PROCEEDINGS
OF THE
23rd ANNUAL MEETING
FERTILIZER INDUSTRY
ROUND TABLE
1973

November 6, 7, 8, 1973
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Tuesday, November 6, 1973

Morning Session
Moderator: Herman G Powers, Chairman

CHAIRMAN POWERS: Good Morning! On behalf of the Board of Directors, I wish to extend to all of you a most cordial welcome to the 23rd Annual Meeting of the Fertilizer Industry Round Table. We sincerely hope you will enjoy this meeting along with the fellowship with others in the Fertilizer Industry. I would like to take this opportunity to extend a special welcome to those atending from overseas, and if there is any way I or any of your Directors can be of assistance, please do not hesitate to contact us.

With the numerous problems facing the Fertilizer Industry today, one could be reminded of the "Battle of Little Big Horn". Some days, it seems the number of problems approach the number of Indians that General Custer experienced at his last stand. Your Round Table will address itself to several of these problems in the course of the next three days.

Your Directors have worked diligently on this year's program to provide a wide range of topics. We will cover transportation, distribution, along with fertilizer custom application. With the growing of speciality fertilizers, an afternoon session is devoted to this topic. There will be technical papers of the latest process developments in the use of Urea and Superphosphoric Acid, along with other current process developments. There will be papers on environmental quality, fugitive dust problems, and "OSHA". On the last day, emphasis will be given to what to do about the Industry's environmental problems which will include talks by representatives of E.P.A., Industry, and process equipment and systems.

At the end of this year's meeting, I doubt if we will leave here with a lot of solutions to our problems, but certainly all of our problems will be better defined.

Our Keynote Speaker, Mr. Edwin M. Wheeler, President The Fertilizer Institute, will discuss with us "Serious Challenges Our Industry Faces During 1974". Mr. Wheeler and his Organization in the past have been very helpful to Our Round Table and this year too we appreciate The Institute cooperation, in addition to the "Keynoter" address, helped us with our Thursday Morning and Thursday Afternoon discussions covering "Environmental Control Development In Fertilizer Production."

Mr. Wheeler we are grateful to you and your Associates and thank you.

Serious Challenges Our Industry Faces During 1974

Edwin M. Wheeler

On behalf of The Fertilizer Institute I want to welcome you back to Washington after your three year absence. I would assume that your return to the nation's capital is because of the numerous job opportunities in high places! We at the Institute would like each of you to drop by and see us at our central down-town location. Should we be able to be of service to you, my staff and I would welcome that opportunity.

Our industry faces 1974 with some serious challenges to our managerial skills — particularly in the fields of engineering and logistics. The marketeers are not going to have much to do but smooth out the dealers' ruffled feathers. To the best of my knowledge every U.S. producer is allocating material with this situation enduring for at least until the end of the 1975 fertilizer year.

Before I turn to the principal thrust of my remarks, I should like to set the current scene as viewed from here. Constant vacillation by our government on Price Controls have badly distorted the market place, causing fertilizer materials to move in strange and wonderous ways — and volume. Consider, if you will, that for June, July and August, 1973, the exports of anhydrous ammonia rose nearly 130% over the same period in 1972. Why? Simply that the material was following the highest legal bidder. Many, if not most, of our materials have shown an identical pattern so that, all in all, we now forecast that by June 30, 1974, the following will obtain (See Chart, page 2).

	1973	*1974	
EXPORTS (million tons)		% change from 1973	1974 tonnage
All fertilizers, except Phosphate Rock	6.5	+ 30	8.4
Muriate Potash	1.2	+ 15	1.4
Urea	0.5	+ 10	0.6
Phosphate Rock	13.6	+ 2	13.9
Am. Phosphate	22.1	+ 34	2.8
An. Ammonia	0.7	+100	1.4

*Estimates with continued COLC regulations

Should our crystal ball be in proper working order and the material is available, we forcast U.S. consumption at 45+ million tons. These are "iffy" because of the gas and power situation about which we will examine in detail. You with slide rules have already started scratching your heads because these exports and domestic tonnage forecasts exceed current capacity, even if we import a little. This is the rub — there isn't going to be enough to reach.

USDA, in late August, concluded we would have a short-fall of one million tons nitrogen (nutrient) and 750,000 tons (nutrient) P_2O_5. We believe that based on field reports, increased acreage, and a given amount of judgment, that the shortage could easily be *double* the government's figures. It is a situation about which we all ought to be concerned. The chickens of deferred or no maintenance, little renewal, no research, no construction, have come home to roost. While certain segments of the total industry were overjoyed about plummeting prices and profits during these past few years, they can now see the economic carnage perpetrated by their own hand.

Profitability is returning to the industry and I would foresee a good deal of black ink by June 30, 1974. While we take comfort in these prospects, let me remind you that in data specifically developed for the Price Commission and the Cost of Living Council, we finished calendar year 1972 with a pre-tax profit of 4.5% based on $2 billion sales. The table affixed at the conclusion of these remarks shows that we had not even returned to a 1967 level. Put it another way, we earned about 1/2 of the prime interest rate before taxes. Indeed, we do have a long way to go.

With the return of profits, I earnestly solicit our top management's attention and tangible support for immediate resumption of research and development. As a practical matter, our spending in the area has been nil over the last five years. Ours is an industry bottomed on science, whether viewed from the production side or the agronomy side. Woe be unto a technically based industry who goes dormant in research. We need bold agressive research now, else we begin to fall behind and fiscally perish. It is my personal view that this was and is a major failure of our railroads and this statement speaks for itself.

Where should this research begin? We see two major priorities. This is not to say there aren't more.

First, an all-out effort needs to be made to obtain a much more efficient process whereby coal or lignite will be a cheap source of nitrogen. In the long pull we believe that either newly discovered gas will be stringently allocated or so ungodly high in price that the industry will be forced to either go off-shore or switch feed stocks. There are many ramifications to off-shore construction. Consider the higher capital costs, the inordinate delays in construction, the shortage of skilled personnel, transportation problems, and one can readily see why off-shore is not the answer for American industry. The real danger in reliance of off-shore location is that a foreign power has its hands on our nation's nitrogen valve. I should like to emphasize that the present Mid East fit of pique in turning off the oil to our country will, at best, cause inconvenience. Can you imagine the panic which would result if our nitrogen — the ability to feed and clothe the nation — were similarly affected?

No responsible U.S. governmental agency could recommend this approach to the growing nitrogen shortage. Our government (regardless of which party is in power) reacts to a situation. By the nature of the beast, it rarely anticipates. What I am saying is that it is the industry itself which must assume not only the leadership in research, but must provide the seed money. By seed money I mean substantial sums. TVA has indicated North America used 8+ million metric tons of nitrogen in 1972 and forecasts an apparent consumption 8 years later at 12+ million or a 50% gain in a relative short period. We, as an industry, better get cracking.

P_2O_5 presents a different yet analogous situation in that gas is the cream of the crop feed stock for ammonia. There are other hydrocarbons available. There is a shortage in our country of high BPL rock, yet there is an abundance of low grade rock. In other words, we are running out of the creme de la creme of rock, but have almost limitless quantities of the lesser material. Here again R & D should be launched at once on a substantial basis in order to learn how to *efficiently* produce P_2O_5 from this lesser quality rock. Much can be done to stretch this wasting asset, it is simply that heretofore we didn't have to think about the subject. Now we have no choice when viewing the rock situation in the long term. Again, we need to get CRACKING.

There are several other areas we have not kept pace such as in the environmental area, the stringent health aspects which in due course will rise out of the Occupational Health and Safety Standards, etc.

There is opportunity, indeed I am so crass as to suggest great profit in research and development *if* ad-

(continued on Page 4)

The Fertilizer Institute Financial Survey

Percentages	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
	Dollar Weighted Averages for All Companies - 18-38 Participants												
Net sales	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Cost of goods sold	76.4	75.8	76.2	75.6	76.1	76.6	77.8	79.3	85.9	89.6	83.3	79.9	80.0
Gross margin	23.6	24.2	23.8	24.4	23.9	23.4	22.2	20.7	14.1	10.4	16.7	20.1	20.0
S.G.&A. expense (total)	11.7	12.2	12.7	12.7	13.1	13.0	13.7	15.8	17.4	18.9	18.9	18.5	15.5
Pretax profit (loss)	11.9	12.0	11.1	11.7	10.8	10.4	8.5	4.9	(3.3)	(8.5)	(2.2)	1.6	4.5
	Simple Averages of Data Reported - 6-19 Participants												
Return on invested capital	18.3	14.7	13.0	7.3	7.9	18.8	17.5	14.2	(1.7)	(7.5)	(1.4)	1.1	3.8
Equity to sales	1.2	1.0	1.0	1.1	0.8	0.8	1.0	1.1	1.2	1.6	1.3	1.6	0.7
Long-term debt (000's)	8,748	8,955	11,452	15,851	15,138	18,414	25,853	30,487	37,651	35,972	33,614	24,686	25,997
Profit as percent of owners' equity (loss)	20.8	17.8	15.5	9.8	10.7	21.9	17.4	11.0	(4.0)	(10.5)	(0.3)	0.1	5.3
	Total Dollar (000) Reported by All Companies - 18-38 Participants												
Net sales	595,058	725,486	825,423	961,372	1,176,942	1,431,569	1,707,113	1,760,660	1,828,712	1,866,675	2,032,035	1,979,139	2,000,078
Cost of goods sold	454,368	549,913	629,073	726,987	895,442	1,096,581	1,327,212	1,396,619	1,570,361	1,671,843	1,692,764	1,581,802	1,600,623
Gross margin	140,690	175,583	196,350	234,385	281,500	334,988	379,901	364,041	258,351	194,831	339,271	397,337	399,455
S.G.&A. expense (total)	69,541	88,311	104,593	122,060	153,745	185,515	234,350	277,247	319,520	354,090	384,685	366,730	310,034
Pretax profit (loss)	71,149	87,262	91,757	112,325	127,755	149,473	145,551	86,794	(61,169)	(159,259)	(45,414)	30,607	89,421
	6-19 Participants												
Long-term debt	52,486	71,640	91,616	126,806	151,386	239,377	361,944	396,326	527,116	539,578	537,827	419,667	493,944
	Dollar Averages Derived from Percentages Reported - 6-19 Participants*												
Invested capital	63,940	57,389	63,723	73,836	71,285	72,280	84,010	93,662	94,494	74,317	74,411	93,882	72,876
Equity	57,756	44,188	51,795	53,562	54,642	51,617	55,630	60,045	53,953	57,902	57,319	60,934	46,879
	Total Dollars (000) Derived from Reported Percentages - 6-19 Participants*												
Invested capital	383,638	459,111	509,784	590,686	712,850	939,639	1,176,135	1,217,603	1,322,909	1,114,755	1,190,580	1,595,992	1,384,642
Equity	288,782	343,305	414,361	428,492	546,417	671,027	778,823	780,589	755,339	868,532	859,791	1,035,884	890,700

Note: This report is subject to the comments in the accompanying letter dated October 17, 1973.

* Except for 1972 when dollar amounts were reported.

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vanced boldly.

As I conclude, I should like to suggest there are several methods by which this could be accomplished. First, individual company effort. Second, greatly increased funding by a governmental agency such as TVA or Department of Interior. Third, a cooperative industry study under the aegis of a trade association or purely several companies joining together to form an R & D corporation.

Of course there are many possibilities and you could mentally put them together. The important thing — the one salient idea — I want you to get from my remarks is simply that under any plan, resumption of research is a must; it should get underway at once if we are to move ahead to have a future. It must get underway at once, if we are to adequately feed our nation.

CHAIRMAN POWERS: Thank you Edwin for your most interesting discussion "1974 Outlook". Gentlemen, We will progress to tear a few of these problems apart. Mr. Richard E. Briggs, Assistant to the President and Director " Office of Information and Public Affairs Association of Maerican Railroads", will discuss "The Transportation Outlook". Prior to joining The Association Of American Railroads Mr. Briggs served as Special Assistant to various members of the Interstate Commerce Commission.

The Railroad Transportation Outlook In An Age Of Shortages

Richard E Briggs

While preparing my remarks for today, I ran across an item which pointed out that Lincoln's Gettysburg Address contains 266 words. The Ten Commandments contain 297. And the Bill of Rights, 557 words.

My remarks contain about 3,000 words. I make this comparison so you will realize how important my message really is.

Actually, as representatives of the railroad and fertilizer industries, we do have a great deal to talk about — you, as our customers, and we, the railroads, as purveyors of the kind of economical, high volume service your industry requires.

Our long association in this respect, I am sure, has been mutually beneficial and will continue to be so.

Today, we not only have a mutual interest, but we also face a common problem. And it is one we share with many other industries. That is, a need for increased capacity to meet the booming demands of domestic and export markets while confronted with federal wage, price and export controls.

But, from the standpoint of consumers, the need for "increased capacity" translates into all kinds of shortages. Few, I think, will challenge the assertion that, in this land of plenty, we are now up to our ears in plenty of shortages.

There are oil and natural gas shortages. Steel, timber and woodpulp shortages. Shortages of plastics, pesticides, pharmaceuaticals, cement, cotton textiles, beef and even cocoa and raisins. There are also shortages of fertilizers and freight cars.

In the face of all these shortages, there is a paradox. With many industries, business was never better and production was never greater.

For example, the steel industry is having the biggest year in its history and next year is expected to be even bigger.

I understand your business has been booming, too, as a result of the expansion of agricultural acreage here at home and sharply increased exports.

Since the railroad industry serves a large number of other principal industries, the high level of production in this country is reflected in rail freight traffic figures which this year are the largest in history.

In fact, when final figures are in for 1973, we will have achieved our second all-time record year in a row. Indications are that the railroads will handle 840 billion ton-miles of traffic, beating last year's previous all-time high of 777 billion ton-miles by about eight percent.

Our biggest commodity increase, as might be expected, has been in grain shipments, which are running 30 percent ahead of last year. But we have had impressive gains in many other commodities as well.

Carloads of metallic ores are up 14 percent; metal and metal products, 12½ percent; grain mill products, 10½ percent; coke, 20 percent; motor vehicles and equipment, 12½ percent; forwarder and shipper association traffic, 27 percent, and piggyback trailers and containers handled are up more than 20 percent after setting an all-time record in this kind of traffic in 1972.

The 30 percent increase in grain loadings means that we have been loading an average of 5,550 more grain cars a week than we did in 1972, and the performance has been even more impressive since the start of the current fiscal year on July 1.

During the first quarter of the new fiscal year, grain loadings averaged 34,640 cars a week and, in half of this period, the average was better than 36,000 cars. The 1972 average was 26,000 cars a week.

So, in recent weeks, the railroads have demonstrated a capability of handling — on a sustained basis — nearly 10,000 cars a week more grain than the weekly average in 1972.

On an overall basis, the railroads at this time are handling more traffic more efficiently than ever before in history. The improvement in efficiency is reflected by statistics concerning car utilization, as expressed in terms of ton-miles per car per day.

In 1972, we set an all-time record in car utilization of 1,481 ton-miles per day. During the first half of this year, we beat that record by 7.8 percent and we hope the improvement will reach ten percent for the full year.

This performance was made possible by improvements in operational practices and procedures instituted by the railroad industry through self-help programs in recent years.

A lot of projects which have been under development for a number of yeears suddenly began to jell at about the same time in 1972. Notable among these was expansion of the covered hopper fleet to the point where it could handle the bulk of grain shipments and development of a computerized, nationwide freight car information system to help in management of the freight car fleet by providing a more reliable and more timely information base.

As a further move to improve fleet management, car hire rules were changed by the railroads, giving the AAR the power to enforce its car service directives, hire more inspectors to police compliance and assess penalties for violations.

Then there were such advances as the expanded use of the run-through and unit train concepts and — in the grain trade particularly — the adoption of special incentive rates to encourage shippers to minimize loading and unloading time.

All of these factors — and many others I could talk about — have played important parts in improving railroad performance and enabling us to put two record traffic years back to back.

In view of such records, you would naturally assume that we are reaping rich financial returns. Unfortunately, such is not the case. Despite traffic records and marked improvement in car utilization and productivity, net earnings have not improved much over their inadequate levels of the past because rate increases have not kept pace with the inflationary spiral.

Within the year, we have had two rate increases — one of three percent on August 19 to offset, in part, a wage level that is nine percent higher than the average for 1972, and another of 1.9 percent October 1 to offset a payroll tax increase resulting from changes in the railroad retirement program voted by Congress.

We always hear complaints about freight rate increases, of course. Yet, between 1962 and 1973, average freight rate charges increased by only 22 percent while consumer prices jumped 49 percent and wholesale prices rose 51 percent during the same period.

With the rate increases this year — and our increased business volume — we do expect 1973 railroad operating revenues to reach a new record of approximately $15 billion. That would be about $1.2 billion above last year's previous all-time high.

But operating expenses will be in the neighborhood of $14 billion, also an all-time peak, and our net income probably will improve only slightly — to about $500 million.

The rate of return on net investment is expected to be no better than 3.2 percent — about one third of what is necessary to provide for expansion, replacement, modernization and return on shareholders' equity.

We will again have a deficiency in earnings and cash flow in relation to capital expenditures — a situation which has existed in the railroad industry for too many years. Obviously, this cannot continue indefinitely in a mature industry like railroading.

Capital spending for 1973 will total about $1.45 billion, representing an increase of 19 percent over the $1.22 billiion spent in 1972. Expenditures for new equipment — freight cars and locomotives — will total about $900 million, with $500 million going for roadways.

During the first nine months of the year, 1,215 new locomotives were installed, increasing the industry's overall power by 2.5 percent, and freight car orders have been about double those of a year earlier, increasing from 36,300 to 71,500 during the first nine months.

Emphasis in car orders has been on covered hoppers and plain boxcars — the types preferred in grain and fertilizer shipments, as you know.

Since January 1, the covered hopper fleet has been increased by more than 13,000 cars — to a total of over 200,000, including privately owned cars.

This is an increase of 127,000 cars since 1960, when the new 100-ton "Big John" cars were first introduced. And the cars in use then were much smaller than the "Big Johns" and very few of them were used in hauling grain.

Concerning plain boxcars, nearly 15,000 have been installed since January 1 of last year and boxcar orders during the first eight months of this year exceeded the 12,700 total ordered during the full year of 1972.

Still, the number of cars in the total boxcar fleet has continued to decline. This is due largely to the high rate of retirements of the old 40-foot cars that used to serve as the backbone of the fleet. But there are several other important reasons for the decline — all dictated by sound freight car economics.

A great deal of the business that formerly traveled in plain boxcars today moves in equipped cars — or specialized cars of one type of another. One example is home appliances. Another is canned food products. Others are automobile parts and grain.

Covered hoppers, as I mentioned earlier, are now predominate in the movement of grain and are much preferred by a vast majority of grain shippers. I suspect this is also true among fertilizer shippers.

The plain boxcar, of course, still has a place in the freight car fleet, and I know that you continue to have a use for this type of car. But when railroads have money to invest in new cars, they have to spread it around among the various types of cars in an effort to serve the needs of all shippers to the fullest extent possible.

There is one other important factor they must consider. That is the long-range need for each type of car. A freight car costs about $18,000 at today's prices and represents a 20— to 30—year investment. So it would be foolhardy to invest heavily in a type of car for which there is a diminishing demand due to changing shipper needs or to preferences resulting from technological advances in equipment.

The expanded potential of the agricultural industry under the new government policy, which went into effect last year, provided the assurance the railroads needed to double their car orders this year, and new emphasis has been placed on covered hoppers because that clearly is the type of car in greatest demand by some shippers.

However, despite expansion of the covered hopper fleet — and the improved efficiency of railroad operations — there have been consistent complaints all this year about "car shortages."

With the rapid increase in traffic that has occured, car supply problems were inevitable — just as the need for increased capacity has become evident in other industries in the face of an unanticipated boom in demand for their products.

In 1972, I would like to point out — and this can be verified by the ICC — there were no serious or prolonged car supply problems in the country in spite of the record level of traffic handled.

This year we have been operating nine percent above the 1972 level and, on top of that, have encountered a series of problems, most of which were weather-related and occurred during the first half of the year. This combination of factors produced side-effects that the public heard about mostly in terms of "car shortages."

This is a misleading, or at least a grossly misunderstood term, and I would like to take a minute to explain to you what it means and what it does not mean.

"Car shortages" are unfilled orders, as reported by individual railroads to the Association of American Railroads each week.. Where car surpluses exist, they also are reported.

These reports are intended to give a general picture of car supply-and-demand in each area. They were devised a number of years ago to help overcome situations in which there might be a shortage of a particular type of car in one area while a surplus of the same type of car existed in another area nearby.

That is the purpose the so-called "car shortage" figures still serve today. They do not — and never were intended to — indicate how many new cars the railroads need.

I will get into that a bit later but, before leaving the subject of car shortages, I would like to point out that the railroads have pulled out the stops in their efforts to meet the unprecedented demands placed upon them.

In December and January, when farmers were unable to get enough natural gas or propane from regular sources to dry out their grain crops, the railroads were called to bring in fuel on an emergency basis. once the railroads were involved, they immediately became, to a few politicians, the whipping boy for the whole problem. The trouble suddenly became car shortages because that always makes headlines.

We also came in for considerable criticism from some groups over fertilizer distribution problems during the prolonged spring flood when barges were unable to operate on the lower half of the Mississippi River for an extended period of time. This not only put an extra burden on the railroads in moving grain to the ports, but also meant that the barges were unable to move fertilizer materials up the river during the time when this movement is usually at its heaviest.

We never heard any criticism of the barges for falling down on the job, and indeed, such criticism would have been unjust. But we heard plenty of criticism of the railroads even though we were having flood complications of our own at the time — and fuel supply problems on top of that.

I don't know whether most of you know it or not but, when the problem of moving phosphate from Florida was most acute last spring, Secretary of Agriculture Butz called a meeting to see what the railroads could do to help out. Ed Wheeler was there, and so were representatives of the AAR and a number of individual railroads.

At the meeting, seven railroads from various parts of the country pledged a minimum of 500 to 600 cars to help in the fertilizer movement and they came through with twice that number, even though it meant taking cars away from their own customers.

Within the last ten years, the Seaboard Coast Line — which, as you know, is the prime mover of phosphate by rail — has expanded its covered hopper fleet by 79 percent. It has invested $96 million in all types of phosphate-moving equipment within the last two years — 1972 and 1973. That includes wet rock cars, rotary dumping flip-top gondolas, boxcars and 1,000 new 100-ton covered hoppers costing about $21.5 million. These cars are now installed and are being used exclusively for shipment of dry phosphate chemicals. In addition, SCL has spent $15 million on its marine phosphate terminal at Tampa in recent years.

I don't bring these things up in a quest for medals, or even a pat on the back, for the railroads. I simply want to illustrate, as forcefully as possible, that the railroad industry is concerned with shipper problems and is making valiant efforts to provide you with the best service possible under difficult circumstances.

I hope my remarks also will serve to illustrate that there are legitimate reasons for our problems other than the hackneyed allegations of bad management, lack of innovation and a don't-give-a-damn attitude.

We do need more freight cars of all types. We know that, and we know what our needs are. Unfortunately, only about a dozen of our largest railroads are financially strong enough to swing the purchase of large numbers of new cars and locomotives without having to pay exhorbitant interest rates. These railroads have been buying equipment and constantly improving their facilities. But many other roads are in trouble, even where equipment replacement is concerned.

We are counting on a continuing improvement in car utilization — and we are working toward that end — as a means of minimizing financial requirements for equipment purchases. This is essential, because we must have more money to put into plant improvements, and these must be financed out of internally generated funds.

In view of these circumstances, the only way the industry is ever likely to be able to buy enough rolling stock to turn the "declining fleet" situation around is through government-guaranteed loans.

Loan guarantees would enable our financially troubled roads to go into the money markets and borrow the money they need — at reasonable rates of interest — so that they can do their part in the purchase of new rolling stock and bring their facilities up to the level of the more affluent railroads.

Loan guarantees are provided for in the industry-supported Surface Transportation Act which has been kicking around Congress for three years now. It was first introduced in 1971, then revised and reintroduced in 1972 and introduced again in 1973.

In its present form, the STAhas the backing of the American Trucking Associations, the regulated water carriers, railway labor and various other shipper groups. I am sorry to say, I don't think it is supported by your Institute. But I would like to express the hope that you will see fit to change your position when the STA comes back under active consideration in Congress, probably early next year.

In recent months it has been pretty much relegated to the back burner by the crisis in the Northeast. But its basic provisions are still as necessary as ever if the root causes of railroad insustry problems are to be successfully resolved.

What happens in the Northeast, of course, is extremely important to our entire industry. We feel that the legislation ultimately adopted to solve the problems there will be the pattern applied in other areas where similar problems exist or may develop.

The basic, underlying problems of the Northeast stem, in part, from overbuilding during the industrial boom which followed the Civil War. The resulting excess in trackage and competition was "frozen in" with the imposition of government regulatory control and still exists.

The south and West were much less affected by overbuilding, largely because their railroads developed with the areas rather than being built to serve an already established and well-populated region. As a result, the southern and western roads are generally in much better condition today.

The problems created by overbuilding in the Northeast were later compounded by changes in the industrial patterns of the area and the arrival of new forms of transportation. The railroads steadily lost out to highway carriers in the handling of short-haul and high-rated traffic, while many of the old industries and products that had required railroad transportation moved out of the area or disappeared.

If the railroad problems of this area are to be resolved today, the answers must recognize present conditions and circumstances. The excess of competition and trackage must be rationalized in line with today's needs.

