think a lot of fertilizer, especially in the spring season, can be made at 4 percent because it never stays long enough to get hard or those kind of things. I think that the fertilizer industry can help themselves an awful lot by doing that sort of thing with or without a dryer installed.

DICK PERKINS: Allen covered some comments I was going to make. I think it depends a lot on what you plan to make in a given granulation plant. To say that you would do completely without a dryer I think might be a bit on the risky side depending on what your future is in products. I think the aim in an existing plant ought to be to minimize gas consumption or fuel consumption. You'd still have a dryer sitting around because you may need it for something. We have found that through formulation there are many grades that you can just about do without a dryer. You decrease the fuel consumption to the point that it is a minimal thing. I think that with the pipe cross reactor if a plant is set up on grades that are suitable to that type operation you might be able to get by without the dryer; but that would be the only way I would want to try it, and I don't think that we would be willing to do that.

AL MALONE: It has been mentioned here already; and, of course, there are many factors influencing whether you dry or not primarily in grades and formulations. In our particular area we are drying, and we are drying down below that 1 percent that Joe mentioned. We don't have the flexibility in control in the spring to let that moisture come up. I grant that's a good point, if that was possible,, it might work at times, but sometimes we don't always sell the material that we make in the spring either in the spring period or move it out right away. We dry to protect through the whole seasonal period, and that energy conservation that we might make here, I think, we might use in breaking that fertilizer up in the field or hauling it back to the plant.

ALLEN JACKSON: Paul, I think a lot is made by drying to low moistures when you really ought to be looking at going to the pile at lower temperatures. I think more people get into more trouble in pile set and in dust in shipping by going to the storage pile much hotter than they should. I don't remember which one of these meetings I saw this but years ago somebody presented a picture in a talk I think it was one of the TVA people, that showed the microphotographs of pellets that had been in storage. It showed the migration of the water to the surface and the little hairlike surface of the pellets. The hotter the particle, obviously the worse this gets. This is the primary source of the dust in shipping mills. It's not the crushing or the mechanical handling. I think a whole lot is made on going to the pile at 1 percent moisture when a lot more emphasis ought to be made to going to the pile as 80 degrees F.

JOHN MEDBERY: Yes, I wanted to make one comment; and that is, it's very unlikely that a regional granulation plant will ever be able to operate without a dryer simply because of the full pushcart of sales. Most of our plants will produce 20 to 30 different products ranging from 0-10-20 and 3-9-9 all the way to 6-24-24 and 8-32-16 and things like this, 16-8-8 and 2-12-6. So you see the problem, and for that reason we need the dryer. However, we can produce a number of grades with the pipe reactor and not need anything more than the pilot flame. We do preheat the system in order to prevent condensation in the ducts and in the dust collector, and once the system is preheated the pilot flame is ample to insure against condensation. If a plant such as the Palmyra plant is making just a few grades, all of them in the high analysis, high phosphate type product, that lend itself to the pipe reactor, that is the obvious answer to the dryer problem.

FRANK ACHORN: Let me correct something. Certainly you will not produce a 0-22-22 without a dryer. I grant that. But I would like to review the grades that have been produced without a dryer and they have stored real well — 12-48-0, 6-24-24, 10-20-10, 8-32-8, 18-46-0 pilot plant wise, 12-12-12, 13-13-13, 8-22-11. So there are a lot of grades that can be produced without the need of a dryer if you use the right amount of chemical heat, and you can produce them economically. The bad thing is that many of the granulation plants find that right in the middle of the winter they are on peak gas and they can't get gas and they'll have to go to an alternate source of fuel. I just think that we've gotten in a habit over the years of not using chemical heat like we should. I think we ought to take advantage of it as much as we possibly can.

QUESTION: LEO COHEN OF USS AGRI-CHEMICALS: I have a question. How do you handle the dust collector problem with high product moisture. How about the dust sticking to the bags?

JOE PROSSER: I think you're saying if we follow the idea that I had of keeping your moisture up to 3 percent or 4 percent, you're indicating we might have trouble on the bag filter.

