PROCEEDINGS
OF THE
25th ANNUAL MEETING
FERTILIZER INDUSTRY
ROUND TABLE
1975

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Editor

Albert Spillman

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*Directors Elected 25th Annual Meeting Business Session
**Director Elected Board Meeting March 18, 1976

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Tuesday, November 4, 1975

Morning Session
Joseph E. Reynolds, Jr.
Chairman

William F. Sheldrick
Moderator

CHAIRMAN REYNOLDS: Our 25th Anniversary causes us to pause and review the history of the Fertilizer Industry Round Table. It is difficult to believe that this group has been together for 25 years. Bob Hope recently celebrated his 25th year on television and now we celebrate our 25th year. A little reminiscing is in order. After 25 years we can look back on many accomplishments.

The Round Table is an outgrowth of the foresight and interest of an unselfish group of men who in 1951 saw a need. The need was to advance progress in production technology through the free exchange of information. Changes in production techniques were indicated; but in the veil of suspicion and secrecy, mutual problems were being solved at a much lower pace than the farmer could tolerate. We are indeed indebted to these men who had the courage to guide the Round Table through a period when exchange of information was practically frowned upon. I will not attempt to mention the names of those 12 to 14 men for fear of leaving someone out, but they were bold enough to promote change for progress.

The Round Table soon became the place for production men to go to obtain answers to their problems and questions. As the years rolled by, the program formats have changed but in practically every case the change has been based on a need. The Round Table participants for the 25 years would fill the fertilizer directory of Who's Who on an international basis.

The Round Table has prospered and advanced because of a feeling of belonging and the realization of the individual that the exchange of information is a two-way street. You also receive when you give freely. The theme of spontaneous questions and discussion for production management was instantaneously appealing. No group existed which permitted the individuality and informality that was possible with this new group. The Round Table is composed of mutually interested persons who volunteer to accept responsibility whenever they are called upon.

The first official Proceedings was printed for the 1955 meeting. Prior to 1955 minimum note taking was tolerated although considerable volumes of lively debate could have been recorded. In review the Proceedings reveals thousands of pages of priceless technical and informative data. Many hours of thorough and careful preparation went into these sharings with others. Our industry received a tremendous boost in production technology through the form of the Round Table.

It would be very difficult to select a breakthrough year when companies really opened up their so-called secrets. However, during the 1956-1960 period we find a very close period in which this transition occurred. The famous 100 questions of 1957 went a long ways toward rapid firesharing of information. We heard the cry for uniformity in the mid 1970's. Try the Proceedings of 1960 for some of these answers. The examples of specifics that have helped people are endless.

Your Round Table has matured. Not only are programs designed to answer in-the-plant questions, but the information presented goes beyond the world of production management. We believe these insights to be important for better understanding of the marketing and overall management aspects of the fertilizer industry.

At this time in 1974 the fertilizer industry was still basking in perhaps one of the most successful fertilizer years we have ever recorded. In 1975 the cycle of supply-demand based primarily on reduced consumption started downward. Our industry is in the midst of considerable production expansion at this time. This is required to meet the challenges of the 1980's. The United States is an agricultural nation again, and our industry has a vital spot in the nation's prosperity.

I would like to challenge this 1975 Round Table to carry on the same recognition of the needs of the changing fertilizer industry. This torch was picked up in 1951 by dedicated men. They were very bold; they were very courageous. As we start our second 25 years, the Round Table is again prepared from your oral and written comments and suggestions. Your directors and officers have pursued all possible leads to bring you timely subjects and qualified speakers.

In the interest of moving into the program, we will briefly outline the format we would like to follow during the 1975 Round Table.

This morning we are requesting the speakers who are on the first session to be in the first couple of rows to my right so that they can move forward as their time occurs.

Questions of course, have been a very important part of our program. If anyone has a question as the speakers conduct their remarks, they should let themselves be recognized.

We have a full program with many things to cover. We have some business to transact on Thursday and a cocktail party on Wednesday night.

I am really impressed with the 1975 attendance. I think this really speaks well for the group. As I said earlier, this is a group of people believing in the Round Table. The Round Table is this group.

We are indeed fortunate to have with us today a very highly respected person of both national and international reputation. His background is quite lengthy in our industry.

Mr. W. J. Turbeville joined the American Agricultural Chemical Company as a salesman in 1936. He held many key sales positions in American Agricultural Chemical and was elected Vice President of Fertilizer Sales in the firm in 1959. He progressed through the organization as Vice President of Marketing, Executive Vice President and was elected President of Agrico in 1963.

During the period that Agrico was a division of Continental Oil he was Vice President and General Manager for Plant Foods of Contico. He served this capacity as well as President of Agrico until the sale to the Williams companies in 1972. At that time he became Vice Chairman of the Board.

In July 1972 he was appointed to his present position as Chairman of the Board of the Phosphate Rock Export Association.

He has served as director and member of many committees of the National Plant Food Institute, is a member of the executive committee and Chairman of the Board of the Fertilizer Institute and is also presently President of the International Superphosphate Manufacturers Association. This is quite an accomplishment. Mr. Turbeville is the first American ever elected President of ISMA.

He has served in many civic activities as member of the Board of Directors.

Mr. and Mrs. Turbeville have two sons and live in Tampa, Florida.

So, it gives me great pleasure to turn the program over to our keynote speaker, Mr. Turbeville.

Keynote Address
Fertilizer — Something Of Value

W. J. Turbeville, Jr.

Mr. Chairman, members and friends of The Fertilizer Industry Round Table, I am honored to have been chosen to keynote this Silver Anniversary Meeting. This is a very special occasion for you — and for me. You are marking twenty-five years of solid achievement. I am experiencing two first; my first participation in the Round Table and my first keynote address.

At the outset, let me say that I have found the assignment formidable. To keynote — to set tone — for a meeting with such a variety of subjects and, with so many expert participants. The topics listed and the array of talent assembled here make it difficult to come up with a single word, or phrase, that will get you off to an enthusiastic start; one that will continue to be a "keynote" throughout this busy week.

A few quick possibilities came to mind — The fertilizer merry-go-round, the roller-coaster or the elevator. About any one of these would be descriptive of our industry antics. But, they were quickly discarded, because our industry is too important, our achievements too great and your discussions too serious for a frivilous theme.

As I reviewed recent headlines relative to Fertilizer industry cycles, it occurred to me that there are a lot of cynics associated with our trade. Then, I recalled an observation of Lord Darlington: "A cynic — one who knows the price of everything and the value of nothing."

There, I had it. We do an awful lot of talking about price, we study costs but, do we give enough consideration to value — fertilizer values; agronomic, economic and social? How many of you — you who are actively involved on a full-time basis — appreciate that ours is probably the world's most important business? How few outside our industry know, or have ever been told, about the value of fertilizer? Sure, they have heard of fertilizer — but not the value.

This, then, is the keynote, the theme, my message — fertilizer, something of value. This will be a great day for me, for you, the fertilizer industry and the hungry people of the world if, after this conference, you truly realize the value of your work — your profession.

In 1950, the year that The Round Table was organized, Dr. Firman E. Bear, Dean of Agriculture, Rutgers University said: "The fertilizer industry represents the most important advance ever made toward providing plenty of food for the peoples of the earth." Do you feel that way? Really?

Sometime ago this letter appeared in a popular advice column: Dear Ann Landers, My husband is in the fertilizer business. When friends ask me what my husband does, What should I say?

An isolated question? Not at all. Any of us who have spent more than a few days in the fertilizer business know that we have been impeded by an "aroma", or connotation thereof, that comes from partial knowledge. The snickers don't bother me anymore. But, I really wonder if this popular notion of what fertilizer is, has been one reason that it has been so difficult for our industry to reach maturity.

As Casey Stengel would have said, "You can look it up."

One Webster version: Fertilizer — a manure — especially a commercial manure.

Manure — fertilizer — especially waste from stables.

January 1952 — Dr. Malcolm McVickar on fertilizer. "The use of commercial fertilizers is the most important means yet known to man or science that will provide an abundance of economically produced food and at the same time conserve our soils — by far our most precious heritage — for generations to come."

So, I found another dictionary. Here is what it says: "Fertilizer — any natural or artificial substance for fertilizing the soil — especially dung or refuse of the stable."

Dr. Steiner, FAO, at the World Food Conference said, "Mineral fertilizers have become a crucial element in resolving the world food problem. An increasing use of fertilizers accounts for a large part of the growth in world food production achieved over recent years."

Important United States fertilizers milestones — or are they millstones? Psychological obstacles to greatness?

1824 — Two barrels of Peruvian guano arrived in Baltimore.

1825 — Ground bone was first used as fertilizer in the U.S.

1830 — First nitrate exported from Chile to Norfolk, Virginia.

1832 — First importation of Peruvian Guano.

1850 — First mixed fertilizer (manufactured guanos) produced in Baltimore, Md.

Our evolution — manure to guano, to bones, to rendering plants producing bone meal and tankage — to blood and fish and cotton seed meal.

Finally — we came to a mixture of nitrate of soda, acid phosphate, kanit and — sand — especially sand.

Don't knock it. Food production kept pace with population growth. Dr. Malthus had not reckoned with fertilizer — especially chemical fertilizer.

By 1950 — the year of the Round Table birth — U.S. fertilizer consumption topped 18 million tons. Our image had not improved all that much. We used a bit of carbon black to simulate the organics, yellow ochre stood in for cotton seed meal — but we kept the sand.

1958 — Jesse W. Markham.

The fertilizer industry — Study of an imperfect market — P.22.

"For nearly a century this problem has been exposed as a simple question — Why is there so much sand in the farmer's fertilizer?" Fertilizer was low grade, low cost and the industry was low profile.

Dr. R. Dudal, Chief of the FAO Soil Resources Development and Conservation Services, Rome, March 1975. "In the 1960's public opinion — and even some decision makers — considered fertilizer as that cheap stuff with which scientists were laying out experiments and trials showing the difference between "with and without".

"1974, however, showed a turning point", continued Dr. Dudal, "as fertilizers could no longer be considered that cheap stuff, as it became rather expensive; furthermore, it was fully realized that fertilizer was not only something to make experiments with, not just commerce, but an essential input for food production, the availability of which was indispensible to the solution of the world food problem."

Here are some of the numbers which Dr. Dudal had in mind.

		DAP	**TRIPLE**	**UREA**
1970	Per ton	$52.30	$36.50	$57.70
	20,000 tons	$1,046,000	$732,000	$1,154,000
1974	Per ton	$350.00	$325.00	$350.00
	Per ship	$7,000,000	$6,500,000	$7,000,000

Phosphate Rock — 30,000 tons
1970 — $180,000
1975 — $1,260,000

For importing countries — mostly the developing world — the change was staggering.

About one-half of the fertilizer used, in developing countries, is imported.

1973/74 Costs $1.6 billion

1974/75 Costs $5.4 billion of which $3.6 billion represents increased prices.

When they ask — What's his business, what do I say? Fertilizer — is food. Fertilizer — is the quality of life. Fertilizer — is life.

You know that to be a fact. I know it. But — the public doesn't — and we get so tied up in what we are doing that we forget.

This must change — first within ourselves — it isn't sufficient to know that fertilizer is of value — we have to believe it.

There is a difference! To know is not necessarily to believe.

There is a saying, "Seeing is believing". This comes rather close to being the truth.

Therefore, we must demonstrate. By demonstration we strengthen our belief. When we become true believers we can tell our story with conviction. Our story is — Fertilizer, something of value.

FAO demonstrations — Begun — 1961

Number 260,000

Yield response — Average 60% on our unfertilized plots.

Economic returns — Average 330% with use of fertilizers.

Statistics such as these are empty unless you have experienced the difference. You truly must see "with" versus "without" to appreciate fertilizer.

I say to you — there is no other product, no other industry more essential to mankind than the one we represent.

The Consultive Group on Food Production and investment, which met here in Washington last spring, said this —

"Fertilizer is the most important single purchased input in the program launched by the World Food Conference to increase food production in developing countries. Apart from human labor and the sun, fertilizers will usually represent the major energy input into the expanded production in developing countries of the basic grains which is essential to reducing the degrees of dependence of food and foreign exchange deficit countries on imports and to raising living standards and reducing malnutrition among the developing country rural poor, the largest poverty group in the world. Its increased use will nearly always increase yields somewhat even if no other action is taken. The costs involved in an integrated package of better seeds, more water, improved cultivation practices, pest control, adequate credit, etc. for grain production can usually be justified only if they are accompanied by a substantial increase in fertilizer use."

I almost forgot to tell you — Ann Landers did reply to the letter — her advice was, "Tell them he is in the Fertilizer business."

So here we are making new headlines — The New York Times — October 20, 1975. "With fertilizer shortage past, poor countries are still hungry."

Farm Chemicals — November, 1975. "What's happening in the big fertilizer war?"

Chemical Insight — August, 1975. "Volatile fertilizer sector moves into position of surpluses worldwide."

Here we are with a job that must continue to be done. A job that will be done with pride and conviction because — Fertilizer — is — something of value.

The speakers who follow me today will discuss fertilizer supply — demand and the world food problem. On the one hand you will probably hear that the fertilizer shortage is over — on the other, that the problem of hunger is still with us.

It simply does not add up — too much fertilizer — too little food — too much hunger.

The answer, of course, comes right down to too poor planning and too little coordination between industry and government — to wit:

Farm Chemicals — current issue — quoting an industry critic: "There is no other field in the chemical process industry in which market research has been more often wrong on its short and medium term projections than in fertilizers."

This isn't exactly new — In 1958 — The Fertilizer Industry Study of an Imperfect Market. R 238 — Mr. Markham concludes: "The principle obstacle to effective competition in the fertilizer industry, therefore, derives not from its structure, nor from collusive agreements, but from the highly imperfect knowledge underlying the demand for fertilizers."

A more fundamental question is also being asked which goes beyond the accuracy of forecasts —

The New York Times — October 20, 1975 "There was a big rip-off last year," said Robert J. Eastman of Blyth Eastman Dillion & Co., a brokerage firm. "The retail dealers and distributors took advantage of the shortages to rip-off farmers in this country, and the producers sold to countries like India and Brazil at inflated prices."

"The sancity of contracts doesn't exist in this business because of the wild price fluctuations," said Emil S. Finley, president of a fertilizer-exporting firm, the International Commodities Export Company of New York." '

What is the solution? Dr. Robert Steiner, FAO, suggested an approach. "The awareness that fertilizers have become an indispensable input to ensure an adequate food production for a rapidly growing world population and that fertilizer production and distribution represents a global interdependence, leads one to question to what degree fertilizer production should not be regarded as a world public utility."

To me, that is not the answer. However, we will be regulated, or worse, if we don't do a better job of eliminating the cycles.

How do we go about it? Keep it simple — stick with basics.

Agronomic Research

Product Research

Market Research and analysis.

Long Term marketing programs.

Realistic manufacturing programs.

Sound fiscal policy.

Close cooperation with government.

But, above all, conduct yourself in such a way that you will be proud of your business — proud of the job that you are doing.

Wives of fertilizer men will never have to ask, "What should I tell them? Because — you will have shown that fertilizer is something of value.

CHAIRMAN REYNOLDS: Thank you very much, Mr. Turbeville. You have given us a stirring message and a real challenge.

As indicated in my brief simple remarks we have matured. The industry has grown up.

I think Mr. Turbeville has done an excellent job of launching our Round Table. We are indebted to him for taking the time to be with us from a very busy schedule.

So, without further comments, I am going to thank Mr. Tubrbeville again. We appreciate him being with us. I am going to turn the program over to our moderator, Bill Sheldrick.

MODERATOR — WILLIAM F. SHELDRICK: Gentlemen:, first of all I would like to say it gives me great pleasure to be moderator this morning. I appreciate this particularly because I am not a U.S. citizen and I am not a member of the U.S. fertilizer industry, but I have been very much concerned with the Round Table as director of the last 10 years or so and I have made most of the meetings and many of the committee meetings.

However, now that I am living in Washington, I find that there is a great deal of contact between the U.S. fertilizer industry and the inter-national fertilizer industry with which I am now very much concerned in the World Bank.

Our first speaker this morning is Charles M. Grau who is Senior Vice-President of the Agrico Chemical Company. Charles is a graduate of Missouri University, in business administration, where he majored in statistics.

He has previously worked for Gulf Oil. With Agrico, Charles is in charge of their domestic operations including engineering, production, marketing and a host of other responsibilities, so it sounds and it is a very big job. Obviously, someone with this type of job has *got* to *know* what is likely to happen in the next year, in the fertilizer industry. It is a pleasure in asking Charles Grau to tell us about the next 12 months.

Fertilizer Supply-Demand 1975—1976

C. M. Grau

It is a real honor for me to participate on a round Table Program. This conference — since its inception — has been one of outstanding accomplishments. Our industry has made so many significant contributions to improved agriculture throughout the world. Many of these advancements would not have happened or were hastened by the exchange of thought and knowledge that has characterized the Round Table idea. You and those who have served before you have caused many good things to happen in our industry.

I need not remind you that forecasting is not an exact science. My topic "Projected Fertilizer Supply — Demand During the Next Twelve Months" has been a continuous assignment of those charged with planning and management of companies within our industry. It is — as always — a difficult question to resolve. I believe it would be fairly accurate to state that most fertilizer forecasters at the time of this meeting one year ago thought demand would exceed supply on all three of the primary nutrients. Developments occurred during the course of spring season that switched the real world from one of shortage to one of surplus — almost overnight. Instead of experiencing the 6% traditional growth in domestic consumption our preliminary figures show a 7% decline. This should be an adequate reminder to all of us that our best thinking on this subject today may not stand the test of time.

There is an old saying, "It is better to have an opinion and be wrong than have no opinion at all." This belief gives me confidence to proceed.

Fertilizer is a tremendously important product. You people know that, Approximately one-third of our domestic crop production is directly attributable to fertilizer. It is a vital link to world food production and in final analysis — to human welfare.

The big three fertilizer elements are still N. P. and K. There are a host of long range problems and opportunities that face our industry. However, to conform with my assigned topic I will restrict my remarks to a look at the N-P-K supply/demand situation over the next 12 months.

First, Nitrogen — although certain question marks exists, our domestic 1975-76 nitrogen *supply* is fairly well defined. One can count the ammonia plants, assess their effective capacities, allow for interruptions due to down time and/or curtailments, forcast the export/import nitrogen balance, assess the industrial usage of nitrogen, allow for inventory and come up with a rather close estimate of our nitrogen supply for the balance of this fiscal year. As you know, there will not be an abundance of new ammonia production this year.

Our counts may not agree exactly, but we tally nine (9) new or expanded nitrogen production projects that promise to add to supply during this fiscal year. Reviewing rated capacities and expected start-up dates, this new supply potential equates to 800,000 tons of ammonia. Our new Verdigris, Oklahoma Plant represents approximately 53% of this figure — the other eight (8) projects represent slightly less production than one 1200 ton per day plant. Converted to actual nitrogen, this represents 664,000 tons of N as new supply from domestic production this fiscal year.

Information to accurately appraise our nitrogen export/import situation for the season ahead is difficult to assemble. According to U.S.D.A. figures for the 1974-75, the U.S. was a net importer of nitrogen. We imported 1.2 million tons of nitrogen and exported 1.1 million tons of N. Comparing nitrogen export/import figures for the first 3 months of this fiscal year vs a year ago, the export tonnage exceeds the import:

JULY-AUGUST-SEPTEMBER

(000) Tons

1974	1975	1974	1975
N IMPORT		N EXPORT	
238	278(+40)	255	321(+66)

(Tariff Comm.— John Mahon)

Our best appraisal of the nitrogen export/import situation is that the tonnage coming in and the tonnage going out will be in close balance. If the present trend continues, we will export slightly more N than we import.

Also for our analysis today, we will assume current operating efficiency will continue with no serious down time other than production loss due to gas curtailment. It is important to remember that we are presently increasing our use of natural gas at four times the rate of discovery. U.S.D.A.'s Fertilizer Industry Task Force has reported an estimated ammonia production loss of 670,000 tons for the April, 1975 to April 1976 period due to gas curtailment.

The overall cutback is expected to be 41% greater than last year. Some 52% of our ammonia production is on inter-state pipelines. These plants are vulnerable to allocations and gas curtailments.

Another important factor in predicting nitrogen fertilizer supply is to account for the industrial demand for nitrogen. Looking back to 1973-74, some 28% of our total domestic nitrogen supply was consumed by industrial users. We know this usage fell off during the past fiscal year due to the downturn of our economy. Industrial users of ammonia, urea and ammonium nitrate cutback in purchases and significant product tonnages were shifted to the agricultural market.

One major industrial use of ammonia is the production of nylon filament and acrylic staple — important synthetic fibers. This graph is indicative of the resurgence of demand for ammonia in fiber production that has occurred since December, 1974. Other barometers of industrial nitrogen use are showing similar turn-around. The full impact of these changes are most likely to be felt during the first 6 months of 1976. We are expecting this shift to result in take-back of some 300,000 tons of N for industrial use that was in our fertilizer picture last year.

We are all aware of the sharp jump in nitrogen inventory that exists now as compared to a year ago. This is a matter of concern but not reason for alarm. An October release from the FERTILIZER INSTITUTE reports the following regarding nitrogen inventory (all products) at the end of August. These figures represent number of days of production equivalent:

1975	**1974**	**1973**	**1972**
39	18	19	40

Nitrogen inventories are comparable to those of 1972 — They are double those of a year ago. They are causing producers concern at this time. since fertilizer use is very seasonal by nature, it was predictable that a more seasonal pattern in purchasing would return once shortage concerns were minimized. the present fertilizer season promises to be more like 1972 and the seasons preceding it. The past two years were atypical. A sizeable inventory is needed to supply the spring peak.

Considering all of the factors mentioned, we believe that the most optimistic nitrogen supply forecast for the present fiscal year would be an increase of 5%. Some predict little or no increase in nitrogen supply.

It is more difficult to predict the demand side. Approximately 75% of our domestic nitrogen usage is applied to four crops — corn, wheat, cotton and grain sorghum. If one can fairly accurately predict 1975-76 acreages of these crops and the application rate per acre — the base for a reliable nitrogen demand forecast is developed.

The largest factor influencing decisions regarding acres to plant and nitrogen rates to apply is embodied in judgments of expected production economics and profitability. Although production expenses and expected yield are important factors, the dominant influence in creating bullishness in crop production is anticipation of high or at least good prices per bushel or pound at harvest. This is always an unknown. Farmers have to count their chickens before they are hatched.

In predicting fertilizer demand one must do the same thing. What will the price of wheat be next July and the price of corn, cotton and grain sorghum be a year from now? Yes, we could all get rich if we had an exact fix on the answer to these questions. It is an unknown with climatic and biotic factors, politics, economics, and other factors here and throughout the world charting the course. It is rather safe to predict that if the price of wheat is $3.50/bu, corn $2.75/bu, cotton $.55/# and grain sorghum $4.25/cwt when planting and fertilization decisions are made nitrogen demand will exceed supply. If wheat is $2.75 or less, corn $2.00 or less, cotton $.45 or less and grain sorghum $3.50 or less, nitrogen supply will exceed demand. A look at cash prices today finds us in a middle zone between these two levels.

If production costs hold near current levels, the present future prices suggest the cost/benefit ratio will favor using adequate fertilizer rates. Obviously, crop prices can go two directions from the current future price level. We are aware of the fact that grain prices have moved concernably lower the past two weeks. Corn belt elevators are full — we still have one-third of the crop in the field. Hopper cars are backed up at our major grain ports — they are hard to come by in the country. Good yields are helping to off-set the disappointment in price. The grower who must sell now is not recording much profit. In spite of the "not too bright" picture at the moment — most predict a price recovery once harvest pressures are over. The demand for grain, the price for grain and the demand for fertilizer ride in the same boat, The following points give reasons why an upward trend looks like the best bet:

1. Only twice in the last 20 years has world food production declined. We need 25 million tons more grain each year to keep up with the increase in world population. About 90% of the world's food is eaten in the countries where it is produced. The remaining 10% goes into world trade or aid. We are the world's major grain exporter. A deficiency exists in the world grain supply. It is obvious that a good export market is of major importance to U.S. farmers and fertilizer people.
2. With no surplus stocks to dump and no reserve acreages to release to production, the U.S.D.A. is without these weapons to hold prices down. News of reduced crop production prospects in any part of the world or any unexpected increase in demand would more than likely send crop prices higher.
3. Nitrogen demand was especially hurt last year by the reduction in cotton acreage and the reduction in pasture application due to unfavorable cattle prices. Our projections show a 10% increase in cotton acreage next spring over last. Most of this increase will come at the expense of soybeans — a crop that receives little or no nitrogen fertilizer. Although cattle prices are still low, they have improved sufficiently to expect greater nitrogen usage on pastures this coming spring.

All of the above subjects are "ifs" at this stage. If they take a bullish course, nitrogen demand will take a bullish course; and so will other fertilizer elements.

The 1973-74 U.S. nitrogen demand was 9.2 million tons of N. That was 10% above the 1972-73 demand. We believe that fertilizer nitrogen demand for the year just passed (1974-75) was down 2% or around 9.0 million tons N.

Looking forward to 1975-76 nitrogen demand under medium tint rose colored glasses, we see a 6% to 7% increase in nitrogen demand. If crop prices hold at current levels or move higher, this estimate is too conservative. Our best opinion is that nitrogen will be in a shortage position this coming spring. The magnitude of the shortage could even be acute.

WHAT ABOUT $P_2O_5$0

The Phosphate supply situation is sharply different from a year ago. The industry — reacting to the shortage — has brought new mines and new upgrading facilities on stream. AGRICO, CFI, IMC, and TGS were the prime contributors. There is little question about it — our ability to supply P_2O_5 during this fertilizer year exceeds our best demand expectation. The only thing that could upset this picture would be a large expansion in export demand. Current inventories of phosphate materials are approximately twice the level of a year ago. As stated earlier, since we are returning to a more traditional seasonal fertilizer purchasing pattern, higher "off season" inventories are to be expected.

We look for our P_2O_5 plants to be operated in the 75-80% capacity range rather than in the 90-95% range that was recorded during the past two years. A number of voluntary cut-backs as well as needed shut-downs for maintenance and major repair have occurred and continue to occur. These moves will result in a closer balance between actual P_2O_5 supply and demand.

The U.S. has always produced more P_2O_5 than our domestic market can consume. The international market has a major impact on our phosphate industry. Phosphorus is the only fertilizer ingredient market we serve as a net exporter. The U.S. will account for over half of the world's P_2O_5 supply increase in 1975-76 over 1974-75. At this time, demand in the world market is nothing exciting. Most authorities believe that we will remain in a lull period until inventories built up during the shortage period are worked off. It may be slightly early to predict a major trend for the year. Nevertheless, we have seen a pick-up in export demand for P_2O_5 in upgraded forms during the July-August-September quarter. P_2O_5 exports for this period in 1974 were 493,000 tons compared to 645,000 tons this year — That's an increase of 152,000 tons or 31% (Tariff Comm. - John Mahon).

Another matter of significance is the fact that phosphate rock has been difficult to come by. Rock inventories at the present time are adequate but not burdensome. There are numerous hold-ups in getting new mines started — there are difficulties in securing permits. There are ever-increasing costs and delays in procuring equipment, there are difficult local restrictions and most remaining deposits are less concentrated in analysis.

There is ample rock but generally it is of poorer quality — lower BPL, more impurities — more costly to mine. It takes an approximate lead time of 5 years to bring a new mine in. This compares to an 18-month to 2 year lead time just a few years ago. Most of the new expansion in DAP, MAP and Triple facilities have been made by companies basic in rock. It follows that these companies will likely step-up efforts to build export markets for upgraded products.

Morocco is the other major world source of phosphate rock. Europe is heavily dependent upon an adequate supply of rock from Morocco. The present political maneuvering in this country plus the high price tag on Moroccan rock is of real concern to companies depending on this supply.

Our figures show an approximate 8% drop in P_2O_5 consumption in the U.S. last year. A number of factors led to this: First, the shortage, then higher prices, adverse weather, and a general pessimistic attitude on the part of farmers regarding expected grain prices. Many wheat, corn, forage, and cotton field were short-changed fertilizer-wise. Many growers have relearned that N.P. and K are still essential Production inputs. With good prices for grain and cotton, with an improvement in cattle prices, with some "catching-up" and return to more typical application rates, with some good old fashion promotion and "hard sell" — we could see a pleasing upward spurt in our domestic P_2O_5 demand this coming spring. Our field people in most parts of the country report good fall movement of P_2O_5 at this time. The continuing transition to higher P_2O_5 analysis mixed goods as a result of substituting phosphoric acid and triple for normal superphosphate aids in increasing per acre P_2O_5 rates.

This table depicts our P_2O_5 supply/demand picture for 1974-75 vs 1975-76. It is obvious that we have more capacity to supply than we have demand. This was true last year — it is more true this year. It is rather clear that this difference between our capacity to supply and domestic demand builds a large gap to bridge. An increase in export of upgraded phosphate is part of the answer. Expanding demand — domestic as well as export — needs to be our industry's battle cry. This will not happen overnight. Until such is the case, we believe plants need to be operated at reduced levels to prevent the build-up of burdensome supplies. This is the solution we see this year.

Now Potash —

Those of you who know me or my company must be thinking "what do those people know about potash?" My defense is that I have called upon some associates in the potash industry for counsel. For the time being, most agree that the potash shortage is over. On the other hand, we are not in an over-supply situation either. The best description that I have heard is that we have a manageable potash supply/demand relationship. Potash has been available in ample quantities through the past summer and early fall. A good fall us is underway, and it appears that we will have a "no more then needed" inventory going into the spring season. As mentioned with nitrogen and phosphorus the return to a more tradition pattern in fertilizer purchasing has put more of the burden of inventory on the producer.

We are the world's No. 1 importer of potash, Canada is our major source. Last year we bought 68% of the total Canadian output. The Canadian Government sets the level of mine operation. Last year the industry, for the first time in history, was granted a 100% capacity operating rate. Labor shortages and the inability to get delivery of new equipment inhibited producers. As a result, production levels fell well below rated capacities.

Last year Canadian production was planned at 6.7 million tons of K_2O but because of the problems the actual production was only 6.1 million tons. Considerable capital will be needed to bring existing Canadian facilities up to their name-plate capacities. Also due to enormous tax burdens — 87.6% of *pre-tax* profits, plus the threat of direct government participation in any new ventures could halt any expansion of the Saskatchewan potash industry.

It appears that there will be no more than 700,000 additional tons of new production added in North America this year — all in Canada — and made possible by present producers reaching name-plate capacities. So if world demand increases roughly 5.5%, we see another 800,000 to 900,000 tons of K_2O needed from overseas production before the end of this fertilizer year. We know of no new overseas production so it appears that a snug potash supply/demand situation will exist come spring.

Since two-thirds of our potash comes from Saskatcheman fields, getting product to the right place at the right time is a growing logistical exercise. Practically all movement is by rail. Between now and April, great skill most come into play in obtaining ample rail cars, scheduling shipments and terminaling product to have material at the marketplace when the spring peak in demand occurs.

Well, you have the picture as best as I can relate today. I have attempted to be a realist with a slight sprinkling of optimism.

In a nut shell — these conclusions appear the most significant:

- We are in a buyers market — the timing of purchases has returned to the traditional pre-shortage seasonal pattern.
- Production people have done their job — now our industry needs to plex our marketing arm.
- Nitrogen — the odds point to slightly more demand than supply for the balance of this fertilizer year.
- Phosphorus — potential supply is greater than demand. Production should be geared to demand requirements.
- Potash — a very close match between supply and demand.

Thank you.

MODERATOR SHELDRICK: Well gentlemen, I think you will agree that we have had a very penetrating and comprehensive analysis of the situation for the next 12 months. We have, I think, time for one or two questions if anyone would like to ask any.

Question: Can you forecast more than the next 12 months for nitrogen especially? Can you give us the forecast for supply and demand for 2 years or 3 years from now?

Mr. Charles M. Grau's Answer— Dan, we see a nitrogen surplus possible in the '77—'78 period, no more than 5-6% range, not a tremendous burden; but then we see a much closer supply-demand, maybe even a slight deficit in the 1980-1981 period.

MODERATOR SHELDRICK: Any more questions, gentlemen? Well, I think that perhaps we will finish that there. We are running well on time. On your behalf I would like to thank Charles for a most professional and excellent presentation. I think a lot of important issues have been raised which we shall all be thinking about in the next 12 months. Thank you very much.

CHARLES M. GRAU: Thank you Bill.

MODERATOR SHELDRICK: Gentlemen, in the keynote speech this morning, Jack Turbeville did raise the question of the importance of fertilizers in resolving the world food problem. This is an issue we are very much concerned with in the World Bank, and I'm very pleased that I have a colleague of mine here today who is going to tell you something about this problem.

Joris J. C. Voorhoeve is a Dutch national who took a master's degree in agricultural economics in Holland; and he followed this with a Ph.D. in international politics at Johns Hopkins University. He joined the World Bank as a young professional and for the last two years he has been very much concerned with the world food problem. Gentlemen, I would like to introduce Dr. Joris Voorhoeve.

Fertilizers and the World Food Problem

Joris J. C. Voorhoeve [1]

I have been asked to sketch the world food problem and the contribution which fertilizers can make to its solution. Perhaps I should start with three preliminary remarks on the general nature of the world food problem. First, it is commonly believed that the world food problem is simply a lack of food in relation to total world population. Acutally, many countries produce much more than is needed to meet human needs. Total world food production is sufficient to feed all people well if it were distributed equally over everybody. This statement conceals, however, overconsumption by rich people and starvation or malnourishment by the poor. These poor, suffering from insufficient food intakes, number, according to FAO, at least 400 million people, that is at least 14 percent of world population.

What we call the *world* food problem is the food deficit of about one third to one half of the developing nations, mainly those of South Asia and Africa below the Sahara. Therefore, it is more a *regional* than a global food problem. As it is first of all the responsibility of the people in these areas themselves, and their governments, to solve their food problem, the world food problem is essentially a *national* problem. This conclusion is reinforced by the fact that in many nations which have, on average, sufficient food, starvation occurs among the socially disadvantaged groups, in the village and slums. As such, the world food problem is a *local* problem.

Whatever the size or location of the food problem, economic inter-dependence among nations makes that which happens far away, e.g. in the Soviet Union or the United States, have a profound influence on the food situation in the deficit areas of Asia and Africa. The grain production and price policies and the import or export policies of the U.S., Canada, the Soviet Union, and other nations, determine the world price and the availability of cerals for deficit mations. The future price which the Indian farmer will receive for his wheat and rice is indirectly related to what decisions are taken right here in Washington. It is because of this inter-dependence that the problems of the food deficit areas are, indeed, world problems. Still, in essence, they are national and local.

My second general remark concerns the frequent belief that food problems are technical in nature, that they are caused by a lack of proper agricultural technology and insufficient and arable land. However, the existing agricultural know-how allows mankind to produce many times as much as is actually done. The world food problem is to a great extent a question of incorrect policies, poor organization, and wrong investment priorities. As such, it is essentially a *political* and not an agricultural question. While millions of poor farmers toil day and night for a larger food production, suppressive and incompetently managed social systems take away the fruits of their work and their incentive to produce more. While the world spends 250 billion dollars annually on armaments, only 1.5 billion dollars is spent as development aid for agriculture. With such priorities, nobody should be surprised that there are serious food problems in the world.

The third general remark is on the subject of population growth. It is commonly believed that there would be no world food problem if the populations of the poor countries did not grow as fast as they do. This belief may not be correct. Several nations with high population growth have been able to feed all their people well, and experience a general, fast economic development. Others, with a lower population growth, are doing very badly in food production. Of 25 poor countries with an annual population growth of 3 percent or more, 15 have been able to expand food production as fast, or even faster, than population growth.[2] Therefore, population growth is only one of the factors, and maybe not the crucial one. What matters most is the way a society and its government respond to a challenge.

I make these three introductory observations only to emphasize that increased use of fertilizers and other agricultural measures, however important they are, cannot solve the food problem on their own. Only in the context of social and political development will a larger supply of fertilizers enable the poor nations to raise food output significantly.

The Present World Food Situation

The bleak outlook of 1973/74 seems to have brightened in 1975 because of favorable weather, particularly in India, and more food aid. The Food and Agricultural Organization of the U.N. estimated that world food production will grow by 5 percent this year. But long-term prospects are still precarious because food stocks are low and future supplies depend heavily on the weather. Unabated population growth continues to push demand further upwards, and creates the prospect of larger and more frequent food crises in the future.

The serious fertilizer shortage of the last years, and the vast increase in world fertilizer prices, have depressed demand for fertilizers, and kept food output below its potential all over the world. Especially in developing nations, farmers have reduced applications and concentrated available fertilizers on cash crops. In 1974/75, the fertilizer imports of the 42 poorest nations were 12 percent beloww the trend. If the poor nations had been able to get the fertilizer they needed, the food situation would be much better, and food stocks would have broadened the small margin which separates South Asia and Africa from famine today.

The Long-Term Outlook

The future food situation is dominated by the following: The earth is presently inhabited by 3.8 billion people. When we enter the next century, that number will probably have surpassed 6 billion, provided no major calamities occur. The explosive increase of the world's population was, until recently, accompanied by a similar increase in agricultural production. Particularly since 1972, we are doubtful, however, whether food production will keep pace with population growth. Many point to the poor agricultural record of some large developing nations in the past. They point to the increasing environmental problems; to what may be a worsening of the climate; to the near impossibility to stop population growth in the next decades; and to the exorbitent capital cost of bringing large uncultivated areas under the plough. These pessimists conclude that we are in for a disaster sooner or later.

Optimists, however, point to the enormous resources that have not yet been utilized, and to the possibilities of technological progress. If more financial resources are made available, and if large numbers of people are mobilized for the fight against poverty, the earth's arable land could more that double. Less than 4 percent of the world's riverwater is presently used for irrigation. Large new reserves of energy are being discovered due to the sixfold rise in oil prices since 1971. Enormous economic resources could be made available to agriculture by cutting down on wasteful pursuits and on activities which should be given a lower priority.

Indeed, there is no convincing set of reasons why the food-deficit nations of the world should not be able to solve their problems in the long run. But, in the short and medium run, factors like adverse weather, a lack of agricultural inputs, and the inability of social systems and their leadership to improve themselves overnight will make further food crises probably unavoidable.

Short-run food problems can be set to a great extent by outside help. The big surplus producer of the world — the U.S.A. — has shown repeatedly that it is ready to provide massive food aid and financial and technical assistance. But disaster relief does not solve the fundamental problem of raising food production in the deficit areas themselves. A long-term dependence of India, Bangladesh, and other nations on American grain would be politically unhealthy and economically infeasible. Increasing food imports would only aggravate rural unemployment and foreign exchange deficits.

What applies to the food problem also applies to the fertilizer problem. The tasks of vastly increasing the use of fertilizer in developing countries and raising the domestic production of fertilizers can easily be solved in theory because the technology is known, and enormous experience is available in the U.S., Japan, Western Europe, and elsewhere. The farmer in poor nations is often easily persuaded that fertilizer use should be increased. But the supply lines are poorly organized. The government often follows a strange set of price policies which keep the price of cereals artifically low and discourage the use of fertilizers even while their price is subsidized. Sometimes, fertilizers are simply not available in the right form, or at the right time. But even if fertilizers are plentiful and cheap, and the farmer is conviced they would boost his yield, it may not be attractive for him to apply fertilizers because his risks and costs could be too great. If most of the extra yield would go to the landowners, if the climate is too uncertain, if the irrigation water supply is inadequate or unreliable, if there are no credit facilities, if the farmer cannot get hold of crop varieties that respond well to fertilizers, or pesticides are not available, then he will calculate that he won't get his investment in fertilizers back. Removing all these constraints on fertilizer use is the very complex task of general agricultural development.

The Importance of Fertilizer

It is estimated that most of the growth of food production needed to keep pace with population has to be achieved through *higher* yields and *more yields per year* from the existing acreage. Possibilities for expansion of cropland in the deficit areas of Asia are limited and also very expensive. FAO has estimated that a growth of 1 percent in food production requires a 3-4 percent increase in fertilizer use. As population growth in food deficit areas is 2.7 percent per year, fertilizer use will have to expand by at least 10 percent per year to food the additional children — without improving the food availability per capita. Therefore, it is not an exaggeration to say that a fast rise in fertilizer application in developing countries is one of the major requirements of coping with the food problems of South Asia and Africa. As these regions are highly dependent on the world fertilizer market, we need something like a world fertilizer policy.

A world fertilizer policy would have three major tasks. First, it should promote the use of fertilizers, especially in the food deficit countires, and encourage the establishment of marketing structures needed to get fertilizers into the villages. This task is the hardest one because it requires improvement of policies and institutions and is dependent on domestic administrative reforms in developing countries.

Second, a world fertilizer policy should enable the poorest countries to become more self-reliant in fertilizers. In 1973/74, the developing countries imported almost 2/3 of their fertilizers. This dependence on the volatile world market makes them too vulnerable to fluctuations in prices and supplies. It costs them more foreign exchange than they can afford.

Third, a world fertilizer policy should bring stability to the world fertilizer market by planning, information exchange, long-tern contracts, and coordination among the largest investors. An harmonious development of supply and a steady expansion of demand would be in the interests of producers and consumers alike.

In recent years, various international agencies active in fertilizers have met regularly to exchange information and assess the short and long term fertilizer situation. This exchange has been intensified, and FAO has recently established a Fertilizer Data Centre to which all interested agencies have access.

To relieve short-term fertilizer problems of some individual developing countries, bilateral fertilizer aid has to be kept up. Multilateral assistance through the International Fertilizer Supply Scheme will also have to be strengthened. Other developing countries which were hard pressed last year have built up large fertilizer stocks and need no fertilizer aid in the immediate future. In the medium and longer term, developing countries have to rely increasingly not on aid, but on trade and their own production. Existing fertilizer plant capacity, which is, on average, under-utilized, needs to be put to complete use. International aid agencies and national donors have made technical and financial assistance available for this purpose.

In the past year or two, some developing countries have made much progress towards a larger fertilizer production capacity in the future. More new plants may come on stream in the coming 5 years in the poor countries than in the rich ones. Some of the large financial surpluses that OPEC nations enjoy and their natural gas can be put to use in fertilizer production.

On the basis of recent projections, a lack of fertilizer plant capacity will probably not be the most serious problem of the future. Increasingly, attention is shifting to the infrastructure of fertilizer use as the bottleneck. This comprises the institutions and capital goods needed to get the fertilizer from the factory to the farmer. It consists of transportation, storage, marketing, research and agricultural extension, and farm credit.

It seems to me that the best contribution which the world's fertilizer industry can make to solving the world food problem is in this area of fertilizer infrastructure. It means that fertilizer companies which operate in developing nations have to diversify vertically and move into active promotion of fertilizer research and use under tropical conditions, marketing, storage and transport. Joint ventures will be needed among foreign and domestic fertilizer companies and those domestic agricultural institutions, such as rural banks and marketing agencies, which have not generally been too active in the promotion of fertilizer use.

Fertilizer promotion in developing countries is a relatively new, very complex area for producers, But, it is also a very promising area, because vast markets can be opened up, while at the same time a crucial contribution can be made to solving the food problems of the Third World.

[1] Policy Planning and Program Review Department, World Bank. The views in this paper are the author's and may not be attributed to the World Bank.

[2] FAO, *Monthly Bulletin of Agricultural Economies and Statistics,* Vol. 23, No. 9, p. 2.

MODERATOR SHELDRICK: Thank you, Joris.

I very much recognize this problem that Dr. Voorhoeve has outlined, such as the need for education, for infrastructure, for credit.

I think we may well find that in many developing countries, fertilizer plant capacity will outstrip our ability to use fertilizer even though the needs are very great and perhaps the farmer would like to have the fertilizer. So I think that I might just say this is an area where the World Bank feels that it must place greater emphasis.

So I would very much like to endorse the things said by Dr. Voorhoeve because I've experienced them recently in developing countries and very much recognize the need that we do something about it. Are there any comments or suggestions at this point? Well, if not, I would like to thank Dr. Voorhoeve on behalf of all of you for a very clear exposition with much food for thought rater than food to eat. Thank you.

MODERATOR SHELDRICK: Gentlemen we have a change in the program at this stage. Dr. Donald L. McCune, Managing Director, International Fertilizer Development Center, was going to tell us about I.F.D.C., however, he could not make it. In his place Travis P. Hignett, Special Consultant to Dr. McCune, will tell us about I.F.D.C.

Now, there isn't any need for me to introduce Travis Hignett. I think that every platform in the world where they have fertilizer technical meetings have seen Travis Hignett. I would just like to say that from a personal point of view, having worked closely with Travis over many years, I have come to Washington to work for the World Bank and then find Travis has also come out of retirement to work for the International Fertilizer Development Center. It is a great pleasure for me to work with him again.

International Fertilizer Development Center's Activities

Donald L. McCune

[Presented by Travis P. Hignett]

IFDC is a very new organization, so my report will by necessity be focused on the type of organization, how it is funded, staffing plans, building plans and programs.

The International Fertilizer Development Center, which we hope will become known by the acronym, IFDC, is a private, nonprofit, nongovernment, educational corporation. It is incorporated in the state of Alabama in the United States of America. Although we will eventually build on TVA land and adjacent to TVA's National Fertilizer Development Center, we will be separate and apart, having our own budgets and staff and our own governing body, an international Board of Directors.

The IFDC was created to become the center of excellence in fertilizers and fertilizer know-how for the developing countries with special emphasis on tropical and subtropical agriculture.

The IFDC differs in two ways from other members of the International Centers network.

It is the first center that works on an input to agriculture. All other international centers work on outputs to agriculture, either on specific crops or on animal problems. IFDC works on an input-fertilizer. IFDC is also the first center *not* located in a developing country. The reasons for this will be explained later.

IFDC was set up in recognition that the temperate zone agriculture could no longer be counted upon to feed a world that continues to grow by 75-80 million people per year. It is now finally becoming recognized that if the world is to be fed most of the food must be produced in the countries where it is to be consumed. The tropics and subtropics are the areas where the greatest threats of famine are occurring and they are the principal targets of IFDC.

Fortunately, there is much potential for increasing food in the tropics. Over half of the potentially arable land and nearly half of the potentially grazable land is found in the tropics.

Also, the potential for long growing season or year-round agriculture wherever rainfall is adequate or irrigation potential exists greatly adds to the food production potential of the tropics. Theoretically, at least, the tropics can become even more productive than temperate zone agriculture.

Historically, the tropics have produced only a small fraction of the world's total food. This is due in large part to the fact that tropical soils are either natively quite infertile or once land is opened to agriculture soil fertility is such that crop yields are adequate for only a year or two. Attempts to cope with this have led to various systems of slash and burn and shifting agriculture.

Evidence is now accumulating that permanent agriculture can exist in the tropics if soil fertility is supplemented and replaced on a continuing basis.

Unfortunately, all present-day fertilizers and most of the research and development on new fertilizers have taken place in the temperate climates for the benefit of temperate zone soils and crops.

The same can be said of fertilizer marketing systems, transport, handling, etc. At best these systems are transplants or adaptations of those used in temperate agriculture.

There has naturally been some success in transplanting fertilizer know-how. There are also cases where it is obvious that fertilizer needs are quite different.

IFDC was created to attend to those needs and to delineate the difference and to mount programs to overcome these shortfalls.

IFDC has, by comparison with other international centers, become a reality very rapidly. Other centers needed three to four years from conception until they became operative.

Only a little over a year ago, at the response to fertilizer shortages and spiraling prices that hit hardest the developing countries, the idea of an international effort to improve fertilizer for tropical agriculture began to receive much attention.

The real push to get on with this idea came from a United nations General Assembly speech by Dr. Henry Kissinger in April 1974. Dr. Kissinger included some seven points in his speech that he felt were necessary to overcome threatening food shortages. One of these points was that the United States would back an international effort to improve fertilizers for the developing countries, especially for the tropics. he also mentioned that efforts should be made to find means of making fertilizers less dependent on natural gas or petroleum derivatives.

Immediately after Dr. Kissinger's speech, United States Agency for International Development (AID) was called upon to develop a proposal for a center to address this problem. AID proposed what was called an International Plant Nutrition Institute (IPNI). This proposal had three main points of emphasis — chemical fertilizers; biological fixation and solubilization of nutrients; and recycling of nutrients from plant, animal, and human wastes. To keep the effort in the international areana, AID presented this proposal to the Consultative Group for International Agricultural Research (CGIAR) and its Technical Advisory Committee (TAC).

For those of you who are not acquainted with this terminology, the Consultative Group (The CG) is made up of representatives of those organizations that fund the network of international centers; and TAC is a group of some 12-15 internationally known scientists (not donors) that advise the CG on priorities for research.

The CG numbers about 30 members — some 18-20 nations, the foundations Ford, Rockefeller, Kellogg, and the International Development Research Centre of Canada plus various International Banks.

The TAC and the CG studied AID's IPNI proposal in July 1974 and recommended that AID push ahead on the chemical fertilizer part but asked for more time to consider what should be done on biological fixation and recycling of nutrients.

AID in the meantime had been studying where this new center should be located. It was felt that the chemical center had to be basic in the so-called building blocks of fertilizers — ammonia, nitric acid, phosphoric acid, sulfuric acid, urea, etc. To build a center in the less developed countries (LDC) from scratch and to make it basic in these essential building blocks would cost an estimated $100-200 million and would require a staff of 100 or more just to operate and maintain these facilities.

Naturally, this was prohibitive. AID then talked with the Tennessee Valley Acuthority (TVA), who is basic in these materials. The TVA Board rejected the idea that the international effort could be part of TVA. They did, however, offer a site adjacent to TVA's national Fertilizer Development Center and offered to furnish the fertilizer intermediates to the international center at cost. They offered the possibility of tying into utilities — water, sewage and electricity, etc. - at the nearest point. Also, the Muscle Shoals location provided the possibility for sharing other facilities such as the library, computers, basic laboratories, basic equipment, pilot plants, etc. The interchange with TVA's large and experienced staff and the possibility of starting the program almost immediately were very attractive.

Thus, the decision was made to locate on TVA land but that the center had to be financed and managed separate and apart from TVA.

Immediately AID went to work on establishing a private, nonprofit educational corporation under Alabama law. By mid-October 1974 the corporation was established and a founding Board of Directors was named.

The founding Board consisted of:

1. Dr. John Hannah as Chairman. Dr. Hannah was formerly President of Michigan State University; formerly director of USAID; and was functioning as number two man in planning and conducting the World Food Conference.
2. Dr. Webster Pendergrass, Vice President for Agriculture at the university of Tennessee, was appointed Vice Chairman.
3. Mr. Lynn Seeber, General Manager of TVA, is Secretary-Treasurer of IFDC's Board.

This Board met in mid-October 1974 and formalized the corporation by drawing up the articles of incorporation and the bylaws. they also requested funds from USAID and the International Development Research Centre of Canada to organize and start the corporation, to develop the plan of work, and to begin staffing.

Money became available in late November and early December, and Dr. Donald McCune became the first employee in November of 1974. Between December 1974 and June 1975 the corporation was organized, plans of work were developed, and reviews were held by the donors, AID and IDRC, as well as the TAC committee. By late May an acceptable plan had become a reality.

The plan that was developed was for a three-year period in the context of a continuing program. It called for some 65-70 employees after three years of operation, of which 35-40 should be technical people. The three-year core budget was to be approximately $15 million, about half of which was to be for capital, buildings, major equipment, etc., and the other half to provide operating funds for the center.

In June 1975 the U.S. Government made the first operational grant of about $3.85 million form fiscal year 1975 budgets with the promise that they would provide up to $15 million over a three-year period to assure establishment of the center and operation at a minimum level.

Thus in June 1975 it was possible to begin staffing in earnest. Since IFDC was to take over most of the international work on fertilizer previously carried out by TVA, the International Staff of TVA was moved to IFDC. This provided eight well-qualified, experienced staff members. We now have about 30 employees, representing five countries: Chile, Denmark, Holland, Taiwan, and the united States.

IFDC next moved to expand the Board of Directors. Three new board members are: F. P. Cardoso of Brazil, Moise Mensah of Dahomey, and S. K. Mukherjee of India.

During the next two years additional staff will be added. Staff standards and qualifications are very high and include multinational and multilingual requirements.

Arrangements are formalized to continue to utilize a limited number of TVA staff. IFDC will use seven or eight man-years of help from TVA to supplement our own staff.

For key positions IFDC will use full-time dedicated individuals but will also consider shorter term assignments such as sabbaticals, post-doctorates, or training positions. Consultants will be used and already seven or eight have worked on short-term specialized work.

The administrative staff occupies temporary rented offices in Florence, Alabama. The old medical center at TVA has been renovated to house 14-16 staff members and furnish five or six laboratories for our technical staff.

A building program for the permanent center is getting under way. An office laboratory building of about 60,000 square feet with space for further expansion, a greenhouse/headhouse complex, and a new pilot plant are on the drawing boards; and contracts are to be let in March 1976.

The original project proposal outlined the work of the Center. Several programs are now in operation and other are in the planning and refining stages.

By taking over the work formerly conducted by TVA, IFDC was immediately involved with a sizable program of technical assistance and fertilizer testing. These programs will expand and the training efforts in both formal and on-the-job training will be strengthened. This work is in the Outreach Division, headed by Dr. Paul Stangel.

Work is in progress to set up a first-rate research program. At present the research effort is divided between a Technology Division and an Agro-Economic Division. Mr. Travis Hignett, retired from TVA, heads up the Technology Division on an acting basis. Dr. Per Pinstrup-Andersen from Denmark, formerly with CIAT, heads up the Agro-Economic Division.

Programs anticipated under the Technology Division include efforts to tailor fertilizers that are more efficient. One approach is development of controlled-release products starting with TVA's sulfurcoated urea. Plans are to make many variations of this approach and have as an objective "to tailor fertilizers with release patterns similar to fertilizer uptake patterns of crops." Phosphates are being researched in an attempt to tailor fertilizers that resist fixation in tropical soils too give the plant a better opportunity to grab onto the applied nutrient.

Another objective is to start programs that will make better use of indigenous raw materials — phosphates, sulfur minerals, potash, etc. Efforts are directed to develop new technology in beneficiation and processing that can handle both problem ores and lower grade ores.

Another objective is to develop better means of making complete fertilizers for the tropics. such fertilizers may have to include S. Mg, or Ca even before one or more of the presently recognized major nutrients. And the whole field of alternate and cheaper sources of micronutrients will have to be explored.

Marketing research will be an important part of IFDC's total program. Searches are on for improved methods of marketing that better serve the consumers, especially the small farmers.

Efforts are in progress to find means to improve the infrastructure, handling, storage, packaging, etc., for the farmer in the developing country.

A major effort will be made to improve market intelligence in an attempt to dampen the large swings in supply and demand.

IFDC's data system will eventually include information not only on production capacity and supply and demand, but also on such things as inventories, production rates, prices, shipping, raw material availability, etc.

In agronomy — being located in the U.S.A., IFDC will be limited on what can be done at headquarters. Facilities for laboratory, greenhouse, and probably growth chamber work will be built; but the bulk of agronomic testing and demonstration will have to be done in the developing countries, with tropical soils and environment.

Thus, agronomic work will be done wherever possible through other organizations. IFDC will work with the other international centers, government organizations, fertilizer associations and through industry itself.

Agronomists at IFDC headquarters will be few in number. However, a few highly trained bilingual individuals are needed to work with other organizations. Already work is under way in some 15 or 16 countries.

Later various staff members may be stationed overseas with other organizations, but for the present work is being done through exising organizations.

IFDC is already working out relationships with centers wanting to get into technology research and development. Informal agreements extend with a group at a university in Sao Paulo, Brazil, and one in Korea — KIST; discussions are going on with Iran, Indonesia, Pakistan, and Venezuela for possible similar cooperation.

Now a word on the long-range outlook — it is good — the biggest problem will be to get the right people in the right positions. If this is done IFDC will gain the respect and credibility that will assure good financing.

IFDC people are very optimistic. All feel that we will become an integral and important part of the network of international centers.

Over the years IFDC will be one of the most productive and effective international centers that contributes to feeding a hungry world.

MODERATOR SHELDRICK: Any questions, Gentlemen? I think Travis has covered this extremely well, particularly as he had to step in an the last moment. Would anyone like to know any more about IFDC?

I personally think this is a tremendous institution and one that's long overdue. I believe that the TVA background and facilities is an excellent basis for IFDC.

Travis — we all are very glad that you have taken up this new career. Your experience is very much needed and we wish you all the best of luck.

MODERATOR SHELDRICK: Our last speaker is Ed Harre from TVA.

Before I introduce Ed and his subject I would just like to tell you a little bit about the working party that represents the international agencies, that is, UNIDO, The World Bank, FAO and also other industrial associations such as The Fertilizer Institute, ISMA, NITREX and many others. This meets twice a year to discuss fertilizer statistics and to try to harmonize these statistics. We believe that one of the problems of cyclical imbalances is caused by the fact that there are so many differing figures on capacities and needs, and it is very essential that the people in this business get together and try to get some harmonized figures and put some judgement on situations where there are differences.

Now, the basis for starting this harmonization is the TVA data bank which is among other things run by Ed Harre, our next speaker. So we rely very much on Ed's work in the international agencies, and I think he is making a splendid contribution to the world fertilizer industry.

Now, Ed himself has had a lot of experience in this business. I think he worked for USDA for four or five years, and he has been with TVA for about 12 years where he has been looking after their marketing research both nationally and internationally. Ed has a degree in agricultural engineering and a master's degree in agricultural economics. Ed, could you please come and tell us about the next five years.

Worldwide Fertilizer Production Facilities As Related to Supply and Demand For The Next Five Years

E. A. Harre, J. D. Bridges, and J. T. Shields[1]

Presented by E. A. Harre

Introduction

The world fertilizer industry is emerging from a two-year period of tight supply and high prices. These high price levels have contributed to a slowdown in demand growth and precipitated a large-scale increase in fertilizer production along with an extensive nitrogen and phosphate plant construction program in almost every region. This paper reviews current capacity additions and the anticipated change in supply levels. It is also a progress report on the expected future market based on capacity estimates as of September 1975. Demand estimates and the method of analysis are unchanged from previous reports. Actual production and use data are available through 1974.[2] Estimates of 1975 actual production, use, and the overall extent of the current oversupply situation are nor available at this time.

Nitrogen supply estimates have been made from nameplate capacities for ammonia plants, adjusted for production and distribution losses, and allocating a portion of the supply for nonfertilizer markets. Operating rates are varied in order to determine the effect of both good and poor plant performance in supply.

Phosphates supply levels have been estimated from phosphoric acid capacity which has been adjusted for losses and use in nonfertilizer markets and variable operating rates. Estimates of normal superphosphate and basic slag production were included with the phosphate rock contribution to supply from concentrated superphosphate and nitricphosphates. Production of these materials plus phosphoric acid supply for fertilizer adds up to the total potential supply of phosphatic fertilizer.

Potash supply estimates are based on potassium chloride capacity data adjusted in a manner similar to nitrogen and phosphoric acid.

The supply surplus or deficit is based on projected supply adjusted for a five percent distribution loss measured against estimated demand. A midpoint in the demand forcast was used; however, the range of future demand estimates was included in the tables in an attempt to show the 1975 supply-demand imbalance of the recently concluded 1975 fertilizer season.

Nitrogen

In 1974 world plant nutrient consumption was almost 84 million tons. Nitrogen represented almost 39 million tons, while phosphate and potash accounted for 24 and 21 million tons, respectively. Relative to phosphate and potash, nitrogen holds a prominent position in the world fertilizer market and future expansion plans indicate that this will continue. Based on current announced expansion plans, world nitrogen capacity will increase from a current level of over 65 million tons N to more than 106 million tons by 1980 — a 60 percent gain in capacity. While fertilizer nitrogen has been in short supply and there has been a general decline in inventory levels, it is, apparent that future supply levels are now increasing faster than expected use levels. Total fertilizer nitrogen demand during the same period should increase by about 45-50 percent.

Expected growth in nitrogen capacity with projections to 1980 is shown in figure 1. Capacity levels in the developed, developing, and nations with centrally planned economies have also been included. Further regional detail of current and future capacity is found in table 1.

The future supply pattern for the nitrogen industry will change in the next five years as the traditional producers — North America, West Europe, and Japan - which had over 50 percent of the capacity in 1974 will only account for 45 percent of the total by 1980. The total increase in capacity from over 34 million tons N to 47 million tons represents a 37 percent increase for the traditional producers while the world total shows a 62 percent gain. North America will move from 28 percent of the total in 1967 to 20.4 percent in 1980 while East Europe and USSR will increase marketshare from 21.5 percent in 1967 to more than 25 percent of the total by 1980.

The developing nations of Africa, Asia, and Latin America will shift, however, from a present level of 15 percent of the total capacity to 23 percent by 1980. If all units presently scheduled come into operation by 1980, capacity will increase from 9.5 million tons N to 24.5 million tons — a 158 percent increase. Clearly, the developing regions are moving closer to supplying domestic nitrogen markets and attempting too decrease their reliance on imported materials.

The overall effect on the world nitrogen supply-demand situation for the remainder of the decade is shown in figure 2. While 1975 supply levels exceeded total use, the cause appeared to be slack demand growth rather than a significant increase in capacity levels. Should demand move back to its normal rate of growth in 1976 or 1977, nitrogen capacity may be inadequate to meet the demand. Based on the midpoint of the longterm demand estimate, potential world nitrogen supplies should exceed expected demand by 1978, and for the remainder of the decade continue to increase at a rate faster than demand. It should be emphasized, however, that the current depressed fertilizer and industrial demand levels prevailing today make any short-term forecasting from long-term trend analysis hazardous.

Table 2 indicates the net nitrogen surplus or deficit that is expected based on supply availability under various combinations of operating rates in developed and developing regions. Calculations are related only to the midpoint value of the demand forecast, thus, may not reflect the short-term supply/demand situation of 1975 and 1976. By 1980 if plants were assumed to be running at 85 percent of capacity in the developed regions and 70 percent in the developing regions, a net surplus of 2.4 million tons of N would exist. This would represent more than a four percent excess in supply over demand. An eight percent excess is indicated if the developing region were to attain an 80 percent operating level in 1980.

Phosphate

The phosphate market is in the midst of an expansion which is the result of construction projects started in 1973 and 1974. The short-term supply outlook is, therefore, markedly different from nitrogen. During 1975 the developed regions, primarily North America, brought into production 3.5 million tons of additional phosphoric acid capacity. Five million tons of new global capacity was added within the last year. The growth in the world's phosphoric acid capacity from 1967 to 1974 with announced plants through 1980 is shown in figure 3.

A detailed regional description of phosphoric acid capacity is shown in table 3. From 1974 to 1980 it is expected that total world phosphoric acid capacity will increase by more than 60 percent. The developed regions will show a gain of 47 percent moving from 12.9 to 19.0 million tons in 1980. Most expansion is in North America, and about half of the total increase is already to operation.

The developing regions will register a gain of almost 200 percent during the same period. Capacity will go from the current 2.6 million to 7.6 million tons of P_2O_5. This will raise their share of the total capacity from 13 to 23 percent of the world total. The developed regions and the centrally planned aconomies will decline in their relative market position.

The expected overcapacity in the phosphate industry for the remainder of the decade is apparent as the demand increase from 1974 to 1980 is just under 30 percent. The overall supply/demand relationship is shown in figure 4. Potential supply is the sum of the expected production of phosphoric acid for fertilizer and the contribution of normal superphosphate, basic slag and the phosphate rock content of concentrated superphosphate and nitricphosphates. As indicated, supply should exceed demand through the remainder of the decade, unless some current announced projects are delayed or abandoned. If all proposed plants are built, it will require a demand increase of 40 percent above current levels to bring supply and demand back into balance by 1980.

The net supply surplus in both the developed and developing regions is shown in table 4. The year in which a maximum surplus level is indicated is 1978, when a potential supply of three to four million tons of P_2O_5 would be available if all plants were running at the maximum operating rates assumed. Deficits only appear in 1980 when the low range of operating rates has been used.

There should be ample supplies of phosphate fertilizers available for the remainder of the decade. The rapid price rise of the last few years has contributed to large-scale investment in the industry and once again the saw-toothed supply cycle is leading to declining prices, profits, and the eventual closing of some plants.

It is expected that the projected imbalance in the phosphate market will be somewhat less than presently indicated. First of all, the latest projections of returns on investment should lead to the reevaluation of some announced projects; secondly, nonfertilizer markets could take a greater portion of the phosphoric acid production than the 10 percent allowed for in the developed regions; and thirdly, as fertilizer/crop price ratios become more favorable for the farmer, demand growth should begin to recover.

Potash

World potash capacity will remain centered in the developed regions and the centrally planned economies. Only one country in the developing area is currently producing potash and no new mines are scheduled in this region. Little new potash capacity is currently scheduled in the developed regions as this area has ample supply capability to meet its domestic markets and provide for a high level of export for the remainder of the decade.

The pattern of growth in the world potash capacity is shown in figure 5. The chart clearly shows that future expansion in potash capacity levels will take place in countries with centrally planned economies. East Europe and Russia have plans for additional capacity that will increase the current level of slightly under 10 million tons K_2O to 17.7 million tons by 1980. This will raise their market share from 36 percent of the total to just under 50 percent — the same level as that projected for the developed nations. The remaining two percent of capacity will be in Africa.

During the rest of this decade, potash use throughout the world is projected to increase by 25 percent. Total world capacity additions amount to a 29 percent increase between 1974 and 1980, thus the world potash market should retain its current supply-demand relationship. The large-scale shift in the major areas of supply, however, could cause imbalances within regions as new trade patterns emerge. Capacity additions may be forthcoming based on regional demand analysis and market prospects. The world potash capacity, potential supply, and future demand estimates are presented in table 5.

The future relationship between supply and demand has been shown in figure 6. High levels of demand could bring the potash market into balance, however, should demand continue to follow the midpoint estimates, no supply problems are indicated. Much depends on future developments in the Canadian potash industry. Producers operated under quota systems from 1970 to 1974 and when allowed to produce at full production found that idleness had lowered the effective capacity of the mines. This, coupled with what is considered unattractive investment opportunities, have contributed to the lack of planned new facilities in the developed regions. Recently, several companies announced that expansion plans for the Canadian industry had been shelved indefinitely, and a search began for new potash reserves.

Since almost all potash mining is located in the developed regions, the expected net surplus or deficit becomes a function of the operating rate attained by the region. From table 6 it is apparent that operating rates must be maintained at the 85 to 90 percent level. A decline to a regional average of 80 percent or below would result in shortages of up to 2.3 million tons K_2O between now and the end of the decade.

The Redistribution of Capacity

With additions of more than 60 percent to current capacity for both ammonia and phosphoric acid scheduled by 1980 it is useful to look at possible changing patterns in the concentration of production within the industry. In the nitrogen portion of the industry the number of countries with ammonia plants has grown from 56 in 1967 to 62 in 1973 and under present building programs will increase to 71 by 1980. A ranking of these countries in descending order of capacity shows that in 1967 the top ten producing countries had 73 percent of the total world capacity. In 1973 the level was still over 70 percent of the total. By 1980, with the addition of nine new countries to the ranks of ammonia production, the pattern in the nitrogen industry will change very little. The 10 leaders will still represent two-thirds of the total capacity.

The cumulative distribution of the world nitrogen industry is shown in figure 7. A line depicting a third of the countries indicates the shift in the pattern between 1973 and 1980. While more countries are scheduled to become nitrogen fertilizer producers, thos countries that have been dominant in the past are also expanding their nitrogen industries.

Phosphoric acid capacity changes show a more pronounced shift than the nitrogen industry. In 1967 there were 38 countries with phosphoric acid plants and 25 percent of the countries represented 84 percent of the total capacity. By 1973 there were 49 producing countries with the top 25 percent having 79 percent of the total capacity. By 1980 a further shift will occur as four additional countries enter the ranks of phosphoric acid producers. At this time the top 25 percent of the industry will represent about 75 percent of the total capacity. The pattern of phosphoric acid capacity has been shown in figure 8. The phosphate fertilizer industry is becoming more decentralized as plants are being built at phosphate rock mine sites rather than relying primarily on the export of rock to a relatively few producing areas.

Pricing and the Market Cycle

This brief review of world fertilizer production capacity and the changes that are taking place would be incomplete without some mention of fertilizer prices and their effect on the supply-demand situation. Economic theory tells us that, in a free market, price is the mechanism that regulates supply and demand. A quick look at the world fertilizer market in the last few years bears this out. Prior to 1973 fertilizers were in ample supply and, in most cases, price levels were not high enough to cover costs of production and distribution. Plants were forced to close and investment in the industry was almost nonexistent. Demand had continued to increase, however, as the farmer, realizing fertilizer's favorable benefit-cost ratio, moved steadily toward higher rates of application. With the release of additional acreage to agriculture in the quest to produce more food, demand for fertilizer increased sharply, with no capacity coming into production or even on the drawing boards. Prices went up two- or three-fold as the fear of shortage in some countries resulted in panic buying and stockpiling. Allocations were made, sometimes to different retailers serving the same market, while producers' inventory levels went down. The high prices and attractive investment return prospects lead to a massive industry building program and even brought new entrants into the industry. But, prices went too high in relation to the prices the farmer received for his production. The farmer could not or would not continue to increase fertilizer use. Price was playing its role in the supply-demand picture. With slackening demand, producers found themselves with excessive inventories and no place to put the new production coming onstream. Prices began to fall in an effort to entice the farmer back into the market, and as they reach a point where the farmer can once again see a favorable benefit-cost relationship, fertilizer demand should again increase.

For the remainder of this decade the world fertilizer market should be a buyer's rather than a seller's market. New investment in the industry has been extensive and has resulted in the scheduling of new capacity at a rate faster than the projected growth in demand. The tight supply seasons of 1973 and 1974 have shifted to one of ample supply availability and the emerging of more than enough capacity to meet future demands.

Extreme in price levels have not been beneficial to supplier or consumer. Oversupply and low prices lead to shortages and high prices for the farmer, while short supply and high price levels lead to overinvestment and eventually to low profits. Part of the problem lies in obtaining pertinent market information on a regular and timely basis so that reactions to market conditions do not take place long after the market trend has already settled on a new course. Greater knowledge of market conditions by both industry and government planners could eliminate the panic of buying or selling, as the case may be, and thereby perhaps smooth the fertilizer supply cycle to a point that is mutually beneficial to the producer, the farmer, and the consumer.

[1] Fertilizer Distribution Analysts, Division of Agricultural Development; and Administrator, International Fertilizer Programs, Office of Agricultural and Chemical Development, Tennessee Valley Authority, Muscle Shoals, Alabama, respectively.

[2] Harre, E. A., O. W. Livingston, and J. T. Shields, *World Fertilizer Market Review and Outlook,* National Fertilizer Development Center, Muscle Shoals, Alabama, Bulletin Y-70, March 1974.

Table 1

WORLD NITROGEN PRODUCTION CAPACITY FORECAST-SEPTEMBER 1975

(Million metric tons of nitrogen)

Region	1967	1970	1973	1974	1975	1976	1977	1978	1979	1980
Developed										
North America	11.1	13.7	14.1	14.2	15.0	16.0	18.9	21.7	21.7	21.7
Western Europe	11.4	13.6	14.7	14.4	13.7	14.5	15.4	16.6	17.3	19.1
Other[a]	2.8	4.3	5.5	5.9	6.0	6.2	6.3	6.3	6.3	6.5
Total	(25.3)	(31.6)	(34.3)	(34.5)	(34.7)	(36.7)	(40.6)	(44.6)	(45.3)	(47.3)
Developing										
Latin America	0.9	1.5	2.0	2.5	2.8	4.1	4.7	5.8	5.8	6.3
Africa	0.2	0.3	0.4	0.5	0.7	0.7	0.9	2.1	2.4	2.6
Asia	2.5	3.9	6.2	6.5	8.2	8.7	10.3	12.2	15.3	15.6
Total	(3.6)	(5.7)	(8.6)	(9.5)	(11.7)	(13.5)	(15.9)	(20.1)	(23.5)	(24.5)
Central Planned Economies										
East Europe-USSR	8.6	12.0	15.1	17.7	19.1	20.0	21.8	22.5	24.8	27.0
Other Asia	2.5	2.8	3.7	3.7	3.8	4.2	6.8	7.4	7.4	7.4
Total	(11.1)	(14.8)	(18.8)	(21.4)	(22.9)	(24.2)	(28.6)	(29.9)	(32.2)	(34.4)
World Total	40.0	52.1	61.7	65.4	69.3	74.4	85.1	94.6	101.0	106.2
Potential Fertilizer Supply[b]	21.3[c]	28.6[c]	35.9[c]	38.6[c]	40.4	42.9	47.6	52.8	57.5	61.7
World Demand										
Low	-	-	-	-	39.6	42.2	44.9	47.6	50.3	53.1
Midpoint	21.8[d]	28.7[d]	35.8[d]	38.7[d]	42.0	44.8	47.8	50.7	53.8	56.9
High	-	-	-	-	44.3	47.4	50.6	53.9	57.3	60.8

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a. Includes Japan, Israel, Republic of South Africa, and Oceania.

b. Potential supply less distribution losses, 1975-80. Based on 90% operating level in developed regions and 70% in developing regions after 3rd year of operation.

c. Actual production.

d. Actual consumption.

Table 2

POTENTIAL WORLD NITROGEN SUPPLY SURPLUS OR DEFICIT UNDER VARIABLE OPERATING RATES IN DEVELOPED AND DEVELOPING REGIONS 1975-1980

	Operating Rate	Year	Developed Regions - Operating Rate		
			80	85	90
			(thousand metric tons of nitrogen)		
Developing Regions	60	1975	(-6,153)	(-4,030)	(-2,592)
		1976	(-6,683)	(-4,844)	(-2,906)
		1977	(-5,327)	(-3,386)	(-1,444)
		1978	(-3,613)	(-1,480)	653
		1979	(-2,703)	(- 405)	1,894
		1980	(-2,222)	(- 174)	2,569
	70	1975	(-5,150)	(-3,027)	(-1,589)
		1976	(-5,622)	(-3,783)	(-1,845)
		1977	(-4,073)	(-2,132)	(- 190)
		1978	(-2,181)	(- 48)	2,085
		1979	(- 859)	1,439	3,738
		1980	11	2,407	4,802
	80	1975	(-4,148)	(-2,025)	(- 587)
		1976	(-4,561)	(-2,722)	(- 784)
		1977	(-2,818)	(- 877)	1,065
		1978	(-1,749)	384	2,517
		1979	986	3,284	5,583
		1980	2,243	4,639	7,034

Table 3

WORLD PHOSPHORIC ACID PRODUCTION CAPACITY FORECAST AND PHOSPHATE FERTILIZER SUPPLY ESTIMATE-SEPTEMBER 1975

Region	1967	1970	1973	1974	1975	1976	1977	1978	1979	1980
	MILLION METRIC TONS									
Developed										
North America	5.6	6.3	6.7	6.9	8.7	9.0	9.1	9.6	10.1	10.3
Western Europe	3.0	3.9	4.4	4.5	6.1	6.2	6.2	6.2	6.2	6.2
Other[a]	.7	1.3	1.6	1.5	1.6	1.6	2.3	2.3	2.3	2.5
Total	(9.3)	(11.5)	(12.7)	(12.9)	(16.4)	(16.8)	(17.6)	(18.1)	(18.6)	(19.0)
Developing										
Latin America	0.2	0.7	0.7	0.8	0.9	1.3	1.7	1.9	1.9	2.7
Africa	0.3	0.3	0.6	0.7	0.8	1.6	2.0	2.4	2.4	2.4
Asia	0.2	0.7	0.8	1.1	1.5	1.9	2.2	2.3	2.5	2.5
Total	(0.7)	(1.7)	(2.1)	(2.6)	(3.2)	(4.8)	(5.9)	(6.6)	(6.8)	(7.6)
Central Planned Economies										
East Europe-USSR	1.5	2.6	4.1	4.9	5.8	5.9	6.2	6.2	6.2	6.2
Other Asia	...	...	...	...	...	...	...	...	...	...
Total	(1.5)	(2.6)	(4.1)	(4.9)	(5.8)	(5.9)	(6.2)	(6.2)	(6.2)	(6.2)
World Total	11.5	15.8	18.9	20.4	25.4	27.5	29.7	30.9	31.6	32.8
Potential Fertilizer Supply[b]	16.2[c]	18.2[c]	22.5[c]	23.9[c]	28.0	29.8	31.0	32.1	32.7	33.2
World Demand										
Low	-	-	-	-	22.8	24.0	25.0	26.1	27.2	28.3
Midpoint	16.1[d]	18.8[d]	22.6[d]	24.3[d]	24.8	26.1	27.3	28.6	29.9	31.2
High	-	-	-	-	26.8	28.2	29.6	31.0	32.6	34.0

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a. Includes Japan, Israel, Republic of South Africa, and Oceania.

b. Includes normal superphosphate, basic slag, and the phosphate rock contribution to supply from concentrated superphosphate and nitric phosphates, plus estimated potential supply for fertilizer from phosphoric acid. Potential supply, less distribution losses, is based on a 90% operating level in developed regions and 70% in developing regions after 3rd year of operation.

c. Actual production.

d. Actual consumption.

Table 4

POTENTIAL WORLD PHOSPHATE SUPPLY SURPLUS OR DEFICIT UNDER VARIABLE OPERATING RATES IN DEVELOPED AND DEVELOPING REGIONS

1975-1980

	Operating Rate	Year	Developed Regions Operating Rate 80	85	90
			(Thousand Metric Tons of P_2O_5)		
Developing Regions	60	1975	1,339	2,155	2,971
		1976	1,517	2,515	3,514
		1977	1,375	2,407	3,439
		1978	893	1,968	3,044
		1979	136	1,230	2,323
		1980	(-808)	309	1,426
	70	1975	1,538	2,354	3,170
		1976	1,761	2,759	3,758
		1977	1,673	2,705	3,737
		1978	1,345	2,420	3,496
		1979	677	1,771	2,864
		1980	(-192)	925	2,042
	80	1975	1,736	2,552	3,368
		1976	2,006	3,004	4,003
		1977	1,972	3,004	4,036
		1978	1,795	2,870	3,946
		1979	1,217	2,311	3,404
		1980	423	1,540	2,657

Table 5

WORLD POTASH PRODUCTION CAPACITY FORECAST--SEPTEMBER 1975

Region	1967	1970	1973	1974	1975	1976	1977	1978	1979	1980
			MILLION METRIC TONS							
Developed										
North America	6.0	9.5	10.2	10.2	10.1	9.5	9.6	9.8	9.9	9.9
Western Europe	5.4	5.8	6.1	6.4	6.8	6.8	6.8	6.8	6.8	6.8
Other[a]	0.6	0.6	0.6	0.6	0.8	0.8	0.8	0.9	0.9	0.9
Total	(12.0)	(15.9)	(16.9)	(17.2)	(17.7)	(17.1)	(17.2)	(17.5)	(17.6)	(17.6)
Developing										
Latin America	--	--	--	--	--	--	--	--	--	--
Africa	--	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Asia	--	--	--	--	--	--	--	--	--	--
Total	(--)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)	(0.5)
Central Planned Economies										
East Europe-USSR	5.8	6.6	8.2	9.8	9.8	12.4	12.4	13.8	13.8	17.5
Other Asia	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	(5.9)	(6.8)	(8.4)	(10.0)	(10.0)	(12.6)	(12.6)	(14.0)	(14.0)	(17.7)
World Total	17.9	23.2	25.8	27.7	28.2	30.2	30.3	32.0	32.1	35.8
Potential Fertilizer Supply[b]	13.9[c]	16.1[c]	19.2[c]	21.1[c]	21.7	22.9	23.4	24.4	24.9	26.9
World Demand										
Low	--	--	--	--	19.0	19.9	20.8	21.7	22.6	23.5
Midpoint	13.1[d]	15.6[d]	18.8[d]	20.7[d]	20.4	21.4	22.4	23.5	24.5	25.6
High	--	--	--	--	21.8	22.9	24.1	25.3	26.5	27.8

---

a. Includes Japan, Israel, Republic of South Africa, and Oceania.

b. Potential supply less distribution losses, 1975-1980. Based on 90% operating level in developed regions and 70% in developing regions after third year of operation.

c. Actual production.

d. Actual consumption.

Table 6

POTENTIAL WORLD POTASH SUPPLY SURPLUS OR DEFICIT UNDER VARIABLE OPERATING RATES IN DEVELOPED AND DEVELOPING REGIONS

1975-1980

			Developed Regions		
			Operating Rate		
	Operating Rate	Year	80	85	90
			(Thousand Metric Tons of K_2O)		
Developing Regions	60	1975	(-1,071)	102	1,275
		1976	(- 978)	212	1,404
		1977	(-1,612)	(- 335)	942
		1978	(-1,701)	(- 420)	860
		1979	(-2,388)	(-1,029)	330
		1980	(-1,519)	(- 155)	1,209
	70	1975	(-1,011)	162	1,335
		1976	(- 918)	272	1,464
		1977	(-1,552)	(- 275)	1,002
		1978	(-1,641)	(- 360)	920
		1979	(-2,328)	(- 969)	390
		1980	(-1,459)	(- 95)	1,269
	80	1975	(- 952)	221	1,394
		1976	(- 859)	331	1,523
		1977	(-1,493)	(- 216)	1,061
		1978	(-1,582)	(- 301)	979
		1979	(-2,269)	(- 910)	449
		1980	(-1,400)	(- 36)	1,328

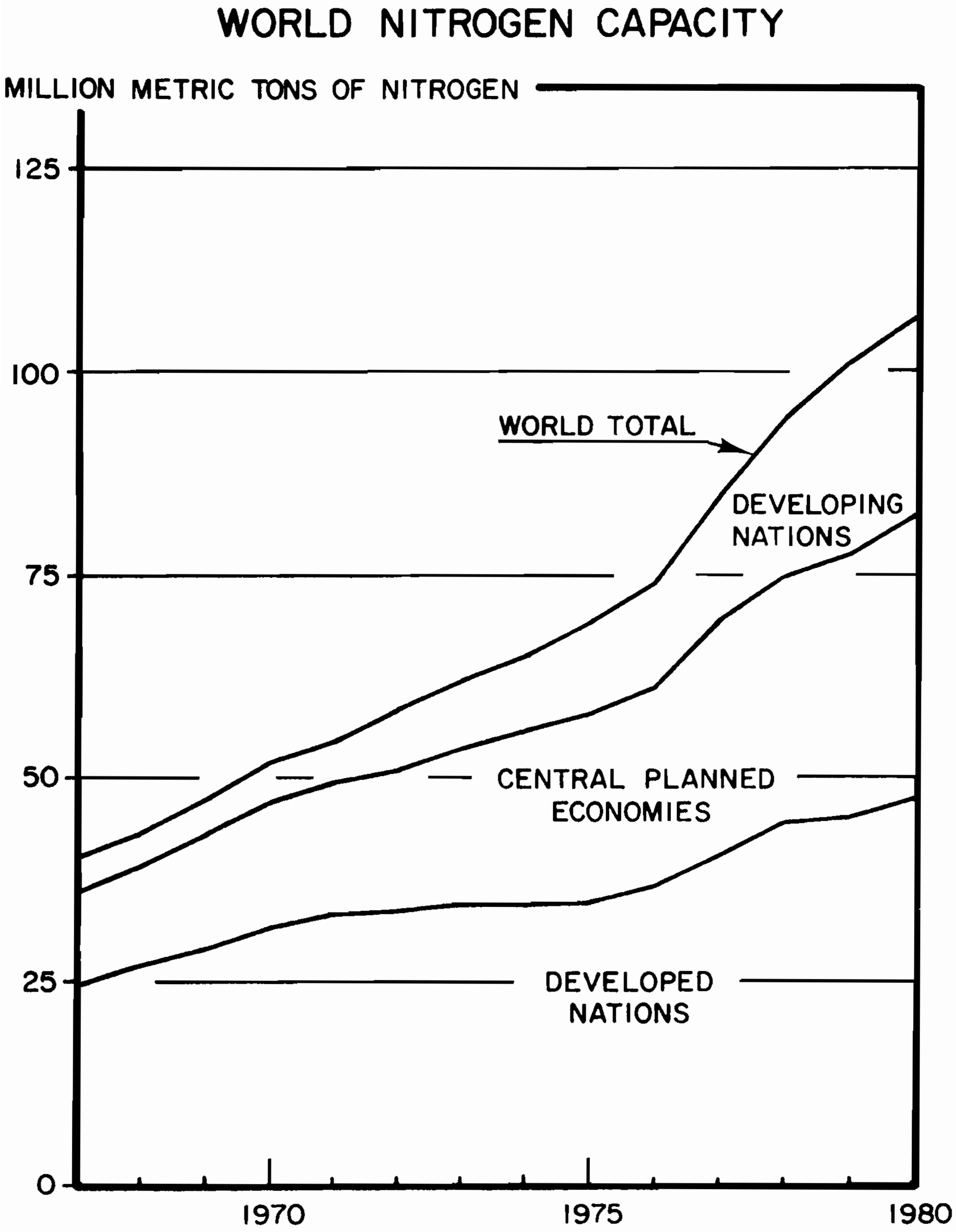

WORLD NITROGEN CAPACITY
MILLION METRIC TONS OF NITROGEN
125
100
75
50
25
0
1970
1975
1980
WORLD TOTAL
DEVELOPING NATIONS
CENTRAL PLANNED ECONOMIES
DEVELOPED NATIONS

FIGURE 1

WORLD NITROGEN FERTILIZER SUPPLY-DEMAND OUTLOOK

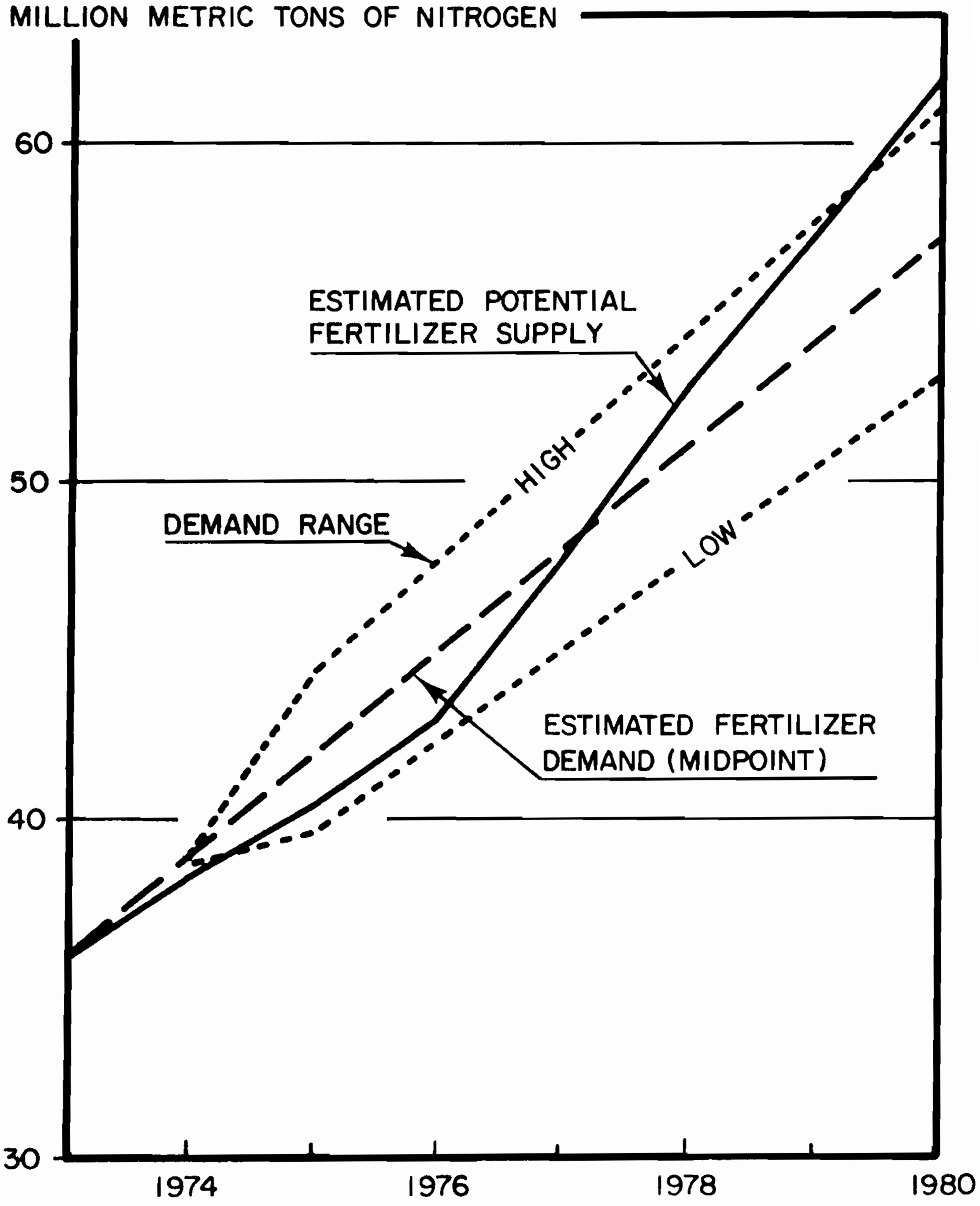


FIGURE 2

WORLD PHOSPHORIC ACID CAPACITY

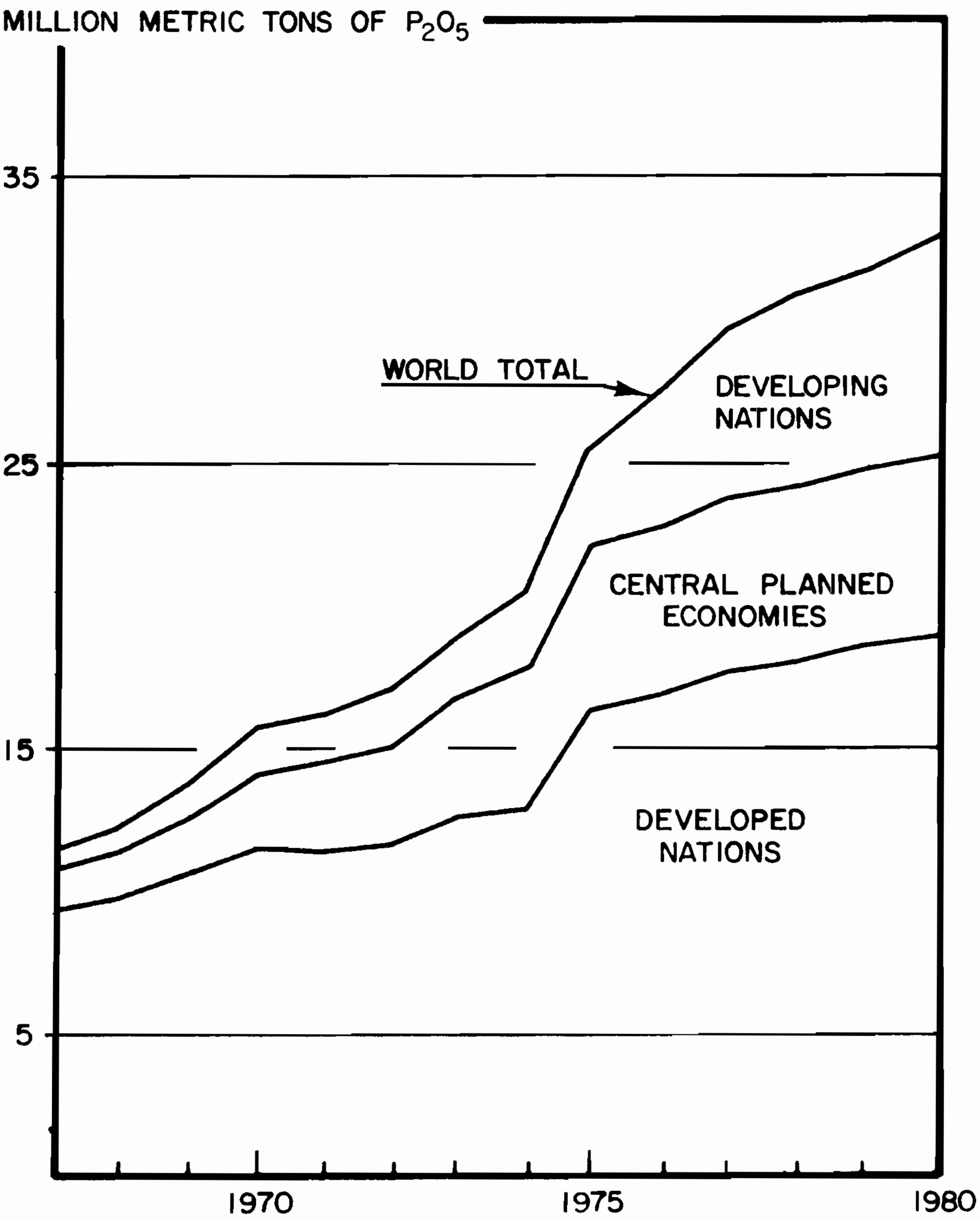


FIGURE 3

WORLD PHOSPHATE FERTILIZER SUPPLY-DEMAND OUTLOOK

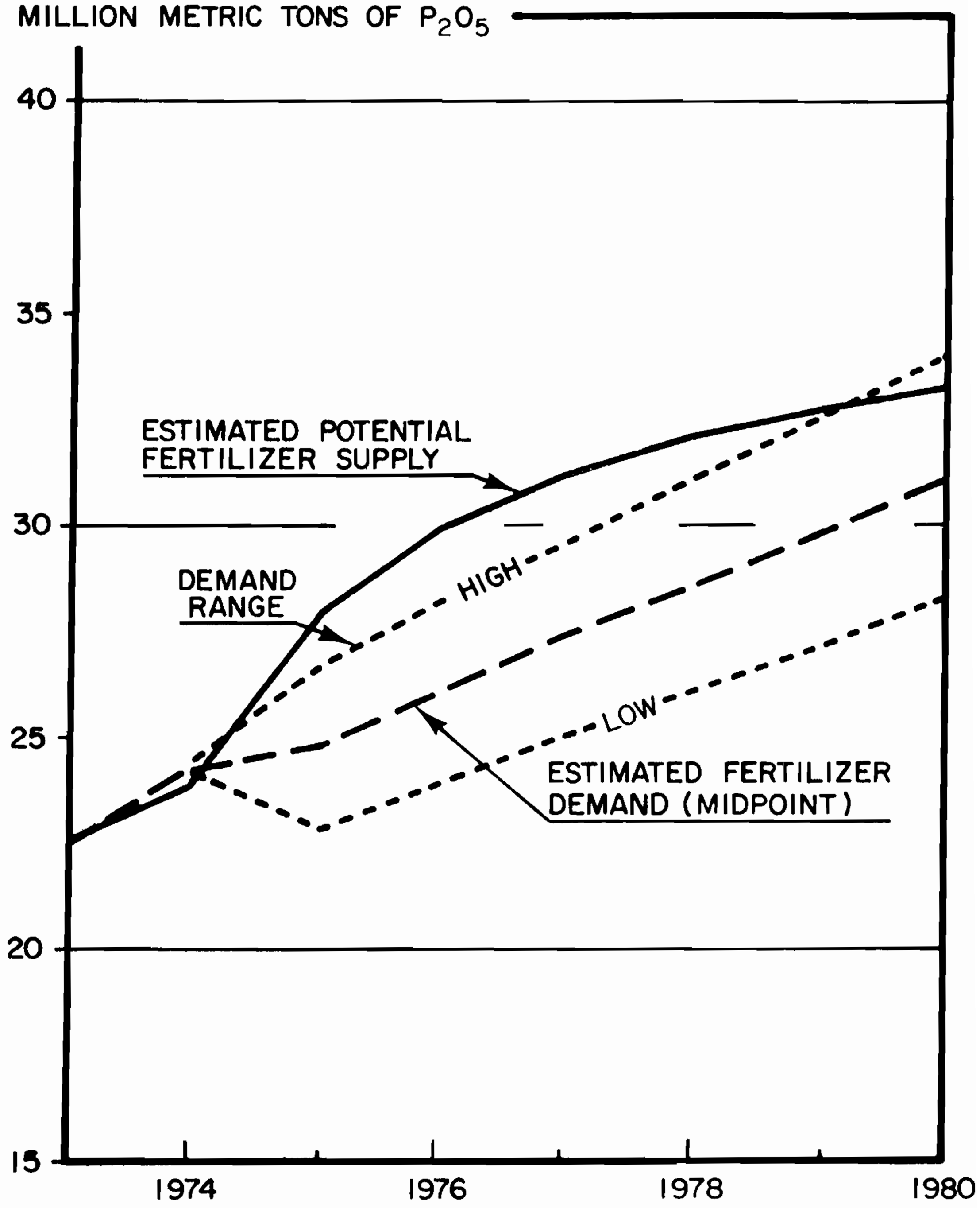


FIGURE 4

WORLD POTASH CAPACITY

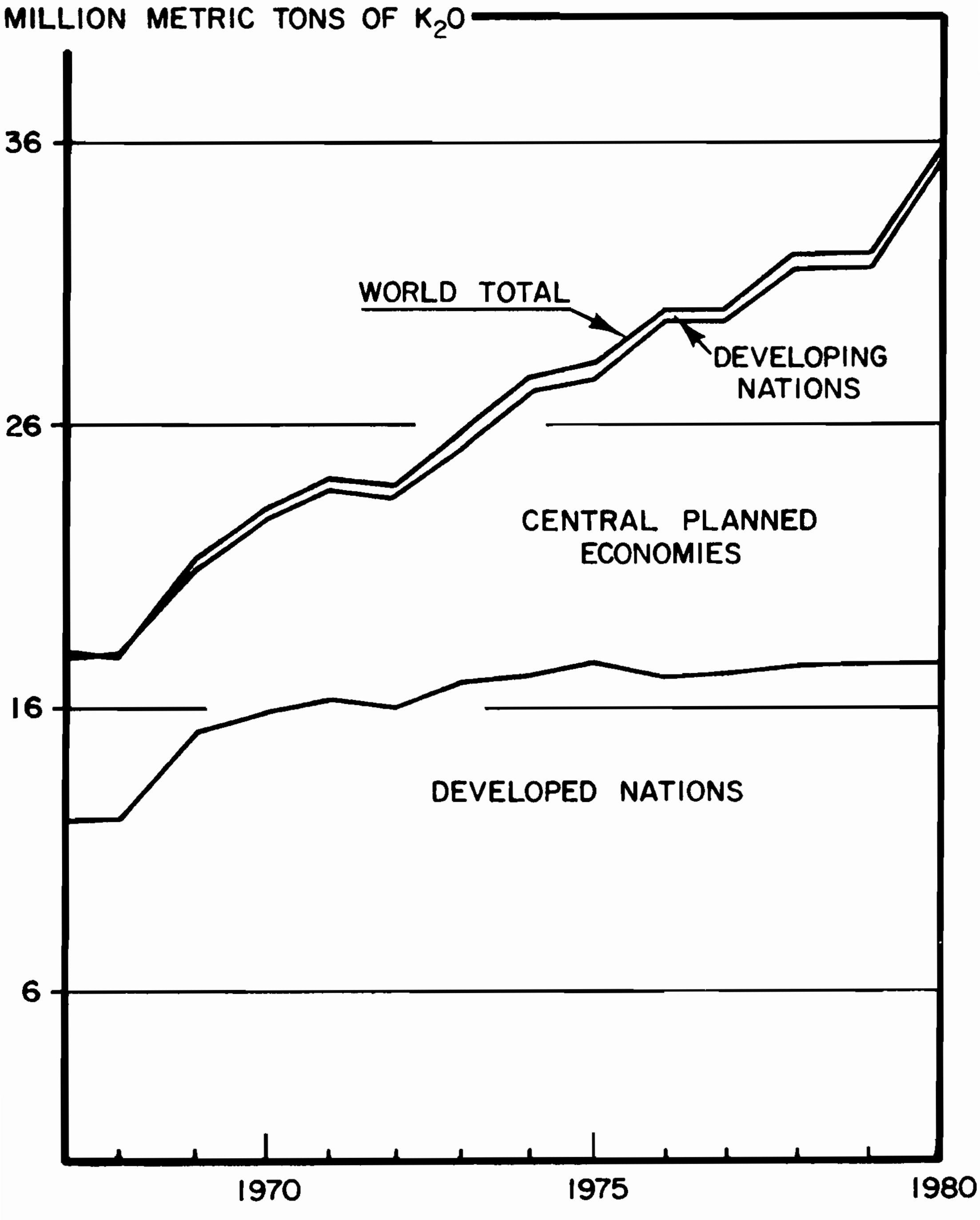


FIGURE 5

WORLD POTASH FERTILIZER SUPPLY-DEMAND OUTLOOK

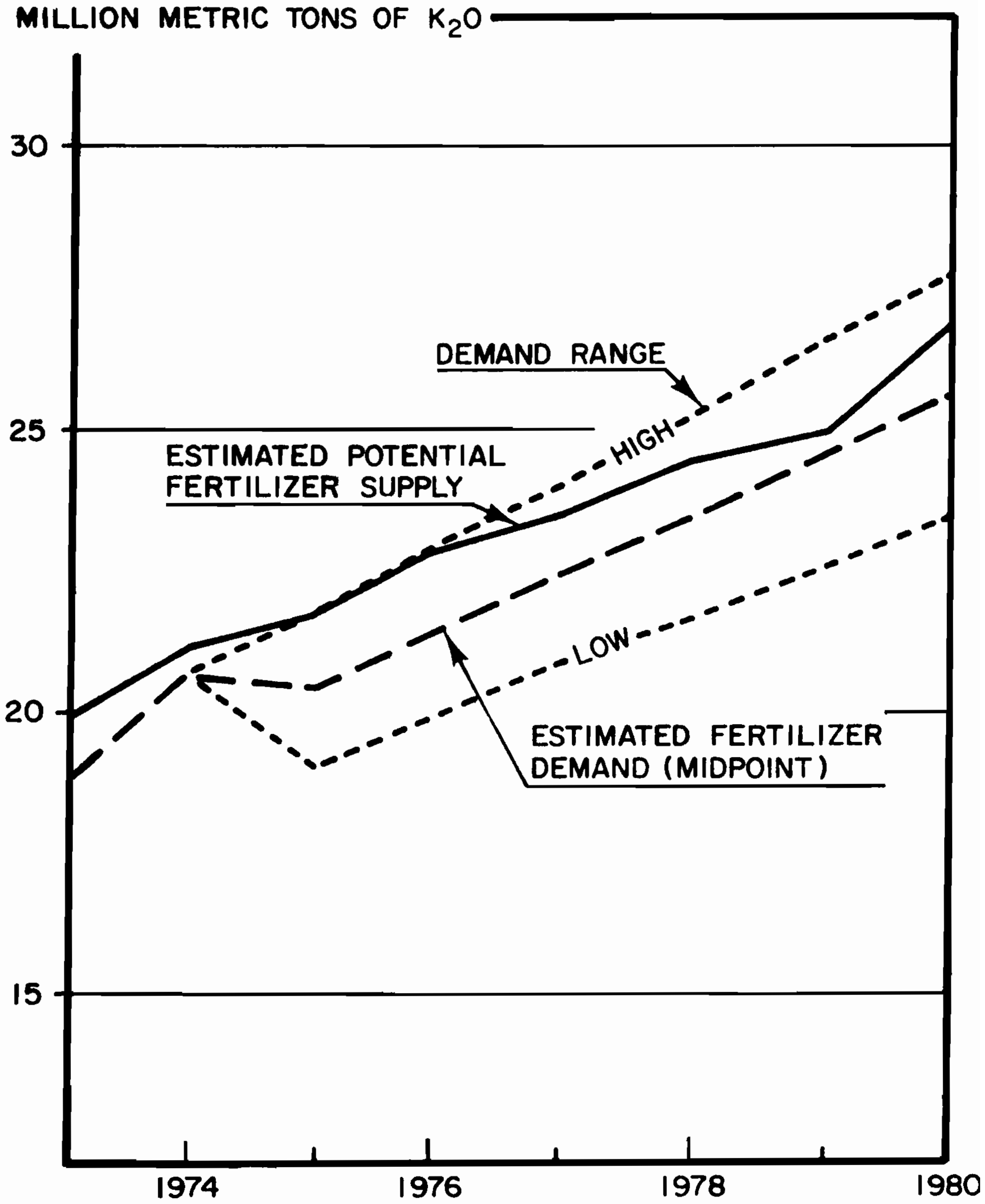


FIGURE 6

DISTRIBUTION OF WORLD NITROGEN CAPACITY

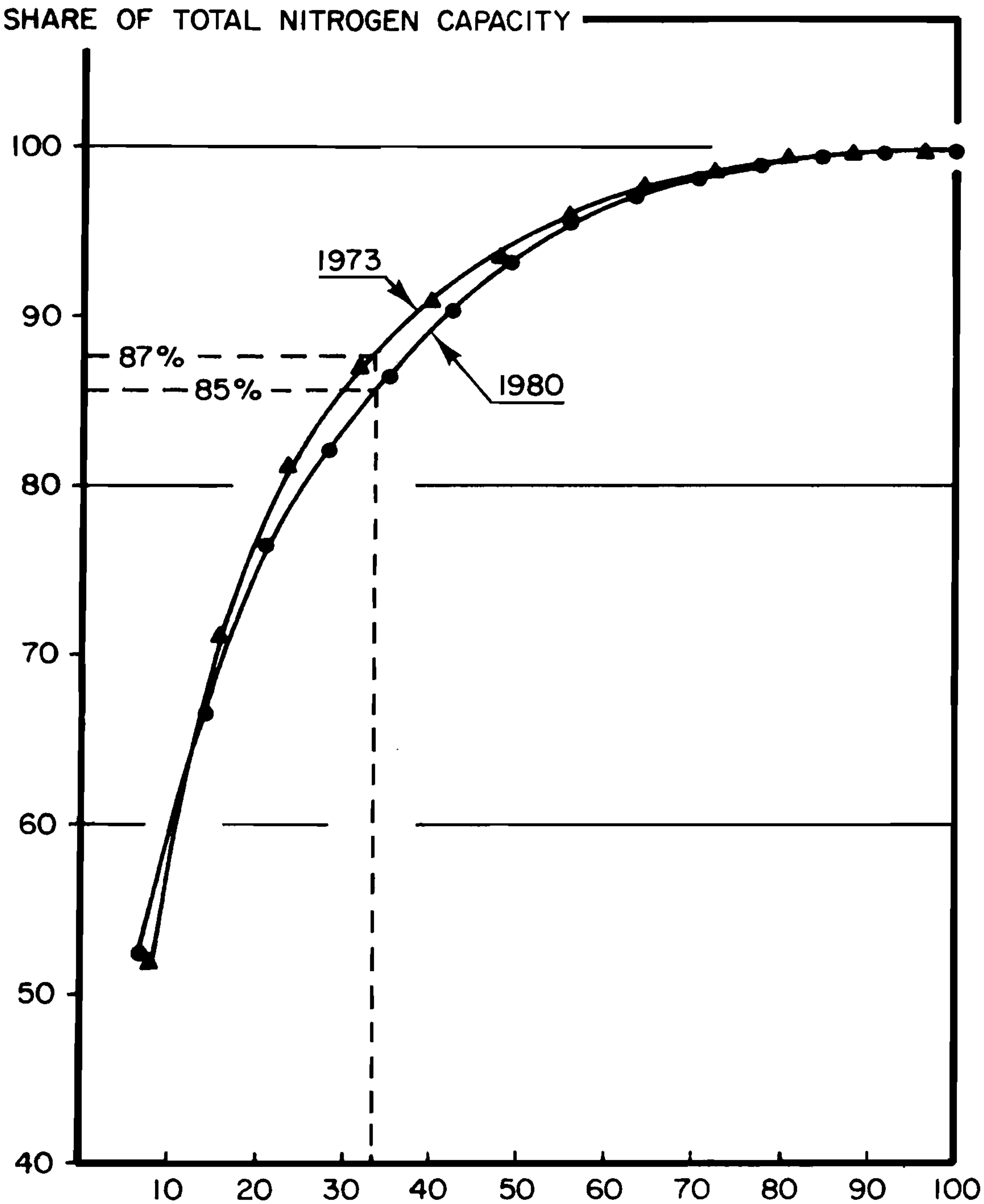


FIGURE 7

DISTRIBUTION OF WORLD PHOSPHORIC ACID CAPACITY

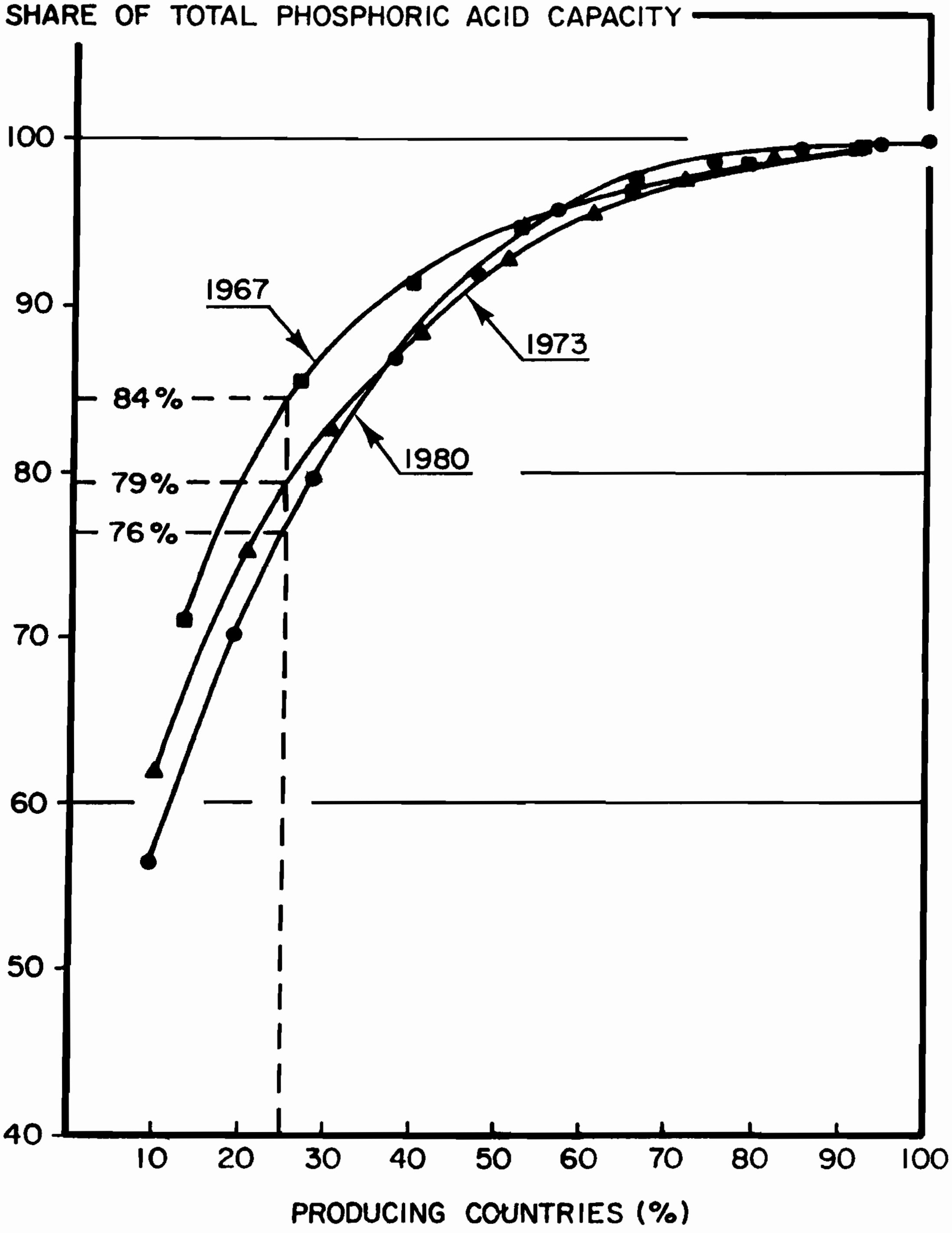


FIGURE 8

MODERATOR SHELDRICK: We haven't had a lot of questions this morning, but I think then it has been probably because we have had an informative series of talks; I think we won't get down to the questions perhaps till we get to the nitty gritty details of granulation and processing later in our program.