In this connection, I understand many of you are concerned about the possibility of railroad abandonments not only in the Northeast but also in certain sections of the Midwest.

Your concern is understandable but, because of what you might have heard or read about the Northeast, I think it might be much greater than warranted. So I will use this situation in an effort to put the picture into better focus.

Actually, the majority of the excess trackage in the entire country is in the Northeast. In this area, it is estimated that roughly 20 percent of the existing trackage is excess. Where branch lines may face abandonment because they cannot pay their cost of operations, I think you will find that Congress is going to provide funds to pay most of the cost of subsidies required to make up losses in order to keep these lines in operation. This would take the form of "matching fund" arrangements requiring a minimal contribution by state or local governments. A Federal-State subsidy on a 70-30 basis for continuing operations on properties now operated by the seven bankrupt roads is currently included in H.R. 9142 which the full House will vote on this week as a solution to the Northeast crisis. A similar provision covering all potential abandonments is incorporated in the Surface Transportation Act.

If this kind of arrangement is ultimately adopted, I would think that those concerned about abandonments can breathe a sigh of relief.

Even if state and local subsidies were not forthcoming in all instances, there are a number of alternatives to assure continued service for shippers.

In some cases where abandonments have occurred already, lines have been taken over and operated by local or regional groups, by shipper cooperatives or as non-profit "short line" railroads. These operations have many advantages in relation to taxes, schedules and overhead costs generally. Labor has been most cooperative, with the aim of helping to keep costs as low as possible. In other cases, substitute truck service has proved to be an adequately and economical substitute. So the calamitous results some foresee from abandonments are not likely to occur.

Solution of the problems of the Northeast won't solve the problems of the industry as a whole by any means — but it will eliminate the most pressing problem and provide substantial relief, without which the industry cannot plan ahead on a sound basis.

As for the long-range future of railroad transportation in this country, we think is is great — for the simple reason that no system has yet been developed that can match the railroads in providing fast, high volume, low cost freight transportation.

I think it is highly significant that last year, for the first time in many years, the railroads increased their share of the nation's total transportation load and we anticipate another and more impressive increase when the figures are in for 1973.

A booming economy, obviously, is partly responsible for our record business. But I believe improved railroad service and more aggressive marketing practices also have played a part. In addition, ecological factors favor rail transportation in the long run, and these are coming in for more and more attention on the part of our public officials..

They know that railroads can be expanded with far less disturbance of the countryside or landscape than highways; that they contribute far less than highway carriers to air and noise pollution, and that they can do four times as much work as trucks on the same amount of diesel fuel.

Because of the fuel situation and the prospects of rising fuel costs and long-range shortages, the railroads already are beginning to get a significant amount of piggyback business from private and commercial truck fleets and are encouraging this with special unit train rates and schedule frequencies that enable the truckers to give fast service and save money by going piggyback instead of using the highways on medium and long hauls.

Railroads efforts to continue to improve their service include development of a much more sophisticated national freight car information system to further improve efficiency of operations through better control of the freight car fleet.

The new computer system is expe cted to be ready for pilot operation late next year and in full operation by mid-1975.

Meanwhile the "car shortage" problem is being attacked on two other fronts not previously mentioned here.

A study is now under way at the University of Nebraska — with industry backing — in an effort to find a better way of distributing the car supply in tight situations. And a committee of AAR directors is well along in a study aimed at possible establishment of a totally free-running, privately owned and operated national boxcar pool for use in helping to ease shortages in seasonal or emergency situations.

Actually, it is impractical to expect the railroads ever to have enough cars to meet, instantaneously, the demands which exist in the fall, when about 75 percent of the annual grain production is harvested within a period of a few weeks coincident with a heavy demand for the same type of cars to move fertilizer materials to the farming areas for fall plantings.

As Interstate Commerce Commission Chairrman George Stafford has pointed out, if the railroads had enough cars to meet all the demands of peak seasons, they would not have enough sidings to store all the empties during times when the demand is small.

We do, indeed, feel the industry has made great strides within the last year. And we will be able to go a lot further in this direction — if government transportation policies are revised in line with provisions of the Surface Transportation Act and loan guarantees are made available to our weaker roads so that they can participate fully in an industry-wide effort to increase capacity.

We feel confident that this legislation — with the widespread backing it has — will be passed. But we are concerned by another piece of legislation which is being pushed in some quarters. That is the so-called "Fastcor Bill" which — like STA — provides for government-guaranteed loans for the purchase of freight cars.

Many improvements have been made in this bill since it was first presented last year. Many of its totally unworkable original provisions have been eliminated or modified and — in concept — it has become a positive bill, especially when compared to the walking disaster which was developed in 1972. In spite of the modifications, however, it still does not offer the incentive to equipment acquisition which is provided by the STA.

Irrespective of the real benefits in the Fastcor Bill — and the industry could well use the $2 billion in loan guarantees which Fastcor calls for — railroads cannot afford to pay the price which would be extracted by one of this bill's so-called "labor protective" provisions.

As you are probably aware, the railroads have always been more than generous in agreeing to compensation of employees who are adversely affected by industry changes.

But the provisions of the Fastcor Bill are not designed to protect employees — they are designed to protect jobs. They require railroads to hire new employees to fill jobs that are not needed. Thus, the railroads utilizing loan guarantees under this bill would not be able to benefit appreciably from increases in productivity because reduction of work force — through attrition — would not be permitted.

Within the last two years, the railroads — with the cooperation of labor, generally — have made great strides toward rationalizing personnel problems. State laws requiring train crews larger than necessary for safe operations have finally been wiped from the books or drastically revised. And the 36-year-old fireman issue finally has been resolved to the satisfaction of both labor and management. Important changes in work rules also have been made to improve operational efficiency and the modification of others is now being worked out.

Most of the gains that have been made in these respects after years of conflict with the unions would be virtually wiped out by the Fascor Bill for any railroads desperate enough to utilize its loan guarantee provisions. Its labor provisions would, in fact, create the worst restrictions on the productive use of labor ever to be imposed upon the railroads or any other industry.

Even though this fact is very lear, some people — who have decried the railroad inefficiencies caused by labor restrictions in the past — have been supporting this bill. I assure you, if it passes in its present form, it will be a giant step backward for the railroad industry.

The quickest and best way to strengthen the railroads and improve rail service in this country is through the prompt passage of legislation that includes the major provisions of the Surface Transportation Act. I think adequate proof of this bill's merits is provided by the widespread support it has attracted. I hope that you will join us in helping to get the STA enacted so that railroads can speed up their revitalization process.

CHAIRMAN POWERS: Thank you Mr. Briggs for defining The Transportation outlook from the railroad viewpoint.

Our next Speaker will concentrate on the Industrial View for Fertilizer Transportation and Distribution. This discussion will be my Mr. J. Howard thompson, Director, Transportation and Distribution, Duvall Sales Corporation, Houston, Texas.

Fertilizer Transportation And Distribution Industrial View

J. Howard Thompson

Since about 22% of the estimated $90 billion U.S. annual freight bill is spent to transport the 680 million tons of farm and forestry products and supplies, there is little wonder why the transportation-distribution function of our Industry receives so much attention.

The memory is still fresh with many of you of last Spring's worst transportation crunch in the Industry's history. This was not unexpected, and was the result, in part, of an unprecedented overtaxing of the nation's transportation system to move the enormous export grain tonnage. In fact, our situation at that time eas somewhat akin to Dr. Kenneth McFarland's story about the farmer in a traffic jam who observed a truck driver ahead of him every few minutes jumping out and beating the side of his truck with a 2 x 4. After watching this exercise a few times, the farmer got out and strolled up to where the truck was waiting in line and asked the driver what caused him to beat his truck on the side with the 2 x 4. Well, said the driver, I've got 4 tons of canaries, but only a 2-ton truck, and unless I keep half of them flying around all the time I'm overloaded. Well, that just about sums up the story of our country's distribution system last Spring: Overloaded. Unfortunately, things don't look much brighter in this regard. In fact, if anything, this coming Spring could find the Industry experiencing a bigger and even more serious transportation crunch than last. This is especially true in view of the continuing heavy export grain sales and some 50 million additional acres to be fertilized.

A while back it was my privilege to participate in a production and marketing symposium sponsored by the TVA. My subject was the "Problems of the Shippers," which were related to the time-worn cliche of "having the right material at the right place at the right time" — and I might add at distribution cost that will permit the sale of the product. The trick, of course, is how to solve this riddle in spite of the vast number of variables, some of which cannot be easily predicted nor controlled by the Industry. Included in this latter category are weather conditions; inadequate carrier service, and with certain railroads the very real possibility of a complete abandoment of service, especially on branch lines; and currently, governmental policies which might affect the flow of products in the export market.

Traditionally, the pattern of fertilizer distribution has included basic producers shipping to wholesale mixers who manufactured and sold finished products to retail dealers who made the final sale to the farmer. During the 1960's, this was supplemented by other distribution systems, each of which was designed to find the most economical way to move plant nutrients from production to the ultimate consumer. These systems included (1) bulk blending; (2) granulation plants; (3) so-called farm service centers, which often include bulk blending facilities in addition to a retail farm service store; and (4) independent retail dealers. Regardless of the system chosen, the transportation distribution function continued to be a dominant part of each individual system.

Regardless of the planning and sophistication built into these systems, it seems obvious that we must make further adjustments and refinements if we are to more nearly solve the distribution and logistical dilemma of having material at the time and place demanded by the buyer. Today we will take a look at some of the distribution and logistical problem areas currently facing the Industry, as well as some on the horizon. Then we will consider possible corrective measures that might lessen somewhat the impact of these problem areas.

Although railroads no longer have a monopoly on the distribution of fertilizer and fertilizer materials, they continue to play a dominant part in the fertilizer distribution concept. This is substaniated by the fact that as late as 1971 about one dollar of every 25 dollars the railroads gross come from the fertilizer industry or its customers. Their overall importance to the nation as a whole is reflected by the fact that they still carry about

39% of our total intercity freight traffic. Therefore, due to the obvious importance of the railroads in the distribution of fertilizer and fertilizer materials, the rails' ability or inability to function properly has much to do with the success or failure of our endeavor.

It goes without saying that the success of any distribution system, including rail movements, is measured by (1) the economic cost of the service, (2) availability of equipment, and (3) quality of service. Our allotted time today will not permit an individual analysis of the various rate systems of fertilizers. However, it is generally agreed that the increased payload of jumbo covered hopper cars and tank cars provide opportunities for shippers and receivers to share in carrier cost savings through reduced incentive rates. These jumbo cars, with capacities of approximately 100 tons, permit reductions reflecting, in some instances, 10% to 15% under the rates in so-called standard cars. Jumbo incentive rates have been followed by other cost savings techniques such as multiple car, annual volume, and unit train rates. While at one time a novelty, these innovations have now become commonplace on such commodities as anhydrous ammonia, phosphate rock, potash, sulphur, and superphosphate to name a few. By shipping greater volumes in multiple car, trainload, or unit train lots, rail unit costs are reduced, allowing a portion of the carriers' cost savings to be shared by the shippers or receivers.

Fertilizer shippers and receivers historically have been plagued with equipment supply problems, which seemed to have magnified with each new passing year due to a continuing decrease in the general purpose boxcar fleet and an ever increasing list of competing commodities vying for equal use of covered hopper cars. This is substantiated by the fact that since 1960, the railroad ownership of 40-foot boxcars had declined from 560,000 to 212,000 today. As to the availability of adequate covered hoppers, in early October the national shortage of these car was already running about 28,000 cars per day for grain alone. Of course, to this must be added the covered hopper shortages for fertilizer which number will be greatly magnified under the usual pressures of the Spring crunch.

Many reasons are advanced for this lack of adequate cars for fertilizers, including inadequate carrier planning, the poor financial state of certain carriers, and the extreme seasonality of the fertilizer movement. Regardless of the lack of total agreement as to the exact cause, one does not have to look very hard to find a unified agreement on the lack of enough cars. Unfortunately, as more and more carriers are being caught in the equipment squeeze, the solution to the problem falls squarely on the shoulders of the individual shipper. It is to his own personal loss if a satisfactory solution cannot be found.

While in years past, shippers would "take their chances" on the available car supply, hoping that the Spring season would be extended until enough cars became available, many shippers have recently begun taking steps to "shape their own destiny." These self-help efforts include seasonal pricing to encourage year round shipments and thus even out the so-called peaks and valleys, off-site storage so as to spread the equipment requirements, and operation of shipper owned or leased covered hopper car fleets. Some shippers have found it to their individual advantage to supplement their production sites with large off-site storage terminals (which might also be served by private car fleets), while others find it to their advantage to engage in seasonal storage through use of storage in private "roller" cars on leased tracks, and still others use a combination of both. In addition to establishing an alternate source of car supply, another advantage of these two systems is to provide the customer expedited delivery as required since the storage terminals and/or roller points are strategically located near or within heavy consuming areas.

A case in point is the recent announcement by a major cooperative. As opposed to their traditional shipping pattern of roughly three months of late Winter and early Spring, the cooperative intends to move fertilizer all 12 months of the year by use of a large fleet of leased covered hoppers. During 9 months they will move phosphate from Florida, ammonia from Louisiana and potash from Canada into strategically located storage facilities in the Midwest. During the other 3 months, they will ship to cooperatives and then to the fields of their farmer-members. As in many distribution systems involving private or leased equipment, the key to this concept is utilization of equipment, the cost of which if not properly controlled can negate its distribution advantages.

Water transportation is also closely associated with the Fertilizer Industry. Although statistics indicate that U.S. water carriers as a whole receive only about 7% of all the nation's freight revenues while carrying about 16% of the nation's total domestic freight, this is misleading as to their importance to the Fertilizer Industry. Barging has maintained a steady growth since World War II; and fertilizer firms, not restricted by sources of supply, continue to seek out processing and storage site locations on the banks of the nation's 25,500 miles of commercially navigable waterways. The reason for this is obvious. Due to many fertilizers moving in heavily-concentrated and repetitive units, they are a natural to reap the advantages of barge tows which are now capable of carrying as much cargo as a thousand railroad freight cars. Consequently, water transportation offers the most economical service other than pipelines. For instance, it has been recently reported that the average shipper's cost of barge freight runs 3 mills per ton-mile (ranging from 1¾ mills for large bulk movements to 7 mills for lesser quantities) compared to about 15 mills via rail and 65 mills or 6½ cents via truck. in addition to the comparatively low charges of forhire water carriers, some firms operate private barge fleets as a distribution tool.

Early barge cargoes included phosphate rock, dry sulphur and superphosphate. Technological advances have made possible many new kinds of barges. These include tank barges for transporting refrigerated anhydrous ammonia and insulated barges for transporting sulphur in liquid form. Other commodities hauled in special fitted tank barges include caustic soda, phosphoric acid, and sulphuric acid.

Just as the McClelland-Kerr Arkansas River Navigation System opened Southwest America towater transportation in 1971, barring some unexpected development, during this decade the Warrior-Tombigbee __system (connecting the Tennessee River with the Gulf of Mexico) will do the same for some Southeastern states. As a result of the LASH (Lighter Aboard Ship) concept, these inland ports are now open to the world. This operation involves specially constructed ocean going barge carriers acting as "motherships" for their individual small barges (lighters), which are about ⅓ the size of river jumbo barges and are designed to be integrated with the regular tows on the U.S. inland waterways. The advantage is direct ocean water shipments from and to inland ports without intermediate handling. It is reported that dry bulk can be moved already, should the need arise and that LASH barges could be designed for liquid products, including those that have to be heated. It remains to be seen whether this concept will be of material benefit to the Fertilizer Industry

Many barge movements have provided opportunities for intermodal coordination. Unfortunately, the voluntary coordination has largely been restricted to water and motor transportation. Examples of this coordination is found in the outbound truck deliveries from sulphur and anhydrous ammonia storage terminals.

Railroads have been usually reluctant to enter into coordinated service with barge lines. This is due to the rails regarding barges as competitors for long-haul bulk traffic. A notable exception is the case of the Seaboard Coast Line Railroad and the Ohio River Company. Phosphate rock moves in multiple car shuttle trains from mines in the Bone Valley area of Central Florida to an automated Tampa port terminal, thence via super-jumbo 26,000-ton capacity runs across the Gulf to a fertilizer plant on the Mississippi River some 55 miles above New Orleans.

While barge capacity has ex panded over 65% in the last 10 years and while an additional 50% growth is anticipated by the 1980's, a recent development casts a shadow over the entire barge industry. Following a 5-year study, in a June report to Congress, the National Waterway Commission recommended that inland water carriers be required to pay the full cost of all navigation maintenance and that local and state governments finance construction of new locks and dams. Future funding of water projects would come out of fuel (user) taxes, lockage charges, etc. The inland water carriers and their shippers are expected to fight any legislation to implement waterway user charges.

Another recent development causing alarm to the fertilizer industry is the shortage of barges for up river fertilizer movements. One large producer-shipper reports that even when such space is available for fertilizer , rates have been increased some 25% this year over last, reflecting the carriers' desire to move barges back up river empty for additional grain loadings rather than move fertilizer on the back haul as in the past. In view of this development, this producer is moving its distribution points from river terminals to interior points which will be served by private rail cars.

Trucking continues to play an important role in fertilizer distribution, especially on finished products and short hauls. As previously mentioned, this is particularly exemplified in the trucking of ammonia and sulphur from storage terminals. In this connection, the trucking of ammonia has become so pronounced that certain shippers have been forced to furnish private ammonia trailers to insure adequate service during the peak demand season. O f course, trucks have historically played a major role in the outbound distribution from certain off-site phosphate storage warehouses.

Trucks may prove to be the Industry's salvation in connection with those areas finding themselves without rail service as a result of abandonments. As questioned in a recent U.S. Department of Agriculture report: "What will be the impact of proposed railroad abandonment of branch lines on rural communities? What new methods of transportation will be required?" Of course, this is a "tough nut to crack." One method is rapidly gaining favor in meeting the threat of loss of all-rail service. In certain Great Plains states and the Southwest, short-line railroads have been formed to continue service to shippers who would otherwise be left stranded. These short lines are said to be able to replace abandoned branch lines in some instances because the reduced scale of operations often show a profit when a trunk line can only operate at a loss. While it is stated that this is an answer to a fair number of abandonments now being sought, it is not an answer to all of them. Another possible answer is an intermodel service such as rail-truck or barge-truck or rail and/or barge to nearby storage terminals thence truck delivery beyond. This concept is already being offered by some carriers whereby rail hopper and/or tank cars are shipped to distribution terminals for off-loading to trucks for ultimate delivery to off-rail locations. This system permits the cost savings associated with long distance incentive rail rates to the distribution terminals, plus the convenience of truck delivery to destination.

Pipelines represent another mode of increasing importance to the Fertilizer Industry. Of prime significance are the ammonia pipelines of Gulf Central, Mid-America, and William Brothers. Also, the latter company transports nitrogen fertilizer solution through its petroleum system. Development work continues on slurry and capsule pipelining. Commodities frequently mentioned as possible condidates for capsule pipelines include potash, sulphur and wheat, among others. So much for the past and present but what about the future? Truckers can be expected to continue advancement in equipment diversification such as multipurpose trailers permitting dry bulk cargo one way and liquid load returns. Other diversifications permit general cargo one way and bulk loads another.

One source predicts an even greater future use of liquid pipelines for fertilizer. However, it remains to be seen how soon technology will permit the economical carriage of solids by pipelines.

Inland waterway interests are talking about 12-foot channels as compared to the present 9 feet. This would permit tows up to 60,000 tons which would be 50% heavier than present with consequent economies of scale. Also, it will be interesting to see how the barge industry will be affected by recent ICC decisions permitting two railroads to operate barge line subsidiaries.

Opportunities still lie ahead for those transporting bulk commodities in volume, both in liquid and in solid forms. Transportation companies can be expected to continue to "tailor make" systems to fit specific traffic flow patterns. Computers will allow carriers to further refine their costing methods, so that special attention wll continue to be given profit-centered business.

But once the economics are agreed upon, how will we move the tonnage? How can we keep up with the physical demand, bearing in mind that one source predicts a likely 40% increase in U.S. fertilizer use in the next seven years? Somehow as an Industry we must educate ourselves so as to maintain year round shipments as opposed to the highly concentrated movement each Spring. Somehow we must find ways to "even out the flow" and eliminate the shipping "peaks and valleys" in which we find ourselves entrenched. Admittedly this won't be easy. It will require cooperation from all segments of the Industry if we are to suceed.

Using the immediate past and present as a guide, especially in the short run, shippers and receivers must also resign themselves to the need for increased shipper involvement in rail equipment acquisition — regardless of the outcome of the several bills pending before Congress to provide railroads federal loan guarantees for additional cars and power. At least until the current shortage of rail equipment is rectified, either from additional acquisitions and/or improved utilization, the fertilizer industry still will be faced with the ever present problem of delivering product when it is needed. The possibility or probability of being unable to deliver from distant sources of supply could very well force the Industry to adopt means to more nearly level out the seasonal shipping peaks and valleys.

In summary, when considering the various transportation and distribution techniques discussed, perhaps the most significant conclusion that can be reached is that there is no one best way to fulfill each need. Each company must make its own decision based on the value it places on the individual factors involved, as well as the individual circumstances applying in connection with each movement being considered.

In other words, each company must use ingenuity pertaining to its own individual circumstances applying in connection with each movement being considered.

In other words, each company must use ingenuity pertaining to its own individual circumstances, similar to the farmer and the professor in a guessing game. It seems a farmer and a professor were traveling together when the professor suggested asking each other riddles to pass away the time. The professor suggested that each time one missed, he would give the other a dollar. The farmer replied: "You're better educated than I am. I should only have to give you 50 cents." The professor being quite confident agreed and told the farmer to make up the first riddle. "What has 3 legs walking and 2 legs flying?" asked the farmer. The professor gave up and handed over the dollar. The farmer said he didn't know either and handed the professor 50 cents. Now that's INGENUITY. That's what we must have to keep up in the years ahead.

CHAIRMAN POWERS: Thank you Mr. Thompson for your timely remarks on the challenges that lie ahead in Transportation.

Mr. Herman A. Hazen, Product Sales Manager, Arenko Machine Co., Inc. Teterboro, N.J., will discuss "Bulk Fertilizer Stock Piling and Reclaiming."

Stock Piling And Reclaiming Of Bulk Materials To and From Storage

Herman A. Hazen

In recent years fertilizer and chemical companies like many other industries have had to in most cases increase their production capacities at very large rates. In most cases this has forced an increase in the storage facilities for raw materials, finished products and often materials in various stages of production. Increased storage area is generally not as much of a problem as the increased rates of material going into storage, so that reclaiming from storage is a constant problem.

There is a sufficient amount of technical information on extraction equipment to remove products from silos and hoppers, but there is a very limited amount of technical information on removing materials from pile storage. Most companies, especially in the U.S. still rely on the classical methods such as front end loaders and gravity-fed tunnels. For small storage capacities and small reclaim rates these techniques may be sound, but with high reclaim rates, especially with continuous operation, the reclaim scraper generall is far more economical and reliable.

What is a reclaim scraper and where did it come from? Unfortunately, many people automatically think of a dragline scraper. Although a dragline is of sililar construction and performs the same fuction as a reclaim scraper, their manner of operation is very dirrerent. The dragline pulls across the pile filling a bucket towards an unloading point, while the reclaim scraper detaches the product with teeth and by using blades merely guides the material towards an evacuation device, usually a conveyor belt. This difference greatly reduces some of the disadvantages unusually associated with the dragline scraper, such as high energy consumption, excessive wear, and a high amount of product degradation.

The reclaim scraper was first developed about 1900 in the lignite mines in Germany; soon after that the potassium industry discovered its usefulness and it is still widely used in this industry. After World War II it became widely used in the fertilizer industry in general in most parts of the world but only in the last few years has it become known and used in the United States. Only in the last eight to ten years has it diversified into many other industries, such as port terminals, glass works, mining, pulp and paper, and cement. The reasons the reclaim scraper was so popular for so long in fertilizer industries is its ability to detach caked materials from the top of the pile without leaving roof formations or vertical walls. This being particularly evident problem with potash and its derivatives.

We can break down the family of scrapers into two main groups, they being (1) reclaim scrapers and (2) blending or homogenizing reclaim scrapers which from this point we will refer to simply as blending scrapers. We know that blending is not generally a consideration in production aspects of the fertilizer industry and we will only cover the highlights of the blending scraper group.

To get an effective blending of a product or combination of products, it is necessary to put the product into the pile forming layers that the scraper can cut across evenly. If this is done and the percentages of the different products going into storage are known, a percentage of blend can be guaranteed. The principle of operation of the blending scrapers is to dislodge and reclaim an even amount of each layer in the pile. The dislodging devices are various and are determined by the products handled. One of the newer devices which has proved very effective is the wire rope method. This device works like a windshield wiper against the face of the pile at the natural angle of repose of the product. This wiper action mixes all layers as the product rolls down. The scraper blades, running parallel to the face of the pile, guide the mixed product across the floor to the reclaim conveyor belt. The wire rope method of blending offers the following advantages as compared to a bridge mounted bucket wheel or a bridge scraper with a reciprocating scraper arm.

1) lower initial cost of equipment
2) better utilization of storage space
3) lower operational and maintenance costs
4) more constant reclain rates
5) a better blend especially concerning size segregation

Blending scrapers can operate in either a circular pile or a longitudinal pile. The circular pile offers the advantage of a combined stacking and reclaiming unit generally with a lesser cost of machinery. The major disadvantage of a circular pile is that expansion of the storage capacity is impossible without building a complete additional system. Although the blending scrapper for circular and longitudinal piles work on the same principle of operation, the longitudinal concept allows for future expansion of storage capacity at a minimal additional cost. All aspects of the customer's current needs plus possible future needs should be taken into consideration of system design.