LEO COHEN: I guarantee you would.

JOE PROSSOR: I don't agree that you would. I think we're talking about the problem with bag filters related only to the dewpoint within the bag filter. If you use a small amount of air and a lot of heat, you'll have a high enough temperature in the bag filter to prevent the kind of problem you are anticipating. If you use a full flow of air and cut the heat off, then you do have a problem.

LEO COHEN: That's the kind of problem we've been having. Thank you.

FRANK ACHORN: I'd like to add to what Joe said. You know really we could do some things about correcting the problem at the source rather than in a bag at the end of the line. I guess most granulation plants still add their sulfuric acid underneath the bed in the granulator. It should be prereacted before it goes into the granulator so you don't form ammonium chloride. I'm sure that most of them are still using a degree of ammoniation of 7.2 pounds of ammonia per unit of P205 for phosphoric acid. At least that's what our surveys are showing. We know ammonium fluoride will be lost at that pH because it sublimes. At a lower pH you can run in MAP and using about 4-1/2 or 5 pounds per unit of P_2O_5 for your phosphoric acid you form ammonium acid fluoride. It will not decompose; it will melt. It stays in your product. More effort ought to be directed toward trying to correct pollution at its source rather than to put in the equipment to collect the pollutants. One suggestion is to have optimum moistures in your products so that they will not be dusty and still will not cake.

JIM HEBBARD: I think that one thing that we have to look at here in answer to that specific question on high moistures is what are the conditions coming our of the dryer. Now in support of what Joe said, in a properly run plant that is not plugging its cyclones up every three or four days you generally have enough driving force in the off gases from the dryer to pretty well dry anything that's going to get up into that duct. If it gets up into that duct and it won't dry, the chances are the breeching wasn't designed properly. So what I'm saying is if you have a problem with plugging cyclones, you're going to have a problem with plugging bags, and you better take a look at what your moisture is in your stuff coming out of the cyclones or out of the bag collector because this can tell you if your processing conditions are a little bit too tight to the edge.

MODERATOR PROSSER: Discuss the dehumidifying of a bulk materials storage building such as one to be used for storing urea — type of equipment, requirements, etc.

I. W. McCAMY: We have a bulk storage building at TVA which is a closed building, that we purge with dehumidified air obtained by passing air through a conventional air conditioning system. With our something like 25,000 ton building we initially had 50 tons of refrigeration, ten five ton units. We seldom run over half of those units at a time. The temperature inside is not appreciably cooler than ambient temperature but the air is dehumidified; and as long as you purge in dehumidified air, then it should maintain a dehumidified condition in the building.

MODERATOR PROSSER: Anybody else want to comment? Suggest procedures to use for safe disposal of fluosilicic acid from scrubbers of normal superphosphate plants into ammoniation-granulation plants.

FRANK ACHORN: There is one plant that we have worked with that is taking fluorsilicic acid and putting it back into the granulator. It has a normal superphosphate plant tied to it. When that plant was operating at the degree of ammoniation we just talked about earlier, 7.2 pounds per unit of P_2O_5 for their phosphoric acid, they lost the fluoride and you could see it visibly from the stack. Since that time they have decreased the degree of ammoniation of the acid, which has not only helped them eliminate their fluorine losses from their stack, but it has also helped them to increase their product ton rate because the lower liquid phase in the granulator. They have done it, and it's running real well. I really see no reason why it shouldn't be done. Especially if you have a lot of triple superphosphate in your formula, you probably tie up part of the fluorine in this calcium fluoride too, which will not decompose. If you are going to put fluorsilicic acid back into the granulator you have to maintain the conditions where you do not form either ammonium fluoride or ammonium fluorsilicates, and those ammonium fluorsilicates are at a relatively low pH and ammonium fluoride at a relatively too high a pH. You need to form ammonium hydrogen fluoride at pH4. The product from the granulator needs to be pH4.

