PROCEEDINGS
OF THE
16th ANNUAL MEETING
FERTILIZER INDUSTRY ROUND TABLE
1966

Held at the
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Washington, D. C.
November 2-3-4, 1966

Executive Committee

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Fertilizer Industry Round Table

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The Sixteenth Annual Meeting of the Fertilizer Industry Round Table

Dr. Vincent Sauchelli, Chairman and Moderator

DR. SAUCHELLI: Ladies and Gentlemen: Welcome to the 16th Annual Meeting of the Round Table.

We look forward with pleasure and some anxiety to this annual gathering. It is only natural that some apprehension develops prior to the rise of the curtain.

Your Executive Committee tries to check the numerous details, but invariably something goes wrong at the last minute, the projector won't function, or a speaker fails to show up, or will the reg. istration be sufficient to keep us in the black in the coming year? Those are typical last-minute anxieties.

Much as we dislike to do it, we had to hike the registration fee this year. But please remember that your registration fee entitles you to a free copy of the Proceedings, which is worth the entire fee. Printing costs and postage take the biggest bite out of the registration income.

We are frequently asked to state what are the aims and purposes of the Round Table. Well, they are simply these: To promote the best interests of our fertilizer industry, and particularly to provide a forum for those directly engaged in the manufacturing functions, as plant managers and superintendents, foremen, supervisory engineers, the quality control staff and the materials-handling and maintenance personnel.

Other groups, societies and institutes also convene during the year to discuss problems affecting some phase of the industry. We are not in direct competition with them.

The remarkable expansion and the many technological developments of our industry in recent years provide many facets that need discussions and explanations. These needs are taken care of through different industry-connected meetings.

Another frequent question we get is How is the Round Table organized? And what makes it tick? The informality, the absence of a typical formalized structure, amaze the questioners.

The Round Table is decidedly informal. It came into being and has earned its continuing support in the idustry because it supplied a need. The operating personnel had no society or formal organization where they could meet to exchange experiences and helpful suggestions on common problems. This was particularly true during the early post-war years. Then the transition from simple mechanical mixing, to chemical engineering, to granulation and ammonium processing was occurring.

The Round Table provided the common meeting ground for such personnel. From its inception it encouraged free and frank discussions among the members concerning their problems and helped many a one to find the answer to his problem.

As a matter of fact, we actually started with a small group sitting around a table for free-for-all discussion.

We are particularly pleased always to have guests from Canada and overseas. I think we have a good sprinkling of them at this meeting. I wonder if I could ask our foreign guests to rise to show us who they are. Thank you for attending.

We request all our members to show hospitality to our foreign guests. We want to make them feel at home. We are always glad to have them with us.

May I emphasize now our policy regarding time for the speakers. We hope that they will keep within the alotted 20 to 25 minutes given each speaker. And if you are reading a paper, you might omit some of the details which are not needed to an understanding of the points being made. What we want is spontaneous observations or conclusions that will stimulate thinking and discussion.

Now for a quick look at the agenda. Bill Copeland, formerly of Olin, starts the program with a discussion of Changes and Challenges facing the Industry. What will the world need in fertilizer materials 15 to 20 years hence? Many have forecast such needs.

Neal Schenet, IMC's marketing specialist, and now VP in Charge of Plant Food Division, takes a deep look in the crystal ball and will tell us what he sees. I know it is going to be very good.

Meeting the World's Food Crisis by means of fertilizer is currently big and popular news. Mr. Koch, president of the National Limestone Institute Inc., has a new angle on this problem. We certainly want to hear his talk.

Granulation is an old hat to most of us. Bulk blend fertilizers is a relative newcomer. How do the economics of these two kinds of processing compare? Grant Marburger, manager Quality Assurance and Technical Services, Armour Agricultural Chemical Company, will discuss this always interesting comparison based on first-hand knowledge and country-wide observations.

Barney Tatum, Marketing Division, Tennessee Corporation, has some very stimulating ideas. He is going to discuss some challenging areas of our industry.

Production men seldom come

in direct contact with state fertilizer control officials, even though what they produce is being constantly inspected and analyzed by such officials.

Last year, you remember, we had Dr. Gehrke and Mr. Baker of the Missouri Regulatory Office and also Bruce Poundstone of the Kentucky Regulatory Office.

We have been fortunate to enlist one of the best known and respected among control officials in the person of Bruce Cloaninger. He will tell us how control officials and fertilizer manufacturers can cooperate for mutual benefits.

Anhydrous ammonia is the fertilizer industry's wunderkind. Its meteoric rise to a top-rank material of the industry is an astounding record. Zenas Beers, Executive VP of the Agricultural Ammonia Institute, was to discuss its relation to production problems. Zenas is not able to be with us. He is on the Pacific Coast.

We have in his place Ben Day, manager of Technical Services of the Agricultural Ammonia Institute. He has had wide experience in the industry. I am sure he is going to give us an excellent talk.

The Foxboro organization representative will explain the Turbine Meter and Anhydrous Ammonia. Tom Magliozzi of that organization was to be with us; however, he was unable to come.

We have in his place D. N. Snyder, manager Flow Group. He is a very worthy representative.

Frank Achorn, of TVA Chemical Engineering staff, is on our program. He will review for us the latest developments in granulation equipment.

You can always be sure of an excellent illustrated review by Frank. And this one is based on a recent comprehensive survey.

Also from the same TVA staff, to bring us up to date on the status of fluid fertilizers, is Archie Slack, who is an internationally known authority on the subject. It is always a treat to have Archie on the program. It has been several years since he has appeared. We certainly welcome him.

Among the other items, each of which is of direct interest to you, are presentations on equipment for dry mixing, by W. R. Stephens of Barnard and Leas and C. P. Koonce of Iriquois Service Co.

How to revamp medium sized plants at reasonable cost for greater efficiency, by David Schwartz, Central Chemical Co.

A more efficient way to handle fertilizer as it goes from the mixer to the bag, by D. Meyer and R. Koenig.

An effective method of screening and classifying by Wayne King and Steve Janovac. Wayne King is the irrepressible person around this organization. We can't keep him down. He is always ready with his wit and congenial remarks. We are always glad to have Wayne.

A feature this year is a panel discussion of conditioners for fertilizers, with Julius Silverberg of TVA, Phil Mischel of Petro Chemical Company, Joseph Iannicelli of the Huber Company and R. J. Harvey, S. W. Potash Co. as panelists.

As participants from overseas we have representatives from the Compagnie Pechiney Saint-Gobain and from Fisons Fertilizers in the United Kingdom.

J. Roubinet will discuss the operation of Saint-Gobain's UCE-GO filter in the production of phosphoric acid.

Fisons' men will discuss their melt granulation process, which has created a great deal of interest, and I am sure all of us are pleased and looking forward to hearing more about this interesting process.

Mr. Hemsley of Fisons also will tell us about a new process for manufacturing ammonium phosphates.

We have Messrs. Scaise and Alton, of Imperial Chemical Industries, to explain their compound fertilizer process.

We have Statistical Concepts Applied to Sampling of Bulk Materials by Renninger and Nichols.

Well, that puts the spotlight on your program for this 16th Meeting. I think we have been able, with your help, to organize what we are looking forward to as a good program.

I want to emphasize again and again that these programs are the results of suggestions from the members. Our organization is based on one big committee acting and that is the complete membership. They form the committee of one and anyone in the organization is welcome to and in fact is urgently requested to send in questions and suggestions for the agenda. We start today for our next meeting. I urge you all to think of some problem, something that we could use for our next program.

We will now start with our planned program. As I said previously a man with wide experience with fertilizer industry problems is the first speaker on the program. Bill Copeland. He has wide experience both in production, sales and what-not. He has been among us for a number of years. Bill is now retired, but like most retired persons, he still keeps active.

It is an honor and a pleasure to introduce him to this assembly. Bill has the rare talent of being able to think clearly and to put his ideas across to the audience. Bill.

Changes And Challenges

W. B. Copeland

IT is a real pleasure for me to be here today and to participate in this round-table discussion of problems facing the fertilizer trade. Someone has said there really are no problems—only opportunities.

However that may be, I feel somewhat like the young man who answered the classified advertisement for the "Opportunity of a Lifetime" and found himself in the presence of a very nervous individual.

"What I am looking for is somebody to do all my worrying," said the nervous individual. "Your job will be to shoulder all my cares."

"That's some job; how much do I get?" asked the young man.

"You get $20,000 to make every worry of mine your own," replied the overwrought individual.

"Where is the $20,000 coming from?"

"Ah, that's your first worry!"

Now, I'm not going to do your worrying for you for any amount of money. But I want to reiterate that perhaps problems really are opportunities that present challenges to us to press on to new heights of achievement.

Living as we do in a climate of change, we face almost unlimited opportunities to improve tomorrow's performance over the best of today's. No barrier to progress is considered insurmountable in this Great Society of ours today. Indeed, we have so nurtured the initiative and stimulated the inventiveness of our people that we seem able to create whatever is needed to attain our goals.

Yesterday we worried about our surpluses of farm produce—today we are concerned lest we don't have sufficient carryover of some of them to see us through a year of disaster. For years we worried about business recessions—now we are concerned about inflation and its effects. Formerly one of our goals was a nonstop flight around the world—now we are on our way to the moon.

And so it goes, so long as we don't lose our initiative and inventiveness. Yesterday's challenges become today's commonplace events.

Problems of Demand

As you know, the world today can be divided into two parts—the "haves" and the "have nots." The gap in living levels between these two groups is steadily widening. This widening gap is the most significant social, economic and political fact of our times.

Nowhere is this gap so noticeable as in the most basic of human needs—the need for food. Two-thirds of the world's people live in countries where diets fail to meet the most basic nutritional needs. The number of people suffering malnutrition is greater than it was a generation ago. Hunger today is commonplace throughout the less developed world. Those of us who have thought of the food-population crisis as being in the future must re-adjust our thinking—it is here now.

So how do we cope with this crisis?

Well, there are two ways of increasing food production—expanding the area under cultivation and raising the yield per acre. Expanding the area under cultivation is not new. Man has been doing this ever since agriculture began. Raising output per acre in a rapid sustained fashion, however, is a fairly recent phenomenon — an achievement confined largely to the more advanced countries.

Over the past quarter century all of the increases in food production in both North America and Western Europe have come from rising output per acre. The area under cultivation in both regions has actually declined. During this period, per acre yields in North America increased 109 percent and in Western Europe 37 percent. In the less developed world they increased only 8 percent.

As the developed regions have exhausted the supply of new land that could readily be brought under cultivation, they have generated take-offs in yield per acre. Today's developing countries, faced with rapid rates of population growth, are running out of new land while still in the very early stages of economic development.

Generating a yield per acre take-off requires capital to purchase yield-raising inputs such as fertilizers, crop protecting chemicals and improved seeds. It requires a favorable relationship between prices for farm products and the cost of these yield-raising inputs. The nonagricultural sector must be capable of providing agriculture with the physical inputs mentioned and all of the services, such as credit, transportation and marketing, needed to support a yield take-off.

Of course you and I know that it is far easier to increase the food supply by expanding the area under cultivation than by raising the output per acre. But the failure to sufficiently appreciate the difference in these two methods and the difficulty in making the area-to-yield transition, particularly in underdeveloped economies, has resulted in a serious underestimation of the world's food problem.

Still another source of underestimation of the world food-population problem is the failure to distinguish between the *potential* for expanding food production rapidly and the *prospects* for doing so.

The potential for expanding food production is usually discussed in physical terms, according to that which is possible. Prospects, by contrast, are what is likely to be achieved—this is invariably far less than that which is technically or physically possible.

Food shortages in the developing countries are due not to a lack of potential for increasing the food supply but to the inability to realize the existing potential as rapidly as current and projected rates of population growth require.

Yes, the developing countries have the potential, but they just don't have the technology, the distributive setup and the economic balance to realize upon it as rapidly as their needs are growing. Correcting this situation will not be easy. The large group of females who will be in the reproductive age group in the early 1980's are already born. Signifiicant reductions in birth rates are not expected soon. Modernizing agriculture is a slow and time consuming operation. The food gap is certain to become much larger before it begins to get smaller.

Consequently, we are called upon to produce in ever increasing amounts, both agriculturally and industrially with those businesses that serve agriculture. We are told, for example, that by 1970 both North America and the world must be supplied with half again as much fertilizer as has been recently used — by 1980 that amount should be almost doubled.

If this is true, the world will see larger increases in fertilizer production in the next 5 to 10 years than it has ever seen before. Of course the major portion of the short-run production increases must be scheduled in areas which have long been producing fertilizers. But the long-run trend indicates a fairly rapid change. The developing nations will gradually but surely enlarge their capacities to produce fertilizers as they strive to achieve better use of manpower and to reduce requirements for foreign exchange funds.

So demand for our products is not a problem. It's there on a worldwide scale for the foreseeable future—and, of course, it's there on a national scale for as far ahead as most of us care to look. How we get paid for the goods is another matter!

Problems of Supply

Now when it comes to supplies of raw materials with which to meet these tremendous demands, the situation appears to be satisfactory with the single exception of sulfur.

Nitrogen (N)

Certainly *nitrogen* appears to be in adequate supply. With U. S. consumption in all forms at about 5 million tons, anhydrous ammonia capacity for fertilizer usage is estimated at over 6 million tons of N. Of course the *theoretical* capacity for total anhydrous ammonia is higher than that — somewhere around 11 million tons of nitrogen — but we must figure that plants will be down somewhat around 20 to 25 percent of the time, and that only about 75 percent of the production will be available for fertilizer usage.

These ammonia estimates are based upon published capacities and construction estimates which, if my addition is correct, will total around 13 million tons of ammonia for the U. S. by the end of this year. And there's another million tons or so in Canada, some of which at least will find its way south of the border.

If all works out in accordance with published reports, the North American supply of anhydrous ammonia should be pushing 20 million tons within two years from next January 1. That's assuming, of course, that no plants shut down from obsolescence or other economic causes.

Again, may I remind you, that is theoretical capacity—a practical working capacity should be more around 15/16 million tons of ammonia, which translates into about 12/13 million tons of nitrogen—enough to take care of the United States' needs and with a good supply left over to help take care of the world. And that's just considering ammonia alone—without taking into account other sources of supply for nitrogen such as the coke ovens.

So, I don't think we need worry much about supplies of nitrogen this year or for the foreseeable future.

Phosphates (P_2O_5)

Now when it comes to *phosphates,* if you really want to worry you can worry some about the sulfur situation. Sulfur is in short supply, no doubt about it—short of all we would like to have for new users as well as old ones. But I think that somehow we will find enough to take care of our *needs,* even if we have to tap some more expensive sources.

The growth of concentrated phosphatic fertilizer materials has been phenomenal. Although ordinary superphosphate is on the decline, concentrated superphosphates, ammonium phosphates and phosphoric acid have shown good growth patterns—patterns which promise to continue. The only bottleneck to further progress is this matter of sulfur which we use to make sulfuric acid and, by the so-called wet process, phosphoric acid. Perhaps here we may have to turn to more costly sources to augment our supplies and keep the wheels of phosphate progress turning.

Last year the production of wet-process phosphoric acid exhibited about a 30 percent increase of the year prior. I don't think that this year we will be able to show such a substantial increase. This year's advance may be more in the nature of 15 percent. Here is where the effects of the tight sulfur supply situation will be most evident. We have been using sulfur faster than we have been mining it. With furnace phosphoric acid also in tight supply, the outlook for substantial increases in overall supplies of phosphates is not too bright.

However, we should have enough P_2O_5 from all sources to meet our needs. P_2O_5 consumption has been approaching 4 million tons, and our supplies have been slightly in excess of that figure. Unless demands skyrocket in 1967, we should have just enough to squeak through.

Let me remind you before leaving the subject of phosphates that superphosphoric acid has become a significant part of our concentrated P_2O_5 supply, and liquid mixtures made from this acid are a "sleeper" that could revolutionize the industry as much as or more than dry bulk blending has done in the past.

Potash (K_2O)

Certainly potash shouldn't present any problems from a supply standpoint in 1966-67, provided there are enough cars to move the tonnages. I understand that over 2 million tons of K_2O were supplied this past spring—up almost 20% over the similar 6-month period of a year prior. Although exports are increasing, imports, chiefly from Canada, are increasing even faster. As a result, imports should more than double the amount exported.

The vast Canadian potash reserves are rapidly being developed and by 1970/71 Canada will undoubtedly be the world's major source of potash. However, as more and more Canadian expansion and development plans are announced, considerable apprehension has sprung up over the prospect of sizable world overcapacity. This situation is being aggravated by entry of new companies into the production picture; however, the world price competition may serve to discourage additional entry of new producers. And the U. S. Justice Department decision negating Standard Oil of New Jersey's bid to purchase Potash Company of America appears to have eliminated acquisition as a means of entry into the potash business for the time being.

While potash overcapacity is a possibility, it should be remembered that:

1. Demand for potash fertilizers is increasing around the world and will probably accelerate if consumption rates for nitrogen and other plant nutrients continue to rise as they give every promise of doing.
2. Many of the companies (domestic and foreign) that are developing the Canadian reserves also produce potash elsewhere from mines that

may become uneconomical by comparison. Some of these older facilities may be shut down or placed on "stand-by" as new Canadian capacity comes on stream.

3. Development of facilities in Canada is expensive and takes some time. Not all those companies with current interests are likely to produce—at the same time if at all.

Please remember that I have hedged my statement about plentiful potash supplies this year with a reference to the rail car situation. I am afraid we are not building rail cars fast enough to keep up with the growth of our economy. Therefore, it seems to me we can anticipate another shortage of cars next spring. Those of you who rely largely on rail transportation, and who were hurt by the car shortage this past spring, should be impressed with the necessity of taking your potash and other supplies early. To the fortunate few who weren't handicapped by the car situation last spring all I can say is, "Be careful . . . you might not be so lucky next year."

Changing Agribusiness

The most miraculous change in American agriculture over the past 20 years has been a widespread source of comment, but too frequently discussion of the nature of the changes has resulted in false impressions and misinformation. Many of our city cousins have concluded that because the number of farms has decreased farming is a declining business—and people such as ourselves who depend on farmers for their customers are in a bad way.

Nothing could be further from the truth.

Measured in 1947-49 dollars, total farm output was $22.8 billion in 1940. In 1960 it was up to $35.4 billion, and in 1980 it is expected to reach $50 billion. Any industry which gives good promise of more than doubling its output in 40 years must be considered a growth industry.

The real dividing line between successful farmers and those on the way out appears to lie with those farms that produce sales of products in the amount of $10,000 or so. Above this line farms are increasing in number—below it they are either dropping out or moving up into the more affluent status.

There were 484,382 farms with sales of $10,000 or more in 1949: about a million in 1964; and it is expected that 1,060,000 farms will exceed this amount by 1980. This should then represent practically all the real farms and almost all the farm output in 1980. If there are any other farms classified as such, they will be part-time and part-retirement farms with only very limited production.

Of course, as a higher percentage of *total* acreage becomes controlled by a smaller *total* number of good farm managers, we can expect the rates of fertilizer application per acre to increase rapidly. This is an acceleration that I feel we have only now really begun to experience—it is one big reason I am so optimistic about the future.

But with all this change to better farmers on bigger farms are coming new demands upon our industry. No longer are large, modern farmers satisfied to be sold products at a price. Products are secondary. Sure, they are still interested in the prices they pay for products, bookings, volume discounts. But they are more interested in *programs*—they want to know what your program is and, most particularly, what it will do for them as an investment.

They are in the nature of industrial buyers now. They want to know what the payoff is on your program. And you had better come up with some very good technological answers that either strengthen or confirm their thinking. Many of them have been to college and learned the technology of farming. They want us to help keep them abreast of current developments, just as the pharmaceutical company's detail men serve other professionals, their doctors. Among modern farmers today the distinction between the innovators and the so-called "early adopters" is becoming blurred. More and more farmers are seeking out and adopting the new technology as soon as it is proved sound and feasible.

So we in the businesses that serve modern farmers will need to hump ourselves and see to it that we stay in the forefront of agricultural progress—hep to all the latest developments from our colleges and other research centers. In fact, we may have to develop some research centers of our own that can work exclusively on our own programs.

The need to be in the forefront is demonstrated by the condition today wherein we find many local fertilizer dealers now getting into the business of bulk blending and distributing *dry* fertilizer mixtures just at a time when the more advanced farmers are becoming interested in *liquid* mixes. And don't sell the liquid mixes short; they are very versatile and can be transformed right on the farm from one grade to another to meet changing circumstances in the program. This is an added bonus to their ease of application.

Yes, today's distribution channels in the agricultural market have become scrambled. What was once a clearcut manufacturer-distributor-dealer-farmer route has been short-circuited. Now everything goes! Manufacturers are not only using the old channels but also selling direct to farmers through controlled outlets, owned outright or financed. Now they are not only competing with each other but frequently find they are competing with themselves. This is not a healthy condition, but it is transition.

Where it will all end up is anybody's guess, but it is certain that in the end the most efficient and economical channels will dominate. In our business of fertilizer manufacturing and distribution, the cost of plant food applied to the ground is going to be the ultimate factor that determines our destiny.

However, let's not abandon the old system before we are sure we are on a better track. The dealer and distributor had a definite and legitimate place in the system. They handled local credits and collections and sales probably better and more economically than any branch office of a manufacturer. I suspect that some of the manufacturers who have gone largely to direct selling are now discovering that the costs of servicing accounts have swallowed up the extra profits they thought they had gained by eliminating the dealer or middleman.

Perhaps this is a time for experimentation—for casting about among all the channels of distribution and dissemination of information, to find that which is most effective. And what may prove most effective to one manufacturer or one section of the country may be found to be ineffective for another.

Some people think that the rural "supermarket" or departmentalized farm supply outlet is the answer. It seems to have many points in its favor. Certainly the large farmers today are learning to pool their expenses and to place them with the concern that can give them the best service from an overall program standpoint. It may be that in time we will see chains of these rural supermarkets as a dominant factor in the system. It seems logical that as farms get bigger they are demanding the services and features that only large supply outfits can afford.

Any way you look at it the next decade is going to be most interesting for all of us. It is going to challenge our ingenuity and initiative to the utmost in both manufacturing and marketing. Some of us are going to have to learn to be customer oriented—which is going to be very difficult for those who are used to thinking they merely have products to make and sell. Now we've got to have programs to offer—programs that fit the future of agriculture.

CHAIRMAN SAUCHELLI: Thank you, Bill. That certainly was a most comprehensive review and projection of the future. I am sure we all enjoyed it.

Does anybody have any questions that they want to ask Mr. Copeland? I enjoyed your paper very much. That certainly shows good thinking—Bill.

The next speaker, Neal G. Schenet, Vice President of the Plant Food Division, of International Minerals and Chemical Corporation, who, up until October 1st was Vice President of the Marketing Division. To put a man at the head of the Plant Food Division, who has had lots of experience in marketing, I think reflects something of the trend that is going to dominate our industry. More and more emphasis will have to be put on the marketing function. We have to admit we have been weak in that field and it certainly needs strengthening.

Mr. Schenet is credited with devising IMC's full orbit customer service program, the Air Veterans Theatre in Moore House and other very progressive ideas that have been adopted by that progressive organization.

We are privileged to have him on our program. He is a dynamic personality. I am sure he has a very interesting talk for all of us. Neal please.

The Fertilizer Explosion: World Supply/Demand Relationship

Neal G. Schenet

DURING the next few minutes I will give IMC's forecast of just how much fertilizer the world will need in the next 14 years. That's only until 1980, but I think it will become quickly apparent that these could be the most challenging years in the history of our world. The need for fertilizer is staggering . . . far greater than actual consumption . . . and will very probably continue as far as we can see ahead . . . certainly over this next 14-year period.

Let us examine and attempt to define the forces which generate these fertilizer needs. Let us look at projections of increased production and the relation of demand and supply.

A phenomenal increase in the world's fertilizer consumption began in 1963. That year, consumption increased by about 10%—in the following year, 1964, by another 10 to 12%, and in 1965, by an estimated 9%. We began to ask ourselves some questions: "Have increases of this magnitude occurred before, or is this a new trend? What factors are generating the increase, and are they likely to continue? How much and where will the need be by 1980, and what will be the balance between the demand and the supply?"

If we look back over the last half century, we see a very slow and steady increase in fertilizer consumption . . . a very small percent of increase, actually . . . from 1906 to the end of the last World War. In fact, there was no year in which consumption increased by anything even approaching 10% over the preceding year. The highest yearly increase in the 34 years between 1906 and 1940 was 7%. We did not have a consistent growth curve at any time before World War II. Rather, the curve shows a continuous series of ups and downs, although the long-term trend is upward.

Now, if that historic growth pattern had simply continued, an extension of that growth line to 1965 would have indicated that world fertilizer consumption today would have been only about 13 or 14 million tons.

But instead, there was a sharp acceleration in fertilizer use beginning about 1947. In these years, from 1947 to 1962, a completely different picture has emerged. Consumption trends are sharply upward over previous patterns . . but even at *these* rates, the annual increase did not reach 10% per year until 1962/63. However, a distinctly *new* trend line *is* reflected in these figures of actual fertilizer consumption during this period.

Now, if we had made another projection, using this newer trend line and extending it from 1962 through this year, we would have said that fertilizer consumption would probably be about 33 million tons in 1965. But, once again, the actual figures are higher—closer to 40 million tons than 33 million!

Is this *another* new trend? It is. I repeat what I said a few minutes ago. A phenomenal increase in the world's fertilizer consumption began in 1963 and has been compounding since. We have subjected the consumption trends of the major *individual* nutrients—nitrogen, phosphate, and potash—to rigorous statistical analysis. The probability that the consumption figures from 1963 onwards *do* indicate a new trend is 99.8%—virtually a certainty. The odds are less than two in one thousand that these figures are a part of the previous trend.

This is *what* is happening. Our next question, naturally, is: "*Why* is it happening? What are the forces that are generating such a phenomenal upward trend?" There are many. Some of them are elemental in their force—the inescapable need for more food to feed millions more people; the necessity to replace soil nutrients; the limits of available land.

Some of them are subsidiary reasons—the profitability factors of fertilizers; demands for higher standards of living; better farmer education; and the higher governmental priorities being given to fertilizers. Let's look at some of these developments. First, one factor that we can do little or nothing to change — the amount of land available for crops.

Most of the world's surface is water, salt water. The oceans and seas cover 70% of the face of the globe. Then from the remaining land surface we must deduct: 8% of the land permanently covered with ice; 7% of the land that is arid, barren desert; 7% of the land that is untillable mountains and rock; 4% of the land that is untillable swamp—and we have remaining only some 4% of our world that is suitable for major agriculture — about 3½ billion acres. Most of the food supply for the entire world must be grown on this minute portion of its surface.

Today and tomorrow, there is an imperative need to feed, from these acres, more people than the world has ever before seen. We are well into the stage of what is described as the world population explosion. From the beginning of Man's history — it was not until 1840 — only a century and a quarter ago — that the population of the world reached its first billion mark. Then, in only 90 more years, the population growth of all recorded history repeated itself. The world reached the two billion level in 1930. Today, only 35 years later, still another billion people have been added. In six more years, by 1972, the earth will see a four billion population, and by the end of this century, we will have a world population of 6½ billions — about two people for every arable acre of land.

Even at today's population levels, we find vast areas of the world with too little to eat—where the land has been exhausted through centuries of cultivation — where farming practices are primitive and of low productivity.

It is ironic, or perhaps tragic, that the greatest population growths are occuring in the less-developed countries, those least able to feed still more millions every year. In fact, between now and 1980, the underdeveloped areas of the world will add five times as many mouths to feed as the developed areas. Although these underdeveloped areas now represent two-thirds of the world's population, they account for only half the land under cultivation.

Virtually all of Asia, Africa, all of the Celebes, and the Arabian Peninsula, portions of Central and South America, have experienced outright food deficiencies. Most of the rest of the world has had marginal food supplies. Only Western Europe, Japan, Australia, New Zealand, the United States, and Canada, are adequately fed.

The shortage of arable land, plus the need for tremendous increases in food production means we must have ever more intensive agriculture at time goes on. We must replace soil nutrients depleted by centuries of cultivation. We must add more nutrients to force higher yields from every acre. This force is very strong in the developed nations, where cultural heritages and technological know-how have permitted agriculture to keep pace with population increases.

There are half-a-dozen of these developed nations today which, because of the land / population squeeze, are using 100 pounds or more of fertilizer nutrients per cultivatable acre — the Netherlands, Japan, France, the United Kingdom, West Germany and East Germany.

Japan, for example, is using about 270 pounds an acre, and the Netherlands an incredible 410 pounds. These countries account for less than 1% of the earth's surface, yet represent about 7% of its people.

It's interesting to note that the United States uses only 40 to 50 pounds an acre. We are agriculturally mature in many respects, but in fertilizer consumption we have a long way to go.

There is a staggering spread between the high and low areas of fertilizer consumption in today's world. Consider five more nations, these with about 9% of the earth's surface and about 20% of its peoples: Uganda, Thailand, Kenya, Rhodesia, and Mainland China. These five nations use less than five pounds of fertilizer per cultivated acre. There is a tremendous unsatisfied need in developing nations like these that someday must be fulfilled.

These are the basic and elemental forces that are demanding more and more use of fertilizers—but there are other factors operative today as well.

One of these is simply the desire for higher standards of living. One analytical yardstick to a peoples' living standard is their consumption of protein. As income increases, diet invariably shifts from starches to more expensive animal protein. In high-income areas, protein intake is very high—97 grams per day in the United States, 83 in Switzerland, for example.

It takes about five calories in grain to produce one calorie of meat protein. Five times more grain must be consumed before one portion of meat can be served—and the cheapest way to get more grain is to use more fertilizer.

Another reason for increased use of fertilizer in the developed nations is the profit motive of the farmer. The bigger his crop, the better his profit.

The prices of other farm inputs have a direct relationship on the use of fertilizer, and can be *a* major force for increased fertilizer demand. When land and labor costs are low, relative to fertilizer, it might be least expensive for the farmer to get greater yields and profits by cultivating more land, but today land costs have risen to high levels—labor is expensive and not always available, equipment costs have risen—while fertilizer costs have remained relatively low. It is easiest, and most profitable, to increase yields through more intensive fertilization. The extra value of the increased yields more than offsets the cost of fertilizer.

Higher government priorities are increasing the use of fertilizers. All over the world, more and more governments are placing top priorities on fertilizer—in assistance programs, in subsidies, in new plant construction. The reason may be very basic, as in countries where the need is stark and implacable . . . to grow enough food to prevent runaway famine in ever-increasing populations.

It may be in answer to restless demands of people in developing nations for a rising standard of living, as in Russia. The Soviets are making great efforts to raise more cattle, and very likely, these cattle are consuming some of the wheat purchased from other countries.

Another reason is the fact that agriculture is a critical factor in the whole economic development process.

And another factor, it reduces the drain on foreign exchange. For example, Greece is supporting grain prices to encourage the raising of more grain so that she can feed more of her people and stop spending her hard-won foreign credit for food.

Australia started subsidizing superphosphate in 1963 at the rate of $12.80 per ton. This subsidy has increased Australian superphosphate consumption by 25-30% each year since. Again, the subsidy was designed primarily to get grasslands fertilized so that Australia could grow more wool for export to get hard cash to buy other things she needed.

This all explains why there is such a high priority on agriculture. But why not put an equally high priority on tractors? Why the emphasis on fertilizer?

Fertilizer is a low-cost input. When you use it, you can quickly see its benefits. It is responsible for more than 50% of increased crop productivity in the United States. In other countries, it has boosted production by as much as 95% without changing a single farm technique other than applying it.

Increasing agricultural education is another of the major forces generating acceleration in fertilizer demand. In the United States, the successful integration of universities, research stations, and extension services has given brilliant results. We have had technological breakthroughs and we have been able to get the information to the farmer. These breakthroughs have been in many areas—more efficient machinery and better farm management practices. But they all boil down to one fundamental achievement: the ability to use more fertilizer more effectively to increase per-unit yield.

Other developed nations have adopted this technology and emphasis on research. Agronomic teams have traveled around the world, studying local agricultural conditions, giving assistance, beating down the barriers of resistance to change so that some nations have progressed 100 years in a decade. Incidentally, this is one way private industry can assist governments with its work.

These are the reasons *why* we see increased fertilizer consumption rising so rapidly in recent years and in the year just ahead of us.

Now, let's add up quantities and see *how much* fertilizer could be needed by 1980: if we take 1962 as a base year—just before the new trend started—we can begin our estimates with a nice round figure—30 million metric tons. That's how much fertilizer the farmers of the world used in 1962.

We have seen that the world's population is growing explosively. By 1980, this factor alone wll requre an additional 20 million tons per year, if needs even at present nutritional levels are to be met.

Then, the increasing standards of living, manifesting themselves in terms of more meat consumption—they will require another 13 million tons. Then we must replace the nutrients that are removed from the soils each year by the growing crops. This will require 15 million additional tons.

Ever-higher farm capitalization will create more demand for fertilizers to increase yields. This will require 20 million additional tons.

Government actions, expanding technology,—these and all other factors will account for another 15 million tons.

The total added to 1962's 30 million tons, adds up to 113 million metric tons a year in 1980—if the economic needs of the world are to be met.

Now, *where* will the needs occur?

The United States and Canada consumed about 8 million tons in 1962—and will need 27 million tons by 1980. Latin America used 1 million tons in 1962—and will need almost 9 million tons by 1980. Russia and Eastern Europe will need 24½ million by 1980. In 1962, other developed countries consumed 13 million tons; by 1980, their need will be 31 million. In 1962, Mainland China used 700,000 tons—by 1980, the need will be nearly 5 million tons.

In the underdeveloped areas of the world, increases should be fantastic. Need in these areas will rise from a little more than 3 million tons consumed in 1962, to a need for nearly 26* million tons in 1980.

That's the economic "need" side of the coin. Now, let's look at the other side — supply. Current total world productive capacity breaks down this way:

	N	P	K
United States & Canada	39%	31%	29%
Russia & Eastern Europe	15%	19%	30%
Other Developed Nations	36%	44%	38%
Underdeveloped Nations	10%	6%	3%

* This total includes the total for Latin American shown earlier.

These total world facilities represent an investment of some 3½ billion dollars. However, it's going to require a total investment of about 16 billion dollars to meet the need for 113 million tons of fertilizers by 1980.

Present total capacity is about 47 million tons. Planned construction will bring the total up to 76 million tons—far short of the 113 million that will be needed.

Let's break down planned expansion and needs on a nitrogen, phosphate and potash basis: Current nitrogen capacity is about 20 million tons a year; announced additional capacity will bring it up to 32 million tons.

But by 1980, capacity for 51 million tons is needed. Current phosphate capacity is about 14 million tons. Announced additional capacity will bring it up to 23 million. But 33 million tons are needed by 1980. Current potash capacity is about 13 million tons. Announced additional capacity will bring it up to 21 million. By 1980, the need will be for 29 million tons. At that time, world capacity will be more than 50% in nitrogen —and this assures certain growth in phosphate and potash. Why? because depletion of natural soil nutrients shows up first in nitrogen. The tendency in developing countries is to begin applying nitrogen first, before working with complete NPK fertilizers.

Nitrogen creates lush, green growth, and will give increased yields—for about three years. Then, yields will drop off sharply unless phosphate is added. Then, after three more years, if potash has not been applied along with the phosphate, yields will falter again. We can almost predict the coming phosphate and potash consumption, following the use of nitrogen.

This is the position at a glance. All announced capacity, both present capacity and planned expansions, would satisfy only the growing need for fertilizers to 1972—a little over 76 million tons. There must be considerably more production expansion if the world is to meet its need for 113 million tons annually by 1980.

So you can see that an extremely short supply/heavy demand situation is building. It would seem we're entering into a golden era for the fertilizer industry. We should be able to sell, at very reasonable profits, every bit of phosphate and potish we can get out of the ground and convert into complete NPK fertilizers.

It would seem that all we have to do is sit back and wait for the orders to roll in and fill them at our leisure. Well, it doesn't work quite that way. We have been talking as if the ability to grow food was distributed equitably throughout the world, and as if the ability to make fertilizer also was equitably distributed. We have been talking as though "need" automatically means a *market*. This is just not the case. The world *needs* to use more fertilizer now, but it isn't using it. All the fertilizer that is needed is not being used, because we live in a world that is split between the "haves" and the "have-nots" . . . between the nations that have and those that have not the manufacturing capacity, the distribution facilities, the capital, and an agricultural community that is knowledgeable in the use of fertilizers.

Consider the situation as it stands today: at the latest United Nations count, there are 200 countries in the world. But, of those 200, only 112 use chemical fertilizers.

Remember that the farmer who uses chemical fertilizers isn't a purchaser of fertilizer raw materials. These raw materials have to be fabricated into an end product and then prepared for use.

So out of these 112, only 40 process or manufacture chemical fertilizers, including 6 behind the Iron Curtain, to whom we do not sell.

Now the basic statistic is this—of the 34 countries which process chemical fertilizers, *6* will account for the consumption of almost ¾ of the fertilizer raw materials that will be produced by the world fertilizer industry. This is where the traffic gets heavy.

We in the fertilizer raw materials business work in a world of apparent surplus, in which the buy-and-sell relationship is in reality a tug o'war between powerful forces. In conditions like these, only the strong, experienced purveyors of fertilizer raw materials—those with strong marketing penetration and position with each of the important users in these six countries will be able to dispose of great volumes under profitable conditions.

Our previous picture, then, of the severe worldwide *needs* for fertilizers funnels down in reality to drastically restricted *markets* for our fertilizer raw materials.

It is obvious that, for the next five years at least, the major fertilizer markets will continue to be in the developed areas of the world, like the United States—areas where production and distribution facilities exist, where agriculture is relatively advanced, and where money is available for payment.

But all is not as dark as it appears; a strong shaft of light is burning through the fog rising from these economic facts. The horizon is turning bright indeed.

We at IMC call it our "Outlook for Optimism" and we base it on a certain confluence of forces that promise to make the forthcoming farm market the most explosive, exciting, profitladen in our history. We are moving from an agricultural environment of surplus and production restraints to one of scarcity and production *incentives*. The indicators are clear; the facts, irrefutable. The implications of these powerful, elemental forces rock the imagination . . . and their impact will rock the fertilizer industry.

What, then are these forces?

First, an unprecedented increase in demand for more food by the explosively multiplying populations of the world. Under foreign aid programs, the output of one acre out of every four we plant goes to undeveloped nations. The communist nations also are huge grain buyers . . . three-quarters of a billion bushels in the year ended June 30, 1966. These and other foreign purchases have depleted supplies of world wheat exporters. Canadian production, for instance, is committed for the next three years. This means more demand for U. S. wheat in world markets.

Add to this our own increased consumption of cereal grains. We are shipping and consuming faster than we have been producing. For three decades, we have been storing surpluses. Now suddenly those surpluses are gone, our reserves dangerously low. And this year's crop carryover in corn, wheat, soybeans will bring our reserves barely to half what experts consider a minimum safe level.

Second, the sharp rise in farm prices. Since March, commodity market prices for major crops have risen steadily. Wheat is up 30%, corn 15%, soybeans 25%. These high price levels are going to be here for some time . . . and are unlikely to go anywhere but up. The world demand for food is too great, and reserve stocks too depleted, for any quick price reversal.

Third, our changing farm policy from farm restraints to emphasis on more production. The Secretary of Agriculture has already authorized a 32% increase in wheat acreage allotments to 68.2 million acres. Our forecast is that 60 million acres will be planted. We expect a 15% increase for corn acreage, 10% for soybeans, 10% or more for rice.

Fourth, government fertilizer purchases. The overwhelming majority of undeveloped countries are deficient in both food and fertilizers. The Agency for International Development recognizes that fertilizers offer the best immediate answer to help the hungry nations feed themselves. In this fiscal year, A.I.D. will triple its fertilizer purchases to a minimum of 300 million dollars worth of fertilizers for export . . . about half in nitrogen, half in other fertilizer material. We look for them to take 1,500,000 tons of phosphate and 500,000 tons of potash from the U.S. market.

This adds up to the most gigantic potential for fertilizer consumption the world has ever seen. There will be more acres to be fertilized. American farmers will fertilize more heavily for higher production and more profit at new high price levels. We forecast that fertilizer demand in the coming crop year will exceed the capacity of the basic producers to supply it. I base that on this prediction: Last year, U.S. fertilizer consumption increased 17% over the previous year, the greatest increase since the end of World War II. But in this *coming crop year, U.S. consumption will add another increase of at least 15% . . . and could easily reach 23% over the record-breaking year just ended.*

So you can see there are ample reasons for our "Outlook for Optimism." There are many "ifs" to be turned into certainties, of course, but if we in the fertilizer industry marshal all the resources at our command, we shall surely mine the bonanza we know lies ahead.

MODERATOR SAUCHELLI: Thank you Neal. That certainly was a very comprehensive and highly illuminating analysis of our situation. It certainly should develop optimism in the industry. It also emphasizes the marketing angle. We have time for some questions.

MR. SAMUEL STRELZOFF, Chemical Construction Corporation. I certainly share the optimism of Mr. Schenet. But I wonder how are we going to build so fast all these production facilities that he indicates are necessary.

I certainly would be glad to know how to do it faster than we are doing it now.

We, in fact, do it slower now. All these big plants that we built recently took twice as much time as used to be. Instead of 12 months, it requires 24 months even in the United States. When we build plants in the so-called underdeveloped countries, it takes twice as much time. Recently we built a plant in India and it took us four years.

So the question is—I do agree very much with all this need for fertilizers. As a matter of fact, I have spent 41 years of my life trying to meet that demand. But how are we going to build that fast? I would like to know, because this is really the most important question right now.

What we are doing right now in the United States, not only do we build very slow, but the equipment that we get is not as good as it used to be because all these shops are being overloaded creating considerable delays in the erection and startup operations.

Many plants were started last year. It took them nine to 12 months to shake down. Maybe the the reason for that was not only the workmanship of the suppliers, but also the workmanship of the designers. Nevertheless, the problem is there: How quickly can we build such plants?

MODERATOR SAUCHELLI: The question is How quickly can we build new manufacturing facilities?

MR. SCHENET: I really don't know the answer. I might as well say that to start with.

What I was trying to point out was the need that exists, the abstract need that exists, and what that poses in terms of a need for production.

Now, there have been many changes in our technology, in our agronomy, which many people, I would say, would not have expected could have taken place as rapidly as they have.

I think that, while this is not an area that any one sector can handle by itself—It's too big for private industry, it's too big for government alone, it's too big for the foundations. However, it has to be a combination effort and we are seeing this in many countries.

I think that when you get that kind of combined effort mingled with the profit motive, that keeps us all going, I think a very good piece of this construction activity is going to take place. Whether it will be fast enough, whether it will be sufficient, is anybody's guess at the moment.

A MEMBER: You gave a figure, that the AID program will be buying about $300 million worth of fertilizer next year. To me that seems like one-quarter of the country's production to be bought by the Government. Is that correct?

MR. SCHENET: I'm sorry. I didn't hear the first part of your question.

MEMBER: The size of the AID program, $300 million.

MR. SCHENET: Oh. About half of that is freight. That's on a delivered basis.

MEMBER: Oh.

MR. SCHENET: In other words, you're talking about roughly $150 million worth of product.

MODERATOR SAUCHELLI: Neal you certainly did a fine job. That was a very interesting discussion.

Our secretary wanted me to emphasize that unless you register you don't get a copy of the Proceedings. And also in order to help the postage business that you should enter your Zip Code on your registration card.

We have arranged for a coffee break. Please come back within 15 minutes.

MODERATOR SAUCHELLI: We

will now resume our program. Our next speaker, Mr. Robert Koch, President of the National Limestone Institute, has been active in agricultural work since early boyhood.

He first came to public notice at USDA in charge of procurement of lime and fertilizer for the Agricultural Conservation Program in the Northeast Region. Many of us remember how active he was at that time, and how most farmers got free lime, most of which wasn't used. Since 1946 he has been with the National Agricultural Lime Institute.

We have had many discussions of the world food crisis. Robert Koch has a new angle to it. Soil pH and the Developing World Food Crisis is the subject of his talk.

As Executive Director of the Committee on the World Food Crisis and a trustee of the American Freedom from Hunger Foundation, he should be well posted to give us a most worthwhile treatment of this subject. Robert please.

Soil pH and The Developing World Food Crisis

Robert M. Koch

IT gives me a great deal of pleasure to talk to you this morning concerning some things about which I feel very strongly. The topic which was assigned to me, of course, seems quite relevant to my professional position. However, I should like to reach it indirectly. As Vince has said, I am also serving as Executive Director of the Committee on the World Food Crisis. Certainly, no group is more interested in the world food programs than you people associated with the fertilizer industry.

I believe that my background makes me more than a little not only aware but knowledgeable about our National and our World pH problems. At first, particularly to the layman, this may appear to be only an academic discussion of a mysterious chemical phrase. And yet, all of us in this room are well awaare of its vital importance.

Important to the farmer who is looking to the soil to produce the maximum for his labors.

Important to the fertilizer dealer who wishes to secure the ideal conditions for the maximum return for his product.

Important to members of the Industry I represent, because their product is essential to bring about optimum-growing conditions in the humid area.

But most significant—important to the peoples of the World because we have now reached—not tomorrow — but now — the point where, unless the entire resources of this World are fully utilized, there will be many thousands dying each and every day.

It is only a few short years—yes, you can actually say a few short months — since this situation has been brought about.

All of us in this room remember the staggering surpluses that overhung our markets. During my years with the USDA I despaired of ever finding a solution to our problem. As we curtailed production, farmers learned how to plant more plants to the acre. New varieties to greatly increase the yields were developed. You men of the fertilizer industry tremendously expanded your sales. And the Federal Treasury was faced with ever-increasing drafts for money to support prices and then to pay staggering storage charges.

But literally overnight we have brought about a miracle. Whether you are a hard-hearted businessman, a complete evangelical Christian moralist, an ardent internationalist or what have you, the Food for Peace Act of 1966 just passed by the 89th Congress and about to be signed into law by the President shines through the dense fog of our World Problems as a tremendous ray of hope for all.

With $7.4 billion to finance its many faceted program for two years, it can chart new paths which, if properly followed, can only lead to a new, better and more peaceful World.

High sounding phrases? Perhaps, but I personally believe that we not only know how but can put our American Agriculture back to work. In this way, the farmer's full economic ability can be attained *and* this ability instead of being a liability can be America's greatest asset in bringing about and maintaining World Peace.

I assume that everyone in this audience is well aware of the population explosion in the World and the critical food situation we are facing. However, at the risk of boring some of you by repeating facts you already know, I am going to show you a few slides of statistics. Statistics at best are usually very dry. And yet, as I have been studying these for the last two years, I find them first interesting, then striking and then alarming.

When I first agreed to sit in on a group that decided we had to do something to mobilize this Nation through the grass roots and Congress—and it was only a little over a year ago—I thought the critical point was sometime in the future—the early 1980's at the earliest. In fact, I anticipated if we were lucky we might get some legislation passed in the 90th Congress, but that it might take five years. From the time we held the organizational meeting of the Committee on the World Food Crisis in this citv last December 9th, the tempo has been literally fantastic. Chairman Harold Cooley of the House Committee on Agriculture, one of the keynoters of our Meeting, pledged that he would introduce legislation as soon as the Congress convened. This he did on January 19th. Senator George McGovern, a member of the Senate Committee on Agriculture and Forestry and President Kennedy's first Food for Peace Director (also a keynoter of our organizational meeting) was of great assistance as were several other Congressmen. As those of you who followed this legislation know, we had several close calls. A practical compromise was worked out so that we now have, as I said a moment ago, $7.4 billion for this program for the next two years—$2.5 billion new authorization each of the next two years and $2.4 billion carryover funds.

This is a most complex program and I will not go into it in detail except to say it will greatly stimulate production in this country, greatly stimulate production of fertilizer facilities overseas and is geared primarily for self-help.

Already we have had a major change in emphasis in our own country. From decades of overproduction and constant effort to manage our surpluses, we switched radically this past year. Secretary Freeman has authorized 32.5% more wheat acreage or 15 million more acres of wheat. He also requested more than a million acre increase of soybeans and a 200,000 acre increase of rice. And at the present time more increases are under consideration. We still have approximately 50 million more acres of cropland that could be pressed into production.

Naturally, there are many opponents to some of these drastic changes. And many are raising difficult questions. Almost everyone agrees that the farmer must be protected. And if National policy shifts drastically again either the farmer will get hurt, or the taxpayer could once again finance huge storage and adjustment costs.

The first and major question to be answered is not what can our farmers do, or what can the plant nutrient producers provide but what is our National policy to be? The President's Message on his Food for Freedom Program and the Congressional action in translating this into the Food for Peace Act of 1966 would seem to be the answer.

But we must have quite a few details spelled out. I happen to believe that this Nation has a moral obligation as good Christians to do what we can to prevent the starving of millions. Furthermore, I also believe that if we are to fight wars such as Korea and Vietnam, it makes a lot more sense to prevent them. And one of the greatest reasons for Communism and unrest is the exploitation of the starving masses. So it seems to me, it is not a question of what is good for our farmers, or what is good from a moral standpoint, but what can we do best to maintain Peace?

We have proven since the turn of the century that we are willing to spend billions to keep the world safe for our principles *and* to sacrifice thousands upon thousands of the flower of our youth.

Shouldn't we at least try the other route of spending billions through Food for Peace instead of munitions?

Now we cannot "feed the world" ourselves. But we can prevent the more extreme cases of starvation as we export our "know-how" through "show-how" teams to get the underdeveloped Nations to do the things they need to do to survive.

So frequently when I talk to people about putting the American farmer back to doing what he knows best, they always remind me that we cannot feed the world. The point is we need to produce all we can between now and the year 2000 to enable us just to help the trouble spots of the world.

Now let me try to set the stage for some of my other remarks. Here is a slide on expected World Population.

World Population

0-1900 to get to 1.5 billion people
1900-1965 to get to 3.0 billion people
1965-2000 to get to 6.0 billion people

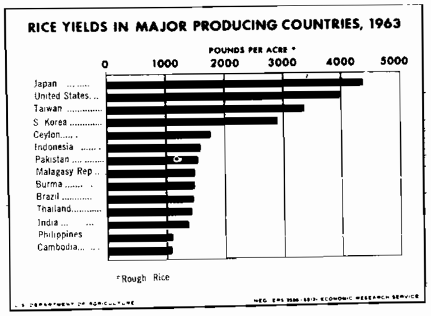
It took all the peoples of the World 1900 years from the birth of Christ to produce a world population of 1.5 billion people. In 1965, only 65 years compared to 1900, the population was doubled. And according to our demographers it will be doubled again in the 35 years from 1965 to the year 2000. So while we have starving thousands today—it is estimated that 10,000 a day die of starvation—we must double the world's food production between now and the year 2000 just to maintain the status quo.

To me this is a staggering situation which only the students of the problem have fully grasped. We all thought that the atomic bomb which was dropped on Hiroshima killing 68,000 was a terrible thing. And yet, we have built-in in this population explosion a force it seems to me that could be more devastating. Think of a 100,000 people dying every day of starvation, compared to the present 10,000! This would mean 36,500,000 people a year! Think of the political situation. What an ideal climate for another Hitler, Mao Tse-tung, etc.! Any of you who have studied the projection of present food production trends know it is absolutely impossible to double the World's food production *under present conditions.*

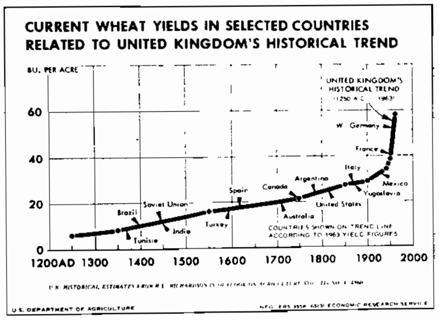
Therefore, if we are to head off, not just in our children's time, but right now, massive starvation with all its attendant political overtones, we must act. We must completely implement the Food for Peace Act just passed and use these pilot experiences to go all out on this World Problem two years from now when this Act expires.

American "know-how" and "show-how" with the help of the other Nations who are already co-operating through the Food and Agriculture Organization of the United Nations can bring about this necessary Revolution.

Let's look at some charts of the World situation. Here is one on rice production.



Japan and the United States produce three times as much per acre as the underdeveloped nations. The next chart on wheat is very striking to me.



Our per acre yield in 1963 was just what Great Britain obtained in 1800. And India and Russia get the same yield now as Great Britain was getting in 1450. To me this clearly defines the problem. And how do we solve in only 35 short years what it took the farmers of Great Britain 500 years to accomplish?

Of course the first answer is

that we can't, and fortunately, the second answer is we don't have to. If the Great Britain yield was translated around the world we *would* have a surplus!

As we try to find the answers to the World Food Crisis, I am constantly confronted with the statement that we can't afford to become involved.

When I came to Washington 25 years ago our gross national product was $91 billion. Last year it was somewhat over $600 billion. If any of us had predicted this fantastic growth in 1940, we would have been written off as completely out of this world. Is there anyone who would say our growth in the next 25 years could not be at the same rate as the last 25 years? It actually seems unbelievable and yet, who would have thought that we could fly around in space as we are now doing?

Gross National Product

1940	$91 Billion
1965	600 Billion
1990	3,600 Billion

If the rate of growth is the same, then our gross national product will be 3.6 to 4 trillion dollars a year. We can't even comprehend billions—in fact, we think of them as pretty staggering figures so how can we think in terms of 3 to 4,000 billions of dollars as our gross national product? And yet, we as forward looking businessmen are going to be forced to think in these enlarged terms.

However, already we have exceeded the President's prediction of a $720 billion gross national product for 1966.

Obviously with this kind of G.N.P. we not only can afford to do the type of activity outlined in the Food for Peace Act of 1966, but can afford to do a great deal more in the future.

Most of you know that the Land Grant College Experiment Stations developed a wealth of information shortly after the turn of the century on the importance of agricultural limestone in the humid area. From 1914 when the Agricultural Extension Service was organized, County Agents in every county in the humid area stressed the limiting factor the lack of agricultural limestone was. First, it was a pH factor, the old litmus paper test was used and eventually the sophisticated potentiometers and evaluation of buffers, aluminum toxicity, calcium shortage, etc., have been used.

The use of aglime bumped along between 1 and 3 million tons a year, until the AAA was declared unconstitutional in 1935 and the Congress passed the Soil Conservation and Domestic Allotment Act in 1936. Never in the history of the World had any Nation launched such a massive conservation program. Over 3 million farmers a year participated for several years. A major by-product was the jump in aglime use from 3 million tons to 30 million tons in 1947. At the same time, we greatly increased the use of phosphate and potash on soil conserving crops.

Aglime Use vs. 80 Million Ton Need

1935	3,505,000
1947	30,283,000
1964	27,002,000

Many of us thought that these massive demonstrations we were arranging on almost all farms would clearly show the farmer the necessity of using aglime. *Nothing was further from the truth.* When Congress, first in an economy mood and then in an anti-surplus mood, drastically curtailed the annual appropriation for the Agricultural Conservation Program—the use of agricultural limestone dropped to 18 million tons a year. Nothing could we in our industry, or you in yours, or the County Agents do to stop this drop. And all the time the agronomists of the Land Grant Colleges had set our Annual National Goal of 80 million tons a year.

Now with the fantastic growth of the nitrogenous fertilizers, particularly the solutions, the need is sky-rocketing. And as some of you know, the agronomists of various states have recently found ways to double their per acre recommendations.

This next chart shows the probable use of N by the year 1970 (as projected by Dr. Raymond Ewell, Vice President of Research, State University of New York at Buffalo) — only four short years from now. Most authorities agree that 300 pounds of N per year for 5 years require an application of 3.5 tons of algime to compensate for the developing acidity. And, if it is not used, the potential of additional applications of N, as well as other plant nutrients, can be reduced *up to 50%*.

Dr. Ewell's Estimate of Fertilizer Consumption by 1970*

	1955/56	1963/64	1970
N	6,675	14,830	29,500
P_2O_5	7,980	12,440	21,700
K_2O	6,760	10,180	16,350
	21,415	37,450	67,550

* in thousands of metric tons

If these projections are correct, then in four years we should be using 39,375,000 tons of aglime in the U.S. and 154,875,000 tons of aglime in the World annually *just to maintain the status quo of the use of N.* We are already falling way behind in our aglime needs to the point, as you fertilizer people well know, of greatly limiting the full value of your product.

According to Forecasts by 1970 (thousands of tons)		Aglime Required
U.S. Use of N	7,500*	39,375
World Use of N	29,500*	154,875

*Metric tons.

We definitely need more fertilizer with particular emphasis on N to approach the mammoth food requirements of the World. However, we cannot overlook the fact that the use of aglime can be a major limiting factor in attaining these goals.

The figures which we are releasing this week show that the 1965 use of agricultural limestone was over 28 million tons. While this showed the best increase outside of ACP in the history of the country, we have a long way to go. In my judgment, not only will the yields be greatly impaired, but the sale of nitrogen could be greatly curtailed because of farmer disillusionment unless we find a better answer on how to increase aglime sales. No one questions the need. But there is still a missing ingredient. The ACP has proven its ability to get aglime used. Should this be expanded? Aglime not only is not "sold" in many areas of the country, but it is not going to be under the present price structure. To point to a few areas where aglime is merchandised is begging the question. Every major oil company in the Nation had market research done on going into the aglime field after they got into the fertilizer business. They couldn't believe it. Market analyst after market analyst was sure I was either hiding something from him or deliberately giving him falsified information to keep them out of the field! One for example, said you mean $2.50 a ton when I told him 25 cents a ton was the average profit in the area he was talking about.

If we have to produce the food we are now producing, to say nothing of adding another 50 million acres, we have got to increase the aglime tonnage or the pH will slip. Obviously, the 645 million tons of aglime used in the 30 years of the ACP did something to the pH of the soil of our land compared to the 68 million tons used in the previous 30 years.

Aglime Use In U. S.

30 Years Before ACP	68,890,000 tons.
30 Years of ACP	645,826,000 tons.

In my judgment, the fertilizer industry, the Agricultural Colleges, the USDA, and the Congress are going to have to develop an effective program for increasing the aglime tonnage for the balance of the century. If the farmers have sufficient funds and prices are right, they will increase their use of aglime. Without this — and it will have to be a very substantial increase — the ACP type program will have to be expanded because the Aglime Industry cannot do it under the present price structure. For example, if the ACP should be stopped tomorrow, I believe the use of aglime would be cut in half if not more.

Conversely, based on my experiences of the last 30 years, I believe the most practical approach is for the Congress to implement the Soil Conservation and Domestic Allotment Act of 1936. This Act authorizes $500 million a year. If we double the ACP appropriation and tie the Extension, Fertilizer and Limestone Industry Promotional Programs together, we can come closer to meeting our aglime needs than by any other method I know of.

I appreciate the opportunity of sharing some of my views on the developing World Food Crisis with you this morning.

MODERATOR SAUCHELLI: Thank you Robert.

Let me correct an impression. I am a thorough believer in lime in the soil. I agree with Mr. Koch that American agriculture is very, very backward in using lime. And the day will come, the day of reckoning, because without lime fertilizer cannot be used efficiently.

Instead of 28 million tons for the year, we should be using, more likely, 70 million tons.

My reference was during that Soil Conservation period. I remember having been on many farms where they had heaps of lime that they were too lazy to spread. The lime was there, but they didn't use it.

Are there questions? We should be firing questions at these speakers. That is our purpose here.

A MEMBER: Why can't the Ag Lime industry support its volume without government subsidies?

MR. KOCH: Well, it's very, very simple. It's a matter of why are you people in business, and the answer is very simple. You're in business for profit. And there is no profit in the agricultural limestone business in many areas of the country. Now don't get me wrong. There are a number of limestone people making a very substantial profit in limestone. For example, we have 564 limestone producers in our organization. Only 15 of them produce agricultural limestone alone.

They can sell 25,000 tons of road stone just as cheap as they can sell ten tons of limestone to a farmer. Why should they have salesmen running up and down the road selling ten tons of ag lime to a farmer when they can make road stone under the present highway program?

Furthermore, these highway programs, which have been a tremendous asset to the limestone industry, are creating fantastic stockpiles of fines that the roadstone producer doesn't want.

These are all over this nation and they depress the price of ag lime to the man who produces it directly, because any trucker can go out, back his truck up and buy it for a nickel a ton or ten cents a ton, or whatever the guy wants to sell it for, and go down the road and peddle it.

I referred to this in my statement. You may have missed the point. However, the oil companies that have recently gone into the fertilizer industry just couldn't believe that the margin of profit was as small as it is in this industry. This is the basic reason, to me. In addition to the 500 producers we have over a thousand limestone producers in this country that don't belong to National Limestone Institute. So there are 1500 limestone producers, and they are just about in the same boat, may I say, as the farmers are. The farmers have to have their prices protected or they would all go broke.

Some of you people don't agree with that, I know, from talking with you in the last 30 years. But if there were no price support programs, your—agriculture in this country would have gone through the wringer. And that is exactly what has happened to the limestone industry.

Under the ACP originally we went up to 30 million tons. When the Congress cut the appropriation we ran 15,000 truckers who were spreading lime through the economic wringer and put them out of business.

There is just not enough economics in this. Now you can show me examples all over the country and we have some outstanding examples among our own members, who have done a real job of merchandising lime.

I'm not talking about this. I'm talking about the nation as a whole. In 80 percent of the country they are in an area where the price of limestone nets them about 25 cents a ton. And the average guy today, he'll do it to get rid of it, because it costs him about 25 cents a ton to get rid of his fines when he is making road stone. It's an economic situation, pure and simple.

Agronomists have taken issue with me ever since I have been in Washington, when I was with the Department particularly, and I have offered many of them, as some of you may have heard, to triple their salary if they would only show us how to merchandise agricultural limestone. As I say, we know how to do it in areas where certain limestone producers are somewhat protected. But when you have a limestone producer who is only five miles down the road from his competitor how do you keep the price where it belongs? Maybe you fertilizer people know how to do it. But we don't in the ag lime field.

MODERATOR SAUCHELLI: It is a problem. Lime is too cheap.

Bob, just a minute. There's a question here.

MR. IRVING SHULTZ (Shell Chemical Company): You mentioned about the Food for Peace program. $5 billion new money, $2.4 billion in carry-over. This carry-over is about a year-and-a-half's appropriation accredited back when we had surplus crops.

How, when we are coming into a shortage of crops, can we move $7.4 billion worth of crops in two years?

MR. KOCH: Well, the answer is very, very simple. We can't.

MR. SHULTZ: You don't think the money will be spent. Is that it?

MR. KOCH: I'm positive the money will not be spent.

In fact, if you read Kiplinger, you will have noticed that his Letter last week says we are only going to spend $4 billion out of the 7.4 during the next two years.

MR. SHULTZ: Why appropriate so much, then?

MR. KOCH: Well, it comes back to the old question of which comes first, the chicken or the egg.

Now, you people in the fertilizer field—I assume most of you are familiar with the problems of producing fertilizer plants overseas. And they are very, very sticky. If you aren't familiar with them, you just look into the problem of trying to build one overseas.

I don't think there is any question but that the Food for Peace Act is going to help a great many of you people expand overseas if you want to.

There is no question—Well, we have a new Farmer-to-Farmer program under the Food for Peace Act that hasn't even gotten started.

Now, all of these new programs require time to build them up. And most of us who are familiar with the problem are convinced that we have got to take this know-how which we have and use it as a show-how deal overseas.

For example, if I may take your time—I don't know how much time you want me to talk here. But let me just make one illustration.

When we organized our group Committee on the World Food Crisis, which, incidentally, is a very loose coalition of about every kind of a group you ever heard of in this country, religious, labor and so on, besides business groups, I was sitting beside Paul Hoffman whom I think most of you know. He was our luncheon speaker. He is now with the United Nations and used to be President of Studebaker, you know, and was President of the Ford Foundation.

He told me as a hard-headed businessman when he went overseas in the beginning and they found an area where they needed to build a big dam to help with the irrigation problems and with electricity and so on, he finally approved the dam and said, Well, here's all the money, they're going to pay for it 100 percent. And he was stunned to find out that when he gave them all the money to build the dam, they couldn't even begin to move because their men were so hungry that they couldn't work.

So he had to go out and find ways to get food to take over there to get those men strong enough so that they could begin to work on the dam, even though they were going to pay for it.

And this is the sort of thing we're up against. A lot of people think we shouldn't be over there, of course. This is no longer an academic question, however. The Congress has said we are going to be.

And the problem is that we have got to help these nations help themselves, or there are going to be a lot more Viet Nam's.

So the answer to your question, Why do we have so many billions? It takes a long time. The gentleman here who spoke about your fertilizer plants, you know what it is to build a fertilizer plant. It takes a long time. You have to have your planning.

And so the Congress, considering all of our needs—and if you will go back and read the testimony before the House Committee on Agriculture, you will find a lot of staggering statistics, and from all walks of life in this nation people saying we ought to do this.

So the Congress is saying that people in this entire area growing additional crops in this country, and we're going to grow a lot more, getting more fertilizer plants overseas, sending teams overseas to help people help themselves, this has all got to be laid out and don't worry about the money, we're going to provide it. This is essentially what the Congress has said.

Now, you people all know that you don't spend a billion dollars all at once. And so AID, Agriculture and other agencies of Government are right now trying to crank up. The only point is, you can't jump from spending two billion dollars a year to $3.5 billion a year overnight. It just takes time.