I think we've been very lucky to have this presentation, and it does emphasize something that was said earlier today — that we have to put a lot more emphasis on the demand side of fertilizers.

Question — Has there been much of a shift in the capacity figures or the operating rate figures in the developing countries in the last three or four years and are you estimating higher operating rates as to utilization rates in the developing countries?

Ed Harre's Answer — Dan, I think the answer to this first part of your question is no. The operating rates in the developing countries have improved very little. They are somewhere on the average, talking on terms of aggregate figures, I think, around 60-70% of the effect of the total capacity. Some countries are doing better than that, others a lot worse.

The second part of your question is, I think, there is a reason to project that operating rates should become somewhat better. Now whether they're on the overall average I don't know, but we are adding in many of these countries sophisticated or large scale ammonia plants in particular; and I think as we go along these plants are really to be operated best when they are running at full capacity and to operate them at less than full capacity is not making a lot of economic sense and eventually the developing regions eill realize this.

So we've done two things in our analysis. No. 1 is because of the large scale influx of the new Kellogg ammonia plants around the world we are allowing less time to bring them up to full capacity. Previously even in developed countries we used only a 30% rate the first year. We are in our analysis now using 60% the first year and then the full 90% or whatever rate you want to assume the second year thereon. I think eventually we will be doing some of this with the newer units in the developing countries also.

MODERATOR SHELDRICK: Any other questions? If not, we just passed the scheduled closing time for this session. On your behalf, I would like to thank once again all our speakers this morning. I think we have had some excellent papers. It certainly made my job very easy. I will now bring this session to a close.

Tuesday, November 4, 1975

Afternoon Session
Allen S. Jackson
Moderator

MODERATOR JACKSON: Good afternoon. We are on schedule. I appreciate the opportunity to moderate this session. Already we have an excellent attendance and more coming in. The program for discussion is timely, interesting and will be helpful to all of us.

Our first paper "Relation of Farm Crop Prices to Fertilizer Demands" will be discussed by Terry L. Francl. He has had several years of active fertilizer industry background in purchasing marketing and management.

Mr. Francl returned to the academic world and in 1972 received a master's degree in Agricultural Economics at Washington State University with emphasis in marketing and finance.

Mr. Francl re-entered the fertilizer industry for a year before going to his present position as Agricultural Economist with the Research Department of the Federal Reserve Bank of Chicago.

Mr. Francl is certainly well qualified to discuss the economics of farm crop prices to fertilizer demands.

Relation of Farm Crop Price to Fertilizer Demand

Terry Francl

During most of the fifties and the sixties the aggregate price indices of crop and fertilizer closely followed parallel courses, albeit for somewhat different reasons. (Chart 1) Crop prices reflect government policies to effect an environment in which farmers receive some minimum level of return on their output. The overwhelming problem during most of this period was what to do with the surplus production. However, fertilizer prices were stable in the face of some rather sharp increases in demand mainly due to a series of manufacturing improvements that enabled the industry to lower its cost curve substantially. There was, of course a period in the late sixties when a surplus of some fertilizer materials caused all fertilizer prices to decline, some quite precipitously.

A wide spread between fertilizer prices and crop prices developed in the early seventies when the government imposed price controls on the fertilizer industry and excluded crop prices from controls. When the government restrictions were lifted, fertilizer prices quickly moved to a level that was on a par with crop prices.

At this juncture, there is a great deal of uncertainty about what is going to happen to crop prices and, therefore, fertilizer prices — equally important to the fertilizer industry is the future relationship between crop and fertilizer prices or perhaps better stated, fertilizer demand. Fertilizer prices are simply a reflection of the demand for fertilizer under a given supply constraint.

In a free market, price gravitates to a level that will clear the market. In other words, the price of a good is a point of equilibrium on a given supply and demand schedule. It is important to note that in the short run there is little or no relationship between price and cost. Of course, this is not true over the longer term. But for the purpose of this discussion prices of both crops and fertilizer will be considered in the context of a short-run situation — a single spring season in which a given supply of fertilizer is available for sale.

Two factors should be emphasized at the outset. First, I plan to put the emphasis on crop prices rather than fertilizer prices — an area with which most of you are quite familiar. Second, I see no reason to believe that there will be a drastic shift in the relationship between crop prices and fertilizer demand because I anticipate that farmers will continue to apply fertilizer at a rate that will provide then the maximum return on their investment under the risk parameters they preceive. The price relationship in the future may not, however, be as conducive to an ever increasing demand for fertilizer products — as has been the past.

Chart 2 shows two fertilizer response curves developed from some Iowa data. Please note that all data presented will be on corn and nitrogen. This is not to say that the phosphate and potash are not important or that nitrogen is more important. It is just that time constraints will not permit going into detail in more than one area. Most, if not all, of the concepts presented with respect to nitrogen also apply to phosphate and potash.

The top response curve depicts a favorable moisture situation. The bottom curve represents a situation where moisture supplies have been restricted. While in this particular case it is a restriction moisture situation, any growing situation detrimental to yields would probably result in a nitrogen response curve somewhat similar to the lower example. Tables 1 and 2 convert these nitrogen response curves into dollar and cents based on 1974 and 1975 prices. By utilizing the average corn and ammonia prices — ammonia will serve as a proxy for all nitrogen throughout the presentation — farmers were facing during these two years, returns accruing to producers can be developed.

The corn and ammonia prices are based on prices received and paid by farmers on the March-May period. Furthermore, actual prices at the farm level may be substantially different than what we are sometimes led to believe. For example, the average Chicago cash price for corn in the March-May period of 1975 was $2.88 per bushel. The U.S. average price farmers received for corn during that period was $2.67 per bushel, with at least a 5 cent bushel plus or minus variation in the corn belt states. Furthermore, the December 1975 futures contract price averaged $2.55 per bushel during the period. The ammonia price is based on an April 15 USDA survey.

The favorable moisture situation depicted in the top response curve probably approximates the yield that a farmer in Iowa might anticipate under normal conditions — from just over 100 bushels per acre with no nitrogen application to slightly over 150 bushels with the optimal nitrogen fertilization rate. The high stress situation may approximate what occurred in Iowa in 1974, although the stress then was not lack of moisture but rather too much moisture and an early frost, among other things.

Note that in both cases the optimal fertilizer level dropped back one increment (20 pounds) going from 1974 to 1975. This is simply a function of the price relationships. Also note that the penalty cost for applying that extra increment of nitrogen was low under both cases. However, let's try to relate this to the actual 1973 and 1974 experience. Assume that in 1973 a farmer was applying the optimum rate of 160 pounds of nitrogen. We must then also assume that he would apply nitrogen at that same rate in 1974, for at the time the farmer was applying fertilizer he had no idea that yields were going to more closely approximate the lower nitrogen response curve. But yields did closely parallel the lower curve, and if you add up the total loss resulting from going two increments or 40 pounds in excess of the optimum rate, you will find it cost the farmer just over $12 per acre. Furthermore, if farmers were putting on an extra increment of fertilizer — not an uncommon practice in many instances — the loss per acre for overfertilizing would total almost $22 per acre. Under either situation it seems apparent that a farmer would seriously reevaluate his optimum application rate.

This brings us to 1975. While the figures are not final, it is obvious that fertilizer consumption was down. Why? Well, partly due to the circumstances just described. Also remember that when yields are down, not as much fertilizer is utilized by the crop leaving some carryover fertilizer from the previous year. Also remember that the price relationship between spring corn and fertilizer prices in 1975 changed enough to push the optimal rate of fertilization down one increment on the nitrogen response curve. With crop acreage approximately the same, how could anyone expect anything else but a decrease in fertilizer usage in 1975?

Now, how about the future? What is going to happen in 1976 and subsequent years? Farmers will continue to apply fertilizer at a rate that will provide them the maximum return on their investments under the risk parameters they perceive. They will probably be a little more conservative about application rates, however, for three reasons. First, in two of the last five years, 1970 and 1974, corn yields dropped substantially below trendline. Farmers may be looking over their shoulders for quite a few years. Second, the price relationship between corn and fertilizer is such that the penalty costs of applying too much fertilizer is much greater than in the past. For example, the penalty was $2.09 per a cre in 1972 versus $4.75 per acre in 1974 ($6.48 per acre in 1975 if farmers applied the previous optimum rate). Last, and perhaps most important, is the fact that the price a farmer receives for corn is subject to a greater degree of fluctuation. The price support is at such a low level that farmers probably could not recover even their variable production cost to say nothing of their fixed cost if corn prices should decline to the support level.

I would like to look at this situation in another way. I have a simple statistical model to look at the relationship between corn, fertilizer prices, and application rates of nitrogen on corn acreage. A total of four variables are considered for this model. (Chart 3) The first is the yield that a farmer is likely to anticipate. The U.S. average trendline yeild is utilized with an adjustment for past experience. This is accomplished by taking one-half the difference between the previous year's actual yield and the trendline yield, and adding it to the trendline yield for the year under consideration. This simply says that farmers have a trendline yield expectation that is adjusted to their most recent experience.

The average price farmers receive for corn in the march-May period — that time of year when farmers determine fertilizer application rates — is multiplied times the calculated yield. This results in a figure identified as gross anticipated income or GAI. Gross anticipated income is divided by the average price a farmer pays for a ton of ammonia — ammonia is the proxy price for nitrogen — to develop the corn/nitrogen ratio or CNRA. Please note that this corn/nitrogen ratio is quite different than that typically presented — the number of pounds of nitrogen a bushel of corn will purchase. The limitation to this more typical definition of the corn/nitrogen ratio is that it does not take yields into consideration. I suspect that those who utilize the concept probably adjust their recommendations to reflect the most likely yield in their area in the current year.

The last variable considered was estimated planted corn acreage. This information was taken from an annual USDA survey made every March 1. Basically, land is a substitute input for fertilizer. If more land is available, one would anticipate that fertilizer application rates might decline for three reasons. First, the land that is brought into production is typically of lower quality and would have a lower nitrogen response curve. Second, if funds are limited and a choice must be made between spending money for that last one or two increments of fertilizer or for land, the rational economic choice would be to add the land and spread the available fertilizer over more acres. While it may not be the optimum rate for any one acre, the net return for the total enterprise would be maximized. and last, the supply of fertilizer is somewhat fixed in any given year. A fixed supply of fertilizer spread over more acres dictates a decline in application rates. (Fertilizer prices would move upward in response to the higher demand and ration the limited supply.)

A multiple regression is utilized where the nitrogen application rate — the dependent variable — is regressed against CNRA and acreage — the two independent variables. The time period considered was 11 years, a relatively short period for this type of analysis from a statistical viewpoint. However, the USDA has been making a survey of application rates only since 1964.

You may have noted that I did not incorporate a nitrogen response curve into the variables. While it is certainly an important factor, it is extremely difficult to ascertain what the nitrogen response curve for the United States is. As an example of the magnitude of the problem, consider the response curves shown here for seven different Illinois locations developed over a five-year period. (Chart 4) As you can see, the problem of developing one U.S. nitrogen response curve is formidable.

Another possible weakness in the model may be the price information. Support prices and "set aside" payments were made prior to 1973 and they have not been included in the farm price. The set aside payment probably had little if any effect on the fertilizer application rates that farmers chose in the past because it was basically an independent event. Also, since support prices are only paid on a predetermined historical yield — which was usually lower than the trendline yeild — they also may have had only a limited effect on fertilizer application rate. Usage of additional investments of fertilizer would most likely push yields above the historical yield and the farmer would, therefore, receive nothing more than the market prices for the resulting production.

The results of the model are as anticipated. The CNRA has a positive sign — which indicates that farmers increase N application rates when the price relationship is conducive to higher profits — and the acreage is negative. The T-statistics suggest that results are statistically significant. The two independent variables accounted for over 80 of the variation in the nitrogen application rate as reflected by the R_2 figure. (Table 2).

Chart 5 shows a comparison between the predicted application rate derived from the model and the actual rate. Please note that in the last half of the sixties the actual application rate exceeded the predicted rate. As you know, the cost of ammonia was falling rapidly in that period. It might be that farmers considered the penalty for that extra increment so small that they, in fact, over-fertilized slightly. The rapid upward movement in U.S. yields during this period tends to reflect this.

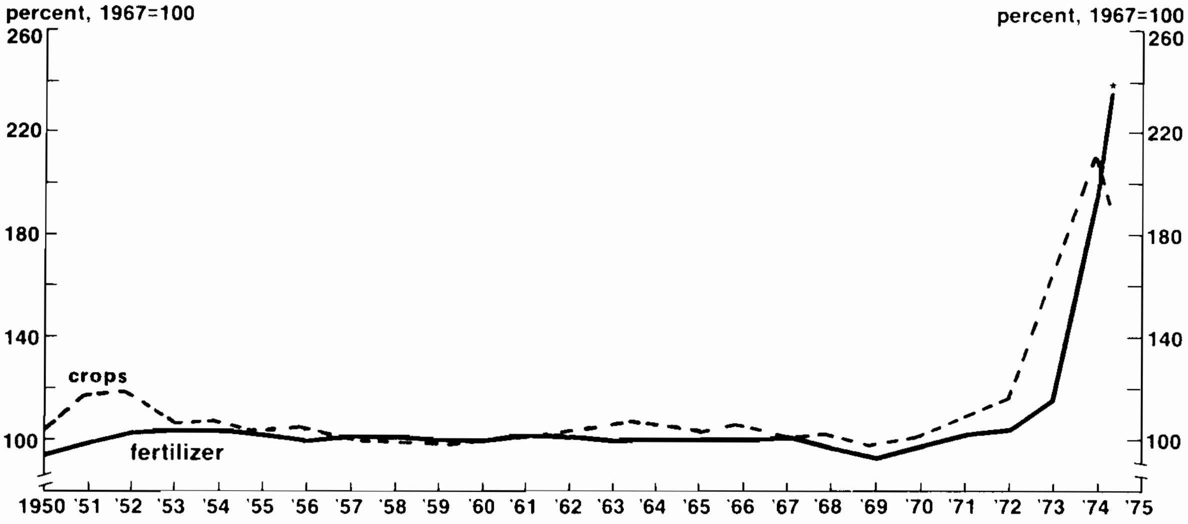
The widest, most recent deviation between the predicted and actual yield occured in 1973 when the model predicted N applications on corn at 123 pounds per acre versus the actual rate of 113 pounds. The corn/nitrogen ratio was favorable and if more nitrogen had been available farmers might have come closer to the predicted rate. Stated another way, fertilizer was underpriced and farmers wanted to purchase more than was available.

The 1975 N application rate per acre of corn can be projected since we know all the components utilized in developing the independent variables. the predicted usage rate is down considerably. According to the model, farmers would have applied 77 pounds per acre of corn in 1975. While I think the predicted direction is correct, I suspect the magnitude of decrease might be considerably less, maybe only half the predicted amount. There are three factors that probably moderated the decline in nitrogen application in the spring of 1975. 1) Fertilizer prices peaked in the very early spring and then dropped fairly rapidly in many areas. The USDA spring ammonia price is based on an April 15 figure. As you may recall, early spring rains kept many corn belt farmers out of the fields until May. 2) Farmers' price expectations could have been substantially higher than the spring prices indicated. Corn prices rose to the mid-$3 per bushel range in the fall of 1974. According to some of the early 1975 surveys, a substantial number of farmers were looking forward to $3 per bushel prices this fall. 3) the average U.S. yield was so low in 1974 that the 1975 adjustment was minus 9 bushels, perhaps more than most farmers would have actually made in their own minds. All three factors would tend to raise the corn/nitrogen ratio. They also point out some of the difficulties encountered in choosing statistical data that accurately reflect the variables under consideration.

Consider a slightly different set of variables for 1975. If ammonia prices were closer to $250 per ton instead of the $265 reported by the USDA, if corn prices were computed at $3 per bushel, and if yields were adjusted down only 5 bushels per acre, the predicted N application rate on corn would be 89 pounds per acre. Even that rate is down considerably. But again, under the circumstances what would one expect?

Chart 1

CROP AND FERTILIZER PRICES TYPICALLY FOLLOW A PARALLEL PATH



Note: Indexes are for crop prices received by farmers and fertilizer prices paid by farmers

*Average of first 4 months of 1975

Chart 2

RESPONSE OF CORN TO NITROGEN UNDER VARYING MOISTURE CONDITIONS–IOWA

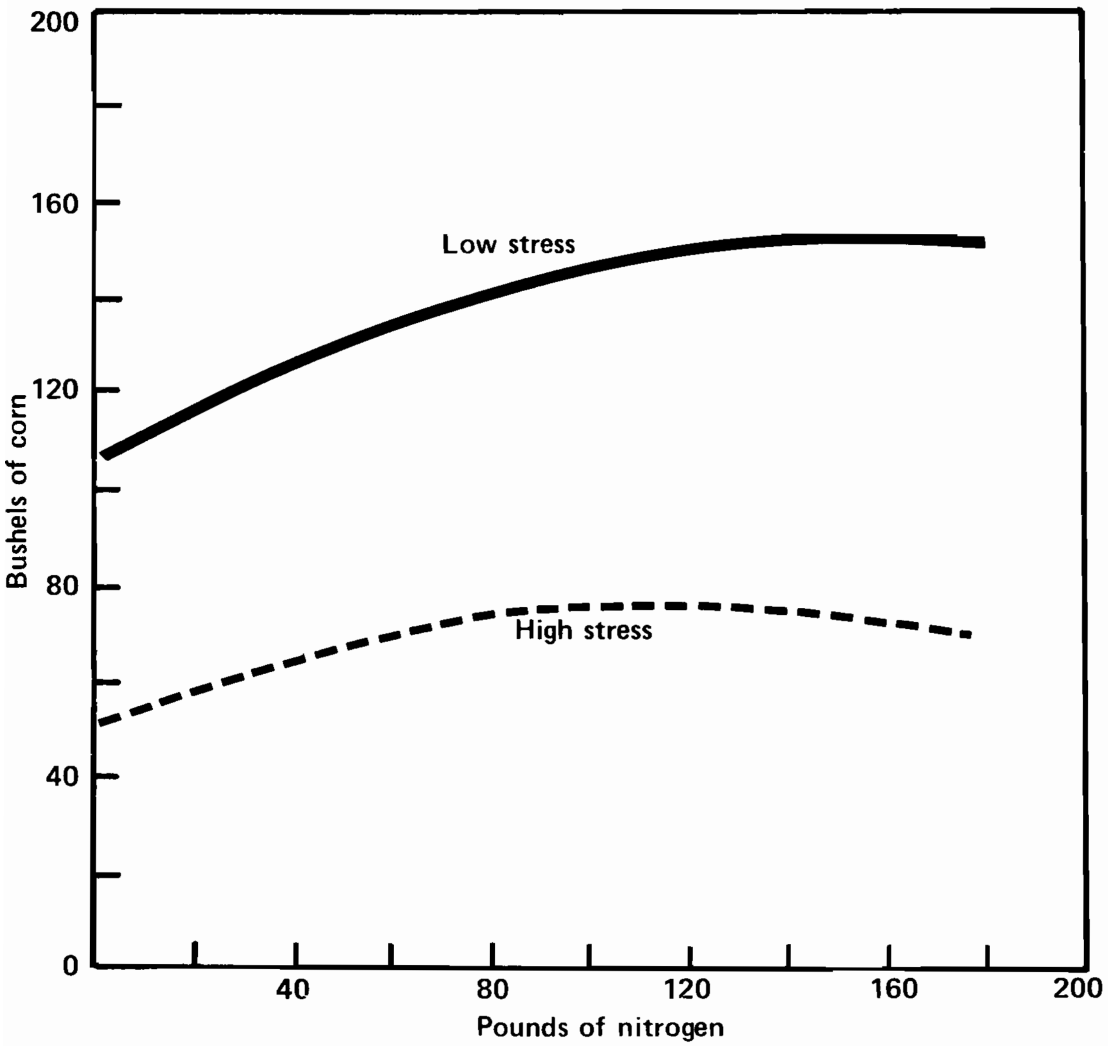
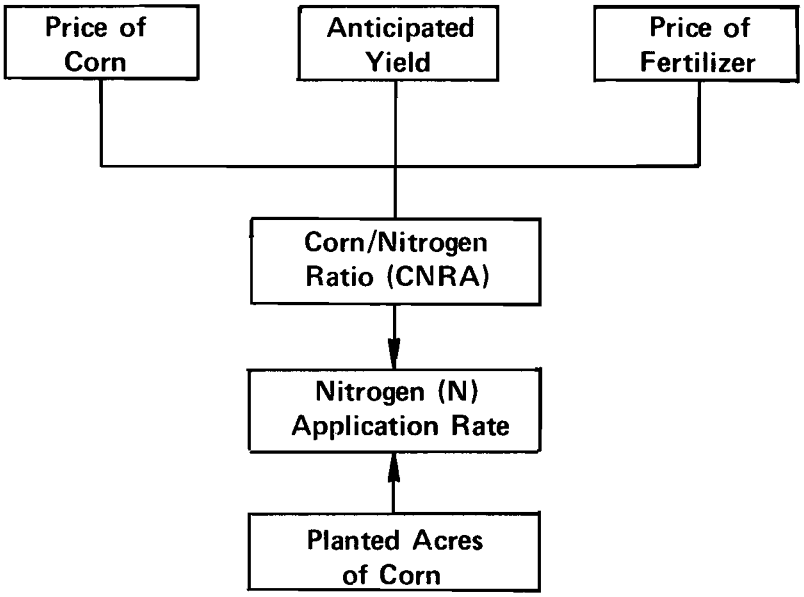


Chart 3

CORN NITROGEN RESPONSE MODEL



Variables and method of calculation:

1. Trendline yield of corn adjusted for previous year actual yield (U. S. average annual yields).

   YIELD = Trendline yield + 1/2 the difference between the **actual and trendline yield of the previous year.**

2. Price farmer receives for corn in the March—May period (PRICE).
3. YIELD X PRICE = Gross anticipated income per acre of corn raised (GAI).
4. GAI ÷ Price per ton of ammonia paid by farmers = Corn/Nitrogen Ratio (CRNA)
5. Intended planted corn acreage (March 1).
6. Nitrogen (N) application rates per acre of corn.

Chart 4

CORN YIELD RESPONSE TO NITROGEN IN SEVEN ILLINOIS LOCATIONS

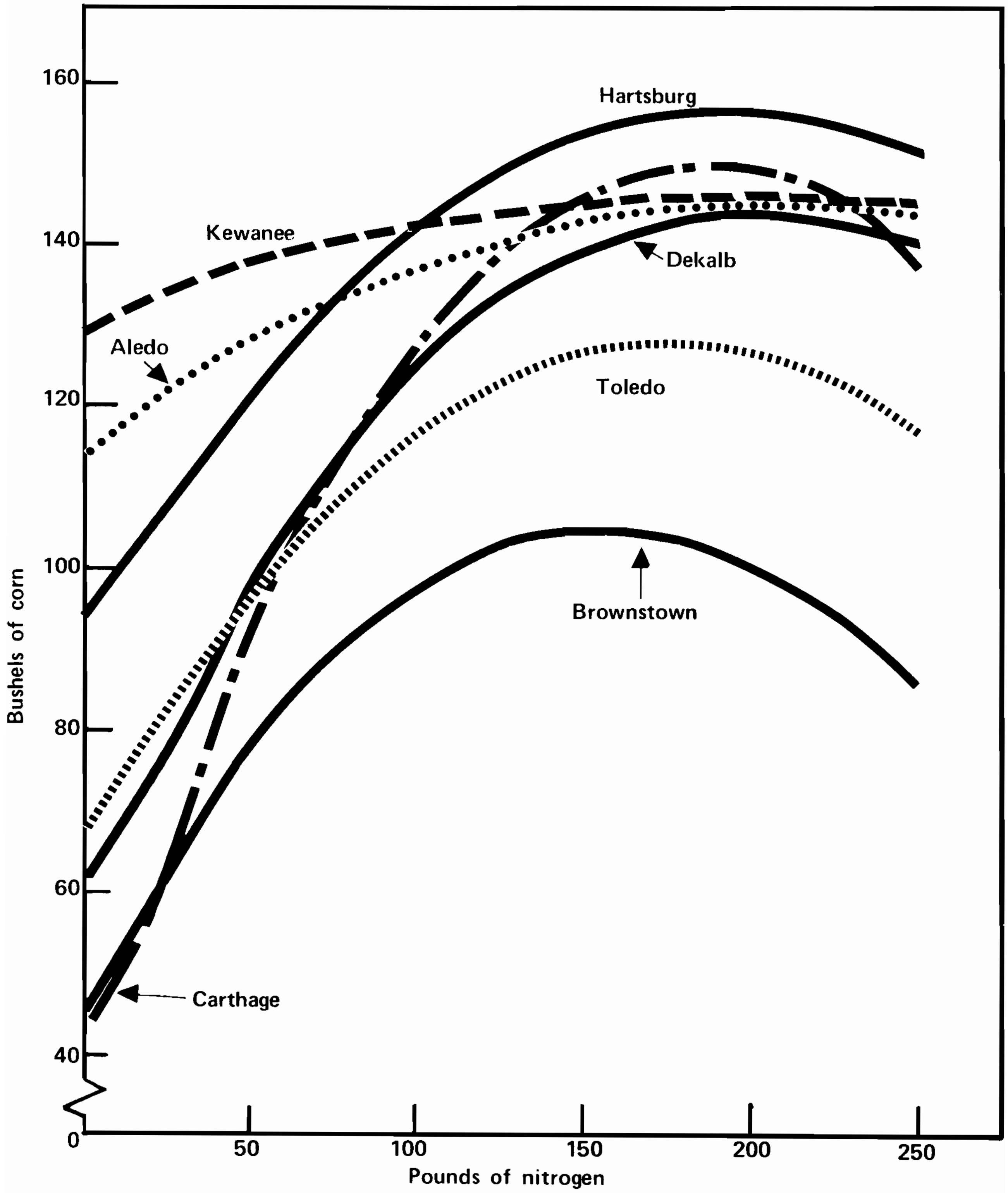


Chart 5

NITROGEN APPLICATION ON CORN

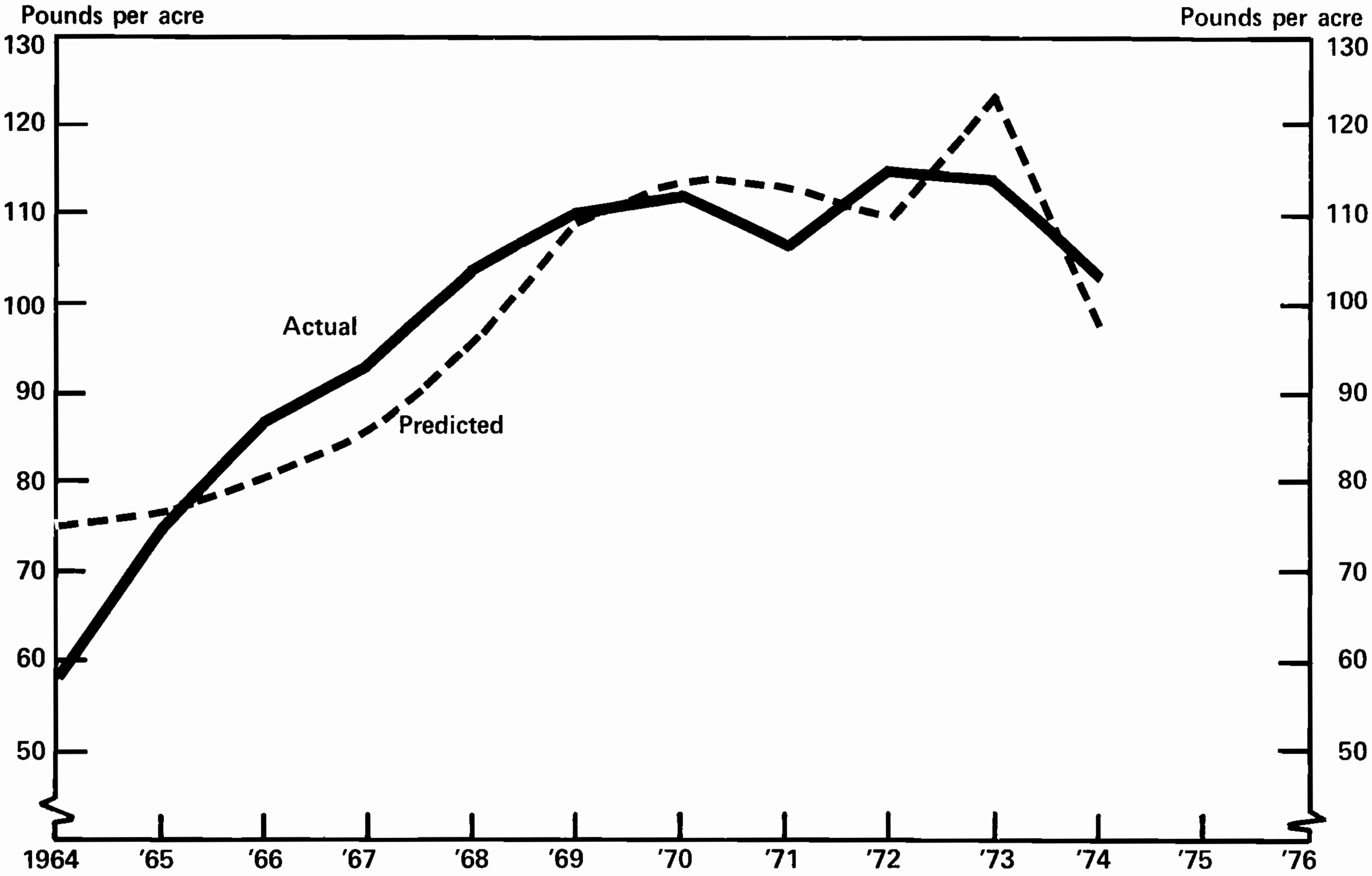


Table 1

Marginal Returns to Producers
Iowa Corn Yield Response Curve

Rate of N application per acre (pounds)	Yield response (bushels)	Net gain (loss) per acre from additional increment of N 1974[1]	1975[2]
	Low moisture stress		
20	11	$25.27	$26.13
40	9	20.35	20.79
60	8	17.84	18.12
80	5	10.31	10.11
100	5	10.31	10.11
120	4	7.80	7.44
140	2	2.78	2.10
160	1	.27	(.57)
180	(1)	(4.75)	(5.91)
	High moisture stress		
20	8	$17.84	$18.12
40	7	15.33	15.45
60	5	10.31	10.11
80	4	7.80	7.44
100	2	2.78	2.10
120	1	.27	(.57)
140	(1)	(4.75)	(5.91)
160	(2)	(7.26)	(8.58)
180	(3)	(9.77)	(11.25)

---

[1] Corn @ $2.51/bushel, anhydrous ammonia at $183/ton (11.2 cent/lb. N).

[2] Corn @ $2.67/bushel, anhydrous ammonia at $265/ton (16.2 cent/lb. N).

Table 2

Results of Model

	T-Stat
Intercept = 109.1 (Constant factor)	2.20043
CNRA = 55.96 (Multiply times CNRA)	5.74866
ACRE = -1.022 (Multiply times acreage)	-1.36998

$R^2 = .80582$

D.W. = 1.46

Deriving N Application Rates from Model

Deriving 1970 Predicted Application Rate

109.1 + (55.96 x CNRA) + (-1.022 x ACRE) = N Application Rate

109.1 + (55.96 x 1.291) + (-1.022 x 66.7) = N Application Rate

109.1 + 72.2 - 68.2 = 113.1

Appendix A
I

Predicting Anhydrous Ammonia Prices

A byproduct of the corn/nitrogen model is the ability to predict anhydrous ammonia prices. Three assumptions must be made to develop a price prediction. They include:

1. the price of corn
2. the yield anticipated
3. planted acreage

In addition to the above three variables some parameters must be set forth on the available supply of ammonia (nitrogen)--the amount of ammonia (nitrogen) that must be sold to "clear the market"--as reflected by the nitrogen application rate. (The "market" refers only to that ammonia (nitrogen) that will be utilized on corn ground.)

The values utilized for the following example included:

Corn price	\$2.50 per bushel
Yield	94 bushels per acre
Planted acreage	75.0 (million acres)

The range of nitrogen application is from 90 to 120 pounds per acre divided into 10 pound increments.

Calculations:

Equation: $109.1 + (55.96 \times \text{CNRA}) + (-1.022 \times \text{ACRE}) = \text{N application rate}$

Determine gross anticipated income per acre (GAI) = \$2.50 x 94 = \$235

Solve the following equations:

Appendix A
II

$$109.1 + \left(55.96 \times \frac{\$235}{\text{Ammonia Price}}\right) + (-1.022 \times 75.0) = 90$$

$$109.1 + \left(55.96 \times \frac{\$235}{\text{Ammonia Price}}\right) + (-1.022 \times 75.0) = 100$$

$$109.1 + \left(55.96 \times \frac{\$235}{\text{Ammonia Price}}\right) + (-1.022 \times 75.0) = 110$$

$$109.1 + \left(55.96 \times \frac{\$235}{\text{Ammonia Price}}\right) + (-1.022 \times 75.0) = 120$$

N application rate per acre	Anhydrous ammonia price per ton
90	$229
100	195
110	170
120	150

The resulting output should be viewed with a good deal of caution. Only that ammonia (nitrogen) utilized for corn is considered in the model, and obviously there are other uses--agricultural and industrial--that have a bearing on the price. Perhaps the most useful output can be generated by observing the relative change in prices under different assumptions, i.e. changes in acreage and/or the price of corn.

Data Utilized in Corn/Nitrogen Model[1]

Year	Farm Corn Price March-May	X	Adjusted Yield Bushels/Acre	=	Anticipated Gross Returns Dollars/Acre	÷	Cost/Ton Ammonia April Price	=	Corn/Nitrogen Ratio	Estimated Planted Corn Acres-March (Million)	Nitrogen Application Pounds/Acre (Actual)	Nitrogen Application Pound/Acre (Predicted)
1964	$1.14		70.7		$ 80.60		$126		0.640	68.9	58	75
1965	1.21		69.0		83.49		122		0.684	66.9	75	77
1966	1.16		75.2		87.23		119		0.733	68.4	86	80
1967	1.26		77.5		97.65		113		0.864	70.6	93	85
1968	1.07		79.8		85.39		91		0.938	64.9	104	95
1969	1.13		79.5		89.84		76		1.182	64.4	110	109
1970	1.15		84.2		96.83		75		1.291	66.7	112	113
1971	1.41		76.9		108.43		79		1.373	71.5	107	113
1972	1.13		87.3		98.65		80		1.233	68.5	115	109
1973	1.47		92.5		135.98		88		1.545	71.6	114	123
1974	2.51		89.6		224.90		183		1.229	78.8	103	97
1975	2.67		80.4		214.67		265		0.810	76.1	--	77

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[1] Relationship of Farm Crop Prices to Fertilizer Demand, partial data from speech presented at The Fertilizer Industry Round Table by Terry Francl, Agricultural Economist at the Federal Reserve Bank of Chicago on November 4, 1975.

MODERATOR JACKSON: Dr. Aaron J. Teller will discuss new developments in Fertilizer Plant Emissions. He is President of Teller Environmental Systems, Inc., has been active in innovative engineering design for the abatement and recovery of pollutants.

Dr. Teller formerly served as the Dean of The Cooper Union School of Engineering and Science. He has published approximately 40 fundemental papers and holds 25 patents internationally.

Dr. Teller serves as a Director of two corporations, a member of the Federal Emissions Policy Group and is chairman of the National Council on Resource Economics.

Dr. Teller, please.

New Technologies In Control Of Fertilizer Plant Emissions Pond Control - Fluoride Products

Dr. Aaron J. Teller

The problem will not go away.

In 1972, in a paper[1] delivered to the fertilizer round table, the success of the scrubbing technology in the fertilizer industry was described. The conclusions were confirmed by the EPA in 1974 when these Teller systems were designated as the highest state of the art.

But a nagging concern was developing in 1972. I stated,

"The real problem emerging is the pond. The solution is obvious. We will have to remove the pond as a component of our system design."

Since that time the problem has grown in intensity. The peculiar mist formation with attendant concentration of the pond fluoride emissions in small air masses and the presence of high nitrogen concentrations in the pond pose new hazards in vegetation damage by ambient air and contamination of streams and estuaries.

Increasingly, authorities are questioning overall emissions exclusive of stack emissions, and initiating constraints on ponds, thus placing restrictions on new plants and esicting operations. Additionally, the maintenance cost, size and life of ponds often have inhibitory effects on expansion of production.

The ponds have always been considered essential components of fertilizer production. Historically they have served the fertilizer industry in providing three services:

1. The separation of gypsum by-product from the acidulation process
2. The removal of heat from the scrubbing liquor
3. The removal of fluorides from the manufacturing system.

The integral service of the pond system is indicated in figure 1. The gypsum pond is the separation mechanism for the gypsum. The sluice rate from the filter is approximately 2000 GPM for a 700 TPD installation. It requires a land area of approximately 150 acres and has a life of approximately 10 years inasmuch as the gypsum accumulates at a rate of 1 acre ft/yr/daily ton P_2O_5.

The cooling pond for a 700 TPD plant must remove approximately 300,000,000 Btu/hr with a land area of the same order of magnitude as the gypsum pond. The heat removal is critical to the efficiency of absorption of the fluorides from the concentrator and product scrubbing systems. As indicated in the previous paper the kinetics of absorption of fluoride gases is critically dependent on the temperature of the scrubbing water.

Inherently the ponds serve to remove the great majority of the fluoride from the process. As indicated in figure 1 and TABLE I, over 90% of the soluble fluorides generated in the manufacture of phosphate fertilizers "disappear" in the pond.

TABLE I

FLUORIDE INVENTORY

700 TPD P_2O_5 PRODUCTION

FLORIDA ROCK

	Lb/Day
Input	
Fluoride in rock	170,000
Output	
Solid Fluorides	
In Gypsum	46,000
In Fertilizer Product	17,000
TOTAL Solid Fluorides	63,000
Soluble Fluorides	
Lost to Atmosphere from pond	50
Lost to Atmosphere in stacks	40
Lost to Pond Discharge(1) (2) and Seepage	14,000
"Disappeared"	92,910
TOTAL Soluble Fluorides	107,000

(1) The pond discharge and seepage quantities were estimated on the basis of a loss of 500 GPD/TON P_2O_5. Actual seepage data from one installation of 700 TPD P_2O_5 indicated a loss rate of only 6 GPM/TON P_2O_5, a small portion of the total water loss.

(2) The fluoride loss in pond discharge and seepage was based on a soluble fluoride concentration of 5000 PPM. Although higher total concentrations have been reported, it has been found on more detailed analysis, that much of the "excess" consists of insoluble fluorides in colloidal suspension.

Thus the ponds serve many valuable purposes, solids separation, cooling and fluoride deposition, and serve them well. However, subsequent to solving the stack emission problems, it was found that ponds themselves constituted environmental hazards.

Gaseous fluoride emission from ponds is relatively small, approximately 0.1 lb/acre day[2]. This quantity under normal windage would produce a frontal concentration of the order of 0.5 to 3 PPB at the edge of the pond. However, during diurnal inversions, the fluoride emission coupled with the vaporization of water begins to accumulate in submicron water particles. When wind flow returns, this concentrated mass moves in plug flow at frontal concentrations greater than 30 PPB.

Seepage in well designed and operated ponds is relatively low. At a well operated site the seepage rate was determined as 4000 GPD. This results in an influx of 167 lb/day into the soil. Normally this quantity will be neutralized by basic materials in the soil prior to reaching any aquifer. If, however, neutralization does not occur, contamination of the aquifer represents a potential hazard.

Overflow, after rain, constitutes a danger and economic loss. Well designed and operated ponds have two stage overflow neutralization systems with operating costs ranging from \$1 — \$4/ton P_2O_5. However, neutralization by lime does not reduce the excessive nitrogen level and does not sufficiently reduce the P_2O_5 level.

Thus, in spite of the effectiveness of the ponds in the total system operation, it is necessary to either reduce the contamination in the ponds to levels acceptable to the regulatory agencies, reduce the degree of pond usage, or, remove the necessity for pond operation.

There is no question that a solution to the "pond problem" *must* be achieved. However, the method will vary with the area, type of rock, and the economics of operation for a specific fertilizer complex.

There are three general methods of solution:

1. Neutralize the pond (i.e., with lime)
2. Reduce the fluoride input to the pond
3. Remove the fluoride from the pond by physicochemical processing
4. Modification of the physical or chemical characteristics of the pond to reduce the equilibrium soluble fluoride concentration
5. Minimize pond requirements by alternative recovery/cooling schemes.

Pond Neutralization

Alternative 1 is economically prohibitive. The cost of such an operation would be of the order of $8 — $12 ton of P_2O_5.

Fluoride Removal by Physico Chemical Processing

Alternate 2 as a single solution would be limited in effectiveness unless the reduction in input exceeded 90% of soluble fluoride input to the pond. The quantity of removal required for Alternate 2 is of such magnitude that consideration was given only to alternates 3, 4 and 5.

Several methods for reduction of fluorides have been proposed and tested. None have this far been reported to be in full scale commercial operation. Critical to the economics of reduction of levels of fluorides, phosphates, and nitrogen within the pond is the chemistry of the pond. It is noted in figure 1 and TABLE I that approximately 90% of the flouride input to the pond "disappears." The disappearance is apparently related to the precipitation of the fluorides in one or more of the 30 insoluble compounds that can be formed by the ions present in the pond[3]. The precipitation of these compounds establishes an equilibrium concentration of soluble fluorides in the pond.

It is unique that throughout the industry the reported pond concentrations are of the order of 4000 - 6000 PPM fluoride. Occasionally there are reports of concentrations of the order of 10,000 PPM of fluoride. The frequency of reports of these higher concentrations predominate in Northern installations. In a series of tests made with pond water samples from high concentration ponds, it was found that the soluble fluoride content was 5000 - 6000 PPM. The remainder of the total fluoride consisted of suspended solids. The frequency of occurrence of the suspended solids would naturally be greater in northern climes where the faster cooling rate will naturally result in the formation of smaller crystalline precipitates.

If indeed the concentration of soluble fluorides in the pond is an equilibrim value with the precipitated salts then the only variations in concentrations will result from differences in rock composition and the degree of pond contamination by ammonia and phosphates.

If the "disappearing" fluoride is caused by solubility equilibria, then decreasing the input of fluorides to the pond by as much as 90% will not reduce the equilibrim concentration as long as the other factors are unchanged. The equilibrim solubility will be a function of the solubility products only and since the activity of a solid is 1, then only one crystal of the precipitate is necessary to maintain the 5000 PPM level. thus a minimum reduction or removal of greater than 90% of the fluoride introduced into the pond would be necessary to reduce the soluble fluoride level. System requirements for physical removal of fluorides by such methods as ion eschange therefore have a requirement for removal of greater than 93,000 lb/day of F— for a 700 TPD plant.

Increasing the Deposition of Soluble Fluorides

The alternative to removal of fluorides is to create a change in the physical or chemical characteristics of the pond to shift the equilibrium fluoride concentrations to lower levels. such procedure will precipitate additional quantities of fluorides, insignificant relative to the present quantities now precipitated but will cause a significant reduction in the soluble fluoride concentration. such a procedure would have minimum cost impact on the pond operation.

The effect of one variable, pH, on the concentration of soluble fluorides and phosphates in the pond is noted in figures 2 and 3.

Typical pond pH ranges between 1.6 and 1.8. At this condition, the concentrations of soluble fluorides and soluble phosphates each range between 4000 and 8000 PPM. (Figs. 2 and 3) If the pH is raised to 2.5 the soluble fluoride concentration drops to 1700 PPM and the phosphate to 2500 PPM. If this could be achieved, emissions would be reduced by a factor of 3.

Increase in pH connot be economically achieved by chemical additions. However, initial work with algae indicates that the pH can be increased to 3 and the fluoride concentration decreased by a factor of 2 to 7 within a period of 3 hours (figures 4 and 5).

Higher plant life, such as the Juncus, and autotrophic bacteria have given indication of providing a similar effect.

An alternative approach is to increase the concentrations of certain cations to produce additional precipitates whose solubility products would result in soluble fluoride concentrations less than 5000 PPM within the present physical properties of the pond.

The exact composition of the present precipitates is unknown and it is accepted that the composition will vary with rock composition and ammonia and phosphate losses. Among the identified precipitates are calcium fluoride, calcium fluosilicate, sodium and potassium fluosilicates, and chukhrovite.

There appears to be a distinct possibility that increasing the specific cation concentrations, already present in the rock, will increase the formation of compounds with lower solubility products, resulting in the reduction of the soluble fluoride concentration to the order of 2000 PPM. thus a reduction in gaseous emissions from the pond of 60-70% could be achieved and a reduction in neutralizing costs in the range of $1.50/ton P_2O_5 could be gained.

Alternate (5) *Reduction in soluble fluoride input to the pond by alternative recovery schemes.*

The addition of fluorides to the pond for a 700 TPD fertilizer complex is as follows:

SOLUBLE FLUORIDE INPUT TO POND

Source	lb/day
Filter	46,000
Barometric condensers	86,000
Digester Scrubber	6,000
NPK Scrubbers	2,000

The major source, the barometric condensers, can be diverted to provide a concentrated product of 23% fluosilicic acid with a 98-99% recovery of the fluoride. Admittedly the market is variable at this time. However, the world supply of fluorides is diminishing and phosphate rock represents the only major source of fluorides on the North American continent. Present consumption of fluorides in the U.S. is of the order of 1.5 x 10_6 tons per year, almost all of it imported. the prices of fluoride materials have risen almost 100% in the past five years. With 50-60% of the fluoride in the phosphate rock available for recovery, the fertilizer industry presents a major source of fluorides for this continent. Thus, the market for this source will be rising in the near future.

The other sources cannot, with present wet scrubbing technology, be recovered in concentrated forms. Thus a change or modification in existing recovery technology must be imposed to prevent their discharge to the pond.

Two solutions have been established. Neither offers a panacea of complete circumvention of ponding. However, both reduce the fluoride input to the pond to such a degree that an excess of precipitating cations are available. Under these conditions, it is anticipated that the equilibrium fluoride value will be of the order of 2500 PPM. coupled with a 2/3 reduction in pond area, the pond emissions will be reduced by approximately 85%.

Case 1 — A variation of this system is now under construction for a complex with a capacity of 1000 TPD. The flow sheet is indicated in figure 6. The pond duty is limited to gypsum separation, thus achieving a reduction of 1/2 of the pond area.

The fume scrubber liquor is used as makeup for the production of concentrated fluosilicic acid in the barometric condenser system, thus removing a total of 92,000 lb/day soluble fluoride loading on a pond system or equivalent.

Neutralization and disposal from the scrubber circuits is thus limited to approximately 3 - 4 TPD of soluble fluoride. the 46,000 lb/day introduced into the gypsum pond circuit will, as presently, be naturally precipitated by the excess cations to a level of 2500 PPM

The major problem in this system design was the introduction of a cooling tower loop to remove the 150,000,000 Btu/hr concentrator system duty presently absorbed by the pond. the use of a cooling tower system develops additional problems that emerge consequentially:

1. Discharge of fluoride gases from the cooling tower
2. Corrosion in the cooling tower
3. Deposition in the cooling tower
4. Deposition in the scrubber system
5. Removal of fluorides in disposable or soluble form.

The "normal" scrubbing of fluoride containing gases is achieved by recycle pond water containing approximately 5000 PPM of F—. The equilibrium partial pressure of $HF + SiF_4$ in terms of F— is of the order of 1.5 PPM. If such a scrubbing solution were recirculated in a 700 TPD phosphoric acid concentrator complex (fig. 6) the gaseous emissions from the cooling tower would be of the order of 110 lbF—/day. For a total complex including NPK or DAP production the cooling tower emissions would be of the order of 220 lb/day. Inasmuch as present regulations in some states permit a maximum emission of 140-280 lb/day for a 700 TPD complex, including stack emissions, the cooling tower gaseous fluoride effluent would exceed the permissible emissions. Further, these emissions would be present at a low elevation and in a water saturated gas. Thus, the ambient air in proximity to the complex would far exceed the 1 PPB limitation at ground level now adopted by several regulatory agencies.

The solution chosen was to recirculate a sodium solution in the cooling tower — scrubber circuit. With proper concentration of sodium ion, gaseous fluoride emissions are precluded and corrosion is minimized. Because the solubility of the sodium salts of fluosilicic and hydrofluoric acid exceed 1% in water solution, design concentrations were established at a low enough level to prevent deposition in the scrubbers and cooling tower.

A slipstream from the cooling tower circuit is diverted to a lime reactor where the fluorides are precipitated by the calcium ion and the sodium ion regenerated. The only sodium makeup required is that necessary to compensate for the sodium adsorbed in the precipitated cake.

The solid product for disposal or sale is 2700 lb/day containing 900 lb/f/uoride in an insoluble form.

Via this recovery process, approximately 92,000 lb/day of fluoride are diverted from the pond and the thermal loading on the pond system is reduced by approximately 150,000,000 Btu/hr. Particularly important is that no ammonia-nitrogen is introduced into the pond system.

NPK EMISSION CONTROL — WET

The pondless system for NPK emission control, fig. 7, requires only slight modification to the existing type of installation. The "conventional" Teller installation consists of a coaxial venturi with phosphoric acid scrubbing for ammonia removal followed by a nucleator with pond water scrubbing for removal of gaseous fluorides and submicron particulates. To prevent contamination of the sludge product with phosphates and to prevent the emission of ammonia from the cooling tower, the residual quantities of these materials are removed by a dilute solution of makeup phosphoric acid in the first stage of the crossflow nucleator. The recovered ammonia and phosphates in the dilute makeup phosphoric acid are returned to process via the neutralizer feed stream.

The second stage of the nucleators remove the gaseous fluorides and the submicron ammonia fluoride-bifluoride particulates with a recycle sodium containing liquor. The thermal pickup in this scrubber section is removed in the cooling tower and is not accompanied by gaseous emissions. A slipstream is removed for double alkali regeneration of the neutralized sodium and a fluoride sludge is created at the rate of 480 lb/day.

An alternative in the double alkali regeneration system is to use the sodium fluoride slipstream as makeup water to the first stage of the nucleator (phosphoric acid scrubbing) and return the fluoride (sodium salt) to the fertilizer product. This is reasonably achieved because of the small quantities of fluoride. Again, no ammonia is introduced into the pond.

TESI Dry System

Another approach is to use a dry system that obviates the use of a cooling tower (Fig. 8). This system provides wet treatment for ammonia recovery by recycle phosphoric acid scrubbing in a coaxial venturi. The gaseous fluoride is captured. If the captured fluoride is to be sold as feed for glass furnace operation the optional removal of small quantities of ammonia and phosphates may be removed in the cross flow section. If discharge of the final product to waste is selected then no further wet treatment is necessary.

The gaseous fluorides are removed at elevated temperatures by a dry chromatographic technique (TESISORB) using a dry collector as the reactor. This absorptive process does not require the low temperatures necessary for absorption by water. Submicron particulates (i.e., $NH_4F.HF$) are also agglomerated by the chromatographic technique. Inasmuch as no cooling is required for this collection, a load of 150,000,000 BTU/hr normally imposed on the ponds is circumvented.

The cost of TESISORB is $0.07/ton P_2O_5. The capital cost for the fluoride emission control system is approximately 1/2 of the requirement for a wet system serving the same purpose. Gaseous fluoride emissions are reduced to 1 PPM and particulate emissions to less than 0.01 gr/sdcf.

Testing recently completed by EPA of such a dry chromatographic system at a secondary aluminum installation with inlet fluoride levels of the same order of magnitude as the off gas from a coaxial venturi attained final effluents of 1 PPM HF and 0.0025 gr/sdcf. In a glass furnace control system with inlets comparable to the inlet conditions of a digester scrubber the outlets ranged from 0.1-1.5 PPM HF and 0.005-0.015 gr/sdcf.

Thus, with new control technology already demonstrated, and / or under construction, the pond size can be reduced to 50 to 67% and the total fluoride pond emissions can be reduced as much as 85%. No nitrogen discharge to estuaries can occur. Additionally, a new source of fluorides can be made available to this continent at a time when dependency on foreign sources has become a risk situation.

The environmental hazards created by ponds can now be minimized.

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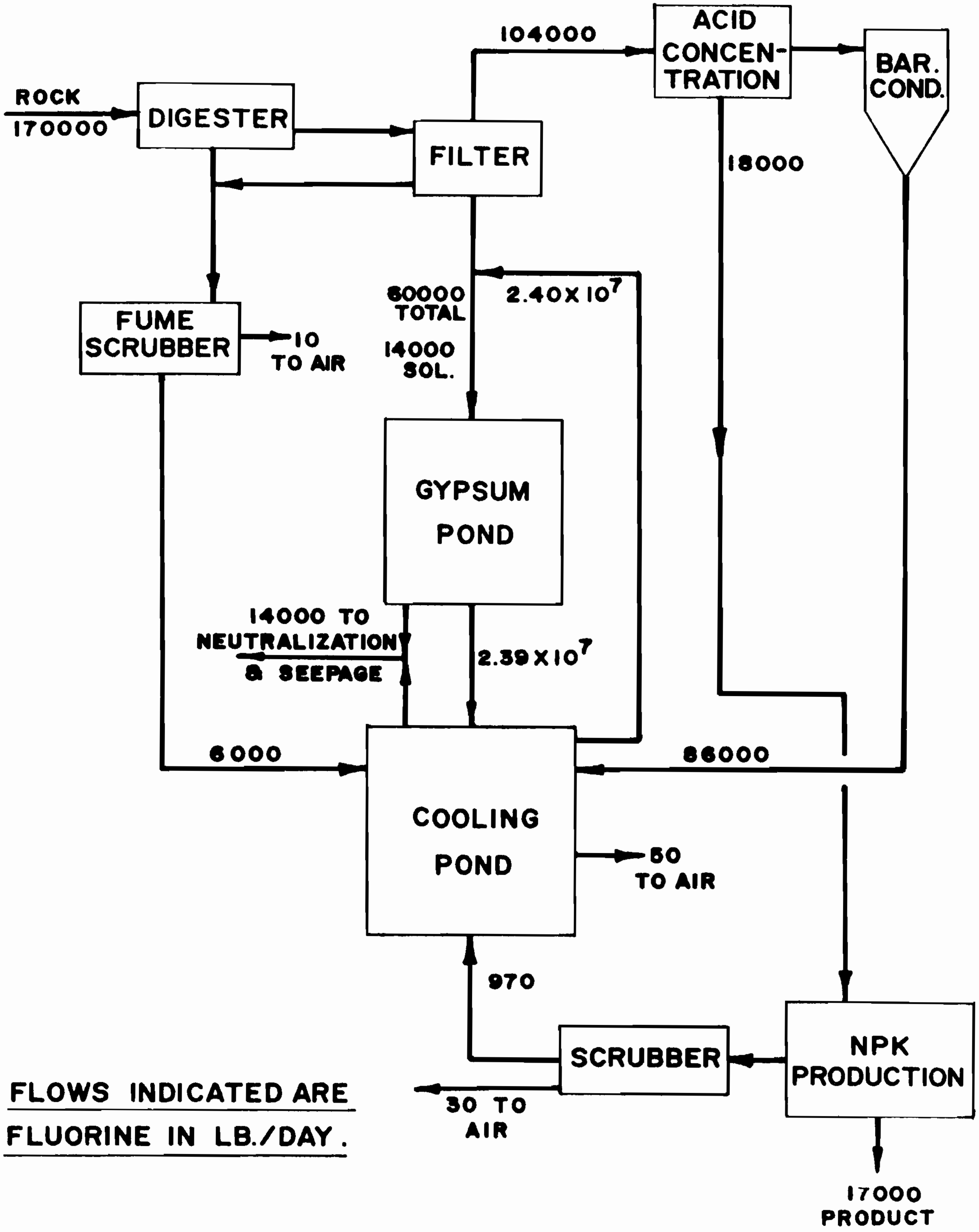
3. "New Developments in Fertilizer Technology", TVA, Nat. Fert. Dev. Center, October 1-2, 1974, Muscle Shoals, Ala., p. 20.

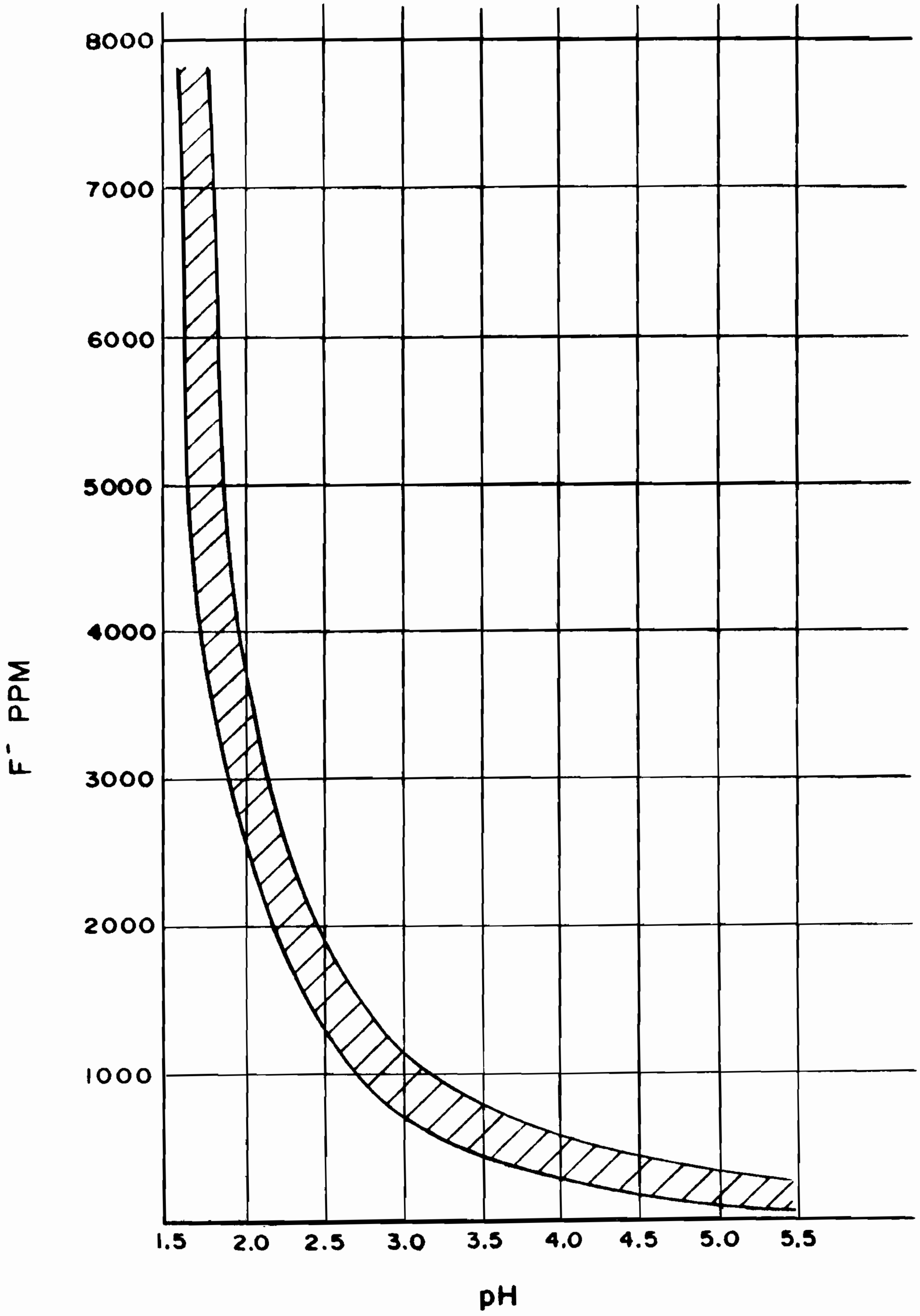


FLOWS INDICATED ARE FLUORINE IN LB./DAY.

TELLER ENVIRONMENTAL SYSTEMS, INC.

DR'N PAK	15 OCT '75	FLUORIDE FLOWS FERTILIZER COMPLEX 700 TPD-P_2O_5	SCALE
CHK'D Frank	15 Oct. '75		DWG. NO. FIG. I
APP'D			

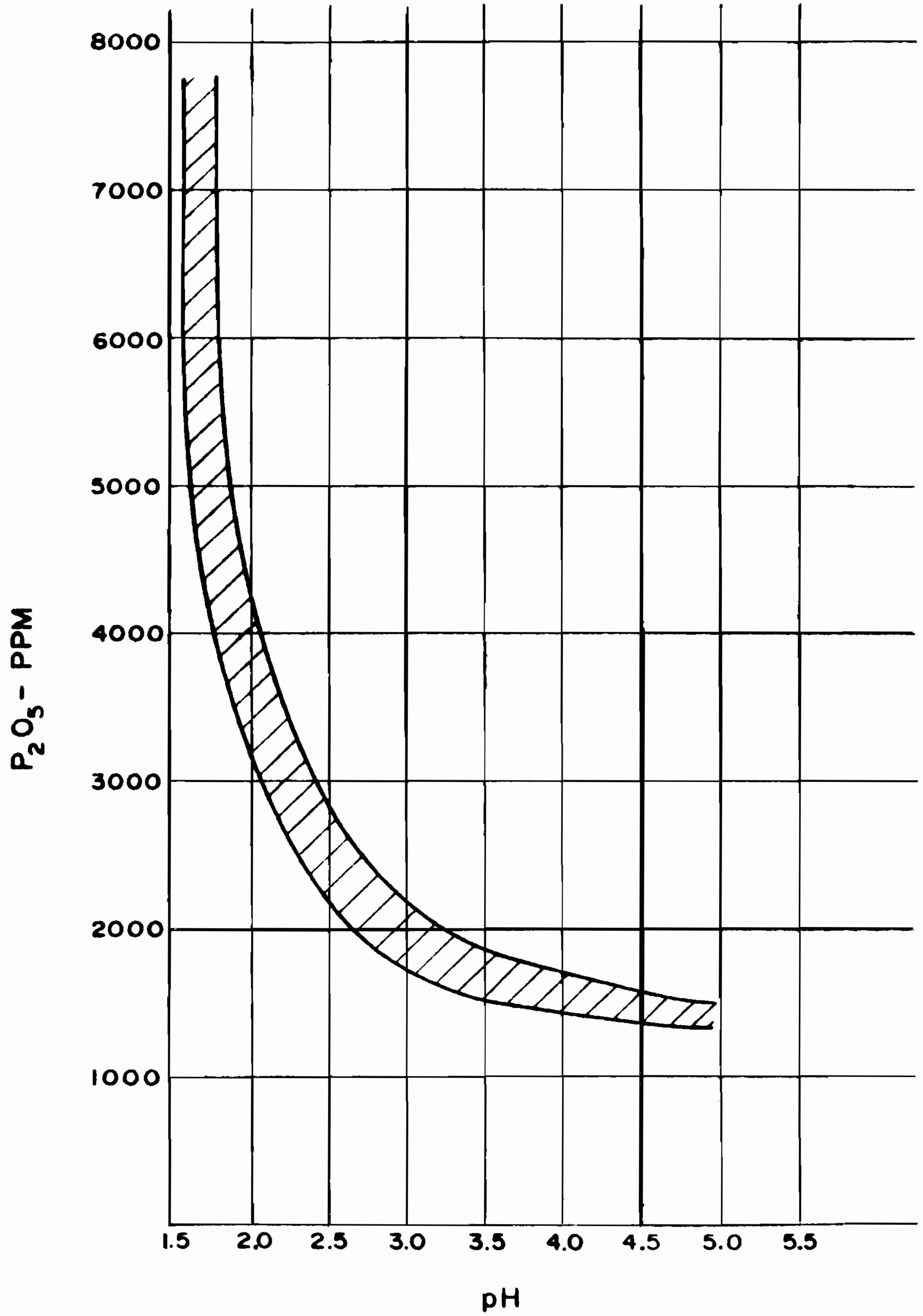
MAKEPEACE P 968



TELLER ENVIRONMENTAL SYSTEMS, INC.

DR'N PAK	20 OCT.'75	POND WATER	SCALE
CHK'D	22 OCT. 75	RELATIONSHIP OF SOLUBLE FLUORIDE CONCENTRATION WITH pH	DWG. NO. FIG. 2
APP'D			

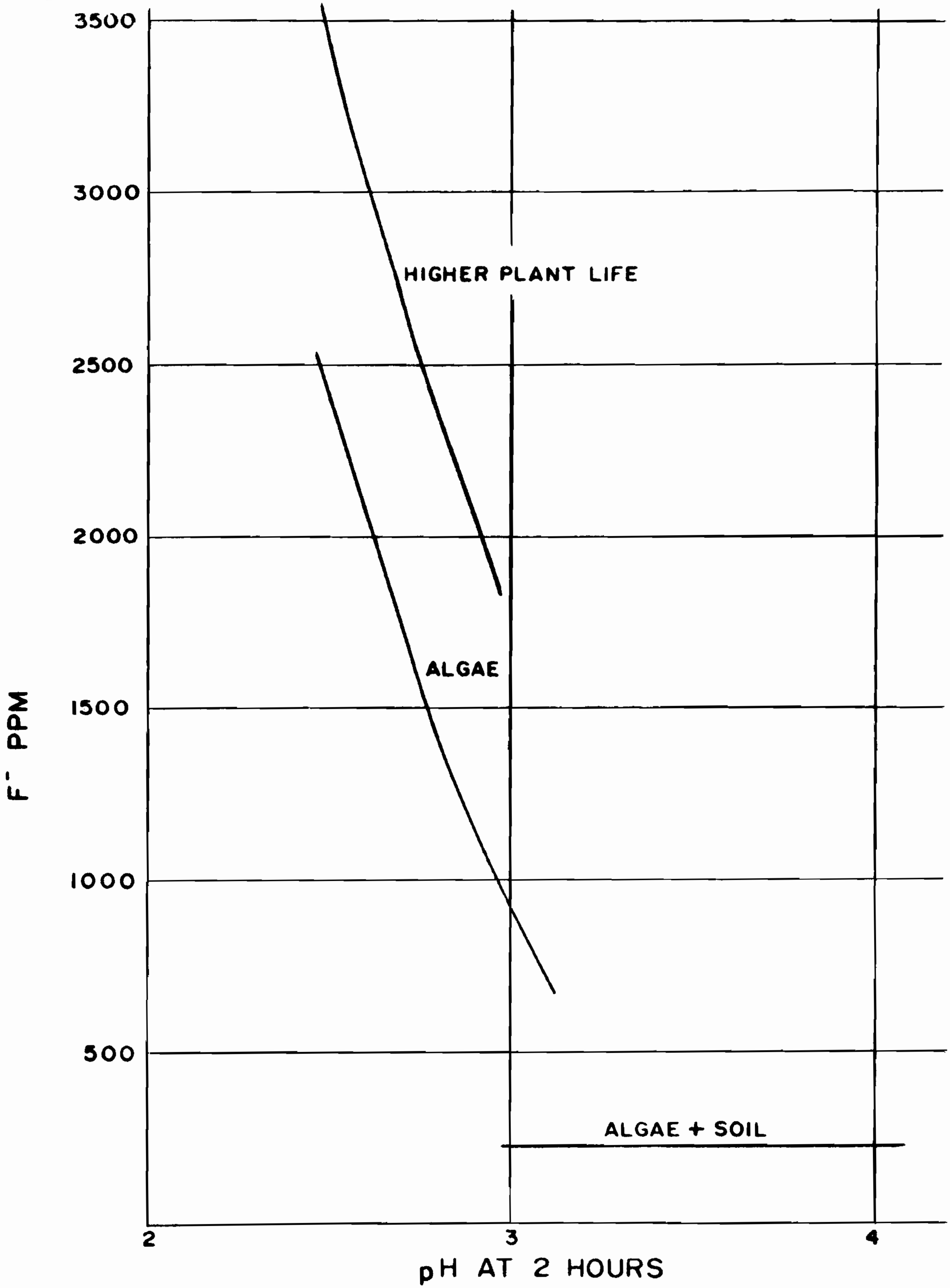
MAKEPEACE P-968



TELLER ENVIRONMENTAL SYSTEMS, INC.

DR'N PAK	20 OCT. '75	POND WATER	SCALE
CHK'D Frank	22 Oct. 75	RELATIONSHIP OF P_2O_5 CONC. WITH pH	DWG. NO. FIG. 3
APP'D			

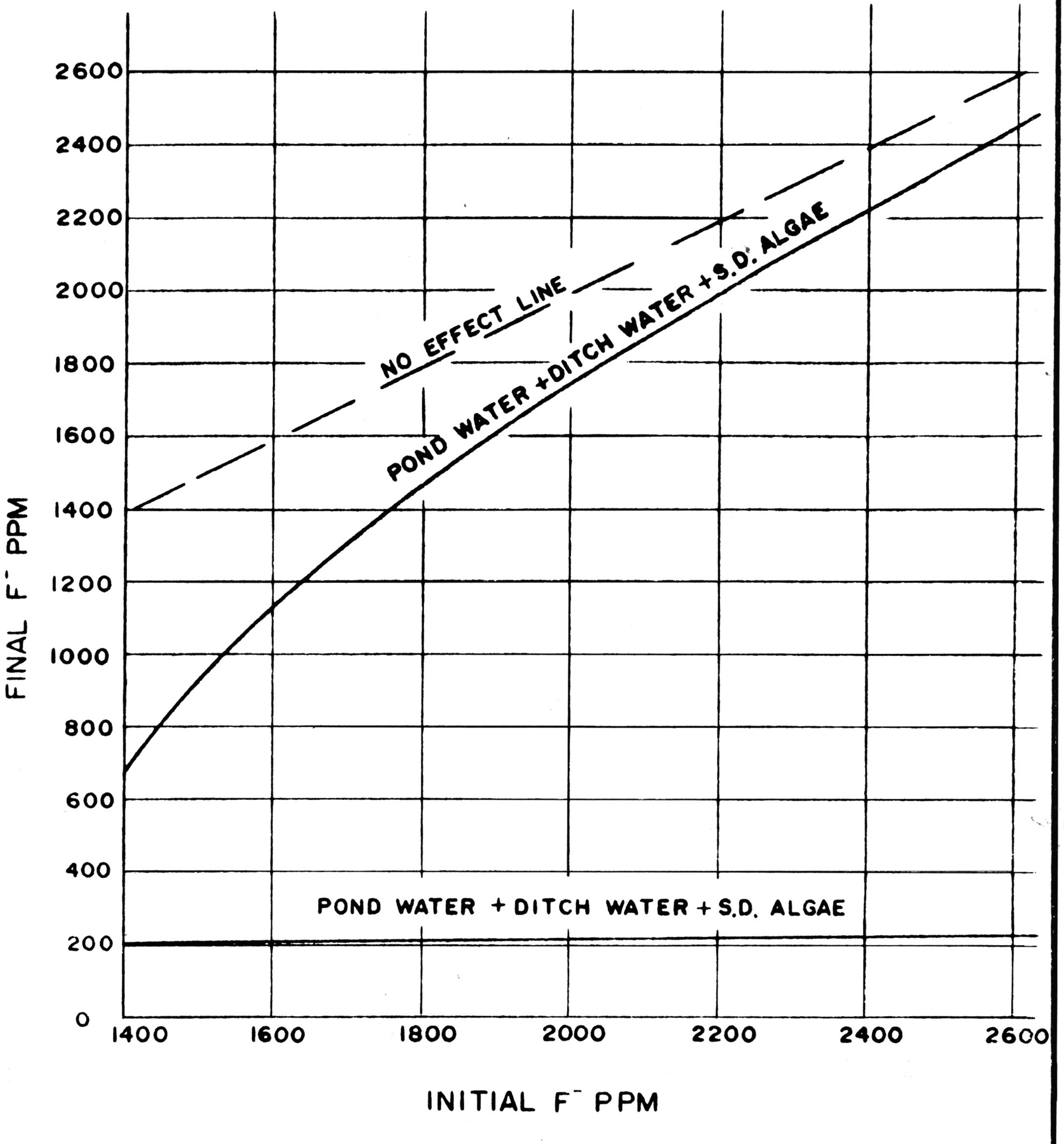
MAKEPEACE P-968



TELLER ENVIRONMENTAL SYSTEMS, INC.

DR'N PAK	20 OCT. '75	RESIDUAL FLUORIDE CONCENTRATION AS FUNCTION OF 2 HOUR pH LEVEL WITH BIOLOGICAL TREATMENT OF POND WATER-DITCH WATER MIXTURES	SCALE
CHK'D	22 OCT. 75		DWG. NO. FIG. 4
APP'D			

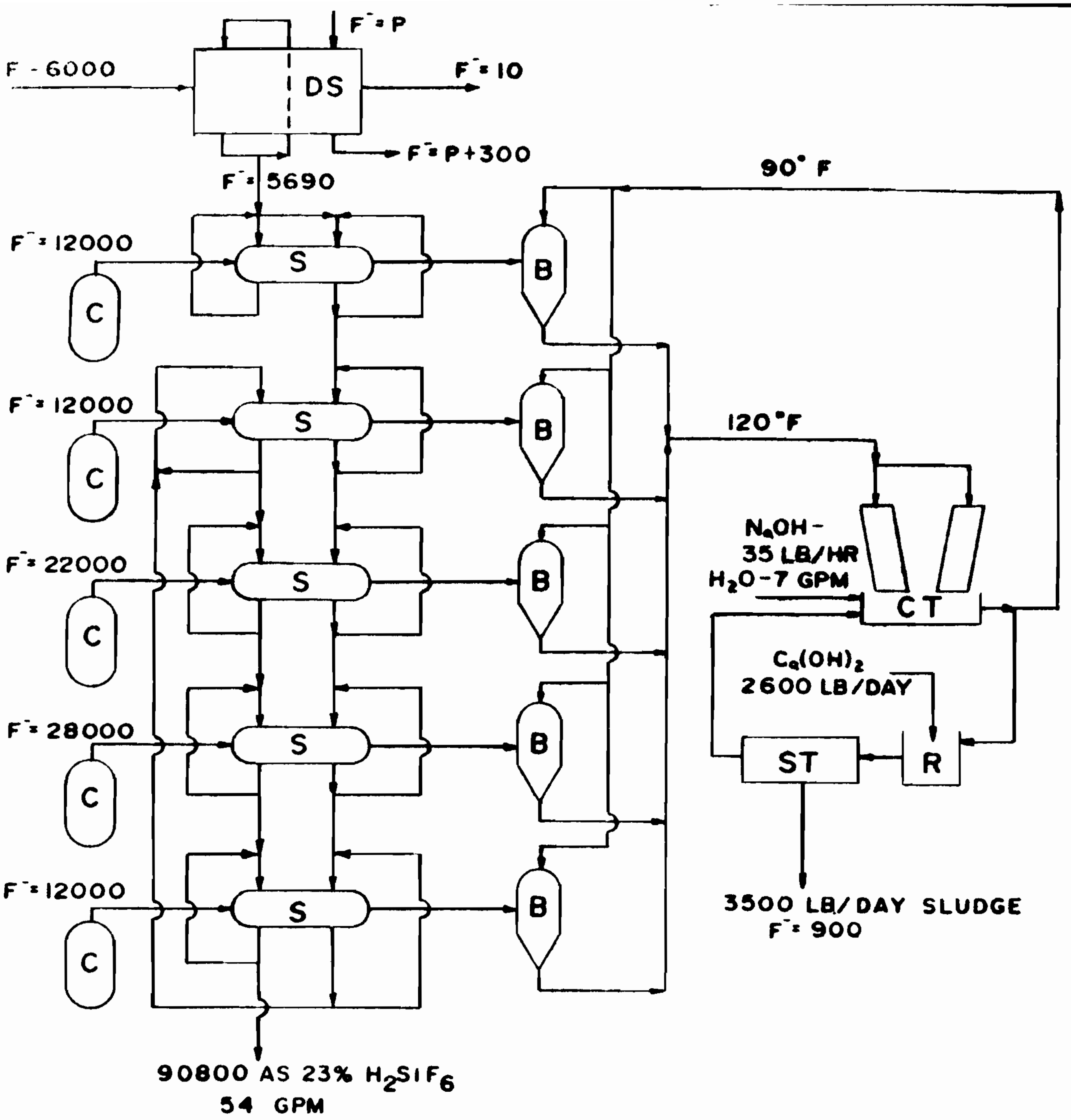
MAKEPEACE P-968



TELLER ENVIRONMENTAL SYSTEMS, INC.

DR'N PAK	20 OCT. '75	POND DATA	SCALE
CHK'D	22 Oct 75	8/11/71	DWG. NO. FIG. 5
APP'D			

MAKEPEACE P-968

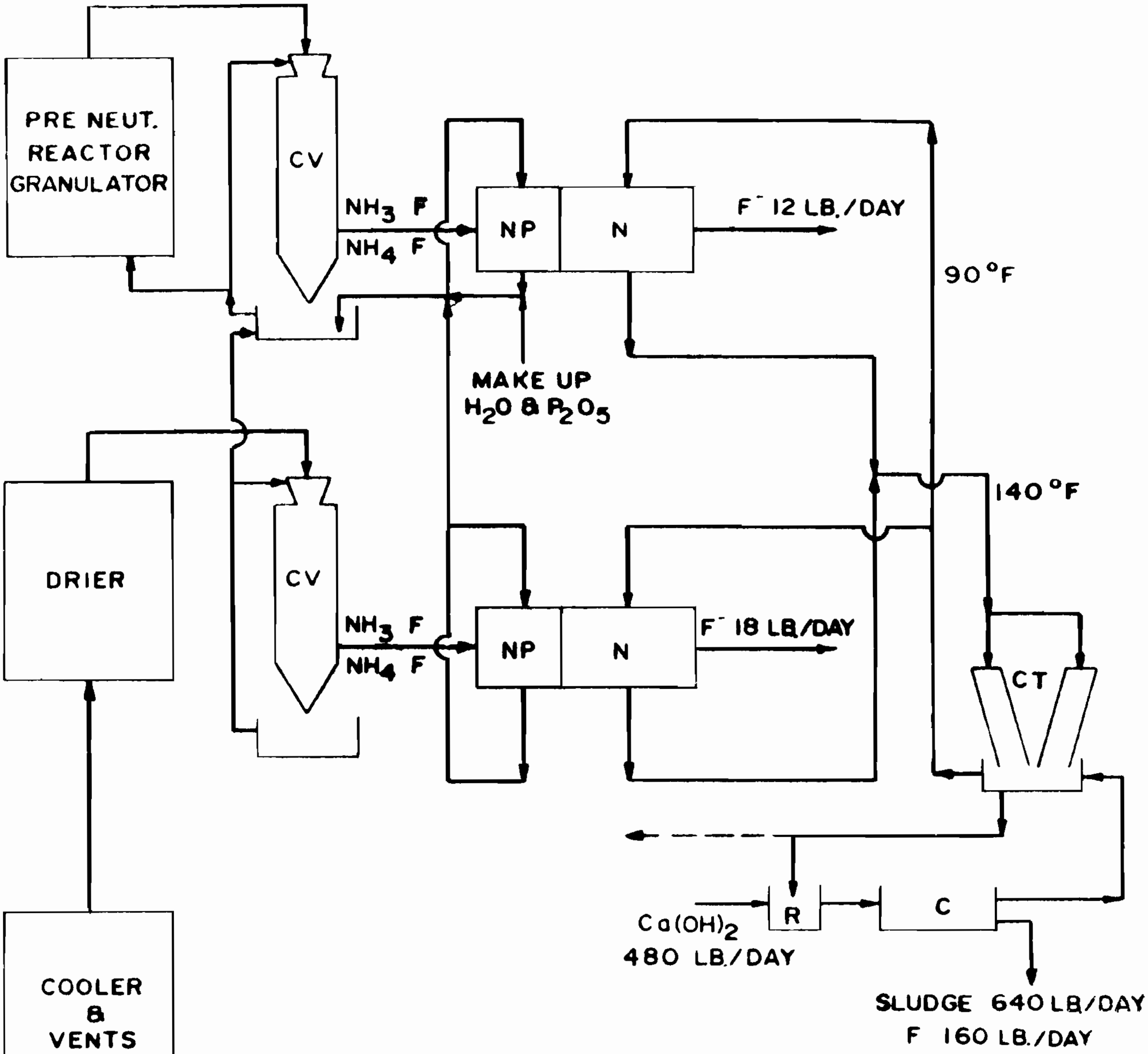


FLOWS INDICATED ARE
LB./DAY FLUORIDE

B - BAROMETRIC CONDENSER
C - EVAPORATOR OR VACUUM COOLER
DS - DIGESTER SCRUBBER
S - SCRUBBER
CT - COOLING TOWER
R - REACTOR
ST - SETTLER
P - LB./DAY FLUORINE IN POND WATER CIRCULATION

TELLER ENVIRONMENTAL SYSTEMS, INC.

DR'N P.A.K.	17 OCT. '75	FERTILIZER - 700 TPD - ACID CONCENTRATION EMISSION CONTROL	SCALE	
CHK'D Frank	17 Oct. '75		DWG. NO. FIG. 6	
APP'D				



CV - COAXIAL VENTURI

NP - NITROGEN-PHOSPHOROUS REMOVAL SECTION

N - NUCLEATOR

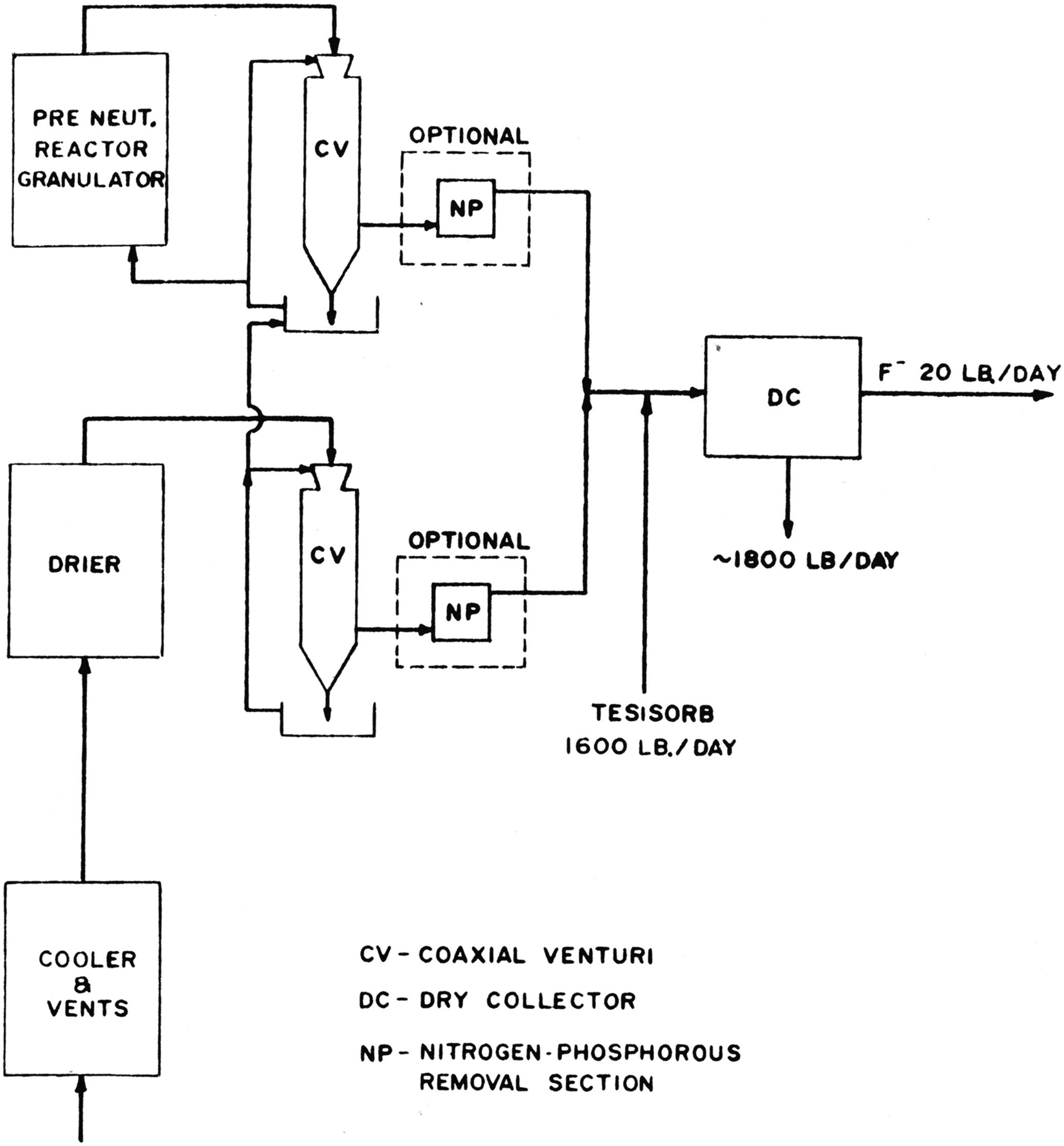
CT - COOLING TOWER

R - REACTOR

C - CLARIFIER

TELLER ENVIRONMENTAL SYSTEMS, INC.

DR'N PAK	21 OCT '75	FLOW SHEET	SCALE
CHK'D	22 OCT. 75	POLLUTION CONTROL SYSTEM	DWG. NO. FIG. 7
APP'D		NPK COMPLEX 700 TPD P_2O_5	



TELLER ENVIRONMENTAL SYSTEMS, INC.

DR'N PAK	21 OCT '75	FLOW SHEET	SCALE
CHK'D Frank	22 OCT, 75	POLLUTION CONTROL SYSTEM	DWG. NO.
APP'D		NPK COMPLEX 700 TPD P_2O_5	FIG. 8

MAKEPEACE P-968

MODERATOR JACKSON: Mr. H. M. (Hugh) Griffith will discuss "Zero Emission". Mr. Griffith is an accomplished "Fertilizer Plant Operator". He entered the industry in 1947, became an assistant plant manager in 1950 and a manager of various plants of the old V-C, Mobil and presently Swift Systems since then.

Hugh's plant at Dothan, Alabama, like many others, has been surrounded by a growing city. The changing area and the company's desire to be a good neighbor dictated updating the plant facilities.

The plant approach to zero emission is an accomplishment of major interest.

Mr. Griffith, please.

Approach To Zero Emission

By H. M. Griffith

At Dothan, Alabama, we have a complete plant — Contact Sulfuric Acid, Continuous Single Superphosphate and Granulation. The original plant was built in 1900 in an area known 'til this day as Acid Plant Hill. As would be expected, over the years, the town has built-up around us.

Through three (3) owners (V.C., Mobil, and now Swift) the main shed suffered the ravages of age and weather. Outbuildings, yards and ditches, and unused property were, to say the least, unsightly. We replaced a typical chamber acid plant with a Contact Plant in 1965. We replaced a Drag Den Superphosphate operation with a continuous unit also in 1965. An old manipulator unit was replaced by granulation equipment in 1964.

Physically, the location has not been an asset to our operation. Besides close residential neighbors on two sides, we have at 150 yards NW an elementary school. Due North about four blocks another elementary school — NE a Church.

Politically things could not have been worse. A town of 40,000 people; fall elections ousted the entire City Commission and Mayor — and one new commissioner (in the building and insurance business) happens to own or control undeveloped property on two sides of the plant. This is not to say that all complaints were invalid, but this situation did make negotiations and planning a wee bit tough. For example — after several meetings with the commission and having submitted plans and guarantees on solutions to our problems, money requirements and time tables — all acceptable to Control Officials — we were told, quote *"We don't care what EPA or AAPCC says is coming out of your stacks, if we get complaints from the neighborhood, we'll shut you down for being a nuisance".* (I found out that our town doesn't have a pollution law, but beware of the all-encompassing nuisance law. Nuisance by definition —

> That which by its use or existance works annoyance to another . . . How ambiguous can a law be?)

Recognizing our responsibilities to the community and the changing environment, we began extensive evaluations, planning and physically working toward three major goals —

We wanted to be:

> Operationally Acceptable to control Officials
> Politically Acceptable to City Commission
> Socially Acceptable to Neighborhood

We planned, fabricated, secured materials, dismantled old equipment, installed new and opproximately nine (9) months later — completion and start-up . . .

We completed stack checks and satisfied about 1-3/4 of the three major aims —

> Stack tests revealed we were now well within air quality standards - No. 1 was achieved — we were operationally acceptable

We had eliminated the "snow in the springtime" effect by eliminating the fall-out on neighborhood foliage — no more heavy clouds of ammofluoride, ammo chloride and particulates — the entire exterior of all buildings was covered with corrugated fibreglass siding — sagging platforms and roof lines were leveled, yards and ditches were graded and cut and shrubbery was planted. What had resembled a haunted castle was transformed into a virtual palace. We have had numerous compliments on our facelifting. I'd score probably 75% on the Socially Acceptable item — but we couldn't please everyone.

Because of political involvement, the close proximity of the plant to two (2) area schools that are to be forcibly integrated by Federal Order this year and opposition to this edict — because of unfavorable, ill advised press, we can only hope that what has been done will be enough to permit full and continuous operations.

This has been an introduction to complications that can and will plague industry as city limits and developers creep into what used to be our remote domains — this can happen to you — slowly but surely!

Beware of the Deceptiveness of the Gradual!

Now for our Operational Problem Areas In

> Contact Sulfuric Acid
> Single Superphosphate
> Granulation

State and Federal standards read:

> "No person shall cause or permit sulfur dioxide tail gas emissions from sulfuric acid manufacturing plants to exceed 27 lbs./ton of 100% acid produced. Tail gas acid mist emissions

> are not to exceed 0.5 lb./ton of sulfuric acid produced and the sulfur trioxide emissions are not to exceed 0.2 lbs./ton of sulfuric acid produced." Originally this read 6.5 lbs. SO_2 per ton 100% acid produced, but this has been amended in Alabama to read 27 lbs. on existing plants. However, on new plants or major changes that increase capacity of older plants the law now reads 4.5 lbs. SO_2/ton 100% acid produced.

These restrictions necessitate close supervision and much attention on the part of all operators. *The best emission control system is the operator.*

Our plant has design capacity of 80 t/d 100% acid. The plant was built in 1965 and differs somewhat in general lay-out from most contact plants. We have no hot gas filter; we have a 4-pass horizontal converter; an economizer and a unique design for towers — 6 to 1 ratio as opposed to about 3 to 1 ratio height/dia. on most other plants. Our towers are 6 x 36 and under full load operating conditionss there is *no visible stack* and no misting.

We have made a couple of changes in our efforts to control and monitor tail gases. Since standards relate to ambiant air quality at ground level, we had a model study (computer) made to determine how our plant must operate. From this study, data indicated that a higher stack would give much better air diffusion. We raised the stack from 50 feet to 92 feet discharge level.

Maintaining temperatures, pressures and air and gas levels within good operating ranges, we operate at design capacity approximately 15% below air quality standards.

I might add that we have, at AAPCC direction, installed a Monitoring System for measurement and recording of SO_2 stack emissions. We are required to hold recordings for their review. We date and note all variations on the chart for reference.

Stack tests taken at design capacity were as follow:

SO_2 23.53 lbs/ton 100% acid vs 27.00 standard
Acid mist .074 lbs/ton 100% vs .5 lbs standard

Emissions tests at ground level would be much less. In fact, AAPCC has received no measurable pollution at a mobile monitoring station located on school ground 150 yards from plant.

We have learned that an increase in production over design capacity causes a very sharp increase in SO_2 emissions —

80 t/d yields 23.53 lbs. SO_2
86 t/d yeilds 42.00 lbs. SO_2

A reduction in rate causes a gradual reduction in emissions —

80 t/d yields 23.53 lbs.
45 t/d yields 17.15 lbs.

From this we learned that we can no longer crowd the unit as we have in the past, but must operate at or below design rates.

We have full operating permit for this unit.

We feel that our superphosphate unit is the main culprit in our pollution problems. This has the most offensive odor and neighbors have associated this with the name *Acid* and with the large volumn of granulator emissions.

Fortunately these gases are easy to scrub if you can get them into the scrubber system.

We have continuous acidulating unit. After lining the den with refractory and wood we sprayed with polyurathane foam. This sealed most of the leaks and protects metal surfaces. We have very little gas fumes at operating levels. Our fan pulls approximately 6000 CFM air through two wet scrubbers. Each scrubber uses approximately 80 GPM water from 30 full cone nozzles. Liquid effluent travels through open terra cotta ditch to 3 — 1/8 acre ponds. Liquid is recirculated to scrubbers.

We developed a serious problem inherent with closed systems. There was not enough evaporation and perkolation to require a significant amount of make-up water. Hence, dissolved solids build-up in the liquid and Ph remains at less than 1.5. This liquid has a high content of fluorine.

Using high-fluorine liquid for scrubbing makes a fluorine aerosol from the exhaust stack. This is illegal in most states. Federal EPA and State Water Improvement Commission prohibit dumping of the low Ph effluent so our only alternative is to neutralize the pond water, or concentrate the solution for sale.

We have installed a neutralizing system. We use carbide lime slurry (30% lime by-product of acetylene industry). We have raised the Ph of three existing settling ponds from 1.5 to 6.

We store the lime slurry in a 24000 gallon tank and feed into a reaction tank an amount sufficient to maintain a Ph of 6 + . While we are still in the test and development stage, we have sufficient use data to indicate that we have a workable and practical system. Tests indicate that approximately 3.5 GPM (212 gph) slurry will be required to maintain a liquid effluent Ph level of 6 at our operating rates. The lime slurry reacts immediately with low Ph effluent — we will regulate additive with a Ph regulator and recorder. Cost of neutralizing will be approximately 30 cents per ton of product . . .

TVA has made extensive studies and F P Achorn's paper on fluorine recovery deals with a system virtually the same as ours. One exception is TVA produced their own alurry from hydrated lime.

In the superphosphate production unit, we also had to control dust venting from the Rock Mill. This unit has a designed emission rate of 32 T/H fine particulate. An outside dust bag collector was a disaster with rock of more than 2% moisture and uninsulated ducts exposed to weather. Bags and ducts plugged after a few hours operation. We discontinued the bag collector and installed a vent line from rock mill to super den air duct to scrubbers. This eliminated the exhausting of particulate to atmosphere.

We also have Operating Permit for this unit.

Pollution Control — Granulation

The granulator was built by a leading manufacturer in 1964 — a stacked unit, modified TVA type — rated at 18/20 tons per hour.

Horsepowers were increased and hopper system was added in 1968 replacing a tractor batching system. Tonnage output has been increased to 30 ton/hr.

A major problem was dust flow out of the building. Contributing to this were:

raw material feed elevator — 2 raw material hammer mills — shaker screen and transfer points

On the product side:

Elevators — cyclone discharge chute and transfer point — double deck product screen — oversize cage mill — numerous transfer and spill points

Bag and bulk shipping units were major contributors to our blowing dust problems.

Light, floating dust left from all building openings — we had a typical fertilizer building — missing windows and doors and so many pieces of missing siding that pigeons and starlings could fly through instead of flying around.

Another major problem was stacking — Fuming, Smoke and Particulate — The fuming and smoke caused by overheating product in dryer.

Particulate emissions were the result of inadequate cyclones, inadequate screening, poor scrubbing and inadequate movement of air through the entire system. Undersizing and poor location of original equipment was a major factor.

Cyclones were low efficiency and were located on the 4th level — all ducts were outside. This made it impossible to keep gas temperature above dew point which in tern permitted rapid build-up and plugging of the air system.

The scrubber was coated fibreglass — low efficiency with inadequate water-air contact. Efficiency was adversely affected by low movement of air (24000 CFM) with fan located on end of system handling cool, wet air and particulate. Wet fan, on top level, was constant source of cleaning and repair problems.

The ammoniator stack entered the scrubber at right angle upstream of air duct baffle in area of spray system. This contributed to fuming and particulate problems by causing uncontrollable build-up of moist solids in the duct restricting air flow.

Stack test with this equipment — clean — at a rate of 18 to 22 tons per hour revealed particulate emissions in excess of 25#/hour.

Scrubber liquid effluent was a part of a joint Superphosphate/Granulator closed circuit — This meant scrubbing with very low PH. Liquor with high fluoride content. This also contributed to fuming conditions.

Another problem was: In-Plant Dust. Primary cause of this was a poor flow pattern — i.e. cyclone discharge and fines from screen entered the elevator feed with weighed raw material via approximately 30 feet drop from cyclone gate and from the screen discharge. This drop of fine dry solids into the elevator provided the motive power to blow the dust.

On the cooler elevator the cage mill crushed oversize screenings and fed into back side of product elevator. Air induced by the falling material provided motive power for blowing huge clouds from this transfer point.

With the stacked system and much floating dust and moist air — product screen performance was greatly reduced, and dust in and around product screen was unbelievable.

Now that I have defined problem areas, I will outline some of our thinking and our approach to solutions of these problems.

Brainstorming this unit revealed a real need for changes in several areas —

It was obvious that equipment was poorly located and undersized.

(a) Fan & Drive were enlarged to improve movement of air from approximately 34000 ACFM to 42000 ACFM — Fan was relocated from the upper level at end of system where it handled only cool, wet gas and particulate, to the ground level between the cyclones and scrubber to handle only hot, dry gas and particulate.

(b) Cyclones were undersized and poorly located on top level. All duct work was outside and not insulated. Two small inefficient cyclones were replaced by three (3) high efficiency long cone, low pressure drop units X— new units are also located at ground level and all duct is inside.

(c) Dryer inlet temperatures were destructively high (in excess of 1600 degrees F.) Dust laden air was pulled thru the furnace combustion chamber. The very high temperature deflurinated the Superphosphate Dust. This flourine and chlorine from overheated potash combined with Ammonia in the dryer to form heavy clouds of ammonium floride and ammonium chloride — These hung heavy over the surrounding neighborhood.

We had to reduce the furnace temperature if we were to correct overheating and fuming conditions.

To accomplish this the entire furnace was jacketed and a tube fan supplies dust — free air thru secondary air ports at a rate equal to air moved by dryer fan. With this change all air will have passed thru the furnace.

This reduced maximum temperature to 800 and eliminated fuming under operation conditions — bonus rewards were added:

Lower heat will greatly extend life of dryer shell, chutes, flights, ducts, and refractory while providing much better working conditions for the entire granulation crew.

As would be expected there is a definite relationship between air flow, dryer temp and particulate. In the new vs the old units:

24000 CFM 1600 degrees F.
25#/hr particulate
42000 CFM 800 degrees F.
5#/hr particulate

Our No. #1 material elevator with a hog mill, two hammer mills and shaker screen was a major dust source — We challenged whether or not particle size of materials was really a factor toward improved physical and chemical quality. We designed, built and installed an oscillating grating to replace the hog mill — this handled materials so easily without dusting and without excessive large lumps that we removed the two hammer mills and the screen. This greatly reduced dust in plant and blowing out of building.

No. #2 Elevator — was a major contributor to in-plant dust.

Very fine cyclone dust, free-falling from cyclone discharges, fines returning from product screen with entrained air down screen chute; fine raw material feed — these were directly related to poor equipment location.

Our solution to this was relocating equipment.

Product screen, formerly 4 x 15 double deck vibrator type was enlarged to 4 x 20 with mechanical vibrators. This unit was turned 90 degrees and fines are fed by screw conveyor directly into charging end of Ammoniator.

Two low efficiency cyclones were replaced by three high efficiency, long cone, low pressure drop units and fines are returned via screw conveyor to the elevator — cyclines placement at ground level eliminated the long discharge chute. Raw materials are still fed in original manner. We have eliminated the floating dust at this point.

The No. #3 or product elevator had a similar problem to No. #2. Crushed oversize falling from screen thru cage mill and then via long chute provided motive power for blowing dust. By relocating the screen we then were able to put crushed oversize directly into the cooler. Fines and floating dust are stripped-off in air flow to cyclones. Sharp edges are rounded thereby reducing dust by attrition in shipping areas. Warm, soft, moist centers of the crushed oversize are cooled and liquid phase is reduced thereby reducing product screen blinding. With this change we now keep screen covers in place 100% of the time even though we can open covers while operating and have no billowing of dust.

There is no dusting at elevator feed; there is no dusting in chain mill area; no dusting at transfer point to storage; and only a negligible amount is visible in the storage area. I might add that while the old screen required much cleaning (at least daily — sometimes more), we now have cleaned on an average of once each 10-12 working days.

Scrubbing is performed with two low pressure drop Venturi scrubbers in series with entrainment separators after each scrubber. The use of two scrubbers allows the final scrubber to operate with minimum solid content of the recirculated water and to cool and condense water vapor on the very small particles giving an easier target to scrub. We feel the two stage scrubber gives top scrubbing efficiency with minimum operating problems. Water is taken from the #1 scrubber and used for process control. All water is used in process, none is drained off in normal operation. We feel we return about a ton of material per day to the product. We had to clean the scrubber one time in eight (8) months because of excess solid build-up. Scrubber water is sampled hourly by filling a graduated cylinder to the 100% mark. The solids are allowed to settle for about 15 minutes and the volumetric quantity of solids indicated is logged with the hourly records. The normal solid content is about 5% for most of our grades. An abrupt rise would obviously indicate a cyclone plug-up. This can be a big help on the night shift.

The small volume of water (approximately 3500 gallons each unit) allows rapid Ph changes depending on grade being manufactured. This Ph variation with large volume of floating abrasive particulate has damaged the No. #1 Venturi to a point requiring replacement. While the replacement is also steel, before installation we lined it with high density polypropylene sheeting. All joints of poly were welded and poly patches were welded over flat bolt heads to prevent liquid from reaching the metal. We know this will greatly improve the life of this unit.

As a general aid to clean-up and maintenance all upper floors are heavy duty expanded metal decking. This allows minor spillage to fall to ground level for ease in cleaning. The area around the cyclones, pumps, scrubbers etc. is cement floor with curb walls — this permits easy cleaning with water hose.