As stated previously blending is not generally a prime consideration in the basic fertilizer producer's industry, so we will spend more time on reclaim scrapers. This group is also broken down into sub-groups; namely, travelling, pivoting and rotating types. Of these subgroups we will cover lightly the pivoting and rotating types in order to cover in more detail the most popular travelling types. The principle of operation on all reclaim scrapers is the same. Each scraper has one or two arms, some times refered to as jibs, with two continuous chains to which blades are attached. Depending on the material handled, teeth can be added to detach it. The arm works in front of or along the side of the pile, loosening and guiding the product from top to bottom and using gravity to assist in removal. Because of the use of gravity and the fact that the scraper in most cases does not lift the material, scrapers today use an average of .1-.2 kw/ton/hour — a feeble rate of energy consumption. The pivoting scraper is the oldest in design of the current reclaim scrapers on the market. It operates against the face of the pile in a pivoting motion. This type of machine has outlived its usefullness in most cases, and to my knowledge none have ever been installed in the United States. The reasons for this being (1) it is very difficult to automate and generally requires a fairly skilled operator to maintain a constant reclaim rate, (2) it requires either a reclaim tunnel w/covers or a bucket elevator to raise the product to a take-away conveyor belt, (3) it has limited reclaim rates.

The rotating reclaim scraper is usually a combined stacking and reclaiming unit which operates from the center of a doughnut shaped pile. The stacker and reclaimer revolve around a common pivot point in the center of the pile. This type of arrangement is generally in a dome type building. The material is brought into the top center of the building and fed into a chute that is supported by a frame that pivots in the center of the building and runs on a rail either at ground level outside the pile or supported on the building above the pile. Building costs determine the location of the rail. This frame with attached chute travels back and forth within a present arc of the circle building the pile in layers. Meanwhile the reclaimer, pivoting also from the center, has a frame which runs on the same rail as the stacker frame and supports a reclaiming arm. The stacker and reclaimer cannot pass each other but each is capable of rotating a complete 360 degrees. The frame of the reclaiming arm also travels back and forth in a preset arc and the arm is lowered each time it reverses its travel motion. The blades guide the material to a hopper in the center of the pile which then feeds a take-away conveyor belt. This system has been used where some degree of blending is desired and the product is usually very dusty. The reasons being that the stacker is capable of building the pile in layers and the system is easily automated, completely operated from remote control. The disadvantages: again no chance for expansion, costly in regards to building costs versus storage capacity

By far the most popular reclaim scrapers on the market today are of the travelling type. This group can be broken down once again to three models — portal, semi-portal and side scrapers. The portal scraper has a frame that spans the width of the pile and travels on two rails at ground level, one on each side of the pile. Semi-portals have a frame that spans half the pile and travels on two rails, one at ground level, the other on a support above the center of the pile. Usually two semi-portal scrapers are installed, one on each side of the pile. Side scrapers are of cantilevered counterweighted type travelling on two rails at ground level both on the same side of the pile. All three types have same method of operation whereby a bin or an area of a pile, or in some cases a whole pile, is selected as the area to be reclaimed. In the case of separated bins each bin wall has limit switches to limit the travel of the scraper. The operator brings the scraper to the designated bin and lowers the arm to the highest point of the pile (if stacking has taken place since last reclaimed) and manually "faces" pile usually with one or two passes. When he has a flat plane, he sets the scraper to the reclaim rate desired and sets it on automatic. From this point on, as long as in that bin, the scraper will work automatically. This is accomplished by a travelling speed coordinated with the chain speed so that the blades fill as they move down and across the pile. When the machine contacts the bin wall limit switch, the traversing movement stops and the arm lowers a preset depth (to meet rate desired). The scraper then reverses the direction until it contacts the wall limit switch on the opposite side of the bin. where traversing stops, the arm lowers, travel reverses. This procedure is repeated until the scraper is stopped or the pile is deleeted. When the pile is gone, the arm will contact a lower limit switch and shut off the machine. In the case of no bin walls moveable rail mounted switch contactors can designate a pile or a section of a pile to be reclaimed. What I have just described is designated as manual operation as an operator must be on the machine to start and stop it or to change reclaim rate. From here varying degrees of automation are offered by remote control. The first step is the most popular, the safest for machine and least expensive.

This still requires an operator to bring the scraper to a selected area and "face" the pile, but the scraper can be stopped, started and the reclaim rate changed from a remote control station. The next step for additional automation would be to operate the scraper completely from a remote station. This is many times requested but it generally requires considerable costs in sensing devices, TV systems and additional safety equipment. This additional cost would probably be offset where many products were being reclaimed and the scraper would be changing bins or working areas frequently on a continuous basis. That briefly is the method of operation of travelling reclaim scrapers. They all offer the following advantages:

1) automation is very simple
2) reclaim rates are constant
3) reclaim rates can be adjusted with precision
4) any number of materials can be stocked and reclaimed with one scraper
5) The system can usually be set up on a first in first out basis.
6) removal is complete — no dead storage.

Those factors that would determine which of the travelling scrapers to choose would be:

1) storage capacity desired
2) reclaim rate desired
3) product(s) handled (caking)
4) building construction costs versus machinery costs.

At this point let us analyze a typical project to see how a particular scraper is utilized. First it must be noted that although reclaim scrapers are designated by model numbers, almost every installation requires a high percentage of new engineering on each machine. This is because of the number of variables involved, such as, number of materials to be handled, their various characteristics, storage capacities desired, reclaim rates, space available for storage area, building costs, soil conditions, automation requirements and others. It is therefore necessary to start with as much information as possible to determine a scraper that will best fit the needs of each installation.

The installation we will discuss had the following basic requirements:

Product: DAP only
Storage capacity desired: 60,000 tons
Reclaim rate: 250 tph
Area available: 600' x 200'
Good soil conditions.

With this and other information available concerning building costs versus machinery costs the following was supplied.

One portal scraper in a modified A-frame building 190' x 420'. The product is brought in by an overhead tripper conveyor. The scraper has the following specifications:

Reclaim rate: 250 tph
Span from rail to rail: 170' 6"
Weight: 115 tons
Power installed: approx. 100 Kw
Width of blades: 52"
Speed of reclaiming chains: 3' 5"/sec.
Power of reclaiming chains:
  primary: 60 Hp
  secondary: 30 Hp
travelling speed operation: 7' 3"/min.
traveling speed placement: 55' 10"/min.
Travelling power: 2 x 12.2/2.2 Hp
Hoisting speed of arms:
  low: 9' 5"
  high: 15' 1"/min.
Hoisting power: 20 Hp/3 Hp

Rather than going into a detailed description of each piece of this scraper I would like to explain how it is operated. This particular portal scraper as most indoor units has two reclaiming arms, outdoor units usually have only one arm that extends past the support beam. This unit also has the two arms attached on an articulated unit. another type has the two arms separated. Each has slight advantages over the other but both work on the same principle that the second arm pushes the product toward the center of the pile and feeds product to primary arm. This requires only one reclaim belt and still assures complete removal of the product. with only one product to be handled, only one pile is built and while one section of the pile is being built, another section is being reclaimed, As this product is basically seasonal at certain times during the year, the product almost completely fills the storage area, while other times it is almost empty. Because of this problem the designated working areas of the reclaimer and overhead tripper are selected by means of moveable limit switch stops. Once an operation area has been selected, an operator on the scraper moves the sccraper in high speed to that area and sets the limit switch stops. He then lowers reclaiming arm to highest point of the pile in that area. He puts the reclaiming chain into motion, starts the traversing motion and makes one or two passes within the area until he has a plane over the whole area. He then sets the desired reclaim rate and dials a switch to remote control. From that point on the reclaimer is controlled by the shipping department until that area of pile has been deleted. The amount of time required to delete an area of pile depends on how large an area is selected and the rate of reclaiming. It is then necessary for the operator to move the scraper to a new area of the pile and repeat the above procedures. As mentioned earlier by using TV cameras or sensing devices, the scraper can be moved to new areas by remote control.

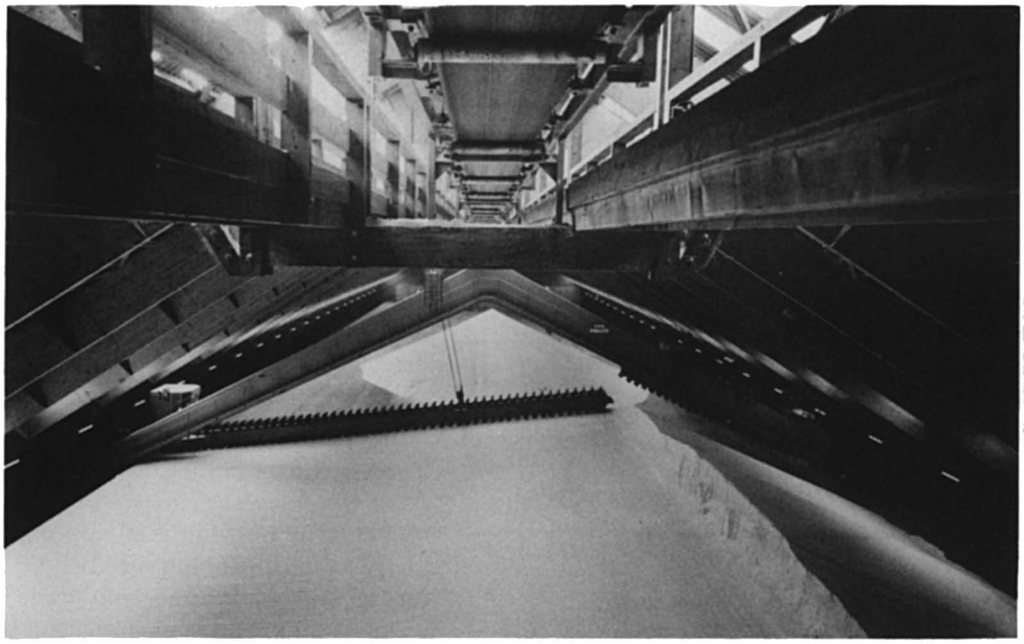
The scraper is electrically operated and has many safety devices via electrical inter-locking, such as:

1) The scraper cannot be started if the reclaim belt is not running and shuts off if the reclaim belt stops.
2) The scraper cannot travel in high speed unless the reclaim arm or arms are in the highest position (to avoid the possibility of running the arms into the pile or a wall at high speed).
3) The arms have upper and lower limit switches (the lower shuts off the machine and sounds a buzzer on the control panel showing pile is deleted).
4) It will not transverse if the cable reel is not working.
5) A cable slack device will stop lowering the hoist if there is slack in the hoist cable.
6) On a two-arm scraper — neither arm will run without the other.
7) Sway detection — if one truck gets ahead of the other, it will automatically correct. If this correction fails, the machine will shut off a a predetermined deflection.

All precautions are considered in the design to protect the scraper, the system and personnel working with the scraper.

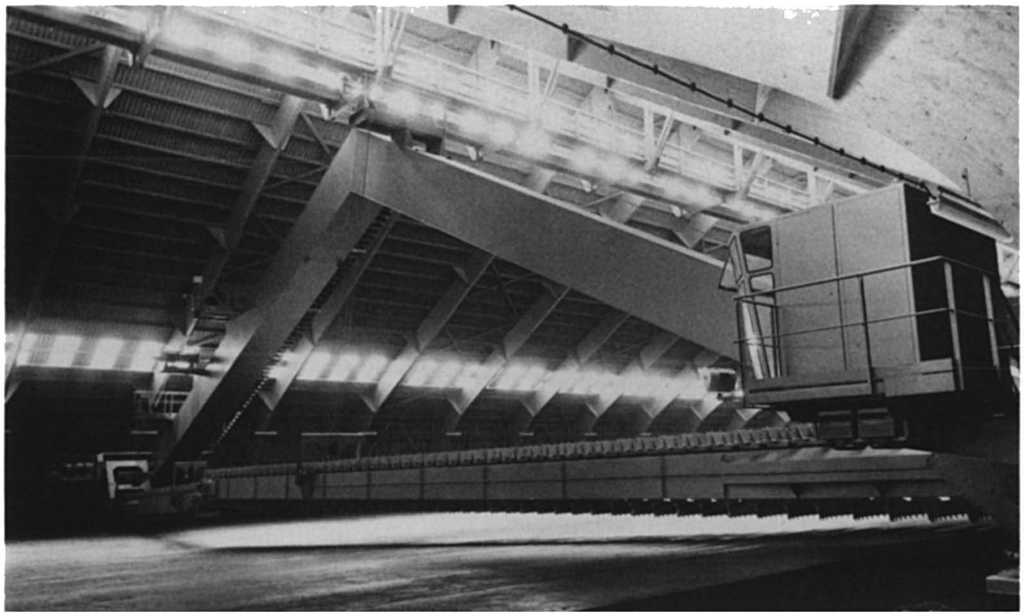
We have discussed reclaiming scrapers of various types and designs but there are some cases, especially when very high reclaim rates are called for that other types of reclaiming equipment might be advantageous. Specifically I am referring to a bucket wheel reclaimer. The bucket wheel reclaimer is a very popular mchine in some industries and does offer certain advantages; however, companies who manufacture both bucket wheel reclaimers and reclaiming scrapers feel that many times a bucket wheel is used when a portal scraper would be better suited at a much lower cost. The reason for the selection of a bucket wheel generally is that it has been proven on high capacities up to 8,000 tph; whereas portal scrapers thus far have only been proven up to 1200 tph, although units have been designed up to 3000 tph. It is human nature to let the other guys try it first.

In summary, it is evident that each installation has its own set of circumstances and requirements and has to be studied to determine the best solution. However, it is becoming more evident that the reclaim scraper will in most cases prove to be the overall most economical and efficient choice for product removal from pile storage.



SLIDE I

A two-arm portal scraper with reclaim rate of 250 tph of urea. Scraper has a rail span of 140 ft. and is capable of complete removal of the product. This scraper has two reclaiming arms which are not connected but operate in relation to each other to remove product in one direction to single reclaim belt.

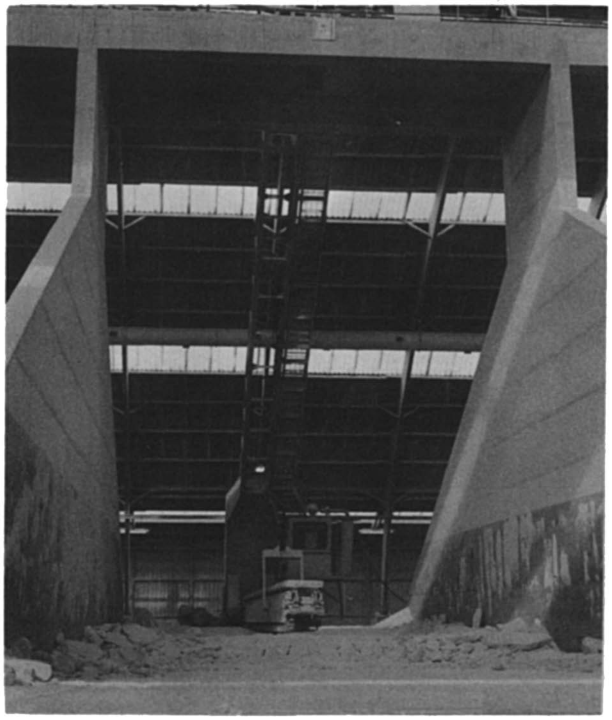


SLIDE II

A two-arm portal scraper with reclaim rate of 250 tph of urea. Scraper has a rail span of 140 ft. and is capable of complete removal of the product. this scraper has two reclaiming arms which are not connected but operate in relation to each other to remove product in one direction to single reclaim belt.

SLIDE III

SLIDE IIIA two-arm portal scraper with reclaim rate of 400 tph of DAP. Scraper has rail span of 150 ft. and also is capable of complete removal of product. This scraper's two reclaiming arms are connected with an articulation device. These reclaim arms also move product in the same direction to a single reclaim belt.



SLIDE IV

One of two semi-portal scrapers in the same building with each having a reclaim rate of 150 tph of various fertilizers. Each semi-portal works independently of the other on opposite sides of the pile so that two products can be reclaimed simultaneously on two reclaim belts, one on each side of the pile.

CHAIRMAN POWERS: Thank you Mr. Hazen for your excellent and most interesting Paper. We have covered the subjects on the importance of Research And Developments; Transportation Outlook Railroad Viewpoint; Transportation Industrial Viewpoint; Stockpiling and reclaiming and now we are ready to get the material out on the Field. Mr. Donald Hemstock, Operations Supervisor, Soils Service Center of "CENEX", Farmers Union Central Exchange, St. Paul, Minn., will talk to us on "Application Equipment."

Fertilizer Custom Application Equipment

Donald Hemstock

Today, the fertilizer dealer must contend with shortage of product, shipping schedules and economic change within his trade area. He must also provide fertilizer custom application equipment to render good service to his customers. Notice the wording "render" good service, not necessarily "give" good service. Our experience at CENEX is that if the dealer renders good service to his fertilizer customers, the customers do not object to paying for that service. It must be *good* service however!

Let's talk about rendering good service to that fertilizer customer and what it takes to get the job done.

First, how much equipment and what type of fertilizer custom application equipment should the fertilizer dealer provide? The size of the dealer's trade area is an important consideration when making these decisions.

Radius of Trade Area	*Total Acres*
10 miles	200,000
15 miles	450,000
20 miles	800,000
25 miles	1,250,000
30 miles	1,800,000
35 miles	2,500,000
40 miles	3,200,000

It is obvious that a 10 mile radius area will give the dealer the area of least cost distribution. He can render good service in this trade area in a short period of time with less custom application equipment than he can if he is operating out in the 30 to 40 mile radius area. The type of equipment will also differ depending on size of the trade area. Truck mounted dry spreading equipment is used to serve patrons located 30 to 40 miles from the plant. Trailer spreaders pulled behind a 4 wheel drive pickup are used to custom apply dry fertilizer in a 10 to 20 mile trade area.

Rate per acre of material being applied will also determine the number and size of custom application units needed to render good service to the fertilizer customer. A customer applying 75 lbs. actual N per acre, using NH_3, located 10 miles from the plant, would require one 1,000 gallon NH_3 nurse tank. Another customer located in the same area applying 150 lbs. actual N per acre, using NH_3, would require two 1,000 gallon NH_3 nurse tanks.

The variety of crops being grown and the soil type in the trade area are also factors to be considered as to the type and amount of custom application equipment the dealer will have to render the customer the good service we are talking about. Row crops will require different equipment than hay or pasture crops. Corn may require dry trailer spreaders (plowdown fertilizer), tender units (delivery of bulk starter) and sidedress or toolbar machines (NH supplemental nitrogen). Alfalfa would only require dry spreaders, either truck or trailer.

If the customer has labor available, he will want to apply his own fertilizer materials. He may want the fertilizer dealer to provide custom application of his fertilizer when farm labor is in short supply. It takes less equipment to provide custom application of fertilizer than it does if the customer rents the equipment and applies his own fertilizer, according to our experience; the reason being it is much more difficult to manage and control rental units compared to custom application equipment, on the dealers part.

Four-season application of fertilizer has enabled us to utilize custom application equipment more efficiently. The more days throughout the year you can utilize a 6 ton trailer spreader, the better the service rendered to your customers. Encourage summer application of fertilizer wherever it is a good sound practice. Fall application of fertilizer has been one of our big promotions, over the years at CENEX. We maintain "one of the best places to store phosphate and potash over winter is in the soil".

The type of fertilizer materials custom applied will greatly influence the type and amount of equipment the dealer must have to render good service to the customers. Nitrogen materials in our area are the products requiring this consideration. Anhydrous ammonia requires special applicators and nurse units; ammonium nitrate requires dry spreaders and 28% and 32% UAN solutions are usually applied with spraying equipment, along with herbidides in most cases. In some parts of our trade areas, you can also add 20% aqua ammonia to this list of nitrogen materials, aqua also requiring special equipment for custom application.

The management of custom application equipment is probably one of the most frustrating jobs the dealer must do if he is to provide the good custom application of fertilizer we have talked about. A late spring, wet fall, product availability, agronomic factors, customer priorities and labor situations are all factors to be considered when trying to manage custom application equipment. This means the dealer must be ready to change his planning to meet these situations when they arise, and still provide good application service to his customers.

The dealer should evaluate equipment usage. Is each piece of equipment being used each day efficiently? Controls must be established. The men actually doing the custom application must know what they are expected to do and how much work they should get done in a day.

Also, the dealer must evaluate the services performed. Was the fertilizer correctly applied to the crop? We use our Crop Monitor program to evaluate services performed and also to evaluate crop response to the plant food applied.

Preventive maintenance is the program we follow on equipment. The dealer can provide good custom application service by following a system of checking, adjusting and replacing worn parts before the piece of equipment actually breaks down in the field.

When receiving a new machine, regardless of the type, you should check to make certain that the screws, bolts and fittings are properly adjusted. These items could work loose during shipping. Also, make certain that wheel lug nuts are tight before using the machine. New telescoping power take off shafts should be checked, and if need be, lubricated before putting into use.

1. Maintance checklist — dry fertilizer equipment (attached).
2. Maintance checklist — for anhydrous ammonoa (attached).

Calibration is a must for fertilizer application equipment. Follow the procedures recommended by the equipment manufacturer and calibrate the equipment regularly!

Check the spread pattern on dry spreaders to be sure the fertilizer is being evenly applied to the entire width of the spreader pattern. This should be done even with a new spreader before it is used in the field. Again, follow procedures recommended by the equipment manufacturer and check the spread pattern regularly!

Expense recovery must be discussed because the dealer must charge the customer at least what it costs him to provide good custom application of fertilizer. Let's discuss fixed costs —

Fixed Cost

New Dealer Cost —

4 Ton Dry Spreader — Stainless Steel	$2880
Depreciation (5 yr.)	$ 576
Maintanance (10%)	$ 288
Insurance, Taxes, Licenses	$ 80
Interest at 8½%	$ 245
Total Fixed Cost	$1189

$4500.00	Cost Pickup
900.00	(5 yr.) Depreciation
450.00	Maintanance
200.00	Insurance, Tax, License
382.00	Interest (8½%)
$1932.00	Total

Our average fertilizer rates per acre of material will be about 335 lbs. per acre or 1 ton of material is spread on 6 acres —

Fixed Cost on Spreader/acre

1200 acres	F.C. = .99/acre
2400 acres	F.C. = .49/acre
3600 acres	F.C. = .33/acres

Fixed Cost On Pickup Per Acre Basis

1200 acres	F.C. = $1.61
2400 acres	F.C. = .80
3600 acres	F.C. = .54

We find that 25 acres per hour is about what we can spread on fairly level fields.

Variable Costs

	Hour	*Acre*
Labor	$3.75	$ .16
Gas, Oil, Tires	1.00	.04
	$4.75	$ .20

Total Spreading Cost/Acre

	Spreader	*Truck*	*Variable*	*Total*
1200 acres	$ .99	$1.61	$ .20	$2.80
2400 acres	.49	.80	.20	1.49
3600 acres	.33	.54	.20	1.07

As you can see, volume per spreader is the key to expense recovery. I feel just this way about custom application services: the dealer should have a good idea of the cost per acre to provide good service and should charge for those services accordingly.

To give the whole picture on the importance of volume to the fertilizer dealer, we tied plant through put costs, high volume and low volume plant, into cost per acre to custom apply the fertilizer.

Expenses

	High Volume (6270 T)	*Low Volume (2005 T)*
Salaries	$17,501.00	$13,504.00
Payroll taxes	939.00	926.00
Hospital insurance	114.00	369.00
Travel	631.00	547.00
Automobile & Payloader	1,101.00	981.00
Automobile Depreciation	782.00	682.00
General Supplies	14.00	331.00
Heat & Fuel	92.00	114.00
Light, Power, Water	744.00	238.00
Repairs & Maintenance	1,563.00	1,129.00
Depreciation — Building	4,665.00	3,130.00
Plant Equipment	1,173.oo	534.00
Office Equipment	347.00	42.00
Insurance	1,521.00	1,538.00
Real Estate taxes	1,406.00	600.00
Rent — lease site — license	87.00	144.00
Office supplies	201.00	679.00
Postage	58.00	111.00
Telephone	271.00	529.00
Miscellaneous	1.00	193.00
Expense recoveries	(120.00)	54.00
Total	$33,095.00	$26,375.00
Volume	6,270 tons	2,005 tons
Thru Put Cost/Ton	$5.28	$13.16

When you consider volume in relation to thru put cost per ton and cost per acre to provide custom application, it becomes very apparent that volume is the key to a successful total operation. Because of supply problems, we do not look for an increase in volume in the near future. We will try to hold down expenses wherever possible, at the plants. We may have to increase gross margins also to keep our operations in the black in the future.

Our program is to promote efficient use of plant food available, chemical pesticides and quality seeds. We feel that plant food recommendations should be based on a recent soil test. When this type of program is followed by the American farmer, the result should be increased production of food.

MAINTENANCE CHECKLIST DRY FERTILIZER EQUIPMENT

DAILY

Check for build-up on chute, floor, and distributor blades before loading.

Check all nuts and bolts during first week of use.

Check wheel studs.

Check dial by closing gate before loading.

Check pocket wheel on rear roller for build-up in pockets.