I think, gentlemen, you will see that the next time we go up to Congress, two years from now, this program is going to be doubled. It's that serious.

MODERATOR SAUCHELLI: Thank you, Bob. Sorry we haven't more time for discussion.

The next speaker, Grant Marburger, is well known to our Round Table. He has made several contributions to our program in the past, and is well known throughout the industry.

Grant recently joined the Armour Agricultural Chemical Company. He has had broad experience in many phases of our industry. He is very well qualified to discuss the subject he has chosen. He has been traveling all over the country in recent years and has come up with some strong conclusions based on observations. I am sure he is going to give us a very interesting discussion of the economics of granulation compared with bulk blends.

Relative Costs of Granulation & Blending

Grant C. Marburger

SINCE this subject is being so widely discussed in the fertilizer industry today, it is appropriate that it appear on this Round Table program. Discussions may not be taking place in your company, or in your circle, but they are in many segments of the country.

This brief discussion will not attempt an elaborate and extensive cost data presentation as a means of covering this subject. To those whose work involves the calculation of business economics, this talk will not yield a large quantity of immediate data because it's not that sophisticated. It has not been programmed on a computer, but is a single calculation on a complex subject.

Of more importance is to bring out some principles that show the relative cost position between blends and granulated materials. One, and only one, principal point will be brought out and emphasized in this material. Data presented otherwise are necessary as background and could in themselves be a subject.

The emphasized point is something that the economist cannot know because it is knowledge that must come from the granulator or mixed fertilizer technician—an operator, a technical man, or a granulation manager. The raw materials that are possible in a granulation plant to make a ton of fertilizer—when the economics dictate—comprise this principal point. In previous years' formulations we used upgraded materials such as ammonium nitrate or solutions, or solid materials in lieu of liquids, whereas today the use of less expensive basic materials must be formulated and used in costing a granulation plant's position.

Since mixed fertilizer formulation is not extensively understood in today's total fertilizer industry, this point is important. By the same token those concerned with formulations must adjust their thinking to the use, or future use, of basic materials.

I also see a necessity to use production costs in lieu of market prices on intermediate raw materials, because of today's integrated industry. In the past we have used market prices in the selection of a least cost formula, and chose our materials in this manner.

Both of these points—the use of basic material, and integrated plant material costs—are important for they determine the formulation selection and the cost calculation.

In comparing the economics of bulk blend with the granulated ammoniated product, we are actually comparing two systems of production, marketing and distribution. We recognize that the producer's cost is not the only factor. Other obvious ones would include the quality of the product, services rendered by the producer, convenience and cost of application, and flexibility in production of unusual ratios or grades in small quantities. Changing technology—new products and processes—is certainly another that must be added.

This comparison of costs between granulated and blended fertilizers is approached by stating the problem in this manner:

The Problem:

Does an integrated company, overall, make more money by selling a ton of ammoniated fertilizer or a ton of blended?

The Case:

A company has a blender and a granulation plant. A salesman gets an order midway between these two points. With which material would he fill the order—blended or ammoniated — to make the most profit?

Under the above assumptions, the same selling price and outfreight to the customer will prevail on each fertilizer. The grades chosen are popular ones normally produced in the industry although somewhat higher grades can be made. Both fertilizers are sold in bulk.

With the larger output of the typical granulation plant, the product must be distributed over a wider sales area. It is assumed that these products will be shipped to distribution stations located away from the processing plant. The cost of shipping to these stations, and the cost of their operation are included.

The blending plant is assumed to cost $60,000 and its annual output is 2,500 tons.

The granulation plant's investment cost is assumed at $500,000. Investment cost of product storage and shipping is a factor common to both cases and is not included. The plant's annual output is 50,000 tons. The investment for distributing stations from the granulation plant is $20,000 each, with an annual output the same as the blending plant at 2,500 tons.

Raw materials to each plant are based on production costs including depreciation, plus freight. The exception is ammonium sulfate, which is at market prices. The location was chosen in the center of the Midwest corn belt.

Table 1. Delivered Raw Material Cost

Granulation		Per Ton	Per Unit
NH_3		$30.00	$ .36½
Solution	44.8%	27.60	.61½
Sulfate	21 %	35.50	1.69
18-46-0		53.40	.35-1.02
Normal	20 %	20.00	1.00
Triple	46 %	46.00	1.00
H_3PO_4	54 %	55.00	1.02
H_2SO_4	93 %	15.00	
KCl	61 %	27.00	.44
Conditioner		40.00	
Blend			
33½-0-0		33.50	$1.00
21-0-0		37.50	1.78
18-46-0		53.40	.21½-1.07½
0-21-0		28.00	1.33½
0-46-0		49.50	1.07½
0-0-61		28.75	.46
0-0-0		4.00	

Table 2. Formula Costs

Granular		12-12-12	15-15-15	5-20-20
		Lbs.	Lbs.	Lbs.
NH_3		152	189	128
H_2SO_4	93 %	412	430	—
Solution	44.8%	279	346	—
H_3PO_4	54 %	199	490	397
Super	20 %	667	175	932
KCl	61 %	394	492	656
Coating		10	10	
Cost*		$27.42	$33.57	$31.64
Blend		Lbs.	Lbs.	Lbs.
18-46-0		522	653	556
0-46-0		—	—	313
33½-0-0		436	545	—
0-0-61		394	492	656
0-0-0		648	310	475
Cost**		$28.47	$34.57	$33.33
Cost Difference		$ 1.05	$ 1.00	$ 1.69

* Includes overformulation and 2% shrinkage.
** Includes 1% shrinkage.

You will note in table 2 the granular 12-12-12 and 15-15-15 formulations use more basic materials than is in general practice. Future granulation plants will use the formulations shown above. The conventional plant with a preneutralizer added, and its accompanying scrubber, will permit this change.

There was quite a flurry about preneutralizers a number of years ago. We in the industry worked hard on it, and it was widely discussed. But it was not used extensively except to permit higher grade analysis.

The reason has always been economics. Formula cost comparison with and without preneutralization was previously unfavorable to most companies at the existing prices of raw materials. But today and in the future this will no longer exist because of the integration of companies. When both basic materials and mixed fertilizers are produced, the overall company has a cost on basic materials that is lower than the market prices we previously used in formula costing. Consequently, the economic look at the use of a preneutralizer in the granulation process is now different.

We must pause here and understand the purpose of a granulation plant. Its function is to convert N-P-K fertilizer materials to merchandisable form. In the language of the economist it is to create form utility.

It is a corollary that this function must be served in the most economical manner. The integrated fertilizer company that makes ammonia will, if it can, avoid spending money on further processing.

The company may elect to shift its profit center to the basic plant by selling to its granulator at market prices. Nevertheless, the basic economics is to place the ammonia into the granulation process at manufacturing cost plus freight. Thus it becomes obvious that the economics of creating form utility involves maximum use of ammonia and this points to the preneutralizer and acids.

Other comments on these 1-1-1 formulations should be made. The formulas used for cost comparison in table 2 used half anhydrous and half solution in 12-12-12 and 15-15-15. Table 3 shows variations in these formulas to meet different conditions ranging from all anhydrous and all nitrate formulations. If you're afraid of high nitrate content, the anhydrous formulation can be used. If your plant equipment has operating problems making large quantities of sulfate in situ (Formula 1), sulfate or nitrate can be substituted (Formula 2). Nitrate was substituted in this formula because of the cost of sulfate. If liquid phase is too high, or if production rate is too low, put in some solid 18-46-0 (formula not shown).

Table 3. Formula Variations

12-12-12

	(1)	(2)	(3)
NH_3	304	152	——
Solution	——	279	558
H_2SO_4	650	412	175
H_3PO_4	265	199	132
Normal	486	667	842
KCl	394	394	394
	$27.63	$27.42	$27.11
15-15-15			
NH_3	345	189	——
Solution	58	346	692
H_2SO_4	666	430	140
H_3PO_4	556	490	409
Normal	——	175	392
KCl	492	492	492
	$33.75	$33.57	$33.25

The cost comparison between granular and blends is given in Table 4. The difference in cost of $5.00 per ton speaks for itself and for your own interpretation. Other comparisons on this subject have been published that indicated cost advantages for bulk blends at 10% to 20%. This presentation was on a different basis than the previous publications and indicates 9% to 12% difference. We don't believe that this amount can be considered significant, for there are too many variables in estimates made on this broad a scale. The $5.00 per ton is a substantial amount, but it could change when the above calculation is made on a specific case.

Table 4. Cost of Granulated 15-15-15 As Compared With 15-15-15 Bulk Blend

	Granular	Bulk Blend
Materials	$33.57	$34.57
Plant Operating Costs*	6.00	6.00
Operation of Distribution Station*	2.00	
Freight to Distribution Plant	4.00	
Sales Cost	00.00	00.00
TOTAL	$45.57	$40.57
COST DIFFERENCE	$5.00	

* Includes depreciation but not interest.

MODERATOR SAUCHELLI: Thank you Grant. Questions please.

A MEMBER: Why the $6 operating cost in both cases?

MR. MARBURGER: The operating costs were calculated for each case from the expenses that would be incurred in each facility. The fact that they were the same in both cases probably prompts the question but this was the result from the assumption made in each case study. For instance a $60,000 capital investment in the blending plant with 2500 ton thru put resulted in a depreciation cost of $1.88 per ton. Labor maintenance and other items brought the total to $6.00 per ton. The deviations of operating costs were not itemized and presented in this table because they were aside from the main subject.

MODERATOR SAUCHELLI: Any other questions?

I know Grant has put a lot of time and effort into preparing this talk. I am sure when you get the Proceedings many of you will be studying very carefully his presentation.

The next speaker, Barney Tatum with the Tennessee Corporation, is known to most of the Round Table. He doesn't need much introduction. He has been very active in processing phosphates, in which his firm is a leader.

He has a little different talk from what the title on the program is. He is going to speak on Challenging Areas in the Industry. I'm sure it will stimulate some thinking. Barney.

Challenging Areas

H. B. Tatum

THE need for more manpower in agriculture and its allied industries is probably more acute today than ever before. The shortage is expected to continue for several years. Fortunately, for industry, there is a two-way shift in manpower. The farm, in its development into larger farm units will require fewer men. The allied agricultural industries services and the associated developing services will require more men. This is not a balance of manpower because the estimated requirements for the agricultural industries will be more than those relieved of farm work.

The recruitment of young men and women for the agricultural industries must be intensified. If the industries are to survive and make reasonable headway, then industry must accept its responsibility to the university system by assisting in steering the young minds toward the agricultural professions.

Through the influence of the 4-H and Future Farmers of America organizations, young people have gone to the universities for training. Some students are now attending the vocational-technical training schools. The agricultural industries can keep the fire burning through financial and moral support — and by letting it be known, through action, that production of food, fiber, servicing of agriculture and the industries, and the research in depth needed in the life sciences, provide career opportunities of the first magnitude.

The total agricultural effort in the United States has been successful in providing this nation and others an abundance of low-cost food. The prayer, repeated around the globe by thousands, "Give us this day our daily bread," is almost meaningless to most people of this country—I regret to say! The general public has become complacent toward agriculture. Agriculture, in a sense, has been downgraded because within the minds of the public, agriculture is associated with manure salts and hard work with few profit returns. It is understandable why the intelligent young high school graduates are lured from the agricultural professions.

At a time when this country is in need of agronomists a recent survey indicates that very few will be graduating next June. Gentlemen—some of us failed to deliver the industry message five to six years ago.

New stature must be acclaimed by agricultural production. Stature will come through the efforts and achievements of the agricultural professionals representing the farm and industry. These scientific heroes of tomorrow and their accomplishments will challenge the bright young minds to enter the agriculture field.

The opportunities in the developing countries for industry to share its knowledge are sufficient. Among ourselves, we discuss the upsurge in plant food consumption, emphasizing the overseas portion. There is no doubt of the food and fiber needs. These can be produced only through the medium of the agricultural services.

The first opportunity lying within the grasp of technicians in this country would be to teach and demonstrate, however, there will be obstacles for we are led to believe that the developing countries are at an agricultural level this country experienced fifty years ago. It will be no simple matter to project their level from boomerangs to jets in ten easy lessons.

The understanding of economics, agriculture, psychology in conjunction with the genuine desire to help, will be some of the pre-requisites of the overseas technician. Think if you will, how difficult it must have been to change the farmers habits in the United States especially along the lines of increasing capital input with respect to labor input on his farm unit especially when strong backs were admired. The change was gradual and the shift from labor to capital input is largely responsible for the agricultural abundance we experience today. The teachers and technicians spoke our native tongue, even then it was difficult to communicate because of the natural suspicions in man. How much success would have been achieved in this country fifty years ago had the agricultural experts been foreign, speaking in their native tongue?

Collectively, are we big enough to comprehend the massive job ahead? Are we big enough to understand the forces that mark progress both here and abroad with the diversifications in the economies that presently exist? We have meager ideas of what is expected of us abroad—but we shall learn.

However, in this country the consumer will, in the near future, expect to have at his command a battery of services that will require the agricultural service men to work longer, harder and more intelligent hours. Concurrently, the large agri-business farmer, one that may have his masters degree in the science of agriculture or one of its related fields, will be equally engrossed developing land under his care and developing the phases of the production cycle in the future complex operation. His time will be consumed in correlating the farm production through processing, marketing, and distribution and evaluating industry services.

The challenge is no longer a matter of hiring and wishing him success.

The challenge today is a matter of selecting calibre men—then formulating and executing the TOTAL program.

MODERATOR SAUCHELLI: Thank you, Barney, for those stimulating thoughts.

We will adjourn until two p.m. promptly.

Wednesday Afternoon Session, November 2, 1966

The Round Table reconvened at 2:00 P.M.

Vincent Sauchelli, Moderator

MODERATOR SAUCHELLI: Before we get started I want to recognize John Osguthorpe. John please rise. John is with the State Department. I want you fellows to know that he did a splendid job with AID in establishing standard specifications. He has worked with the Industry and is a very fine fellow to know.

The next speaker, Bruce D. Cloaninger, is nationally known among state regulatory officials. He is a staunch friend of our Industry and is respected alike by Industry and Government officials for his progressiveness and fairness. It is an honor to have him on our program. Bruce.

MR. CLOANINGER: Mr. Chairman, distinguished guests and members. After such a flowery introduction I can hardly wait to hear what I am going to say.

Relationship Between Fertilizer Manufacturers And State Control Officials

Bruce D. Cloaninger

MY subject, "Relationship Between Fertilizer Manufacturers and State Control Officials," is an extremely broad one. In fact, one finds himself in the position of the mosquito in a nudist colony—He knows what he wants to do but not where to start. A good starting point, however, with this Relationship is with *you* and with *me*. We both need to give and take, in order to have a workable program. It behooves all to know each other better, to know our problems better and then proceed in a gentlemanly and dignified manner to accomplish the goals. We all—if asked to define "Relationship"—would have many different definitions, but in essence each of us has the firm idea as to its real meaning.

I take this opportunity of complimenting the fertilizer industry, agricultural agencies and Control Officials for their close cooperation and feeling of mutual understanding which apparently exists among all of you. Deep down—why not? We are all working for the same goal. Namely, to increase agricultural production, reduce the unit cost and up the net profits available so that farmers throughout the country may enjoy a better livelihood and a higher standard of living. Neither the industry nor agricultural agencies have anything to hide. Our goals are the same. Our principles and our code of ethics are identical.

You, of the fertilizer industry, have been extremely farsighted in establishing research projects grants-in-aid with institutions, while others have carried on their own research work relative to technological developments in the field of soils, chemicals and many other projects. These developments have moved so rapidly and have meant so much to expanding agriculture until one finds himself in the position of the janitor answering the phone at the bank, etc. You, in the industry, are looking ahead 10 to 20 years. Your research development and planning paths are flexible and are gathering information which, no doubt, will permit your company to remain highly flexible and cope with any existing situations. Might be in the position of the widower who had two wives who preceded him to the grave, etc. Think back during our boyhood days—the manufacturers of buggies and harness who continued in these lines failed; whereas, those who looked ahead and converted their activities to manufacturing golf balls or baseball bats succeeded. One never makes progress nor furnishes the proper leadership for an organization by becoming stalemate. We either go forward or backward. We never stand still.

Never has it been more imperative that industry, research and control officials establish realistic goals and surround themselves with capable staffs to accomplish such goals. No group has the inside track nor the Utopia. By pooling our real efforts, *problems* will be turned into *opportunities*.

Are we, as Control Officials, spinning our wheels, or are we cooperating to the fullest in establishing laws, rules, regulations, etc., which are realistic and not standing in the way of progress? Colleges and universities were founded on progress; your firm has thrived on initiative, progress, honesty, and service to your customers. Certainly there might be additional headaches for certain practices used by your firm, but headaches come with initiative, progress and expansion.

Communication and Public Relations: This is an unscratched field. Too few people realize the enormous task of producing food and fiber for a rapidly expanding country, plus the many others to whom we find it necessary to furnish food. As the population increases, there will be an increased demand for your plant food. In 1950, there were 3.1 acres of farm land per person in the USA. By 1975, there will be 2.2 acres per person, and by 2000 only 1.6 acres. Using these figures as a conservative estimate, our yield per acre must increase by 40% to furnish food in 1975 and must double by the Year 2000. The answer is simple—More intensive farming; larger acreage, which means more mechanization; and most important of all, larger amounts of higher analysis fertilizer. The number of farms is decreasing, but the acres per farm are increasing. The business-like approach is being applied to farming. Laborious methods of handling fertilizers and doing other farm tasks are being alleviated. Bulk distribution has become popular due to the shortage of labor and higher analysis mixtures which prevent seedling injury.

So much for the background and statistics with which, no doubt, you are all familiar. Let's get to the facts . . . What can you do and what can I do as a Control Official to eliminate or to reduce to a minimum the number of control problems related to commercial fertilizers? In 1963 I compiled a questionnaire and sent it to certain Control Officials in 25 states, asking this specific question. "What are some problem areas which we, as Fertilizer Control Officials, will probably encounter during the next 5 years?" I had a total of 36 different questions. These ranged from P and K guarantee, bulk blending, chelates, uniform methods of analyses of certain trace elements, correlation of legal or penalty tolerances with agronomic responses, inspection probes to physical forms to control availability. These were all published in Publication No. 18, a copy of which I hope you will get and familiarize yourself with some of these. In the same questionnaire, I asked this question: "What can we, as Fertilizer Control Officials, do to have a more progressive program?" I received 23 different suggestions. A few of these are as follows:

Shift control measures from consumer sampling to factory control.

Publicize State Extension Programs.

Coordinate with adjoining states on fertilizer violations.

Write the Model Bill in legal terms.

Prepare a guide or an inspector's manual on inspection procedures.

Make more and better reports.

Cooperate and participate in industry and consumer programs.

Drive toward uniformity in labels and laws.

Effectively enforce every feature of the Fertilizer Law, which should be patterned after the Uniform Bill.

Strive for labels which adequately describe the product.

Make legislators and administrators aware of responsibilities of Control Officials.

There is an Association of Economic Poisons Control Officials, an Association of Feed Control Officials and an Association of Fertilizer Control Officials. The Association of American Fertilizer Control Officials was first organized in Washington, D. C., in October, 1946. Prior to the establishment of this Association, the question of uniformity of labeling was simply unheard of. It would be impossible to state the number of hours the Uniform Fertilizer Bill Committee devoted to establishing the guideline for a uniform bill. I am happy to announce that some 38 states have adopted the Uniform Bill, while many others have followed it extremely closely.

Many of you, I am sure, have encountered extreme difficulty in getting a uniform label for specialty fertilizers. To date, 45 states have adopted the Uniform Fertilizer Label. Some states have requirements, as set forth in their code of laws, which are necessary to show, while others have been very considerate and permitted these guarantees to be shown. For instance, in many states the guarantee for urea is not required, however, in a few states, I understand, it is required, while other states show no objection to its being guaranteed. Immediately following the Uniform State Fertilizer Bill in Publication No. 20 is the Regulation for Specialty Fertilizer Labels, plus a Regulation for Interpretation of Specialty Fertilizer Labeling Format. The N.P.F.I. Advisory Committee, working closely with the Specialty Fertilizer Committee of the AAFCO, has made uniform labeling and marketing possible.

Tonnage Reports: The logistics of moving approximately 31 million tons of fertilizer in the United States annually in a relatively short period and incidentally, in our section of the country it gets shorter each year, is no small job. The president of one large manufacturing company stated that timely, accurate tonnage data by states would be worth 15¢ per ton to his company. The Association of American Fertilizer Control Officials, at the request of Mr. Paul Truitt, President of the NPFI, requested that the AAFCO instigate in 1964 a Task Force Tonnage Committee. This committee was, and is still, composed of two members from USDA, two from the Fertlizer Industry and two from AAFCO.

It was soon recognized bv the committee that the easiest, cheapest and most accurate means of securing timely tonnage data was the invoice reporting system. This is very simple, and in essence requires the registrant to report the tonnage; that is, submit a copy of his invoice on which would be shown the name and county of the consignee, the grade, analysis and tons or fraction thereof. These would be submitted to Control Officials within 48 hours after a shipment was made. This confidential information would be placed on some type of computer and published monthly. Many states using this system are, on the 5th of each month, publishing to the industry the tons of mixed fertilizer and the various type materials used for direct application. Then, semi-annually, the report is published showing the tonnage by grades and counties. This information is not only extremely helpful to the fertilizer industry but also to agricultural workers, as the tonnage of plant nutrients used are immediately available. County agents and agricultural teachers can easily check to see if their recommendations have been followed as to grade. Many states have compiled this data for much less than 1¢ per ton. At present, only 22 states are using the invoice reporting system, however, a recent questionnaire revealed that 82% replying stated that it would be beneficial. Fifteen states report monthly. I am happy to report that these forms were unanimously adopted by the AAF CO at the August, 1965 Meeting and that the plan was also submitted to and approved by the National Association of State Departments of Agriculture during their October 1965 Meeting at Princeton, New Jersey. It is hoped that within the very near future the majority of the states will be reporting and publishing timely fertilizer data. As previously mentioned, this business is too large and too important for a "hit and miss" procedure for collecting and reporting tonnage data. Think of your large meat packing plants. Computers compile figures on pounds of baked hams, sidemeat and bacon processed Versus pork sold. At a minute's notice, the amount in stock is available information. You might say they get more per pound than you do for fertilizer. Gentlemen, let's dignify the profession and the product. You are in a highly organized chemical industry. You no longer kill your neighbor's dog and bury it under the warehouse to get an organic smell. It doesn't take that —as some old timers used to think— to produce a crop.

Confidentially, I hate the words "regulatory" and "Control Official." Who is regulating whom and who is controlling whom? These terms or names have been with us so long until it would be hard to dispense with them. You, in industry, are equally interested in seeing that the laws are properly enforced and that all are treated alike. The regulatory control official is simply the referee for you and the farmer. Part of his duty is to see that the label attached to the container describes the product but does not glorify it to the extent that the farmer or purchaser is misled. When I think of industry and the cooperative feeling existing with agricultural agencies I am reminded of the father on his death bed who called in his seven sons and asked each to bring a small twig with him, etc.

Law enforcement of any type, to be properly effective, must be manned by capable, unbiased people. Sure, we will all make mistakes; but let's be man enough to admit them and not only admit them to the manufacturer but write a letter to the customer, who might have been notified in error. We, as Control Officials, must not only have good personnel, but we must also have schools to train them. Let them feel and realize beyond any doubt that they are cogs in the wheel of agriculture in their state. Their jobs are important ones and must carry dignity and prestige, along with a lot of work. Your reputation, Mr. Industry, is based largely on our work. Rest assured that we are not going to let you down.

All regulatory associations, in my opinion, must work with the industry on sampling procedures and with AOAC, the agency which is charged with this responsibility. A sample must be procured accurately if it is to represent the product.

What Can You in the Fertilizer Industry Do to Improve Fertilizer Control?

1. Instill into every man the importance of doing a good job— from the superintendent to the clean-up man in the plant. He must get interested in your business if you are to pay dividends.

2. Systematize your operations and hold the proper individual responsible. Use the old army procedure. If he can't produce, hunt yourself a new man.

Too many errors are made and too little attention is given to the manufacturing and shipping procedures. A plant cannot be operated by remote control. The human error will appear. Your superintendent is paid more and your foreman is paid more than the average worker because he has proven to you that he can and will accept the responsibility. I tire of hearing superintendents say: "The Control Official is wrong; The sample is drawn improperly; or The laboratory used student help instead of degree chemists." In our laboratory, we never use students.

Means must be devised to reduce errors to a minimum. Simple things such as chains across bins containing different bulk commercial fertilizer could be useful in keeping the payload operator from getting in the wrong bin. As an officer in the last war, I tried to teach our men that they only had one chance—being accurate and a good shot determined whether they lived or died. It isn't quite this bad in manufacturing fertilizers, but the situation is somewhat synonymous.

A diversified superintendent and foreman are "A Must." Many concentrate on analyses and forget weights. You can't give it away or short change the customer and continue in business. "Work is that annoyance people must endure between coffee breaks."

Get your dealer, who in most instances is becoming obsolete, to realize his responsibility. Discourage his sending you fertilizer on a wet truck or one with nails sticking up to snag the bags. If it isn't labeled right, let him call you before an inspector finds it. He is your representative.

Encourage your industry people to offer every assistance to the state agricultural colleges. Many fine Advisory Boards are formed by members of the fertilizer industry. Your help is needed, Gentlemen.

In summary, let me re-emphasize several points: (1) Let's all practice co-ordination, cooperation and communication— (2) Continue to offer full assistance to State Control Officials by adopting the Uniform Fertilizer Bill; strive for greater uniformity for Specialty Fertilizers and put forth a special effort to secure timely, accurate tonnage data. This will be most useful to Industry and agricultural agencies of your state.

Agriculture is Big Business. It is not on the wane as some would attempt to lead you. It is my feeling that agriculture will really come into its own in the near future. As you know better than I, indications are that the government programs will be somewhat reversed and that greater emphasis will be placed upon producing and on feeding a hungry world rather than on paying farmers to kill pigs and reduce the acreage. With the present surplus, it is estimated that many countries could have extreme famines by the year 1970.

Through the concerted and coordinated efforts of members of the fertilizer industry and regulatory control officials, many *problems* have been turned into *opportunities*. The subject of "Control" is not confined to chemical analysis but to regulating the product from the point of origin to the nth degree in manufacturing, sale and distribution. I hope that these remarks will be of assistance in clarifying our needs and developments in fertilizer control work.

It has been my pleasure to meet and visit with many of you during this conference and I have been tremendously impressed with the caliber of men present here. Frankly, I would hate to be against anything that you were for. It has been a real pleasure.

MODERATOR SAUCHELLI: Thank you Bruce. That certainly was a fine presentation of the control official's position with respect to the industry.

We thought it was a good thing to have a control man, an outstanding control man, with us on this program because he doesn't come into contact too much with the operating personnel in the industry. It is so important that both the operating personnel and the control officials get together.

I want to recognize at this time Mr. Paul Truitt, President of the National Plant Food Institute. There has been a very close association between the National Plant Food Institute and the Association of American Fertilizer Control Officials. Paul, will you stand up and take a bow?

It is by cooperation between the two organizations that we make progress.

I mentioned this morning that we had on our program as the next speaker Zenas Beers who is President of the Agricultural Ammonia Institute. Zenas is well known to many of you in the industry. Zenas had another assignment. In his place he has selected Ben F. Day, Manager of Technical Services of the Agricultural Ammonia Institute, to present the paper that he was going to present.

Ben is a newcomer to many in our industry, and we are looking forward to an interesting talk.

Ben is a graduate of the Virginia Polytechnic Institute. He was Plant Engineer for Crompton-Richmond Company of New York in a $6 million complex constructed at Oscello, Arkansas.

I'm sure, that from what advance information we have had, we can look forward to a splendid talk by Ben Day. Ben.

Anhydrous Ammonia And Granular Fertilizers

Ben F. Day

THE Agricultural Ammonia Institute is complimented that the Round Table asked us to be present today. Our subject, Anhydrous Ammonia and Granular Fertilizers, is a broad topic, and time does not permit us to present many details.

We are grateful also to members of the Institute for contributing to this paper; to International Minerals for donating the time of Bill Johnson and Bob Heck. We are especially grateful to the members of the AAI staff for their many contributions and consultations. We think you might also be interested in some facts about ammonia—its physical and chemical characteristics that are important to the safe handling of ammonia, besides taking you through the process of feeding ammonia into an ammoniator granulator.

Some, who know the Institute, may wonder about the topic for today inasmuch as the Ammonia Institute was established several years ago, basically to serve the retailer, producer, and consumer of anhydrous ammonia for direct application fertilizer. We are the first to recognize that anyhdrous has many other uses, and that there are several sources of nitrogen fertilizer for use, not only as D.A. material, but in the fertilizer industry as a whole.

Since 1950, the production capacity for ammonium has increased about 17 times; about one million tons, to about 17.5 million tons predicted for 1968, '69 or 1970. The actual production of anhydrous ammonia has reached about nine million tons for the year 1966.

The use of ammonia in agriculture has increased from approximately 22,000 tons in 1947, the first year it was recorded separately in the USDA Fertilizer Statistics, to an estimated 1.6 million tons nitrogen as anhydrous ammonia for the fertilizer year of 1966. The use of anhydrous ammonia has doubled every five years since 1950, with the estimated total in 1966 running about 1.6 million tons of nitrogen or two million tons of ammonia for direct application fertilizer. In 1964, according to the Stanford Research Institute, fertilizers in various forms consumed an estimated 76% of the total ammonia production in that year. In the same year, synthetic fibers and plastics consumed an identifiable 5.6%. Industrial explosives accounted for an estimated 3.6%. The remaining 15% was distributed to and through a wide range of industrial and chemical diversities.

In 1965, anhydrous ammonia accounted for about 28% of all nitrogen used as fertilizer in the United States, and about 39 to 40% of all direct application of nitrogen fertilizer in the United States applied during the fertilizer year of 1965. It is estimated that all nitrogen increased about 11% in the fertilizer year of 1966, whereas anhydrous ammonia increased about 25% from a base of about 1.2 million tons of nitrogen as anhydrous.

We were very fortunate to have a group of forward-thinking people in 1951, who were capable of visualizing the growth of the ammonia industry. This vision led to the creation of the Agricultural Ammonia Institute. Our purposes and aims are to stimulate and encourage agriculture, horticulture, and the mechanical and scientific arts; to accumulate and disseminate information on the response of crops to agricultural ammonia and on equipment and methods of handling and applying agricultural ammonia together with other subjects which influence the well-being of farmers who use ammonia. We advance knowledge and learning in the sciences, and stimulate invention and research, especially as applied in the agricultural ammonia industry; encourage advancement to the highest degree of safety, efficiency, and standardization in the manufacture of equipment required and used in the industry.

In carrying out the foregoing broad general purposes, our staff and committee responsibilities follow the areas of publications, public relations, and the establishment of liaison with state associations, as well as formulating and continually updating standards for handling and storage. We are engaged in reviewing, collecting, and disseminating information relative to the agronomic use of ammonia as well as making recommendations on any technical problem, including equipment, arising out of storage, handling, application or agronomic use. Basic information contained in our workshops can be applied to any situation, regardless of the method of storage or transfer.

We are dealing with a product which is a liquid at low temperature, or under pressures, and a gas if the temperature is raised or the pressure is released. It might be well, at this point, to go into a little more detail regarding its properties.

Ammonia, strictly speaking, is not a poison. It has no cumulative toxic effects, as do lead or mercury. However, it has a powerful corrosive action on tissue. Exposure to atmospheric concentrations of ammonia above 5,000 ppm, or ½ of 1% by volume, can produce death by suffocation within minutes. Concentrations above 2,000 ppm, or 2/10 of 1%, can burn and blister the skin after a few seconds of exposure. Liquid ammonia in contact with the skin can produce severe burns, not only because of its strong corrosive action, but also through the freezing effect produced by its rapid evaporation, although this latter effect is minor.

Concentrations above 700 ppm will cause severe eye irritation. Hemorrhages and swollen lids, if not treated immediately, may lead to partial or total loss of sight. Prolonged exposure to atmospheric ammonia above this concentration may produce severe scarring of the exposed eye tissue, especially the cornea. The flammable limits of ammonia and air are 16 to 25%. The flammable limits of ammonia and oxygen are 15 to 79%. However, ammonia-air mixtures are difficult to ignite, and they burn with little vigor in the absence of oxygen enrichment. The risk of accidental ignition is low. Ignition temperature is about 649° Centigrade, 1200° Fahrenheit.

Many chemical reactions take place in liquid ammonia in which the ammonia is the ionizing agent. In such reactions, ammoniates may be formed with one or more of the resultant compounds. With proper catalyst and under controlled conditions, ammonia will react with elements and compounds too numerous to cover at this time. *Lange's Handbook of Chemistry,* Ninth Edition, lists 243 organic and inorganic compounds that can be made using ammonia either directly or indirectly.

Anhydrous ammonia does not affect common metals, but moist ammonia will react rapidly with copper, silver, zinc, and most alloys of these and other metals in the presence of oxygen. Explosive compounds may form when mercury is brought in contact with ammonia.

Jones and McCants found that commercial propane, containing up to 100 ppm of ammonia, did not corrode mild steel. This is important to know if equipment is used alternately for ammonia and propane.

Ammonia is soluble in water. Water and other compounds added to liquid ammonia lower its freezing point. Because the freezing point of ammonia is 77.7° Centigrade, or 107.9° Fahhrenheit, further lowering is not needed for agricultural use. Water and other compounds added to ammonia raise its boiling point and lower its vapor pressure. Urea and ammonium nitrate are used to lower the vapor pressure of ammonia. There are numerous combinations of ammonia, water, urea, ammonium nitrate solutions on the market. These solutions are generally termed nitrogen solutions and are sold under the trade name of the manufacturer.

As we have said, ammonia has a burning effect. In the event of an ammonia burn, seconds count. To prevent such a burn, we recommend that rubber gloves with a long gauntlet turned up be worn to prevent the liquid from running down the arm and burning. We also recommend the eyes be protected at all times.

Standards call for and rules and regulations require safety equipment at every ammonia installation. The following equipment should be maintained, readily at hand, for field transfer operations:

(1) Tightly fitting safety goggles or full-face shield;

(2) Protective gloves, boots, slickers or jackets, and pants made of rubber or other material impervious to anhydrous ammonia;

(3) Gas mask with ammonia type canisters and refill canisters within date limits;

(4) At least five gallons of readily available clean water.

Water in quantity is the best first aid for an ammonia burn.

In cooperation with our membership, we have created the "Ammonia Safety Commandments":

Always have ample clean water available.

Always stay clear of hose and valve openings.

Always wear gloves and goggles while transferring ammonia.

Always close valves and disconnect hoses when plant is unattended.

Always be sure pressure is relieved before disconnecting hoses or parts.

Never fill a tank over 85% of capacity.

Never leave transfer operations unattended.

Never tamper with relief valves or other safety devices.

Never try to "get by"—use only approved ammonia equipment.

Never tow a trailer without secure connecting parts and safety chains.

As we said in our Commandments, never fill a tank over 85% of its capacity. At 85% liquid capacity and 40° Fahrenheit, the pressure is 58 psig. If the temperature rises to 100° Fahrenheit, the pressure then becomes 197 psig with a liquid volume of 92.2%. If this same tank were filled to a liquid volume of 92%, instead of the recommended 85% at 40° F, and if the temperature should rise to 100°, the liquid volume of the tank would then be 100%, and the pressure 250 psig. This causes an actuation of the safety valve and a loss of product.

There are two general classifications of ammonia storage tanks:

(1) high pressure tanks and (2) refrigerated tanks. The high pressure tanks range in size fro m6,000 to 90,000 gallons. These tanks must all be constructed and tested in accordance with ASME Codes designed for a minimum pressure of 250 psig. The more common sizes range from 6,000 to 30,000 gallons. Medium pressure tanks fall under the classification of refrigerated tanks and are usually spherical in shape, and are supported above the ground on steel legs. They range in size from 500 to 3,000 tons capacity. These tanks are covered with 4 to 6 inches of insulation. A complete refrigeration unit is connected to the tank, and ammonia is used as its own refrigerant.

As liquid ammonia absorbs heat, some of the liquid vaporizes, increasing the pressure within the tank. To maintain a constant pressure within the tank, the vapors are drawn from the tank by compressor units. Compressed, condensed, and returned to the vessel in the form of a cold liquid. This cycle continues until the pressure is reduced within the normal operating range. The refrigerator units operate automatically and cut off and on by the raising and lowering of pressure within the tank.

Atmospheric storage, a relative newcomer to the ammonia industry, is merely the refrigeration of ammonia to or below its boiling point of –28° Fahrenheit. Tanks of this design range in capacity from 10,000 to 30,000 tons and are usually of a double tank design—one tank within the other and the space between being fully insulated. The inner tank must be constructed of a special steel having qualities suitable for use at this low temperature. The design pressure of these tanks is usually one psig with an operating pressure range of .25 to .75 psig. At the usual operating pressure of .5 psig, the temperature of the liquid ammonia would be –27° Fahrenheit. The refrigeration equipment is similar to that used in a medium pressure tank.

All refrigerated tanks are equipped with a relief valve. They are spring loaded for medium pressure tanks, set at a pressure not to exceed the design pressure. Atmospheric pressure tanks have weighted relief valves set for one pound pressure relief. A liquid level gauging device, which is a direct reading tape connected to the float, is normally used. As refrigerated tanks normally are equipped with much larger liquid openings than are found in high pressure tanks, these openings are generally protected by an air or vapor operated remote control shut-off valve, rather than by a spring-loaded excess flow valve.

Refrigerated systems are required to have a stand-by emergency power source and stand-by compressor units of sufficient capacity for handling the total refrigeration load. Bulk storage plants usually have high pressure tanks, while tanks of the refrigerated type are normally found in terminals or manufacturing plants.

The transferring of liquid ammonia can be divided into three general classifications: (1) the use of vapor compressors to produce a pressure differential between vessels; (2) positive displacement liquid pumps, and (3) producing a pressure differential by bleeding off vapor from the container being filled.

Compressor transfer equipment normally is used with all sizeable field storage and is essential for vapor recovery in tank car unloading. Storage plant valves and piping are arranged so that compressor suction or discharge may be directed alternately to any vessel in the system. Vapor pressure is withdrawn from the vessel being filled with liquid, discharged into the supply tank; and the resulting pressure differential causes liquid ammonia to go from high pressure to lower pressure. The ideal compressor for normal field storage operation is a two-cylinder unit with approximately a three-inch bore by three-inch stroke and a displacement of 20 to 25 cubic feet per minute when powered by a 5 or 7½ horsepower electric motor. Such a unit can, with unrestricted liquid flow, unload an 11,000-gallon tank car in an average time of 90 minutes or fill a standard fitted 1,000-gallon nurse tank to 85% capacity in 15 minutes. The ammonia compressors should not contain copper or copper alloy. It should have a safety feature, such as a spring-loaded cylinder head, to discharge accidental liquid intake without damaging the unit.

Liquid pumps normally used for transferring ammonia in field bulk storage operation are rotary, positive displacement, sliding vein types. A two-inch pump operated at 650 rpm with a 5 horsepower electric motor will discharge approximately 65 gallons per minute. A three-inch pump operated at 615 rpm with a 7½ horsepower motor will handle about twice this volume. Although pumps may be installed for roughly 75% of the cost of compressors of comparable capacity, compressors are more trouble free. Pumps have another disadvantage in that they will not completely unload tank car shipments.

The earliest and probably still the most common method of transferring liquid ammonia from field tank to applicator tank is purging or bleeding off vapor pressure from the applicator tank to create the necessary pressure differential. Undue emphasis has sometimes been directed to the loss sustained in this operation. Tests by the Mississippi Agricultural Experiment Station in which ammonia vapor was discharged into a closed container of ice water and all vessels accurately weighed have demonstrated that there is an average loss of 2.54% when a ten-pound pressure differential is maintained. Since the optimum liquid flow through standard tank fittings and ¾ inch nurse tank hose is gained by maintaining a ten-pound pressure differential, ammonia losses rise sharply with an increase over the ten-pound rate. At the 2.54% rate, the loss in handling approximately 80 tons of ammonia would pay the cost of installing the gas operated vapor pump.

As we move away from the general subject of ammonia transfer and into a specific, such as transferring ammonia from storage into an ammoniator granulator, we are thinking in terms of the liquid pump and liquid transfer. And as we said earlier, the rotary, positive displacement pump is utilized. We face the decision of actually spending the money for the equipment while considering the results this expenditure will have on the manufacture of fertilizer in a particular location, and within the framework dictated by the location of the plant. The equipment itself is relatively inexpensive. The pre-cooler can be homemade or purchased for less than $500. A recording meter costs approximately $600; a mixing tee about $150.

If ammonia is not available at the location, it is necessary to think in terms of a safe, permanent type storage. A liquid pump is required to move the ammonia; piping is required, as well as the components previously mentioned. We are probably looking at a total cost of installation of $2500 to $3,000. The logical question of management is then, "What is the return on this investment?" This is simple arithmetic. By substituting ammonia at 82.5% N and 100% free ammonia for solutions or any nitrogen sources in a formula. In the particular plant cited here, the low "N" grades presented the greatest problems of production. Therefore, it was these grades such as 5-10-10, 6-8-8, and 5-20-20 that anhydrous ammonia was utilized to raise the temperature of the ammoniator. Anhydrous ammonia was simply substituted into the formula, and extension of the cost gave the answer to justification for the expenditures. In this process of moving to the ammoniator granulator, it is necessary to meter the liquid ammonia.

(1) This slide is a schematic showing the basic components used to transfer liquid ammonia into a granulator. The pre-cooler is a heat exchanger that assures we are metering liquid. The ammonia enters the inner pipe from supply and passes through the inner pipe into the meters. From the meter, the line is brought back to outer pipe where it normally flashes some vapor which provides a cooling of the liquid coming through the inner pipe. The ammonia then leaves the outer pipe on the opposite side and goes to the point of use, such as a TVA ammoniator.

(1) This is a close-up shot showing the action of agricultural grade anhydrous ammonia on brass pipe.

(1) The next slide shows the supply and discharge end of a pre-cooler. From the pre-cooler, the ammonia flows through the meter. The turbine type is perhaps the most accurate available to date, when installed properly. However, this particular slide shows a rotary meter. A few plants use a magnetic meter. However, in order for this type meter to operate properly, a slight amount of impurities of a conductive nature is required in the product. Some companies introduce a small amount of tap water to accomplish this. By tap water, I mean any type water that does have a small amount of mineral content.

(1) The next slide is that of the mixing "T" where the nitrogen solution and anhydrous are introduced. The flow is in the direction of the finger. The ammonia is introduced from the back and the solution through the top pipe. The inner jacket is composed of a perforated pipe which runs approximately half the length of the "T."

(1) This is a shot showing piping arrangement entering the ammoniator. This particular plant introduced sulfuric acid, solution and ammonia, or solution ammonia and water through the same line with a separate line for steam. End result in this particular plant was a reduction in re-cycle since the ammoniator was run hotter, resulting in a firmer granule with better screening characteristics and a more uniform particle size.

(1) Sorry, Slides were not available.

MODERATOR SAUCHELLI: Thank you Ben. When you consider the difficulties that a pinchhitter has you are to be congratulated on a very fine presentation.

Do you have any questions to fire at Ben?

MR. ED SABIN: Mr. Day you touched upon cryogenic storage of ammonia. Of course my Association is concerned with this. I wonder if your Institute has taken a position or published safety precautions in connection with this storage.

MR. DAY: I think your question could be answered by a study of the Standards which we publish and which have been accepted in many states, either verbatim or using our Standards as a basis for state laws and regulations. We have an Operator's Manual, Safety Manual and our Standards. This work is done in conjunction with the industry. Does that answer your question?

MR. SABIN: Yes. Thank you.

MR. STRELZOFF: Do you believe when you are wearing the goggles and rubber gloves and you are surrounded by ammonia gas that you are well protected?

MR. DAY: It has been my experience in this instance that anhydrous ammonia is described as having a pungent odor, and as a result of this odor, no one will voluntarily stay within its limits for any prolonged period of time.

MR. STRELZOFF: I believe that, because I have had that kind of experience. And you run right away, it really attacks a certain part of the body, and you just can't stand it.

MR. DAY: I would add that this list of safety equipment which we recommend is a minimum list.

You notice that in the list there is no such thing as a shortsnorter or the Scott Respirator or anything of this nature.

The plant which I was employed in did have the shortsnorter arrangement. However, fortunately, we never used it.

We are in the process at this time of publishing a booklet called Facts for Firemen. We have found throughout the United States that many volunteer fire departments are requesting information on what to do in the event of an ammonia leak. We are getting the information to them just as fast as we can.

MODERATOR SAUCHELLI: The next paper, The Turbine Metering and Anhydrous Ammonia, was to be given by Tom Magliozzi of the Foxboro Company. Mr. Magliozzi has been transferred. In his place we have a paper prepared by David Snyder, Manager of the Foxboro Flow Group and co-authored by Frank Engstrom who is Manager of the Industry Group. Mr. Snyder will give the paper.

The Turbine Meter And Anhydrous Ammonia

D. N. Snyder and F. G. Engstrom

MUCH of today's flow measurement technology has been directly applied to turbine meter design and its application on anhydrous ammonia. Design and performance developments speak for themselves. But, work does not cease for the turbine meter manufacturer. New design concepts are being developed, with specific emphasis on longer bearing life and wider range of applications.

To date, Foxboro has installed more than 25 turbine meters in anhydrous ammonia service. For the most part, operation of these meters has been excellent. Some have been in service for over two years.

Meter Operation and Calibration

Two very significant factors justify the use of turbine flow meters. One is accuracy, stated as a percent of actual flow rate and the other is its wide usable flow range.

The turbine flow meter measures volume flow. Its output is digital pulses, each pulse representing a finite flow volume. A term "K" is used to denote the number of pulses generated for each volume unit passed through the turbine meter. The linearity of this K factor with flow rate determines the performance of the meter.

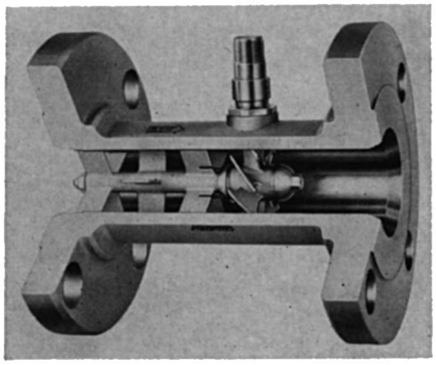


Figure 1

As shown in Figure 1, a magnetic pickup coil detects the rotational speed of the meter rotor and transmits it as a pulse stream. Each time a rotor tip cuts the magnetic field of the permanent magnet, a voltage pulse is generated in the coil windings.

Each flow meter is calibrated in a precision flow stand. The calibration data relates the pulse output to actual flow. As with any measurement instrument, the required operating range determines the accuracy of performance. The universal fluid, water, is used for calibration, although other fluids can be used if the need arises. The calibration data, when displayed in curve form, has a characteristic shape as shown in Figure 2. A logarithmic scale is used for the flow coordinate to expand the critical low flow region.

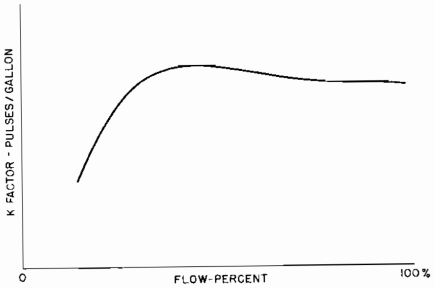


Figure 2

In order to be more useful, a mean K value is selected for each turbine meter based on the required accuracy and meter rangeability (Figure 3). A 1 percent band represents ±½ percent accuracy on the calibration curve shown in Figure 4.

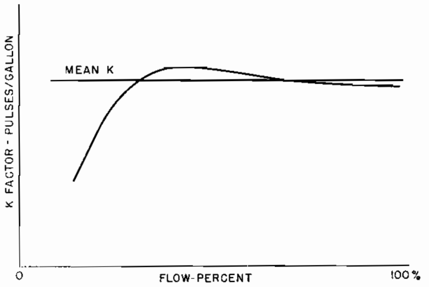


Figure 3

Point A to Point B designates the flow range over which the calibration curve stays within the 1 percent band. Thus over the A to B flow range, the true K factor does not deviate from the selected K factor by greater than ½ percent. The range A to B is thus considered the linear flow range of the meter.

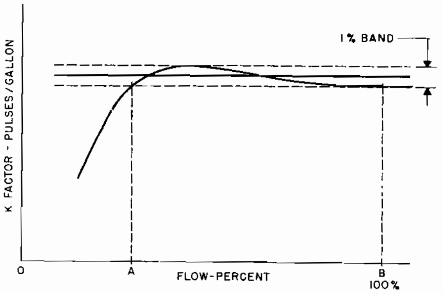


Figure 4

Many times, the accuracy of a meter is confused with its linearity. When the turbine flow meter is used over its entire linear range, linearity and accuracy become synonymous terms. For narrower flow ranges within the linear range, accuracy can be better than linearity.

Any difference between the true K and selected K at any flow rate is an error in the number of pulses that represent a volume unit of flow. Error is expressed in pulses per volume unit. For decreasing volume flow rate, pulse frequency decreases, but the error is always the same percentage of flow rate or reading (Figure 5). Analog error, conversely, is constant in absolute value. Therefore its value, as a percent of flow reading, increases greatly at low flows. Such error is expressed as a percent of instrument scale or span. This accounts for the rangeability limit of analog systems, where high accuracy measurement is required.

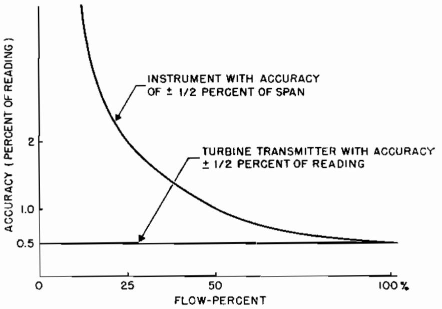


Figure 5

Turbine Meter Construction

The turbine meter consists of a housing, straightening vanes, shaft, rotor and bearings as shown in Figure 6.

The segmented straightening vane section provides optimum

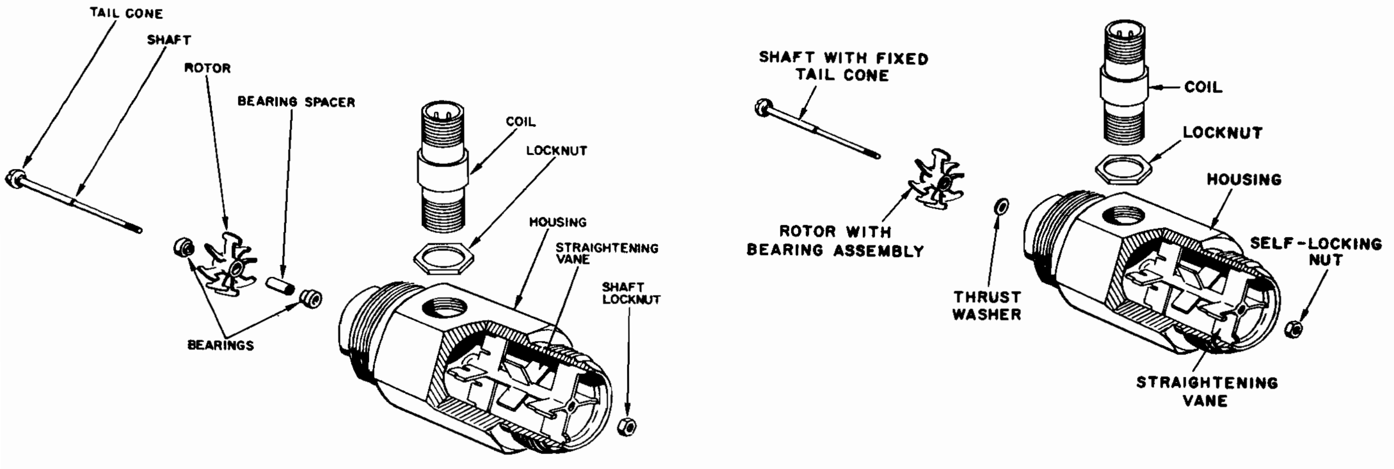


Figure 6

flow straightening in a short distance with minimum pressure drop. The vanes are fixed in the housing and used to support the turbine shaft. Concentricity and alignment are thus assured.

Two styles of bearings are available. The ball bearing flow meter (Figure 6—left) is most widely used because of its exceptionally wide flow range capability. The sleeve bearing meter was designed to minimize the effects of abrasive solids and nonlubricating fluids (Figure 6—right). In the viscous sleeve design, the rotor and bearing are hydrodynamically floated to balance radial and axial loads. The natural fluid motior through the open bearing design tends to clean the bearing and keep particles from being trapped. This meter should yield significantly longer useful bearing life under more difficult fluid conditions.

The meter also allows easy disassembly for cleaning and quick bearing change. Periodic cleaning or replacement of bearings on a regular schedule can help guarantee good performance when difficult fluids are being metered.

Factors In Meter Application

Any in-line rotating device with bearings is subject to friction, especially when the bearings are constantly exposed to a nonlubricating process fluid. The Foxboro design provides operation with minimum friction for wide rangeability, high accuracy and long life. The bearings provided represent the best and latest in bearing technology and manufacturing techniques.

Effective use of the turbine meter, however, requires the attention of both the user and the supplier. The user must be cognizant of all the factors which can diminish useful bearing life: overspeeding, the presence of abrasive solids in the process stream, shock and vibration, corrosive impurities and infrequent and poor maintenance.

To remove abrasive solids from the process fluid suitable strainers should be mounted upstream of the turbine flow meter. If the meter is installed close to partially throttled valves or centrifugal pumps, additional straightening vanes may be necessary for best measurement accuracy. These vanes minimize noise, which can also contribute to bearing wear.

Associated Electronic Equipment

A full line of digital electronics is available to complement the turbine flow meter. Accuracy of these instruments is unique, in that each digital electronic instrument introduces no additional error to the measurement. In any given time period, the instruments operate to within ± one count. At the high pulse rates typically generated by the turbine flow meter, one count is insignificant in terms of actual fluid. By comparison, every analog instrument in a measurement system introduces its own analog error, expressed as a percent of full scale. Therefore, the initial measurement is further degraded.

Digital instrumentation performs such tasks as scaling the turbine pulses to engineering units, indicating flow rate, flow totalizing and batching, digital control and, if necessary, conversion to the commonly used analog signals.

These functions are performed by individual instruments or instruments which are in combined packages. Among the many features available with digital electronics is density compensation. The volumetric flow measurement is corrected for density changes to allow totalization in pounds rather than gallons. The compensation system employs a temperature technique which has been used successfully by the petroleum industry for several years. It has proved equally successful on anhydrous ammonia with some modification of the system's time cycle.

The Turbine Meter for Anhydrous Ammonia

It was only a matter of time before anhydrous ammonia became another application for the turbine meter. The need for accuracy and rangeability led the way.

Through actual operating experience, much has been learned about the application concerning corrosion, abrasive solids, flashing across the meter and buildup of oil residues.

In metering pure anhydrous ammonia, corrosion has not been a serious problem. Stainless steel ball bearings and retainers (440C), Armco 17-4 rotors and 300 Series stainless for other parts have been successful in ammonia service.

The abrasive problem is best solved by removing the abrasive particles from the process line with suitable strainers. While the installation of the strainer rests with the user, the meter supplier can rec-

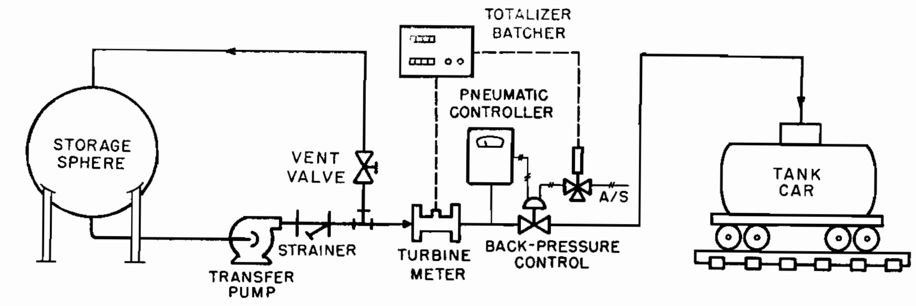


Figure 7

ommend size and mesh requirements. Abrasive solids must be given even more attention when the process fluid is considered nonlubricating, as is anhydrous ammonia. On initial start-up, it is imperative that process lines be washed of solid materials and purged of gases before the meter is placed in service. This precaution alone can help prevent premature bearing failure.

Flashing of ammonia across the turbine meter can cause severe overspeed of the rotor and greatly increased loads on the bearings. The result is accelerated wear which can damage the bearing races and possibly disintegrate the bearings. The meter system must therefore minimize the possibility of vaporization or flashing (Figure 7).

To prevent flashing, sufficient pressure head should be designed into the system. This is usually done by elevating the tanks, by pumping the ammonia and by providing back-pressure control. A good rule of thumb is that system design should provide at least 10 psi at the meter above the maximum vapor pressure expected in the flowing stream.

In one installation, head is maintained through use of a float switch in a liquid-vapor separator (Figure 8). The separator is a section of vertical pipe. However, a tank would have served the same purpose. This system maintains a positive liquid head on the meter at all times. Another technique subcools the anhydrous ammonia at or near the turbine meter by flashing ammonia through a jacket surrounding the process line.

No one seems absolutely certain as to the origin of the oily residue found in anhydrous ammonia lines. This residue can produce interesting results in a turbine flow meter. When sufficiently soft and fluid, the residue provides excellent lubrication to the meter bearings. At the lower temperatures sometimes encountered in anhydrous ammonia lines, the residue becomes very heavy and tacky, causing severe drag or even stoppage of the rotor. Consequently, the residue can be either a benefit or a detriment to meter operation. Flushing the meter with a solvent has successfully corrected this situation without requiring removal of the turbine meter from the line.

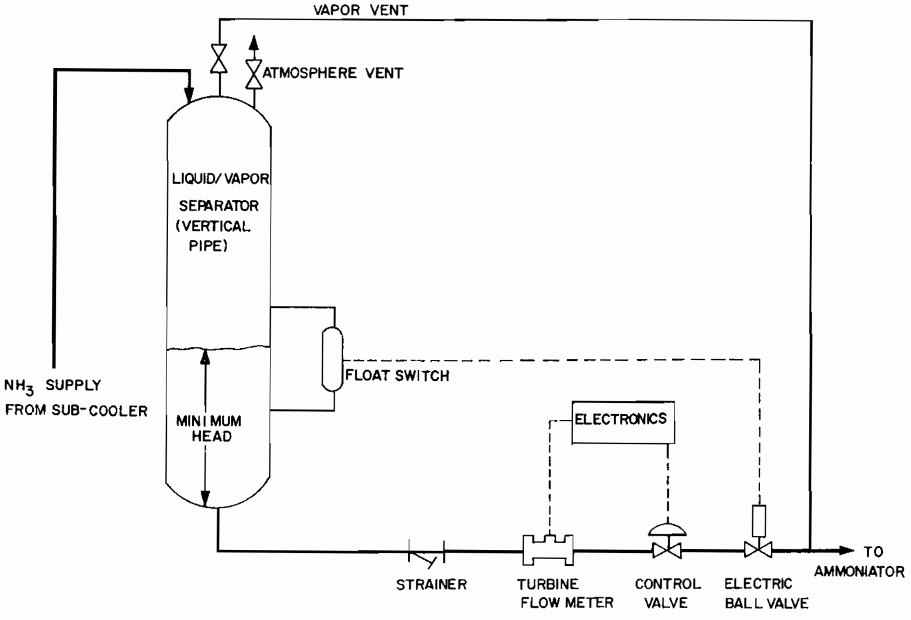


Figure 8

Start-up procedure is of particular importance with turbine flow meters. The idle system must always be purged of vaporized ammonia before start-up. This can be done by providing a vent back to the storage vessel. The vent connection should be located so that no vapors are pulled through the turbine meter during the purging operation. Another successful system uses a bypass around the turbine meter and a visual sight glass or rotameter to tell when the line is purged.

Conclusions

How have turbine meters performed in anhydrous ammonia service? The operation of these meters, in the majority, has been extremely satisfactory. Figure 9 shows a typical installation. Better strainers, pressure control, and line cleaning have solved most field problems.

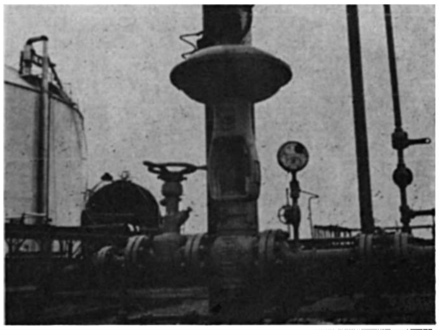


Figure 9

Studies have shown that the turbine meter not only provides excellent accuracy and rangeability but that it compares very favorably with other meters for anhydrous ammonia service. Table I shows a detailed comparison.

The turbine meter has proved its usefulness as a tool for measuring the flow of anhydrous ammonia. With proper system design and maintenance, the user can be assured of accuracy and dependable service.

Table 1.

Meter Comparison

Type of Meter	Transmitter Accuracy	Range-ability	Recommended Installation	Output	Approx. Cost Transmitter*	Approx. System Cost Incl. Remote Reset Totalizer*	Remarks
Variable Head (Differential Pressure)	±½% of Span or better	4:1	Any Position: primary device can require straight run 30 pipe diameters upstream, 10 downstream.	Pneumatic or Electronic	$290.00 (Stainless Steel)	$1100.00	Easy to calibrate and maintain.
Variable Area	±2% of full scale	10:1	Vertical only.	Local indicator. Available with 3-15 PSI output.	(2-inch size, stainless steel)	$1100.00	Price is for all metal unit. Glass type is subject to breakage.
Positive Displacement	±½% of flow rate	10:1	Horizontal only	Local counter or indicator. Pulse output available.	$1570.00 (2-inch size, stainless steel)	$1700.00	Strainer recommended upstream.
Weigh Scale	±½% of setting	5:1	Area free from vibration and wind effects.	Contact closure for shutoff	$4000 and up, complete. (Depends on tank size)	$4000.00 and up	Installation costs can be extremely high.
Magnetic Flow Meter	±1% of full scale or better	10:1	Any position: unaffected by disturbances up- or downstream.	Millivolts: converters available for pneumatic, electronic, or pulse output.	$875.00 (2-inch size, stainless steel, Teflon-lined)	$2000.00	Ammonia conductance too low to meter successfully.
Turbine Flow Transmitter	±¼% of K-factor curve or better	33:1	Horizontal best: recommended 10 meter diameters straight run up-stream and 5 downstream.	Pulse: converters available for recorder output.	$645.00 (2-inch size, stainless steel)	$1400.00	Fluid must be clean and of low viscosity.

MODERATOR SAUCHELLI: Thank you David. I am sure some of you must have questions you wish to ask Mr. Snyder.

MR. MACARTHUR: Can you tell us the order of magnitude where .8 is with relation to zero. Let's say zero to ten gallons per minute meter.

MR. SNYDER: The ¾″ turbine meter has a linear range of 1.0 to 15 gpm for ±½% accuracy and an operating range of 0.5 to 15 gpm. To include 0.8 gpm within the linear range would require that the accuracy band around the K curve be expanded slightly. A meter specifically calibrated for 1 to 10 gpm would include 0.8 gpm within its linear band.

A MEMBER: I would like to ask regarding overspeed. Is overspeed a common cause of meter failure? And how do you guard against it?

MR. SNYDER: The turbine meter that I am discussing today is designed for liquid flow, and therefore, when a high velocity gas passes through the meter it is going to overspeed with consequent overheating. Even at the same relative fluid velocity, the rotor in a gas stream will tend to run faster due to reduced drag on the rotor blades. And there is almost nothing that we can do to prevent the bearing from overheating when a gas is passing through it. Compounding the heating problem is the fact that gases do not dissipate heat as well as liquids. It is the combination of overheating and speed that causes the bearing to fail.
Therefore it comes back to the system control o fmaintaining positive pressure, back pressure, on the system, or pumping the fluid to a sufficient pressure to prevent flashing. It is thos overspeed due to flashing that causes the bearings to fail.

MEMBER: Is it necessary to pump the ammonia to maintain this pressure?

MR. SNYDER: Not necessarily. The individual installation would probably determine what steps are required too maintain pressure If sufficient head is available a back pressure valve would be adequate.

MEMBER: Suppose you are pumping from a tank that goes empty, so that you have no more liquid.

MEMBER: Is a turbine meter available in a size capable of metering quantities as low as 100 pounds an hour, of ammonia?

MR. SNYDER: We convert that to GPM.

MR. FRANK ENGSTROM: In the case where the tank ran dry, I doubt very much if your pump would pump the vapor anyway, so you would immediately lose flow.

That would be your built-in protection there.

MEMBER: Is a turbine meter available in a size sufficiently small to meter 100 pounds an hour, of liquid ammonia?

MODERATOR SAUCHELLI: Do you want to answer it, Frank?

MR. ENGSTROM: No. I think you're just about at the lower limit. They are made down to a one-half inch body with a three eight inch throoat. This turbine meter will measure down to about 0.23 gallons per minute.

MEMBER: Thank you for the conversion.