There are numerous other small items that aid in controlling the operation to prevent unwanted emissions. Most of these are just plain good operating practices and experience has proven these to be extremely important for overall control of pollution as well as chemical and physical quality:

(1) Properly sized, spaced and maintained spargers — prevent buildup in ammoniator — prevent hot spots (oversized holes) gives uniform liquid/dry material contact
(2) Conveniently located flow controls — preferably recorders for historical checks located with easy access for operator
(3) Warming signals — very important on: dry

feed — acid — scrubber pumps

(4) Conveniently located electrical controls

(5) Closely timed batching intervals: No big gaps in material feed to cause wet & dry spots

(6) Accurately weighed and metered materials

(7) Well trained operators and constant alert and aggressive supervision is a must and is still one of the greatest guards against pollution episodes.

Experience has proven one thing to us comparing our new system with the old; and I want to be sure that I leave this thought with you!!

> "*A DUST CONTROL SYSTEM* WHILE IS INCORPORATED INTO PROPERLY LOCATED, PROPERLY SIZED EQUIPMENT IS MUCH BETTER THAN A *DUST COLLECTING SYSTEM*"
>
> WITH THIS AS A BASIS OF ACTIONS, *WE ARE APPROACHING ZERO EMISSIONS IN DOTHAN BY ANYONE'S DEFINITION*

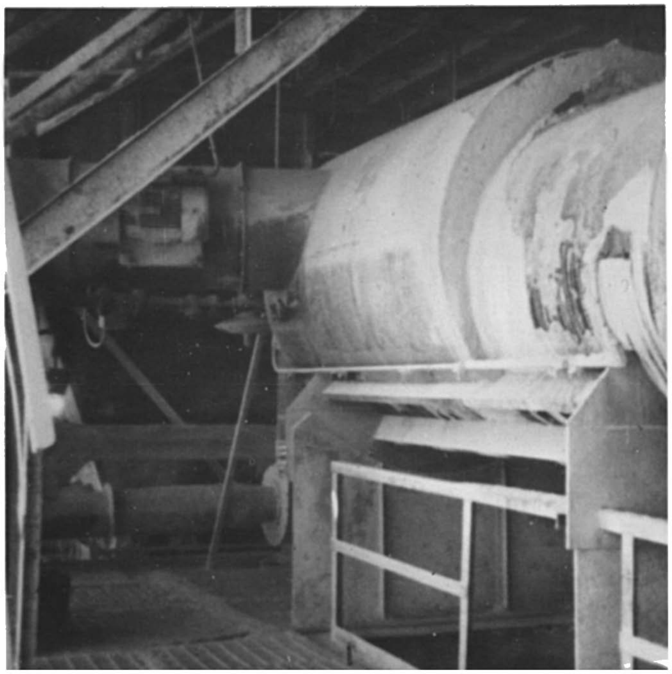
The following descriptive slides will give you the highlights of my discussion. Thank you.

Slide #2

Building and stacking before control started.

Slide #3

Building and stacking after control system was installed.

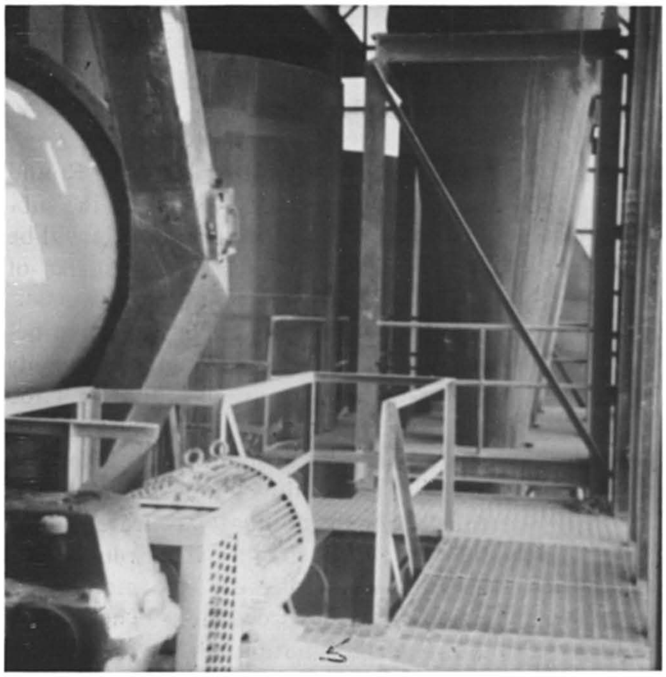


Slide #1

Furnace jacket. Piping Clean Air to Burner reduced burner temperature from 1600' to 800'.

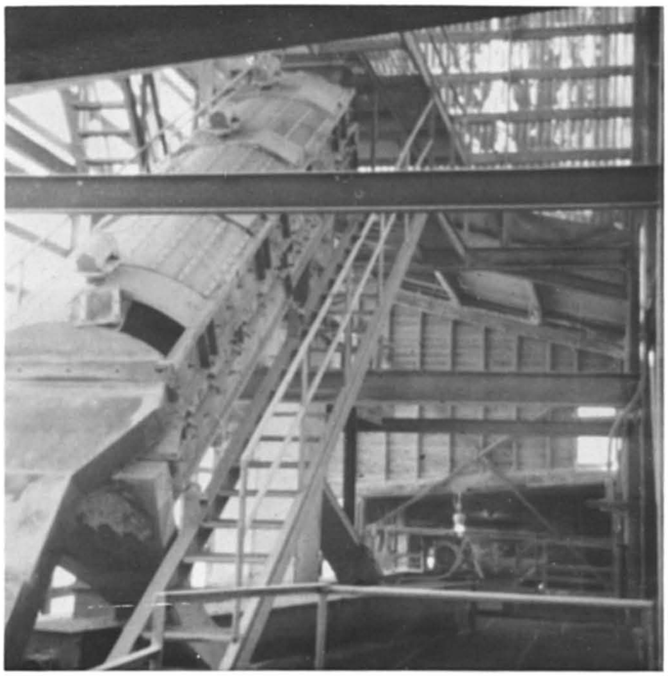
Slide #4

Contact sulphuric acid plant. No visible stacking from absorbing tower stack.



Slide #5

Dryer and cyclones. Union in full operation.

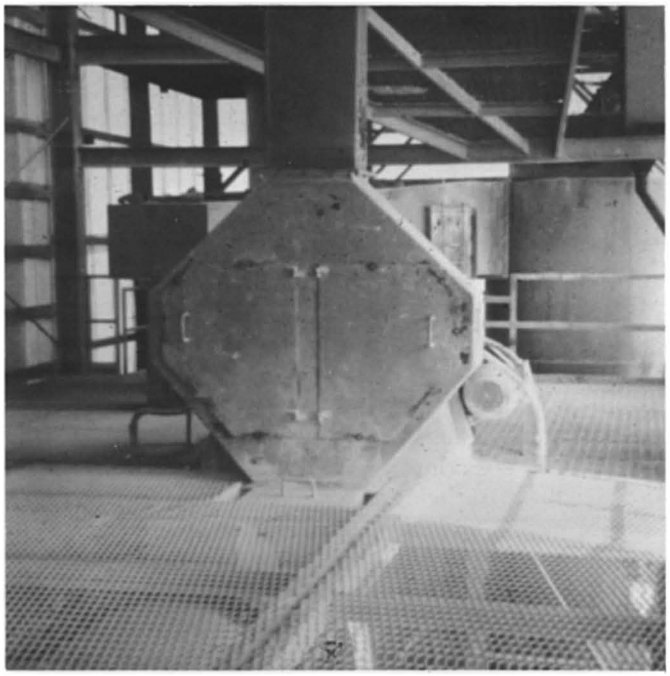


Slide #6

Dry material feed belt.

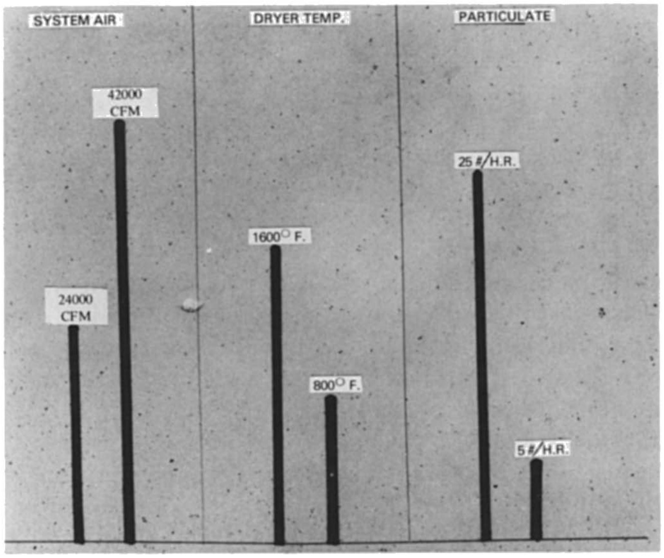
Slide #7

Screen with covers operating at full load at 30 tons per hour. No dusting.



Slide #8

Oversize chain will mill in operation. 30 tons per hour.



Slide #9

Air temperature particulate relationship of temperature/particulate with increase air flow thru system.

MODERATOR JACKSON: Mr. John L. Medbery will discuss "OPACITY" relating to emissions from process stacks of conventional N-P-K. ammoniation granulation plants. John has actively engaged in fertilizer manufacturing for 23 years. During this time he has served with International Minerals Corporation as plant manager, technical supervisor and at present is Director of Operations and Production with the Rainbow Division, the fertilizer manufacturing and marketing unit of International Minerals and Chemical Corporation.

His responsibilities include any function of the plant that helps or hinders its acceptance in the neighborhood. Visibility of the plant, whether real estate or transit plume are equally important.

John's paper relates to his experiences with measurements, causes and control of visible plumes.

John is a graduate of the University of Minnesota, June, 1949 — Bachelor's Degree Chemical Engineering.

Employed by U.S. Bureau of Reclamation, Department of the Interior on Water Resource Study, 1949 — 1952.

John joined International Mineral & Chemical Corporation, January, 1952 and served at a number of locations including Mason City, Iowa; Cincinnati, Ohio; Atlanta, Georgia; Fort Worth, Texas; Chicago, Illinois; etc.

John please.

OPACITY

J. L. Medbery

Fellow members of The Fertilizer Industry Round Table, I have been asked to present a paper on the subject of Opacity. The context in which this subject will be discussed relates to emissions from process stacks of conventional N-P-K ammoniation-granulation plants.

An old saying is, "Beauty is in the eye of the beholder". We might paraphrase that by saying, "Opacity is in the eye of the beholder". Actually, this is not too far from the truth; opacity is usually quantified by visual measurements made by a qualified observer. He becomes qualified by "calibrating his eyeballs". He is certified by demonstrating his ability to accurately judge the amount of light passing through a stack plume. His certification must be renewed every six months by repeating the qualification procedure. The entire procedure for visual determination of the opacity of emissions from stationary sources is given in Appendix A, Federal Register, Vol. 39, No. 219, of Tuesday, November 12, 1974.

It is not in the scope of this paper to re-hash the Federal Register; there are, however, a few aspects which relate to our problem in the fertilizer industry, and in this regard they shall be mentioned.

A number os states which have promulgated an opacity regulation for fertilizer plants have exempted "uncombined water vapor" from the opacity limitation. What they are saying in effect, is: "if the obscuring of visibility by a stack plume is caused by particulate matter, it is objectionable, but of the obscuration is caused by a water vapor fog, it is OK". That is somewhat paradoxical, and also poses a number of practical problems. For instance, how do we know what causes the plume, water vapor or aerosols? Aerosols are the very small particles of fertilizer salts which are airborne in the stack emission.

The Federal Register, in the cited reference, attempts to clear this up. For example, it states in Paragraph 2.3.1, "Attached steam plumes. When condensed water vapor is present when it emerges from the emission outlet, opacity observations shall be made beyond the point in the plume at which consensed water vapor is no longer visible. The observer shall record the approximate distance from the emission outlet to the point in the plume at which the observations are made ". It further states in Paragraph 2.3.2, "Detached steam plume. When water vapor in the plume condenses and becomes visible at a distinct distance from the emission outlet, the opacity of the emissions should be evaluated at the emission outlet prior to the condensation of water vapor and the formation of the steam plume".[1]

As practical plant operators, we all know that atmospheric temperature and humidity govern where condensation will occur. Usually, on a cool morning, condensation will occur in the stack and a steam plume will exist at the stack opening. We also know that, on a warm afternoon, a gap will often appearr at the mouth of the stack and the plume will appear a short distance away, and that this plume will be much less noticeable than that occuring during the morning, all else being equal; the formula, dryer temperature, operating techniques, raw materials, recycle load, etc. What I am saying is that the outward appearance of a plume may vary greatly from time to time, but that the actual particulate emissions will be substantially unchanged.

The authorities, in attempting to regulate particulate emissions have hit upon opacity as a handy way to monitor the amount of such emissions. Since opacity measurements must be made by qualified observers viewing the stack under the most favorable of conditions, this is a somewhat subjective method of enforcement. For this reason, automated stack monitors have been developed. These are "electric eye" devices which "read" the amount of blockage of visibility across the diameter of the stack. They are usually mounted on the stack wall in a region of non-turbulent flow and yet close enough to the base of the stack so that condensation of water vapor has not yet occured. A flow of clean purge air keeps the "eye" from being coated-over with dust, water droplets or settled fume particles.

There are a number of practical problems with automated stack monitors too. For instance, they must be calibrated and serviced frequently. The purge air supply must not fail, and fluorine etching of the glass surfaces can certainly effect the accuracy of the reading and the service life of the components. Because the purpose of opacity readings is the measure the output of particulate matter, perhaps another way to resolve the problem is available. This would be via a mathematical correlation of operating parameters with a measured particulate emission. The known relationship can be computer programmed and a predictable percentage of opacity or a Ringelmann number can be inferred. (For comparison, Ringelmann 2 is equivalent to 40% opacity.)

At the August, 1974, meeting of the American Chemical Society in chicago, Mr. M. H. Hyman and Mr. F. L. Pizzimenti; of Fredriksen Engineering Company, presented a paper wherein this approach is discussed.[2] They report that their company has developed a correlation between opacity and grain loading of fine particulate emissions for a number of different fertilizer production applications. They go on to state, "If efficient abatement devices are employed, then the particulates finally discharged are mainly submicron in size. This is where the potential for opacity (caused by light scattering) is the worst." They went on to show a straight line relationship between opacity and grain loading of sub-micron particulates for any diameter of stack. This approach is completely immune to the often confusing and frequently inaccurate opacity readings obtained visually when a water vapor is present.

Several years ago, IMC made a rather thorough study of particulate emissions and scrubber efficiencies for a variety of operating conditions in a 30 TPH granulation plant. These studies were made on a 5-10-15 grade to minimize formulation variables, but other grades and formulas were studied too. This data was summarized in a paper given at the 1967 Fertilizer Industry round Table by J. A. Hammett.[3] The most troublesome visible emission constituent was identified as ammonium chloride. It was found that a concentration of ammonium chloride of .001 grains per cubic foot is invisible to the human eye. It was also found that concentrations of .003 grains per cubic foot are barely noticeable and cause virtually no opacity in a stack emission. The objective of scrubbing, then, must be to reduce the particulate concentration to within a range of .003 grains up to about .007 grains per cubic foot of stack gas released. This will comply with the 20% opacity standards of two states in which we operate.

We favor a combination approach to solving the opacity problems. First, reduce the quantity of submicron particulates as much as possible by controlling operating conditions, equipment and formulations. Secondly, use a scrubber with enough particle removal efficiency to reduce the emission to an acceptable outlet grain loading. The balance of this paper will deal with our program for accomplishing these goals.

I have a number of slides, and I will show these, with brief captions, at the conclusion of my presentation.

The Biblical King Solomon, writing in the Book of Ecclesiastes made a number of philosophical observations. One of these said, "There is nothing new on the earth". As I prepared this paper, I reviewed the proceedings of previous meetings of The Fertilizer Industry round Table and I found a vast number of references concerned with means of preventing, reducing or controlling fume and dust emissions from dryers and ammoniators. Those of you who attend the round Table frequently may find much of what I have to say to be repetitous. Accordingly, I will be brief and will include in the bibliography a list of references which will be convenient for those wishing to obtain more information on a particular item.

The generation of fume in dryers was very thoroughly discussed by a number of authors who have papers at the 1958 round Table meeting. Lang[4] discussed the generation of fume caused by the overheating of particles of fertilizer in the dryer. He pointed out that material which stays on the feed chute or the dryer flights and is heated to an excessive temperature will generate a considerable amount of fume. He also described laboratory studies wherein they raised the temperature gradually through a range of 200 degrees to 300 degrees, and so on, and the heating brought about a progressive increase in the amount of smoke generated. He explained the relationship of radiant heat, such as would be produced by the hot refractory surface of a furnace lining, and the resultant formation of fumes. He concluded that shielding of the fertilizer material from the luminous heated surfaces would be necessary to control the generation of fume, even in situations where the combustion chamber temperature itself was kept in the 700 degrees to 900 degrees temperature range.

Alfrey and Bridger[5] gave a paper comparing countercurrent and co-current dryers. They referred to laboratory studies which determined the temperatures at which visible fumes would evolve for six granulated mixed fertilizer grades. These temperatures range from just under 300 degrees F. for 10-10-10 to just over 500 degrees F. for 15-15-15. X-ray diffraction analysis of the fume showed that ammonium chloride was the primary constituent. In the case of a no-potash fertilizer, an ammonium-fluosilicate and another unidentified phase were present and these were the main constituents of the fume. Very small amounts of fertilizer produce tremendous amounts of fume which infers that only a small part of the fertilizer in the dryer throat, or caked on the dryer feed chute, need be overheated to produce copious volumes of fume. they identified three possible circumstances that would produce fume:

1) Very small particules of fertilizer suspended in the inlet combustion gas.
2) Fertilizer sticking to the dryer feed chutes or flights.
3) Fertilizer spilling into the furnace.

A number of pilot plant studies were discussed wherein various aspects of these three circumstances were investigated and proved. It was also shown that counter-current drying was much less prone to produce fume that co-current drying. Additionally, counter-current drying required less fuel to achieve the same amount of moisture removal.

D. E. Bonn[6] presented a paper concerned with particulate removal and medium pressure drop wet collectors. He included the Sylvan chart which is a comparison of emission particle sizes, the type of processes which produce these particles and the type of control which would ordinarily be used to capture these particles. This particular chart is a valuable part of any engineer's technical reference library. He also includes some very useful information on fan laws, the relationship of volume and static pressure and horse power, and ties this to operating parameters normally encountered in air handling situations.

In the proceedings of the 1961 Fertilizer Industry round Table, Mr. gilbert G. Schneider[7] gave a very complete paper giving the characteristics of the various control devices — bag collectors, scrubbers, etc. which are commonly used. This is a particularly useful general information type of reference.

At the 1965 Round Table, Larry Samules[8] gave a paper on ways to control dust and fumes in the fertilizer granulation unit. Practically every one of the items mentioned by Mr. Samuels are employed by fertilizer companies today in their constant quest to reduce fume. Rather than discuss each item separately at this time, I will cover them a little later when we talk about the programs employed by IMC.

At the same meeting, David E. Bonn[9] gave a paper on equipment and methods for controlling air pollution problems associated with fertilizer plant operation. This is another very excellent reference source for general information on scrubbing devices.

The references cited so far have treated dust and fume emissions in general terms, or as generated by fertilizer dryers. We also know that fume can be produced by the ammoniator. Ammonium chloride is released whenever sulfuric acid and muriate of potash combine in the ammoniator to make muriatic acid. The muriatic acid is subsequently contacted by free ammonia and the ammonium chloride is released as a copious white cloud of sub-micron particles. the stack is also saturated with water vapor and the sub-micron particles become enveloped with a thin film of water fog. The moisture layer increases the refractive index and light scattering characteristics of the particles, making the appearance of the stack emission much heavier than would be the case if the moisture were not present. The actual amount of ammonium chloride involved is generally very small in terms of pounds per hour, but appears to be immense from the appearance of the stack.

The ammonium chloride from an ammoniator stack can be removed by high pressure drop scrubbers. These units are not too expensive to build but tend to be quite expensive to operate because of the high electrical energy consumption. The combination approach to controlling sub-micron particulate emissions from an ammoniator is probably the most economical. This is the two-step control program which I mentioned earlier. First, reduce the amount of the ammonium chloride generated in the ammoniator by:

1. Good sparger arrangement, proper spacing and proper drilling.
2. Proper maintenance of the spargers.
3. Formulation to avoid use of excessive amounts of sulfuric acid.
4. Substitution of phosphoric acid for sulfuric to whatever extent is possible.
5. Not exceeding the heat load capacity of your ammoniator drum.

I would like to mention in this regard that we have successfully reduced fume emission by mixing sulfuric and phosphoric together in a mixing tee prior to sparging the mixed acid under the bed. We have found that this produced much less fume than would occur with the same formula if the sulfuric was sparged under the bed and the phosphoric was sprayed on the surface of the bed. We have also reduced the amount of fume produced by using 78% sulfuric acid rather than 93%. The sparger arrangement, which we have found to be most satisfactory, is very much like that described by Mr. Achorn in his paper given at the 1971 Round Table[10] and discussed again at the 1974 Round Table meeting.[11]

At the 1969 Round Table, Mr. R. R. Heck[12] gave a paper wherein the gross heat affect of a fertilizer formula was tied to the bed dimensions within the ammoniation drum. Controlling the heat release rate, in terms of BTU's per cubic foot per hour, was found to be a valuable method of preventing the generation of excessive amounts of fume. It also prevented the decomposition of nitrates and the resultant yellow-brown stack emission caused by oxides of nitrogen in the stack gas. Mr. Heck's paper was based on investigations by Mr. Nielsson and in-plant studies by myself.

In 1959, TVA had an open-house affair and published a booklet entitled the "Pilot-plant Demonstrations of the Production of Granular Fertilizers."[13] This publication correlated the propensity for fume generation, nitrate decomposition, and other emissions with such things as production rate, ammoniator drum dimensions, and sparger length.

At the 1970 Round Table, John Surber[14] delivered a paper wherein he showed the effect of formulation upon the appearance of the stack. A series of slides showed vividly how the use of phosphoric acid in lieu of sulfuric acid would clean up the appearance of the stack. Mr. Surber's paper included formulas for 5-10-15 showing the amounts of acids used and these are clearly correlated with photos taken of the stack emission.

At this point, I would like to outline various steps taken by IMC in our N-P-K granulation plants for control of fume.

1. We have lengthened the combustion chambers at a number of our plants. This moves the flame further away from the feed chute into our co-current dryers. Any fertilizer that may spill from the chute into the dryer inlet throat and fertilizer which clings to the flights at the feed end of the dryer will be further removed from the flame.
2. We have baffled the passage through the refractory lined combustion chamber leading to the dryer inlet. This has the affect of reducing the amount of radiant heat transmitted to the fertilizer from the refractory lining.
3. We have provided an air channel on the back side of the feed chute. Secondary combustion air is fed through this channel and serves to cool the chute, thus preventing localized overheating of the fertilizer.
4. We have modified our burners so as to produce the shortest possible flame that will give us the amount of heat required for drying. In some cases, this has resulted in a 28% reduction in total heat capacity of the burner; however, we seldom require the entire rated capacity of a burner anyway and this has not been a restriction on our production rate.
5. We have ducted clean, fresh air from outside the plant to the secondary combustion air blower. In some cases, this means bringing air from some distance away where it will be unaffected by airborne dust from such things as bulk shipping, materials unloading, or dusty roadways. This clean air is supplied to the combustion chamber directly and is also provided as inlet air to the primary combustion air blower. To do this, we have constructed pressurized rooms which totally enclose the burner end of the combustion chamber. The clean, fresh air from the secondary combustion air fan is supplied to the room to keep a slight positive pressure within the room. The primary air blower derives its air from the clean air within this room.
6. We have provided good, tight seals at both the inlet and outlet ends of our dryer. These seals are kept in good condition and not allowed to be broken lose by misalignment of the dryer drum or excessive thrust tolerances.
7. We have found it mandatory to provide precise temperature control devices on our dryers with close control of fuel supply to the burner and effective modulation of the flame. We use a 3-point temperature controller which was developed by our own instrument specialists. Although new, this device promises to be very effective, both in temperature control and burner modulation.
8. We have found it necessary to keep the flights in our dryers in good condition and they must be kept clean. A uniform curtain of falling material must be maintained to achieve maximum benefits from the heated air passing through the dryer. Avoidance of sticky phases which clog the flights is necessary, or, if unavoidable, the dryer should be shut down and cleaned following each occurrence. A good knocker system helps.
9. We have installed an instrument panel specifically designed for monitoring our pollution control equipment. We also have a burner temperature indicator on this panel with a high temperature alarm device set to sound a horn at 800 degrees F. We consider this to be the maximum combustion chamber throat temperature that we should allow. The monitoring

panel also contains ammeters for fans and pumps, and other equipment associated with the plant's dryer and cooler circuits, scrubbers, and related equipment. At several plants, we have initiated the use of a log sheet which requires the hourly logging of the data from the monitoring panel, plus visual observations of such things as weather conditions, wind direction, wind velocity, and stack appearance.

10. We control fume generation from our ammoniators by use of the formulation techniques mentioned earlier.
11. We also are careful to maintain in our 8' diameter drums a bed depth of 20". We adjust our production rate to accommodate the total heat load of the formula being produced. The parameters used here are in line with those given in the Heck paper referenced earlier.
12. We employ the sparger positioning concepts given in the two Achorn papers previously referenced. We inspect our spargers frequently, replace them whenever the holes become enlarged, or other problems are apparent. We generally use Hastaloy C pipes for all spargers in the ammoniator. We find that, although expensive, this gives the best service and presents the least amount of production interruptions due to required maintenance of spargers.
13. Five of our six granulation plants employ rubber lining to ensure a clean ammoniator shell. This is very beneficial in preventing build-up and the subsequent abrasion of the sparger pipes and interference with the freely tumbling bed action. Good bed action is essential for uniform distribution of the liquids within the bed.
14. We have found that excessive heat release in the ammoniator will decompose ammonium nitrate contained in the ammoniating solution. When this occurs, a brown or yellow stack appearance will be noted. Sometimes, this brown color is masked by a heavy white ammonium chloride fume. When a scrubber is employed, the ammonium chloride is removed and the brown plume remains. Proper operation, formulation, and equipment maintenance will prevent the generation of the NO_x gas. Steam can be used as an aid to granulation rather than excess sulfuric acid. Excess acid generally produces ammonium chloride and often will produce the brown NO_x plume.

Up to this point, I have discussed ways to prevent the formulation of fume. Now let me describe how IMC controls or reduces the amount of fume that is generated so that we are in compliance with the opacity regulations of the states in which we operate.

On dryers and coolers, we employ a box-type wet scrubber. This scrubber started out to be much simpler in design than it's present configuration would indicate. We now use a 4" pressure drop venturi on the dryer duct. Water is sprayed into the duct above the venturi. We also spray water into the final vertical section of the air duct coming from the cooler. This tends to remove coarse dust particles quickly and also helps to hydrate the fine particles so that they are more easily captured in subsequent sections of the scrubber.

The two air flows pass vertically downward through the inlet half of the wooden scrubber. They then pass horizontally through a packed bed consisting of an 11" thick layer of 2" pall rings. Water is sprayed downward through the bed of pall rings which serves to keep the surfaces of these rings washed clean, and also provides a wetted surface for contacting the particulate material traveling in the air stream. Much of the medium-sized and fine particulate matter is trapped by surface impingement while negotiating the tortuous path through this packed bed.

Next, the air stream passes vertically upward through the exit side of the scrubber. In some of our scrubbers, we have an additional packed bed with water spraying through it to further clean up the air stream. Much of the medium-sized and fine particulate matter is trapped by surface impingement while negotiating the tortuous path through this packed bed.

Next, the air stream passes vertically upward through the exit side of the scrubber. In some of our scrubbers, we have an additional packed bed with water spraying through it to further clean up the air stream. In all of our scrubbers, we employ a mist elimination unit at the top just prior to exiting the scrubber via the stack. The mist eliminators that we use are commercially produced by the Heil Process Equipment Company and provide a curved vane surface with water droplet disengagement hooks. The moisture droplets are thrown to the outside of the curving air flow by centrifugal force. As they follow the curved surface of the vane, they are caught by the disengagement hooks and drained to one side where they fall back down into the scrubbing water reservoir. The total pressure drop across the entire scrubber, including the venturi, the packed bed and the mist eliminator, is approximately 10" of water column.

The water reservoir under the scrubber is partitioned into two parts. The inlet side of the scrubber is referred to as the dirty side. This water is pumped through the inlet sprays on the dryer and cooler ducts. Most of the dust is captured here as is some of the fine particulate matter.

The remaining fine material is largely removed by the packed bed and the mist eliminators. The packed bed is supplied with clean water which is pumped from the outlet helf of the scrubber basin. This design requires the use of two pumps. However, it has the advantage of maintaining the solids accumulation in the front half of the scrubber where it can be more easily removed.

We employ hydraulic cyclones to thicken the fluids in a branch stream from the dirty pump and the thickened material is salvaged by introducing it back to the process in the ammoniator. This technique was discussed by D. L. Dibble of IMC at the 1972 Round Table.[15]

We are presently using several different makes of scrubbers on ammoniators. They all operate in the medium to high pressure drop range. That is, between 20" and 36" water column. We have found that this gives adequate insurance against excessive fume emission when good operating techniques are employed as previously outlined. A scrubber with approximately 90% efficiency will reduce a grain loading of .03 to a grain loading of .003, which we know will probably not be visible to the naked eye. We have several scrubbers which permit the pressure drop to be varied as the demands of the situation dictate. These employ movable discs which can be adjusted to provide whatever pressure drop is necessary to clean up the stack appearance. At one plant, we use the Research-Cottrell flooded disc scrubber. This scrubber is rather thoroughly described in an article appearing in the October 6 issue of Chemical Engineering Magazine.[16] We have also modified a conventional low pressure drop venturi by inserting a tapered-edged disc made of thick PVC mounted on a threaded stainless steel rod. By turning a handle at one end of this rod, we can move the tapered disc upward and downward within the throat of the venturi thus varying the area of the annular opening around the disc and, of course, producing a pressure drop which can be changed as necessary.

We pre-condition the inlet gases to our ammoniator scrubber by spraying fresh makeup water into the ducts ahead of the scrubbing device. All makeup water required for both scrubbers in the plant are fed through these sprays. The excess water from the ammoniator scrubber reservoir overflows to the dryer-cooler scrubber and becomes makeup to that system. This concept of sub-micron particle scrubbing is so beautifully described in the reference just cited from Chemical Engineering Magazine, that I would like to quote directly from that article as follows:

> "Particulate scrubbing is a two-step process. In the contact step, particles are wetted, or more commonly, captured by drops of scrubbing liquid. This, often aided by agglomeration, solves the problem of collecting tiny low-mass particulates by creating particulates of greater mass. These are separated from the gas stream by simple inertial means in the second, mist elimination step. In low-energy scrubbers for collection of relatively large particles, the two operations proceed simultaneously in the same area of the scrubber, and gravity may be enough for separation. In high-energy scrubbers, mist elimination is a distinctly separate stage following the contact stage. It is accomplished, typically, with a baffled gas flow path, or spiral gas flow to create centrifugal force, for separation."

We employ one, and sometimes two, separate mist eliminators on all of our ammoniator scrubbers. We find this to be an essential part of the operation of these units. Generally, a blower is employed to pull the air through the scrubber. If adequate mist elimination and droplet devices were not used, the blowers would become damaged by the liquid carry-over.

These droplets would also be blown up the stack opening and would then become a particulate emission in their own right. Adequate droplet and mist removal is essential.

Ladies and Gentlemen this concludes the narrative part of my paper. Now I would like to show you a group of slides depicting many of the items which I have discussed.

FIGURE 1

A portable smoke generator used to qualify stack observers. Note the optical device on the stack which measures the amount of opacity through spectral response of photocell. This is set to read on the same wave lengths as are visible to the human eye.

FIGURE 2

The control box for the smoke generator. The operator adjusts the fuel-air mixture to obtain a steady reading on the photocell indicator. The amount of light transmitted and received across the diameter of the stack is electronically converted to percent opacity. The speaker equipment advised the qualification group when to mark their observation on the record sheet.

FIGURE 3

Black smoke from portable generator, 65% opacity. Black is viewed against a contrasting background, in this case the light blue sky.

FIGURE 4

Research-Cottrell scrubber used on an ammoniator. Variable pressure drop is obtained by adjusting internal clearances in the uppermost white part, a cone section at the gas inlet. The large white cylindrical unit is the primary droplet separator. This is followed by two fans in series.

FIGURE 5

Entoleter scrubber used on an ammoniator. This unit has a variable pressure drop capability, and is usually operated at 30 inches water column. Scrubbing action occurring in vane cage on lower level. Droplet separator is on middle level, fan on upper level. Note fresh air intake to combustion chamber at right of photo.

FIGURE 6

The discharge end of the ammoniator is tightly hooded to capture fumes. Plexiglas shield protects operator in event of flash fire.

FIGURE 7

Superphosphate plants also emit a plume from the exit stack. We have made ours almost invisible and captured another 70% of the residual fluorine by installing a third-stage on our 30" size water-jet eductor type scrubber system.

FIGURE 8

This plant is manufacturing 10-10-10 at 25 TPH. The formula contains 410 lbs. of solution 410 (22-65-0), 185 lbs. of 60 degrees Be. sulfuric acid, and sulfate of ammonia, superphosphate and muriate of potash. The dryer stack in background is emitting virtually no fume. The ammoniator stack is scrubbed with an Entoleter scrubber which controls the ammonium chloride. Visible emission which appears in photo is NO_x *caused by poor sparger placement allowing mixing of solution and sulfuric acid.*

FIGURE 9

This plant is producing 13-13-13 at 30 TPH. Dryer burner is not properly modulated and sudden surges of flame cause the decomposition of fertilizer resulting in the heavy fume emission shown here.

FIGURE 10

The box scrubber used by IMC on the dryer and cooler exhaust air. Cooler duct is in foreground. Dryer duct in background has a low pressure drop venturi above the cypress wood scrubber enclosure. Ladder and platform are for stack sampling.

Fig. # 1

Fig. # 2

Fig. # 3

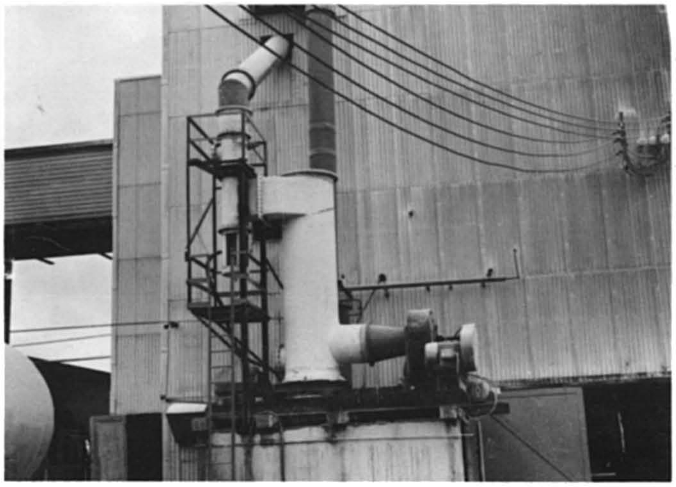


Fig. # 4

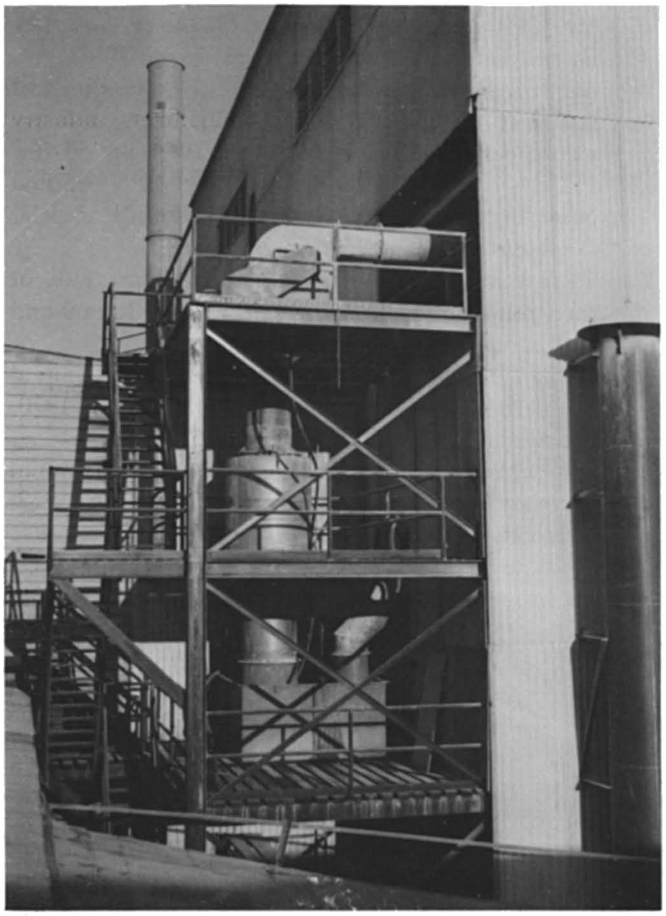


Fig. # 5

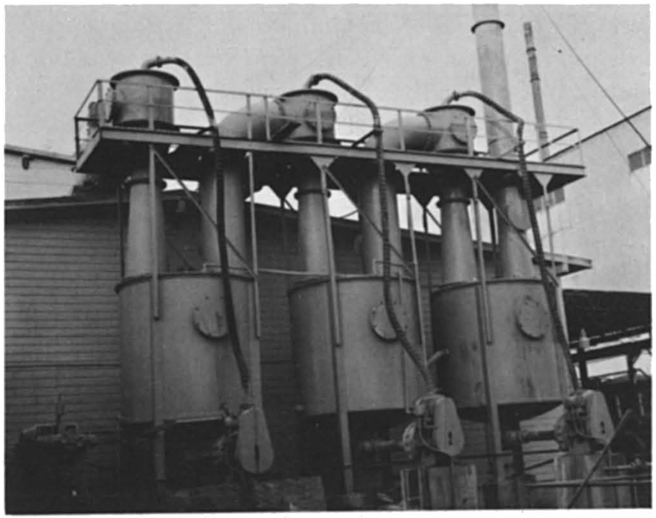


Fig. # 7

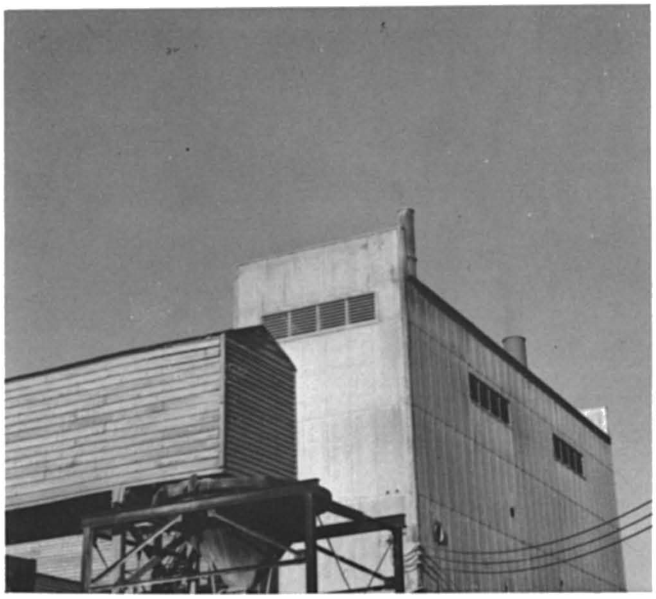


Fig. # 8

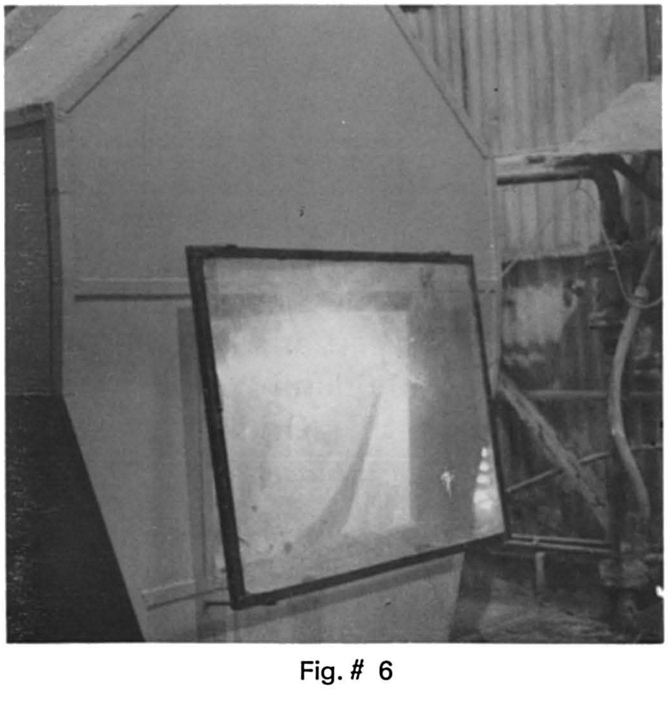


Fig. # 6

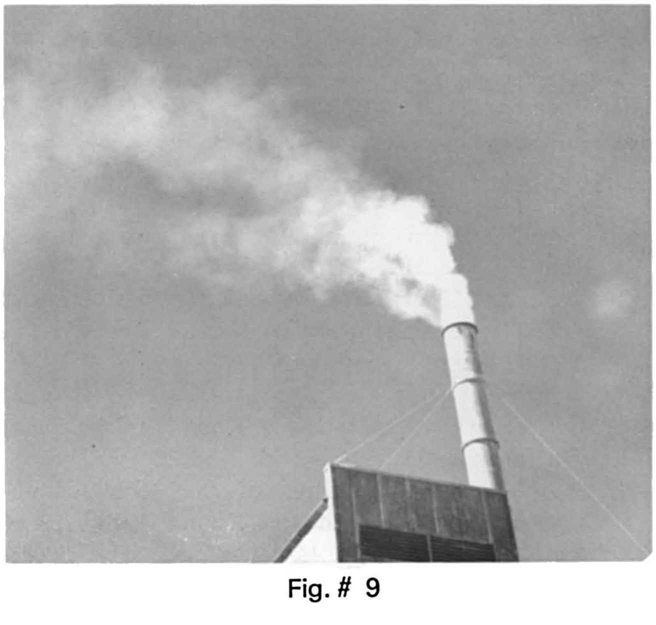


Fig. # 9

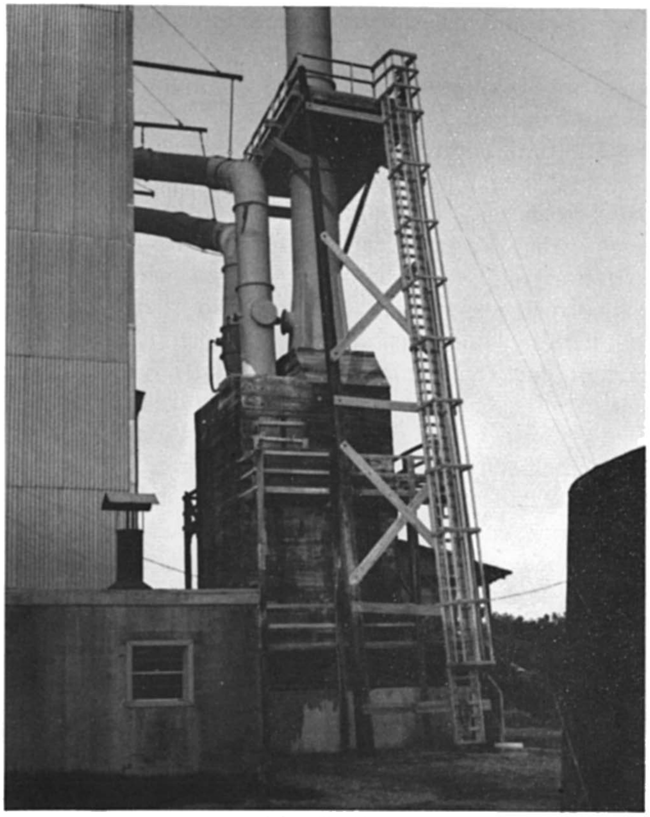


Fig. # 10

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(1) Federal Register, Appendix A, Volume 39, No. 219, Tuesday, November 12, 1974.

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MODERATOR JACKSON: Our next discussion by J. R. Futers, Manager-Engineer, International Minerals and Chemical Corp., Canada, Limited, P.O. Box 70, Duville, Ontario NIA-2Y6, will discuss: 3000 Ton Sulphuric Acid Storage Tank Rupture at I.M.&C. Corp. (Canada Limited) Port Mainland Plant, Dunville, Ontario. John has worked 11 years in the industry with Erco Industries and I.M.&C. Most of this time he has been associated with maintenance work.

Currently John is Manager of Engineering and he will tell us about some of the problems that arise when a larger acid tank ruptures.

John please.

3000 Ton Sulphuric Acid Storage Tank Rupture At International Minerals and Chemical Corp. (Canada) Limited Port Maitland Plant Dunnville, Ontario

J. R. Futers

The primary purpose of this presentation is to acquaint other sulfuric acid manufacturers and acid users with the potential hazards of undetected corrosion in sulfuric acid storage vessels.

On June 16, 1975 a severe side wall rupture occurred in a 3000 ton sulfuric acid storage tank at the International Minerals & Chemical Corporation (Canada) Ltd. Plant, Port Maitland, Ontario. I will give highlights of the investigation of this failure and also show several slides of the damage which occurred to other tanks and equipment in the plant area. Fortunately, no injury occurred to operating personnel.

The storage tank which ruptured was one of three similar tanks as shown in fig. 1 It was constructed of mild steel plate ASTM A-283 grade C plate and was in service for 14 yrs. The tank was 51 ft. in diameter and 26 ft. high. It was built on a thick concrete foundation. The original side wall plate thickness varied from 1/2 inch in the bottom course to 3/8 inch in the upper course. The floor plate was 1/2 inch thick plate and the roof was of arch construction supported on the side walls.

Before we look at further details of this tank failure let us review briefly the types of corrosion and inspection methods normally used for sulfuric acid storage equipment. Generally, the most common materials of construction for sulfuric acid handling or storage have been mild steel or cast iron. In the original design a corrosion allowance is added onto plate thickness to give an economic life span. Common types of corrosion in this equipment are:

a) Uniform attack over the entire surface area.
b) Pitting corrosion.
c) Erosion-corrosion.

Normally "uniform attack" corrosion occurs in sulfuric acid storage tanks and can easily be measured by test procedures such as test drilling of the plate or ultra-sonic thickness tests. The sonic test procedure has the advantage of allowing corrosion measurements while the tank is still in service, however these tests give only a thickness measurement at a specific point. Enough test points must be measured to ensure a reliable analysis of remaining plate thickness assuming the corrosion is fairly uniform throughout the tank.

Visual inspection can be very useful in detecting pitting corrosion or erosion corrosion areas but has the disadvantage of complete tank shutdown, washout etc. Another disadvantage is, this method relies completely on observations of the inspector and a serious corrosion pattern can be easily missed for various reasons.

The tank failure I will describe resulted from an unusual corrosion pattern which was missed both by ultra-sonic testing and visual inspection 10 months prior to the tank rupture. The same pattern was also missed on 2 adjacent tanks. This type of corrosion could be classed as erosion-corrosion or "grooving-corrosion". This grooving-corrosion pattern occurred on the tank side wall in line with the acid inlet nozzle in the roof and extended from about 3 ft. below the roof to within 1 ft. of the tank floor. (See fig. 2) The grooves in the plate were straight and vertical, with a spacing of about 1/8 inch and were cut into the plate about 1/16 inch deep. This pattern extended about 4 ft. around the tank circumference and also showed general thinning. If anyone is interested in looking at this pattern more closely. I have a small sample section which you can look at after this presentation.

The tank rupture occurred vertically through steel plate (not welds) and near the center of the grooved corrosion pattern. (See fig. 3) The rupture appears to have started about 8 ft. from the tank floor at a horizontal weld seam which had thinned, where the vertical corrosion grooves crossed the weld at right angles. The fracture line was straight from top to bottom through plate ranging in thickness from 1/8 inch to 3/8 inch. (See fig. 4) When this vertical fracture line reached the "T" weld where side walls were attached to floor plates and roof plates the weld was sheared off around the entire tank base and roof. With the sudden release of potential energy when the fracture occured and as acid gushed out, the tank walls unrolled to an almost straight position. (See fig. 5) This sudden burst of energy moved No. 2 tank, which was almost empty, about 20 ft. and bumped it into No. 3 tank causing severe damage to both tanks. A smaller tank which was also empty was moved about 75 ft. from its concrete base and bumped against railway cars stored on an adjacent siding. Several rail cars which were loaded with acid were moved off the railway track and the railway was severely damaged. A concrete block pumphouse was levelled at the foundation and debris was picked up over 150 ft. away. As No. 1 tank unrolled it struck a cast iron pipe cooler used in manufacturing the acid and about 75% of the pipe was broken or cracked. A 12 inch water main feeding the pipe cooler was sheared off and underground piping was broken. (See fig. 5) The extensive equipment damage resulted in 6 weeks of complete plant shutdown for cleanup and equipment restoration, however this could easily have been a much longer period.

— Show slides of damage —

The cause of the unusual, localized corrosion pattern which resulted in this failure appears to be related to the location of the acid fill pipe which was 1'-0 from the tank wall, in the roof. (Fig. 3) Grooving corrosion and metal loss in this area may have been caused by acid flowing down the tank wall, thus removing the protective film of iron sulphate on the mild steel plate or may be caused by gas bubbles rising and grooving the steel plate as a result of corrosion or acid aeration when the acid free falls from the roof inlet nozzle. Our investigation has not been completed on the corrosion mechanism as yet.

After this failure we carried out a very detailed ultra-sonic and internal visual inspection of all sulfuric acid tanks at the plant. The three tanks which store acid produced in our sulfuric acid plant all showed a similar corrosion pattern in relation to the inlet nozzle. Two of the tanks were scrapped due to severe damage during the No. 1 tank rupture, while the third tank was rebuilt to original specification by removing all plates showing this grooved pattern. All four tanks which showed the grooving-corrosion had been inspected by ultra-sonic and visual internal inspections ranging from 2-7 months prior to the rupture of No. 1 tank. The grooved area was not noticed on visual inspection likely due to an oxide film covering the walls when the tank was washed out with water. General thinning in the grooved area was not picked up due to an 8 ft. spacing on sonic test points.

Four other tanks in other process areas of the plant were inspected but did not show the grooved pattern, in spite of the fact that inlet nozzles were close to the side walls. We also inspected 2 tanks at another company's plant in the area and a similar grooved pattern was found which was even more severe than in our tanks but was not attributable to fill pipe location. The corrosion may be our tanks but was not attributed to fill pipe location. The corrosion may be attributable to the method of filling tanks with acid which was blown from the tank trucks using air pressure. It is notable that this company had made several internal repairs to the tanks but did not notice the grooved-corrosion pattern until they saw cause of our tank rupture. They have now scrapped the two tanks.

During our recent inspection program we also found side manway nozzles or acid outlet nozzles to be susceptible to grooving corrosion in the top section of the nozzle. While a major failure of a side wall nozzle would cause serious acid leakage problems, it would not likely result in a catastrophic type of side wall failure. Side manway nozzles are a major weakness in design and we have now eliminated them from our tanks. We have also relocated top inlet nozzles, wherever practical.

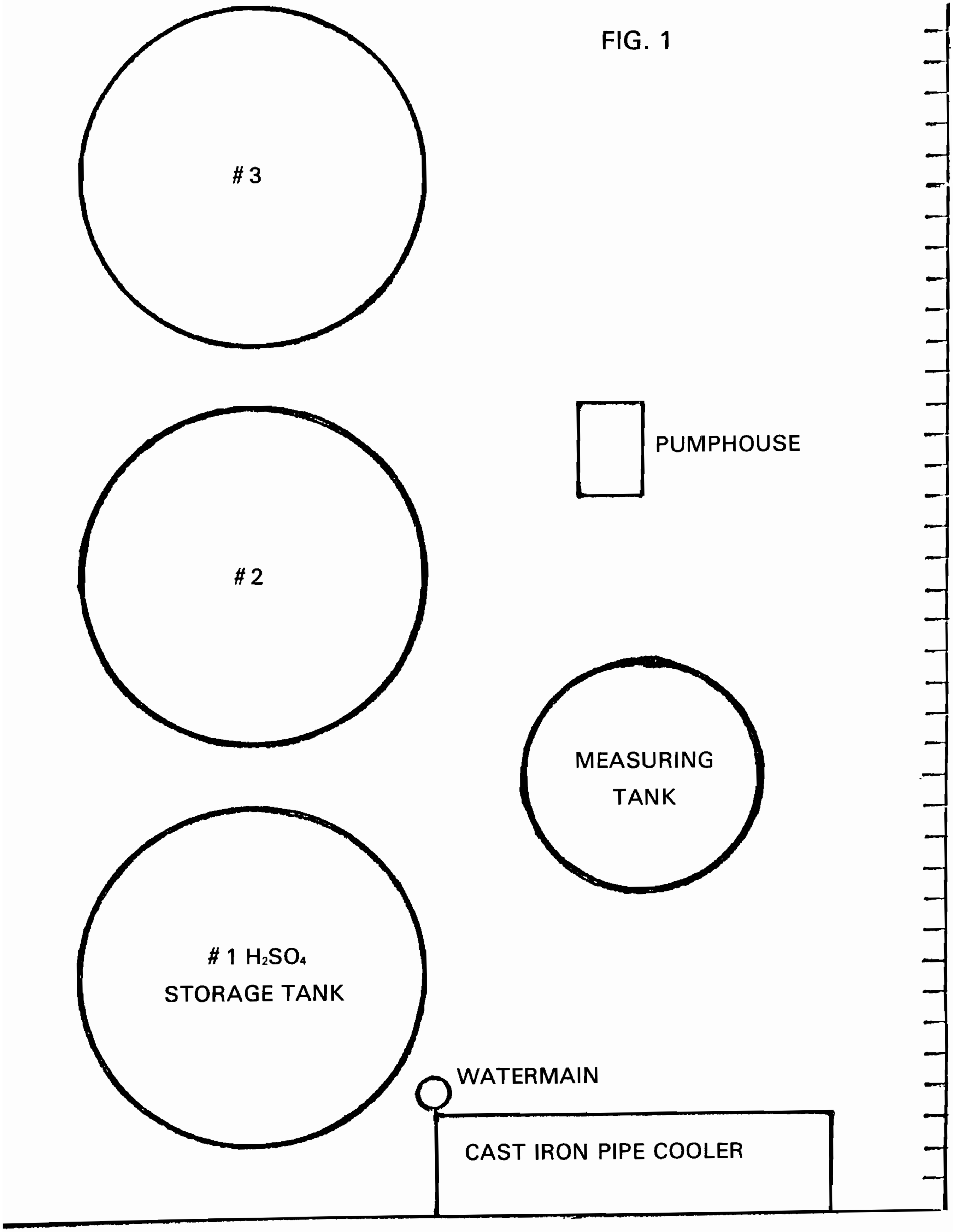
Summary

It should be clear that a thorough inspection and testing program is essential. Ultra-sonic thickness testing is a good method for determining general corrosion thinning but has limitations. Reliability depends to a good degree on the skill and conscientousness of the operator. Test equipment must be carefully calibrated and test points on the tank wall must be carefully cleaned to give good probe contact. Sonic testing will *not* pickup a grooved-corrosion pattern. This can most easily be found by visual inspection or could be found by radiography. Areas where acid impingement and corrosion-erosion is suspected should be visually inspected in a thorough manner including buffing or sandblasting the metal surface to ensure a serious corrosion pattern is not hidden by a corrosion film on the plate surface.

Tanks which are 15 or 20 years old should have sections of the weld seams radiographed to determine weld integrity. We found very serious weld quality problems in one tank recently inspected. The tank is about 16 years old and when constructed the welders did not achieve full plate penetration. We estimate this penetration as less than 50%. After radiographing several weld seams and finding this condition in all welds we decided to remove all original welds and reweld the entire tank. In this case, the tank platework was in excellent condition based on our visual inspection and ultra-sonic tests. In gouging out some minor weld pinholes for repair, we discovered the lack of weld joint penetration and tested further with radiography. This tank could have easily ruptured through a weld seam if we had not found this welding quality problem.

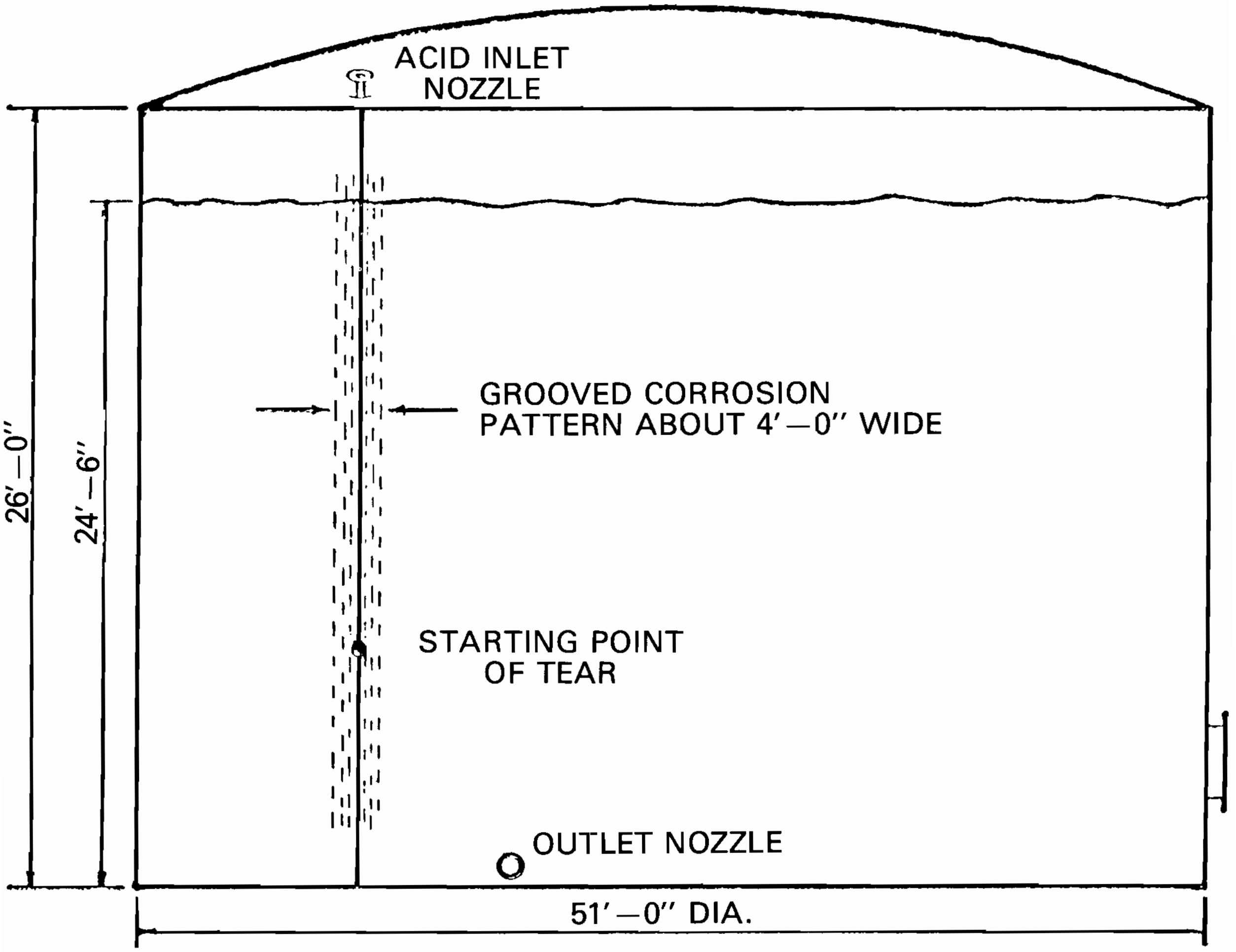
I hope this presentation will improve awareness of plant personnel to the potential hazards of a major tank rupture and cause them to look more carefully at test procedures and methods as well as new tank construction or repairs to ensure that only completely reliable tanks are used throughout the industry to store sulfuric acid.

FIG. 1



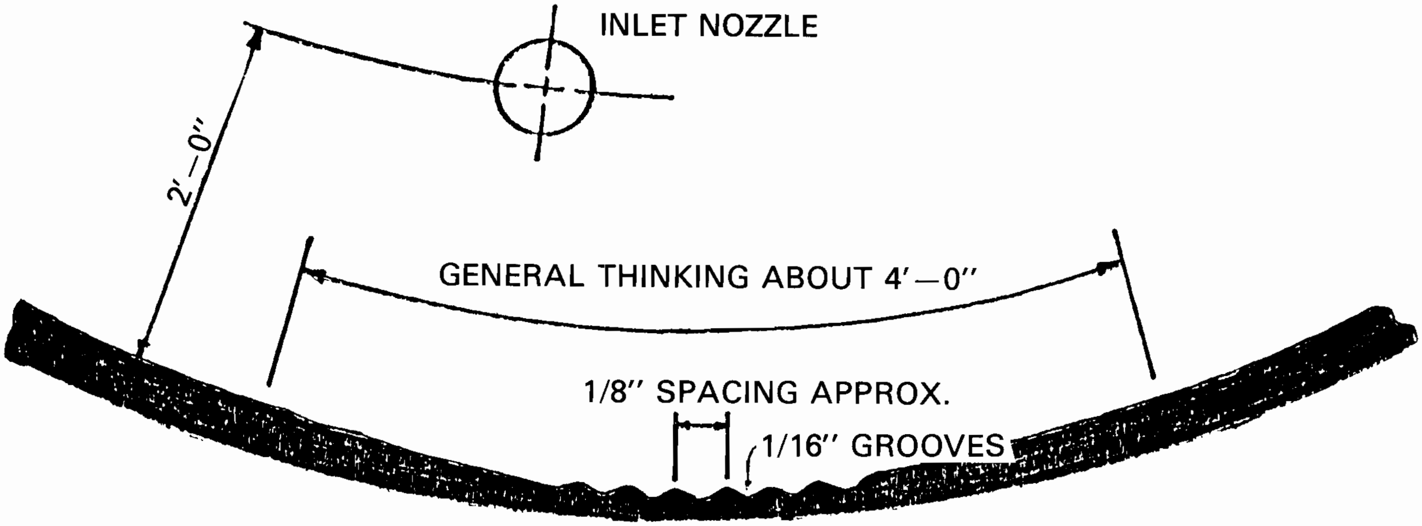
3
PUMPHOUSE
2
MEASURING TANK
1 H_2SO_4 STORAGE TANK
WATERMAIN
CAST IRON PIPE COOLER

FIG. 2



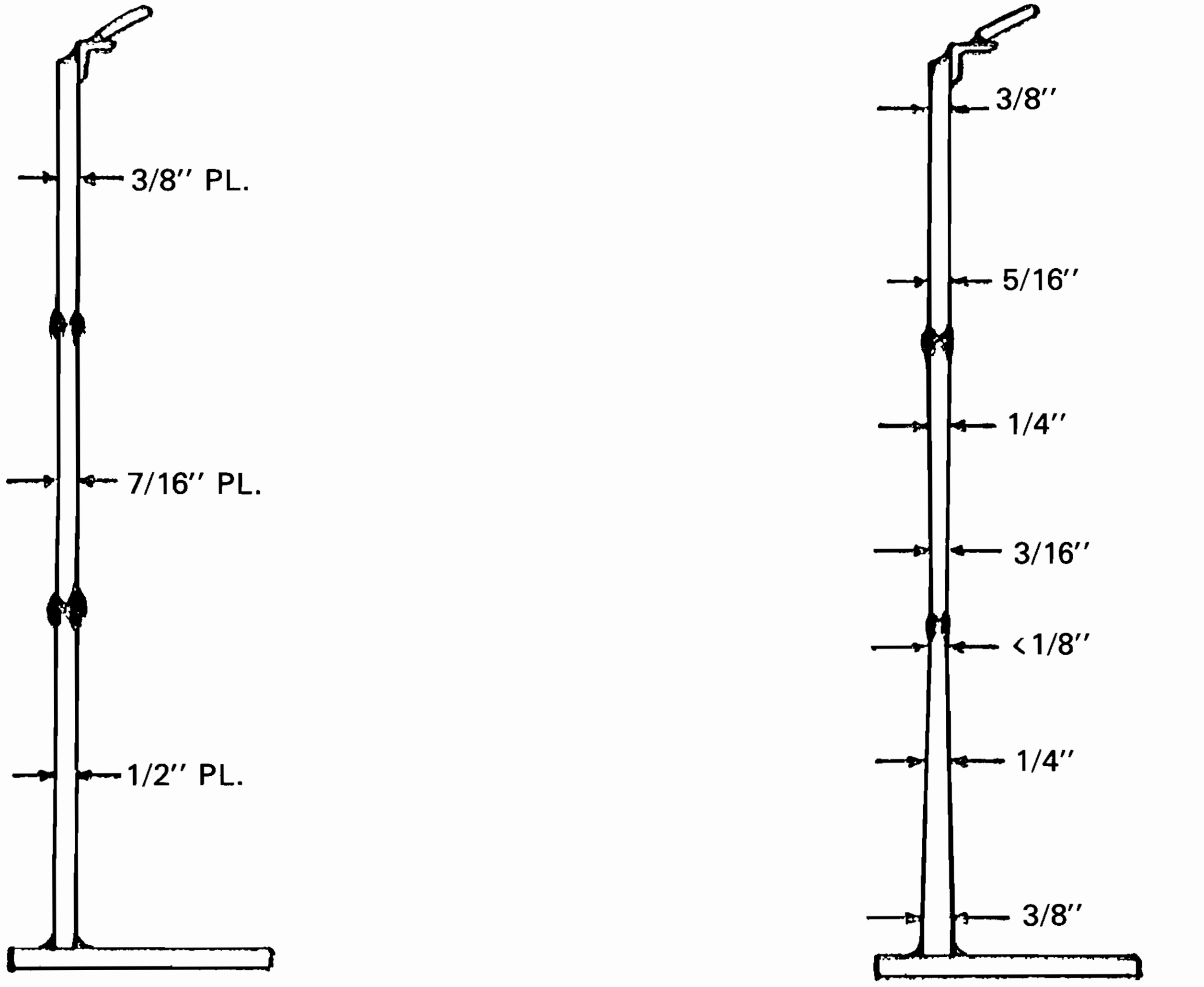
3000 TON SULFURIC STORAGE TANK

FIG. 3



CROSS-SECTION THROUGH GROOVED-CORROSION AREA

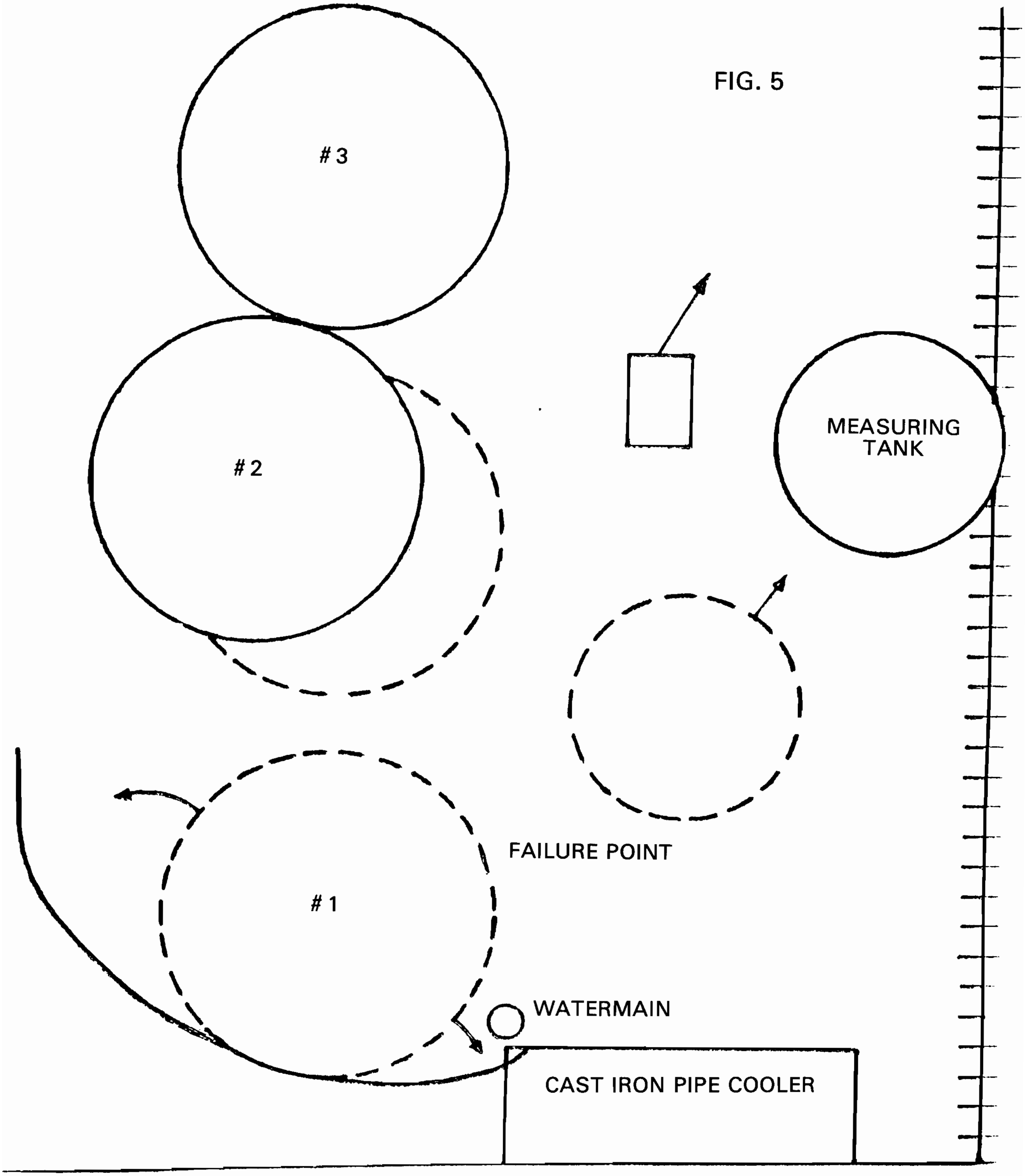
FIG. 4



ORIGINAL PLATE THICKNESS

PLATE THICKNESS ALONG RUPTURE LINE

FIG. 5



3
2
MEASURING TANK
FAILURE POINT
1
WATERMAIN
CAST IRON PIPE COOLER

SLIDES 1, 2, 3

These prints show how the tank sidewalls unrolled along the circumference of the tank to an almost straight-line position. The welds at the tank base and roof attachment sheared and the tank roof dropped down in one section.

SLIDE 4

This print shows the No. 1 tank roof and damage to cast iron pipe cooler to the left of the roof. To the right of No. 1 tank roof, No. 2 tank can be seen moved from its foundation about 15 feet. The measuring tank on the extreme left was pushed about 50 feet off its foundation.

SLIDE 5

This print shows a close up of the cast iron pipe cooler damage caused when No. 1 tank side wall unrolled. The 12" water main rising from the ground at bottom left hand was sheared off as well.

SLIDE 6

This print shows the measuring tank moved from its foundation and pushed up against rail cars. The small foundation near the measuring tank was a concrete block pumphouse which was completely demolished when the tank was moved from its foundation.

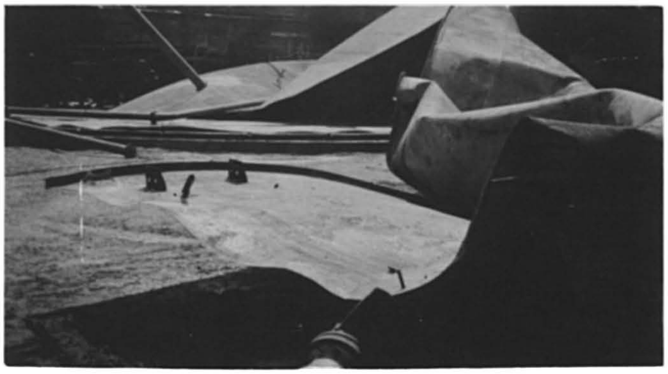
SLIDE 7

This print shows miscellaneous piping, concrete blocks, pumps and motors which were moved about 100 feet when the pumphouse was demolished.

SLIDE 8 & 9

These prints show how loaded rail cars were derailed and the rail track bed was destroyed in the area adjacent to tank failure. About 75 feet away from tank.

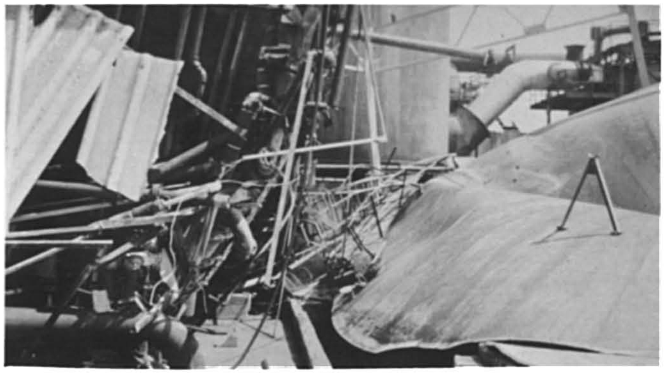
SLIDE 1



SLIDE 2

SLIDE 3

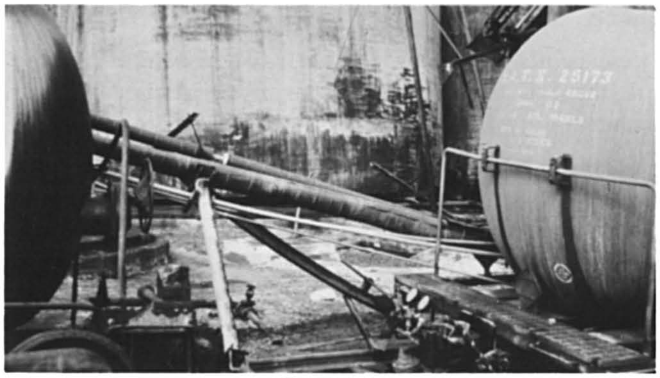
SLIDE 4



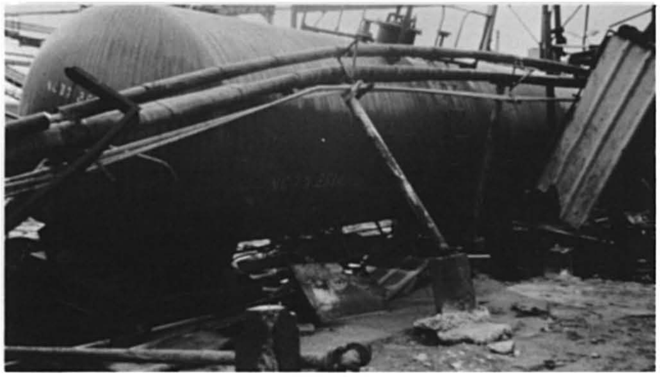
SLIDE 5

SLIDE 6

SLIDE 7



SLIDE 8



SLIDE 9

MODERATOR JACKSON: Our final topic is a most interesting sound motion picture titled "Florida's Vital Key to a Better Future For Many", compliments of I.M.J.C. Corporation and arrangements by our good friend Frank T. Nielssen.

Florida's Vital Key To A Better Future For Man

I.M. & C. Corp — Frank T. Nielsson

Editor:

The film highlighted the "Phosphate Rock Operations Viz: Mining, Refining, Mined Out Land, Reclaiming and Finished Land for other uses:

Please note some of the major photos. Photo #1 Dragline Mining. Photo #2 Washing Plant. Photo #3 Flotation Plant. Photo #4 Mined Land. Photo #5 Setting Up Reclamation. Photo #6 Reclaiming in Progress. Photo #7 Reclaimed Land Ready for Agriculture or Housing.

Also by compliments from I.M.&C. Corporation.

1 — Environmental Fact Sheet 1975

2 — Economic Fact Sheet 1975

Photo No. 1

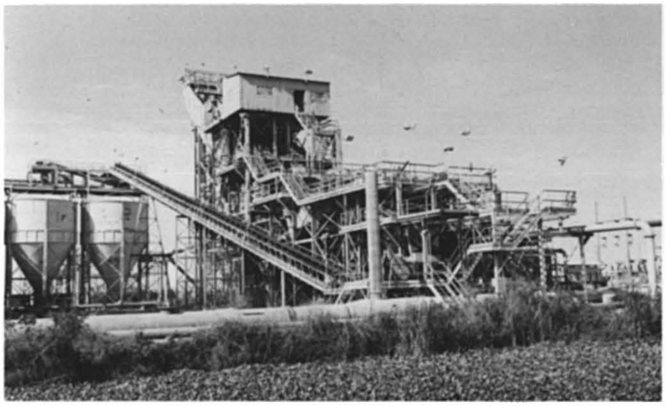


Photo No. 2

Photo No. 3

Photo No. 4

Photo No. 5

Photo No. 6

Photo No. 7

ENVIRONMENTAL FACT SHEET
1975

In the past 10 years (1964-74) members of the Florida Phosphate council have spent $190 million for research, development, and installation of systems and equipment for the purpose of air quality control, water quality control and water conservation. In the same period of time, the cost to operate and maintain these systems has been $105 million.

In 1974 alone, Florida Phosphate Council members spent $16 million for air quality control, water quality control and water conservation. In order to keep these systems operating, the cost was almost $23 million.

Florida Phosphate Council members spent almost $5.6 million in 1974 for land reclamation. These companies will be continuing or starting new reclamation projects on almost 6,000 acres in 1975.

Members of the Florida Phosphate Council had completed reclamation or had reclamation projects underway, on 28,000 acres in the past 10 years. In 1974, nearly 8,500 acres of reclamation projects were either underway or being completed.

Council members donated 181 acres of land for public purposes in 1974, making a total of 581 acres donated in the past two years. These lands will be used for recreation areas, wildlife refuges, parks and other public uses.

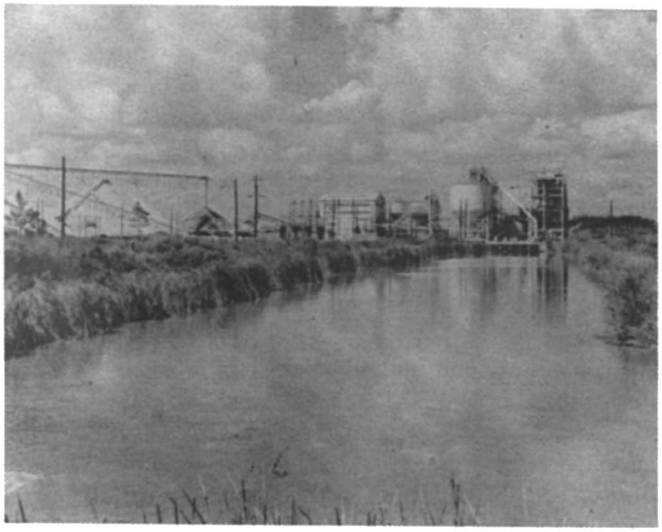
The Florida Phosphate Council is a trade association composed of the following phosphate mining and processing companies; Agrico Chemical Company; Borden, Inc. — Chemical Division/Smith-Douglas; Brewster Phosphates; Conserv, Inc.; Electro-Phos Corporation; Farmland Industries, Inc.; Gardiniar, Inc.; W. R. Grace & Company, Agricultural Chemicals Group; International Minerals & Chemical Corporation; Mobil Chemical Company; Occidental Chemical Company, Suwannee River Phosphate Division; Royster Company; Swift Chemical Company; USS Agri-Chemicals.

Council members are continuing and intensifying conservation programs in 1975, including: committees to study all plant operations, all companies are cutting back on unnecessary usage of energy, smaller company vehicles, lowering thermostats, carpools for employees, restricting fuels to vital operating equipment.

Some of the intended uses of reclaimed land are: pasture, farming, citrus, home-sites, pine forests, recreational and industrial purposes and wildlife refuges. The value of Florida land and the severance tax reclamation refund provisions, give the companies an added incentive for an already highly regarded voluntary system of land reclamation.

Council members will be investing almost $33 million for additional system and equipment in 1975 for air and water quality control and water conservation.

Florida Phosphate producers are among the leaders in the nation in the conservation of water, with an industry recirculation average of 85%.



ECONOMICS FACT SHEET 1975

Florida produced over 80% of the nation's marketable phosphate rock and one-third of the world production in 1974, according to the U.S. Bureau of Mines. That amounted to approximately 35 million tons.

As of January 1, 1975, members of the Florida Phosphate Council had over 10,000 employees on their payrolls. This created a payroll for 1974 of over $100 million.

Polk and Hillsborough Counties account for over 8,000 of these employees, with the remainder living in 23 other Florida counties and the State of Georgia.

Property taxes paid by members of the Florida Phosphate council in 1974 totalled almost $5.8 million. Of this amount, Polk County received almost $4.3 million and Hillsborough County received almost $1 million. The remainder was spread among the Counties of Manatee, Hamilton, Hardee, Duval, De Sota and Pasco.

State sales taxes paid by Phosphate Council members in 1974 amounted to $8.2 million. Vehicle fuel taxes paid by the same companies totalled $133 thousand.

Since the inception of the minerals severance tax, July 1, 1971, Florida Phosphate Council members have paid over $15.6 million in this tax. This represents about 97% of the total Florida severance tax on minerals. Of the total paid, $4.1 million has been refunded to miners for reclamation projects, through 1973.

The 14 members of the Florida Phosphate Council spent a total of $260 million on new construction, expansion and replacement in 1974. Approximately $158 million of this was spent with Florida firms. These companies will spend $302.3 million for new construction, expansion and replacement in 1975.

Exports of Florida Phosphate rock were to such countries as Canada, Japan, West Germany, Italy and

India, with Canada and Japan being the major users. Almost 95% of all outbound cargo shipped through the Port of Tampa was phosphate rock or related products.

Phosphate is used primarily in the production of high analysis fertilizers, but also is used in the production of food preservatives, dyes for cloths, vitamin and mineral capsules, steel hardeners, gasoline and oil additives, toothpaste, shaving creams and soaps, bone china dishes, plastics, optical glass, photographic films, light filaments, water softeners, insecticides, soft drinks, road fill, livestock feed supplements, and much more.

For transportation, Florida phosphate companies paid Florida railroads approximately $73.3 million, trucking firms $6.1 million, and shipping firms, barges, etc., approximately $22 million.

Electric power companies received $51 million from Phosphate Council members in 1974. Telephone companies received almost $1 million. Member companies paid $7.8 million for natural gas.

Total expenditures by Phosphate Council members for equipment, supplies, (Including raw materials), and services in 1974 amounted to more than $301 million. Of this amount, $201 million was spent with approximately 1,500 Florida businesses.

The Bureau of Mines estimates the total phosphate industry investment in Florida at $3 billion, and the annual impact on Florida's economy is $1.5 billion. 61,000 jobs in the state are directly or indirectly created by the phosphate industry.

The Florida Phosphate council is a trade association composed of the following phosphate mining and processing companies: Agrico Chemical Company; Borden, Inc. — Chemical Division/Smith-Douglas; Brewster Phosphates; Conserv, Inc.; Electro-Phos Corporation; Farmland Industries, Inc.; Gardinier, Inc.; W. R. Grace & Company, Agricultural Chemicals Group; International Minerals & chemical Corporation; Mobil Chemical Company; Occidental Chemical Company, Suwannee River Phosphate Division; Royster Company; Swift chemical Company; USS Agri-Chemicals.

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LAKELAND, FLORIDA 33803
Compliments of:
INTERNATIONAL MINERALS & CHEMICAL CORP.
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MODERATOR JACKSON: I take this opportunity to thank all of our Speakers for their most interesting, timely discussions and to our audience for their kind attention. Someone in the room commented they made a rough count of the attendance showing approximately 265. I am grateful and thanks to all of you.

Wednesday, November 5, 1975

Morning Session
Moderator: Charles H. Davis

MODERATOR DAVIS: I have been asked to serve as your moderator. It is nice to see such a good crowd out this morning. I am honored to function in this capacity.

Before we get into the program there are a couple of announcements I would like to make. If there are any who have not yet registered, please do so at your earliest convenience this morning. I would like to remind you that this evening at 6 P.M. in this room we are having a cocktail party that will commemorate our 25th Silver Anniversary of the Fertilizer Industry Round Table.

Our first paper this morning is on the topic of fluid fertilizers. The authors of the paper are two of my long time friends and co-workers at TVA, Bill Scott and Amos Wilbanks. Both of these men are dhmical engineering graduates of Auburn University and have extensive experience in fertilizer research and development at TVA. I think Bill has numbered about 33 years and Amos just a little less. Both of these men have been involved in development of fluid fertilizer technology since its very beginning in the United States, and I can say without reservation that their contributions have been a very significant factor to the growth and success of fluid fertilizer industries in this country.

Bill will give the paper today, but Amos is present and he will be available for questions and discussion.

In addition to work at the fertilizer center at Muscle Shoals, Bill has also provided technical assistance on overseas projects in Nigeria, Columbia, Ecuador and Indonesia. As Assistant Chief of the Processing Engineering Branch his present job duties include both administration and technical supervision of our pilot plants and our demonstration plants. Bill is a member of the American Chemical Society, American Institute of Chemical Engineers, and a fellow of the American Institute of Chemists. He is a recipient of the National Fertilizer solutions Association's honorary member award.

FLUID FERTILIZERS
1975

W. C. Scott,
J. A. Wilbanks,
and
L. C. Faulkner
Presented by W. C. Scott

Industry Trends

The position of fluid fertilizers in American agriculture and industry is well established in 1975. Farm consumption of anhydrous ammonia, aqua ammonia, nitrogen solutions, and fluid mixed fertilizers totaled over 12 million tons in 1974 and constituted about 26% of all fertilizer used in the United States[1].

The growth of consumption of fluid fertilizers during the past 15 years is shown in Figure 1. Since 1959 there has been a 500% increase in the use of anhydrous ammonia, a 40% increase in the use of aqua ammonia, a 700% increase in the use of nitrogen solution, and a 600% increase in the use of fluid mixed fertilizers. The consumption data given for fluid mixed fertilizers include both liquids and suspensions, and most of these materials were NPK grades. As was recently established by Achorn and others[1], about 55% of the total nitrogen and 12% of the total P_2O_5 applied in fertilizers were in the fluid form. The consumption of fluid and solid fertilizers for the past 15 years is compared in Figure 2. Since 1959 there has been a 464% increase in the use of fluid fertilizers while solid fertilizer consumption increased about 50 % during the same period.

Survey data on the number of fluid fertilizer plants in operation show that this number increased almost 300% during the past 10 years as shown in Figure 3. In 1974 there were 2800 plants in the U.S. with 75% of these plants being located in the midwestern states. The average rate of addition of new plants during this period has been about 200 per year, although the rate has decreased significantly during the last 4 years.

These plants consist of both the hot- and cold-mix types. Various estimates show that about 40% of the total number of fluid fertilizer plants are hot-mix plants. Nearly all of the plants for making fluids are operated batchwise. There are only about 100 plants in the U.S. that are of the continuous operation type, and these are all hot-mix plants.

Methods and equipment used for the manufacture of liquids and suspensions have continued to be relatively simple and inexpensive. The investment (battery limits) requirement for a typical 15-ton-per-hour hot-mix fluid fertilizer plant currently is in the range of 5 to 10% of the cost of a 475-ton-per-day granular diammonium phosphate (DAP) plant. A standard cold-mix plant can be constructed for about 2% or less of the cost of the DAP plant.

Among the main reasons for the increased use of fluid fertilizers are their ease of handling and the accessibility of raw materials for their production. The advantages of fluid fertilizer have been described and discussed in detail in the literature *(2, 3, 4, 5,* and *6).* However, a few of the advantages will be briefly repeated here for the reader's convenience. In addition to being easy to handle, liquids are homogeneous, free flowing, water soluble, and dust free. Furthermore, they can be applied accurately. Usually the desired quantities of micronutrients can be added, particularly to liquids containing poly-phosphates. Their chief disadvantages usually are comparatively low analysis and the generally higher cost of raw materials which are required for their production.

Suspensions have most of the advantages of liquids and in addition they can compete in nutrient content and cost with high-analysis granular fertilizers. Suspensions are compatible with most pesticides. High-purity raw materials can be added in the desired quantity.

Equipment Design

Commercially Built Equipment: As mentioned previously, annual increase in the number of new plants built per year has been high. This increase has been possible because 18 or more commercial manufacturers now make equipment and complete plants for fluid production. It is estimated that about 75% of the plants for making fluid fertilizers are built and installed by commercial equipment manufacturers. A list of these manufacturers was recently published[7].

Detailed description of plants and equipment can be found in the literature[8]. A typical cold-mix batch-type plant is shown in Figure 4. This is still the simplest form of fluid fertilizer plant and it has been in general use for more than 15 years. This plant consists of a mix tank equipped with a turbine agitator, a pump, and raw material storage facilities for a fluid ammonium phosphate such as 11-37-0, nitrogen solution, and potash. Various formulations of fluid fertilizers are made by metering or weighing the appropriate quantities of the raw materials in the mix tank and mixing.

Another type of commercially built plant is designed for hot-mix operation. These plants are slightly more sophisiticated than the cold-mix plants since they provide for the reaction of phosphoric acid and ammonia to furnish the ammonium phosphate component of NPK mixed fluid fertilizers.

There has been a trend toward the use of more stainless steel or other corrosion-resistant materials to minimize corrosion and the maintenance problems encountered when mild steel is used for construction of the reactor, storage facilities, coolers, and applicator tanks.

Pipe Reactors: Development of the pipe reactor process has provided a convenient means of producing high-polyphosphate fluids from low-polyphosphate (20-30%) content wet-process superphosphoric acid [9]. This process consists of reacting the acid with anhydrous gaseous ammonia in a simple pipe reactor. A sketch of the acid-ammonia feed arrangement for the pipe reactor installed in the TVA plant is shown in Figure 5. Ammonia is added through the inside pipe of the tee and is usually discharged into the pipe reactor about 2 inches past the end of the tee section. The low-polyphosphate wet-process superphosphoric acid is added through the side inlet of the tee and reacts with the ammonia in the pipe. The heat of reaction results in temperatures of about 600 degrees to 750 degrees F. and converts a large part of the orthophosphate contained in the feed acid to polyphosphates. The reaction product made at the high temperature is an anhydrous melt of about 10-62-0 grade in which 70 to 80% of the P_2O_5 is present as polyphosphates. This melt is discharged continuously into a reaction tank (above or below the liquid level or in a hot well in some reaction tanks) where water and supplemental ammonia are added and cooling of some type is provided. The experimental plant-scale pipe reactor system at TVA is designed to produce about 15 tons per hour of fluid fertilizer. This reactor, shown in Figure 6, includes a 10-foot section of straight vertical pipe with downward flow. This vertical configuration is usually less costly and simpler to install and service than other configurations. However, it must be operated at full capacity or otherwise its effectiveness as a polyphosphate producer will be lessened. The TVA reactor is fabricated from 2.5-inch-diameter Schedule 40 Type 316L stainless steel pipe. The effective capacity of the mix tank is about 1500 gallons, and it is equipped with a turbine-type agitator for mixing the feed materials of water, ammonia, and the ammonium polyphosphate (APP) melt which is discharged 2 feet below the liquid level. A diagram of this plant is shown in figure 7. Since anhydrous gaseous ammonia is available at TVA, the TVA plant pipe reactor does not require an ammonia vaporizer. The fluid in the reaction tank or vessel is cooled by constant recirculation of the fluid through a shell-and-tube heat exchanger. A sketch of this heat exchanger and the reaction vessel is shown in Figure 8.

In most commercial plants the reactor is usually made from 4-inch Schedule 40 Type 316 stainless steel pipe[10]. However, several 6-inch pipe reactors have been fabricated recently. Those plants that use 4-inch diameter pipes are usually designed to produce about 25 tons per hour of fluid fertilizer. The reactor design is typically based on a U-shaped configuration and includes a pipe tee connected to about 4 feet of vertical pipe for upward flow, about 2 feet of horizontal pipe, and a downcomer section. The total length of pipe is usually between 10 and 14 feet. A picture of a typical commercial pipe reactor system is shown in Figure 9. In some plants, hot melt from the pipe reactor is discharged onto the surface of the solution in the reaction tank or vessel. In these plants the reaction tank must be equipped with a scrubber to recover the ammonia. Also, water and supplemental ammonia (liquid) are added into the reactor tank to adjust the specific gravity and pH. Good mechanical agitation is provided. The fluid is cooled by constant recirculation through a cooler of some type. A vaporizer is usually installed in the recirculation line to vaporize liquid ammonia for use in the pipe reactor.

In other plants the hot melt is discharged above the surface of the liquid into a hot well located at the bottom of the reactor tank. The hot well usually has depth equal to about 25% of the tank height and occupies about 50% of the cross-sectional area of the tank. The other half of the cross-sectional area is used as a product well[10]. In the range of 60 to 80% of the total ammonia required is added through the pipe reactor. The remainder of the ammonia is added in a recirculation line or through spargers in the reaction vessel. The liquid from the hot well is recirculated through a bed of packing near the top of the tank cooler. This packing is supported by a metal screen and serves as a cooler. Air for cooling is blown up through the packing by a large fan from below. Liquid dropping through the packing falls onto a baffle that covers about two-thirds of the tank bottom. The baffle discharges cooled liquid into the hot well of the cooler which overflows through a weir into the product well.

Partially cooled liquid from the product well is circulated through a shell-and-tube heat exchanger to assist in vaporizing ammonia for the pipe reactor. Cooled product from this vaporizer is pumped to storage.

The primary difficulty experienced with a pipe reactor is the formation of scale on the inside of the pipe which eventually causes plugging. When this occurs, the pipe reactor must be dismantled for cleaning. As would be expected, the scale builds up up more rapidly with acids having a high impurity content than with low-impurity acids. However, as the impurity content of the acid is substantially decreased, corrosion of the pipe increases. In such cases, water jacketing the pipe has minimized corrosion. TVA is working on several ideas to alleviate the problem of scaling.

Raw Materials

Low-Polyphosphate Wet-Process Superphosphoric Acid: It is simpler for the producers of wet-process superphosphoric acid to make acid in the range of 15 to 30% polyphosphate than to make it at the 50% level required several years ago, before the advent of the pipe reactor[10]. The lower range is reached in one stage of concentration with commercial vacuum concentrators instead of two. In one-stage concentration, alower production cost and less difficulty in the operation are advantages. Also, the storage properties of the low-poly-phosphate wet-process superphosphoric acid are slightly better than those of the higher polyphosphate acid.

In the past it has been difficult to produce a 10-34-0 or 11-37-0 liquid fertilizer with excellent long-term storage properties from wet-process superphosphoric acid in a conventional tank reactor. The reason for this was that the polyphosphate content of the product was too low. Normally, wet-process superphosphoric acid is too viscous to handle easily when it contains much more than 50% of the P_2O_5 as polyphosphate. Polyphosphates in liquids are desirable for good storage life. Also, polyphosphates in liquids sequester the impurities introduced in the wet-process superphosphoric acid. Otherwise, iron, aluminum, and magnesium precipitates form in the liquid and settle to the bottom of storage or transport tanks, causing difficulty in handling the liquid. Liquid such as 10-34-0 should contain at least 50% polyphosphat, and 11-37-0 should contain at least 65% polyphosphate to store satisfactorily at 32 degrees 32 degrees F[11]. Still higher polyphosphate contents (about 80%) are required to avoid precipitation of magnesium compounds when acids of high magnesium content are used.

Wet-process superphosphoric acid containing about 30% polyphosphate can be used in the pipe reactor process to produce liquids containing 70 to 85% polyphosphate.

Urea and Urea-Based Intermediates: Urea has become a major source of nitrogen for the fertilizer industry, particularly for fluids, during recent years. Large quantities of prilled urea were used last year in fluid mixtures because it was more readily available than urea - ammonium nitrate (UAN) solution. Some liquids in which all of the supplemental nitrogen is supplied as urea salt out at lower temperatures than those in which the supplemental nitrogen is supplied as UAN solution. On the other hand, some nutrient ratios in liquids are inferior when all of the supplemental nitrogen is supplied as urea. Usually some advantage is gained in a 1:1:1 and a 2:1:1 NPK weight ratio by adding all the supplemental nitrogen as urea. However, in a 1:2:2 ratio liquid there is no significant difference in the salt-out temperatures regardless of whether it is made with urea or UAN solution. In a 1:1:0 ratio and a 3:1:0 ratio, there are disadvantages encountered in supplying all of the supplemental nitrogen as urea. These results are tabulated below.

Plant nutrient ratio	UAN solution	Prilled urea
1:1:0	19-19-0 (11°F)	17-17-0 (32°F)
1:1:1	7-7-7 (30°F)	10-10-10 (43°F)
1:2:2	5-10-10 (20°F)	5-10-10 (20°F)
2:1:1	10-5-5 (32°F)	14-7-7 (25°F)
3:1:0	24-8-0 (11°F)	18-6-0 (32°F)

Note: The source of P_2O_5 for all mixtures is high-polyphosphate 10-34-0 or 11-37-0. Salt-out temperature of the mixtures are shown in parenthesis.

Typically, liquids of the same grade that contain potash have lower salting-out temperatures when all of the supplemental nitrogen is supplied as urea rather than as UAN solution.

In some instances, an additional advantage in lowering the salting-out temperatures of liquid fertilizers is gained by having about 10% of the supplemental nitrogen supplied as ammonium nitrate. Therefore, companies have utilized prilled urea for a twofold purpose:

1. To supplement UAN solution which was in short supply
2. To improve the quality of their products

The increased use of urea in liquid fertilizers should cause no pollution or control problems and sampling errors should be minimized since no troublesome precipitates of potassium nitrate will form during storage.

Use of urea is increasing rapidly in areas other than fluid fertilizers such as the ones listed below:

1. Bulk-blended fertilizers
2. Cattle feed
3. Industrial chemicals

New Materials for Fluid Mixtures: TVA is now operating a demonstration-scale plant that produces a 28-28-0 grade urea — ammonium phosphate (UAP). This material can be used successfully to make bulk blends and fluid fertilizers. Chemical and physical properties of the product are as follows.

Properties	Specification	Range
Chemical analysis, %		
Total nitrogen	28.0 minimum	28-29
Urea nitrogen, % of total	80.0	
Ammonia nitrogen, % of total	20.0	
Total P_2O_5	——	28-29
Available P_2O_5	28.0 minimum	28-29
Polyphosphate P_2O_5, % of total	——	20-40
Water-soluble P_2O_5, % of total	——	99-100
Moisture	0.4	——
Biuret	0.5 maximum	——
Bulk density, lb/ft^3	48	——
pH of 10% solution	4.9	——
Critical humidity, % relative humidity	——	50-55

UAP has been used commercially to produce both liquid and suspension products. There are two main advantages in using UAP for the production of fluid grades:

1. Higher analysis liquids containing potash can be produced than with conventional nitrogen solution although the quality of the acid used to produce the UAP will cause variation in the product quality.
2. Companies far from the production plant find it advantageous to ship granular UAP for fluids instead of phosphoric acid. Also, less ammonia and UAN solution must be shipped.

UAP does have two slight disadvantages: (1) it is slow in dissolving, often requiring as much as 45 minutes' mixing time and (2) since ammonia has to be added to the UAP to adjust the fluid pH to about 6, the popular 1:1:1 ratio cannot be produced. The lowest $N:P_2O_5$ ratio solution that can be made under these conditions is about 1.17.

Production and Use of Clear Liquids

Processes and Practices: The continuous and batch processes for the production of fluid fertilizers were mentioned briefly earlier. Most liquid fertilizer plants that employ a continuous process are considered hot-mix plants and are normally large plants that make a base liquid of NP grade, such as an 8-24-0, 10-34-0, or 11-37-0. The hot-mix plant derives its name from the heat generated by the continuous ammoniation of phosphoric acid that results in a hot mixture.

The required quantity of water is added to make the desired base liquid. In the continuous process, the acid flow is set at a constant value and the pH of the solution normally controls the ammonia flow. Although this is not normally done, the hot-mix plant can be used to make a three-component fertilizer containing potash. Most of the $N:P_2O_5$ base materials are used in cold-mix plants to produce the NPK grades.

In hot-mix plants either commercial-grade orthophosphoric acid (54% P_2O_5) or superphosphoric acid (70-80% P_2O_5) of either furnace or wet-process type can be used. There are other variations such as methods of introducing the raw materials into the reactor and the methods of removing heat.

Most of the liquid plants in this country produce liquids by a batch process. These plants are of both the hot- and cold-mix types. A cold-mix plant is one in which a base liquid, such as 8-24-0, 10-34-0, or 11-37-0, is simply blended with other raw materials, such as a UAN solution (28-32% N), potash (62% K_2O), and water to make the desired product. Since there is almost no heat of reaction, the operation is considered a cold-mix procedure.

Cold-mix plants are so simple that there are few major differences among them. Storage tanks, meters, scales, and a simple mix tank make up the equipment list. In this plant the liquids are weighed and mixed in a batch mix tank made of carbon steel that is similar to the tank that is normally used as a reactor in a hot-mix plant (see Fig. 4).

Product liquid fertilizers are usually stored in vertical mild steel storage tanks of about 20,000-gallon capacity each. These tanks are equipped with suitaable pumps to pump from each tank as well as to recirculate the liquid to the top of each tank for mixing purposes. Nurse and applicator tanks do not have to be equipped with agitators; however, it is good to have some means of agitating the liquids in these tanks. If pesticides are added to the liquids, agitation is required since most of them have an oil base and they separate from the liquids unless they are constantly agitated. Strainers are normally used in the application equipment. This is particularly true if broadcast equipment is used. The filters will keep foreign material out of the small spray nozzles.

Clear liquids are used mostly as starter fertilizers. The most popular grade used for this purpose is 7-21-7. Clear liquids are also uses as complete fertilizer and applied both in the raw and by broadcasting.

Production and Use of Suspensions

Processes and Practices: Usually suspension fertilizers are produced in about the same manner and with about the same equipment as clear liquids. The main difference in the production procedure is the dispersion of small quantities of a suspending agent such as attapulgite-type clay in the suspension product. Also, suspensions have varying quantities of undissolved soluble plant nutrients. For these reasons more vigorous agitation is normally required to produce quality suspension than is required to produce clear liquid fertilizers.

If a plant with a suspension fertilizer-handling system is properly equipped, the product can be produced and handled as easily as clear liquid fertilizers. Usually, the extra equipment needed is of minor cost. These items are listed below.

1. High-shear agitation is required in the reaction vessel to properly disperse the clay. A turbine agitator used with a centrifugal pump having an impeller tip speed of 60 to 90 feet per second gives acceptable dispersion.
2. Mechanical or air agitation is necessary in the storage, nurse, and applicator tanks.
3. When broadcast equipment is used, a few spray nozzles with large diameters should be used rather than many spray nozzles with small diameters.

For storage tanks a mechanical agitator can be used; however, this type of agitator is quite expensive. Normally, air spargers are more economical and do a good job of agitating the product. This type system is shown in Figure 10.

For agitation of the suspension product in nurse tanks and application tanks, recirculation pumps or air is commonly used with a sparger system as shown in Figures 11 and 12.

A typical rig for broadcast application of suspensions is shown in Figure 11.

Suspensions are applied primarily by broadcasting. However, some are applied in the row.

Development work on a process for producing an all-orthophosphate suspension fertilizer is in progress at TVA. Grades such as 12-36-0 containing about 1.5% of clay have been produced in a pilot plant and a demonstration-scale plant. Merchant-grade wet-process acid is ammoniated in two stages in this process and the product contains no polyphosphates. Current work is directed toward improving the physical properties of the product to prevent settling of undissolved nutrients from the suspension during rail shipment.

Current Status of the Industry

Growth in the production and use of fluids is expected to continue. Suspension fertilizers seem to be somewhat slower in taking over the fluid market than was originally thought. This is probably due, at least in part, to an unwarranted fear of suspected difficulties in producing and handling these products. Suspensions should eventually take over a much larger portion of the fluid fertilizer market as well as some of the high-analysis solids market.

Also, availability of new products such as UAP and potassium phosphates should help the fluid fertilizer industry.

In recent years the techniques of manufacturing, storing, and applying suspensions have improved greatly.

Interest in fluid fertilizers is increasing in Europe and gradual increases in use of these materials appear probably in that area of the world.

Increased use of fluids in the U.S. will continue. A trend toward larger plants that offer custom application services is established and is expected to continue.