Lubricate universal joints on P.T.O.

Lubricate drive chains.

Check hitch for cracks, wear.

Complete wash down.

Lubricate P.T.O. shaft.

WEEKLY

Check all V-Belts.

Clean metering gates.

Lubricate all bearnings on distributor drive line.

Check all nuts and bolts.

Check conveyor belt tension and calibration.

Check tire pressure.

Soak auger in water and run wet sand through augers on combination units.

MONTHLY

Grease conveyor belt roller bearings.

Check fan blades and replace as required.

Lubricate drive frame bearings.

Check gear box oil level (if applicable).

Check brake fluid.

SEMI-ANNUAL

Change oil in reservoir and replace type A automatic transmission fluid on combination unit.

Change oil filter on combination units.

Bleed and adjust brakes — check linings for wear.

Remove roller chains and soak in fuel oil.

run sharp clean sand through auger units.

Clean and repack universal joints on P.T.O.

Clean and repack wheel bearings.

Steam clean or pressure wash, wipe down with fuel oil.

ANNUAL

Lubricate conveyor roller bearings.

Clean all rust to bare metal, spot prime and paint as required.

Check axle bushings.

MAINTENANCE CHECKLIST FOR ANHYDROUS AMMONIA

PAINT AND MARKINGS
1. Clean all rust to the bare metal once a year, spot prime and paint as required.
2. Apply markings according to state regulations.

SAFETY EQUIPMENT
1. All safety equipment should be kept with unit at all times.
2. Minimum of 5 gallons of water with unit at all times.
3. Wear goggles and gloves at all times when filling.

VAPOR PUMP
1. Close valve on suction side. If gauge goes to zero, suction is O.K.
2. Close valve on Discharge Side. If pressure relief (pop-off) works, discharge side is O.K.

HOSES (All hoses are stamped with date of manufacture.)
1. Change rayon braid hoses semi-annually.
2. Change stainless steel hoses every 5 years.

KNIVES
1. Check periodically for wear and uniform pitch.

FLO-TROL VALVE
1. Clean valve screen daily.
2. Overhaul valve annually.

PRESSURE RELIEF VALVE
1. Change semi-annually.

WHEEL BEARINGS
1. Clean repack as needed.

CHAIRMAN POWERS: Thank you Donald and thanks to all of our Speakers this morning for outstanding, timely, valuable and lots of food for thought discussions to help us in our day to day operations. We shall now adjourn and thank you. Our meeting this afternoon will begin at 2 P.M.

Tuesday, November 6, 1973

Afternoon Session
Symposium On Speciality Fertilizers
Harold D. Blenkhorn, Moderator

THIS GARDEN ENGLAND COLOR AND SOUND PICTURE

Courtesy: International Minerals & Chemical Corporation

MODERATOR BLENKHORN: I wish to take this opportunity to thank Frank Nielsson and International Minerals and Chemical Corporation for arranging and showing that most interesting, beautiful "Color and Sound Picture Titled "This Garden England". The Picture is a Wide Screen Technicolor Technirama Production, Prepared for I.MC. by Empire Photosound, Inc., Minneapolis, Minn.

Filming Locations were all in England, as follows: Cliffs On Devin Coastline Blenheim Palace; Bodiam Castle; Leonardslee Windsor Great Park; Barrington Court — Hampton Court; Hever Castle; Stourhead Sheffield Park; Boureton-On-The-Hill Chipping - Campden; Chelsea Garden Show Wisley Gardens; Scotney Castle; Regents Park.

"This Garden England" it is said that Britian's climate enables her to grow successfully a wider range of plants than any other country in the world. "This Garden England" endeavors to portray the unlimited variety of English Gardens and capture some of their majesty. International Minerals & Chemical Corporation, with extensive interests in growing things, takes this means to share with all peoples the splendor and beauty of "English gardens."

In the rear of this room Frank Nielssen has left many copies of a booklet explaining the highlights and showing a number of beautiful pictures of the "Gardens" you saw on the screen.

Should you be interested in showing this picture at one of your sales meetings, it is possible by contacting Mr. Nielssen, he may get permission to loan the film to you. If there are not enough of the booklets "This Garden England"please write Mr. Nielsson. I am sure if he has a supply at his office that he will be very happy to send you a copy.

In American Fertilizer circles "Spciality Fertilizers" are quite insignificant if you look at the total tonnage. Probably if you knew what the dollar volume was they might not be quite so unimportant as you might think. The Speciality Fertilizers, lawn, garden, etc., are kind of a unique segment of the Fertilizer Industry. They differ from farm fertilizers in that there is an entirely different approach to marketing and they have their own unique manufacturing problems. The formulation of the product that you make in the specialty line differ quite a bit from farm fertilizers. It is a segment of the Industry that lends itself to great ingenuity. If you go to a garden center, and look around, and look at the products offered, and read some of the labels, you will see that the ingenuity used in marketing these products seems to know no bounds. This afternoon we have three presentations to be followed by a group discussion. The group discussion will serve the purpose of giving the Speakers an opportunity to answer questions relating to their papers, and to discuss questions which any of you might have on the Fertilizer Specialty Line in general.

Out first speaker is Mr. Roger Brown, National Accounts Manager, for Swift & Co. He has a broad background in just about all facets of the speciality fertilizer business from herbicides, to fertilizer manufacturing, to marketing. He has devoted most of his working life to the marketing end of it. In addition to being Accounts Manager for Swift & Co. he, like all of us, have several reasons for working. A while ago, that old rascal "Victor Borga" came to Montreal and I had the pleasure of hearing his concert and at the end of it he said "You can thank my parents for making this program possible and you can thank my children for making it necessary." Mr. Brown's necessity, in addition to the fact that he loves to work, is connected with the fact that he has been living with the same wife for 22 years and he has two boys in college and a boy and girl in high school. So I give you Roger Brown with his own personal view of the "Specialty Fertilizer Market."

A Personal View of Specialty Fertilizer Marketing

Roger A. Brown

I would like to tell you of an incident that happened to me that has a very relative and pointed moral to it. I was riding a New York subway early one morning when at one of the stops a drunk stumbled onto the car that I was seated in. His hat was askew, his tie was pulled back, he had lipstick smeared all over his face and he was really a mess. He popped himself doen on the seat and he happened to sit next to a Roman Catholic Priest. There was a newspaper lying on the seat next to him. He picked it up and started to read it. After a while, out of the clear blue, he nudged the Father sitting next to him and said, "Say, do you know what's the cause of arthritis?". I could see the glint in the Priest's eye and I imagine he thought "Here's my chance to give him a little sermon, alittle preaching, and perhaps get him back on the straight and narrow Christian path." He says, "My good man, arthritis is caused by over indulgence in alcohol, carousing around with loose women, and an overall sinful type life." The drunk just shrugged his shoulders and went back to reading the newspaper. the Father felt he had been too hard on him and to make amends tapped the drunk on the shoulder and asked, "I say my good man, where does the arthritis bother you the most?" The drunk said, "Heck, I don't have arthritis but I was reading here in the paper where the Pope as a severe case of it." Well the moral of that story is never preach a false sermon or don't ever make an untrue sales pitch, to make a point, or it will surely backfire.

There have been many companies that have entered the lawn and garden fertilizer business with high hopes only to flourish, falter, and fail. The interesting thing to me is that, most of these companies make the same mistakes others have made before them, and very few have benefitied from these nistakes. It is my opinion that dynamic aggressive inexperienced people are to blame.

How is the Lawn and Garden business?

It's good and getting better. More and more people are moving into homes and neighborhoods that demand a decent lawn. More leisure is giving people more time to pay added attention to their lawns and gardens creating a new and interesting hobby, which also improves the appearance and value of their property. The cost of fresh vegetables has reinstated the old victory garden.More people are growing their own produce now, than did during the second World War.

Lawn fertilizer was originally sold in a bag to cover 5000 square feet. Now the best seller is a 10,000 sq. ft. bag with a 15,000 sq. ft. size available. Combination products to feed and deweed lawns, prevent crabgrass and insects as well as nourish the grass, are very popular to save time and labor. Small package insecticides, fungicides, weed killers, and specialty fertilizers are still popular. Rose food with systemic insecticide and weed control, a new product, has all but taken over the sale of straight rose food. Five years ago the average household spent $7.56 on garden supplies anually, today it spends $10.09 an increase of 32%.

Have lawn and garden products changed?

Basically no. The dry product in a bag that is spread by means of a drop or broadcast spreader is still the king. Of course we have come a long way from the 50 to 80 lb. bag of farm type heavy weight (60 lb./ cu. ft.) grades of 5-10-5, 10-10-10 and 10-6-4 for grass. We now have light weight products with analysis as high as 34-5-5 and densities of 24 lbs. per cu. ft. sold in 20 to 25 lb. bags. Slow release nitrogen, the addition of secondary and micronutrients, and a balanced agronomically correct ratio for turf are some of the improvements.

What is the difference between private, control, and branded label?

When a customer decides to put his own name on the bag then that is private label. A manufacturer produces an analysis mutually agreed upon and puts it in the customer's bag. Control label is a bag and name owned by the manufacturer. He may give a customer exclusive use of this bag for a given territory or a special price on a low margin product. The branded labels are the locally or nationally advertised products such as O. M. Scott's Turfbuilder; Swift chemical company's Vigoro; Eli Lily's Greenfield; U.S.S. Agri-Chemical's vertagreen; Borden's, Nutro; Standard Oil's Ortho; Agrico's Grass Food; and many other branded lines too numerous to mention. Most of the branded lines are owned and manufactured by fertilizer companies basic in at least one or more raw materials but there are some that are produced by outside sources.

Which is ahead in sales, branded line or private label?

With all the different private label products on the market, it is difficult to believe that branded lines are still the biggest sellers. The customer, with some exc eptions of course, has come to think of the private label as a price item. When the retail buyer wants specific quality and know how assurance, he chooses a branded line. The average homeowner knows that some fertilizer company is making the private label for the store, so unless the price is right, why not buy it direct from the manufacturer?

What are the pros and cons of having a private label fertilizer?

A company buying private label use to be able to earn a substantial savings over branded line, since the manufacturer didn't have to spend any money on advertising, or salesman to check stock etc., and the big private label user would usually have T/L or carloads shipped direct to his warehouse early in the season. Now with the increased cost of warehousing and redistribution, the savings gap has substantially narrowed. If the private label's only merit to the customer is price, then his type of buyer isn't looking at the name on the bag, but at the price tag and his only loyalty is to cost, consequently, the private label has lost it's effect. If the private label is as good or better than the most popular brand at a substantially better price, and the retailer can woo the customer into trying it, then he has an item that will draw that customer back into his store. This to me is or should be the purpose of a private label.

Here are some of the problems that confront a prospective private label customer:

1. Empty bags must be ordered in quantities of 20,000 for each item to receive a good price. You would need 200 tons of light weight fertilizer or 500 tons of heavy weight fertilizer to fill this number of bags.
2. On a new pesticide or weed and feed type product, it takes from 4 to 6 months to receive final E.P.A. registration.
3. State registration fees and tonnage taxes keep increasing and are different for every state.
4. Local and federal restrictions are constantly changing. Products that were allowed last year are banned this year.

These are a few of the factors that make the private label fertilizer business complicated.

A well known and accepted branded line increases the acceptability of a store to the customer. While the branded line may not be *the* calling card, it is one of many that add up to the reason for the customer to choose that particular store to shop in.

Who is the biggest single mover of gardenline goods?

The discount chain in 1972, sold $1,300,000,000 representing over 20% of the total market. The Hardware stores sold over $2,000,000,000 worth of hardware and gardenline products, but this also included paint which is a big item with hardware trade.

Why are the discount chains the biggest?

They are numerous, well located, well merchandised and carry every possible item the consumer can think of in one shopping area. By having several stores in and around large metropolitan areas, their advertising dollar goes further than the local hardware or the independent. Consequently, they can flood the papers with large attractive ads.

Discount and department stores are developing patio garden areas that have everything necessary for the home including live nursery stock, flowers and vegetables. Unfortunately, all too often, these areas are not manned by properly trained personnel, and many sales are lost. If the customer is turned off too many times by lack of information, service, or product, he will turn to the independent lawn and garden dealer who specializes in knowing his business. This independent lawn and garden group is still fourth in volume and above the department store. In 1972, they sold $454,680,000 worth of hardware and gardenline products vs. the department store's $365,900,000.

What's new in the lawn and garden industry?

A new source of slow release water insoluble nitrogen called Isobutylidene diurea, (IBDU). It does not rely on bacteria action to become available and is completely consumed during one season.

Landscape franchise businesses are springing up everywhere. For a few cents per square foot, a company will feed, seed, weed, debug, and apply fungicide to your lawn at given intervals during the growing season. All the home owner has to do is water and mow.

A liquid fertilizer for lawns is being test marketed with an applicator for the garden hose that leaves a foam so the applier can see where he has sprayed. Cost is comparable to conventional fertilizer including applicator.

A high concentration of nitrogen, phosphorous, and potash is available in a box that is placed on a special type spreader that punctures the box and spreads the product without the lawn owner ever touching the product.

Are there any problems in lawn and garden production?

Quite a few as a matter of fact. There for a while, everyone was getting into the fertilizer business, buying plants or building them. In the last five years the reverse has been true. Some of the better granulation plants have been shut down because of costly pollution regulations. Other plants have been eliminated because of merging companies that already had production facilities in the area. As a result, there is a shortage of the type of manufacturing operation needed to produce the more sophisticated light weight home owner fertilizer. To this problem add increasee business, then throw in an extreme raw material shortage, and increased cost of materials and labor. If that's not enough, bring in new state and federal laws and restrictions on the type of products and labels allowed, and of course, OSHA with the safety restrictions. We won't even talk about labor unions or paper shortages, or the fact that labor isn't overly excited about seasonal work in a fertilizer factory. These problems can be solved, but they will take time, money, and careful planning as well as some leveling off, and consideration from some of the restriction agencies.

What about the institutional business?

The institutional business is comprised of: Golf courses, landscapers, schools, industry, cemeteries, parks, roadsides, military bases, airports, zoos, and national forest. The difference between selling institutional customers, and the homeowner is that, in most cases the institutional user knows something about fertilizer and the homeowner does not. The golf course superintendent doesn't have to be sold with a TV commercial or full page ad in the Sunday paper, or a beautiful bag with photographed grass on it. He wants results. He wants the very best turf for the least amount of money. The institutional buyer is loyal to a good product, but if he is doing his job properly, he is always on the outlook for something better. Universities have turf clinics and field trails that have excellent attendance by the professional and commercial men to see what is new and better.

Who spends the most money on turf?

Homeowners — over $3,000,000,000 annually

Highways are second, cemeteries third, and golf courses are fourth at approximately $50,000,000/year for fertilizer alone.

Thank you gentlemen for your kind attention and remember my slogan

"DON'T LET YOUR GRASS GO TO POT,
MAKE IT STAND UP FOR IT'S ROOTS"

MR. BROWN: If the Moderator will agree I have three minutes of my own time in which I can answer questions since I will not be here for the "Question and Answer Period".

MODERATOR BLENKHORN: "Yes indeed, sorry you cannot stay longer with us." Questions from the floor please.

QUESTION: Are combination products on the increase?

ANSWER: The combination products are definitely on the increase. Everybody is looking for service and labor saving devices and a combination product is that. The weed and feed, of course, is the most popular and has a long season span. It is growing quite rapidly. I would say the weed and feed product is rapidly approaching the volume that the straight fertilizer is.

QUESTION: Are Lightweights continuing to grow?

ANSWER: The lightweights are basically taking over the market. The areas where lightweights are still not too polular are in the South. Down South you still have the old products we talked about — the 10-10-10, 10-6-4, the 6-10-4, 10-20-10, basically farm fertilizers, they've got a long season and they have to feed the grass regularly and they want a fast acting type fertilizer. Lightweights are making increased growth in volume down South, but very, very slowly, but overall the lightweight is the king of the market.

QUESTION: Are water insoluble nitrogen fertilizers going up in sales?

ANSWER: Definitely going up. Your water insoluble nitrogen from urea formaldihide, IBDU, or from organic sources, gives the customer a longer lasting fertilizer, much safer fertilizer, and the homeowner who burns his lawn, and had to resod or reseed it, learns very quickly that the cheap fertilizer is one of the most expensive fertilizers he can buy, which is also true of grass seed.

Thank you Mr. Moderator. My compliments. We are right on time and my time is up. Don't forget my slogan — Don't let your grass go to pot. Make it stand up for it's roots."

MODERATOR BLENKHORN: Thank you very much Roger.

There is one minor thing I forgot to mention. It is not of much importance and I don't know if anyone is interested or not. My name happens to be Harold Blenkhorn. I was transplanted from Nova Scotia to Montreal many years ago and am still there. It is a pleasure to be in your famous city. It is not the place of a Canadian or an outsider to be commenting on a foreign country's internal problems, but the other day I was reading a book of quotations by America's famous philosopher "Will Rogers" and there was a section devoted to politics and referring to politics in general. He said something like this. He was referring to Congress and the Government. He said, "The system is there. It exists. It is bigger than all of us; and no matter what clowns they put in there, none of them are good enough to improve it and hopefully none are bad enough to harm it for a very long." I wonder what he would say if he was alive today?

MODERATOR BLENKHORN: I mentioned ingenuity a while ago. We are fortunate enough to have with us a man from Denmark to bring us some of the ingenuity of the European technology. His paper does not deal with lawn and garden, in the true sense, but it fits into the overall framework of the speciality fertilizers in that it is a highly specialized and unique fertilizer. The speaker is Mr. K. C. Knudsen. He holds a Masters Degree in Engineering. He is in charge of process and product development for "Superfos of Denmark". He is the inventor of the process which he is about to describe.

Superfos Pure Plant Food An Advance in Fertilizer Technology And A Contribution to Reducing Environmental Problems

K. C. Knudsen

I am sorry I am not enough familiar with your language to start my speech by telling a joke. At least I would not be able to understand it myself. But, I would like to tell you something instead of a joke, and that is whatever a proper definition of the speciality fertilizer might be, it appears to me that it is a product with a limited usage. It has a usage because it has special provinces or merits but at the same time the usage is limited due to higher selling prices which are justified by the higher manufacturing costs in order to obtain these special provinces.

The product I am going to tell you about is not a specialty fertilizer in regards to manufacturing costs. My company is producing an agriculture fertilizer and this product is produced in big quantities, along with other agriculture fertilizers. It's only a special fertilizer in the sense that it has the provinces and merits which justify the higher selling price of specialty fertilizer . . . and this is no joke.

INTRODUCTION

A concentrated NPX fertilizer today — like f. inst. a 17-17-17-normally means a product containing ammonium nitrate, ammonium phosphate and potassium chloride. Here you have 4 ions of plant nutrient value — ammonium, potassium, nitrate and phosphate — and one nonnutrient, the chloride. For specialty purposes some chloridefree NPK's are produced by deriving the potassium from the potassium sulphate instead of potassium chloride. The proportion of chloridefree fertilizers varies from country to country — in USA it is 5-6% of total K_2O. Such NPK's are more expensive to make because the sulphate costs more as a raw material than the chloride, and now you have got the heavy sulphate ion instead of the chloride ion in your endproduct in addition to the 4 valuable ions. In principle, it is possible to use potassium nitrate instead of the chloride or sulphate thereby obtaining a product containing practically only the desired 4 nutrients ammonium, potassium, nitrate and phosphate, but this is not done to any extent today, simply because the potassium nitrate is far too expensive for all but very special purposes.

The Superfos Pure Plant Food which we are now presenting to you is a pure NPX fertilizer containing ammonium nitrate, ammonium phosphate and potassium nitrate (plus optionally a small amount of calcium phosphate). It is the product you would obtain if you used potassium nitrate instead of potassium chloride or sulphate in your NPX manufacture. But what makes this new product unique is that it can be made at a cost no higher than that of making the common chloridecontaining NPK's, which means much cheaper than the chloridefree NPK based on potassium sulphate — and very much cheaper than chloridefree NPX based on potassium nitrate.

In my presentation today I shall try to answer the following two questions: Firstly, *how* can it be possible to make a potassium nitrate containing NPX product at a cost comparable to that of the conventional chloridecontaining NPK fertilizers? Secondly, *why* is it desirable to make such products, i.e. what are the merits of our Pure Plant Food fertilizers as compared with conventional NPK's?

THE PROCESS

To answer the first question (how to make cheap potassium nitrate based NPK) let us consider the raw materials normally used for making concentrated NPK products (slide 1): N from ammonia and nitric acid, P_2O_5 from phosphate rock and k_2O from potassium chloride. Essentially, in our raw materials we have 4 plant nutrient ions, ammonium, potassium, nitrate and phosphate plus two unwanted ions, calcium and chloride. Practically all the chemistry in NPK manufacture today is a matter of getting rid of the calcium — mostly by buying sulphur or pyrites to make sulphuric acid, to make phosphoric acid, to make ammonium phosphates — whereas the chloride is generally accepted as a constituent in the finished product.

Now, the whole idea of our new process is based on the fact that of the two unwanted ions one is a cation (calcium) and the other is an anion (chloride). On slide 2 we can see in a simplified way what happens when we solubilize phosphate rock in nitric acid:

$Ca_3(PO_4)_2 + 6\ HNO_3$ ——— $3\ Ca^{++} + 2H_3PO_4 + 6\ NO_3$ (1) and when we solublize potassium chloride in water:

$KC1\ H_2O\ K^{+} + C1^{-}$ (2)

What we need is clearly a simple way of making $Ca^{++}$and K^{+} change places, so that we get a solution containing K^{+}, H_3PO_4 and NO_3 plus a solution containing Ca^{++} and $C1^{-}$.

If this were possible in a single operation it would replace not only the shole sulphuric-phosphoric acid route to remove calcium but also the costly procedure to remove chloride from KC1, such as the conversion of KC1 into KNO_3 by means of HNO_3 or the conversion to K_2SO_4 using sulphuric acid. Furthermore, if this single operation could be carried through at about the same cost as the sulphuric-phosphoric acid removal of the calcium alone, then the chloride would be removed at no cost, which gives a potassium nitrate containing NPK no more expensive than a potassium chloride containing NPK.

We found that it is possible to make the two cations calcium and potassium change places by using a cation exchange resin similar to the resins commonly used in water treatment and purification processes. If the letter R indicates one negatively charged group on the surface of the resin the production reaction is (slide 2, equation 3):

$(3Ca^{++} + 2H_3PO_4 + 6NO_3^{-}) + 6KR$ ——— $(6K^{+}\ 2H_3PO_4 + 6NO_3^{-}) + 3CaR_2$(3) and the regeneration is slide 2, equation 4):

$(6K^{+} + 6C\text{-}1) + 3\,CaR_2$ ——— $(3\,Ca^{++} + 6C1^{-}) + 6KR$ (4)

This application of the ion exchange technique is very different from conventional applications, and it created a number of problems. The main two were the stability of the ion exchange resin in the highly aggresive nitrophosphate slurry and the design of a practicable ion exchange equipment for treating the concentrated solutions without excessive dilution and losses. These problems were studied and solved first in the laboratory and then on the pilot plant. based on the experience obtained we constructed an industrial-size ion exchange plant which has now been in operation for almost two years and which has a daily capacity of 400 tons of NPK.

Slide 3 shows you the central part of the ion exchange plant. Here the nitrophosphate solution containing calcium nitrate and phosphoric acid is converted into a product solution containing potassium nitrate and phosphoric acid. The product solution contains 60-65% water and is concentrated to about 30% water in a spray concentrator. This solution is then made into the final NPK product in a traditional neutralizing and granulating equipment. Slide 4 shows the simple flow diagram of the process.

ECONOMICS

The question now to be examined is: What are the costs of operating the ion exchange process based on the experience from this plant compared to the costs of making NPK the traditional way?

To illustrate this we shall look into two examples. First we shall consider an NPK manufacturer already producing a substantial volume of granular NPK and wanting to convert 100.000 tons per year of it to chloride-free NPK. To produce this chloride-free material he may buy K_2SO_4 and use this instead of KC1 in his existing NPK plant or he may install an ion exchange unit in addition to his existing plants. On slide 5 we have listed the costs for these two cases.The estimates are based on a 16-16-16-grade for the K_2SO_4—containing NPK and on a 17-17-17-grade for the KNO_3—containing NPK made by ion exchange, assuming that the costs for these grades would be representative of several grades that might be produced. The P_2O_5—watersolubility for the 17-17-17-grade is 75% and for the 16-16-16-grade higher than 90%.

The raw material cost of the Superfos PPF is very much lower than that of the K_2SO_4— based material, not only because we use KC1 instead of K_2SO_4 but also because slightly more than half of the P_2P_5 comes from phosphate rock instead of phosacid. Part of this advantage is offset by the extra operating and fixed costs for the ion exchange plant (including the raw materials preparation and the evaporation), but there is still a considerable difference as indicated by the $ per unit cost of 1.31 for the K_2SO_4-based NPK against 1,15 for the Superfos PPF. Of course the exact difference between the two processes depends on the unit prices for raw materials and utilities, and the consumption of each item is given so that each reader can put in his own local prices.