JIM HEBBARD: I'd like to add to what Frank said. For those of you who went to sleep when someone said normal super and fluorsilicates there are other problems coming along the pike like fluorine emission when you're using phos acid, and the eventual result is going to be the same fluorides are going to have to go back in the granulation. I hope there are no spies in here who are going to prove that you can't put fluorides in fertilizers, because that's where it's going to have to go. Yes, these conditions that he's talking about we're all going to be very familar with in a few years if we're running granulation plants.

ALLEN JACKSON: Frank and I may be talking about the same plant, but there are currently three plants that are recycling both the fluorine water and the granulation plant by combining them. All of the plants have reduced first the fluoride content of their super plant by raising the pH up to about 1-1/2 or 2 with a calcium hydroxide. That generally precipitated out in the super pond and made quite a good bit of silt. It's been found that we could keep the super pond at a pH of about 1-1/2 by bleeding over some of the water from the granulation plant to it. If the pH dropped down to below about 1-1/2, the silt that was in the pond begins to come back into solution, especially if it's stirred up a little bit. It gives a very, very good stabilizing influence to the granulation pond. So even though you are going to neutralize it with ammonia some of it is still desirable to have a good bit of calcium silt in the pond. Most granulation plants and the three plants using these are basically southeastern type plants. They either cannot sell their fluorsilicic or they are made with a spent acid which makes it unsalable. The granulation plants will consume anywhere from 3,000 to 10,000 pounds of water an hour. This water is generally supplied to the granulation plant from the super pond. The pH 1-1/2 water, brought over to the granular plant, if it's ammoniating, must not exceed the amount that wouldn't lower the pH below about 4 or 4-1/2. If you lower the granulation below a pH of 4, you can expect fuming in your granulation scrubber. If you stay in the 4 or 4-1/2 range, you can consume a lot of water from your super plant. When this low pH water from the super plant hits the granular plant water and is raised from 1-1/2 to 2, you immediately get a precipitant. It comes out in a hurry. The neutralization has to take place in a separate tank or separate pond. This silt pond then is used, pumping the silt as you would the slurry in an ammo. phos. plant, to contain the solids so that it can be pumped to the granulator and used for your control water. The fluorides are pretty well tied up in calcium compounds at that point. It is a fairly easy way to get rid of the silt. You can consume it all within the plant, and operationally there are few troubles with it. It does take a little bit of operator monitoring or management monitoring. If the ponds have any size, nothing is going to change in a hurry; but you must monitor the ponds reasonably close not to let one get way out of bounds on pH. If you run a lot of "O" grades in the granulator plant, obviously you come to a halt in consuming the super pond water. You are going to drop your granular plant pond water down to ph 1 or 2, without addition of the super waste water. Total implant consumption of water is being used; it is not particularly difficult; it does not show any great corrosion in the metal stacks or ducts and cyclones. It does consume all of the water. There is no water effluent from a plant. The plant is a water user instead of a water emitter. It is a reasonably satisfactory way to run a super phosphate plant and a granular plant. I can imagine one problem. If you make super for four other plants besides your own and make a disappropriate amount of super, you could get into trouble with a little bit too low of pH water or not being able to bring enough fluorine over to the granular plant to dispose of it.

FRANK ACHORN: I had forgotten this earlier that we took actual measurements from a plant that was ammoniating to MAP or PH-4 they were using a lower degree of ammoniation, and we couldn't find any fluorine nor chlorine coming off of the plant. We're going back to take some additional stack gas analysis; but I'm pretty sure we're going to find we don't have any fluorine in there, and this is not always true in diammonium phosphate operation. So I think that there will be some benefit derived from this type of work that can be related over to the production of diammonium phosphate too and the conditions to operate that scrubber not to strip any fluorine out.

ALLEN JACKSON: The efficiency of the super phosphate scrubber scrubbing with pH 1-1/2 water has been demonstrated that three stages of scrubbing will get you just about .1 pound of fluorine effluent per ton of super. It will be 1 pound or less. There's one problem that if you're using spent acids, particularly an alkalation type spent for making super. Run a little test before you start putting ammonia in the pond if you do it without calcium. You may end up with a pond full of jelly. So be careful on that one. Do a few lab tests before you crossflow ammonia with some types of spents.