MR. BILL GAINES: I would like to find out if they do have turbine meters of a size big enough to handle barge loadings, let's say, 4500-5,000-ton anhydrous ammonia barges.

MR. ENGSTROM: I don't know the exact figures here. But we make them up to a 12-inch size. In the oil industry, they measure flows of 200,000 to 300,000 barrels a day through one meter. Is that sufficient for you?

MEMBER: I think that is.

MR. SNYDER: You're talking of the 12-inch size?

MR. ENGSTROM: Yes.

MR. SNYDER: Which is rated 12,500 barrels per hour or 300,000 barrels per day.

MR. BILL MULLINS: How long does it take to change the bearing in your turbine meter on a half-inch size?

MR. ENGSTROM: I would say it wouldn't take more than 10-15 minutes. The primary time involved there would be removing it from the line, depending on what type of connection you had in there, either the AN or a flange-type fitting. The changing of the bearings is very simple. It just takes a small hand tool, screwdriver or wrench.

MR. JIM REEVES: This may sound like a stupid question, however we've been having a lot of debate on it. You keep talking about overspeeding from flashing across your meter. Say you have pretty well purged your lines and have liquid moving in the lines and you happen to have a few gas pockets or a few vapors in there moving at the same speed as the liquid, do you get any bad effects on your meter?

MR. ENGSTROM: I'd say no to that question. When we're talking of overspeeding I think we are referring more to continuous operation than we are just an intermittent operation. It takes some time for the bearing to start developing heat, and heat is what ruins the bearing.

MR. REEVES: That brings up one more point. If you are using a pump, a liquid pump, and say you have no bypass on your line and you turn your pump on and bring your entire line up to pressure, you probably leave some vapor pockets in there, but if you start metering it and are not getting any flashing, you, in turn, should not be damaging your rotor. Right?

MR. ENGSTROM: I wouldn't think so not for example if your line isn t completely full of vapor. For example you have a couple of hundred feet of line and you pushed vapor all the way from the pump through that 200 feet of line through the meter, you might develop heat then to start wearing out the bearing. A properly designed venting system would elimiate vapor problems at startup.

MR. REEVES: Thank you.

MR. LARRY SAMUELS: I had some experience with a previous employer where we can eliminate this vapor getting into the turbine meter. When the tank goes empty, it's no problem. It all revolves around an ammoniator control room where we have a tank that holds about 30 gallons of liquid anhydrous. If you get any flashing, it goes to the top of the tank and the liquid stays in the bottom of the tank. We meter out the bottom of the tank. There is a selenoid valve in the line ahead of the turbine meter.

The selenoid valve is controlled by a magnetron flow switch that is installed in a separation tank. Any time you get vapor, or if you have less than two feet of vapor in this tank, you slam the selenoid control valve and – no ammonia. Theoretically this only happens when a tankcar goes empty. The operator hooks up another tankcar or switches to a storage tank.

We have five installed. One over two years. We've never replaced the bearings. We don't know of any problems with it.

MR. SNYDER: Thank you very much.

I hadn't heard of that particular application to prevent this flashing problem. However, I can see that where you are unloading tankcars or some other type of vessels where you would get intermittent operation this would certainlp be a worthwhile system.

J. D. C. HEMSLEY: Another silly question. Can you tell me what happens when the ammonia goes backwards?

MR. SNYDER: The rotor, being a free-wheeling rotor, will reflect the passage of the fluid in either direction. The problem with digital electronics is that the pulse does not indicate direction. So if you get reverse flow, you will get an output, but you will not know that it is reverse flow unless you have some other means in the line of detecting flow direction.

MR. ENGSTROM: I would suggest a check valve.

MODERATOR SAUCHELLI: Thank you very much.

Before we proceed with the program, we will take a one-minute stretch. Please don't leave the room.

We have just two papers more on the program, so we will get started with them.

At practically every meeting of the Round Table we have been privileged to have as participants at least one or two members from the Tennessee Valley Authority

Organization. It is always a privilege to have a representative from that organization. It has done so much for our industry in the way of research. We are all indebted to some of the fine research work published and communicated by the different members of the Tennessee Valley Authority Research Center.

The next speaker is known to most every one here. He has been on our program bfore. He always gives an interesting paper, and I'm sure today's presentation will be up to standard.

It gives me great pleasure to introduce Frank Achorn who is going to tell us about latest developments in granulation equipment.

1966 Survey Of Continuous Ammoniator-Granulator

Frank P. Achorn and J. S. Lewis, Jr.

Introduction

At the annual meeting of the Fertilizer Industry Round Table in 1961, A. B. Phillips presented and discussed the results of a survey concerning the TVA continuous ammoniator-granulator. Last fall it was decided that TVA should make another survey to determine the changes that have occurred in ammoniator-granulator practices in the past five years. Questionnaires were sent to 142 companies that were licensed by TVA to use the continuous ammoniator-granulator. We have received replies from 57 companies concerning 122 ammoniator-granulators. I hope that those of you who operate continuous ammoniator-granulators will be interested in seeing where your operation fits into the overall picture.

One major trend that has occurred is that the size of the ammoniator-granulator has increased. Also, in 1961, the ammoniator-granulators were primarily used for the ammoniation of superphosphate base grades and now a significant number of them are being used for granulation of ammonium phosphates, ammonium phosphate nitrates, and granular superphosphates. Of the ammoniator-granulators included in the report, 46 percent were used to produce ammoniated superposphate grades, 26 percent were used to produce ammonium phosphate grades, and 28 percent were used to produce both.

Table 1 shows the ten most frequently mentioned grades and five most frequently mentioned ratios which were reported for those plants that ammoniate superphosphate. The 1966 survey is compared with the 1961 survey. These results indicate that plants which ammoniated superphosphate produce about the same grades and ratios now as they did in 1961. The average plant food concentration in all grades reported remained at about 34 units; however, there was some tendency to drop some low analysis grades, such as 6-20-0 and 3-12-12.

Table 1. Ten Leading Grades and Five Leading Ratios For Those Plants That Ammoniate Superphosphate

Grades	Order of Popularity 1966	1961
5-20-20	(1)	(1)
5-10-10	(2)	(6)
16-20-0	(3)	—[a]
6-12-12	(4)	—[a]
3-9-9	(5)	—[a]
12-12-12	(6)	(2)
10-10-10	(7)	(3)
5-10-15	(8)	—[a]
4-12-12	(9)	—[a]
6-24-24	(10)	(5)
Average plant food concentration, units of plant food	34	35
Ratio		
1:2:2	(1)	(3)
1:4:4	(2)	(1)
1:1:1	(3)	(2)
1:3:3	(4)	—[b]
4:5:0	(5)	—[b]

[a] Not one of the 10 leading grades.
[b] Not one of the 5 leading grades.

The ten most frequently mentioned ammonium phosphate grades and five most frequently mentioned ratios are shown in Table 2. These data show that, as would be expected, the plants which produce ammonium phosphate grades usually produce higher analysis grades. The average plant food concentration for the ammonium phosphate grades which were reported was 50 units of plant food — about 47 percent higher than the plant food concentration of the ammoniated superphosphate grades. As can be seen in the table, the five ammonium phosphate grades, in the order most frequently reported, were 6-24-24, 8-32-16, 10-20-20, 8-24-24, and 18-46-0. This is not to imply that the tonnage movement of these grades was in this order. Other data indicate that over 50 percent of the ammonium phosphate produced in this country was produced as the 18-46-0 grade. The survey simply shows that of those reporting using the ammoniator-granulator to produce ammonium phosphate, more of them reported that they produced the 6-24-24 grade than any other.

Table 2. Ten Leading Grades and Five Leading Ratios for Those Plants That Produce Ammonium Phosphate Grades

Grades:	(1)	6-24-24
	(2)	8-32-16
	(3)	10-20-20
	(4)	8-24-24
	(5)	18-46-0
	(6)	5-20-20
	(7)	16-20-0
	(8)	7-28-14
	(9)	8-22-11
	(10)	6-28-10
Average plant food concentration, units of plant food		50
Ratios:	(1)	1:4:4
	(2)	1:4:2
	(3)	1:2:2
	(4)	1:3:3
	(5)	9:23:0 (18-46-0)

Ammoniator Detail

There was quite a variety of sizes reported ranging from 4.5 ft. to 12 ft. in diameter and 6 ft. to 25 ft. in length. The maximum sizes reported are considerably larger than the maximum sizes reported in 1961, when the maximum diameter reported was 8 feet and the maximum length was 16

Table 3. Size of Ammoniators

Diameter x Length, Ft.	% of Those Reported
8 x 16	18
7 x 14	13
7 x 12	12
7 x 10	9
6 x 12	7
6 x 10	5
10 x 20	5
7 x 16	4
8 x 14	3
7 x 15	3

feet. Table 3 shows the ten most frequently mentioned sizes. They were 8 ft. x 16 ft., 7 ft. x 14 ft., 7 ft. x 12 ft., 7 ft. x 10 ft., 6 ft. x 12 ft., 6 ft. x 10 ft., 7 ft. x 16 ft., etc. They account for about 80 percent of all those reported. The most popular sizes were the 8 ft. x 16 ft. and 7 ft. x 14 ft. ammoniator-granulators. However, the survey shows that in the new installations the 10 ft. x 20 ft. ammoniator-granulators are showing some prominence.

Figure 1 shows two bar graphs. The one on the left gives the distribution of diameters and the one on the right, length-to-diameter ratios. As you see, the 7-foot diameter and a length-to-diameter ratio of 2:1 is the most popular.

The reported speed of the ammoniator-granulators varied from 6 to 16 rpm; however, the average was about 28 percent of critical speed. The critical speed is that at which material in the ammoniator-granulator would be carried around the drum by centrifugal force. It is calculated by dividing 76.5 by the square root of the diameter of the drum in feet.

Most ammoniator-granulators contain retaining rings equal in height to 6 to 30 percent of the diameter. Usually, as the diameter of the ammoniator-granulator is increased, the height of the retaining ring represents less of the total diameter. Therefore, it is not unusual to find 10 ft. x 20 ft. ammoniator-granulators which have 20-inch retaining rings and to also have a 6 ft. x 6 ft. ammoniator-granulator with the same size retaining ring.

Table 4 shows a tabulation of the types of shell cleaners reported. These data indicate that stationary scrapers and knockers, the two ma-

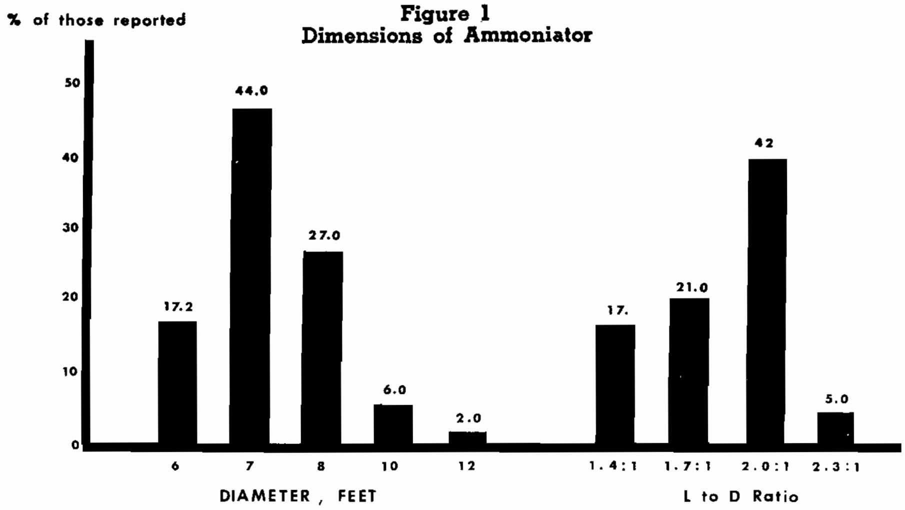


Figure 1
Dimensions of Ammoniator

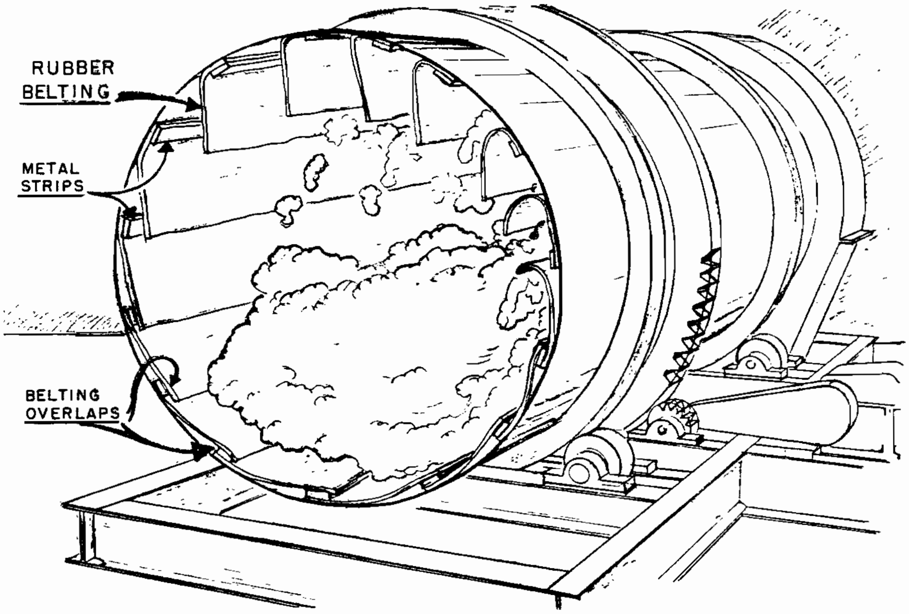


Figure 2
Ammoniator Granulator Lined With Rubber Belting

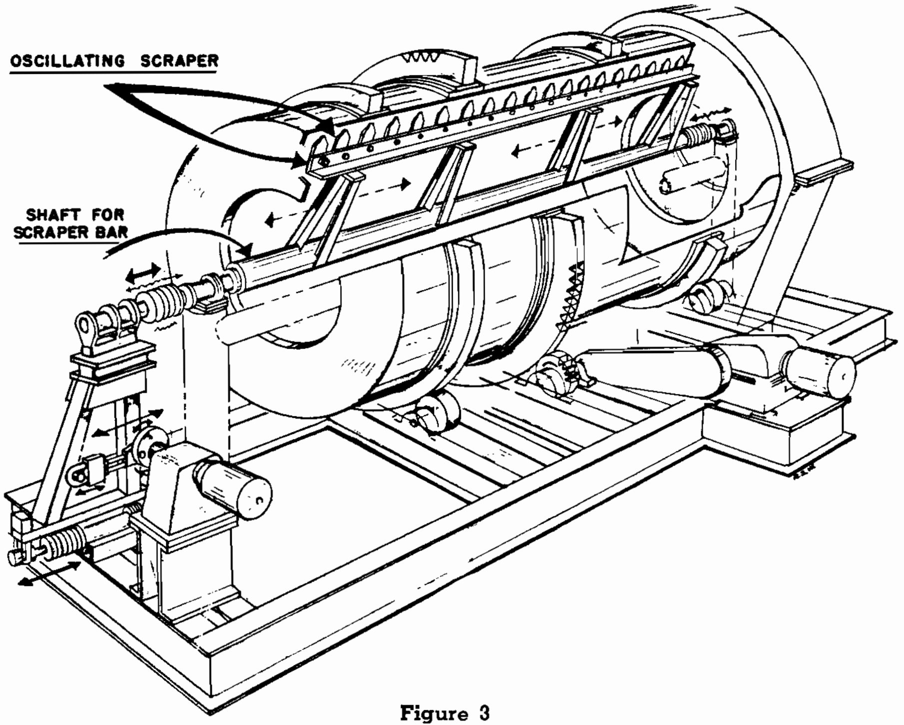


Figure 3
Ammoninator Granulator With Oscillating Scrapper

Table 4. Shell Cleaners

Type of Cleaner	% of Those Reported
Stationary scrapers	24
Knockers	22
Rubber flaps	13
Knockers and stationary scrapers	11
Moving scrapers	10
Manual	8
Rubber liners	2
Two flexible panels	1

jor types of shell cleaners used in 1961, are still the most popular cleaners. However, many new innovations have been introduced in shell cleaners. Typical examples of two of these innovations are shown in the next two figures. The use of rubber flaps, such as those shown in Figure 2, has become significant. The use of the oscillating scraper, Figure 3, has gained some prominence. Lately, some operators have reported considerable success using rubber liners. Contrary to the usual prediction concerning these liners, they do have a life longer than one year, and they do not tear easily.

The survey showed that the majority of operators used simple drilled pipe type spargers. A few use the block type sparger, and some use the slotted lip type that was the original TVA design.

Table 5. Materials of Construction of Acid and Ammonia Spargers

Metal	% of Those Reported	
	Acid	Ammonia
Hastelloy C	57	11
Black iron or mild steel	25	44
Stainless steel	18	45

Table 5 shows the materials used in construction of acid and ammonia spargers. The survey revealed that about 60 percent of those reporting are using Hastelloy C for the acid sparger. This is quite a change from the 39 percent reported in 1961. Those who reported they use Hastelloy C indicate that the longer sparger life they receive is well worth the additional cost. The survey also shows that most of those reporting use stainless steel or Hastelloy for ammonia spargers, whereas in the former survey, most were using carbon steel ammonia spargers, and only a few were using the higher priced metals.

Most of the ammoniator-granulators that revolve in a counter clockwise direction have the spargers located at the four o'clock position. Those that rotate in a clockwise direction usually have the spargers located at the eight o'clock position. The sulfuric acid sparger is usually located above and slightly to the side of the ammonia sparger. The usual practice is to bury the sparger about three-fourths of the bed depth. Phosphoric acid is usually added on top of the bed through a drilled pipe sparger.

Various size electric motors are used to drive the ammoniator-granulator depending on the size of the ammoniator-granulator. Usually the smaller sizes, such as the 7-ft. by 14-ft. are driven by a 30-50 h.p. motor, whereas the larger 10-ft. by 20-ft. ammoniator-granulators are driven by a 125-h.p. motor. Most of the ammoniator-granulators are driven by a pinion gear which drives a bull gear that is mounted on the ammoniator-granulator itself. The pinion is usually attached directly to the shaft from the speed reducer. Recently, many fabricators of ammoniator-granulators have used chain sprockets on both the pinion and shaft from the speed reducer. Therefore, the pinion is driven through a chain drive, and it is easy to align the drive. Also, in reversing the ammoniator-granulator for cleaning, less shock is transmitted to the drive gears because of slack in the chain drive. Many of the smaller ammoniator-granulators have a chain sprocket around the shell, and a direct chain drive from the speed reducer is used to revolve the ammoniator-granulator.

The survey showed that about 50 percent of those reporting do not have separate granulation sections in their ammoniator-granulators. Of those that do have granulating sections, about 55 percent have sections that are less than 5 feet in length. The smallest granulating section reported was 2 feet. It is interesting to note that only two companies now report that they use separate granulators. As you are probably aware, in the early days of granulation, it was felt that a separate ammoniator and granulator driven independently of each other were required.

The need to slope the ammoniator-granulator has often been questioned. The survey shows the maximum slope reported was 1.5 inches per foot and about 15 percent of those reporting indicate there is no slope to their ammoniator-granulators. Those who have level ammoniator-granulators indicated they operate smoothly, and the spargers are well covered throughout the length of the sparger.

Other Plant Equipment

Many of the plants which were used exclusively to produce ammoniated superphosphate grades when the previous survey was made have now been converted to permit the production of ammonium phosphate grades by the installation of a preneutralizer and an ammoniator-granulator scrubber to their existing granulation facilities. Also, all new plants which use the ammoniator-granulator to produce ammonium phosphate grades include a preneutralizer and a scrubber. To determine the trend toward the production of ammonium phosphate grades in the ammoniator-granulator, our questionnaire asked if a preneutralizer was used in the plant. More than 25 percent of those reporting had preneutralizers. Several of the companies indicated they were using the preneutralizer in the production of ammonium sulfate and X-O-X grades. As you are probably aware, TVA now uses the preneutralizer and ammoniator-granulator in the demonstration scale plant for the production of nitric phosphates.

The average capacity of plants which use ammoniator-granulators has increased extensively in the past few years since the ammoniator-granulator has been widely adopted as the best equipment for the production of diammonium phosphate. The survey shows that some diammonium phosphate plants that utilize the ammoniator-granulator have a capacity in excess of 1,000 tons per day. One company reported they have total throughput capacity as high as 285 tons per hour. This plant has a 10 ft. by 20 ft. ammoniator-granulator. With the advent of larger throughput and the necessity for the removal of larger quantities of liquids, the dryers in the granulation plant necessarily have become larger. One plant had a dryer that measured 12 feet in diameter and 120 feet long. The largest cooler of which we have knowledge measures 12 feet by 70 feet.

Although the question of screen size used in the plants was not asked in this survey, other surveys and data obtained in plant visits indicate most companies try to screen their products so that at least 95 percent of the granules are in the 6 to 16 mesh size. Recently, there has been a definite trend to narrowing this size specification to minus 7 plus 14 mesh. One new producer of granular ammonium nitrate has set size specification at minus 8 plus 12 mesh. The information we have concerning screening area per ton of throughput indicates that the most frequent size is about one square foot per ton of throughput for both the oversize and product size screens. However, recent contacts with industry indicate that there is a trend toward increasing this size to at least 1.5 square feet per ton of throughput for the product size screen. The reason for this trend probably is the fact that the recent emphasis on narrowing the particle size distribution in the product stresses better size separation which is possible with the larger screening area.

Granulation Control

A very important consideration in the control of granulation is the ratio of liquids to solids—commonly referred to as "liquid phase"—in the ammoniator-granulator. A specific question with regard to means of controlling the liquid phase was not included in the survey. However, TVA field engineers who have visited granulation plants report the most common way of controlling liquid phase in the ammoniator-granulator is to vary the recycle rate by adding varying amounts of onsize product to the crushed oversize and fines which are recirculated to the ammoniator-granulator. The amount of product that is returned with the recycled fines is controlled in several ways. One way is to have a damper in the fines hopper of the screen. A sketch of this type of screen is shown in Figure 4. The product screen deck has several screens that have openings that are well within the product size range. Therefore, some product size material is continually passing through this screen and into the fines hopper. The damper is adjusted so that the proportion of product diverted into the fines hopper is controlled. Another method of controlling the amount of product being returned to recycle is to have a "split boot" from which a controlled amount of product is withdrawn by a gravimetric feeder. A sketch of this type of apparatus is shown in Figure 5. The product which is not withdrawn by the product feeder overflows through a chute to the recycle feeder. Of course, another popular method of controlling liquid phase in the granulator is to control the amount of liquids added by varying the production rate or by changing the formulation. Also, many times steam and/or water is added to promote granulation.

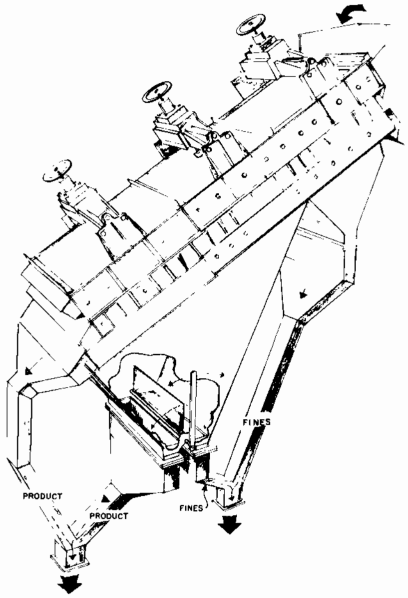


Figure 4
Screen With Damper To Control Product Delivery To Recycle

In conclusion, I would like to thank all of the plant personnel, many of whom are in this audience, for taking time to complete and return the questionnaire. Certainly the survey revealed much interesting information that would be difficult to obtain in any other manner.

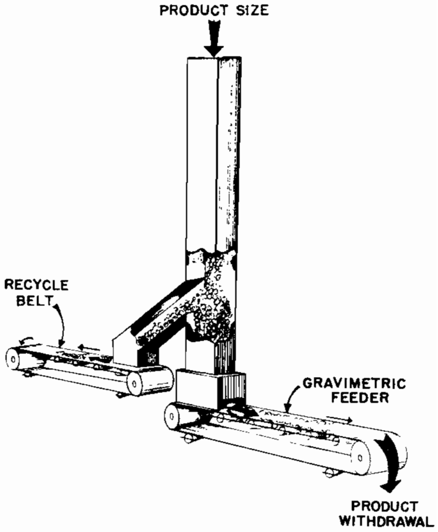


Figure 5
Split-Boot Recycle Control

MODERATOR SAUCHELLI: Thank you Frank. We have some questions.

MR. MORTENSEN: Are copies of this report available now?

MR. ACHORN: Yes I have a few left.

MR. MORTENSEN: They can be obtained from your office?

MR. ACHORN: Yes.

MR. MORTENSEN: Thank you.

MR. HEMSLEY: One interesting correlation that I would be very interested in knowing about, which is probably available from the questionnaire, is the correlation between total throughput and granulator size.

MR. ACHORN: If I understand the question, you want to know the ratio or the relationship between total throughput and the narrowness of size range.

Is that what you are looking for?

MR. HEMSLEY: The correlation between througput and the dimensions of the granulating drum.

MR. ACHORN: We have that outlined specifically in a paper that Mr. Hignett has written on granulation.

I don't have the figure now, but there is an empirical figure for throughput for unit of surface area that you can use in calculating the size of granulator that you need. I don't happen to remember the figure.

Mr. Achorn: I'll be glad to send you a copy of Mr. Hignett's paper if you will see me after this discussion.

Moderator Sauchelli: Thank you, Frank, for this very valuable information that you have collected.

The next speaker on the program was to have been Mr. Leyshon, of Dorr-Oliver, who was going to talk on the Blunger Mill for Granulation. Unfortunately Mr. Leyshon was not able to be here. On short notice he was sent out of the country. Sorry we will have to omit that part of the program.

Our speaker has earned a lot of respect and renown internationally. He has been asked to present papers and to discuss the subject of fluid fertilizers.

Archie V. Slack, Tennessee Valley Authority, has been on our program before. -He doesn't need much introduction to this group. He is known to most of you.

Again it is a privilege to have a member of TVA, and particularly Archie Slack, on our program.

Mr. Archie V. Slack: Thank you, Vince. I have always been impressed by Dr. Sauchelli and his Committee and the way they have handled this Round Table, from getting it started in the first place to bringing it where it is today. I think some of the secret of their success is in the way they arrange these programs.

Now, you might think that being last on the program today would be a disadvantage to me, but it isn't because the Committee has arranged another liquid session immediately following this one. They are going to complement each other. It is logical that I should say something about the advantage of liquids over solids, and at five o'clock you will have a practical demonstration of the advantages of liquids over solids.

Status Of Fluid Fertilizers

A. V. Slack and F. P. Achorn

Up until about 20 years ago, there was no need for names to distinguish between various physical forms of fertilizer, because the term "fertilizer" automatically conveyed the meaning "solid fertilizer," the only physical form of any significance at that time. In the years since, however, the liquid or fluid form has grown rapidly in importance; anhydrous ammonia, aqua ammonia, nitrogen solutions, and liquid mixed fertilizers were introduced and have become important fertilizer products.

In the beginning the term "liquid fertilizer" could be applied generally to the various products and became particularly associated with liquid mixed fertilizers. Today, the advent of suspensions, often thick and viscous, makes the term "fluid fertilizer" more applicable as a generic name for all nonsolid fertilizers.

Consumption

The present status of the various fluid fertilizers is approximated in Table I. The nitrogen materials, anhydrous ammonia and nitrogen solutions, lead the field. Liquid mixed fertilizer, for which only an approximation of consumption can be given, is in third place but nevertheless is significant because about a million tons per year is being produced. Altogether, fluid fertilizers supply about one-fifth of the total nutrient consumption, a major accomplishment for an industry only two decades old.

Emphasis in this paper will be mainly on liquid mixed fertilizer. Nitrogen solutions and suspensions will be covered also, but there are relatively few recent developments in manufacture and distribution of these products.

Growth in consumption of liquid mixed fertilizer has been rapid but not so fast as for nitrogen solutions and ammonia. Figure 1 shows the trend in liquid mixed fertilizers over the past few years. Whereas solutions and ammonia, for example, now supply 64% of the total straight nitrogen used, liquid mixed fertilizer supplies only about 6% of the mixed fertilizer demand.

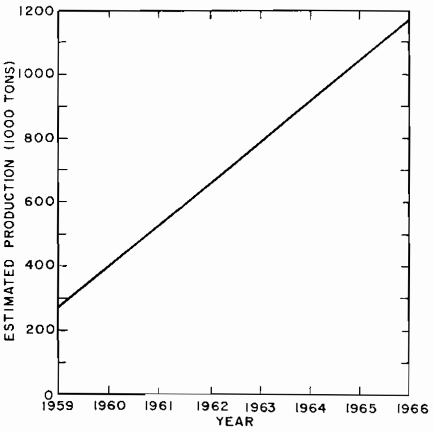


FIGURE I
APPROXIMATE ANNUAL PRODUCTION
LIQUID MIXED FERTILIZERS 1959-1966

Liquid fertilizers are used in all sections of the United States but the distribution is quite different from that of solids. For example, about half the nitrogen solution consumption is in the North Central states, but only about a

Table I. Consumption of Fluid and Solid Fertilizers in 1964-65[a]

	Tons of material (1000 tons)	Tons of nutrient (1000 tons)
Anhydrous ammonia	1,545	1,269
Aqua ammonia	720	147
Nitrogen solutions	1,884	592
Liquid mixed fertilizer	1,140[b]	297[b]
Total fluid fertilizer	5,289	2,305
Solid fertilizers	23,662	8,622
Total	28,951	10,927
Fluid fertilizer, %of total	18	21

[a] Data from U. S. Department of Agriculture (Statistical Reporting Service, Crop Reporting Board) and from various estimates.

[b] Approximate.

third of the solid mixed fertilizer is used in that area. About a fourth of the solutions and a third of the solid mixed fertilizer are consumed in the South Atlantic states, but the area uses very little anhydrous ammonia. Growth in nitrogen solution consumption has been particularly rapid in the Southeast in the past few years; percentage increase since 1961 is 145% for the South Atlantic and 230% for the East South Central states as compared with 100% for solutions over the entire United States.

Good data are not available on regional consumption of liquid mixed fertilizers and suspensions. However, use of liquid mixes normally follows that of nitrogen solutions since the same storage, handling, and application equipment can be used. Hence it is not surprising that use of liquid mixes is now increasing fairly rapidly in the Southeast. A substantial percentage of the liquid mix total is used in the Pacific area, where the practice first began. And similar to nitrogen solutions, the North Central states are large consumers of mixes.

Liquid fertilizers are produced also in other countries, particularly England and France. There are now nine liquid mixed fertilizer plants in England, some of them producing from 6,000 to 10,000 tons of product per year. Liquid mixed fertilizer now accounts for about 2% of the total fertilizer used in the United Kingdom and a further large increase is expected next year. In view of the fact that liquid mixed fertilizer is a relatively new product in the United Kingdom, this is a rapid rate of growth.

Production

Liquid mixed fertilizers are made in two types of plants, generally known as "hot mix" and "cold mix." The hot mix is the older type, involving neutralization of phosphoric acid with ammonia and addition of supplemental materials to give the desired formula. The heat of neutralization gives a hot mix. The cold-mix type is quite similar to bulk blending. The producer stocks ammonium phosphate solution, urea-ammonium nitrate solution, and potash and mixes these as needed in a simple mixing operation. Since there is no heat of reaction, the operation is a cold-mix one.

Hot-Mix Operation: There is considerable variation in hot-mix plants—in batch versus continuous operation, furnace versus wet-process phosphoric acid, ortho versus superphosphoric acid, method of introducing raw materials into the reactor, and method of cooling to remove reaction heat. A complete discussion of all these variables will not be attempted here. Instead a typical plant, representative of the majority practice, will be described (Fig. 2). In this plant, the liquid raw materials — phosphoric acid. aqua ammonia, urea-ammonium nitrate solution, and liquid base solution (10-34-0 or 11-37-0) — are stored in tanks with capacities that usually range from 10,000 to 20,000 gallons. All these tanks are fabricated of carbon steel; however, the acid storage tank has a rubber or a plastic lining. Solid raw materials (potash and urea) are stored in the building that houses the mix tank. The mix tank is usually of the batch type, and of 5- to 20-ton capacity. It is usually fabricated of carbon steel but in some plants is made of stainless steel or has a

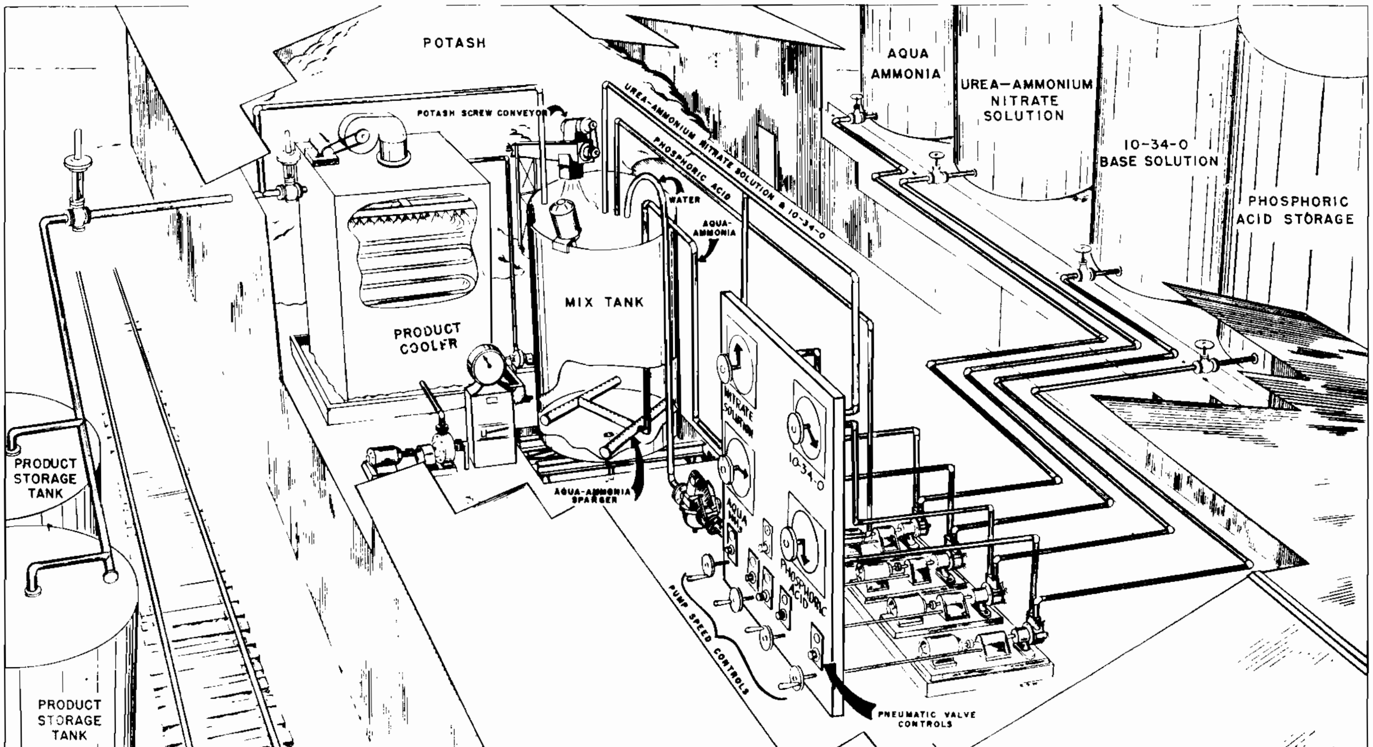


FIG. 2
LIQUID HOT MIX PLANT

plastic liner. It is usually equipped with a portable agitator and mounted on a scale; the solid raw materials are weighed in the tank.

The recirculated liquor and the raw materials, except aqua ammonia, are added onto the surface of the liquor in the mix tank. Aqua ammonia is added through perforated pipes mounted near the bottom of the tank so as to get uniform distribution across the bottom of the mix tank.

In preparing a batch of product, the liquid raw materials (aqua ammonia, phosphoric acid, nitrogen solution, and water) are metered simultaneously to the mix tank. When all of the liquids have been added, the potash is conveyed to and weighed in the mix tank. During mixing, the liquid is recirculated through a cooler to prevent excessive boiling in the mix tank. The temperature of the solution is usually kept below 180° F. After the materials are mixed, the finished product is pumped from the mix tank to storage or nurse tanks.

In the smaller hot-mix plants, standard furnace phosphoric acid (ortho type) is the usual choice. It gives little difficulty in storage and production, and the price usually is only a little above that for wet-process orthophosphoric acid. However, some producers use wet-process acid either to save money or because of better availability, and therefore must cope with the problem of voluminous precipitate formation when the acid is ammoniated. One solution is to sequester the impurities by supplying part of the posphate in the form of polyphosphate, either as superphosphoric acid or a base solution (10-34-0 or 11-27-0) which is made from superphosphoric acid. The practice does not seem to be growing.

In the past, most of the hot-mix plants were of the "community" type, small units serving a limited area. There appears to be a current trend to another type — large central plants producing ammonium phosphate base solution for use in cold mixing much as large central plants make solid diammonium phosphate for use in bulk blending. The TVA 11-37-0 demonstration plant was the first of this type, started up in 1957. Superphosphoric acid is used in order to get a high-analysis base solution, since 11-37-0 can be made with superphosphoric acid as compared with 8-24-0 the usual base solution from orthophosphoric acid.

The TVA work has all been with furnace-type superphosphoric acid, but production of wet-process superphosphoric acid has started at several points around the country during the past 2 years or so. The wet-process type generally contains less polyphosphate than the furnace type because the large increase in viscosity accompanying concentration of wet-process acid makes it difficult to concentrate to the P_2O_5 levels needed for high-polyphosphate content. The TVA furnace superphosphoric acid (79-80% P_2O_5) contains about 80% of the P_2O_5 in the polyphosphate form; wet-process superphosphoric acid (68-72% P_2O_5) normally contains about 50% as polyphosphates. For this reason, the grade of the base solution usually is reduced to 10-34-0 when wet-process acid is used.

Another recent development is construction of a plant to make superphosphoric acid from elemental phosphorus by a commercial fertilizer producer in Texas. Most of this acid will be used in making base solution at a central plant.

Cold-Mix Operation: Cold-mix plants are so simple that there are few major differences between them. Storage tanks, meters, and a simple mix tank make up the equipment list. A typical unit is shown in Figure 3. In this plant, the liquids are weighed and mixed in a batch mix tank (usually 5-ton capacity) similar to that used in the hot-mix plant. Cooling equipment, acid-storage tanks and acid-handling facilities are not required. Therefore, the investment cost for this plant is considerably less than that for the hot-mix plant. Some typical grades produced by cold-mixing are 19-19-0, 7-21-7, 4-10-10, and 3-9-9.

A further subdivision is that of a coldmix plant serving satellite stations. A typical station of this type is shown in Figure 4. In this system the cold-mix unit makes a potash solution (usually 3-9-9 and 4-10-10) in addition to the usual grades. The potash solution is shipped to the satellite station so that operation there requires metering and mixing of liquids only—11-37-0, 32-0-0, 3-9-9, and 4-10-10. Production of the 3-9-9 and 4-10-10 is mildly complicated because solid potash must be weighed in and dissolved.

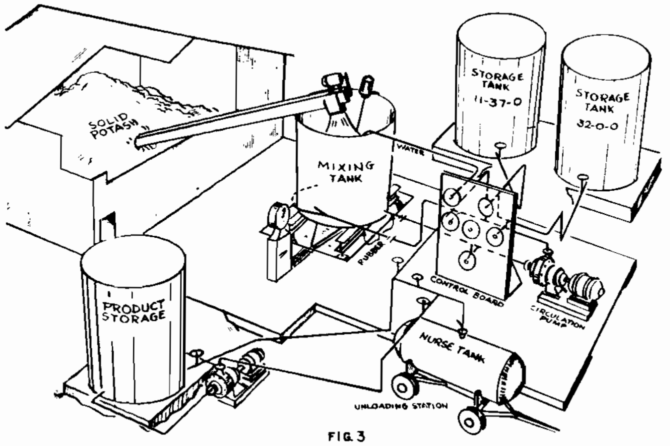


FIG. 3
LIQUID COLD-MIX PLANT

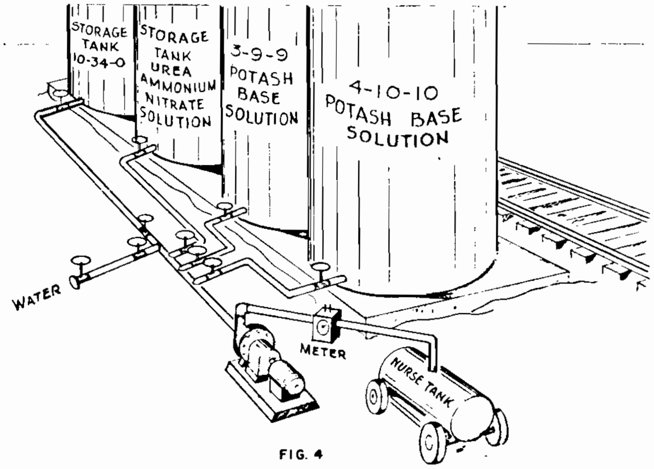


FIG. 4
LIQUID SATELLITE STATION

Since the cold-mix plant does not have neutralization facilities, a source of ammonium phosphate base solution is essential. In the Pacific Northwest, 8-24-0 from a Canadian producer has been the source for several years; in this case the 8-24-0 is made from wet-process acid by separating the precipitated impurities after neutralization. There has been some similar use of 8-24-0 (made from furnace acid) in California but in other parts of the country very little orthophosphate base solution has been used.

TVA has been a major source of ammonium polyphosphate solution (11-37-0), but with the rapid increase in wet-process superphosphoric acid production it is expected that 10-34-0 (or perhaps 11-37-0) from commercial producers will soon become the major base solution. It is estimated that superphosphoric acid (both furnace and wet acid) now accounts for about 10% of the total phosphoric acid made in this country, and in view of the several announcements of planned wet-process superphosphoric acid production, it is expected that this percentage will increase.

Solid Ammonium Polyphosphate

Instead of a base solution, a solid ammonium phosphate can be used in a cold-mix plant. This is not very popular because solids handling is more difficult and expensive than handling of liquids.

TVA recently started experimental production of solid ammonium polyphosphate (15-61-0), made by ammoniating furnace superphosphoric acid and granulating the resulting anhydrous melt in a pugmill. The product is useful both as solid fertilizer and as a base material for liquid fertilizer. For liquid fertilizer, it has the advantages of lower shipping cost as compared with 11-37-0 and of stability against hydrolysis during storage. Use in either cold- or hot-mix plants would be feasible but the latter is preferable because some ammonia must be added to get the best $N:P_2O_5$ ratio for solubility. The material can be used in cold-mix plants, even though such plants do not have ammonia spargers in the mix tanks, by using aqua ammonia to supply the relatively small amount of ammonia needed and pouring it into the tank along with the necessary amount of water or other liquids. Some companies plan to do this in making 10-34-0 for use as a base solution.

It will take a considerable testing period on solid ammonium polyphosphate to determine its ultimate status in the liquid mixed fertilizer industry. Perhaps one good use will be as a reserve of phosphate to serve as insurance against unavailability of phosphoric acid during the busy production season.

Marketing Trends

The trend in production is definitely toward cold-mix operation. It is estimated that over 60% of the liquid mixed fertilizer consumed is now marketed through cold-mix plants. The advantages are the same as those in bulk blending of solids: (1) low investment, as is needed for the limited sales area and small annual volume, (2) simple operation so that unskilled help can operate the unit, and (3) adaptability to combining with other services such as elevator operation, feed mixing, or general farm supply. However, cold-mix liquid units are much less costly than an equivalent bulk-blending plant. A cost of less than $10,000 has been reported for a standard cold-mix plant (5-10 tons/hr.); from a recent survey the average total investment appears to be about $15,000. A comparable bulk-blend unit probably would cost more than $40,000.

Cold-mix liquid plants often are installed in conjunction with solid fertilizer operations to round out the product line. In general, liquids are more suitable for row application and formulation cost is lower for high-nitrogen liquid fertilizers; conversely solids usually are preferred for broadcast application and high-phosphate grades are cheaper to formulate than for liquids. When pesticides or micronutrients are to be added, liquids have a major advantage because of ease of incorporation and absence of segregation.

The system of a regional network of cold-mix units served by a central hot-mix base solution plant appears to be spreading rapidly. Some of the companies now operating such systems are Consumers Cooperative Association, J. R. Simplot Company, Allied Chemical Corporation, Goodpasture Grain and Milling Company, and Indian Point Farm Supply Company.

Suspensions

The development of superphosphoric acid has made high-analysis liquid mixed fertilizers possible. Grades such as 11-37-0 and 19-19-0 compare well with most solid fertilizers and illustrate the advantage of having polyphosphate in the formulation; without polyphosphate the comparable grades would be 8-24-0 and 13-13-0. Unfortunately, when even a medium content of potash is required in the formulation, the polyphosphate loses most of its beneficial effect and the resulting products are relatively low in grade.

The most promising way for solving this problem is use of suspensions—solutions carrying undissolved salts in suspension. By using a suspending agent such as attapulgite clay to stabilize the suspension, grades such as 7-21-21 and 15-15-15 can be made and applied satisfactorily, as compared with 3-9-9 and 7-7-7 as clear solutions. Suspensions have the added advantage that they provide a means whereby sufficient quantities of micronutrients may be uniformly applied to the soil. It has been demonstrated that liquids such as 28-7-0-3Zn can be easily broadcasted or row applied.

The earliest suspensions were made with orthophosphoric acid in standard hot-mix plants. Although a few plants continue this practice it has various drawbacks. A more attractive system is production of a polyphosphate base suspension at a central point and use of this in cold-mix plants to make the final product.

The major activity of this type is TVA production of 12-40-0 suspension by ammoniating 79 to 80% P_2O_5 superphosphoric acid and adding about 3% attapulgite clay as the suspending agent. The product is shipped to cold-mix plants over the country where experimental N-P-K suspensions are made and used. In addition to the advantage of high concentration of the 12-40-0, the polyphosphate crystals suspended in the liquid do not grow nearly as rapidly as do orthophosphate crystals.

Suspensions have considerable promise for removing the handicap of low grade in N-P-K fluid fertilizers. However, the presence of the finely divided solids in the product introduces some differences in handling characteristics, as compared with clear liquids, that must be considered in evaluating the future of suspensions. Even though an effective suspending agent is used, there is some degree of settling during storage that makes redispersion of solids necessary before withdrawal from the tank. Secondly, although the suspending agent represses crystal growth there will be some growth during extended storage. If these problems become significant in using and applying a suspension, then the advantage of high analysis becomes more than offset by difficulty in handling and application.

Settling during storage does not appear to be an important problem, because the settling is very slow in well-prepared suspensions and the solids can be easily redispersed, preferably by circulating the suspension through the tank with a pump or by sparging air into the tank. Severity of the crystal growth problem depends on the type of crystal involved. For the 12-40-0, in which polyphosphates make up the crystal phase if the polyphosphate level is high enough, crystal growth is quite slow. For other suspensions, such as N-P-K products and the 37-0-0 described later, compounds such as potassium nitrate and urea are found in the solid phase. The rate of crystal growth is faster for these materials but is generally acceptable. Research is continuing on ways to further reduce the growth rate.

The suspension method is used not only to get higher analysis but also to get lower formulation cost. The major example of this is acidulation of phosphate rock with nitric acid followed by ammoniation to give a fairly heavy slurry. The grade is low — about 8-8-0 with no additive — but the raw material cost is also low because phosphate rock costs less than phosphoric acid. In addition, the product has good stability against settling without any addition of clay. TVA has done experimental work on the method and there has been some commercial production.

A major problem in making nitric phosphate suspensions is accomplishing ammoniation without losing citrate solubility of phosphate. In the presence of the large amount of calcium (from the rock) in solution, it is quite difficult to avoid formation of basic calcium phosphates (such as apatite) that are relatively insoluble. There are three approaches that can be taken in solving this problem.

1. Ammoniate only partially. When the pH was left at about 1.0 in the TVA tests, solubility was good — but the grade was low (8-8-0) and the product corrosive. Saving in raw material cost over a phosphoric acid-based suspension was $17 to $42 per ton of nutrients (depending on the cost of nitric acid).
2. Add a little sulfuric or phosphoric acid to the formulation. By applying 20% of the total P_2O_5 as phosphoric acid (ortho), good alkaline citrate solubility was obtained, the pH increased to 3.0, and the grade increased to about 11-11-0. However, some of the cost advantage is lost.
3. Addition of polyphosphate. By supplying 24% of the P_2O_5 as 11-37-0, good solubility was obtained, the pH was raised to neutral, and the grade increased to 11-11-0. Formulation cost was increased further but there was still a major saving ($14-$33/ton nutrient).

Agronomic tests showed the value of high alkaline citrate solubility, even though most of the suspensions had little water solubility. The polyphosphate-fortified and the low-pH suspensions, both of which had 90% or higher alkaline citrate solubility, gave yields about the same as for standard liquid fertilizer or for triple superphosphate. Without additive or low pH, yield was poor. It should be noted, however, that good dispersion over the soil surface was necessary for good results with the suspensions.

Although nitric phosphate suspensions give a major reduction in formulation cost, the plant is more expensive to build and operate and more skill is required in operation. The higher investment is a particular drawback because the low grade limits sales area and volume and hence makes capital charges per ton of product more important.

Developments and Trends

The seasonal nature of the fertilizer industry makes cost of storage an important consideration for any new product. It appears that fluid fertilizers, particularly high-analysis base solutions and suspensions, are promising in this respect. The average cost of storage for large tonnages of liquid fertilizer is about $6 to $7 per ton of material as compared with $10 to $12 per ton for solid fertilizer. Since the average plant nutrient content of a clear liquid fertilizer is about one-half that of solid fertilizers, the cost of storing plant nutrients as clear liquids or solids is about the same. The average concentration of plant nutrients in suspensions, however, is about the same as the average concentration of plant nutrients in solids, so that storage cost for suspensions is about one-half that for solids. Among the reasons for this lower cost is the fact that the storage tank can be completely filled, with no voids, whereas the solid storage building cannot be filled completely and the pile of solid fertilizer itself contains some voids. Another reason is that the bulk density of the liquid or suspensions is considerably higher than that of the solids. For example, a 15-15-15 solid material usually has a bulk density of about 60 pounds per cubic foot, whereas a 15-15-15 suspension has a bulk density of about 90 pounds per cubic foot. The cost of pumping and transferring a liquid is considerably less than the cost of handling a solid material because of the extra labor and handling equipment required for the solid.

Polyphosphate base solutions of higher concentration may be feasible. In recent work at TVA, a 12-42-0 clear solution with good storage properties at low temperature was prepared in the laboratory. However, the polyphosphate in the solution hydrolyzes at a relatively rapid rate at high ambient temperature; further testing will be needed to evaluate the feasibility of using such a solution in the industry.

A new way of making ammonium polyphosphate is being tested by TVA and several of the fertilizer companies. Instead of making wet-process superphosphoric acid and ammoniating it, standard wet-process acid is ammoniated in insulated vessels so that the heat of reaction not only drives off the water but also dehydrates the orthophosphate molecule to the polyphosphate form. Considerable heat economy is achieved and the overall operation is somewhat simpler. The process is being pilot-planted currently at TVA. Major difficulties encountered so far are getting enough heat into the system and avoiding citrate insolubility when acid containing relatively large amounts of iron and aluminum is used.

In the suspension field, TVA is engaged in development of a straight nitrogen suspension. A 37-0-0 with good storage properties has been made by combining urea, ammonium nitrate, and water in such a way as to crystallize urea in very finely divided form as the solid suspended phase. The product can be used directly or can be combined with 12-40-0 in making nitric phosphate and N-P-K suspensions. In both cases there is a considerable reduction in shipping and handling cost.

Another recent development is use of free-ammonia suspensions. In early work at TVA (1957), phosphoric acid was reacted with ammoniating solution to give high-nitrogen suspensions containing free ammonia. Under the test conditions, 7.5 to 10% P_2O_5 was the maximum for good fluidity and a typical product was 34-7.5-0. (In such products, all the P_2O_5 is in the solid form, as triammonium phosphate.) More recently, free-ammonia suspensions made from anhydrous ammonia have been produced commercially. A typical grade of this type is 18-9-0. The main advantage is the low formulation cost resulting from use of anhydrous ammonia, but cost of application is higher because the suspension must be injected under the soil surface.

Application of Liquids

In the past most liquids have been row applied as a starter fertilizer. However, since suspensions now provide a means whereby high-potash grades can be produced, broadcasting of liquids may become more popular. Most liquids are applied in the row by the use of gravity-flow tanks equipped with an orifice plate and a breathing pipe. A sketch of this type of tank is shown in Figure 5. The design is such that a constant head is maintained on the orifice plate. The application rate is varied by varying the speed of the tractor and the size of the opening in the orifice plate. For suspensions, this type of equipment has not as yet proved to be satisfactory. Other equipment is more suitable, particularly positive displacement pumps for the movement of liquid from the applicator tank to the injection knives. A typical applicator of this type (Fig. 6) is equipped with a liquid fertilizer tank and a positive displacement pump of the hose pump type. It has been reported that such an applicator works well for applying either clear liquids or suspensions.

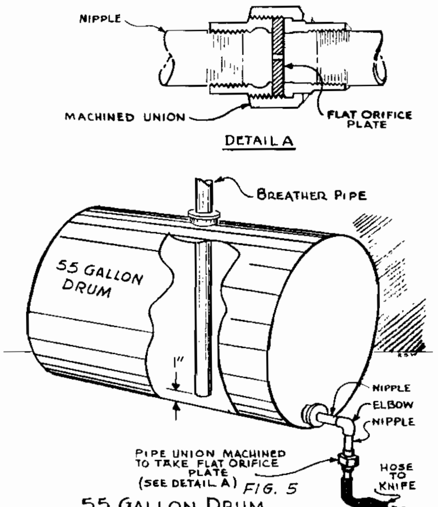


FIG. 5
55 GALLON DRUM
EQUIPPED FOR ROW APPLICATION OF LIQUIDS

A typical application truck for broadcasting suspensions is shown in Figure 7. An air compressor mounted on the truck forces air into the tank to give enough pressure for applying the liquid. The application rate is controlled by the air pressure in the tank, speed of the truck, and height and size of the nozzles. The ease of applying liquids with the equipment described above is one reason some

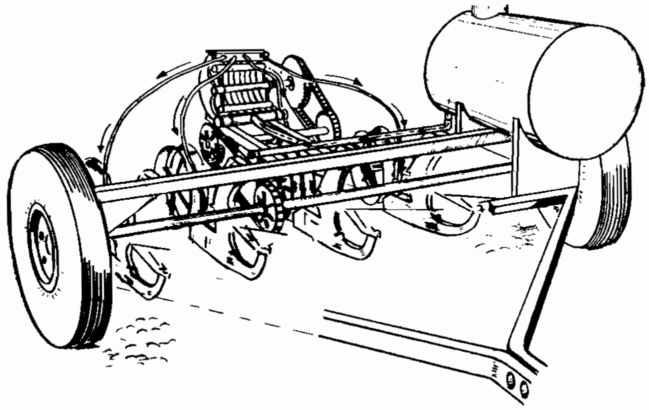


FIG. 6
PLANTER ATTACHMENT
FOR SUSPENSIONS

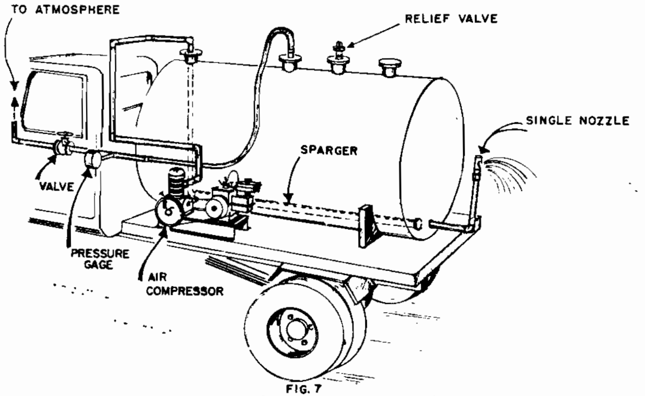


FIG. 7
BROADCAST APPLICATION TRUCK
FOR SUSPENSIONS

farmers presently prefer liquid fertilizers.

MODERATOR SAUCHELLI: Thank you Archie for a very comprehensive insight into this whole liquid fertilizer development.

Do you have any questions you want to fire at Archie?

MR. WILLIAM COATES: I want to thank Mr. Slack for a very interesting story. One matter that you didn't discuss, and I wish you would tell us a little about it quickly, is the materials of construction of tanks, pipelines and pumps.

MR. SLACK: The question was on the materials of construction for the various parts of equipment required in producing and handling liquid fertilizers. I didn't get into that in this paper because there is just too much to cover. It is a variable practice, I would say in the plants themselves, carbon steel is used mainly. In application there is a fair amount of stainless steel used particularly in applicators. Plastic tanks, or glass fiber reinforced plastic, seem to be growing more popular.
Perhaps Frank Achorn would like to observe on that.

MR. ACHORN: Generally speaking, in the cold mix operation, which is the major method, Carbon steel is the material used. There is a trend to storing product in pits. We had some bad experiences earlier with phosphoric acid in pits. But good results are being obtained in storing ammonium polyphosphate solutions 11-37-0 or 10-34-0 in pits that are just dug in the ground and have asphalt-coated walls.

MR. JOE FULLER: Regarding undeveloped or semi-developed countries that have little or no fertilizer industry now, would those countries be better off to try to leapfrog directly into a liquid fertilizer system, or would it be better to go through the conventional solid routes and wait until they are developed to go to liquids?

MR. SLACK: I think you all heard the question. It is concerned with what a developing country might best do, whether they should really modernize and go to liquid fertilizers. This question has come up with us several times, because the State Department asks us to send teams around the world to advise developing countries on what they should do. I think invariably we have advised against any form of liquid fertilizer for such countries mainly because the farmer has to have some sort of special equipment to apply liquid fertilizer; whereas, a solid can always be applied by hand out of the bag.

The problem in developing areas, as we have seen it, is mainly one of getting people to use fertilizer.

If, in addition to overcoming the normal barriers to using fertilizer, we introduce the additional one of asking farmers to get accustomed to special equipment, then I think that would be a very great handicap to overcome.

MODERTOR SAUCHELLI:

Archie thank you again for your presentation.

We adjourn to just across the way. Reference has already been made by Archie to the liquid.

Tomorrow we have a full day with some equally interesting papers. We start promptly at nine a.m. We hope that all of you will be on hand. Nine a.m. tomorrow morning.

Thursday Morning Session, Nov. 3, 1966

Albert Spillman, Moderator, presiding.

The Round Table reconvened at 9 A.M.

MODERATOR SPILLMAN: Good morning, ladies and gentlemen. Welcome to the 16th Annual Round Table Meeting.

On behalf of our members and The Executive Committee, many thanks to Albemarle Paper Company, International Paper Company, St. Regis Paper Company and West Virginia Pulp and Paper Company for hosting a most delightful cocktail party last evening.

The purpose of the Round Table has been thoroughly discussed by our Chairman. It has been a challenge, a privilege and indeed my pleasure to be a member of your Executive Committee.

This program takes a lot of planning, meeting discussions and correspondence. Fortunately, your Executive Committee was materially assisted, during the planning stage, by many members who are here today. We have an interesting program. We wish to thank all of the panelists who have contributed their time and energy preparing each of their useful and timely discussions.

Our first paper this morning is titled Automated Dry Mixing Equipment. This paper will be discussed by W. R. (Bill) Stephens, Vice President, Chemicals Plant Division, Barnard and Leas Manufacturing Company, Cedar Rapids, Iowa and C. P. Koonce, General Manager, Iroquois County Service Company, Watseka, Illinois.

Many of you here know Bill Stephens. He is also President of National Fertilizer Solutions Association. Mr. Stephens will present some of the highlights of the automated mixing equipment and Mr. Koonce will discuss actual experiences with the equipment at three locations operated by Iroquois County Service Company. Bill please.

Automated Dry Mixing Equipment

W. R. Stephens and C. P. Koonce

W. R. STEPHENS:

AUTOMATION on the modern American farm is common place today. The farmer has had to learn new techniques and use new products to meet the great demand for the bountiful crops that are necessary to feed a hungry world. In order to meet this demand, he has turned to the merchant on Main Street and the manufacturer in the city to give him aid and assistance.

One of the men on Main Street who is responsible for meeting the farmer's demands at the grass roots level is Mr. C. P. Koonce, Manager of the Iroquois Service Company of Watseka, Illinois. He has been able to give his farmer-customer faster service, increased accuracy and improved quality of bulk blend fertilizer.

Mr. Koonce will tell you about his dry mix operation and how he called upon my company to assist him in this endeavor.

It is my great personal pleasure to have you meet Mr. G. P. Koonce, a gentleman who is very knowledgeable in the subject which he intends to discuss with you today.

C. P. KOONCE: It is indeed an honor for me to appear before the Fertilizer Industry Round Table here in Washington to discuss with you the Iroquois Service Company dry mix fertilizer operation.

It will soon become apparent to you that I am not a chemist or a technician. I do not intend to discuss anything other than the dry mix operation of our company. My sole purpose in being here is to tell you the reasons why we got into the dry mix business in the first place. Before this we put the materials in the truck in layers.

I have been around farms and farmers all my life, so I am sensitive to their wants and their needs.

Our dry mix plant is located in Watseka, Illinois, in the east central part of the state. We put into operation previously a liquid fertilizer plant. We are one of 94 farm service companies in Illinois, and as far as I have been able to determine, our dry mix plant was the first in the country. It might interest you to know that since installing the first dry mix plant we have added three more installations. Later on in the presentation I intend to show you a few slides we have taken of our operation; and will describe the actual mechanics of the plant. Also, I will be happy to answer any questions you may have.

The large red and black "FS" on the sides of our trucks is our trademark. We are part of the largest cooperative in the State of Illinois doing a $153,000,000.00 business this year.

We took the bags off of potash and shipped the first bulk potash for straight application in Illinois, and we sold nitrogen when most authorities said "you can't do that."

The success of our dry mix

operation spread quickly, due to a story in "Farm Chemicals" and we began to have interested visitors stop to see us, not only from our own cooperative, but from many other firms. We have always attempted to explain, and show our facility to all who visit us. Not only can we be proud of the numerous people who came from surrounding states, but from the countries of Australia, Switzerland, Sweden, Argentina, South America, and a story in an Argentina, South American magazine . It was the story in "Farm Chemicals" magazine that brought the visitors. I have found several people here who have visited our plant.

The old method of mixing dry fertilizer materials was just too slow. It took too much time, and it wasn't accurate enough. When you are short on man-power and not getting the tonnage, you start thinking of ways to do this job better.

The usual pattern of business in this country is to invent a product, build it, and sell it. Then, it is up to the customer to tell you what is wrong with it. So you make modifications and go back into production. In the case of the Iroquois Service Company, and the Barnard and Leas Manufacturing Company, it was a different story.

We recognized the need and proceeded to fill it, with the help of Bill Stephens, the gentleman who so kindly introduced me to you. Up to this point, nothing had been built to fill this need. Bill was the motivating force behind the company that said "We recognize your need, and we will attempt to fill it for you." The farmer, who wasn't getting his dry mix fertilizer fast enough, and accurately enough, put the prod on us, and we, in turn put the prod on Bill Stephens. And that's exactly how the Barnard & Leas Dri-Mix Blending Plant got launched. Today, in Iroquois County alone, there are 29 such fertilizer mixing plants in 26 townships. Not all are Barnard & Leas. The attempt to blend is being done in every conceivable fashion and only a few are satisfactory.

Barnard & Leas supplied us with our liquid fertilizer plant and it was only natural that I would discuss our dry mix problems with them. Bill admitted that his company did not know very much about dry mixing, although they had given it some thought. I have tried other methods of mixing, including ribbon blending because I though it was the most accurate. But it proved to be too costly and complex. We agreed between us that whatever Bill came up with had to be simple and fast. . . yet automated. We were thinking of continuous blending by automation.

Bill Stephens went back to the Barnard & Leas drawing board and it wasn't very long before he was back with some ideas. Naturally, there were some bugs that had to be eliminated but, generally speaking, the proposed design incorporated all the features we wanted. First of all, the plant had to be safe as the machinery would be running with no one present. It had to be efficient. We didn't want something that would have to complete a cycle. We wanted something that could be stopped if it was necessary. Next, of course, we wanted peak production.

We started putting the pressure on Bill in 1963, in the fall of the year, and by the spring of 1964, we were in operation with our first unit. So you can see that Bill didn't waste any time. He could see that a good dry mix plant had possibilities for his company.

Since this unit was to be of one ton capacity, I couldn't for the life of me see how we could expect any reasonable tonnage out of it. I was very skeptical at this point. Bill guaranteed that we could get at least 18 tons per hour out of the contraption manually, and as long as he personally guaranteed it, I had nothing to lose. If he had that much faith in his design I knew it had to work. Actually, we have been getting up to 30 tons per hour on automatic, almost double of what Bill had guaranteed me.