The second example is an NPK manufacturer wanting to expand his NPK output by 300.000 tons per year, but not paying attention in the first instance to the fact whether this material is chloride-free or not. He may expand his NPK plant as well as sulphuric, phosphoric and nitric acid plants the tradional way or he may consider the ion exchange route. On slide 6 we have compared the costs assuming only one grade, 17-17-17, in both cases. The main difference is the savings in phosphoric acid against the costs of running the ion exchange plant. It appears, that the total costs are practically the same in the two cases. Therefore, if the absence of chloride is considered of no marketing value, the decision in each specific case must obviously depend on local conditions. Here, the intermediate acids are the main factors. E.g. if you have got a surplus of cheap phosphoric acid and no nitric acid the conventional route will make the cheapest product, whereas if you are short of phosphoric acid but have nitric acid available the ion exchange route will be the most economical.

Before leaving the section on economics I should like to mention two possibilities which may have a significant impact especially under U.S. conditions, one is regarding KNO_3-coproduct and the other regarding $CaC1_2$-coproduct.

When the major part of the calcium in the nitrophosphate solution is replaced by potassium in the ion exchange process you get a product solution having a K_2O: P_2O_5 — ratio about 2:1. To get a 1:1:1-product, as in the two examples discussed, we add phosphoric acid thereby "upping" the P_20_5-content. However, if you cool the concentrated product solution potassium nitrate will crystallize out, and so you may reduce the K_20-content by removing KNO_3instead of increasing the P_20_5-content by adding phosphoric acid. this will give you a KNO_3-coproduct and at the same time reduce the phosphoric acid consumption, and this may be especially attractive in United States where KNO_3 is a fertilizer in strong demand.

The $CaC1_2$-solution from the regeneration section in our plant in Denmark is pumped into the sea along with the gypsum from our phosphoric acid plant. However, the disposal of the $CaC1_2$-solution may give rise to problems in plants located inland. We have recently started investigations regarding uses of solid $CaC1_2$, such as f. inst. for deicing roads in wintertime, for stabilizing the surface and for suppressing the dust on unpaved roads, for improving the setting behaviour and strength of concrete and for making high grade calcium carbonate. At the same time we have found that by neutralizing the $CaC1_2$-solution we can recover the P_20_5 lost in the $CaC1_2$-solution and during evaporation of the solution we can recover a great deal of the KC1-loss. This means that, where there is a market for the $CaC1_2$ we can not only meet a demand and solve a disposal problem but, at the same time, we can reduce raw material losses in the ion exchange and thereby further improve the economics of this process.

THE PRODUCT AND ITS APPLICATIONS

What are the merits of our Pure Plant Food fertilizers as compared with conventional NPK's?

the product was originally developed because it has merits in regard to thermal decomposition problems. In Denmark there is a demand for Cu-bearing NPK grades, and the copper catalyses the well known self sustaining decomposition of NPK fertilizers containing ammonium nitrate and potassium chloride. When the chloride is absent there is no "cigar-burning" problem. It was this situation which led us to study the ion exchange route, because it gave us a possibility of removing chloride under circumstances which did not increase our costs as compared with the manufacture of conventional chloride — containing NPK fertilizer.

However, in addition to the safety advantage our new product clearly has a number of other benefits and potentials because of the absence of unwanted ions, because of the low production cost and because of the high concentration — for example 18:18:18, 14:114:28, etc. are possible.

The value of chloride-free fertilizers is already well recognized in certain areas of agriculture horticulture, but at the same time the higher cost of manufacture sets limits to their use. In the USA today chloride-free NPK fertilizers based on K_2SO_4 are mainly used for crops such as tobacco, potatoes, grapes, vegetables, fruit, citrus and for horticulture. It is estimated that in the tobacco area about 1 mill. tons per year of K_2SO_4-based fertilizer is used. In addition to that a comparatively small amount of potassium nitrate is produced in the USA and used for specialty purposes, such as tobacco. Potassium nitrate is an even more expensive source of K_20 than the sulphate.

It is obvious that in the areas where K_2SO_4-based NPK is used today there will be very good prospects for KNO_3 — containing NPK's which are less expensive and more concentrated that the sulphate-based material. Due to the availability of KNO_3 in USA a number of tests have already been made comparing nitrate with sulphate, and KNO_3 is well recognized today as being a superior fertilizer for a number of crops. A cheap KNO_3 — containing NPK fertilizer like our Pure Plant Food will have obvious benefits and potentials in these areas.

However, the cheap substitution of chloride by nitrate in Superfos Pure Plant Food opens up a range of possibilities which have not been well tested before because no economic solution has previously been available.

In semi-arid areas where the rainfall is not high enough to cause through-leaching there is at present in most cases very little use of potassium fertilizer, because the soils are often adequate in potassium due to the low degree of leaching. Taking crops steadily from these soils means that the need for potassium fertilization will gradually increase and then the chloride can cause difficulty owing to the lack of leaching. For instance, in Greece the state authorities impose the exclusive use of potassium sulphate in NPK manufacture in order to avoid chloride in thee soil building up to a damaging level. In USA an area with a high potential use of chloride-free fertilizers on these grounds is the wheat belt in the Mid-West.

Where irrigation is used conventional fertilizers may lead to salts build-up unless the water-usage is high enough to wash chloride from the soil. We are sure that major steps will require to be taken in the next few years in many areas to assume fuller control over water resources for irrigation because of the decreasing availability and increasing cost of water. A fertilizer with no unwanted ions will offer a high degree of flexibility when low-irrigation techniques are to be adopted. Furthermore, since with Superfos PPF there is no need to wash fertilizer chloride from the soil, there is a means of minimizing contamination of ground waters with nitrate which accompanies chloride in leaching.

Also in general humid-zone agriculture we believe that the freedom of unwanted ions may be advatageous in a wide sphere of use. The low salt index means less danger of germination damage or of reduction of yield at high rates of application. Low salt index is especially important during the first few days immediately after planting and under circumstances where fertilizer and seed are close or in actual contact — for example in the direct drilling technique associated with "No-till" or when "Pop-up"-fertilizers are used. At present it is quite a common practice to apply fertilizer in the autumn so that the favourable effect of leaching of chloride in autumn and winter can be obtained, but this may under some circumstances (soiltypes, climatic conditions etc.) result in leaching also of plant nutrients and thereby lower efficiency of fertilizer usage. Spring application of chloride-free fertilizer would be more safe. A further merit of Pure Plant Food may appear in regard to improving the quality and flavour of a number of crops which traditionally are being fertilized with potassium chloride — simply because of the low price.

We have recently embarked on a substantial three-year program of agricultural research in Europe in order to quantify all these benefits and potentials of Superfos Pure Plant Food.

More generally speaking it is our belief that manufacturing industry the world over will inevitably move more and more towards producing products which contain fewer unwanted constituents and which are less environmentally objectionable than existing products: The Fertilizer Industry will be no exception.

The fertilizer manufacturer and the farmer now have to accept a new social responsibility in addition to the age-old one of feeding mankind economically. We have now to do this job with the added responsibility of doing it whilst putting minimum burden on the environment. If we do not do this our soils and our surface and ground waters (and thus our drinking water) will deteriorate in quality or lead to high extra expense in putting them right. And so a new limitation is placed on the freedom of action of the fertilizer manufacturer and the farmer.

CONCLUSION

This afternoon's session is entitled Speciality Fertilizers. Today KNO_3-containing NPK fertilizers are considered speciality fertilizers. This of course, is due to the fact that they have been more expensive to make that the KCl-containing NPK's. We believe that this general view will be changed in the years to come for two reasons: Firstly, because advances in fertilizer technology are making it possible to produce KNO_3-containing NPK at a cost no higher than that of producing chloride-containing NPK. Secondly, because environmental considerations will require that the fertilizer manufacturers shall supply only plant nutrients and that large quantities of unwanted elements such as chloride shall not be put into the soil, if it is not technically and economically necessary. Therefore, we believe that in the future the KNO_3-containing NPK will be considered not a specialty fertilizer but simply the preferred form of commonly used NPK fertilizers.

Slide 1

N: Ammonia Nitric Acid

P_2O_5: **Calcium** - phosphate

K_2O: Potassium - **chloride**

$$S \xrightarrow{O_2} SO_2 \xrightarrow{O_2,\ H_2O} H_2SO_4$$

$$3H_2SO_4 + Ca_3(PO_4)_2 \longrightarrow 2\ H_3PO_4 + 3\ CaSO_4$$

$$H_3PO_4 \xrightarrow{NH_3} NH_4H_2PO_4 \text{ or } (NH_4)_2HPO_4$$

Slide 2

$$Ca_3(PO_4)_2 + 6\ HNO_3 \longrightarrow 3\ Ca^{++} + 2H_3PO_4 + 6\ NO_3^- \qquad (1)$$

$$KCl \xrightarrow{H_2O} K^+ + Cl^- \qquad (2)$$

Ion Exchange

Production:

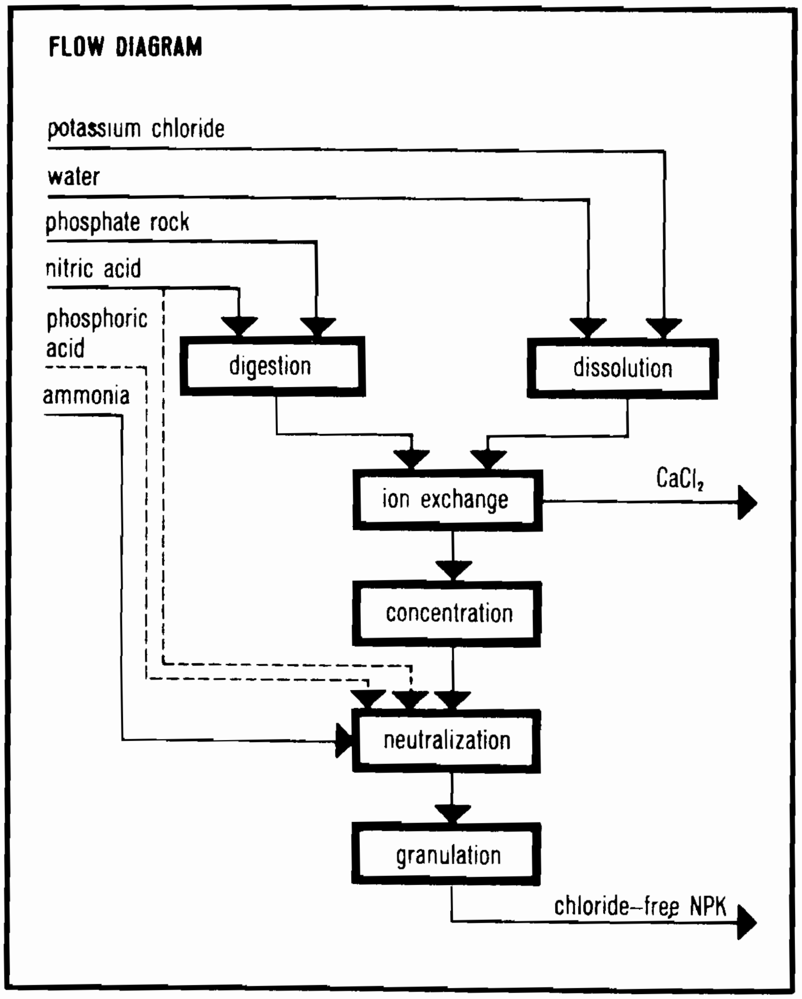
$$[3\ Ca^{++} + 2H_3PO_4 + 6\ NO_3^-] + 6\ KR \longrightarrow [6K^+ + 2H_3PO_4 + 6\ NO_3^-] + 3CaR_2 \qquad (3)$$

Regeneration:

$$[6\ K^+ + 6Cl^-] + 3\ CaR_2 \longrightarrow [3\ Ca^{++} + 6\ Cl^-] + 6\ KR \qquad (4)$$

Slide 3

Slide 4



FLOW DIAGRAM

potassium chloride

water

phosphate rock

nitric acid

phosphoric acid

ammonia

digestion

dissolution

ion exchange

$CaCl_2$

concentration

neutralization

granulation

chloride–free NPK

Slide 5

100.000 tons per year of chloride-free NPK.

	Price $ per unit	16-16-16 K_2SO_4-based		17-17-17 Superfos PPF	
		Units per ton	$ per ton	Units per ton	$ per ton
P_2O_5 from Rock	0,40			9,8	3,90
P_2O_5 from H_3PO_4	1,20	16,4	19,70	7,8	9,40
N from HNO_3	0,80	5,6	4,50	9,9	7,90
N from NH_3	0,40	10,9	4,40	7,8	3,10
K_2O from K_2SO_4	1,22	16,3	19,90		
K_2O from KCl	0,66			18,9	12,50
Conditioner			0,50		0,50
Raw Material Cost			49,00		37,30
Operating Cost NPK			4,00		4,00
Operating Cost Ion Exchange^{+})					3,50
Fixed Cost NPK			7 00		7,00
Fixed Cost Ion Exchange^{++})					4,00
Storage and Shipping			3.00		3 00
Total, $ per ton of product			63,00		58,80
$ per unit of plant nutrient			**1,31**		**1,15**

$^{+}$) Units per ton of	17-17-17
Electricity	30 kWh
L. P. Steam	0,4 ton
Fresh water	3 m^3
Resin	0,2 $
Labor	0,25 manhour
Maintenance	1,0 $

$^{++}$) Estimated Investment 2,– mill. $

MODERATOR BLENKHORN: Our next speaker is an old friend of the round Table. He delivered papers to Round Table audiences many times. He's been introduced many times. We know him so well that we take him for granted sometimes. I am referring to Frank Nielsson. Perhaps for those of you who haven't met him, I mention just a few highlights of his long career in the field of fertilizer technology. While he was a process engineer at TVA, he was the inventor of the TVA ammoniator. Perhaps you didn't know that. He spent most of his professional life in the phosphate field and is an expert in his own right in that field. He worked for two years, on loan, to the United Nations Industrial Development Corporation as a Senior Industrial Development Officer, and he is now Technical Service Consultant with International Minerals. He could speak to us on many different pases of fertilizer technology. This afternoon he is goin to speak to us on:

I. M. & C. Experiences in Speciality Fertilizer Manufacture

Frank T. Nielsson

I.M.C. used to be active in "The Speciality Fertilizer Business". In 1968 they gave me a two year leave of absence. I went to work in Vienna for the "U.N.". However the first thing I had to do, before leaving, was to write a manual for the Company on what we were doing for "The Lawn and Garden Manufacturer". The outcome was a booklet like this. Copies are in the rear on a table. This booklet describes, roughly, what we did at our Chicago Heights Plant. This plant is now closed. I have also composed a shorter manual and copies are also on the table in the rear. As I talk you will note there are some times that are not made anymore; the compaies are not in business anymore, however, most of the items mentioned are pretty much so today.

GENERAL

Lawn and Garden (L&G) fertilizers are the major classification of specialty fertilizers in the ever-growing, non-farm market.

A lawn is a pasture grown for pleasure. Just as lawn grasses are specially adapted for their purpose, so are lawn fertilizers specially formulated, although they follow the pasture fertilization idea; that is, high nitrogen relative to low or medium phosphate and potash.

For the average fertilizer plant superintendent and his operating personnel, the most difficult concept to grasp is that L&G is sold primarily in single bag orders to a homeowner whom they visualize as a fussy little old lady, who demands a clean package, a well-filled package, and a non-leaking package.

If the little old lady weighs her one bag purchase on the bathroom scale and the weight is one ounce short, you hear about it.

If the package is dirty, she doesn't buy it and it is returned to you.

If it leaks, as she hauls the package from the car, through the kitchen, down to the cellar, the dealer hears about it.

The above are general comments from the marketing angle that are very important if one is to get away from the urban concept that fertilizer and manure mean the same thing.

DENSITY

L&G fertilizers may be classified by density; as heavy weight, (60-70 lb./cu. ft.); medium weight (40-50 lb./cu. ft.) and light weight (30-36 lb./cu. ft.)

The heavy weights, in many cases, are field fertilizers acreened to minus 8 mesh, and packaged in special bags. Grades like 16-8-8, 10-10-10, 10-6-4, and 5-10-5 are common in this category.

The light weights were the first lawn fertilizers formulated especially for homeowners lawns. A lawn requires about one lb. nitrogen per 1,000 sq. ft. every 6-8 weeks to maintain a good green growth. Assuming that the average lawn covers 5,000 sq. ft., a bag containing 5 lb. N could be used for each application. To make it convenient to handle, the bag should weigh in the 20-25 lb. range. This means a nitrogen analyses in the 25% to 20% range.

The average lawn apreader is essentially a volumetric feeder. In order to spread 20 lbs. over 5,000 sq. ft., the material must occupy about 0.7 cubic feet of volume.

This means a density of about 30 lb. per cu. ft. A 30 lb. per cu. ft. fertilizer requires the use of a very lightweight filler. The best filler for this purpose is an expanded mica called vermiculite, under trade names like Zonolite or Coralux.

For most lawn fertilizers a No. 3 vermiculite is used. This is about an 8 mesh particle weighing 6-7 lb./cu. ft. With a low liquid phase formula, about 300 lb. vermiculite per ton will yiield a 30 lb./cu. ft. product. For a high liquid phase formula, the amount of vermiculite needed may be in the range 400-500 lb./ton.

In weed killers, where it is desired to have the poison contact the leaf surface, a fine vermiculite No. 4 is generally used. This is about a 14 mesh particle weighing 10 lb. per cu. ft.

Vermiculite is very absorbent. One pound will absorb about one pound of water before it appears wet.

With the right formula, densities can be held plus-minus one lb./cu. ft. More water in the mixer, or more heat in the dryer will *increase* density in a given formula because voids are filled with dissolved salts.

The only successful competitor to vermiculite are ground corncobs. These consist of the hard outer shell of the cob ground to various size fractions, designated by U.S. Sieve screens.

The product generally used in lawn fertilizers is

12/20 (Minus 12 plus 20 U.S. Sieve series, or minus 10 plus 20 Tyler mesh). The product generally used in weed killers is the 20/40 designation.

Ground corncobs weigh about 30 lb./cu. ft. They are used in medium weight fertilizers (42-50 lb./cu. ft.) at a rate of 400-500 lbs./ton of fertilizer. Cobs are rarely used in grades containing over 20% N. Cobs are non-porous and extremely hard (an average cage mill will not grind them).

NITROGEN

Nitrogen is the fertilizer element that contributes the most to a *green* healthy lawn. Because a lawn does not produce fruit or seeds, the phosphate and potash are low in relation to the nitrogen.

All valuable nitrogen will help grass grow, but the cheap, chemical forms of plant available nitrogen are very soluble. Extreme solubility leads to lack of lasting power due to leaching and to "burning."

The answer is to use a water-insoluble or a low-water soluble form of nitrogen.

Low water solubility may be achieved through particle size adjustment of compounds like magnesium ammonium phosphate or oxamide. The larger the particle, the less the water solubility in a given time period. Low water solubility may be attained also by coating the soluble nitrogen with a water-resistant coating like sulphur, or a drying oil-based varnish. Coated nitrogen is less expensive than other forms of low solubility, but manufacturing problems have kept it from being a high-tonnage material.

Water-insoluble nitrogen is the most widely used form to prevent leaching and burning. It is called "organic" nitrogen because it was first found in natural organics like seed meals, tankage and sewage sludge. The most important synthetic organic nitrogen is urea-formaldehyde, alled urea-form. it is sold in finished solid form as Uramite or Nitroform, and in partially finished liquid forms as N-Dure, Valron, UAL-37, Durana 20, and HUF solution.

Solid ureaform contains 38% total N and 26-27% W.I.N. or 75% of the total. With liquids, W.I.N. will vary from 20% of the total with UAL-37 and Durana 20 to 45-60% of the total with N-Dure, Valron and HUF.

The Japanese have developed isobutylidene urea (IBDU) and are shipping it to this country as a solid synthetic organic nitrogen. It contains 32% total N and 19% W.I.N. or 59% of the total.

It should be pointed out that regular urea is *not* an organic nitrogen in the fertilizer sense because it is extremely soluble whereas in fertilizers, organic nitrogen implies long-lasting, non-burning properties.

Water-insoluble nitrogen becomes available to plants after the soil bacteria have changed the W.I.N. into a form that can be assimilated by plants.

The fact that a nitrogen compound is water-insoluble does not mean that soil bacteria will transform it into a plant available form. With natural organics, experience has indicated that this does happen. A chemical test called "Permanganate Index" indicates availability, although it is rarely used.

With synthetic organics, the composition can be varied from completely inert to overly soluble by manipulating conditions during manufacture.

To indicate availability, two tests have been devised.

The first is a biological test of some duration. Soil is neutralized to a pH of 7 and mixed with the nitrogen product. Portions are placed in a number of flasks and stored at a given room temperature. At weekly intervals, a flask is removed and the amount of nitrate nitrogen is determined. Soil bacteria transform all available nitrogen ultimately into nitrate nitrogen. Because nitrate nitrogen is the form best assimilated by plants, the rate of nitrification determines the rate at which the nitrogen becomes available to plants. Since soils vary in their nitrification ability, a control is run at the time using ammonium sulfate which is known to nitrify in a rapid manner. Nitrification tests take a lot of time.

For rapidity, a second availability test has been instituted. This is "Activity Index" or A.I. In this test the water-insoluble nitrogen is determined as usual with cold water. Next, the cold water onsoluble nitrogen (WIN) is contacted with hot water. The ratio of hot water insoluble nitrogen is called activity index expressed as:

$$\frac{\text{CWIN-HWIN}}{\text{CWIN}} \times 100 = \text{A.1}$$

If the A.I. is 40 or more, the nitrogen fertilizer is said to be fully available. A.I. has been correlated with nitrification studies and field studies. It is a reliable test when applied to a single nitrogen nutrient. However, the A.I. value of the nitrogen in a mixed fertilizer can be somewhat lower without affecting quality. We believe an A.I. of 25 is adequate in mixed fertilizers.

The A.I. test does not work with natural organics, so it is misleading if both natural and synthetic organics are present in a mixture.

GENERATION OF WATER-INSOLUBLE NITROGEN

Our experience has been only with area-formaldehyde based water-insoluble nitrogen.

Urea is an odorless, white, crystalline solid with a cool saline taste, and the formula $(NH_2)_2CO$, containing 45%-46% N in technical grades. It has the following physical properties:

Molecular weight	60
Melting point	271 degree F.
Heat of solution in water	(—)108 BTU/lb.
Solubility in water at 68 degree F.,	108 lb./100 lb. H_2O
at104 degree F,	167 lb./100 lb. H_2O
at140 degree F,	251 lb./100 lb. H_2O
at176 degree F.,	400 lb./100 lb. H_2O

Urea decomposes if held above its melting point into compounds like biuret and cyanuric acid. It hydrolyzes in water solutions into ammonia and carbon dioxide.

Formaldehyde is a colorless gas which liquifies at 2.2 degree F. below zero and solidified at 180.4 degree F. below zero. Both liquid and gas polymerize readily at ordinary and low temperatures so formaldehyde is sold only in solution or as a solid polymer (paraformaldehyde).

Its formula is CH_2O and its molecular weight is 30.

We use the term "mol ratio" in this discussion. A mol (or mole) is a unit quantity in chemistry and is the weight of the substance in grams (gram mol) or pounds (pound mol) which corresponds to the molecular weight.

Thus, urea has a molecular weight of 60. One hundred lbs. of urea contains 100/60 or 1.67 pound mols or mols of urea. The molecular weight of formaldehyde is 30. One hundred lbs. of formaldehyde contains 100/30 or 3.33 mols of formaldehyde. Mixing 100 lb. of urea with 100 lb. of formaldehyde yield a weight ration of one or a urea-formaldehyde mol ratio of 0. 5 (U/F mol ratio = 0.5).

Commercial plastics utilize U/F mol rations of about 0.7. When the U&F mol ratio is less than one, the product is completely water-insoluble and releases nitrogen too slowly to be of value in fertilizers.

When the U/F mol ratio goes much beyond 2, the polymers take a long time to form. The undiluted product is tacky and feels wet.

A polymer is a substance composed of giant molecules that have been formed by the union of a considerable number of simple molecules with each other. The simple molecules are called monomers and their union is called polymerization.

The first urea-formaldehyde generating solution was DuPont's UAL-37. It contains 35.3% urea, 8.0% formaldehyde, 8.4%CO_2, 23.3% water and 25.0% free ammonia for a total nitrogen content of 36% (U/F mol ratio is 2.20).

Under proper conditions 20% of the total N became W.I.N., so the solution is formulated at 7.4% W.I.N. In the days of pulverized fertilizers, especially in low-nitrogen tobacco grades, there was enough residual acidity from the superphosphate after ammoniation to cause polymerization in the pile after about one week's storage. The U/F mol ratio is so high that more urea cannot be used in the formula without decreasing W.I.N. However, the high U/F mol ratio results in good A.I. values.

When the DuPont patents on UAL-37 expired, Allied developed their version called Durana 20.

Durana 20 contains 15.9% urea, 8.0% formaldehyde, 53% ammonium nitrate, 9.4% water and 13.3% free ammonia for a total nitrogen content of 37%. U/F mol ratio is 1.0. Under proper conditions, almost all of the urea reacts to form water-insoluble nitrogen which amounts to 20% of the total. The solution is formulated 7.4% W.I.N. just like UAL-37.

The above-mentioned solutions under the best conditions yield only 20% of the total nitrogen in the water-insoluble form. Addition of extra urea to UAL-37 will decrease W.I.N. dormation, while addition of extra urea to Durana 20 can cause hygroscopicity problems because of the urea-ammonium nitrate salt combination.