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FIGURES

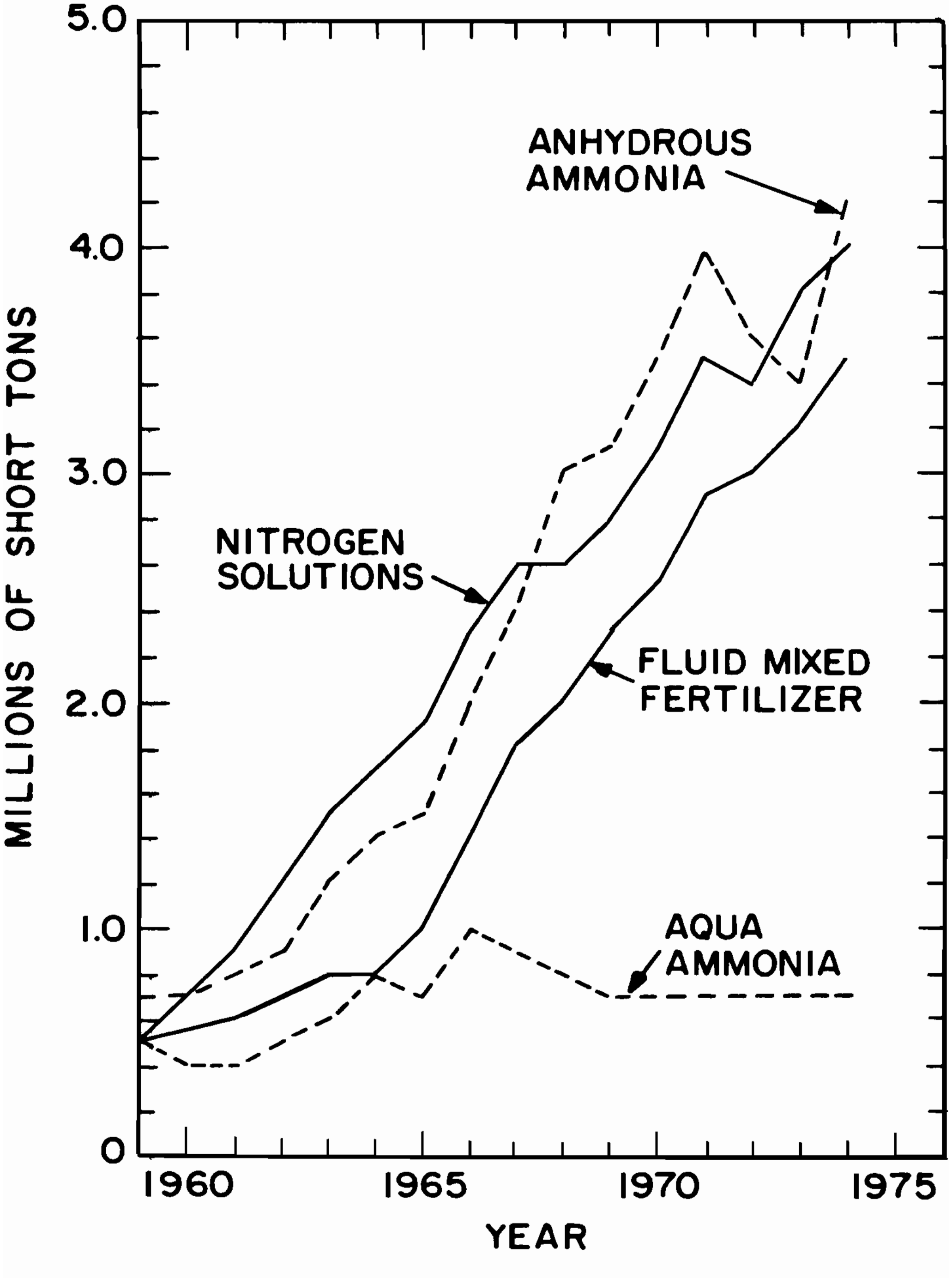


FIGURE 1

Consumption of Fluid Fertilizers in United States

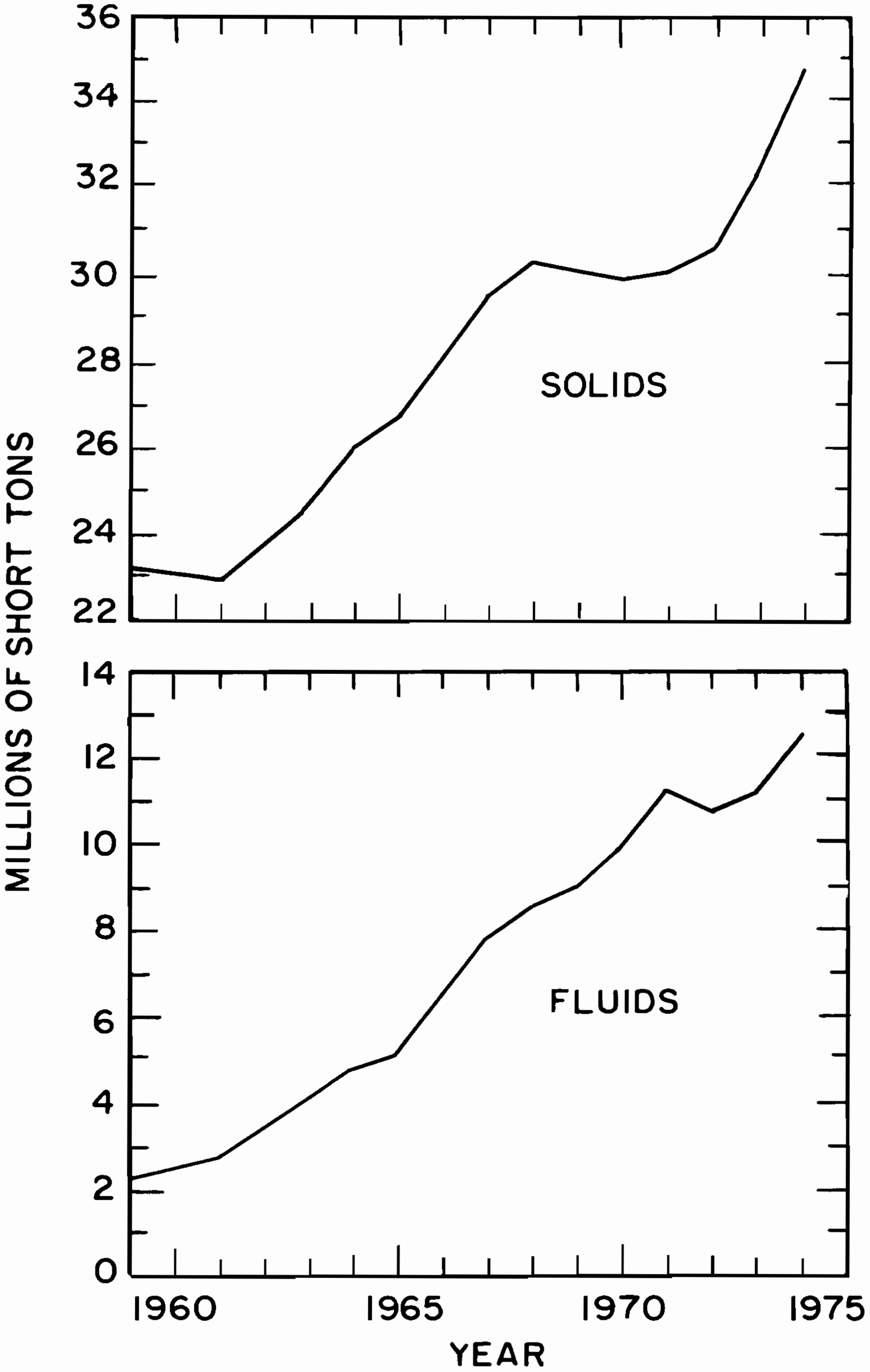


FIGURE 2

Consumption of Fluid and Solid Fertilizers in United States

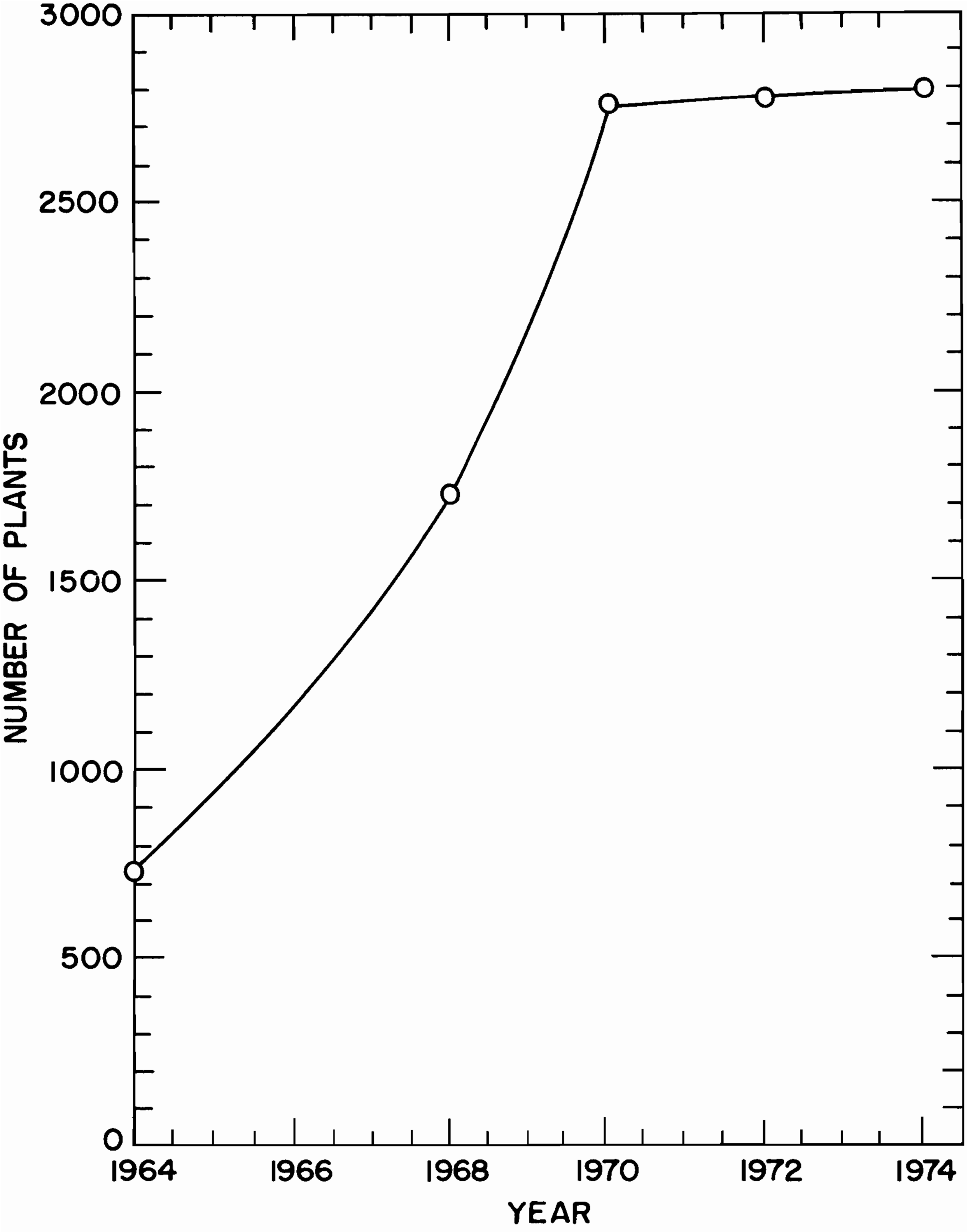


FIGURE 3

Fluid Fertilizer Plants in the United States

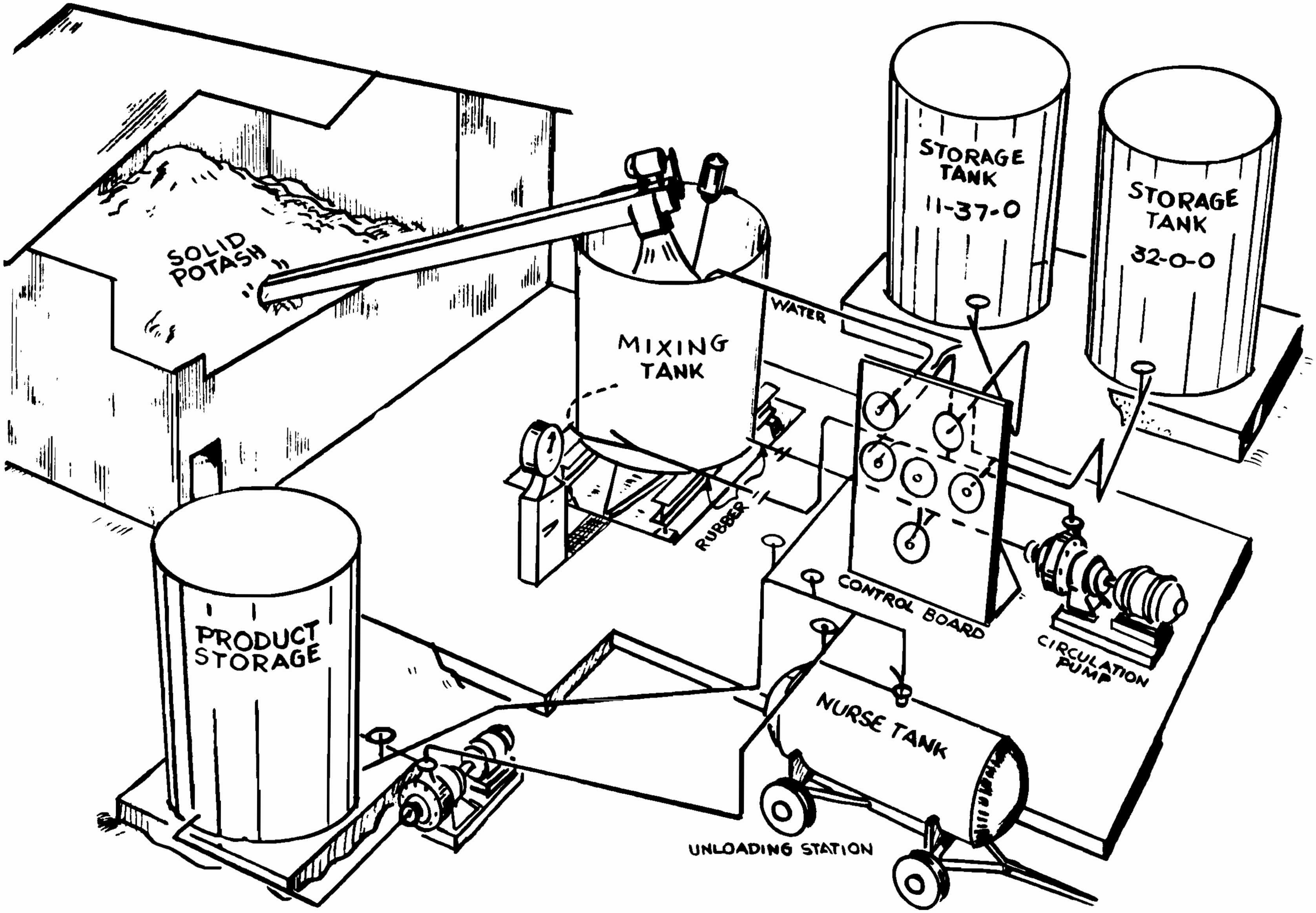


FIGURE 4

Typical Liquid Cold-Mix Plant

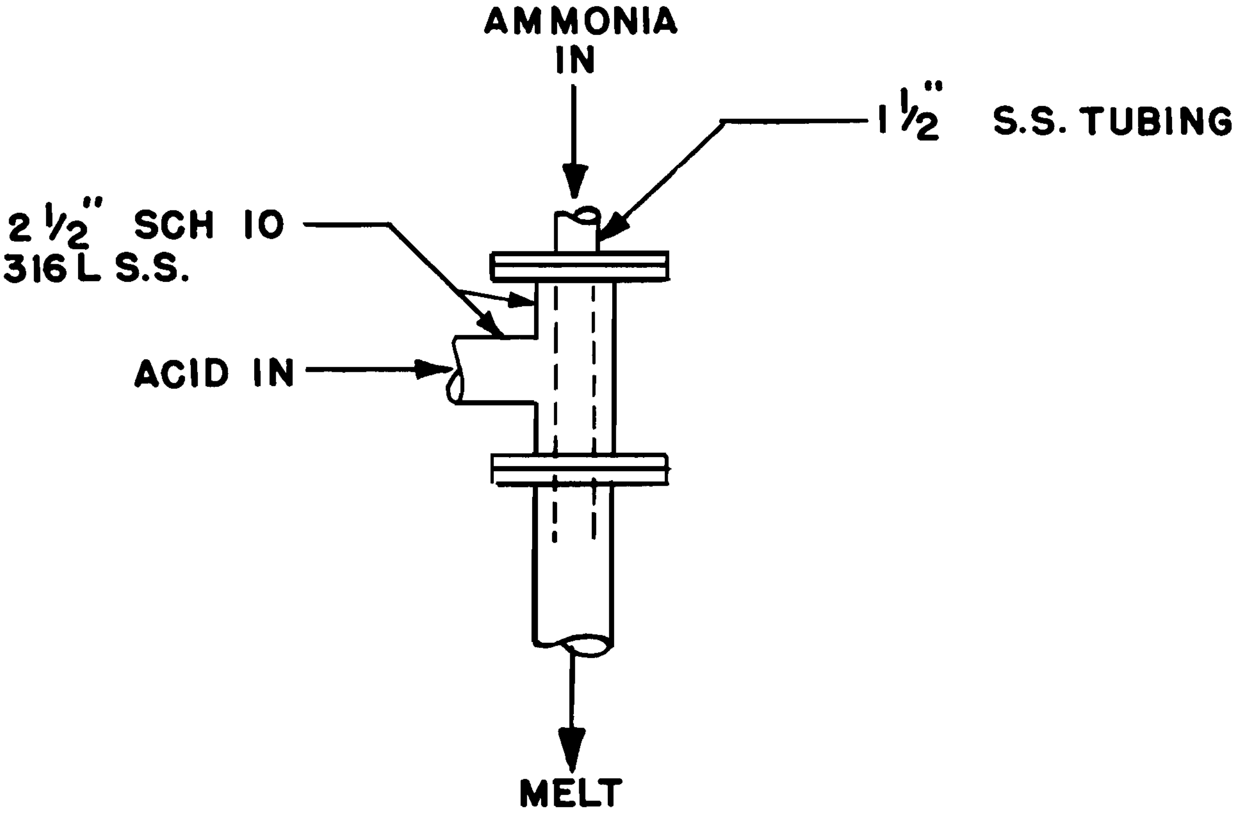


FIGURE 5

Acid-Ammonia Feed Arrangment for Pipe Reactor

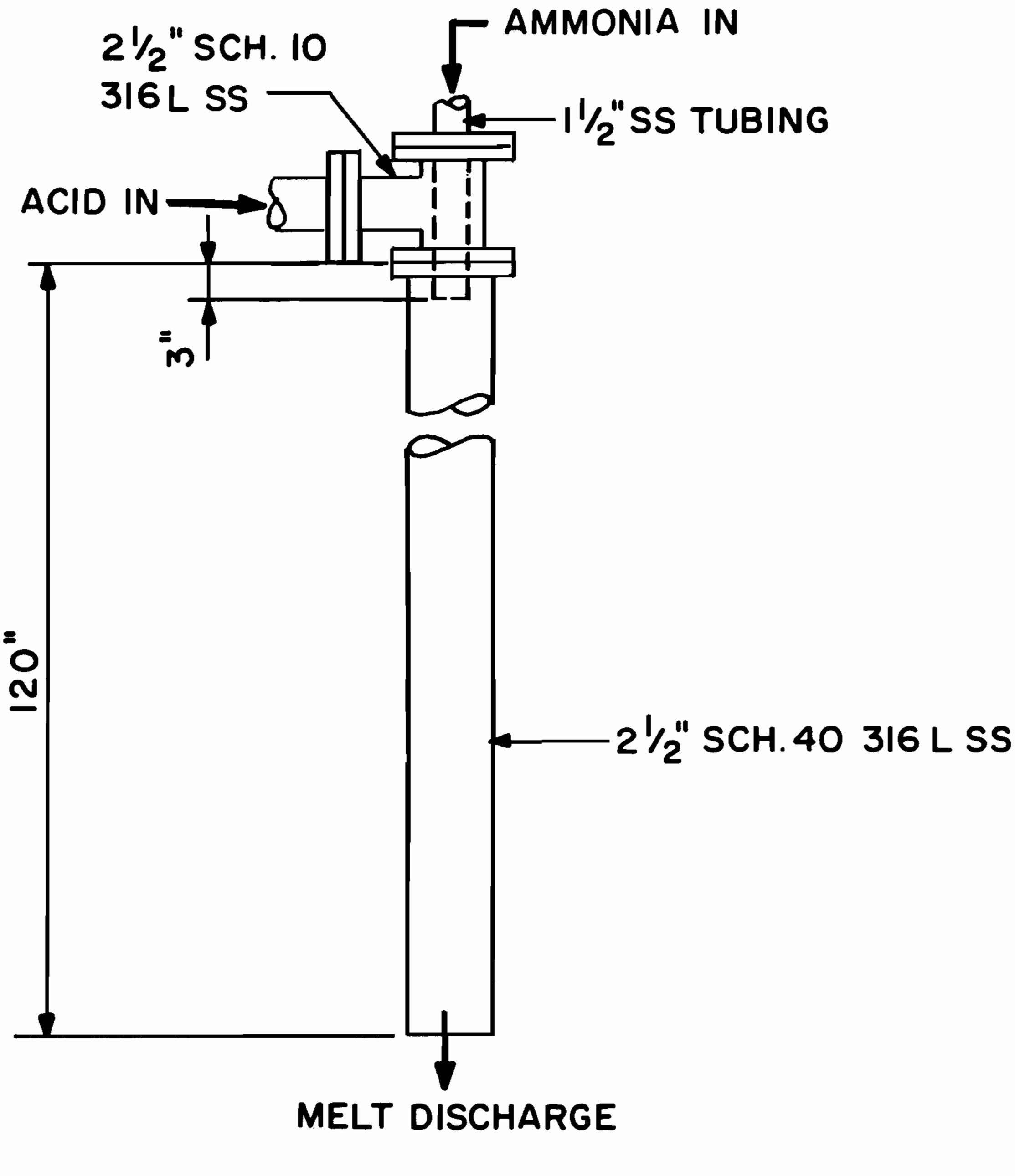


FIGURE 6

Two and One-Half-Inch Pipe Reactor for Production of 15 Tons Per Hour of High-Polyphosphate 11-37-0 Liquid Fertilizer

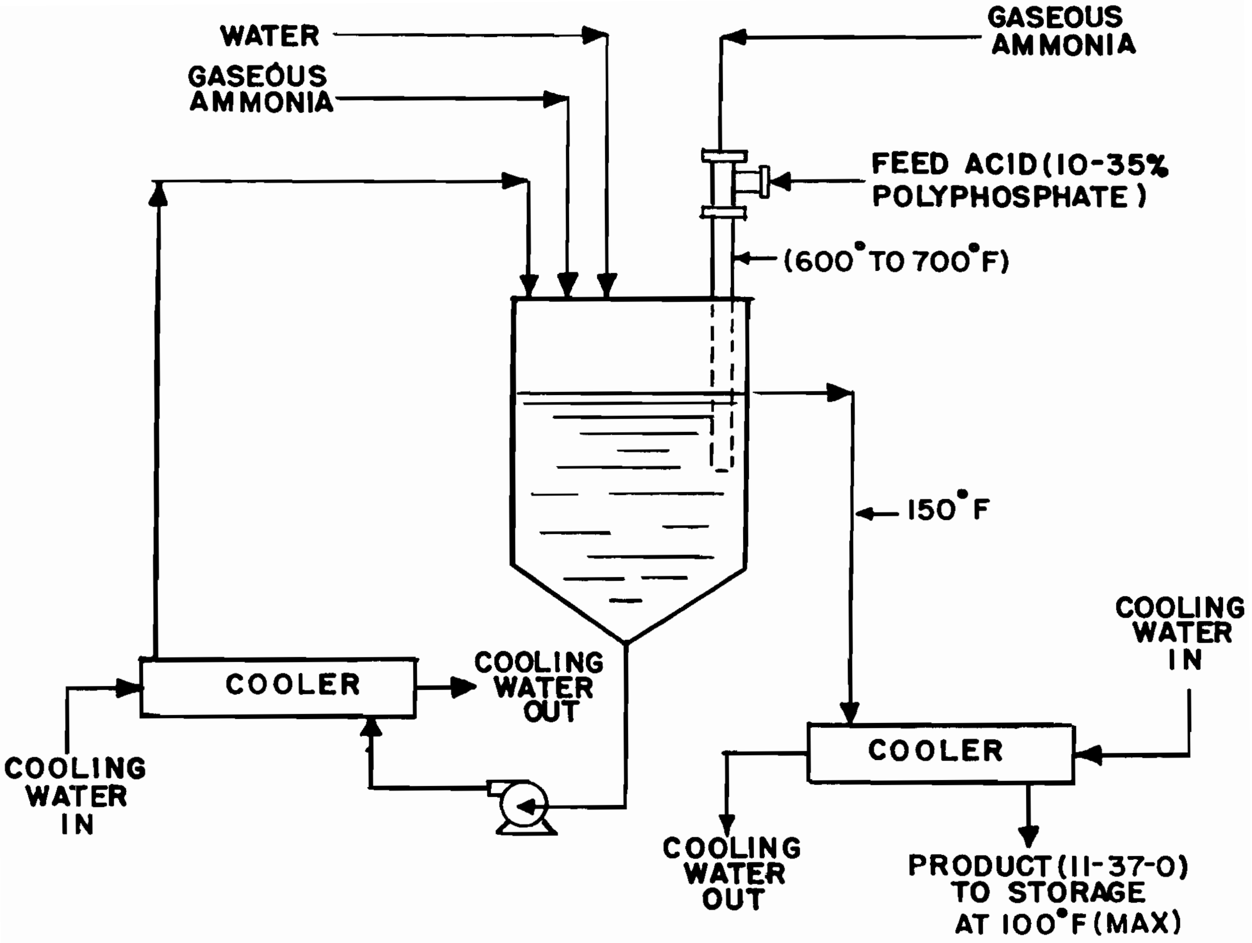


FIGURE 7

Process Flow Diagram of TVA Plant Pipe Reactor System

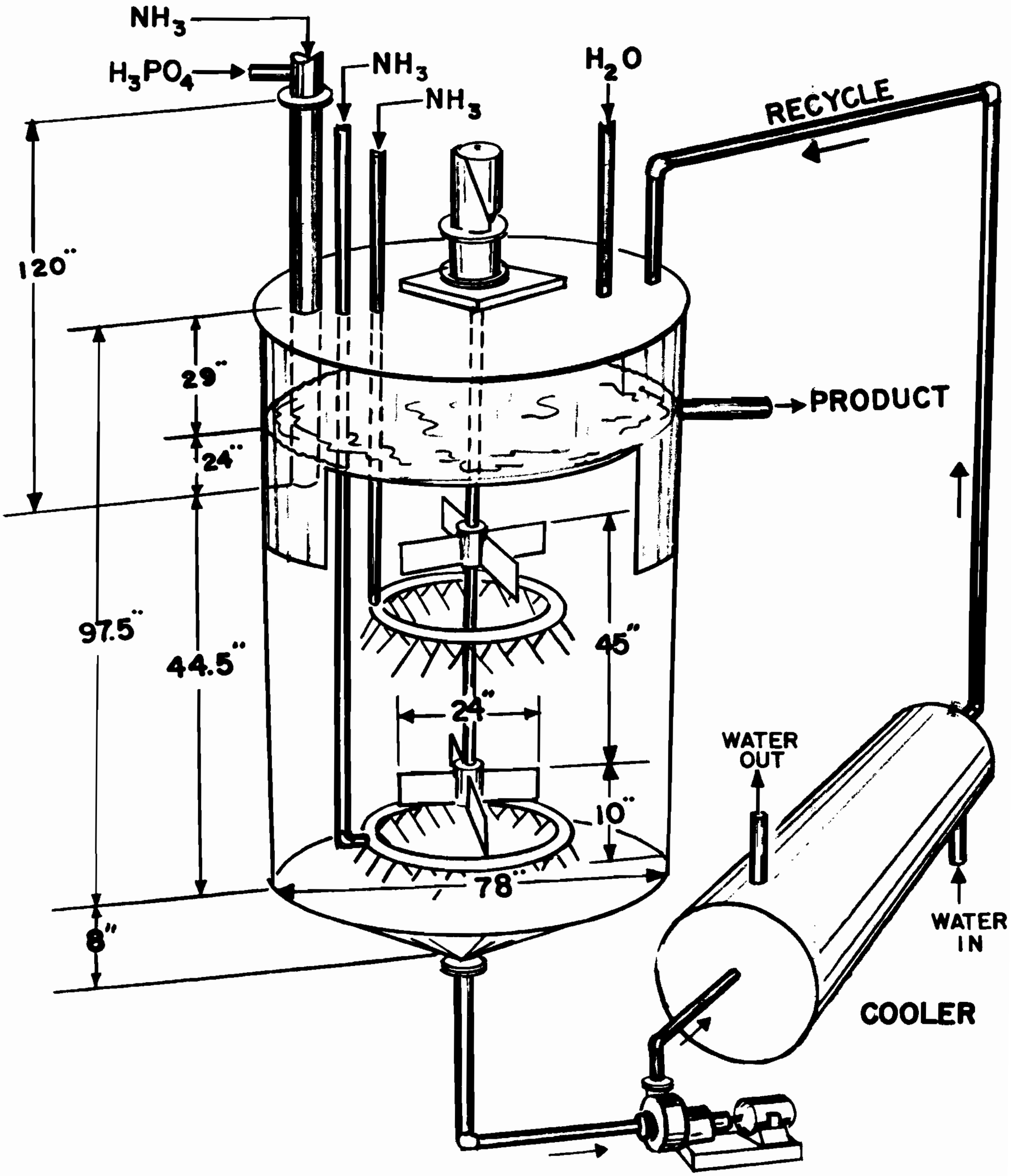


FIGURE 8

TVA Plant Pipe Reactor Showing Cooler and Details of Reaction Vessel

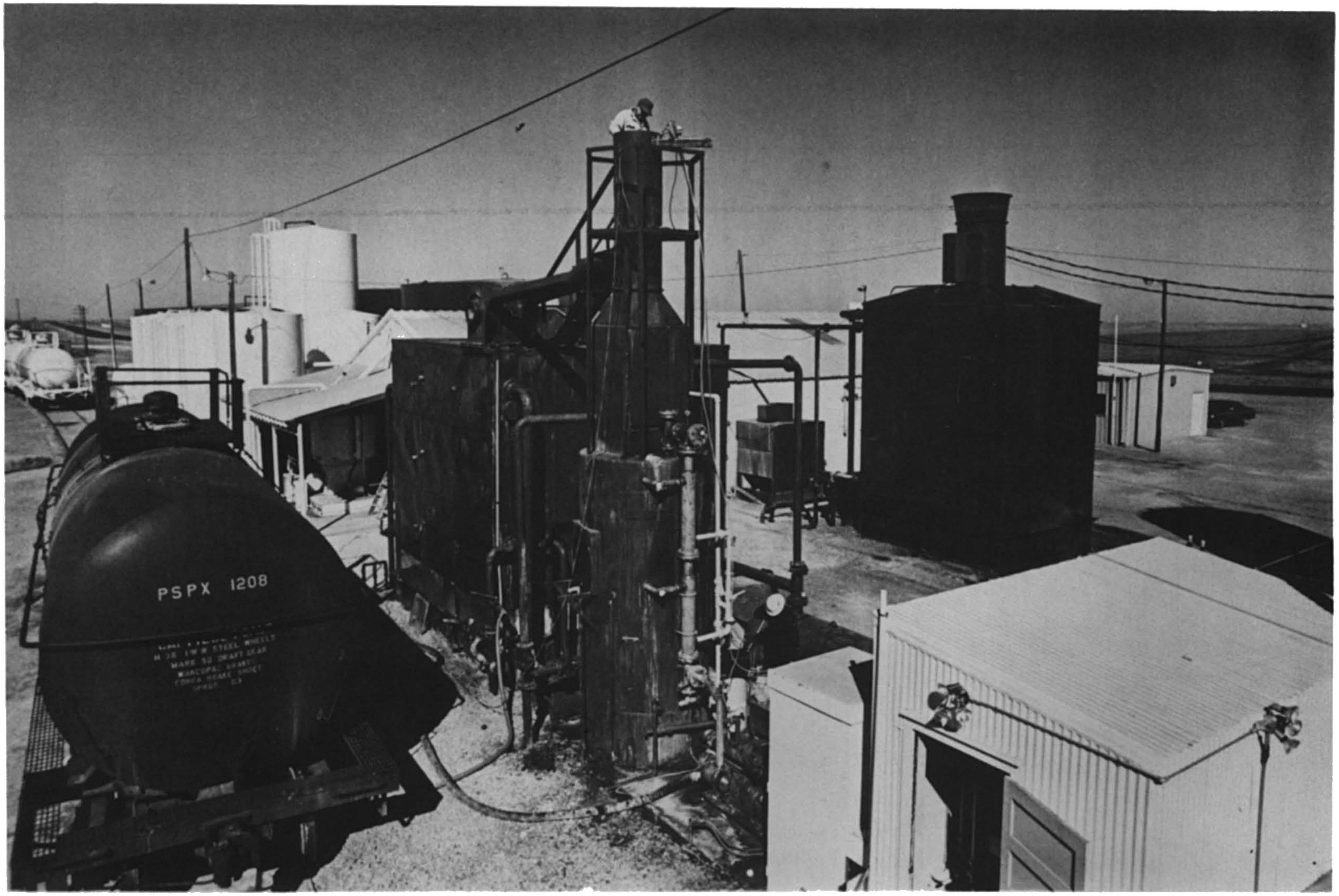


FIGURE 9

Typical Commercial Pipe Reactor Plant

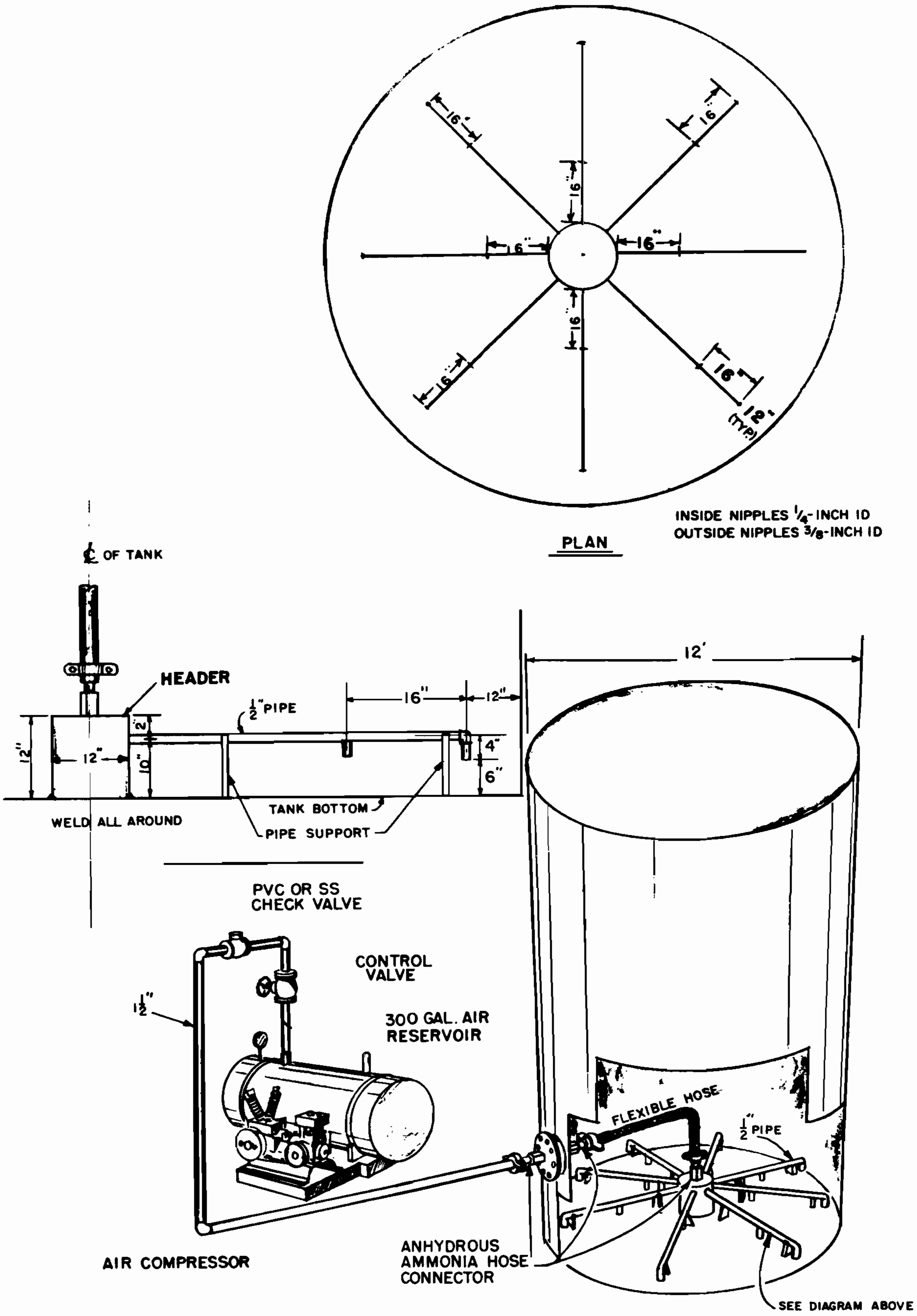


FIGURE 10

Pipe Sparging System for Suspensions

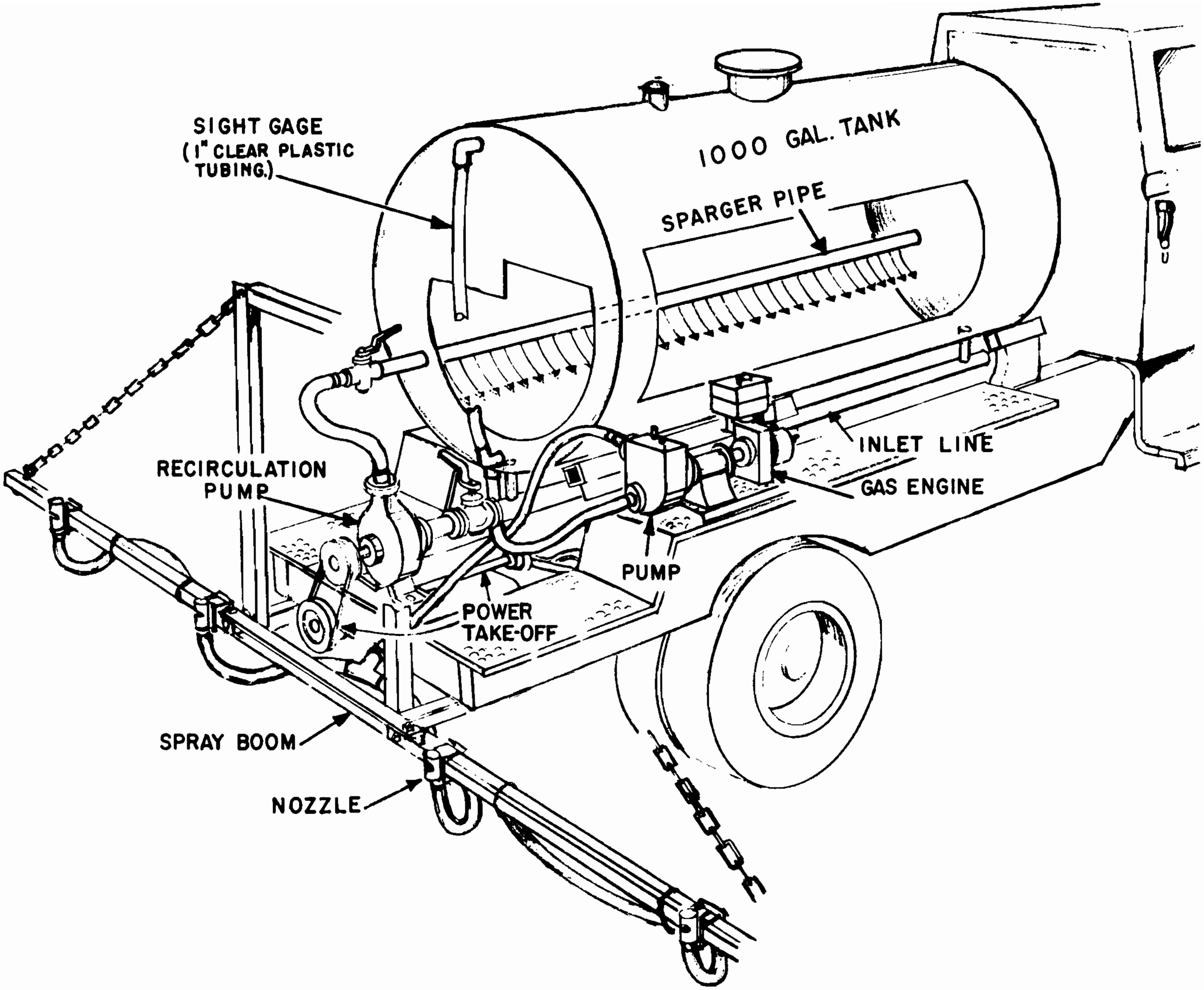


FIGURE 11

Applicator for Suspension Fertilizers

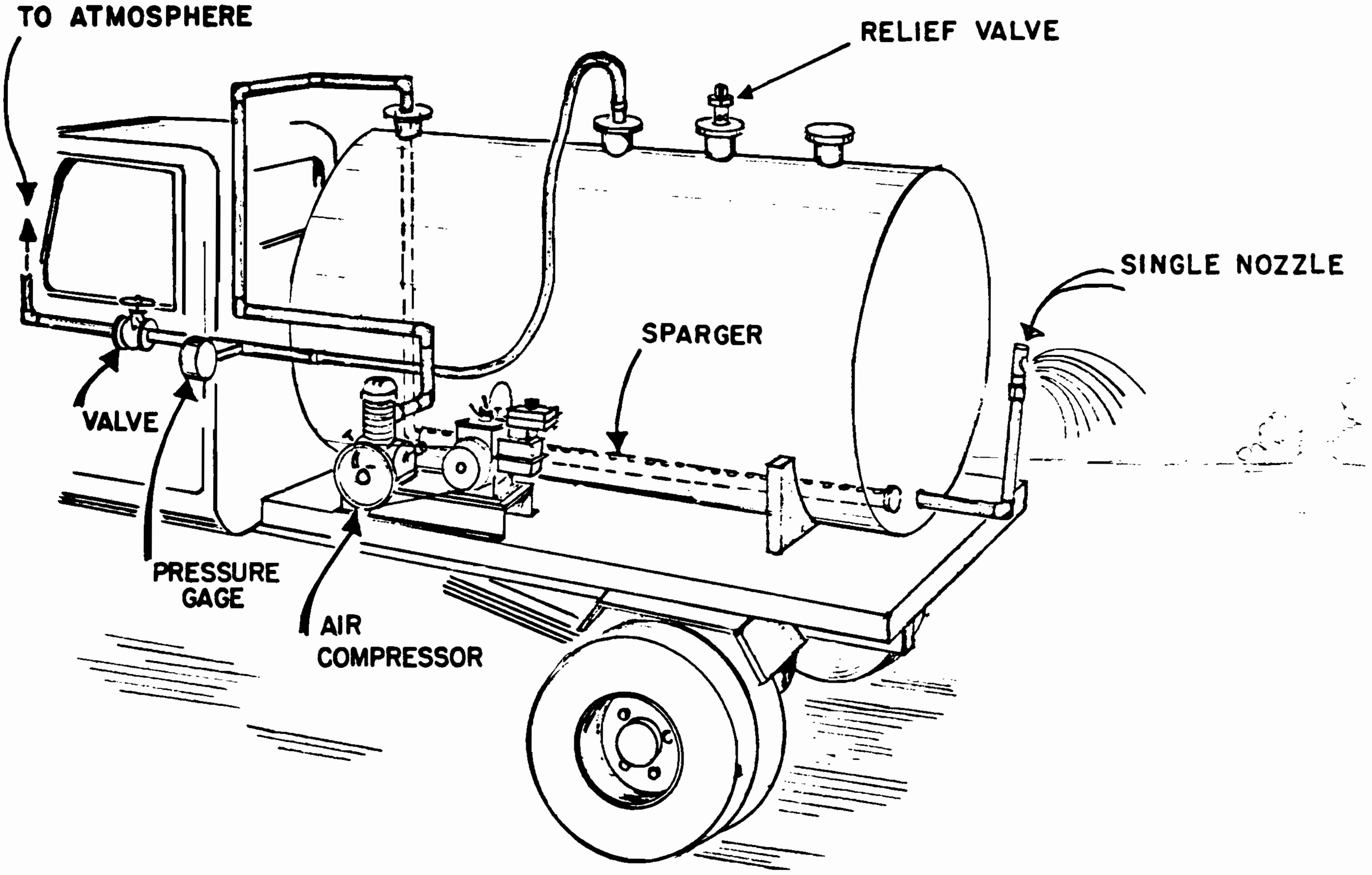


FIGURE 12

Broadcast Application Truck for Suspensions

MODERATOR DAVIS: Do you have any questions for Bill while we have him here.

QUESTION: What is the critical humidity of the 28-28-0?

ANSWER: About 55% is the critical relative humidity of the 28-28-0 granular material. It needs to be stored with plastic over it when it is stored in bulk.

QUESTION: In storage of suspensions, how do you prevent the suspension from going back into the sparger pipe?

ANSWER: Every one of these spargers that I've had anything to do with or have heard anything about are nor foolproof; but in our plant, for instance, if we get a sparger stopped up, it's sort of unusual. We blow it out with a little steam and everything is pretty. So I guess there's several ways that you could approach this. One thing that was tried several years ago, and probably is still in use to some extent, is to make that distributor out of a piece of plastic tubing with a slit in it; and when you take the air pressure off, theoretically the slit will close up. But actually I don't really think that's the problem. We haven't had experience which indicates to us what it is.

QUESTION: What is the maximum controlled flourine content of the phos-acid you can have to avoiding corrosion?

ANSWER: I think typically the fluorine content of our domestic acids is still around 8 or 9/10's of a percent. Now, we haven't experienced any wide variation in that fluorine content and we don't know how high you would have to run it to get into trouble. Frank, have you got a comment on that?

FRANK ACHORN COMMENT: We haven't had a corrosion problem; we had a scaling problem. I wish we could get a little more fluorine in the acid so the liquids may store better.

BILL SCOTT: Well, going back to one little point I tried to make in that paper, if your acid has normal impurity content encountered in the country, and I am speaking specifically of acid made from Central Florida rock, your problem in that pipe is not corrosion because very quickly you will form a layer of scale on the pipe that completely protects the pipe. And then your problem is you wish you didn't protect it quite so much because the scale will eventually plug the pipe. Where there is high purity in the acid, of course, you have got more of a corrosion problem than you do a scaling problem. But we haven't experienced any difficulty because of fluorine content.

MODERATOR DAVIS: Any other questions for Bill? Thank you, Bill.

A very fine summary of the state of fluid fertilizer technology in the United States.

The next speaker this morning is Mr. Douglas Caine of Swift Agricultural Chemicals Corporation. Douglas is a native of the black hills of South Dakota who somehow found his way over to Great Britain for his education. He attended grade school, high school and was graduated from the University of Manchester with degrees in both chemistry and pharmacy.

He is an affiliate of the Pharmaceutical Society of Great Britain, a member of the Royal Society of Health in London, the American Chemical Society, the American Society for Quality Control and is also a member of the Board of Directors of the Fertilizer Industry Round Table.

Doug began work with Swift in 1951 as chemist, and he was appointed in charge of quality assurance for the Agricultural Chemical Division of Swift in 1966. He serves as industry advisory member on several committees of the Association of American Plant Food control Officials including fertilizer terms and definitions, inspection and sampling, soil amendments, elemental guarantees and environmental control. He is a member of TFI Product Quality Committee, and this morning Doug Caine will give us a "Report From TFI Product Quality Committee" group. Doug.

Product Quality Report From TFI Product Quality Committee

Douglas Caine

The TFI Product Quality Committee was formerly known as the Chemical Control Committee in the days when it sparent body was the National Plant Food Institute. It became apparent, in recent years, when the scope of this committee was undergoing expansion, that Chemical Control was an extremely limited description of its function. This report may serve as an introduction to some of its recent activities.

Regional Inspector's Training Conferences

One of the most vigorous and rewarding interests of this committee is its active support and participation in the Regional Training Conferences for Plant Food Inspectors, established by the Association of American Plant Food Control Officials. The first of these was held in Mayfield, Kentucky in September of 1969. Since the launching of this first meeting, no fewer than thirteen of these conferences have been held in the space of six years, the last being as recent as September of 1975. The accompanying map will *(Slide 1 and 2)* testify to the range of the activity of the Association's Inspection and Sampling Committee and that of the TFI Product Quality Committee. Since inception, approximately 350 inspectors, 63 State Control Officials and 120 industry representatives have attended one or more conferences. Participation in the 13 workshops has included representatives from 41 States.

A 1964 report by the State Control Officials noted that the 50 states used 28 different sampling devices thus making it apparent that there was a need for research on sampling commercial fertilizer, especially bulk. Several important points were brought out as a result of collaborative study between the State Officials and industry participants along with the AOAC Associate referee on sampling. These points are enumerated:

1. It is generally necessary to secure vertical probes in sampling bulk dry fertilizers.
2. Conventional uncompartmented probes will not secure representative vertical cores.
3. Dry fertilizers tend to separate by particle size during flow into a sampling compartment. However, compartmented samples do secure sufficiently representative cores if inserted vertically.
4. The Missouri D tube has been found to be superior to other triers.
5. The stream sampling procedure will secure accurate samples when there is a uniform sustained flow of sufficient duration to permit following the prescribed procedure.
6. To secure reproducible samples a standard, uniform sampling pattern must be followed.

It was apparent that there was a definite need for uniformity, so the inspection conferences were organized and geared to emphasize the importance of uniformity in sampling and to develop procedures to attain this objective. This became an excellent opportunity to exchange viewpoints and ideas, and gain information on the level at which the main processes of State fertilizer control programs really operate.

The Inspector's Manual was first published in 1968 and the first revision appeared in 1971. Instruments and procedures for sampling bulk and bagged dry fertilizers have been adopted by the AOAC. Objectives have been developed which serve as guidelines for the workshops of the Regional Training Conferences. These are:

1. To disseminate information concerning official (AOAC) sampling procedures and instruments.
2. To promote use of the Inspector's Manual.
3. To emphasize the importance of the inspector's work.
4. To exchange and consolidate information on the best procedures used in participating states.
5. To develop and promote uniformity among the states in inspection and sampling procedures.

The subjects covered in the conferences include planning of itineraries, public relations, conduct, labeling and actual sampling. Since state chemists also attend these sessions and some field men practice riffling, although this is generally regarded as a laboratory procedure, sample reduction is also discussed.

The sampling procedures are the most strongly emphasized portions of the conferences. Equipment appropriate to each type of material is fully discussed, whether it is found in bags or bulk as dry fertilizer, or in fluid forms such as liquid or suspension.

Location of material and technique appropriate to each situation is evaluated whether it be in a warehouse, storage pile, on a truck or in a railcar. The underlying theories for core sampling, stream sampling and compositing of cores and cuts are fully covered in the session.

The fertilizer industry values very highly the opportunity to cooperate with state officials in these sessions. This is an ideal method to develop uniform inspection methods and assure the maintenance of high quality fertilizer products.

Particle Size Survey

The USDA reported in 1972 that 22 million tons of mixed fertilizers were sold in the United States. At least one-third of this volume was in the form of bulk blends, which consist of 2 or more basic materials combined. The ratio of fertilizer in the form of bulk blends has been steadily increasing for many years. Associated with the increase in blending has been an off-grade problem in a number of states. This problem manifests itself as a condition where the nutrient contents fail to meet guarantees as found by analyzing samples taken by state fertilizer control officials. The percentage of off-grade samples in some states has reached substantial levels.

Research has shown that the major factor contributing to the off-grade problem of blends is segregation due to difference in particle sizes of the materials. Other physical properties such as shape, surface condition and density are relatively insignificant in contributing to segregation. A Particle Size Task Force of the TFI Product Quality Committee was organized in 1972 and cooperated with TVA in developing information on the range of particle sizes of the major materials used in blends.

The survey showed wide variations in particle sizes between different materials, between different producers of given materials, and even between different shipments of a given material of a single producer. Using the average *(Slide 3)* data for the products in the survey, one can see the relative potential for satisfactory blending by this graph. A close alignment *(Slide 4)* is also seen for the average figures for diammonium phosphate and granular potash. The similarity in particle sizes between these two materials will promote uniformity in blends, while the disparity which is seen between coarse potash and diammonium phosphate will contribute to segregation. *(Slide 5)* The Particle Size Task Force arrived at several conclusions from the results of analyzing the survey.

1. Industry should adopt the Tyler mesh, eliminating confusion with U.S. screen data.
2. Industry should adopt five uniform screen sizes for the Tyler mesh: 6, 8, 10, 14 and 20 mesh for materials used in blends.
3. Industry should adopt a uniform method of reporting particle size analyses, using the cumulative and individual fractions for the screen sizes listed.
4. Producers, where practical, provide purchasers with screen analyses as specified.
5. Increase educational programs to minimize the segregation problem resulting from varying particle sized materials.

There was no judgment made in favor of industry suggesting recommended particle sizes for material to be used in blends, although this was an earlier goal of the Task Force. The development of this goal came about as a result of pressure by some fertilizer control officials for standardizing particle sizes of blend materials.

It can be theorized that the matching of materials with a wide range of particle sizes would be a logical step to take. However, in actual practice, handling and delivery to storage will cause these materials to segregate by particle size by themselves. A blender could thus be mixing large particles from the base of one pile with the fines from the center of another pile. Anti-segregation devices to counteract the effect of 'coning' are only effective when they are being used. The problem of separation by particle size still remains in field application with throw type spreaders. Independent action by producers to narrow the particle size distribution would not be considered a good move. It could possibly lead to even greater segregation problems than those which presently exist. A single particle size range for blending materials is considered too restrictive and undoubtedly would require considerable expenditures. Recognition of the problem by all interested parties is a major step. Our real goal remains the achievement of uniform blends.

Bulk Blend Quality Control Manual

Production of this manual was a recommendation which followed logically upon the work of the Particle Size Task Force. It is a guide for quality control practices in fertilizer blending operations. It is useful to basic producers of fertilizer materials and to blender operators, both of whom have major responsibilities in the production of blended fertilizers of high quality.

For the producer, the manual describes basic characteristics of materials that are essential for proper matching and compatibility. For the blender, it explains in clear, understandable fashion the causes of a number of everyday problems and how they may be corrected, or better still, avoided. This is "product quality" under direct control.

It is interesting to note how the form in which fertilizer is distributed has changed in the past 25 years. Bagged fertilizer has shown a steady decline since the middle 1950's while dry bulk fertilizer has increased, with an accelerated rate since 1960. The use of liquids has also increased, but to a lesser extent. A recent estimate indicates that over 40 percent of all solid fertilizer sold in the U.S. is bulk blended. Therefore, the producer of basic materials and the blender operator share a large responsibility for producing high quality blends.

The manual supplies information on the following:

1. High quality blends and the type of fertilizer materials needed to produce them.
2. Acceptable blending equipment.
3. Procedures for determining if a given material is suitable for use in good quality blends.
4. Desirable blending plant operating practices including personnel training, housekeeping, sampling, analyses, scheduling, inventory control, customer service and observance of state laws.

In material selection, chemical analyses must be known and particle sizes matched. Successful blending can be pre-determined by means of the view box or by running screen tests. Charted information is given on chemical compatibility of blend materials and critical humidities of fertilizer salts. Computation of formulas is fully covered including the use of varying analysis raw materials and acceptable fillers. Guidance is given on the addition of secondaries, micronutrients and pesticides to formulas.

Quality blends are also dependent on the use of well designed facilities and equipment. The manual describes plant equipment, including maintenance. Emphasis is placed on hopper design and the use of anti-segregation devices to minimize or prevent "coning" whether it be in bagging, bulk loading or holding hoppers. Sections are devoted to good operational control, house-keeping and analysis, including chemical nutrient content, sieve-analysis with particle-size distribution, and measurement of bulk density. For the statistically-minded, an appendix is devoted to determination of process capability of blending and bagging equipment. This manual has to be considered a must for everyone with any level of interest in fertilizer blending. The product quality committee regards it as one of its more significant achievements.

Sampling and analytical methods handbook

Fertilizers have been estimated to provide 13 of the 16 essential nutrient elements for plants. Each of these elements has several different methods for chemical analysis with varying degrees of accuracy and reliability. Results of nutrient analyses by two or more laboratories depend upon both laboratory accuracy and uniformity of methods. If the methods are not uniform, neither will be the results. Thus, uniformity of use of proven, accepted methods becomes critical.

Those accorded official recognition by the Association of Official Analytical Chemists (AOAC) have become the reference or basic methods for most accurate comparisons. These have been developed after years of work by analysts where every detail is minutely scrutinized for accuracy and repeatability before the final stamp of "official" is applied.

The AOAC methods, however, are written in condensed forms which present difficulty, even to experienced chemists, in interpreting them uniformly. Much of the technique and many of the details are omitted in the AOAC methods.

In recognition of this situation, the fertilizer industry chemists affiliated with the national Plant Food Institute issued, in 1961, the first edition of an "Analytical Methods" handbook. Its objective was to provide fertilizer chemists and others with quality control responsibilities a convenient reference for detailed descriptions of the best analytical methods for fertilizers, plus information on other critical procedures such as sampling and physical testing. The 1961 edition of the National Plant Food Institute Analytical Methods, was followed in 1964 by the Second Edition with a second printing of the latter in 1968.

An expanded edition, known as the "Sampling and Analytical Methods Handbook" was produced in 1974. This Third Edition, like its predecessors, is the product of chemists who are specialists in the field of fertilizer quality control. With extensive use of the most recent AOAC methods, publications of the American Association of Plant Food Control Officials, and a wealth of experience, this edition has been prepared.

The sampling section has been extended, and for the first time, the edition includes a section on "Rapid Methods", contributed by TVA.

These rapid methods were developed by TVA at the request of the Product Quality Committee of The Fertilizer Institute in 1972. Conditions attached to the request stipulated that the methods should be simple, not require expensive equipment, and be capable of yielding results with acceptable accuracy. It is imperative that grade be maintained during the operation of the process for production of fertilizer. Ideally, only a short time should therefore elapse between taking a sample and reporting its analysis.

These rapid methods are therefore designed to yield determinations of nitrogen, phosphorus and potassium within one hour; require laboratory equipment costing no more than $3,000; be carried out in a laboratory space no larger than 8 by 10 feet; and yield satisfactory results in the hands of a plant foreman with a high school education. They should meet the practical needs of speed without intolerable loss of the accuracy of the AOAC methods. There are restrictions on the applicability of the methods to certain forms of nitrogen. However, this section does add significantly to the usefulness of the handbook.

The Product Quality Committee of The Fertilizer Institute, as the instrument for producing this Third Edition, is owed a debt of gratitude by the fertilizer industry for this valuable and highly recommended piece of work.

Uniform State Fertilizer Bill

The Fertilizer Institute, through the Product Quality Committee, has been an ardent supporter of the Uniform State Fertilizer Bill. It has assisted in the development of many of the rules and regulations now forming part of the Uniform Bill.

An obvious area of concern for the committee has been in the sampling of fertilizer. A representative sample is an integral part of any chemical analysis. Fertilizers offer unusual problems in sampling, a feature which sets them apart from most other materials in channels of trade, in that they can be composed of several unlike materials of different particle sizes and densities.

We would like to acknowledge this diagram *(Slide 6)* prepared by U.S.S. Ag. Chem. which depicts sources of variance in a sample of fertilizer. At first glance, these sources appear to be so numerous that any analytical result developed after exposure to these variances would be an exception if it bore any close resemblance to the parent product. There are no doubt studies which support the existence of all of these sources of variance, which range from the inherent variance through that due to sampling, reduction, preparation, chemical analysis and true lot-to-lot variance.

A notable cooperative study undertaken with the regulatory state officials was the evaluation of sources of variation which had effects on routinely reported inspections of fertilizers. These variations were recognized to be the result of the effect of taking the sample, the effect of reduction of the gross sample, the daily variation of analysis within a laboratory and laboratory bias due to methods and/or analysts. The variances are correlated with levels of nitrogen, available phosphoric acid and potash ranging from 4% to 32% in each case.

These findings *(Slide 7)* are graphically illustrated as they relate to each individual nutrient. It should be noted that the sum total of these variations is described as an investigational allowance and not as a tolerance. A comparison is shown between the percentage of allowance from all nutrients in the AAPFCO investigational allowances compared with that used in Missouri. These show an increasing percentage of allowance at lower nutrient levels in the AAPFCO investigational allowance figures which those in Missouri are uniform at all levels of nutrient guarantee.

We are assured by the spirit of co-operation existing between industry and state officials that as all things change with time, changes in this field will be instituted when the need arises.

After many years of using the word "lot" as applied to a quantity of fertilizer, industry and control officials alike were somewhat surprised to learn that no definition of the term "lot" was included in the Uniform State Fertilizer Bill. The term was used in the Bill in sections dealing with stop sale orders, and with seizure, condemnation and sale.

AOAC and AAPFCO procedures used the term "lot" in connection with bagged fertilizer without any suggestion of the size of a lot.

Reference was made to bulk shipments in official procedures. By inference from the use of the sampling pattern, a truckload or carload of fertilizer could be considered a "lot".

At the time of this discussion, it was interesting to note that the 1970 edition of the ASTM Book of Standards defined the term "lot" in no less than 36 ways.

Once again, co-operative efforts between the Product Quality Committee of TFI on the one hand and the Uniform Fertilizer Bill and Definitions Committees of the AAPFCO resulted in the development of a definition for the term "lot". It was accorded tentative status in 1972 after very frief, but fruitful discussion. Official Publication No. 28 now defines it as follows: For purposes of obtaining an official sample, a "lot" shall be represented by an identifiable quantity of commercial fertilizer that can be sampled according to AOAC procedures, up to and including a freight car load or 50 tons maximum, or that amount contained in a single vehicle, or that amount delivered under a single invoice.

The Magruder Fertilizer Check Sample Program

The Product Quality Committee of TFI has supported this program for many years. The program name came from its originator, Dr. E. W. Magruder of the Royster Guano Company, who distributed the first check sample to 29 participating laboratories in 1922. No methods were prescribed. By comparing results with those of other laboratories and the average of all laboratories, each analyst could assess the adequacy of his own method.

Each sample report listed laboratory averages based on as many repeat analyses as a laboratory decided to do. An unweighted grand average of these averages was provided for each plant nutrient. The monthly reports were deemed of great value throughout the United States and Canada for improving the methods and standards of fertilizer analyses.

After 36 years in 1958, the program was transferred to the joint sponsorship of the Association of American Fertilizer Control Officials and the National Plant Food Institute. A joint committee established annual subscriptions to cover the cost of sample preparation and distribution. Subscriptions were handled by the Secretary-Treasurer of the Control Officials, statistical evaluations by W. R. Grace and the printing and mailing of reports by the N.P.F.I. At this time participants numbered 126. Ten years later, in 1968, there were 184.

Statistical reports were first issued in January 1959. These showed:

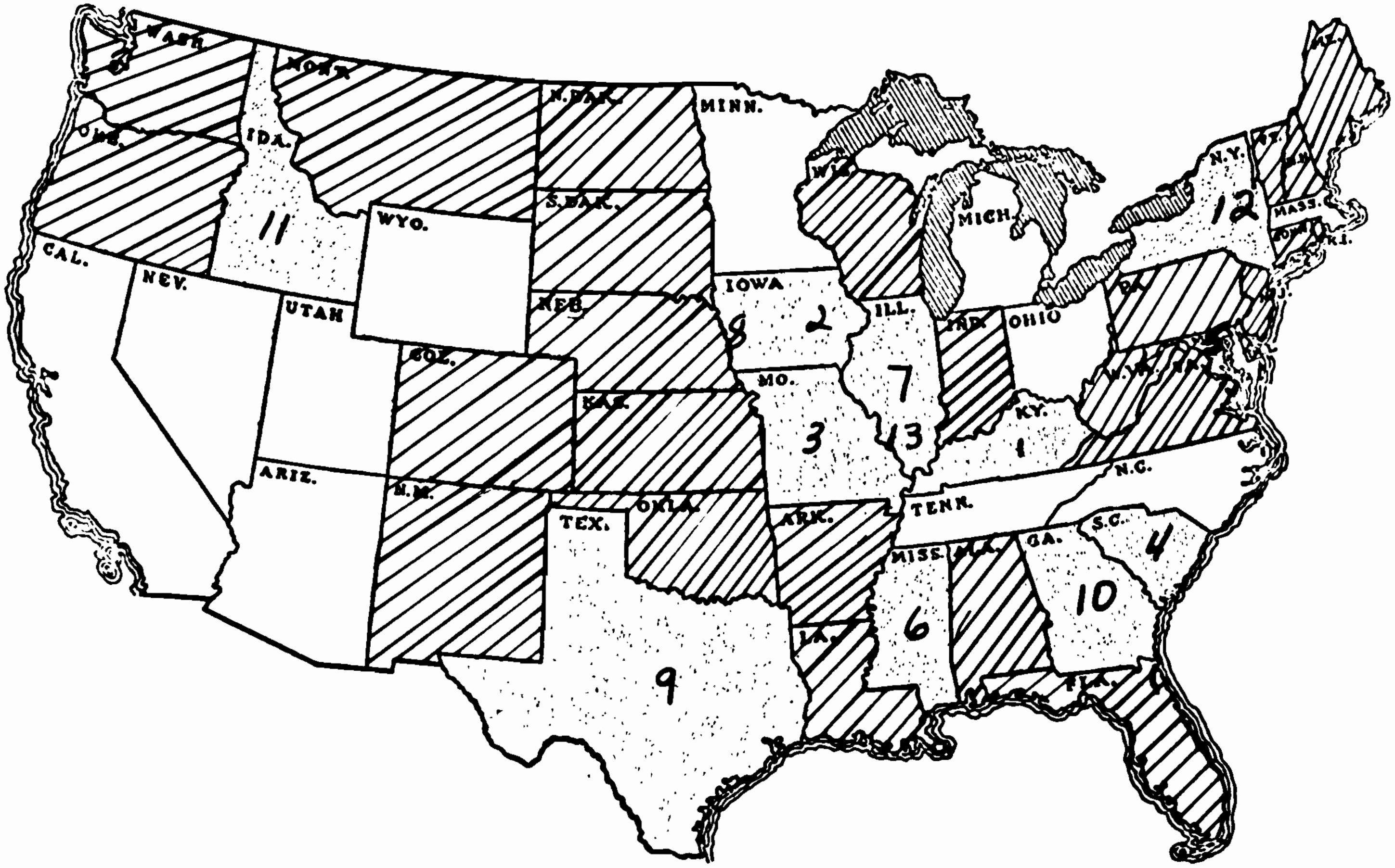
1. Laboratory averages based on duplicate analyses.
2. Respective ranges between duplicates.
3. Properly weighted grand averages.
4. Average ranges of duplicates.
5. Standard deviations of laboratories but no identification of analytical methods.

In 1960, computer programs were first employed and individual analytical methods were identified in reports. Subsequent expansions to the computer program allowed the potential of the Magruder data to be more fully used. One hundred types of analyses can be accommodated with as many as ten methods for each type. Confidential performance reports quantitatively evaluate laboratory performance in the use of individual analytical methods together with average performance over all methods.

These confidential reports rate performance of the laboratory in terms of normalized bias, precision and accuracy. The data used comes from repeat analyses of the three most recent check samples. This small number is used to make the report sensitive to changes in performance. Computer programming continues to be provided by W. R. Grace and Company with the services of Mr. E. M. Glocker. The Fertilizer Institute furnishes secretarial help and handles the mailing of results to participants. Members of the Product Quality committee actively participate on the Magruder Committee and assist in its programs.

It is hoped that this summary report of the activities of the Product Quality Committee has been sufficient to illustrate that it is a viable, progressive group with an active interest in promoting product quality with the full co-operation of regulatory officials and having a sincere desire to provide the consumer with the best product suited to his needs.

INSPECTORS' TRAINING CONFERENCES



(░) HOST STATES
(▨) PARTICIPATING STATES

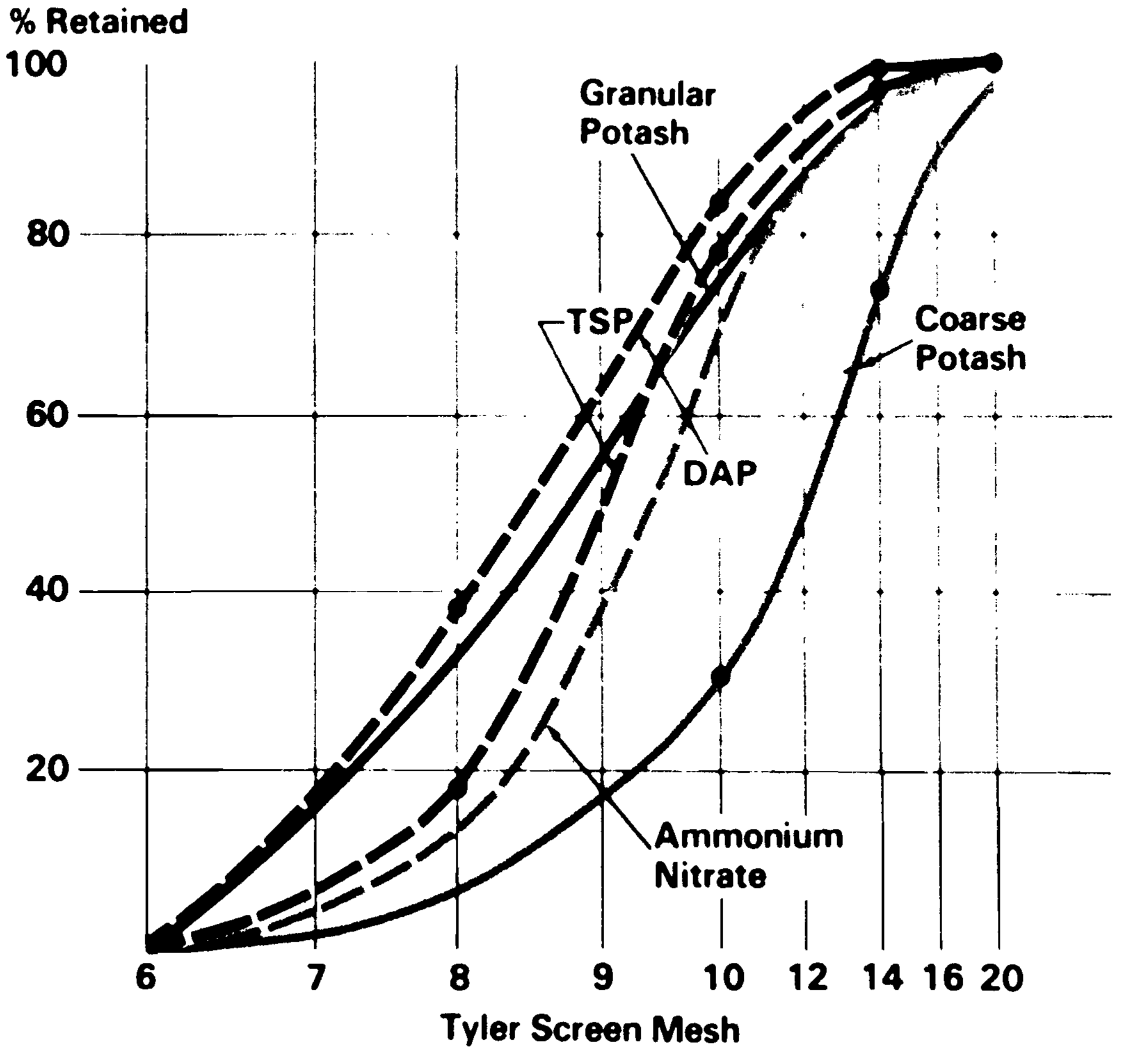
SLIDE 2

INSPECTORS' TRAINING CONFERENCES

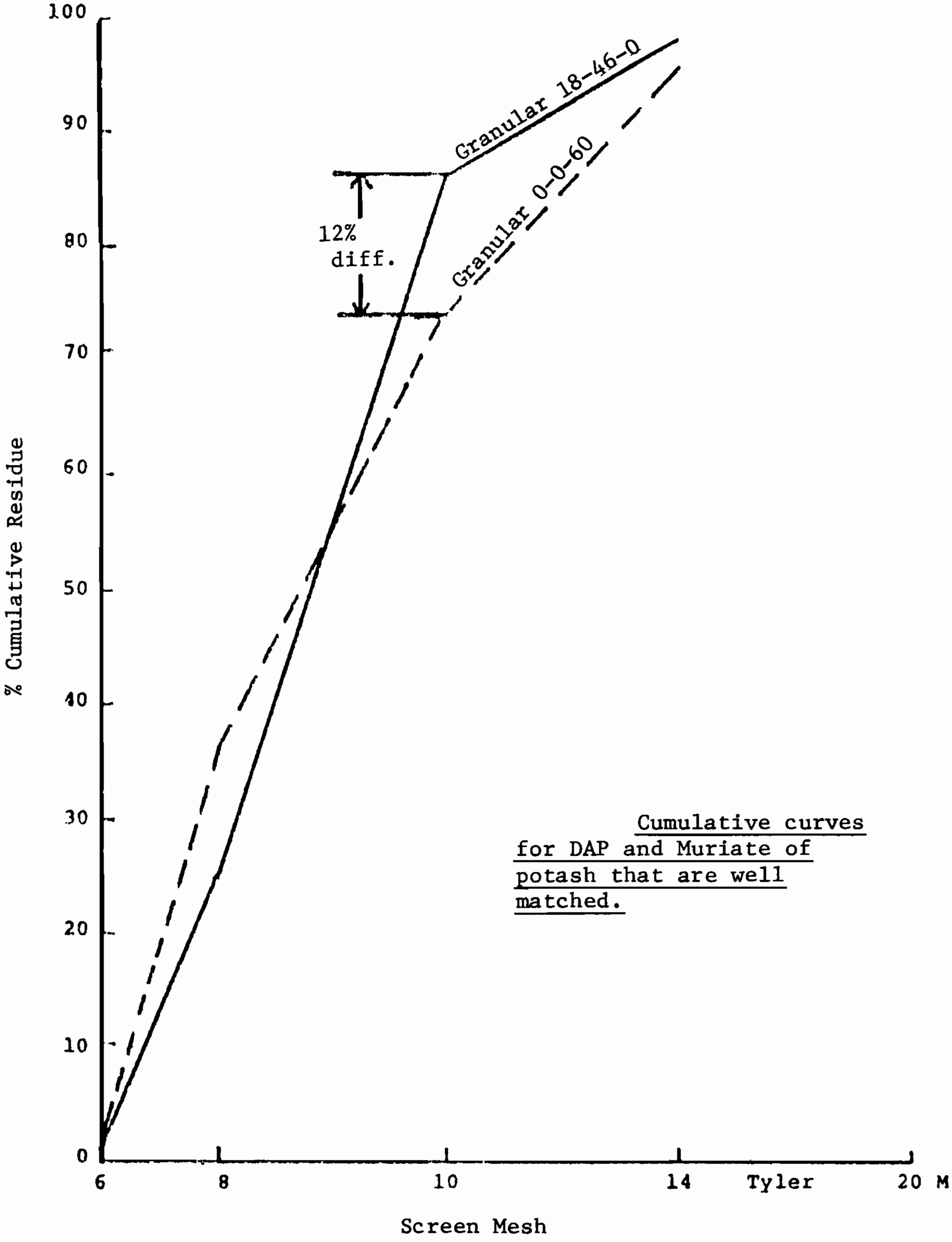
The following tabulation shows the number, location, time and participating States since the inception of these conferences. The information is graphically illustrated on the accompanying maps.

No.	Location	Date	Participants
1.	Mayfield, KY	September, 1969	KY, AR, IN, MO
2.	Dubuque, IA	October, 1969	IA, MO, WI
3.	Joplin, MO	December, 1969	MO, AR, KS, OK
4.	Clemson, SC	January, 1970	SC, AL, VA
5.	College Park, MD	February, 1970	MD, NJ, DE, PA, VA, WV, ME
6.	Vicksburg, MS	January, 1971	MS, LA, AR, AL
7.	Springfield, IL	March, 1971	IL, IN
8.	Sioux City, IA	October, 1971	IA, SD, NB, ND
9.	Plainview, TX	November, 1972	TX, NM, OK, CO, KS
10.	Tifton, GA	November, 1973	GA, FL, SC, AL
11.	Boise, ID	March, 1974	ID, WA, OR, MT
12.	Albany, NY	February, 1975	NY, CT, NH, VT, RI, PA
13.	Springfield, IL	September, 1975	IL, MO

AVERAGE PARTICLE SIZE DISTRIBUTION OF FERTILIZER MATERIALS IN SURVEY

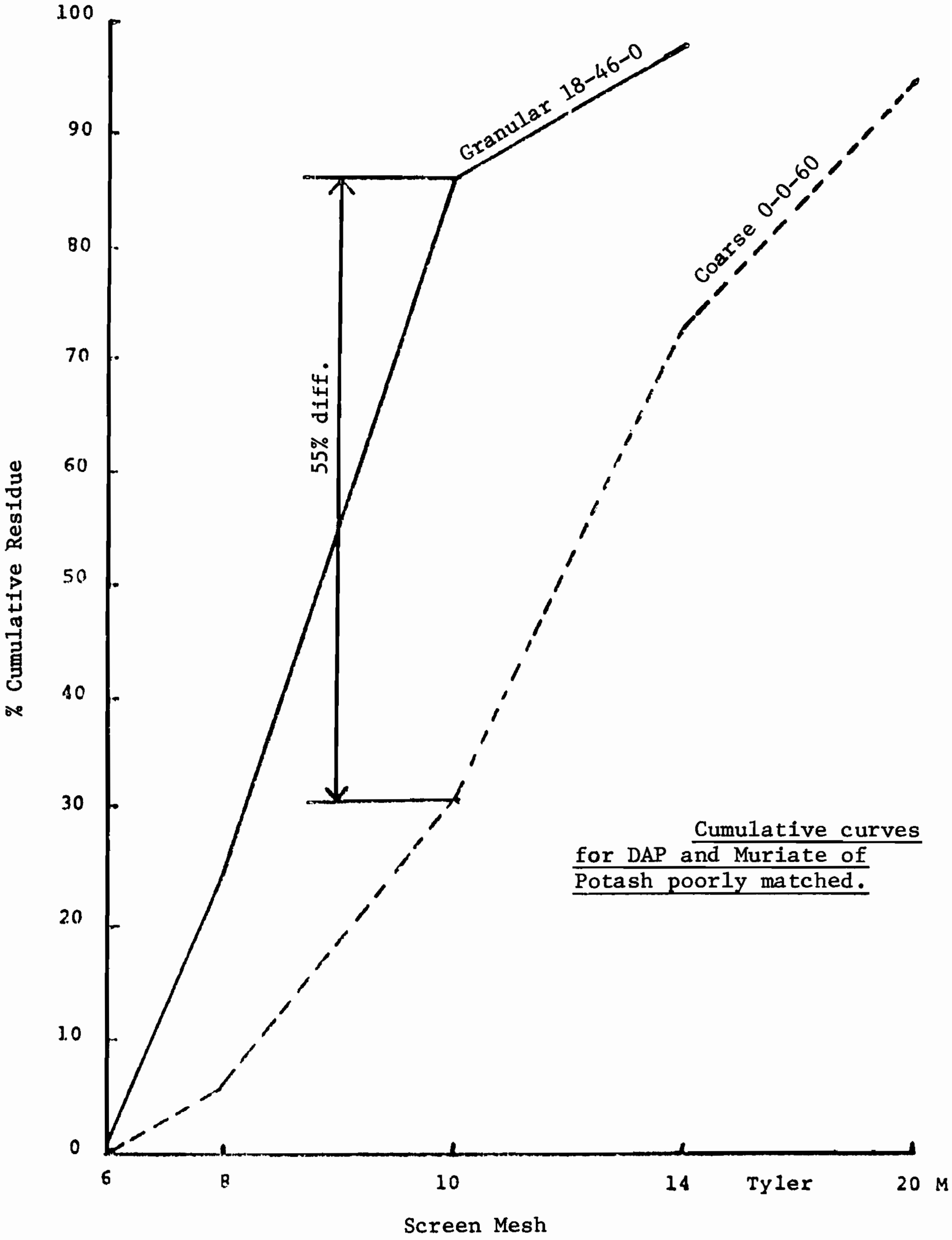


SLIDE 4



Cumulative curves for DAP and Muriate of potash that are well matched.

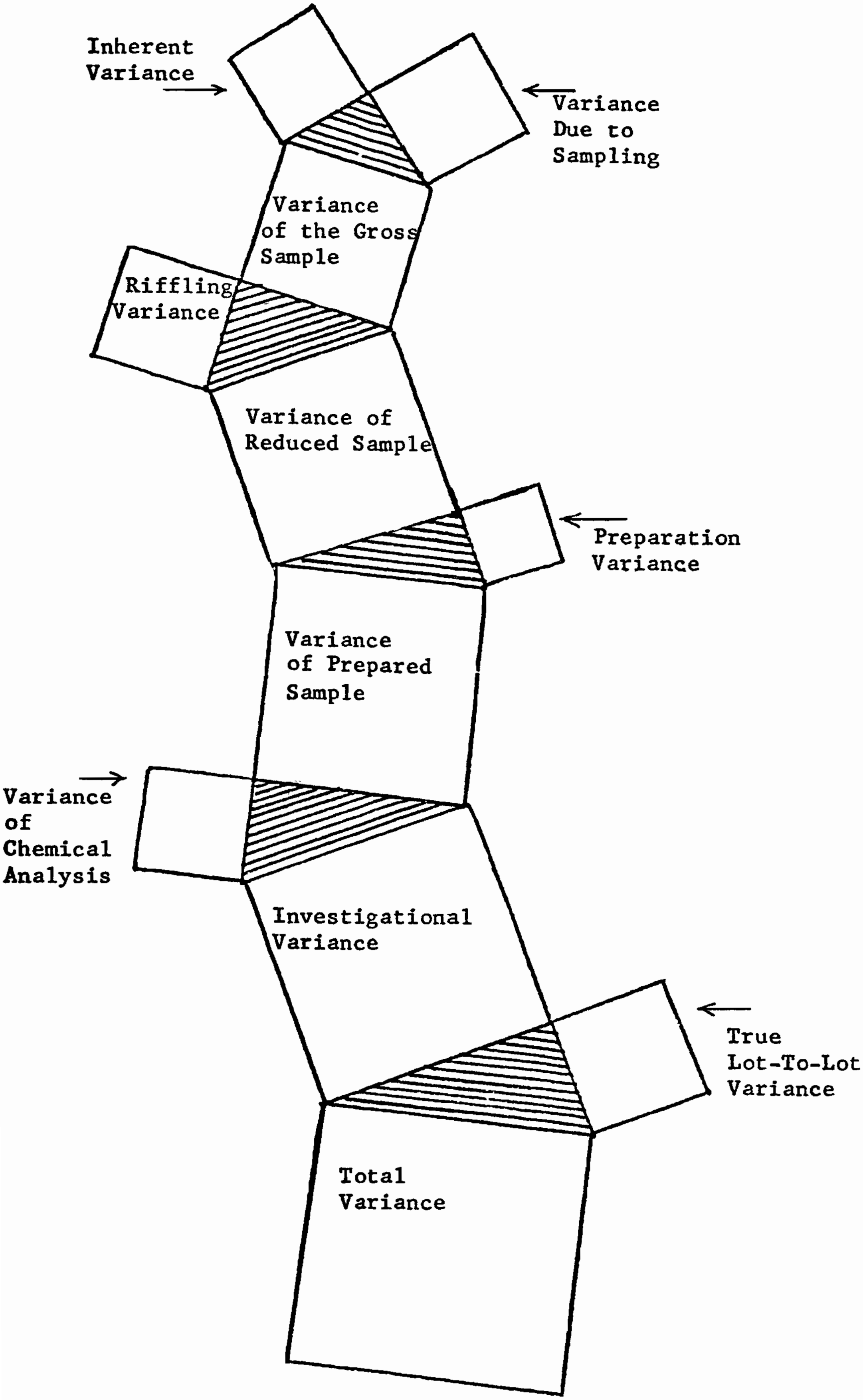
SLIDE 5



Cumulative curves for DAP and Muriate of Potash poorly matched.

SLIDE 6

Sources of Variance In Samples



Inherent Variance

Variance Due to Sampling

Variance of the Gross Sample

Riffling Variance

Variance of Reduced Sample

Preparation Variance

Variance of Prepared Sample

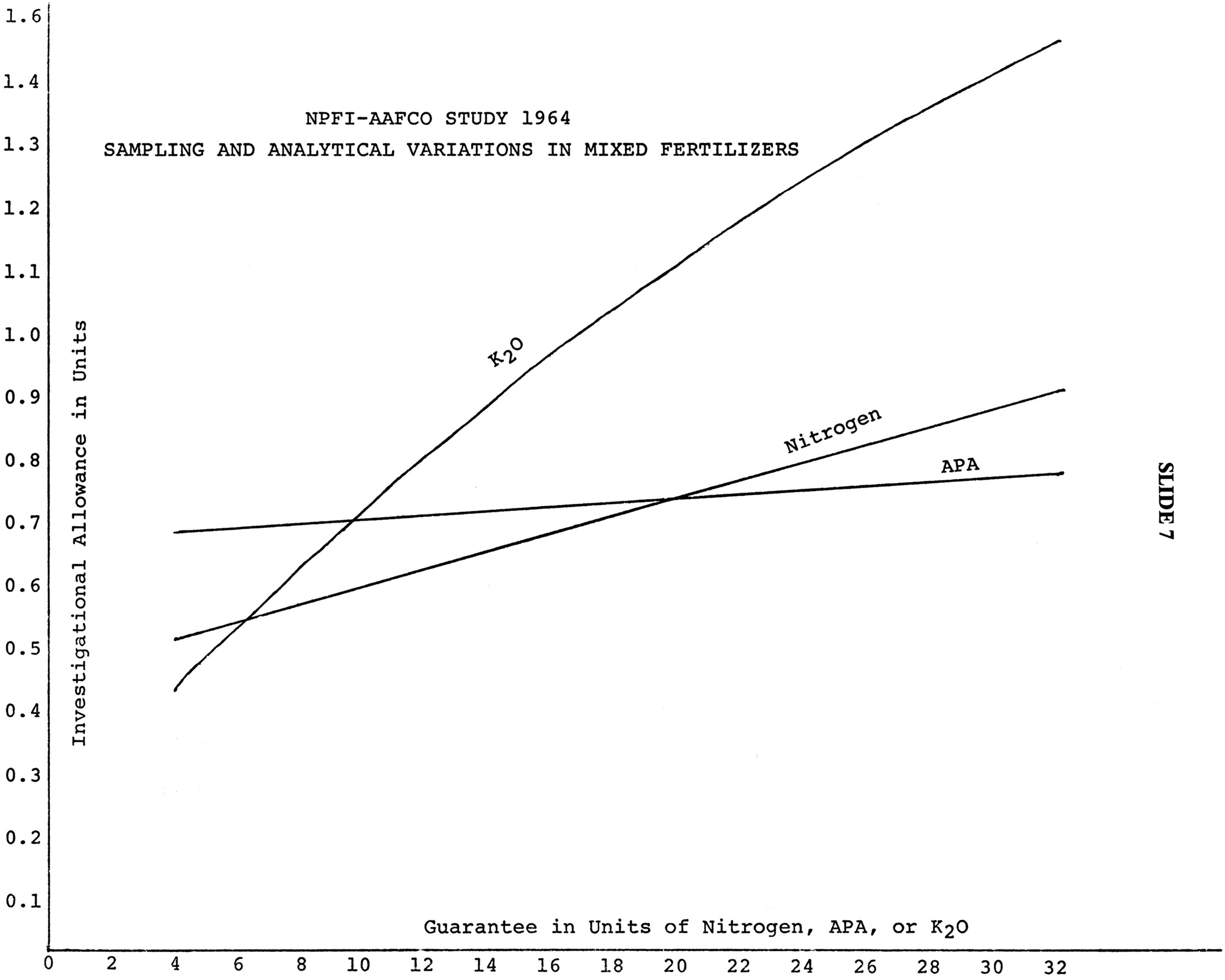
Variance of Chemical Analysis

Investigational Variance

True Lot-To-Lot Variance

Total Variance

(Not drawn to scale) Courtesy USS Ag Chem



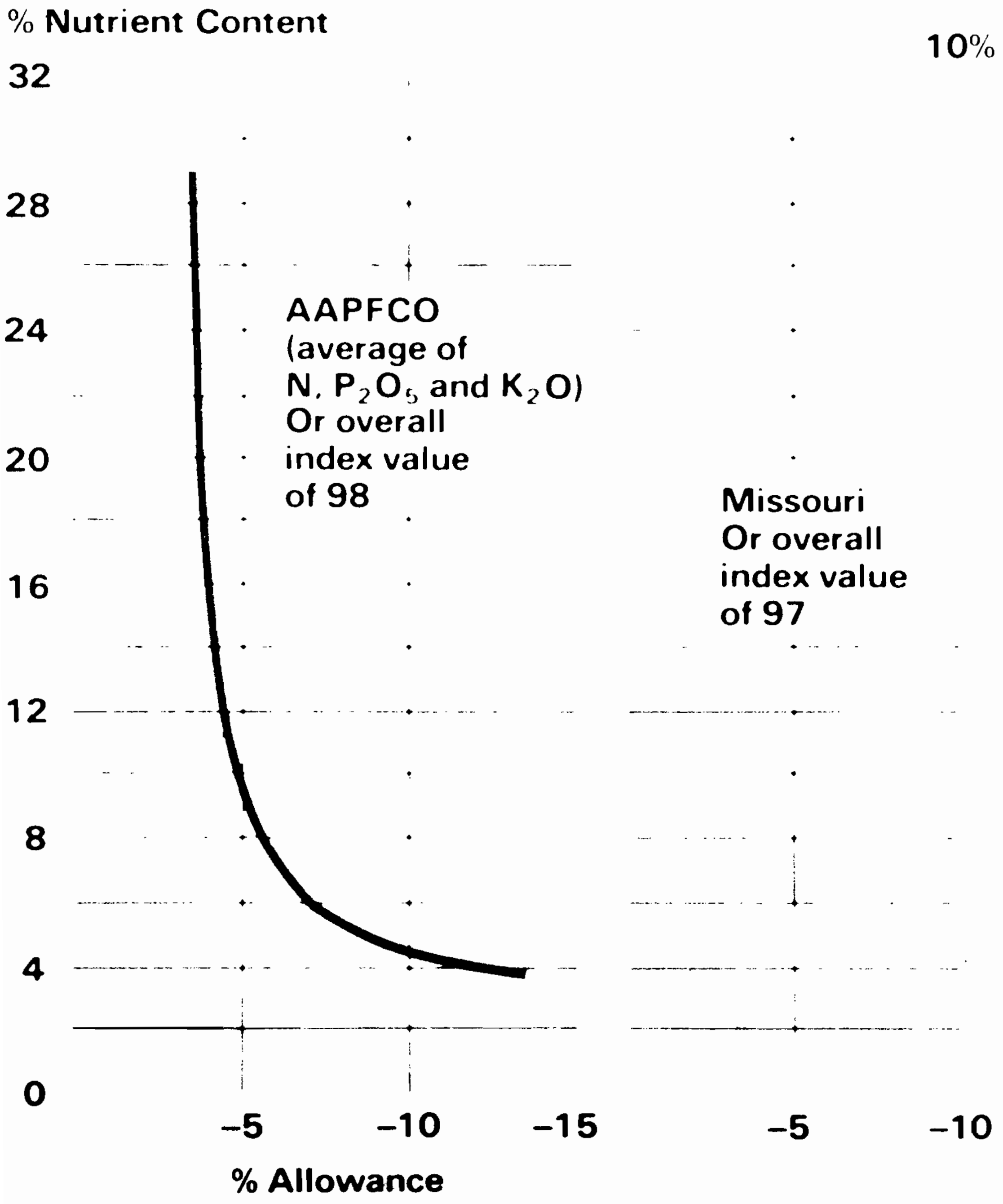
NPFI-AAFCO STUDY 1964

SAMPLING AND ANALYTICAL VARIATIONS IN MIXED FERTILIZERS

SLIDE 7

SLIDE 8

AAPFCO VS. MISSOURI INVESTIGATIONAL ALLOWANCES



MODERATOR DAVIS: Thank you, Doug. That was certainly a very comprehensive and well illustrated report. In essence of time I will have to ask you to communicate personally with Doug on any questions that you may have.

Our next paper this morning will be by Mr. Joe Kealy who is also from Swift Agricultural Chemicals Corporation. Joe is located in Bartow, Florida.

He has a degree in chemical engineering from University of Minnesota and has been working in research and development of fertilizer products and processes with Swift for some 25 years. He specializes in agronomic testing and research and development of slow release nitrogen fertilizers holding two patents in this field. Joe is a member of the American Society of Agronomy. He will be speaking to us this morning in his field of speciality.

Slow Release Nitrogen

J. P. Kealy

Thank you Mr. Davis.

Ladies and Gentlemen, I appreciate this opportunity to address the 25th Fertilizer round Table on my 25th year with Swift. The topic in your program is listed as slow release fertilizers.

I will cover mainly the use and performance of several commercially available slow release nitrogen fertilizers, with a cursory glance at other ways and compounds to lengthen the fertilizer feeding time for plants.

A Noyles survey booklet of 1968, "Controlled Release Fertilizers", covers the subject in 278 pages. My talk will necessarily be confined mostly to the commercially available slow release fertilizers for turf and ornamentals.

Why is there a need for mostly slow release nitrogen? Phosphate is quicly fixed in the soil and potassium is held in the soil depending on the cation exchange capacity of that soil. Nitrogen can be readily moved deep into the soil out of reach of the roots by heavy rainfall. In a sandy soil even light rainfall, (1"), will move the soluble nitrogen compounds down 10 inches. Some crops need a steady supply of nitrogen for more than 4 months, such as grass, vegetables, rice and fruit.

The advantages of slow N are many. Only one or at least fewer applications perform as well as soluble N. We can now store N in soil. There is less damage to plants and less care needed in placement, less leach and denitrification.

We obtain slow N release in three ways: 1) by using low soluble compounds; 2) by capsulation of high soluble salts; or 3) to inhibit the nitrification reaction of ammonia into nitrate.

(Slide 1): Each of the low soluble forms has distinct advantages and disadvantages. The ureaforms are high in N, 38%, having 11 units of fast N, 17 units of slow N, and 10 units of *extremely* slow N (at rate of 15% per year). Ureaform's release rate is governed by the concentration and attack of micro-organisms in the soil. The activity of the Micro-organisms is effected by *Moisture and Soil Temperature,* thus causing variations in release of the nitrogen.

IBDU and OXAMIDE are soluable to the extent of (0.03 to 0.3) and (0.4) parts per 100 parts water, respectively. They are 90% Win. Both have low solubilities and are simple chemical compounds, rather than extensively long poly chainups like ureaform. Because of this, their rate of release is governed by the solubility and consequently the surface area exposed to the water. Particle size, then, also imposes an additional governing rate of release over the basic chemical solubility.

Magnesium ammonium phosphate is 0.02 parts soluble in 100 parts of water, but is very low in N being a (9-46-0) with 16% MG. The rest of the compounds are expensive to produce except ammoniated coal, but the amount of slow N in this case is very small, for only ammonia is added in processing.

(Slide 2): Encapsulation is a good idea if there be a need for the particular properties that a cheap simple coat will perform; but when you try to change and enhance further properties by means of coating thickness and size of original pellet of the highly soluble N's, like urea, A/S and A/N, then the cost becomes prohibitive for the performance in extending feeding beyond 6 months.

All coatings have one weakness, one pin hold and the osmotic pressure difference between the highly soluble salts and the soil solution quickly draws the fertilizer out of the shell. To feed evenly with coated types one needs infinite differences in coating thickness and sizing with no pin hole development. *(Slide 3):* Nitrifying inhibitors are gaining some use but the costs of the material must be weighed against the gain of nitrogen pick up by the plants. This is true for any slow N release for economic crops.

Synthetic nitrogen fertilizers start with NH_3 and revert to NH_4+ in the soil. The solid compound carriers are A/S, A/N, K/N and urea. The urea can be further reacted with aldehydes: like formaldehyde, to make ureaforms (uramite and nitroform), or isobutylaldehyde to make IBDU, or crotonaldehyde to make CDU.

Bacterial activity is needed to change the NH_4+ (ammonium) to $NO_3—$ (nitrate). To change the ureaforms (WIN) water insoluble nitrogen to NH_4+ requires bacterial activity. The dissolving of IBDU and Hydrolysis to urea requires only moisture.

(Slide 4): These are some of the products on which the following slides will show performance on plants:

IBDU COARSE — USED IN TURF FERTILIZERS
IBDU BRIQUETTES — 1.0 & 1.3 GRAM SIZE
FRIT + P&K (60 MESH) — USED IN ORNAMENTALS & CITRUS.
OSMOCOTE — 18-6-12 RESIN COATED.
SULFUR COATED UREA — LOOKS LIKE OSMOCOTE. COLOR & SIZE.
SEWAGE SLUDGE OR MILORGANITE — THE BLACK WITH THE 8-4-5 MATERIAL.

(Slide 5): Nitrification over 15 weeks is shown here — powdered IBDU quite fast like urea and —8+12 mesh — others falling off rapidly at 4 weeks (sewage sludge) and 8 weeks (the ureaforms).

(Slide 6): Particle size of IBDU effects the nitrogen release.

—8+12 50% release at 8 weeks at 34% H_2O (Rice Paddy)
20% release at 22% H_2O (Upland Rice)

(Slide 7): These IBDU turf tests were laid out at Purdue 3 weeks before this photo in 1967. The response of the 2 lbs. N/N is just beginning to show color. This is the 3 week delay inherent with IBDU use on turf at normal feeding rates.

The next three slides show a test conducted at Purdue where 0.2 G. N *(Slide 8):* was placed in nylon bags, 9 per pot, in the root zone of grass grown in sand. 1/4" H_2O/Day was added for 192 days. *(Slide 9):* a bag was removed at planned intevals dried and weighed. *(Slide 10):* the amount and rate of fertilization is readily apparent. Milorganite was very good for 30 days.

The uramite, slowly, for 10 days (about 40%), then slowly beginning at 100 days. The IBDU released more steadily than the others.

(Slide 11): Here, 4 lbs. N/M had been applied to Kentucky blue grass at Purdue and data collected as clippings weighed over an 18 week period, as well as grading the color, vigor and general condition of the turf. There was more growth and higher grade ratings for the IBDU.

(Slide 12): The next seven slides show plant growth response of the briquettes of IBDU and Frit (0-15-30) on various ornamental plants. The fertilizers were mixed into the soil at time of potting the plants.

(Slide 13:) This test (12 months growth) by Dr. Whitcomb was conducted at the university of Florida (This is fast growing Lantana). Left is Osmocote (treated plant at a total of 2400 lbs. N/ACRE/YR., 18-6-12) surface fed three times (every 4 months); and right is briquette IBDU + Frit at 2400 lbs. N/ACRE/YR., at a ratio equivalent to 16-4-8, all the 2400 lbs. N/ACRE fed by mixing into soil when potting the young plants.

(Slide 14): Here you see the lantana roots, at one year, clustered around the IBDU briquette. This shows graphically the low salt index and the long lasting of the IBDU (about 1/2 dissolved).

(Slide 15): This compares the Osmocote to the IBDU briquette on Junipter at 2,000 lbs. N/ACRE/YR. — 1 year's growth.

(Slide 16): This shows the second year's growth of an orange tree. The culture is 1 year field grown, then potted for the second year before sale and placement in groves. Rate of IBDU briquette was 3,400 lbs. N/ACRE/YR. mixed into soil at time of potting the one year old tree. This one feeding and response was equal to twelve surface feedings of 8-4-5 at total of 6400 lbs. N/ACRE/YR.

(Slide 17): This is a 1½ year old test at UCLA on grass grown in a soil mix of 1/2 redwood shavings and 1/2 redondo sandy loam. Rates are 1.5, 2.5, 4 and 6 lbs. N/YD.$_3$ as IBDU (A to D), briquettes + Frit (0-15-30) at total ratio equivalent to 16-4-8. Note there is not too great a difference between 1.5 and 6 lbs. N/YD.$_3$, even after 1½ years. This shows a kind of demand feeding effect.

(Slide 18): This is in same test program at UCLA with SCU 15 + Frit at 1.5, 2.5, 4, 6 & 8 lbs. N/YD.$_3$. It has played out to a greater extent than the IBDU briquettes. Note A & B in each photo. The D & E of this test showed reduced growth early because of salt injury.

(Slide 19): The next seven slides show visual results of the application of 3 lbs. N/M of a 24-4-8 product containing 20 units of IBDU coarse (0.7 to 2 MM size) applied on grass at the swift R&D center in Oakbrook, Illinois in September 1969.

(Slide 20): Here is a shot after applying on September 12, 1969. We will follow 6 and 7 plots through to next July 1970.

(Slide 21): Third week of November 1969.

(Slide 22): December 16, 1969, after melt out of a light snowfall.

(Slide 23): First week of March 1970, after all snow melted.

(Slide 24): Eighth of April, 1970.

(Slide 25): Seventh of May, 1970.

(Slide 26): First week of July, 1970, the fertilizer is used up.

The proceeding test showed for the first time the cool season feeding of grass when using IBDU (late green in fall and early spring green-up).

There have been 25 test programs sponsored by Swift at Universities to study various slow release nitrogens over the last 7 years, and to conclude the presentation, here are the results from the latest one.

(Slide 27): This work was conducted during 1975 by Dr. G. M. Volk at the University of Florida at Gainesville and covers the win sources widely used on turf today (new on scene is SCU).

2 lbs. N/M were applied on June 4, 1975 to three replica plots on three grasses. Dr. Volk averaged the grading ratings. 9 is tops in rating. 1 is poorest. 5 is of marginal acceptance.

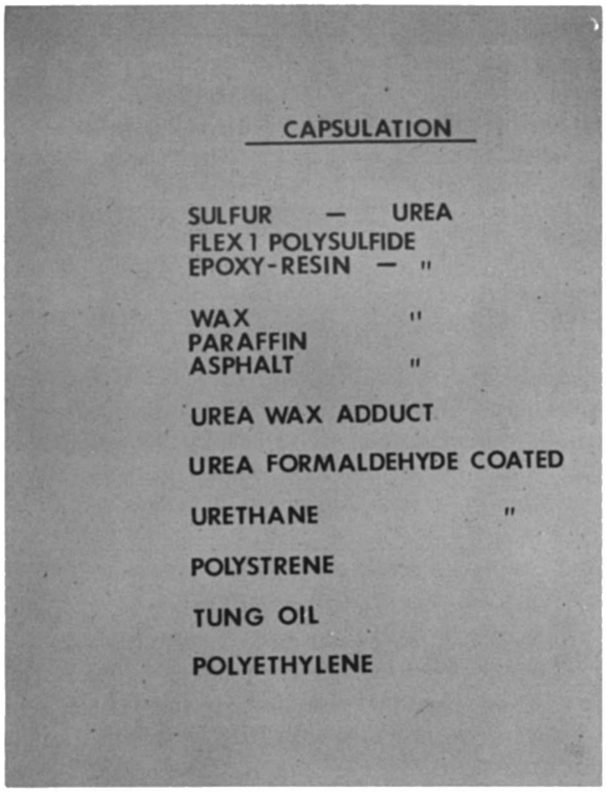
Many college turf experts rate 9 to 6 as an acceptable range for turf, so Dr. Volk is being more lenient here at a 5 cut off point.

Note the excellent 9 rating of A/S for 4 weeks; thereafter falling off rapidly. The IBDU held up the best; above 6 for 12 weeks. Next is SCU 29; above 6 for 10 weeks, but not ever above 7. The milorganite held above 6 for 9 weeks, reaching 7 once. The UF (blue chip nitroform) never reached 5. In fact, it was very close to the control of no nitrogen.

Generally, these kinds of results have been obtained at the other University tests and show the true worth of the various kinds of WIN (water insoluble nitrogen) sources offered to the public.

Thank you for your attention.

Note:
WIN (Water Insoluble Nitrogen)
A/S (Ammonium Sulphate)
A/N (Ammonium Nitrate)
K/N (Potassium)
* (Lbs. Nitrogen/1000 Sq. Ft.)



CAPSULATION

SULFUR — UREA
FLEX 1 POLYSULFIDE
EPOXY-RESIN — "

WAX "
PARAFFIN
ASPHALT "

UREA WAX ADDUCT

UREA FORMALDEHYDE COATED

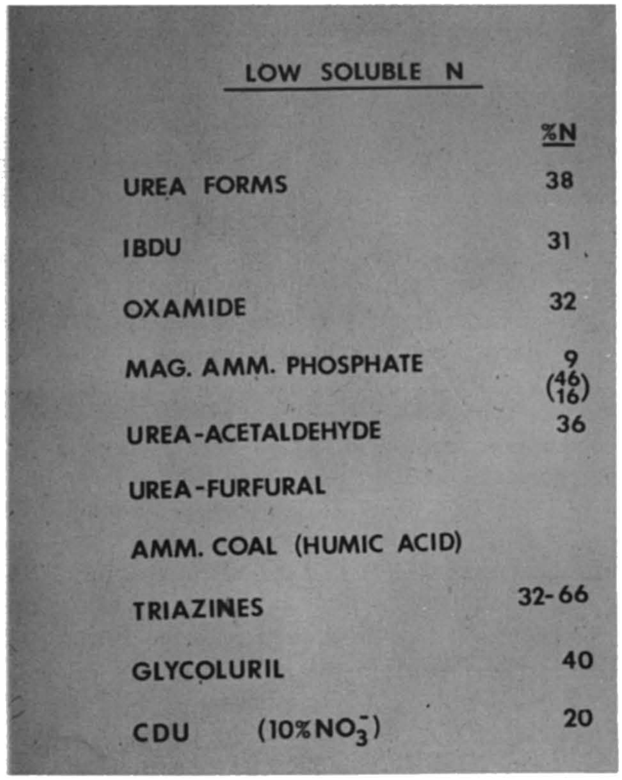
URETHANE "

POLYSTRENE

TUNG OIL

POLYETHYLENE

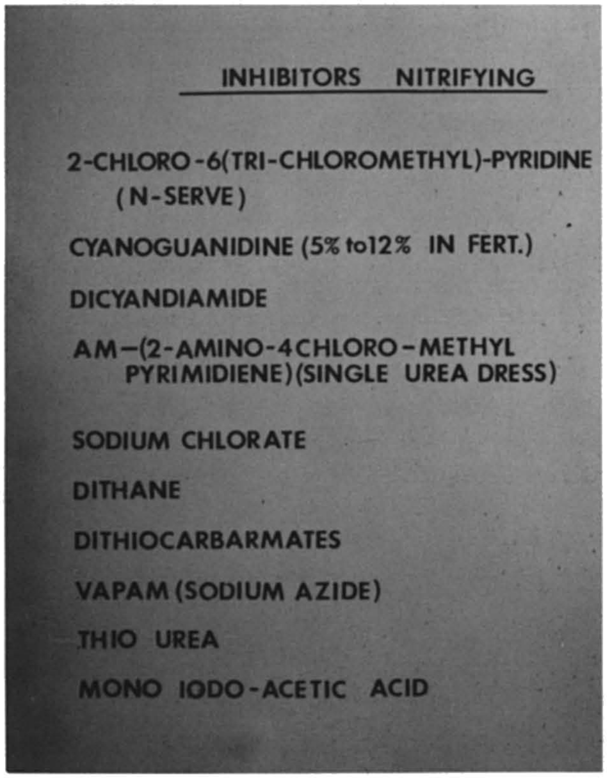
Slide 2



LOW SOLUBLE N

	%N
UREA FORMS	38
IBDU	31
OXAMIDE	32
MAG. AMM. PHOSPHATE	9 ($\frac{46}{16}$)
UREA-ACETALDEHYDE	36
UREA-FURFURAL	
AMM. COAL (HUMIC ACID)	
TRIAZINES	32-66
GLYCOLURIL	40
CDU ($10\% NO_3^-$)	20

Slide 1



INHIBITORS NITRIFYING

2-CHLORO-6(TRI-CHLOROMETHYL)-PYRIDINE
(N-SERVE)

CYANOGUANIDINE (5% to12% IN FERT.)