My next move was to take up the matter with our board of directors. We all looked over the dry mix operation pretty carefully. My people were wondering if a small plant like ours could justify the automation that would come out of this. My president told me "I don't know if it will work or not, but if there is any money to be lost on this operation, we, as farmers, should be the ones to lose it, because we farmers stand to gain the most." That was wonderful philosophy.

The B & L Dry Mix Plant has a graphic control panel that provides a fully automatic or manual type operation. Also, available is a remote control panel, allowing us to operate the plant from our office 150 feet away. This punch card, which I now show you, looks like a musical record because it is round, but it plays a different kind of tune. It might be round in form, but that's where the similarity ends. The card is actually the heart of the system. It accurately weighs and mixes each batch. Also, this card has space available for the name of the customer, the date, the mixing formula and the net weights, and can be filed for future reference. The ingredients are weighed into the scale, one at a time, assuring precise weight.

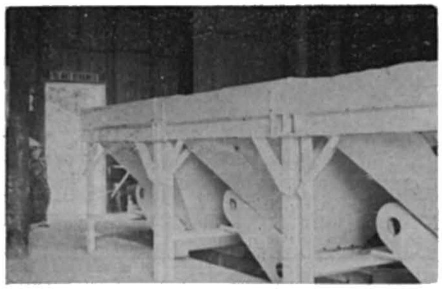
We rocked some boats in the bagging industry, using this automated system. We now buy raw materials bulk and bag the blended material. All of this was a departure from industry tradition and I must say not too popular. But at this time we were talking about $15.00 to $25.00 difference in price a ton applied. The corn yield average per acre in Illinois up from 52 bushels in 1953 to 100 bushels in 1965. We like to think we had some part in this increase.

I am happy to say that the B & L Dry Mix Plant has done everything Bill Stephens claimed it would. Our production has gone up, our work force has been decreased by seven men and we now have an accuracy in weighing and mixing that is dependable . In addition, it has put the responsibility for dry mixing into the office, instead of allowing it to stay back in the plant. It is in the hands of more responsible people this way. I might add, my son, Rob, is the manager of our fertilizer plants and has the responsibilty for seeing that we give efficient and responsible service. It was his idea that we try to get some better way than what we had. Under the old method after we got the order, it took some time to load the bins and weigh the materials. Now we can put the material into the farmers truck within a few minutes.

We use a paddle type mixer, of 82 cu. ft. capacity, driven by a 20 horsepower motor. A longer mixer life is assured because this type of mixer utilizes only 50% of its capacity. This type of mixer is better for us because we keep the batch smaller, and this increases accuracy. We are ready for the time when micro nutrients and trace elements come along, too. In fact we are mixing some now.

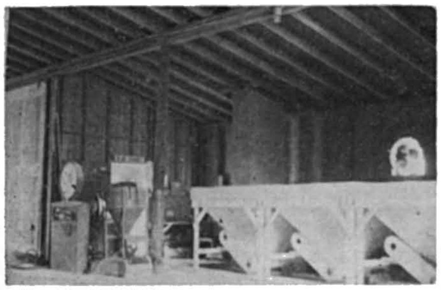
It should go without saying that a dry mix plant that allows you to weigh, mix and load faster and with fewer employees is more profitable.

And now, I would like to show the slides of our B & L Dry Mixing Plant, after which I will be happy to answer any questions you might have.



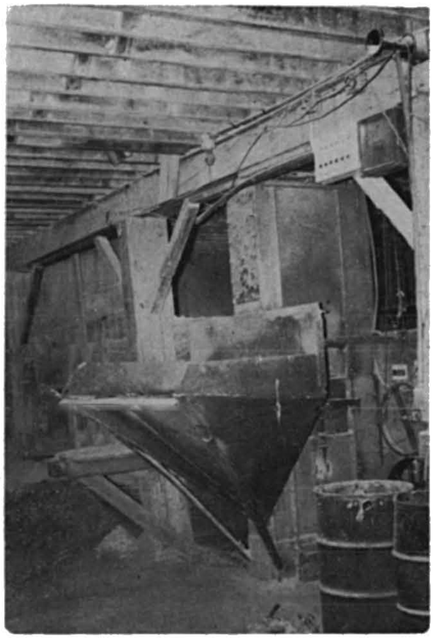
Slide 1
This a view of the first mixers. It is made of three boxes dumping into a screw and then into an elevator.

Slide 2
This is a view of one of the early mixers made up of three boxes, a screw, a scale and a leg for loading.



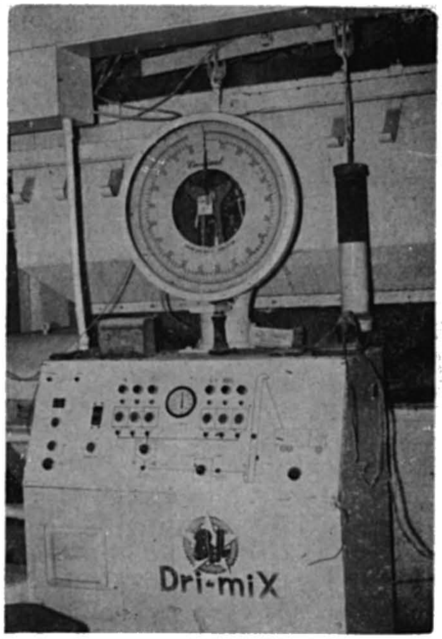
Slide 3
This is a different view of the first mixers showing the boxes a little better.

Slide 4
This is a better view of the three bins, the scale and the loading elevator.

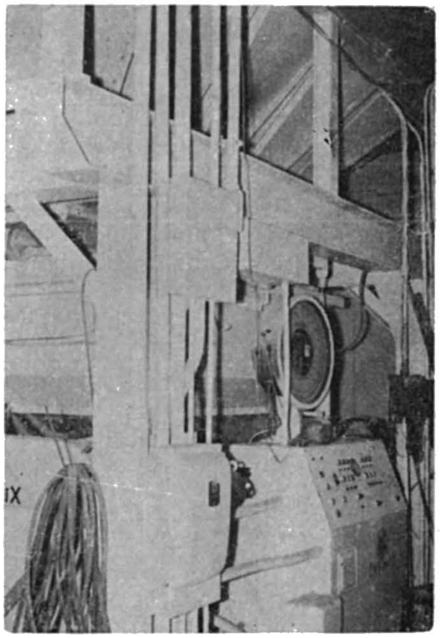


Slide 5
This is a hopper built on the side of a leg to feed our overhead storage.

Slide 6
This shows loading of bulk blend material into farmer's truck.



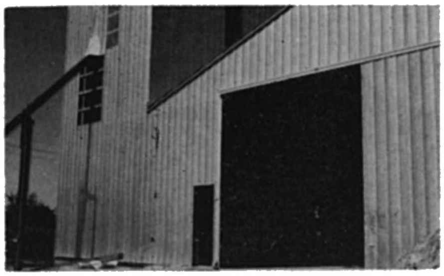
Slide 7
This showes the scale and the lighted panel of the B. & L. Mixer with provisions for operating by hand.



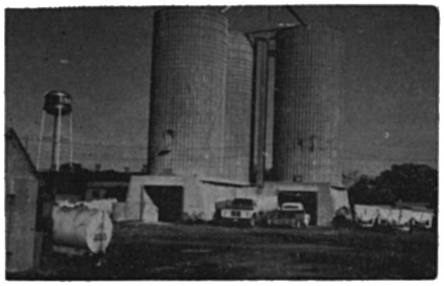
Slide 8
This is a view of the B. & L. mixer showing overhead storage.

Slide 9
This is part of Iroquois Service Company facilities.

Slide 10
This is another view of facilities.



Slide 11
This is the loading spout on the B. & L. Mixer.



Slide 12
More of the facilities.

Moderator Spillman: Are there any questions for Bill Stephens and C. P. Koonce?

Mr. Spillman: The hoppers that hold the materials. What are the capacities?

Mr. Koonce: They only hold about ten tons each. You can make them any size you wish. We figured it was easy in these one-man operations to put ten tons of each material up there. He can run awhile.

Moderator Spillman: There is a question in the middle aisle.

Mr. Cliff L. Hart: Mr. Koonce, you mentioned mixing trace elements in your dry blends. What form of material do you use and how do you get a mix?

Mr. Koonce: We have another bin on this machine upstairs and simply weigh the trace elements in as needed. We actually mix the trace elements with potash first and package in 50 lb. bags. When we get an order requiring trace elements, we dump a 50 lb. bag into the mixer and run it through that way. This is sort of a crude way, however, we are feeling our way before making additional changes.

Moderator Spillman: Thank you Bill and C. P. for giving us the story on your automated blending facilities.

Moderator Spillman: More production, lower costs and quality improvement are always a challenge to operating personnel. Modernization was a must at the Central Chemical Company fertilizer plant at Milton, Pennsylvania.

Mr. Dave Schwartz, Vice President, Central Chemical Company, Hagerstown, Maryland, and the Sackett Organization cooperatively surveyed the receiving manufacturing and shipping facilities at Milton and agreed on the modernization changes to be made.

Mr. Schwartz will discuss increasing production and reducing plant costs through modernization. Dave, please.

Increasing Production and Reducing Plant Cost Through Modernization

David Schwartz

LAST year our company reached the conclusion that the unloading and manufacturing operations at our Milton, Pennsylvania plant had become antiquated and costly. It was decided to modernize and streamline both operations. The firm of A. J. Sackett & Sons Company of Baltimore was employed to survey our plant operations there and submit recommendations for improvements. The survey was made and recommendations submitted, and after consideration these recommendations were put into effect.

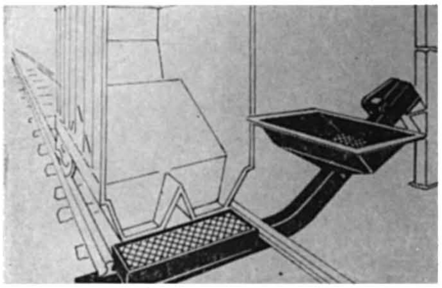
We are now going to discuss the conversion of this fertilizer plant originally designed to produce 12,000 tons of pulverized fertilizer per year to an operation capable of producing and shipping 17,000 tons per year of both pulverized mixed goods and bulk blends and to produce this tonnage at a considerable reduction in cost.

Prior to the conversion of equipment, our operation consisted of unloading all rail box cars by front end loaders which materials were dumped into Georgia buggies at the rail platform level for transfer through confined quarters to an elevator and thence by overhead conveyors to storage bins. This operation not only required the employment of excessive manpower, but also used the same elevator and conveying system required for transferring manufactured goods to the storage bins . The 12,000 tons of raw materials required by this plant could only be unloaded when manufacturing was not being carried on and at most times of the year, this meant overtime payments for unloading at night so that enough raw materials were on hand for the next day's production run.

Our former manufacturing process consisted of batching raw materials from storage bins by front end loader using a scale mounted in the floor. We then dumped into an elevator for charging into a one ton batch mixer where nitrogen solutions were introduced. This mixer discharged into our unloading elevator mentioned earlier, and the fertilizer was then conveyed to bulk storage bins.

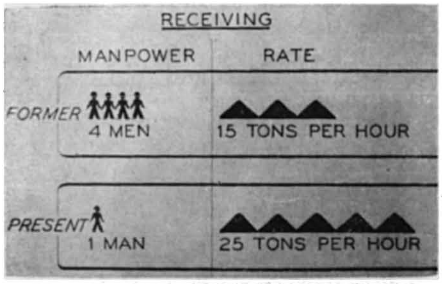
During the winter of 1965-66, the existing obsolete equipment was removed and replaced with new equipment designed for a more efficient operation as recommended by The Sackett Company. We first tackled our unloading operation by the installation of an undertrack BULK-TOTER capable of unloading bulk hopper cars. This BULK-TOTER consists of a permanent undertrack drag chain which discharges into a newly installed elevator for delivery to raw material bins.

SLIDE #1 shows a view of the undertrack hopper car unloading system. This BULK-TOTER is easily installed by simply spreading



Slide 1
Undertrack BULK-TOTER Unloader

two of the cross ties a bit, opening up the small area between and slipping the BULK-TOTER in place securing it to the bottom flanges of the spur track. This unit is provided with a weathertight cover. We have been almost 100% successful in receiving delivery by hopper car since the installation of the unloader; however, a hopper has been provided at platform level so that bulk cars may be unloaded should the necessity arise. This hopper does not interfere with the use of our platform as we are able to cover it when it is not in use.

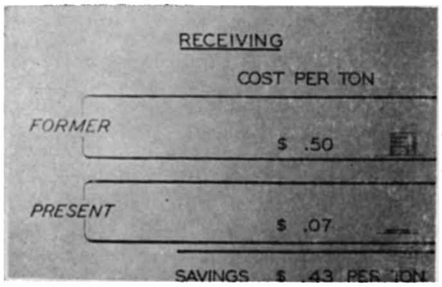


RECEIVING

	MANPOWER	RATE
FORMER	4 MEN	15 TONS PER HOUR
PRESENT	1 MAN	25 TONS PER HOUR

Slide 2
Improvements in Manpower and Unloading Rates

SLIDE #2 shows improvements in manpower and unloading rates that we have realized by our new equipment installation.

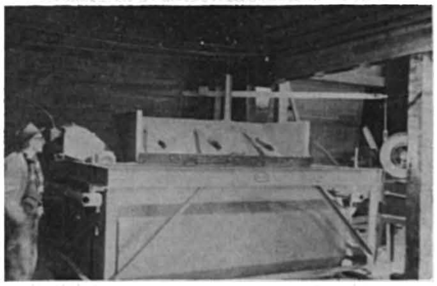


RECEIVING

	COST PER TON
FORMER	$ .50
PRESENT	$ .07
SAVINGS	$ .43 PER TON

Slide 3
Reduction in Unloading Costs

SLIDE #3 shows substantial reduction in our unloading costs.

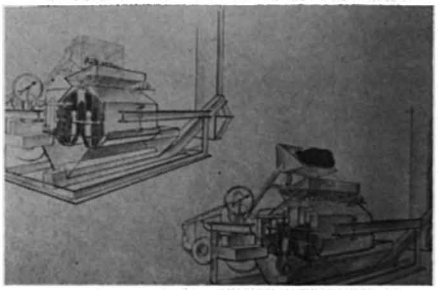


Slide 4
MITEY GIANT Weight-Blend Unit

SLIDE #4 shows the new MITEY GIANT Weigh-Blend Unit which accomplishes the milling, screening, blending and metering in 4 ton batches.

Slide 5
Charging the MITEY GIANT Unit

SLIDE #5 shows the means by which the materials are weighed into the weight-blend unit by front end loaders, the dial scale being readily visible by the operator as the weighing progresses to insure correct weights.

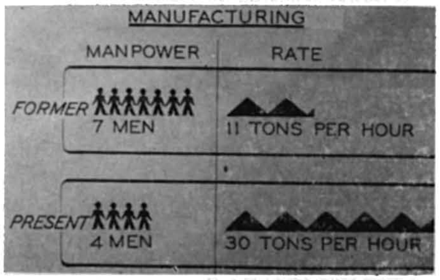


Slide 6
Interior Views of MITEY GIANT

SLIDE #6 shows two interior views of this weigh-blend unit. One as the batch is being prepared and the other as it is being discharged. This unit has a screening device and a means for pulverizing lumps in our raw materials. The blender is suspended from a 5 ton capacity dial type scale and is so constructed that materials entering the unit drop into compartments or blending cells. The first raw material entering the blender comes to rest in the center section and when this is filled, material overflows into the two surrounding cells on either side of the center of the unit. In like manner, each of the outer compartments is filled and overflowed until the complete 4 ton batch is assembled. At time intervals, the bottom gates open discharging the 4 ton batch into the surge hopper and BULK-TOTER below. A variable speed drive on the BULK-TOTER allows a continuous flow to be delivered to a newly-installed bucket elevator and T.V.A. Ammoniator located upstairs.

Slide 7
T.V.A. Ammoniator in operation

SLIDE #7 shows the T.V.A. Ammoniator in continuous operation. Nitrogen solutions are introduced into the ammoniator by use of a flow meter. The products thus produced are taken to storage bins by belt conveyor. All of our regular grades of fertilizer are produced in this manner and we have successfully run 32 to 36 tons per hour.



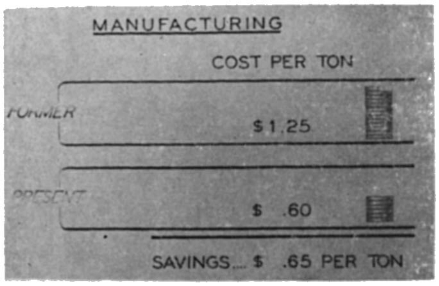
MANUFACTURING

	MANPOWER	RATE
FORMER	7 MEN	11 TONS PER HOUR
PRESENT	4 MEN	30 TONS PER HOUR

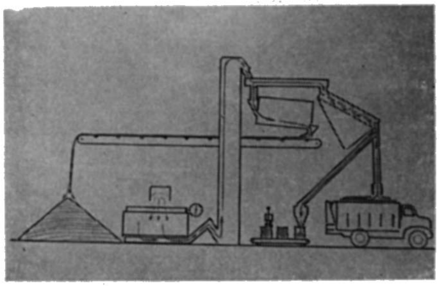
Slide 8
Reduction in Manpower and Increased Manufacturing Rate

SLIDE #8 shows the reduction in manpower as well as the increase in manufacturing rate realized by this modernization program.

SLIDE #9 shows the cost savings made possible by this new equipment.



Slide 9
Manufacturing Cost Savings



Slide 10
Flow Plant of New System

SLIDE #10 is a flow plan of the new manufacturing and bulk blending system installed.

In the Milton area, we have an increasing demand for blended ratios to fill recommendations from soil testing. These mixtures are dry blended at a rate of 10 4-ton batches per hour through our blender, after which they are elevated and screened for bulk shipment by tow-type spreader or bulk trucks.

Moderator Spillman: Thank you, Dave. Questions please.

Member: Dave; if it is not too personal. What tonnage does your Milton, Pa. plant ship?

Mr. Schwartz: 17,000 tons per year.

Moderator Spillman: What was the approximate cost for modernization at Milton?

Mr. Schwartz: Around $45,000. We figure we can write this off thru operating savings in 2 years.

Moderator Spillman: Mr. Schwartz has demonstrated for an expenditure of $45,000 what really can be done to eliminate bottlenecks and reduce costs with complete return of original investment in a short period of time.

Question by Mr. Ted Rosenblatt: Mr. Schwartz do you find the weighing and blending unit causing any problems with bulk granular materials versus powdered materials? In other words does that multi-cell distribution and blending system work equally well with granular materials rather than just powdered? What about a uniform mix?

Mr. Schwartz: We have had very good success with the granular materials. We feel this equipment works equally as well with granular and fine materials for getting a uniform mix.

Moderator Spillman: Thanks Dave for a job well done.

Dr. Sauchelli: Mr. Moderator May I make a brief comment. When we hear about small plants it is heartening to learn that there is definitely a place for the small plant. At our Round Table Meetings we always like to give some credit to the standing of the small plant. Dave Schwartz has given us this morning a splendid achievement of modernizing a small plant and permitting competition with the larger plants.

Moderator Spillman: Thank you Dr. Sauchelli for those kind remarks.

Moderator Spillman: At this time I wish to recognize Mr. Samuel Strelzoff who wishes to make a comment or two.

Mr. Samuel Strelzoff: I certainly learned quite a bit yesterday and today about dry mixing. But, with your permission, Mr. Chairman, I would like to go back to some questions that came to my mind after thinking more about a certain paper which was very important yesterday about market research on a worldwide basis made by the gentleman from IMC.

With your permission I would like to say a few words and then introduce a gentleman who came to this meeting from Germany especially on my invitation. I would like to have his opinions on certain subjects that were discussed yesterday and today.

First of all, I would like to say that I am an engineer but my wife is a physician. She is not here in the audience, so I may tell you that the biggest troublemakers are the engineers and doctors, because we have created a problem which was discussed here yesterday. The engineers have repaired all the dams in China and the doctors have helped sanitary conditions. However, the population explosion cannot be controlled any more with the pills that the gentleman just mentioned, because the pills may not be properly used .

Yesterday the question arose in my mind How quickly can we build so many plants that it was mentioned should be built, and nobody answered it. Now, let me try to answer my own question.

First of all a much more rational policy should be used in the world. People try to build too many plants under impractical conditions.

Every new developing Nation starts by building a presidential palace, an airline, a refinery and ammonia plant, regardless whether they have natural gas or not.

I would suggest that nitrogen plants be built where we have very large deposits of natural gas, where it is not used, for instance in Saudi Arabia, where a lot of it has been burnt out, and the ammonia could be shipped to locations where they don't have such cheap resources. The same is true for phosphate.

The only people who are really utilizing this kind of rational policy are the potash people. Nobody has as yet invented a way to create a potash plant where there is no potash.

My next question: Why should the United States be the only country to give away so much in terms of machinery and food? Yesterday it was mentioned that $300 million worth of fertilizer alone would be shipped by AID. What can be contributed by other countries?

This is the reason I would like to invite Dr. Jockers from Badische Anilin & Soda Fabric AG (BASF) Ludwigshafen am Rheim Germany to comment on the subject. Maybe he can help us answer this question.

Moderator Spillman: We would be pleased and honored to have Dr. Jockers' comments if he will kindly come to the rostrum.

Mr. Strelzoff: Dr. Jockers is a director of Badische. His company produces about 2,000 tons per day of nitrogen in the same location. One of the things they are mixing there is one million tons of nitrophosphate per year. I call attention to this particular figure because we would like very much to see the same kind of progress made in the United States.

Moderator Spillman: Dr. Jockers, please let us have your comments.

Comments By Dr. Kurt Jockers

Mr. Strelzoff here has given me the apple and I must eat it.

FIRST of all, we should bear in mind that it is highly conjectural whether the forecast rapid growth of the world's population to about 6,000 million in the year 2000 will actually become a reality. If, however, the present growth tendency should continue in the near future, then the construction of new fertilizer plants alone will not solve the problem.

It is a frequently observed phenomenon that huge modern fertilizer plants are planned whilst the prerequisites for the transport, distribution and application of the fertilizers are not or cannot be provided either beforehand or simultaneously.

The importance of this problem becomes apparent when we hear of a modern 1,000 st/day ammonia unit with a 2,200 st/day ammonium nitrate sulfate plant (26% N) and a 1,100 st/day ammonium sulfate plant being planned for a location from which distribution of the 3,300 st/day of fertilizers is quite unfeasible for lack of adequate rail and road transport facilities.

Furthermore, if we leave exceptions and details out of consideration, it is interesting to note that the following general rule holds both for the past and the present: The higher the percentage of the agricultural population in a populous country, the less its people are protected against food shortage unless special measures are taken. Only a modern industrial economy, in which the agricultural population is small in number but well equipped with machinery and fertilizers, can ensure permanent and adequate food supplies for the whole community. Consequently, the developed nations should go all out, not only to build fertilizer plants or even merely sell fertilizers in the developing countries, but to modernize the entire economy and structure of the latter.

This is a task of immense proportions, and we should lose no time in devoting all our attention and abilities to it.

Moderator Spillman: When I started in the fertilizer business in 1925 the total production of fertilizers was about three million tons, not of the 12-12-12, but just of around 1-9-4. Now we come to the year 1966 and we're moving something like 30 million tons. I think in our country and even in your country, as the demand grows and grows, we are going to find ways and means to put out this production as fast as it is humanly possible to do it. We thank you Dr. Jockers and Mr. Strezloff.

Moderator Spillman: Phosphoric acid production and its usage has continually increased during the past decade. This material is now one of our most important ingredients for production of dry and liquid fertilizers.

Through improved processes and more technical know-how the quality of wet phosphoric acid has continually been improved and costs have been lowered.

It is my pleasure to introduce two gentlemen representing Pechiney-St. Gobain. They will discuss "Improvement in the Filtration of Phosphoric Acid using the UCEGO Filter."

Mr. Pierre Boutan, Technical Liaison Representative of Pechiney-St. Gobain, with offices in New York City, will read the paper prepared by Mr. J. Roubinet, Pechiney St. Gobain, "D. T. M. Section" France, will answer any questions.

Improvements in the Filtration of Phosphoric Acid The UCEGO Filter.

Jean M. Roubinet and Pierre Boutan

Mr. Boutan: Thank you very much for your time Mr. Chairman, members of the Round Table, ladies and gentlemen. The work has been by Mr. Roubinet and I shall simply read the paper for him.

1) - Basic Principles Involved In Filtration

The production of wet process phosphoric acid, no matter what process is used (dihydrate, hemi-hydrate or anhydrite), always entails the separation of liquid (phosphoric acid) from solid (calcium sulfate dihydrate, hemi-hydrate or anhydrite,) together with certain impurities.

The method of separation now used by all manufacturers of phosphoric acid is "continuous vacuum filtration."

Although this method of filtration is well known, we feel it would be useful to take a brief look at certain basic principles which will help in the understanding of this report.

1.1—*The Techniques of Filtration*

In the case of the filtration of phosphoric acid slurry, a relatively thick layer of solid cake is formed on a filter cloth.

As soon as it is formed, it acts as filter medium and the influence of the filter cloth lessens as the cake increases in thickness.

This cake is composed of a mass of small particles, more or less regular in shape. It is porous, and there are small capillary tubes within the mass linking its lower and upper surfaces. It is through these capillaries that the liquid to be filtered flows. This flow is streamlined and obeys the law of POISEUILLE.

1.2—*Equations Relevant to Filtration*

The law of POISEUILLE has been written, as follows, in "Chemical Engineers' Handbook" — John H. Perry, Editor — Third Edition — p. 965:

$$\frac{dV}{A\,d\theta} = \frac{P}{\frac{\mu(\alpha W + r)}{A}} \qquad (I)$$

with:

V=Volume of filtrate collected.
θ=Time.
A=Filter area.
P=The difference in pressure between the two surfaces of the cake. It is equal to the pressure drop throughout the cake.
=viscosity of the filtrate.
W=weight of the dry cake on the filter.
=average specific resistance of the cake.
r=average specific resistance of the filter cloth.

When applied to the case of a continuous filter, this equation becomes:

$$\frac{Q}{S} = \frac{P}{\frac{\mu(\alpha W + r)}{A}} \qquad \text{(II)}$$

with:
Q=Total volume of filtrate collected per unit of time.
S=Effective area of filter (under vacuum).
P=Vacuum created under the filter cloth.
G=Quantity of dry cake produced per unit of time.
T=Effective time of filtration.

In general the specific resistance of the cloth 'r' is negligible in comparison to that of the cake, and equation (II) becomes:

$$\frac{Q}{S} = \frac{P}{\frac{\mu\alpha G\ T}{S}} \qquad \text{(III)}$$

For the purpose of this discussion we shall limit ourselves to a specific slurry, and therefore, 'U' and ' ' will be constant.

The term GT represents the weight of dry cake deposited on the area S of the filter. Consequently, GT/S represents the weight of the cake per unit area. For our specific slurry, this term is proportional to the thickness of the cake.

Equation (III) may be rewritten in the well known form:

$$\frac{Q}{S} = K_1 \frac{P}{e} \qquad \text{(IV)}$$

Where K_1 is a constant, e is the cake thickness and Q/S is the volume of filtrate collected per unit time and per unit area. This term therefore constitutes a measure of the specific production of the filter in the exact conditions of filtration.

Moreover, for a given phosphoric acid slurry, there is a linear ratio between the quantity of filtrate Q collected per unit time and the quantity of dry cake G produced per unit time.

We can write:

$$Q = C^2 G. \qquad \text{(V)}$$

where C is a constant.

If we combine (V) and (III) we obtain:

$$\frac{Q}{S} = C\sqrt{\frac{P}{\mu\alpha T}} \qquad \text{(VI)}$$

To simplify, we shall consider the case of a circular filter and fixed filtrate and cake properties. T, effective filtration time, is in inverse ratio to the rotation speed N.

Thus we can write:

$$\frac{Q}{S} = K_2\sqrt{P.N.} \qquad \text{(VII)}$$

where K_2 is a constant.

1.3—*Conclusions*

From the equations (IV) and (VII) we can draw the following conclusions:

1.3.1—For a given slurry, where cake thickness is constant, specific production of a filter is *proportional to the vacuum* (P).

1.3.2—For a given slurry, operating at constant vacuum, specific production of a filter is *inversely proportional to the thickness* (e).

1.3.3—For a given slurry, operating at constant vacuum, specific production is *proportional to the square root of the rotation speed* (N).

2) - Criteria for Choosing A Filter —Application to UCEGO Filter

The ideal industrial filter would have the following qualifications:

high productivity,
high extraction efficiency,
the highest possible concentration of the acid produced (minimum dilution),
clear filtrates,
low investment, and,
low cost of operation (low maintenance cost).

When Pechiney-Saint-Gobain and Union Chimique—Chemische Bedrijven made a common study of the UCEGO filter, they endeavored to meet all these requirements.

We shall now give briefly the various solutions we have found. We shall deal with these in more detail when describing the filter.

2.1—*High productivity*

We have seen from paragraph 1.3 that productivity is a function of vacuum and thickness of the cake.

2.1.1—*Vacuum*

The quality of the vacuum, which can be obtained with an industrial filter, depends on the airtightness of its vacuum box. This airtightness will depend on:

a. compactness of the box,

b. close contact between the moving and fixed parts of the box, and,

c. separation of the box from the rotating table.

We therefore chose:

a. a circular compact type vacuum box,

b. a joint between the fixed and the moving parts of a special self-lubricating material, and,

c. a flexible connection making the box independent of the table. With this arrangement, the contact between the two parts of the box will remain perfect, in spite of any irregularities there might be in the rotation of the table.

2.1.2—*Thickness of the cake*

We have already seen in paragraph 1.3.2 that the productivity of the filter is in inverse ratio to the thickness of the cake, or, proportional to the square root of the speed of rotation of the table (paragraph 1.3.3). The filter must be able to rotate as fast as possible. It is necessary however to adapt its speed to the desired production and a variable speed drive has been incorporated in its design.

The maximum speed of a filter is generally limited by mechanical as well as hydraulic problems:

A) *Mechanical:* tilting pan filters, for example, have limited peripheral speed to avoid shock and vibration. Tray belt filters are limited by the mechanical resistance of the belt. We therefore chose a rotating table type filter which is not subject to this kind of limitation.

B) *Hydraulic:* the filtrates which have passed through the cake travel on the bottom of the pans and require a certain amount of time to reach the openings for drainage. In order to maintain high extraction efficiency, it is imperative to avoid the mixing of two different qualities of filtrate. It is also vital that none of the water from the washing of the cloths be allowed to enter the first filtrate.

In order to overcome this difficulty we have:

a. Considerably increased the number of trays, compared with classic filters (30 trays on small filters, 36 on large filters). This permits better separation of the filtrates, whatever the rotation speed may be.

b. Increased the number of outlets per tray (2 on the small filters; 3 on the medium, and 4 on the large) so that each filtrate has the shortest possible distance to travel.

c. Put a sharp slope on the bottom of the pans in order to increase the speed of flow of the filtrates.

We can note immediately that all these details which enable the UCEGO filter to rotate at a greater speed than other filters give it a higher specific output. Ordinary rotary filters are generally limited to a speed of one rotation every three minutes, but the UCEGO filter can rotate twice every three minutes without any mechanical risk whatsoever, and without mixing or diluting the filtrates. This means that its specific productivity is increased by a factor of $\sqrt{2}$ or that it is approximately 40% greater than that of other filters.

2.2—*High extraction efficiency*

High extraction efficiency is a function of several factors, among which are:

2.2.1—*Evenly distributed slurry*

The cake must be level and of constant thickness; even a slight variation in thickness may result in a very poor extraction efficiency.

For this reason we have carefully designed the shape of the slurry feed box, in order to have a flow of slurry proportional to the passing surface, that is, proportional at each point to its distance from the center. This slurry is brought to the level of the table by means of a rubber drip-flap.

For this reason also we have developed continuous surface filtration. There are no pan edges to lift the drip-flap and cause uneven slurry distribution. The possibility of filtrate channelling at pan edges is eliminated and cake release from pans is no longer a problem.

2.2.2—*Even distribution of washing liquids*

As in the case of the slurry, it is important that the flow of liquid be proportional to the passing surface. It is also important to avoid resuspension of the upper part of the cake, first because the best washing is obtained by the "piston" effect of the washing liquid and, second because any violent flow of liquid forms grooves or holes in the surface.

In order to achieve this we have designed the shape of the feed box to bring the liquid to the level of the cake by means of rubber drip-flaps which can protect the cake in the absence of pan edges. We also placed rubber dams in such a way as to maintain a certain depth of liquid on the surface of the cake, thus again improving the distribution.

2.2.3—*Satisfactory separation of filtrates of different qualities*

We have already seen in paragraph 2.1.2 that in order to achieve a satisfactory separation of filtrates, the UCEGO filter has been provided with numerous troughs under the filter cloth and also that each trough has several outlets. It is necessary to be able to adapt the filter rapidly to conditions of the moment (quality and quantity of the slurry produced). For this reason it must be possible to shift the washing liquid feed boxes without difficulty.

It may also be necessary to modify the conditions of operation because of change of phosphate, or change in concentration of the acid produced, etc. We must therefore be able to make adjustments to the different parts of the vacuum box easily and quickly.

In conclusion we should point out that for high extraction efficiency it is necessary to have a filter cloth which is in perfect condition. Great care must therefore be taken in extracting the gypsum and washing the cloths.

It is this particular point which prompted us to replace the fixed edge of classic filter tables with an edge made by a rubber belt that can move away from the table. With the UCEGO filter it is possible to remove all the gypsum and also to wash the cloths thoroughly.

2.3—*High concentration of acid*

As the manufacture of phosphoric acid is usually followed by a concentrating process, it is desirable to produce an acid of the highest possible concentration. This will save steam in evaporation steps and reduce the volume of liquid to be handled.

The filter must therefore not dilute the acid produced in the reaction section.

Dilution is caused by water from cloth washing which has not had time to escape. The faster the filter rotates, the greater the risk of this dilution.

In order to avoid this dilution we have the following features in the UCEGO filter:

a. The bottoms of the troughs have been designed to facilitate the rapid drainage of liquids.

b. A section for drying the cloths by suction of air has been installed just after the washing section.

c. The first small amounts of filtered acid which may be polluted by water remaining on the bottom of the pans are returned to the reaction section, leaving only undiluted acid for production. This separation takes place in a small section of the vacuum box, known as the PRESECTOR. This PRESECTOR is patented in most industrial countries.

2.4—*Clear filtrates*

In the first stage of filtration, before the formation of a layer of cake, small amounts of acid are polluted by gypsum, which passes through the clean filter cloth.

The PRESECTOR, which we have just mentioned, completely overcomes this difficulty, and it is possible to obtain perfectly clear filtrates from the UCEGO filter.

2.5—*Minimum investment*

Investment in equipment is composed of the purchase price of the equipment and the cost of installation.

Where the cost of the filter itself is concerned, the design and the materials used must be born in mind for they will influence the maintenance cost. Also, comparison should be made between filters of equal output and not of equal area.

In comparison to filters of equal output, the UCEGO filter will be much cheaper to buy in spite of the use of greater amounts of special alloys.

Savings will also be felt in the installation cost of the filter. The UCEGO filter is delivered ready for installation. Small concrete blocks for the supporting rollers (6 to 12, according to the dimensions of the filter) are all that are required for its installation. Competitive filters very often require extensive engineering and construction, such as installation of circular troughs of the same width as the filter, made of acid-resisting bricks.

2.6—*Minimum operating cost*

In this respect also, the UCEGO filter stands out. The operating costs are minimized because:

a. It has the highest output, and the lowest downtime.

b. There are few or no stops for maintenance.

c. Rapid changeover of the filter cloth is done by means of a carefully designed attachment method.

d. Efficient working of the filter cloths lengthen their useful lives.

e. Ingenious removal of the gypsum neither strains nor tears the cloth.

All manufacturers of phosphoric acid agree that maintenance accounts for a large part of the budget of a phosphoric acid plant. Many manufacturers have examined this filter and their opinions were seriously considered. Great effort has been spent in designing this filter to limit cost of maintenance to a bare minimum.

The maintenance of a filter is influenced by 3 factors: corrosion, mechanism and wear.

A) *Corrosion:*

The filter operates with a very corrosive acid, which gives off corrosive fumes.

The parts of the filter which come into contact with the acid itself are always of the proper type of stainless steel. But filter manufacturers all too often forget that other parts of the filter, such as the framework, the filter drive, the support mechanism, etc., are exposed to corrosion by acid, acidic water, etc.

In the UCEGO filter, any parts which are in danger of corrosion are of stainless steel.

The only parts made of carbon steel are the ring gear and the outer framework of the filter. The ring gear is located well under the filter and away from acid or fumes. The framework, safely removed from the actual filter parts, merely supports the acid feedboxes and does not affect the rigidity of the filter. Only acid-resisting paint is required.

B) *Mechanism:*

We feel it unnecessary to deal at length with this aspect. The only moving parts of the filter are the support rollers and the filter drive. These few moving parts have been made very strong, and there is little maintenance required on them.

C) *Wear:*

Wear has been held down to a minimum:

a. The gypsum removal screw should be adjusted every 3 months and remachined once a year to maintain a constant clearance from the table.

b. The rubber belt whose only function is to prevent liquids pourerd onto the filter from running over the sides should be adjusted to achieve the desired water-tightness. It is under very little strain however and does not slip because it is in contact with ¾ of the circumference of the filter table, which drives it.

Finally, we should point out that every part of the filter is easily accessible.

3)—Description of the Filter

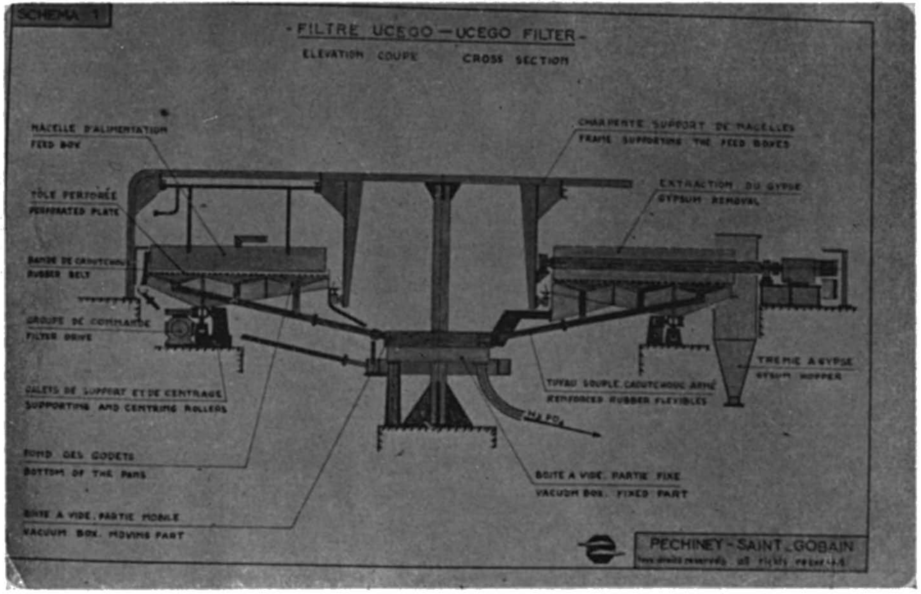
We shall now give a more detailed description of the filter. In the slides we are going to project it will be easy to see that the principles indicated above have been strictly followed.

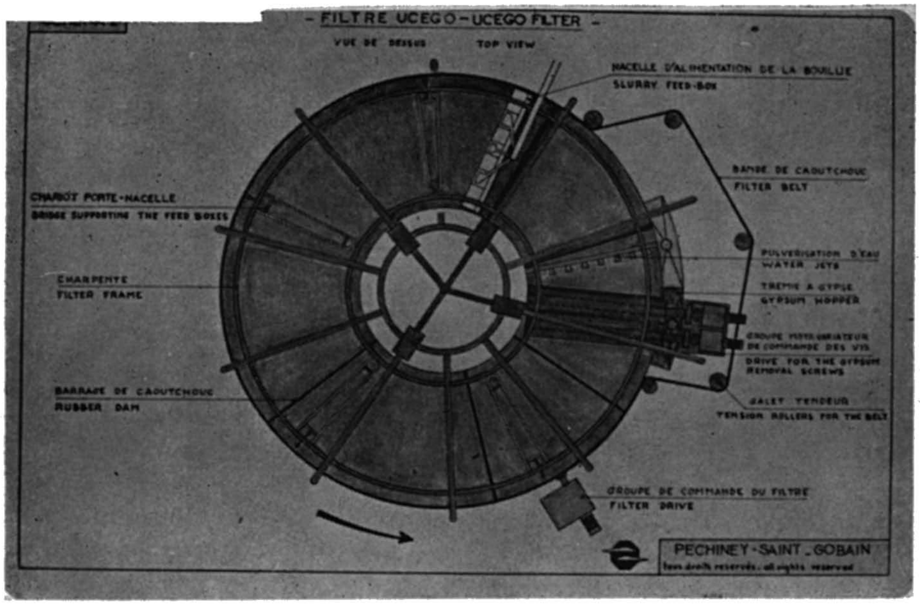
Slide 1 gives a general view of the filter, showing the filtration table and the vacuum box.

In particular, it can be seen that:

a. the filter rests entirely on the supporting rollers, placed under the filtration table (no risk of splashing).
b. the outer framework only supports the feed boxes and the gypsum removal screw.
c. splashes and leaks, if any, are recovered in troughs and returned to the reaction section.
d. each of the trays is divided into three parts with three openings.
e. the bottoms of the trays have steep slopes.

Slide I.
Cross Section





Slide II.
Top View

f. the drains also have steep slopes.

g. the connection between trays and vacuum box with flexible pipes allows the raising of the moving part of the vacuum box without dismantling.

h. the rubber belt is positioned to hold back the slurry (shown on left).

On Slide 2 can be seen the rubber belt surrounding the filter, and moving away just before the gypsum hopper.

It is thus possible to remove the gypsum and to wash the cloths thoroughly.

The bridges supporting the feed boxes are on roller tracks. They enable the feed boxes to be moved into position quickly and easily.

The slurry feed box is situated just behind a dam for control of liquid level.

The screws for the removal of gypsum and the watersprays for the washing of the cloths are shown at the right.

Slide 3 shows the various parts of a filter pan. There is a succession of three pans forming a radial tray.

We can see:

a. the steeply sloped bottom.

b. the supports of the perforated plate located according to the lines of maximum declivity.

c. the removable perforated plate, held by screws (a single plate for the three pans, forming a tray).

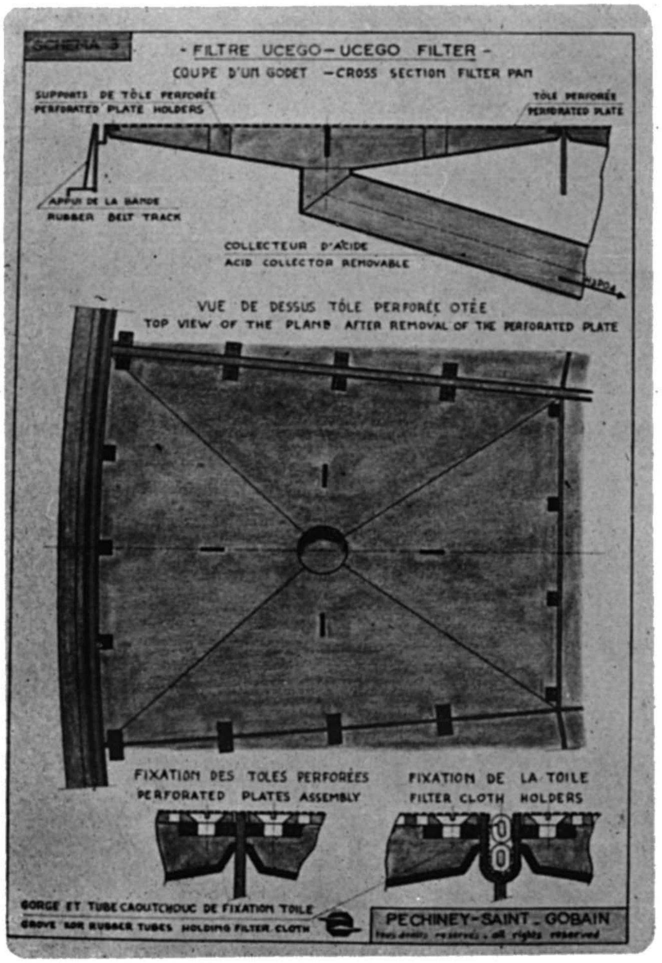
d. the supporting plate of the rubber belt.

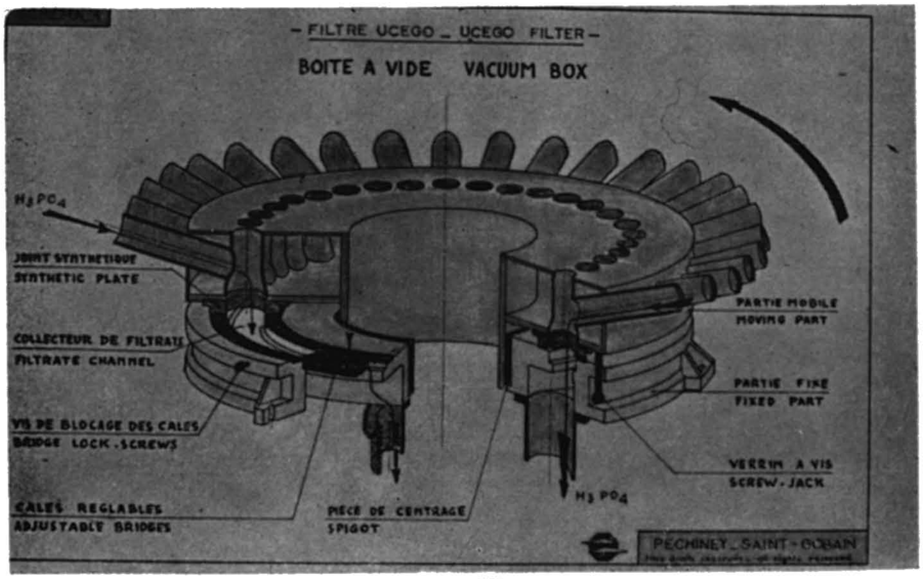
e. the grooves to hold the cloths.

On the small diagram, bottom right, can be seen the system for holding the cloths. It consists of two rubber tubes which are fitted into the grooves provided, and which grip the cloths. As there is no air blowing under the cloth, this system of holding is very efficient and quick. It takes an average of ten minutes for a trained operator to replace the cloth.

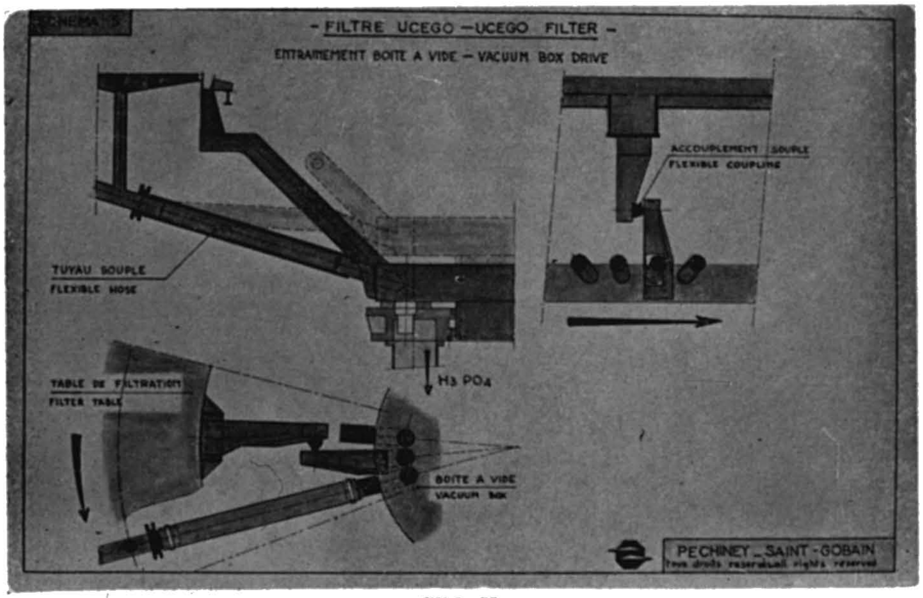
The small diagram, bottom left, shows the junction of two consecutive trays. It can be seen that the filter cloths cover two trays (in order to limit their number) but that each tray has its own perforated plate held by screws. The trays are therefore independent of one another from the standpoint of vacuum.

Slide III.
Cross Section of a Pan

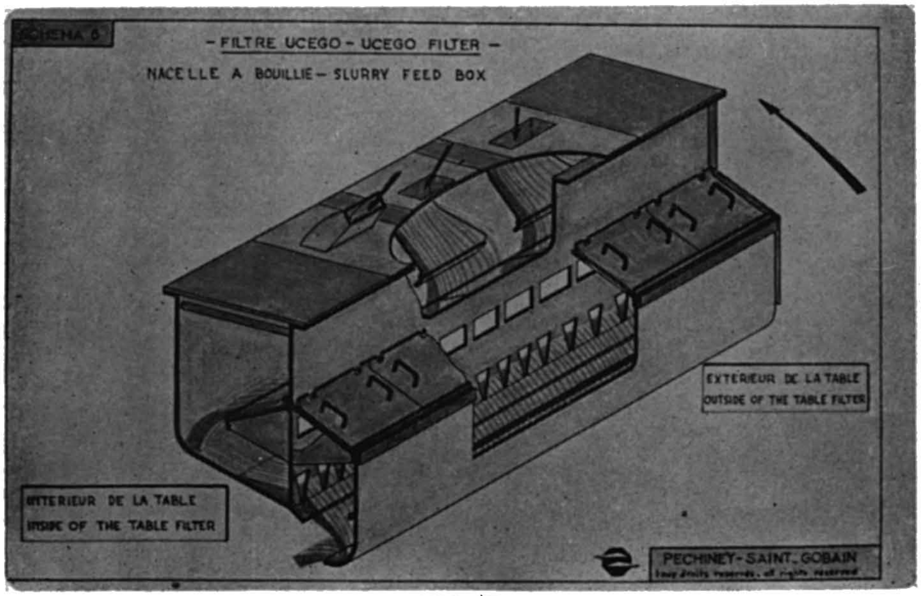




Slide IV.
Vacuum Box



Slide V.
Vacuum Box Drive



Slide VI.
Slurry Feed Box

On Slide 4 can be seen:

a. the entrance of acids in the moving part of the vacuum box.
b. the filtrate reception channel in the fixed part of the vacuum box. This channel is divided into several sections by fixed partitions. The size of the sections may be altered by moving the adjustable bridges or steps.
c. the removal of the acids from one of the sections to the corresponding separator.
d. the joint of plastic material.
e. the centering ring made of the same material.
f. the two removable friction rings on the fixed part.
g. one of the three screw-jacks to lift the moving part.

Slide 5 diagrams show that the vacuum box is entirely independent of the filter table.

The only links with this table are the filtrate pipes and the drive system. The filtrate pipes are flexible pipes which insure the drainage of liquids without any mechanical strain. The drive system consists of rubber stop-pins set on arms (generally three) which are part of the table and touch arms attached to the vacuum box.

One can see that the two parts are completely independent of each other.

Another advantage of the rubber stop-pins is that the three arms work in unison, whereas if the connection were rigid, only one working arm would be used.

In the diagram upper left, the upper part of the vacuum box. when in raised position, has been indicated by dotted lines. This shows that this operation is possible without dismantling other parts of the filter. Three screw-jacks on the fixed part of the vacuum box are used for this purpose.

We can thus easily examine the inside of this box, clean it if necessary, or, change the position of the bridges.

Slide 6 shows all the care which has been taken to insure an even distribution of slurry over the whole width of the filter table.

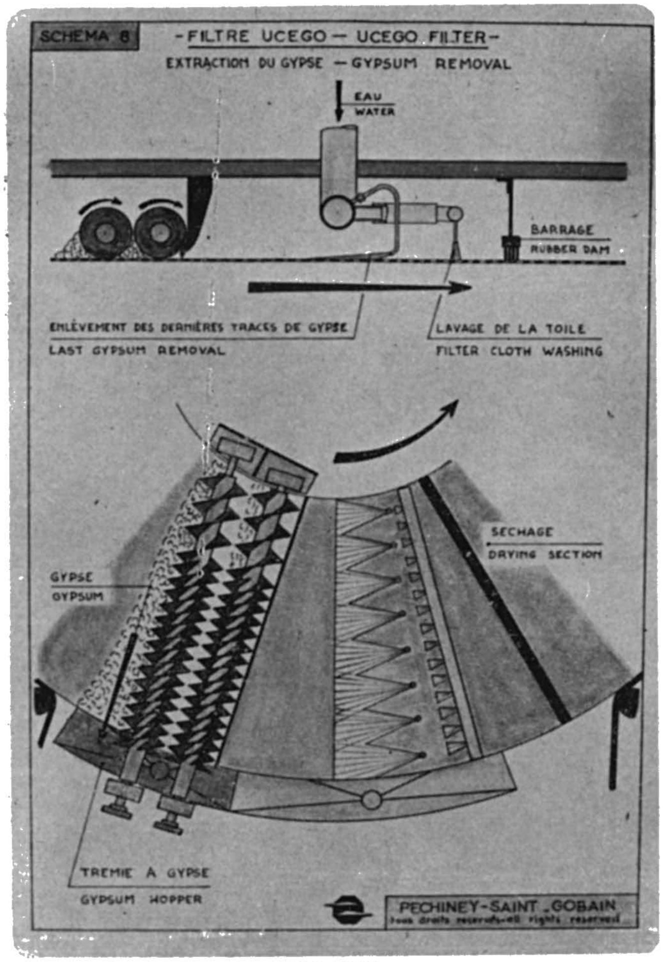
We would point out again that this width can vary from 1 m. (filter No. 1) to 4 m. 850 cm. (filters Nos. 10 and 11).

For these great widths the following arrangements have been provided:

1) The flow of slurry is divided in thirds and reaches the feed box through three pipes.
2) It is distributed by three deflectors beneath the feed box entrances.
3) It is then distributed again into a continuous deflector.
4) Next the slurry stands at a certain level in front of triangular outlets, which insure a distribution proportional to the distance from the center of the table (more openings on the outside of the table than on the inside).
5) Finally, the slurry is spread on a rubber drip-flap which breaks the force of the slurry jet in order to create a completely level cake. The rubber drip-flap also forms a first barrier, which prevents the slurry from escaping from the part under vacuum. In this way it works with the watertight barrier preceding the feed box.

The rectangular openings are overflows which are only used if the lower openings are blocked, in order to prevent the slurry from overflowing and falling outside of the filtration table.

All these deflectors are movable, to allow easy cleaning of the feed box.



Slide VIII.
Gypsum Removal

In the acid feed box Slide 7, great care has been taken to channel and distribute the washing liquids and to eliminate turbulence.

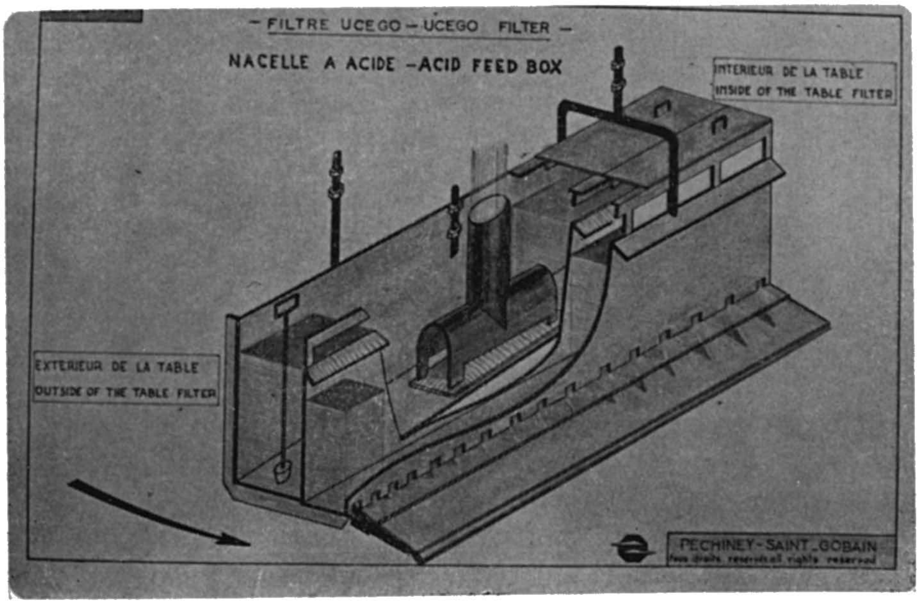
In large filters the flow of liquid is very great. It may reach, in the case of filter No. 11, more than 200 m3/h.

The acid feed box therefore has two compartments; a settling compartment and a distribution compartment. The settling compartment is designed to still the incoming liquid. In it a T-shaped manifold redirects the vertical flow into weaker horizontal flow. The distribution compartment, fed from the preceding compartment by overflow, has large openings along its lower edge. These are sized to establish a certain liquid level within the compartment. It is thus possible to have a flow proportional to the distance from the center of the filter by proper distribution of the outlets. A rubber drip-flap insures the streamlined flow of the liquid onto the surface of the cake.

The settling compartment slopes towards the outside of the filter, and possesses an opening for drainage. It is thus extremely easy to clean this compartment. The distribution compartment has an overflow outlet in the unlikely event that the lower openings should ever be blocked.

We would point out the ad-

Slide VII.
Acid Feed Box



vantages of a system whereby the liquids pass through openings low down as opposed to a system of overflow. For the latter system it is vital that the feed box be perfectly horizontal, otherwise the liquid will be poured on one side of the filter only. And if this level position is easy to achieve for one position, it is very difficult to obtain for every other position of the feed box.

With our system, any inaccuracy in positioning will result in only a very slight modification of flow (the normal height over the openings is 15 to 20 cm.) which will have little effect on the distribution.

This diagram, Slide 8, is self-explanatory; we shall therefore spend little time on it.

We would point out, however, that there are the two cloth-washing manifolds, the first of which is designed to remove the last layer of gypsum and to carry it to the hopper, and the second to thoroughly wash the filter-cloth. The sprayers of the first manifold are adjusted so that their jet is almost tangent to the table, while those of the second manifold have a jet which is perpendicular to the cloth.

Because of these adjustments, much of the water sprayed onto the table passes through the cloths and may be recycled onto the filter (it is possible to recycle about 60% of the water used).

The washing section is separated from the drying section by a rubber dam.

Drying is by suction of air through the cloth.

4) - Industrial Installations and Performance

This filter is the result of many years of experience in the field of phosphoric acid manufacture. Many types of filters have been used in our company, starting with drum filters, then continuous belt filters, traybelt filters, and tilting pan filters. Each of these has its own advantages and disadvantages.

We would have liked to have found, already on the market, a filter possessiong all the advantages of these different filters, but of course none of the defects. Being unable to find this "rare bird," Pechiney-Saint-Gobain decided to build its own filter.

The first filter was very modest in size: 7.3 square meters of effective area. It had been made small on purpose, so that it might always be used to full capacity. In this way we became fully aware of its capabilities.

It was installed in a plant having two production lines, each of 50 t/day of P_2O_5. It should be fed by either of the reaction tanks and could also be fed in parallel with either of the other two filters using the same slurry. One of these was a traybelt type and the other a tilting pan type.

The performances achieved have been summarized in the table (slide X).

Slide X

Ucego Filter

A few performances of a Ucego filter: Characteristics of filter #1.

Filtering surface: 7.3 m^2; total surface: 10 m^2

Phosphate slurry feed obtained by the UCB. P.S.G. single-tank process

M° of Campaign	Raw phosphate used	Conc. of product acid in % P_2O_5	Eff. Prod. Per 22h in tons P_2O_5	Spec. prod. in tons P_2O_5 per M^2 per 24h	Duration of campaign
1	Marocco 75	27	68	10.20	1 month
2	Togo	31	66	9.85	2 months
3	Togo	33	58	8.65	4 months
4	Togo	35	47	7.00	5 months

The effective products mentioned in the table relate to 22 hours operation per day. This begins, up to the present, the duration of manufacture in compliance with usual working methods of the other filters in the plant where the campaigns were conducted.

These figures should be increased by 20 to 50% for cases where the same phosphates would be used ground.

By comparison, the specific productions of the two other filters fed with the same slurry (No. 1 on Slide X) were:

5.9 t. P_2O_5/m2 per 24 hours with the traybelt filter.

5.3 t. P_2O_5/m^2 per 24 hours with the tilting pan filter.

Furthermore, it must be noted that the traybelt filter had caused practically no dilution of the finished acid (less than 0.25%—which is the same as the UCEGO filter), while the tilting pan filter caused a lowering of strength of 2.3%.

The specific production obtained with the slurry No. 4 on Slide X was:

4.3 t. P_2O_5/m2 per 24 hours with the traybelt filter.

It was not possible to use the

Slide XI

Ucego Filter

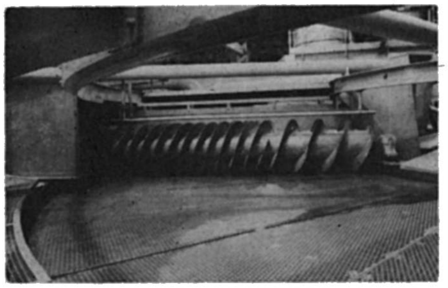
Types of Ucego Filters and References

Filter M°	Filtering surface in sq. meters	Outside diameter in MM	References
1	7.3	4.200	1 in service since 1963 1 in construction
2	13.0	5.300	
3	20.0	6.400	
4	30.0	7.600	1 in service since 1965
5	35.0	8.200	1 in service since 1966 1 deliverey 1 in construction
6	45.0	9.900	
7	55.0	10.800	I in service since 1966 1 in construction
8	75.0	12.300	
9	95.0	13.700	
10	115.0	15.400	
11	135.0	17.250	

tilting pan filter for this slurry, because the strength of the acid would go down from 35% to 32%.

The small UCEGO filter was installed in November 1963. It has been in permanent use since that date and continues to give satisfaction to its users.

Since that time many filters have been constructed, or are at present under construction. A list of them is shown on Slide XI which also indicates the different models planned.



Slide XII

Slide #12 (Gypsum Removal) Screw used to remove gypsum from table.

In conclusion, we would like to point out that the improvements this filter shows in the production of phosphoric acid can be successfully applied to other fields where filtrations are necessary.

Moderator Spillman: Thank you Mr. Boutan for reading Mr. Roubinet's excellent and most interesting paper covering "The UCEGO Filter." We have a question in the center front isle.

Mr. Samuel Strelzoff: I would like to be more sure about what you said that the capacity of the filter was. I don't know whether anybody here can represent "Tilting Filters." I would like to be sure your filter can do twice as much as the "Tilting Filter." What will be the price per square meter or per square foot as compared with other filters? What kind of filter cloths are you using? I am not too sure that the evacuation of gypsum by the screw is an innovation. This has been done before. Frankly speaking this may not be as attractive a feature of your filter as the titlting filter because I don't know whether you could wash off the filter cloths after the screw possibly has left some of the material on the filter cloths.

Mr. Roubinet:

1. Specific productions given in this conference have been expressed in metric tons of P_2O_5 per square meter of effective filtering surface per 24 hours.

2. In the present case, a UCEGO Filter size #1 with an effective surface of 7.3 m2 produced 10.20 tons of P_2O_5 per square meter per 24 hours. With the same slurry (see figure #10), and expressed in the same way, the productions of the traybelt filter and of the tilting pan filter were 5.9 and 5.3 tons per m2 per 24 hours respectively. This is indeed a little more than ½ of the specific production of the UCEGO Filter.

3. The price of a USEGO Filter is approximately the same as that of other filters of equal effective surface. Production being equal, this implies about a 40% savings for the user.

4. We use on our USEGO Filters, filter cloths made of polyethylene monofilaments. Polypropylene monofilaments were not available in France until very recently and we are now testing them.

5. The removal of gypsum by means of a screw is not a new idea. What is new, however, is to have replaced the fixed side of a filtering table by a moving rubber belt. It is because this belt can be pulled away from the side of the filtering table that it is possible to remove the greatest part of the gypsum from the table. The gypsum which remains is usualy washed away by the first bank of water jets. The second bank of water jets is used to completely clean in depth the filter cloths. The effectiveness of these water jets is excellent and for the next cycle of filtration the cloths are perfectly clean and dry.

Moderator Spillmans Mr. Roubinet and Mr. Boutan will be with us during the remainder of our meeting. Those of you who wish more information please contact these gentlemen. They will be extremely happy to answer your inquiries.

We will now adjourn for a 15 minute coffee break.

Moderator Spillman: We have two discussions on bag filling equipment, conveying, stacking and loading methods. First we will hear from Donald O. Myers, Manager Packaging Systems Dept. RaymondBag Co. and Charles T. Stewart, President, Stewart—Glapat Corp. In addition to the paper they will narrate a movie showing different methods of bagging, conveying, palletizing and storage for remodeling existing plants and modern suggestions for new installations.

Mr. Myers: Thank you Mr. Spillman. We have several short films on two conveyor systems we would like to show you today which demonstrate the highly efficient managements which can be provided. We will comment on components and systems during the showing of the films and will be happy to answer questions on completion of our discussion.

Mr. Stewart has been designing and manufacturing specializing custom materials handling systems for about 30 years.