To generate guaranteed W.I.N. when large amounts of urea are in the formula, part of the urea and formaldehyde must be reacted separately. For every mol (30 lb.) of formaldehyde, one mol (18 lb.) of water results in a U&F polymerization reaction. Because water solutions of pure formaldehyde would add even more water to a fertilizer formula, the most widely used formaldehyde carrier is a solution of 60% formaldehyde, 25% urea and 15% water. It is formulated at a 49% water content to allow for the water formed during polymerization. Allied calls their product N-Dure, while DuPont calls theirs Valron. The U&F mol ratio is 0.208 and total Nitrogen is 11.6.

Due to a mathematical freak, weight ratios of urea to N-Dure are very close to total urea-formaldehyde (U/F) mol ratios. One hundres fifty pounds of urea to 100 lb. N-Dure yields a mol ratio of 1.46, very close to the 1.5 weight ratio.

Polymerization time, W. I.N. and A.I are function of UIF mol ratio, amount of water present, temperature of reaction and pH of reaction.

These effects can be summarized as follows:

		Polymerization time	**W.I.N. as % of total N**	**A.I.**
U/F mol ratio	high	slow	low	high
	low	fast	high	low
Water	much	slow	low	high
	little	fast	high	low
Temperature	high	fast	high	low
	low	slow	low	high
pH	high	slow	low	high
	low		high	low

The U/F mol ratio is the primary controlling factor. Ince the polymer is formed, continued exposure to low Ph will degrade the A.I. For that reason, polymerization is followed by neutralization with ammonia.

Solid ureaforms, Uramite or Nitroform, have a U/F mol ratio of 1.33. These are made under closely controlled conditions and can yield 75% of the total N as W.I.N. with a good A.I. value. In the average fertilizer plant, conditions cannot be so closely controlled, therefore U/F mol ratios are usually in the range 1.5 and 2.0. These mol ratios yield 40%-60% of the total N as W.I.N. with fair A.I. values. The higher the W.I.N. as percent of total N, the more difficult it is to maintain an A.I. of 40.

At a 1.5 U/F mol ratio, one can assume about 50% of the total N will become water insoluble under proper conditions, or 80 lb. urea plus 40 lb. N-Dure will yield one unit water-insoluble N (20 lbs.).

If no solid urea is present, a simple way is to mix a urea-ammonia solution with N-Dure prior to the ammoniation sparger, and add it under the bed in the ammoniator. The local over-acidulation from the acid spargers will cause polymerization, which will be enhanced by the heat of ammoniation.

If slid urea is present in the formula, there is danger that some of this urea might dissolve before the solution-N-Dure combination polymerized. When this happens, the extra urea takes part in the reaction, increasing the U/F mol ratio. The percent conversion to W.I.N. decreases, while the reaction becomes unpredictable.

In a continuous ammoniator, the urea would have to be added through a separate feeder and spout near the dscharge of the mixer to ensure that urea addition took place after polymerization.

However, in light weight lawn fertilizers with high N content and high W.I.N. it would be difficult to handle the liquid phase resulting from solution-N-Dure combinations. The answer is to dissolve urea in a heated kettle (predissolver, Figure 1) with water, mix N-Dure into it and spill the solution on top of the bed in a continuous system.

It is important that all of the ureaform be intimately contacted with acid. A method that works is to use a sawtooth sparger for the predissolver overflow sized to handle 300 lb. of ureaform solution per inch of length per hour. An extra acid sparger is located to the side of the urea-form sparger so the falling ureaform is hit with a spray of air atomized acid. this will ensure polymerization as soon as the ureaform hits the bed. Adding air and sulfuric acid through the Hastelloy C sparger drilled with 1/8 inch holes on 1/2 inch centers provides a strong mist of sulfuric acid for intimate contact. Figure 2 shows a sketch of a sparger, while Figure 3 shows the way an N-Dure formula is written.

About one lb. of water per 5 lbs. of solid urea is used for the solution of the urea. About one lb. of 66 degree sulfuric acid per 7 lb. of solid urea is added through he auxiliary sparger. this acid requires neutralization by ammonia just as any other acidic material in the formula.

In this discussion, DuPont's Valron can be used throughout instead of Allied's N-Dure.

A pre-dissolver tank full of urea-N-Dure and water at a 1.5 U&F mol ratio will have a pH of about 7-8. In the ammoniator, the pH is dropped below 2 to start polymerization. If the pH should drop in the pre-dissolver tank, polymerization will take place in the tank resulting in a mass of hot cottage cheese-like material that becomes progressively harder with time and is a mess to remove.

This has happened when urea contaminated with super or triple was added to a pre-dissolver.

One way to overcome the low pH of phosphate contamination is to add ammonia as needed, using pH paper for a check.

A simpler way is to add part of the N-Dure to the pre-dissolver overflow where it will mix on its way to the sparger. With only 1/3 of the N-Dure being added to the pre-dissolver, the U/F mol ratio is so high that low pH caused by contamination will not cause significant polymerization under the 20-30 minute retention time found in the pre-dissolver. The retention time in the sparger feed pipe is too short for 1.5 U/F mol ratio polymerization at contamination pH's (4-5).

As noted before, urea has a negative heat of solution of 108 BTU/lb. of urea. External heat has to be supplied to raise the temperature to about 140 degree F. in order to get high solubility at low water content. The addition of N-Dure to the urea-water solution generates about 1/2 of the needed heat. However, more external heat must be supplied if only part of the N-Dure is added to the pre-dissolver.

Allied developed a new urea-formaldehyde solution for W.I.N. generation. This is HUF (high urea formaldehyde).

This solution has the following composition:

Total N	30.0
Urea	61.1
Formaldehyde	10.0
U/F mol ratio	1.6 eq. to 1.67 lb. urea & 1 lb. N-Dure
Water	15.0 (formulated as 28% H_2O because of formaldehyde)
Ammonia	2.0
Sodium hydroxide	1.0
Sp. Gr.	1.258
Salt out	o degree F.

Under proper conditions, 15% W.I.N. or 50% of the total can be generated.

The viscosity of HUF solution is 30 centipoises at 77 degree F. On the other hand, the viscosity of N-Dure is 260 cps. at 77 degrees, increasing to 1250 cps. at 32 degrees F. HUF can be unloaded into manufacturing with air on the tank car, while N-Dure has to be pumped into manufacturing with a gear pump.

HUF could be compared with pre-dissolver overflow with none of the complications entailed in feeding solid urea, N-Dure and water into a stirred heated tank. It is added to the mix like pre-dissolver overflow through a sawtooth sparger in a continuous system.

HUF has an advantage for small producers because 150 lb. of HUF is used in place of 50 lb. N-Dure plus urea. This makes it possible to order a tank car for a run whereas N-Dure might have to be ordered in drums.

It has one disadvantage. It polymerizes somewhat slowly. At comparable U/F mol ratios using N-Dure, it takes 1 lb. of 66 degree H_2SO_4 to polymerize 13 lb. of predissolver overflow. The resulting reaction is so fast that it is unaffected by extra urea in the bed.

On the other hand, HUF requires 1 lb. of 66 degree H_2SO_4 per *6 lb.* of HUF, and even then, the reaction is so slow that excess urea in the bed cannot be tolerated much above 50 lb. per ton of product.

This means that in a lightweight like 22-5-9, 3.6% W.I.N. with 550 lb. exc ess urea, a pre-dossolver system using urea-N-Dure is needed. On the other hand, heavy weights like Pr. Thrive 12-6-6, 6% W.I.N., or Gold Cup 18-5-9, 5% W.I.N., having no excess urea can obtain all their W.I.N. from HUF solution.

Generation of W.I.N. saves money.

It also improoves product quality. It is possible to control polymerization sufficiently so the hardening takes place as the fertilizer granule is formed. This results in hard, dust-free pellets with generated W.I.N.

Six units W.I.N. from generation have been our maximum in a successful formula. Generally, 4 units generated W.I.N. is the practical limit in high excess urea light weights. W.I.N. above the 4 unit level is derived from solid ureaform or natural organics.

NATURAL ORGANIC NITROGEN

Natural organics were the first source of long-lasting, nonburning nitrogen. The common sources today are Tankage, 10% total N, 9% W.I.N.; Cottonseed meal, 5-1.3-1.0, 4.4% W.I.N.; Soybean meal, 5-1.5-2, 4.5% W.I.N.; Activated Sludge, 5-5-0, 4.5% W.I.N. The nitrogen is sold on an ammonia basis. Their low analyses prevents much usage of natural organics in high analysis lawn fertilizers, although they are common in grades like 10-6-4 lawn fertilizers and 8 or 10% N rose and tree foods.

Activated sludge is quite popular as a direct application lawn fertilizer. It is especially popular on the sandy soils of Florida. It has the severe disadvantage that in warm, humid weather, the breakdown of the sludge releases odors, making the neighbors believe you have a dead elephant in the shrubbery! anyone who lives next to a golf course using sludge on their fairways knows that this is not funny. However, in mixed fertilizers at rates of up to 1,000 lb. per ton, odor after application has not been a problem.

In the days of pulverized fertilizers, natural organics had a secondary function of enhancing condition by decreasing caking tendencies. Since granulation can be called controlled accelerated caking, it was believed in the early days of granulation that natural organic formulas would not granulate. However, they do, even with 1,000 lb. organic per ton of product. With organic levels in the 200 lb. — 500 lb. range, pellets are about as hard as without organic. At higher rates, the pellets become noticeably softer than non-organic pellets.

The use of generated W.I.N. is especially helpful in producing hard pellets in natural organic grades because of the plastic encapsulation from the generated W.I.N.

HERBICIDE AND PESTICIDE MIXTURES

We said a lawn is a pasture grown for pleasure. To many persons a green growth is not enough. They demand a heavy green growth of *grass* not of grass mixed with weeds. For them, we mix herbicides and pesticides with a fertilizer to control weeds and insects. Fertilizer is food for plants while herbicides and pesticides are like medicine.

Some herbicides kill all plants. These are used to keep railroad and highway right-of-ways free of any growing plants. In L&G practice, we use *selective* herbicides to control only certain plants.

The most popular herbicides is 2,4-D. It attacks broad leaf weeds like dandelions while not harming turf grasses when applied as recommended, after they have sprouted (post-emergent). It is usually used as a diluted oil solution of the isopropylester or as an amine. Isopropylester not only is water-insoluble like most esters, it also has low volatility. This is important because the vapor from an ester of 2, 4-D could kill shrubs which were near the point of its application to a lawn.

Amines are water-soluble, but not volatile. though a more safe form of application of 2,4-D, continual use of the amine salt can cause penetration of a lawn for enough to come in contact with the roots of shrubs and trees, causing some injury to them.

The ester form 2,4-D can be purchased as "technical," that is very concentrated, or in 4 lb. or 6 lb. dilutions. The latter means that there is 4 lb. of 2,4-D ester per gallon of solution. The amine is purchased usually in 4 lb. dilutions. In each case, the label will state "equivalent to X% 2,4-D acid."

Many lawn herbicide mixtures use 2,4,5-T. The combination of 2,4-D and 2,4,5-T has a "synergistic" effect. this means that the combination works better than either component alone. Another additive for broad leaf weeds is Silvex, 2,4,5-TP.

The above compounds are plant hormones that stimulate growth in tiny amounts, but so overstimulate growth in larger amounts that the weeds die from starvation. These chemicals can be added as a spray on the lawn in a separate operation. However, to ease labor for the homeowner, they can be incorporated with fertilizers and applied with a lawn spreader as a Feed & Weed product.

Because the fertilizer generally has absorbed all the liquids it could, further addition of liquid chemicals would cause a sticky coat on the surface of the fertilizer particles. The large fertilizer particles will fall through the grass and weeds to the soil surface. This results in poor control of weeds because the herbicide is not contacting the weed leaf surface. Therefore, a good Feed and Weed product will contain a carrier like No. 4 vermiculite, or 20/40 cobs, in addition to the fertilizer. The carrier absorbs the herbicide and sticks to the weed leaves, while the larger fertilizer particles fall to the soil to fertilize the grass.

Amines are water-soluble, are diluted with water for spraying into carriers, and asphalt-lined bags are satisfactory. Esters are oil-soluble, are diluted with naphtha or fuel oil, and will bleed through asphalt-lined bags. Ester formulation products should be packaged in polyethylene lined bags.

Some herbicides come as "wettable powders." Wettable powders are clay carriers containing chemicals and ground fine enough to be mixed with water for spraying. Spraying wettable powders is not suitable for a fertilizer product. In our case, we used "sticking agents." These are synthetic starches like carboxymethyl cellulose. The powder is added with the feed to the mixer and sprayed with a CMC solution. The starch acts as a glue between the carrier and the wettable powder. Just as it is difficult to mix flour and water, the same difficulty exists in mixing starch and water. However, if the starch is first wetted with alcohol, then it can be readily wetted with water. If a formula calls for a CMC sticking agent and water, add wood alcohol first to the CMC, just enough to wet it, then mix in the desired amount of water. Finally, spray the starch solution into the mixer.

In Lawn and Garden products, pest control usually is aimed at grubs, worms or ants.

The most polular L&G pesticides are chlordane and heptachlor. These are very viscous vaseline-like compounds that must be diluted with naphtha before spraying. A/so, they must be heated before they can be transferred from the receiving drum into the dilution tank.

Recently we have begun using our really first dangerous pesticide. this is Di-System, a systemic poison that enters a plant through the roots and travels with the plant fluids throughout the plant structure. If a bug eats or chews on the plant, it is killed by the poison within the plant. Di-System is purchased as a 68% liquid formulation.

This is one of the new group of organic phosphates that are very lethal for only a specific period of time. After that period, they oxide into ortho-phosphates and become harmless to living things with no residual effect. Although Di-System is diluted when purchased, strict rules of personal cleanliness and air exhaust should be observed during its handling. In a fertilizer base, it is so dilute that danger through handling is minimal. It is used primarily in conjunction with fertilizers to be used around shrubs and flowers.

All compounds that are potentially injurious to humans or animals have their toxicity expressed in terms of LD_{50}. LD stands for lethal dosage, while 50 means that half the experimental animals, usually rats, died with that dosage. the dosage is expressed as milligrams of compound per kilogram of body weight. A kilogram is 2.2 pounds. A milligram is 0.0000352 oz. LD_{50} is listed as oral (taken through the mouth) or inhalation. The latter is used with substances that are used in the vapor form. Someone told me that they knew of a case where a horse died after eating 5 lbs. of ammonium nitrate. If that were so, let's assume a 2200 lb. horse, or 1,000 kilograms. Five pounds is equivalent to 2,272,000 milligrams. The oral toxicity for ammonium nitrate could be expressed as $LD_{50} = 2272$ (horse). Theoretically, you need a test where a dose fills only half of the experimental animals.

Oral toxicity, LD_{50} for some of the compounds you will use in herbicides and pesticide work is shown in the following tabulation:

COMPOUND	**LD_{50}**
Di-System	12.5
Aldrin	55
Heptachlor	70
2,4,5-T	100 (dogs)
Chlordane	457
2,4-D	500
Silves	650
DSMA	700
Dachtal	3000
Borax	5330

LD_{50} has nothing to do with the length of time toxicity persists. It means simply that the pure compound is lethal to rats is swallowed at the indicated dosage. But is is a measure of relative toxicity. The lower the LD_{50}, the more care should be exercised in handling the compound. Parathion has an LD_{50} of 3.0.

Personnel involved in herbicide-pesticide production should be indoctrinated in good personal hygiene methods. Also, the work area should be well venelated with a scrubbed exhaust.

There is nothing complicated about a herbicide-pesticide unit. A weighed quantity of chemical is sprayed or mixed with a weighed batch of carrier or fertilizer.

The problems arise from the necessity to spray materials of varying viscosity into a mixer in such a way that the entire batch is contacted by spray. If all the spray is absorbed by a small portion of carrier, the chemical will not be re-absorbed by another portion of carrier. In some cases, if 10 lb. of chemical is indicated, you should stretch it with 20-30 lb. of diluent like fuel oil or naphtha in order to have enough volume of spray to cover the batch.

If a mixer is filled to such a degree that poor tumbling action results, then the resultant mix will be poor.

If the sprays are set so the chemical wets the shell, then poor mixing results.

There is no screen on the mixer discharge. Therefore, all solid raw materials must be properly sized before they enter the mixer.

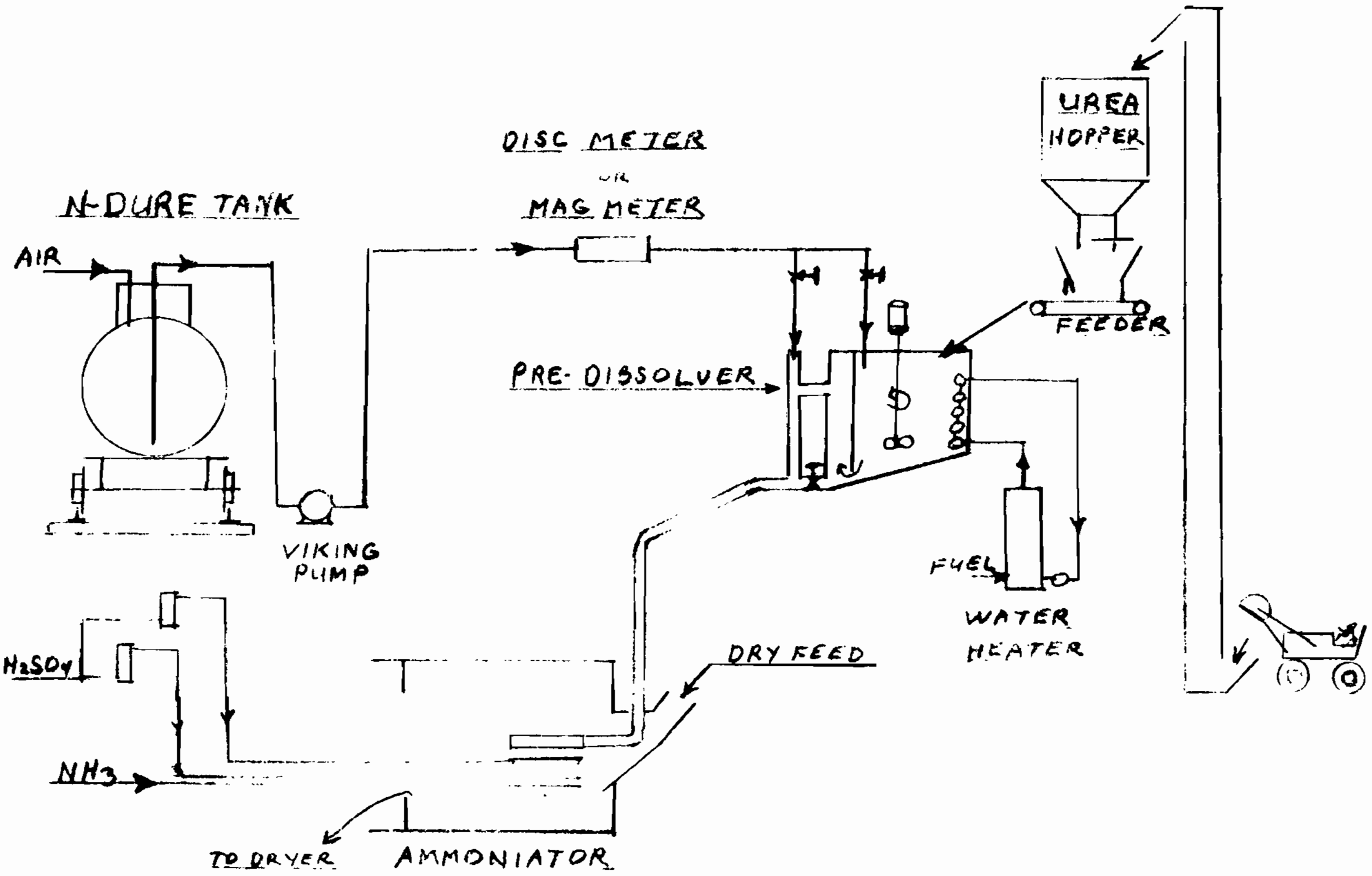
If the formula has room, product density can be adjusted by varying the amount of No. 4 vermiculite and 20/40 cobs until the desired package fill is obtained.

Herbicides and pesticide mixtures are not stored in bulk. The mixer discharges directly into the packer hopper. Therefore, sampling must be performed by taking portions from the filled bags before sewing.

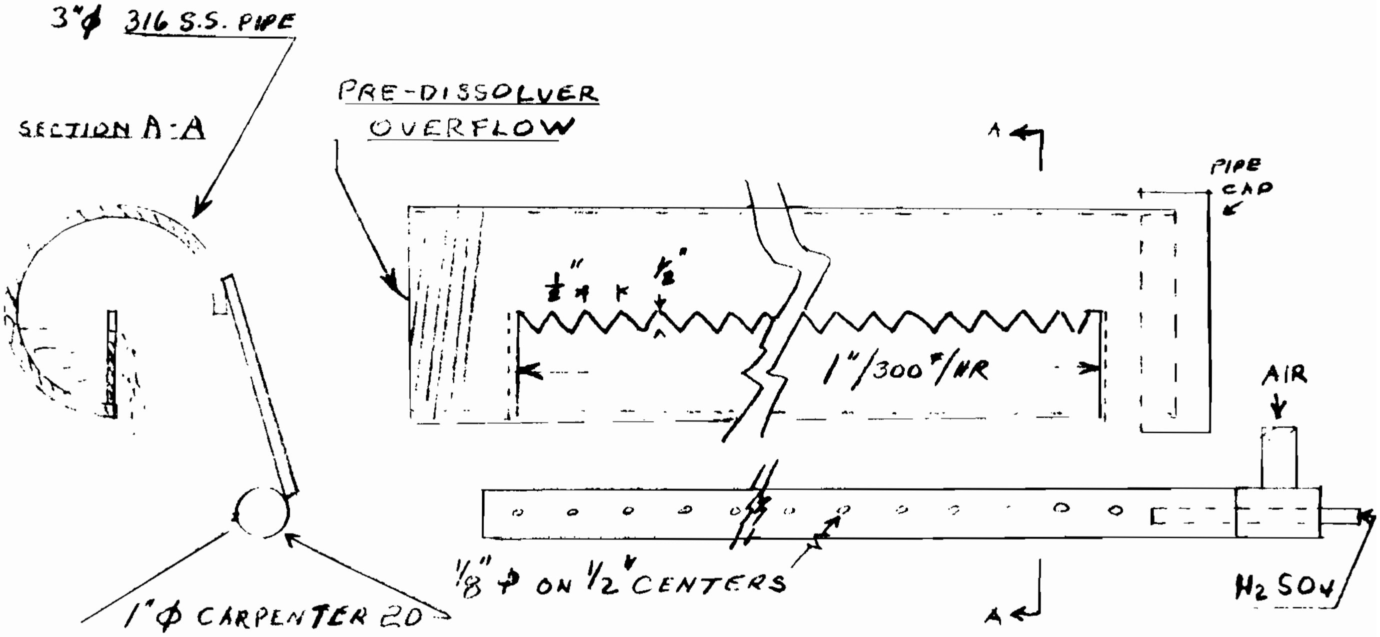
Tomatoes are very susceptible to injury from 2,4-D. therefore, if you were to use your herbidice mixer for mixing a special batch of tomato fertilizer, after you had made a run of 2,4-D weed killer, the mixer and packer must be well-cleaned before starting the tomato run. Ammonia will change esters into water-soluble amines so water and ammonia with detergent make a good cleaning combination.

Similar common sense thinking will dictate the necessity and frequently of mixer cleaning between runs of various products.

PRE-DISSOLVER



SPARGER


3"φ 316 S.S. PIPE
SECTION A-A
PRE-DISSOLVER OVERFLOW
A
PIPE CAP
1/8"
1/2"
1"/300°F/HR
AIR
1/8" φ ON 1/2" CENTERS
H2SO4
A
1"φ CARPENTER 20

GUARANTEE

Nitrogen	A.P.A.	Pot.	MgO
25	5	10	

With ______ Lbs. Or ______ % ______________ Per Ton

Super X
Brand or Other Special Designation

INTERNATIONAL MINERALS & CHEMICAL CORPORATION

RAINBOW DIVISION
STANDARD COST FORMULA ☒
PRODUCTION FORMULA ☐

FORMULA NO. Base X
or
Shipping ______

Plant Chicago Hts. No. ______
Date ______

						Lbs. to Ton							Material Cost	
Code	Lbs.	MATERIALS	Material Analysis Percent	NH_3 EQ	H_2O	Total Nitrogen	A.P.A.	Potash	MgO	NH_3 EQ	H_2O	Acidity	Per Ton	$ Amount
	70	Anhydrous	82 N	-100		57 40				-70				
	370	Uramite	38 N		5	140 60	(75% WIN)							
	262	Urea	46 N			120 52								
	50	H_2SO_4	66° Be	+32	7					+16	3			
	190	H_3PO_4	54 P_2O_5	+19	19		102 60			+36	36			
	340	Muriate Pot. Coarse	60 K_2O					204 00						
	172	Vermiculite	#3											
	230	N-Dure } P.D.	11.6 N		49	26 68	50%(WIN)				112			
	380	Urea } P.D.	46 N			174 80								
	50	H_2SO_4 } P.D.	66° Be	+32	7					46	3			
	60	Water } P.D.		1	100						60			
										+2	214			
											174			
	(174)	-Evaporation-NH_3 Loss-APA Reversion				20 00	2 60	4 00			40		SUB-TOTAL	
	2,000					500 00	100 00	200 00			2%		SHRINKAGE	

	Total "N"	NITROGEN BREAKDOWN							
		NO_3	NH_3	WSO	WISO				
	25		1.9	13.1	10.0	PLANT FOOD UNITS	25.00	5.00	10.00
						LAB. ANALYSIS			

TOTAL MATERIAL COST	$		

	DIRECT LABOR	OVER HEAD	XX	XXXXXX
MANUFACTURING				
TOTAL MANUFACTURING	XXXX	XXXX		
SHIP BULK				
TOTAL BULK COST	XXXX	XXXX		
SHIP BAGGED				
LB BAGS @ / 1000	XXXX	XXXX		
TOTAL BAGGED COST	XXXX	XXXX		

Signed Date

Formula Made By F. T. Nielsson
Approved By ______
Costed By ______
Cost Checked By ______

REMARKS:
Minus 8 mesh
37-39 #/Cu Ft.