DICYANDIAMIDE

AM—(2-AMINO-4CHLORO-METHYL
PYRIMIDIENE)(SINGLE UREA DRESS)

SODIUM CHLORATE

DITHANE

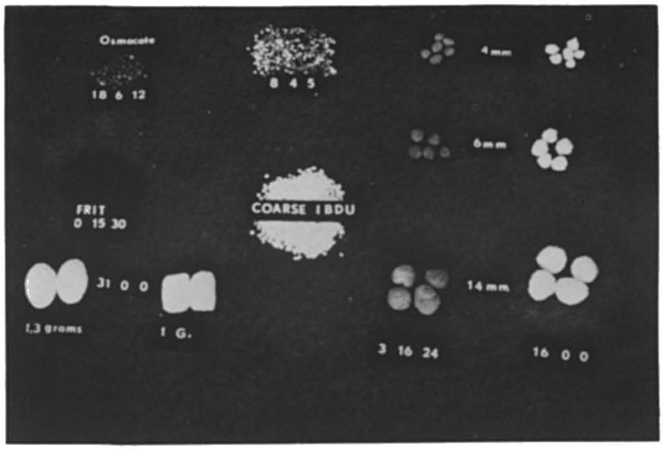
DITHIOCARBARMATES

VAPAM (SODIUM AZIDE)

THIO UREA

MONO IODO-ACETIC ACID

Slide 3



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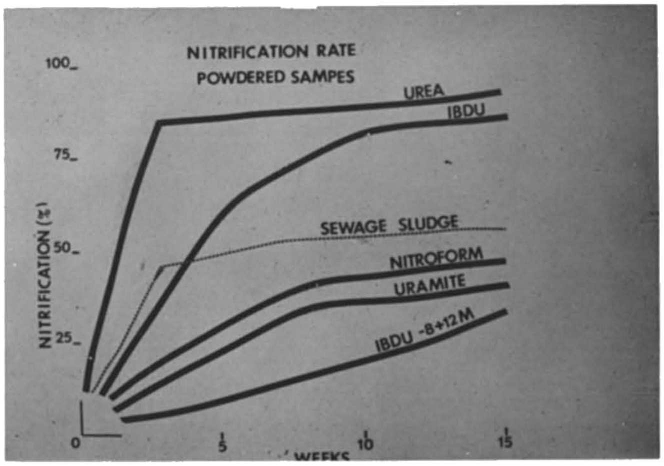

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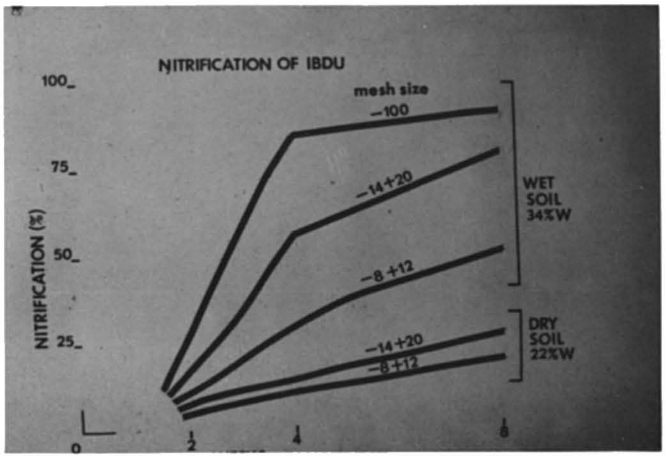

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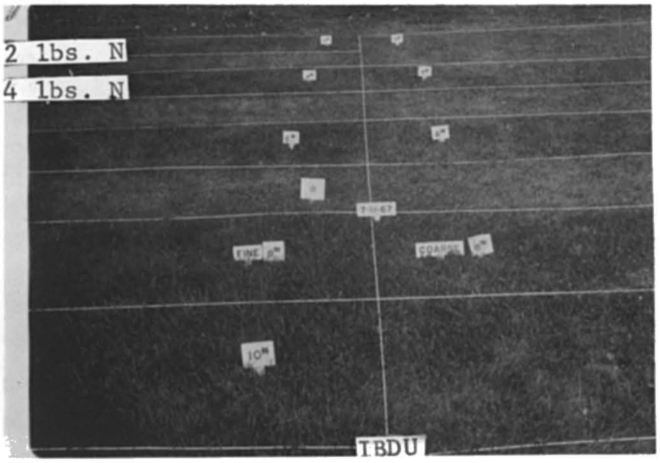

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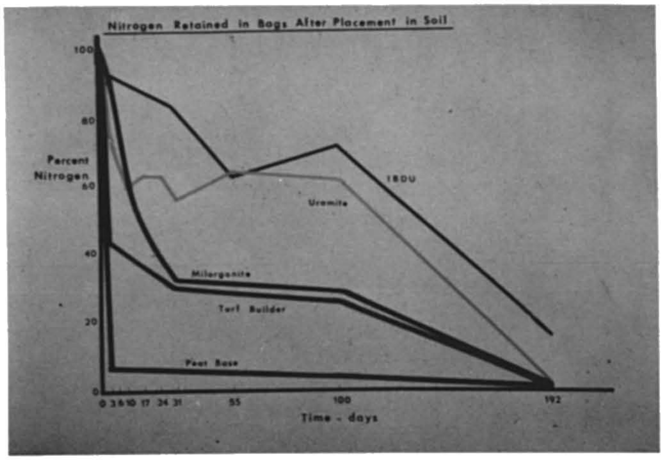

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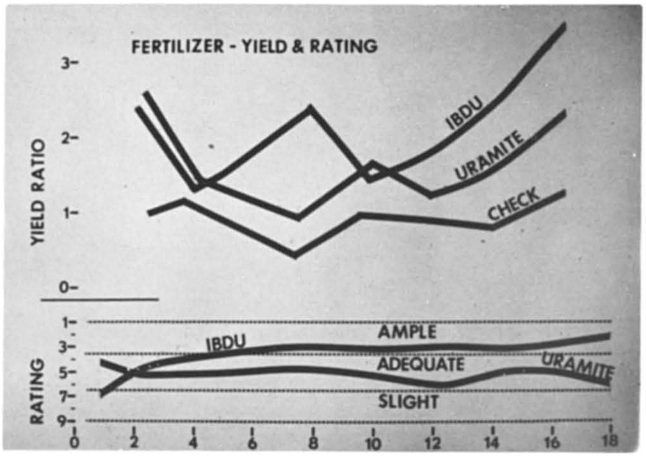

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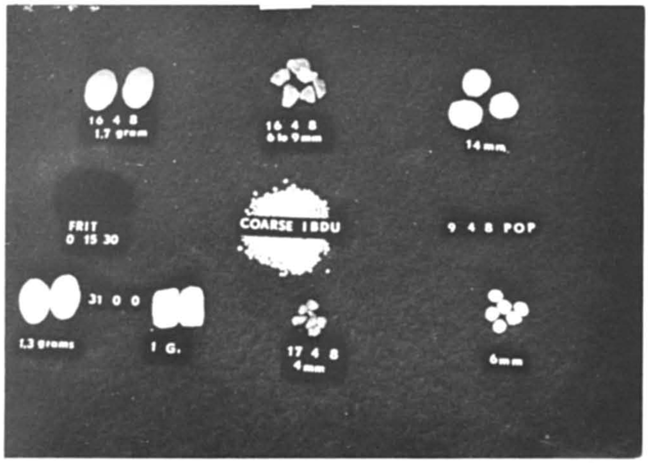

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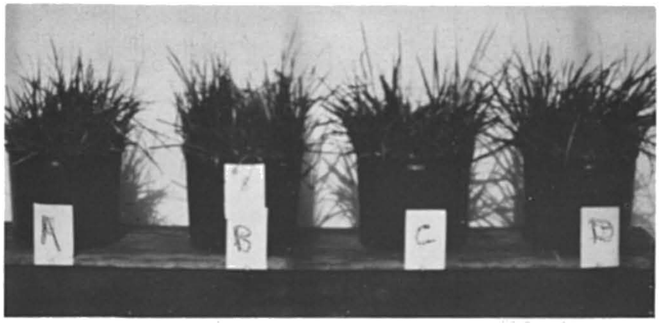

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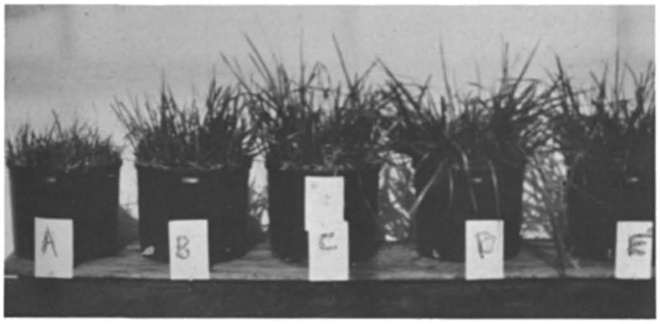

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Slide 20

Slide 21

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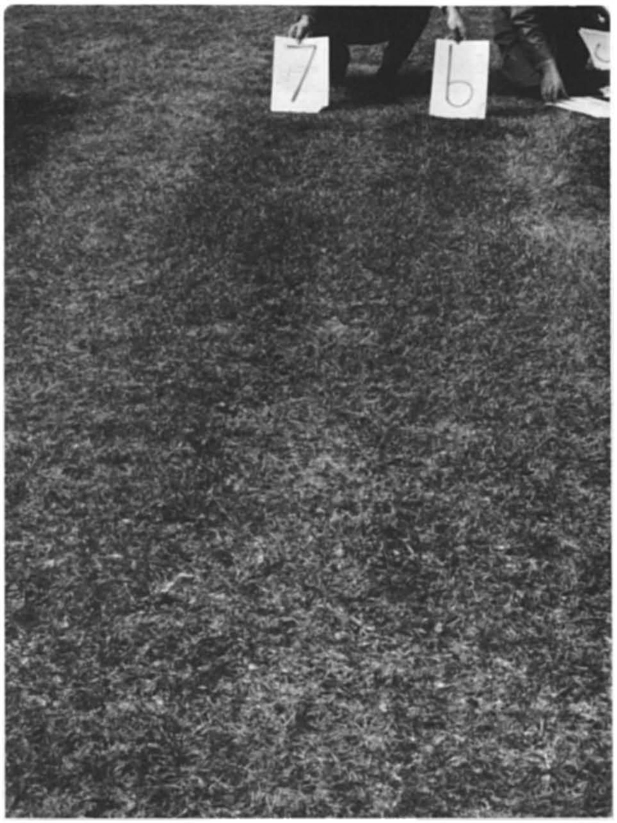

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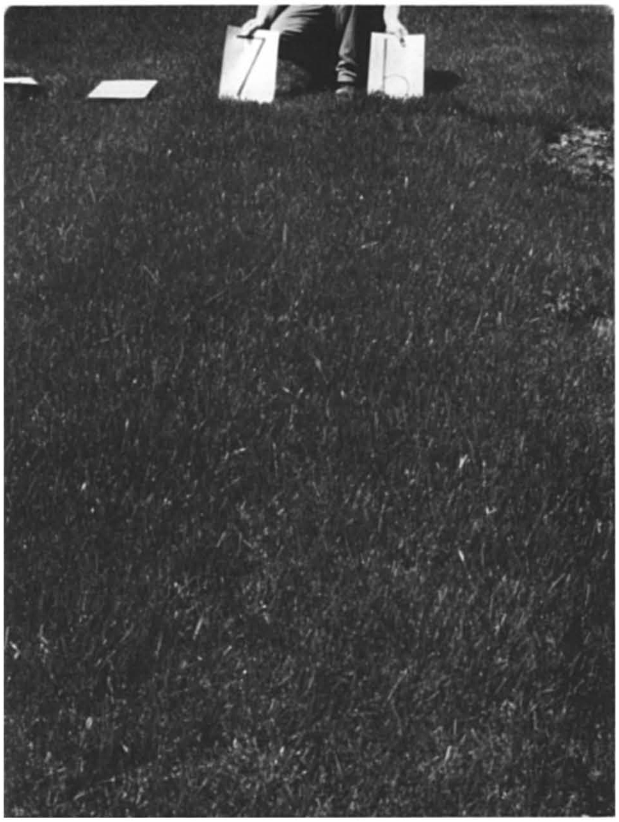

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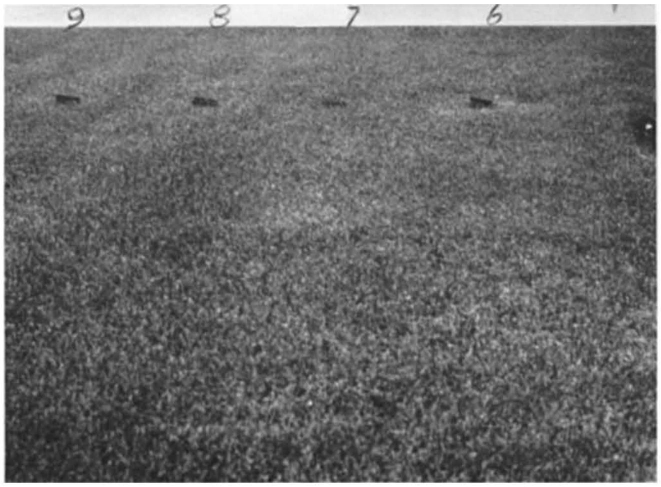
Slide 24

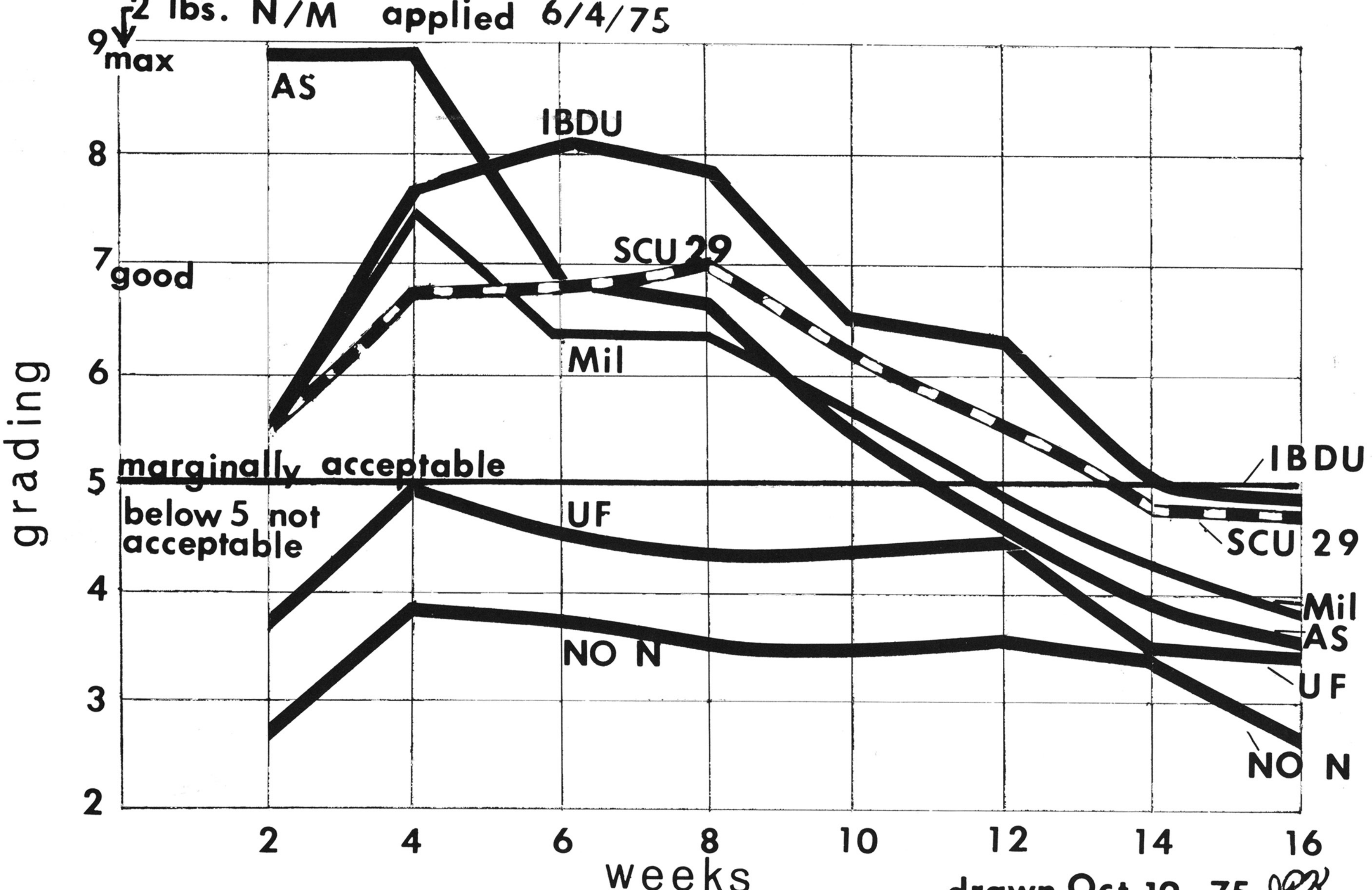


Slide 26

Visual Rating of Three Grasses - Five N Sources - U. of Fla.

9reps | St. Augustine
Centipede
Bermuda

Dr. G.M. VOLK



drawn Oct 19, 75 JPK

MODERATOR DAVIS: We have time for a question for Joe Kealy. Any questions? If not, thank you very much.

Our next paper is the first of two this morning to be given by guests from overseas. We especially appreciate the extra efforts that we know are involved in long distance travel required.

There is a change in the authorship indicated in your program. The paper will be on the Rhone-Poulenc Phosphoric Acid Process, but Mr. Barloy who is indicated as the author in your program has recently changed to Lebanon Chemical Company in Beirut. He was kind enough to come to the meeting today, and we appreciate that and know you will enjoy talking to him.

But to give the paper we have Mr. Djoldian from Rhone-Poulenc Company. Mr. Djoldian is a chemical engineering graduate from the Institute of Chemical Engineering in Toulouse. He is presently chief of Technical and Process Services. He has been involved quite extensively in phosphoric acid technology and particularly lately has been studying solvent extraction for purification of wet process acids. The wet process acid system that he'll be describing for you today is already a commercial reality having been proved in some six operating plants. So at this time I give you Mr. Djoldian to talk about "The Rhone-Poulenc Phosphoric Acid Process."

Phosphoric Acid Manufacture The Rhone-Poulenc Process The Reaction Section

C. Djololian

We appreciate very much your welcome as well as having the opportunity to speak to such an assistance.

1 — General Discussion

The RHONE-POULENC Process was originally devised in 1953. It has since been constantly improved because of the experience gained from operating plants either in RHONE-POULENC or in the licensees' plants and because of the studies and of the research carried out by the laboratories of the RHONE-POULENC Company.

This process is used in approximately 50 plants either operating or in construction in 25 different countries.

The process is characterized by the use of one single tank without internal partition equipped with one agitator and with a table filter trademark UCEGO® *(Fig. 1).* This paper will be limited to the digestion section.

Process development had for principal aims:

— the reduction of the size of the unit,
— the simplicity of the layout,
— the ease of operation,
— the stability of operating conditions,
— the lowering of maintenance,
— the elimination of liquid and gaseous polluants.

Rhone Poulenc was able to devise these important features because its process was conceived and improved by operating people in liaison with Research and Development.

The flexibility of the plant leads to other advantages:

— the use of ground or non-ground phosphate rock,
— the successful treatment of phosphate rock either known or new and specially of low grade content
— the possibility of optimizing according to the desire of the user, production capacity, P205 content of the acid (up to 32%) and yield. It is possible to greatly increase the daily production if one accepts a slightly lower P205 content of the acid produced,
— the possibility of operating at lower capacity either continuously or by campaign (either with two shifts out of three or stopping during the weekend). The only requirement in such cases is to continue to agitate the reaction tank.

The material used to build the units has been carefully studied and tried so as to give to this unit a long life and a low maintenance cost when operated under the usual conditions.

2 — Mechanism of the reaction of phosphate rock and its influence on the yield

The main objectives of phosphoric acid processes are 1) the lowest possible investment per ton of acid produced and 2) the highest yield of P205. The P205 yield is influenced by three types of losses:

2-2- *Loss of P205 because unreacted*

This loss is the result of a certain number of external factors to the reaction system. First, it is the result of the type of phosphate used and of its properties:

— specific surface (volcanic or sedimentary origin of the rock),
— particle size and particle size distribution,
— chemical composition,

and second, the design of the reaction system and the choice of the operating variables.

The reaction of phosphate rock is very rapid in a medium where the concentration of sulfuric acid is maintained at its optimal value (value which depends on the rock, on the concentration of phosphoric acid, on the temperature of the reaction). A yield of 95% is reached in less than two minutes with most of the ground or unground rock of sedimentary origin, while volcanic rock however requires almost 10 minutes. To better understand the reaction and to determine these values, we devised a method which would give us accurate kinetic curves.

It is indeed not possible to obtain these kinetics directly because one cannot establish a representative model of the system by means of experiments in a non-continuous process. Feeding concentrate rock for a short period of time leads to a change in the condition of crystallization. Calcium sulfate tends to precipitate on to phosphate grains and this all the more if the concentration of sulfuric acid is high to start with, if the speed of formation of calcium sulfate is rapid and if few seeds of calcium sulfate dihydrate are present. This condition also favors the formation of co-crystallized P205 (high concentration of free calcium ion in the medium during the reaction of phosphate rock).

We have therefore measured the kinetics of the reaction from experiments carried out on a *continuous basis* in the laboratory with a *single tank reactor* for a *given concentration of sulfuric acid and of* P_2O_5 and at a *constant temperature.* The method used is the following: the yield of the reaction of the phosphate rock with sulfuric acid has been measured for different values of the ratio $t = v/q$ (t being the retention time in the reactor), where v is the volume of the reactor, q the rate of feeding.

The details of the mathematical model will be given later on.

We particularly studied three phosphate rocks, two of sedimentary origin (A & B) and one of volcanic origin (C). We obtained the following results:

Phosphate A				
(h)	**1**	**2**	**4**	
Yield (%)	**98,55**	**98,8**	**99,1**	
Phosphate B				
(h)	**1**	**2**	**4**	**6,25**
Yield (%)	**98,3**	**98,8**	**99,15**	**99,25**
Phosphate C				
(h)	**2**	**4**	**6**	
Yield (%)	**96,2**	**97,8**	**98,4**	

The curve which we have obtained appears in graph No. 2. One will note the high slope obtained for the sedimentary phosphate and the notable difference found for phosphates of volcanic origin. This curve will be very useful to define the process.

For what has been described, the concentration in sulfuric acid and in P_2O_5 together with the temperature were kept constant.

These three factors however have their importance. When a grain of phosphate rock reacts, calcium ions diffuse toward the reaction medium while sulfate ions migrate toward the crystals. The greater the solubility of the medium, the faster the reaction and the faster the crystals of calcium sulfate formed are carried away from the phosphate grains. Because of this condition, the reaction can be carried out without risk of being blocked. The solubility of calcium sulfate decreases when the concentration in free sulfuric acid of the medium increases. It appears consequently that it would be best to keep it as low as possible. One must however keep in mind the filtration which becomes more difficult and the losses in P_2O_5 co-crystallized when the sulfuric acid concentration is too low. The final concentration of sulfuric acid in the slurry is therefore the result of a compromise which is also function of the origin of the phosphate, of its particle size, of the design of the reactor and of its operating conditions.

Finally, a high temperature favors the yield of the reaction. It is limited however by the crystallization zone of the semihydrate and by the formation of deposits on the equipment.

2-2- *The loss of P_2O_5 through co-crystallization*

During the solubilization of the phosphate rock, a number of HP04—— ions are precipitated with SO4-- ions to give an insoluble dicalcium phosphate which is co-crystallized as ardealite (CaHPO4, CaSO4, 4 H20). This phenomena is irreversible as only a change in the degree of hydration can free the HPO4--ions which are locked into the crystalline structure of gypsum. The formation of this unwanted compound is a function of the ratio of free calcium ions to that of free sulfate ions present in the acid during the crystallization of gypsum. The greater the ratio calcium over sulfate, the more favorable the medium for the formation of the co-crystallized material, especially when the P_2O_5 concentration is increasing.

2-3- *The water soluble P_2O_5*

The conditions of crystallization of the gypsum play an important role on the washing characteristics of the crystals which are formed during the reaction. These crystals, when formed and grown into a very homogeneous and very stable medium, will be very even and large and therefore easily washed.

3 - *Main features of the agitation in the reaction tank*

The agitation in the reaction tank must fulfill six requirements:

3-1- *The introduction of the phosphate in the slurry:* The phosphate must be carried in rapidly so that it does not float on surface in zones of weak turbulence because on one hand the carbonate contained in the phosphate will give off carbon dioxide, therefore leading to foaming in these zones and, on the other hand, if the medium is not rapidly replaced around the phosphate grains during the reaction, the sulfuric acid concentration around these grains will decrease as the reaction progresses and the conditions will become favorable to the formation of co-crystallized P_2O_5, which should be avoided.

3-2- *The creation of a higher rate of flow:* We have seen earlier that a large part of the phosphate reacted within a few seconds after its introduction in the slurry. It is consequently at this moment that the formation of co-crystallized P_2O_5 must be avoided. Because the phosphate is attacked by the free acid in the slurry, the concentration of this free acid will not decrease if the flow of slurry is rapid.

This flow has been calculated so that the decrease in the concentration of free sulfuric acid does not exceed 1,5 gram per liter as an average in the slurry. roughly speaking, this flow is such that the total volume of the reactor goes through the central agitator with the phosphate every 25 seconds.

3-3- *To create an important turbulence* in the zone where phosphate is introduced. This important condition is generally neglected. It would be indeed illusory to satisfy condition N°2 if the gradient of sulfuric acid were only an average.

It is what happens when one does not accept to spend a certain energy of turbulence to breakdown the phosphate aggregates in order to individualize each grain. This form of energy, which would be a waste in only a classical type of agitation were required, is largely recovered if one compares it to the gain in P_2O_5 yield which it gives. A speed of the blade in the slurry has been selectes so that condition N°2 be met not only on an average basis but also around each grain of phosphate under reaction.

3-4- *To assure the diffusion of the medium* so that one obtains a homogeneous composition of the slurry in each point of the tank except of course in very localized areas where the raw materials are introduced. It has been verified, in particular in the 700 m3 tank of Annaba in Algeria which is agitated by a central agitator of 320 KW effectively used, that the composition of the slurry is the same in all points of the tank, in particular the solid concentration, the concentration in P_2O_5 of the acid, the free sulfuric acid and the quantities of P_2O_5 unreacted and co-crystallized.

3-5- *To assure the diffusion of the heat* so that the temperature is constant throughout the tank. One knows that the calories are brought in by the dilution of the sulfuric acid and by the heat of the reaction. Frigories are brought in by the raw material introduced and by external cooling of the slurry. When proceeding to temperature controls at different points of the reactor, the usual equipment used did not permit to find notable differences. Conditions 4 and 5 are assured in such a manner that the tank operates at the final stage.. The slurry can be pumped to be sent on the filter from almost any point in the tank with the exception of small zones located near the introduction of the raw material.

The homogeneity of the composition and of the temperature of the slurry during all the time it remains in the tank gives the best conditions necessary for a good crystallization, a minimum quantity of P_2O_5 unreacted or co-crystallized and a maximum rate of attack of the phosphate.

3-6- *To bring back gypsum in suspension after a shutdown.* Generally, the central agitator continues to operate during shutdowns. It may be stopped however for specific reasons such as the draining of the reductor, a loss of electric power, etc. . . . The agitator has been designed so as to be able to put in suspension the totality of the gypsum which can settle at the bottom of the tank even after a certain shutdown. When one crites the equations of the agitation which will meet all these requirements, one finds that when requirements 2 and 3 are met, all the others are also met. Consequently one defines the agitator by requirements 2 and 3 and it is not necessary to add other agitators at other points in the tank. From these considerations, it can be seen that:

— in tanks with several agitators the power installed is not sufficient in some zones and wasted in others,

— the reaction system in several tanks where it is necessary to put at least one agitator per tank cannot have the advantages of a single agitator.

Furthermore the agitation is more rational from a hydraulic standpoint: the path followed by the particle is very well defined and there are no dead zones in the tank. From a mechanical standpoint, there are no conflicts between agitators and consequently no alternate flexion efforts which can bend or break axles. Lastly, the use of a single agitator permits to improve the quality of the agitation with the minimal expenditure of energy, of investment and of maintenance.

To summarize, the use of a single agitator is the only way by which the requirements of agitation are fulfilled with maximum efficiency and minimum expenses. To have a single agitator however requires a single reaction tank system.

4 - *Cooling of the slurry*

Three methods are used to cool the slurry:

— cooling under vacuum by circulating the slurry in a vessel under an absolute pressure of the order of 200 torr.

— cooling under vacuum by putting the tank itself under vacuum.

— cooling by circulation of air at atmospheric pressure on the surface of the tank. This method has been devised by Rhone-Poulenc and can staisfy the pollution standards in vigor,

A very compact surface cooler of a propriety design rotates at a speed close to 1,000 turns per minute, able to project a low of slurry droplets of 600 m3 per hour at a distance of 1.5 meter and at a height of 1 meter, is installed per each 100 m3 of tank. Therefore every 10 minutes the total volume of the reactor is projected as droplets.

The cover of the tank which is 1.2 meter above the slurry is drilled by many holes on about half of its surface so as to allow atmospheric air to come in. A hood to allow exit of the air is built at the opposite extremity. A fan preced by a washing column is used to circulate the air.

The contact air-slurry is such that it is possible to obtain an air saturated with water and at a temperature of 5 to 8 degree C. inferior to that of the slurry which is to be cooled. Under this condition it is possible to limit the flow of air to minimal values even for units of 1,000 tons per day of P_2O_5.

The temperature of the slurry is adjusted by changing the speed of the fan. The design of the agitator is such that the flow is not affected by variations of the level of the slurry. The slurry is removed by overflow and consequently, as a matter of fact, the level does not vary. For a given operating rate, the temperature remains stable by itself without further adjustment.

Furthermore, the fall of the little droplets breaks down mechanically the foam for some rocks. It is not necessary therefore to use antifoaming agents.

We make use of the surface agitators which project the droplets to introduce fresh sulfuric acid by means of a proprietary method devised by Rhone-Poulenc.

The sulfuric acid, introduced on a disk mounted on the axle of the cooler, is projected on a 3 meter circle which cuts the circle of the same diameter formed by the droplets of the slurry. Mixing is excellent and the temperature controlled because:

— the flow of slurry is important,
— the repartition takes place practically on the entire surface of the tank,
— the mixture sulfuric / slurry is cooled in the air before it reaches the tank surface at a point where the $\triangle$ T is greatest.

Because of this improvement, 98% sulfuric acid can be used without any bad effect on the crystallization such as hot spots or points where there is greater concentration of free acid.

5 - *Description of the tank*

A diagram of the tank is shown on figures 3 and 4. Rhone Poulent has standardized tanks of 200 to 1,500 m3.

The largest tank, actual useful volume of 800 m3, is being installed at SAFI (Morocco). The central agitator has an installed power of 400 Kw. Several 600 and 700 m3 are operating today.

Total height of the slurry is limited to 5.5 meters to keep a sufficient exchange surface for cooling. It might be possible to increase this height in the large tanks if cooling allows it.

The 1,500 m3 tank has an internal diameter of 18.7 meters and an agitator with an installed power of 950 Kw. Capacity is expected to be 1,200 MT/day of P_2O_5 on Morocco 75 or Florida 73 and over 1,800 MT/day on Togo.

To avoid the rotation of the slurry, these tanks have internal baffles of brock, made part of the wall of the tank.

The outside tanks can be either steel or concrete and the inside lined with carbon brick. A rubber coat between inside and outside prevents possible leaks. The thickness of the brick lined has been increased under the agitator to avoid eventual eroding of the bottom.

The phosphate rock is fed from a skirt arranged around the axle of the agitator and above the level of the slurry. This prevents the carrying over of the ground rock.

The agitator and the surface coolers are mounted on a metallic frame with is independent of the tank itself.

The cover of the tank is composed of sectors in reinforced polyester held on the outside by the side of the tank and at the center by hooks tied to the supporting frame of the agitator.

6 - *Pumping the slurry*

The level of the slurry in the tank is controlled by an overflow through which the slurry flows toward the aspiration of a pump without any intermediate holding tank.

Experience showed that if the pump is well chosen, no cavitation occurs, and the pump will deliver a very uniform flow of slurry to the filter whether the unit operates at full or at half of its capacity.

The advantages of this system are the following:

— Rate of flow to the filter absolutely constant and therefore:
  — no need for adjustment. Tank and filter operations are coupled without any inertia, a necessary condition for a stable operation of the unit,
  — gain in the capacity of the filter. The production is increased by the margin allowed for the adjustment of the flow of the slurry and this may represent from 5 to 10% of the maximum capacity of the filter.
— Level of the slurry in the tank rigorously constant and therefore:
  — stable temperature of the slurry,
  — maximum efficiency of the coolers with regards to destruction of surface foam,
  — even operating conditions of the agitators and of the coolers from a hydraulic as well as from a mechanical standpoint.
— No need for human intervention.
— Lowering of the power required by the pump because it is fed by the flow corresponding to the production.
— Decrease of the investment, because the pump is smaller and does not require costly controls.

This method of pumping slurry has been successfully used in several units with capacities ranging from 100 to 800 MT/day of P_2O_5.

7 - *The absorption of fluorinated products*

The air coming out of the reaction tank is generally saturated with moisture and at a temperature very close to that of the slurry (T less than 8 degree C.) because of the efficiency of the cooling system which also considerably reduced the amount of air used. Coming out of the tank, the air also picked up various compounds, especially HF, SiFe and CO2. The respective concentration of these compounds will vary according to the composition of the phosphate, to the temperature of the slurry and to the concentration in phosphoric acid. Phosphate rock dust and slurry droplets may also be carried our by the air eventhough it is unlikely because the speed at which the air comes our is slow and because the rawmaterials are introduced in such a way as to minimize entrainments. The air coming out is contacted with a solution of H2SiF6 to absorb HF and SiF4.

A global and schematic picture of the overall process can be represented by the two following reactions:

$$3\ SiF4 + 2\ H20 \rightleftarrows 2\ H2SiF6 + Si02$$

$$6\ HF + Si02 \rightleftarrows H2siF6 + 2\ H20$$

We studied the gas - liquid equilibrium and found that several factors affect it:

- If the molar ratio HF / SiF4 in the gas is less than 2, there is an excess of Si02 in the liquid phase. If greater than 2 we have free HF with the H2SiF6. We also know that by diluting the solution we increase the molar ratio (R) HF / Sif4 in the gaseous phase (R = 3 if H2SiF6 concentration equals to 10%; R = 7 if H2SiF6 equals 5%; R = 13 if H2SiF6 equals 1%) and consequently we displace the equilibrium toward the formation of HF.
- From laboratory experiments we found that for concentrations of H2SiF6 of 10% or less by weight, the solutions can be considered as ideal (the activity coefficient γ in water is consequently equal to 1) but that for greater concentrations γ can go down up to 0.75.
- Lastly we also determined the partial pressures of HF, SiF4 and H20 as function of the temperature and of the concentration in H2SiF6.

Knowing these various factors, we were able to device the best possible process to collect the fluorine. Obviously the type of removal desired will depend on the regulations to be met. The well known unit transfer principle has been found most useful to describe the overall system.

The gas coming our of the reaction tank is passed through a cyclonic column, then a fan and finally through a second washing. Each of these washings can be considered equal to 1.5 transfer unit. The remianing fluorine is essentially as hydrogen fluoride. The absorption of hydrogen fluoride is consequently more difficult and, if it is necessary to remove it, a third stage is added to the system. It allows, by the use of an alkaline wash which will reduce the partial pressure of fluorine in the gas, to reach the standards imposed by pollution boards. The additional water required correspond to the process water and is introduced at the second washing and the excess solution of fluosilicic acid at the first washing is used as a washing for the filter. The quantity of water which is introduced is a function of the total water in the unit. With this system of circulation, a part of the fluorine which escapes finds its way in the reaction tank and therefore can be recovered at a later stage of the manufacture of phosphoric acid.

The third washing, which is an alkaline solution, is independent of this circuit and the small excess solution is recycled in the reaction tank, it does not affect the filtration rate.

The temperature in the system remains relatively constant because the gases at the entrace are saturated with water. Frigories are limited to those contained in the water which is used to adjust the concentration.

The cyclonic columns have been designed by Rhone-Poulenc. They have been tested thoroughly at the pilot stage before being adopted.

The pressure on the sprayers of the type full cone has been selectess so as to create a spray sufficiently strong, so as to offer a great specific surface to absorption. This pressure has been limited however so as to:

- avoid entrainments (the free height above the sprayers has been calculated from a model defined from pilot plant experiments),
- avoid the destruction of the cyclonic currents created by the design of the entrance.

A circular crown placed ahead of the exit on the wall of the column stops a thin film which creeps up the column. fouling is very limited because the cyclonic currents limit the deposit of Si02 on the wall.

Our process gives a thorough washing and an excellent removal of fluorine. It does not affect in the reactor tank the conditions necessary to a good crystallization and avoids the loss of liquid effluents by limiting the use of water.

Figure 1

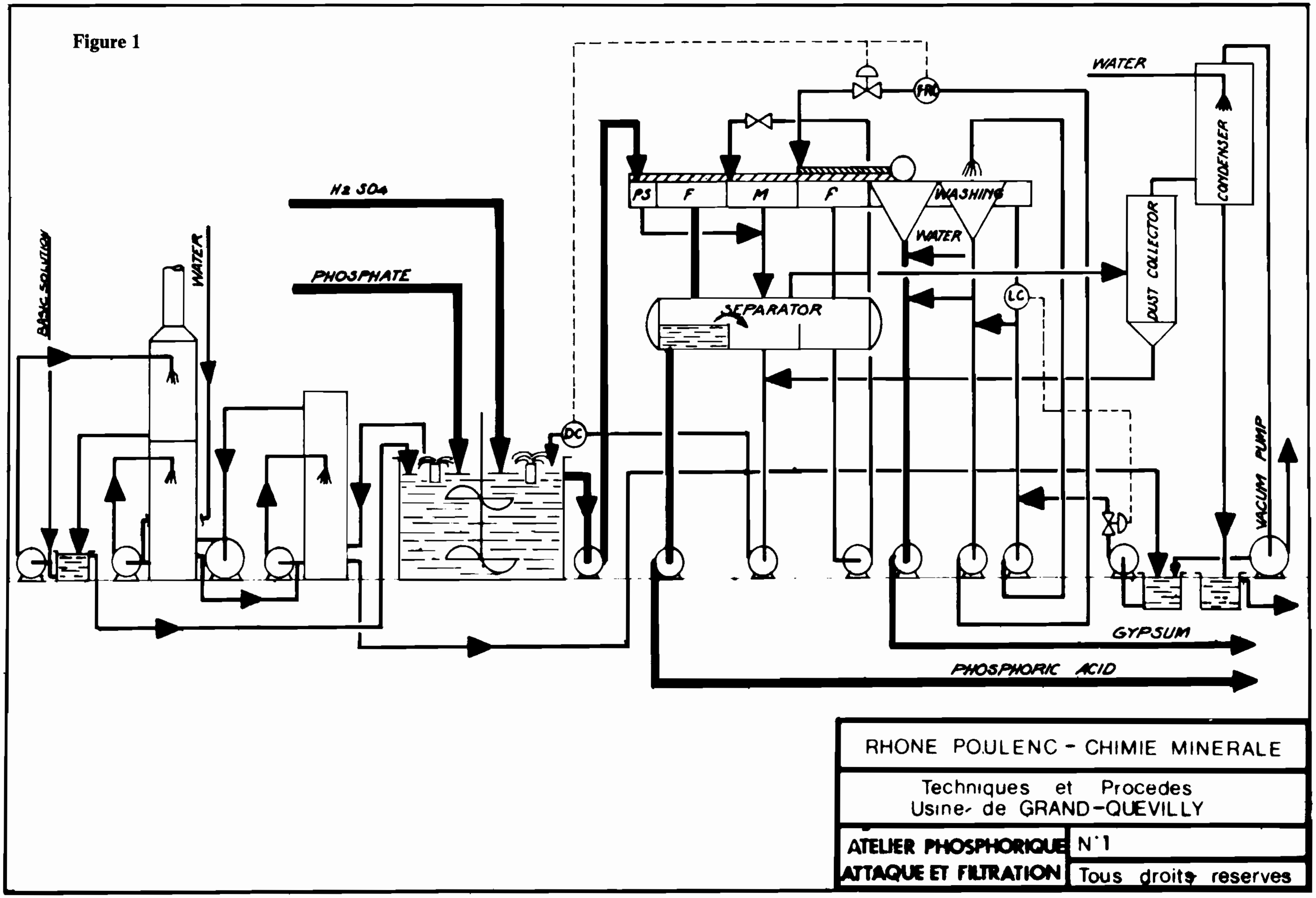

BASIC SOLUTION
WATER
H2 SO4
PHOSPHATE
DC
FRC
PS
F
M
F
WASHING
WATER
SEPARATOR
LC
DUST COLLECTOR
WATER
CONDENSER
VACUM PUMP
GYPSUM
PHOSPHORIC ACID
RHONE POULENC - CHIMIE MINERALE
Techniques et Procedes
Usine de GRAND-QUEVILLY
ATELIER PHOSPHORIQUE
ATTAQUE ET FILTRATION
N°1
Tous droits reserves

Figure 2

REACTIVITY OF DIFFERENT PHOSPHATE ROCKS

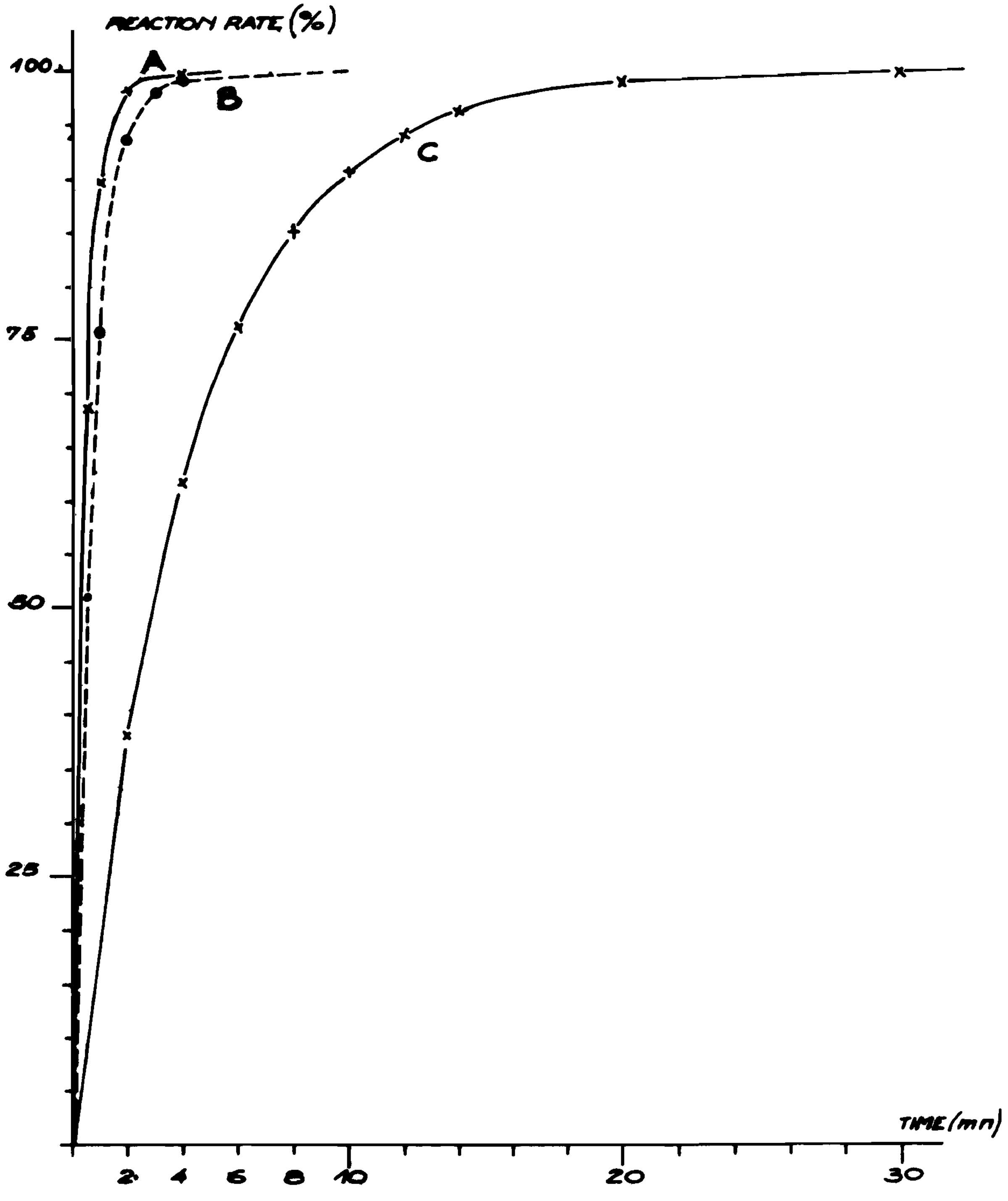
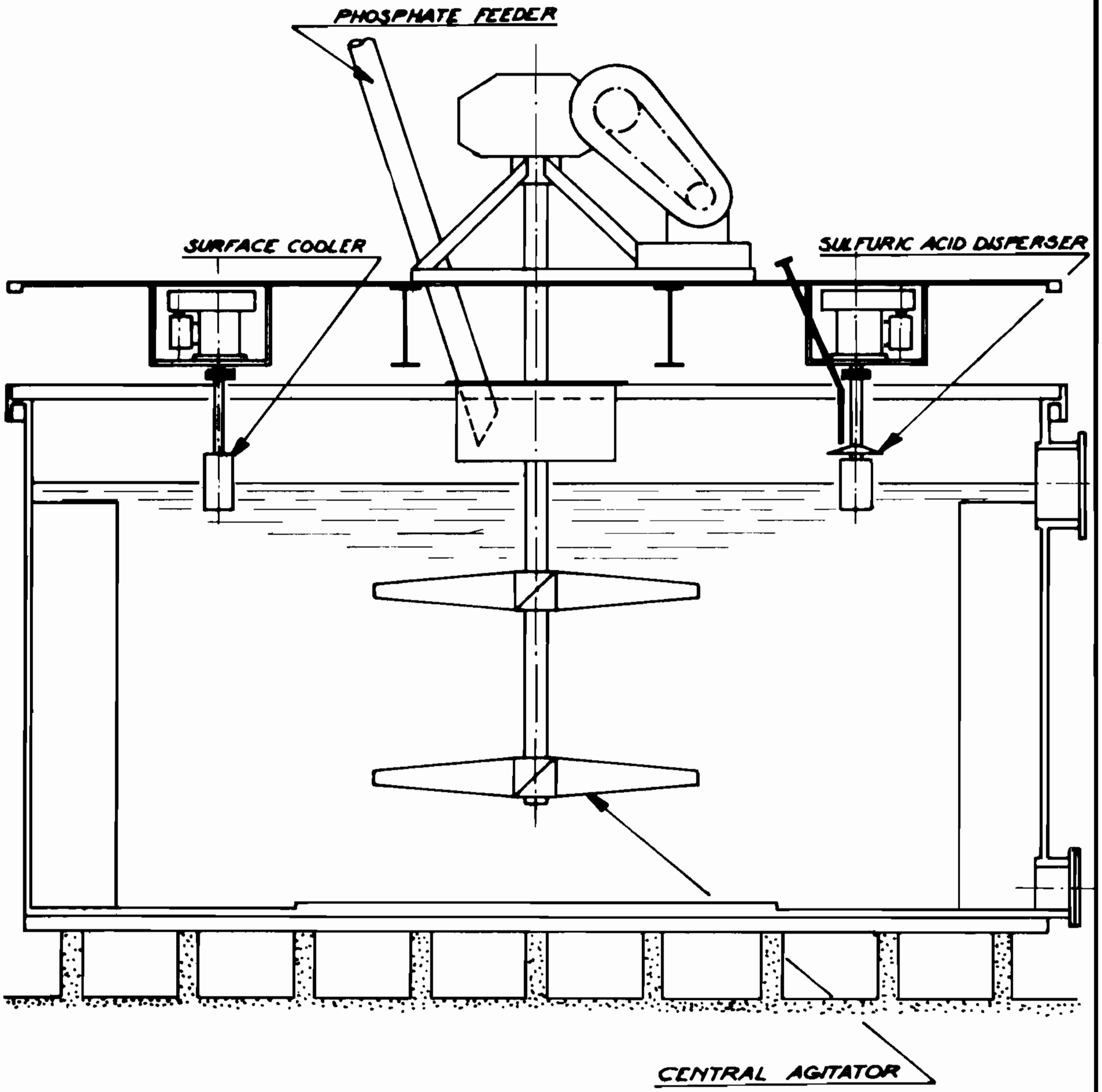
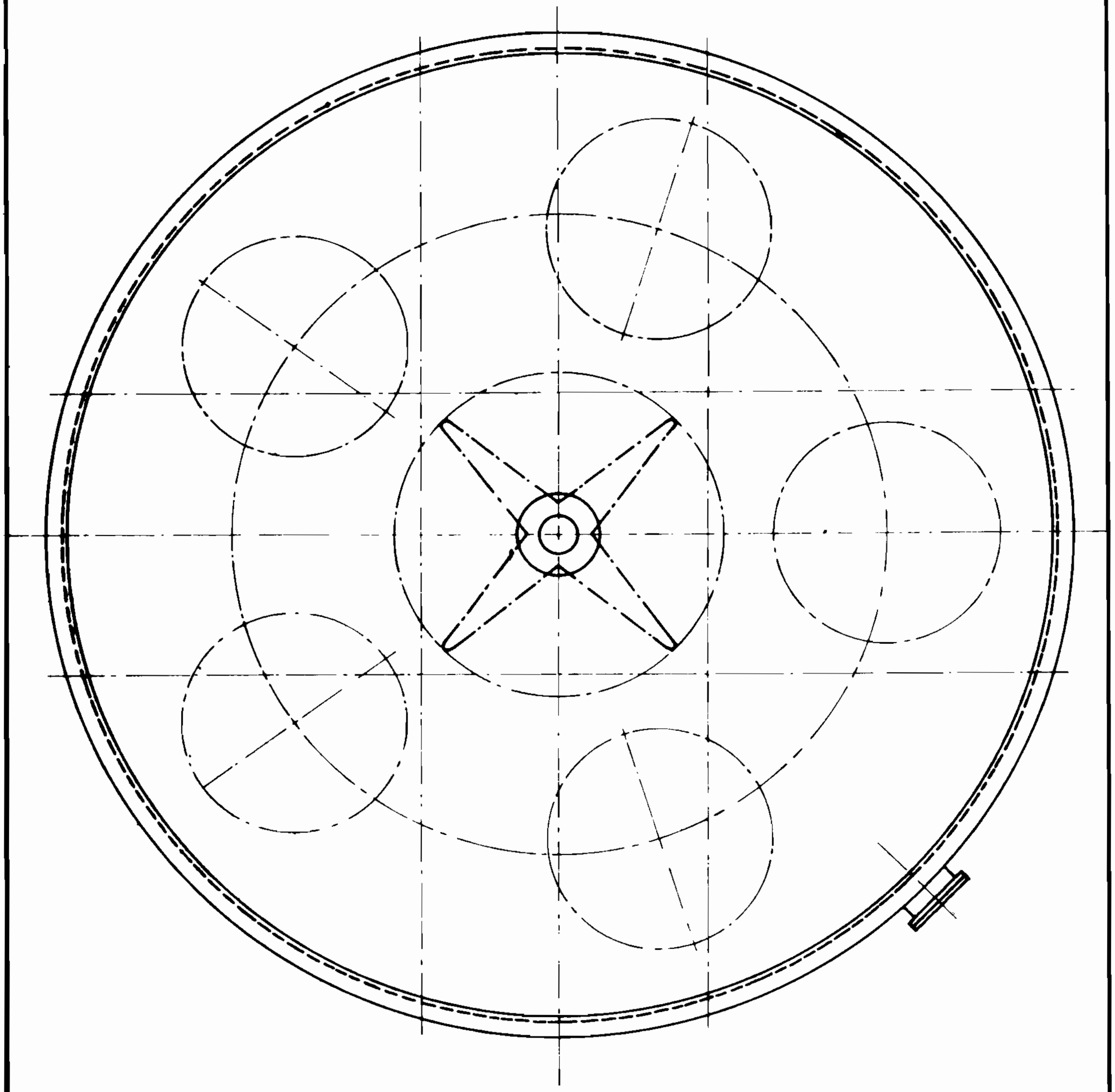


Figure 3



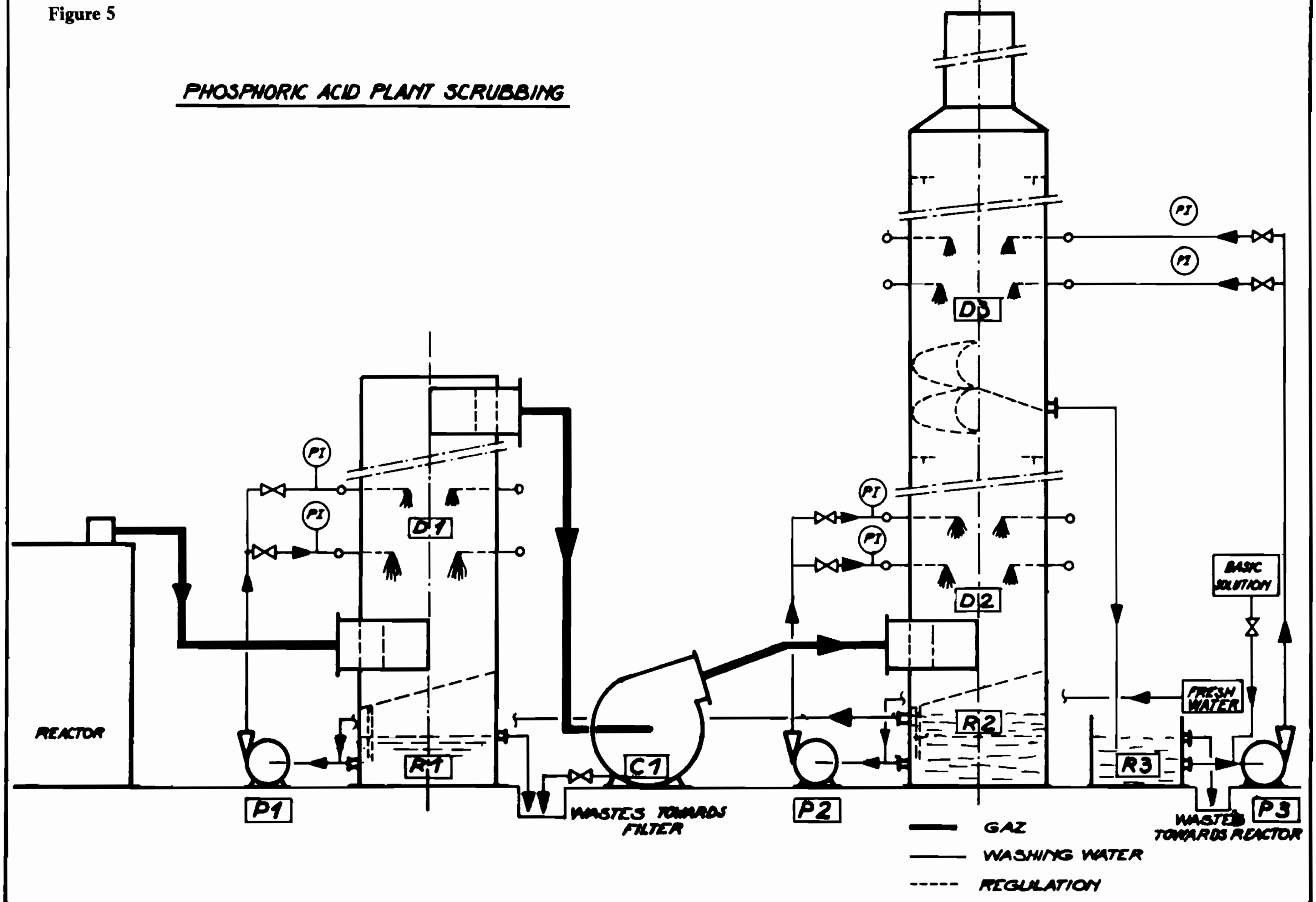
SCHEMATIC VIEW OF THE REACTOR

Figure 4



SCHEMATIC VIEW OF
THE REACTOR

Figure 5



PHOSPHORIC ACID PLANT SCRUBBING

MODERATOR DAVIS: Thank you very much. Mr. Djoldian was talking with me last night, and he told me that this was his first visit to the U.S. and he mentioned his concern about being able to speak in such a way that we could understand him. I think he did a very fine job in presenting his paper.

Our next speaker this morning also is from across the seas, Mr. John Poulton of Pertwee Landforce Ltd. in Colchester, England. The Pertwee group is one of the largest supply and distribution organizations in the United Kingdom. In addition to the fertilizer activities their interests also include quarrying, animal food production, egg and meat production, grain freighting and agrichemicals.

Mr. Poulton was educated at the Essex Technical College in Engineering and at the Essex Institute of Agriculture.

He is presently Managing Director of Pertwee Landforce Ltd., and he is also a director in the Pertwee group.

He was responsible for the design and commissioning of a 50,000 ton per year bulk blend plant in Norfolk, England in 1970 and for the development of contract services for applying fertilizer to some 300,000 acres. In only six years of production Mr. Poulton's company's output of blended goods grew from 2,000 tons to about 50,000 tons. More recently he has designed and developed a unique bulk container system for landing and distributing bulk materials. Today this system is in use in 32 countries with some 5 companies in the U.S. recently becoming involved in its use. Its practicality has been proved by its financial success in its operation.

I give you Mr. John Poulton to talk about "Bulk Blending in the United Kingdom."

Bulk Blending Practices In The United Kingdom

John W. Poulton

U.K. Market

With an agricultural industry so well served by granulation plants predominantly owned and operated by international groups such as I.C.I., Fisons, Albright and Wilson and U.K. F. Shellstar, we must ask ourselves the question — Is there a need within the U.K. for bulk blending at all? However, before I attempt to answer the question a brief look at the U.K. Industry will place in perspective the contribution that blending makes.

Currently there are 34 granulation plants in operation, 23 of which are owned by the four international companies and they currently supply 84% of the total United Kingdom compound fertilizer requirements, the remaining 11 plants producing just 5.2%. Liquid fertilizers have a 3% share of the U.K. compound market and there are just 6 plants in operation. Three of which each exceed 50,000 tons per annum, the remaining three each contributing less than 10,000 tons per annum. Imported compounds, mainly from near European countries supply approximately 2% of the market which leaves just 5.8% from bulk blending.

ENGLAND AND WALES COMPOUND MARKET 1974/75

I.C.I. Fisons, Albright & Wilson, UKF/Shellstar	**84.0%**
Granulators	**5.2%**
Liquids	**3.0%**
Imports	**2.0%**
Blenders	**5.8%**

(1975 I.C.I. Estimate)

Blending

The United Kingdom has at present just 9 blending plants and these can be basically placed into three groups. On the West Coast three plants are mixing powder ground rock phosphate and potash which is used exclusively in the marginal grass and hill areas and for forestry. Two plants are used for the production of NPK products, however, they are part of a production complex which also features granulation facilities. Four plants, including that of my own company produce a wide range of fertilizers both NPK, PK and specialist products for crops such as Sugar Beet and Potatoes. They are also centred within the intensive arable area of the United Kingdom. Production from blend plants ranges from between 3000 - 50,000 tons per year.

In addition, we do know that one of the Major U.K. granulators has blended complex products for a number of years. This would appear to have been done to extend the product range and all production continues to be marketed as compound granular fertilizer rather than as a blend.

Despite the existance for many years of the three West Coast powder dry mixing plants, bulk blending of the type practised in the United States is relatively new to the United Kingdom and certainly slow to develop.

In the case of my own company, the system was a natural development for we already had considerable contracting services strength, and our experience over many years in the handling, distribution and application business substantially influenced our entry. Our initial approach to blending was I consider quite revolutionary — we commenced by carrying out a survey of soils throughout seven counties of England and as a result established that considerable areas of land were deficient in Magnesium. We then looked at the most responsive crops i.e. Potatoes and Sugar Beet and started by producing a range of products based on Magnesium specifically for these crops, and today after 6 years of operations — 80-85% of our output goes to that market area.

For blending to survive in the United Kingdom it is essential that one offers a full comprehensive service, a look at some of my own company operations will serve to illustrate how important service is to a successful blending operation.

Soil Analysis
Custom Formulation
Incorporation of Micronutrients
Technical advice to Growers
Development of Fertilizer Handling Systems
Products available in bulk, 50Kg bags
(polyethelene, heat sealed)
mini BULK, (a 1 ton bulk container)
Fertibins, (8 ton hopper with telescopic legs)
60 Spreading Teams
On farm calibration of equipment
Technical advice & Fields Trails
Research, Agronomic studies
and raw material developments

Production

Now let us look at the Pertwee Landforce Blend Plant. First of all, I would like to emphasize that there is nothing new about our factory or our system. The plant was designed and constructed following a visit to this country some 4½ years ago, at which time I was most fortunate to receive considerable help and guidance from the staff of both the Tennessee Valley Authority and members of the Round Table. The fact that you have invited me back today surely confirms the value of your advice.

Unlike the majority of U.S. Blending Plants, raw materials are delivered to us by coaster or small boat of up to 1500 tons. This therefore necessitates considerable raw material storage facilities. Anyone with shipping and chartering experience will be all too familiar with the hazards of such an operation, raw material storage capacity is therefore considerable, approximately 5000 tons, or around four weeks supply. Discharge of boats is by grab to trucks in the case of bulk shipments, for materials needing to be packaged for shipment we use mini BULK (the low cost I.B.C. Unit) Normal discharge rate for both systems is 60 tons per hour. The factory is situated just 250 yards from the dock side, upon receipt of trucks at our plant all vehicles are weighed, this of course assists us in our stock inventory. Following weighing, bulk material is discharged into a ground receiving hopper from which it is then transfered by conveyors to some ten 500 ton storage bays, the walls of which are constructed of steel column and railway sleepers. The filling of bays is achieved by a mobile cross conveyor which totally eliminates any labour involvement. Materials currently used within the plant are C.A.N., D.A.P., T.S.P., Potash, Sodium and magnesium Oxide.

Conveyance of materials from storage bays to the process equipment is by 1 ton shovels. We have found that a minimum 1 ton bucket capacity is essential if operatives are to work efficiently and effectively in a plant producing anything up to 50 or 60 tons per hour. Raw materials used for NPK and PK production are first of all pre-screened to a particle size range of 2 — 4mm before being conveyed to pre-mixing storage bins. This operation is essential for products leaving our works in 50 Kg bags for application by farmers through modern sophisticated planters, if we did not carry out this operation we just would not exist for we are expected to produce fertilizer at least the equal of any of the major international granulators.

The plant is supplied through a 5 tonne batching hopper, by either shovels or conveyors from the holding bins. Ingredient and product volume information is indicated to operatives by an electronic digital display system and weighing is recorded by G.E.C. Elliott Electronic Load Cells. All gate and flap controls are pneymatically operated. In the case of the batching hopper the interior is so designed that we achieve a basic blend of material as it discharges onto a 36" drum feed conveyor, appearing as a sandwich in clearly defined layers. At the point of entry to the drum micronutrients such as boron or coating clay can be added, such materials are fed from four 1 ton capacity hoppers which are situated immediately above the drum entry. Coating is carried out using either water or oil, micronutrient and clay feed is by variable speed screw feed suger interlocked to the oil and water supply thereby ensuring that we only apply the 1 to 1½% of material required.

The mixing drum is perhaps unusual, it is some 28' in length and 6' in diameter, internally it is partitioned into two sections, the first, approximately 60% of the drum for coating and mixing, the second section for mixing and discharge. The drum wheels rotating in a clockwise direction receives the material and mixes, after one minute for mixing or two minutes for mixing and coating it is reversed, this enables the batch to pass through baffles to the discharge section, the product then passing through a second group of baffles at the discharge end of the drum to a surge hopper, this enables us to reverse the drum after only 1½ minutes to receive yet another 5 ton batch, even though perhaps some material may remain in the drum, consequently we are able to reduce considerably the cycle time. While we are mixing a specific product we do not completely discharge, at any time only between batches when products of differring analysis are being produced does total discharge become necessary and this can be achieved in 3½ to 4 minutes.

The surge hopper receiving mixed material from the drum is situated at the foot of a 120 ton per hour elevator, this hopper, as with all such units within the plant, is equipped with anti-segregation sections, the efficiency of such equipment can be judged by our performance over 4 years. On no occasion have we failed to comply with the standards required by the Consumer Protection Inspectors. After leaving the main elevator a final screening is carried out to remove any over-size and at the same time we are also able to remove by aspiration any dust or excess coating clay. Following this screening the product is directed to one of three hoppers. Loose bulk for discharge direct to trucks or to 50 Kg and mini BULK packaging. Mini BULK packaging is simple, it is easy to operate and does not any any stage physically involve operatives. With this unit we achieve 30 ton per hour with 3 men and I am pleased to say we have experienced a phenomenal swing to this system of packaging and of course it has totally eliminated the need for pallets. The 50 Kg or 1cwt packaging plant features a semi-automatic filling spout, vibrator and heat — sealing unit. Although rated by the suppliers at 30 tons per hour we normally only achieve around 20 tons per hour and we certainly use the latter figure for production planning. The unit is labour intensive, expensive to maintain and our hopes are that within 2 to 3 years we can phase out this system completely.

Mini Bulk

This system has contributed greatly to our success, it has proved to be beneficial in all aspects of our business, whether it be marketing, production or distribution. In the case of marketing the delivery of fertilizer onto the farms in a fully weatherproof bulk container allows our customers to take full advantage of any early delivery rebates. Permanent storage buildings are no longer essential, and the fertilizer is in the right place when the time comes to use it. Delivery to the farm does not involve farm labour, terribly important to us in the U.K. where we are seeing a considerable reduction in farm labour. Product losses through broken or burst bags have been totally eliminated, and despatch from the factory can be undertaken at all times regardless of either weather or land conditions.

Our substantial Contracts Services Section operating over a very large part of South Eastern England, has been able to achieve greater work rates, no longer are we faced with the problem of phasing lorries to arrive at farms with spreading units, no longer are we faced with the stop go situations which are so often created by sudden weather changes, no longer are valuable man-hours lost through handling, ripping and tipping then finally disposing of plastic sacks. Environmentally, mini BULK is right. Product identification is made easier, for every container is labelled and shows not only the grade of material but also the contract details, for example, the name of the field on which it is to be used.

In terms of production the benefits are considerable, those raw materials previously received in bags now come to us in mini BULK. This has shown us savings in shipping and discharge costs. We have been able to reduce our labour in the plant and further more when the containers are empty they are made available for distribution of fertilizer. Upon arrival at the docks, if we are unable to accomodate the full cargo in the factory then the material can remain on the quayside, the product is not put at risk. We have been able to remove the tremendous peaks and troughs normally associated with a bulk blending operation and now produce fertilizer during the period June to April — 10 months. Full utilization of plant and labour has resulted in lower production costs, and by achieving planned and regular production the chartering of ships has been made so much easier. We are now able to benefit substantially from long term charter contracts rather than negotiating for individual vessels at peak times.

Summary

Bulk blending and its many supporting services are nothing more than progresional developments of fertilizer distribution. A future in the United Kingdom is assured while those involved continue to develop products and systems that the farmer wants and needs. Certainly since the fertilizer price increases of the past eighteen months farmers have attached more importance to soil analysis findings and the need to provide exactly what the soil/crop needs has never been greater. If this trend continues and the large granulators are unable to convince farmers that custom formulated products are unneccessary then bulk blending may well develop very much more quickly than it has during the past decade.

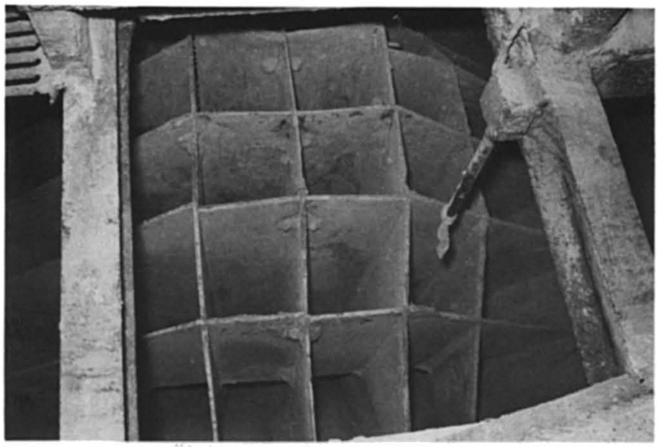
Slide 1 — Hopper-Anti Segregation Sections

Slide 2 — Mixing and Coating Drum

Slide 3 — General View of Blend Plant

Slide 4 — 1 Ton Crane Fitted to Agricultural Tractor Landing 1 Ton Mini-Bulk Container Discharging Fertilizer to Spreader.

Slide 5 — Farm Delivery Truck Equipped with 1 Ton Crane For Delivery of Mini-Bulk containers.

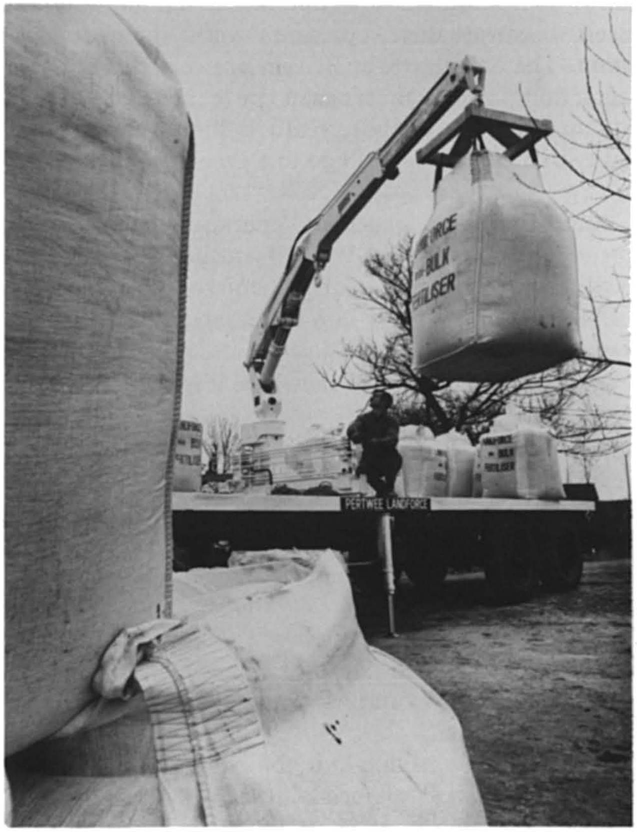


Slide 1

Slide 2

Slide 3

Slide 4



Slide 5

MODERATOR DAVIS: Do we have a question for John Poulton?

FRANK ACHORN: Did I hear you right that you have not had a fertilizer grade penalty all year?

ANSWER: Four years.

FRANK ACHORN: What do you attribute this to? Screening the materials and sizing them properly before they go into the mixture?

ANSWER: Prescreening is essential for us and secondly the system that I introduced following my visit to TVA, is nothing new. I have nothing in that plant to overcome segregation which has not already been developed by you people at TVA.

FRANK ACHORN: I think we have missed an opportunity in the U.S. with this type of operation. I do not believe most of us can single out someone who has not had a fertilizer grade penality in four years. What about the product specifications in England? Are they less restricted than the U.S.?

ANSWER: Yes. They are very much in line. And, of course, we are now currently switching on to EEC standards. But yes, they are every bit restrictive. We have someone here from the U.K. who would be able to answer this question. Where is Bill? Bill can probably answer this one on standards within the U.K., being an Ex-Vice and Production Director.

WILLIAM F. SHELDRICK: I will not mention which Company I came from, however, I ran the production operations in competition with this organization. I think, now that I am out of it, I am pleased because this represents very intense competition. The Standards in Britain are very tight. There is something more to it than pure standards. The publicity of having a failure really is such a tremendous penality that companies will go to a great length to avoid this.

John Poulton's excellent operating record is a tremendous achievement. While I am here I would like to ask about the mixing of the micronutrients which presumably seemed to go into the mixture as a powder. How do you prevent segregation of this, John?

ANSWER: It is coated therefore it is used as a coating rather than as an additive to the mix.

QUESTION: John will you be kind enough to tell us a little more about discharging into the plant.

ANSWER: We use the Silverburg baffles that you have seen. Mr. Silverburg sold me this idea when at TVA. In the case of discharging bulk mixtures into trucks, the hopper is so designed that the material discharges thru baffles into a flat section. The truck is moved forward and backward until the complete consignment is loaded. This method allows no coning to occur. What I have seen in the U.S. in a number of plants, the trucks are stationary when loaded. This causes coning to the top of the truck and the material starts falling over the sides before the truck is moved. Maybe we are lucky. We are subject to tests in the plant once a month. In the case of packaged materials samples are taken at random from 1 bag per pallet. The samples are bulked. As I said there is probably a degree of luck and I just hope that it continues. Thank you very much.

Thank you very much, John. That was certainly a fine paper, well illustrated. And I think that you can tell that John's a very innovative person.

On behalf of the Fertilizer Industry round Table, and also myself personally, I would like to thank this morning's speakers. I think the quality of their papers is evidence of the fact that they put a lot into their preparation.

I have a few announcements here that I would like to make. First there are copies of Bill Scott's paper that will be available here on this table at the close of our session this morning. That's the only paper of which the authors brought extra copies with them.

There are about 30 of the commenorative bells for sale immediately after the close of this session at the registration desk. They will be $5.00 each.

I would like to again remind those who haven't registered to please do so right away and also remind you about the cocktail party in this room at 6:00 this evening.

Thank you very much for your kind attendance. This afternoon's session starts at 1 P.M. Please come early. We now adjourn. Have a good lunch.

Wednesday, November 5, 1975

Afternoon Session
Rodger C. Smith
Moderator

MODERATOR SMITH: Let's get this afternoon session started in fairness to the speakers. The dining facilities tend to be slow and so people will gradually drift back I am sure.

Let me say that we continue with a very excellent Round Table program. The range of topics at this meeting underscores the many subjects and responsibilities of the fertilizer production supervision today. Your attendance confirms the importance to you of these subjects.

Just a few details — I suggest that we fill the seats in the front as much as possible where you can see the slides better than against the back wall and on the sides. there are copies of a few of the papers that are being given this afternoon on the table in front of the podium and the table over here and also a copy of Ed Harre's paper which he gave yesterday. I would encourage questions this afternoon following the speakers and especially during the panel discussion which should be of real interest to all us us. I remind you that there are microphones around that can be used or otherwise please speak up so everybody can hear the question as well as the answer.

Before we do start with our first speaker I would like to make note of the overseas industry people who are present. It is always good to have them here. We heard a couple of very fine papers this morning by the people from overseas. Two of those present are Carl Weil and Ole Lie with whom I became acquainted this past August during a United Nations meeting at Helsinki that I attended. We are certainly pleased to have all of you people from overseas here with us.

Now we will move on to the first speaker who is Norman Hargett; and his paper is co-authored by Mr. Robert Wehrman of the Missouri Control Service, University of Missouri.

Our speaker Norman Hargett is a native of Mississippi. He has a bachelor's and master's degree from Florence State University, Florence, Alabama. His present position is Fertilizer distribution Analyst in the Division of Agricultural Development at TVA in Muscle Shoals.

He is the author or the co-author of some highly useful publications. A couple most recently which he has authored are the "Fertilizer summary Data" which is a biannual publication and another very recent the "Directory of Fertilizer Plants in the U.S. in 1974" which is a very important contribution to the everyday work of all of us in the fertilizer industry especially since the Farm Chemicals people no longer publish a directory.

Norman will speak to us on the subject of Fertilizer Production Distribution Facilities in the U.S.

Fertilizer Production And Distribution Centers In The U.S.

Norman L. Hargett
and
Robert H. Wehrman
(Presented by Norman L. Hargett)

Introduction

The traditional fertilizer marketing pattern was for basic producers to sell intermediates to mixing plants owned and operated by wholesale distributor mixers who combined the basic materials into a small number of fertilizer mixtures which were then further distributed to many independent retail outlets for sale to the farmer. But during the past 25 years, rapid growth and tremendous changes have occurred in the fertilizer industry.

In the early 1950's, there was a strong move toward large-scale granulation facilities which remain an important segment of the fertilizer industry. The use of granular materials brought about a complete revamping of the fertilizer distribution system in the U.S. Granulation plants tended to be located in urban areas and materials had to be transported long distances to serve the farmer. The practice of bulk blending of fertilizers was introduced by the middle 1950's. Some of the bulk blenders formerly were small manufacturers of mixed fertilizers, but most of them were new retail fertilizer dealers. Production and distribution through the bulk blend route was simpler and more economical than the traditional method, and many bulk blending plants were built. Bulk blending grew at a rapid rate and today represents the largest single method of manufacture and distribution of fertilizer mixtures in the U.S.

The manufacture of fluid fertilizers on a large scale started in the late 1950's with several technical developments that combined to bring fluids into a competitive position with solid fertilizers. Growth of the fluid fertilizer industry was bolstered when furnace grade phosphate acid became available at lower prices. This meant higher analysis and lower cost plant nutrients. Even with its problems of limited supplies of basic materials, the fluid fertilizer industry continues to expand and now has a strong position in the fertilizer market.

Shortages of fertilizer materials in the U.S. for the past two years have revived the conventional chemically mixed granulation fertilizer plant. Farmers, who wanted to assure that they had adequate supplies, bought and stored bagged granular products on the farm. The granulation plants also provide an excellent way for incorporating micronutrients in mixed grades and for using byproduct fertilizer materials which, because of unsatisfactory physical properties, could not be used by the farmer or blender.

Granulation, bulk blend, and fluid mix fertilizer plants produce and distribute nearly all fertilizer used in the U.S. The purpose of this paper is to describe each of the segments of the fertilizer market system.

Survey of the Fertilizer Industry

A recent survey of the U.S. fertilizer industry, conducted by the Association of American Plant Food Control officials in cooperation with TVA, describes the 1974 fertilizer distribution facilities. A total of 6,581 questionnaires were completed and returned by fertilizer registrants throughout the U.S. Included were bulk blenders, fluid mixers, retail distribution outlets, granulation plants, and some basic producers. Based on the number of fertilizer mix or blend plants reported from other sources, we estimate that the survey covers about 70 percent of the industry.

A total of 5,023 plants in the survey indicated they were manufacturers and they either mixed, blended, or granulated fertilizers. Table 1 shows the regional breakdown by the types of fertilizer plants included in the survey. Appendix tables A, B, and C contain a regional summary for the data in the survey.

Regionally, 63 percent of these fertilizer plants are located in the east North Central and west North Central states where 43 percent of all fertilizer material was used in 1974. Perdentages of materials distributed by all plants in the survey are shown in Table 2. Distribution by class indicates that more than 42 percent of all fertilizers was distributed as dry bulk or bagged blends in 1974; fluid fertilizers (including mixtures, anhydrous ammonia, nitrogen solutions, and direct application materials) accounted for 26 percent. Granulation materials accounted for 11 percent. This does not include the material from granulation plants which is distributed through bulk blend facilities. The remaining 21 percent consisted of dry and fluid direct application materials, such as 33.5-0-0, 18-46-0, and 10-34-0.

Granulation Plants

The conventional chemically mixed U.S. fertilizer granulation plant uses ammonia, nitrogen solutions, and ammonium sulfate as its principal nitrogen sources. Phosphoric acid, triple superphosphate, and normal superphosphate are the main P_2O_5 sources. Diammonium phosphate (18-46-0) produced in conventional granulation plants as an intermediate has become a popular source of both nitrogen and phosphate for granulation of complete mixtures.

Since the conventional granulation plant requires large capital investment and production levels, there are relatively few such plants in the U.S. The Potash Institute of North America estimated in 1973 that there were 160 such plants. The AAPFCO-TVA study included 118 granulation plants (Table 1). Almost 40 percent of these are located in the South Atlantic region. Of the total, 28 had granulation facilities only and were used to describe this segment of the fertilizer market system. Ninety of the granulation plants has other facilities plus those for granulation.

The 28 plants included in the sample indicated production of almost 2 million tons of fertilizers for an average annual throughput of 70,993 tons per year. Of this total, 43 percent was sold to bulk blenders for use in their plants or for resale. Rawmaterials and finished product storage amounted to 33.2 percent of total annual distribution (Table 3). The total of all granulation plants, including units with bulk blend and/or fluid facilities, indicated a storage capacity of 25.2 percent of annual distribution. Eighteen percent of the 28 plants added pesticides and 75 percent provided for adding nicronutrients. Only 3.2 percent of the total tonnage of the granulation plants was custom application (Table 4), almost all of which was applied by truck application.

Results of the survey indicate that granulation plants complement bulk blend plants and that both have a significant role in the fertilizer marketplace.

Considering the average throughout and the estimated total number of granulation plants, we estimate that the percentage of the market for granulation plants is between 20-25 percent of the total U.S. fertilizers consumed.

Bulk Blend Plants

Bulk blending works best with well granulated, closely sized, and dry materials so that they do not deteriorate in storage. Bulk blending and granulation have been complementary developments, as the needs of blenders have motivated manufacturers of granular materials to provide an increasing supply of materials with improved physical properties. Materials most commonly used for bulk blending are ammonium nitrate, ammonium sulfate, granular triple superphosphate, diammonium phosphate, and potassium chloride. Other materials used include urea; normal superphosphate; some grades of ammonium phosphates, such as 16-20-0, 27-14-0, and 11-48-0; and complete mixtures, such as 6-24-24.

Table 5 shows the total number of bulk blend plants built in the U.S. over the past 15 years and indicates a phenomenal growth rate until 1970 with only small increases since then. This is the same pattern for liquid and suspension plants. Of the 5,023 plants included in the survey, 2,784 were bulk blend facilities only and are considered in describing this part of the industry.

The typical bulk blend plant in the U.S. has an annual throughput of 4,730 tons of all materials. Table 6 shows a breakdown of this tonnage. Of the total, 2, 731 tons was dry bulk mixtures. The average bulk blend plant also distributed 509 tons, about 10 percent of the annual tonnage, of direct application materials such as ammonium nitrate and diammonium phosphate. the typical plant also distributed 436 tons of anhydrous ammonia and 206 tons of nitrogen solutions — about 14 percent of the annual throughput.

While this 4,730-ton average annual distribution may appear to be high, a frequency distribution of these 2,784 bulk plants (Figure 1) indicates the greatest number of plants is in the 1,000- to 3,000-ton range. Many plants with tonnages above 10,000 distort the curve and result in the higher average. A survey by *Farm Chemicals* in 1963 showed the output of bulk blenders to be similar to that shown in Figure 1 with 55 percent of their respondents having tonnages of 1,000 to 3,999. the AAPFCO-TVA survey shows 60 percent of the respondents with tonnages of 1,000 to 3,999 tons.

The 2,784 bulk blend plants had storage capacity for raw materials and finished products of 46.7 percent of their total annual distribution (Table 3). Storage is an important function of the retailer because of the highly seasonal pattern of the business and the need for basic producers to maintain monthly production levels. When all 3,791 blend plants (including combination plants) are considered, storage capacity amounts to 42.1 percent of the total annual distribution.

Among the reasons for the rapid growth of bulk blending is that blenders have provided the farmers with services they want and need. Probably the most important single service is bulk application or spreading. A total of 29.9 percent of the tonnage from bulk blend plants surveyed was custom spplied (Table 4). The method used most often for applying this tonnage was truck application, 19.3 percent and floater application, 4.2 percent. The mountain region had the highest percentage of fertilizer custom applied by bulk blend plants. Sixty percent of the tonnage from these bulk blend plants was custom applied with 41.3 percent of the tonnage being truck applied and 10.4 percent floater applied. It is significant that while only 29.9 percent of the total tonnage in the survey was custom applied, more than 83 percent of the plants offered spreader rental service. Therefore, the amount of material applied by farmers is greater than the amount custom applied by bulk blenders.

Other services, such as adding pesticides and micronutrients to fertilizer mixtures, are shown in Table 7. Forty-four percent of the bulk blend plants provided for adding micronutrients, 27.2 percent added pesticides, 35.5 percent added seeds to their dry bulk blends, and 23.2 percent of the bulk blend plants also had bagging facilities.

Fluid Fertilizer Plants

Fluid fertilizers include liquids and suspensions and each is considered in this analysis. The expansion in elemental phosphorus production capacity in the 1950's produced more phosphoric acid than that needed for the industrial market. This surplus capacity was used in liquid fertilizers, being neutralized with low-cost ammonia to produce 11-37-0 or 10-34-0. Production of urea and ammonium nitrate further promoted production of liquid fertilizers. This made it possible to produce a high-nitrogen, nonpressure solution which could be used in the manufacture of fluid mixtures or as a direct application nitrogen solution. Advantages of fluid fertilizer include ease of mixing, ease of incorporating additives and securing homogeneity of the mixture, convenience of mechanical handling, and reliability of fluid application systems.

Suspension fertilizers are defined as liquids in which salts are suspended by the incorporation of a suspending agent (clay). Complete solubility of the phosphate is not required in suspensions and a wider range of phosphate materials can be used. Suspensions also permit the production of higher analysis grades than is possible with liquids.

The number of liquid and suspension plants in the U.S. is shown in Table 5. The estimated number of plants in 1959 was 335 with 717 reported in 1964. The phenomenal growth rate of fluid plants slowed in 1972 when more phosphoric acid was unavailable. The estimated number of fluid mix plants in 1974 is 2,818. The total distribution of fluid fertilizers has grown rapidly to a reported tonnage of 3.5 million tons of mixtures in 1974. Ten years ago, four states — California, Illinois, Indiana, and Iowa — accounted for 58 percent of all fluid fertilizer mixtures in the U.S. In 1974, the four leading states were Illinois, Indiana, Iowa, and Texas; they accounted for 40 percent of the total fluid mixtures consumed.

The AAPFCO-TVA survey shows an average annual throughput of 3,433 tons for the 545 plants reporting only liquid mix facilities. This included 1,571 tons of liquid mixtures, 388 tons of anhydrous ammonia, 619 tons of nitrogen solutions, and 491 tons of liquid direct application materials, such as 10-34-0 and 8-24-0 (Table 6). In addition to fluid mixtures and materials distributed, 10 percent of the fluid plant throughput was bagged, dry mixtures and materials, such as ammonium nitrate, diammonium phosphate, and complete N-P-K mixtures.

Comparable data for the suspension fertilizer mixing plants show an average annual throughput of 2,573 tons. This includes 1,232 tons of suspension mixtures, 167 tons of anhydrous ammonia, 543 tons of nitrogen solutions, and 66 tons of dry and liquid direct application materials (Table 6). Similar to the fluid plants, these suspension plants distributed 14 percent of their annual tonnage as bagged, dry kixtures and materials. Storage capacity of the liquid fertilizer plants surveyed amounted to 23.6 percent of the total fertilizer distributed annually. The suspension plants, however, had storage capacity for 37.1 percent of the annual tonnage. Storage capacity by region and type of fertilizer is shown in Table 3. As indicated, the storage capacity for fluids is much less than for bulk blends.

Almost 39 percent of the liquid fertilizer tonnage reported was custom applied (Table 4). The breakdown of the Total tonnage as to applicator types was as follows: truck, 20.4 percent; floater, 12.2 percent; and other, 6.2 percent. We estimate that farmer application, mainly with planter, is equal to or greater than dealer application.

The percentage of suspension fertilizers custom applied is higher than that for bulk blends and liquids combined. More than 74 percent of the total annual throughput is custom applied. Truck application is the highest with 42.9 percent of the tonnage being custom applied in this manner. Floater application methods are next with 23.4 percent, and then other application methods with 7.7 percent. These higher percentages are indicated because suspensions generally require more sophisticated application equipment. In both liquid and suspension plants, 40-45 percent offer application equipment rental service.

Summary

Analysis of the questionnaires returned in the national AAPFCO-TVA survey by fertilizer registrants has produced a composite picture of the fertilizer market system. Of the 6,581 respondents, 5,023 had manufacturing facilities, bulk blenders, liquid mix, suspension, granulation, or basic nutrient plants. Almost 42 percent of the respondents offered anhydrous ammonia for distribution, 62.6 percent offered custom application services, and 26.9 percent added pesticides to fertilizer mixtures. Of the 5,023 manufacturers reporting, 44.8 percent offered anhydrous ammonia; 69.5 percent provided custom application services; and 32.8 percent added pesticides to their fertilizer mixtures.

An item of particular interest in recent years has been the amount of nonfarm fertilizer use in the U.S. Survey results indicated that 4.8 percent of the total tonnage for all respondents was for nonfarm use. Granulators sold 2.1 percent of their annual tonnage for nonfarm use; bulk blenders, 3.2 percent; and fluid mix, 2.0 percent. It appears that more nonfarm or small packaged fertilizers are sold direct from basic producers to consumer or retailer than from the granulators, bulk blenders, or fluid mixers. Almost 7 percent of the basic manufacturers' tonnage was for nonfarm use.

About 75 percent of all the manufacturing plants had bulk blend facilities and 33 percent had fluid mix facilities. A third of the fluid mixers had both liquid and suspension facilities.

A directory of respondents to the AAPFCO-TVA survey is available. It lists plant location and plant type; i.e., bulk blend, fluid mix, or granulation. It also includes the plant owner's or manager's name, storage capacity, and related services offered by each plant. copies are available from the Distribution Economics Section, TVA, Muscle Shoals, Alabama 35660 at $3.00 each.

TABLE 1
TYPES OF PLANTS IN AAPFCO-TVA SURVEY[1]

	Bulk Blend			Fluids		Granulation		
							Gran	All
Region	All	BB Only	All	LIQ	SUS	All	Only	Plants
New England	24	17	9	-	-	2	-	30
Middle Atlantic	93	73	24	9	2	9	1	123
South Atlantic	238	179	154	44	17	48	14	393
East North Central	881	634	329	35	10	10	2	1,052
West North Central	1,677	1,222	638	153	15	9	1	2,110
East South Central	202	180	47	19	2	12	6	249
West South Central	412	349	344	257	9	17	4	743
Mountain	177	86	67	11	-	4	-	198
Pacific	87	44	70	17	-	7	-	125
Total	3,791	2,784	1,682	545	55	118	28	5,023

[1] AAPFCO-TVA Fertilizer Plant Survey-1974.

TABLE 2
DISTRIBUTION OF FERTILIZER MATERIALS BY CLASS-1974

Class	% of Total Fertilizer	
	Survey Result[1]	USDA Report
Dry Bulk Blends	33.3	27.9
Dry Bagged Blends	9.2	17.9
Fluid Mixtures (Liquids & Suspensions)	8.7	7.7
Anhydrous Ammonia	7.2	9.3
Nitrogen Solutions	7.1	9.0
Dry Direct Application Materials	19.7	26.1
Liquid Direct Application Materials	2.7	2.1
Bulk Granulation	4.9	—[2]
Bagged Granulation	6.2	—[2]
Total	100.0	100.0

1. AAPFCO-TVA Fertilizer Plant Survey-1974 includes Bulk Blend, Liquid, Suspension, and Granulation Plants.

2. Granulation tonnage included in blends (mostly bagged).

TABLE 3
STORAGE CAPACITY OF BULK BLEND, FLUIDS, AND GRANULATION PLANTS[1]
(% of Total Distribution)

Region	Bulk Blend	Liquid	Suspension	Granulation
	(% of Total Fertilizer Distribution)			
New England	56.3	-	-	-
Middle Atlantic	42.4	38.4	52.9	40.8
South Atlantic	26.1	22.3	38.7	31.9
East North Central	57.9	16.2	41.1	23.5
West North Central	57.9	30.0	31.5	61.2
East South Central	53.5	26.3	38.4	30.2
West South Central	31.8	20.4	28.2	38.3
Mountain	34.1	31.0	-	-
Pacific	60.4	6.8	-	-
Total	46.7	21.9	37.1	33.2
Number of Plants Reporting	2,784	545	55	28

1. AAPFCO-TVA Fertilizer Plant Survey-1974.

TABLE 4
CUSTOM APPLICATION SERVICE
BULK BLENDS, FLUIDS, AND GRANULATION PLANTS-1974[1]

Method	Bulk Blend	Liquid	Suspension	Granulation
	(% of Tonnage)			
Truck	19.3	20.4	42.9	2.9
Floater	4.2	12.2	23.4	0.2
Aerial	0.4	0.1	0.2	0.1
Other	6.0	6.1	7.6	-
Total	29.9	38.8	74.1	3.2

1. AAPFCO-TVA Fertilizer Plant Survey-1974 includes those plants indicating only bulk blend, liquid, suspension, or granulation facilities.

TABLE 5
TOTAL NUMBER OF BULK BLEND & FLUID MIX PLANTS

Year	Bulk Blend	Fluid
1960	441	390
1961	736	538
1962	908	556
1963	1,326	617
1964	1,536	717
1965	2,551	975
1966	3,153	1,231
1967	3,650	1,480
1968	4,140	1,728
1969	4,649	2,239
1970	5,158	2,751
1971	---	---
1972	5,308	2,773
1973	---	---
1974	5,391	2,818

Source: Fertilizer Trends - 1973
1974 - TVA estimate

TABLE 6
AVERAGE THROUGHPUT FOR BULK BLEND, LIQUID MIX, AND SUSPENSION FERTILIZER PLANTS, 1974[1]

Class	Bulk Blend	Liquid	Suspension
		(tons)	
Dry Bulk Mixtures	2,731	140	192
Dry Bagged Mixtures	772	40	137
Liquid Mixtures	36	1,571	236
Suspension Mixtures	3	44	1,232
Anhydrous Ammonia	436	388	167
Nitrogen Solutions	206	619	543
Direct Application - Dry	509	140	24
Direct Application - Liquid	37	491	42
Total	4,730	3,433	2,573
Number of Plants	2,784	545	55

1. AAPFCO-TVA Fertilizer Plant Survey-1974 (unidentified tonnage prorated).

TABLE 7
OTHER SERVICES OFFERED[1]

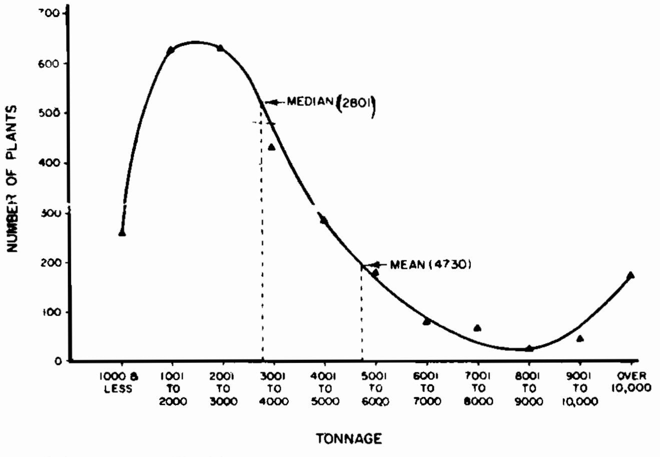
Service	Bulk Blend	Liquid	Suspension	Granulation
	(% of Plants)			
Adding Pesticides to Mixtures	27.2	31.6	61.8	17.9
Adding Micronutrients to Mixtures	44.1	47.3	61.8	75.0
Adding Seeds to Mixtures	35.5	2.6	55.0	3.6
Spreader Rental	83.5	40.2	45.4	28.6
Bagging Equipment	23.2	-	-	79.2
Number of Plants	2,784	545	55	28

1. AAPFCO-TVA Fertilizer Plant Survey-1974.

Figure 1

FREQUENCY DISTRIBUTION FOR U.S BULK BLEND FERTILIZER PLANTS

(TOTAL U.S.)



SOURCE AAPFCO-TVA FERTILIZER PLANT SUMMARY 974

APPENDIX TABLE A

Regional Summary of Bulk Blend Plants—Fertilizer Plant Survey

1974

		REGION									
		New England	Middle Atlantic	South Atlantic	E.N. Central	W.N. Central	E.S. Central	W.S. Central	Mountain	Pacific	Total
Bulk Blend Plants Only[1]											
Number		17	73	179	634	1222	180	349	86	44	2784
Avg. size plant	T.	7298	5435	11690	4303	3344	5583	5832	3219	5648	4730
Storage cap. as % of Distrib.	%	56.3	42.4	26.1	57.9	57.9	53.5	31.8	34.1	60.4	46.7
Fertilizer custom applied	%	3.7	30.4	19.4	27.0	37.1	38.7	26.3	63.0	11.3	29.9
Method—truck	%	3.7	24.6	16.1	15.7	20.1	32.8	18.2	42.3	4.8	19.3
—floater	%	-	0.1	1.1	5.5	6.8	0.9	2.7	10.4	4.9	4.2
—other	%	-	5.7	2.2	5.8	10.2	5.0	5.4	11.3	1.6	6.4
Plants Offering:											
Spreader rental	%	23.5	65.8	62.9	92.0	88.6	83.3	68.2	91.9	69.0	83.5
Add. of pesticides	%	11.8	20.5	44.6	35.3	21.1	43.3	20.3	17.4	38.1	27.2
Add. of micronutrients	%	52.9	52.1	58.8	52.5	38.3	40.0	33.2	69.8	71.4	44.1
Add. of seeds to Mix.	%	5.9	35.6	64.0	39.4	24.0	82.2	39.5	20.9	4.8	35.5
Plants with Bagging Equip.	%	47.1	28.8	38.3	28.7	18.5	25.6	17.5	7.0	71.4	23.2
All Bulk Blend Plants											
Number		22	84	224	807	1420	191	387	132	82	3349
Avg. size plant[2]	T.	9048	7179	15033	5056	3692	6256	9949	5632	9995	6002
Storage cap. as % of Distrib.[3]	%	45.7	37.6	26.6	56.3	52.5	45.9	29.7	27.9	29.6	42.1
Fertilizer custom applied[2]	%	11.9	33.5	32.4	38.1	44.9	42.6	21.1	61.4	37.1	36.9
Method—truck	%	11.9	26.9	27.5	21.6	22.1	35.2	14.1	39.7	14.5	22.9
—floater	%	-	1.0	2.2	9.9	11.6	1.8	2.6	9.6	10.4	6.9
—other	%	-	5.6	2.7	6.6	11.2	5.6	4.4	12.1	12.2	7.1
Plants Offering:[3]											
Spreader rental	%	33.3	58.1	62.6	87.5	77.7	80.7	64.1	73.5	71.3	76.6
Add. of pesticides	%	25.0	24.7	45.4	41.7	22.8	42.6	21.1	23.7	47.1	30.1
Add. of micronutrients	%	58.3	57.0	61.3	54.6	36.6	41.1	35.4	62.7	73.6	45.2
Add. of seed to Mix.	%	20.8	31.2	58.8	40.2	21.5	79.7	37.6	17.5	6.9	32.7
Plants with Bagging Equip.[3]	%	54.2	37.6	43.3	25.0	16.6	26.2	18.7	11.3	51.7	22.3
Non-Farm Tonnage[2] (% of total distribution)	%	14.8	12.6	5.1	3.8	1.1	2.6	1.9	1.4	5.1	3.2

1 All data for Bulk Blend Plants Only based on returns of 2784 plants.
2 Based on 3349 plants
3 Based on 3791 plants

APPENDIX TABLE B

Regional Summary of Fluid Mix Plants—Fertilizer Plant Survey

1974

		REGION									
		New England	Middle Atlantic	South Atlantic	E. N. Central	W. N. Central	E. S. Central	W. S. Central	Mountain	Pacific	Total
Liquid Mix Plants Only[1]											
Number		-	9	44	35	153	19	257	11	17	545
Avg. size plant	T.	-	1506	5114	8628	2420	2576	3112	3720	4153	3433
Stor. cap. as % of total Dist.	%	-	38.4	22.3	16.2	30.0	26.3	20.4	31.0	6.8	23.6
Fertilizer custom applied	%	-	69.0	52.2	45.7	46.0	80.2	26.9	46.9	24.3	38.8
Truck	%	-	28.7	41.7	39.7	11.1	59.5	11.6	4.0	-	20.4
Floater	%	-	40.3	5.3	4.4	27.1	2.5	10.7	11.3	8.3	12.2
Other	%	-	-	5.2	1.6	7.8	18.2	4.6	31.6	16.0	6.2
Plants Offering:											
Applicator rental	%	-	11.1	45.5	42.9	61.4	42.1	26.5	36.4	52.9	40.2
Add. of pesticides	%	-	66.7	54.5	68.6	51.0	57.9	7.0	45.5	35.3	31.6
Add. to micronutrients	%	-	44.4	70.5	57.1	50.3	78.9	36.6	72.7	52.9	47.3
Add. of seed to Mix.	%	-	-	-	5.7	4.6	5.3	1.6	-	-	2.6
Suspension Plants Only[2]											
Number		-	2	17	10	15	2	9	-	-	55
Avg. size plant	T.	-	550	4721	2215	1567	1550	1267	-	-	2573
Stor. cap. as % of total Dist.	%	-	52.9	38.7	41.1	31.5	38.4	28.2	-	-	37.1
Fertilizer custom applied	%	-	50.0	76.3	51.9	76.6	89.7	17.7	-	-	74.1
Truck	%	-	50.0	47.1	37.9	27.7	71.2	8.7	-	-	42.9
Floater	%	-	-	22.6	11.3	43.6	18.5	3.6	-	-	23.4
Other	%	-	-	6.6	2.7	5.3	-	5.4	-	-	7.7
Plants Offering:											
Applicator rental	%	-	50.0	47.1	50.0	46.7	100.0	22.2	-	-	45.4
Add. of pesticides	%	-	100.0	64.5	70.0	60.0	100.0	33.3	-	-	61.8
Add. of micronutrients	%	-	50.0	70.6	60.0	46.7	100.0	66.7	-	-	61.8
Add. of seed to Mix.	%	-	-	17.6	-	-	-	-	-	-	5.5
ALL FLUID MIX PLANTS											
Number		8	22	138	309	513	41	334	62	62	1489
Avg. size plant[3]	T.	6046	3838	10848	5869	5338	4727	7307	14912	14471	7191
Stor. cap. as % of tot.Dist.[4]	%	39.0	44.3	35.0	41.3	41.5	38.7	16.5	32.2	34.1	30.4
Fertilizer custom applied[3]	%	44.8	39.4	44.8	56.9	41.9	64.0	34.5	37.8	95.7	49.7
Truck	%	44.0	28.4	31.6	33.0	14.7	48.6	14.3	20.6	9.6	21.5
Floater	%	-	9.4	9.5	18.8	21.2	2.9	13.8	6.8	7.5	14.5
Other	%	.8	1.6	3.7	5.1	6.0	12.5	6.4	10.4	79.6	13.7
Plant Offering:[5]											
Applicator rental	%	44.4	33.3	55.2	72.0	58.0	53.2	29.7	76.1	68.6	55.3
Add. of pesticides	%	88.9	75.0	55.9	72.9	50.3	63.8	11.6	50.7	50.0	48.3
Add. of micronutrients	%	100.0	70.8	73.4	73.9	53.0	72.3	41.0	88.1	72.9	59.9
Add. of seed to Mix.	%	44.4	8.3	13.6	35.9	10.5	21.3	4.7	13.4	7.1	15.0
Non-Farm Tonnage (% of Tot.)[3]	%	16.5	3.0	3.9	2.1	0.8	2.3	1.7	0.4	3.5	2.0

1 All data for Liquid Mix Plants Only based on returns from 545 plants.
2 All data for Suspension Mix Plants Only based on returns from 55 plants.
3 Based on 1489 plants.
4 Based on 1678 plants.
5 Based on 1682 plants.

APPENDIX TABLE C
Regional Summary of Granulation Plants — Fertilizer Plant Survey
1974

		REGION									
		New England	Middle Atlantic	South Atlantic	E. N. Central	W. N. Central	E. S. Central	W. S. Central	Mountain	Pacific	Total
Granulation Plants Only[1]											
Number of plants		-	1	14	2	1	6	4	-	-	28
Avg. size plant	T.	-	70,000	81,271	55,000	58,000	58,667	65,000	-	-	70,993
Stor. cap. as % of Tot. Dist.	%	-	40.8	32.9	23.5	61.2	30.2	38.3	-	-	33.2
Fertilizer custom applied	%	-	-	2.6	-	.5	2.5	9.4	-	-	3.2
Method—truck	%	-	-	2.2	-	.5	2.5	9.4	-	-	2.9
—floater	%	-	-	.3	-	-	-	-	-	-	.2
—other	%	-	-	.1	-	-	-	-	-	-	.1
Plants Offering:											
Spreader rental	%	-	-	28.6	-	100.0	16.7	50.0	-	-	28.6
Add. of pesticides	%	-	-	7.1	50.0	-	40.0	25.0	-	-	17.9
Add. of micronutrients	%	-	-	71.4	100.0	100.0	83.3	75.0	-	-	75.0
Add. of seed to Mix.	%	-	-	-	-	-	16.7	-	-	-	3.6
All Granulation Plants											
Number of plants		2	9	42	9	8	12	17	3	4	106
Avg. size plant[2]	T.	31,500	40,000	103,018	47,426	194,096	52,083	196,481	177,667	55,000	107,995
Stor. cap. as % of Tot. Dist.[3]	%	33.0	38.3	24.8	42.1	20.3	32.3	19.4	21.1	52.4	25.2
Fertilizer custom applied[2]	%	-	1.9	8.9	8.2	.8	8.3	1.2	3.6	2.3	4.9
Method—truck	%	-	1.0	8.6	8.2	.8	6.6	.8	3.6	.9	4.5
—floater	%	-	.9	.1	-	-	1.5	.3	-	-	.2
—other	%	-	-	.2	-	-	.2	.1	-	1.4	.2
Plants Offering:[3]											
Spreader rental	%	-	33.3	40.5	33.3	37.5	41.7	41.2	66.7	25.0	38.7
Add. of pesticides	%	-	22.2	21.4	33.3	12.5	41.7	23.5	33.3	25.0	24.5
Add. of micronutrients	%	50.0	77.8	90.5	88.9	62.5	91.7	64.7	66.7	75.0	81.1
Add. of seed to Mix.	%	-	-	16.7	11.1	12.5	50.0	5.9	-	-	15.1
Non-Farm Tonnage (% of Tot. Distribution)		.5	7.6	1.6	9.6	.3	2.3	2.4	.1	-	2.1

[1] All data for Granulation Plants Only based on returns from 28 plants.
[2] Based on 106 plants.
[3] Based on 118 plants.

MODERATOR SMITH: Are there any questions for Mr. Hargett? Let me ask one out of my own curiosity? On the addition of seed to fertilizer mixtures, is this related to a particular region or particular crop?

ANSWER: I can't answer the question as far as the particular region or crop. We did not determine that. The paper will indicate as to the particular region where it would have been applied.