Materials Handling In Fertilizer Plants

Donald O. Myers and Charles T. Stewart

OUR purpose is to support your efforts to reduce the cost of handling bagged product in both large and small fertilizer plants.

The fertilizer industry is a mass production business with a need to operate as a job shop customer service. Studies conducted by many engineering and cost analysis organizations consistently indicate that one of the largest areas of unnecessary loss in many types of industries, and particularly in the chemical fertilizer industry, is in the materials handling functions. During 15 years of extensive work with fertilizer companies throughout the country we have found materials handling efficiency levels in a large percentage of plants varying from 40% to 60%. The cost of this low efficiency level increases every year. As bulk handling increases and the percentage of product shipped in bags decreases, the need for improved efficiency in this area becomes even more essential.

The first and most basic rule for improved bagged product handling efficiency is to keep the packing machines running as continuously as possible. The second is to select bagging equipment providing a production rate commensurate not only with total daily production needs, but customer service requirements as well.

Analysis of the causes for the major portion of these materials losses indicates two prime contributing areas. The first is losses due to product analysis changes, and the second is time lost in changing from loading one carrier to another.

Production downtime between product analysis will vary from two to as much as seven minutes. At an average of only three minutes for the many plants where as many as 30 to 40 changes are made in a single day, this amounts to an hour and a half to two hours of the production shift loss. This results in increased cost per ton packed of approximately 15 to 25% for all labor, supervision, and plant and building depreciation.

Carrier loading lost time amounts to twelve minutes for each unit in a great many of the operations throughout the industry. At a bagging rate of 20 units per minute, and 600 bags per carrier load, or 30 minutes loading time, an average of five minutes per truck load amounts to an additional increased cost per ton packed of 15% In many plants these losses amount to as much as 30 and 40%. We do not believe these losses are necessary. We do not believe the fertilizer industry can continue to support these low levels of efficiency as labor rates continue to increase and customer service demands increase at the same time. Decreased availability of the seasonal labor required in many fertilizer plant operations for this type of work also is adding to the problems created by low efficiency levels.

There are definite answers to these problems. During the past several years we have been discussing the advantages of considerably increased filled bag storage facilities in all production ranges of plants. With proper planning, increased filled bag storage areas will greatly reduce the number of product changes during the shipping day and also will contribute to increased efficiency at the loading dock. In some instances, we have been told that increased filled bag storage areas are out of the question and cannot be considered. The present trends in labor and service needs require very serious consideration of increasing capacity of these storage areas. Increased filled storage does not necessarily mean provision of complete new warehouse buildings. Even asphalted ground areas, with shed roofs of tarpaulin covers can be used for this purpose. In some cases, the storage of empty bags in outside areas with tarpaulin covers will make present empty bag storage areas available for filled bag storage, and in some cases will result in the paper being in better condition for bag strength than is the case in the inside empty bag storage conditions. In plants producing 20,000 to 30,000 tons of product per year, and bagging 300 to 600 tons per day, filled bag storage areas for a minimum of 2,000 tons of product should be provided. In addition to practically eliminating product changes not planned by production management, this minimum storage capacity will extend the packing season, and provide productive work for those rainy days when packing crews have been asked to report for work but no customer trucks show up. Planned product changes require considerably less time than changes made for customer convenience. The filled bag storage facility will eliminate the one, two, and as many as four changes sometimes required in the loading of a single customer's truck. These small lot orders will be bagged at the convenience of the production facility and stored, with shipments made up of small lots being drawn entirely from this storage. In most cases, it is possible to direct the customer truck to a loading area other than that directly connected to the bagging facility. If a filled bag storage cannot be located adjacent to the bagging area, then filled bags should be power conveyed to the storage area and carried either by pallet loads on fork trucks, or power conveyed back to the loading dock as needed.

Those few analyses which are the largest movers during any particular season should be loaded directly off the bagging system by a conveyor system designed so that at least two, and preferably three truck loading spots can be fed from each bagging station. Accurate mechanical count control combined with a conveyor system which delivers bags one at a time at the stackers waist height, and at the point where they are to be stacked, permits one man to finish off one truck while the second prepares to load the next. The bags may be automatically switched from delivery to one truck to delivery to the next, without as much as one bag production being lost at the packing station. If no truck is available, or if there is need to change product analysis but some product remains in the screening or bagging system, then bagged product would be diverted to a palletizing station until all of the first analysis has been bagged, or a customer's truck is available.

In many palletizing arrangements we have seen, bagging stations must be shut down each time an empty pallet is required, and additional shutdowns occur awaiting availability of a fork truck to remove completed pallet loads. Fifty per cent efficiency loss is not uncommon in palletizing arrangements where these delays occur. A system which delivers bags evenly spaced, where empty pallets either are automatically selected and positioned, or where one is placed manually while another is being loaded, and a system which includes accumulation for filled pallets sufficient to assure availability of fork trucks will permit the packing station to operate continously. Units to automatically select empty pallets from a stack and deliver to the palletizing point, and units to move filled pallets to an accumulation conveyor are easily justified when a true analysis of the effect of low efficiency to cost per ton packed in inefficient palletizing operations is made.

Automatic palletizing is only beginning to come into the picture.

Special considerations of standardization of packages, as well as provision of protection against dust and corrosion, are required before successful application of automatic palletizing units will be obtained. Time does not permit complete evaluation or discussion of automatic palletizing in the fertilizer industry today. Serious study of this materials handling method will be increasingly important both to machinery manufacturers as well as the larger fertilizer complexes. Much can be done to improve palletizing efficiency short of automatic palletizing for those concerns wishing to expand filled bag storage, without incurring low efficiency in palletizing operations. Systems can be provided to assure no packing line down time, and at the same time to make the labor of loading pallets easy enough so that stackers can both maintain production rates and provide a solid, good stacking and good appearing pallet.

We have some short films on two conveyor systems we would like to show you, which demonstrate the highly efficient arrangements which can be provided We will comment on components and systems during the showing of these films and will be glad to answer any questions after the showing has been completed.

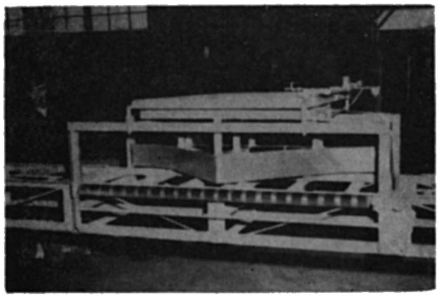
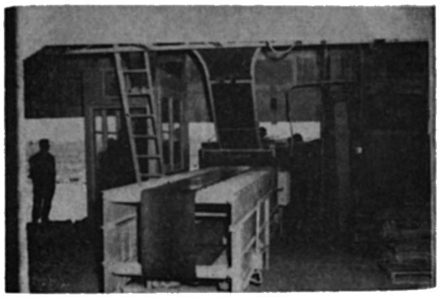


Figure 1
Two Way Bag Diverter.



Slide 2
Telescopic Truck Loader.

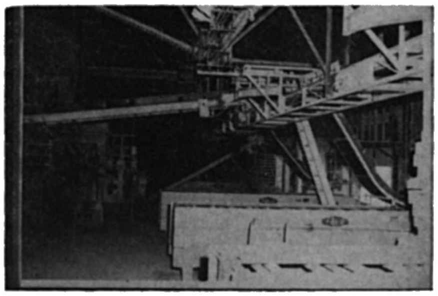


Figure 3
Overall View Conveyor System for 4 truck loading stations.

As shown in photographs, a two-packer producing facility should be equipped with a conveyor system permitting bag conveying from either packing station to at least three truck loading points. The photograph illustrates a four-truck loading facility where bags may be delivered to all four of the loading doors from each of the packers, or from each packing station to a common pallet loading point. The basic arrangement can be provided either with an overhead or floor level system.

Plants requiring production rates of six to twelve units per minute, where tonnage produced will not support multiple truck loading systems, still should convey product from packing station directly to point of stacking in the truck, or at the palletizing point. Photograph two illustrates a low head room, power traveling truck loader to deliver bags at the man's waist height at point of loading in truck or for palletizing. Where head room is not a problem, a similar open struss construction loader at one level is available at slightly lower cost. The lower the bagged production rate in a plant, the less that plant can support excessive labor for inefficient materials handling methods. The proper arrangements of packer, closing equipment, and materials handling equipment will permit these plants to pack, close, and load at rates up to 12 bags per minute with two men.

Following the basic principles of systems planning to keep the packer operating, systems can be designed for all levels of production to increase operating efficiency and lower cost per ton packed in the range of 30% to 40% in nearly every plant.

MODERATOR SPILLMAN: Thank you Mr. Myers and Mr. Stuart for your excellent suggestions on how to improve packaging, storing and loading for maximum savings.

MR. SPILLMAN: Our second discussion on packaging is titled "Force Flow Valve Packaging Systems Filling the Changing Needs of Fertilizer Packaging and User's Report" by John H. Dively, Marketing Manager, Industrial Packaging St. Regis Paper Co., and William F. O'Brien, Superintendant, Madison, Wisconsin plant, Royster Guano Co. This will be the last paper for this morning's session. The four gentlemen will be here this afternoon to answer your questions. John, please.

The Force Flow Valve Packaging Systems—Filling the Changing Needs of Fertilizer Packaging.

John H. Dively

I CERTAINLY appreciate the opportunity to again discuss with you a packaging development that has been perfected to help fill the changing needs of your industry.

Five years ago, I presented a new concept for warehousing that was designed to help you fill the need for improved customer service at lower costs. That system has since been adopted by many fertilizer plants. Then in 1964, I described a new fertilizer package to you — a multiwall bag that had one ply of plastic film in it to provide improved moisture protection for your high analysis goods and resistancse to acid attack from your so called "O" grade goods such as 0-20-20 and even triple super. Millions of those bags were used this past spring for fertilizer, and the film/kraft combination is rapidly becoming the "standard construction" for your industry.

Today, I'll be talking about another development of interest to you. It's not as new as the bag that combined film and paper in 1964 and perhaps not as revolutionary as the warehousing concept was in 1961, because upwards to 200 Force Flow systems are already ink operation in fertilizer plants in the U. S. and Canada.

Therefore, I am not going to introduce a brand new development to you, because the Force Flow Packer was originally developed for fertilizer back in 1959. Instead, I will be presenting a progress report which, I believe, is long overdue . . . a report which I trust will answer such questions as which of your needs does the Force Flow fill today and what needs will it fill in the future.
Let's check out the major needs one at a time.

1. Need to handle a wide range of packing rates.

As we all know, there is no such thing as a typical or standard fertilizer plant. Plant tonnage ranges all the way from less than 1000 tons to well over 100,000 tons per year. Force Flow systems have been designed, built, and are now successfully operating in the small, medium, and large tonnage plants at rates of 5 to 30 plus bags per minute in 50#, 66 ⅔#, 80#, and 100# sizes. The Junior Force Flow System was designed specifically for the Bulk Blenders. For the chemically combined fertilizer plants, the regular units are available in one, two, three and four tube models.

2. Need to pack a full range of the basic types of fertilizers, analyses, and materials.

Here again there is no such thing as a typical or standard fertilizer. Collectively, you men in this room are packing pulverized, semi-granular, 100% granular and pelleted goods, plus bulk blended products. In addition, many of you are packing basic ingredients such as triple super, potash, ammonium phopshate, ammonium sulphate, ammonium nitrate and urea. Force Flow systems are already working on all of these.

3. The need for bags that provide adequate product protection.

You cannot afford to use any filling machine regardless of how efficient it is unless it turns out filled packages that provide the performance you *and* your customers need — at your mill, in your warehouse, on your shipping dock, in transit, and in your customer's storage or on the farm.

Force Flows can and are packing valve bags of every construction currently available in open mouth, both paper and all-plastic, as well as the paper plastic combination. Most Force Flow operators are using pasted valve bags because they have no needle holes to let moisture in or sift product out: they handle and stack better than sewn bags; and they can provide identification on six sides as you see on the bags shown here.

4. The need for Minimum Labor

With the Force Flow systems, weighing is automatic and valve bags are self-closing. Therefore, only one operator is required, even at rates of 30 bags per minute. The operator's only task is to place the empty bags on the filling tubes. Nothing could be more simple.

The Force Flow utilizes a completely new concept in fertilizer packaging. Its design is based on simple pneumatics — in fact, it is a completely pneumatic machine using high pressure air for its controls and low pressure air for the actual packing operation. It has no high-speed rotating or reciprocating parts at all.

Now, I'd like to show you what it looks like and how it works.

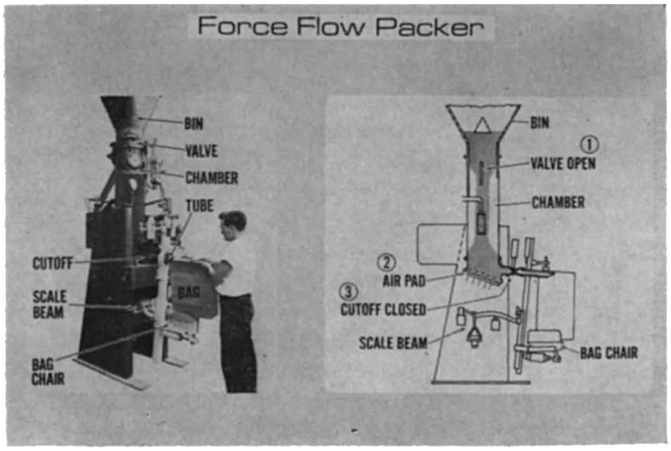
On the left side of slide "A" there is a photo of a single tube Force Flow. Starting at the top and working down, we see: the lower portion of a bin and a butterfly type valve operated by an air cylinder. Next is the pressure chamber, the filling tube with an empty bag applied to it, and the cutoff device that controls flow of product into the bag. Below that is the scale beam and finally the bag chair.

On the right hand side is a schematic that shows what is actually happening internally between filling cycles. The butterfly valve (1) at the top of the chamber is open so that the product can flow by gravity from the bin into the chamber. As the chamber fills, low pressure air is introduced into the product through a porous air pad (2) at the bottom of the chamber. The cutoff device (3) between the chamber and the bag is closed.

At the left of slide "B" we have the schematic that was shown on the previous slide of the packer when it was not filling a bag.

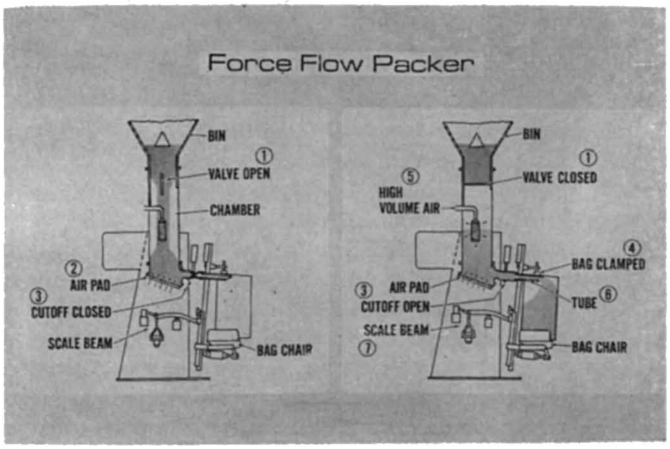
The schematic at the right shows what happens when the bag is fully applied and we start filling a bag.

Slide A



Force Flow Packer

Slide B



Force Flow Packer

- Chamber is sealed at top by closing the butterfly valve (1)
- Cutoff device (3) at filling tube opens and bag is clamped (4)
- High volume of low pressure air enters chamber from top (5)
- Chamber pressure increases and product flows through filling tube (6) into bag.
- When the correct weight is reached, the beam (7) reacts and it signals the control circuit to close the cutoff; release the clamp; and discharge the filled bag . . . all automatically.
- Another empty bag is then placed on the tube and the cycle is repeated.

Now I'd like to show you a two minute film of one of these systems in operation. It is a 4-tube unit installed at Valley Nitrogen, Helm, California packaging 80-pound bags at rates in excess of 30 bags per minute.

1. Overall Shot — At Rest

The installation consists of the packer, the operator's seat, bag conveyors, and air supply. It replaced an open mouth sewing line that turned out 16 to 17 eighty-pound bags per minute with a three man crew.

2. Overall — Operating

The operator sits on a seat in front of the packer. Empty bags are stacked beside him. As you see here, his only task is to place empty bags on the filling tube — everything else is automatic. The operation is simple, clean, and provides maximum reliability. Each filling head is a separate and independent machine. Should one unit become inoperative, the other three units can still be operated.

3. Close-Up of Hanging Bag

This shows the ease with which bags can be applied to the filling tubes. When a bag is fully applied, it contacts a small lever that is connected to the control circuit. This automatically starts each filling cycle.

4. Close-Up of Tube & Clamp

This is a close-up view of the tube, the bag clamp and the cutoff device. They are operated in correct sequence by the pneumatic control circuit. The operation is very clean. This is a typical of these systems across the country.

5. Bag Discharge to Conveyor

The filled bags are automatically discharged to a 36″ wide conveyor. Here again we see there is no spill or dust and that valve closure is excellent. With this system, fertilizer is weighed in the bag as it is packed which eliminates the need for complete cleanout and delivery of preweighed charges.

6. Bag Transfer

The filled bags are transferred to a conveyor system for delivery to the warehouse, the truck loading dock, or the rail siding.

They normally operate at 30 to 32 bags per minute but while this shot was being taken, the operator put on a little show and ran at 36 per minute by the stop watch.

It is my pleasure now to introduce to you Mr. William F. O'Brien, Superintendent of the F. S. Royster Guano Company plant at Madison, Wisconsin. Mr. O'Brien's plant has been using a St. Regis Force Flow system for almsot 2 years, so he can give you first-hand information on results.

St. Regis Force Flow Systems-User Report.

William F. O'Brien

Thank you, John.

Gentlemen, I am sure you will all agree there is no such thing as a static industry. As man moves forward, all industry must keep in step, and ours has come a long way.

To illustrate, I would like to very briefly describe what has happened in our own company over the years.

When the Madison plant went on stream in 1947, all of our mills were equipped with new valve packers — the St. Regis belt type 160-FB, which was in our opinion, the most efficient packaging system at the time .

In those days, we were producing only pulverized fertilizer; and we shipped all goods in 80-pound sewn valve bags with an asphalt laminated moisture barrier ply. The highest complete analysis we manufactured then was 3-12-12, which contained 27 units of plant food.

That's the way it was done in those days. Since then, we — like most of you — have made dramatic changes.

Today we are a 100 per cent granular plant. Currently, our highest complete analysis is Bonanza 8-32-16 — or 56 units of plant food. In the late 1950's we switched to pasted valve bags and PE coated paper in place of sewn bags with asphalt paper. We added a bulk loading station and 2 years ago we installed a St. Regis 4-tube Force Flow Packer. Along with this, we upgraded our warehousing operation. Then last year we started using bags with a ply film in them.

These are some of the ways in which our company has kept in step with a progressive industry.

With progress, of course, comes change. And as the needs of our sales department changed, we in production had to change.

As sales increased, we found ourselves faced with the problem of either building more shipping mills or increasing production in our three mills with the 160 FB's on them.

Now as a firm rule, we make every effort to keep a step ahead of the sales boys; but I think we actually gained a *couple* of steps on them when we installed the Force Flow. It has done an outstanding job for us.

We were already operating the 160 FB's at 16 to 18, and sometimes 20 bags a minute. St. Regis told us this was the absolute tops those packers could turn out; and, in fact, they said it was better than most operators were getting from the 160's.

A 4-tube Force Flow, they said, was guaranteed to produce 25 bags a minute, with some customers reporting as many as 30. In addition, we were assured that with the Force Flow, our efficiency and weights would be improved and maintenance reduced. All of this could be had with no increase in labor and bag costs.

So we decided to go the Force Flow route on one mill.

Now, what has our experience been?

Since the 4-tube Force Flow Packer was installed in late December of 1964, we have packed over 80,000 tons with it, and I can say without qualification that its performance has exceeded the guarantee in all aspects.

For example, we were guaranteed 25 bags a minute. In actual operation, we regularly maintain 25 eighties (80's) a minute; and on occasion we hit 29. On the 50's we regularly maintain a rate of 34 a minute and have actually reached 43 a minute for brief periods.

In order to achieve those rates, it is important to have both quality bags and competent operators, of course. We are fortunate to have both.

The next point is efficiency, and this is somewhat more difficult to define. It is important to achieve a high packing rate per minute; but with actual tons bagged per hour or per day, along with labor cost per ton is the real measure of efficiency.

How has the Force Flow improved our efficiency?

1. It offered higher instantaneous packaging speeds.

2. It eliminates filling tube plugging that is sometimes troublesome on the 160-FB units.

3. There is less operator fatigue with the Force Flow, even though he is handling more empty bags a minute.

4. It offers a dust-free operation for a better working environment. In addition, there is little bag breakage or spillage to cause clean-up problems.

5. The Force Flow enables us to run a well-managed warehouse. To achieve maximum daily tonnage, it is important to hold grade changes down to a minimum. Since we regularly pack approximately a ton a minute when the Force Flow is operating, 30 minutes of accumulated delays during a day for grade changes would mean that we have 30 fewer tons to ship. Here, our warehouse makes a significant contribution to overall efficiency by drastically reducing lost time due to needless grade changes.

6. Last, but by no means least, is our improved output per man-hour.

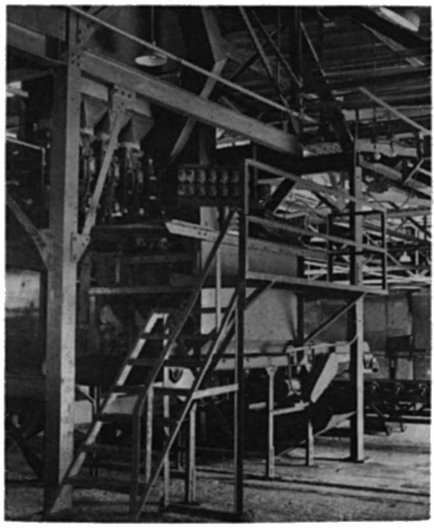
Today, we are producing as many tons a day with the Force Flow and one crew as we formerly produced with two shipping mills and two crews. In other words, daily operating with one less shipping mill for bagged goods .

Now, with regard to weight accuracy, let me say this. We have found that the Force Flow gives very uniform and constant weights. Once it is set at a given weight at the start of a run, only a very sensitive checkweighing scale can detect any weight variation between bags. As a result, each time we change grades or net weight, we checkweigh filled bags from each tube, reset the poise weights on the packer, if necessary; and then only periodically check filled bags throughout the run.

As far as maintenance on the Packer is concerned, costs have been extremely low. We have spent only $136.55 for replacement parts in approximately 2 years. However, I might add that we feel strongly about preventative maintenance and consider it one of the major components of a truly efficient plant. There-fore, the unit is checked and greased on a regular basis.

Now to illustrate the work we are doing with the Force Flow, I would now like to show a few slides to you.

Description of Slides



Slide 1

Slide No. 1 — This slide shows our installation: Near the top is the lower portion of our bin and below that is the 4-tube Force Flow; the operator's seat and the conveyors. It is very similar to the setup that was shown on the film a few minutes ago.

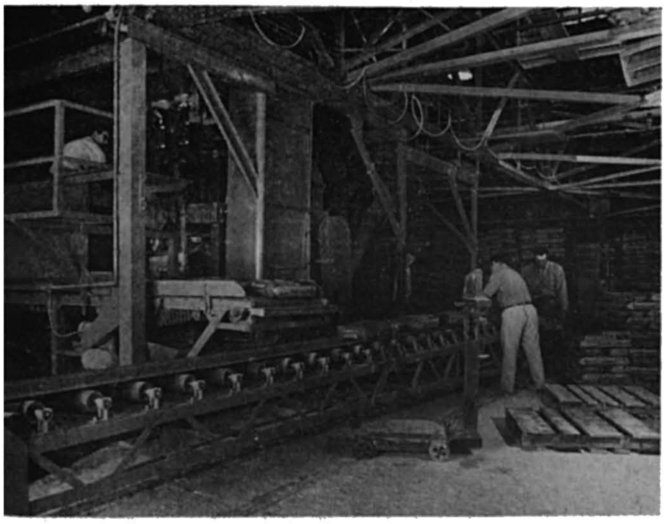
Slide 2

Slide No. 2 — This slide shows our operator. Notice how with one hand he easily applies an empty bag to the packer and with the same motion energizes the start lever.

Slide No. 3 — Here is our system in operation. Filled bags are transferred on a 36″ wide conveyor from the packer to a 20″ reversible shuttle conveyor. The shuttle conveyor serves both trucks and our palletizing station. At the same time this shot was taken we were loading pallets.

Slide No. 4 — This is a closer view of our palletizing operation. Empty pallets are placed along the shuttle conveyor where two men load them. The pallets are loaded complete, one at a time. Then the men move to the next one. This shot is typical of our 50-pound palletizing.

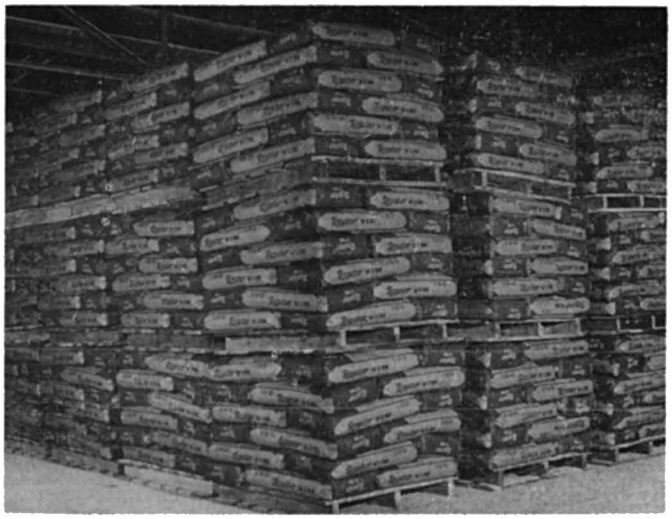
Slide No. 5 — We pack both 50-pound and 80-pound bags and currently stack them on 42″ X 42″ pallets. We use a 4-bag pinwheel or chimney pattern for 1-ton loads. On 50's we go 10 high high as shown on the right; on 80's we stack 6 high with the 25th bag in the chimney. When we first started palletizing we packed only 80-



Slide 3

Slide 4

Slide 5



Slide 6

Slide 7

pound bags and adopted the 42″ square pallets. 50's did not come into large usage until last year. So far in 1966, approximately 70 per cent of our shipments have been in 50's. Our present pallet was acceptable as long as only a few 50's were sold, but now we are redesigning our pallets for more efficient palletizing and warehousing of 50-pound bags.

Slide No. 6 — This is a shot in our warehouse of palletizied 80-pound bags tiered three high.

Slide No. 7 — This last slide, also taken in the warehouse, shows both 50's and 80's. Since we must palletize the 50# bags ten high on our present pallets, they can only be double tiered. This is why we are redesigning our palletizing methods for 50's.

That, gentlemen, is a low-cost, high-efficiency operation at work and the Force Flow is making it possible.

MODERATOR SPILLMAN: Thank you, John Dively and William O'-Brien. Your discussion covering "The St. Regis Force Flow Packaging system" was thouroughly understandable and will be useful information. This concludes our morning session. The topic "Screening" left off this morning will be discussed this afternoon. Thank you. Meeting adjourned. Please report promptly at 2 P.M. for the afternoon session.

Thursday Afternoon Session, November 3, 1966

The Round Table reconvened at 2:00 P.M.

Joseph E. Reynolds, Moderator, presiding

MODERATOR REYNOLDS: It is my pleasure and privilege to be your Moderator this afternoon. As was indicated this morning, we are going to be slightly off schedule but we will do our best to make up the time and still keep the program effective.

We had one subject which was left off the morning program. We will start at that point. The speaker who will start the festivities needs no introduction to this group. He is Mr. Round Table as far as we are concerned.

Wayne King of W. S. Tyler Company will make the opening remarks on the subject of Fertilizer Screening and Classification. He will be assisted by his associate Stephen J. Janovac.

Screening-Classification

Wayne King and Stephen J. Janovac

WAYNE KING: Thank you Uncle Joe. What a nice looking bunch. How about that? Thank you for inviting me. My discussion will be very short. My associate Stephen Janovac, will give you a thorough paper on screening and classification.

It would be trite to wish this Round Table less than success because this is one of America's best known units of technical knowhow information exposse! Likewise, you all have had a reasonable success in your own business or you would not be here.

I have been requested to discuss vibrating screen capacities with some emphasis on the relation of screen width to screen length.

Well now — Basically width governs tonnage capacity and length relates to accuracy or efficiency of separation. Obviously, we compromise to some extent with these factors. We may attempt to be precise; but variable factors alter individual installations, plus frequent structural limitations.

Now — any two surface operations is a compromise. However, for our own granular fertilizer problem two surface does offer some serendipitous dividends, such as a salt shaker feed from first to second deck and avoidance of a heavy deep slug of material at feed end of fines removal screening medium. Alternately, single surface has other advantages known to all of us as deck accessability. Here we always balance out the cost of each which should be apparent with increased headroom needs for single surface.

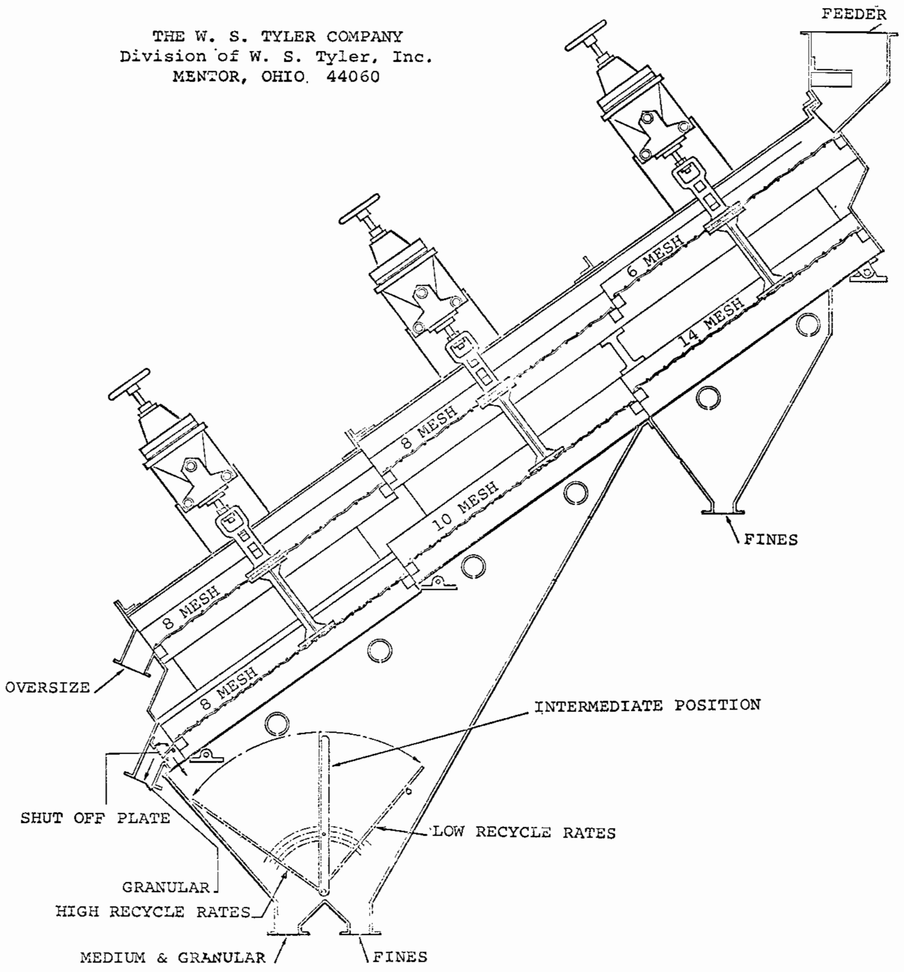
You will need to have considerable faith in the engineers of your own choosing plus their willingness to adhere to known factors and information regarding the screening art.

Now I wish to introduce my associate Mr. Stephen J. Janovac, one of our principal application engineers from Ohio, and a good one. Steve.

STEPHEN J. JANOVIC: Thank you Wayne: Mr. chairman and friends. Wayne and I appreciate the opportunity you have given us today to discuss screening, etc. We hope our papers and discussions will be useful.

The Tyler Hum-mer Screen is a unique device of simple, rugged construction which acts as a dry classifier and screen. The classifier action is brought about by the rapid opening and closing of the bed of feed material in such a manner that the finest particles work to the lower strata and the coarset particles are on the upper strata. The wire surface acts as the medium to separate the stratified bed and in operation the finest of the particles are separated at the feed end while the near-mesh sizes are separated at the discharge end. In other words, as the coarser the separation becomes.

Fertilizer screening is unique in screening installations, and fertilizer classification involves a processing control operation in addition to physical sizing Since fertilizer granulation varies from grade to grade, and with various raw material composition and equipment configurations, it is extremely difficult to select a single screen cloth for product sizing and recycle control. Because of this the Tyler Company suggests a screening arrangement which permits size and process by an adaption of the basic Hum-mer unit. This unit is designed to separate the oversize and to make a variable separation of the intermediate or



Slide 1

product size dependnig upon process requirements, and this is done by the use of an adjustable gate coupled with the careful selection of the second surface wire cloth. (As Slide #1) Restated, this device is designed to yield, after coarse separation, product size granules, everyone of which is larger than any re-cycle particle.

The second slide shows a comparison of two methods for regulating recycle, one by the proposed system and the other by a conventional system screening at 14 mesh for product and recycling a portion of this product. Examining this table you will observe that the Tyler System separates a very closely sized product while concomitantly recycling smaller sized granules, whereas the conventional arrangement tends to separate the less uniform product even though practically one mesh size product is possible at high product recycle ratios. The recycle stream contains large product size granules, a practice which is essentially self-defeating since such particles tend to become oversized on the next cycle, overloading the mill and creating more dust.

The third slide was presented at this same meeting in 1964, and indicates the NPK distribution by particle size and indicates the wide variation in analysis in the 6 to 8 mesh range, and in the 12 to 16 mesh range, but at the same time indicates a close chemical control in the 8 to 12 mesh fraction.

Slide 2

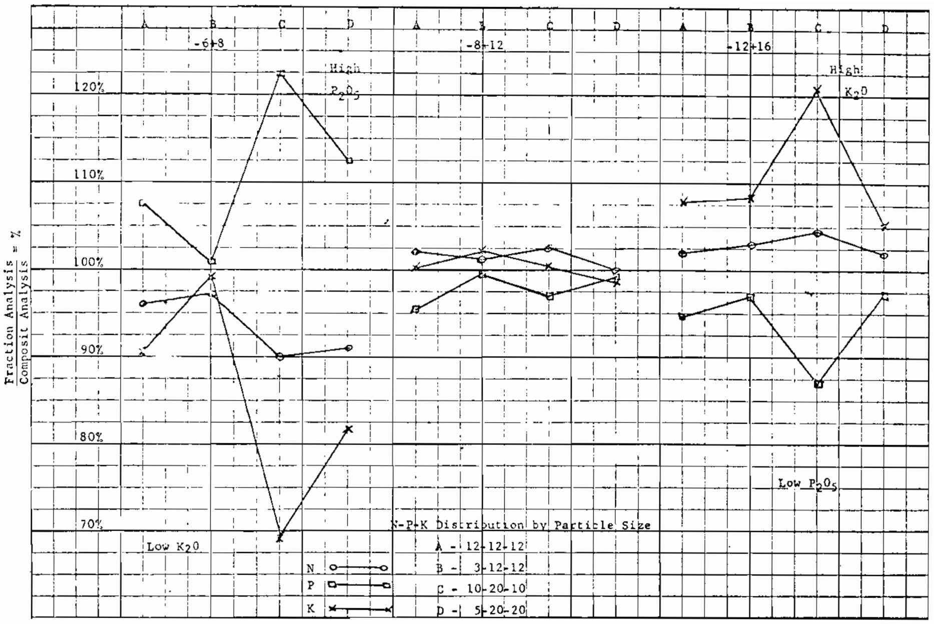
		Tyler System				Conventional System			
Tyler Mesh	Feed* % Cum.	⅓ Recycle Product	Ratio Recycle	1/10 Recycle Product	Ratio Recycle	⅓ Recycle Product	Ratio Recycle	1/10 Recycle Product	Ratio Recycle
+8	10	30		100		20	4	20	9
+10	30	90			22	60	14	60	27
+14	50	100	25		44	100	25	100	44
+20	70		55		67		55		67
−20	30		45		33		45		33

*Assumed

Now perhaps we have oversimplified the issue for the sake of brevity but we did state that practically one mesh size is possible at high recycle rates. Practically speaking, high recycle products would have a more realistic analysis of a trace to 2% +8 mesh and 98-99% +12 mesh, assuming an 8x12 mesh product. The significance of this is an absence of +6 and +8 mesh material in the product and a relative absence of coarse material in the recycle.

In order for this system to function as conceived, it is necessary to have screen cloth openings which will permit control in the area regulated by the adjustable gate. The screen surface not controlled by the gate should be selected to prepare a product with minimum specifications or with a wire cloth to yield a 14 or 16 mesh product if this is the minimum product required. We have found, through experience, that final selection of wire cloth at the discharge end on the second surface can generally have the same opening as the same position on the top surface and in some cases even slightly larger. Failure to have sufficiently large openings will cause the gate to be placed in the extreme positions instead of a floating position where the recycle can be trully controlled. And again the first slide graphically illustrates the selection of the wire cloth and the relative positions of the gate at the extreme and intermediate positions which would be determined by the amount of recycle required at a specific time.

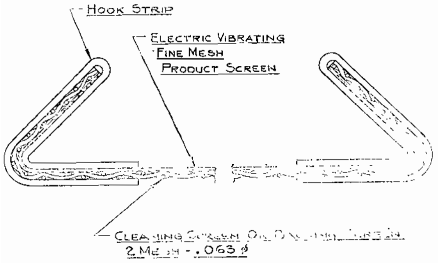
Further recovery of a maximum amount of near-size -6 and -8 mesh material can be improved by the use of retarding curtains for use on the last 10' of the top surface of a classifier screen. Since the vibrator has to be adjusted for optimum vibration on the second surface, the relatively light load on the top surface is overly active. However, the retarding curtain holds close to the screening medi-



Slide 3

um the slight oversize, thus optimizing the opportunity for the near-size -6 or -8 mesh material to pass.

While generally the gravitational forces imparted to the wire cloth are extremely high and ordinarily sufficient to keep the cloth free and open, there are upset conditions resulting in wet materials that subsequently blind the wire cloth. This can be combated by the use of half-sandwich screen sections, Slide #4, where there is a coarse 2 mesh .063 Steel backing cloth in the same set of hooked edges as the facing cloth. This backing cloth has a different resonance of vibration and, therefore, slaps the facing cloth, relieving the blinding and maintaining a free and open condition for the screening medium.



Slide 4

Moderator Reynolds: Thank you very much Wayne and Steve. I'm sure that there will be some questions later on in the program. We will move along to our afternoon session as established officially here by our program.

Our next speaker comes to us from England. We are very fortunate to have him here this afternoon. We all recognize the worldwide distribution of fertilizers by Imperial Chemical Industries. We further recognize the tremendous amount of development work and research effort that they have put into fertilizers. We feel that they have really spent a lot of time on developing high-quality products and I think the record stands by itself.

Our speaker this afternoon is Mr. Michael D. L. Alton who has been active in the development area of the I.C.I. Compound Fertilizer Process. He is also active in the licensing of the process and he is fully familiar with the technicalities of what makes the process click. Without further comments, I will turn the program over to Mr. Alton.

The ICI Compound Fertilizer Process

Michael D. L. Alton

Mr. Chairman and Members of the Round Table, we thank you for inviting us.

Introduction

A GOOD compound fertilizer process can produce various combinations of nitrogen, phosphates and potash to suit the requirements of the crop, the climate and the soil. In this respect the flexibility of the ICI process is a considerable advantage.

It can be argued that a wide range of combinations of plant foods can be obtained by mixing together the separate components in powder form but dry mixes of fertilizers of various grain sizes in powder form do not spread on the land easily or uniformly. Such mixes are liable to segregate in storage and in transport and compact into solid masses when stored either in bulk or in stacks of bags.

To overcome these difficulties, ICI developed its process to produce the plant foods in the form of free-flowing, uniform, non-caking granules. The compounding of the fertilizer ensures that it not only spreads or drills uniformly but that the plants get the proportion of nitrogen, phosphates and potash which they require. A special treatment is given to the granules to prevent them caking under normal conditions of storage in bulk or in bags.

Development of the Process

ICI first introduced a range of granular compound fertilizers containing ammonium sulphate, ammonium phosphate and potash in the early 1930's. These products contained more plant food units than the traditional compounds based on superphosphates. They proved very popular with the UK farmers, who appreciated both the handling and storage advantages obtained with a free-flowing granular fertilizer and the savings in handling costs achieved by the increased plant food concentrations.

Although compound fertilizers based on ammonium sulphate represent a great improvement on the traditional fertilizers, they have the disadvantages of relatively high cost and low nitrogen-content. The sulphate radical in ammonium sulphate is of little value except for sulphur deficient soils and therefore in every ton of fertilizer there is a large unwanted portion which has to be produced and paid for usually as sulphuric acid. The manufacture of nitrogen as ammonium nitrate requires, however, no major raw material except ammonia, likewise the manufacture of urea requires ammonia and, of course, carbon dioxide, a by-product of ammonia manufacture.

For nitrogen concentration, ammonium sulphate containing 21%N compares unfavorably with ammonium nitrate with 35%N and urea with 46%N. The use of components with low nitrogen content affects the cost of the fertilizer products, because the unwanted diluent carries with it extra manufacturing costs for sacks, packing, transport and handling and also increases the farmers' own storage and handling costs. This is best illustrated by the plant food units achievable for 1:1:1 compounds which are 13.5:13.5:13.5 with ammonium sulphate, 17:17:17 with ammonium nitrate and 19:19:19 with urea.

Ammonium sulphate is now often replaced in commercial compound fertilizers by ammonium nitrate and in some cases by urea. Urea has the great advantage of higher nitrogen concentration than ammonium nitrate but in temperate climates urea has definite disadvantages. The investigations made at the ICI Jealott's Hill Research Station in 1963* showed that, where fertilizers containing more than about 15% of urea are combine drilled with cereal seed, a retarding effect on germination is found in some soils and in some weather conditions because of the hydrolysis of the urea to form free ammonia. This hydrolysis is assisted by moist conditions and is most pronnouced in calcareous or alkaline soils. When compounds containing high urea content are top dressed losses of ammonia occur in moist weather due to hydrolysis. These disadvantages limit the quantity of urea which may be used in compound fertilizers for use in temperate climates.

For certain tropical crops, for example for rice grown in irrigated paddy areas, it is well known that ammonium nitrate gives worse results than urea because soils under irrigated conditions tend to reduce the nitrate form, which is harmful to plant growth.

During the last 15 years ICI has designed and installed plants at Billingham* and Severnside and for their associates at Belfast, incorporating ammonium nitrate as the primary nitrogen contributor instead of ammonium sulphate. Work has, however, been done on the semi-technical and on the full scale to ensure that this process can be adapted to make urea based compounds.

The ICI process was evolved to manufacture compounds with N/P_2O_5 ratios unattainable if ammonium sulphate were used, thus the Severnside plant was designed in 1961 to make 22:11:11 using ammonium nitrate, ammonium phosphate and potash, and was commissioned in 1963 for this purpose. The NPK granulation plant at Billingham designed by Messrs. Dorr-Oliver to use ammonium sulphate as its main nitrogen constitutent was adapted to the new process during the course of 1964. This allowed ICI to make a range of the more concentrated ammonium nitrate based fertilizers as well as, if need be, the popular sulphate based fertilizers.

Range of Formulations Made By The ICI Process

The following table gives the range of standard fertilizers made by the ICI process at Billingham and at Severnside.

Typical formulations containing urea for growing such crops as rice in irrigated areas are:-

	% N	% P_2O_5	% K_2O
2:1:1	26	13	13
1:1:1	19	19	19
1:1:0	27	27	0

In tropical or sub-tropical regions with high rainfall and for acid soils with high humus content, it is possible or even advantageous to replace the water soluble ammonium phosphate with ground phosphate rock, e.g. containing 37%P_2O_5. A plant designed by

Table 1
ICI Fertilizers based on Ammonium Nitrate

Component Ratio	Code No.	% N	% P_2O_5	% K_2O
3:1:1	No. 6	25	9	9
2:1:1	No. 2	23	11½	11½
1½:1:1	No 4	20/21	14	14
1:1:1	No. 5	17	17	17
1:1:1½	No. 1A	15	15	21

* Capacities of Plants.
ICI Severenside 200,000 tons/year (1 stream)
ICI Billingham 300/350,000 tons/year (2 streams)
Richardsons Belfast 140,000 tons/year (1 stream)

Table 2
ICI Fertilizers based on ammonium sulphate

Component Ratio	Code No.	% N	% P_2O_5	% K_2O
1½:1:1	No. 7	15	10	10
1:1:1½	No. 1	12	12	18
1:2:2	No. 3	10	20	20

The following table gives other compounds based on ammonium nitrate and/or ammonium phosphate which can be made by the ICI process.

Table 3

Component Ratio	Code No.	% N	% P_2O_5	% K_2O
1:2:2		11	22	22
1:3:0		16.5/17	47	—
1:2:1		14.5	29	14.5
1:4:4		6	25	25

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*Urea as a fertilizer — Ammonia Evolution and Braiding of Wheat by G. C. Mees and T. E. Tomlinson, J. Agric. Sci. (1964) 62, 199.

ICI for the Chemical Company of Malaysia Limited* will shortly be making the following formulations: -

% N	% P_2O_5	% K_2O	% MgO
11	11	4	3
11	18	4	3
15	7	13	4

Before proceeding to describe the steps in the ICI process and the developments we are making, the advantages of the process are briefly summarized as follows:-

1. Solid ammonium sulphate can be eliminated as a separate component. It may be convenient, however, to add a little sulphate as a diluent by neutralizing sulphuric acid with ammonia if a fertilizer with integral percentages of N. P_2O_5 and K_2O are required, e.g. 22:11:11 instead of 23:11½: 11½.

2. A very wide choice of formulations to suit all crops, soil types and climates can be made on the same basic plant, e.g.

(i) Full range of N/P_2O_5 ratios from 10:40:10 to 25:9:9.

(ii) P_2O_5 water solubility of 95%, which enables maximum response on potatoes or sugar beet to be obtained.

(iii) Replacement of part or all of the ammonium phosphate by the cheaper ground phosphate rock for crops on acid (particularly tropical) soils where water solubility of the phosphate is not considered essential.

(iv) Choice of urea for tropical crops or ammonium nitrate for temperate climate crops as the main source of nitrogen.

3. The very high ICI standards for handling and freedom of flow both before and after storage are maintained.

For example, the products are all in the form of well-shaped granules in the size range 1.5 to 3.5 mm. which is best suited to modern fertilizer spreading machinery. There is no dust to give nuisance or loss while spreading the fertilizers on the land. The products remain free flowing after storage for 12 months or more in bag stacks of 40 high 50 kilo sacks.

4. The products are not liable to self-sustained decomposition which causes trouble with certain other kinds of fertilizers containing ammonium nitrate.

Stages in The ICI Process

An outline flowsheet of the ICI fertilizer process includes the following steps (C.27206).

Plant View (W.84490).

1. Nitric acid (preferably at least 55% HNO_3) is neutralized at atmospheric pressure with gaseous ammonia and then concentrated in special low hold-up evaporaters to give 95% ammonium nitrate liquor.

The absence of equipment holding any substantial quantities of ammonium nitrate liquor with strength in excess of 90%, together with adequate automatic control assures safe operation. (W.86207).

2. Wet process phosphoric acid (made from any of the ordinary commercial phosphate rocks) is concentrated to 35-45% and then neutralized to the required mixture of mono and di - ammonium phosphates in the saturators. (W.84985).

3. Concentrated ammonium nitrate liquor, ammonium phosphate slurry, potash and recycled fertilizer product of controlled size grading enter the paddle mixer or blunger at controlled rates and are granulated together. The correct design of equipment to handle the rather sticky mixtures met with nitrates or urea-based compounds is very important for the successful operations of the process.

4. The moist granules from the mixer are dried to the requisite low moisture contents necessary to give the products excellent handling properties. (W.75087).

5. The dried granules are screened to give a product stream and a recycle stream. The oversize component of the recycle plus sometimes part of the product stream is crushed with a swing hammer type of mill. (W.51643).

6. The product stream is cooled and then coated, in accordance with the methods designed by ICI, to give a free flowing product. (W.84228).

7. All gaseous and liquid effluents are treated to ensure complete absence of nuisance from dust decomposition, fog formation or river contamination. An internal dedusting system ensures dust-free conditions for the plant operatives.

The more important factors in producing high quality granular fertilizers will now be considered a little further.

The granulation stage is probably the most important of the process and must be performed well for successful operation of the whole plant.

Granules are produced in the blunger partly by a layering and partly by an agglomeration process in which particles of recycle material and the feed new materials are cemented together by a paste of soluble fertilizer salts. The extent of granulation is directly proportional to the amount of solution phase present (consisting of the water present plus the soluble fertilizer salts dissolved in it). This means that the greater the amount of solution phase, the larger the average size of granules produced. ICI has determined particle size gradings for a range of solution phase contents for a wide range of compound fertilizer formulations.

Fertilizer solubility measurements have been done in the presence of a large excess of solid — to represent conditions occurring in the blunger. This information enables the solution phase at any moisture content temperature to be calculated. Solubility and consequently the amount of solution phase is markedly dependent on temperature and formulation. For example 22:11:11 and 15:15:21 which contain ammonium nitrate are more soluble than 12:12:18 which contains ammonium sulphate as its principle nitrogen constituent.

At normal granulation operating temperatures and conditions the amount of solution phase is eight times the amount of water present in the 22:11:11 formulation, is four times the amount of water present in the 15:15:21 formulation, but is only twice the amount of water present in the 12:12:18 formulation. Consequently, the moisture contents required for the 22:11:11, 15:15:21 and 12:12:18 leaving the blunger are in the ratio of 2:4:8.

Another important factor which influences the amount of solution phase required for optimum

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*Capacity 208,000 tons/year (1 stream)

granulation is the particle size of the solid feed to the blunger. The larger the particle size of the feed, the less solution phase is required to make the particles grow to product size.

The moisture content required for the fertilizer materials leaving the blunger is dependent on the moisure content of the feed constituents and the amount of dried fertilizer recycled to mop it up.

The normal water content of ammonium nitrate liquor fed to the blunger is about 3-4% but this depends on evaporation, size and pressure of steam available.

It is well-known that MAP is less soluble than mixtures of mono and di-ammonium phosphate. An eutectic exists for 1.4 NH_3/H_3PO_4 mol. ratio at the normal neutralizer operating temperature of 110°C. with a moisture content of the saturated solution of 17% With the standard two stage stirred neutralizers, the slurry moisture cannot usually be reduced below 14 - 16%, as it is essential to get steady flow conditions from the discharge launder to achieve steady granulating conditions in the blunger. Under these circumstances NPK fertilizers with high ammonium nitrate content such as the 2:1:1 formulation would require a recycle ratio of about 5-6 and formulations such as 1:1:1½ would require a recycle ratio of 3 - 4.

With pumped recirculation of the neutraliser contents, the moisture content of the mono/di-ammonium phosphate slurry can be reduced to 10 - 12% with much improved ammonia conversion and feed control to the blunger. Consequently the recycle ratios can be reduced by 25 to 30% and the outputs for a given solids loop (i.e. drying, screening and recycle) capacity are increased by a similar amount. Alternatively a smaller solid loop is required for a given plant output rate.

For some time ways of reducing ratios have been investigated in order to reduce the plant capital cost and reduction in the moisture content of the ammonium nitrate and ammonium phosphate constituents has seemed the likeliest method of approach.

Much work has been done by many concerns including T.V.A., Dutch State Mines, Fisons and ourselves on co-neutralization of phosphoric and nitric acids and subsequent evaporation of the liquor. It must, however, be remembered that granulation efficiency, i.e. the amount of material made in the blunger within the specified size range of 1.5 to 3.5 mms. often does not exceed 30 - 40%, hence recycle ratios of 2½ - 3 are needed to obtain sufficient product within this size range. Low moisture contents in the ammonium nitrate/phosphate melt coupled with low recycle ratios of, say 1/1, are thus unlikely to yield sufficient product of specified size continously.

Economies in drying are, however, likely due to the high blunger operating temperatures.

High ammonia efficiency is an important feature of fertilizer manufacture and scrubbers have usually been in the forefront of operators' mind for various reasons. ICI has installed the Aerotec type of wetted turbulent sphere scrubber on its phosphoric acid neutralizers at their Severnside Works with very encouraging results.

Fertilizer granules made in the blunger are soft and contain free moistures, so need drying to enable them to be transported and subsequently to be free from unacceptable caking tendencies. Fertilizer drying techniques have, until quite recently, let us admit, been rather imprecise, however this stage is now passed.

It is recognized that the drying rate of a fertilizer is proportional to its moisture content and to the differential vapor pressure between the fertilizer and the drying air stream.

One of the most important factors in drier design is the residence time of the fertilizer in the drier which is calculated from the mass transfer coefficient and vapor pressure. This is complicated because both of these vary down the length of the drier, since the moisture content is reduced down the drier and also some heat is lost from the drier shell. Drying is considered in a series of steps down the length of the drier and four differential equations are set up with residence time as the independent variable. These equations are obtained from heat and mass balances and rates of heat and mass transfer and are solved successively on our computer. The method we use is similar to the work published by Fisons in 1964* in the transactions of the Institute of Chemical Engineers, London. Residence time is related to permissible exit temperature of the fertilizer from the drier which may be governed by ammonia vapor pressure for fertilizers containing high N/P ratio ammonium phosphate or by softening temperature for fertilizers containing, for instance, urea.

Drier slope and power are obtained by standard equations.

It is usual to design driers with about 13% of the cross section filled in operation, which amounts to filling the space between the lifters, however ICI have increased the percentage fill with consequent improvement in drier output or reduction in specific drier size.

We also tailor our lifters down the length of the drier depending on the cohesiveness of material to be found successively down the drier length.

The use of urea or ammonium nitrate in compound fertilizers poses difficult material handling problems owing to the sticky adherent character of the mixtures before they are completely dried and cooled. These problems are overcome by ICI by careful attention to the detailed design of the equipment.

For instance the crushing of oversize has been a problem. The sticky nature of the products, at this stage uncooled and uncoated, may lead to rapid build-up on walls and moving parts of the crusher. By paying careful attention to the condition of the material entering the crusher, in particular to the need for adequate drying of the product and to adequate venting of the crusher, it is possible to use a commercially available crusher, such as the British Jeffery swing hammer type of mill.

Prevention of Caking in Storage

The anti-caking treatment given to the products of the ICI process is perhaps its most import-

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* Computor simulation of Rotary Driers by Sharples Clikin and Warner. Trans. Inst. Chem. Eng. 42 (1964).

ant aspect. In one test two sacks of ICI No. 2, one with and the other without anti-caking treatment, were stored for 12 months beneath a stack of 1 cwt. sacks 40 sacks high. The untreated material caked into solid masses whereas the treated material remained completely free-flowing and free from aggregates of granules. (W.84287 & W.84492)

Avoidance of Thermal Decomposition Risks

The presence of ammonium nitrate in compound fertilizers does not make them inherently unsafe, however attempts to break up fertilizers of this type, which have caked in storage with robust methods such as explosives must never be attempted.

It is well known that the decomposition of ammonium nitrate is catalyzed by the presence of chlorides thus all compound fertilizers containing ammonium nitrate and potassium chloride decompose or "fume off" if strongly heated. The decomposition results from the acidity which is developed at temperatures above 115°C. Such decompositions can occur in fertilizer plant driers if the material temperature is allowed to rise too high by mal-operation.

Reports have been made on a different type of decomposition in which large amounts of nitrate based fertilizer in stores at Frankfurt in 1961, at Cambridge (Maryland, U.S.A.) in 1963 and at Vlaardingen, Holland in 1963 at ambient temperature were decomposed after a relatively minor thermal initiation, such as an overheated conveyor belt or a buried electric light bulb. These decompositions are almost impossible to stop by normal fire fighting methods and are dangerous to health because the gases evolved contain chlorine and its compounds and oxides of nitrogen.

This second thermally initiated type of decomposition has been investigated by the Research Department of the Agriculture Division of ICI and has been fully reported in a paper by A. B. Parker and N. Watchorn.* to the Society of Chemical Industry in the U.K. They found that the decomposition of certain formulations of N.P.K. composed fertilizers containing ammonium nitrate and potassium chloride proceeds at a rate of 10 and 100 cms/hour if initiated locally by a standard method, in the manner of a slow burning fuse or burning cigar butt at temperatures of between 200 and 500°C. The decomposition is clearly shown in the photographs (Figures 1 and 2). (W.76906 & W.76903)

About 100 formulations of fertilizers have been tested. The work showed that the potassium salt in chloride mixtures has to fulfill two functions. A small amount of chloride provides the necessary catalyst. The major part of the potassium component simply provides a suitable solid matrix for burning. Simple N.K. compounds are not vigorous cigar burners but the addition of inerts such as kieselguhr converts them into fast "cigar burners."

The addition of ammonium sulphate to N.P.K. fertilizers invariably increases the capability of the "cigar burner" to burn. Dilute fertilizers containing a proportion of ammonium sulphate in place of ammonium nitrate may be "cigar burners" whereas the concentrated product of the same plant food ratio containing more nitrate and chloride may not.

A special study has been made of formulations consisting of ammonium nitrate, potash and fertilizer grade ammonium phosphate. It can be seen from figures 3 and 4 (C.27208 and C.27207) that formulations capable of undergoing "cigar burning" are restricted to a well defined area. The limited burning range of the ammonium phosphate based fertilizers is an inherent safety factor of this class of fertilizer for even in the centre of the region the maximum burning velocity is only about 15cms/hour.

Evidence is being assembled on the burning ability of N.P.K. fertilizer compositions made from single and triple super-phosphate.

It has been clearly shown by the large scale occurrences referred to earlier that the burning ability of fertilizer compositions based on water insoluble phosphates, such as di-calcium phosphate produced by the nitro-phosphate process, covers very much wider range of formulations.

Space prevents going into this very important subject to fertilizer manufacturers more extensively, but it must be stressed that the ICI fertilizers based on ammonium nitrate; ammonium phosphate and potassium chloride are much less liable to self-sustained decomposition than the corresponding nitrophosphate and superphosphate range.

Analytical Control

Control of product composition is in the fore front of all fertilizer production not only to keep within limits laid down by Statutory bodies such as the U.K. Fertlizer and Feeding Stuffs Regulations but also for efficient operation.

A noteworthy advance in this field has been the installation and development of the Technicon 'Auto Analyzer' for continuous automatic determination of plant food constituents. A full description of our work in this field has already been published in the Proceedings of the U.K. Fertilizer Society No. 79 - November, 1963.

Acknowledgment

I would like to thank my colleagues in the Agricultural Division of ICI for their help and assistance in the preparation of this paper.

MODERATOR REYNOLQS: We will open the floor to some questions. Mr. Alton, that was an excellent paper and it has a tremendous amount of detail. Thank you for this excellent presentation. Who has the first question?

MR. THEODORE M. ROSENBLATT: What is the pH of the fertilizers that you have? What is the range of pH's using a ten percent solution as a criterion?

MR. ALTON: It's a little difficult to answer that because I am not really familiar with that scale. Mr. Scaife might have a comment.

DR. SCAIFE: 5.5 to 6.

MR. ROSENBLATT: How much oil do you use for your conditioning.

MR. ALTON: Less than half of 1%.

MR. ROSENBLATT: Do you still

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* Journal of Food and Agriculture June, 1965. 16.355-368. A. B. Parker and N. Watchorn.

find that even with this pH you get significant losses with a urea base fertilizer?

Mr. Alton: I would think no. Not during processing, but losses can occur is some soils and some weather conditions due to hydrolysis of the urea to free ammonia.

Mr. Rosenblatt: You find not send the fertilizer ou with that mal decomposition with approximately ½% of oil?

Mr. Alton: No. It has never been traced. Otherwise we would not send the fertilized out with amount on.

Dr. Scaife: Can I just add a point about the urea-based compounds in place of ammonium nitrate? You have to control the temperature of the exit dryer at a lower figure than you do for ammonium nitrate-based, and it is, of course, preferable to have some diammonium phosphate at this stage, because this prevents the decomposition of the urea. So that with urea you work with a rather lower exit dryer temperature and with an ammonium phosphate-diammonium phosphate ratio of about 1.5.

Bill Weber: You mentioned briefly that you have testing techniques for predicting caking. Can you tell us the nature of these tests?

Mr. Alton: Yes. We have a specially designed machine where we take a standard sample of material and compress it so far and then apply pressure continuously and determine at what load the cake gives way.

Bill Weber: Could I ask you, Mr. Alton, whether you have tried or considered ammoniating to a higher mole-ratio in the blunger with the thought that, in the first place, it is more economical if you can scrub more ammonia, which is cheaper than ammonium nitrate; and with the other thought that by ammoniating in the blunger you get additional water evaporation and better granulation?

Mr. Alton: Yes, that is a very good question. We have, in fact, gone up to 1.6 nitrogen to H_3PO_4 ratios and it is largely dependent on your efficient scrubbing . With the installation of the Aerotec scrubber, I think we will be able to return back up towards those sort of figures.

Dr. Scaife: Well, to answer Bill Weber's question, I am pleased to see Bill here, we do not ammoniate in the blunger. If we do want to go to an NP of 1.6, we do it in the second saturator but we do no additional ammoniation in the blunger.

Member: Well, there is a disadvantage to doing it that way, because you have to go to a lower solids on the slurry. You are at a lower point in solubility. Whereas, if you stayed at your 1.4 mole ratio on your slurry and then ammoniated in the blunger, you would have a very much smaller water load on your dryer.

Dr. Scaife: Yes, I agree that the solids would be less but we have developed this new circulating saturator in which there is a large circulation in the saturator and the problems are not as great. We are ammoniating into the circulating stream in the saturator.

This also enables you to pump the ammoniated ammonium-phosphate slurry direct and measure direct the rate into the mixer.

Mr. Ed Sabin: I look forward to receiving the Proceedings because it is going to take a lot of study of your paper to digest it. However, reference was made to the fact that ICI Fertilizers tend less to this cigar-burning effect. I am sure that is not to save the English fire insurance companies money. What do you attribute this to? Is this a tendency to higher analysis fertilizers or just what is the reason that you can make a statement like that?

Mr. Alton: I think it is just that the cataytic effect is damped down and in practice the phosphate-ammonium nitrate type of mixtures do not support combustion.

Mr. Sabin: Is this an intended result on your part because you recognize the problem and you know how to control it, or is this just a happy circumstance, as it were.

Dr. Scaife: We are in ammonium phosphate-based fertilizers because we have the requirement of water solubility of P_2O_5 in the United Kingdom, thus we are away from the normal nitrophosphate type of fertilizers, and ammonium phosphate based formulations have the advantage of not being cigar burning except in a very restricted range. Thus we were lucky to be in this field of fertilizers. Nevertheless it is true that we do look at this very carefully and we have great difficulty in persuading our manufacturing people to even have a very, very low rate of cigar-burning fertilizer.

If we tell them that they ought to be manufacturing something that is getting onto the borderline of the curve that you saw, they show great reluctance to do this, even though this may be only a rate of a centimeter an hour of burning which you could easily deal with.

Mr. William Coates: This is not a question directed to the authors of this paper, but to one of the gentlemen who spoke this morning on handling of bagged goods. Has the system of skid back handling which ICI and others in the UK developed been used over here?

Moderator Reynoldss As I understand the question is related to polyethylene between stacks, say like, instead of pallets that we use here, the practice of using polyethylene sheeting. Is this a practice in the States? This is new to me. Is anyone here familiar with this in the States?

It is sure a good way to save the cost of pallets.

Mr. Alton: I would add a small point. We don't give the polyethylene sheeting away to the customer.

Moderator Reynolds: We have time for one more question.

A Member: Two more short questions in relation to product quality. What is the moisture content of the high-analysis fertilizers, and about how much and what type of this inert powder is required for conditioning?

Mr. Alton: This varies a bit, depending on the fertilizer. The high-nitrogen-content fertilizers, 2-1-1, usually contain about .25 to .3 per cent free moisture. The coating dust, again, will vary, but it will be somewhere in the region of two to three per cent, sometimes one.

Moderator Reynolds: Thank

you very much Mr. Alton and Dr. Scaife. That was an excellent paper and covered a tremendous amount of detail. I'm sure there will be some other questions that will come along later. If we have time, we will try to get these gentlemen back before the group and direct the questions to them. Of course, as you recognize, the information will be printed in detail in the proceedings.

Our next subject relates to sampling bulk materials. Ever since bulk fertilizers became a way of life here in the United States, this has been a continuing problem as to how we sample these materials.

Some of the state control people have frankly made statements that they can't sample, obtain an effective and a typical sample by going into bulk trucks or into bulk piles and come up with anything that is reasonable.