WHITE PLANT OFFICE CANARY ATLANTA
PINK [illegible] ACCOUNTANT GOLDENROD ZONE OFFICE

MODERATOR BLENKHORN: Thank you Frank for your most interesting paper. You will find the essentials of Frank's discussion on the tables in the rear of this room. You will also find copies of Mr. Knudsen's discussion on the same table. I would like to ask for volunteers to comeup here to help handle the "Round Table Question and Answer Session". Roger Brown, our Marketing Man, had to leave this morning soon after he presented his paper. He did, however, answer a few questions. We are fortunate too have Mr. Aaron Mathis, Fertilizer Sales Manager, H. J. Baker and Brother, join our Table here to answer questions on "Marketing Aspects of Specialty Plant Foods."

Panel
Question and Answers — Specialty Fertilizers

H. D. Blenkhorn
K. C. Knudson
Frank T. Nielsson
Aaron Mathis

QUESTION: Is nitrogen short to fill the demand for Spring, 1974?

ANSWER: Mathis: I would say that in light of Ed Wheeler's comments this morning and in view of the entire overall nitrogen picture, thru the phase going around this meeting, if it has "N" in it, buy it. Milwaukee "Milorganite" and Chicago "Sludge" have completed installation of Scrubbers to replace their previous equipment to meet "Enviromental Standards". The Plants are in operation and apparently the new equipment is working well, therefore, Milorganite and Sludge from this source should be greater than they have been for the past two years. The overall Specialty Plant Food Products, whether they are made from Urea or Urea Formaldehyde Compounds, of course, are dependent on the availability of Urea. I would think that all manufacturers, including ourselves, are faced with the shortage right now, however, we believe that materials will be available and that is the concensus of opinion in the Industry, there will be sufficient raw materials to make the "Specialty Plant Food Products that we are talking about.

QUESTION FOR MR. KNUDSEN: What is the solubility of your pure NPK Grade Fertilizer?

ANSWER — KNUDSEN: The solubility in the examples I gave show 75% Solubility and this can be regulated. It is a question of how much of the P205 you take from Phosphate and how much from Phosphoric Acid and, of course, it depends on which phosphate you use. In the example shown in my paper it was Florida Phosphate, 73% BPL and it was anticipated that 55% of the P205 was taken from Phosphate Rock and 45% from Phosphoric Acid. In this case you get a 17-17-17 Grade with 75% water solubility.

QUESTION FOR MR. KNUDSEN: How do you dispose of your Calcium Chloride and Gypsum?

ANSWER — KNUDSEN: Our Calcium Chloride Solution is wasted together with our Gypsum. We have a Phosphoric Acid Plant, Sulphuric Plant, Nitric Acid and NPK Plants situated at the Sea. Our Gypsum is slurred in Sea Water and pumped thru a pipeline into the sea. After having installed the "ION Exchange Unit" we use the Calcium Chloride Solution instead of sea water for slurring the Gypsum. That is the way we get rid of the Calcium Chloride. If you are inland you will get into Environmental Problems, in many cases, if you want to dispose of the Calcium Chloride Solution that way. There are a number of possibilities for using the Calcium Chloride. As far as I have learned the production of solid Calcium Chloride in the U.S.A today, is 1.9 billion pounds, something like 1 million tons of material. This material is used for a number of different purposes and I have named some of these, for de-icing roads in winter time, for suppressing dusts, for stabilizing the surface on unpaved roads, for making pure Calcium Carbonate and so on.

ANSWER — NIELSSON: Just a comment. One of my first jobs, out of School was a Chemist at The Solvey Process Co., Syracuse, N.Y. The Big By-Product from Solvey is Calcium Chloride. They have that stuff coming out of their ears. So, if you have Calcium Chloride you have to compete with Solvey. At first they just put the material in wooden vats and pumped it into the Lake and they finally had to stop doing this. Now they pump the material in large wooden vats and let the water drain out. The dry material piles up and looks like large mountains of chalk. Solvey pushed programs to use the Calcium Chloride as a de-icer and road stabilizer and other uses. I know at one time the employees were asked to try the material in their Radiators as an Anti-Freeze and the Company got tired of buying radiators for the people.

ANSWER — KNUDSEN: Maybe I should add. Of course the Solvey people have a large amount of Calcium Chloride. The amount we produce per year in the plant, producing 400 tons a day of NPK, is 20,000 tons of Calcium Chloride.

QUESTION — MR. BLENKHORN FOR MR. MATHIS: Roger Brown told us something about the magnitude of the Lawn and Garden and gave us stastics of something like 5 million acres of Lawn which I was not aware of and find that very interesting. One thing that has not been touched on is the "Greenhouse Business". Does anybody know just what the magnitude of Commercial Greenhouses is including vegetables, flowers and the whole bit? How significant is that?

ANSWER — MATHIS: there is an increase trend toward growing under plastic which means a Greenhouse in the field. So, we are looking at one area which is a Commercial Application. Looking at it from the agronomic point of view of Greenhouse Growing, if you include that, it would be behind lawns quite obviously and I would say it would not be one half as large as say "The Garden Market."

ANSWER — FRANK NIELSSON: I ould like to comment on a couple of things. One, we had a small plant at Woburn. Woburn is a surburb of Boston and it is a big Greenhouse area. We had one customer who had five acres under glass growing Carnations for the Flower Market. This will give you an idea what the score is. I don't know if you are including Japan. In that Country it is about half covered with Greenhouses made with plastic. You saw the picture we showed in the beginning of this program "Our Garden England". I have been in Europe just long enough to realize that "Over There" you and I call it a yard, a front yard or a back yard. The people in Europe call it a garden. When they say garden they do not mean a tomato patch or flower patch.

MODERATOR BLENKHORN: Can anyone make further comments on the extent of the Greenhouse Business? I suspect the acreage under glass and the use of Specialty Fertilizers, Calcium Nitrate, and Potassium Nitrate, and perhaps Mr. Knudsen's Fertilizer, would have quite a potential in that regard and I think that further information would be very interesting and surprising.

QUESTION — MATHIS: What would you assume is the largest crop in the United States? Soybean? Corn? Hay? Grass? Would you believe Grass? Grass is the absolute largest crop in the United States. Now, whether you are talking about 5 million acres or 50 million acres, when you are looking at the Specialty Plant Food Market this is your largest market, and if you are thinking of getting into this business or if you are in it now, grass is the Target. I think Roger mentioned the largest is the highways. You also have tremendous opportunities in Golf Courses. As you tour the country and you look at the number of Golf Courses. As you tour the Country and you look at the number of Golf Courses under construction, this is the coming thing.

QUESTION: Testing for "Activity Index". Are all of the States in agreement? Do the tests mean the same for straight organics as well as Urea Products?

ANSWER — MATHIS: Tackling the second half of your question first. When you have a mixture of AI Tested Type Product many states at this point are not equipped to test the AI of the finished product. The Activity Index Test is designed purely for Urea-Form Products. We sell a good deal of Organics and we are prohibited in some states, by law, from advertising the Activity Index Test for an Organic. Organiforn is a good example. We cannot claim an AI for Organiform because it is an Organic, it is not Urea-Form. So, by state law these things are very well defined, particularly in Florida where a tremendous amount of Organics are used. We are specifically prohibited there from claiming any Activity Index.

ANSWER — NIELSSON: " would say that if you take a straight organic and run an AI on it you would probably get an 80 or 90. We know a synthetic UF, once you get about 40, the material is not any good or its ability to nitrify decreases. You are in trouble then because if you get something which experience has shown with an 80 to 90, it works, you have another one in there that shows that once you get over 40 it does not work, and you mix the two together, how can you judge it except by nitrification.

ANSWER — MATHIS: I will comment on that this way and maybe Frank has something to say. Most of these products for the State Highway System are on State Bids and they have, in most cases in my experience, a water insolubility requirement. I would say they would be classified as Specialty Plant Foods. Would you agree Frank?

ANSWER — NIELSSON: It depends upon which part of the country you are working. I know in the southern states they will just take bids from regular fertilizers and in some cases they might put in some sludge to give it a little "WIN" but that is about all. It depends upon what kind of "Sales Crew" you have and how good a selling point they can make to the Highway People as to whether or not they should be Fertilizers of the Lawn and Garden Type or the General Type. The other thing depends upon the kind of system the Highway Department is using. If they are using the system where they are spraying the water, the grass seed and the mulch out on a bank or something, they have to use different fertilizer than the people who have already seeded and are just applying fertilizer. So, this becomes an individual case and I think, generally where we have been associated with it in most cases they were using largely the standard grade like 16-8-8, of that order for highways, chiefly because the highways will not pay the money for a Lawn and Garden Fertilizer unless you have a good sales force.

ANSWER — KNUDSEN: Regarding the statistics for Specialty Fertilizers, I heard that CVA, uses Speciality Fertilizer Applications to flowers, domestic gardens, lawns, golf courses, etc., on an annual bases 1.6 million tons of fertilizer. I do not know if that is exact, however, might give you some idea of the total usage compared to your total usage of a cultural fertilizer. I would be something like 14 million tons, I suppose.

ANSWER — NIELSSON: On an absolute tonnage basis the total non-agricultural use of fertilizer might be 2% to 3% of the total. I think that most of you in the room are involved in the "Specialty Plant Food Business" If you are not, and you are thinking of getting into it, it is really the technique of "Sales" that has carried the "WIN" products home. Because you are looking at an Educational Process, not only of your Sales Force but also of your Clerks in the Retail Store, and that is where the emphasis has to be placed to get the Clerks at the Retail Level to sell what he knows. He is going to do that anyway. Your objective has to be the effort to make the Retail Clerk know the story that you are trying to tell.

ANSWER — KNUDSEN: In fact, the reason why we started this development work was the Danish Farmers, in some areas, wanted a copper bearing NPF. The copper is a micronutrient and the Chloride together makes a very dangerous product from a symetry composition point of view. This is what started all of it as far as the agriculture fertilizer is concerned. Here we use copper as a micronutrient, we add some boron for some fertilizers, we add quite a lot of magesium for nearly all of our NPK Products. With regards to the garden fertilizer in Denmark. Of course we use garden fertilizers, but as I said right from the beginning, my company is producing "Cultural Fertilizers" not really garden fertilizers. We have N.P.K. plants consisting of a "Wet Section" and a "Spheredizer Section", and to the wet section we add phosphoric acid, nitric acid and ammonia, as well as the product solution from the "ION" Exchange Plant containing Potassium Nitrate and Phosphoric Acid. All of these products are added to the "Wet Section". Here also, before it is granulated into the slurry, we add Magnesium Sulphate, Copper Sulphate and whatever we need of Micronutrients, is added to the slurry before it is pumped into the Spheredizer. Of course you can use whatever equipment you want for granulating. We use the "Spheredizer". You could use the Granulating Drum or Prilling equipment, and you add the Micronutrients before you granulate.

MODERATOR BLENKHORN: This has been a long afternoon here. Just before we close off, I wonder if Mr. Mathis, Mr. Nielsson or Mr. Knudsen have anything further they would like to say.

MR. KNUDSEN: Just one short remark. I have a message from my wife that I should not forget to tell you that there are reprints available and she would not like to carry them back to Copenhagan again!

MODERATOR BLENKHORN: I wish to thank the Panelists and I think particularly Mr. Knudsen, for coming so far to give us a very interesting address on a very significant piece of work on his part. Are there any announcements I should be making? Isn't there an "Attitude Adjustment Period Tonight?", otherwise known as a "Cocktail Party"? That is tomorrow night. You will be left to your own devices tonight, men, to adjust your attitudes. thank you very much.

Wednesday, November 7, 1973

Morning Session
Moderator: Frank P. Achorn

MODERATOR ACHORN: The first speaker this morning will be Charles H. Davis. I am particularly proud to introduce Bud. I have known him for years. He is one of the most competent Engineers in "TVA" and I think in the Fertilizer Industry. Occasionally Bud and I argue a little! You know that in the state of Alabama, we are blessed with two good football teams and Bud went to "Auburn" and my children went to "Alabama". Bud is a graduate Chemical Engineer from Auburn and an outstanding one. I will say no more about him. Bud will discuss the Paper prepared by Ronald D Young and himself, titled:

Use of Urea In Granulation Formulations For Compound Fertilizers

Charles H. Davis and Ronald D. Young

I thank you Frank for those kind remarks. I will overlook the part about the Alabama Football Team! Ronald Young is my Co-author on this Paper. He is out of the country on special assignment. He asked me to express his regrets in not being able to be here with you today and to give each of you his warmest personal regards.

Introduction

Urea is becoming the leading form of solid nitrogen fertilizer. As indicated in Figure 1, world urea capacity is expected to exceed ammonium nitrate capacity by about 1975. Figure 2 indicates that U.S. urea capacity is rapidly overtaking ammonium capacity. The increasing trend to urea is said to be due largely to favorable economics in comparison with other nitrogen sources. Until now, U.S. granulation plants have normally used ammonia-ammonium nitrate solution and/or ammonium sulfate to supplement anhydrous ammonia as a nitrogen source. With an increasing future availability of urea at attractive prices, more use of it in granulation plants seems likely. Future solid nitrogen imports will likely be urea rather than ammonium nitrate or ammonium sulfate.

There are approximately 200 operational granulation plants in the U.S., not including the plants that produce only ammonium phosphates. Figure 3 by Harre (*2*) shows the trends in production of mixed fertilizers in the U.S. (excluding ammonium phosphates). The general trend seems to be more to bulk blending or liquid mixtures, rather than to granulation of the final mixes in local plants. However, the tonnage of granular compounds is substantial and is holding up quite well at about 10 million tons per year. Ammoniation-granulation products (excluding ammonium phosphates) represent about half the total tonnage of mixed fertilizers marketed. It appears likely that appreciable tonnages of homogeneous granular compounds products will continue to be produced in the foreseeable future.

Figure 4 shows the location of the granulation plants and the urea plants in the U.S. (This does not include some small urea plants that are used only in production of urea-ammonium nitrate solution.) Generally, the granulation plants are not located in close proximity to the urea plants. Hot concentrated urea solution cannot be transported very far because of urea hydrolysis problems and resulting buildup of pressure in cars. Transport of urea-ammonia-water solutions is also not very attractive because of the high water content required. Therefore solid urea is probably best suited for general use in granulation plants. Almost all of the solid urea product in the U.S. is in the form of prills. Increasing importation of prilled urea is anticipated.

For the reasons outlines above, this paper will be primarily concerned with the use of urea prills in granulation plants to produce compound products. Other feeds will include the usual materials now used, such as anhydrous ammonia, ammonium sulfate, sulfuric acid, superphosphates, ammonium phosphates, and potash. This paper will be divided into three parts: (1) a discussion of some pertinent fundamental considerations, (2) a review of existing worldwide technology related to use of urea in granulation, and (3) coverage of recent pilot studies at TVA on use of urea in conventional granulation formulations of the type outlined above.

Fundamental Considerations

Normally urea would be used in place of the ammonium nitrate and/or ammonium sulfate in granulation formulations which usually also include anhydrous ammonia. Therefore changes in operating conditions and product properties due to this substitution of urea are of interest.

Hygroscopicity: The critical relative humidities of urea, ammonium nitrate, and some salt mixtures are tabulated below (*11*).

Material	Critical relative humidity, % at 86 degree F.
Urea	75
Ammonium nitrate (AN)	59
Ammonium sulfate	79
Urea — ammonium phosphate (UAP), 29-29-0	57
Ammonium phosphate nitrate, 25-25-0	55-60
Nitric phosphate (NP), 20-20-0	57
Urea + ammonium nitrate	18
Urea + ammonium sulfate	56
Urea + potassium chloride	60
UAP + potassium chloride	45
20-20-0 NP + potassium chloride	50
14-14-14 grade with 25% urea	45-50
13-13-13 grade with AN	55-60

The above data indicate that straight urea has less tendency to absorb moisture from the air than ammonium nitrate, and about the same tendency as ammonium sulfate. When urea and ammonium phosphate are mixed, the urea — ammonium phosphate (29-29-0) has about the same hygroscopicity as nitric phosphate (20-20-0) which contains substantial proportions of ammonium nitrate and ammonium phosphate. When potash is added to the above mixtures, the mix with urea becomes a little more hygroscopic than the one with ammonium nitrate. A 14-14-14 granular product containing urea produced in the TVA pilot plant had a critical relative humidity of 45 to 50% with 55 to 60% for a similar product (13-13-13) containing ammonium nitrate.

A few indications from the abbreviated data above are summarized below.

- Straight urea is only moderately hygroscopic.
- Mixtures of urea and ammonium nitrate are excessively hygroscopic.
- Nonpotash grades of urea and ammonium phosphate have about the same hygroscopicity as equivalent ratios made from ammonium nitrate plus ammonium phosphate.
- Adding potassium chloride to mixtures containing urea and ammonium phosphate gives mixes that are more hygroscopic than equivalent ratios with ammonium nitrate instead of urea.
- There is no apparent reason why compound products containing urea are too hygroscopic to be stored and handled satisfactorily.

Melting Point: Some melting points of fertilizer products are tabulated below *(4).*

Material	Melting point, degree F.
Urea	277
Ammonium nitrate (AN)	323
Urea — ammonium phosphate (29-29-0)	292
Ammonium phosphate nitrate (25-25-0)	307
Urea + ammonium phosphate + potassium chloride (25-15-15)	271
Urea in formulation with superphosphate (14-14-14)	290-330
AN in formulation with superphosphate (13-13-13)	276

These dats show that urea has a significantly lower melting point than ammonium nitrate. The melting points for urea — ammonium phosphate combinations were also lower than for ammonium phosphate nitrate products. Whenever urea was included in formulations that contained a substantial proportion of superphosphate, the melting point of the products was relatively high. Comparative melting point data are of interest in establishing operating criteria for granulation and drying.

Bulk Density: Bulk densities (loose pour) for several fertilizer products are given below.

Material	Bulk density, lb/ft3
Urea prills [a]	46
Ammonium nitrate prills [a]	55
Urea — ammonium phosphate (UAP), 28-28-0 [b]	43-47
Ammonium phosphate nitrate (25-25-0) [a]	55
UAP + potassium chloride (17-17-17) [a]	56
Nitric phosphate (15-15-15) [b]	61
Granular product containing 25% urea and superphosphate (14-14-14) [b]	58

[a] Commerical-scale product.
[b] Pilot-plant product.

The above data indicate that compound products containing urea can have significantly lower bulk densities than equivalent products made with ammonium nitrate. this factor must be considered when estimating costs for bagging, storing, shipping, and handling of products.

Particle Strength: The crushing strengths for some fertilizer materials are tabulated below.

Material	Crushing Strength, lb.
Urea prills [a]	2
Ammonium nitrate prills (AN) [a]	3
Urea — ammonium phosphate (UAP), 28-28-0 [b]	11-13
Nitric phosphate (20-20-0) [a]	6
Diammonium phosphate (18-46-0) [a]	7
UAP + potassium chloride (17-17-17) [a]	3-4
Granular products containing urea and superphosphate (14-14-14) [c]	11-13
Granular products containing AN and superphosphate [c] (12-12-12, 13-13-13)	7-12

[a] Commercial product.
[b] Pilot-plant product, contains polyphosphate.
[c] Pilot-plant product.

The limited data given above indicate that products containing substantial proportions of urea can have crushing strengths as good as materials containing ammonium nitrate. The granular compound products containing either urea or ammonium nitrate are stronger than either straight urea or ammonium nitrate prills.

Drying Rate: Data by Hensley *(3(* on drying rates for 1:1:1 ratio products based on urea — ammonium phosphate (19-19-19) and ammonium phosphate nitrate (17-17-17) are given in Figure 5. These data indicate that the granular compound product containing urea dried more rapidly than the product based on ammonium nitrate. Others have reported similar observations. However it should be pointed out that the lower melting point for materials containing urea and the tendency for urea to hydrolyze at high temperature will likely restrict the drying operation to lower temperatures than can be tolerated for materials containing ammonium nitrate.

Chemical Reactions: Hignett *(5)* had described the chemical reactions that can occur in a granulation system based on urea, superphosphates, ammonium phosphates, potash, and ammonium sulfate. These reactions are summarized below.

Urea and monocalcium phosphate (in superphosphate) can react as indicated below.

$$\mathrm{Ca(H_2PO_4)_2H_20 + 4CO(NH_2)_2 = CA(H_2PO_4)_2.4CO(NH_2)_2 + H_2O} \quad (1)$$

As the reaction releases the water of hydration, the mixture can become wet and muddy. The above reaction probably is not rapid enough to have much effect on conditions in the granulator. When ammonium sulfate and potash salts are included in the mixture, various other reactions may occur — some more rapidly than reaction 1.

$$\mathrm{CA(H_2PO_4)_2H_20 + (NH_4)_2SO_4 + H_20 =}$$
$$\mathrm{CaSO_4.2H_20 + 2NH_4H_2PO_4} \quad (2)$$

$$\mathrm{(NH_4)_2SO_4 + CaSO_4 + H_20 = (NH_4)_2SO_4.SO_4.H_20} \quad (2)$$

$$\mathrm{(NH_4)_2SO_4 + 2KC1 = K_2SO_4 + 2KC1 = K_2SO_4 + 2NH_4C1} \quad (4)$$

$$\mathrm{K_2SO_4 + CaSO_4 + H_20 = K_2SO_4.CaSO_4.CaSO_4.H_20} \quad (5)$$

$$\mathrm{Ca(H_2PO_4)_2.4CO(NH_2)_2 + (NH_4)_2SO_4 =}$$
$$\mathrm{CaSO_4.4CO(NH_2)2 + 2NH_4H_2PO_4} \quad (6)$$

$$\mathrm{H_3PO_4}\text{ (as free acid in superphosphate) +}$$
$$\mathrm{(NH_4(_2HPO_4 = 2NH_4H_2PO_4} \quad (7)$$

The ammonium and potassium syngenites formed by reactions 3 and 5 are only slightly soluble. Their formation consumes water, which may account for the observed drying and hardening of superphosphate — containing mixtures when ammonium sulfate is added. Ammonium sulfate is usually added in the form of fine crystals, so reactions involving it may proceed more rapidly than with coarser urea prills.

Urea tends to hydrolyze at elevated temperature.

$$\mathrm{CO(NH_2)_2 + H_20 = 2NH_3 + CO_2} \quad (8)$$

Hydrolysis during processing and storage can be significant if the temperature of the material in the dryer is sllowed to exceed about 210 degree F. or if material is fed to storage at temperatures above about 120 degree F.

The ammonia generated by reaction 8 (or from decomposition of any diammonium phosphate in the formulation) reacts with the monocalcium phosphate in the superphosphate.

$$\mathrm{Ca(H_2PO_4)_2 + NH_3 = CaHPO_4 + NH_4H_2PO_4} \quad (9)$$

A result of reaction 9 is a decrease in the water solubility of the $\mathrm{P_20_5}$.

Growth of crystals of a urea — ammonium chloride adduct, $\mathrm{CO(NH_2)_2.NH_4C1}$, has been observed on the surface of granules during storage. This crystal growth has been reported as a cause of caking in these types of products *(4(*.

Review of Present Technology

Present worldwide technology related to the use of urea in granulation of compound products will be briefly reviewed in this section. Most of the operations have been described in detail by others. Some of the information was given in papers presented at the American Chemical Society Division of Fertilizer and Soil chemistry meeting in Chicago, August 29, 1973.

British Practice

British practice on use of urea in granulation has been described by Hignett *(5)* and Sharples *(10)*. The usual practice is to use prilled urea in formulations containing single or triple superphosphate, ammonium phosphate, ammonium sulfate, and potash. The 20-10-10 grade is a favorite. Since there is a premium value on water-soluble $\mathrm{P_20_5}$, the superphosphate is usually not ammoniated. The urea content of the products does not exceed about 30% because of agronomic considerations.

Most of the plants are small, in the range of 7 to 12 tons of product per hour. Steam, hot recycle, and in some small plants a direct flame, are used to promote granulation. The ratio of recycle to product is usually between 0.5:1 and 1.5:1. Most of the granulation actually occurs in the dryer.

The operators prefer granular ammonium phosphate and granular potash. When diammonium phosphate is used, the proportion is restricted to the amount that will neutralize only the free acid in the superphosphate. Because of the limited chemical reactions, the absence of acid, the granular feeds, and the low operating temperatures, the plants are reported to be relatively free of dust and fume.

The high-analysis grades like 20-10-10 are dried to about 0.5% moisture. The cooled products are coated with 0.5 to 1.0% of oil and 1 to 2% of clay. Use of this oil-clay treatment masks any appearance of non-homogeneity that might occur from the use of the high proportion of granular feeds.

Studies in Australia

Pilot-scale studies and limited plant-scale tests of drum granulation of urea prills and single superphosphate (nongranular) have been carried out in Australia. Results have not been formally reported. Most of the studies were made of granulation of a mix comprised of 45% urea and 55% superphosphate.