QUESTION: Did you say 42% of all the fertilizer producing, storing and marketing systems were for bulk blending or the whole works?

ANSWER: That 42% was the number indicated by the 3,791 respondents that indicated that they had bulk blend facilities. Now of the total of those who have bulk blend facilities only, which was 2,784, 46% of their total annual contribution they indicated they had that much storage capacity.

QUESTION: Do you have anything recorded that says how much was being stored at that time?

ANSWER: No, this is one thing that is much needed but we did not provide for it in the questionnaire. We only provided for what the capacity was not what the actual storage at the time was.

FRANK ACHORN: Is there any way the system can be improved to periodically show how much fertilizer is in the market?

ANSWER: Yes Frank. I think personally this is the first time we have attempted anything of this nature, a survey like this. The control officials really are the ones to be complimented. I might just add this. I hope that industry will let them know to what avail, if this is worth anything. Let them know about it. It will be dependent upon interest of industry. Frank, in answer to your question, there can be additional information supplied from something like this that would be of great value to market research people in terms of storage, and what's actually in the field that could be taken care of in a survey of this sort.

QUESTION: How did you obtain the names to send the questionnaire to?

ANSWER: The control officials of each state were responsible for distributing the questionnaire to the fertilizer registrants in each state, and they were the ones that determined that. Instead of a survey this almost ends up being a census. We did have a few states that because of maybe problems of some kind, maybe budget problems or other legal problems, they did not get to send out the questionnaire. It was a completely voluntary thing even as it was sent out. But it was distributed by each control official in each state, and then we in turn put it together and provided the analysis.

QUESTION: Did I understand you to say that the control officials sent this to the registrants? I originally understood that actually the control officials did the survey. But they sent this questionnaire out to the registrants?

MR. NORMAN HARGETT'S ANSWER: That's correct. Now, there may be one or two states where the control official had enough knowledge to do some of this; but as far as I know, some of the states handled it in this manner. They gave it to their inspectors who (in turn, maybe if they had 15 districts, these inspectors in turn carried it to their plants in their district; and they) brought them back in. In most states they said this is great. We need this information ourselves. Several states handled it in that manner.

RODGER C. SMITH (Moderator): Yes.

QUESTION: What can we infer from the fact that really since 1971 you haven't had the same type of increase in the building of bulk fluid and dry bulk blend plants?

MR. NORMAN HARGETT'S ANSWER: Well, of course, I'm giving you my opinion on that. With both bulk blending starting in the late '50's and reaching a peak somewhere in the '70's, fluid really getting started a little later and reaching a peak in '70's it was just a matter of a phenomenal growth rate as in the case of any new marketing system such as blending was. So as a result, it peaked out. Now, maybe someone else would like to offer an explanation. Someone else here might be able to answer that question better than I could. But as far as the growth rate, it would be a natural thing as far as the new marketing method being initiated.

ANSWER FROM THE AUDIENCE: Probably the tons per blending unit gives some indication that we've got a lot of units out there but haven't got up to economic size, and there's a matter of maturing I would think.

ANSWER— MR. HARGETT: It's interesting along that line to look at the average sized plant in the areas where the most plants are located because you will find that that average tonnage is smaller.

MODERATOR SMITH: Any other questions?

Norman, that was a most useful, interesting and well presented paper. It is obvious that everybody appreciates having that information available.

Now, we move to another important and major North American fertilizer market. We go to the North to Canada. We are certainly pleased to have this contribution. This paper is also co-authored. The author is Harold Blenkhorn, who was born in Nova Scotia, received his bachelor's degree at McGill University in 1950. He has been employed as a field man in soil testing in Nova Scotia Department of Agriculture, as a laboratory supervisor in the Defense Industries, Ltd. and joined Brockville Chemical in 1961 as technical service representative and at present his position is Manager of Technical Services.

The other author is J. W. Brown, better known as Jim Brown, who is a native of Ontario, graduated at the University of Guelph there in Ontario. He has been a lecturer at the University of Guelph, joined Cyanamid of Canada as a field sales representative in 1955 and then filled various management positions with Cyanamid of Canada in commercial development and product management up to 1964 and since then has been Manager of Cyanamid of Canada Retail Fertilizer Department. As a side additional duty, he is Chairman of the Statistics Commirree of the Canadian Fertilizer Institute. The subject of this co-authored paper is "The Fertilizer Market in Canada." The presentation will be made by Jim Brown. Jim.

The Canadian Fertilizer Market

J. W. Brown — H. D. Blenkhorn
(Presented by J. W. Brown)

INTRODUCTION

The fertilizer industry in Canada currently has a capital investment in excess of 1 billion dollars. An additional billion dollars is invested in potash mines in Saskatchewan. Nitrogen expansions in progress or planned could increase the investment by an additional billion dollars by 1980. Annual sales in the current fertilizer year ending June 30, 1975 are expected to exceed $900 million and the industry will ship more than 14.6 million tons of its products into the Canadian, U.S. and offshore markets of the world during the same year. Approximately three million tons (20%) of that output will go into the domestic agricultural market. Canadian farmers purchased $340 million of fertilizers in 1974 and an estimated $400 million during 1975.

The Canadian fertilizer industry has its roots in the extractive industries — mining and petroleum. It produces all three primary nutrients through the upgrading of basic Canadian resources.

Nitrogen capacity has increased threefold since 1950 and is in the incipient stage of even greater expansion to meet rising North American and world demand. Most of the expansion will take place in Alberta close to the source of natural gas. Phosphatic fertilizers are manufactured utilizing phosphate rock imported from Florida and other eastern and mid-western U.S. sources. Canada has no commercial indigenous deposits of phosphate rock. Phosphatic fertilizer production is likely to increase modestly utilizing by-product sulphuric acid derived from metals extraction and sulphur recovered from natural gas. Potash is mined in Saskatchewan from one of the world's largest reserves of this nutrient. Expansion by existing mines has been currently deferred due to political differences between the producers and the government of Saskatchewan.

Most of Canada's present fertilizer production capacity is located inland, and most of the expansions in nitrogenous fertilizer capacity are in Alberta. Canada tends to be at a disadvantage in regard to offshore fertilizer trade because of the additional rail freight costs required to transport product to costal ports. With mainly inland nitrogenous and phosphatic plants located close to the U.S. border, it is understandable that the main focus of the Canadian fertilizer industry's expost capacity is towards the U.S. An exception to this is potash which is competitive in world markets.

The Canadian fertilizer market falls into two separate geographical sectors, one in Central and Eastern Canada and the other in Western Canada. Eastern and Western producers do not compete with each other in the Canadian market because Canada does not have a continuous agricultural market and there is a high rail freight barrier between these markets. There is almost no movement of product, except potash, between Eastern and Western Canada. The Eastern and Western Canadian markets are currently about equal in size.

FERTILIZER CONSUMPTION IN CANADA

Canada exports approximately one dollar in every three of its gross farm receipts and as a result fertilizer consumption is greatly influenced by international markets. Currently world grain inventories are low and export sales for Canadian wheat, oil crcps and feed grains look promising for the future. High grain prices have a favourable influence on canadian farm cash income and consequently fertilizer consumption.

Sales of mixed fertilizers and direct application materials during the fertilizer year 1974 were 2.9 million tons. 1.8 million tons of the total were fertilizer materials and 1.1 million tons were fertilizer mixtures. Sales in Eastern Canada were 1,547 thousand tons; 494 thousand tons of materials and 1,054 thousand tons mixtures. Sales to Western Canada customers were 1,328 thousand tons; 1,271 thousand tons materials and 57 thousand tons of mixtures. Sales statistics are not yet available for the 1975 fertilizer year but there will be little change in physical volume compared to 1974.

CONSUMPTION OF PRIMARY PLANT NUTRIENTS — CANADA

Consumption of combined primary plant nutrients in Canada was 1.3 million tons or 6.9% of combined plant nutrients consumption in the U.S. during 1974. Combined plant nutrients consumption has been growing at an average annual rate of 9% per year over the past 20 years, substantially higher than the U.S. growth rate.

NITROGEN

Fertilizer nitrogen consumption in Canada has shown the most dramatic increase of the three nutrients. Fertilizer nitrogen has experienced an average annual growth of 15% over the past five years and 14% over the past 20 years. Increased nitrogen consumption is due primarily to growth in corn acreage in Eastern Canada and higher application rates on cereal grains in Western Canada. Fertilizer nitrogen consumption is expected to increase rapidly and could reach 800 to 900 thousand tons N by 1980, providing the international grain market remains strong.

PHOSPHATE

Phosphatic fertilizer (P_2O_5) consumption in Canada has experienced an average annual growth rate of 8% per year over the past 20 years and 9% per year during the past five years. Phosphate consumption will continue to increase but at a somewhat slower rate than during the past five years. Consumption could be in the 800 - 900 thousand ton range by 1980 contingent on the world grain market.

POTASH

Potash consumption is confined largely to Eastern Canada. Growth over the past 20 years has been a steady 6% per year and 4% over the past five years. Potash consumption will reach the 280 to 300 thousand tons K_2O by 1980.

REGIONAL FERTILIZER CONSUMPTION IN CANADA

The Eastern Canada fertilizer market is made up of the provinces of Ontario, Quebec and Atlantic region.

Ontario is the foremost and most diversified province in agricultural output in Eastern Canada. Ontario's agriculture has had a rapid shift from oat to grain corn production and consequently a quick acceleration in plant nutrient consumption particularly nitrogen. Quebec's agricultural production is largely in the St. Lawrence low lands with livestock production contributing 70% of farm cash income. The introduction of early maturing grain corn has resulted in a dramatic increase in grain and silage corn production. This trend will continue and give rise to an expanding fertilizer market within the province. Combined plant nutrient consumption represents 22% of total of Eastern Canada. Agricultural production in the Atlantic provinces is confined to small pockets. Plants nutrient consumption amounts to 10% of the Eastern Canada market with potatoes being the principal crop fertilized. Potato acreage is fertilized at maximum rates, the acreage is static and hence only small growth is anticipated in the region.

The Western Canada fertilizer market consists of British Columbia and the three prairie provinces of Alberta, Manitoba and Saskatchewan. Potash doesn't give a positive growth response on cereal grains grown in the prairie region, hence consumption is minimal. Cereal grains, sugar beets along with oil crops such as flax and rapeseed provide the main market for fertilizers. Farm cash income in Western Canada has fluctuated widely depending on the international market for wheat, oilseeds and other feed grains. Fertilizer consumption in the past has fluctuated with farm cash income. Currently world inventories of cereals are at an all time low and international grain sales look good for the immediate future. Hence Western Canada farm cash income should be strong and fertilizer consumption will reflect the farmers' strong cash position.

FERTILIZER PRODUCTION IN CANADA

NITROGEN

The production of fertilizer nitrogen in Canada in 1974 was 885 thousand tons N, of which 545 thousand tons were consumed domestically and 325 thousand tons were exported. 106 thousand tons of ammonia were exported, as well, for fertilizer and industrial end-use. An additional 200 thousand tons N were consumed in the Canadian industrial market. Exports of fertilizer nitrogen have been declining coincident with an increase in domestic demand. Repatriation of exported nitrogen has helped supply expanding consumption for Canadian agricultural and industrial markets.

ANHYDROUS AMMONIA

In 1975, the annual name plate capacity for anhydrous ammonia in Canada was 1.8 million tons. During the year Beker Industries commenced production from the reconstructed Dow plant at Sarnia. C.I.L. extended its existing output at Courtright by 70 thousand tons by the addition of two skid units. Natural gas is presently not available for additional expansion in the East. In the West, Canadian Fertilizers, Medicine Hat, will commence production in mid 1976 with the first of two 400 thousand ton ammonia units.

Ammonia production for the fertilizer year ended June 30, 1975 was 1.4 million tons. By 1978, Canadian ammonia capacity will increase to three million tons annually. 1980 Output will far exceed Canadian domestic requirements estimated to be 1.3 million tons N. The balance of the production will be exported as ammonia or as nitrogenous materials, mainly to the U.S. market.

UREA

Canadian capacity for urea production in 1975 was 425 thousand tons. Production during the calendar year 1974 was 424 thousand tons. Approximately 178 thousand tons were consumed in fertilizer products in Canada with some of the urea consumed in nitrogen solution exported to U.S. markets. Domestic industrial consumption accounted for about 75 thousand tons and 162 thousand tons were exported mainly to U.S. markets.

Two new urea production facilities, under construction, will increase annual capacity to 1.4 million tons. Most of the new production capacity will be available for the export market.

AMMONIUM NITRATE

Current production capacity for ammonium nitrate is 1.1 million tons. In 1975, C.I.L. increased its capacity at Courtright from 130 to 160 thousand tons annually and Brockville Chemicals increased its annual capacity from 60 to 180 thousand tons. The only announced new production facility for ammonium nitrate is the C.I.L. plant at Carseland, Alberta with an annual capacity of 250 thousand tons. Production from this plant is earmarked for the industrial explosives market. Solid ammonium nitrate production in Canada in 1974 was 941 thousand tons. The domestic fertilizer market consumed approximately 575 thousand tons of ammonium nitrate, the domestic explosive market 195 thousand tons, and 245 thousand tons were exported to U.S. markets.

AMMONIUM SULPHATE

Ammonium sulphate is produced as a by-product of a nickel refining process in the West and the steel industry is in the East. Canadian production for the 1975 fertilizer year was 222 thousand tons. 129 thousand tons were exported to the U.S. and the blance consumed in the domestic market.

NITROGEN SOLUTIONS

Nitrogen solution production in Canada for the fertilizer year 1975 was 155M tons. Of this total, 54 thousand tons were consumed in the Eastern Canada market, 20 thousand tons in Western Canada and 81 thousand tons exported to the U.S. market. Approximately 20 thousand tons were used in the East for manufacturing mixed fertilizers. The balance was sold as non pressure solutions for direct application.

FERTILIZER PHOSPHATE PRODUCTION

Canadian phosphatic fertilizer production is based on imported phosphate rock and by-product sulphuric acid derived from the base metal refining and sulphur removed from sour gas. Phosphate rock imports during the fertilizer year 1975 were approximately 4 million tons of which 3.2 million tons were consumed in fertilizer production. Phosphatic fertilizer production in 1974 was 768 thousand tons P_2O_5. 312 thousand tons P_2O_5 were exported during 1974, 37 thousand tons P_2O_5 imported and domestic consumption was 545 thousand tons.

WET PROCESS PHOSPHORIC ACID

Canadian production capacity for wet process phosphoric acid is approximately 950 thousand tons P_2O_5 annually with 425 thousand tons in the East and 532 thousand tons in the West. No new plant expansion have been announced but existing plants in Western Canada are being extended to provide additional production. In the West, plants have operated at/or near capacity, whereas total production in the East has been substantially below rated capacity.

AMMONIUM PHOSPHATES

Canadian ammonium phosphate production capacity is approximately 1.8 million tons. Plants in Western Canada have been operating close to capacity, whereas in the East production is below potential output. Present production facilities are expected to meet requirements between now and 1980.

SUPERPHOSPHATES

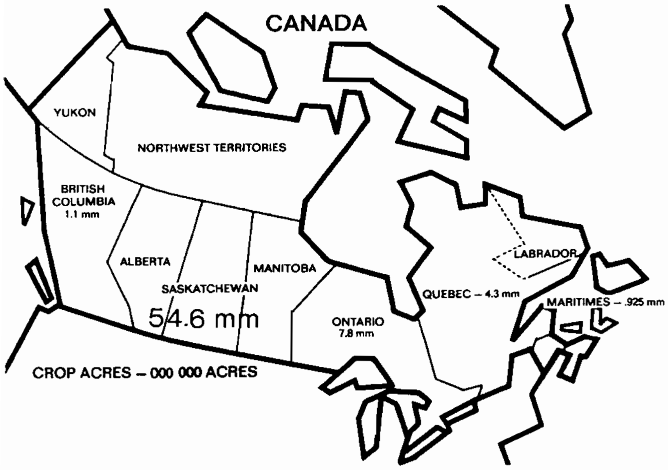
Canadian production capacity for normal and triple superphosphates is currently about 380 thousand tons of product or 100,000 tons P_2O_5 annually. Production from these plants has been substantially below capacity with shipments of 186 thousand tons product (42M tons P_2O_5) for the past two years. All of the superphosphate plants are located in Eastern Canada and production is used largely for mixed fertilizer production. No expansion of superphosphate capac ity is anticipated.

POTASH

The first commercial production of potash in Saskatchewan was attempted in 1951. Early attempts at mining ended in failure due to the Blairmore formation which consists of a layer of sand and water under extreme pressure. Technology eventually overcame the troublesome Blairmore formation and subsequently Canada's potash production during the sixties increased in seven short years from zero to 8.3 million tons per year of K_2O. Initially the mines operated at less than 50% of name plate capacity but in 1975 production increased to 6.3 million tons K_2O. Shipments from Saskatchewan during the 1975 fertilizer year were 5.5 million tons K_2O of which 3.5 million (64%) went to the U.S. market, 1.7 million (31%) to offshore markets and .26 million tons (4.6%) to the Canadian market. Sulphate of potash and sulphate of potash magnesia are both imported to supply Canadian requirements.

SUMMARY

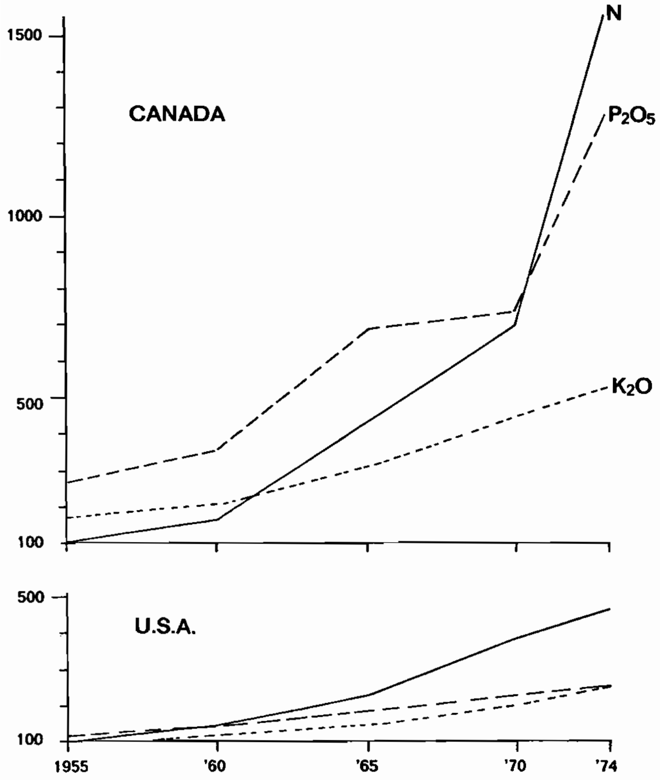
Presently Canada represents only 6.4% N-P-K consumed in North America, but supplies 26.4% of total primary plant nutrients consumed in the U.S. and Canada. Canada is self sufficient in the production of all three of the primary plant nutrients. In the future, Canada is expected to produce sufficient N-P-K for its own domestic requirements and continue to supply an increasing percentage of the North American market, particularly nitrogen and potash. Phosphate production in Canada will continue to be ample to meet domestic requirements with a small quantity available for export to border states. The lack of indigenous phosphate rock deposits will restrict large scale participation in world markets for phosphate fertilizers.



PRIMARY PLANT NUTRIENT CONSUMPTION UNITED STATES & CANADA 1974

	N	P_2O_5	K_2O
		Thousands of Tons	
U.S.	9,157.2	5,098.2	5,082.0
CANADA	565.1	544.7	222.6
CANADA AS % OF U.S.	6.2	10.6	4.4

N, P_2O_5, K_2O Growth Index — Canada and U.S.A.



N Consumption 1955 = 100

CANADIAN FARM OPERATING EXPENSES FOR FERTILIZER 1974 AND ESTIMATED 1975

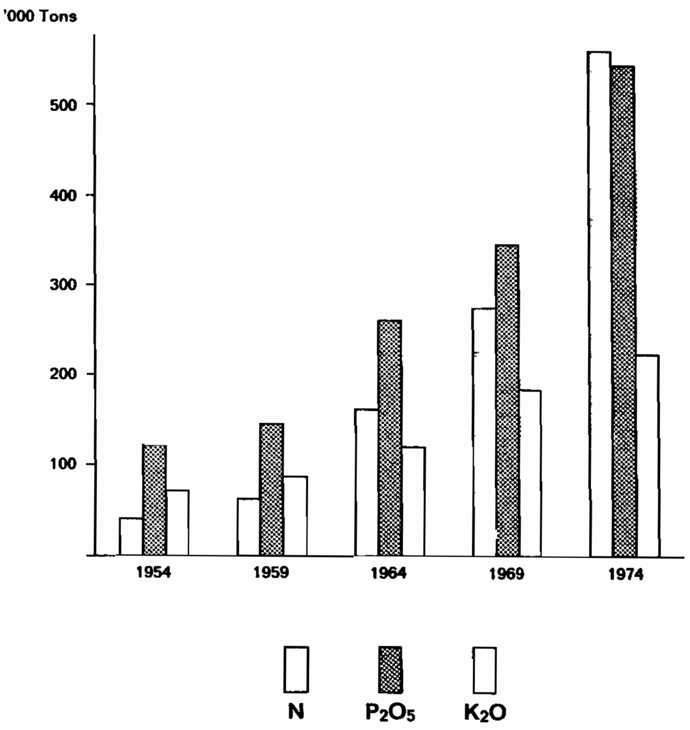
	1974	ESTIMATE 1975
	Millions of Dollars	
EASTERN CANADA	170.6	208.0
WESTERN CANADA	168.3	212.0
TOTAL:	338.9	420.0

SOURCE: STATISTICS CANADA

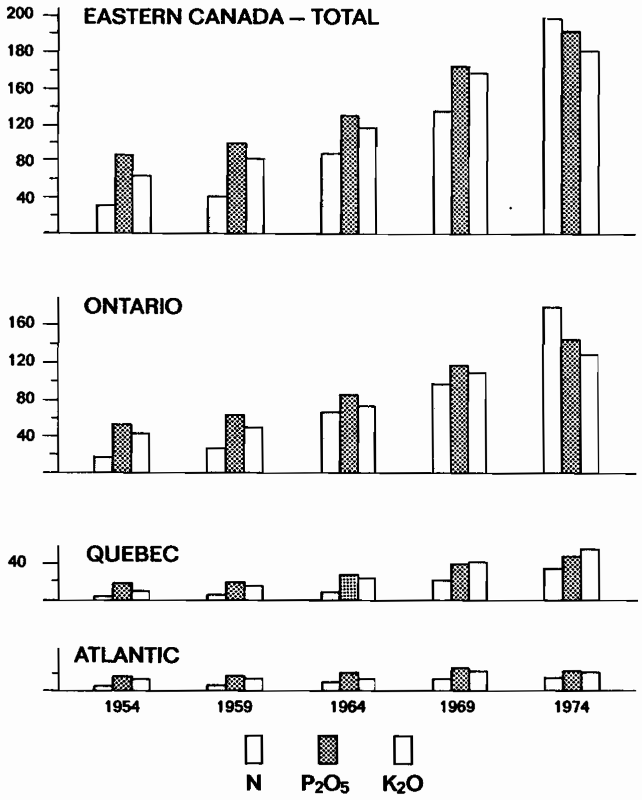
PLANT NUTRIENT CONSUMPTION CANADA 1954-1974 000 Tons

	1954	1959	1964	1969	1974
N	42.0	62.1	165.6	277.6	565.0
P_2O_5	122.4	144.9	264.2	347.8	544.8
K_2O	69.0	88.0	120.7	185.6	222.7
Total	234.3	295.0	550.5	811.0	1,332.5

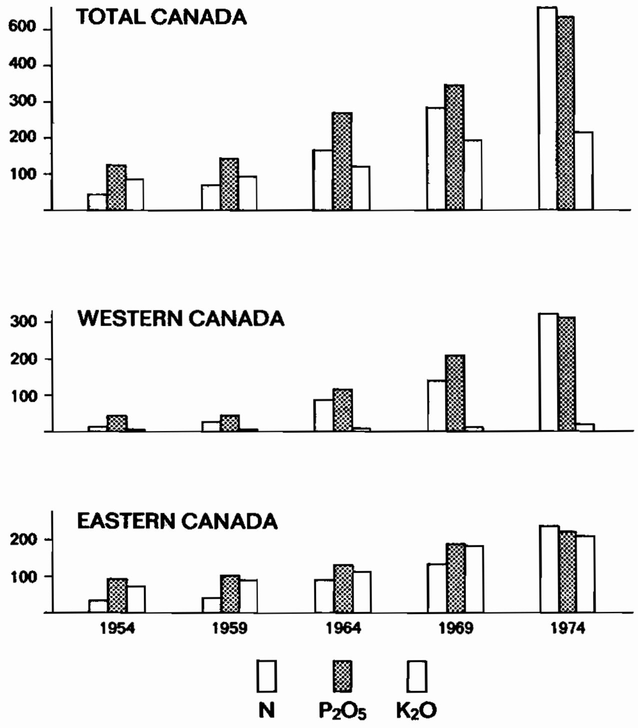
Plant Nutrient Consumption — Canada — 1954-1974 000 Tons



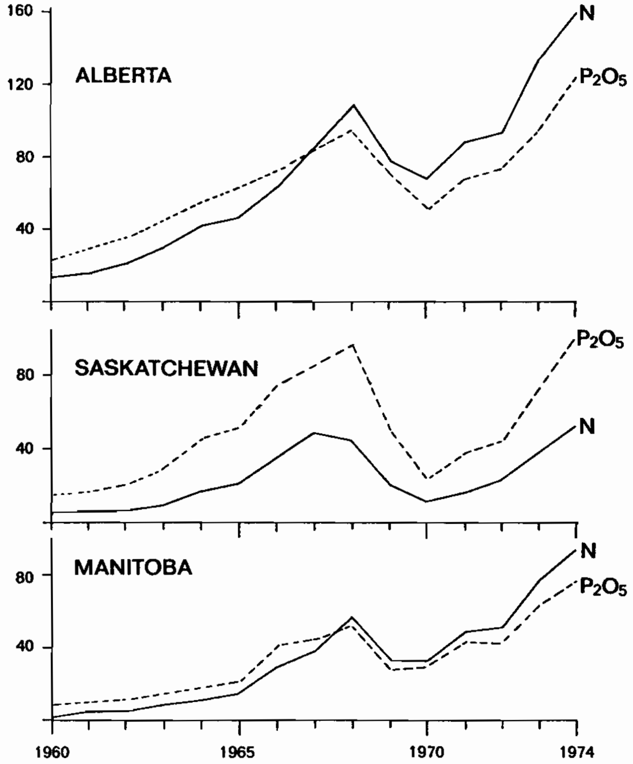
Plant Nutrient Consumption Eastern Canada — 1954-1974 000 Tons



Plant Nutrient Consumption Canada East — West — Total 1954-1974 000 Tons



N, P_2O_5 Consumption — Prairie Provinces — 1960-1974 000 Tons



ANHYDROUS AMMONIA — PRODUCERS CANADA — 1975

COMPANY	LOCATION	ANNUAL CAPACITY 000 TONS
Beker Industries	Sarnia, Ontario	160
Brockville Chem. Ind.	Maitland, Ontario	88
Canadian Industries Ltd.	Courtright, Ontario	400
Cyanamid of Canada Ltd.	Welland, Ontario	250
	TOTAL EASTERN CANADA	898
Cominco Ltd.	Calgary, Alberta	125
Cominco Ltd.	Trail, B.C.	70
Esso Chemicals	Redwater, Alberta	210
Sherritt Gordon Mines	Fort Saskatchewan, Alberta	160
J.R. Simplot Co.	Brandon, Manitoba	110
Western Co-operatives	Calgary, Alberta	70
Western Co-operatives	Medicine Hat, Alberta	65
	TOTAL WESTERN CANADA	810
NEW PRODUCTION CAPACITY		
Canadian Fertilizers Ltd.	Medicine Hat, Alberta	400 — 1976 400 — 1978
Cominco, Ltd.	Carseland, Alberta	400 — 1977

CANADIAN END-USE ANHYDROUS AMMONIA 1974

	NH_3 EQUIVALENT ANNUAL 000 TONS
PRODUCTION	1,400.0
END-USE	
AMMONIUM NITRATE	444
UREA	254
AMMONIUM PHOSPHATE	270
AMMONIUM SULPHATE	57
FERTILIZERS — DIRECT APPLICATION	173
INDUSTRIAL (PULP & PAPER, METALS, FIBERS)	120
TOTAL	1,318
EXPORTS	106
TOTAL	1,424

AMMONIUM NITRATE PRODUCTION CAPACITY CANADA — 1975

	Annual 000 Tons
EASTERN CANADA	
C.I.L., Beloeil, Quebec	70
C.I.L., Courtright, Ontario	160
Cyanamid of Canada, Welland, Ontario	200
Brockville Chemical, Maitland, Ontario	180
Sub-Total	610
WESTERN CANADA	
Cominco, Calgary, Alta.	70
Simplot, Brandon, Manitoba	150
Western Cooperatives — Calgary, Alta.	85
Western Cooperatives — Medicine Hat, Alta.	65
Esso, Redwater, Alta.	90
C.I.L., Calgary, Alberta	30
Sub-Total	490
Total Canada	1,100
NEW PRODUCTION CAPACITY	
C.I.L., Carseland, Alta. (1977)	250

AMMONIUM NITRATE END USE CANADA — 1974

		000 TONS
PRODUCTION		941
END-USE		
Fertilizers		
(dry mix, solution, D.A.) —	East	228
	West	346
	Sub-Total	574
Industrial		
	East	120
	West	75
	Sub-Total	195
Exports		245

UREA PRODUCTION CAPACITY CANADA 1975

		ANNUAL 000 TONS
EASTERN CANADA		
Cyanamid of Canada, Welland, Ontario		100
C.I.L., Courtright, Ontario		75
Brockville Chemicals, Maitland, Ontario		50
Sub-Total		225
WESTERN CANADA		
Cominco, Calgary, Alberta		80
Sherritt Gordon, Fort Saskatchewan, Alberta		90
Simplot, Brandon, Manitoba		30
Sub-Total		200
Total Canada		425
NEW PRODUCTION CAPACITY		
Cominco, Carseland, Alberta	1977	480
Canadian Fertilizer, Medicine Hat, Alberta	1976	480

UREA END-USE CANADA 1974

		000 TONS
PRODUCTION		424
END-USE		
Fertilizers		
(Blends, solutions, D.A.) —	East	76
	West	102
	Total	178
Industrial	East	57
	West	18
	Total	75
Export		162

CANADIAN NITROGENOUS FERTILIZER SHIPMENTS NUTRIENT CONTENT

	Canada	U.S.	Offshore	000 Tons Total
	Short Ton N			
1973/1974	493.8	277.9	25.5	797.2
1974/1975	536.1	217.1	27.8	781.0

SOURCE: CANADIAN FERTILIZER INSTITUTE

CANADIAN PHOSPHATE ROCK IMPORTS

YEAR	ROCK IMPORTS TONS
1963	1,297,427
1965	1,695,296
1967	2,279,767
1969	2,201,331
1971	2,844,453
1973	3,622,193
1974	3,689,165
1975	3,970,757

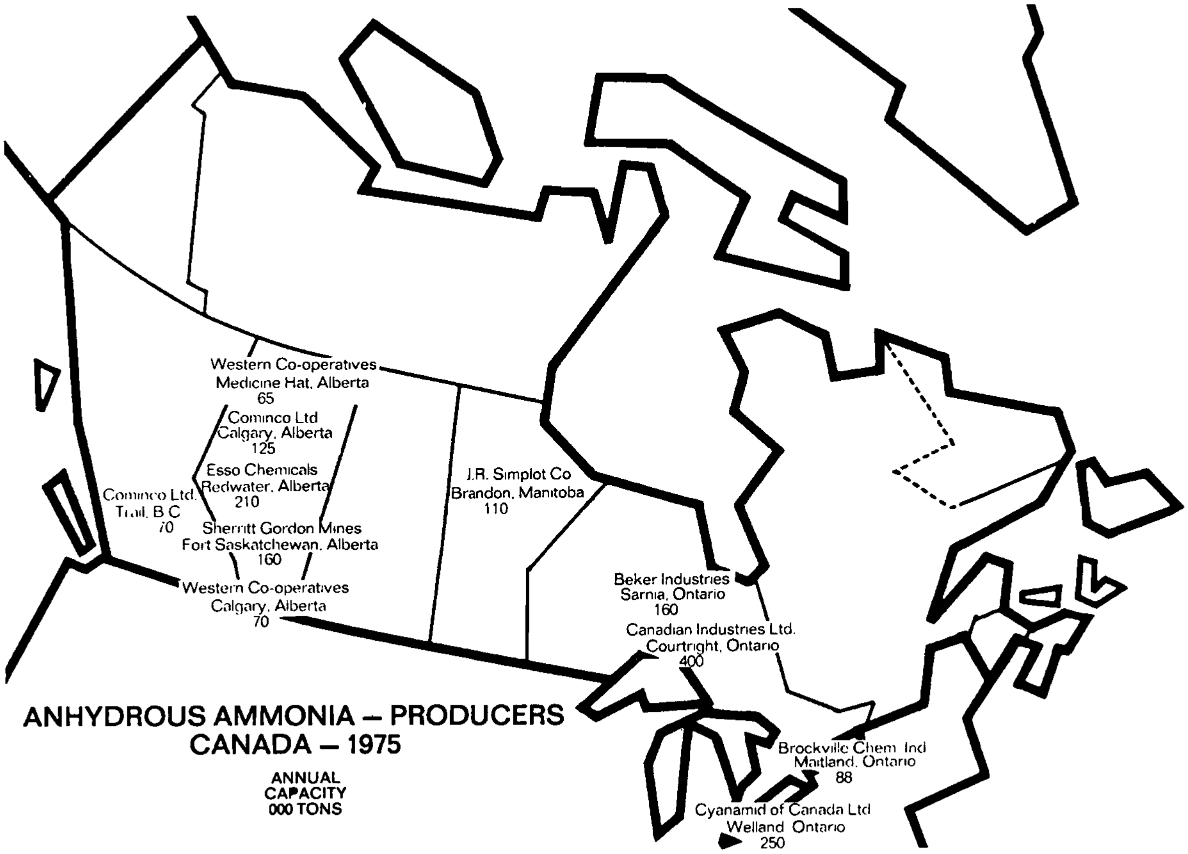
SOURCE: STATISTICS CANADA

CANADIAN PHOSPHORIC ACID CAPACITY — 1975

	ANNUAL CAPACITY 100% P_2O_5 000 Tons
EASTERN CANADA	
Belledune Fertilizers, Belledune, N.B.	150
C.I.L., Courtright, Ontario	96
I.M.C., Port Maitland, Ontario	130
St. Lawrence Fertilizers, Valleyfield, P.Q.	50
TOTAL EASTERN CANADA	426
WESTERN CANADA	
Cominco, Kimberley and Trail, B.C.	209
Esso Chemicals, Redwater, Alberta.	80
Western Cooperatives, Medecine Hat, Alta.	80
Sherritt Gordon, Fort Saskatchewan, Alta.	53
Western Cooperatives, Calgary, Alta.	110
TOTAL WESTERN CANADA	532
TOTAL CANADA	958

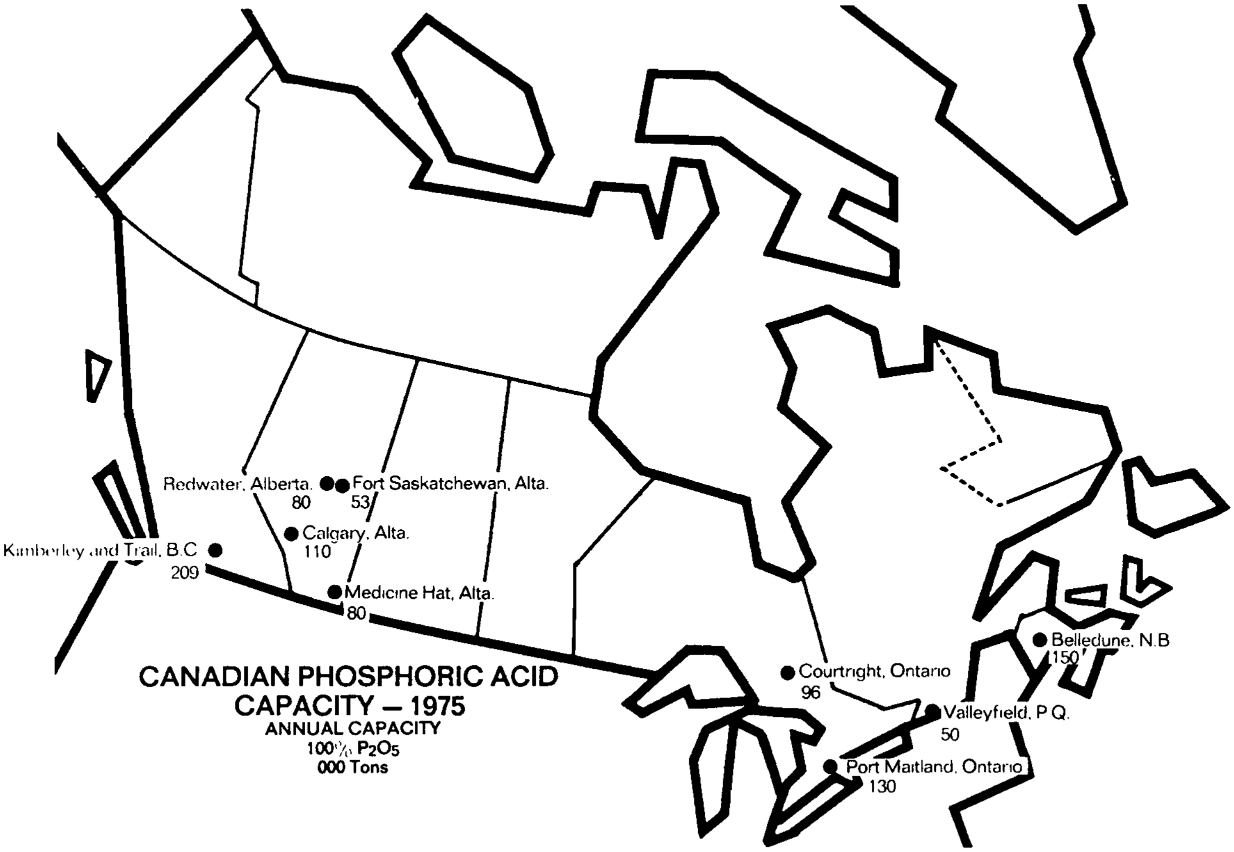
AMMONIUM PHOSPHATE PRODUCTION CAPACITY CANADA — 1975

	000 TONS/YEAR
EAST	
C.I.L., COURTRIGHT, ONTARIO	190
ST. LAWRENCE FERTILIZER, VALLEYFIELD, P.Q. (NORANDA)	60
BELLEDUNE FERTILIZER, BELLEDUNE, (NORANDA)	300
TOTAL:	550
WEST	
ESSO CHEMICALS, REDWATER, ALTA.	190
WESTERN COOPERATIVES	
— CALGARY, ALTA.	150
— MEDICINE HAT, ALTA.	200
SHERRITT GORDON, FORT SASKATCHEWAN, ALTA.	135
COMINCO, KIMBERLEY AND TRAIL, B.C.	415
J.R. SIMPLOT CO., BRANDON, MAN.	160
TOTAL:	1,250
TOTAL CANADA:	1,800



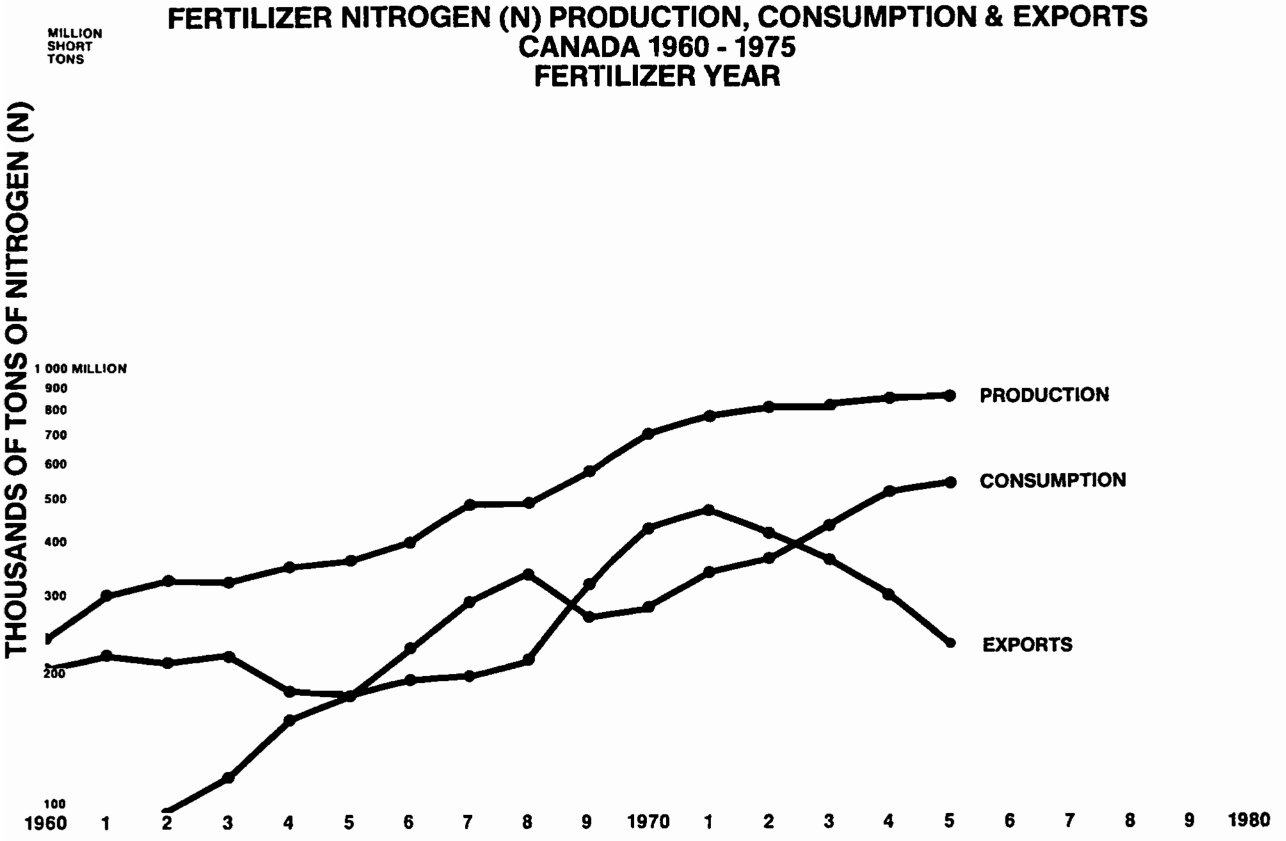
ANHYDROUS AMMONIA – PRODUCERS CANADA – 1975

ANNUAL CAPACITY 000 TONS



CANADIAN PHOSPHORIC ACID CAPACITY – 1975

ANNUAL CAPACITY 100% P_2O_5 000 Tons



FERTILIZER NITROGEN (N) PRODUCTION, CONSUMPTION & EXPORTS
CANADA 1960 - 1975
FERTILIZER YEAR

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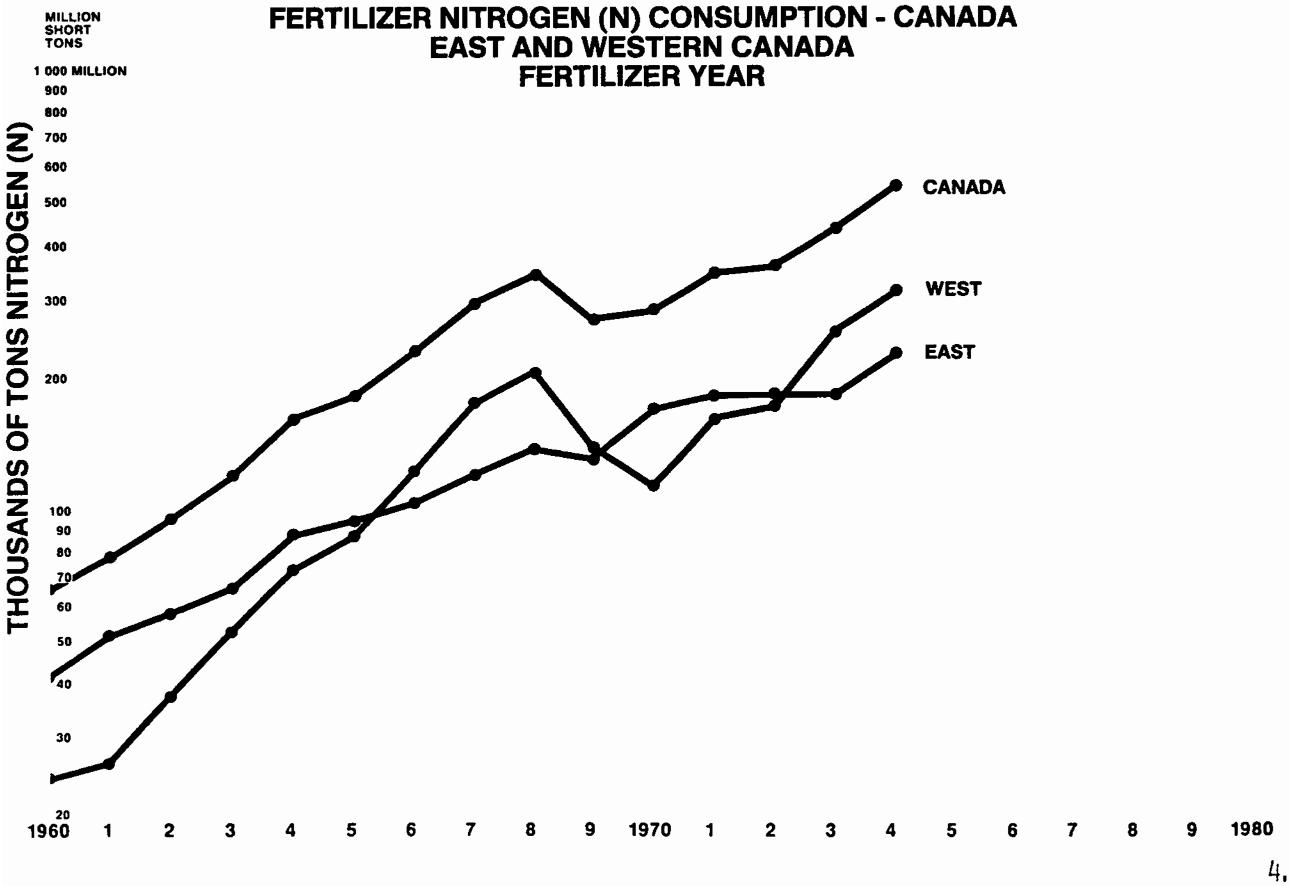
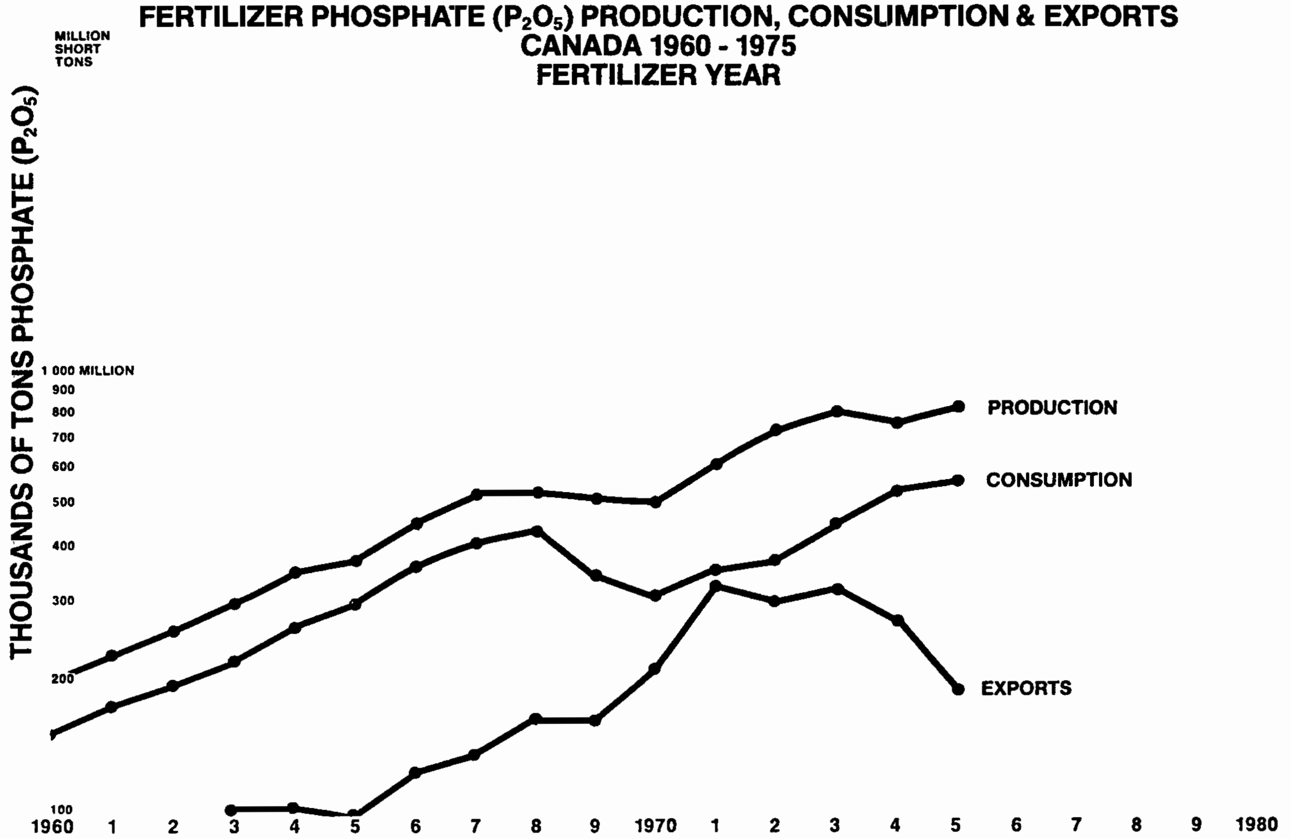


FERTILIZER NITROGEN (N) CONSUMPTION - CANADA
EAST AND WESTERN CANADA
FERTILIZER YEAR

4.

FERTILIZER PHOSPHATE (P_2O_5) PRODUCTION, CONSUMPTION & EXPORTS
CANADA 1960 - 1975
FERTILIZER YEAR



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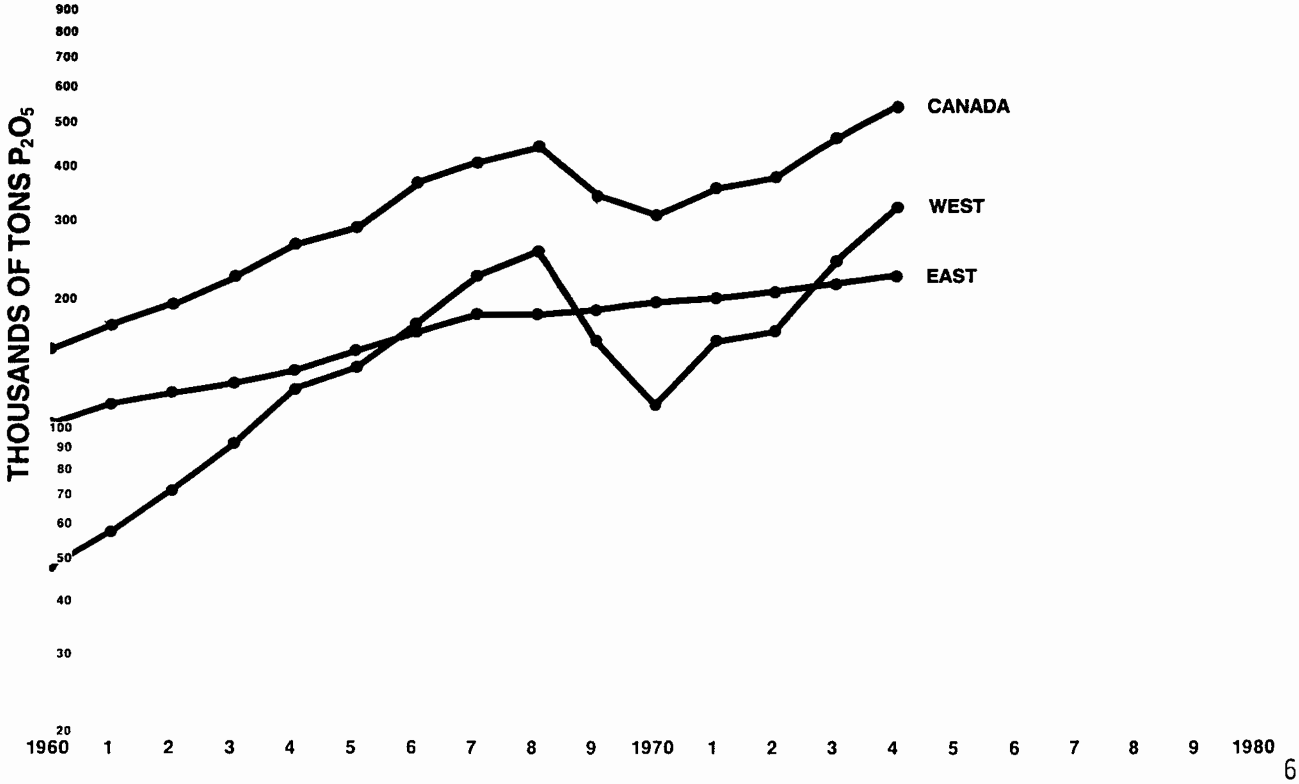
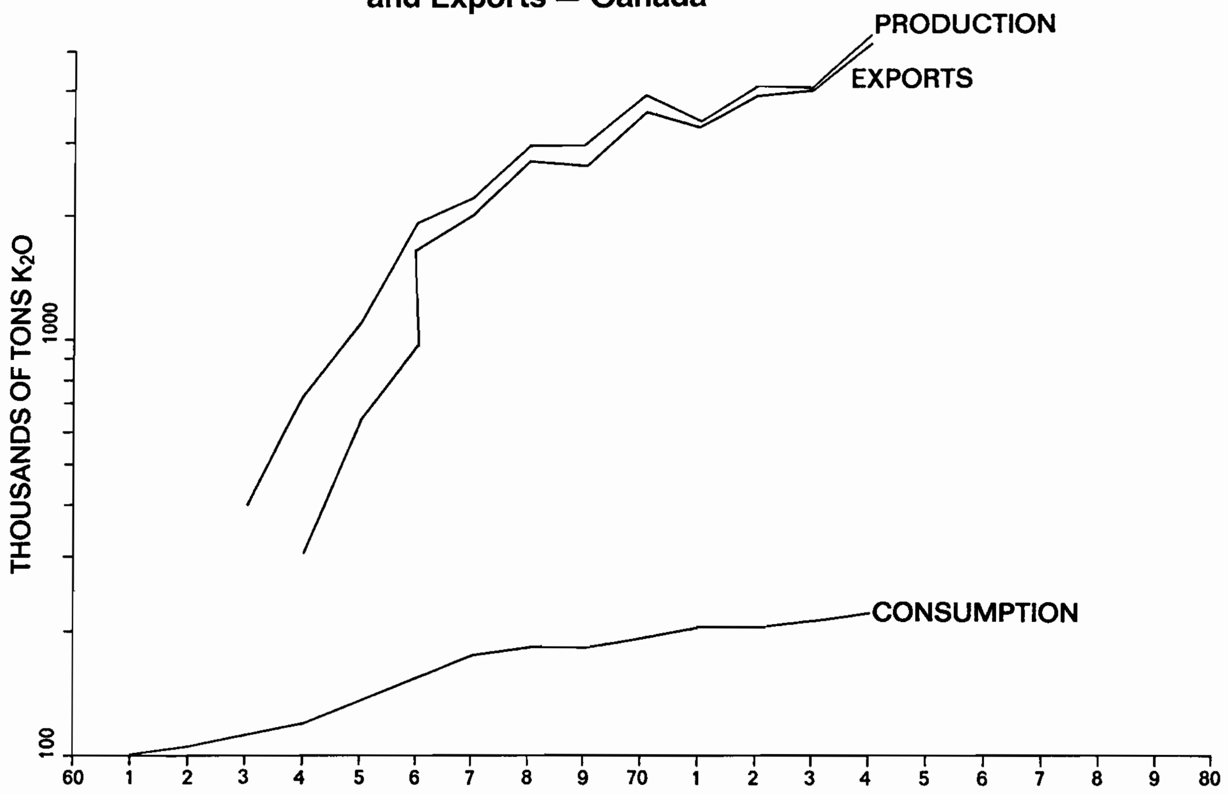
FERTILIZER PHOSPHATE (P_2O_5) CONSUMPTION
EAST AND WESTERN CANADA
FERTILIZER YEAR



6.

Fertilizer Potash (K_2O) Production, Domestic Consumption and Exports — Canada



SUPERPHOSPHATE CAPACITY CANADA — 1975

		ANNUAL CAPACITY 000 TONS/YEAR
I.M.C. — PORT MAITLAND, ONTARIO	(NORMAL & TRIPLE)	200
C.I.L. — BELOEIL, QUEBEC	(NORMAL)	120
NORANDA — ST. LAWRENCE FERT. VALLEYFIELD, QUEBEC	(TRIPLE)	60
		380

SASKATCHEWAN POTASH CAPACITY

	Muriate	K_2O equiv.
	('000 tons/year)	
Allan Potash, ALLAN (U.S. Borax, TGS, Swift)	1,500	913
Alwinsal, LANIGAN (Potacan)	1,000	600
Central Canada, COLONSAY (Noranda/CFI)	1,500	900
Cominco, VADE	1,200	720
Duval, SASKATOON	1,200	730
IMC, ESTERHAZY (IMC/Amax)	4,000	2,330
Kalium, BELLE PLAINE (PPG)	1,500	937
Potash Corp., LAKE PATIENCE (Ideal Basic)	750	460
Sylvite, ROCANVILLE (Hudson Bay Mining)	1,000	600
Total	13,650	8,190

CANADIAN PHOSPHATIC FERTILIZER SHIPMENTS NUTRIENT CONTENT (SHORT TON) 1973/1974 AND 1974/1975

	Canada	U.S.	Offshore	Total
	Thousand of Tons P_2O_5			
1973/1974	486.5	211.3	66.2	764.0
1974/1975	488.4	117.5	75.5	681.4

SOURCE: CANADIAN FERTILIZER INSTITUTE

SASKATCHEWAN POTASH SHIPMENTS NUTRIENT CONTENT Thousand Short Ton (K_2O)

	Canada	U.S.	Offshore	Total
1973/1974	261.9	3,949.0	1,599.3	5,810.2
1974/1975	258.8	3,548.0	1,732.3	5,539.0

MODERATOR SMITH: Gentlemen, are there questions? That was an excellent report. Any questions or is it so clear that perhaps there aren't any? If not, we will move on to the next speaker. Let me say Harold and Jim again that that was a very fine analysis of the production facilities in the market, and it's very useful to have this information presented so nicely.

Going on to our next speaker who is from quite nearby, Mark Evans. Mark is with the Statistical Report Service of the U.S. Department of Agriculture. He is presently responsible for the fertilizer consumption statistics having been in that position for the past two years. Mark is a native of Ohio and has worked in the Ohio and Pennsylvania offices of the SRS prior to moving to Washington. Mark will speak to us on the subject that we are especially interested in hearing in view of the gyrations of the fertilizer market during the past year. His subject is "Analysis of USDA Consumption Report." Mark.

Analysis Of U.S.D.A. Consumption Report

Mark A. Evans

INTRODUCTION

The U.S. Department of Agriculture has had a responsibility for providing statistical information on america's agriculture since its inception more than a hundred years ago. The need for U.S. agricultural statistics was actually recognized nearly two hundred years ago when George Washington collected crop information for English businessmen.

In the early years of the USDA, its statistical responsbility was primarily one of providing farmers information about the supply of agricultural products to help them judge the value of their production. This was limited to estimates on the production of crops and inventories of livestock. As agriculture spread across the continent and farms became more specialized, an increase in dependable but inexpensive estimates and forecasts became necessary. The scope of agricultural estimates has increased with the demands for information by producers, processors, and manufacturers, but the goal has remained steady — to provide reliable marketing information.

Today, the Statistical Reporting Service prepares estimates on some 200 crop, livestock, and related agricultural items and issues some 550 reports a year carrying these data. These items include such things as State and National estimates of acreage, yeild, crop production, inventories of livestock, livestock products, grain stocks, cold storage stocks, prices paid and received by farmers, farm labor and wages, and, of course, fertilizer consumption. The great desire of modern business to anticipate demand and sales is reflected in these many estimates.

The preparation of these estimates is accomplished by 43 State Statistical Offices and our National Office here in Washington, D.C. Nearly all the State Offices additionally provide end-of-season estimates at the county level for major crop and livestock estimates. Many of you dissatisfied with the available county data on fertilizer may find your answers in these offices' county estimates of corn, soybeans, and wheat, for example.

Data Sources

The data sources for the Statistical Reporting Service estimates are rather unique in that the information gathered to prepare the estimates is provided voluntarily by the Nation's farmers and business community. No reporting is mandatory. No compensation is given. The desire for these statistics is reflected in the high rate of voluntary cooperation to mailed inquiries. Other methods of data collection ranging from aerial photography to estimate the raison crop in California to research in satellite data collection procedures are used to improve the accuracy of these estimates, but the bulk of the information is still obtained through mailed surveys or personal interviews.

Requests for increased information on agricultural inputs is the reason SRS is in the fertilizer statistics business today. Although some fertilizer statistics have been available since about 1850, the job did not fall within the USDA until the mid-1930's.

Types of Reports

Today SRS publishes fertilizer statistics in four major types of reports. In fact, one of those reports, the preliminary annual report for the fiscal year just ended, was released at 3:00 PM this past Monday. We will look at this report momentarily.

The three other reports include an annual fertilizer report in May which is an update and provides additional detail to the November preliminary report. This report includes tonnages on additional materials and tonnages by major mixtures, whereas the preliminary report only includes major materials and total mixtures. A report on consumption-by-class follows the May report. This report includes tonnages on bag, bulk, and fluid fertilizers, plus an average analysis for fluid fertilizers.

The fourth type report is the monthly fertilizer report which was first published about three years ago. This report has grown from 14 States to 20 at present. These 20 States account for more than half the total fertilizer consumption.

Preparation of Reports

Fertilizer consumption statistics are compiled from reports returned to us by fertilizer manufacturers, blenders, and other sales outlets and the reports of State

Fertilizer control Officials. I have a slide that presents a graphic explanation of our data collection sources. (Slide No. 1) You will note immediately the information comes from the fertilizer manufacturers, blenders, and sales outlets.

You will also note the information passes through State Fertilizer Control Officials before we receive it. However, we do receive some information directly from industry. You may ask, isn't this dual reporting to two government agencies? You're right, it is, but let me explain why it is necessary. The number one problem is lack of uniformity of the State Fertilizer Control Officials' laws and reports. Many are not timely or lack the completeness and detail that you in the industry have deemed necessary. Therefore, we must supplement the State control data in those States lacking these criteria. Fortunately, about 40 States have adequate details on major mixtures and materials. Unfortunately, few are concerned with adequate coverage of organic and micro-nutrient fertilizers.

We presently survey about 1400 firms in the fertilizer industry in an attempt to present complete and timely data. Again, interest in statistics is reflected in the response rate; over three-fourths have returned their completed inquiries.

The monthly reports issued by SRS are simply a reissue of reports prepared by the Control Officials. Only total levels are presented and no attempt is made to conform all reports to the same definition of mixtures and materials. All other reports standardize the Control Official's tonnages and industry reports to the Uniform Fertilizer Tonnage Reporting System. That is, 18-46-0 is considered as a mixture rather than a material.

You will also note reference to a data base at the bottom of this diagram. Many users of the data were disturbed when State tonnages were presented alphabetically rather than by regions. This was a government-wide directive. Our solution is to include all data published in the reports into a data base system that will allow the data users to combine the tonnages as they prefer. Details are not completely final but you should have access to these tapes within the next year. Other data bases such as State and National crop estimates are being designed and will also be available to the public. County estimates of crops and livestock are also being considered.

Report Highlights

Now, let us look at the content of one of these fertilizer reports. I can only present data that is historic. I cannot attempt to interpret this data to guess what the situation may be in the future. This is outside the realm of the Statistical Reporting Service; however, what has happened is necessary to forecast the future. Forecasting the future is left to you and other economists.

Slide No. 2 — This chart shows the *total consumption* of fertilizer through June 1974. Due to the lead time necessary to prepare these slides, only tonnages through 1974 are included. I will give you the latest tonnages where appropriate.

The annual fertilizer report released this past Monday indicates total consumption during the 1974-75 fertilizer year dropped to 42.5 million tons, 10 percent less than the previous year, 2 percent less than the 1972-73 tonnage, and the first decline in tonnage in more than 15 years. Most of the decrease occurred in mixed fertilizers.

Slide No. 3 — This slide shows the *nutrient consumption* of each of the three primary nutrients and their total. Fifteen years ago, consumption of N, P, and K was nearly equal. Obviously, nitrogen has increased at the fastest rate. Total nutrient tons dropped 9 percent this past year. Nutrient tons of nitrogen dropped 6 percent; phosphate dropped 12 percent, and potash was down 13 percent.

Slide No. 4 — In 1960, *N-P-K percentages of total nutrients* were fairly equal at 37, 34, and 29 percent, respectively. This had changed to 47 percent N, 26 percent P_2O_5, and 27 percent K_2O during the 1974 fertilizer year. The percentages for the year just ended were 49 percent N, 26 percent P_2O_5, and 25 percent K_2O.

Slide No. 5 — This is a chart of plant *nutrient consumption in mixed fertilizers.* P_2O_5 accounts for almost half the nutrients in mixed fertilizers. Also shown is the average analysis of mixed fertilizers. You will note the average analysis has changed from 8-16-13 to 10-18-13 during the past 10 years. The analysis for the year just ended was 10-18-12.

Slide No. 6 — Here we present the *ranking of the major fertilizer mixtures.* The leading mixture for the past 8 years, according to the Uniform Fertilizer Tonnage Reporting System was 18-46-0. As you can see, a dramatic shift of major analyses occured during the mid-1960's. Five-ten-ten tonnage dropped from 1.6 million tons in 1960 to slightly over 0.6 million tons in 1974. Tonnages for the year just ended will be in the May report.

Slide No. 7 — This slide shows the tonnages over the past 15 years for some of today's *major mixtures.*

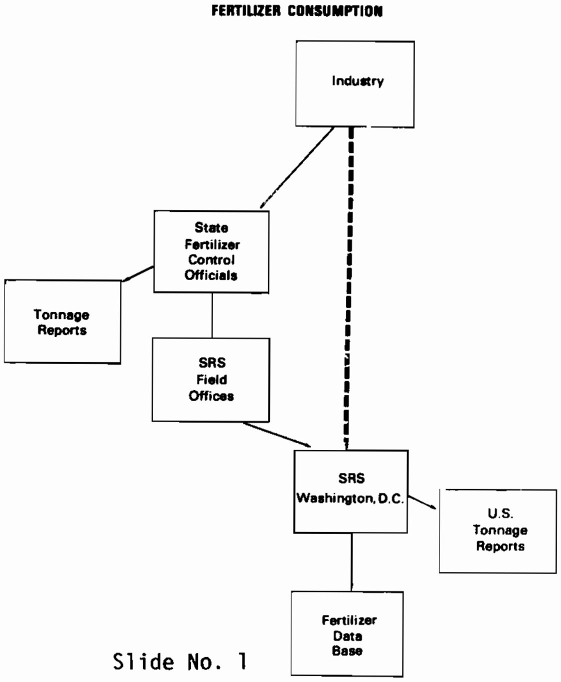
Slide No. 8 — Anhydrous ammonia is the leading *fertilizer material today.* This chart also compares nitrogen solutions, potassium chlorides and superphosphates over 22 percent. The 1974-75 figures not included on this chart are: anhydrous ammonia, 4.0 million tons, down 3 percent; nitrogen solutions, 4.1 million tons, up 1 percent; potassium chloride, 30 million tons, down 8 percent; and superphosphates at 1.2 million tons, up 1 percent.

Slide No. 9 — Later next spring, the *consumption by class* report will show the tonnage of dry bagged, dry bulk, and fluid fertilizers. Here is a line chart showing the tonnages by class for the past 8 years. In recent years, dry bulk fertilizers have increased at a slightly faster rate than fluids.

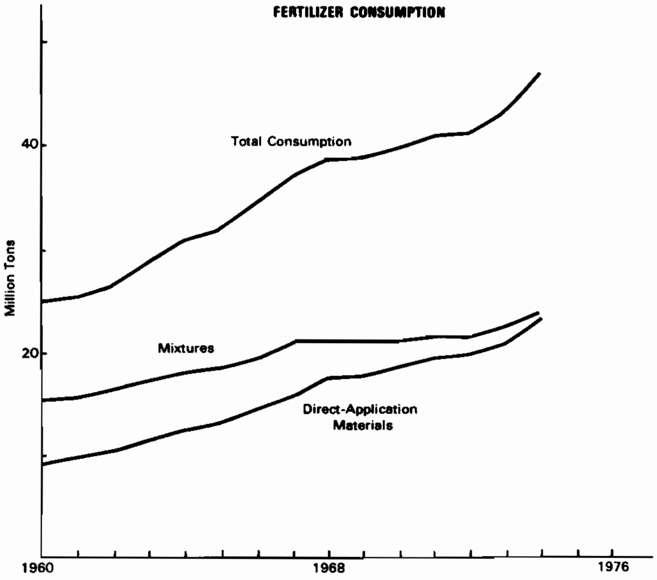
Slide No. 10 — This chart compares the percent of *mixtures consumed by class* to fertilizer materials. Bulk mixtures represented 34 percent of the total in 1967 compared to 52 percent today. Bulk materials have increased from 35 to 44 percent of total materials.

Summary

These slides have presented only a few of the many comparisons that can be made with statistics in these fertilizer reports. As I mentioned before, our agency is not in the business of forecasting fertilizer consumption in the years ahead, but we do have some of the inputs necessary for you and other economists to interpret. A supply of the preliminary report released this past Monday is available here today. If you are not now receiving these free reports or desire to receive other reports on crop production, livestock, or agricultural prices, please give me your name and address or write to us at the address shown on the reports.



Slide No. 1



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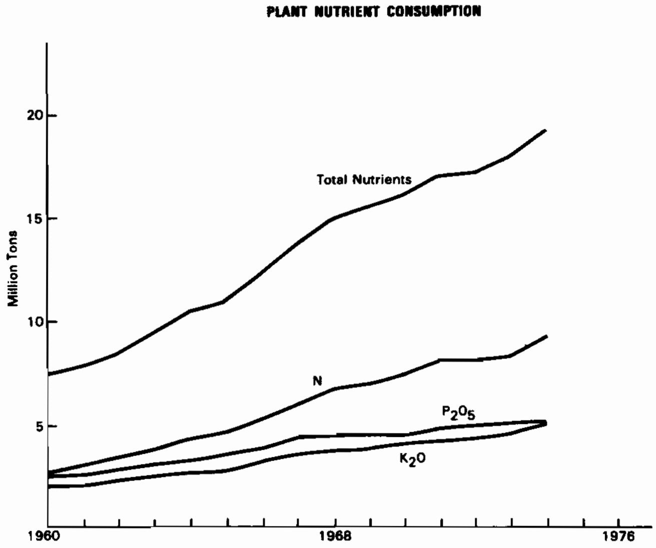

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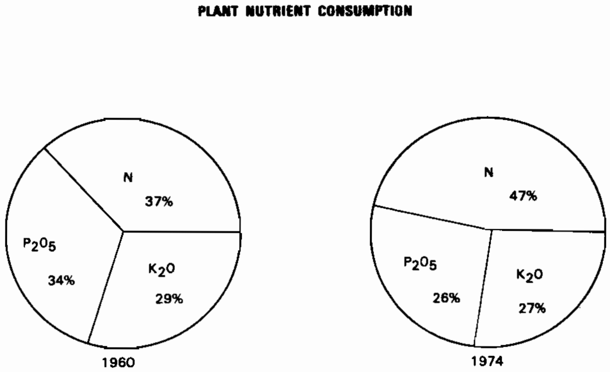

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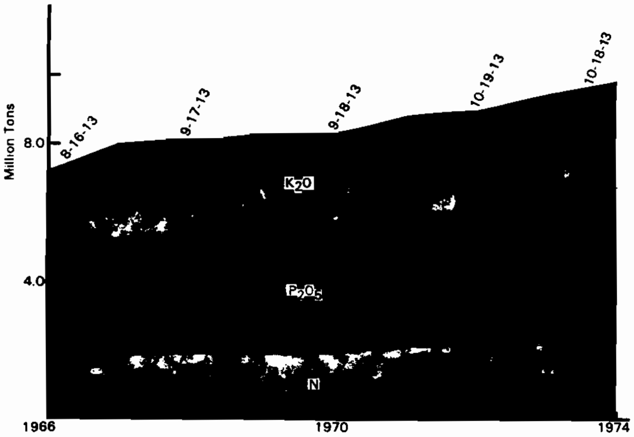
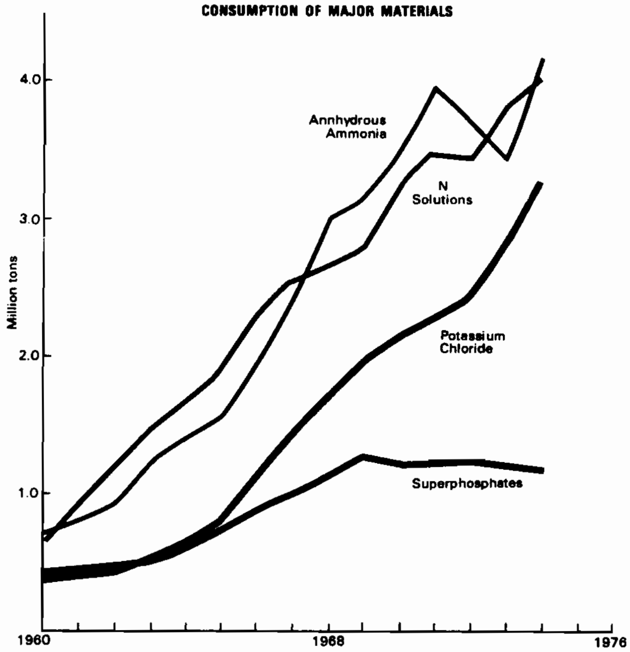
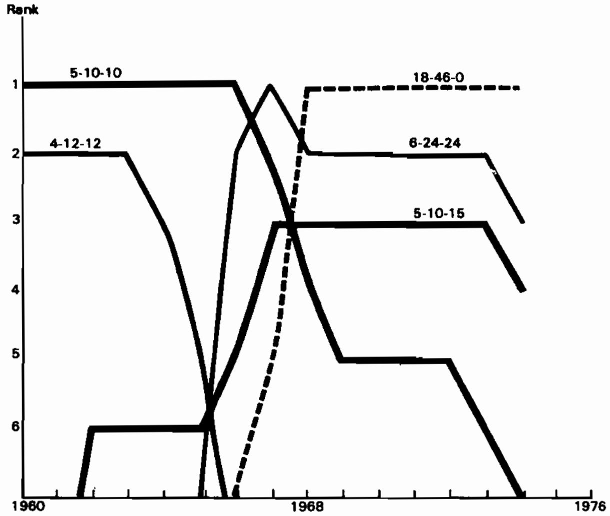

PRIMARY NUTRIENT CONSUMPTION MIXED FERTILIZER

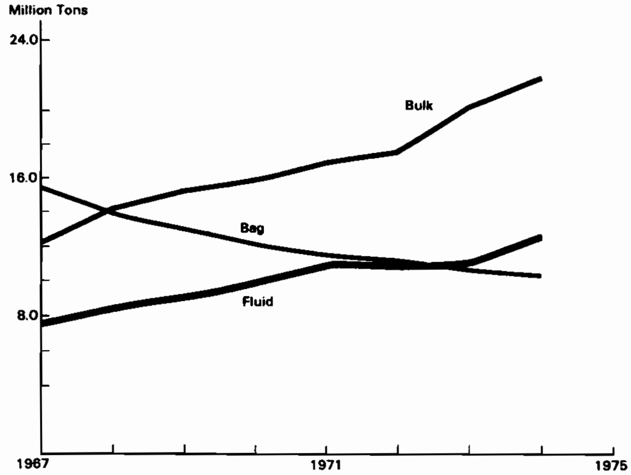
Slide No. 5


CONSUMPTION OF MAJOR MATERIALS

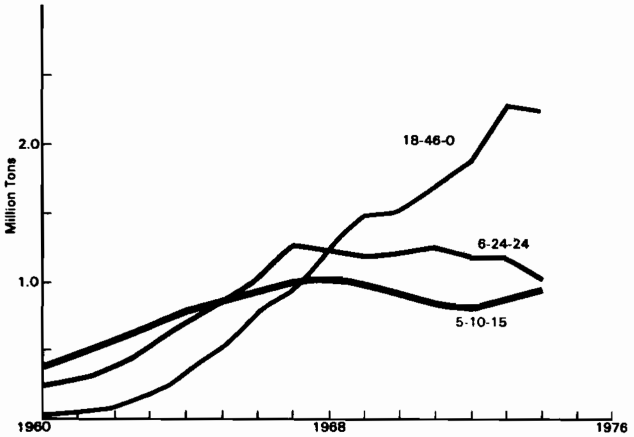
Slide No. 8


RANKING OF MAJOR MIXTURES

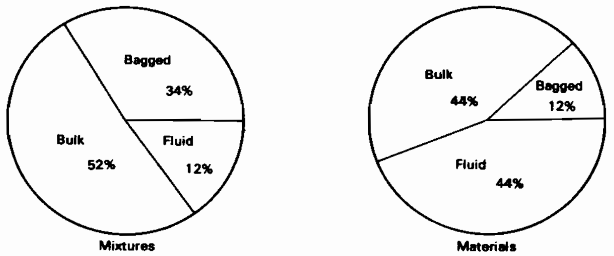
Slide No. 6


CONSUMPTION BY CLASS

Slide No. 9


CONSUMPTION OF PRINCIPAL MIXTURES

Slide No. 7


CONSUMPTION BY CLASS 1974

Slide No. 10

MODERATOR SMITH: Are there questions? Yes.

JOE REYNOLDS: Mark, you mentioned that you have approximately 20 states now participating on the monthly report. Is there anything that could be done to get more states participating?

MR. MARK EVAN'S ANSWER — Well, as you know, the state reports are issued by the state fertilizer control officials, and at the federal level we don't feel that we can apply any pressure to encourage them to publish these reports. There have been numerous groups such as TFI and NASDA that have tried to apply some pressure. If the states wish to initiate monthly reports, we will provide all the help we can to convert them to the uniform tonnage reporting system.

We feel that the pressure has to be applied from you in the industry. We have lost some states in the last year. We have had trouble getting data in from some of the states, and again I would expect some response from the industry is the answer to get these reports more timely. Louisiana discontinued their estimates this past year. I have heard it through the grapevine that if enough people write to them that they might be talked into reissuing their reports.

JOE REYNOLDS: I have a suggestion. I found that in some states if you take this report around that Mark referred to, the monthly report which showed these 20 states how important information is, particularly during the period of shortages we went through a couple of years ago when senators and congressmen were upset some of the states who were absent on there were kind of embarrassed, and they wished that they could get into that program. Maybe as we go around to these various state agencies, we might have a copy of that report that he is referring to that might be of some help.

MODERATOR SMITH: Well, thank you very much, Mark. That was very useful and again well presented.

MODERATOR SMITH: I think we do not all fully understand and appreciate the very major role that C. F. Industries plays in the mining of rock phosphate and the production of concentrated phosphates in the United States.

We are pleased to have General Manager George B. Shearon, CF Industries, to give us an insight into the part of the fertilizer industry that some of us are not that close to but interested in.

George joined CF Industries in January, 1969, with previous experience in engineering, development and production positions with I.M.C. In 1971 he was promoted to the position of Production Superintendent followed by a promotion to Manager — Production in 1972 at the CF Industries Barton, Florida Chemical Complex. In January 1975, he was elevated to the position of General Manager CF Industries, Inc., Plant City Chemical Complex which is his current position.

George received a BCHE degree in 1954 from the University of Florida. After a brief period with Standard Oil of New Jersey, he was called in to the U.S. Air Force and in 1956 received his pilot's Wings.

Wet Grinding And Feeding Of Phosphate Rock Plant City Phosphate Complex

George B. Shearon

I appreciate the opportunity to be able to speak before the Fertilizer Round Table and to present to you some relatively current information regarding our experience with wet rock grinding. Wet rock grinding has been a very much discussed process during the past several years and many claims have been made regarding the advantages of this process over conventional methods of grinding phosphate rock for use in a phosphoric acid plant.

Wet rock grinding is a challenging and relatively new approach to size reduction or grinding of phosphate rock for use in phosphoric acid production. By challenging, I am referring to the fact that with any new innovation, there are problems and difficulties that must be faced during the initial stages of operation and during thed following period when rates are being maximized and the performance optimized.

Wet rock grinding in some form or another has been used in the phosphate rock mining industry for many years. Although wet rock grinding for phosphoric acid plant use has been carried out in the past, I believe that the two Ball Mills at CF Industries' Plant City Complex are the first major installation. At the present time, there is another major installation in operation at Agrico's Faustina Complex. The unit at the Agrico Complex is an open circuit wet grinding mill.

In my discussion today, I will review with you a general description of our enclosed circuit wet rock grinding mill system, provide a summary of the performance information, and discuss some of the problems that we have faced during the initial operating period. I do not plan to provide an economic comparison of dry rock grinding versus wet rock grinding or any detailed economic evaluation of the use of wet rock grinding. However, I will provide general guidelines, regarding some of the performance factors for wet rock grinding that may affect operating costs.

There are two identical wet rock grinding mills installed at the CF Industries' Plant City Complex. Each mill is a Hardinge Koppers 14 ft. diameter, by 24 ft. long bail mill, equipped with a 2500 HP motor. The mills were designed for a capacity of 180 tons per hour of phosphate rock feed providing a product with no greater than 0.5% plus 35 mesh. Wet rock stored in a 400 ton rock feed bin is withdrawn through two discharge spouts into two variable speed belt feeders. each belt feeder discharges rock to a mill feed conveyor. A continuous weigh belt scale measures the rock feed to the mill and control the speed of the variable speed feeder. The original intent was to also weigh the recycle from the wet screening operation, however, this was abandoned prior to the startup of the unit. The grinding mill was designed to operate at a solids content of 68% with the feed rate being controlled by the feed conveyor belt scale and the water content being monitored by a density unit, which in turn, controls the water addition.

The ball mill product discharges into an agitated pump box with the slurry level being controlled by a level indicating controller and a variable speed pump system. This enlarged agitated pump box was a modification made after startup.

Phosphate rock oversize recycle material from the screens, make up water, and the new feed enters the chute to the wet rock grinding mill. The pump tanks at the discharge of the mill are equipped with variable speed Allen-sherman-Hoff rubberlined pumps, model B-11-5 hydroseals. The purpose of the variable speed pump is to supply a constant feed of slurry to the screens. The transfer lines conveying the ground rock to the screens are equipped with density instruments designed to measure the density of the slurry and provide for control of the water make up. Each of the wet grinding mills is equipped with a 6 foot by 12 foot Tyler Ty-Rocket vibrating screen designed to make a 35 mesh separation. There is also a third screen system which can be used as a spare or shared by either one of the mills. The screens are equipped with sprays to allow for washing or repulping of the material on the screens. These sprays were only placed in operation for a short period of time due to the problems with the water balance. The screen underflow flows by gravity to a constant head agitated weigh tank which monitors the density or solids content of the product. The original intent was to have the slurry density at this location provide for control of the screen spray wash water. Overflow from the weigh tanks flows by gravity to a common holding tank which has a surge capacity of approximately 10 minutes. Slurry is pumped from the holding tanks to two agitated slurry tanks located near the phosphoric acid plants. These tanks provide for approximately 4 hours of holding time for the phosphoric acid plants. Slurry is transferred to the phosphoric acid plant using belt driven Allen-Sherman-Hoff model B-11-5 hydroseal rubberlined pumps. ASH pumps are used for the screen feed, to transfer from the mill to the phosphoric acid plant holding tanks, and to transfer from the phosphoric acid plant holding tank to the phosphoric acid plant.

I would like to remind everyone that our system is a closed circuit operation. I believe for wet rock grinding for use in a phosphoric acid plant, that this is the first and only one of its kind. The other wet rock grinding unit, most recently installed at Agrico's Faustina Complex, is an open circuit operation. For comparison and for those of you who would like to do some economics regarding closed circuit versus open circuit grinding, the horsepower requirement for a comparable capacity open circuit grinding mill is approximately 3800 to 4000 horsepower. This compares to the 2500 horsepower required for a closed circuit system. If we use for the cost of power a value of $175.00 per annual horsepower the difference in power cost for the same rock grinding capacity is $225,000 annually for each unit.

There are several distinct advantages for those who use wet rock grinding. Several are obvious and several we have observed during the initial operating period for the various plants.

The most obvious reasons for selecting the wet rock grinding process are:

1. The storage of wet rock in large quantities allows the plant to have a substantial storage of feed material for the phosphoric acid plant in a relatively inexpensive outside storage area. This allows the plant to have the freedom to operate without the possibility of an interruption due to failure in the rock deliveries.
2. Wet rock unloads at an excellent rate. Recently a wet rock unloading crew unloaded 64 cars of rock in a single shift.
3. The wet rock unloading area, storage and wet rock grinding system and phosphoric acid plant feed system are free from dust. This really makes it a nice operation. If you have ever been involved with the handling of dry ground rock, you can really appreciate a wet rock unloading, storage, grinding and feed system.
4. Regarding observations in the phosphoric acid plant, I feel that the gypsum cake that is formed while using wet rock appears to be consistently in a more filterable form. Foaming in the digestion system appears to be of the same magnitude as experienced with dry rock. The frequency of washing the filter and the pipelines is essentially unchanged.
5. I have heard it stated by some that the use of wet rock leads to a substantial increase in the capacity of a plant that had formally used dry rock. At the present time, we are operating our 'A' Phosphoric Acid Plant at a rate of 0.89 — 0.95 tons of P_2O_5 per day per active square foot of filter area. For the 'B' Phosphoric Acid Plant, which has only operated on wet rock, we are currently operating at 0.80 — 0.90 tons P_2O_5 per day per active square foot. Our phosphoric acid plants at the Bartow Plant, which uses dry

ground rock, normally operates up to 0.9 to 1.0 tons of P_2O_5 per day per square foot of active filter area. Quite frequently when we are discussing rates in a phosphoric acid plant, it is necessary to define under what conditions you plan to operate. many times plants operate at lower rates because the operators are unwilling to accept the losses that may occur at higher rates. There may also be other limiting factors. Because of these differences, it is quite difficult to compare rates for different phosphoric acid plants.

6. We feel that the additional cooling, provided by the ground wet rock feeding the digestion system, may lead to a potential 5% to 10% increase in capacity if the plant is not filter limited. In our case, the plant is frequently filter limited. Normally, in the phosphoric acid business it seems that we face a situation the majority of the time where the restriction is filtration and not one of the other factors that could be a problem or a limitation.
7. Recently we had a condition develop where a hole occured in our 'A' Phosphoric Acid Plant digestion tank, a Dorr Oliver Plant built in 1966. It was necessary to drain the digestion system and repair the damage. We were extremely well pleased with the condition of the tank. The quantity of build up was very minor compared to the normal conditions observed when using dry ground rock. This is particularly true in the area where the rock is fed into the digester. This was very encouraging because of the future concern that we have regarding the cleaning of our larger 'B' Phosphoric Acid Plant. This could be quite a sizable job if the build up is extensive. We have not had the opportunity to determine the quantity of build up in the 'B' phosphoric acid plant.
8. Another advantage of wet rock grinding, is that you avoid the requirement of a batch or a continuous dry rock weigh scale which is a source of headaches to every person who has ever been involved in a phosphoric acid plant. However, we have created another headache, the instrumentation required for measuring the density of the wet rock and for metering the wet rock.
9. Finally, wet rock systems eliminate the need for rock handling equipment such as elevators, airslides, and screws that quite frequently make a phosphater's day difficult.

Even though wet rock grinding has many attributes and I think many of these have been discussed at length by the people who are in the business of selling this process, there are some disadvantages to the process, particularly the disadvantages created by the closed circuit system we have at our plant. Possibly our situation may be unique because rock quality has been a significant factor in the performance of our plant. Also our plant was the first of its kind and I am sure improvements will be made in the design of future plants.

Several major problems encountered with our wet rock grinding system are described below:

1. The effect of the clay in the phosphate rock during the startup days was almost disastrous and at times created a very thick slurry, which was not screenable or pumpable. I have been asked at times what level of clay will cause problems with a wet rock grinding system. I feel that any poorly washed pebble rock will provide problems in a wet rock grinding system. If the rock feels quite sticky and clay chips are visable to any extent, it will cause problems in a wet rock grinding operation. Because we currently have a large inventory of rock containing clay, it has been necessary for us to blend in other rocks containing less clay so that we may use all the rock we have in inventory. Presently, we are blending in approximately 30% high clay rock with other rocks. There is a distinct difference in the performance of the wet rock grinding mills when operating with pebble, concentrate, or pebble containing clay. With a heavy clay rock, it is difficult to impossible to screen out the oversize and quite frequently it is difficult or impossible to transfer the rock to the screens or from the slurry tanks to the phosphoric acid plant. A high level of dilution is required to handle a high clay rock. In addition, the clay does not allow for complete dewatering of the screened oversize, resulting in difficulty in controlling the water balance.
2. The use of a phosphate pebble rock containing a low level of clay, or concentrate rock allows for reasonable operation of the ball mill. However, even under the best of conditions, screening of the slurry is still not what you would consider a completely successful operation. There are normally large globules of material being recycled that contain both oversize material and fine material adhering to the coarse rock. It is necessary to operate at a lower solids content in the mill to allow for pumping in addition to passing of slurry through the

screens. We are presently at a standstill as to what is the best approach to provide for improved screening of the slurry. Possibly we could operate at a higher solids content in the mill and add additional water in the pump tank. In order to increase the operating rate of the unit and allow for operating at a higher level of solids content, it has been necessary for us to compromise somewhat on the size of the screen and allow coarser material to be discharged with the mill product. In other words, we have had to open up the screens to increase the solids content in the product from the mill. We also feel that the pumps themselves are somewhat marginal regarding the head available. This has also forced us to operate at a lower solids content.

3. Because of the various conditions of operation, the screened slurry product will run in the range of 3 to 5% plus 35 mesh instead of the 0.5% as planned in the design. Even with a very clean rock, I do not believe our closed circuit mill system could ever approach 0.5% plus 35 mesh in the product.
4. Problems with the slurry pump packing gland and the amount of dilution water caused by the packing gland did create very serious problems in the early days of operation. For those who are not familiar with the ASH hydroseal pump, the pump is not equipped with an expeller. Because of this, the pressure at the seal must be slightly greater, I believe 15 pounds, than the discharge head of the pump. This requires that a booster pump be provided in the seal water system. We have had difficulties where the water leakage through the seals was so great that the booster pump would be at the far end of its performance curve and we would be at a point where the pressure would be less than the discharge head of the slurry pump. This allowed the solids to get into the seal and cause damage to the seal and pump shaft sleeves. This condition continues to be a problem but we feel with experience and with modifications to the packing gland water make up system we will be able to at least bring this problem into a controllable range. We have modified the seal to reduce the quantity of water that can enter to approximately 2.5 GPM by reducing the size of the orifice in the lap ring. We have provided flow indicators, and are experimenting with an orifice that controls the flow of water to a preset quantity. This variable orifice will adjust itself to upstream pressure variations. Shaft wear and impeller damage has also been a problem. The pump average life is approximately 1½ - 2 months based on the impeller wear.
5. Pluggage of the transfer lines has been and continues to be a troublesome problem. Serious blockage can take long periods of time for cleaning and considerable manpower.
6. Regarding the solids concentration from the ball mill, we have been able to maintain a level of approximately 63% to 65% with a minimum of 62%. The design was 68% solids. The percent solids in the slurry at the phosphoric acid plant varies between 61% to 63% with an average of approximately 62%. We experience a 1% - 2% drop in solids content between the rock grinding operation and the phosphoric acid plant caused by the packing gland water required for the rubberlined Allen-Sherman-Hoff pumps.
7. Typical operating conditions are as follows:

	% Solids	**% + 35 M**
Normal rock	**62 — 64**	**4.0**
Very clean rock	**64 — 67**	**3.0**
Concentrate	**66 — 69**	**3.5**
Rock with clay	**59 — 62**	**5.0 — 6.0**

In the phosphoric acid plant, the picture changed quite a bit when the 'A' phosphoric acid plant was converted to wet rock feed. For the 'B' plant, there was no comparison since the plant was designed for wet rock feed and has never operated using dry phosphate rock. The problems encountered in the phosphoric acid plant are as follows:

1. During the initial period of operation, the losses were excessive due to the problems with erratic free acid control and the low solids content of the rock slurry reducing the amount of water available for washing the gypsum cake. Frequently the losses that we experienced during the early period were extremely high and of serious concern. The control of free acid was quite difficult and the water balance was a problem. Some of these problems were due to the erratic rock feed caused by problems with the rock slurry meter. This wet rock slurry meter is designed to actually control the dry rock feed rate to the digestion system. The instrument was designed to adjust the feed rate by integrating rock slurry density and flow measurements.

Complications with the instrument and some of the components, along with the complexity of the instrument have created problems with its reliability. Problems with this unit still have not been completely resolved. Regarding the density instrument at the wet rock grinding unit, we still have an unreliable arrangement. We have been advised by the suppliers of this instrument that the relationship between rock density and the instrument reading varies with the type of rock. In other words, if the plant is using concentrate, the relationship will be different than when feeding pebble or a mixture of pebble and concentrate. Because of this condition, the reliability of this instrument for an accurate reading of solids content is only fair.

2. The high level of plus 35 mesh in the rock slurry, running in the 3% to 5% range, may also be a contributor to the problems of free acid control. High variation in the free acid level causes less than desirable chemical efficiencies. Reviewing the past performance for the 'A' Plant and comparing it to the performance with the wet rock, we find that the losses in the cake due to citrate insoluble losses have increased by at least 2 to 3 times. Citrate soluble losses are approximately the same as experienced prior to the wet rock operation. One of our biggest problems areas has been the water soluble losses. The dilution caused by the lower than design rock slurry solids content reduces the quantity of water available for washing the cake. We are still experiencing filter losses that are above what we would consider satisfactory and above what we experienced with the plant prior to the switch to wet rock grinding. We are concentrating our efforts on these various loss factors.
3. Regarding a general comparison of wet rock and our experience in the past with dry rock, we find that the wet rock phosphoric acid plant is much more sensitive and more difficult to control than what you would experience with a conventional dry rock operation. The variation in chemical efficiencies, from one shift to the next is quite great. Some of this control problem may be due to the quality of the rock that we use in our plant, which normally runs in the 65 to 68 BPL range and more commonly averaging between the 66 and 67 BPL. Unquestionably, the quality of the rock is a factor in performance of any digestion system.
4. Due to the low solids content of the slurry, it has been necessary for us to compensate by the addition of water to the filtration system to insure that we wash the cake, at lwast reasonably well. Because of this, the concentration of the acid that we produce off the phosphoric acid plant will at times drop down to as low as 26% and will range at the 27 to 28% level. If the plant had not been designed and provided with a substantial evaporation capacity, but, had been based strictly on the requirements of 30% and 54% acid for granular slurry TSP and DAP, we may have been in very serious trouble with our evaporation capacity and could have had a serious restriction in this area.

Regarding the other operating items of interest, our experience to date has been as follows:

1. In our budget, we planned 0.5 pounds of balls per ton of product based on the recommendations that were provided to us. So far, we are using 0.4 pounds of balls per ton of product, however, we have not consistently pushed the units to their full horsepower rating during this total operating period due to problems with the motor which prevented us from operating at full horsepower.
2. Regarding the mill liners, a recent inspection by the Koppers people indicated to us that there was minimum wear and the stimated life of the mill liner was two years. We feel that it is necessary for us to keep a close watch on both the ball usage and the liner life.
3. Another area where we feel we could improve the overall operation is to provide for more surge capacity of rock between the grinding mills and the phosphoric acid plants. I believe that as time goes by, there will be periods when additional ground rock inventory will be of great value during periods of sudden or lengthy shutdowns for the rock grinding mills.

We have a long way to go in the learning process of how to really make the best use of our wet rock grinding unit and on how to optimize the operation of both the wet grinding unit and the phosphoric acid plant. This, we understand and we are working toward solutions to the various problems we have discussed. I have heard that the Agrico Plant, with its open circuit operation, is having more success than we have had with our mill maintaining a high level of solids content and also in doing a better job of controlling the plus 35 mesh. This may be one of the advantages to the open mill operation. On the other hand, it is conceivable that the quality of rock that they are receiving is somewhat superior compared to the rock received at our plant. Possibly, some time in the future a paper could be presented by an Agrico representative reporting the benefits of the open circuit type of wet grinding operation.

I sincerely appreciate this opportunity to present this side of the wet rock grinding picture.

MODERATOR SMITH: Are there questions on this subject? Yes, sir, I see a hand.

QUESTION: If you had it to do all over again, would you do it?

MR. GEORGE SHEARON'S ANSWER: That's a rather hard question to answer right at the moment because I think you would have to look at a lot of other factors. I couldn't answer it right at the moment.

MODERATOR SMITH: Did I see another hand back there?

QUESTION: Are you highly content with all your variable speed pumps metering your ground rock feeding to the digestion system?

MR. GEORGE SHEARON'S ANSWER: The metering of the rock to the digestion system is not the variable speed pump system. The viriable speed pump is used for controlling the flow of rock to the screens for the grinding mill, to prevent surges. We have to rely upon the rock density instrument feed system to meter the rock to the digestion system. Poor operation of this unit causes process problems.

MODERATOR SMITH: I think I see a hand over here. Yes.

QUESTION: What did you say you did to the wet rock between the mill and the phosphoric acid plant? Is it agitated?

MR. GEORGE SHEARON'S ANSWER: Yes, it is agitated. All the ground rock storage has to be agitated.

MODERATOR SMITH: Yes.

QUESTION: If you had to ship rock a long distance, would you consider wet rock grinding a feasible operation?

MR. GEORGE SHEARON'S ANSWER: I think basically, with all the advantages of wet rock, I would not see any reason why it would not be a good selection. I think that what you have to do is to understand its limitations and to compensate for them in the initial design of the plant. And one of them, in our case, is the water balance situation and the quality of the rock.

MODERATOR SMITH: Wouldn't the freight cost of the water kill that approach?

MR. GEORGE SHEARON'S ANSWER: The water content for the wet rock ranges from about 8 to 14% in the unground wet rock. I think much rock is shipped out in a wet rock state. I really don't know the economics of it, but the percent moisture in the wet rock does vary considerably.

MODERATOR SMITH: Yes.

QUESTION: If you have a four hour storage of the slurry in your phosphoric tank, when the mill stops grinding, is the solids concentration the same during the four hours you use it up? In other words, is your agitation completely uniform?

MR. GEORGE SHEARON'S ANSWER: As far as I know, the agitation does a pretty good job. this is one reason the tanks are not too big. I think that if you start getting away from this size tank you would probably have more troubles. I have not heard any serious complaints about solids variations with the exception of periods of time when we get the level of the tank too far down and below the impeller of the agitator. We run into trouble here. We've had to maintain a minimum level in the tank to avoid that situation.

QUESTION: What is your loss — wet grinding vs. dry grinding?

MR. GEORGE SHEARON'S ANSWER: We do not have any methods to compare dry rock grinding and wet rock because all we've done in our experiences is related to wet rock grinding. All the other rock that we've purchased has been dry ground rock. But I would think that your recovery of rock would be very good because you don't have any significant losses.

QUESTION: What is the quality of water used?

MR. GEORGE SHEARON'S ANSWER: The quality of water that is used in wet rock grinding is well water. We do not use pond water. That would be a challenging experience, I think.

MODERATOR SMITH: Thank you, George.

That proved to be an extremely interesting subject obviously from the number of questions and discussion and so on.

MODERATOR SMITH: Now we come to another very important and useful subject, the subject of shrinkage. I can recall participating on an industry task force to study the subject perhaps some 20 years ago. The conclusion at that time was that the cost of shrinkage was greater than the combined profit of the fertilizer industry. I hope that doesn't prove true today. Since then pollution standards, scale improvements, training of personnel have hopefully reduced shrinkage. However, it still is a very significant operating cost in any method of mixed fertilizer production.

We all welcome this panel. I might ask at this time that the three panelists come forward as I give some background on them.

First there is Louie Ingram who is a native of Memphis, Tennessee and graduated from the University of Tennessee in Knoxville in 1957 with a degree in chemical engineering. He was employed by the Grace organization upon graduation from the University of Tennessee at the Memphis plant which produces urea and ammonia, was in the Technical Services Department associated with the Grace slurry mix program in the mid-West from 1964-66, joined the mixed fertilizer group in Baltimore in November of 1966 and was transferred to Memphis in 1968. His present responsibilities involve most phases of the operation and engineering aspects of Grace's granular fluid and blend mix fertilizer plants.

Next is Al Malone who is with Agway. He is presently Production Engineering Manager for the Fertilizer Chemical Division of Agway. He is responsible for the engineering and all phases of production operation including also fertilizer formulations, process, environmental standards and controls. It gives me a special pleasure to introduce Al Malone since he works at some of the plants that I did when I was with one of the parent organizations of present Agway.

And Dick Tayloe. Dick has been an active member of the fertilizer industry for a number of years. He started with Davison Chemical at Baltimore in superphosphate production. As Jack Turbeville recalled for us yesterday, this is where the U.S. fertilizer industry began. He worked for National Potash Company for five years before they contracted their tonnage to CF Industries. For a number of years he has been with the Smith-Douglass Division of Borden at Norfolk responsible for formulation and other key activities in their fertilizer operations as Assistant Production Manager.

It is a pleasure to welcome these three very experienced and capable members of the fertilizer industry here to this panel, and I will let them take it from here. Who is going to take it from here? I want to remind before we get into it here that this is a panel and the success of it no doubt will be the degree of questions which you offer. So please don't be bashful with questions.

Shrinkage Panel Discussion

Louis E. Ingram

Al V. Malone

Robert Tayloe

OPENING REMARKS: LOUIS INGRAM: This afternoon I will present to you some of the shrinkage factors and methods that W. R. Grace applies in its mixed fertilizer plants. Considerable experience has been obtained over the years in the operation of nine granular mixed fertilizer plants, five large blend plants and five fluid mixed fertilizer plants. annual shipments from the granular mixed fertilizer plants vary from 20,000 tons per year to almost 100,000 tons per year. Shipments of fluid mixed fertilizer from the five plants vary from 4,500 tons per year to 30,000 tons per year. Shrinkage factors that I will present on bulk blends have been applied to plants that produce and ship in excess of 120,000 tons per year.

But first I feel that I must define shrinkage. For the purposes of thiss presentation shrinkage will be defined as the loss of raw materials or product from the time it is received at the plant site until it is shipped out of the gate. There are many factors that enter into actual shrinkage such as product quality, analysis of raw materials, accuracy of bag weights, weights of bulk trucks, etc. All of these factors must be considered in a plant operation and do effect actual shrinkage. Time will not permit a discussion of this magnitude as we could talk for days and barely scratch the surface of this subject.

This afternoon I will present the shrinkage factors that we have used in our plant operation and very briefly our methods of evaluating these factors. These factors will be what we use in our accounting system to account for our production.

W.R. Grace has used two methods of shrinkage or product accountability as we call it in the past several years. We changed our methods of product accountability on January 1, 1975. First, I will present the old method. Prior to that time we had used a shrink factor on products made in the plant and a dollar reserve factor generated on shipments our of the plant.

No shrinkage was applied to materials received. A 2% shrinkage factor was applied to all granular mixed fertilizer produced, that is, 98 tons were put on the book for every 100 tons produced. A 1½% dollar reserve was taken on the bulk value of all granular mixed fertilizer shipped from the plant. This gives a total shrinkage plus reserve of 3½% on plant thruput of granular mixed fertilizer. Blends and fluids were treated somewhat differently. No shrinkage was taken on receipts nor on production. However, a 1% dollar reserve based on the bulk value of the product was generated on shipments from the plant.

The product accountability method was changed at the end of 1974. There are several reasons for this change; one being that our management decided that no reserve should be generated. The present method of product accountability is as follows:

1. A 1/2% shrinkage of all raw materials with two exceptions, phos acid is 3% and material received in bags will receive no shrinkage.
2. Shrinkage is built into the formulation of granular mixed fertilizer and can vary with each raw material.
3. All products are shrunk 1/2% at time of shipment with two exceptions.
    a. All fluids and liquids and material received in bags and shipped in bags receives zero shrinkage.

We have evaluated the actual shrinkage of our major raw materials over the past several years and applied general loss to the actual formulas for granular mixed fertilizers. As an example let's assume that a given grade of granular mixed fertilizer required 100 pounds of anhydrous ammonia and the present shrinkage factor of ammonia in the formula is 2%. We would actually add 102 pounds of ammonia to the grade as it is being produced. Offhand this sounds like it may increase actual losses due to over ammoniation. However, investigation of formulations has shown that this over formulation with the various shrink factors is very small and has had no effect on actual ammoniation rates or losses. The net effect of the present formulation method is that we actually produce more tons than we actually book to inventory.

The present method of product accountability for fluids and blends is somewhat different for fluid mixed fertilizers and blend mixed fertilizers. I will present each of these individually:

1. *Fluid Mixed Fertilizers*
   a. One-half percent (1/2%) shrink factor applied to all incoming raw materials except for phos acid which is 3%.
   b. No shrinkage on production.
   c. Product Accountability system allows no shrinkage of liquids shipped.
   d. Net effect — 1/2% to 1% overall shrinkage depending upon the amount of phos acid received. Overages should show up in raw materials at time of inventory.
2. *Blend Mixed Fertilizers*
   a. One-Half per cent (1/2%) shrink factor applied to raw materials as received.
   b. An additional 1/2% shrink of raw materials applied as blend is produced and shipped.
   c. Net effect — 1% shrinkage of raw materials.