MODERATOR PROSSER: Anybody else? Any questions from the audience? It is just a minute or two after 12:00, I believe. We will be happy to continue for a few more minutes. We will continue for about 15 minutes till 12:15 if that's agreeable. Is that agreeable with the panel? What is the best meter to meter liquid ammonia? Go ahead, Jim.

JIM HEBBARD: I haven't actually put one in, but I think it's going to be in the long run, if the prices come down a little bit, the fluidic meters. A lot of this depends on what your temperature of your ammonia coming in is. If you have liquid ammonia and it's going to stay there for a few seconds, you can put it through a rotameter obviously, but you can also put it through a fluidic vortex flowmeter such as Moore makes, with no worry about flashing. You can always put it through a turbine meter if you want. My experience is that in a granulation plant you're going to pop some bearings on that turbine meter sooner or later so you might as well look at the fluidic right now.

DICK PERKINS: We are still using turbine meters in all of our plants on liquid ammonia. It is a maintenance problem, but so far we're satisfied with the accuracy that we get with them if they are maintained properly.

PAUL PROSSER: Anybody else? Anybody from the audience? Discuss pH measurement and control in preneutralizers in fertilizer plants.

FRANK ACHORN: I imagine he is looking for a continuous pH meter, one that measures continuously. There may be one, but the best one that I have found is a portable one that you can periodically take a sample. We've been misled more from a continuous pH meter in a preneutralizer than we have been directed by it really. I don't mean to just give negative comments about it, but I haven't found one that consistently works well. I hope this can be solved.

JIM HEBBARD: I think for most of the process people they realize that a lot of the problems with the pH meters are fluorides. There's a lot of work being done in this area, and a lot of the vendors say that they have a machine that will do the job. You can't prove it by me. I tell the foremen that I work with on startups or the like do not forget to have some pH paper with you.

FRANK ACHORN: If he's making diammonium phosphate, I hope he's running mole ratios and not just pHs. I think mole ratio determinations are a better way to control preneutralizers than by pHs because most plants that are producing diammonium phosphate are running NH_3 to H_3PO_4 mole ratio of 1.4 or 1.5; and at that part of the pH curve is pretty flat, and you can't get very good PH measurements. So you need to determine mole ratios to get your controls.

JOHN MEDBERY: Just to find out what would happen we tried a little experiment using a typical laboratory pH meter with a glass electrode. We put it in a beaker, and using a small laboratory pump we circulated scrubber water from the ammoniator scrubber which, of course, contained some fluoride ions through the beaker, and it went for 28 hours and then, of course, we had a complete failure of the electrode. So I think that's what we would run in to a short electrode life. If you're going to pay for that, you probably could make something work.

MODERATOR PROSSER: Anybody else? Any question? How can buildup be eliminated in the ammoniator exhaust fan? With a fire hose?

FRANK ACHORN: That's an equipment question. That's not a process question.

JOHN MEDBERY: Of course, we never did solve that problem until we went to wet scrubbers on our ammoniators. The wet scrubber, of course, is ahead of the fan. Then you must provide a good droplet removal device after the scrubber before the fan. If you provide this and it works efficiently, you have no trouble whatsoever with the fans. We've had some run for a year and maybe 150,000 tons of fertilizer and never been cleaned.

QUESTION: How can buildup be eliminated in the ammoniator exhaust fan? With a fire hose?

JOE PROSSER: That works fine. Sometimes you trade if off for the duct plugging up ahead of the scrubbers. I think about all you can do in that case is try to arrange your ductwork so that you put a water spray ahead of it.

JOHN MEDBERY: I neglected to mention that our ductwork slopes downward toward the scrubber, and we bring a water stream up to the high point of the ducts so that it flushes the duct into the scrubber.

MODERATOR PROSSER: Anybody else? Discuss the collection of off gases in a bulk storage building. Jim, do you want to talk?