Today we are going to branch over into the Crushed Stone Association and see what they have come up with. We understand that they have had some of the same or similar problems as we have had in the fertilizer business. We are very fortunate today to have two speakers with us from the National Crushed Stone Association, Mr. Frederick A. Renninger and Mr. Frank P. Nichols, Jr.

Statistical Concepts Applied to Sampling Bulk Materials

Frederick A. Renninger and Frank P. Nichols, Jr.**

Introduction

Statistics, or statistical methods as they are ofttimes called, are playing increasingly important roles in almost all fields of human endeavor. The influence of statistics has spread to most branches of science and engineering, particular emphasis being placed on problems relative to data analysis, product or process quality control, acceptance sampling, and specification compliance.

The increased use of mathematically statistics has not come nor is it coming into being without the generation of a good deal of comment and confusion. Unfortunately, statistical methods of quality control and product acceptance are more easily applied to the production of essentially identical unit items like golf balls than to inherently variable bulk materials, like fertilizer or crushed stone. However, certain statistical concepts are applicable to bulk materials, and a thorough understanding and appreciation of a few basic fundamentals will greatly faciliatte the orderly acceleration of these applications.

What Are Statistics?

Statistics are numerical facts arranged in an orderly fashion to facilitate the making of decisions or deductions. In simple situations an intelligent individual should need no more than a simple array of the numbers to make the correct deduction as to their meaning, but as the complexity of the data increases, certain manipulations of the numbers must be done to prevent erroneous interpretations. To be able to perform these manipulations, one must understand certain elementary principles and concepts from the science of statistics, the science of probability and variability. The purpose of this paper is to review some of the more basic of these concepts — the normal distribution of results, measures of central tendency, measures of variation, and factors affecting the variability of results of certain measurements of quality. More specifically, reference will be made to the so-called "normal curve," to average or mean values, to the standard deviation of individual values from the mean, and to the coefficient of variation.

Basic Fundamentals of Mathematical Statistics

What is the so-called "normal curve?" Experience has shown that in most instances, if production is carried on with the proper care and accuracy the variations in product characteristics will be distributed in a "normal" pattern over a certain range. The characteristic bell-shaped curve representing a normal distribution of test results or product characteristics is a familiar image to most technical personnel. The curve is developed by plotting the number of times, or frequency, with which a given result is obtained against the magnitude of that result. Consider the following simplified example as a basis for defining and studying the normal curve, standard deviation, etc.

Imagine a pair of fair dice. By fair is meant that each of the six faces has an equal chance of turning up. Now consider the probability of occurrence of each of the combinations totalling two through twelve. There is only one way to roll "snake eyes" or "box cars," two ones or two sixes, respectively. There are two ways to roll a combination totalling three or eleven, a one on one dice and a two on the other or vice versa, etc. Likewise, there are three combinations for four or ten, four ways to throw a five or nine, five ways to roll six or eight, and six ways to "crap out" or throw seven. Thus, there are 36 different combinations of the faces of two dice which can appear. If only 36 rolls were made, some combinations, by chance, might not appear while others might appear twice or more, but if the dice were rolled an infinite number of times, the distribution would reduce to that predicted here by considering probabilities.

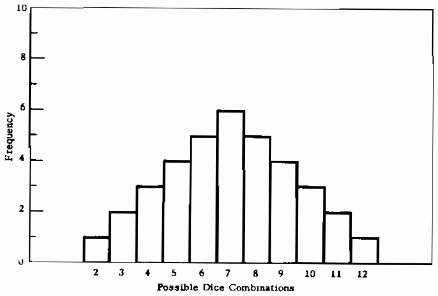

Figure 1
Probability Distribution For Fair Dice

Figure 1 illustrates graphically the numerical data cited above. The horizontal scale represents the characteristic measured, in this case the twos, three, fours, etc. which

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** Geologist and Assistant Engineering Director, respectively, National Crushed Stone Association, Washington, D. C.

Table 1

Calculation of Fundamental Statistics

Number (Dice Combinations) x	Frequency f	Wgt. Number xf	Deviation $(x - \bar{x})$	$(x - \bar{x})^2$	$f(x - \bar{x})^2$
2	1	2	-5	25	25
3	2	6	-4	16	32
4	3	12	-3	9	27
5	4	20	-2	4	16
6	5	30	-1	1	5
7	6	42	0	0	0
8	5	40	1	1	5
9	4	36	2	4	16
10	3	30	3	9	27
11	2	22	4	16	32
12	1	12	5	25	25
	$\Sigma f = 36 = n$	$\Sigma xf = 252$			$\Sigma f(x - \bar{x})^2 = 210$

$$\bar{x} = \frac{\Sigma xf}{\Sigma f} = \frac{252}{36}$$

$$\bar{x} = 7.0$$

$$\sigma = \sqrt{\frac{\Sigma f(x - \bar{x})^2}{n - 1}} = \sqrt{\frac{210}{36 - 1}}$$

$$\sigma = \sqrt{\frac{210}{35}} = \sqrt{6.0}$$

$$\sigma = \pm 2.4$$

($\bar{x}$, read "x-bar", is the arithmetic mean)

(σ, read "sigma", is the standard deviation)

turned up on the dice . In practice it might be the percent nitrogen, phosphate, or potash present in a given fertilizer or percentage passing the No. 4 sieve in a given crushed stone size, as indicated by different tests. The vertical scale represents the number of times each characteristic was recorded or, in other words, the frequency. If the individual segments of the histogram were connected by a smooth curve, the characteristic bell-shaped distribution would take form centering on the number seven. The arithmetic associated with this example is given in Table 1. The average, or arithmetic mean, is 7.0. In statistical rotation, the mean is represented by the symbol $\bar{x}$ (read x-bar). The average is a measure of the central tendency of a group of values. The normal curve, therefore, centers about its mean or average, in this case the value 7.0.

How much do the values recorded vary from the average or mean? Variation such as this is measured by the standard deviation, the coefficient of variation, or the variance. Consider first the standard deviation. What is it? How is it calculated? Technically, the standard deviation is the "root mean square deviation," a special form of average deviation from the mean. Actually, it is simply a method for the measurement in quantitative terms, of the variation of a group of values and nothing more than that.

The standard deviation is calculated as shown in Table 1. Here a new term, degrees of freedom, is introduced. Degrees of freedom may be defined simply as the number of independent trials needed before a definite conclusion may be reached. It is always one less than the total number of tests. As an example of this concept consider the old shell game — there are three shells, a pea under one of them. One need look under but two of the shells, to definitely locate the pea, for if it is not under the first two shells, it *must* be under the third.

Total Number of Objects
(shells) $= N = 3$
Maximum Observations
Needed $= 2$
Degrees of Freedom
$= N - 1 = 2 = \gamma$ (nu)

Having calculated the standard deviation (σ) as shown in the table, the distribution of results in the dice example may be represented by it and the average ($\bar{x}$) as 7.0 ± 2.4, with $N = 36$.

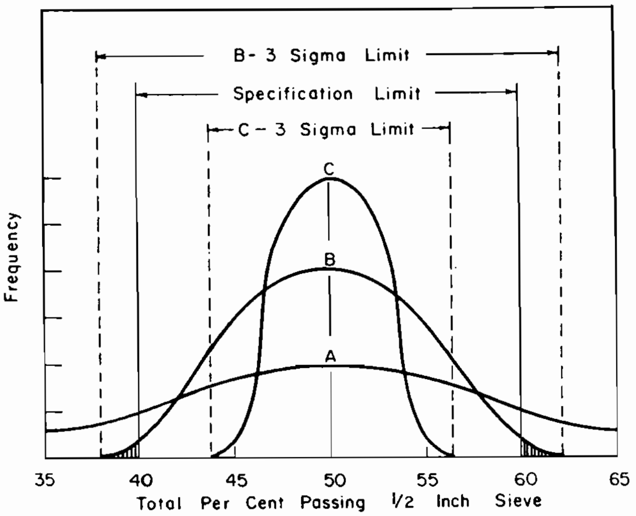
Now what is the significance of the standard deviation? If one were to move in either direction one standard deviation or 2.4 units from the average of 7.0 he would be located at values of 4.6 and 9.4. Summing up the number of times combinations between these limits were observed, that is, the number of times a 5, 6, 7, 8, and 9 were rolled, (see Table 1), one finds a total of 24 separate occurrences. Based on the total of 36 observations this interval of the average plus and minus one standard deviation includes two-thirds or about 67 percent of the observations. Moving out two standard deviations from the mean (2.2 and 11.8) all the data except the single occurrences of "snake eyes" or "box cars" are included. That is, 34 of the 36 observations or 94.4 percent of the results are included within this interval. All the data are included within the range established by the three sigma limits.

The dice examples used was a simplified illustration. Based on the normal laws, or by actually computing the area under the respective portions of the normal curve, it can be shown that —

$\bar{x} \pm \sigma$ would include 68.27 percent of the data
$\bar{x} \pm 2\sigma$ would include 85.45 percent of the data
$\bar{x} \pm 3\sigma$ would include 99.73 percent of the data

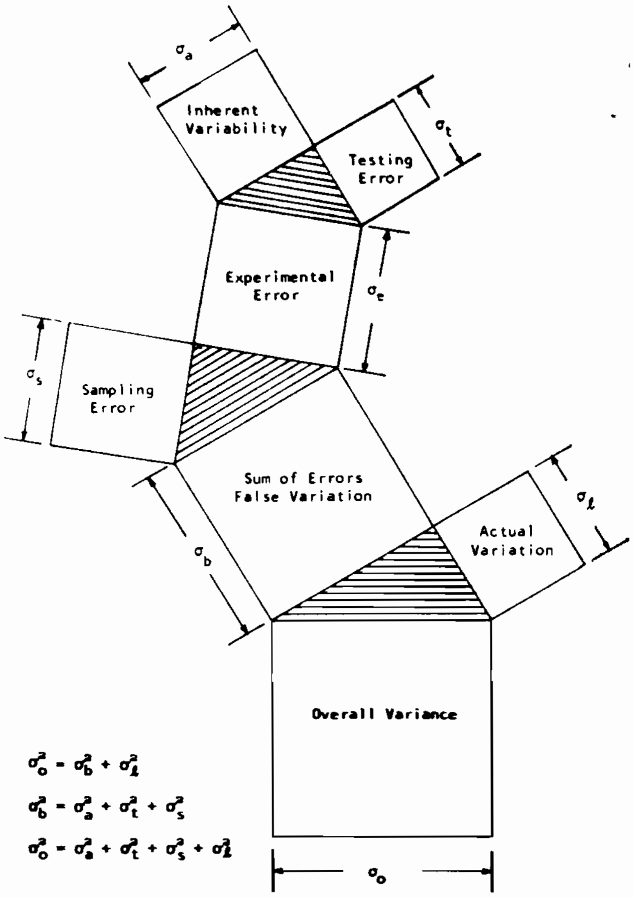
These relations are the major physical significances of the normal curve and the standard deviaation. All other uses of elementary statistics are based upon them .

The coefficient of variation (V) and the variance (σ^2) are also measures of the variation of distribution of test results or product characteristics. The coefficient of variation is simply the standard deviation expressed as a percent of the mean. It is useful in a number of specific instances. Unlike the standard deviation, it is a dimensionless entity making it possible to compare variations of dissimilar operations or products. In some instances the standard deviation may



Sampling Procedure	Average, $\bar{X}$	Standard Deviation Sigma,%	3-Sigma, Percent	3–Sigma Range Percent
A	50	±9.5	±28.5	21.5 – 78.5
B	50	±4.0	±12.0	38.0 – 62.0
C	50	±2.1	±6.3	43.7 – 56.3

Figure 2
The Standard Deviation and Specification Compliance



$\sigma_o^2 = \sigma_b^2 + \sigma_\ell^2$

$\sigma_b^2 = \sigma_a^2 + \sigma_t^2 + \sigma_s^2$

$\sigma_o^2 = \sigma_a^2 + \sigma_t^2 + \sigma_s^2 + \sigma_\ell^2$

Figure 3
Sources of Variance

be dependent upon the process or product average, and it may be more meaningful to express variation in percent rather than standard deviation units: As an example, consider the nitrogen content of fertilizers. Consider a 6.0 percent nitrogen fertilizer having a standard deviation of ± 0.6 percent and 15 percent nitrogen fertilizer having a standard deviation of ± 1.5 percent. At first glance one might conclude the 15% fertilizer displayed more variation. Percentage-wise, however, both exhibit a coefficient of variation of 10 percent and, in fact, one is no more variable than the other.

The variance of a set of test data is defined as the square of the standard deviation. A process or product variation may be composed of several elements whose sum effect is the process variance. The sum, however, of the individual standard diviation is not the process standard deviation. In other words, variances may be added, standard deviations may not. The principle involved is the "Pythagorean Addition Theorem" first discovered by an ancient mathematician while working with triangles.

Figure 2 illustrates the last fundamental statistic of particular concern, that of the probability of specification compliance. Each of the three distribution curves represents a product or process distribution of test results. Although Figure 2 refers specifically to an aggregate gradation problem, the principles involved apply equally to any such specification item. Each curve centers at the specification midpoint but each has a different standard deviation. Note that as the standard deviation increases, the risk of rejection or the risk of off specification product also increases. To operate safely at some point other than the specification midpoint, that is, in order to accomodate a shift in the process average, the standard deviation of the measurements must be reduced even further than that illustrated in Curve C in order to ensure 100 percent compliance. These are points to be illustrated in the paper when consideration is given to acceptance sampling plans.

Variability in Bulk Materials

To this point probability and variability have been discussed in rather general terms. The importance of a thorough understanding of variability as it affects producers of bulk materials like crushed stone or fertilizer is becoming more and more apparent.

Specifications for crushed stone establish limiting values of a number of characteristics which are judged to have an important bearing upon performance. Examples of such characteristics are: particle size distribution (or gradation), abrasion resistance, soundness, particle shape, and the presence of deleterious foreign substances. Test values for each of these characteristics vary from sample to sample, as would be expected.

Traditionally, specifications were written to include fixed limits on each characteristic, beyond which no test value should fall. Some characteristics had fixed minimum or maximum values while others included permissible ranges between minimum and maximum. In either case, it was judged that the limits would take care of normal variations in test values.

Any given amount of a bulk material — all the material in a bin or large stockpile, all the material in a barge or hopper car, in a dump truck, or in a wheelbarrow — will have one true value for each important characteristic, such as gradation. The only way to determine this true value positively is to test all of the material. Obviously, though, one can't pass an entire truckload of stone over a set of sieves to determine its true gradation, so one must estimate its gradation as closely as possible by testing small portions of the mass. *The method of selecting these small portions or samples has a great deal to do with the accuracy of this estimate.*

This total mass of material, especially a large one such as a barge-load, may have been assembled from smaller masses, perhaps truckloads. Again, each truckload would have one true value of each important characteristic — one true gradation, for example, which might have to be estimated by testing small samples.

Each of the above described masses of material may have variable characteristics — gradations different from those of other like masses. Also there may be some considerable variation between samples which might be selected from within even the smallest of masses — within the material contained in a single bag of fertilizer, for example. It is this type of variability that has such a marked effect on the accuracy of estimates of the true value of a given characteristic in a mass of a given size.

Proper inspection of bulk materials for acceptance or rejection cannot begin until a basic decision is made at some high administrative level on a question of basic philosophy as it applies to each particular material. The question is: how small an increment of the mass must fall substantlly within specified limits? Will the presence of a small increment, by itself somewhat outside of the specifications, have an adverse effect on performance, or will this small increment be mixed with many other such increments to constitute batches of the ultimate product?

Consider two examples of widely different bulk materials, one a concentrated chemical lawn fertilizer packaged in 22 lb bags and the other a 3 inch top size stone to be used in mass concrete for construction of a dam. In the case of the first, each bagfull should conform to the guaranteed chemical analysis printed on the bag, while in the second case variations in gradation between 22 lb increments would be practically meaningless.

It can be said that each LOT of material about which a decision regarding acceptability must be made will consist of some number of BATCHES of the material, each of which should substantially conform to the specification requirements. Smaller increments which might be taken from within BATCHES might stray outside the limits established for the BATCH, but such variations would be of minor importance if the true value for the entire BATCH, or the average value from an unlimited number of samples, met the criterion for acceptability.

Variations between small increments may lead to serious errors if the acceptance decision has to be based entirely on the results of a test on only one such increment. Sadly, many decisions in the past with regard to the acceptability of large LOTS of stone have been made on the basis of only one small increment taken from the surface of a bargeload or stockpile. The size of the error in estimating the true value of a particular characteristic in a BATCH or LOT of material may be seen visually in Figure 3, borrowed from a highway research report (3) prepared by Miller-Warden Associates. The relative contributions of the more important sources of visibility — expressed as variances and summed up through a series of Pythagorean triangles — are shown in this Figure. Again, the example of gradation, or percentage passing a certain sieve size, will be used.

First is the contribution of inherent variability in any mixture of particles of different sizes. Some such variability exists in any random arrangement of heterogeneous material, and can be reduced no further by continued mixing. It is represented by σ_a. Next is testing error, caused not by a technician's mistakes but by the lack of repeatability of the procedure; in sieve analysis, even when the same sample is passed through the same sieves again and again, the results may differ. These two sources of error combine to represent experimental error, σ_e.

Next is added the sampling error, σ_s, caused by variation between test-sized increments which might be taken from the same BATCH. As noted above, a determination should have been made as to the size of a BATCH whose characteristics might be expected to affect performance. The sampling method should then be such as to minimize the error in estimating the true gradation of the BATCH. Obviously one should not base this estimate on a single 22 lb. sample in the case of a 3 in. maximum sized aggregate. Sampling error, added to the experimental error involved in testing the sample, would result in the sum of all errors, also known as false variation, σ_b, caused by apparent variability *within a batch;* this, in Figure 3, appears to be of greater magnitude than the actual variation between different batches. Such should not be the case. What one is interested in is the actual variation, or within a lot variation whose standard deviation is shown as σL. This is the variation that is of concern to the purchaser and which the producer can take steps to control. It is to minimize the error in estimating this actual variation that acceptance sampling plans should be devised. The overall variance, σ_{o2}, should be influenced to the least possible extent by false variation.

Acceptance Sampling Plans

The statistically oriented acceptance sampling plan is a tool designed to enable its user to reach a reliable decision relative to the acceptability of a lot of material.

It must be so developed that the samples chosen are (1) large enough to minimize the effects of the inherent variability (σ_a) and (2) of a composite nature to help de-emphasize the within-batch variability (σ_b). The plan, when so designed, permits a truer evaluation of the actual variability (σ_L) of the material free from overshadowing effects of false variation. Whatever variations are noted should be between batches or lots of material and not just between improperly obtained samples.

Even with the above design safeguards, statistical estimates, being nothing more than simple estimates, are still subject to error. There still exists the possibility of accepting poor material and rejecting good material. Whenever small samples or a small number of samples are taken to estimate the parameters of a larger mass of material, such errors of decision are possible. They are defined as the statistical risks. A well designed acceptance sampling plan should permit one to render a decision regarding acceptability which involves a minimum of such risk or at least a predetermined degree of risk or error.

The error of decision may be one of two types — rejection of material which is, in fact, satisfactory or acceptance of material truly unsatisfactory. The first type of error, termed a TYPE I ERROR, is the seller's risk; the second, a TYPE II ERROR, the buyer's risk. The prime purpose of an acceptance sampling plan is to define and reduce, where possible, the probability of making either of these errors.

A discussion of risks divorced from the particulars of a real situation is extremely difficult to follow. Related to a real situation the relation, one to another, of the buyer's risk, the seller's risk, the standard deviation of the measurements relating to the lot, and the number of test results can be more readily understood.

Assume now that a decision to accept or reject a finite lot of bulk fertilizer is to be made on the basis of a chemical determination of the nitrogen content. Previous experience has indicated that —

(a) A similar product has performed satisfactorily for the particular usage in question when it contains 24.0 percent nitrogen with a standard deviation of individual measurements corresponding to 0.36 percent. Satisfactory fertilizer then can be refined by describing the distribution of the nitrogen content as follows: $\bar{x}' = 24.0$, $\sigma' = \pm 0.36$.

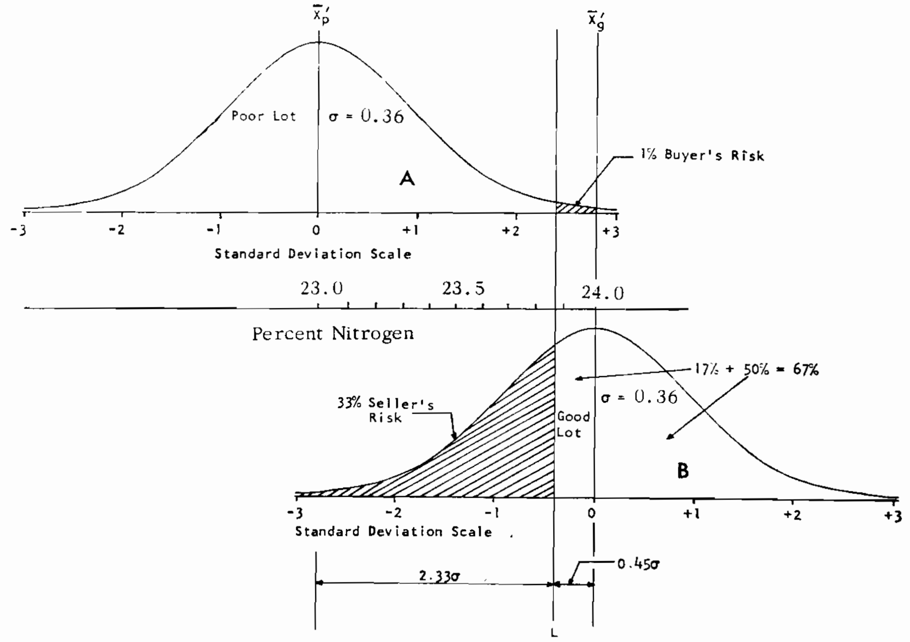


Figure 4
Acceptance and Rejection Based on Single Measurements

(b) A fertilizer having a nitrogen content of 23.0 percent is judged unsatisfactory for the selected use. This distribution of the nitrogen content measurements in this definitely unacceptable quality fertilizer can be described as $\bar{x}_P = 23.0$, $\sigma' = \pm 0.36$.

Figure 4 depicts the above situation graphically. The upper distribution curve represents the distribution of individual test results from a poor lot, the mean value being 23.0 and the standard deviation 0.36. The lower one shifts the curve one percent to the right and represents individual test values from a good lot, the mean value being 24.0 and the standard deviation again being 0.36. Bear in mind that the curves are for individual samples taken in some specified manner.

The acceptance rule should be that some number of samples, n, should be taken from each lot, the nitrogen content should be determined and the results averaged. If this average value, $\bar{x}$, is above a certain limiting value, L, the lot should be accepted; if below, it should be rejected or corrected. The value L, then becomes the acceptance limit under the rule adopted.

The question is: What should this L value be? Its location must depend upon how many samples are to be averaged and what the buyer's and seller's risks may be. Suppose the purchaser wishes to take only a single sample from each lot ($n = 1$) and is willing to take only a one percent risk of accepting a poor lot ($\bar{x} = 23.0$ **or** less), that is, a buyer's risk of accepting no more than one bad lot in 100. Then L will be located to the right of the bad population average, $\bar{x}'_p$, so that but one percent of the area under distribution curve A will fall to the right of L. Based on the laws relating to the normal curve such a point is located 2.33 standard deviation units from the average, or on the percent nitrogen scale in Figure 4 at $\bar{x}_P + 2.33\,\sigma = 23.00 + 2.33\,(0.36) = 23.84$ percent nitrogen.

If the above is the case, that is, 23.84 percent is to be the acceptance level with a one percent buyer's risk, what happens to the producer or seller? Examine Curve B, the distribution curve for acceptable fertilizer in Figure 4. The cross-hatched area to the left of L represents the number of times the purchaser will reject a truly satisfactory lot of fertilizer. This is the seller's risk. In this particular case, the seller's risk amounts to 33 percent or, in other words, one time in three in order to insure against acceptance of a bad lot, the purchaser will reject a good lot. This obviously is ridiculous situation; the seller could not tolerate such a condition without skyrocketing prices, etc.

Fortunately, the risks of making either type of error, due to simply chance effects, can be substantially reduced by increasing the number of measurements which, in effect, increases the evidence on which the decision is based. As the number of tests increases, the variation in sample averages will decrease according to the relation —

$$\frac{\sigma}{\sqrt{n}} = \sigma_{\bar{x}}$$

where $\sigma_{\bar{x}}$ is the standard deviation of sample averages

The new distribution curves will have the same grand averages, $\bar{x}'_p$ and $\bar{x}'_g$, but will be much narrower since the values plotted are themselves averages of four determinations rather than individual sample values. If acceptance is to be based on averages of four $(n = 4)$, then the risk situation changes drastically, as can be depicted in Figure 5. Assuming the purchaser is willing to take the same one percent risk of accepting a bad lot, L will be located $2.33\sigma_{\bar{x}}$ units to the right of $\bar{x}_p$. But since

$$\sigma_{\bar{x}} = \frac{\sigma_{\bar{x}}}{\sqrt{n}} = \frac{0.36}{\sqrt{4}} = 0.18,$$

L will be located at 23.00+233 (0.18) = 23.42 percent nitrogen. This value, 23.42, now becomes the acceptance level with this sampling plan. Dropping to the bottom curve in Fiure 5, the seller's risk of rejection has been reduced from 33 to 0.07 percent, a rather substantial improvement.

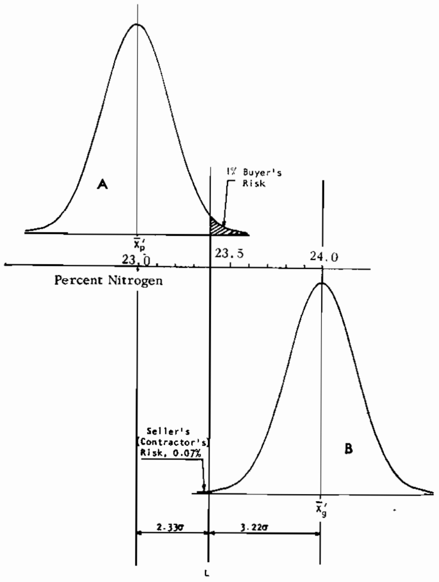


Figure 5
Acceptance and Rejection Based on Four Measurements.

This type of plan is the best available for deciding on the acceptability of lots of bulk material like stone, gravel, sand, or fertilizer. It would work best when the standard deviation of test values on samples obtained in the prescribed manner is accurately known. A plan of this sort is an example of a procedure described in various texts as "Sampling by Variables." (4)

The second major class of acceptance sampling plans, described (5) as Attributes Plans, is applicable to sampling situations dealing with individual units of product. The percent defective approach is used and the lot of individual units is accepted or rejected on that basis. Attribute plans would be most suitable for the situation of insuring that individual bags of fertilizer contained at least the minimum guaranteed nutrient value contents printed on the bag. Such an application is beyond the scope of this paper.

Summary

This paper has attempted to define and explain the fundamental concepts of mathematical statistics, the sources of variation in test results for manufactured items and production processes, and the concept of acceptance sampling of bulk materials. The applicability of variables sampling plans to the question of the bulk sampling of fertilizers has been illustrated and mention of the suitability of the attributes plans for the acceptance of bagged fertilizers was indicated.

A main purpose of the paper has been to emphasize the important role played by the method used in physically extracting the samples from a sizable mass of bulk material. The importance of sound sampling practices to the determination of the actual variation between lots or between significant portions of a lot is gradually becoming generally recognized. A paper reporting the results of research on this subject in Connecticut, by Professor Jack Stephens (6), has done much to clarify thinking in this area.

Acknowledgments

The authors wish to acknowledge the following sources of information upon which they drew for background information and in some cases specific examples of the basic concepts.

1. Enrick, N. L., "Quality Control," *The Industrial Press,* New York, 1960

2. Hughes, C. S. Enrich N. L. and Dillard, J. H., "Application of Some Statistical Techniques to Experiments in Highway Engineering (Rough Draft)," *Virginia Council of Highway Investigation and Research,* Charlottesville, Virginia, February 1964

3. Miller-Warden Associates, "Development of Guidelines for Practical and Realistic Construction Specification," *National Cooperative Highway Research Program Report 17,* Highway Research Board, 1965

4. Military Standard, "Sampling procedures and Tables for Inspection by Attributes," *MIL-STD-105D* (Apr. 29, 1963) pp. 1-64

5. Military Standard, "Sampling Procedures and Tables for Inspection by Variables for Percent Defective," *MIL-STD-414* (June 11, 1957) pp. 1-110

6. Stephens, Professor Jack E., "Reduction of Apparent Aggregate Variation Through Improved Sampling," *Report No. JHR 66-1,* School of Engineering, University of Connecticut, May 1966

MODERATOR REYNOLDS: Thank you Mr. Renninger and Mr. Nichols for your clearcut discussion on sampling. I am certain our membership will get a great deal of information and real use from your paper when they have had an opportunity to thoroughly digest all of the valuable data.

Our next subject is one that I believe is well in line. We have been discussing the need for more plant food and higher plant food concentrates. We have had a presentation on the ICI Process. In this paper there was a section relating to conditioning. We are going to try to explore the subject of conditioners in depth with four excellent speakers.

In the past we have heard a single presentation on this subject of fertilizer conditioning and the expected behavior of fertilizer raw materials when they are combined.

This afternoon we hope to expand this subject of conditioners much beyond the previous presentations.

The problems of fertilizer conditioning have been largely solved for medium to high-analysis fertilizers when the fertilizer industry entered granulation. This was accomplished by controlling temperature, moisture and particle size.

Now we are pushing for still higher plant food concentrations which have higher water solubility and the materials are much more hygroscopic. Therefore, we are faced again with the need to know more about the problems of conditioning.

The four papers to be discussed on conditioning will be given in order by:

1 – Mr. Julius Silverberg, T.V.A. "Storage Properties and Conditioning Requirements."
2 – Philip B. Mischel, Petrochemicals Co. "Use of Liquid Conditioners in Fertilizer Production."
3 – Joseph Iannicelli: J. M. Huber Corp. "Factors Affecting Performance of Organo Clay Coating Agents in Fertilizer.
4 – Robert J. Harvey, Southwest Potash Co. "Evaluation of Different Coditioners on a Single Fertilizer Material."

Please hold your question until the four Panelists have completed their discussions. They will be available at the Table here for a thorough discussion on your questions.

I have had an opportunity to review the information and I can assure you that you are in for a real treat this afternoon.

We will start with our first speaker, Mr. Silverberg, who has pulled together considerable information on this subject. Julius please.

Storage Properties and Conditioning Requirements Of Various Fertilizers

Julius Silverberg

Mr. Reynolds, fellow panel members, ladies and gentlemen of the RoundTable. This is quite a Round Table. I am anxious to hear our panel speakers.

NOT many years ago, a farmer bought low-analysis fertilizers, expected and accepted lumps, hit the lumps with a stick —no complaints.

Today, we have sophisticated, high-analysis fertilizers—and sophisticated farmers — who want a free-flowing product. And, we have a sophisticated industry that wants to store highly water-soluble fertilizers in bulk— in hot, humid climates, and in bags for long periods of time.

The purpose of this paper is to discuss the bulk-and bag-storage properties and conditioning requirements of several fertilizers currently being studied by TVA (urea-ammonium phosphate, nitric phosphate, and ammonium polyphosphate) and also to review briefly the properties of our so-called standard high-nitrogen fertilizers: ammonium nitrate, urea, and diammonium phosphate.

First, I should like to mention several facts that are well known to those who have been involved with high analysis fertilizers and that will be of interest to those just getting involved.

The storage properties of a fertilizer depend chiefly on its chemical composition and moisture content.

Caking of fertilizer, in most cases, is the result of intergrowth of crystals of soluble salts that form on the surfaces of the granules.[1] Some caking may occur because of plasticity—but most always—crystal bonding is involved.

A material will absorb moisture from the atmosphere if its critical relative humidity is below that of the atmosphere.

The types and amount of soluble salts in a fertilizer depend on the formulation. With the, present practice of producing high-analysis fertilizers, the proportions of salts are high and the effect of a small proportion of moisture can be a large factor in the degree of drying and protection

FIGURE I
CRITICAL HUMIDITIES OF FERTILIZER SALTS AND MIXTURES AT 30°C.(86°F.)
(VALUES ARE PERCENT RELATIVE HUMIDITY)

CALCIUM NITRATE	46.7														
AMMONIUM NITRATE	23.5	59.4													
SODIUM NITRATE	37.7	46.3	72.4												
UREA	-	18.1	45.6	75.2											
AMMONIUM CHLORIDE	-	51.4	51.9	57.9	77.2										
AMMONIUM SULFATE	-	62.3	-	56.4	71.3	79.2									
DIAMMONIUM PHOSPHATE	-	59*	-	62*	-	72*	82.8								
POTASSIUM CHLORIDE	<22.0	67.9	66.9	60.3	73.5	71.3	70*	84.0							
POTASSIUM NITRATE	31.4	59.9	64.5	65.2	67.9	69.2	-	78.6	90.5						
MONOAMMONIUM PHOSPHATE	52.8	58.0	63.8	65.2	-	†5.8	78*	72.8	59.8	91.6					
MONOCALCIUM PHOSPHATE	46.2	52.8	68.1	65.1	73.9	87.7	78*	-	87.8	88.8	93.7				
POTASSIUM SULFATE	76.1	69.2	73.3	71.5	71.3	81.4	77*	-	87.8	79.0	-	96.3			
29-29-0 UREA-AMMONIUM PHOSPHATE†	-	-	-	-	-	-	-	45*	-	-	-	-	57*		
20-20-0 NITRIC PHOSPHATE†	-	-	-	-	-	-	-	50*	-	-	-	-	-	57*	
15-60-0 AMMONIUM POLYPHOSPHATE†	-	-	-	-	-	-	-	-	-	-	-	-	-	-	63*

NOTE: VALUES FROM LITERATURE FOR PURE SALTS EXCEPT AS NOTED BELOW:
† TVA EXPERIMENTAL PRODUCTS (CONTAIN IMPURITIES)
* APPROXIMATE VALUES OBTAINED BY TVA

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[1] Silverberg, Julius, Lehr, James R., and Hoffmeister, George, Jr. *J. Agr. Food Chem.* 6 442-8 (June 1958).

needed to ensure satisfactory storage and handling prorperttes.

Critical Relative Humidities of Fertilizers

An insight to the problems that may be encountered in bulk storage of fertilizers is revealed by the critical relative humidities (C.R.H.) of some of the soluble salts they may contain. Figure 1 shows these values for several pure salts and combinations of salts. The C.R.H. of ammonium nitrate at 30°C. (86°F.) is 59.4. This means that when the temperature is 86°F. and the relative humidity of the atmosphere in contact with the fertilizer is above 59.4% the ammonium nitrate will absorb water. When the relative humidity is below 59.4, it will lose water (crystalliize). The C.R.H. of urea is 75.2; diammonium phosphate, 82.5; and potassium chloride, 84.0. The TVA nitric phosphates have a C.R.H. of about 57; urea-ammonium phosphate, about 57; and ammonium polyphosphate, 63.

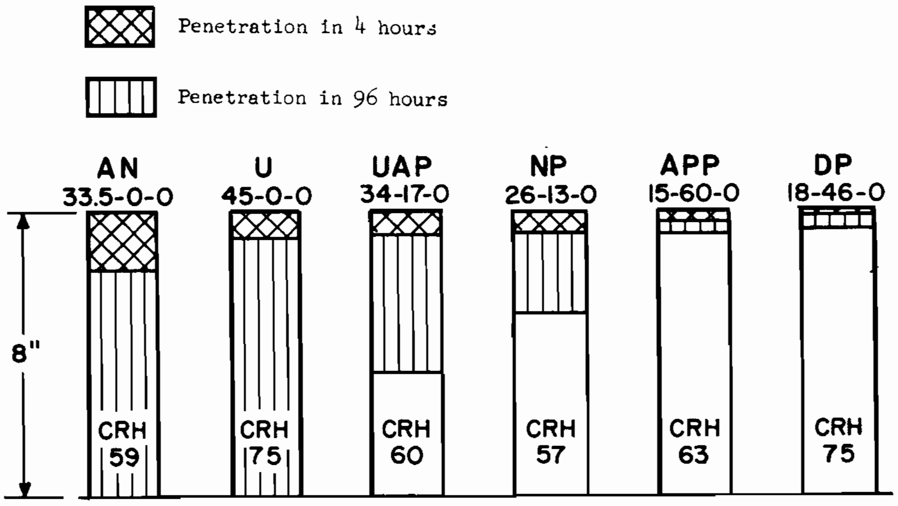
It can also be seen that the C.R.H.'s of mixtures of salts often are lower than those of the individual salts. Also, reaction products result in different salt combinations. For example, when potassium chloride is mixed stoichiometrically with ammonium nitrate, the reaction products are potassium nitrate and ammonium chloride, and the C.R.H. of the mixture is about 68. However, if there is an excess of ammonium nitrate, an ammonium nitrate - ammonium chloride complex forms that has a C.R.H. of about 51. About the worst situation is the mixing of urea with ammonium nitrate. A mixture of these two salts has a C.R.H. of 18 at 86° F. The mixture becomes wet and turns to liquid.

The fact that combining salts usually results in a lower critical relative humidity than that of the separate salts is a big factor in the caking of mixtures of materials that, by themselves, store satisfactorily. For example, in suitable bags, conditioned urea rarely gives trouble, and diammonium phosphate from wet-process acid stores well without conditioner. However, when these two materials are mixed together, the salt pair has a lower critical relative humidity. Usually there is enough moisture in the system for solution to form at the points of contact and for crystals to grow with cycling temperature. The result can be caking. This problem may be solved by adding a conditioning agent that will absorb the solution or spread it to prevent the growth of long crystals that can bond together. It is interesting to note, also that the C.R.H. of TVA urea-ammonium phosphate (30-30-0) decreased from about 63 to 45 with the addition of potassium chloride, and that of TVA nitric phosphate (20-20-0) decreased from 57 to about 50.

Bulk Storage: Moisture Absorption and Penetration

Figure 2 shows the results of laboratory exposure tests of some fertilizers; the results may serve as a guide for storing these fertilizers in bulk. In these tests, the fertilizers were exposed in a temperature-humidity cabinet at 86° F. and 80% relative humidity. In 4 hours, moisture penetrated into the conditioned ammonium nitrate (C.R.H., 59) to the extent of about 2 inches. Penetrations into conditioned urea (C.R.H., 75), urea-ammonium phosphate (C.R.H., 60), and a nitric phosphate (C.R.H., 57) were somewhat less. The ammonium polyphosphate showed very little penetration but the top layer was sticky. It should be noted that the C.R.H. of the ammonium polyphosphate as determined in the laboratory was fairly low (65%). However, it seems to have the property of not transferring moisture by "wicking" as do other fertilizers. There was little penetration into wet-process diammonium phosphate. This diammonium phosphate contained impurities and its C.R.H. was about 75 instead of 82 as for pure diammonium phosphate.

In 96 hours the ammonium nitrate and urea became wet throughout (ammonium nirtate more rapid). Moisture penetration into the urea-ammonium phosphate and nitric phosphate continued at slower rates and the top layers disintegrated (soft and mushy). The ammonium polyphosphate was sticky for a depth of only about ¼ inch. Some moisture was present in the top layer of the diammonium phosphate; however, it had not penetrated very far into the sample. This benefit, derived from the impurities in the diammonium phos-



AN = Ammonium nitrate
U = Urea prills
UAP = Urea-ammonium phosphate (10% of P_2O_5 from rock, rest from electric-furnace acid)
NP = Nitric phosphate from nitric and phosphoric acids
APP = Ammonium polyphosphate (P_2O_5 from electric-furnace acid)
DP = Diammonium phosphate (P_2O_5 from wet-process acid)

Note: All products, except DP, conditioned (2% diatomaceous earth).

FIGURE 2

Penetration of Moisture into Fertilizer Exposed at 80% R.H., 86° F.

phate, was found to be a very significant factor in the storage properties of the diammonium phosphat and in TVA urea-ammonium phosphate, as will be shown later.

The tests simply show again that most high-analysis nitrogen-containing fertilizers must be protected from humid atmosphere if stored in bulk. It also should be pointed out that conditioning the fertilizer is not a cure for exposure to humid atmosphere. Coating urea prills with kaolin clay, diatomaceous earth, calcined fuller's earth, or an organic-treated clay did not decrease moisture absorption or penetration.

To prevent absorption of moisture by fertilizers in bulk storage, some companies have installed equipment for dehumidifying the air in the storage buildings. TVA has a large building that is equipped with ten standard 5-ton air conditioning units. They are not operated to a specific temperature but, instead, simply to dehumidify the air. The air is from outdoors (no recycle). With closed doors, there is a slight pressure in the building. The relative humidity generally has been about 45 to 50%, which is more than low enough to protect the products (C.R.H. at 86° F.: ammonium phosphate nitrate, 30-10-0 and 25-25-0, 55; nitric phosphate, 20-20-0 and 26-13-0, 57; ammonium polyphosphate, 15-60-0, 63).

Another way to protect bulk piles, especially in small installations where buildings may not be tight, is to cover the fertilizer with something to keep it out of contact with moving and changing air. Some plants cover tthe piles with plastic sheets. Good results also have been obtained by covering piles with finely ground phosphate rock or finely ground limestone during a long wet season.

Bag Storage—Experimental Products

When fertilizers are stored in bags, the bags are chosen to prevent absorption of moisture from the atmosphere. Therefore, any caking that occurs usually is due to the moisture left in the product and to the influence of cycling temperature. Caking in a bag or inside a pile of fertilizer can be prevented by drying to such a degree that there is not enough moisture to permit growth of crystals, or by adding a conditioner. The conditioner does not necessarily stop the formation of crystals; its function generally is to absorb and immobilize the solution phase, and to act as a separator between granules. (Addition of materials to modify crystal habit also has been suggested; however, this approach will not be discussed in this paper.)

In our tests of pilot-plant products at TVA, drying was carried to a practical degree, and then the products were treated with conditioning agents—they included kaolin clay, diatomaceous earth, and calcined fuller's earth. Tests with these materials are reported here. Omission of tests with other conditioning agents does not mean that they may not be satisfactory or economical. For example, calcined dolomite is a good conditioner for some fertilizers. Also, good results have been obtained with some organic-treated materials. It should be understood that a particular type of conditioning agent may vary appreciably in effectiveness, depending on source. However, no sure means of evaluating is available other than actual test.

In carrying out these tests, products as made and after coating with conditioning agents were stored in 50-pound "moisture-proof" bags in an unheated warehouse. The bags were subjected to a pressure of about 3.5 pounds per square inch (equal to the pressure on the 20th bag in a stack of 50-pound bags). The degree of caking was taken to be the percentage of plus 2-mesh lumps in the bag after is was dropped once from a height of 3 feet. In some cases, tests were made with 3-pound bags under the same conditions.

Diammonium-Phosphate. The first pilot-plant tests of the ammoniator-granulator process for the production of diammonium phosphate were made with relatively pure electric-furnace orthophosphoric acid such as is produced at TVA. The products caked badly

TABLE I
Diammonium Phosphate

Grade	Moisture content %	Conditioner	% +2-mesh lumps/hardness[a]			
			1 mo.	3mo.	6 mo.	9mo.
Electric-Furnace Phosphoric Acid						
21-53-0	0.2	None	41/H	51/H	75/H	—
		2% kaolin	8/M	9/M	39/H	—
Wet-Process Phosphoric Acid						
18-46-0	1.6	None	0	5/L	4/L	8/L

[a] H = hard, M = medium, L = light.

TABLE II
Urea-Ammonium Phosphate

Grade	Moisture content %	Conditioner[b]	% +2-mesh lumps/hardness[a]			
			1 mo.	3mo.	6 mo.	9mo.
Electric-Furnace Phosphoric Acid						
30-30-0	0.4	None	30/H	70/M	76/M	—
		2.5% c.f.e.	9/L	21/M	22/M	—
20-20-20	0.4	None	43/H	94/H	—	—
		2.5% kaolin	61	69	—	—
		2.5% c.f.e.	53	72	—	—
Wet-Process Phosphoric Acid						
		None	9/L	8/L	30/M	—
		2.5 %kaolin	2/L	8/L	9/L	—
		2.5% c.f.e.	0	0	0	—
25-15-15	0.6	None	0	0	22	46
		2% c.f.e.	0	0	0	0
Electric-Furnace Acid + 5% P_2O_5 from Phosphate Rock						
34-17-0	0.6	None	52/H	57/H	61/H	—
		2% kaolin	3/L	3/L	8/L	—
		2% d.e.	0	0	—	—

[a] H = hard, M = medium, L = light.
[b] C.f.e. = calcined fuller's earth.

at about 0.2% moisture even with 2% of kaolin clay as conditioner. However, as can be seen from the data of Table I, diammonium phosphate made later in the TVA pilot plant from wet-process acid had improved properties; this product stored satisfactorily without conditioner at about 1.6% moisture. One explanation for the difference in behavior is that the latter product contained colloidal iron and aluminum phosphates which immobilized moisture (salt solution) to such a degree that little if any moved from the interior to the surface. Also, crystal growth probably was inhibited by the impurities.

Urea-Ammonium Phosphate: The data of Table II also show the beneficial effects of the impurities in wet-process acid on the physical properties of fertilizers. In storage tests of urea-ammonium phosphates made with urea solution or prills, ammonia, and electric-furnace phosphoric acid (30-30-0 and 20-20-20) severe caking occurred even when the moisture content was as low at 0.4% and the products were conditioned with about 2.5% by weight of kaolin clay or calcined fuller's earth. However, when merchant-grade wet-process phosphoric acid was used, the products had improved storage properties. A 29-29-0 product containing 1.1% moisture was in excellent condition when coated with 2.5% of calcined fuller's earth or diatomaceous earth. (Kaolin clay was not as effective in preventing caking.) Potash grades also had much better storage properties.

Another interesting and important finding was that, when electric-furnace acid was used, improved physical properties were obtained by supplying as little as 5% of the P_2O_5 as phosphate rock. This is shown by the data for tests of a 34-17-0 urea-ammonium phosphate with 0.6% moisture; 2% of diatomaceous earth or kaolin clay gave good results.

Ammonium Polyphosphate: Demonstration-plant production of ammonium polyphosphate from ammonia and electric-furnace superphosphoric acid was started by TVA in July 1966. The product (15-60-0) has about 50% of its P_2O_5 in the form of polyphosphate. Large-scale storage tests of this material, which currently is being conditioned with 2% of diatomaceous earth, are in progress.

TABLE III

Ammonium Polyphosphate

Moisture content %	Conditioner[b]	% +2-mesh lumps/hardness[a]		
Electric-Furance Phosphoric Acid (15-60-0)		1 mo.	3 mo.	6 mo.
Nil	None	0	12/M	80/H
	2% c.f.e.	0	0	0 H
	2% d.e.	0	0	10/L

[a] H = hard, M = medium, L = light.
[b] C.f.e. = calcined fuller's earth; d.e. = diatomaceous earth.

It first was believed that the conditioning agent would not be required since granulation was at high temperature and practically no moisture was present. However, it was found that severe caking occurred with extended storage. This caking is believed to be due to changes in solid-phase composition (1) change in the hydration state of crystalline triammonium pyrophosphate—generally the anyhdrous recrystallizing as the monohydrate, and (2) a surface alteration of triammonium pyrophosphate to diammonium pyrophosphate. Table III shows that caking of unconditioned product progressed slowly during the first 3 months of storage but that at 6 months the material was badly caked. The addition of a conditioner to act as a separating agent prevented significant caking. Good results were obtained with calcined fuller's earth and diatomaceous earth. As we noted in other tests, the use of wet-process acid, which contains R_2O_3, significantly improved storage properties.

Nitric Phosphates: Table IV shows the storage properties of nitric phosphate fertilizers. These data are for products made from phosphate rock, nitric acid, furnace phosphoric acid, and ammonia in the ammoniation-granulation pilot plant. The use of wet-process acid did not have a significant effect on the physical properties since both types of products contained the iron, aluminum and other impuities present in the phosphate rock.

A 20-20-0 product containing 1.0% moisture caked badly without conditioner. Coating with 1% of calcined fuller's earth or 2% kaolin clay gave excellent storage for at least 9 months. A product of the same grade but with only 0.6% moisture was satisfactory without conditioner for 6 months. 26-13-0 and 15-15-15 products with 0.6 to 0.7% moisture were satisfactory with 2% of kaolin clay.

Demonstration-scale production of 20-20-0 and 26-13-0 nitric phosphates was started by TVA in February 1966. The products, which contain about 1.0 to 1.3%

TABLE IV

Nitric Phosphate

Moisture content %	Conditioner[b]	% +2-mesh lumps/hardness[a] 1 mo.	3 mo.	6 mo.	9 mo.
20-20-0					
1.0	None	7/M	21/M	29/M	40/H
	1% kaolin	3/L	7/M	12/L	22/M
	1% c.f.e.	0	0	0	4/L
	2% kaolin	0	0	0	0
0.6	None	1/L	5	3/L	11/L
	1% kaolin	0	0	0	0
15-15-15					
0.6	None	18/H	35/H	56/H	—
	2% kaolin	0	0	5/L	—
26-13-0					
0.7	None	5/L	2/L	12/M	34/H
	2% kaolin	0	0	1/L	1/L

[a] H = hard, M = medium, L = light.
[b] C.f.e. = calcined fuller's earth;

moisture and are conditioned with 2% of diatomaceous earth, have excellent storage properties. Diatomaceous earth is used at present because it is the conditioner currently being used for the other products in our new demonstration combination granulation plant. Other conitioning agents will be tested with the new plant product.

Other T.V.A. Products: TVA's new facilities include equipment for the production of ammonium phosphate nitrates (30-10-0 and 25-25-0) and ammonium nitrate sulphate (30-0-0-5s by pan granulation. The products, which contain 0.2 to 0.3% moisture, are conditioned with 2% by weight of diatomaceous earth. Other conditioners are being tested.

Granular concentrated super phosphate (0-52-0) is conditioned with about 0.7% of ammonia; this decreases the free acid and prevents bag rot. Crystalline diammonium phosphate, 0.08% moisture, is shipped unconditioned for some uses. When bagged,it is conditioned with 1% by weight of calcined dolomite.

Moderator Reynolds: Please hold your questions until the last speaker has finished at which time we will have all of these gentlemen up here at the table. We will move on to our next speaker Mr. Philip B. Mischel.

Use of Liquid Conditioners in Fertilizer Production

Phillip B. Mischel

Thank you Joe. I am happy to be here at this excellent meeting.

WE at Petrochemicals Company would like to thank the members of the executive committee, as well as the many fertilizer manufacturers who have cooperated in helping us help them, for the opportunity to present this talk covering the use of conditioners in fertilizers.

As most of you are aware, Petrochemicals Company produces a line of anti-caking and conditioning agents, sold under the trade names of PETRO AG Special, PETRO P, and PETRO S, which are used to aid in the handling of fertilizers and chemicals associated with the fertilizer industry.

These products are offered in both liquid and dry solid forms, alone and in combination with a variety of inert conditioners. Since there (will be or have been) other papers prepared on the use of dry solids to condition ammonium nitrate and granulated fertilizers, I will confine this talk to the use of liquids as conditioners in fertilizers and fertilizer components.

Basically, our products are unique surface-active agents that retain their physical and chemical properties under the severe conditions of changing pH, heat, temperature, and electrolytic conditions associated with the fertilizer industry . In addition, because of these solubilizing, wetting, and coupling properties, these products provide those ecects that are required in the processing, storage, sale and application of fertilizer products.

As a result of the versatility of these PETRO products, we find ourselves associated with many of the problems encountered in the fertilizer industry, namely, uniform application of product, granulation, handling of raw material, both liquid and solid, and as an active component of the fertilizer itself. Therefore, I hope to cover some of the application work being done or that has been done with our products.

The first of these applications is in the use of liquid conditioners to alter the freezing points of nitrogen solutions. Here, it was shown that the best effects of PETRO AG Special were obtained on urea/water solutions.

In this study, the salting-out temperature is defined as the temperature at which the first crystals appear with cooling, and the dissolution temperature is defined as the temperature at which the last crystals go back into solution.

The procedure used follows the ASTM test tentatively designated as the third preliminary draft.

Solutions of urea, ammonia, ammonium nitrate, and water were made up. To half of each of these was added the indicated amounts of PETRO AG Special. (It should be pointed out that commercial ammonium nitrate and urea solution were used along with the impurities entrained in them).

Two samples were run for each solution, with and without PETRO AG Special, and the rate of cooking and heating was 2-3° per minute.

The average values obtained with and without PETRO AG Special are shown. Slide #1.

Following this, to two of the solutions previously tested, 1% sand was added to parallel contamination obtained in the loading and transporting of solution, and to observe the effect of these nuclei on the precipitation of crystal material. Slide #2.

It should be noted that these nucleation sites appear to have little effect on these results, and it is thought that PETRO AG Special wets out the surafce of these impurities, removing them as nucleation sites.

In addition, it appears that the salting-out temperatures are fixed using this additive despite the impurities in the system.

A second application of PETRO AG Special liquid is in the conditioning of granulated ferti-

Slide 1

% By Weight					Degree F	
NH_3	NH_4NO_3	Urea	H_2O	PETRO® AG SPECIAL	Salting Out Point	Point Dissolution
4.3	—	37.5	58.2	—	−2.7	35.5
4.2	—	37.2	57.6	1.0	−12.3	32.0
—	—	50.0	50.0	—	3.5	62.0
—	—	49.5	49.5	1.0	3.5	62.0
8.7	69.9	—	21.4	—	82.5	93.5
8.6	69.2	—	21.2	1	79.8	90.3

Slide 2

		% By Weight				Degree F	
NH_3	NH_4NO_3	Urea	H_2O	PETRO® AG SPECIAL		Salting Out Point	Dissolution Point
4.3	—	37.5	58.2	—	1.0	2.0	38.3
4.2	—	37.2	57.6	1.0	1.0	−11.0	35.5
		50.0	50.0	—	1.0	22.5	70.5
		49.5	49.5	1.0	1.0	18.5	65.8

lizer products. In this instance, it was desired to treat grades 5-20-20, 6-24-24, and 12-12-12.

The components of the 6-24-24 grade with which we will specifically deal are shown.

The components consist of. See slide #3.

Slide 3

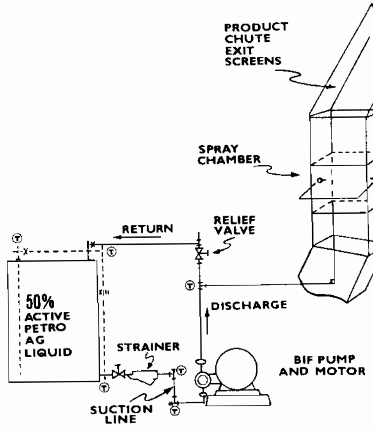
82.2%	Anhydrous Ammonia
448 (25-69-0)	Nitrogen Solution
60° Be	Sulfuric Acid
19%	ROP Super Phosphate
46%	Triple Super Phosphate
61%	Muriate of Potash

Because of an uneven flow of raw materials to the ammoniator-granulator a dry addition of PETRO AG Special powder proved unsatisfactory. Instead, a liquid application containing PETRO AG Special in a 50% aqueous solution was decided on, at a point between the discharge of the screens and the cooler. The following scematic shows how this was accomplished. Slide #4.

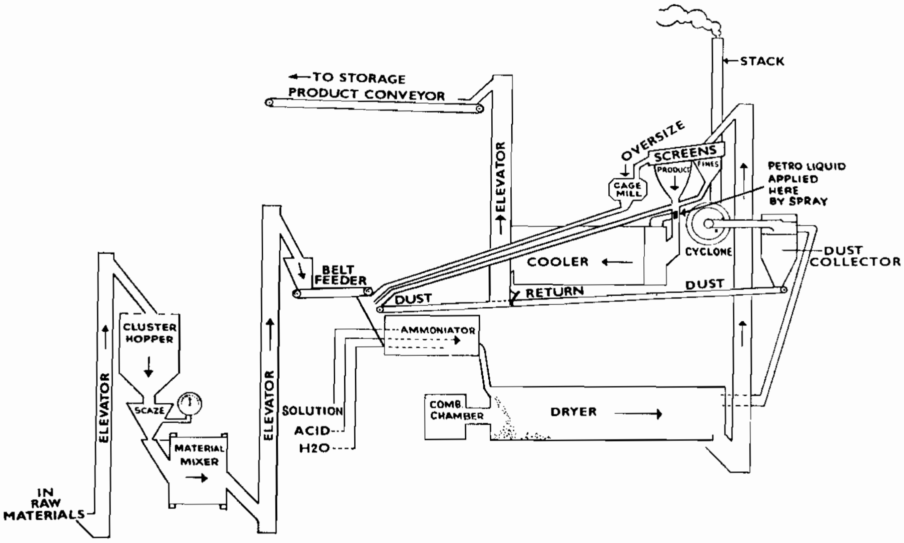
A section of chute was removed and two spray head nozzles were inserted. These nozzles were designed to deliver a set rate of liquid conditioner based on the average throughput of the installation. In addition, these nozzles were selected to give a uniform mist effect, with an overlapping pattern, in order to contact all the material falling through the chute. Slide #5.

Samples of treated products were taken at selected intervals and determinations of % PETRO, water, and caking tendency tests were performed.

Slides #6 and #7. For determining caking tendency of chemical products, our laboratory has devised a penetrometer type test that is designed to determine this tendency quantitatively. As shown, this consists of an apparatus to make up the various samples of material to be tested and a penetrating apparatus to measure the force necessary to penetrate these cakes.



Slide 5



Slide 4

Our experience with this and other procedures, especially the crush strength test, allows us to predict with fairly good accuracy the outcome of commercial test work and ideal percentages at which commercial scale test should start.

Another application where liquid conditioners have shown promise is in the treatment of run-of-pile and granulated triple superphosphate. In this commercial application, 0.03% of PETRO AG Special liquid is added to the suction of the phosphoric acid pump by use of a metering pump.

The primary concern here was to treat the run-of-pile product in order to avoid caking or hardening in storage and handling that was causing customer complaints and extensive labor costs.

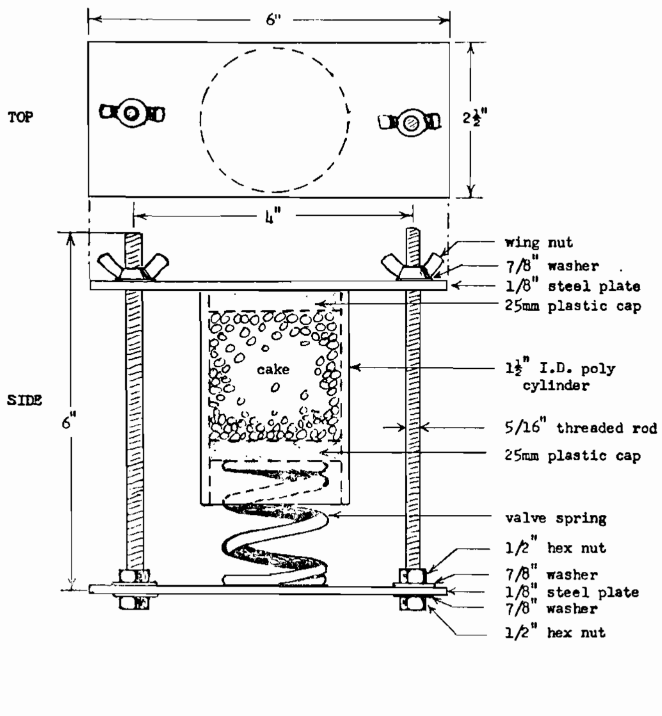
However, during the extensive use of PETRO AG Special for this application, other side effects were noted. These were:

1. There was less downtime at the cone in the acidulation operations, because of bridging that had become prevalent prior to the use of our product.

2. The rates of conversion to an analysis of 46% APA were altered. (That is, the triple run-of-pile goes to the curing pile at an analysis of 43% and is allowed to remain there unti a guaranteed analysis of 46% APA is reached.

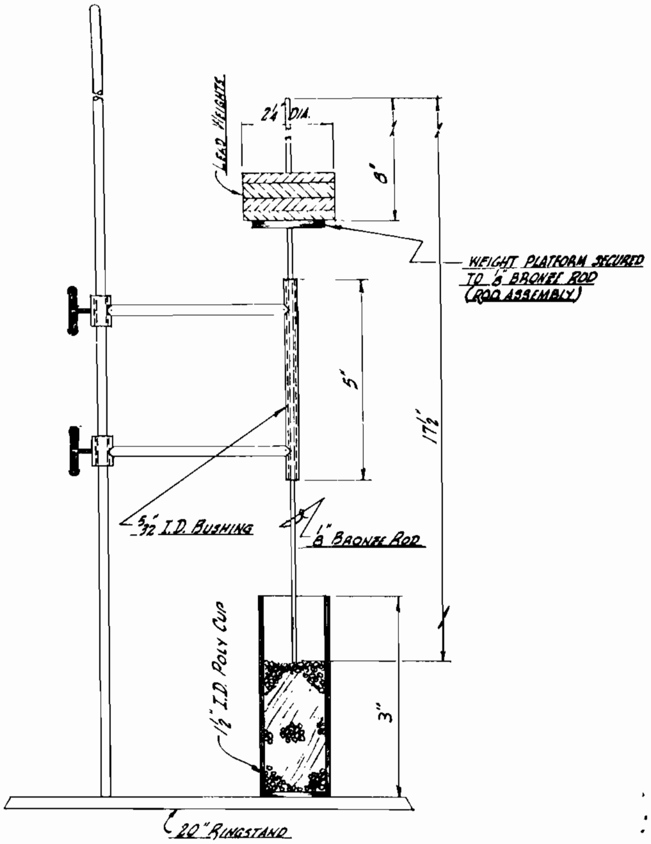
The treated phosphate begins to cure out faster but then slows down in the latter days of curing. It is belieed this is due to the ability of the PETRO products to initiate the exothermic reaction faster, driving off the excess moisture until such time as an equilibrium is reached, while still remaining stable under conditions encountered in the processing step.

Although increased P_2O_5 analysis was not looked at in this particular installation, in work done by European sources in a diammonium phosphate operation, an additional 2.6 kg of P_2O_5 per 100 kilos of diammonium phosphate was obtained. This was



SAMPLE AND SPRING RETAINING APPARATUS

Slide 6



Slide 7

achieved by the addition of 0.50 Kg of the PETRO product to the phosphate slurrry prior to ammoniation.

3. No effect was noted on dry run-of-pile product diverted to the granulation systems although remarks were made as to the better and more uniform granules produced.

Another project in the phosphate operations where liquid conditioners are of interest is in the production of diammonium phosphate. Here, caking and handling problems were causing delays in shipments as well as added labor costs . After some preliminary work, the following procedures were adopted to increase handling efficiency.

The system was first purged for 8 hours by adding the PETRO liquid to the phosphoric acid. The dosage was ¾# of active PETRO AG Special per ton of finished diammonium phosphate product, or 1½ parts per actual ton of finished DAP, assuming 459 lbs. of phosphoric acid per ton of finished product.

This was accomplished by adding 120 gallons of PETRO AG Special 50% active liquid to 104,000 gallons of phosphoric acid at the holding tank.

Observations, in addition to a more storable and free-flowing product, include a harder and more polished granule that was more uniform in size, and a considerable less dusty end product as well as cleaner processing and handling equipment.

Our final interest in phosphate-base work is in the granulation of superphosphates. This study was to determine the effect of our PETRO S, which is somewhat chemically different than our PETRO AG Special.

In this study, the word "superphosphates" is used to denote any P_2O_5 formulation of less than 22% P_2O_5.

Fertilizer grades of the order 0-20-0, 0-20-20, 5-15-15, etc., are considered to be superphosphate grades, although some additional P_2O_5 in the form of phosphoric acid is added to raise P_2O_5 content.

The scope of this work was restricted to laboratory studies of granulation on a 5-10-10 grade. This grade was selected since, in

Slide 8

Treatments In 1962	Yields In 1963	
	Bushels/Acre	Quality of Corn
1. Nothing on low calcium ground.	21.0 Bu.	Very Wet and poor.
2. Six tons of limestone worked in with rotovator.	33.5 Bu.	High moisture and fair.
3. Six tons of limestone plowed under.	35.5 Bu.	High moisture and good.
4. PETRO®S on soils as in the first treatment. 15# of powder dusted on per acre and plowed under.	55.0 Bu.	Corn was dry and excellent quality.
5. Same as No. 4, but 50# of PETRO®S.	11.0 Bu.	Worthless

COMMENTS:

The above results were obtained on plots which received PETRO®S for soybeans the previous year. *"Results were curtailed by the direct summer in many years,"* reports the researcher.

1. 15# PETRO® S - rotovated	51 bushels
2. 60# PETRO® S - rotovated	31 bushels
3. No Limestone-800# residue, rotovated	29 bushels
4. 12 Ton Limestone-½ applied after rotovated - rotovated	38 bushels
5. 6 Ton Limestone (Hydrated)	26 bushels
6. Ton Limestone plowed under	43 bushels
7. 3 Ton Limestone plowed under 3 Ton Limestone after plowing	29 bushels
8. Subsoiled 6 Ton Limestone, plowed under	31 bushels
9. 6 Ton Limestone rotovated, plowed deep 6 Ton Limestone after plowing - rotovated	38 bushels
10. Plowed 6 Ton Limestone deep 6 ton Limestone - rotovated	51 bushels
11. Plowed deep 6 Limestone - rotovated	41 bushels

PLOTS 20 X 80 FEET — 36" ROWS

(Five inches of rain fell from May to December, 1962 during which these tests were carried out.)