I have presented the two methods of product accountability that Grace has used. I feel that both of these methods are practical as are many other methods. However, there must be an constant evaluation of any method of shrinkage or as we call it, product accountability. Everyone is aware of the problems that plant shortages can create; however, in my opinion, a large overage at inventory time is just as bad as a shortage from a plant operations standpoint. We essentially evaluate the factors used in our product accountability annually. Detailed inventories are taken twice a year, usually at tht end of the spring season and just prior to the end of the year. Bulk piles of fertilizer are shaped to definite geometric forms which are measured and the total volume calculated. From the total volume and densities that are determined in the inventory process, total tonnage of the bulk piles can be calculated. Actual overages and shortages of all raw materials and products are then determined by comparing book values with actual inventory tonnage.

Table 1

1975 FORMULATION SHRINK
EASTERN REGION GRANULATION PLANTS

Material	%Shrink
Ammonia	2
440 Solution	1
Durona Solution	2
A/S	1
18-46-0	1
Granular Triple	1
ROP Triple	3
Phosphate Rock	2
ROP Superphosphate	3
Phosphate Acid	1
Sulfate of Potash	3
Muriate of Potash	1
Sulfuric Acid	1
13-0-44	3
15-0-14	3
All Others	2

OPENING REMARKS: Al V. Malone.

Shrinkage In Agway Fertilizer Plants.

Agway Inc. is a farm supply and food marketing cooperative owned by 117,000 member-stockholders. It serves agriculture in 12 Northeastern states and has it headquarters in Syracuse, New York. Its Fertilizer-Chemical Division manufactures and distributes fertilizers in Delaware, Maryland, New Jersey, New York, Pennsylvania and the New England States.

Shrink is an old and familiar foe to Agway's Fertilizer operations. It is a notable part of the production cost accounting system. We battle Mr. Shrink daily. We don't know if our strategies will win the field but we believe we are gaining some ground. We will show you some of our actual shrink data but before that, we want to present briefly our tactics for combatting Mr. Shrink.

As a result of the efforts of many in shrink control within our Division we developed *(Slide 1)* a "Program for Management of Shrink". This program is incorporated in an operational manual and it is based on the concept that to have shrink control you must have control of all areas of operation which affect the total efficiency of the plant.

(Slide 2) Here is the INDEX of our "Shrink Management Manual". The core of the program is an operating check list which includes all items that can influence plant food losses. Included in the manual is the reasoning for and discussion of each item on the check list. This is important to the training of supervisors and operating personnel in the techniques of shrink management. We will not attempt to discuss the items

on this index, but you will note that most areas of operation in a granulation plant are listed. Our blend plant managers are supervised by the granulation plant managers, and similar principles of shrink management are applied at the blend plants.

In the manual, we also attempt to get attention and put emphasis on Mr. Shrink by a little bit of caricaturing as we illustrate with these slides. *(Slides 3, 4, 5)*

So, how do we treat Mr. Shrink? Following, we will show in Tables I, II, and III actual shrink data from our fertilizer plants for the three most recent fiscal years of operation. Our fiscal year begins in July 1.

(Slide 6) Table I shows the average shrink in terms of dollars per ton of mixed fertilizer manufactured for ten granulation plants. *These values are determined by comparing input raw materials and plant manufacturing costs per ton against the manufactured cost of tons shipped, and the product and raw materials inventories.* Cost accounting is based on standard formulations and manufacturing costs for each mixed product. A shrink reserve is established by charging three percent of the raw materials costs to the standard cost of each mixed product. The trend of increasing fertilizer costs is evident in this shrink history.

(Slide 7) Table II shows for the same ten granulation plants their average annual shrinks in terms of percent of the cost of raw materials consumed in production. These percentages would be lower if other manufacturing costs were included. However, as a measurement of plant performance, we find this approach to be adequate and production supervision can quickly extract this data from the computer printouts of operating statements. These plants vary widely in respect to types and quantities of products manufactured. Some produce home and garden fertilizers in addition to farm grades. Also, the bulk-bag ratio varies significantly. We know that these variables can and do effect our degree of shrink, but definition is difficult on a quantitative basis. Processing systems are essentially the same in these plants. The results shown for plant number 6 deserve some comment here. We feel this plant does have a good shrink record, but the gain indicated for the past two years is not truly representative. During this period, this plant was on a scheduled program of bins repair and reconstruction and significant quantities of fertilizer were reclaimed from previously inaccessible areas.

(Slide 8) Table III shows the shrink for our blend plants in terms of dollars of raw materials per ton of product shipped. All of these plants are bulk operations. There is no bagging. Results are arithmetic averages of the number of plants noted.

(Slide 9) This is how we have treated Mr. Shrink for the past three fiscal years. Gentlemen we believe we can get a better wrestling hold on this guy and like the steer we intend to keep trying.

PROGRAM FOR MANAGEMENT OF SHRINK

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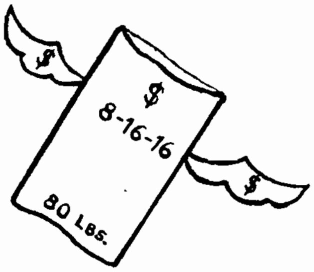
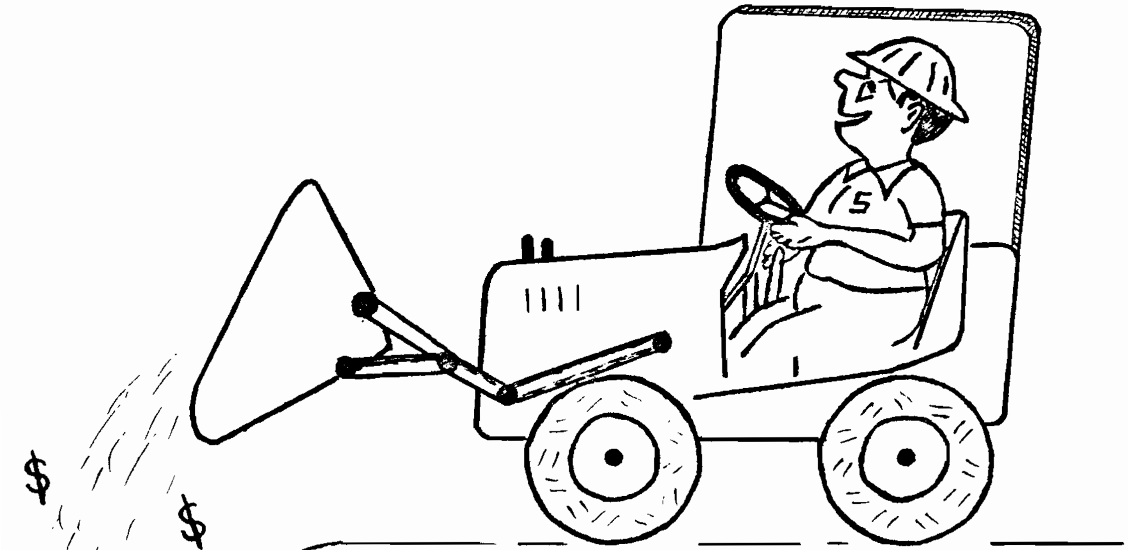
(continued on page 173)

"MR. SHRINK"

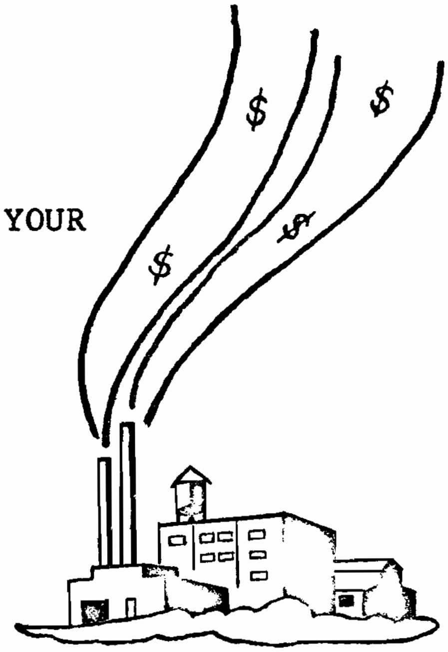
DOES HE RIDE YOUR PAYLOADER?

DOES HE SIT AT YOUR BAGGER?



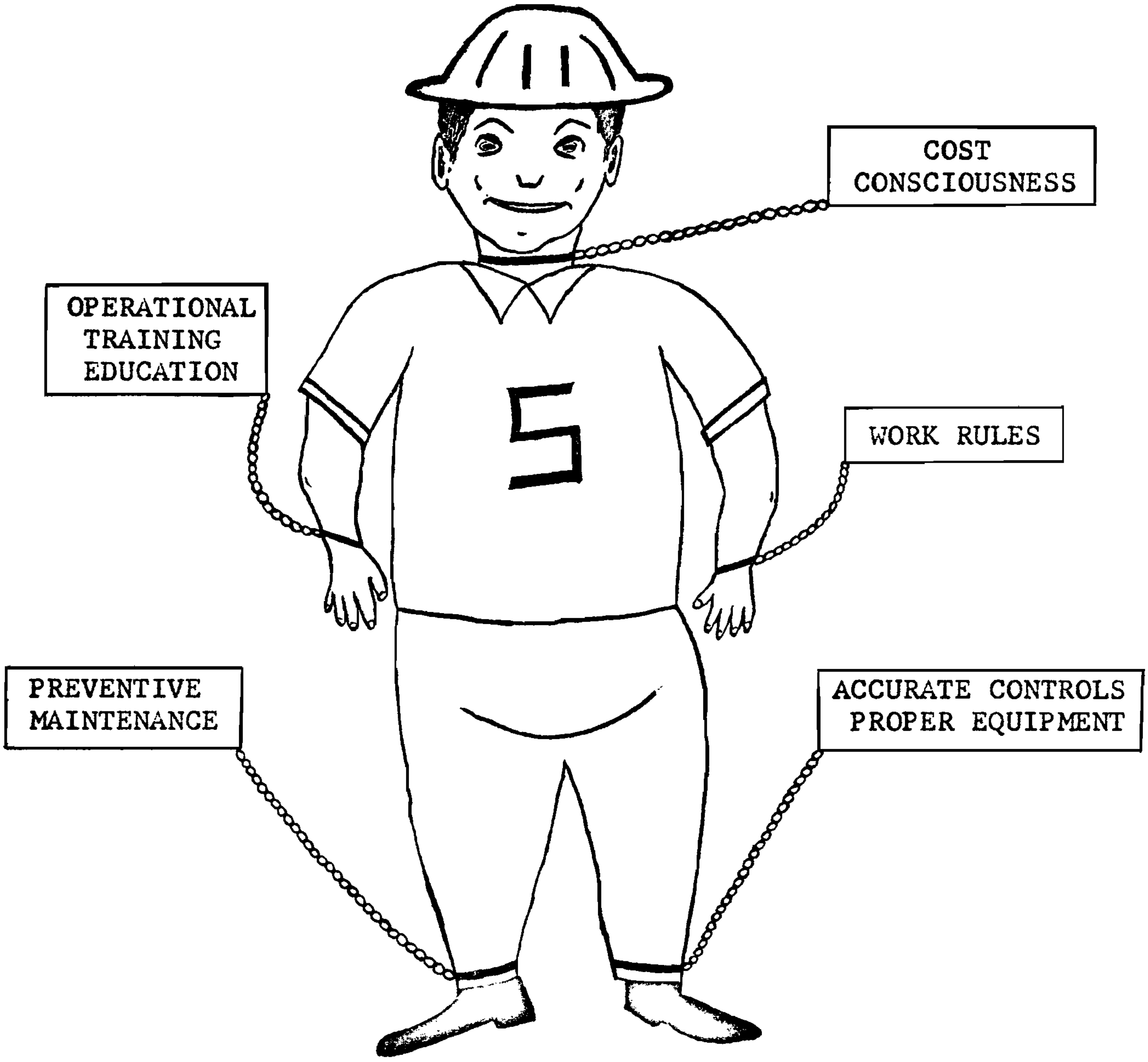


IS HE TURNING THE VALVES IN YOUR PROCESS?



HOW WELL ARE YOU ACQUAINTED WITH THE IRASCIBLE AND INTREPID MR. SHRINK?

HOW YOU CONTROL "MR. SHRINK"



MAY MEAN THE DIFFERENCE

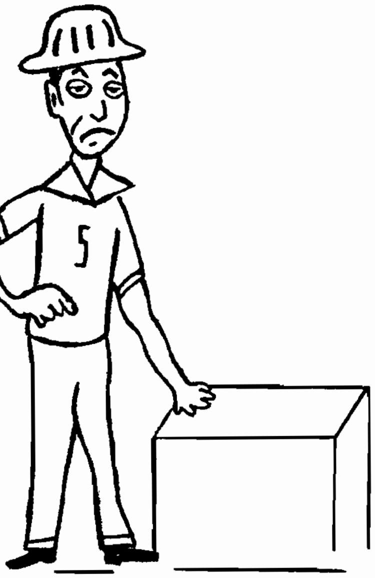
BETWEEN $0.70 & $4.36 AS

SAVINGS PER TON OF FERTILIZER AT YOUR PLANT

SO

HOW DO YOU TREAT "MR. SHRINK"?

KEEP HIM SKINNY?

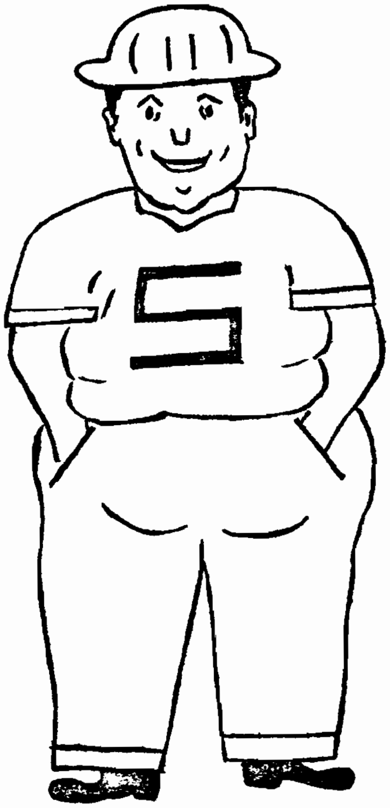


Plant Food
Losses

$0.70 Per
Ton Product

OR

SET THE
BIG TABLE?



Plant Food
Losses

$4.36 Per
Ton Product

TABLE I

SHRINK FOR GRANULATION PLANTS

PLANT NO.	$ PER TON MANUFACTURED 1972-73	1973-74	1974-75
1	2.57	1.47	3.81
2	0.50	0.41	1.31
3	1.39	0.56	2.94
4	2.02	0.97	2.01
5	0.80	0.99	1.97
6	0.78	(0.11)	(0.21)
7	0.55	1.22	0.78
8	1.78	0.82	1.41
9	1.70	2.03	2.41
10	1.15	0.79	1.71
WEIGHTED AVERAGES	1.39	0.92	1.87

ANNUAL TONNAGE PER PLANT VARIED FROM 22,000 TO 65,000

TABLE II

SHRINK FOR GRANULATION PLANTS

PLANT NO.	% OF VALUE OF RAW MATERIALS INPUT 1972-73	 1973-74	 1974-75
1	6.6	2.5	3.7
2	0.9	0.7	1.2
3	2.1	0.7	2.0
4	3.7	1.7	1.7
5	1.4	1.8	2.0
6	1.5	(0.2)	(0.2)
7	1.3	2.4	0.9
8	3.7	1.4	1.4
9	3.7	4.2	2.6
10	2.4	1.5	1.9
AVERAGE	2.7	1.7	1.7

TABLE III

SHRINK FOR BLEND PLANTS

FISCAL YEAR	1972-73	1973-74	1974-75
NO. OF PLANTS	33	37	40
$/TON SHIPPED (RAW MATERIALS COSTS)	0.25	0.30	0.36

PLANT THRU-PUTS HAVE VARIED FROM 1500 TO 6300 TONS/YEAR.

OPENING REMARKS: R. D. Tayloe.

Shrinkage, the loss of plant food brought into the factory versus that shipped out, is a real problem. If the overall shrink from source to field is 3%, we are talking about something like 600,000 tons of fertilizer. This is enough fertilizer for the whole state of South Carolina, or Virginia, or California.

Note that I am not talking about overformulation to ensure meeting guarantees. This too is a loss or rather a reduction in plant food efficiency, but this is built into the formula and picked up on the batch sheet. I am talking about the materials that come into your plant and apparently never go out, the handling loss.

Our approach to allowing for shrinkage is tied to the batching step in the production of either granular fertilizer or blends. On the premise that the use of materials to make a hundred tons of product will not result in the shipment of a hundred tons of product, we take our batch count of materials used and reduce the production we should get from these materials by 3%. In some cases this figure will vary, but the general practice is 3%.

To off-set this, the material cost in a standard cost is inflated by 3%. This inflated material cost plus the factory cost and container cost, if any, is the fertilizer cost transferred to the Sales side of the house.

About five years ago, it began to penetrate our minds that we were leaving out part of the picture. The batching weight, we feel, is the most accurate measure we have of the raw materials on their way from the back door to the front door, and the 3% takes care of losses after that batching weight, but it also follows that a fifty ton car of potash coming into the plant will not show up as fifty tons going through the batching hopper, after unloading, storage and in-plant handling. At that time, with some thought and consultation, a shrinkage factor was developed by which reported usage is increased to reduce inventories and account for these handling losses of incoming raw materials.

The easy way to go at this is to shrink receipts, but because we are computer oriented and operated, there are problems in this approach. If the branch reduced the raw material by the appropriate factor, and reported a reduced receipt, our computer would look at what the supplier sold us and what we received and make noises because the two did not agree. It probably would bill the vendor for the difference.

A figure that does not get into Accounts Payable, and other such records, is the usage report from the branch. We, therefore, built into our computer updating procedure an increase in usage by this shrinkage factor. The net effect of this, and the production shrinkage mentioned previously, is that the branch will report the use of material to make one hundred tons of fertilizer. They will report the production of ninety-seven tons of product. The computer will tack on one or two percent to their reported usage and relieve the raw material inventory accordingly.

To keep the dollars straight on this raw material shrinkage we put into the product standard cost material cost inflated by the amount of the shrinkage factor. Carrying the figures across the board, we say it takes one hundred and one tons of potash coming into the plant to put a hundred tons through the batch hopper and this, in turn, will put ninety-seven tons in the product leaving the plant. The price at which the ninety-seven tons is transferred to Sales is inflated to account for the one hundred and one tons coming into the plant initially.

These shrinkage factors vary from ½ of 1% to 2%, with anhydrous ammonia being an exception at 5%. We figure that items like sulphuric acid or phosphoric acid would have little loss and plug them in at ½ of 1%. Superphosphate, potash, ammonium sulphate and most solid materials are set at 1% shrinkage. A few items, and this includes manufacturing solution, triple super both granular and ROP, and 18-46-0 are set at 2%. I am not sure, from this distance in time, why we set superphosphate at 1% and ROP triple at 2%. The figures were a judgment decision and we have made very few changes since they were initially established. These shrinkages are also applied when materials are sold as such, with a usage being automatically reported by computer.

At one plant, we have a deplorable method of handling inbound potash. The storage are is a good ways from the manufacturing unit and we haul the material across the yard, including a railroad crossing, and the losses are obvious. At this branch, the shrinkage factor has been increased from 1% to 2% to match this obviously abnormal loss.

In discussing these various shrinkages with our operating people, the feedback is they do a pretty good job of accounting for the shrinkages which occur. These are checked by frequent physical inventories which are used to monitor the data process developed book inventory. A closer central control might well develop changes in some of these factors, but I feel that the cost of closer monitoring might well offset the advantage gained, and the necessity for the unpleasant accounting procedure known as an inventory "write-off" is held to a reasonable minimum by the factors we are now using.

Adjustments, either up or down, flag problems such as faulty metering equipment, reporting errors or other abnormalities and our inventory control checking can be concentrated in these areas. To borrow a figure from radio astronomy, this separates the background noise of what we accept, reluctantly, as normal shrinkage from the true signal that here is a problem.

Reduction of this normal shrinkage is often a major engineering problem rather than an error somewhere between receipt and shipment, an error in handling or record keeping. The occurrence of repeated inventory discrepancies signals a serious problem and calls for an in-depth study to find the cause. We've had them all, from rather obscure mechanical problems such as a scale binding in part of its range or an incorrectly assembled flowmeter, through accounting — the keypunch operator was consistently misplacing a decimal — to simple stealing by not recording shipments.

Correcting such abnormal shrinkages, real or apparent, is generally a one-shot operation. Reducing the normal shrinkages is a never-ending process of maintaining and improving equipment and operating methods.

MODERATOR SMITH: Thank you. It's obvious from the remarks of these three experts shrinkage is still a factor in mixed fertilizer life. It's still a very substantial dollar factor.

You have heard the statements from these three people. It is most appropriate now that we get contributions from all of you out there and more questions of our three panelists. Who has the first one or first comment? Yes, isr.

QUESTION: I have a question for Mr. Ingram. I believe he mentioned pushing materials into geometric piles and then determining their bulk density. No problem on the geometric pile, but how are you determining the bulk density of say something like each box?

MR. LOUIS INGRAN'S ANSWER: We determine the bulk density of each raw material and each product twice a year at our inventory time. We have a one cubic foot box that is constructed, and this is at each plant location. We determine three densities — what we call a light, medium and a heavy density.

On our light density we fill the box up, strike it off level, determine the gross tare and the net weight. That is the light weight.

On the medium weight we fill the box halfway up, strike the corners four times, fill it all the way up, strike it four more times, level it off and get the net weight.

Then we determine the third density, the heavy weight. This box is filled while continuously rocking it and striking it on the floor.

You can get a wide variety of densities from our low to our high. In a normal plant we average all three. Now the problem I feel is not in determining the density in this manner but getting a good representative sample from which you can determine the density.

MODERATOR SMITH: Who's next? Yes, in the back.

QUESTION: I just wanted to ask in your granulation plant where is the greatest source of shrink?

Who wants to tackle that?

AL MALONE'S ANSWER: I'll give it a try. I'm not sure that we know. I indicated that it's quite difficult to arrive at a quantitative analysis of each one of these areas in the plant. But it's a materials handling game all the way in these type operations; and one of the large areas we know is just all the handling points where materials are spilled, where there are accumulations and dust and everything where you have to clean it up, recover and reuse it. That's one area where you can't recover at 100% of value. Also there is analysis of raw materials. It is difficult to use them at the optimum or the maximum input values of the raw materials with the great variability that we have in some of our raw materials supplies and particularly some of the by-products.

MODERATOR SMITH: Correctly or incorrectly, I just assumed that the major source of error was in the batching weigh hopper and in the slight overage put in each bag of bagged fertilizer which multiplied by 25 can get to be a factor. Now that there's much less percentage of bagged goods hopefully that should be minimized, but there are many other sources of loss, of course.

Who is next? Yes, Dudley George.

DUDLEY GEORGE: Has there been any study of railroad weights on incoming materials and the actual weight?

MODERATOR SMITH: Can anybody comment on that either from up here or in the audience. Louie.

LOUIS INGRAM'S ANSWER: I think it's the general consensus of all three of us that we are not doing it. Personally I will state that with the situation the railroads are in right now we are happy to get our raw materials, period. We have done quite a bit of this in the past, and I just had a meeting with a group of our people to start doing this again. We met yesterday on this. We have extreme difficulty in doing this due to the poor service of the railroads.

ANSWER FROM THE AUDIENCE: Mitch White from Hawkeye Chemical in Clinton, Iowa. On specific cases of inbound urea I have checked our weight against the railroad's and generally our weight would be a bit higher, and it wouldn't be a problem. But generally they pretty well agree.

MODERATOR SMITH: I think we all recognize that with railroad scales they they just don't get down to a few pounds. There's got to be a few hundred pounds probable difference from the actual, but hopefully it varies up and down and neither party is consistently shorted.

AL MALONE'S ANSWER: I might add, Rodger, in regard to receivings we have a system which we think helps in at least establishing inspections to see that they are within the ballpark, what they should be. Each car shipment or truck received is inspected and results reported on a standard combination form of a receiving report which is made to our central accounting system.

MODERATOR SMITH: Good idea. Any other comments from the panel or audience?

DICK TAYLOE'S ANSWER: We have from time to time checked inbound shipments, and our experience has been like the gentlemen from Hawkeye. They generally pretty well agree. Sometimes inspection of a car will reveal the presence of a leak; and then, of course, you have got a special case. But by and large I think our experience would back up his experience that the shipper's weight is reasonably accurate.

MODERATOR SMITH: I just can't help but comment. I recall that at Eastern States Farmer's Exchange one plant consistently year in year out had the best record of shrinkage. Of course, we used to accuse them of doing what Dick Tayloe just mentioned. But he had his men trained. This was the Wilmington, Delaware plant. He had his men trained that when they stopped doing something else they picked up a broom and swept the aisles and so on. He had the best housekeeping that I've ever seen in a mixed fertilizer plant, and his shrinkage was the least.

MODERATOR SMITH: There were a couple of hands over here.

QUESTION: One of the gentlemen mentioned outright theft. I was wondering if he could tell us how they discovered this and how it was accomplished.

DICK TAYLOE'S ANSWER: I'm not sure how it was discoverd except they were consistently having inventory shortages of mixed goods, finished fertilizer. The shortages we just couldn't account for any way in the plant. I think the manager got suspicions and started getting out in the field a little bit and talking to people. He picked up some information which never got finalized enough to bring a court case, but it was finalized enough to have some people sweating around the plant. He did find out that some of our product was showing up at a real bargain price, but he never could find out how it got there. Anyway, the clue was a consistent shortage of finished product. It went on apparently for quite an extended period of time before we got on top of it.

QUESTION: I have one for the two gentlemen who pretty well agree with what a 3% shrinkage was. Do you assign that to the rock in the finished product or is it in the process itself?

LOUIS INGRAM'S ANSWER: I am one of those that say we use 3% shrink on phos acid, but I was thinking it is a little too high. I think it's going to vary from year to year, but I was thinking it's going to get worse as the quality of our rock decreases and we get more sludge in it. I can't give you an exact answer. It's a problem, and I believe it's going to get worse.

QUESTION: Is that after the rock becomes a finished product?

LOUIS INGRAM'S ANSWER: No. This is from the time the car comes into the plant gate.

MODERATOR SMITH: Yes, sir.

QUESTION: I don't know if I can phrase this question properly. In all the shrink figures we've heard is there a case where for instance, you may overformulate on nitrogen in addition to the tricks that we heard.

DICK TAYLOE'S ANSWER: The figures I was talking about did not include the overformulation factor. Yes, we do overformulate on everything, all three plant foods. We can't reach the record of the gentlemen from England on penalties, but we've trying. This is in addition to physical handling.

LOUIS INGRAM'S ANSWER: We handle it in the same way. We do overformulate.

AL MALONE'S ANSWER: We handle similarly.

QUESTION: How do you handle yields in cars where you have sludge like phos acid and maybe some other materials that settle out of the car. Do you take that as weight loss or do you charge it back to the distributor or how do you handle it?

LOUIS INGRAM'S ANSWER: You have two groups of Grace people here, and you are about to get a fistfight started.

DICK TAYLOE'S ANSWER: We get our phos acid for the most part from our own plant in Florida, and I don't think any of them are here. But they weigh the car on its return to the Florida plant and give the branch which sent it back credit for the weight of sludge returned. They do this on the basis that the weight of sludge in the car is not 54% P_2O_5, it's 40%.

RODGER C. SMITH: Yes, sir. Way in the back.

QUESTION: Does the 3% loss include moisture?

MR. LOUIS INGRAM'S ANSWER: Moisture loss is accounted for in the formulation, if I understand you correctly, and the answer is no. There is one thing I want to point out. I was talking about a 2½% to 3½% loss, and this is relative to a dollar value. Now when you go into a mixed fertilizer plant, it's not beyond the realm of possibility that you'd have 1/10% to maybe 2/10% of your product either taken back as sweepings or tailings or reformulated. This will give you a higher dollar cost which enters into the shrinkage. I don't feel we have a 3% tonnage loss, maybe close to it but not quite.

QUESTION: How do you formulate the moisture loss?

MR. DICK TAYLOE'S ANSWER: You formulate it on the basis of the moisture as contained, and you allow for a moisture content in the product.

QUESTION: Do you formulate it on a dry basis or a wet basis?

MR. DICK TAYLOE'S ANSWER: Actually, our formulation is done on a dry basis with the product moisture we shoot for as part of the formula. We convert this back to the as-is basis for the batched weight. Of course, the moisture in the superphosphate, for example, is picked up in the weight of the superphosphate and presumably driven off in drying to get back to your formulated product moisture.

MODERATOR RODGER C. SMITH: I think that it's understood that any discussion of shrink here is completely irrespective of moisture changes.

MR. LOUIS INGRAM: This is an important factor in your actual shrinkage. You must take your actual moisture into account. In the springtime when you start getting run-of-pile single, it's high in moisture; and if you don't take this into account, come inventory time you've got a real bad problem.

MODERATOR RODGER C. SMITH: I think I saw another hand.

QUESTION: I would like to make a remark on the weighing of cars. If you handle a lot of box cars not hopper cars, you really get in trouble with the tare weight. In the box car there is more inaccuracy in the marked weight of the car then in the hopper car.

MODERATOR RODGER C. SMITH: Yes, John.

QUESTION: John Medbery of I.M.C. Concerning normal superphosphate inventory control and so on. This is one place where in my experience we have great variation from time to time. Has anyone accounted for superphosphate in terms of P_2O_5 rather than pounds of super?

MR. LOUIS INGRAM'S ANSWER: I think the answer to that is nor for all three of us.

JOHN MEDBERY: Green super, of course, contains moisture and unreacted rock, and in the course of curing some of this moisture becomes gypsum and some of it escapes to the atmosphere. The density of green super might be as high as 70 pounds a cubic foot and cured super as low as 60 pounds a cubic foot. I was wondering if anyone had attempted to adjust for the curing characteristics, the change in bulk density and the change in the P_2P_5 aspect? Evidently not.

LOUIS INGRAM'S ANSWER: Well, yes and no. We know that we must watch the analysis of our run-of-pile triple and our run-of-pile single very closely when we get into the spring season which is when the suppliers ship green triple and green single. You must have a certificate of analysis, you must formulate the APA so that at time of shipment the APA may become higher. The moisture is extremely important. In the spring you are going to have a higher moisture content; and if you don't watch yourself on that, you will get some bad quality product and have an inventory problem if you don't take this moisture change into account when you formulate.

DICK TAYLOE'S ANSWER: I think what you're getting at and I think I agree is that if a supplier loads a car of super with a 10% moisture in it and it comes across three states in the hot sun and is 10 to 15 days on the road, there will be some loss in weight due to moisture evaporation. It won't be indicated by a simple moisture determination because some of the moisture gets tied up as Lou said in gypsum. There will be some drying out of superphosphate in storage and in shipping, and I guess that's where some of your shrink comes from. It's probably a pretty hairy figure to tie down.

AL MALONE'S ANSWER: It is possible in regard to the moisture content that the water of crystallization, the water of constitution, or whatever you may call it, we do consider that in the formulation because you will have some release of this water on ammoniation.

MODERATOR RODGER C. SMITH: Yes, Al Spillman.

AL SPILLMAN: Do you keep your shrinkage on a pound basis in the records?

MR. DICK TAYLOE'S ANSWER: As I said, we take our shrinkage of inbound materials at the time of batching not at the time of receiving because it appeared to be an unsolvable problem to get that past the computer. Yes, sir, we record the weights as received and than by physical inventory and batched weights going out evaluate what our shrinkages have been. This was pretty much the basis for this shrinkage on raw materials plus this 3%, what I call the normal shrinkage. That agrees we think within reasonable limits with our actual experience. I might add a comment to that that I got from one of our superintendents the other day. He thinks maybe that his yields are going to be a little bit better because of the dust control system he has gotten in. He is now catching fugitive dust and feeding it back, and he thinks that's going to show up in yields.

MODERATOR SMITH: Anyone else? Yes, John Medbery.

JOHN MEDBERY: This kind of relates to stack sampling. When fertilizer stacks are sampled, you discover ammonium chloride for instance and nitrofluoride, NOX, gases of all sorts. In 1959 when TVA did some studies of sparger length, drum diameters, drum dnesities and so on for ammoniators, they discovered there was also quite a bit of elemental nitrogen in the stack gas that didn't come there from the air. Evidently some of the nitrogen used in the fertilizer materials was converting to this form. Now, has anyone attempted to determine what this is and account for it in a formula?

LOUIS INGRAM: No, not specifically.

MODERATOR SMITH: Apparently, they don't have any information on that, John. anyone in the audience? Are there any other comments or suggestions? Joe Reynolds.

JOE REYNOLDS: While they were talking about water content they got into a discussion of formulating on a dry basis and then calculating over to an as-is, it brought to mind the situation that you are talking about — the importance of your moisture factor. As you all recognize, an important part of shrinkage consideration is if you formulate to 1% moisture and you let it go to 3% moisture, you have one set of tonnage information in the pile; but if you formulate 3% and you drive it down to 1%, then you have lost 2%. I think this is an important consideration, too. Sometimes an operator might get a little bit happy and let that burner run dry on him and the next thing you know he's got a pretty good loss, a pretty good shrinkage hanging out there.

MODERATOR SMITH: I was glad to hear the

panelists mention manual and training programs. I think we all recognize that you are dealing here with not only mechanical equipment but the human equation and certainly lack of understanding of what people are doing or lack of a concern for some other reason is very definitely a factor in shrinkage. Any other comment? Yes, sir, in the back.

QUESTION: What is the goal which most plants set for shrinkage loss?

LOUIS INGRAM'S ANSWER: I think you are going to have to tailor your shrinkage program to your own individual and your own individual plant. What is acceptable in one plant will not be acceptable in another. I think mostly you can determine your overall losses on an average value; but when you get down to specifically determining your losses on run-of-pile triple and getting down to that last 1/2%, it is extremely difficult to evaluate. At least this has been my experience.

DICK TAYLOE'S ANSWER: I quite agree. It depends on the circumstances. For instance, we have one plant that stores potash across the yard from the manufacturing unit and hauls it 1/2 a mile to get it over to the weigh hopper, and he has obviously a greater shrinkage loss there then the plant that stores in next door. As for a target, I don't know ehether 1% would be a realistic goal overall or 2% for that matter. I don't know what a realistic goal would be. I would hazard a guess that maybe 2%. It might be attainable in a very well run, very well designed, very well maintained plant.

LOUIS INGRAM'ANSWER: I have been in several situations where we has some very unreal and unrealistic inventory losses. We have never been able to find where these losses occured, but we started taking a physical inventory once a month and things just all of a sudden started getting in line. When you set your factors, you better make sure you don't set them too high.

AL MALONE'S ANSWER: We have several of our plant managers in the audience so I've got to be real careful here in setting any standards. I still go to the percentages as presented in overall percentage of dollar cost and that's as close right now as we can get to an actual plant food accounting, in terms of dollars. I don't think it's too unrealistic to shoot for a goal of 1 to 1½%; and that can be tough, but we've got a lot more cleanup to do within our plants, general housekeeping in relation to emission control. This is part of it, and I think it's going to make a difference as we do get those more under control.

MODERATOR SMITH: Anyone else? Dudley George.

DUDLEY GEORGE: Where do you set your scales for bagged goods?

LOUIS INGRAM'S ANSWER: We set ours at 80 pounds plus the bag weight. Then we check weigh, and we record the weights of about each 10th bag that comes off that bagging line. That's kept as part of our plant operating data. These are investigated periodically to make sure we are maintaining our standards and giving them 80 pounds.

DICK TAYLOE'S ANSWER: Dudley, I don't mean to say that we don't set the scale to allow for the weight of the bag. I don't know what weight they use on an average bag, but they do set the scale to try to hit maybe 80½ or 80¼; and that is one big source of loss undoubtedly.

MODERATOR SMITH: We've had an excellent discussion here; and we owe appreciation to the speakers and the panelists and certainly to all of you who have participated. Let's give the three panelists a hand.

There are two announcements. The registration desk has some commemorative bells still available if you would like to take an extra one along. The other is that the meeting tomorrow morning will not be in this room. It will be in the Palladium room where we were yesterday morning when we first began the Round Table meeting. The meeting will begin at 9 o'clock tomorrow morning in the Palladium room.

Unless someone else has an announcement of some sort I want to say thanks again to all the speakers and to all the participants and the meeting is now recessed.

Thursday, November 6, 1975

Final Session
Moderators:
Joseph E. Reynolds, Jr.
Paul J. Prosser, Jr.
Frank T. Nielsson

CHAIRMAN REYNOLDS: Good morning. We have a full schedule for this final session of our 25th Annual Meeting. One of the highlights will be the question and answer panel.

I shall now turn the meeting over to our esteemed Secretary-Treasurer who has worked so diligently in this area. Paul Please.

Secretary-Treasurer Report
Paul J. Prosser, Jr.

Good morning. Our 25th Anniversary meeting is nearing to a close. We certainly hope that the program, as presented, has been of much help to you. As you know, the people who organized the program and lined up all the speakers, worked very hard and spent a lot of time. We are hopeful that this is meaningful to you.

When I came into the meeting, this morning, the attendance count was 338 registered. That is very significantly larger than last year's registration of 270. Quite an increase.

You probably know plans are to hold next year's 26th Annual meeting in Atlanta, Georgia. More details later.

We had a supply of attendance lists printed, courtesy of Mr. William E. Robinson, and we are presently searching for the surviving copies which disappeared.

We have a lot to do, therefore, I would like to read the financial statement, covering the period, November 1, 1974 to October 31, 1975.

FINANCIAL STATEMENT

November 1, 1974 to October 31, 1975

CASH BALANCE — November 1, 1974		$7,319.18
Income 1974 — 1975		
Registration Fees 1974 Meeting	$9,555.00	
Sale of Proceedings	1,967.02	
Transferred from Cocktail Party Fund	80.12	
Total Income November 1, 1974 to October 31, 1975		11,602.14
Total Funds Available November 1, 1974 to October 31, 1975		$18,921.32

Disbursements November 1, 1974 to October 31, 1975

1974 Meeting Expenses	$1,375.15	
1973 Proceedings, including printing, postage, etc.	6,274.80	
1974 Proceedings, including printing, postage, etc.	6,203.57	
Membership letters including postage	457.06	
Miscellaneous expenses including office supplies, postage for mailing back issues, etc.	316.22	
Directors Meetings, including mail notices, postage, etc.	830.41	
1975 Meeting — Preliminary Expenses including souvenirs, plaques, certificates, etc.	1,411.18	
Total Disbursements November 1, 1974 to October 31, 1975		16,868.39
CASH BALANCE — October 31, 1975		$2,052.93

We had a substantial cash balance when we came here and obviously we should be financially all right after this excellent attendance and the registration fee. Thank you.

CHAIRMAN REYNOLDS: Thank you Paul. Are there any questions? That was a very fine report. It summerises extremely well. I have had several people inquire here, Paul, concerning past proceedings. I think that the impact of the collectors' item for the Proceedings is coming in. I notice your financial report shows about $2000.00 income during the year for past Proceedings. This is a further indication that people are trying to fill out a complete set of Proceedings going back to 1955. If any of you need past Proceedings please contact Paul. I think it is becoming increasingly important to fill out your file with the past Proceedings that you do not have. As soon as the existing supplies of previous years' Proceedings are no longer available, they are really out of print. As a last resort for Proceedings no longer available, write Paul and he will try to get you an approximate cost for "Xeroxed Copies."

Our good friend Wayne W. King will now give us his report covering the Nominating Committee.

Nominating Committee Report

Wayne W. King, Chairman

Our Committee is recommending 6 additional members to our Board of Directors. The Names are:

David W. Brochstein,
Manager Fertilizer Oper.,
U.S.S. Agri-Chemicals,
P.O. Box, 1685,
Altanta, Georgia 30301

William E. O'Brien, Mgr.,
Planning and Evaluation,
Mississippi Chem. Co.
P.O. Box 308,
Yazoo City, Miss. 39194

Cecil F. Nichols,
Production Manager,
Southern States Coop, Inc.
P.O. Box 1656,
Richmond, Va. 23213

John W. Poulton,
Managing Director,
Pertwee Landforce, Ltd.,
Harbour House,
Colchester, Essex, England

William F. O'Brien, Mgr.
Plant Operations
Royster Company,
P.O. Box 1940,
Norfolk, Va. 23501

Clyde D. Stevans,
Vice President
Lebanon Chemical Corp.,
P.O. Box 180,
Lebanon, Pa. 17042

I shall make the motion that we accept this report and declare these very fine Gentlemen, whom most of you know, elected to our Board of Directors. I note a seconding nomination from the audience.

CHAIRMAN REYNOLDS: You have heard the motion and Seconding. All in favor please say "Aye" and opposing say "Nay". The Audience unanimously voted "Aye". We thank you W. E. Obrien, W. F. O'Brien, Dave Brochstein, Cecil Nichols, John Poulton and Clyde Stevens for "Joining Our Board".

WAYNE KING: Our fearless leader, Chairman Joe Reynolds, has consented to continue as "Chairman" and on behalf of all of us we thank him for a marvelous job, so well done during the years of 1974 and 1975.

No additional nominations. Thank you.

CHAIRMAN REYNOLDS: Thank you Wayne.

Tom Athey, Chairman Entertainment Committee and Chairman Meeting Place and Dates Committee, will now give us his report.

Entertainment Committee Report

Tom Athey, Chairman

On behalf of our "Members", Our "Board of Directors" and our Officers, I wish to thank our "Hosts" for that beautiful "Cocktail party" last night. Needless to tell you that we all enjoyed all of it.

ATLANTIC UTILITY WORKS
C&I/GIRDLER INCORPORATED
COMMONWEALTH LABORATORY INCORPORATED
DAVY POWERGAS, INC.
FEECO INTERNATIONAL INC.
FESCO, INC.
JACOBS ENGINEERING CO.
DORRCO FERTILIZER PLANTS DIVISION
KIERNAN-GREGORY CORP.
THE PROSSER COMPANY, INC.
EDW. RENNEBURG & SONS CO.
ST. REGIS PAPER CO.

FLEX-KLEEN CORP.
HOWE RICHARDSON SCALE COMPANY
J&H EQUIPMENT, INC.
THE A.J. SACKETT & SONS CO.
STEDMAN FOUNDRY AND MACHINE CO., INC.
WEBSTER INDUSTRIES, INC.
WHEELABRATOR-FRYE, INC.

Meeting Place and Dates Committee

Tom Athey, Chairman

Arrangements have been made for our "26th Annual Meeting" to be held at the Sheraton-Biltmore, Atlanta, Georgia, Tuesday, Wednesday and Thursday, October 26, 27 and 28, 1976. I will be in direct contact by mail, phone and several visits to Atlanta, between now and the meeting, to cover the many details needed to be worked out for a successful meeting.

Please make note of our Hotel Accommodations and Meeting Dates for our 26th Annual Meeting and make your reservations early. We promise you another excellent and interesting 3 day meeting.

CHAIRMAN REYNOLDS: Any other questions. I think Tom has done an excellent job arranging for our move to Atlanta and his handling of the "Entertainment Arrangements". We thank you Tom. Tom has had some help from our local friends in Atlanta and I have been assured they will continue to help Tom and Paul.

Walter Sackett, Jr. has some items he wishes to discuss with us. Walter Please.

Public Relations Chairman

Walter J. Sackett, Jr.

Thank you Joe. In as much as this year is our 25th anniversary we decided that we should present a "Plaque" to the People who have worked very hard to make this meeting a success. This is our Board of Directors. I would like to announce each of the names and have you come forward to the Podium to receive the "Plaque". Seven of our Directors who could not make this meeting will receive their "Plaque" by mail or by direct contact. Chairman Reynolds will personally present the "Plaque" to each Director present.

CHAIRMAN REYNOLDS: Thank you Gentlemen for a job well done. The "Plaque" read:

25th Annual Meeting
The Fertilizer Industry Round Table
presents the
Executive Committee Award
to
(Director's Name)
In recognition and appreciation for
dedicated service on the
Board of Directors of the Fertilizer Industry
Round Table
November 6, 1975

Acknowledged by The Audience with a great deal of Applause.

WALTER SACKETT, JR.: We also have a few "Special Awards" that I would like to present. Our fearless Secretary-Treasurer has gotten us in the black again this year. We present a special award to Paul J. Prosser, Jr. for Outstanding Work on behalf of Our Round Table.

Also for really dedicated service to the life of Our Round Table and he did a marvelous job with the facilities this year, we present a special award to Tom Athey.

And last but never least for outstanding dedicated services, whenever called upon to help Our Round Table. we present a special award to Wayne W. King.

The Special Plaques were compliments for Extra Dedicated Services to Our Round Table.

CHAIRMAN REYNOLDS: Thank you Walter. I cannot really express enough appreciation to this Group. As I indicated in my opening remarks, Tuesday Morning, this is a great Group that really belongs to the individuals. The Round Table is made up of Individuals. There is a tremendous feeling of belonging and responsibility represented here. I do not know if it is recognized as such, however, when our Secretary-Treasurer schedules a Board of Directors' Meeting the attendance is tremendously high. I would say in the range of 80-85% of those on the "Board" actually participate, and I can assure you when the program is put together everyone there has an input.

As far as those who appear on the program, you are to be complimented also for feeling the responsibility of participating. Whenever we ask people to participate in any form, either behind the scenes or up here in front of everyone, we get about a 95% OKAY on the first asking. I do not know of another Organization that can make that statement. I think this reality is because you feel that this is your "Group" and your "Meeting" and if you ask for something, and you indicate a need, the Group tries to respond to it.

Another person that I wish to thank is Al Spillman. Al, of course, has been very active, with Our Round Table, from the very beginning. One of the Executive Committee when there was a very, very small Group. Although Al has retired he has served as "Chairman of this Group" and is still on the Board of Directors and participates very heavily. One of the items that he contributes, which is a tremendous job and quite an undertaking, is putting out the "Proceedings". If you can just visualize the problems of assembling the papers, editing, reading, etc. that is quite a job. We really owe Al a real vote of appreciation and gratitude for the work that he does. Lots of Applause.

CHAIRMAN REYNOLDS CONTINUES: We seem to be running pretty close to schedule. I really appreciate the size of the crowd here on the third morning of Our Round Table. Looks like we have almost a full room and this is really great.

Without taking up any more time we will get along with our Program and if at the end you think of something, that should come before the Group, by all means we want to hear from you.

I will now turn the program over to our good friend, Frank T. Nielsson.

Much, Much Applause and many compliments to our Chairman, Joe Reynolds, for moderating.

Moderator: Frank T. Nielsson

Good morning, gentlemen, ladies, any present. We are approaching the end of our three day program, and it reminds me of the time when I was a kid and I would run over to the drug store on the corner when the Rose Bowl program was on. Always on the program you would hear these very significant words, "This game is approaching its end as the sun sinks over the western wall," and we hope that in the twilight of this meeting you will hear some more meaningful things for you.

Our first speaker today is George Hebbard, a chemical engineer from Lehigh University, a school, that when I went to Syracuse, we never could beat wrestling. He has been one year with Sackett, process engineer with W. R. Grace, and also worked for the Pigment Division of Glidden. His paper will be "Methods of Minimizing Granulator Building." George.

Methods of Minimizing Granular Buildup

George Hebbard

Good morning Ladies and Gentlemen. My name is George Hebbard, and I'm from The A. J. Sackett & Sons Company, in Baltimore. I'm going to be speaking to you for a few minutes on the subject of ammoniator Granulator build-up control. Specifically, I'll be discussing Drum Granulators and some of the techniques used to minimize buildup in them during operation.

First, a little background by way of qualification may be in order. The A. J. Sackett & Sons company has been concerned with granulation in the Fertilizer Industry since it's inception and has supplied equipment to many of you in this room, including separate ammoniation and granulation drums, the unique Star Granulator, and the more recent Unified Single Drum Ammoniator Granulators. Our equipment has been used for ordinary fertilizer granulation and even mashed potatoes. Although we've built quite a few Pugmills, both Pugmills and Pan Granulators are excluded from this talk.

The entire subject of granulator buildup control will be put in better prospective if we look at a few of the factors that influence rate of buildup before looking at the methods we and others have used to remove buildup.

This crust or cake I am calling buildup is caused by liquid phase reaching the shell of a granulator and forming a deposit there. This can be from either an upset condition such as when liquid feeds are maintained high while the recycle rate is allowed to lag excessively, or the natural rolling of wetted granules against the shell. In the first case, buildup may be rapid and in the second, gradual. Drum cleaning methods may vary as far as suitability for removal of this buildup condition. Changes in operating procedures, intended or not, also effect removal efficiency.

When any method of drum cleaning becomes less than satisfactory, it is wise to look at the problem from the standpoint of granulator operating conditions first. Have new operators been assigned to the job? Has that new scrubber upset the water balance? Has a different sized raw material been soaking up less liquid, etc.? After you are reasonably sure some such unknown will not reverse itself as soon as you change, you may then want to consider another cleaning method.

It might be wise to interject a comment on drum speed. For a given drum size and product there is usually a particular rate of rotation most suitable to good granulation and consequent predictable rate of buildup. This speed is most readily related from drum to drum by calculating the percent of critical speed of the drum, expressed as:

$$100 \times \frac{\text{RPM}}{76.5 \sqrt{d}}$$

Slide 1

And this value will run somewhere around 25% to 50% for the average installation. If your granulator rotational speed has been changed recently, you can expect each old grade to be a new problem as its turn comes along until all operators adjust to the change. I won't elaborate on this formula because more information is readily available. I mentioned it only because it has a definate bearing on operation of and buildup in a Drum Granulator.

Most of the methods to follow are equally valid for slurry and non-slurry granulation. There will be slight differences in the nature of the deposit. Removal of this buildup is generally performed mechanically and the next slide shows a common unit, the Reciprocating Scraper; most of our customers who have these swear by them and wouldn't change even with purchase of a new unit. Some people swear at them and those who have changed, have usually opted for rubber linings. The average reciprocating Scraper is driven hydraulically with a small pumpset and reversing switch and moves back and forth in response to limit switches. The teeth are usually carbide tips that are adjustable and fairly easy to renew. *(Slide 2)*

Another common scraper is the two-stage unit shown in this slide #3. The toothed unit does not reciprocate and the ridges between the teeth are cracked off by the second stage blade. This unit is adjustable toward the drum for tooth wear and the individual teeth are replaceable when worn. A third scraper is the single stage with buildup removal taking place more or less evenly the entire length of the blade. *(Slide 4)* The 3 scrapers discussed so far are relatively equal in so far as power consumption goes For a fixed scraper, the horsepower lost from the action of the scraper will depend on granulation operation, rate of buildup, and will increase directly as shall diameter and/or rate of rotation increase. The purpose behind individual removable teeth is promarily to allow harder metals, such as the carbides, to be used on an economical basis.

(Slide 5) Finally, we come to the Cadilac of scrapers, the Rotary spiral. This unit is driven by a 7-1/2 HP drive and minimizes the horsepower absorbed from the main drum drive. There are very few of these units in use. TVA has a 9'—11" x 20' drum of our manufacture with one. The main drum drive is somewhat oversized at 150 HP, but if this unit were to use the common 10 to 50% of main drive horsepower, often lost to a fixed scraper, the auxilary 7-1/2 HP motor required for this rotary scraper would be a welcome change. The slide you are looking at does not show the removable and adjustable tips fitted to the scraper. All these scrapers have 2 problems in common: that is, high wear and a varying degree of horsepower lost in driving the scraper or turning the drum against the resistance of the scraper. Tooth life has been variable, say from 2 weeks to half a season. The purpose of the scrapers is not to chip or break the fertilizer crust off the shell, but rather to leave a thin protective layer which serves to slow the rate of shell corrosion. In 1966, when Frank Achorn of TVA gave a talk on ammoniator granulator practice at this Round Table, some of you will recall this list:

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**

(Source: TVA 1966)

Slide 6

An up-to-date version of this list is not at hand, but it would undoubtedly show increases in the rubber liner and flexible panel catagory and a significant drop-off in number of fixed scraper units.

(Slide 7) The most popular rubber system in 1966, was rubber flaps. As you can see, the flexing and later impact of this flap on the lay-back cage will result in removal of the buildup once it hardens and reaches a minimum thickness. Probably the greatest objection to flap linings is the lack of shell protection and inability to reverse the drum for cleanout if the Granulator has a louver dam or even to expose the spargers for repair.

I've ignored knockers and this is a popular shell cleaning method. In general, it appears the ideal knocker will be silent, will not tear up the shell, and will not expose the shell to direct corrosive effects of acids. We have not developed this yet. More effort could be spent in the area of good release linings, perhaps Kynar or PVC to lower the amount of impact required from a knocker, but a comparatively high amount of sliding goes on in a Granulator. This means that the lining must be exceptionally abrasion resistant and since this sliding is not desirable, a slick surface compatible with easy release may not be compatible with optimum granulation. Even closely spaced, short, coated flights would appear to be only a partial solution.

(Slide 8) A second style of rubber lining gaining prominence is the panel style wherein fabric reinforced synthetic rubber conveyor belting is fastened to the shell in longitudinal panels along the sides and at the ends. Bars and bolts are generally mild steel construction although stainless and rubber coated parts have been used. One installation we are following has gone 3 seasons on a single lining. This particular lining has flat bar under the panels next to the shell is accessible from the outside by tapping on T-bars passing through the shell and welded to the flat bar. Operating people tell us little tapping is required as the weight of the bars and attachements flex the rubber sufficiently. This agrees with installations working well with lengths of chain under the panels, and others with rod stock anchored lengthwise. The unit shown is 8'Ø, and has 30" wide 2-ply panels. Others we know of vary in panel width from 2' to 4' for the same diameter.

A variation of the fixed panel system is the tube lining. An earlier version of this has the standard fixed dam set in several feet to give a granulation shelf. This version, *(Slide 9)* you will note, has the gate-dam attributed to Mr. Joe Edge of V. C. & Mobil. This dam, as you can see, is independent of the rotating shell and the active bed spills out over the lip or shoulder which can be adjusted in a clockwise or counter-clockwise direction to control the depth of bed. You will note, the inner edge of this dam tapers to take advantage of product size segregation, much as occurs in a Pan Granulator. The space between the lining and the edge of the gate does not appear to be critical and wear of the shell or lining under the gate is not excessive. The drum is easy to unload by reversing direction. The construction of this lining is critical and there have been some premature failures attributable to top light construction. Just recently, a lining failed when the lengthwise bars dividing the panels fatigued and broke tearing the lining. The inner bar should be up to 4" wide x 1/2" thick and have a minimum 5/8" ∅ grade 5 bolt installed on 4" centers. Bars and bolts can be carbon steel.

A frequent cause of rubber lining trouble is mechanical damage from cleaning tools that should have been kept out of the shell in the first place. The most successful installations combine adequate lining strength and flexibility with preplanned maintanence so that chance damage can be repaired with minimum down time. And this chance damage *must* be repaired. One of these linings is expensive enough to be worth salvaging at an early stage when a cut or tear is first noticed. One major operator maintains spare panels and bars all carefully matched to the ones in service and is willing to undertake a repair in the middle of the night. The bolt holes in the spare panels are cut in a jig, and any bolt holes and welding needed in the bars is done accurately ahead of time under the best of conditions.

(Slide 10A & 10B) This is a cross section of some typical lining connections. The rubber linings can be attached with butt joints, overlapped, or clamped. There wouldn't seem to be much to choose between the butt and clamped joints with the proviso that the clamping forces have got to be quite high. the overlap joint is quite popular, but it should be pointed out that extra spacers are required at the ends of the panels to make things come out right.

Lining materials vary from old used conveyor belting to specially purchased 2-ply nylon or dacron reinforced premium belt. The main requirement is good flex resistance, and an acid resistant carcus.

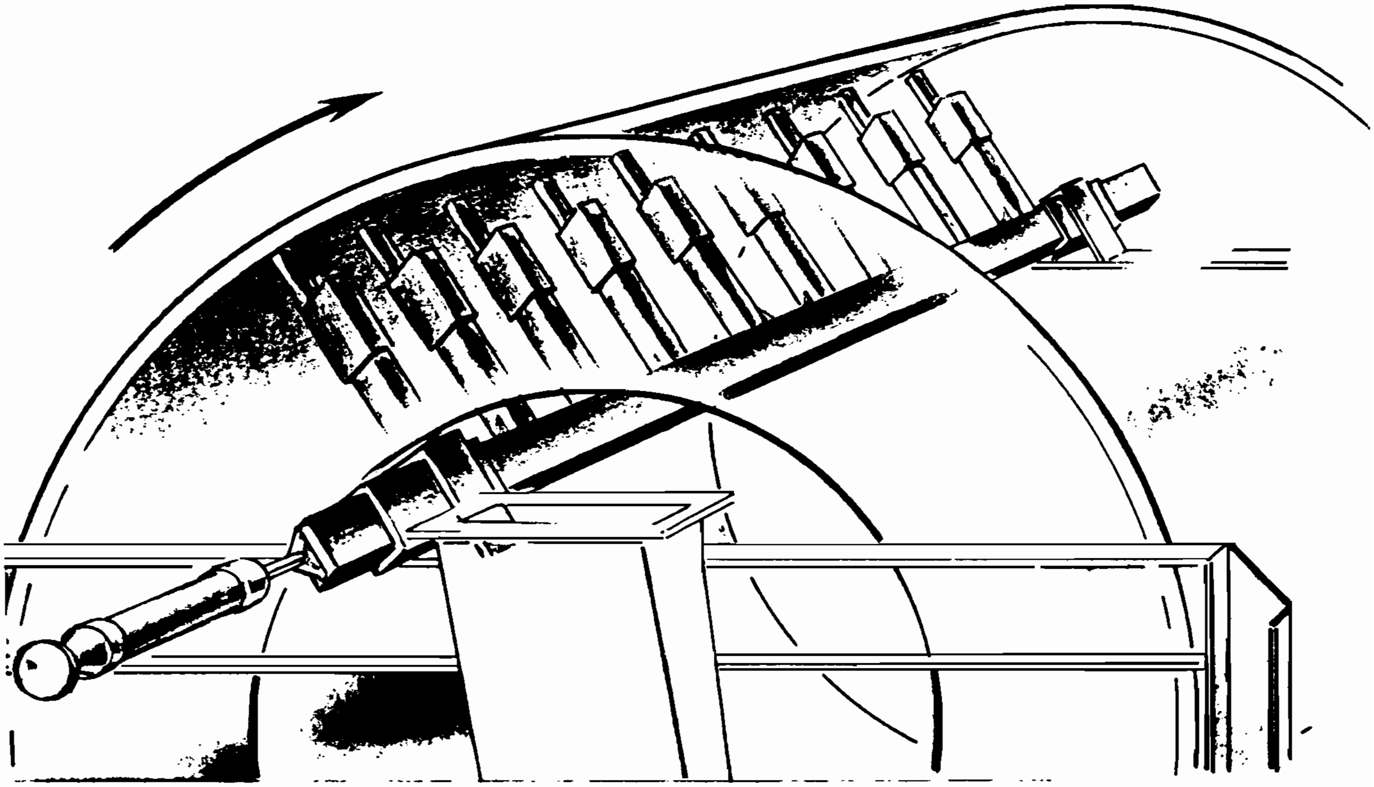
The decision to use one form of drum cleaning over another should be based on actual experience rather than conjecture. Accurate experience is hard to accumulate, however. A difference of opinions exists as to whether or not the grade granulated should determine the drum cleaning method. Those not granulating super goods feel a scraper system would be a necessity with those grades; while some of those granulating with super and using rubber linings indicate complete success.

One major manufacturer of granulated fertilizers has most plants with rubber linings, and gets 100 to 150 thousand tons of production per lining while one of his plant managers sticks to a scraper system. He feels he maximizes production with the scraper. The point here is that individual preferences largely determine the equipment purchased, and that once installed, operating success or failure must be the final jury.

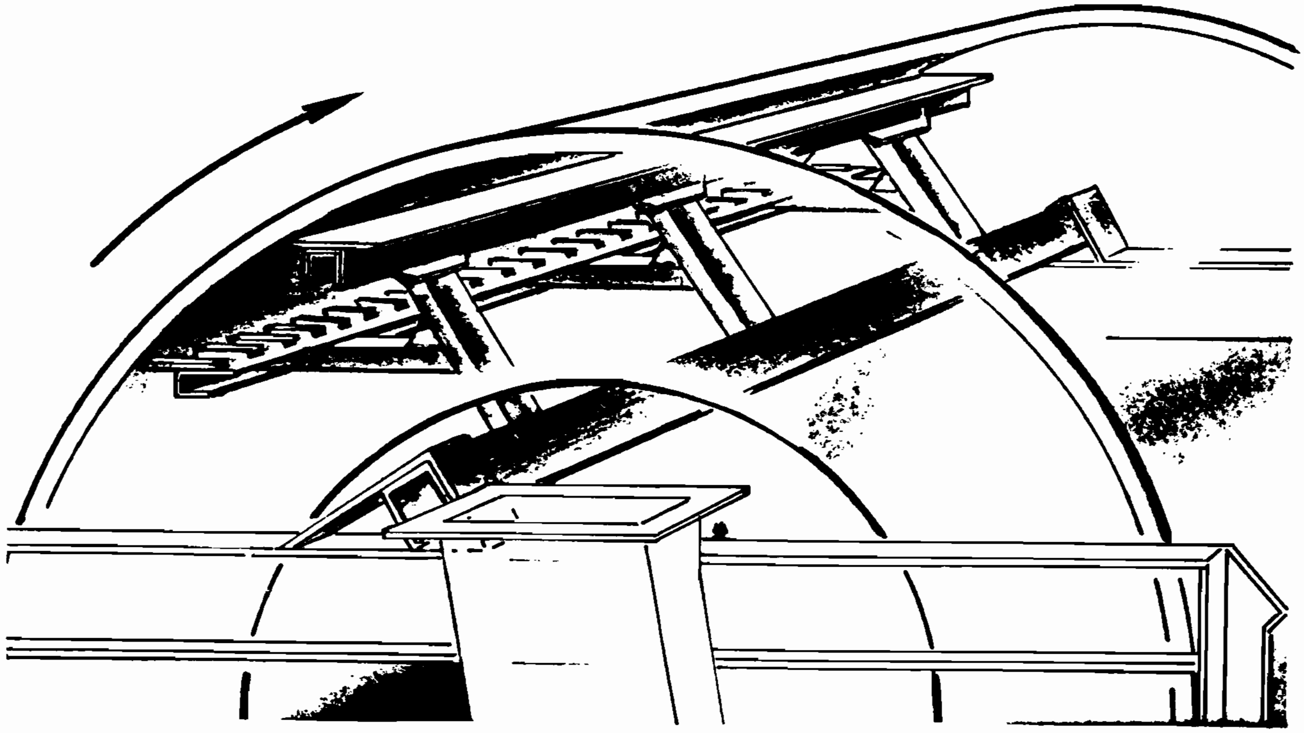
As important as any other factor is the actual operating techniques of plant personnel, granulating efficience, formulation, use of preneutralizers, and general accuracy of control all appear to exert an inseperable effect on the performance of scrapers and rubber linings.

This talk would be incomplete without a recommendation. If you are undecided about the new unit you are ordering, our recommendation would be to try the panel or tube style rubber lining, using the best recent design, careful fabrication, and a thorough preventative maintenance program with prefabricated backup parts. The louver dam gives easy cleanout. The non-rotating gate allows the rubber lining to reach the end of the shell, and has some advantages of its own. One of the two combinations, look to us to be the best bet at this point.

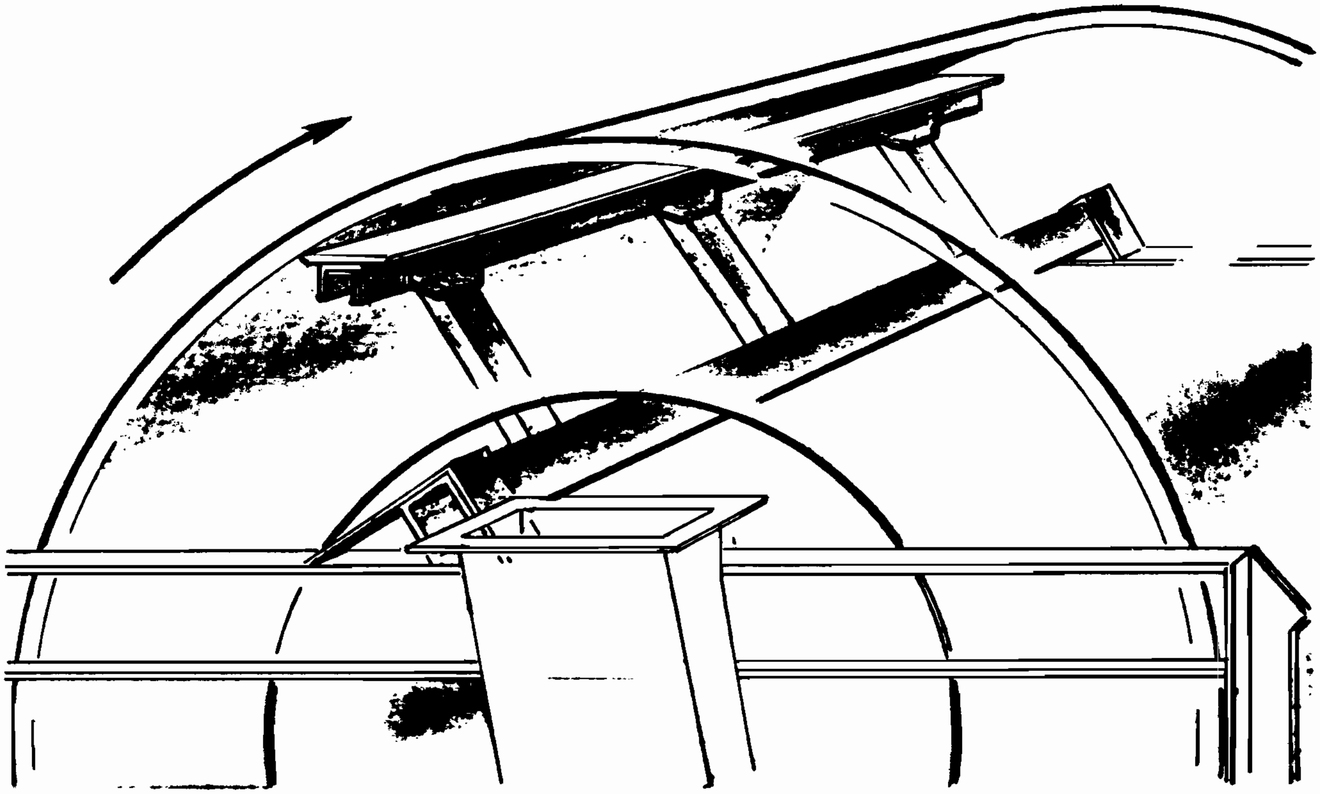
(continued on page 189)



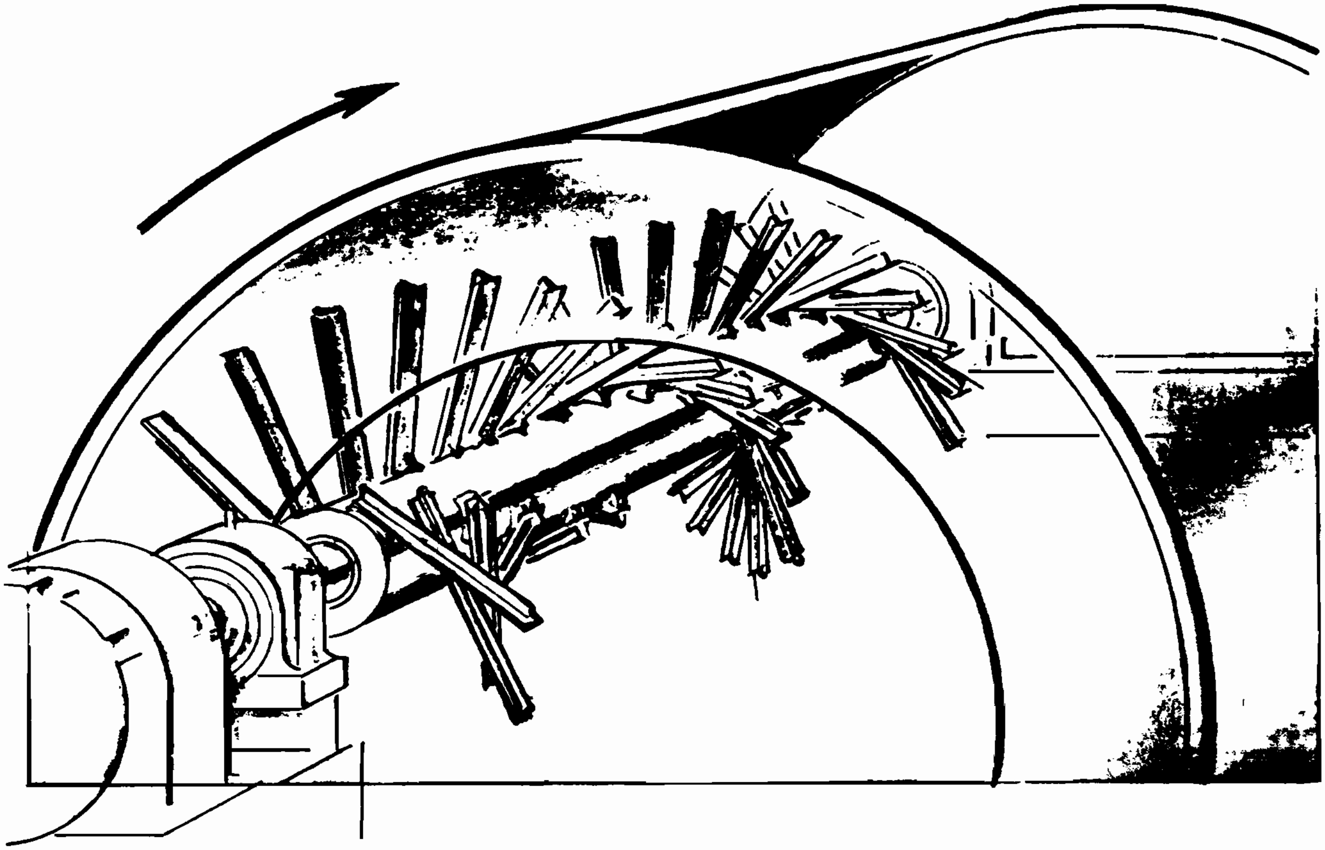
SLIDE 2 - Reciprocating Scraper



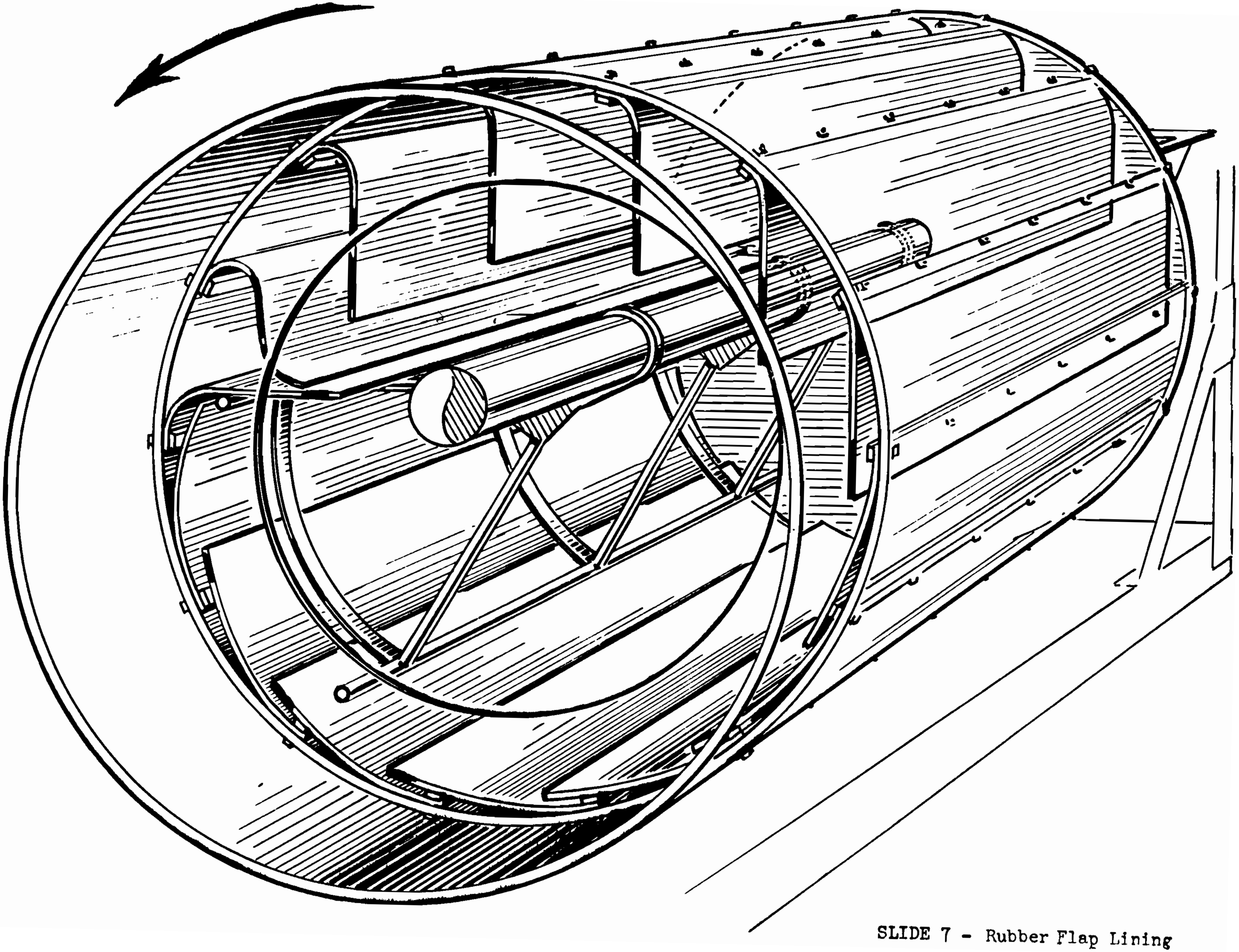
SLIDE 3 - Two Stage Fixed Scraper



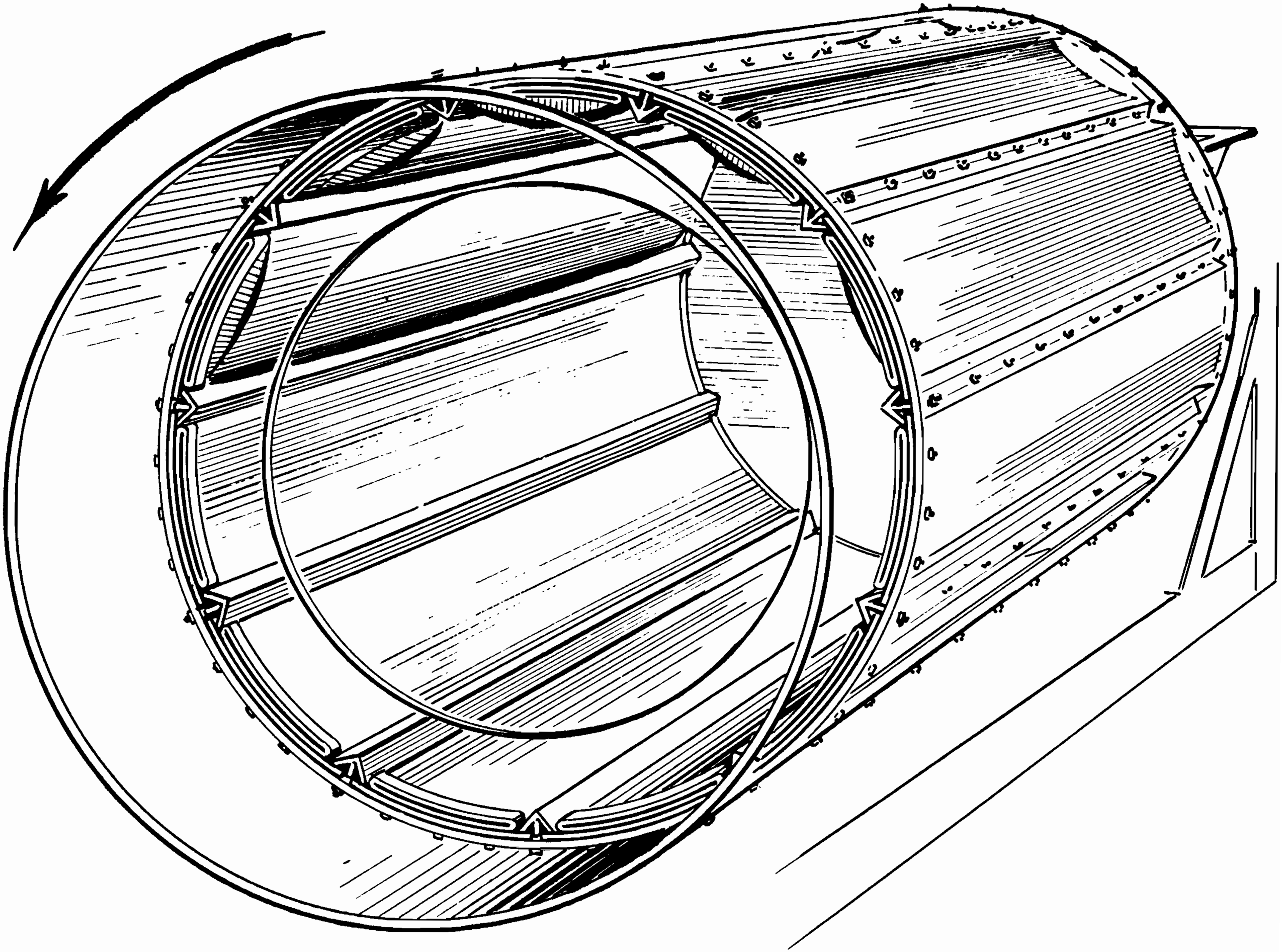
SLIDE 4 - Single Stage Fixed Scraper



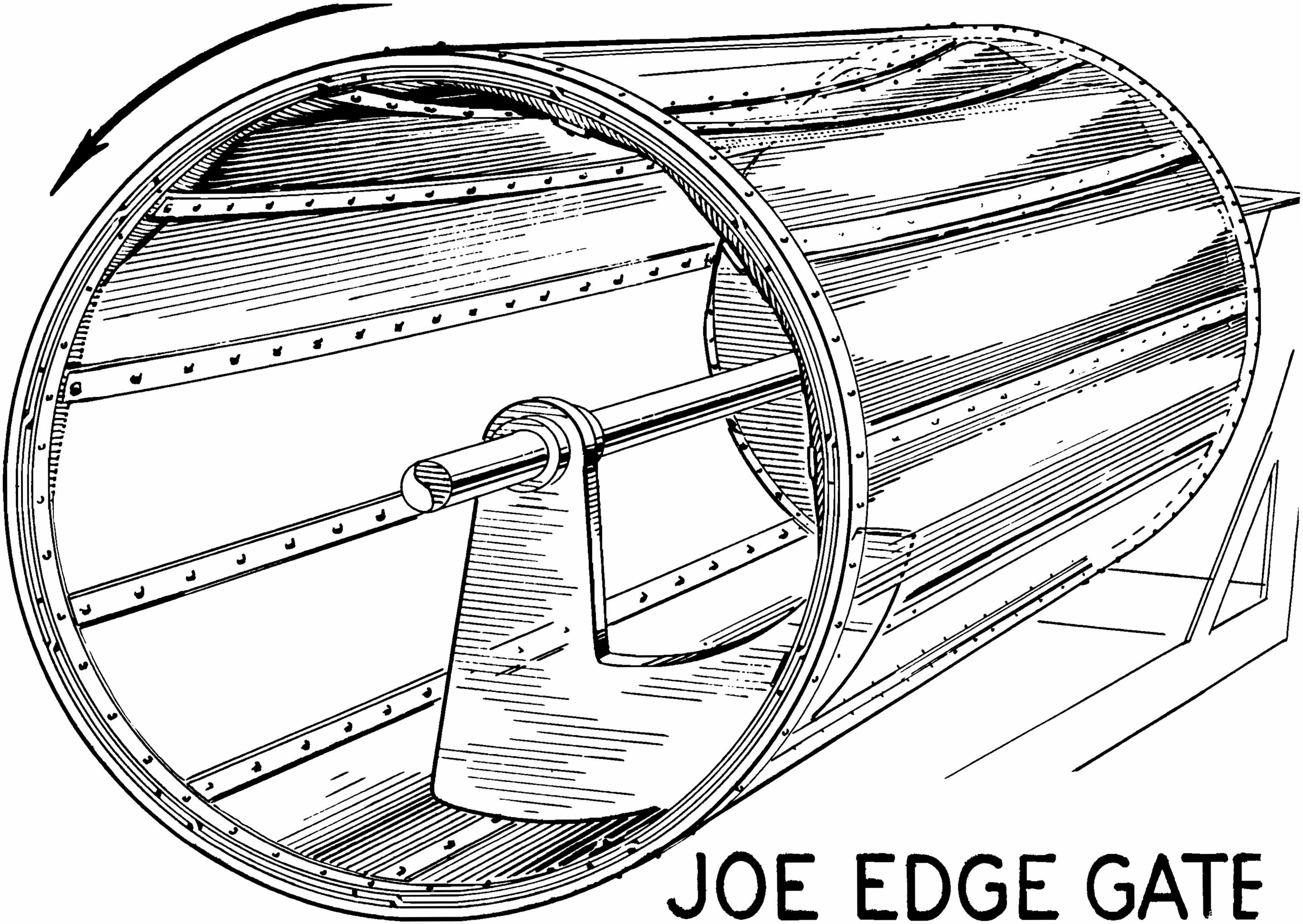
SLIDE 5 - Rotary Spiral Scraper



SLIDE 7 - Rubber Flap Lining

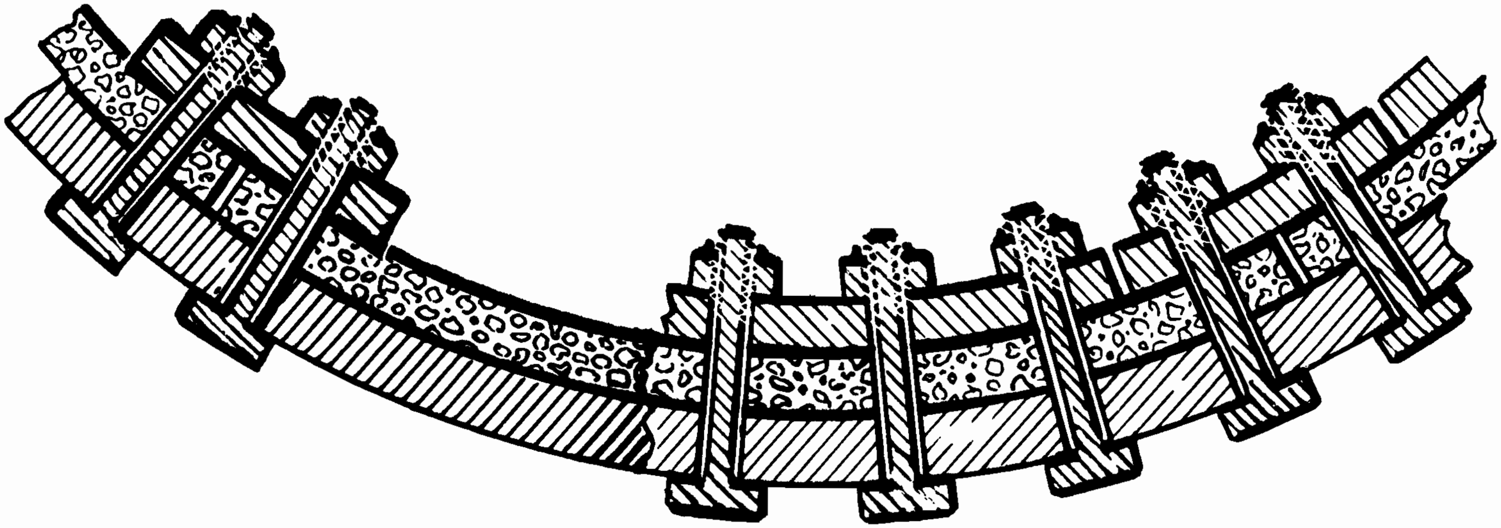


SLIDE 8 - Rubber Panel Lining



JOE EDGE GATE

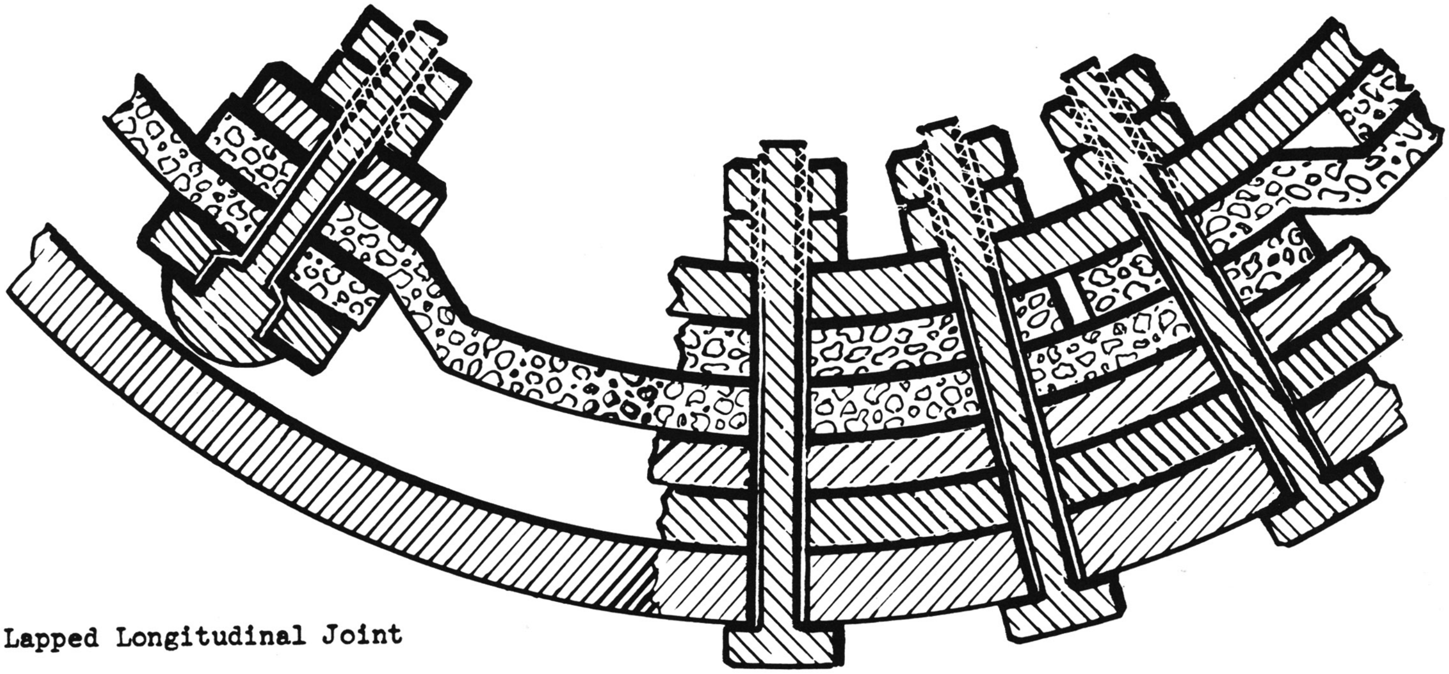
SLIDE 9 - Tube Style Lining



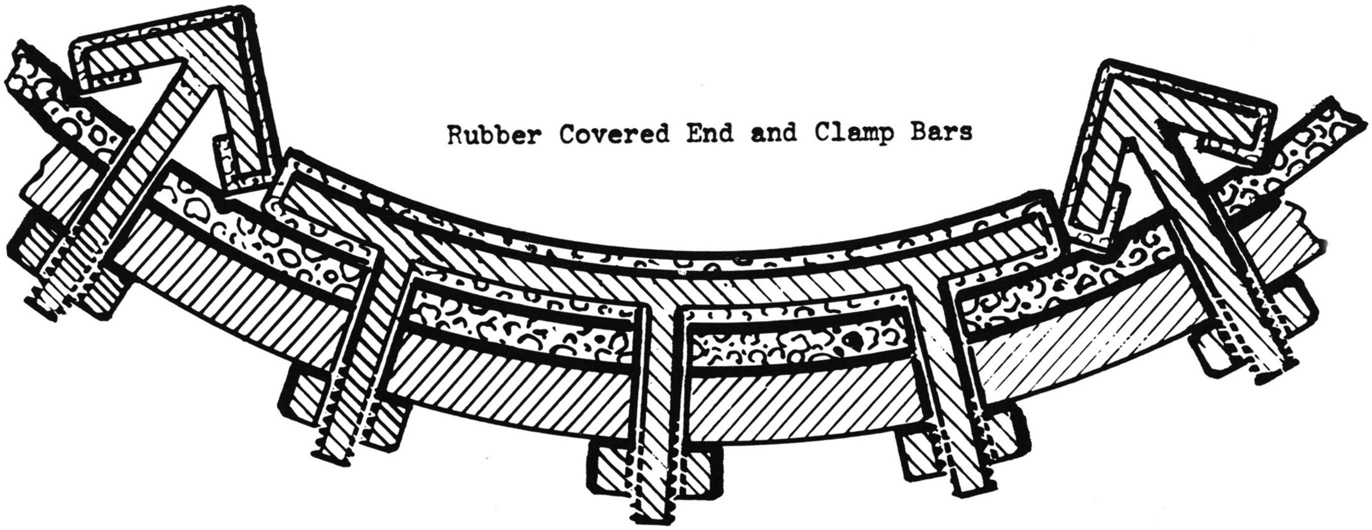
Longitudinal Joint Construction

End Bar Construction

SLIDE 10-A - Butt Jointed Lining



Lapped Longitudinal Joint



Rubber Covered End and Clamp Bars

SLIDE 10-B

MODERATOR NIELSSON: Thank you, George. I think that talk really gave some people some good ideas about keeping their granulators clean.

Our next talk is about the TVA pipe cross reactor for producing monoammonium phosphate grades. The speaker will be Frank Achorn, a chemical engineer from the University of Louisville and 26 years with TVA. He is Head of the Process and Product Improvement Section. In actuality he is the field engineer for TVA ideas. Years ago my claim to fame used to be that I had a little bit to do with the TVA ammoniator. In recent years my claim to fame is the fact that once I used to be Frank Achorn's boss. Frank.

Production of Monoammonium Phosphate in A Pipe-Cross Reactor

Frank P. Achorn — David G. Salladay

Presented by Frank P. Achorn

The pipe-cross reactor was first employed in efforts to solve a pollution problem that arose in a TVA study of the incorporation of sodium nitrate in fertilizers. The nitrate which is a byproduct of a Defense Department operation, consists of fine and relatively moist crystals. Because the nitrate is not suitable for direct application, plant tests were conducted to investigate its incorporation with other fertilizer materials in an ammoniation-granulation plant. The Missouri Farmers Association, Palmyra, Missouri, cooperated with TVA in conducting the tests in its franulation plant (similar to the one shown in figure 1). Early troubles were encountered when the reacting nitrate, sulfuric acid and ammonia broke into flame and emitted large volumes of brownish-white fumes. The addition of phosphoric acid did not suppress the fires and fuming.

It appeared that the violent reaction could be avoided if the sulfuric and phosphoric acids were partially ammoniated before admission to the granulator. A prereactor less complicated than the conventional preneutralizer was desired and this led to a decision to ammoniate the acids in a pipe-cross reactor (figure 2). First tests were in a 3-inch stainless steel (series 316) pipe cross in which the acids were added to two arms of the cross and partially vaporized ammonia to a third arm. The ammonia passed through a 1-inch pipe that extended past the two acid inlets and two inches into the outlet arm or reaction tube. The reaction tube was a 3-inch stainless steel (series 316L) pipe about 7 feet long and jacketed in an 8-inch mild steel pipe. It was expected that the ammonia would be completely vaporized in the hot annular space between the pipes. Previous experience had shown that charging liquid anhydrous ammonia directly into a pipe reactor could cause a violent reaction (1, 2, 3).

The pipe reactor discharged into a conventional 8' by 16' TVA-type rotary ammoniator-granulator. Figure 3 shows the pipe-cross installation and the associated sparging equipment. Figure 4 is the plant flow diagram. Material from the granulator is dried in an 8' by 50' rotary cocurrent dryer. Oversize is removed from the material discharged from the dryer by two 4' by 15' Tyler-Hummer screens. The oversize is crushed in a modified hammermill, which has the good features of both the hammer and chain mills. This crushed oversize is returned to the ammoniator-granulator. A damper is installed in the chute between the dryer and cooler so that some of the product and undersize can also be recirculated to the granulator. Figure 5 shows a sketch of this unique recycle control mechanism. Material from the screens is cooled in an 8' by 50' rotary countercurrent cooler. The material from the cooler is again screened, and fines and crushed oversize are recirculated to the granulator. A damper is also installed in the product chute to storage so that part of the final product from storage can be recirculated to the granulator. The total throughput capacity (product plus recycle) is about 100 tons per hour.

The first test was unsuccessful because strong vibrations in the reactor shook the granulator so violently that the unit could not be operated. It was obvious that the ammonia was not being vaporized enough to prevent violent reaction in the pipe. Because the objective was to prereact the acid in equipment less complicated than the preneutralizer (and not to produce polyphosphate), it was decided to charge hot aqua ammonia to the reactor instead of anhydrous ammonia. Previous small-scale tests had shown that acids reacted much more smoothly with aqua ammonia than with liquid anhydrous ammonia.

The reactor was rearranged as shown in figure 6. Hot aqua, made by premixing ammonia and water, was charged to the pipe cross. About 4 parts by weight of ammonia was premixed with one part of water. It was anticipated that corrosion of the stainless steel would occur at the relatively high temperatures (about 300 degrees F.). For this reason cooling water was passed through the jacket. The pipe-cross reactor operated very smoothly with the hot aqua ammonia. Enough ammonia was added to neutralize the sulfuric acid (0.347 pounds NH_3 per pound 100% H_2SO_4) and to adjust the remaining ammonium phosphate portion of the slurry to a NH_3:H_2PO_4 mole ratio of 0.65. It was possible to produce grades such as 12-12-12 and 6-24-24 with minor proportioned sodium nitrate included in the formulation. There were no fires in the granulator and much less plume was emitted from the plant. However, after 10 days of operation, the stainless steel reaction tube failed because of corrosion. By that time, the supply of sodium nitrate had been exhausted.

Results of these preliminary tests showed that this type of reactor should be a practical replacement for a conventional preneutralizer in the production of ammonium and ammonium phosphate sulfates. Development was continued. A 3-inch Hastelloy C reaction tube was installed (figure 7) without a cooling-water manifold. Subsequent results showed the Hastelloy C tube to be corrosion resistant without cooling.

Production of Fertilizers Containing Monoammonium Phosphate

The pipe-cross reactor has been used successfully in the production of several $N:P_2O_5:K_2O$ mixtures such as 12-12-12, 6-24-24, 8-22-11 and 8-32-16. In all formulations the phosphoric acid was reacted with ammonia in such proportions as to form monoammonium phosphate (MAP). Figure 8 shows the solubility relationships of ammonia and phosphoric acid. These data show the relatively low solubility of ammonium phosphate produced by limiting ammoniation of the acid (or acids) to about 5 pounds of ammonia per unit of P_2'O_5 in the phosphoric acid (equivalent to MAP). This is desirable so that the liquid phase in the ammoniator-granulator will not become excessive when large proportions of phosphoric acid (as much as 1800 pounds of H_3PO_4 per ton of product) are used. Some reasons for formulating with large proportions of phosphoric acid are:

1. There is enough chemical heat of reaction to completely dry the product. The Missouri Farmers Association reports that with the use of the pipe-cross reactor no external heat is required to dry the product — an important advantage in view of the energy shortage.
2. Phosphoric acid is often more readily available than superphosphate, the usual phosphate material for mixed fertilizers.
3. The preference for ammonium phosphate grades by blenders.
4. Higher analysis grades can be produced from phosphoric acid than from superphosphates.
5. It may be more economical to transport phosphoric acid and ammonia to regional plants for production of ammonium phosphate mixtures than to produce DAP in primary plants and ship it to mixers. This may be especially true where ammonia can now be transported by pipeline and acid moved by barge.

Operating data and results obtained in production of an $N:P_2O_5:K_2O$ mixture by pipe cross are shown in test 1 of table 1. With the pipe cross, it was possible to produce the 6-24-24 grade at a rate of 28 tons per hour. About 34 percent of the required phosphoric acid and all of the sulfuric acid was fed to the pipe-cross reactor. The acid and ammonia feed rates were adjusted to convert the sulfuric acid to ammonium sulfate and the phosphoric acid to monoammonium phosphate ($NH_3:H_3PO_4$ mole ratio = 1.0).

The balance of the phosphoric acid was added to the granulator along with ammonia, potash, solid raw materials and recycle. The ammonia passed through a drilled stainless steel sparger beneath the surface of the tumbling material. Enough ammonia was added to convert all of the phosphate acid to monoammonium phosphate. Magnetic flowmeters controlled ammonia and acid feeds so that the pH of the product was held at 4 (pH of MAP). This extra control has improved the record of this plant for the production of ongrade product.

Melt from the granulator is almost anhydrous (1.8% H_2O). Analysis of the exit gases from the ammoniator-granulator and dryer-cooler scrubber is shown in table 2. The exit gases were sampled with the pipe cross in operation to produce a 6-24-24 grade (test 1) and without the pipe-cross (test 2).

One-third as much particulate was lost from the ammoniator-granulator with the pipe cross as without it. About 1800 pounds of water per hour was removed from the granulator when the pipe cross was operated. In both tests the loss of chlorine and fluorine was mil. Thus, the pipe-cross operation eliminates the troublesome emission of ammonium chloride particulate from the granulator — a problem that has plagued the industry for years. The amount of ammonia loss from the pipe reactor could not be determined because during the sampling period the scrubber liquor of the ammoniator-granulator had a pH of about 8.0. Therefore, it was not known if the ammonia loss that was detected was due to stripping of ammonia from the scrubber liquor, or if part of the loss was from the pipe-cross reactor. There was not an excessive ammonia odor in the granulator area, and when the pH of the scrubber liquor was lowered to 5.0, no ammonia could be detected in the exit gases of the plant stack. It is important to note that as of now we do not know if there is an ammonia loss from the pipe-cross reactor. However, if further tests show a loss, the ammonia could be recovered in a wet scrubber and the scrubber liquor would be returned to the ammoniator-granulator. This is current practice at the Missouri Farmers plant.

The amount of chlorine in exit gases from the dryer-cooler scrubber with the pipe reactor was half that without the reactor. So there was considerably less plume from the plant stack when the pipe-cross reactor was operated. The losses fall well below maximum tolerances for particulate allowed by most state pollution control regulations. There was also a high loss of ammonia from the dryer-cooler stack; however, this was because of the high pH of the scrubbing liquor and could be avoided if the pH of the liquor was adjusted with a small amount of the feed acid.

In the production of 6-24-24 with the pipe reactor a little external heat (natural gas) was applied to dry the product to a moisture content of 0.4 percent. Bulk and bag storage tests show excellent storage characteristics of the product. Fuel consumption data from the plant show a fuel savings of about 50 cents per ton of product fro the pipe cross in making monoammonium phosphate sulfate grades over conventional equipment and formulations. Fuel savings or elimination of the fuel requirements are important. In many instances, plants cannot obtain natural gas at any cost.

Similar results were obtained in the production of the 8-32-16 and 12-12-12 grades. The tests show that about 0.3 pounds of water per pound of ammonia was required for smooth operation of the pipe-cross reactor. However, lower water rates were not tested. Adding water may contribute to preventing scale formation in the pipe-cross reactor. Generally, there is considerable trouble with scaling in pipe reactors in which anhydrous ammonia and acid are reacted.

The average recycle rate for the production of the three grades was about two pounds of recycle per pound of product. This is somewhat higher than the 1:2 ratio usually obtained when superphosphate is a material, but not so high as to make the process impractical for most of the regional ammoniation-granulation plants.

Production of Monoammonium Phosphate, 12-48-0

This grade is not straight monoammonium phosphate. Sulfuric acid and ammonia are added to adjust the N:P_2O_5 ratio to 1:4, which is more suitable for bulk blends.

Results of two tests for the production of the 12-48-0 are shown in table 3. In test 1 the plant was operated at 15 tons per hour and a recycle rate of 4.1 pounds of recycle per pound of product. All the sulfuric acid and 32 percent of the phosphoric acid was added to the pipe-cross reactor. The remainder was dribbled onto the surface of the material in the granulator. Enough ammonia was added to the pipe cross to convert the sulfuric acid to ammonium sulfate and ammoniate the phosphoric acid to a NH_3:H_3PO_4 mole ratio of about one. About 50 percent of the total ammonia required was added to the pipe reactor. About the same quantity of water per pound of ammonia was added to the pipe cross as was added in the production of NPK grades. Slurry from the pipe reactor contained 4.8 percent water which is substantially lower than the 10 to 25 percent moisture usually found in slurries from preneutralizers. At this low moisture level the melt sprayed uniformly onto the surface of material in the granulator.

The average temperature of the melt from the pipe reactor was about 310 degrees F. The calculated $NH:_3H_3PO_4$ mole ratio of the materials fed to the pipe cross was 0.94, and at this degree of ammoniation there was no excessive ammonia odor at the ammoniator-granulator platform. The amount of water evaporated in the reactor was calculated to be 2100 pounds per hour, or 140 pounds per ton of product. The exhaust blower for the granulator (capacity 10,000 cfm) was large enough to remove all water vapor.

Average temperature of the material from the granulator was 228 degrees F., and its average pH was 4.1. When the pH was increased above 4.5 or decreased below 3.5, overgranulation occurred; when operations were continued at this high or low pH, the plant had to be shut down due to overloading of the crushers. During the entire test of 16 hours, there was some need to recirculate sized product to the granulator. A total of 2093 pounds of acids per ton of product was used in the formulation, which is about five times the quantity normally used in a conventional ammoniator-granulator.

Because of the high temperature of material from the granulator, it was possible to dry while cooling the product. No external heat was required in the dryer which was operated as a rotary cooler. There were no crushing or screening problems. The product was dry (1% moisture) and free flowing, and the granules were almost perfectly round. The product had excellent storage characteristics and did not dust excessively when removed from storage.

In test 2, a 12-48-0 grade was produced at an average production rate of 20 tons per hour and an average recycle rate of 3.4 pounds of recycle per pound of product. The reason for the higher production rate in test 2 as compared with test 1, was the average size of the recycle was smaller in test 2. Therefore, the surface area was higher in test 2 than in test 1 which provided more area to be wetted without causing overgranulation.

The average temperature of material from the granulator was 244 degrees F. and its average pH was 4.0. the pH was critical in this run and, to maintain this production rate, it was necessary that the pH of the material from the granulator be kept in the range of 3.8 to 4.2.

No heat was required in the dryer which was operated as a cooler. There was no difficulty in screening, crushing, and cooling the product. The product has an excellent size distribution for bulk blending. One precaution which should be observed in starting up the pipe-cross reactor is to add the acids and water to the cross before the anhydrous ammonia feed is started. On one occasion in which this procedure was not followed there was a slight explosion inside the pipe. This procedure avoids plugging of the pipe during start-up.

There was some corrosion of the Hastelloy C tube after it had been in operation for about a year. Several holes appeared in a narrow strip along the bottom portion of the tube. There seemed to be no corrosion in the rest of the tube. Plant operators have patched the holes with Hastelloy C welding rods and turned the pipe so the patch section is now located at the top of the tube. They expect to receive at least another year's operation before the tube will need replacement. Perhaps this corrosion could have been prevented if a higher degree of ammoniation could have been maintained in the reactor. Analyses of melt samples show that in many instances the degree of ammoniation of the phosphoric acid was as low as 0.4 $NH_3:H_3PO_4$ mole ratio. It was difficult to supply enough ammonia for the acid because the back pressure that developed in the small pipe (3-inch) caused the acid rates to fluctuate at high production rates. It is believed that with a larger pipe it will be easier to consistently ammoniate to higher pH. Also, corrosion data indicate that Hastelloy B metal may be more suitable for the reaction tube than Hastelloy C. A short test was conducted using a teflon-lined elbow (90 degrees) at the discharge end of the reaction tube. After about one month of operation the elbow failed.

Advantages for Pipe-Cross Reactor

Some of the advantages found for the substitution of the pipe-cross reactor for the preneutralizer in a conventional ammoniator-granulator plant are:

1. Large proportions of acid, both phosphoric and sulfuric, can be used in the formulations.
2. No dryer is required — with consequent fuel savings.
3. There is less formation of the troublesome ammonium chloride fume which is difficult to scrub or remove from exit gases.
4. The investment cost of a pipe-cross reactor is much lower than that of a preneutralizer.
5. The pipe-cross reactor is much easier to operate because no slurry pumps, lines, meters, etc., are required for transporting slurry.
6. The moisture content of the slurry, or melt, from the pipe-cross reactor (about 1 to 4%) is much lower than that of slurry from a preneutralizer (10-25%); therefore, the moisture balance of the process with the pipe-cross reactor is much more favorable than with the preneutralizer process.
7. The pipe-cross reactor provides a convenient means of producing a granular monoammonium phosphate that should be an excellent product for blending. A wider range of grades can be blended with monoammonium phosphate (12-48-0 or 11-55-0) than with 18-46-0.

Design Factors for the Pipe-Cross Reactor

Some of the design factors which should be considered in design of this reactor are as follows:

1. Cross section area. BTU per hour per square inch of cross section. The maximum heat released in the pipe was 1.0 MM BTU per hour per square inch of cross section. When this value is exceeded, the back pressure in the pipe cross exceeds 40 psig and it is difficult to pump the acids into the pipe cross.
2. It is recommended that the reaction tube of the reactor be at least eight feet long and long enough to discharge melt over the first half of the length of the bed.
3. The pipe cross of the reactor should be made of stainless steel pipe type 316L. The reaction tube section should be made of Hastelloy C or B.
4. The one-inch pipe for adding hot aqua ammonia to the reactor should also be stainless steel (316L) and its length should extend into the Hastelloy C reaction tube.

There are now three pipe-cross reactors in operation. No unusual difficulties have been reported with their operation, except for the minor corrosion problems mentioned earlier. However, corrosion can probably be eliminated by operating at a higher degree of ammoniation in the pipe, or perhaps using a reaction tube made of Hastelloy B. Preliminary tests indicate it may be possible to produce diammonium phosphate (18-46-0) in the pipe reactor. It has been shown that if the water added to the reactor is increased so that the moisture content of the slurry from the reactor is 15 ot 20 percent and the slurry $NH_3:H_3PO_4$ mole ratio is 1.45, there is not an excessive loss of ammonia from the reactor. With this higher degree of ammoniation in the pipe reactor, it should be possible to further ammoniate the slurry to diammonium phosphate ($NH_3:H_3PO_4$ mole ratio of 2.0).

Tests are continuing in efforts to further develop the pipe-cross reactor process and to determine its various applications in the production of improved fertilizers.