JIM HEBBARD: I'll just repeat what John Medbery and I were saying here without the mike. First of all, it's expensive. Second of all, John was mentioning that well maybe we're talking about super phosphate storage. All the plants are being pushed into this if they're not already doing it and that again is expensive. The third thing is that there's getting to be quite a push on this EPA particulate per cubic meter or however you want to look at it. That's expensive. I think we'll get some more comments from the other members of the panel, but the first thing to look at is don't scrub the whole building if there's only a man in one bin or one area of the building. Or if you can do it, rig it up so the bins are sealed. There's a lot of ways to go, but the beginning of getting the cost down is to scrub as little as you have to or dry clean or whatever as little as you have to.

JOE PROSSER: We've had a little bit of experience with this. I really don't think it's so expensive. In big storage buildings particularly phosphate rock, and I'm talking about dust problem now, it isn't all that bad because the standards for the amount that has to be moved per hour in a building where there's only one or two people working are pretty small. You can get away with such things as one change of air per hour or 1-1/2 depending on who you talk with, maybe 2. This is really not a whole lot of cfm if you take the volume of the building and divide it down by 60 and so forth to get it down to changes per minute. It's not really bad. A big storage building I'm saying can be handled with an air movement, say a 15 or 20,000 ton storage building for phosphate rock for example, of something like I remember of 25 or 30,000 cfm which really isn't all that bad if somebody is breathing down your neck and saying you must clean the building up. I think it's something possible and we've done it in two cases and it's working. It costs money, but that's it.

MODERATOR PROSSER: Go ahead, Jim.

JIM HEBBARD: I just wanted to add and back to what I said earlier. Yes, what we must do is complying with standards, but when the standards are written in terms of dust measured per cubic foot sometimes you can't get away with a certain number of cfm per building. So it does get fairly complicated. Fortunately or maybe not fortunately, most of the jurisdictions haven't gone that way yet.

MODERATOR PROSSER: Any other comments?

Gentlemen, I think the time is about up. Before we leave I would like to say we're going to turn the microphone over to Rodger Smith, and before that I wish you would join me in a round of applause to thank these panel members for their information and candor. *Lots of Applause)*

CHAIRMAN ELECT RODGER SMITH: Thank you, Paul, and thank you, panel.

As this Round Table approaches a close, this 26th round Table, I am sure you all will join me in expressing appreciation to Joe Reynolds for the fine leadership that he has exercised in behalf of the Round Table during the last three years and many years before as a matter of fact. Also for the major contributions in addition to Joe - Paul Prosser, Tom Athey, Al Spillman, Wayne King, Walt Sackett and others. I am sure you also join me in expressing appreciation to all those who have delivered papers, the panelists and the moderators.

The consensus as I've heard it in the last 2-1/2 days is that the program has been outstanding and the participation has been excellent.

I am sure we also appreciate the contribution of the engineering companies in making possible the very fine party last evening.

As we look forward toward another year, I assure you in behalf of the Board of Directors that they invite your ideas on subject matter and format or any other aspects of the meeting this coming year in Washington.

Is there any other business, anything that anyone wants to bring up before the Round Table before we break up?

If not, have a good year. I hope it is a successful one. The meeting is adjourned. *(Applause-Applause)* Meeting adjourned 12:30 P.M.

Comments by Albert Spillman

Editing Chairman

These "Proceedings" give an excellent accounting of "Our Round Table 1976 — Three Day — Five Session — 26th. Annual Meeting."

I am sure you will enjoy reading the "Timely, Interesting and Valuable Discussions covering the many Phases of Your Daily Fertilizer and Chemical Operations.

It has been my pleasure to again "Edit, Organize and Supervise this Project."

I wish to take this opportunity to thank all of you, Our Chairman, Directors, Moderators, Speakers, Secretary-Treasurer and his office, and to those in Our Audience, asking questions and giving answers, for helping me promptly when I called on you to clear up the many details necessary to complete the printed proceedings.

Hope to see you at our 27th Annual Meeting, to be held in Washington, D.C. — Shoreham - American Hotel — Tuesday, Wednesday and Thursday, October 25-26-27, 1977. Most of our attendance will be arriving in the afternoon and evening, Monday October 24th.