Slide 9

addition to the P_2O_5 present as superphosphate, calcium sulfate, ammonia, and potassium chloride, plus the various salts and impurities normal to phosphate rock, are present. In addition, 5-10-10 has sufficient salts to form reciprocal salt pairs, to promote caking, and enjoys a large market.

The use of a completely water-soluble product, PETRO S, in granulation, is two fold, one direct and one indirect.

Slide #8 and #9. The direct application is as an aid in promoting granulation by increasing water migration among the particles. An indirect method is for agronomic considerations. An example of indirect application of PETRO S is shown on the slide. We fully realize that various crops and soil types make analysis of data difficult.

This indicated crop response to the addition of PETRO S to the soil in combination with fertilizer, as opposed to other similar type products, is now in the process of being verified at several test locations throughout the U. S.

The problem of adding a liquid conditioner, to act both as an anti-caking agent and a penetrant, that allows the nutrients to disperse more advantageously in the soil becomes a consideration as to when to add these products during granulation.

If these products are added during granulation, recycle will cause a buildup of these materials unless careful control is initiated to consider recycle rates. Also, several manufacturers have maintained that the presence of common surface-active agents in the granulation of nutrients prevents effective granulation.

Slide 10

PETRO® S

Soy Bean Lots — Young Farm

1. Speed of drum - ⅓ critical speed.
2. Feed — Fines, water spray.
3. Method of adding PETRO® — Premixed with fertilier in slurry state.
4. Time of granulation — Variable for particle size formation.
5. Drying time — one hour.
6. Drying temperature — 250°F.

Slide #10. This study was designed to show the effect of PETRO S on the granulation of 5-10-10 on a laboratory scale. It is clearly understood that while such data obtained on a laboratory unit is not directly transferable to plant size operations the relative data is significant and comparable.

The sample of 5-10-10 was regranulated under experimental conditions without the presence of PETRO S. A (-8+16) fraction was selected as the screen size.

The procedure followed was to take ground 5-10-10 material, premoistened to the same degree with or without PETRO S, and then charged to a rotating drum. A fine water spray was used until particle formation appeared complete.

The mass was then discharged to drying pans . Moisture determinations were performed to assure uniform results.

After drying, the granules were screened to a -8+16 fraction, then weighed as a fraction of the whole sample, on a dry basis.

A yield of 80.9% based on an average of 5 runs was obtained on the -8+16 fraction of 5-10-10, using the 0.05% PETRO S.

The corresponding yield without PETRO S was 65.2%. The moisture at the time of discharge from the granulation of the 5-10-10 containing 0.05% PETRO S was 9.7%.

It is our opinion that 0.05% PETRO S is sufficient to wet out all surfaces of -60 particle size. Test runs were made at other concentration to verify the effect and to demonstrate any changes.

These concentrations of PETRO S in 5-10-10 were 0.10%, 0.05%, 0.10%, 1.0% 10%, The higher values were used to see if excess amounts of PETRO S caused granulation difficulty.

These tests indicated that at *no concentration* used above were there any differences detected in the granulation characteristics of 0-10-10, which is contrary to our experience with other types of surface-active agents.

In fact, at 10% concentration of PETRO S, granulation was equally as easy as at lower concentrations, and a yield of 78.5% of -8+16 was obtained.

In summarizing these uses of liquid conditioners, an attempt has been made to briefly outline the potential that these products have in the processing, handling, and agronomic effects of fertilizers. We feel, based on our experience in serving the fertilizer industry, that all too often these types of products are looked upon too hastily as an added cost, and results obtained from one type of product are assumed to hold for all similar products.

It has been our experience that in most instances the use of PETRO products significantly contributes to a reduction in labor, handling, and shipping charges, and returned products.

Indirectly, these additives, acting as an anti-caking and conditioning agent or penetrant, serve to improve product performance for the ultimate consumer, thus assuring continued repeat business of a particular brand of products.

We hope we have touched on some of the inherent difficulties now being encountered in the processing, handling, and sale of fertilizer products, and that somehow we have made the use of liquid conditioners a part of the problem solving tools used by this great industry.

Thank you.

Moderator Reynolds: Thank you Phillip. Your paper is indeed interesting and very valuable. Our next panelist Mr. Joseph Iannicelli.

Factors Affecting Performance of Organo Clay Coating Agents in Fertilizers

Joseph Iannicelli

I wish to thank Dr. Sauchelli and the executive committee for the privilege of appearing on the Fertilizer Round Table.

Background

USE of inorganic coating agents has been the traditional method for the reduction of caking in ammonium nitrate and other synthetic fertilizers. A wide variety of finely divided mineral fillers has been susccessfully used for this purpose over the years.

The trend to high analysis fertilizers has served to intensify caking problems—despite significant advances in granulation, drying, packaging, and storage of such fertilizers. As a result, a small group of high performance inorganic agents has displaced most of the marginal mineral fillers in coating outlets. More recently, a new class of coating agents has emerged in which anticaking performance of inorganic fillers has been significantly enhanced by surface modification with functional organic chemicals.

Mechanism of Caking in Granular Fertilizers

Work at TVA (Silverberg, Lehr, Hoffmeister, 1958) has shown that the caking of high analysis granular fertilizers results from crystalline intergrowths between granules which are deposited from solutions of salts present in the fertilizer as residual moisture.

The potential crystal bridging effect from small amounts of moisture is graphically illustrated by Fig. 1, which shows solubility of ammonium nitrate as a function of temperature.

Fig. 1 shows that temperature decrease from 100°F. to 50°F. during storage of ammonium nitrate can deposit an amount of new nitrate crystals equal to the residual moisture content. While ammonium nitrate is unusual in this respect, the effect is qualitatively similar with most fertilizer salts.

In addition to the temperature/solubility effect, ammonium nitrate also undergoes the well-known phase transitions resulting in volume changes that tend to exaggerate caking tendencies.

Caking Inhibition by Mineral Fillers

The mechanism of caking inhibition by mineral fillers has been nicely explained by TVA workers (Silverberg, Lehr, Hoffmeister, 1958). They found that finely divided fillers such as kaolin and diatomaceous earth inhibited crystal bridging when coated on granules . These fillers were found to function by:

1. diffusing the crystallizing solution phase over the granule surface and reducing local concentrations,
2. nucleating small, finer grained crystals,
3. mechanically insulating or parting granules from each other to decrease probability of crystal bridging, and
4. removing moisture by surface or internal absorption.

Caking Inhibition by Surfactant Modified Fillers

The trend to higher analysis fertilizer and the rapid rate in use of industrial grade ammonium nitrate created a need for special coating agents that are more effective or more versatile than the usual mineral fillers.

As a result of work by a number of research groups, it was found that the crystal inhibition effect or organo sulfonates could be synergized by modification of fine particle mineral fillers with these agents. The most widely

Figure 1
Solubility of Ammonium Nitrate in Water Vs Temperature.

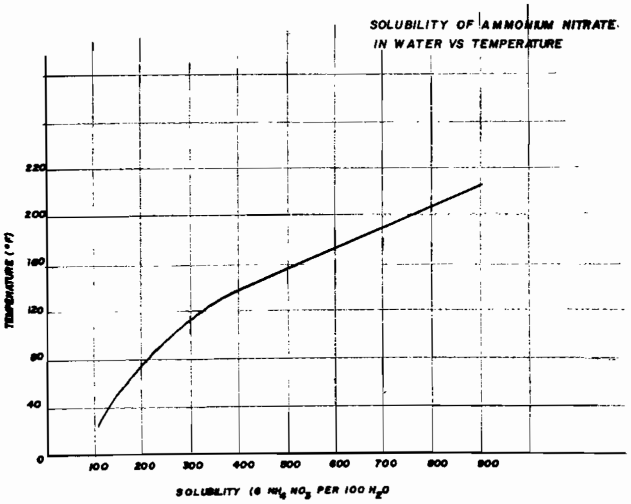
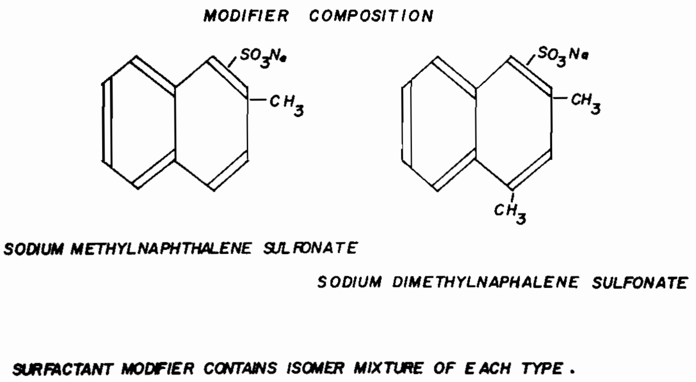


Figure 2
Modifier Composition



used such organo sulfonate/filler combination today is sodium mono-dimethylnaphthalene sulfonate/ kaolin (Fig 2.)

The striking crystal inhibition properties of sodium mono-dimethyl-naphthalene sulfonate are illustrated in Fig. 3 which shows two hot saturated ammonium nitrate solutions (67% nitrate) prepared from

a) kaolin (3% on nitrate) coated prills, and

b) sulfonate (1% on kaolin) modified kaolin (3% on nitrate) coated prills.

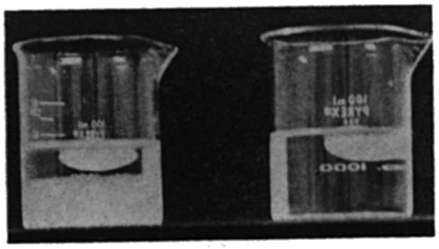


Figure 3
Two Hot Saturated Ammonium Nitrate Solutions (67% Nitrate).

These solutions were allowed to cool to room temperature and stored 18 hours. Incorporation of 0.03% sulfonate completely inhibited crystallization of ammonium nitrate in this experiment.

In addition to the powerful crystal inhibition effect which this surfactant exerts, it also reduces caking because it lowers surface tension of mosture droplets and promotes film formulation. This effect tends to reduce bridging of granules by droplets and subsequent crystal bridging of such granules.

Properties and Applications of Surfactant Modified Kaolin

Sodium naphthalene sulfonate modified kaolins are commercially available in a range of modifier levels. Uses and properties of these clays are summarized in Table I. Properties of the kaolin substrate are shown in Tabl 2.

Recommended application levels of modified clays usually are 2.5-3.% based on weight of fertilizer. This amount of clay is required to obtain adequate coverage of prill surface.

Industrial grades of AN are coated with not more than 1% of the more concentrated modifications because higher levels of clay would interfere with explosive wave propogation. The higher level of surfactant only partially compensates for the ca. 1% application level of coating agent and as a result, caking protection obtained on these grades is, in many cases, lower than obtained with the usual application levels on fertilizer grade nitrate.

Table 1
Properties and Typical Applications of Surfactant Modified Clays

% Surfactant On Clay	Typical Conditioning Outlets	% Clay Based On Fertilizer	% Surfactant Based On Fertilizer
0.6	Diammonium Phosphate and Other Less Caking Applications	2,3	0.012—0.018
1	AN, DAP, AUL; 21-14-14, 23-10-11; 10-10-25; 17-11-22 15-15-23; 15-15-15, 14-14-14; 12-12-12; 16-8-8; 20-0-20 30-10-0.	3	0.03
2	Same As I	2,3	0.04—0.06
3	Same AS I	2,3	0.06—0.09
5	Industrial Grade An	1	0.05
10	Same As 5	0.6—1	0.06—0.10

Table 2
Properties of Kaolin Substrate

Surface area	—20-24 M^2/G
Mean particle diameter	—0.3 Micron
Particle size (stokes)	—85-95% -2 microns; max. 4%+44 microns
Particle size (dry)	— <2 microns
Moisture	—1-4%, as specified
Color	— Cream
Composition	—Hydrated aluminum silicate (Al_2O_3 .$2SiO_2$.$2H_2O$

One of the most important factors governing performance of surfactant clay is adherence of clay to granules. Good adherence is favored by coating low moisture granules with relatively high moisture organo clay or vice versa. In

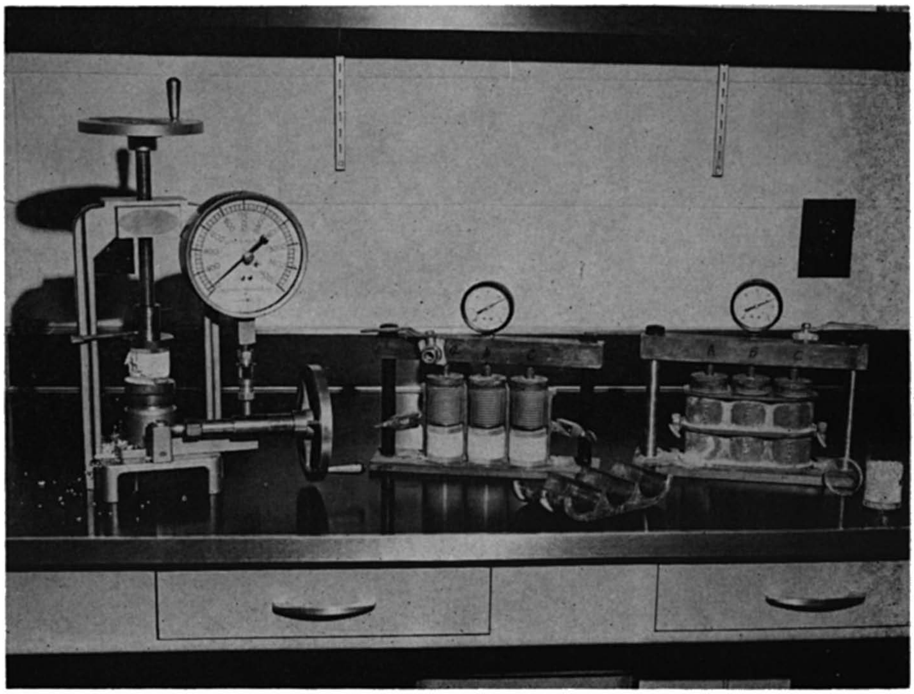


Figure 4
Compression Tester, Test Specimens of an Prills in Cement Molds, and Partially Assembled Test Plug of an Prills.

general; superior coatings are achieved when granules are coated hot (above 90°F). Good adherence of clay to granules requires extremely well pulverized clay as discussed later.

Anticaking Performance of Surfactant Clays

We maintain a continuing laboratory program for the evaluation of new anticaking coating agents and for testing of present commercial organo clays on specific fertilizers from different producers. Two independent laboratory tests are used which are usually, but not always, indicative of actual warehouse storage performance. Only when both laboratory tests agree that a coating agent gives good caking protection on a given fertilizer product do we feel that it warrants production trials.

A. *Test Methods*

Test procedures used in this work are the accelerated temperature cycled test (ATC) which is a modification of the method developed by Wilson et al (1962) and the Columbia Nitrogen lever press (LP) test. ATC test equipment and a chart of the temperature cycle (°C) are shown in Figs. 4, 5, and 6. Photographs of LP equipment are shown in Figs. 7 and 8.

Temperature Cycled Tests

This procedure is given below:

1. Place 71 gram sample of above conditioned nitrate in a cylinder consisting of a 1 15/16″ diameter lucite disk (¼″ thick) fitted with a 3 mil. polyethylene sleeve. Place a second disk on the nitrate and trim excess tubing off.

2. Insert 3 test specimens in three-cavity cement mold (Model CT-34 manufactured by Soil Test, Inc., Evanston, Illinois). Covers for the mold consist of an air actuated bellows fitted with a pressure gauge. Fasten bellows covers over the test specimens and inflate the bellows with air to 24 p.s.i.g.

3. Place molds containing tests specimens in a Hotpack environmental test chamber (Model No. 1248), at 25°C and maintain at 80% relative humidity.

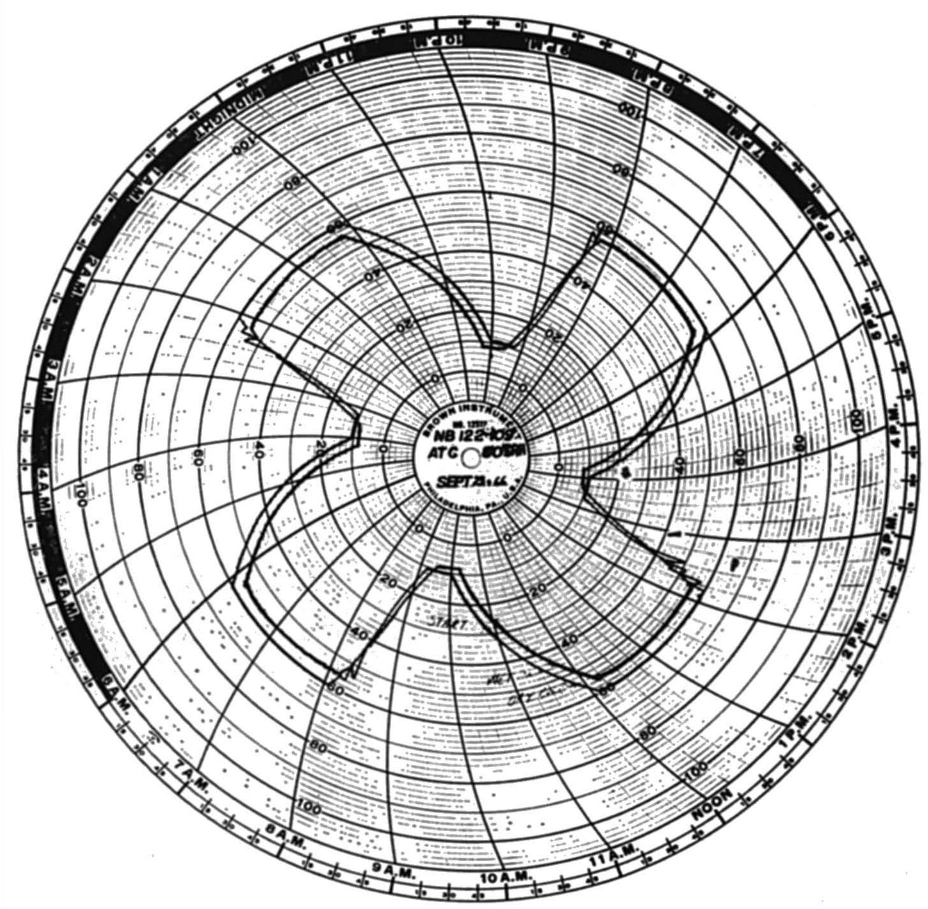


Figure 6
ATC Test Cycle Showing Dry and Wet Bulb Temperatures (°C at 80% RH)

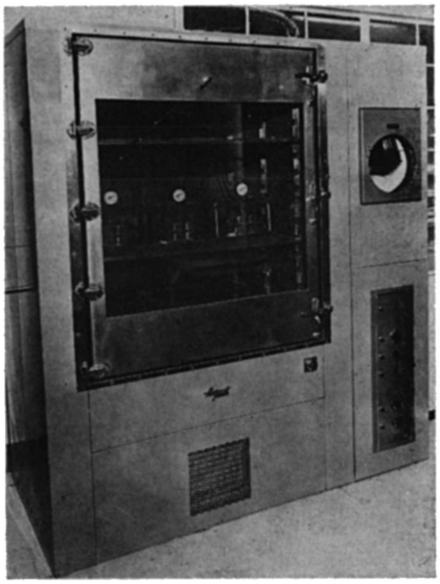


Figure 5
Hotpack Environmental Test Chamber.

4. Seal the chamber and vary temperature as follows:

25-60°C (77-140°F) - 1 hr. 15 min.
60°C (140°F) - 2 hr.
60-10°C (140-50°F) - 1 hr. 15 min.
10°C (50°F) - 45 min.
10-25°C (50-77°F) - 45 min.

5. Run 3 additional cycles as in 4.

6. After 24 hours, remove samples from test chamber and equilibrate at room temperatue for 30 minutes. Record final pressure (should be over 20 p.s.i.g.) and release pressure.

7. Remove test specimens from mold cavities, record final height of prill cakes, and remove the polyethylene sleeves by slitting.

8. Determine crushing strength of cakes on a Research Products Company Compression Tester, Model MC-602A.

Columbia Nitrogen Lever Press Test
Determination of the Caking Tendency of Fertilizers

Sample

Use the product as received; before filling the bags the sample must be properly mixed.

Preparation of the Waxed "Kraft" Paper Bags

Cut the paper as indicated; place the wooden block (60x90 x15 mm) on the paper and successively fold the parts A, B_1, B_2, and C around the block. Seal the joints

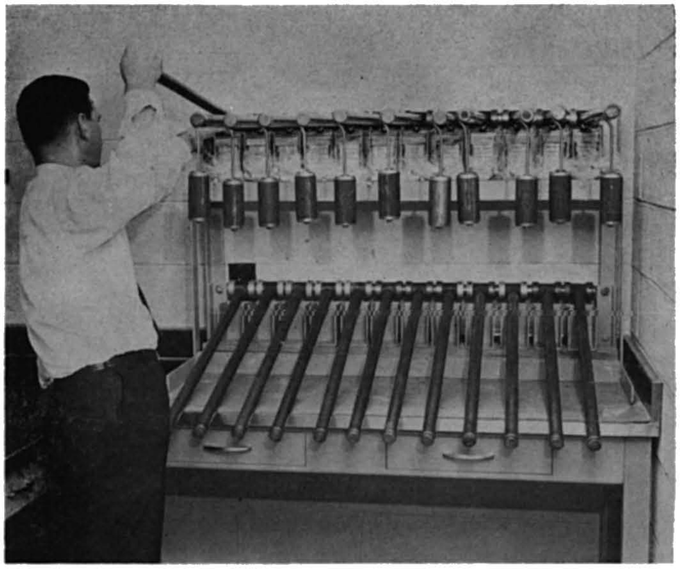


Figure 7
Columbia Nitrogen Lever Press

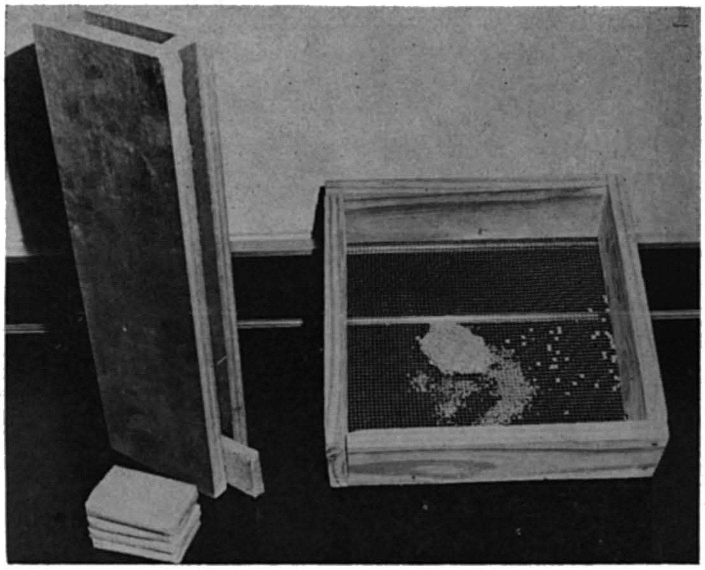


Figure 8
LP Drop Case and Screen

with adhesive tape and remove the block.

Filling the Bags

Place the bag in the metal mold, taking care that it touches the walls of the mold all-round. Transfer the sample to the bag in such a way that the bag is filled to the top evenly and without interruptions. Fold the strips projecting above the mold inwards, carefully lift the bag a short distance, and seal it with adhesive tape. Fill 5 more bags in the same way.

Compressing the Bags

Stack the 6 filled bags (plane A horizontal) right on top of each other, inserting metal or P.V.C.—plates (100x70x3 mm) between the bags . Place the stack in a plastic cover 110-70-200 mm) and close the latter.

Place a metal plate (100x70x3 mm) provided with a central notch, on top of the stack and put a steel ball (ϕ15mm) in the notch. Place the stack on the table, seeing to it that the distance from ball to pivot point = 10 cm. Put the lever (length =L cm) on the ball, seeing to it that it is horizontal; if necessary, slip one or more metal or P.V.C. —plates (100x70x3 mm) under the stack. Load the end of the lever with a weight (=G kg) with eye, so that a force of 27 kg is exerted on the stack (pressure =½ kg/cm) . Choose 1 and G in such a way that G&L = 27x1. After a few hours, check whether the lever is still horizontal and correct, if necessary. Keep the bags under presure in a thermostated room for two weeks at a pre-determined temperature.

Determination of the Amount of Caked Product

Carefully remove the stack from the press and take the bags out of the plastic cover. Treat each bag as follows: drop the bag,

Table 3
Effect of Modifier Structure and Application Level on Caking of Ammonium Nitrate

Compound	% Based On Clay	% Coating Agent On Nitrate	ATC Average Crushing Strength P.S.I.	Lever Press Tests (1 Month) % Caked
Sodium mono and Dimethylnaphthalene Sulfonate	1	3	121	0
	2	3	73	0
	3	3	78	0
	10	0.8	97	0
	10	1	93	0
Sodium Alkyl—Benzenesulfonate	1	3	149	—
	3	3	143	
	10	0.8	198	18.0
	10	1	204	23.8
None	Diatomaceous Earth	3	106	0
None	Unmodified Kaolin	3	204	6.9
Rosin amine D acetate	1	3	174	—
	3	3	159	—
Polythylene Oxide Glycol	1	3	174	—
	3	3	187	—
Ethoxylated castor oil	1	3	211	—
	3	3	176	—
Styrene maleic anhydride	1	3	240	—
	3	3	247	—
Bis (hexamethylene) triamine	1	3	209	0
	3	3	182	—

with plane B horizontal (plane B_1 below), through the wooden drop-case. Repeat this with plane B_2 below. After t hat, cut the bag open, collect the caked product (= lump), and weight (= a g). Also, weigh the remaining part of the content of the bag (= b g).

Calculation

Calculate the caking tendency, in % w, using the formula:

$$W = \frac{a}{(a+b)} \quad \text{x -100}$$

Where:

a = sum of the amounts of caked product (g). a+b = sum of the amounts of sample (g). Round off the results to a multiple of 5.

B—Test Performance.

Performance of various organo clays is summarized in Table 3 which illustrates end results from screening of hundreds of different surfactants and dispersants.

The most effective agents in this series are the sodium naphthalene sulfonate clays which compare favorably with untreated diatomaceous earth.

Table 4 shows that the only modifiers equaling or approaching the anticaking performance of sodium mono-dimethylnaphthalene sulfonate were other alkylnaphthalene sulfonates and calcium stearate.

The above test work was confined to ammonium nitrate, but also applies to many other high analysis mixed fertilizers. Data reported herein were obtained on free flowing nitrate prills coated within several days of manunfcture.

A crucial factor for obtaining reliable information in these laboratory tests is the necessity that test coating agents be applied to free flowing ammonium nitrate. This is possible only when the nitrate is freshly prepared, i.e., not more than a few days old. Uncoated ammonium nitrate which has been allowed to age undergoes severe caking. In such a condition its recaking tendencies are greatly reduced and hence any evaluation of anticaking candidates with aged nitrate is likely to be misleading. Failure to recognize this factor has been responsible for many of the discrepancies obtained in previous laboratory evaluations.

Table 4
Effect of Modifier Structure and Application Level on Caking of Ammonium Nitrate

Compound	% Based On Clay	Coating Agent On Nitrate	Average Crushing Strength P.S.I.	Lever Press Tests (2 Weeks) % Caked
None	Diatomaceous Earth	3	86	2.2
None	Unmodified Kaolin	3	141	11.4
Sodium mono and Dimethylnaphthalene Sulfonate	1	3	91	0
"	10	1	112	0
Sodium Lignosulfonate	1	3	140	0
"	10	1	268	21.9
Calcium stearate	1	3	111	0
"	10	1	261	23.4
Ammonium alkyl Naphthalene sulfonate	1	3	91	0
"	10	1	119	2.8
Sodium alkyl Naphthalene sulfonate	1	3	119	0
"	10	1	105	2.0
Sodium alkyl ester Sulfonate	1	3	113	12.6
"	10	1	259	19.6
Sodium ispropyl—Naphthalene sulfonate	1	3	109	0

Effect of Dry Particle Size

Kaolin fineness of grind strongly controls its anticaking performance as shown in the accompanying plot (Fig. 9.). Fineness of grind or dust size of kaolin was measured by porosity tests on the Fisher Subsieve Tester.

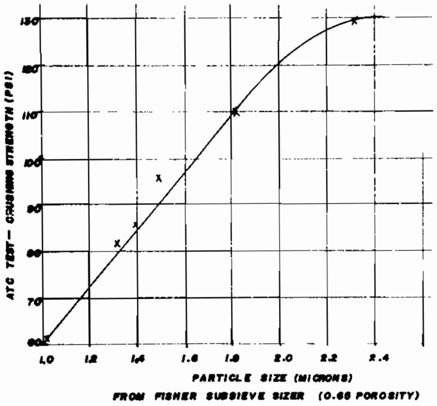


Figure 9
Caking Strength U. S. Particle Size of Surfactant Modified Clay.

Maximum caking protection with organo clay requires that the average dry powder size of such clays be below 2 microns. Clays having an average dry particle size above 2 microns are too coarse to give good adherence on granular fertilizers and as a result protection against caking sugers.

Preparation of high performance, finely pulverized organo clay requires careful selection of crude clay coupled with efficient milling during manufacture. The most suitable clays for this purpose are the so-called "hard clays" of the Aiken, South Carolina, and Wrens, Georgia, area. The term "hardness" derives from the high reinforcement properties of such clays in rubber. These clays have a B. E. T. surface area of over 20 M^2/g. In the case of organo anticaking clays, the surface area is 20-24 M^2/g. These clays exhibit exceptional ease of grindability during manufacture and can be readily pulverized to fine powders which give good adherence to granular fertilizer.

Summary

Fertilizer, organo clay, and process parameters which affect caking performance are summarized in Table 5.

A comparison of two types of

Table 5

Fertilizer Properties	Organo Clay Properties	Process Variables
1. Chemical composition	1. Modifier type	1. Amt. clay on fertilizer
2. Physical form	2. Amount modifier	2. Coating temperature
3. Moisture content	3. Surface area & particle size	3. Storage conditions
	4. Moisture content	

organo clays and untreated diatomaceous earth is shown in Table 6. The main advantage of organo clays are low cost in certain areas, ease of handling, and reduced dusting.

References

1. J. Silverberg, J. R. Lehr, and G. F. Hoffmeister, "Microscopic Study of the Mechanism of Caking and Its Prevention in Some Granular Mertilizers," *Agricultural and Food Chemistry,* Vol. 6, No. 2, (June 1958) pp. 442-448.
2. J. F. Wilson, J. C. Hillyer, V. C. Vives, and R. E. Reussser, "Testing the Caking Tendencies of Ammonium Nitrate Fertilizers," *Agricultural Chemicals,* September, 1962, pp. 42-45, 116.

Acknowledgment

The author is indebted to numerous individuals in the fertilizer industry and in particular to Tom Champion and other personnel of Columbia Nitrogen for many productive suggestions in connection with anticaking research and for permission to discuss the Columbia Nitrogen lever press test procedure. The author also acknowledges with thanks the efforts of co-workers at J. M. Huber Corporation, especially to Messrs. Paul R. Odom, James R. Kimberly, William Hatfield, and Phillip McCard.

MODERATOR REYNOLDS: Thank you Joseph, your paper is most valuable. We will move on to our final speaker, Mr. Robert J. Harvey.

Table 6
Comparison ot Coating Agents

Coating Agent	Modifier	Coating Type	Mechanism	Advantages	Disadvantages
Surfactant treated clays	Sodium mono and dimethyl naphthalene sulfonate	Surface tension reducer and crystal habit modifier	Reduces surface tension of water droplets, impedes droplet bridging between prills and spreads moisture over entire prill. Reduces crystal growth at contact between prills. Interferes with ability of nitrate to grow into well formed crystals.	Suitable for wide range of fertilizer and industrial grades	Coated fertilizer cannot be recycled
				Low cost (east of Mississippi) easy handling	Not effective for some high moisture grades
Hydrophobic clays	Calcium stearate	Moisture Repellent Coating	Coats prills with moisture barrier; prevents migration of water between prills and avoids bridging crystal growth	Same as surfactant	
Diatomaceous Earth	None	Moisture absorption	Absorbs or imbibes moisture from prill surface	Excellent moisture absorber, particularly effective on high moisture grades	Dusty, handling.

Evaluation of Different Conditioners on a Single Fertilizer Material

By *G. L. Bridger, *I. J. Bowen, †R. J. Harvey

Thank you Joe. Glad to be here.

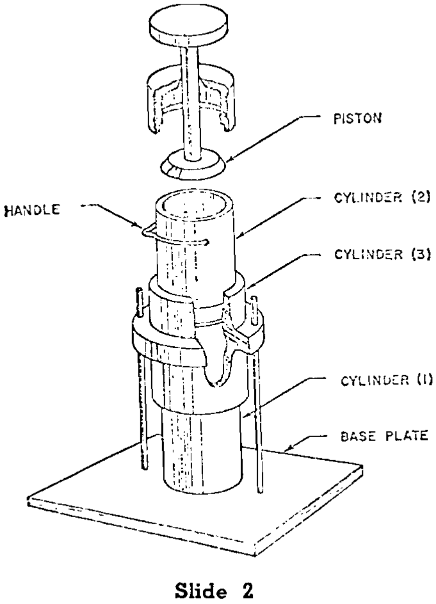
THIS will be a brief discussion on the effect of six different classes of conditioners on a single fertilizer material, namely potassium nitrate. A single fertilizer compound was selected to eliminate the aspect of continued chemical reaction from affecting the results, thus leaving only the physical properties of the material to influence conditioning. As you are well aware these properties are: particle size, particle shape, particle surface, density, hygroscopicity, hardness and pH and further you know of the difficulty of translating or correlating these properties with results in the field.

In the case of standard agricultural potassium nitrate, the material is in the −20+65 mesh range consisting of individual ovoid crystals with many knob-like irregularities on the surface . The density of the material is 2.1 and is classed as a hard, "non-hygroscopic" material having a pH of 9 to 10. The purpose of this study was to evaluate different conditioners with four different test methods to establish what class and level of conditioning was satisfactory and to establish the reliability or lack thereof of the test methods. The different classes of conditioners together with the number tester are shown on Slide #1. Four test procedures were used as shown in Slide 2.

Slide 1

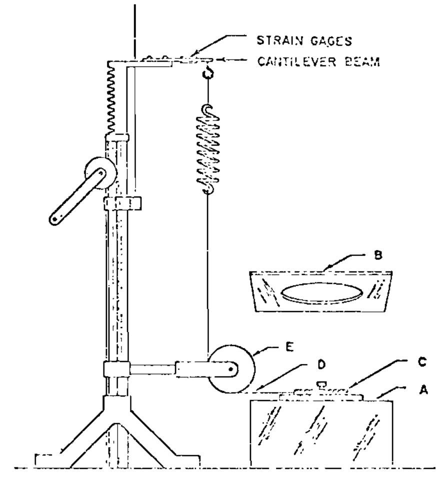
TEST METHODS APPLIED

1. Bulk Tensile Strength
2. Powder Shear Strength
3. Compressive Strength
4. Small Bag Storage



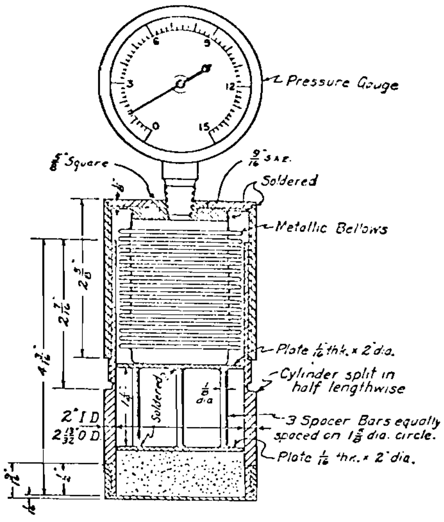
Slide 2
Apparatus For Measuring Bulk Tensile Strength.

The apparatus used for the bulk tensile strength is shown in Slide 3. In this test a sample of the material was compressed into a vertical cylindrical shape inside a cylinder that was divided horizontally in the middle. Force was applied to the upper cylinder by means of a force balance and measured by a strain gage. The force at which the upper cylinder breaks away and material flows out from the opening between the cylinders is called the bulk tensile strength. This test was reported to have been successful on determining the effectiveness of conditioning for a silicate material on wax particles. We were not able to duplicate any results and feel that our particle size was too large for this method.



Slide 3
Apparatus For Measuring Powder Shear Strength.

The powder shear strength apparatus is shown on Slide 4. A cylinder with a very low height to diameter ratio is formed under different compressive loads. This cylinder is confined between two horizontal plates. Force is applied to the upper plate by the same means as in the bulk tensile strength method. The force at which the upper plate shears the cylinder is taken as the powder shear strength. About 160 different tests were made with the conclusion that this method will only differentiate between levels of conditioning for the same conditioner but will not differentiate between conditioners.



Slide 4
Diagram of Caking Bomb

The compressive strength apparatus is shown in Slide 5. Perhaps this is more commonly called "crushing strength." A cylinder of material is compressed in a "bomb" by applying a load at a given temperature. The force which is applied to crush or crumble the cylinder so formed is called the compressive strength. We noted quite a range of variability in crushing strengths for the same results on the small bag storage test and concluded that the test is more sensitive than the bag storage test.

Slide 5

Classes and Number of Conditioners Studied

A. Diatomaceous Earths	10
B. Clays	11
C. Clays Treated With Surfactants	7
D. Silicates	11
E. Stearates	2
F. Surfactants	22
Total Number	63

The small bag storage test consists of placing five pounds of test material in a 2 mil polyethylene bag which was inside a 2 ply paper bag with polyethylene coatings on both inside and outside and placing it in storage for a 30-day, 90-day, 180-day, or one year period under a load simulating conditions at the bottom of a stack of 12 - 100 pound bags. These tests are still continuing. This test with the compressive strength give the best indication of the effectiveness of conditioners.

The results of our tests on potassium nitrate are shown on Slide 6. by classes, the number of materials tested and the number effective in each class and the ranking of that class of materials, based on both compressive strength tests and 30-day storage tests. It should be emphasized that the 30-day storage tests are not long enough for final ratings, and that after

Slide 6

Test Results

	Avg. Level of Conditioning Wt. %	Basis Compressive Strength Number Tested	Number Effective	Ranking	Basis 30-Day Storage Number Tested	Number Effective	Ranking
A. Diatomaceous Earths	2	10	2	4	10	0	—
B. Clays	2	11	8	1	11	10	1
C. Clays Treated With Surfactants	2	6	2	2	7	6	2
D. Silicates	1.3	7	2	3	11	7	3
E. Stearates	1.0	2	2	6	2	0	—
F. Surfactants	0.1	2	2	5	26	1	4
TOTAL		38			67		

longer periods, some of the conditioners may not be effective.

Two clays treated with 10 weight percent surfactants gave the best results although one of the silicates tested fell in between them. The silicates are ranked third largely because of the large spread in compression test results.

We would be happy to show the results to individual suppliers within their class of materials. of the various materials tested, We would also like to caution that the results are specific only for our potassium nitrate and should not be used as an indication for other materials as to the type or level of conditioning which would be effective.

We appreciate the opportunity to discuss this subject at this conference and are now open to question.

Moderator Reynolds: This completes our 4 papers on conditioners. On behalf of all the membership and our Executive Committee many thanks to each of you for preparing your valued papers. Will the panelists come to the round table on the platform to answer questions.

A Member: This is for Dr. Silverberg. Doctor, in your work with ureas, did you notice any difference in the particle size of urea so far as penetration and effect of moisture, and also did you go into the various types of ureas manufactured by various suppliers? I do not want any names, of course.

Mr. Silverberg: Your name? And with whom?

Member: My name is Charlie Paynter. I'm with Federal Chemical Company.

Mr. Silverberg: Charlie, I almost didn't want to mention urea because TVA has not produced this material and, didn't have any reason really to study it. We got involved through AID somewhere in making sort of a comment on whether unconditioned urea would cake in storage. I think we have gotten samples from possibly 14 companies now. All I can say about urea, the unconditioned urea, is that we have not tested any yet that has not had some set to it.

We had one that was a conditioned urea from France that did not cake. This was done in a three-and-a-half pound bag with pressure applied at three and a half pounds per square inch, about, which is the same as on our big bag test, and was done for a month in the same warehouse.

We found after dropping the small bags twice that each bag had a lump. The lumps were not too hard. If you worked them with your hands the lumps broke down and the material would be alright and possibly in some areas are used that way.

Moderator Reynolds: Do we have another question?

Dr. Kurt Jockers (Badische) What happens with these organics in the soil?

Moderator Reynolds: Who would care to answer that question? Phil? Do you want to come to the mike — As a matter of fact, why don't all four of you come to the table, please.

Mr. Mischel: We feel that these surface-active agents degrade in the soil. We have had work done in the associated detergent industry to verify this.

Dr. Jockers: But you have no experience about this?

Mr. Mischel: Oh, yes, we have quite a lot of experience.

When I presented my paper, I was just trying to show where conditioners can find application. We're not trying to sell conditioners as yet for this type of application.

Some research people are doing just this, though, and we are helping them and also looking at this type of application ourselves.

I understand this happened many years ago. The use of wetting agents was looked upon as a way of increasing crop yields, and we have been carrying out such developmental work now for about five or six years with various commercial fertilizer organizations, specialty fertilizer producers, and also experimental stations throughout this country.

There are as yet no definite conclusions to be drawn from this work.

Mr. Makower: I would like to ask Mr. Mischel — I believe he mentioned the use of a penetrometer for measuring caking tendency. I wonder if you would care to enlarge just a bit. Is it a needle and you measure the force required to penetrate a cake? Or just what is involved?

Mr. Mischel: That's correct. It's a device we have adapted from the work we do in the general chemical industry to measure caking tendency. We have performed such work qualitatively for many years.

Just recently people wanted to know quantitatively what causes caking and what are the relative degrees of it.

We can't compare our results from one set of samples to another.

But this procedure does measure the force necessary for a shaft to penetrate a cake after a set of storage times. In other words, we use, as I said, a force of 12 psi applied to the samples after they have been formed into a cake for seven days. For ammonium nitrate, we again use a 12 psi force after the samples have been held for 48 hours and have been cycled four times, with varying temperatures. We do not control the humidity.

Mr. Benjamin Makower: Well, I'm not clear. Does this mean the force required to penetrate the cake through a certain distance or to penetrate through the cake.

Mr. Mischel: Penetrate through the cake, that's right.

Mr. Makower: Oh, completely through the cake.

Mr. Mischel: That's correct.

Mr. Makower: I see. About what thickness is your cake, just roughly.

Mr. Mischel: The cake formed is approximately 3 inches long by 1½ inches wide and is held in place by a polyethylene cylinder of approximately a 6 inch length. The cylinder is capped on either end with a 25mm plastic cap.

Mr. Makower: I would like to ask Mr. Harvey. You mentioned the use of silicates for treatment. Could you tell me what type of silicate was used and how it was applied?

Mr. Harvey: These silicates were of course applied in the dry form and mixed in a laboratory-type blender to the best of our ability.

We have tested a number of them. I would be willing to show you exactly which ones they were, both in the compressed and uncompressed form.

Mr. Makower: Do you mean a silicate such as magnesium silicate or aluminum silicate, or do you mean something like a liquid sodium water glass, or sodium silicate spray?

Mr. Harvey: That's right. These materials were silicate pigments.

Mr. Makower: Oh, they're silicate pigments.

Mr. Harvey: Yes.

Mr. Makower: Thank you very much.

Moderator Reynolds: We'll have one more question.

Mr. Horn: One or two of you gentlemen on the panel listed the properties of fertilizer which affect or cause caking. I would like to ask this question to all members of the panel: Does temperature have any effect on the fertilizer?

Mr. Silverburg: Storage temperature?

Mr. Horn: Yes, Going to storage.

Mr. Silverberg: Yes, temperature can have an effect. Most of the fertilizer granules contain soluble salts. When the fertilizer is cold, practically all of the salts are present as crystals, since the product usually is low in moisture content. When the fertilizer is hot, there is increased solution phase, which may cause the granule to be softer. When soft granules are under pressure, as in bags or in a pile, lizers. Dr. Iannicelli will you kind- they will flatten a little and contact areas will increased. Also, when hot granules with increased solution phase cool, the soluble salts crystallize and you have a caked situation.

Dr. Scaife: I am very interested in these talks on various methods for conditioning fertilizers. Dr. Iannicelli will you kindly give me some idea about how the very fine clays were obtained by grinding? What kind of mechanism was used?

Dr. Iannicelli: These clays were processed by a Raymond Mill using rotary dried lump clay treated with surfactant solution.

Fineness of grind is controlled by preselection of crude clay and by proper mill setting. Crudes chosen for this purpose are characterized by high surface area (known as hardness) which contributes to ease of comminution. Adjustment of the air classification system of Raymond Mills governs the recycle ratio and the fineness of clay particles that are collected from the grinding rollers. Thus we can control the grind very accurately.

Moderator Reynolds: I think we are going to have to call the session here concluded for today. You have been a very attentive audience. We appreciate your staying with us. The paper on Safety by John S. Mark, will be carried over until tomorrow morning. Thank you very much. Meeting adjourned at 5:30 P.M.

Friday Morning Session, Nov. 4, 1966

The Round Table Reconvened at 9:15 A.M.

Dr. Vincent Sauchelli, Moderator, presiding.

MODERATOR SAUCHELLI: Good morning. I am glad to see so many of you here this morning. I understand quite a number have had to go back home, especially to the Midwest, because of the snowfall. Eighteen inches of snow in Lima, Ohio, Dayton Ohio and the central area is swept by a severe storm. We are lucky here that we just have freezing weather.

We are going to start our program with an interesting presentation from John Mark of the National Safety Council. Safety instruction in the fertilizer plant has been growing particularly in the last ten years. A fine record has been made but it is still not perfect. There is a great deal more to be done on the importance of keeping the subject alive so that all employees in the fertilizer plant become conscious of the importance of safety, which is the objective of the National Safety Council. John Mark is known to many of the folks here and he is an interesting speaker. John.

Safety in the Fertilizer Plant

John S. Mark

MY thanks to Chairman Sauchelli and your Executive Committee for asking me to participate in your program. It is my pleasure to meet many of my fertilizer industry friends.

I think it is wonderful to see so many here so early in the morning. It's my pleasure to come before you to talk about a subject that has always been of great interest to me.

It was interesting to me to hear the speakers Wednesday and Thursday talking about the increased need to take care of the increasing population in the years to come. To me in my present position, "In the work for safety" this means we will need more efficient plants, new people, new management, more training and finding better ways of producing the fertilizer needs and delivering it to the market efficiently.

This kind of situation calls for the best in safe-minded engineering talent to produce the most efficient plant. In addition to training our personnel to use the machinery, storage facilities, etc. in the most efficient way, we should include a good safety program.

Safety is a word that has been used around the world in many ways, however, the definition of safety to me is recognizing the hazards that are involved and devising ways and means for safe and efficient operations. When you create this kind of a situation you have an efficient—safe plant.

In these new plants you will find a good opportunity to include safety. Safety seems to have been a stepchild in some operations. In most companies, however, it is part of production, it is a part of management, it is an integral part of the total operation.

In operations where it is a stepchild this is a strange thing because actually you cannot escape safety. Whatever you do safety is involved. If you will look at it, from the standpoint, that if you train your people to do a job a certain way, to do it efficiently and to use the machine that you have developed for the job to give you the most that there is in it, in a way, whether you recognize it or not, you are involved in safety. Because in the act of training a man to do right and efficiently and to use a machine correctly there is an element of safety involved in that there is a procedure set up to do the job right.

If you reverse the thinking for a moment and say we are going to train our people to work safely, you will also back into it because you will, in the process of training your people to work safely, you will at the same time teach them to do the work right, to get the most out of the machine, to make it as efficient as possible. So I would like to say that you cannot escape safety. I think it has been recognized through the years that the operations that have a very good safety program or have a safety program usually also have the best operating costs.

I would suggest that we plan for safety in these new plants. All of this philosophy means nothing unless I can give you some "for examples."

The fertilizer industry in the last 15 years has made tremendous progress in reducing the accident rate. The "for examples" I use are those in industry who are members of the National Safety Council. This is the only record that we have that we can point to and say, "This is what the fertilizer industry has done."

In 1950 the frequency rate for the fertilizer industry was over 16. We are talking about two things. The Bureau of Labor Standards reports showed an accident frequency rate of 16. The frequency rate means the number of accidents per million man-hours of work.

In 1956, six years after the

Fertilizer Section of the National Safety Council was formed the accident rate among reporting members of the National Safety Council dropped to 10.82 . The overall record of the industry, who report to the Bureau of Labor Standards, still was better than 16.

Last year the record of the fertilizer industry, who are members of the Safety Council, the frequency rate dropped to 8, while the national average of all industry, those who are not members of the Council still report to the Bureau of Labor Standards, still continued to be better than 16.

This shows the progress that has been made in the fertilizer industry as far as promoting safety is concerned. This is a cut of almost 50 per cent in the frequency rate. Just think of the reduction in human suffering and economic loss.

Another interesting aspect of this is that we received a report from the State of Georgia advising that the fertilizer industry there had realized a substantial reduction in the workmen's compensation rate and they attribute this to the fact that there has been a substantial decline in the number of accidents in Georgia in the last few years. This just doesn't happen, because somebody somewhere has been working to accomplish safety.

Another interesting fact. Among the members of the Fertilizer Section a number of them report to the National Safety Council thru a Fertilizer Plant Safety Contest. This is done on a voluntary basis. The reports are sent in by each company every month.

In the year 1965 there were 181 reporting units and of these 78 had perfect records.

In the first six months of 1966, and this, incidentally, is a year where I have been hearing reports that because of the war effort in Viet Nam, and the additional demand for labor, that the fertilizer industry has been forced to hire people who are not quite the best caliber, but even so, of the 159 reporting units the record shows that 80 of them have turned in perfect records. If we assume that the spring season is the heavy season in the fertilizer industry, this would also indicate that in spite of the fact that from some quarters I hear that the accident rate is going up because of the kind of labor we are hiring, there are more plants turning in perfect records. This would seem to show that some body is still working to reduce the accident rate.

Another outstanding example, and this is a matter of record, one fertilizer operation in this country at the last reporting period has turned in 11,700,000 man-hours of work without a lost time accident.

In the Chemical Section, and this is only to substantiate what can be done toward reducing accidents in the industry, the du Pont Company in one of their plants, has turned in at the last reporting date some 30 million man-hours without lost time accident.

Now, why do I say these things? I am saying these things because those who have a safety program know what I am talking about and for those of you who may still be lukewarm about safety there is a job to be done which isn't difficult to do. I will get into how that can be done a little bit later.

As I said before all of this was accomplished because industry through its dedicated people had decided that safety is an integral part of their operation, that it pays, that it is important and they have taken steps to implement the program.

In 1949 or 1956 two or three interested people in the industry felt that there was a need for an organized safety group in the fertilizer industry. They met for a year here and there and then finally, gathering numbers, they went to the National Safety Council and asked that a Fertilizer Section of the National Safety Council be formed.

It took some two to three years before the group finally got going. Today the Executive Committee of the Fertilizer Section consists of some 39 members representing every phase of the fertilizer industry, nitrogen, mining, phosphate, small plants, medium sized plants, large plants, insurance associations and even representatives of government.

These men give of their own time and money to attend meetings, to work and to turn out publications that are of benefit to members of the Fertilizer industry. They like to feel that they had a hand in helping the industry reduce its accident rate. The Executive Fertilizer Committee of the National Safety Council is considered a working group. They come to do a certain job. They are assigned certain jobs to take home and accomplish before the next meeting and this is the reason they are successful. In fact, their progress had been so good that in 1964 they won what is known in the Council as the "Cameron Award."

The "Cameron Award" is awarded to the section that turns in the most outstanding job in all fields of safety activity in a given year. Some of the areas where they have turned in an excellent job is in engineering, in training, in programs, and I refer to the programs at the Annual Congress in Chicago, in schools, liaison with associations, fire protection, industrial hygiene, legislative and others.

For a relatively new section, the Fertilizer Section is one of the younger sections of the National Safety Council. I think this is an excellent record because there are 27 sections in the National Safety Council industrial group.

It might be of further interest to you to know that in the Cameron Award activity the Fertilizer Section has never placed lower than fifth and in many years they have been second and third and fourth. This, I think, is a good record for the Fertilizer Section which represents your industry.

I might mention that the Cameron Award is an award that was developed after one of the first founders of the safety movement which is now the National Safety Council founded about 35 or 40 years ago Mr. Cameron and two secretaries. This was all that the safety group amounted to. Mr. Cameron travelled all over the country knocking on doors of industry saying "we ought to have an organized safety group." In honor of his memory and the work he did toward organizing the National Safety Council, the Cameron award was developed.

There is another interesting aspect of this accomplishment and that is the Fertilizer Supervisor Safety Schools. There are four of them held each year. One is at Wilmington, North Carolina, Biloxi, Mississippi, Fresno California, and the Midwest school held in Chicago.

In the seven years that these schools have been conducted there have been about 1,500 students from the fertilizer industry; supervisors, plant superintendents, safety directors and other interested people have attended these schools.

This year, with the Wilmington the Biloxi and the California schools already held, some 240 students attended these schools. The Midwest school will be held in Chicago on December first and second.

The Fertilizer Section feels that the conduct and the holding of these schools around the country has helped supervisors and people in the industry to do a better job in safety when they went back to their plants.

I need to make this comment because without this particular association I think sometimes the Fertilizer Section might have floundered. The National Plant Food Institute has been an early promoter of safety in the fertilizer industry and they have done yeoman work through correspondence and other ways to help the Fertilizer Section promote safety. In recent years since they have taken over sponsorship of the Fertilizer Safety Supervisor Schools we think that interest in these schools has grown tremendously.

The Fertilizer Section is also very happy that the other associations are helping, namely, the Agricultural Ammonia Institute, the National Fertilizer Solutions Association and the Sulphur Institute. I might mention here that even though I am here the safety exhibit which you see over there (indicating) actually was set up and is manned by Dave Bixby of the Sulphur Institute and Mr. Ritnour of the National Plant Food Institute.

The work of the Fertilizer Section is done almost entirely by the members. Here are some accomplishments.

Publications. Some several years ago the Fertilizer Section saw the need for a fertilizer safety guide and, as a result of that, the book titled "Fertilizer Safety Guide," was developed and it was very well accepted in the industry. It is now being revised and should be ready for industry sometime next year.

Many of you probably receive the Fertilizer Section Newsletter. This is a publication that is geared specifically to problems in the fertilizer industry. In recent years, those of you who receive the letter will see articles on off-the-job safety. This is a separate subject which I will not get into. You see other subjects that are of a general interest.

An interesting thing about the Newsletter is that it is edited by a member of the Executive Committee of the Fertilizer Section. This year his name is Ed Conroy with Texas Gulf Sulphur in New Gulf, Texas. He gathers all the material that is sent to him by members of the committee and members of the industry and puts together the Newsletter which goes out to you in the industry.

Data sheets. Right now in process are three data sheets. One is on liquid sulphur which should be out early next year, another is on phosphoric acid which should be out by next spring and the other data sheet is on fertilizer pile overhangs which has been needed for a long time. That one, incidentally, is causing a lot of problems because the data sheet in the process of development, by ballot review, was sent to 150 to 200 members of the industry asking for their comments. It is amazing how many different approaches there are to: How shall we whip this problem of overhangs?

The ballots come back to me and I have to cull them out, consolidate them and those that I can't resolve go back to the people concerned for more studying and this takes time, if the data sheet is going to be factual and meaningful to you when it is published.

I think I would be remiss if I didn't say something about what constitutes a good safety program. I think we all agree that when it gets down to the firing line it is your first line supervisor who will make your safety record. Too many times we think that the safety man is the one who makes the plant safe. The safety man in his position in the company has a staff function and can do very little to make your plant safe, if he doesn't have the backing of top management and the cooperation of line management.

What I am saying is that the safety man can't make your plant safe. He can provide the means and the knowledge and the recommendations and help first line supervisors make the plant safe. He can help top management set their policy on safety. The first line supervisor cannot be successful unless he has the backing of top management.

You may find, as time goes on, that you can afford a safety man. But don't let your safety slide because you feel you cannot afford certain things. Safety is an integral part of supervision, of production and it is a matter of setting up a policy that will include it in your day-to-day activities.

Unless you are in a position to provide your own materials, your best source of materials for your safety program we feel is through membership in the National Safety Council. This thing of membership in the National Safety Council, and I am selling now, but let's remember that once this membership is bought the benefit is all yours. Of the annual membership dues some 65 per cent of that money is immediately set aside for materials that are to be mailed to you. The rest of the money, of course, goes for overhead which we all have.

To get other materials, the Council has a book of materials and needs for a safety program which you select at will .

You have seen the safety posters that are mailed out from Council offices. There are two ways that these posters get into your industry. One is by the optional service in which you select your own. The ones that you think are appropriate to your particular needs. The other is the standard service. When you choose the standard service, I as the staff representative for the fertilizer industry select the posters that I think are appropriate. Most of them take the standard service and I certainly hope that the posters are satisfactory for those of you who have seen them.

We recommend that you give your supervisors an opportunity to exchange ideas on safety by sending them to one of the Fertilizer Supervisor Safety Schools that are held around the country. The four schools that are held now are by no means the limit. If the demand arises for more schools the Executive Committee of the Fertilizer Section is prepared to open up schools where they are needed.

We recommend that, when possible, your people attend the National Safety Congress. There they will hear speakers talking on subjects that are of specific interest to the industry. Many of these talks are given by members of the Executive Committee of the Fertilizer Section and by members of the fertilizer industry. They also mix with people from other industries who have like interests and usually come back home with an idea to help them promote safety in their own plants. Another feature of the National Safety Congress that I think is sometimes overlooked is the exhibit of safety equipment. In the Conrad Hilton you can find virtually every piece of safety equipment that is made in this country. It gives you an idea of what is available to provide protective equipment for your people.

There are other helps that can be provided for your supervisors. There are the home study courses. This is a course developed bv the Safety Training Institute of the National Safety Council for supervisors in industry plants who probably would never see a Congress or get exposed to any formal training as far as safety is concerned. This course, if you are a member of the National Safety Council, costs about $27. The student has one year to complete this course. He is sent a textbook which consists of 12 chapters on various phases of safety. He is required to study each chapter. An examination is given to him which he sends in to the Council offices. It is graded and sent back to him or to your personnel office or to the safety director.

It may be interesting to know that some 6500 supervisors have taken this course so far and at the present time there is an excellent enrollment of some 1200 and the interest in this is growing.

For those who are full-time safety directors, the Council conducts what is called Advanced Course for Safety Directors which deals in the area of safety management and areas for corporate safety men who deal at the policy level.

Gentlemen, I hope that in these few words I have given you something about safety which you can take home with you and, in closing, I would just like to say congratulations to all of those in the industry who have turned in an excellent record of accident reduction. It shows what can be done. But let's not be lulled to sleep.

In the last Congress, one of the vice presidents of industry said that in his examination of the safety record of all 27 sections he found something that is bothering all of us. For a good many years we worked very hard and brought the safety frequency rate down to a good level and all of a sudden for some reason it stopped and it neither went up or down very much. But in the last few years among a few, it has begun to rise. What is happening? Have we gotten to the point where we think we are doing such a good job that no further effort is necessary or have we reached rock bottom?

I think the first is true, that probably we have made such a good record in such a short time, we feel, let's just rest there. Actually, we know there is no limit to how low the frequency rate in the industry can get.

Some industries today are not dealing any more in frequency calculations but are counting the hours, manhours of work from one accident to another, because the record is getting so good.

To those of you who are not members of the National Safety Council or do not have a formal safety program, I sincerely hope that the words I have spoken to you about the record of those who enjoy a good safety record will encourage you to get into the field.

Thank you very much.

CHAIRMAN SAUCHELLI: Thank you, John, a very interesting presentation. The policy of the Round Table, of course, is to frown on any sales pitch but in this case we certainly think that anything that can be done to sell the idea of safety in the fertilizer plant is very much worthwhile and should have every opportunity here on this platform.

We will continue with our program. In line with the subject of safety we have in place of the scheduled paper: Fibre, Dust and Mist Eliminators, which was assigned to Mr. J. A. Brink of Monsanto Cemical Company, a substitute, equally good, in the person of Mr. J. E. Zatek, Product Line Manager, The Mine Safety Company of Pittsburgh, Pa.

His talk is on The Portable Instruments for Detection of Effluents in Fertilizer Plants. I mentioned that to one of the trade press representatives and he is one of the great punsters and he said, "Did I understand you to say detection of affluence in fertilizer plants?" I corrected him. I said, there is no affluence in fertilizer plants; it's effluents.

Portable Instruments For the Detection of Effluents In Fertilizer Plants

Jos. E. Zatek

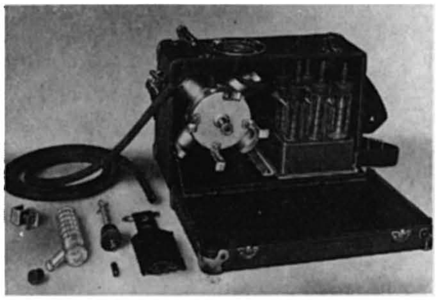
LADIES and Gentlemen, perhaps this paper should have been entitled, *"Portable Instruments For Measuring Atmospheric Contaminants."* Being a substitute speaker on the program, I do find it quite an opportune time to be on this portion of the program since the subject of my talk will be along the safety line—specifically covering portable instruments which have been designed for the measurement of toxic contaminants.

I suppose when one considers the history of instruments which are capable of detecting different materials in the atmosphere, all of us would agree that the first sampling device used for measuring a contaminant was the now famous yellow canary.

The next apparatus used was the one designed in England by Davey which was the flame safety lamp. This has been made available in the United States by a couple of manufacturers. We at our company have been marketing the Wolf Flame Safety Lamp for a number of years.

Following this sampling device, the next piece of equipment that has been extensively used is still quite popular, it's the National Bureau of Standards "Carbon Monoxide Tester." Essentially this equipment consists of a detector tube which in its initial manufactured state has a yellow indicating gel and on exposure to carbon monoxide changes to various shades of green.

My intention this morning is to introduce and acquaint you with some of the equipment that manufacturers presently have developed and are commercially available for the measurement of various atmospheric contaminants. Mine Safety Appliances Company, not only manufactures portable sampling devices for detecting toxic gases and dusts, but, in addition manufactures sampling equipment for measuring noise and explosive gases. This morning, my remarks will be limited to equipment which is available for indicating toxic dust, gas, and vapor concentrations.



Slide 1
Universal Tester.

Slide 1. For a number of years equipment manufacturers have developed and sold individual testers for measuring various atmospheric contaminants. It has been necessary in recent years that because of the introduction of a great number of new contaminants, that a single-purpose instrument be designed which can measure a variety of different impurities. This particular slide shows one of the instruments that is on the market today. I can recall some five or six years ago when we first introduced this tester, it was capable of only measuring approximately 39 different contaminants.

Today this sampling pump along with appropriate accessories can be used to quickly identify some 118 different toxic materials.

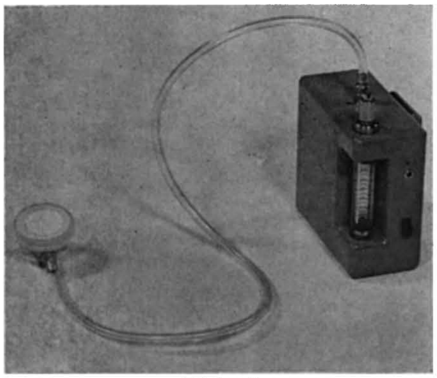
When I mention the term "toxic material," I am referring to the Threshold Limit Values which are published by the American Industrial Hygiene Conference. This association is composed of both industrial and govermental hygenists and every year following their annual meeting, publish a table listing the toxicity of several hundred different contaminants.

These figures have been published to indicate the toxic level of different materials from a standpoint of possible physiological damage which could occur to an individual exposed to a contaminant for an eight-hour period. This listing of TVL's is available from the American Conference of Governmental Industrial Hygiene Association. Mine Safety Appliances Company also furnishes these to companies on request.

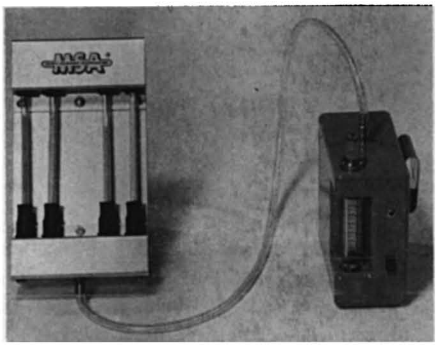
This slide shows the Universal pump, including a detector tube. It is packaged in a metal carrying case with various accessories and a variety of different packages of detector tubes.

The tube itself is sealed in our factory and has a shelf life of two years from the date of manufacture. The individual interested in measuring a contaminant with one of the tubes, merely breaks the sealed ends of the tube, inserts it in the inlet end of the pump, draws in an appropriate volume of sample and by means of a developed stain in the chemical bed measures the concentration present.