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3. Meline, R. S., Lee, R. G., and Scott, W. C., TVA, "Use of a Pipe Reactor in Production of Liquid Fertilizers with Very High Polyphosphate Content," *Fertilizer Solutions,* March-April 1972, pp. 32-45.

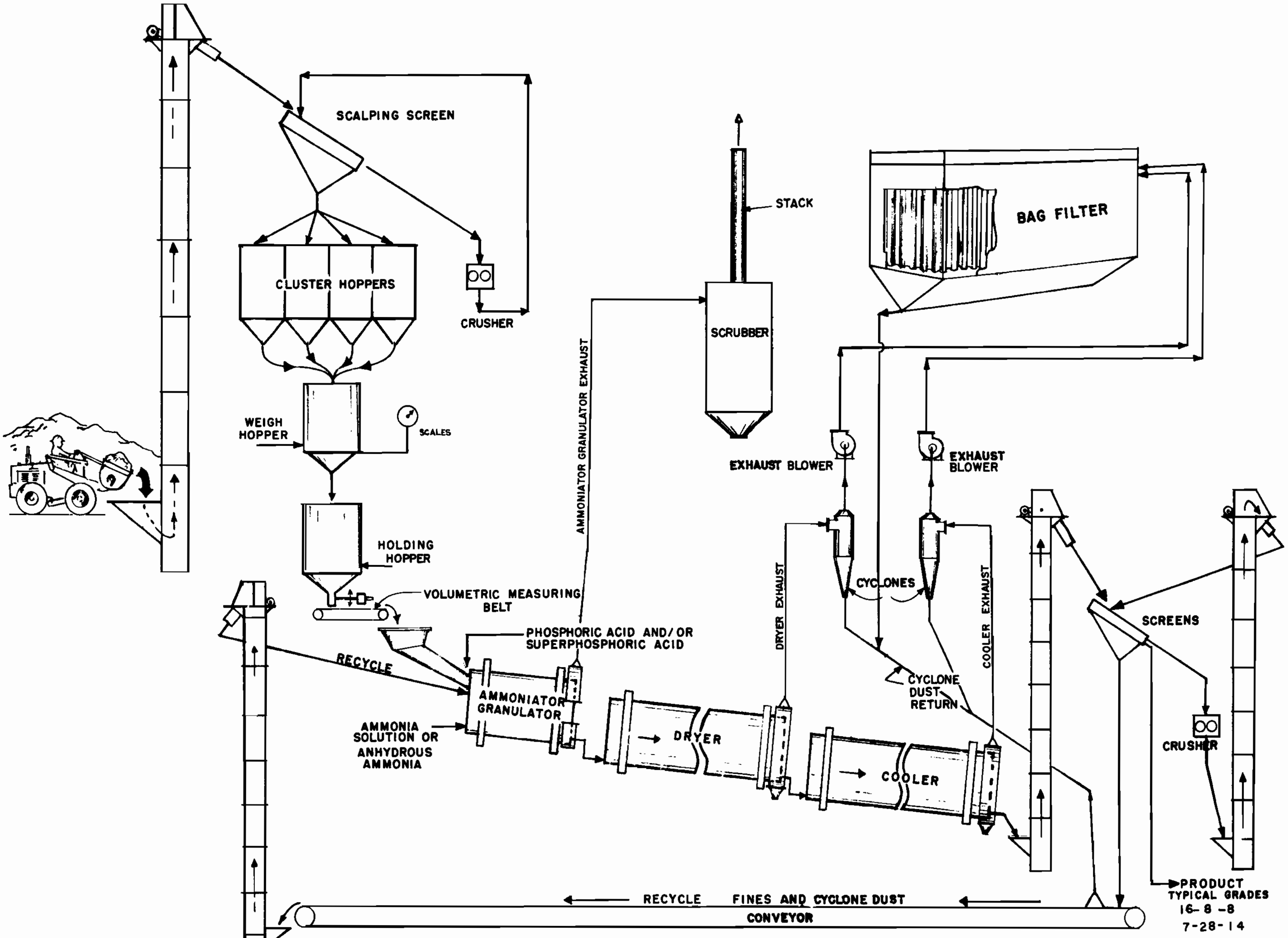


FIGURE 1

AMMONIATION–GRANULATION PLANT

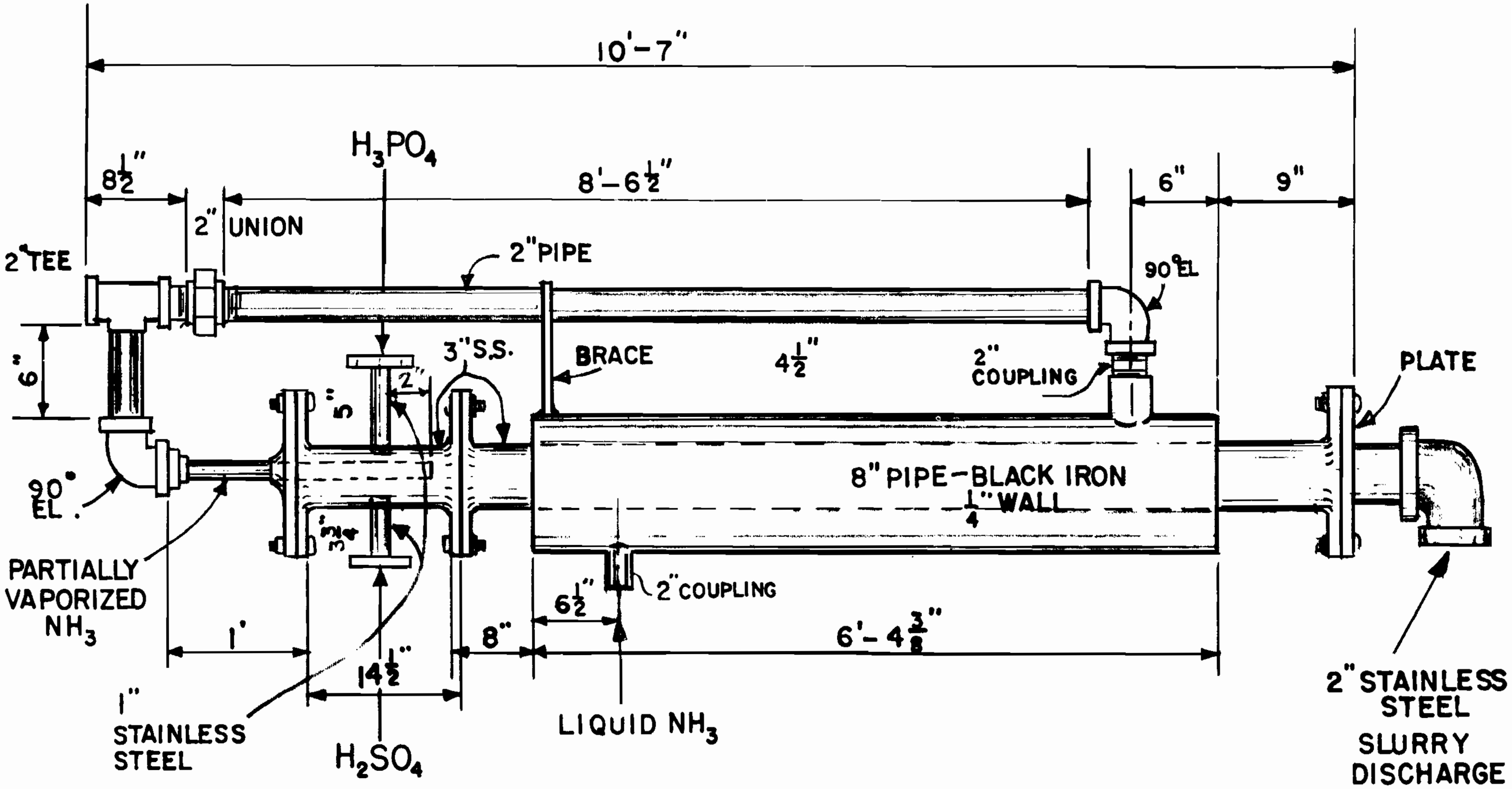
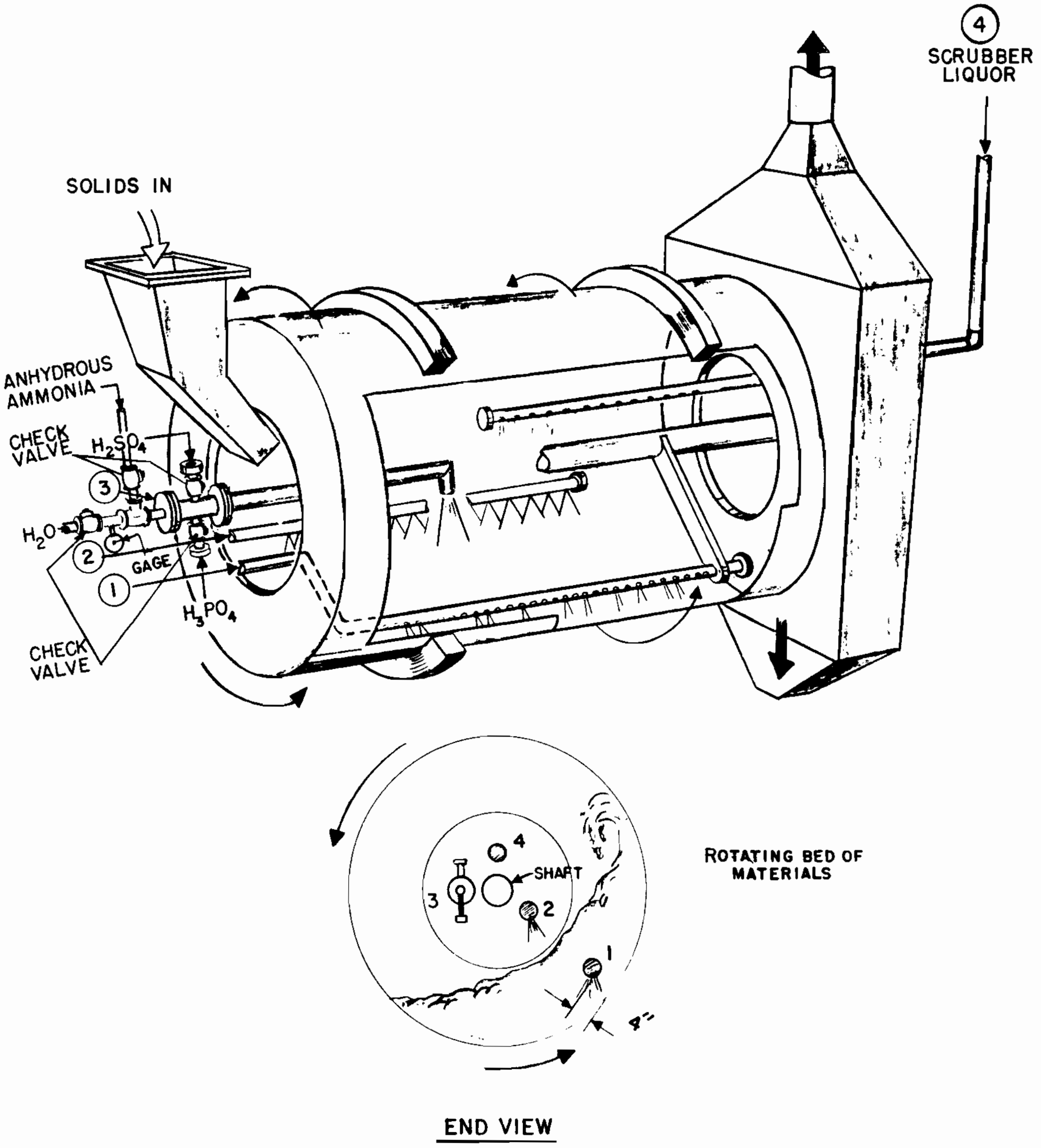


FIGURE 2

PIPE-CROSS REACTOR

STAINLESS STEEL REACTION TUBE, AMMONIA VAPORIZER



①	AMMONIA SPARGER	LOCATED AT THE 4 O CLOCK POSITION $4\frac{1}{2}$" FROM GRANULATION SHELL WITH HOLES FACING THE ROTATING STREAM OF MATERIALS. OVERALL LENGTH-12 FEET. ONE HUNDRED AND FORTY TWO $\frac{1}{16}$" HOLES ON ONE INCH CENTERS WITH SMALL QUANTITY OF WATER ADDED TO PREVENT CAKE AROUND SPARGER.
②	PHOSPHORIC ACID SPARGER	LOCATED TO DISCHARGE PHOSPHORIC ACID ONTO THE TOP AND NEAR THE CENTER OF THE ROTATING BED OF MATERIALS. OVERALL LENGTH-8.9 FEET. SIXTEEN $\frac{3}{8}$ INCH HOLES ON THREE INCH CENTERS.
③	PIPE-CROSS REACTOR	
④	SCRUBBER LIQUOR	LOCATED ABOVE THE BED IN GRANULATOR TO DRIBBLE SCRUBBER LIQUOR ONTO BED.

FIGURE 3

LOCATION OF PIPE CROSS REACTOR AND SPARGERS IN AMMONIATOR-GRANULATOR

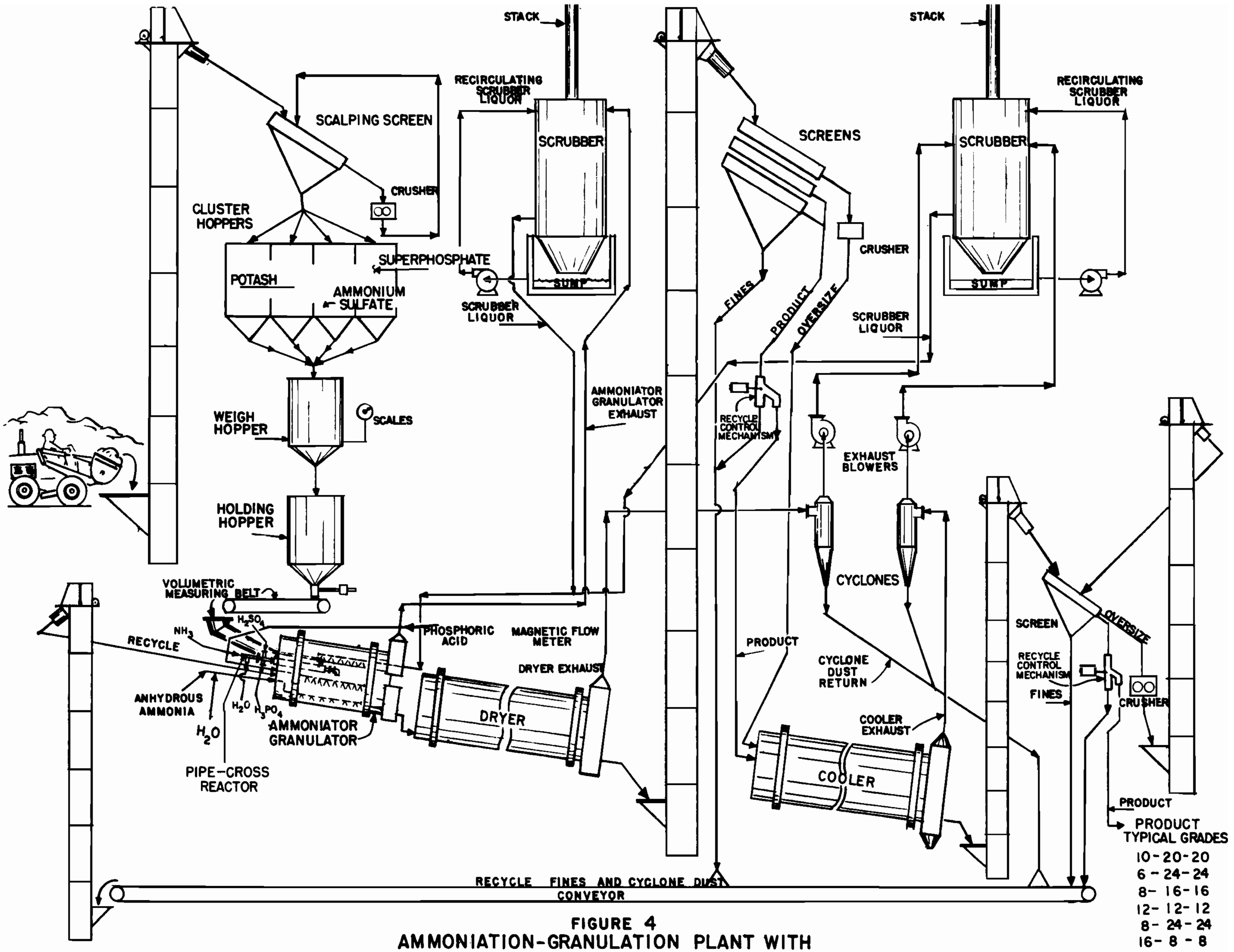


FIGURE 4
AMMONIATION-GRANULATION PLANT WITH PIPE-CROSS REACTOR

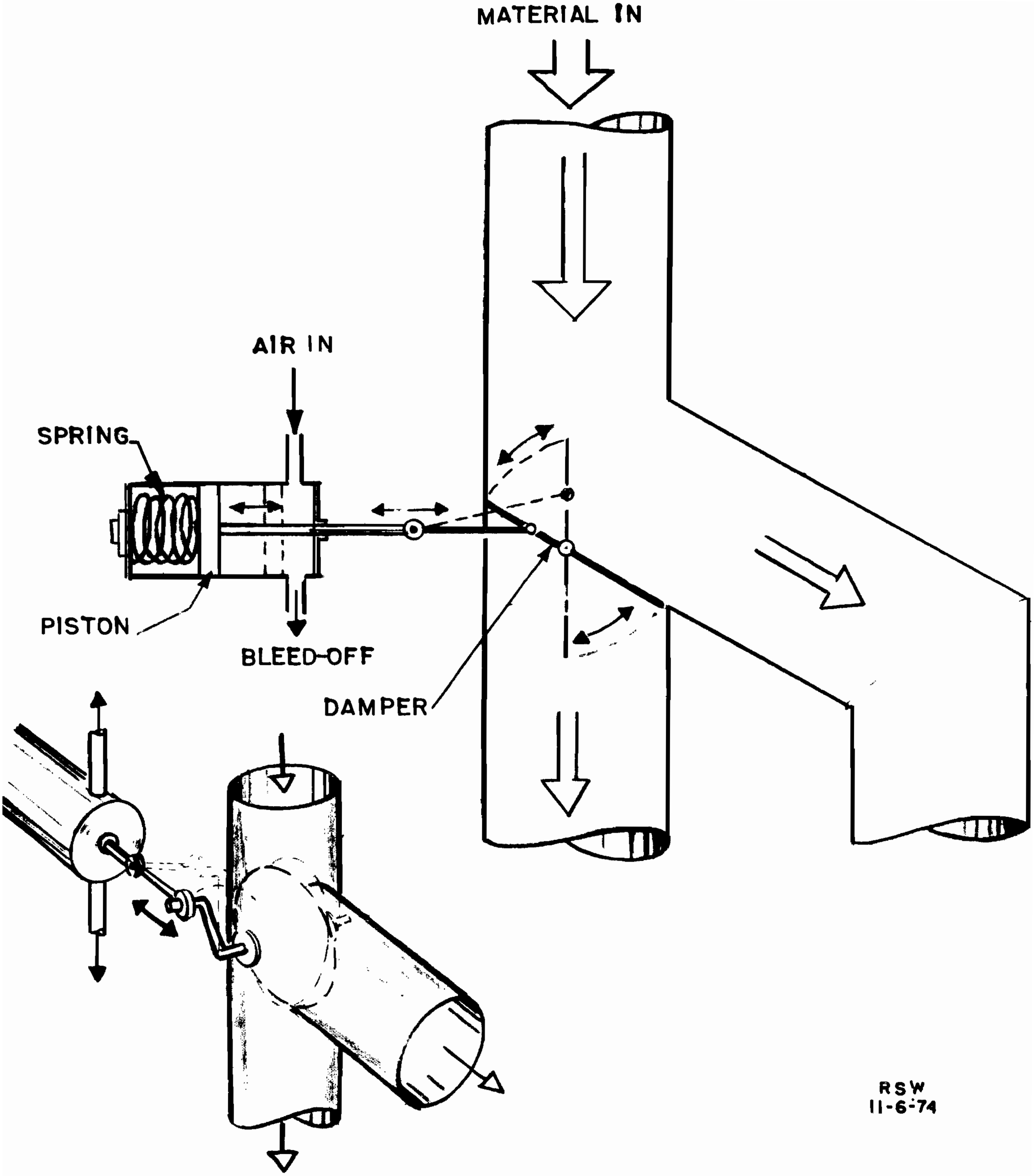


FIGURE 5

RECYCLE CONTROL MECHANISM

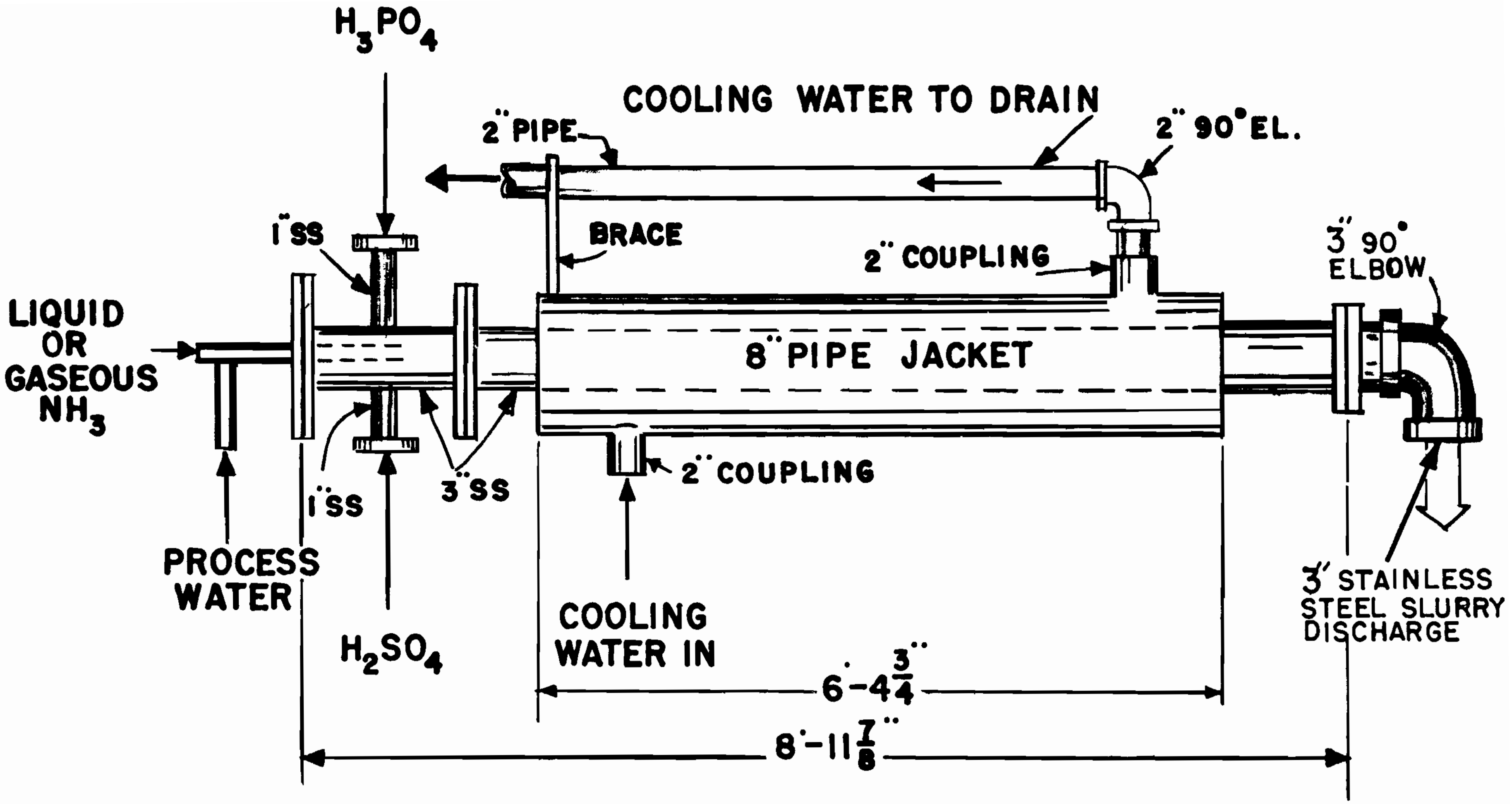


FIGURE 6

PIPE-CROSS REACTOR–STAINLESS STEEL REACTION TUBE, AQUA AMMONIA, COOLING WATER JACKET

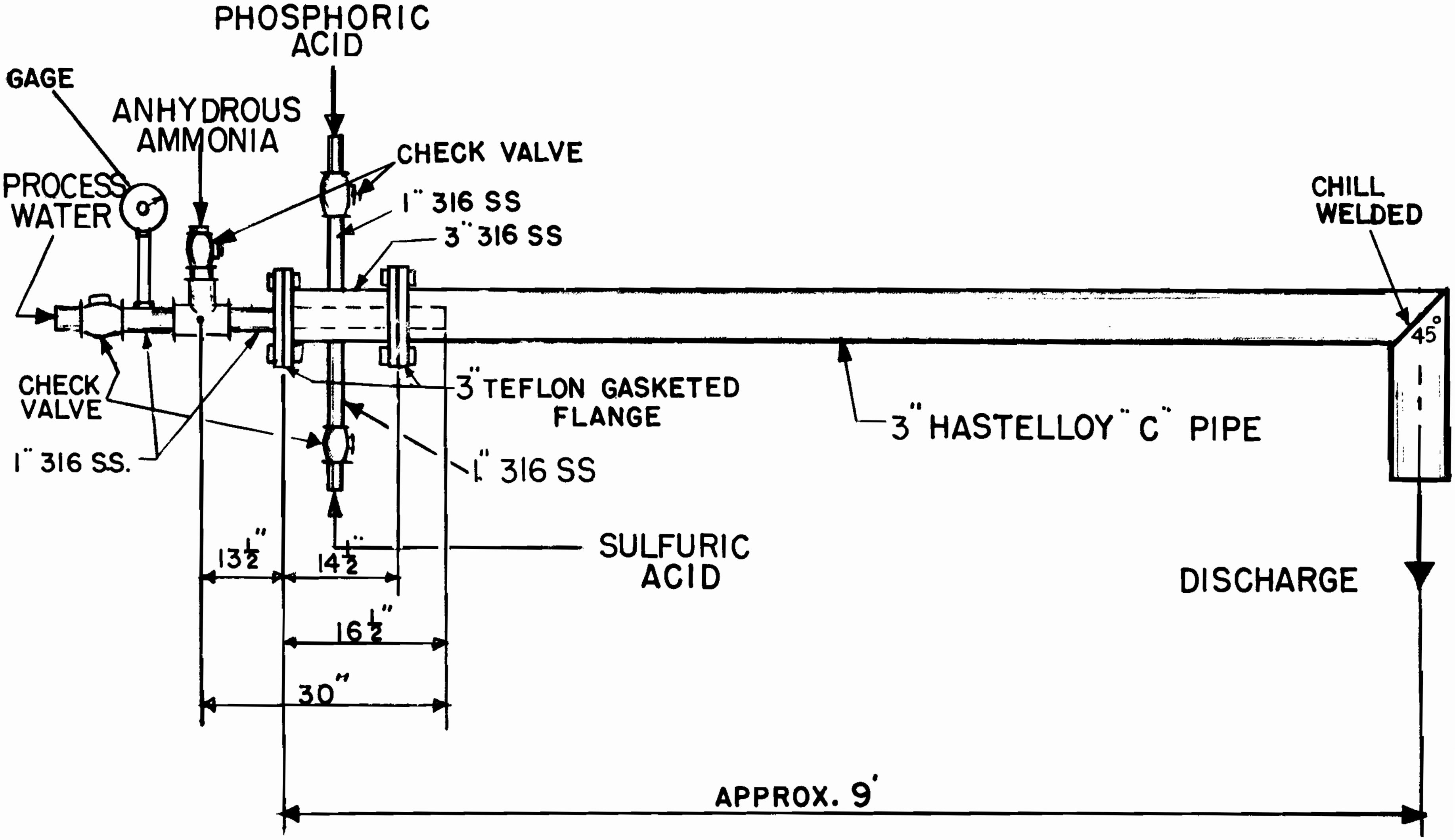


FIGURE 7

PIPE-CROSS REACTOR

HASTELLOY "C" REACTION TUBE, AQUA AMMONIA

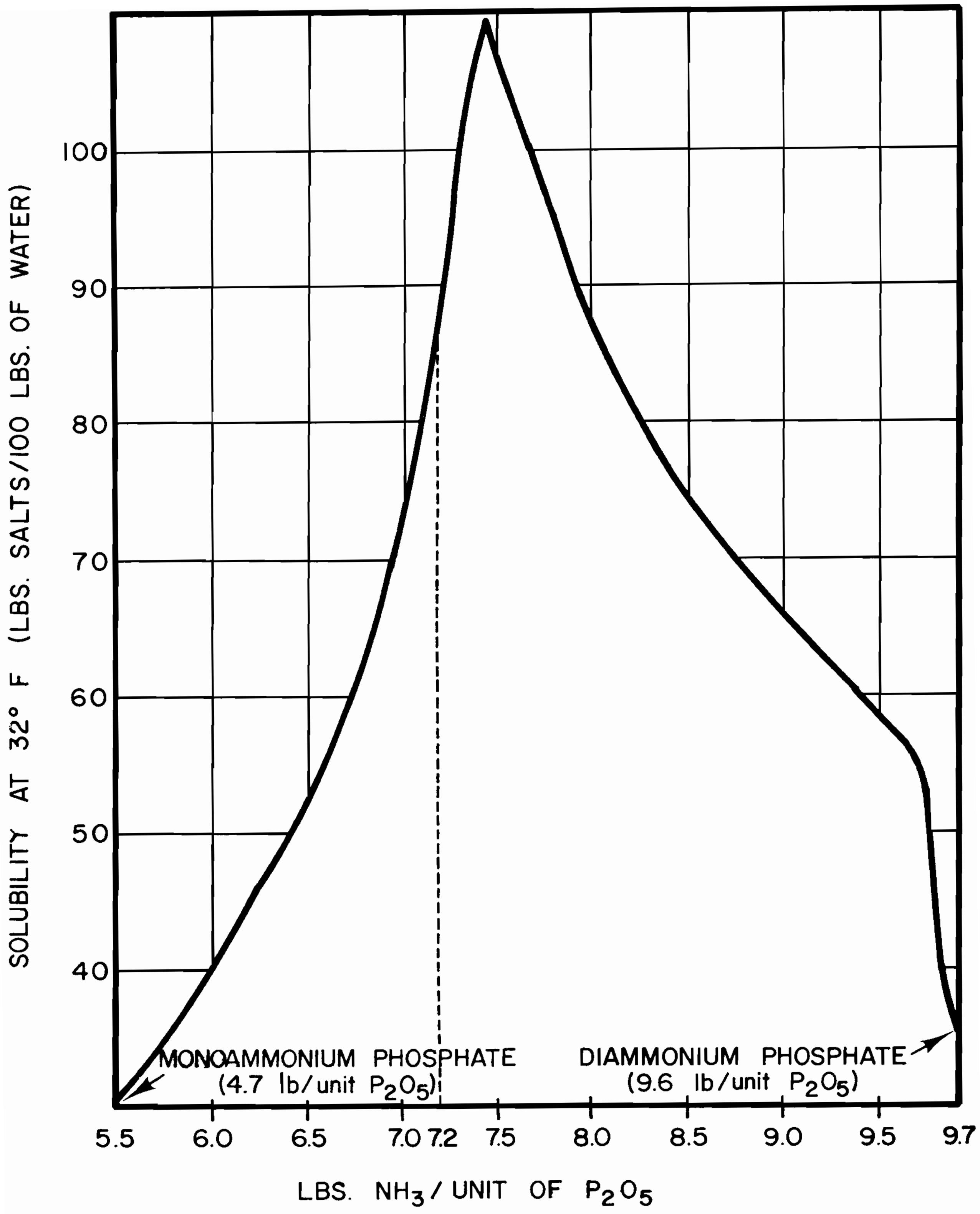


FIG. 8
SOLUBILITY OF SATURATED AMMONIUM PHOSPHATE SOLUTION

Table 1

Production of Monoammonium Phosphate Sulfate Utilizing TVA Pipe-Cross Reactor[a]

Test Number		1
Formula Number		B-613
Grade		6-24-24
Formulation, lbs. per ton product		
Pipe-Cross Reactor		
Ammonia		72
Sulfuric acid (66°Be)		103
Phosphoric acid (54% P_2O_5)		308
Water		23.6
Ammoniator-Granulator		
Ammonia		78
Phosphoric acid (54% P_2O_5)		600
Potash (60% K_2O)		809
Filler		191
Scrubber liquor		63.8
Duration of test, hr		8
Operating results		
Production rate, tons per hr		28
Recycle ratio tons, recycle/ton product		1.01[b]
Granulator, product average pH		4.0
Temperature, °F (average)		
Material from granulator		209.7
Material from dryer		157
Dryer exit gas		165
Product to storage		90.6
Chemical heat		
Released in pipe-cross reactor, 10^6BTU/in^2/hr		0.61
Released in formulation 10^3BTU/ton		348.9
Total wt acid, lbs/ton product		1011
Product Chemical Analysis, %	N	6.4
	P_2O_5	23.9
	K_2O	24.0
	H_2O	0.4
Product Screen Analysis, % (Tyler Screen)	+6	1.8
	-6+8	22.8
	-8+12	40.4
	-12+14	14.3
	-14+16	8.2
	-16+20	7.7
	-20	4.8
Scrubber liquid flow rate, gpm[c]		472

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[a] Three-inch pipe

[b] Calculated, by measuring volume of material on recycle belt

[c] Measured in wooden trough

Table 2

Stack Emissions From Ammoniator-Granulator and Dryer Scrubbers

Test No.	1	2
Grade	6-24-24	6-24-24
Pipe-cross reactor in use	Yes	No
Exit gas rates, ft^3/min[a]		
Ammoniator-granulator stack	10,200	14,500
Dryer-cooler stack	40,700	46,700
Losses, lbs/hour		
Ammoniator-granulator scrubber		
Particulate	0.33	1
Ammonia	165[b]	37
Fluorine	nil	nil[c]
Chlorine	nil	nil
Water	1790	900
Dryer-cooler scrubber		
Particulate	7	7
Ammonia	11	65
Fluorine	nil	nil
Chlorine	0.5	1
Water	5870	8670
pH of scrubber water	7.0	7.7
Temperature of scrubber water, °F	130	130
Percent nitrogen losses		
Percent of total N from granulator	4.0	1.7
Percent of total N from dryer-cooler	0.3	1.8
Total NH_3 loss, percent of total	4.3	3.5
Total pounds of particulate per pound of product x 10^{-4}	1.3	1.3
Total pounds of ammonia per pound of product x 10^{-4}	40	16.3
Total pounds of losses per pound of product x 10^{-4}	41.3	17.6

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[a] Gas density at one atmosphere and 100°F.

[b] 209 lbs. actually measured minus 34 lbs. expended during sparger cleaning.

[c] "Nil" denotes amounts not measurable.

Table 3

Production of Monoammonium Phosphate Sulfate Utilizing TVA Pipe-Cross Reactor

Test Number		1	2
Formula Number		B-MAP-4	B-MAP-4
Grade		12-48-0	12-48-0
Formulation, lbs/ton of product			
Pipe-Cross Reactor			
Ammonia		147	147
Sulfuric acid (66° Be')		228	228
Phosphoric acid (54% P_2O_5)		600	600
Water		59	59
Ammoniator-Granulator			
Ammonia		146	146
Phosphoric acid (54% P_2O_5)		1265	1265
Duration of test, hr		16	16
Operating results			
Production rate, tons/hr		15	20
Recycle ratio, tons recycle per ton product		4.1[a]	3.4[a]
Granulator, product average pH		4.1	4.0
Temperature, °F (average)			
Material from granulator		228	244
Dryer exit gas[b]		173	174
Product temperature (estimated)		110	110
Chemical heat			
Released in pipe-cross reactor 10^6 Btu/in^2/hr		.73	.98
Released in formulation 10^3 Btu/ton product		686	686
Total wt. acid in formulation, lbs/ton product		2093	2093
Product chemical analysis, %	N	12.8	12.9
	P_2O_5	46.5	46.9
	H_2O[c]	1.2	1.2
Product screen analysis, % (Tyler Screen)	+6	0.6	1.0
	-6+8	36.0	60.6
	-8+12	63.0	38.2
	-12+14	0.3	0.2
	-14+16	0.1	0
	-16+20	0	0
Recycle screen analysis, % (Tyler Screen)	+6	0	0
	-6+8	11.1	18.2
	-8+12	64.6	48.6
	-12+14	14.6	15.2
	-14+16	6.3	9.5
	-16+20	2.4	6.3
	-20	1.0	2.2

---

[a] Calculated by measuring volume of material on recycle belt

[b] Burner off during all these tests, dryer used as a cooler

[c] Estimated by doubling the results of the rapid analysis method

MODERATOR NIELSSON: Thank you, Frank. It was a good paper, a lot of good information. We are running close on time, a little bit over; and we will save all our questions because we have a panel discussion afterwards primarily for questioning anyway.

Our next paper is on "The Agronomic Aspects of Urea". There is more and more use for urea throughout the world. There are also more and more questions about how does urea behave in this country. They don't have too many questions in other parts of the world. The speaker is Dr. Roland Hauck of TVA. He has been 15 years with TVA. He is a soil scientist, got his B.S. at North Central Illinois University and his master's and doctorate degrees at the University of Illinois. He has worked for the past 15 or 16 years with nitrogen chemistry in soils. So he should be a good one to tell us about what happens with urea. Dr. Hauck Please.

Urea: Soil Chemistry and Agronomic Efficiency

Roland D. Hauck

World use of urea as a nitrogen fertilizer has increased steadily since 1965 and there seems little doubt that urea will become the major solid nitrogen fertilizer in world agriculture. In the U.S., urea production capacity has more than tripled during the period 1965-1975. It is evident that special attention should be given to the problems sometimes encountered in the use of urea as a fertilizer. These problems result largely from the rapid hydrolysis of urea to ammonium carbonate in most soils through soil urease activity and the concomitant rise in pH and liberation of ammonia. They include damage to germinating seedlings and young plants, nitrate toxicity, and gaseous loss of urea nitrogen as ammonia.

In the U.S., urea has been used mostly in solid form for direct application and for nitrogen solutions. Until recently, little urea was incorporated into granular mixed fertilizers, but this situation is now changing rapidly as urea is replacing ammonium nitrate in solid mixed goods. The inclusion of urea in mixed fertilizers somewhat limits their versatility because an examination of the chemistry of urea in soils reveals that urea, alone, or in combination with other fertilizer, cannot be surface-applied, without following with tillage nor banded without running the risk of decreasing the efficiency of nitrogen use.

Urea belongs to that class of water-soluble fertilizers which form an alkaline microsite in soil at the point of application. Particles of diammonium phosphate and urea ammonium phosphate fertilizers also form alkaline microsites after they dissolve and hydrolyze in soil. On the other hand, ammonium sulfate, ammonium chloride, ammonium nitrate, and monoammonium phosphate form acid microsites. In acid soils, especially those of low buffer capacity, nitrogen fertilizers which form alkaline microsites nitrify at a faster rate than acid-hydrolyzing fertilizers. For example, in an acid soil, urea nitrifies faster than ammonium sulfate, while in calcareous, well-buffered soils, there may be little difference in nitrification rate between these materials. Banding urea or diammonium phosphate can result in nitrite accumulation in either acid or alkaline soils, whereas nitrite will not accumulate in bands after addition of acid-hydrolyzing nitrogen fertilizers, with the possible exception of band application of ammonium sulfate applied to calcareous soils. The chemistry and biochemistry of the reactions leading to these effects are fairly well understood. The principles involved can be uses as a guide toward increasing the efficiency of nitrogen fertilizer use, especially in regard to urea.

The efficiency of urea as a fertilizer can be increased by coating urea particles with some material that slows their rate of dissolution in soils, through use of chemicals that will inhibit soil urease activity or nitrification when applied to soils in conjunction with fertilizer urea, by mixing urea with substances which lower the pH of the urea particle site after hydrolysis, and by improved management.

The main problem with the coating approach has been to find effective low-cost coating materials and to develop satisfactory methods of applying them. Progress towards solution of this problem has been made by the Tennessee Valley Authority by their development of sulfur-coated urea. This product shows the most promise of being useful for areas in which there is excessive loss of fertilizer nitrogen by leaching or volatilization. Coating urea and other soluble nitrogen fertilizers not only slows their rate of solution, but also control to some extent the rate at which nitrogen is supplied to the plant. Controlling the rate of urea dissolution can increase efficiency of urea use by preventing the rapid buildup of high ammonium carbonate concentrations at the fertilizer-soil microsite. Many chemicals that will inhibit soil urease activity have been tested recently. Substituted p-benzoquinones seem the most effective of the chemicals thus far proposed for this purpose, and 2, 5-dimethyl-p-benzoquinone shows promise of being useful for reducing gaseous loss of urea nitrogen as ammonia from sandy soils. There is evidence that a combination of chemicals will probably be needed to effectively block the complex mass of urease activity in fine-textured soils. However, a urease inhibitor needs to be effective only for a comparatively short time, long enough for the diffusion process or rainfall to dilute the urea concentration at the microsite. In contrast, a nitrification inhibitor, in order to be effective, must protect against nitrification of fertilizer-derived ammonium for several weeks. A chemical that will inhibit both urea hydrolysis and nitrification in soils would be ideal.

The nitrification reaction has three main effects on the efficiency of nitrogen fertilizer use: (1) It affects plant nutrition because the rates of assimilation of ammonium and nitrate by plants can be different. (2) It may lead to nitrogen loss by leaching because it converts a relatively immobile, cationic form of nitrogen to a mobile, anionic form. (3) It produces oxidized forms of nitrogen which are susceptible to loss through denitrification. Nitrification inhibitors have contributed to an increase in urea use efficiency under these conditions where formation of urea-derived nitrate could result in nitrogen loss from the soil-plant system.

Problems of urea use associated with the high pH and ammonium concentrations at the fertilizer-soil microsite can be ameliorated in part by practices which decrease microsite pH. Mixing ammonium sulfate or acid phosphates with urea prior to granulation has reduced ammonia loss from surface-applied urea, but additional research is needed to evaluate this approach. Fertilizer application methods which prevent the association of 2 or more urea particles at a single microsite can increase urea efficiency, and knowledge of fertilizer-soil microsite chemistry can explain why ammonia will evolve from soil at high urea application rates but not at lower rates.

Misuse of urea can result in considerable reduced efficiency. However, when used according to the best available information on its use, there is no measureable difference in the efficiency of urea and other nitrogen fertilizers in most cropping situations.

MODERATOR NIELSSON: It gives me joy to hear a paper which is not technical in a somewhat related subject but which keeps me interested throughout the entire paper.

As I was listening to Dr. Hauck's talk, it occured to me that as you read the old Proceedings and come through to the new ones you may realize that the papers change somewhat and the technologies seem to be getting better; but the one thing you won't realize is that the quality of the presentations themselves has definitely improved throughout and that was a good one. Thank you, Doctor.

Our next speaker will describe the "Use of Urea in Bulk Blends." This is a combination paper by George Hoffmeister and George Megar. George Hoffmeister will present the paper. He is a chemical engineer from Rice University. He has been 33 years with TVA, is Section Supervisor for Product Evaluation for the Applied Research Branch. George Please.

Use of Urea In Bulk Blends

George Hoffmeister and George H. Megar

Presented by George Hoffmeister

Production of urea for fertilizer use in the United States has increased steadily since 1960. During this time, about half of the urea has been applied as solution, and half as solid prills. At present, the tonnage of fertilizer nitrogen produced as solid urea still is only about half as great as that produced as solid ammonium nitrate; but, based on present plant construction and announced plans, the indications are that total urea production soon will equal or exceed that of ammonium nitrate[1]. Advantages of urea spurring this growth are its lack of fire and explosion hazard, higher analysis, lower hygroscopicity, better storage properties, lower pollution level in manufacture and use, and lower overall production cost.

With this increased availability of solid urea, bulk blenders have come face-to-face with its use in place of their old standby nitrogen source, ammonium nitrate. As with most changes, this has presented some new problems and uncertainties. In one of our TVA publications of 1972[10] we listed the following major problem:

1. Small particle size of prills promotes segregation
2. Mechanical weakness
3. Chemical incompatibility with nitrates
4. Limited chemical compatibility with superphosphates

Today, I will review briefly the progress that has been made on these problems since 1972.

The Problem of Particle Size

It is well established (*5, 6, 8*) that nonsegregating bulk blends can be made only from ingredients that are well matched in particle size distribution. Since diammonium phosphate is the phosphorus source in most bulk blends with urea, it is of interest to compare its particle size to that of the ureas available to blenders. Such a comparison is shown in Figure 1.

Improvement in Prills: The solid curve in Figure 1 represents the average particle size of granular diamonium phosphate produced in the United States, as determined in a 1973 survey by The Fertilizer Institute[2]. This is believed to be rather reliable average, since it is based on a full month's production analyses submitted by each of eight major producers. The origianal size problem with prilled urea is obvious by comparing the screen analysis curve labeled "small prilled urea." This curve, which is typical of most prilled ureas sold for fertilizer use during the early years of blending, deviates drastically (up to 56 percentage points) from the curve for the average diammonium phosphate, and these two materials segregate severely in blends.

In recent years, some producers of prilled urea have succeeded in increasing the average size of their products. Screen analysis typical of such "improved" prills is labeled in Figure 1 as "large prilled urea." This improved product contains considerably less minus 10-mesh fraction than the old type product and makes better blends with typical diammonium phosphate. However, prill producers apparently have had little success in increasing the proportion of 6- to 8-mesh fraction, which amounts to about 35% in typical diammonium phosphate. The deviation of the curve for large prilled urea from that of typical diammonium phosphate is still about 30 percentage points.

Granular Urea. A recent, very significant development in regard to improving the particle size of urea is the construction of a number of plants to produce granular urea that is of considerably larger particle size than prills. We understand that at present there are five urea granulation plants in operation in the United States using a drum-granulation process and that their combined production capacity is 3600 short tons per day. In addition, TVA is operating a pan-granulation demonstration plant with a capacity of 200 tons per day. If operation of all these plants for 300 days per year is assumed, the granulation capacity already is about three-fourths of that required to furnish all the solid fertilizer urea used in the United States last year. Also, we have been told that additional drum-granulation plants now in various stages of construction will substantially increase this capacity. The outlook is, therefore, that there will be abundant granular urea for blenders.

Particle size of the granular ureas marketed thus far has ranged from a good match with diammonium phosphate to excessively large. A screen analysis curve for some of the largest granular ureas being produced is shown in Figure 1 labeled "large granular urea." This material is almost 90% in the 6- to 8-mesh range, and deviates from the average diammonium phosphate by about 50 percentage points. Segregation tests in our laboratory indicated that material of this size will segregate from average diammonium phosphate about as severely as the old, small prills. We are told, however, that smaller granular product will be available commercially, at least from some producers. In our TVA pan-granulation demonstration plant, we have had good success in making granules of a size closely matching that of typical diammonium phosphate; a screen analysis from a period of good operation is shown in Figure 1 as "small granular urea."

We believe that efforts should continue in the direction of bringing the sizes of all blending materials, including urea and diammonium phosphate, into close agreement.

Harder Urea

In regard to the mechanical weakness of urea, introduction of granular urea has helped, because granules are larger and stronger. Also, it has been found that small proportions of certain additives in the urea melt are effective in hardening either prilled or granular urea. Formaldehyde is one such additive; this is effective in proportion of about 0.3 to 0.4% in the urea melt. Use of formaldehyde additive also usually eliminates the need for an anticaking dust coating and thus allows production of 46% N product.

Chemical Incompatibility of Urea with Nitrates

The chemical incompatibility of urea with ammonium nitrate is a problem that has been handled by education. Some blenders were at first actually turned away from urea because they tried to include it in blends with nitrates. Most blenders now realize, however, that any mixture of urea with nitrate will be excessively hygroscopic and that all possibility of mixing should be avoided. Mixtures of urea with ammonium nitrate have the unusually low critical humidity of 18% (at 86 degrees F.), and thus will absorb moisture rapidly under most atmospheric conditions.

Limited Compatibility of Urea with Superphosphates

In regard to the compatibility of urea with superphosphates, bulk blenders have reported widely varying results. Some report that they regularly blend urea with granular superphosphates and have no troubles. Others report that they tried such blending and ended up with a "gooey mess." It now appears that the differences in these reports have been a result of differences in reactivity of superphosphates, differences in exposure of superphosphates before blending, and differences in the time lag between mixing and field application.

A little over a year ago, we decided at TVA to do some more work on this problem, and the rest of this paper covers this work. The objectives were:

1. To compare the reactivity of superphosphates from various manufacturers and types of processes.
2. To see if superphosphate could be treated in some way to make it nonreactive with urea.
3. To see if urea could be treated in some way to make it nonreactive with superphosphates.

This problem is of interest also in developing countries where urea often is the most readily obtainable nitrogen source and superphosphate is a readily obtainable phosphate. The desire there usually is to blend the materials and bag the mixture. This would result in long contact time under pressure, and would require very low reactivity. In view of this overseas interest, part of the TVA work was funded by the U.S. Agency for International Development.

The Problem: The problem with urea-superphosphate incompatibility is not one of critical humidity lowering, as with urea and ammonium nitrate, but rather is a problem of chemical reaction. TVA chemists, Frazier, Lehr, and Smith[4], in 1967, identified the troublemaker as the following reaction:

$$Ca(H_2PO_4)_2.H_2O + 4CO(NH_2)_2 = \overset{\text{Adduct}}{\overline{Ca(H_2PO_4)_2.4CO(NH_2)_2}} + H_2O$$

One molecule of monocalcium phosphate monohydrate, the main constituent of superphosphates, reacts with 4 molecules of urea to form a urea-monocalcium phosphate adduct; and in doing so releases a molecule of free water. The adduct itself is highly soluble, thus it dissolves in the water to form a large volume of solution which wets the fertilizer. Once such wetting begins, the reaction is hastened and it spreads in chain-reaction fashion.

Reactivity of "As-Received" Triple Superphosphates: For our study of the reactivity of various triple superphosphates (TSP), we purchased tonnage quantities from five of the large U.S. producers. To evaluate their compatibility with urea, we blended a portion of each superphosphate with an equal weight of unconditioned prilled urea of 0.2% moisture content to give an approximate 23-23-0 grade blend; then we submitted each blend to three tests, as follows:

Bottle Test—

Tightly capped 4-ounce bottles of the blend were stored in a constant-temperature oven at 86 degrees F., and were inspected for wetting after 1 day, 3 days, 7 days, 1 month, and 3 months.

Small-Bag Test—

Three-pound moistureproof bags of the blend were stored under pressure for 1, 3, and 6 months. the storage was at ambient temperature and the pressure was equivalent to that in the bottom bag of a 20-bag stack of 50-pound bags.

Large-Bag Test—

Pressure and exposure conditions were the same as in the small-bag tests, but storage was in full-size 50-pound fertilizer bags of 7-mil polyethylene, and inspections were made only at 1 and 3 months.

In all three tests, at each inspection, we rated the condition of the blend according to the following scale:

Rating symbol	Blend condition
D	Dry, free flowing
W-1	Damp or wet in spots, but usable
W-2	Damp, slightly sticky, but probably usable
W-3	Wet and sticky throughout, unusable
W-4	Very wet, unusable
H	Caked hard, unusable

The five commercial TSP's when blended "as received" showed wide variance in reactivity, as shown in Table I. The five products are arranged in order of increasing reactivity. Product A was the least reactive, while product E was the most reactive. The worst rating made on blend containing product A was W-1, thus the blend was usable under all test conditions. Blend containing product B was usable except after 6 months in the small bags, where the rating was W-3, "wet and sticky throughout." Product C, D, and E were progressively more reactive. Product E, the most reactive, was unusable within 1 day of mixing; in fact, wetting usually was noticeable within the first hour.

After we found that we did have a series of products of different reactivities, we attempted to correlate reactivity with TSP analysis. Analyses of the as-received superphosphates are given in Table II, along with analyses after drying, which will be discussed later. No correlation of reactivity was found with P_2O_5 content. The available P_2O_5 analyses varied from 44.5 (product E) to 46.9% (product B), but the variations had no relation to reactivity. Likewise, the availability and water solubility of the P_2O_5 did not correlate with reactivity. There had been suggestions that high free-acid content might promote reaction. However, in the present tests the free-acid P_2O_5 contents varied only from 1.5 to about 2.5%, and the greatest reactivity was with the products of lowest free-acid content. Therefore, we concluded that free acid was not responsible for the reaction.

Moisture contents of the as-received superphosphates are given in Table II and are plotted in Figure 2. Determinations were made for both total and "free" water contents. The difference between these two values is the water present as hydrates. The total water was determined by a normal-amyl alcohol distillation method described in a publication[3] by Duncan and Brabson of TVA. Free water was determined by the usual AOAC vacuum desiccator method[7]. It is obvious, from the figure, that reactivity of the superphosphates did not correlate with free-water content. In the case of hydrate water, however, a correlation is indicated. Increase in hydrate water from 2.8% to 5.0% followed the trend of increased reactivity.

Other attempted correlations were with method of manufacture and granule hardness. These are shown in Table III. However, no definite correlations are evident. The three products A, B, and C made by the slurry-blunger process varied considerably in reactivity. The process used for the most reactive product (product E) was also a slurry process, but with use of a drum instead of a blunger. Likewise, there appears to be no definite correlation with granule hardness; the least reactive product A was the hardest, while product C was almost as hard but more reactive. Products B and E were both relatively soft but differed considerably in reactivity.

Bulk Exposure of As-Received Triple Superphosphates: Since reactivity appeared to be related to moisture content of the superphosphates, it was considered likely that the less reactive as-received superphosphates might become more reactive if exposed to humid atmosphere during bulk exposure. To check this, open-top vessels 12 inches deep by 12 inches in diameter were filled with two of the least reactive products (A and B) and were exposed to open warehouse conditions at Muscle Shoals, Alabama. After various periods of exposure up to 6 months, TSP samples from various depths were blended with urea and checked for compatibility by the bottle test. The 1-month results, given in Table IV, show that in this time the upper 2-inch layer of the exposed products absorbed 1 to 1.5% moisture and became incompatible with urea. Lower layers absorbed less moisture, but incompatibility extended to about 6-inch depth. Other data showed that in 3 months even the 6- to 12-inch layer was rendered incompatible. These results indicate that the exposure of superphosphates subsequent to its manufacture can affect its compatibility with urea. Data in Table IV show that materials stored in moistureproof bags remained in good condition.

Effect of Light Ammoniation: One treatment of the superphosphates that was tested as a possible means for improving their compatibility was light ammoniation. Fully ammoniated product is known to be compatible with urea[9], so it was considered possible that light surface ammoniation of granules would provide a protective coating. Ammoniation was carried out continuously in a 3-foot diameter by 6-foot-long TVA ammoniator drum at a food rate of 1 ton per hour. Anhydrous ammonia was sparged under the bed at several different rates. The sparger was 3 feet long and drum rotation was 11 rpm. Retention time was about 8 minutes. Discharge temperatures ranged from 130 degrees to 210 degrees F. In some tests the ammoniated product was passed through a rotaty drum cooler fed with ambient air, but this did not seem to affect properties of the product.

Results of compatibility tests of the ammoniated superphosphates with urea are shown in Table V. The full ammonia-holding capacity of triple superphosphate is 3.0 to 3.5 pounds per unit of P_2O_5, which results in nitrogen content of 5 to 6%. In the present work, the degree of ammoniation used ranged only from 0.4 to 1.4 pounds per unit of P_2O_5 and nitrogen contents of the ammoniated products were 0.8 to 2.8%. Even only a quick glance at the compatibility results in Table V shows that light ammoniation was not effective. All the products were as incompatible or, in many cases, more incompatible than the corresponding unammoniated products. Microscopic examination of the ammoniated grannules showed that some surface hulls of monoammonium phosphate and dicalcium phosphate had formed but that these generally were thin and discontinuous. Chemical analyses showed that ammoniation had little effect on moisture content of the TSP's, but in most cases caused a slight drying. We feel that the results of this series of tests practically eliminate light ammoniation from our further consideration as a method for improving the compatibility of granular TSP.

Effect of Drying: The second type of treatment that we tried with the granular TSP's was drying. The dehydration temperature of monocalcium phosphate monohydrate is 228 degrees F.; therefore, one series of drying tests was made above this temperature. Dryer discharge was 250 degrees F. The dryer was a 3-foot diameter by 24-foot-long gas-fired rotary drum fed at the rate of 1 ton per hour. Retention time was 30 minutes. The discharged product was cooled to about 85 degrees F. by passing it through a rotary cooler. The results of this series of drying tests are shown in Table VI.

Drying reduced free moisture content by 0.7 to 1.4 percentage points (values in parentheses, Table VI) and hydrate water by 0.5 to 0.8 percentage points. In the case of product A, there was an indicated slight increase in hydrate water at the expense of free water. The total water removed by drying was 0.3 to 2.2 percentage points. Again, only a quick glance at the compatibility results is needed, but this time the results show that the treatment was highly effective. All the dried products were perfectly compatible with urea under all test conditions. Although these results were obtained with relatively small reductions in total water content of the TSP's, it is likely that drying on the granule surfaces was considerably greater than indicated by the overall analyses.

These results suggest that drying would be an effective treatment for TSP to make it compatible with urea; however, several questions arise in regard to practicality. For example, (1) how much will drying cost, (2) what effect will it have on TSP composition, and (3) will the dried product withstand storage without reverting to an incompatible form.

In regard to cost, drying in the pilot-plant equipment required about 0.9 million Btu per ton of TSP fed. At present-day fuel costs, this would represent about $2 per ton of TSP. However, it is expected that considerably higher heating efficiency could be achieved in large equipment.

The effects of drying on chemical analyses were included in Table II. These data show that effects of drying on composition were minor and generally not unfavorable. Drying increased total P_2O_5 concentration by 0.7 to 1.6 percentage points. Available P_2O_5 was increased by 0.2 to 1.4 percentage points, except in product A where an insignificant decrease of 0.1 percentage point was indicated. There was no consistent effect on P_2O_5 availability, which is the percentage of the total P_2O_5 that is "available"; indicated changes ranged from a 0.5 percentage point increase to a 1.7 point decrease. Free-acid P_2O_5, likewise, showed little change. Our overall conclusion from the data is that drying granular TSP's at 250 degrees F. probably would have no undesirable effects on their composition.

To determine the storage properties of the dried TSP's, bulk exposure tests were made, similar to those described earlier for as-received superphosphates. The results, given in Table VII, show that during 1 month of exposure at ambient, open-warehouse conditions the exposed surface layers of the dried materials absorbed considerable moisture and the material in these layers became incompatible with urea. The top 2 inches of the various products contained 5.4 to 7.0% total moisture and were very incompatible after 1 month. Likewise, the 2- to 4-inch layer of all except product B was very incompatible. Below 4 inches, the effect was much less; the blends made with the 6- to 12-inch layer were all usable (D to W-2 ratings). When the 1-month storage of the superphosphates was in a bag, instead of bulk, they remained dry and fully compatible. The moisture analyses indicated that the moisture contents of the 0- to 2-inch surface layers rose to about the same levels as before drying, while moisture increases in deeper layers were progressively less; with storage in bags, there was in most cases no increase in moisture content. Other data showed that when bulk storage was extended to 6 months, even the 6- to 12-inch layer of all products was very incompatible. These results indicate that dried TSP would have to be protected from Atmospheric exposure in order to maintain its compatibility with urea.

Drying tests were made also in which the drying temperature (30-min retention time) was only 160 degrees F. instead of 250 degrees F. Data from these tests, which are given in Table VIII, show that less water was removed and that the products were somewhat less compatible with urea. This supports our feeling that drying should be above the monocalcium phosphate monohydrate decomposition temperature of 228 degrees F.

Tests with Ordinary Superphosphate: Incompatibility with urea is a problem also with granular ordinary superphosphates. We did not have large quantities of ordinary superphosphate to work with, but did make some small-scale tests that showed drying to be effective with this material also. We used granular ordinary superphosphates from two Australian manufacturers. Results are shown in Table IX. Drying was at 250 degrees F. for 24 hours in an oven. Before drying, the two products contained 4.7 and 2.6% free water; during drying, this was reduced to 0.3-0.4%. Hydrate water was originally 2.7 and 4.0% but was reduced to 2.2-2.3% by drying. Total water, which was originally 7.4 and 6.6%, was reduced to 2.7-2.5% by drying. The compatibility results show that, without drying, both products were very reactive with urea, but that after drying both were completely compatible. Drying caused no reduction in P_2O_5 availability; it had the desirable effects of increasing grade by about 1 percentage point and decreasing free-acid content by 1 to 2 percentage points.

Conclusions: The chief conclusions reached in the compatibility study were, briefly, as follows:

1. Granular TSP's manufactured with relatively low level of hydrate water, preferably below about 4%, are likely to be sufficiently compatible with urea for most bulk blending applications. However, such TSP must be protected from excessive atmospheric exposure in order to maintain compatibility.
2. Light ammoniation is not an effective way of improving compatibility of granular TSP.
3. Drying at 250 degrees F. is an effective way of improving the compatibility of granular TSP's with urea. However, the dried TSP's would have to be protected from atmospheric exposure to prevent reabsorption of moisture and reversion to non-compatible form.
4. Drying is effective also with granular ordinary superphosphates.

Treatment of Urea To Improve Compatibility

As I mentioned earlier, we have done some work also on the coating of urea to protect if from reaction with superphosphate in blends. All I have time to say about this today is that no inexpensive, practical coating was found. Good protection was provided by light sulfur coatings overcoated with wax, but, just to provide compatibility with superphosphate, the expense and equipment involved in applying this coating would probably be excessive.

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MODERATOR NIELSSON: Thank you George for your most interesting paper and valuable up-to-date information on "Use of Urea in Bulk Blends".

TABLE I

Chemical Compatibility of "As-Received" Granular TSP's in 23-23-0 Blends with Prilled Urea

Mfgr. of TSP			A	B	C	D	E
Compatibility with urea[a]							
Bottle test (86°F)	Days	1	D	W-1	W-2	W-1	W-3
		3	D	W-1	W-2	W-2	W-3
		7	D	W-1	W-4	W-2	W-3
	Months	1	W-1	W-2	W-4	W-4	W-4
		3	W-1	W-2	W-3	W-4	H
Small bag	Months	1	D	D	D	D	W-4
		3	D	W-2	W-1	W-4	H
		6	W-1	W-3	W-1	W-4	H
Large bag	Months	1	D	D	D	W-1	W-4
		3	D	D	W-1	W-4	H

[a] See text for rating scale.

TABLE II

Chemical Analyses of Undried ("As-Received") and Dried (250°F; 30 Min) Granular TSP's

Mfgr. of TSP		A	B	C	D	E
Total P_2O_5, %	Undried	47.1	47.9	47.9	47.2	45.8
	Dried	47.8	49.1	48.3	48.4	46.7
	Change	+0.7	+1.2	+0.4	+1.2	+0.9
Available P_2O_5, %	Undried	45.0	46.9	46.4	46.5	44.5
	Dried	44.9	48.3	46.6	47.0	45.3
	Change	-0.1	+1.4	+0.2	+0.5	+0.8
Availability, %	Undried	95.5	97.9	96.9	98.5	97.2
	Dried	93.8	98.4	96.5	98.5	97.0
	Change	-1.7	+0.5	-0.4	0	-0.2
Free-acid P_2O_5, %	Undried	2.4	2.6	2.0	1.6	1.0
	Dried	2.4	2.1	1.7	1.5	1.1
	Change	0	-0.5	-0.3	-0.1	+0.1
Total H_2O, %	Undried	4.7	5.1	6.0	6.1	6.8
	Dried	4.4	3.3	4.3	3.9	4.7
	Change	-0.3	-1.8	-1.7	-2.2	-2.1
Free H_2O, %	Undried	1.9	1.6	1.7	1.8	1.8
	Dried	1.2	0.3	0.7	0.4	0.5
	Change	-0.7	-0.3	-1.0	-1.4	-1.3
Hydrate H_2O, %	Undried	2.8	3.5	4.3	4.3	5.0
	Dried	3.2	3.0	3.6	3.5	4.2
	Change	+0.4	-0.5	-0.7	-0.8	-0.8

TABLE III

Manufacturing Process and Granule Hardness of Granular TSP's

Mfgr. of TSP	A	B	C	D	E
Process					
Slurry to blunger with recycle	X	X	X	-	-
Slurry to drum with recycle	-	-	-	-	X
Steam granulated	-	-	-	X	-
Granule hardness (-7 +8 mesh), lb	8.3	3.3	8.0	4.0	3.6

TABLE IV

Effects of 1-Month Storage on Moisture Content and Compatibility[a] of "As-Received" TSP's

Type of 1-month storage	TSP-A			TSP-B		
	% H_2O			% H_2O		
	Free	Total	Compatibility[a]	Free	Total	Compatibility[a]
None	1.9	4.7	W-1	1.6	5.1	W-2
In 7-mil polyethylene bag	2.1	4.6	W-2	1.9	4.7	W-1
In open bulk pile at indicated inches from pile surface						
0-2	3.0	6.0	W-4	3.0	6.3	W-4
2-4	2.7	5.5	W-4	2.3	5.8	W-4
4-6	2.3	5.1	W-4	2.0	5.4	W-4
6-12	2.0	4.8	W-2	1.9	5.4	W-1

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[a] In 23-23-0 blend with urea.

TABLE V

Chemical Compatibility of Lightly Ammoniated Granular TSP's in 23-23-0 Blends with Prilled Urea

Mfgr. of TSP			A	← B →			C	← D →		← E →		
N, %			0.8	1.9	2.3	2.8	2.3	1.8	2.6	1.8	2.0	2.6
Lb NH_3/unit P_2O_5			0.4	1.0	1.2	1.4	1.2	0.9	1.3	1.0	1.1	1.4
Compatibility with urea												
Bottle test (86°F)	Days	1	W-1	W-3	W-3	W-3	W-2	D	D	W-2	W-1	W-3
		3	W-2	W-3	W-3	W-3	W-4	W-1	W-2	W-3	W-2	W-3
		7	S-2	W-4	W-4	W-4	W-4	W-2	W-3	W-3	W-3	W-3
	Months	1	W-2	W-4	W-4	W-4	W-4	W-4	W-4	W-4	W-4	W-4
		3	W-3	W-3	H	H	W-4	W-4	W-4	W-4	W-3	H
Small bag	Months	1	W-1	W-4	W-4	W-4	-	W-3	W-4	W-4	W-4	W-4
		3	W-3	W-4	W-4	W-4	-	W-4	W-4	W-4	W-4	H
		6	H	W-4	W-4	W-4	-	W-4	W-4	W-3	H	H
Large bag	Months	1	W-1	W-4	W-4	W-4	-	W-3	W-4	W-4	W-4	W-4
		3	W-3	W-4	W-4	W-4	-	W-4	W-4	W-3	W-3	H

TABLE VI

Chemical Compatibility of Dried (250°F; 30 Min) Granular TSP's in 23-23-0 Blend with Prilled Urea

Mfgr. of TSP			A	B	C	D	E
Moisture:[a]	Free, %		1.2(-0.7)	0.3(-1.3)	0.7(-1.0)	0.4(-1.4)	0.5(-1.3)
	Hydrate, %		3.2(+0.4)	3.0(-0.5)	3.6(-0.7)	3.5(-0.8)	4.2(-0.8)
	Total, %		4.4(-0.3)	3.3(-1.8)	4.3(-1.7)	3.9(-2.2)	4.7(-2.1)
Compatibility with urea							
Bottle test (86°F)	Days	1	D	D	D	D	D
		3	D	D	D	D	D
		7	D	D	D	D	D
	Months	1	D	D	D	D	D
		3	D	D	D	D	D
Small bag	Months	1	D	D	D	D	D
		3	D	D	D	D	D
		6	D	D	D	D	D
Large bag	Months	1	D	D	D	D	D
		3	D	D	D	D	D

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[a] Values in parentheses are change during drying.

TABLE VII

Effects of 1-Month Storage on Moisture Content and Compatibility[a] of TSP's Dried at 250°F

Type of 1-month storage	TSP-A			TSP-B			TSP-C			TSP-D			TSP-E		
	% H_2O			% H_2O			% H_2O			% H_2O			% H_2O		
	Free	Total	Com.[a]	Free	Total	Com.[a]	Free	Total	Com.[a]	Free	Total	Com.[a]	Free	Total	Com.[a]
None	1.2	4.4	D	0.3	3.3	D	0.7	4.3	D	0.4	3.9	D	0.5	4.7	D
In 7-mil polyethylene bag	1.2	4.1	D	0.5	3.3	D	1.1	4.2	D	0.4	4.0	D	0.8	5.3	D
In open bulk pile at indicated inches from pile surface															
0-2	2.8	6.4	W-4	2.7	5.4	W-4	3.4	7.0	W-4	2.2	6.1	W-4	1.7	6.2	W-4
2-4	2.0	5.1	W-4	1.5	4.2	D	2.5	6.1	W-4	1.5	4.8	W-4	1.1	5.4	W-4
4-6	1.7	4.7	W-2	0.7	3.4	D	1.6	5.0	W-3	1.1	4.6	W-2	0.9	5.1	W-2
6-12	1.3	4.3	W-1	0.5	3.4	D	1.0	4.4	W-2	0.6	3.8	D	0.7	4.5	W-1

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[a] Compatibility in 23-23-0 blend with urea.

TABLE VIII

Chemical Compatibility of Dried (160°F; 30 Min) Granular TSP's

in 23-23-0 Blend with Prilled Urea

Mfgr. of TSP			A	B	C	D	E
Moisture:[a]	Free, %		1.6(-0.3)	1.7(-0.4)	1.5(-0.2)	1.2(-0.6)	1.0(-0.8)
	Hydrate, %		2.9(+0.1)	3.5(+0.1)	4.0(-0.3)	4.4(+0.1)	5.2(+0.2)
	Total, %		4.5(-0.2)	5.2(-0.3)	5.5(-0.5)	5.6(-0.5)	6.2(-0.6)
Compatibility with urea							
Bottle test (86°F)	Days	1	D	W-2	D	D	W-1
		3	D	W-3	D	D	W-1
		7	D	W-3	D	D	W-2
	Months	1	D	W-3	W-1	D	W-4
		3	D	H	W-1	D	H
Small bag	Months	1	D	D	D	D	D
		3	D	W-1	D	D	W-2
		6	D	W-1	D	W-2	W-3
Large bag	Months	1	D	D	D	D	-
		3	D	D	D	D	-

[a] Values in parentheses are change during drying.

TABLE IX

Effects of Drying (250°F; 24 Hr) on Moisture Content and Compatibility of Granular Ordinary Superphosphate

			OSP-A		OSP-B	
			As made	Dried 250°F	As made	Dried 250°F
Available P_2O_5, %			20.0	21.4	19.6	20.4
Moisture:	Free, %		4.7	0.4	2.6	0.3
	Hydrate, %		2.7	2.3	4.0	2.2
	Total, %		7.4	2.7	6.6	2.5
Compatibility with urea[a]						
Bottle test (86°F)	Days	1	W-4	D	W-2	D
		3	W-4	D	W-3	D
		7	W-4	D	W-3	D
	Months	1	W-4	D	W-3	D
		3	W-4	D	W-3	D
Small bag	Months	1	W-4	D	W-3	D

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[a] In 50:50 blend by weight.

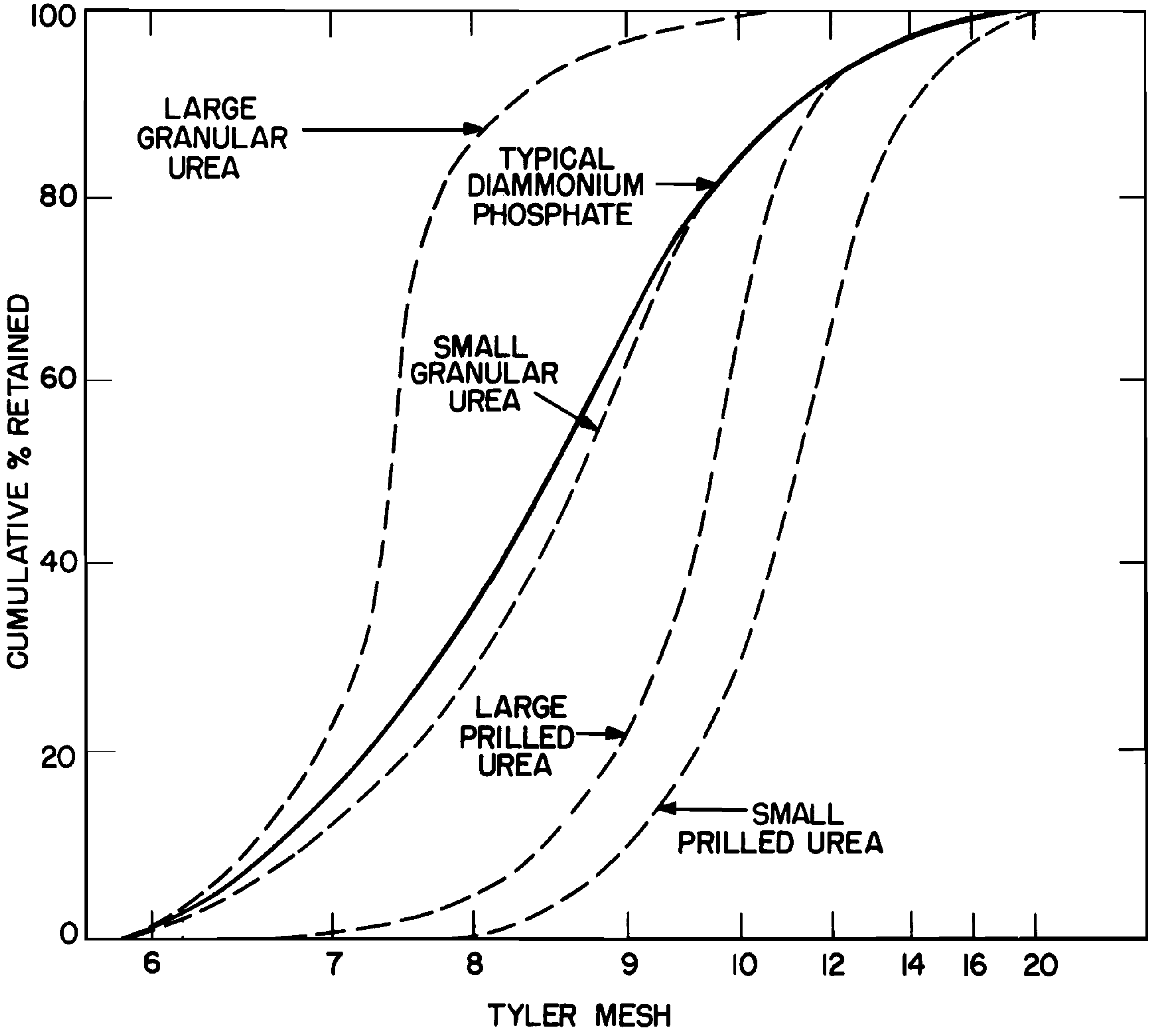

FIGURE I

PARTICLE-SIZE DISTRIBUTION OF UREAS COMPARED WITH THAT OF TYPICAL DIAMMONIUM PHOSPHATE

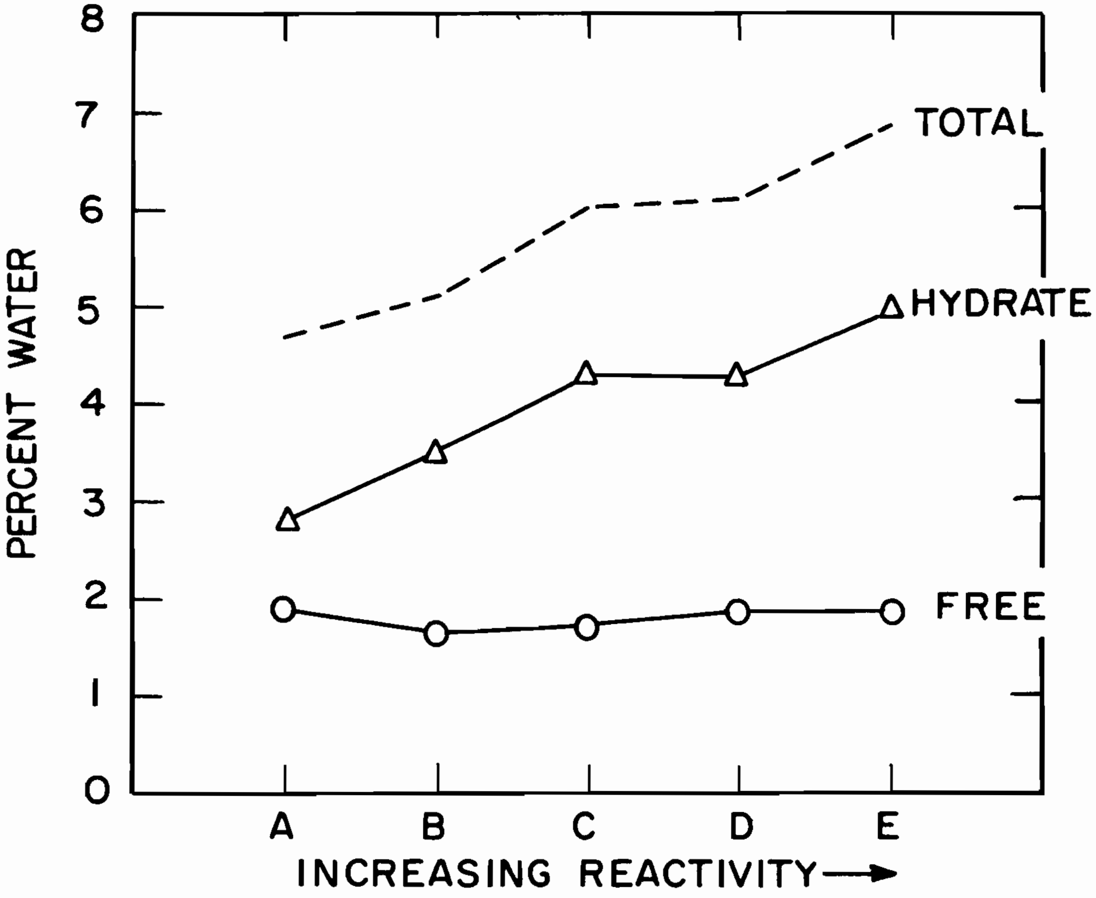

FIGURE 2

WATER CONTENTS OF "AS RECEIVED" GRANULAR TSP'S vs REACTIVITY WITH UREA

Editor's Note: We did not have time to present Harold F. Flynn's discussion covering his paper "New Interest in Sludge-Based Fertilizers". This discussion was offered to us at a late date and we advised Mr. Flynn, if time did not permit to present his paper, we would be glad to include the information in our Proceedings for 1975. Mr. Flynn understands and thanks us for our hospitality to him during his stay at our meeting. Mr. Harold Flynn is Vice President, Martel Laboratories, Inc., 1025 Cromwell Bridge Road, Baltimore, Md. 21204.

New Interest in Sludge-Based Fertilizers

Harold F. Flynn

Our sludge research came to the attention of the Fertilizer Industry Round Table's, Board of Directors and I was asked to give a talk on the new interest in sludge-based fertilizers.

In the last few years, there has been considerable interest in the potential of sludge-based fertilizer.

My company, Martel Laboratories, is one of a score of groups across the country researching and developing processes that will enhance the use of sludge as a fertilizer.

I will give you an overview of the sludge situation and suggest some of the markets that sludge-based fertilizer can serve.

First, a definition: sludge is the residue from wastewater treatment. And, as you are aware, the recent clean water laws passed in the early seventies are causing all American cities to upgrade their wastewater treatment.

As wastewater treatment is upgraded, more sludge is created. Within a few years it is estimated that the U.S. will be producing annually some 10 million metric tons, and that is dry weight.

The problems for the municipal wastewater treatment plants are severe.

Under the environmental guidelines established by the clean water laws, the municipal treatment plants must remove 95% to 98% of the waste from the water. A few years ago it was sufficient to remove 85% of the waste from the water.

In addition, to add to the problem, garbage-disposal units are becoming common — the garbage grinders add to the water-borne waste.

Furthermore, in processing wastewater, the municipalities must avoid polluting the air, the soil or the water — be it surface water or ground water.

Finally, the sludge produced must be disposed of in an invironmentally acceptable way — not dumped at sea, not landfilled as raw sludge, not land spread without treatment.

Obviously, the cities could be overwhelmed by sludge if they do not find a use for it.

Given the seriousness of the sludge problem, all options are being studied.

Currently, incineration of sludge is being widely discussed. There are some advantages to this disposal method *but* a major limitation is that the ash — perhaps 35% of the initial volume — still presents a disposal problem.

And incineration is still a disposal method — it is not realizing any benefit from the nutrient-rich sludge.

A more interesting option is the use of sludge-based fertilizers.

Sludge-based fertilizer is an old idea which may soon be revitalized. There is a long history of the use of sludge to produce a low-grade fertilizer. Depending upon the process, sludge-based fertilizers are generally either 6-4-0 or 2-2-0. Additives, be they organic or inorganic, can vary the N, P, or K to fit particular needs.

As you know, sludge-based fertilizers have long been proven as a source of stable organic matter.

Sludge, properly processed, is an excellent soil amendment. Sludge-based fertilizers cause a rapid increase in the humus content of soil, and have been successfully used in applications where slow release is desirable.

- Lawn applications havd been widely discussed. The recent trend toward "organics" has given lawn use of sludge-based fertilizer a boost.
- Land reclamation with sludge-based fertilizer is now ongoing in several states.
- Severely disturbed or eroded lands are benefiting from the application of sludge-based fertilizers.
- In some areas, abandoned strip mined lands are being reclaimed by application of sludge-based fertilizers.
- And, in some areas, sludge-based fertilizers have been used in agriculture.

However here a note of caution has been sounded.

There are two well advertised potential problems with sludge-based fertilizers in agriculture. The problems are pathogenic content and heavy metal content.

Pathogens — be they viruses or other organisms — can be a public health hazard.

Heavy metals are also a problem. Traces of some 14 elements (including zinc, copper, lead, and cadmium) are found in sludge, and these can cause toxicity problems in plants.

Research shows that proper treatment can bring the sludge's pathogen level down to the same level as that of soil or sand. In our tests, we produced sludge with plate counts lower than 100 organisms per gram.

Heavy metals problems are being attacked from several sides. Industry, a major source of heavy metals, is being forced to clean up plant discharges, thereby reducing the amount of heavy metals in wastewater.

On another front, agricultural scientists are developing fertilizer management practices which help reduce the heavy metal problem. Some scientists feel that with good fertilizer and soils management there will never be a heavy metal problem from sludge-based fertilizers.

It is interesting that recent nutritional studies show indications of some potentially advantageous relationships between man's heavy metal intake and the prevention of major diseases.

I have discussed some of the major problems with sludge-based fertilizers. It might be a good time to talk about some of the minor or cosmetic problems.

The problem of putricity have been successfully solved. Those of you who have worked with sludge-based fertilizers, such as those produced in Chicago or Milwaukee, know that the product is similar in size and texture to ground coffee, the color is dark and rich, and the aroma is pleasant.

The economics of sludge also have some pleasant aspects. Across the country it is available free — many cities will pay you to take it away.

And the processing costs can be kept low enough to give a fair return from sales.

The technology to dry and process sludge is available and proven. Some cities are using flash drying, some are using rotary dryers.

We at Martel Laboratories, in our development of a sludge-based fertilizer, have worked with the Edward Renneburg Company of Baltimore, who have a complete line of processing equipment. We have not yet disclosed particulars of our process.

Several of the alternative sludge-treatment processes are well known to you in the fertilizer industry.

In summary, the new pressures for clean water are creating new volumes of sludge that could be of interest to the fertilizer industry.

By 1980 there will be 10 million metric tons of dry sludge available every year.

Thank you.

MODERATOR NIELSSON: My thanks to all of the Speakers for their most valued up-to-date information they gave us. All of us appreciate your kind cooperation.

We now come to the question and answer panel session. I will turn the meeting over to Mr. Paul Prosser who will moderate this portion of the program.

New Practices for Ammoniation-Granulation Plants

Panel Discussion —

Paul J. Prosser, Jr., Moderator

PANEL:
Frank P. Achorn
Donald J. Brunner
John Hudson
Allen S. Jackson
Frank T. Nielsson
Richard Perkins
Joseph Prosser
Walter J. Sackett, Jr.
Derrick Stassfort

MODERATOR PROSSER: First of all, I invite our panel to show up up front here. For the benefit of those who must make the transcripts, so that they may recognize the voices from the tapes, I am going to ask the panel to introduce themselves. So if we will begin at the far left side, Frank.

Now, the purpose of this panel discussion and question and answer period is to answer questions that those of you in the audience may have. We invite those questions. We would like you to approach one of the microphones and to identify yourself in the same manner that the panel has done. Now, do we have any questions, or do you want me to fire one at these guys to start off?

QUESTION — BILL ADAMS OF ALLIED CHEMICAL: I would like to ask Frank Achorn, with regard to his paper on MAP, whether it is feasible or whether he thinks it is feasible to go to a 2-1-1 ratio, and what was the supplementary nitrogen above the 1-4 or the lower grades? I could not read your formulation very well.

FRANK ACHORN: Billy, we have just tested the grades that I showed you. I think as an opinion you could go to a 2-1-1 grade. The source of supplemental nitrogen was ammonium sulfate when we had to use a supplemental source. Most of the time we just generated our own ammonium sulfate by including sulfuric acid and ammonia in the pipe cross itself. Does that answer your question?

BILL ADAMS: Yes, thank you.

QUESTION — DAVE LEYSHON, JACOBS ENGINEERING: I would like to ask about the practice of rubber lining in granulation drums with the use of sulfuric acid. Is this practice done here in any of those particular rubber linings as were shown?

WALT SACKETT: Yes, it is. Jim Hebbard gave the talk this morning and he's sitting in the front row. Jim, why don't you answer that question. I think you are best able to.

JIM HEBBARD: Yes, there are very few rubber lined granulators in the field that aren't doing everything any granulator is doing. Most of the people we work with are granulating with sulfuric acid.

The tube style lining you saw in one of those pictures, that particular version was designed with the tube lining coming out of the end of the drum because when that lining was originally stopped at the original fixed dam, there were corrosion problems at the end of the lining where it met the drum. So, that particular lining was built with the idea in mind of preventing acids from getting to the shell and getting to the boundary between the shell and the rubber. The bars in the middle apparently coat up enough just like any granulator that you don't lose them too fast.

FRANK NIELSSON: At our Americus plant we have a rubber lined drum. It's the butted rubber belting with the 1/4" plate strap over the longitudinal joints. At the end of the drum a rim of steel covers the ends of the belt. They have had no problems at all.

QUESTION — My name is Douglas Caine, and I'm with Swift Agricultural Chemicals. Reference was made in the Sackett paper this morning to the Joe Edge gate. We've had experience with these in plants, and I think Mr. Nielsson did express interest in this some time ago. So at this time I would like to ask Mr. Stassfort if he will give us his personal opinion on the Joe Edge gate as opposed to the conventional dam.

DERRICK STASSFORT: We used the Joe Edge gate about two years very satisfactorily with one or two exceptions that we found. On certain grades where the potash ratios were high and not a premixed feed going through the ammoniator, the granulation varied all over the board. In other words we couldn't hold enough bed in the ammoniator. Other than that we never had any problems with it except on one occasion we did have a building on it. It swung around and tore out all the sparger plates. Personally, I like a fixed dam better.

PAUL PROSSER: Anybody else on the panel want to comment?

FRANK NIELSSON: I saw this gate for the first time at our Americus plant. I was surprised because for a man who has seen nothing but fixed dams to see something like that operate as well as it did was just a real shock. The fantastic thing about it is that when you reverse the drum, of course, it just empties right on out — no problem at all. I wonder if either Feagin or Medbery are here because they can give personal experience on that. John.

JOHN MEDBERY: I'm John Medbery with I.M.C. We prefer the Joe Edge type gate or dam because it enables us to bring the rubber lining all the way to the discharge lips of the drum. When we attempted to secure the lining right behind a stationary dam, as Jim Hebbard pointed out, we had lots of problems, the buildup particularly forming a fillet type formation right behind the dam and thus depriving us of a great deal of our rolling bed action and also catching on the ends of the sparger pipes making it necessary to shorten up on the spargers which, of course, isn't always desirable. So we prefer this type of dam.

Now it is important to get the dimensions just right. It ends up looking more or less like a half moon slice of steel, and we support it on struts coming downward from the central tool bar support. There's two or three struts straight down and then one angled inward from the outside of the ammoniator to give it lateral bracing.

WALT SACKETT: One question I would like to ask John. When Joe ariginally designed that gate with the old V.C.-Mobil Group; the original idea, I think, was to incorporate some of the advantages of the pan into the drum ammoniator controlling the bed height by the rotation of the gate. Do you find that you have any better control on granulation?

JOHN MEDBERRY: I would say you probably lose a little granulation efficiency. The stationary dam going around with the drum pulls granules with it so you tend to get a little more active tumbling with the stationary dam, and you do lose that with this. There's also a space between the bottom edge of this and the shell, and granules will roll out or material will roll out; but what you are getting there are large particles because the larger diameter granules gravitate to the outside perimeter of the turning mass.

PAUL PROSSER: Anybody else on the panel? Next question. All right, here's one. What is the best metering system for solid materials?

JOE PROSSER: If you say the best and not the least expensive and not the easiest, it may very well be using an automatic drop batch weigher. We've used on accasion a bagging machine, chopped off, and let it drop 50 pounds or whatever it wants to drop on some cycle. We've found that's a pretty sure way, accurate measurements and so forth of getting weighed. It takes a little bit extra height and may cost a little more than some other systems, but it may be a pretty good idea.

WALT SACKETT: We do the same thing with a little different variation. We feel that the idea of batch weighing all of your raw materials, then mixing, then putting them over a continuous scale again, is kind of silly and a duplication of equipment.

What we have dome in a number of plants, I'm thinking of one particular 30 Ton Per Hour Granulation Unit, is to use a 6 Ton Batch Weigh System. The unit is very similar to our standard bulk blend operation and, therefore, blends as it weighs. It is front end loader fed with gates at the bottom of the scale hopper, automatically operated by a timer on a 12 minute cycle. The material drops into a good size surge hopper which sits over a variable speed drag conveyor. The speed is adjusted so that the last of the material is being removed from the surge hopper at the time the 12 minute cycle ends, just as the timer releases the gate again. It works very well.

PAUL PROSSER: Anybody else? Here's one. Suggest the most efficient type of scrubber. Let's start up there somebody.

JOE PROSSER: I will suggest a Venturi scrubber.

PAUL PROSSER: Anybody else?

JOHN HUDSON: Venturi type scrubbers are still hard to beat for efficiency.

DERRICK STASSFORT: Well, I'd say we'd have to modify the question a little bit as to what we are going to scrub. I still say the Venturi would be probably the No. 1 choice; but there again it's a high energy scrubber, and you don't necessarily use a high energy scrubber where it's not necessary. There are a lot of impingement scrubbers that can be used, but overall I think so far as most granulation plants today they are going to the Venturi type.

QUESTION — FOR FRANK ACHORN: Frank Mortenson, Globe Engineering. When the pipe cross reactor is used what did you do with the air that you took out of your cooler? Apparently you had to cool the product, and all that air can serve to pick up a lot of moisture as you carry it through the scrubber stack.

FRANK ACHORN: That air went into a separate scrubber that tied to a common pit, and they recirculate out of the pit. They scrub two separate streams, but the scrubbing liquor comes out of a common pit.

FRANK MORTENSON: Was there a plume from your cooler scrubber?

FRANK ACHORN: There was much less than there had been when we used a dryer. The dryer stream and the cooler stream are combined and go into one scrubber where the ammoniator stream, exit gas, goes through a separate scrubber. When we stopped using a dryer, there was a significant cutdown in the amount of plume from the cooler; but there still was a plume.

FRANK MORTENSON: In other words you probably have saturated air leaving the cooler so you couldn't take advantage of the extra drying effect or the pickup.

FRANK ACHORN: Right.

FRANK MORTENSON: O.K. Thank you.

PAUL PROSSER: Mr. Sheldrick.

BILL SHELDRICK: Frank, I would just like to comment on this question of taking water out in making monoammonium phosphate in this manner. I think one of the advantages perhaps of operating a small pressure reaction before your pipe cross reactor or before your sprays is that you can in fact take all the water out; and in instances that I've seen and been concerned with not only have they been able to take the water out, but they've been able to generate low pressure steam because you can operate a pressure ammoniator at about 30 to 40 pounds per square inch, and this will allow you to generate steam at about 15 to 20 pounds.

FRANK ACHORN: Well, Bill, this reactor was operating at 40 pounds. It was operating under pressure, and there was steam coming out of the pipe cross. Also we see no need for preneutralization prior to the reactor since the mixture content of the melt from the reactor was about 1%.

BILL SHELDRICK: You probably know that point I am making that if you have this small pressure reactor not only will you be able to disengage the steam; but because you operate it with a pH of 4 you don't have any corrosion with this, and you can get away with a relatively low grade stainless steel.

FRANK ACHORN: I think one of our problems with the higher pressure is not related to your question, but it was related to the corrosion. The grades that we've made, the amount of sulfuric acid that we added we found it difficult to maintain a constant ammonia pressure. This was probably the reason for the corrosion. I'm really not too disturbed about the corrosion problem. I think we'll solve that either through higher degrees of ammoniation or through lower velocity through that reactor.

I will emphasize again though. You've got to get rid of the steam someway. If you put water in the process, it's got to come out; and it's got to come out of scrubbers. So the idea is to get enough air passing thru the scrubbers and get it high enough so the plant doesn't have a plume. It kind of burns me that we can't put steam out without getting people excited.

PAUL PROSSER: Yes, sir.

JOHN HUDSON: One of the reasons we abandoned the use of preneutralizers was the fact that it scared the help so bad that they didn't want to use them. This would be a matter of real concern about using a pipe neutralizer like that, its effect on the help.

DON BRUNER: I'll add on that. This is one of the real good features that we like about the pipe cross reactor. When we started with this, we were in a position where we needed to start up a preneutralizer and train personnel. This cross reactor is so much simpler to run. You just turn on the flows and it goes and it really would be very easy to teach operators this process.

PAUL PROSSER: You think we've had enough of this? Oh, excuse me, Frank.

FRANK ACHORN: Well, just to add one thing, they had the choice of running the pipe cross reactor or the preneutralizer; and they chose the pipe cross reactor. Frankly, that first day that that reactor ran I got scared of it the way that reactor was jumping around; but when we started adding water which is a very important point it sounds like a little jet of steam going inside the granulator and it operates smoothly.

PAUL PROSSER: Anything else on this question? Let's get an oldtimer. Can a granulation plant be operated without a dryer, and if so how.

JOE PROSSER: I think the answer to that is that granulating plants have been operated without dryers. I think that this brings up a major discussion for this group.

Everybody is worried about energy and so forth. Some fertilizers can be made without a dryer; some of them obviously can't. So long as the sales folks are going to tell us that we have to make our product 8 x 12 with 1/2% moisture we are going to have to use a dryer and use energy. If everybody became more realistic and permitted us to go back to a 6 x 20 or a 6 x 24 fertilizer which we made ten years ago, and it grew corn just like the stuff grows corn now we could save energy and make some grades without a dryer and make all grades by using a whole lot less fuel. The grades you could make would obviously be those that have a lot of heat of reaction. They're the same grades that should be the driest.

I recall making a lot of 10-10-10 fifteen years ago without a dryer and getting the moistures down to about 1-1/4% to 1-1/2% which maybe isn't real good, but it worked.

DERRICK STASSFORT: Well, the question was asked can you run a granulator without a dryer? The question would be what kind of scrubber you would need. Here again where is the location of your plant? What is the relative humidity in your operating area?

We have one plant that has been running without a dryer in there for almost 20 years. It is one of the California plants. We use no dryer at all. It is all done by chemical heat.

FRANK ACHORN: I think there's room for a lot of improvement in the way we utilize solubilities in chemical heat in ammoniation granulation. I think that most or at least some of you have written me and told me that you are interested in that, and I think we need additional data to get that solubility data to improve ammoniator granulator operation.

I think a lot of times, there is a lot of skill in running a granulator, certainly there is; but it is not all skill. There is a little bit of chemistry involved in it, and I think we need to, as we approach energy problems and in getting enough energy or simply having materials to do it with or gas to dry with, we need to study the system and the solubility systems involved on their effects on liquid phase in the granulation plant. Most of us have stuck to this old 7.2 pounds per unit of P_2O_5 for phosphoric acid and you are considering energy and you are pricing energy into your cost calculations. That probably is the wrong place to ammoniate to.

I think there's a lot of room for improvement and a lot of room for studies along this line. I'd hate to think that we can't solve them. I think we will.

QUESTION — BOB MAC DONALD. Frank, your statements are a little incongruous with your previous statement — making MAP instead of DAP.

FRANK ACHORN: I didn't quite understand what you were talking about, Bob.

BOB MAC DONALD: You recommend the industries go to MAP which is obviously much less heat evolution than DAP.

FRANK ACHORN: Well, what I said was I think we need to study the solubility of phosphoric acid or utilize the solubility studies we know of phosphoric acid and ammonia to evaluate liquid phase and production rate as related to thee cost of fuel.

BOB MAC DONALD: If we're going to use chemical heat, obviously DAP gives us more chemical heat than MAP, and it's the acid that is the limiting factor here.

FRANK ACHORN: By operating at MAP (5 lbs. NH_3/unit P_2O_5 from phosphoric acid) larger quantities of ammonia can be added to the granulator without encountering liquid phase problems that would be encountered at the normal 7.2 lbs NH_3/unit P_2O_5 ammoniation rate. Also in production of DAP water has to be added to the system so that the slurry can be pumped from the preneutralizer to the dryer. This water must be removed by fuel energy. In producing the MAP there is no need for the addition of water.

BOB MAC DONALD: My point was that you previously thought that MAP was the future of the fertilizer industry. Now, are you changing this?

FRANK ACHORN: No. I think MAP still is a very good thing for the fertilizer industry. It might save in the consumption of energy, and it is primarily used out in the field to blend, because the blender can make a lot more grades with 11-55-0 and 12-48-0 than he can make with 18-46-0 with fewer materials. To make 6-24-24 or to make a 1;4;4 ratio with DAP, he must use both triple and DAP. To make a 1:4:4 in the field, all I've got to have is MAP (12-48-0) and potash. So I just think it gives the blender more flexibility.

I think we need to look further into the energy conservation aspects in granulation plants but certainly from the blending point of view, it has an advantage in that it has more flexibility.

Or the direct application point view. If you want to dual apply an ammonium phosphate grade and anhydrous ammonia, it is more economical for that dealer to get MAP and anhydrous ammonia that it is to get DAP.

Those are all marketing reasons, in addition to the process reason.

PAUL PROSSER: Anybody else on this subject? Any comments? It is about 12:15. If you gentlemen prefer, we will stay to 12:30 or so. Is that the way we feel? Well, I'm the only guy voting so we'll stay till 12:30.

Yes, JOHN MEDBERY: I want to ask a question about ammoniation rates. In a situation where you have sulfuric, phosphoric and triple and possibly single super all in one formula, how can we be sure that we have set the ammoniation rate of the phosphoric to give us this low solubility mole ratio of 1:1.

FRANK ACHORN: I don't believe we can be sure. I think that that is an area of work that we need to study in.

DON BRUNER: I would like to comment there. I use the theory, which is probably right, that your ammonia will go to the one that has the highest degree of ammoniation. If anybody gets starved, it would be the one that can't grab it.

PAUL PROSSER: Any other questions from the floor? All right. For installation of a preneutralizer in an existing plant do you prefer to locate the preneutralizer above the granulator and use gravity slurry flow or to locate it one the ground and pump the slurry? Yes.

JOHN HUDSON: We had one located above the granulator and it worked well that way. The slurry ran right down into it. There's one objection to it. If you locate it up there, it scares the help and they object. So the only way you can do it safely is to put it on the ground and pump up to your granulator. It is a continuous problem to keep one going; and if it's above your head, it really does worry people.

PAUL PROSSER: Yes.

DERRICK STASSFORT: We've had a few of them. Most of them have been above the granulator, but I would certainly doubt with the material of construction you're just into another problem. You are going to have to start pumping it.

PAUL PROSSER: Dick, do you want to comment?

DICK PERKINS: We've done it both ways. The wase of getting the material into your granulator from a gravity feed is an advantage, but we always had quite a bit of problem getting an even feed that way; and that is the reason and the safety factor possibly why we would prefer to pump it from ground level. You have to design your pumping system so as to minimize maintenance, but I think this is much the best way to do it.

PAUL PROSSER: Joe.

JOE PROSSER: I agree with what Dick's saying mostly. I think that our feeling is that for small units we put them upstairs and for big units we put them downstairs mostly because a big unit is more of a problem to put upstairs. When we do put them upstairs, we usually try to protect the help by putting a highly curved concrete floor under them, something like that so if something does happen, it doesn't run down everybody's neck.

FRANK ACHORN: When you put them up elevated above the granulator, do you meter your slurry? Do you record the amount of slurry going to the granulator, those who have it above the granulator?

DERRICK STASSFORT: We don't do it anymore.

FRANK ACHORN: I think there is an advantage for having the preneutralizer on the ground and pumping it because you can know what your flow rate of slurry is.

DICK PERKINS: I think that's true and without the pump pressure it's hard to meter, I believe. If you're gravity flowing, you just about have to take the best flow you can, and it's not going to be a consistent flow all the time.

DONALD BRUNER: I would prefer to have it on the operating floor where it's convenient, as close to the ammoniator as possible. I would prefer it to be pumped so that the flow can be recorded.

PAUL PROSSER: Anybody else from the floor?

JOHN HUDSON: If you put the preneutralizer above the granulator you can usually run it at a much lower water content till it's almost a melt, that it would be impossible to pump because of the problems with a hot melt.

PAUL PROSSER: Let's take another question. What type of crusher is best for oversize in granulation plants? Now there's a can of worms!

WALT SACKETT: If you are talking about a crusher that will allow you to recover as much of your oversize as possible in product, 6 x 16 mesh, for instance, we find that a twin rotor mill composed of a combination of chain and cage applications has given best results. Tests have shown 75 to 80% thru a 6 mesh on first pass with oversize recirculating across the screen and final recovery of 70 to 75% of your total oversize load in the product range. We think this is very good performance and we also find that the twin rotor mill does not tend to build-up as most machines do in this application. Maximum product recovery and minimum maintenance. We feel it is the way to go.

JOE PROSSER: I think it's really a shame we let Allen Jackson go home because I am sure he has a preferred mill also. The chain mills are working well everyplace. We don't build a chain mill, but we build a thing like that. It is something that doesn't have any bottom in it. We build a thing called a swing bar mill, and it's trying to do the same thing. All of us are trying to do the same thing, trying to get a cage mill that is not a cage mill. It is flexible in some ways so that you can't break it so easily.

PAUL PROSSER: Anybody else? Anybody from the floor? Any questions? What is the recommended filler for granulation plants? Any comments from the operators?

DON BRUNER: Good old river sand's the best.

FRANK ACHORN: I would say sand would be the best because it is the filler with the least reactivity. You don't get a reaction. Limestone sometimes causes ammonia loss problems.

DERRICK STASSFORT: I agree with Frank. No reaction and it is also cheaper, but a lot of times if we are making low grade analysis, we found by using tremendous amounts of sand as filler that our recycle was excessive. So in order to keep our tonnage going we went to granular limestone which offset the cost of the difference between the granular limestone and the sand.

FRANK ACHORN: That is a very good point. Trying to get all that amount of filler in a low analysis grade, you can't do it with sand. It takes something like granular limestone.

PAUL PROSSER: Any questions from the floor?

O.K. Can anyone explain why the delivered cost of P_2O_5 and phosphoric acid is about the same or more than the delivered cost of P_2O_5 and diammonium phosphate? Doesn't it cost to convert phosphoric acid to diammonium phosphate, or is this just a marketing problem? Any comments?

FRANK ACHORN: I don't understand why it is different. I have had some explanations given as to the difference of the cost of phosphoric acid and diammonium phosphate as related to the delivered cost of phosphoric acid itself. One of the reasons, of course, is that the freight rate of phosphoric acid is higher than the freight rate, that is, dollars per tons, for DAP. The other one is that some of the basic producers feel that this diammonium phosphate and triple superphosphate is a means for them to get rid of some of the sludge that is in thier phosphoric acid. Some of the sludge also goes into triple super. Perhaps there is some room for development of some way in sending sludgy acid to granulation plants by suspending the impurities in the acid.

But the price is the same. Of course, a guy I work for is a marketing man. He tells me all the time production cost doesn't have a thing to do with the price of material.

DICK PERKINS: I wouldn't try to explain that much better, Frank, I don't think. It depends entirely on how the price is put together, I think. There is additional cost for phosphoric acid as such as compared to phosphoric that you make diammonium phosphate from. There is additional cost to clarify phosphoric acid for shipment and that does enter into it along with the freight rate.

PAUL PROSSER: Any questions from the floor? That being the case, then, if my watch is somewhere near correct, we are just about at 12:30. I see no hands raised for questions so I think if you would offer the panel a vote of thanks by means of some applause, we'll adjourn this part of the program. Thanks very much.

CHAIRMAN REYNOLDS: I just want to add my thanks to the panel in appreciation for their participation. I think we've had a real fine meeting.

I know there are people we should have recognized that we somehow or other failed to. There is one person here that we really owe a debt of gratitude — our machine operator, projectionist, recorder, etc. She has done a tremendous job. Applause.

So let us hear from you. Next year, as you know, we are in Atlanta; but before we get to Atlanta we've got to have a lot of work. We need to hear from you, your questions, suggestions. So as we start our next 25 years, let's get off to a bang. 26 can be even better. Thanks for coming, I hope to see you in Atlanta. Meeting Adjourned. Lots of applause.

Comments By Albert Spillman

Editing Chairman

I wish to take this opportunity to thank all of you, Our Chairman, Directors, Moderators, Speakers, Secretary-Treasurer and his office and those asking questions and answers from the audience for helping me to prepare "Our 1975 Proceedings".

True, this chore took considerable time, however, I enjoyed the task and your prompt cooperation when I called on you for help to cover many of the necessary details required to complete this very important project.

We had an excellent, interesting 3 day meeting, good attendance at each of the 5 sessions and much interest from our audience.

I am sure you will enjoy reading Our 1975, 25th Annual Meeting Proceedings and hope to see you in Atlanta for Our 26th Annual Meeting October 26, 27 and 28, 1976.