Slide 2. One of the techniques that we have developed in measuring at mospheric contaminants is by employing filter papers and chemical reagents. These reagents are packaged in individual ampoul in plastic syrettes. There are many atmospheric ingredients such as lead and hydrogen fluoride which are more suitably analyzed with filter paper spot test methods than other conventional test procedures.



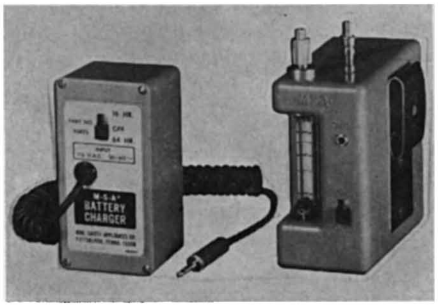
Slide 2
Universal Tester With Paper Holder.



Slide 3
Universal Tester With Pyrolyzer

Slide 3. Shown is a pyrolyzer which is another accessory item availabl ewith the Universay pump. This is useful in measuring halogenated hydrocarbons. It is employed in conjunction with the pump to measure carbon tet, trichlorethylene, freons and many other halogenated hydrocarbons.

The test procedure requires a sample be drawn through the inlet of the pyrolyzer and passed over a heated filament. The halogen in the sampled gas is liberated by thermal decomposition which then is measured by the discolorization of a detector tube .



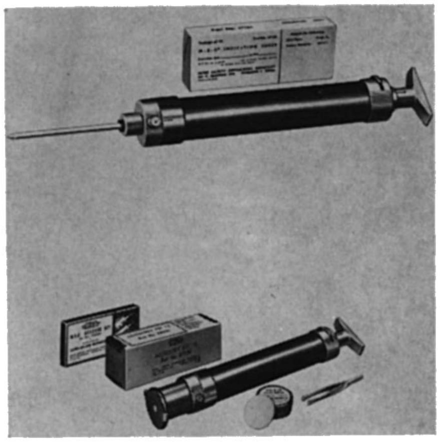
Slide 4
Miniature Pump and Battery Charger.

Slide 4. This next apparatus is one that we recently introduced. It is the Monitaire Sampler. Ideally all of us would like to have an apparatus that could be attached to the lapel or in close proximity to the individual's breathing zone to allow a sample to be taken over an extended period of time which would permit one to determine the workers cumulative exposure.

In the past, portable instruments have not been available for this type of analysis.

In order to obtain data of the average weighted time exposure of an employee, MSA has developed this miniaturized pump and this battery charger. This small pump can be carried on the belt of the worker or can be used as a bench type sampler. This self-powered pump draws in a known volume of sample over an extended period of time.

The Monitaire Sampler contains a nickel-cadmium battery and on a full charge will run continuously for seven hours.



Slide 5
Single Tube Holder

Slide 5. Shown here is the battery charger designed for recharging the pump battery. The cord and plug of the battery charger is connected to the charging jack of the Montaire pump.

The pump's battery can be recharged on a 16-hour overnight or 64-hour weekend period using 110-120 volt AC current.

A single tube holder has been designed with the Monitaire for in-plant sampling of a single contaminant for a period up to four hours. The single tube holder is placed in close proximity to the breathing zone of the worker and for a period up to four hours, regardless of the individual's working habits or movements, a test is obtained of his cumulative plant exposure.

After the four-hour period of sampling, the tube is taken out of the single tube holder, is read on a calibration curve which is provided with the instrument, and another tube placed in the tube holder allowing a second sample to be taken for an additional period of time.

This sampling device thus gives the safety director, the industrial hygienists and others who are responsible for the plant's testing program, an opportunity to know what the man has been exposed to for not just a limited period of time on a spot test basis but over an extended work cycle.

Using a midget impinger flask which is filled with a solution of alcohol, a sample of dust is drawn through the top inlet of the flask and is collected in the liquid. Subsequent counting of the dust particles captured in the flask establishes the degree of dustiness in the atmosphere. The Monitaire Sampler provides the vacuum source for drawing a sample into the Midget Impringer flask.

Slide 6
Midget Impinger

Slide 6. This is the last slide on the program. It shows the standard Midget Impinger which has been used for a number of years for dust appraisal studies. With this instrument a hand crank provides the suction which is regulated at 12 inches of water vacuum creating a flow of 0.1 cfm. Normally a ten-minute sample is taken.

Besides the equipment shown, here are other portable instruments which are available for the atmospheric measurements of toxic materials. In the time permitted me, I have attempted to acquaint you with some of the sampling devices normally used in industry to detect toxic dusts and gases.

I hope as a result of my presentation this morning that I have been able to better acquaint you with some of the portable instruments available for the atmospheric detection of toxic contaminants. Used and maintained properly, they provide additional tools for the protection of life and property .

CHAIRMAN SAUCHELLI: That certainly showed an amazing ingenuity in trying to solve these problems of contaminants in effluents in plants. Thank you Mr. Zatek.

We have all been looking forward to the next presentations on this morning's program. Representatvies are here from Fisons Fertilizer Company who are very well equipped to give us an interesting story about new developments.

The way the program has been arranged, Dr. Guy Jorquera of Foster Wheeler Corporation, has been instrumental in arranging for the Fison's gronp to be on our program.

The papers to be given by Fisons are as follows:

1. Fisons Melt Process For the Manufacture of Concentrated Granular Fertilizers. Paper prepared by S. J. Porter and W. F. Sheldrick.
2. A New Process For the Manufacture of Powder Mono-Ammonium Phosphate Paper Prepared by J. D. C. Hemsley.

Dr. Jorquera will you kindly introduce the speakers.

DR. JORQUERA: I feel I am privileged not only to have met my British friends, whom I will be delighted to introduce to you, but also to have been associated with them for the last few years. I, too, appreciate my friends for coming here to contribute their talents to your Round Table.

Mr. Sheldrick will deliver the paper on Fisons Melt Process and both Mr. Porter and Mr. Sheldrick will be available for answers to questions from the memberships.

Mr. Sheldrick is Manager Technical Services and Mr. Porter Head Technical Development for Fisons. Mr. William Sheldrick and Mr. Stanley Porter will you please come to the platform.

Fisons Melt Process For the Manufacture of Concentrated Granular Fertilizers

S. J. Porter and W. F. Sheldrick

MR. SHELDRICK: Mr. chairman, members of the Round Table. First of all, on behalf of my colleagues, Mr. Porter, Mr. Hemsley and myself, let me thank you most sincerely for inviting us to your conference and for the great kindness that everyone has shown to us.

This morning we would like to tell you something about the Fisons' melt process for the manufacture of concentrated granular compound fertilizers.

Introduction

The manufacture of granular compound fertilizers has undergone two major trends in recent years in the United Kingdom. One of these is towards fertilizers of high concentration based on ammonium nitrate, ammonium phosphate and potassium chloride; the other is towards fertilizers of high nitrogen ratios, for example 2:1:1 and even 2½:1:1.

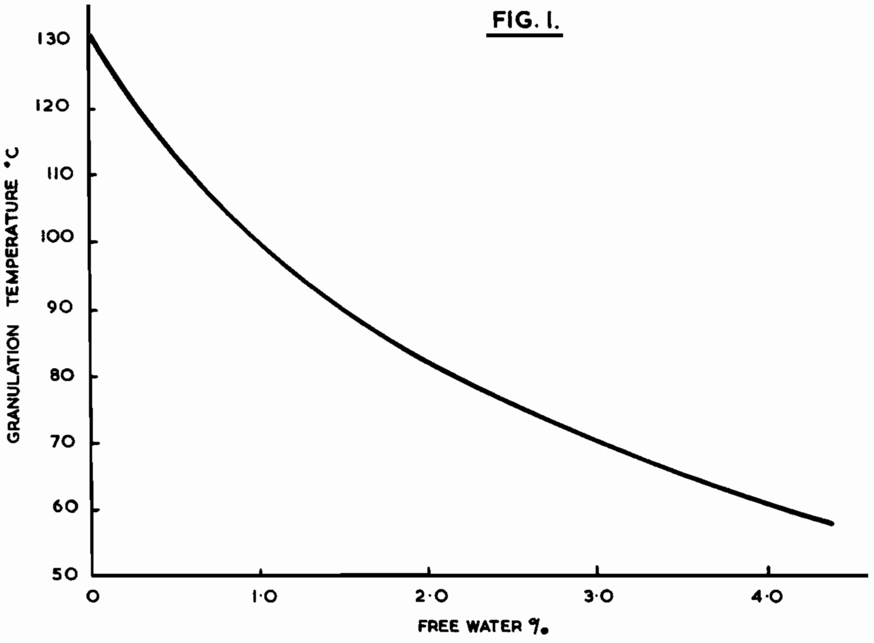
These trends have posed many problems for fertilizer manufacturers who have tried to produce these high concentration fertilizers in existing conventional granulation plant such as those incorporating a blunger or a drier. Mixtures of ammonium phosphate and ammonium nitrate exhibit a high degree of fluidity even with only small quantities of water present, so that under conditions normally used for granulation a high recycle is required.

For example 2:1 or higher. Although reference has been made in a previous paper of the seed for a minimum recycle of about 3:1, in order to achieve a satisfactory granulation efficiency, it is our experience that if water removal is not the limiting conditions satisfactory granulation and product shape can be achieved with a recycle ratio of about 1:1.

In order to develop satisfactory methods for processing these concentrated fertilizers, the Levington Research Station of Fisons Fertilizers Limited carried out a comprehensive study of the basic physical and chemical properties of ammonium phosphate and ammonium nitrate mixtures. From the results of our own granulation practice, and also from published results, it was found that where mixtures of soluble salts are used as ingredients for granular fertilizers, it is possible to correlate the conditions at which granulation occurs. A typical correlation is presented in Fig. 1. This confirms that in order to achieve successful granulation without excessive recycle, it is necessary to remove most of the water from the ingredients before granulation. Another obvious reason for limiting the water entering the system, is to minimize the load on the drying equipment, and this is particularly important for heat sensitive materials containing ammonium nitrate, which must be dried to a moisture content of 0.5%, or less in order to achieve satisfactory storage properties.

The main finding, however, from our studies was that it is possible to produce anhydrous molten mixtures of ammonium nitrate and ammonium phosphate at temperatures below the melting points of their component salts as shown in Fig. 2. These mixtures can be prepared easily by the ammoniation of nitric and phosphoric acids in such a way as to utilize the heat of reaction to remove water from the system. It was also found that at the temperature of preparation, and within the range of N:P ratios required, the molten mixtures had relatively low viscosities, i.e., between 4 and 20 centipoises, and were chemically stable so that they can be handled easily and safely well below the decomposition temperature of ammonium nitrate. The preliminary work also showed that the molten N.P. mixtures can be solidified in a controlled manner in any one of the conventional

FIG. I.



MOISTURE CONTENT / GRANULATION TEMPERATURE RELATIONSHIP FOR 2:1:1 COMPOUND BASED ON AMMONIUM PHOSPHATE, AMMONIUM NITRATE & POTASSIUM CHLORIDE

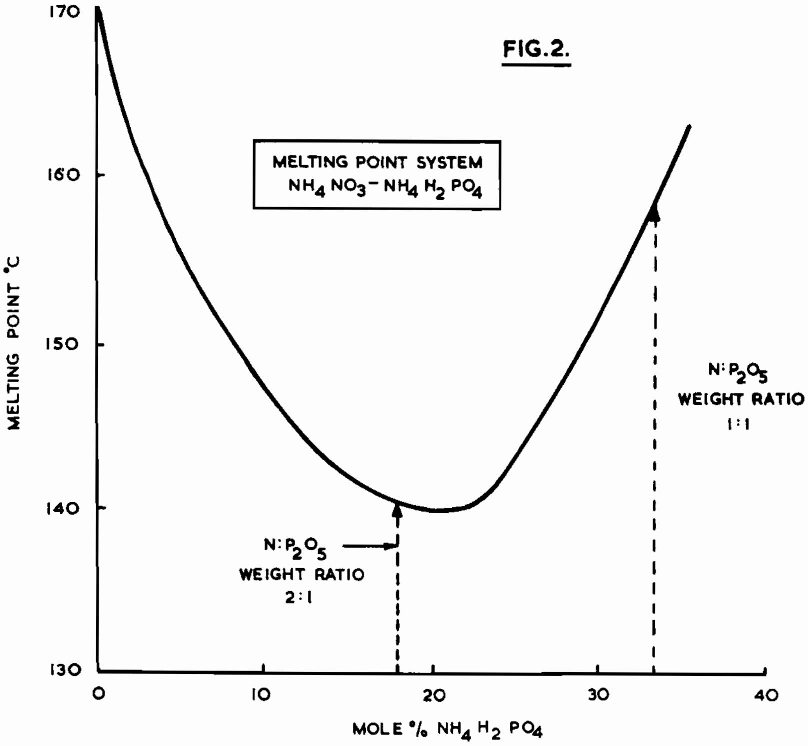


FIG.2.

methods, such as rotary drum granulation, flaking or prilling to produce a product of excellent physical form, which require no further drying. Potassium chloride can also be added during the solidification stage, if required.

Development of the Process

The choice of "solidification" process is determined mainly by the final composition of the required product. Where it is necessary to add potassium salts to the product this can best be achieved using the rotary drum granulation process, and in our case as the main product requirement was to be 25-10-10 our first main process development incorporated a rotary drum granulator.

The manufacture of ammonium phosphate-ammonium nitrate melts can be achieved either by the direct ammoniation of mixtures of nitric acid and phosphoric acid, or by ammoniation of a mixture of ammonium nitrate solution and phosphoric acid and our experimental work has covered both techniques. Our own operations in the U. K. at the present time, however, are based on concentrated ammonium nitrate solution, which is already available in large quantities at all our factories, and, therefore, the version of the process which we have developed and built for our own use is one in which phosphoric acid, ammonium nitrate solution and ammonia are used as the feed materials.

The first stage of the investigation covered the ammonium of mixed acids in a tubular reactor. Although complete reaction was achieved at a high throughput rate, two major problems were encountered. The first was that due to the differential rate system, precipitation of insoluble iron and aluminum phosphates occurred at a specific point in the reactor corresponding to a critical pH, and very quickly blocked the reactor . The other problem was that there was excessive ammonia loss from the system in this co-current reactor.

These problems were overcome using a two-storage reaction system. The first reactor is a stirred tank operating under steady state conditions such that insoluble phosphates are precipitated harmlessly into the mass of the solution without any significant scaling of the equipment. This reactor is also operated at a slightly lower degree of conversion than mono-ammonium phosphate, so that there is no significant loss of ammonia. The second stage comprises a counter-current reactor, in which the liquids are fed to the top of the reactor and hot air and ammonia are fed to the base to complete the reaction and remove the remaining water from the melt.

This process was operated first on a micro plant with a capacity of 50 lbs/hour. Following this, the process was established on a pilot plant containing both liquids and solids sections with a capacity of about 1500 lbs/hour. Every stage of the process was investigated during a period of two years' operation, and many hundreds of tons of granular compound fertiliers were produced .

This material, which was subjected to the most rigorous tests of all forms, was shown to be an excellent fertilizer of good physical form, very hard and resistant to breakdown in handling, and to have excellent storage properties.

On the basis of this development work, a large scale plant was designed and built by Fisons Fertilizers Limited at their Immingham factory and successful operation of this plant has been established.

Description of the Process

The flow diagram for the process is given in Fig. 3.

Feed Materials

The process normally starts with 95% ammonium nitrate solution, but should ammonium nitrate solution be available at lower concentration, it can easily be concentrated by means of a steam heated falling film evaporator. The concentrated solution is then preheated before it is fed to the melt reactor. Wet process phosphoric acid containing 50% P_2O_5 is required, and before being fed to the reactor, the acid is preheated and used to recover ammonia in the scrubber. Anhydrous liquid ammonia is vaporized using heat recovered from the process. Most of the ammonia is fed to the melt reactor and the remainder is fed to the stripping column. Potassium chloride, preferably of a fine crystalline form, is added to the drum granulator when NPK compounds are required.

Reaction Section

The production of the molten mixture of ammonium nitrate and ammonium phosphate is achieved by the ammoniation of a mixture

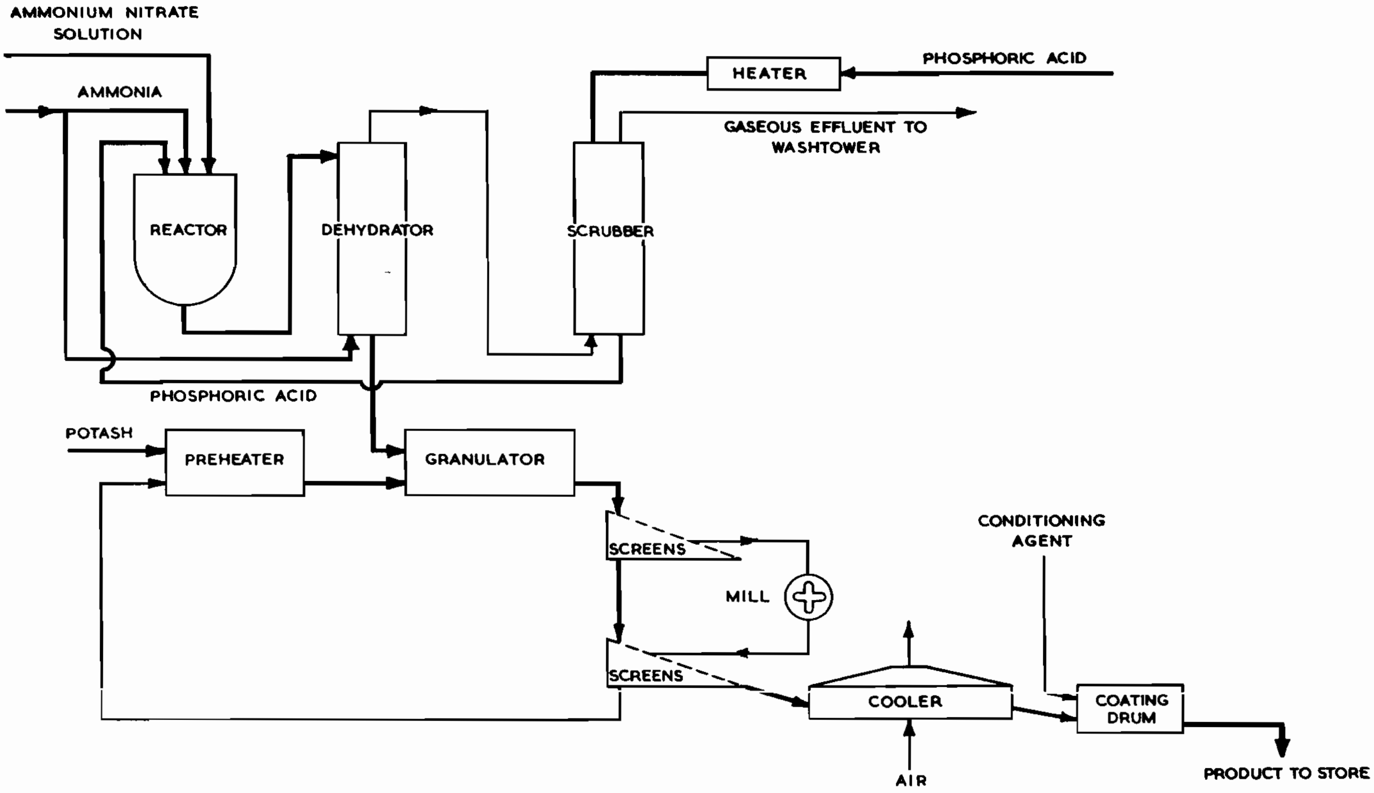


FIG. 3.

MELT GRANULATION PROCESS

of concentrated ammonium nitrate solution and wet process phosphoric acid in two stages. The system is carefully designed to ensure that the product from the ammoniation stage is almost completely stripped of water using the heat of reaction to achieve most of this removal.

The first stage melt reactor is a stirred tank into which preheated 95% ammonium nitrate solution and concentrated phosphoric acid are fed. The phosphate acid, which was first passed through the recovery equipment, has had its initial concentration raised slightly from 50% P_2O_5 to perhaps 51 or 52% P_2O_5. It also contains a few percentage of nitrogen as recovered ammonia. Gaseous ammonia is fed to the reactor through nozzles and an agitator is provided in the tank to ensure good ammonia absorption and reaction and also to facilitate the evolution of steam formed during the reaction. This steam is recovered and used for the vaporization of ammonia.

The heat of reaction between ammonia and phosphoric acid is sufficient to boil off water and maintain a steady state condition in the tank, in which the liquid has a temperature of about 160°C to 170°C and has a moisture content of between 3 to 5% as measured by Karl Fischer determination on frozen samples. The pH of a 10% solution of this liquid is usually between 2.5 and 3.0 corresponding to about 80% conversion of the P_2O_5 to the mono-ammonium phosphate form. The liquid which contains a small amount of solid matter as a fine suspension can be handled easily, although as its freezing point is in the region of 135°C to 150°C, depending on the composition, it must be handled in steam jacketted pipes.

The product from the first stage reactor is fed to the top of a counter-current stripping column, in which the reaction to mono-ammonium phosphate is completed and substantially all the remaining water removed. This is achieved by passing a mixture of ammonia and hot air into the base of the stripping column. The mixture leaving the base of the stripping column contains about 0.2% or 0.3% water, and the pH of its 10% solution is about 4.0. This material which is fed to the granulation plant is essentially an anhydrous melt of mono-ammonium phosphate and ammonium nitrate possessing good fluid properties and a high degree of stability.

Ammonia Recovery Section

The gases from the top of the stripping column which contain air, steam and unreacted ammonia vapour pass to the ammonia scrubber, where ammonia is recovered by counter-current washing with hot phosphoric acid. The temperature of phosphoric acid is about 75°C and this ensures that no steam condenses in the phosphoric acid to cause dilution. There is a circulation of phosphoric acid around this scrubber because the amount of make-up to the reaction system is not itself sufficient to wet the packing for the absorption.

Although the gases from the scrubber would normally satisfy the U. K. Alkali Inspector's requirements for discharge to the atmosphere in our first plant all the off-gases from the plant pass through a wet gas scrubber.

Melt Granulation Section

The molten ammonium phosphate-ammonium nitrate mixture leaving the stripping column is pumped to the rotary drum granulator, where it is sprayed onto a rolling bed of fines or fines plus crystalline potassium salts, according to whether an NP or an NPK fertilizer is required.

It has been found that the most critical factor in granulation is the temperature of the granulation zone. It is necessary to hold the molten material in a liquid state long enough for smooth round particles to be formed before it freezes, but care is necessary to achieve the balance between too rapid freezing, leading to misshapen agglomerate particles, and delayed freezing, leading to very large granules and a build-up in the granulator. Although recycle can be varied to control the granulation process further, it has been found that low recycle ratios tend to give better shaped particles because of the greater ratio of melt to recirculated fines in the product. The normal recycle ratio is about 1:1. Recycle ratio not so critical as a conventional process or probably not so great without dryer .

The material leaving the granulator is separated by screening into three fractions. The product fraction is taken through a spouted bed cooler, and then to a product coating drum, where it is treated to a surface coating. This can either be in the form of an amine, or alternatively a mineral oil, together with finely divided kieselguhr, kaolin or ball clay. The oversize stream is broken down through a high speed rotating cage mill, and returned with the fines. Provision is made to break down enough product in addition to the oversize, to maintain a fines level adequate for the return of a controlled stream of fines to the granulation zone. The temperature of the fines recycle is adjusted in the rotary fines heat exchanger prior to entering the granulator.

Product

A typical range of concentrated fertilizers which can be produced are those normally associated with components A.P., A.N., KCL., covering a $N.P_2O_5$ ratio about 1-1.5 up to 3-1 $N.P_2O_5$, is as follows .

Compound Ratio	Compound Analysis
1 - 1 - 0	24 - 24 - 0
2 - 1 - 0	28 - 14 - 0
3 - 1 - 0	30 - 10 - 0
1 - 1 - 1	17 - 17 - 17
2 - 1 - 1	23 - 11 - 11
1 - 1 - 1.5	15 - 15 - 23
1.5 - 1 - 1	20 - 14 - 14

These analyses can be obtained using normal wet-process phosphoric acid. If clarified wet-process acid is used it is possible to increase some of these analyses slightly, and for example 25-10-10 is produced in this way. The water content of the finished product is about 0.3-0.4% and normally a coating agent (1-2% w/w) would be added to ensure good storage properties over long periods.

Operating Data

Utility requirements vary slightly according to the type of product or rate of production. A table will be included in the published paper. There we cover items that would be necessary for making the same compounds in a conventional process.

A plant to produce about 200,000 tons per year of NPK compound or 150,000 tons per year of NP compounds would require the following utilities.

	Consumption per ton of finished fertilizers		
Uitlity	24-24-0	17-17-17	25-10-10
Electric power KWH	30	28	28
LP steam (15 psig,) lbs.	85	60	35
HP steam (250 psig,) lbs.	175	120	180
Dock water (Imperial gallons)	570	410	480

Main Features of the Process

1. The removal of water from the mixed liquid ingredients rather than by drying the solids after granulation results in a more simple and controllable process.

2. Completion of neutralization before granulation eliminates the possibility of decomposition reactions which could occur when concentrated acids are fed directly to a granulator containing potassium chloride.

3. The capacity of the granulation unit is virtually constant for a wide range of compounds. This is a particularly important factor when processing high nitrogen compounds, for in most conventional processes the output of the plant falls significantly as the proportion of nitrogen in the compound increases.

4. The method of preparation of the solid granules from the melt ensures that there is complete and intimate mixing of the components of the granule. As a result of this dispersion of ammonium phosphate throughout the ammonium nitrate, the poor storage and handling properties normally associated with ammonium nitrate are negated. Also there is no diffusional drying process from the solid stage, as there would be in more conventional processes. This eliminates the production of porous granules with the more soluble components, such as ammonium nitrate diffusing to the granule surface. Granules produced directly from melts are of good physical form, they are extremely hard and resistant to breakdown during handling, and have very good storage properties.

Patents

Patent applications covering this new process have been filed in the major manufacturing countries of the world.

Mr. Porter and myself will be pleased to answer any questions you might have.

CHAIRMAN SAUCHELLI: Thank you Mr. Sheldrick and Mr. Porter for a most interesting presentation.

I am sure there are going to be questions here. Who is going to start the first question. Will you take the microphone and identify yourself.

A MEMBER: This is an extremely interesting presentation of a new process for granulation and I am sure that everybody is extremely interested in it.

There is one thing I would like clarification on and that is on the safety or hazards involved in the process. Now, it is known that potassium chloride sensitizes molten ammonium nitrate and it is quite a dangerous thing to mix the two when you have it in the molten stage. On the other hand, the phosphate tends to dampen the activity so that there is a balance when you combine the phosphate and your molten ammonium nitrate. But I would like to know, and I think most people would here, what the parameters are and what work has been done at what point you can reach an explosive range on this?

CUAIRMAN SAUCHELLI: Mr. Sheldrick do you want to answer that or, Mr. Porter?

MR. SHELDRICK: I'd just like to answer that question by saying that our company has done a great deal of work on the stability of ammonium nitrate in compound fertilizers and some of you may be aware of two papers we have presented in the last year or two, one to the British Fertilizer Society and another one recently ,in Milan.*

We were the first company in Britain to incorporate ammonium nitrate into NPK compound fertilizers and you can rest assured that the safety aspects of this process have been thoroughly covered.

Of course safety is a function of temperature, pH and other sensitizing agents and full cognizance is taken of these conditions in the design of the plant.

MEMBER: If an error was made in operation and they neglected to let the phosphate in do you think there would be a hazard if you did mix the potassium chloride with the ammonium nitrate?

This is mal-operation but could this happen?

MR. PORTER: A complete answer to this question would take a very long time, of course. The particular point which is worrying the questioner is the sensitization of the ammonium nitrate by the chloride ion. In fact, the presence of the phosphate is helpful but the real question here is the action of acid melt on chloride and as long as the pH control on the melt manufacture is adequately operated this could not happen. In fact, in our designs there is an alarm and diversion valve which is operated by the pH signal arising from too low a pH at this point in the plant.

A MEMBER: I'd like to verify your pH figure. Was it pH-4 in the final product?

MR. SHELDRICK: The pH of the melt was four, yes.

MEMBER: Yes, and even after the addition of the potassium chloride it is still approximately the same?

MR. SHELDRICK: Yes.

MEMBER: Thank you.

CHAIRMAN SAUCHELLI: There must be other questions. The gentleman in the back there.

A MEMBER: I just want to be sure that your mono-ammonium phosphate is always 2, is that correct and not diammonium phosphate?

MR. SHELDRICK: No, in this process we don't go to diammonium phosphate. There is a variant of this process which allows the manufacture of diammonium phosphate but the process that I have described this morning is making mono-ammonium phosphate.

MEMBER: Could you allow yourself certain parts to be diammonium phosphate?

MR. SHELDRICK: Yes, we could.

MEMBER: Thank you.

MR. SHELDRICK: But it wouldn't quite be the same process. What I should have said was that this is one of many processes that can be based on these basic physical and chemical properties of ammonium phosphate nitrate mixtures. You can, of course, get even better fluidity conditions if you use diammonium phosphate instead of mono-ammonium phosphate.

A MEMBER: I probably missed what you said about the preheater. I would like to know what fuel you use for preheating and the approximate temperature.

MR. PORTER: The preheater is a flighted drum similar in design to a small dryer. The heating medium in the preheater is hot air which, of course, can be produced either by direct fuel, like an oil burner, or indirect heating by steam. It is just a question of plant economics.

The temperature of solids in the preheater will vary according to the grade being made and the granulating conditions but temperatures around 100-120° Centigrade would probably be fairly suitable.

CHAIRMAN SAUCHELLI: I believe there is another question in the back there.

A MEMBER: Did you not say the pH in the first neutralizer was 2.5? I did not get what the concentration was but do you think there is any safety hazard at this low pH?

MR. PORTER: The pH in the first reactor is about 2.5 but around 3 to 5 per cent moisture. There is no chloride present at this stage and that particular risk doesn't arise. In actual fact there are conditions which could cause a decomposition in this reactor but they are very far removed from the normal operating condtions. They are far removed both in temperature and in pH and in matters like chloride concentration which necessarily is zero.

MEMBER: Thank you.

A MEMBER: I think the most remarkable feature of this process is the claim that you can have a one to one ratio, cycle ratio to small particles. Would they really guarantee such a thing for a process might sell to somebody else? Would they give a quarantee on this, if there is a requirement for a one-to-one ratio as against the usual three-to-one ratio or higher?

MR. SHELDRICK: Gentlemen, as I said earlier, we regard a two-to-one ratio as a high recycle ratio and we make more than one million tons of granular compound fertilizers a year and I don't think the average recycle ratio is more than one-to-one. So in this plant the process is specifically orientated towards low recycle because this is the way our processes are designed.

MEMBER: I believe it in your own product but, if the engineering has to guarantee it to somebody else, would that still be backed by you, that you would guarantee the requirements of one-to-one as against two-to-one or three-to-one?

MR. SHELDRICK: I think it is probably a little premature to give guarantees at this stage. As I understood, this wasn't to be a sales presentation.

A MEMBER: Is there a point in the melt process where the melt

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* (1) Proceedings No. 85 Fertilizer Society Ammonium Nitrate: Manufacture and Use by C. H. Solomon and K. S. Barclay.

(2) XVII International Congree Milan. Physical-Chemical Studies on Decomposition Reactions and the safe handling of ammonium nitrate bearing fertilizers by K. S. Barclay.

is pumped through conventional pumps and does this constitute a hazard for organic contamination which might sensitize ammonium nitrate?

MR. PORTER: I think the answer to this is that the pumping of the melt is on exactly the same footing as the pumping of ammonium nitrate which probably most of the people in this hall are already well familiar with. Certainly we use the same kind of pump running at the same speed and I expect the hazard is exactly the same .

MR. HARVEY (Southwest Potash): I was interested in your choice of a rotary drum granulator when you added potash to your anhydrous melt. I noted in a recent Monsanto patent that when they attempted to prill with potassium chloride the potash inhibited the spheriodizing tendency in free fall.

Did you find this to be the case?

MR. PORTER: We chose the rotary granulator for this first plant because we wanted to build it quickly and we designed the full scale plant while we were designing and operating the pilot plant. What we would choose when all the work is finished is something we shall find out.

A MEMBER: Going back to your previous mention of the use of diammonium phosphate in the process, would this still be a melt process, anhydrous, if you do go to a certain proportion of diammonium phosphate or even completely diammonium phosphate?

MR. SHELDRICK: This is a question I would really prefer to duck because of the patent situation but I think it is fair to say that you can do this in another stage either as a melt or in the rotary drum granulator.

MEMBER: Yes.

MR. SHELDRICK: I think we have more experience with the melt condition than we have in the rotary drum.

MEMBER: Do I understand also that there is a large plant in operation? I wasn't quite clear from the discussion. Or is this just your pilot plant?

MR. SHELDRICK: This is a very large plant, I think, by American standards for NPK fertilizers, and by our standards as well, yes.

MEMBER: About what capacity?

MR. PORTER: I hesitate to give an exact capacity here because this has not been released anywhere.

MEMBER: I see.

MR. PORTER: But this is the biggest single granulating unit which Fisons possess.

MEMBER: Then a final question. In connection with the cooler that you use, is it an air suspension cooler?

MR. PORTER: This is a spouted bed on a perforated plate.

MEMBER: Yes. How much coating agent is required? Is it a normal amount like one uses in ammonium type of products?

MR. PORTER: This would depend on the grade being made, of course, but the particularly well shaped granules with smooth surface that we get from this enables us to use a smaller quantity of coating than we would otherwise think of.

MEMBER: Thank you.

A MEMBER: May I just ask a question to get the point clear that some of the other questioners asked. Do I understand that in the first neutralizer the ammonium phosphate NP ratio is 0.8 and in the second neutralizer 1.0?

MR. SHELDRICK: You mean the NP with regard to ammonium phosphate?

MEMBER: Yes, I do.

MR. SHELDRICK: That's about right, yes.

A MEMBER: Could you tell us what the limitations on NP ratios are? I understood you to say that you made a triple 17. I didn't know you could go down to as low an NP ratio as that.

Can you make a one and a half or one-two?

MR. PORTER: In the pilot plant we have made one to one and a half for long periods, days and weeks. We have not done very much with one-to-two yet. But on paper, it's possible.

MEMBER: Thank you.

MR. JORQUERA: Thank you Mr. Sheldrik and Mr. Porter. We have a second paper on the program. A New Process for Manufacturing Powder Mono-Ammonium Phosphates to be given by Mr. J. D. C. Hemsley, author of this paper. Mr. Hemsley is senior chemical engineer for Fisons. It's a great pleasure ladies and gentlement for me to present to you our good friend David C. Hemsley.

A New Process For the Manufacture of Powder Mono-Ammonium Phosphate

J. D. C. Hemsley

Mr. Chairman, Dr. Jorquera, Ladies and Gentlemen. Thank you for inviting us to your Round Table Meeting. I hope my discussion on Mono-Ammonium Phosphate will be of interest to you.

Introduction

FOR a number of years now there has been a considerable interest in the development and use of the so-called "pre-neutralization" techniques as an important and valuable addition to the conventional NPK granulating plant. This technique allows the direct use of phosphoric and other acids, together with ammonia and sometimes concentrated nitrogen solutions under controlled conditions with minimum ammonia loss, and is of particular value where high analysis fertilizers are required.

Fisons Fertilizers Limited have been using this technique for several years and one particular system which later formed the basis for the development of the process now to be described, was the simple ammoniation of phosphoric acid to NH_3:H_3PO_4 mole ratios of around 1:1 or 1:3:1, depending on the formulations required, to produce an ammonium phosphate slurry, which was then pumped to the granulator of an NPK fertilizer plant. A major disadvantage of this system when operated to produce substantially mono-ammonium phosphate is the considerable quantity of water needed in the slurry to maintain sufficient fluidity for trouble-free operation within the ancillary handing equipment.

The concentration of a saturated MAP solution at the boiling point is approximately 68 per cent, and in practice slurries containing 70-75 per cent MAP can be pumped, metered and piped without undue difficulty. Even so, the considerable water content does mean that high fines recycle ratios are required, particularly if there are other water bearing raw materials used as ingredients. Plant output, therefore, will be significantly reduced when this pre-neutralization technique is brought into use. Thus, there was a strong incentive for considering ways and means of overcoming the disadvantage of MAP systems with high water content.

Consideration of the published solubility data for mono-ammonium phosphate showed that the solubility curve is steep and linear over the range 20-110°C. Extrapolation of the data suggested that concentrated solutions containing only 10-15 percent water could exist at temperatures around 150-160°C (see Figure 1). It seemed likely that by operating a reactor under pressure in order to elevate the boiling temperature, it would be possible to take advantage of the solubility characteristics of the salt and produce concentrated MAP solutions containing considerably less water than in the conventional ammoniation reactor operating at atmospheric pressure. Furthermore, it would be expected from theoretical considerations that additional water would be flash evaporated during the discharge from the reactor, and the extent to which this would occur would be dependent on the operating pressure. The lack of the appropriate solubility and boiling point data hindered any close estimate of the likely operating pressure to attain useful advantage, but it appeared likely that it would lie in the range 15-30 psig. No unusual operating or engineering difficulties were expected at the moderate operating pressure, and temperature conditions anticipated. However, other factors had to be considered, and in particular the viscosity-temperature relationship and the vapour pressure of ammonia over concentrated solutions of mono-ammonium phosphate at temperatures much higher than in conventional systems.

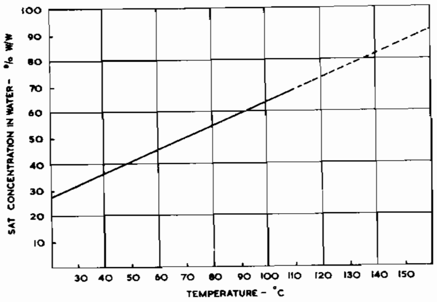

Figure 1
Solubility of mono-ammonium phosphate in water.

In view of the nature of the system and time required for establshing the necessary physical data at the temperature, pressure and concentration conditions envisaged, it was decided to set up a pilot scale continuous pressure ammoniation facility to prove the viability of the process at or close to the conditions anticipated, and to determinc thc fundamental physical data necessary for process design purposes at a later time, subject to satisfactory and acceptable operation of the pilot unit. In the event, the pilot unit did operate successfully, and with some unexpected results to the development of a process utilizing pressure ammoniation for the production of a mono-ammonium phosphate powder eminently suitable as a solid intermediate raw material for granulation purposes.

Pilot Plant

The pilot plant was modified and developed a number of times in accordance with operating experience and the changed emphasis of the work towards the production of an ammonium phosphate powder.

Initially, a small stirred tank reactor with a diameter of 18 inches was installed, together with provision for continuously metering wet process phosphoric acid, make-up water and gaseous ammonia. Steam released by the heat of reaction was vented to a total steam condenser via a control valve used to maintain the reactor operating pressure at the desired level. The ammonium phosphate product was released through a control valve into a launder leading to a disposal area. The first few runs were carried out at production rates of two or three hundred lbs per hour at operating pressures in the range 15-40 psig and temperatures around 150°C. The ammonia-acid ratio was adjusted to maintain a product pH of 3.5-4.0% corresponding to a mole ratio $NH_3:H_3PO_4$ of 1:1.

In these runs the product moisture content was in the range 15-20 per cent, and the slurry itself slowly set with cooling into a hard mass. With further operating experience, steady runs of several hours' duration were carried out, mainly at 30 psig and with relatively less make-up water than had been previously used. Operating temperatures increased to around 155-160°C and under these conditions the product immediately set a hard honey-combed mass after leaving the reactor discharge valve. It was at this time that the possibility of manufacturing a powder ammonium phosphate bv a simple spraying or "prilling" process became apparent. A crude experiment was, therefore, devised, whereby after attaining steady reactor conditions, the new raw material feeds were stopped and the reactor contents transferred to a portable insulated pressure vessel under substantially equilibrium conditions. This vessel was then transferred to the top of a building where there was a free fall of approximately fifty feet to the ground level, and the contents rapidly released. A solid product of finely divided ammonium phosphate powder containing fourteen per cent water was recovered from the floor beneath the pressure vessel.

Following this experiment, the pilot unit was re-erected on the top floor of the building with a larger reactor having a diameter of two feet, and with facilities for continuous spraying over a free-fall height of 47 feet. A simplified flow diagram of the facility is shown in Figure 2, and a sketch

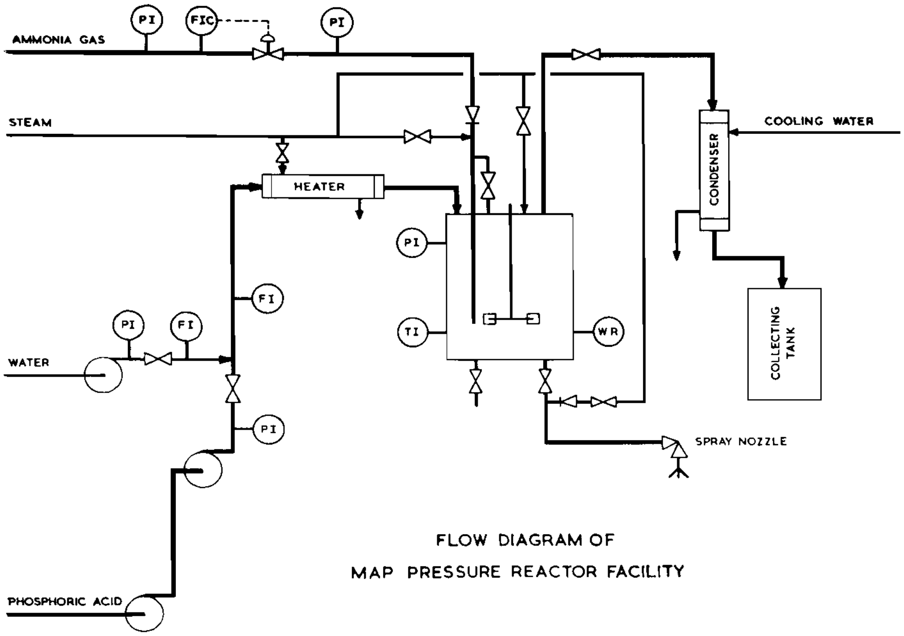

Figure 2
Flow diagrams of experimental MAP pressure reactor facility.

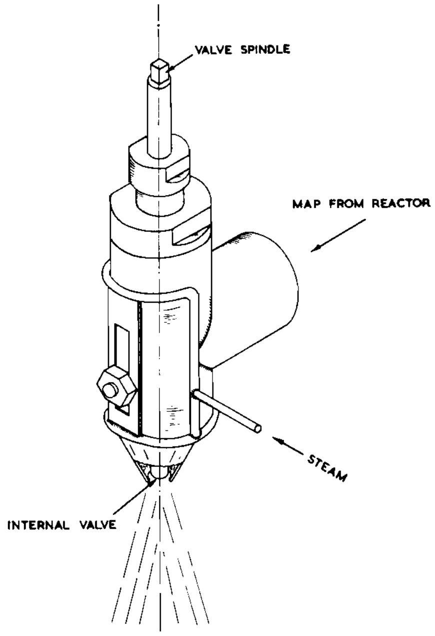

Figure 5
Pressure spray nozzle/control valve

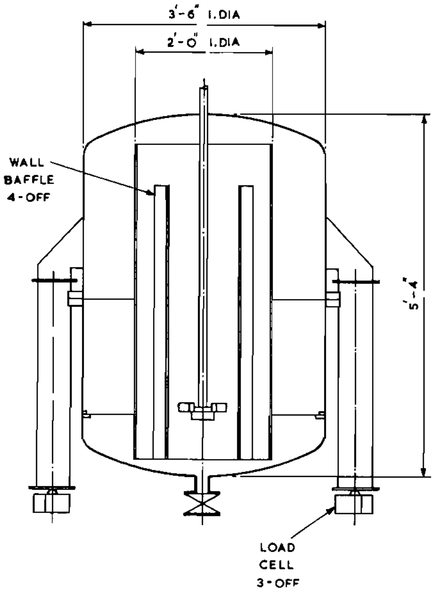

Figure 3
Pressure reactor.

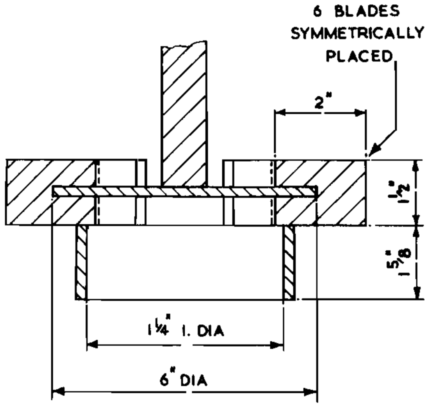

Figure 4
Reactor impeller

of the reactor in Figure 3. The reactor itself was mounted on a system of three electronic strain gauge load cells coupled to a 0-1 ton circular scale indicator. It was fitted with a radial six blade impellor of conventional pattern, and designed to absorb four horsepower at 1,000 rpm. Gaseous ammonia under automatic control was injected beneath the impellor by means of a single open and dip pipe. Phosphoric acid was metered by a PVC variable area flowmeter fitted with a stainless steel float. The ammonium phosphate flowed by pressure from the bottom of the reactor via a one inch teflon seated ballvalve and a short length of stainless steel pipe to a pressure spray nozzle fitted with a manually adjustable valve to control the flow, which in normal operation was set to maintain the weight of the reactor contents, and thus the liquid level in the reactor constant. Additionally, a set of electrical conductivity probes was fitted to monitor the actual level since the density of the reactor contents changed markedly with the production rate. Ammonium phosphate powder was recovered at ground level with a mechanical shovel and conveyed to storage.

The pilot plant was operated at production rates in the range 1.1 — 1.7 tons per hour mainly at a reactor operating pressure of 30 psig, and a temperature of 165 - 170°C. Water injected into the phosphoric acid line under flow control was used to maintain steady temperature conditions and to compensate for changes in the quality of the phosphoric acid. The acid used was settled Morocco based material of around 49 per cent P_2O_5 concentration.

Once the plant was started up steady process control was easily accomplished even though there was a minimum of automatic control equipment provided. Some care was needed to maintain a

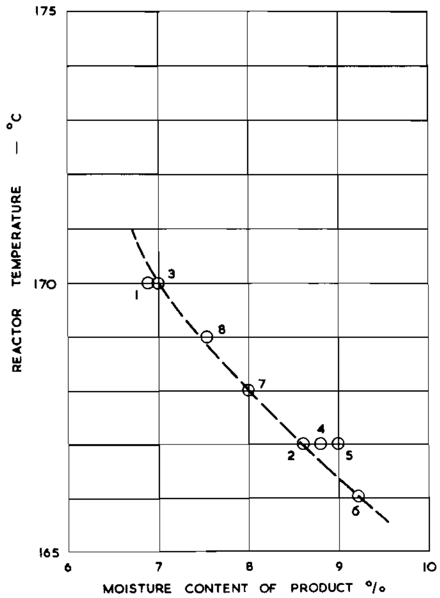

Figure 6
Reactor Temperature—Product moisture content.

steady operating pressure since rapid downward changes caused flash evaporation and surging of the reactor contents. Control of the reactor contents level by manual regulation of the spray nozzle valve was satisfactory. Occasionally the nozzle outlet built-up but this generally broke away without help. Although the reactor retention time at the highest production rates was only five to six minutes, pH determinations of the product at thirty minute intervals were generally adequate in maintaining a steady pH value of in the range 3.6 - 4.2. It was found that when the reactor was operated at a pH of 5-5.5 the product became soft and sticky.

A few runs were carried out with phosphoric acid pre-heat up to 75°C. Under these conditions considerably higher make-up water levels were required to maintain the reactor temperature at 170°C.

In order to check the characteristics of the product at much higher spraying rates than was possible under continuous operation, runs were carried out in which, after a short period of stable continuous operation, the reactor contents were rapidly discharged through a larger outlet valve. In this way it was possible to attain spraying rates of 8-10 tons per hour over very short periods.

Discussion

The pilot plant data obtained on the reactor have proved the validity of the early assumptions. At the reactor pressure and temperature conditions used, analyses of samples taken from the reactor show that the water content of the ammonium phosphate is 10-12 per cent. Even with this low water content, the ammonium phosphate appeared to be in complete solution and be very fluid. Examination of the reactor after operation did not show any trace of encrustation on the walls, dip pipes or impellor shaft such as commonly occurs in conventional ammoniation reactors. The specific gravity of the ammonium phosphate solution in the reactor calculated from weight and level determinations was only at 0.6 at the lowest production rate of 1.1 tons per hour, and at 1.7 tons per hour, it had dropped 0.2. Specific gravity determination on the material in the discharge pipe gave a normal figure of 1.5. The low apparent density of the reactor material was undoubtedly a function of the low effective reactor volume compared with full scale ammoniation reactors, and the high steam release rates which it was possible to attain without entrainment losses. At the highest production rate of 1.7 tons per hour, the measured steam release rate based on the available surface area of the reactor was 235 lbs per hour/ft.^{2}. Limitation on ancilliary equipment prevented operation at even higher outputs. Steam release rates of this order are not normally possible with conventional reactors operating at atmospheric pressures without considerable entrainment and it seems clear that the lower specific volume of steam released from a reactor operating under a pressure of around 30 psig is sufficient to enable pressure ammoniation reactors to be designed with a considerable reduction in diameter over their equivalent atmospheric counterparts.

The runs with pre-heated phosphoric acid indicate that the acid feed concentration can be reduced to 44-45 per cent P_2O_5 if the acid temperature is not less than 75°C., and this still allows a small quantity of make-up water (around 2-3 per cent of the acid flow) necessary for control purposes. Where gaseous ammonia is available, waste reaction steam could be used for pre-heat purposes, but where only liquid ammonia is available it would be economically advantageous to utilize the waste heat for ammonia vaporization.

Water balance measurements over the reactor and spraying zone confirmed that a significant amount of water is flashed off at the spray nozzle. The reactor material itself contained 10-12 per cent water, and the water content of the product after flashing was reduced to around seven per cent. During evaporation, considerable cooling of the material took place, and the temperature of the sprayed material within a few feet of the nozzle was reduced to 130°C. The reactor temperature appears to have very critical effects on the water content of the product over the range studied, and an increase in operating temperature of only 5°C reduced the product water content by 2-3 per cent.

The mechanism of water removal and cooling in the spraying zone has not yet been studied in detail. It is clear that a considerable part of the water flashed off occurs close to the spray nozzle. A high proportion of the ammonium phosphate solution droplets are quickly fragmented into small particles by the energy of the released water vapour, though some escape this ordeal and the characteristic hollow spheres complete with blowhole of a spray dried product can be observed in the product.

Provided that the $NH_3:H_3PO_4$ cleanup $NH_3:H_3PO_4$ ratio is close to 1:1, the product removed from the ground level during the operation was dry in appearance and free flowing with a size grading substantially within the range 0.2-1:0mm. Freshly made heaps of material took on a slight initial "heat-set" but this caused no difficulty in recovery. Similarly, material stored for some twelve months in bulk heap was easily recovered and passed through the intake and weighing installation of a granulation plant.

Measurement of ammonia and phosphoric acid in the reaction steam condensate gave 0.002 per cent P_2O_5 and 0.13 per cent N. This represents a nitrogen efficiency of better than 99.8 per cent and an insignificant P_2O_5 loss. Although the steam condensate contained around 0.15 per cent fluorine, the bulk of fluorine present in the phosphoric acid remained with the product.

Summary

The pilot plant results have established the promising nature of a novel, cheap and efficient process for the manufacture of a powder mono-ammonium phosphate. At this time our work on the pilot plant scale is continuing mainly to obtain more basic data on the spraying operation. A full scale production unit has been designed and will be in operation during early 1967.

This process has special attraction in that phosphate acid can be readily converted to a solid form, transported, stockpiled and used more cheaply than the acid itself, particularly so when lengthy transport distances are involved. Additionally, the capital investment and operating costs for such a plant would be very much less than for a plant producing granular ammonium phosphate of equivalent capacity. This process, therefore, would be particularly suitable for use by phosphate rock producers, as it represents a very cheap method of upgrading P_2O_5 prior to transport.

The product appears to have very good properties compared with similar powder intermediates in terms of storage and handling. This process also has a useful advantage over other comparable processes for the manufacture of powder ammonium phosphate, in that no sulphuric acid diluent is required to augment the phosphoric acid-ammonia heat of reaction, and the P_2O_5 analysis is comparatively higher. Its bulk density is 55 lbs per cubic foot, and only slightly less than the granular material.

Although the main object of this Paper is to describe the development of a process for the manufacture of mono-ammonium phosphate powder, pressure ammoniation also represents a significant advance in the techniques of preneutralization generally, as it allows the production and handling of ammonium phosphate slurries with much lower water contents. When this is sprayed directly into a granulator it will result in significant reductions in recycle ratios required for granulation, and hence savings in capital and operating costs.

Patents

Patent applications covering this new process have been filed in the major manufacturing countries of the world.

CHAIRMAN SAUCHELLI: Thank you Mr. Hemsley for that very thorough and interesting paper you prepared on Mono Ammonium Phosphate Powder.

Any questions to ask of Mr. Hemsley?

A MEMBER: May I ask a question. What is the analysis or the N and P205 content of the product? I am not sure you may have given it but it hasn't registered.

MR. HEMSLEY: The analysis of the product made on the pilot unit was slightly over 12 percent nitrogen and slightly over 56 percent P_2O_5 expressed on a dry basis.

I should point out here that we were using Morocco Acid which had been settled for at least several days. For phosphoric acid processed directly from an evaporator the analysis would probably drop to around 11-5—53.

There are some samples of this material available in the room somewhere in a box. They are on top of the piano at the platform here and you are welcome to take one, if you wish.

MR. ALLEN LONGACRE: I would like to inquire about the corrosion effect of the ammoniated phosphoric acid under the conditions of your experiments.

MR. HEMSLEY: We used 316 stainless steel for the internal reactor and pipework. We don't anticipate any serious corrosion problem at the pH level that was used. If the reactor were operated at a low pH, for example, around 2.5 for long periods of time, there could well be corrosion with the 316 series steels but I would say that these steels are quite suitable for the pH of around 4 that is required for this process.

MR. LONGACRE: I assume then that this was from examination of the equipment subsequent to your operation. Were there any tests of other materials in your system?

MR. HEMSLEY: No, we haven't done any corrosion tests at all, apart from visual observation of the reactor equipment after its operation. Although the operating temperature is higher than in a conventional ammoniation reactor, all other conditions are similar and we don't anticipate any corrosion problems.

MR. DAVID GOLDSTEIN: Do you have any analyses of the phosphate species in this material?

MR. HEMSLEY: You are thinking in terms of the presence of polyphosphtes perhaps?

MR. DAVID GOLDSTEIN: Right.

MR. HEMSLEY: We have looked at the polyphosphate picture in our research labs and we have not been able to pick up any higher level of polyphosphate than the very low level that is normally present in phosphoric acid or in its conventionally ammoniated form.

Furthermore, the water content level in the reactor is such that we would not anticipate any significant conversion to polyphosphate.

CHAIRMAN SAUCHELLI: Any other questions?

If not, I certainly want to thank the members of Fisons Fertilizers Limited for their splendid contributions to our program. It is always a pleasure to have research presented to us from abroad. Dr. Jorquera we thank you very much for arranging for the Fison's group to be on our program.

Many people don't realize the advanced technology that is common in Europe in the fertilizer industry. So it pleases us very much to be able to present to our people here evidences of the fine research capabilities of our friends overseas.

Now we will have to proceed with our program. We have a Business Meeting but prior to the Business Meeting I am going to ask is Grant Marburger still in the audience.

A MEMBER: He left the room.

CHAIRMAN SAUCHELLI: I was going to ask Grant to give us a brief report on the IMI Phosphoric Acid Cleaning Process but that will propably be for next year.

I am going to ask our Secretary-Treasurer, Dr. H. L. Marshall to give us a brief report.

Secretary-Treasurer Report

Dr. Housden L. Marshall

Ladies and Gentlemen: Your secretary-treasurer has kept things rolling pretty well this year. I still have a number of reprints of proceedings 1961 through 1965. These are available for $22.50 per set. I

Financial Report

Cash on hand 10/31/65		$ 667.52
Income. 1965-66.		
Registration 1965 Meeting.	$4,590.00	
Membership List 1965.	550.00	
Proceedings, Reprints, Coffee Breaks.	1,081.35	6,221.35
Total Cash Handled.		$6,888.87

Expenditures 1965-66

Meetings Expense.	1965	$ 878.13	
Membership Lists.	1965	270.54	
Proceedings (Printing Costs.)	1965	3,861.50	
Operating Expenses.	1965-66	624.93	
Preliminary Meeting Expense.	1966	370.59	$6,005.69
*Cash on hand Sept. 30,1966.			$ 883.18
*Equitable Trust Bank Balance		$ 883.18	

have about 10 copies of 1958 and 1959 proceedings. Just send us your request and we will mail promptly and invoice you.

The membership attendance for this meeting as determined presently, is around 560. This is the largest number we have ever had and we are indeed proud.

Now for your financial report. My report today covers a 11 month period because I did not get the bank statement for October yet.

Chairman Sauchelli: Thank you Mr. Secretary-Treasurer.

We will go through the formality of asking a motion to accept the Treasurer's report.

A Member: I so move.

Second Member: I make the motion that the report be accepted as read.

Chairman Sauchelli: All in favor?

(A chorus of ayes.)

It is carried. We are a very informal group here.

Chairman Sauchelli: We are committed next year for the Mayflower Hotel for November 15th, 16th and 17th. There has been some question about 1968 and 1969. Some folks have indicated that perhaps we might do well to transfer the meeting from Washington to perhaps Chicago or some other city.

The majority has always voted for holding the meeting here in Washington. We don't have a very large representation here at the moment but I am going to ask for a vote on whether we should consider going to some other city than Washington in 1968 or 1969 or shall we remain here in Washington.

It is very difficult to get accommodations and reservations at these hotels without two, three or four years prior notice. What are some of the comments? Let me hear something.

A Member: I would like to say that we have been quite successful in the last few years and I am sure we are very anxious for overseas visitors and I think it would be wonderful for them and I think it would be more difficult for them and I think you would get fewer visitors if you moved out of Washington.

Chairman Sauchelli: Anyone else? (No response.)

I think the majority are content to leave it as is. Our Secretary has had difficulties in getting advance reservations and we have reservations tentatively beyond 1967 at this hotel.

Secretary Marshall: I would like to say that we are not committed. We have reservations up to 1973 here. Fortunately we feel from the attendance standpoint that the first half of November is the time to have it. However, we have election day to contend with and we don't want any of you fellows to stop voting to come here. So we have to move it around between the first and second weeks in November.

The reason for next year being so late is because the National Order of the Eastern Star, have taken over all the hotel space in all of the hotels in Washington. That's no joke, and they took our week. The hotel asked us to move forward. So it is the 15th, 16th and 17th.

Chairman Sauchelli: As I said in my remarks on Wednesday, we are always glad to have visitors from abroad. This year we had 24 visitors from Europe, three from Germany, three from France, one fom Belgium, nine from the United Kingdom, three from India, two from Mexico and we have 17 from Canada. We are very glad always to welcome our foreign guests.

If there is no further business I want to take this opportunity to thank all of the speakers who have made this year's meeting so memorable and so informative and so valuable.

I want to thank my associates on the Executive Committee and particularly the Secretary-Treasurer, who works like a beaver. He is a hard worker. We can't hold him down sometimes but he is a dedicated soul.

I want to thank the trade press representatives. They are hard workers. It is not easy to take down a lot of the papers, that is, to make reports and digests of the papers that are given, but they do a splendid job. They have been doing that every year and it has helped very much to popularize and publicize the activities of the Round Table and we thank them deeply.

I want to thank the hotel. The Mayflower Hotel people really go out of their way to help us. It has been pointed out that a hotel will treat its clients who come year after year much better than those who just come for one year or two years. We really get fine service here from the Mayflower Hotel.

There has been some criticism, Mr. Secretary, about the loud speaker business here and next year we want to make sure that we have an improved speaker system.

We, of course, have already started to work out our agenda for the coming year. I have two suggestions. One—That we hold another symposium on phosphoric acid, which is of increasing interest to the industry. The other—That we have a symposium or a seminar on sulphur and its various aspects.

That is not only brimstone sulphur but other forms of sulphur as they might influence the fertilizer industry.

I throw those out as suggestions and hope that you will send in your ideas, your suggestions and your comments and probably even suggest personnel who might handle the different phases of these two symposia. But then we don't want to stop with those two ideas, if you have other ideas please cooperate with us by sending them in.

It is your meeting. It is as much your problem as ours to get up a strong agenda for next year's meeting.

Do you have anything, Mr. Secretary?

SECRETARY MARSHALL: Not a thing.

CHAIRMAN SAUCHELLI: Does anyone have any comments to make? Yes, sir.

MR. JACK EVERETT: Mr. Chairman, this is the first Fertilizer Industy Round Table that I have been privileged to attend. I would like to say that I enjoyed it very much.

I also would like to say that from my personal appraisal of the papers given I think that we would all have to agree that these gentlemen from Fisons have done a remarkable job and in my opinion have probably presented papers with more meat and more interest than possibly some of the other papers. When we think of ourselves as Yankee entrepreneurs, we must at once be aware that our former forefathers are still very much in the running.

I would also like to make one brief comment and that is that possibly in the preparation of the agenda for next year, if it might be possible to have a few less papers presented per morning and per afternoon session with some latitude of time in between each paper given to allow adequate question and answer sessions.

CHAIRMAN SAUCHELLI: Thank you. Those comments accord with our thinking. We ask you to send in some suggestions for actual papers on the agenda for next year too.

SECRETARY MARSHALL: Generally, about the first two or three weeks in January we send out a circular letter telling you about when the proceedings will be ready and the status of the order at the moment and we also always, if you will check back, ask you to submit the questions, subjects and whatnot that you have on your mind and you want to hear about. That is your first chance.

CHAIRMAN SAUCHELLI: We are aware that the value of the Round Table, as I have insisted, year after year, is the discussions, the questions and answers from the floor, and what makes our meetings a little different from the stereotyped meetings is that feature, the discussions, frank discussions that should characterize a Round Table. So that your point is well taken. I think we should have fewer papers.

In making up the program, it is very difficult at times. We usually give about 20 minutes to a speaker and sometimes that is abused by the speakers, not intentionally but they just don t figure on timing and so on.

MR. WEBER: My comment is along the same line. I think the most valuable portion of these meetings are the discussions.

I think as this organization develops we are getting more and more sophisticated papers, more technical papers with a lot of meat in them and I wonder if the Executive Committee wouldn't consider the possibility of having these papers preprinted and pre-distributed. I think this would make for much more discussion and for better discussions and it would allow more time for discussions.

The two most efficiently organized technical meetings that I attend are the Fertilizer Society in London and ISMA the International Superphosphate Manufacturers Association and they both do that. They distribute the papers ahead of time. They have somebody briefed to start the discussions. The paper is only presented in abstract and there is a great deal more time available and the discussions are much better under those circumstances.

Now, I realize this is difficult and also expensive but I would suggest that the Executive Committee give it very careful consideration.

CHAIRMAN SAUCHELLI: Thank you, Bill. That's been discussed time and again. I am particularly familiar with the operations of ISMA and the Fertilizer Society of London. They have a paid staff, they have an office, an organization and they can do things .

But I was talking about that very thing with one of the gentlemen from Fisons and he took the other viewpoint, that the fact that the membership here does not have a chance to see the paper in advance makes it possible to have more spontaneous or more spontaneity in the discussions that follow. So there are two viewpoints.

Sometimes the authors don't have the paper prepared until about a month before or wait until the last minute. After all, we can't force these people. It is all on a voluntary basis. If we did have some papers in advance, I think it would be an excellent idea, Bill, and we will keep that in mind and we will try to do it and get our proceedings out as quickly as possible.

We have Miss Jo Ann Withers here. She does the best she can getting the transcription so that we can get the transcribed proceedings to the printer and so on.

We are not on the defensive here in the Executive Committee. We are open to suggestions. We want to make this and continue to make the Round Table the most popular and the best organization of its kind in the country. So that, if you don't have these suggestions now, write them in, let us know just what you feel about it. It's your organization. It's nobody else's organization but your own and you have the privilege of shaping it, of helping to make it a better organization.

It's inevitable, Bill, that we follow the trend of more sophistication because the industry is getting to be more sophisticated and more technical. I have always pointed out that, after all, the European industry technologically was far ahead of us for many, many years and in many phases it still is. Thanks to the fine research work of the Tennessee Valley Authority and our Fertilizer Industry we are catching up but don't sell the European technology short by any means.

Does anyone have any good word for the order?

A MEMBER: You know, I enjoyed being on this program and someone over here said to me, You know Vince pretty well; why don't you get up there and tell these people what a wonderful thing he is doing to have this meeting and to work so hard and make it such a wonderful success.

So I think we ought to all say: Thank you.

CHAIRMAN SAUCHELLI: Thank you, but it is the Executive Committee as a whole and the membership as a whole that are responsible for the good work but I thank you for those kind comments.

Again, I want to thank you all for your attendance and for your help in making the 16th Annual Meeting one of our best.

We stand adjourned until next year. Thank you.

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