From these studies it was concluded that it is technically feasible to granulate urea-superphosphate mixtures. Ammoniation, at least to the degree required to neutralize the free acid in the superphosphate, was required for satisfactory granulation. Careful control of temperatures and moisture levels in the system was required. Handling and storage of the granulated mixture were satisfactory provided the material was dried below 1% moisture. Drying data indicated that a drying time of at least about 25 minutes would be needed to attain the 1% moisture level. Corrosion of plant equipment appeared to be increased by use of urea in the granulation system.

Japanese Practice

Ando *(1)* and Kuwabara *(7)* have recently reported on the use of urea in granulation in Japan. An increasing trend to the use of urea in granulation was indicated. The urea is mainly added in solid form, as crushed prills or crystals. Other nitrogen materials are ammonium sulfate and ammonium chloride. Phosphate materials are mainly ammonium phosphate and single superphosphate, with the trend to more ammonium phosphate. The ammonium phosphate may be added in either solid or slurry form. the solid ammonium phosphate may be granular, semigranular, or nongranular.

A variety of granulation systems is utilized. Rotary drums make up about half of the total number of granulators in operation.

Indian Practice

Urea — ammonium phosphates are being produced in two large-scale production plants operating in india. Papers have been presented describing these operations at the Coromandel complex *(9)* for production of 28-28-0 and 20-20-0 grades and the Madras complex *(6)* where 14-28-14 and 17-17-17 grades are made. Feeds are urea prills, wet-process acid, anhydrous ammonia, and standard potash (Madras only).

In these two plant systems, the phosphoric acid is ammoniated to an $NH_3:H_3PO_4$ of about 2. Therefore, the plants are basically diammonium phosphate systems with the urea and potash fed as supplemental materials. In both systems the material from the dryer is screened hot and only the product size is cooled.

The Coromandel system is comprised of two drum-granulation lines each of which is rated at 1040 metric tons per day of 28-28-0 grade. The 20-20-0 grade is produced by simply adding filler (soft brown earth) to the 28-28-0 formulation. The product is essentially minus 6 plus 14 mesh and is dried to 1% moisture. The product is coated with dust and stored in bulk before bagging. Only bagged product is shipped.

Two granulation lines are also used in the Madras system, each having a capacity of 35 metric tons per hour. The lines are identical, except that a drum granulator is used in one and a pugmill granulator in the other. The drum granulator was reported to have the best ammoniation efficiency.

The potash — containing products are dried to a moisture level of about 0.7%, coated with clay, and bagged directly from production. The humidity is controlled in the bagging hopper. Some special operating and handling techniques were developed to cope with the relatively hygroscopic (critical relative humidity of 45%) material.

Spanish Practice

Papers given at the International Superphosphate and Compound Manufacturers Association (ISMA) Technical Conference in 1972 described the use of urea in the Fertiberia *(3)* and ERT (Union Explosivos Rio Tinto, S.A.) *(8)* granulation plants in Spain. All of these plant systems utilized prilled urea and nongranular monoammonium phosphate with other materials in producing a variety of high-analysis compound products.

In the Fertiberia operation the feeds are prilled urea, powder monoammonium phosphate, potash, sulfuric acid, and ammonia. Pproduct grades include 8-36-16, 10-20-20, and 18-18-18. Production rates are about 400 to 500 metric tons per day.

The feed materials, together with the recycle, are fed to a pugmill where steam and sulfuric acid are added as required for granulation. The mix from the pugmill is discharged into a rotary drum where ammonia is fed. The drum discharge is dried, cooled, and then screened. Undersize and crushed oversize from the screens are recycled. The product size is coated with dust and oil and fed into bulk storage. Product moisture levels were given as 0.8% for the 18-18-18 grade and 1.2% for the 10-20-20 product. Recycle-to-product ratio for the 18-18-18 grade was about 1.5 to 2.0.

Bulk and bag storage properties of the products are said to be satisfactory provided care is taken. Bagging the products in polyethylene bags soon after manufacture was recommended. Humidity control was suggested for bulk storage.

The ERT group is comprised of three granulation plants each of which is of somewhat different design. Two of the plants have drum granulators only, while the third has a pan followed by a drum. One of the plants screens material between the dryer and cooler, one after the dryer and cooler, and the third after a cooler only (no dryer). Production rate in these units is in the range of 10 to 22 tons per hour.

In addition to urea prills and powder MAP, feeds to these plants are ammonia, single superphosphate, sulfric acid, phosphoric acid, granular diammonium phosphate, potassium chloride, and potassium sulfate. Product grades included 16-16-16, 20-10-10, and 26-16-0. The proportion of urea in the granular products ranges from 3 to 45%. The percentage of P_20_5 from superphosphate is about 20 to 50% of the total, with the remainder supplied by ammonium phosphate.

Conditions for granulation were optimized for a number of formulations and operating conditions. Importance of good control of temperatures and moisture levels was emphasized. This included drying with a considerable airflow at moderate temperature. Fertilizers with chloride and urea were reported to show a marked tendency to form lumps. A network of white intergranular bridges was identified as $NH_4C1.CO(NH2)_2$.

Pilot-Scale Studies at TVA

Urea in Formulations with Single Superphosphate

Most of the pilot)plant work at TVA involved use of urea prills in 1:1:1 ratio formulations with run-of-pile single superphosphate. Other feeds included some combination of crystalline byproduct ammonium sulfate, granular ammonium phosphate, and standard potassium chloride. The large TVA granulation pilot plant was utilized for most of these studies at a production rate of 1 ton per hour. In initial studies no ammonia was added and results were never entirely satisfactory. This work has already been reported *(5)*.

In recent studies anhydrous ammonia was utilized and also sulfuric acid in some formulations. About half the P_20_5 was derived from single superphosphate (Florida rock) and the remainder was supplied by granular 18-46-0. Varying degrees of ammoniation of the superphosphate were tested to establish the degree which gave best granulation operation.

Results showed that granulation was satisfactory in all tests when the degree of ammoniation of the superphosphate was between about 0.8 and 3.5 pounds of ammonia per unit of P_20_5 in the superphosphate. Lower degrees of ammoniation than 0.8 pound of ammonia per unit of superphosphate P_20_5 resulted in unsatisfactory operation because of persistent stickiness of the material. Ammoniation degrees higher than 3.5 resulted in sandylike product with too little agglomeration.

A flow diagram of the pilot plant, including sizes of key equipment items, is shown as Figure 6. the raw materials except urea were preblended in a ribbon mixer. The urea prills were kept separate to avoid reaction between urea and superphosphate. (In a plant-scale system having short retention time for the feed, the urea probably could be added directly to the blend of other materials.) the solids were fed and metered to the drum granulator with a volumetric feeder. Analyses of the raw materials are summarized below.

Analysis of Solid Raw Materisls Fed in Tests of the Use of Urea in 14-14-14 Granular Fertilizer

	Granular 18-46-0	Urea	Single superphosphate	Potassium chloride
Chemical analysis, %				
Total N	17.8	46.2	——	——
Total P_2O_5 As % of total P_2O_5	45.4	——	20.2	——
Available P_2O_5	——	——	94.9	——
Water-soluble P_2O_5	89.4	——	80.0	——
Free acid P_2O_5	——	——	1.4	——
K_2O	——	——	——	59.9
K_2O (vacuum desiccator)	1.6	0.2[a]	5.2	0.1
Screen analysis (Tyler), %				
+mesh	0.3	0.0	1.2	0.0
—6 +10 mesh	96.3	10.9	13.0	0.0
—10 +16 mesh	3.4	82.6	11.4	6.3
—16 +28 mesh	0.0	6.2	13.4	32.8
—28 +35 mesh	0.0	0.3	12.3	24.1
—35 +60 mesh	0.0	0.0	16.8	21.7
—60 mesh	0.0	0.0	31.9	15.1

[a] H_2O by Karl Fischer.

Formulations Tested Using Urea in Production of 14-14-14 Granular Compound Fertilizer

Formulation No.	GU–3	GU–4	GU–13
Feed material, lb./ton product			
Anhydrous NH_3	10	22	54
Urea prills	483	461	391
Granular 18-46-0	330	350	361
Single superphosphate	672	672	600
Standard -potassium chloride	467	467	467
Sulfuric acid	0	38	125
Conditioner	50	40	40
Input NH_3/unit P_2O_{55} superphosphate	1.5	1.5	2.5

Granulation was controlled in most of the tests by the use of steam to supply heat and liquid phase in addition to that supplied by the ammoniation of the superphosphates. In some of the tests, small to moderate amounts of sulfuric acid were included in the formulation to supply supplemental heat and liquid phase. With a sulfuric acid rate of about 125 pounds per ton, no steam was required for granulation.

The same basic information was used in all the 14-14-14 tests, except for variations in the degree of ammoniation of the superphosphate (and the user of sulfuric acid in some tests). The urea prills comprised 20 to 24% of the weight of the product. Three of the formulations tested are shown below.

In the formulation GU-3, no sulfuric acid was fed, and supplemental steam (about 100 lb/ton) was needed for granulation. For formulation GU-4, about 40 pounds of H_2SO_4 per ton of product was fed and additional heat and liquid phase were supplied by about 70 pounds of steam per ton of product. The formulation G-13 included about 125 pounds of H_2SO_4 per ton of product and no steam was needed.

Usually the temperature of the granulator product was about 130 degrees to 140 degrees F. and the moisture content was about 3% when no sulfuric acid was fed. When about 125 pounds of sulfuric acid was used per ton of product, the granulator temperature increased to about 175 degrees F. and the granulator product moisture was only a little over 1%. Recycle to product ratios were usually in the range of 0.5-1.0.

The products were dried to moisture contents in the range of about 0.5 to 1.0%. the dryer product temperature was in the range of 170 degrees to 180 degrees F.

The cooler product was screened at 5 and 12 mesh, which is somewhat coaser sizing then is normally used in the U.S. for these types of granular products. The use of the screens with larger openings improves product appearance by permitting any uncoated urea prills to pass through the undersize screen and be recycled back to the granulator. The 14-14-14 product was relatively smooth and well rounded and has a very good overall appearance.

The water solubility of P_2O_5 in the product was 63 to 78% with the highest ammoniation rates having the lowest water solubility. Ammonia loss from the granulator varied from nil at the lowest degrees of ammoniation to about 20% of input at the highest degree (5.8 lb NH_3/unit P_2O_5 in superphosphate). Ammonia loss was less than 3% throughout the range of degrees of ammoniation (0.8-3.5 lb. NH_3/unit P_2O_5) that gave acceptable granulation.

Urea in Formulations with Triple Superphosphate

Only a limited amount of test work was done with formulations containing run-of-pile triple superphosphate. In general, the results from these tests indicated that satisfactory results could also be attained with low degrees of ammoniation of the superphosphate. However, initial results have indicated that granulation control may be more difficult with triple superphosphate than for single superphosphate.

16-16-16 Formulation: A formulation for a 1:1:1 ratio was tested using triple superphosphate instead of single superphosphate. The degree of ammoniation used in this test was 1.5 pounds of NH_3 per 20 pounds of P_2O_5 in the triple superphosphate. Sulfuric acid was included in the formulation at the rate of 130 pounds per ton of product. Steam was not added. Urea made up about 26% by weight of the finished product. The temperature of the granulator product was 165 degrees F. at a moisture content of 1.4%. Granulation was fair during this test but somewhat difficult to control.

10-20-20 Formulation: A formulation for a 1:2:2 ratio was tested using run-of-pile triple superphosphate to supply about 18 units of P_2O_5. The additional two units of P_2O_5 were supplied as granular 18-46-0. Urea prills comprised from 16 to 17% by weight of the finished product and supplied about 8 of the 10 units of nitrogen. The additional 2 units of nitrogen were supplied as anhydrous ammonia and diammonium phosphate. About 40 pounds of steam and 75 pounds of sulfuric acid were added per ton of product to supply liquid phase for granulation. The degree of ammoniation of the triple superphosphate was varied from 0.8 to 1.2 pounds of NH_3 per unit of P_2O_5. The temperature of the granular product was 167 degrees to 172 degrees F. with a moisture content of 1.7%. Operation of the plant was only fair during these tests with periods of both overagglomeration and underagglomeration.

Urea in Formulations with Nongranular Monoammonium Phosphate

Urea was tested in limited studies of 12-24-24 and 18-18-18 formulations in which all of the P_2O_5 and part of the nitrogen were supplied by nongranular monoammonium phosphate. Anhydrous ammonia, standard potassium chloride, and byproduct crystalline ammonium sulfate (for 18-18-18 grade only) comprised the remainder of the feeds.

The ammonia in these formulations was proportioned to ammoniate the monoammonium phosphate intermediate to an N:P mole ratio of 1.5. However, ammonia loss was excessive. Apparently a concentrated solution of urea covered the monoammonium phosphate and prevented its absorbing much ammonia.

Granulation was only fair and was very sensitive to slight changes in liquid phase. there was very little fuming in the ammoniator-granulator with these formulations.

More work is planned for formulations of urea and nongranular monoammonium phosphate. Major objectives will be to find conditions of good granulation without excessive ammonia loss.

Conclusions

Plant-scale and pilot-scale tests have shown that urea can be satisfactorily utilized in a variety of formulations and granulation equipment. In formulations containing superphosphates, low degrees of ammoniation were required for good operation. Stem and/or sulfuric acid was usually needed to help supply liquid phase for granulation.

As compared with the use of ammonium nitrate in granulation formulations, the use of urea generally necessitates lower granulation and drying temperatures as well as cooling the product below 120 degrees F. This is due to the lower melting point for urea and the tendency for urea to hydrolyze at high temperatures. Inclusion of ammonium sulfate in formulations containing urea is helpful because of the drying and hardening effect in the ammoniator-granulator. Screening these types of products on larger size screens is helpful because blinding is minimized and any uncoated urea goes back as recycle. Except for a lower bulk density, storage and handling properties of granular products made from formulations containing urea are not substantially different from similar materials with ammonium instead of urea. Ammonium nitrate and urea should not both be utilized in the same granulation system because these two materials together from a eutectic that is excessively hygroscopic.

As urea becomes more economical in relation to ammonium nitrate, most U.S. granulation plants should be able to satisfactorily utilize urea instead of ammonium nitrate. However, careful attention should be devoted to establishing proper operating criteria necessitated by the different properties that urea will impart to the granulation mixture.

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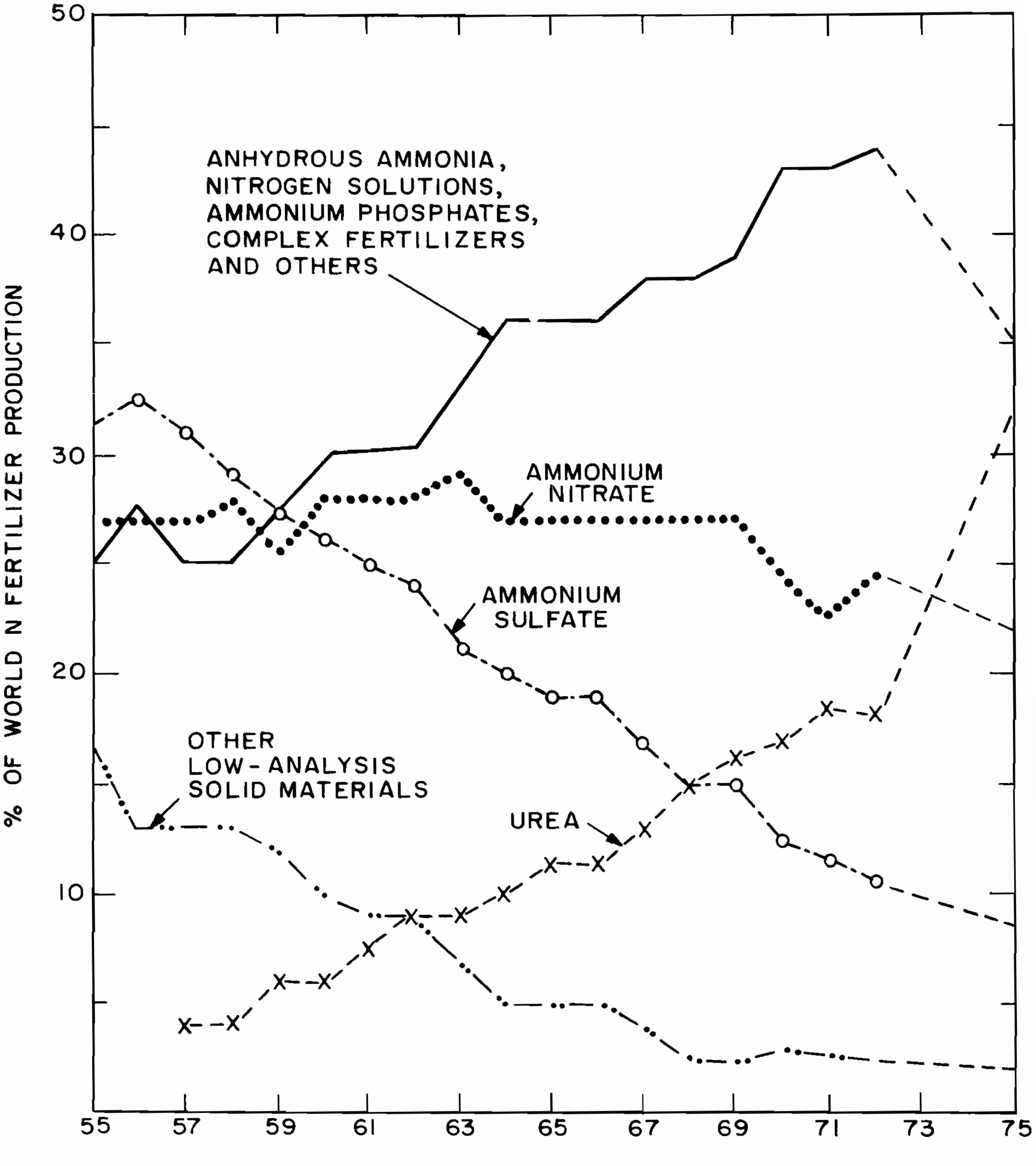

FIGURE 1
World Trends in Types of Nitrogenous Fertilizer Materials (FAO data; does not include USSR or Communist Asia)

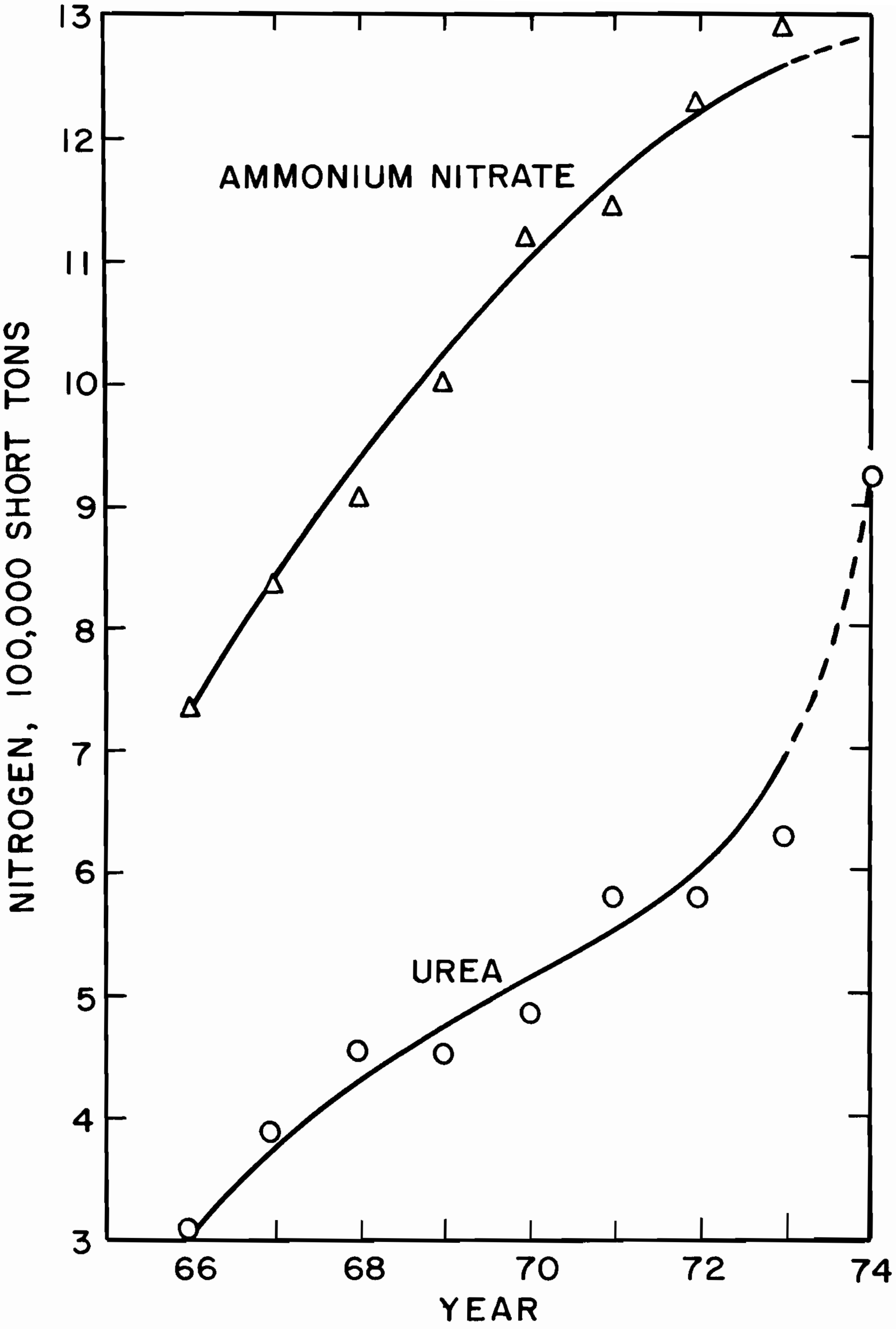

FIGURE 2
Estimated Supply of Nitrogen Fertilizers
in United States

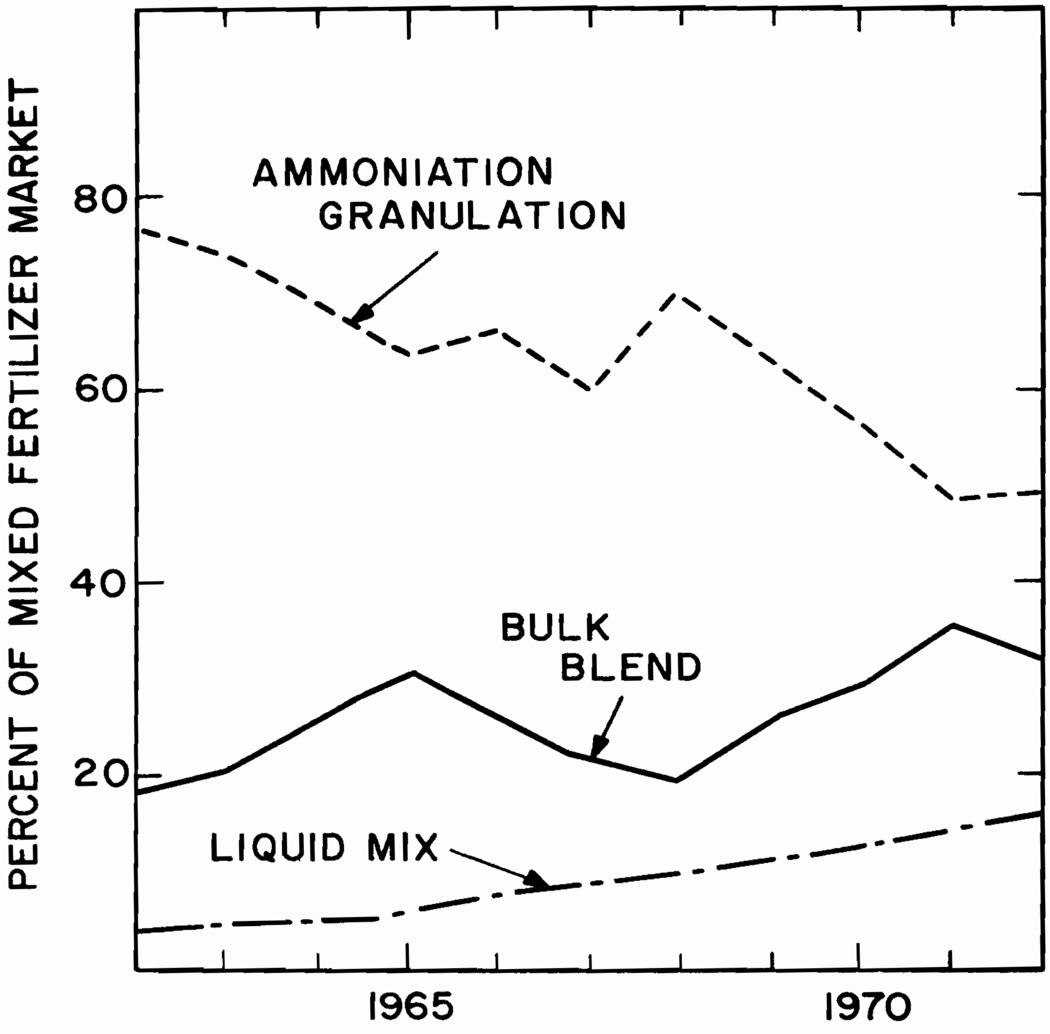

FIGURE 3
Share of Mixed Fertilizer Market
by Type of Product

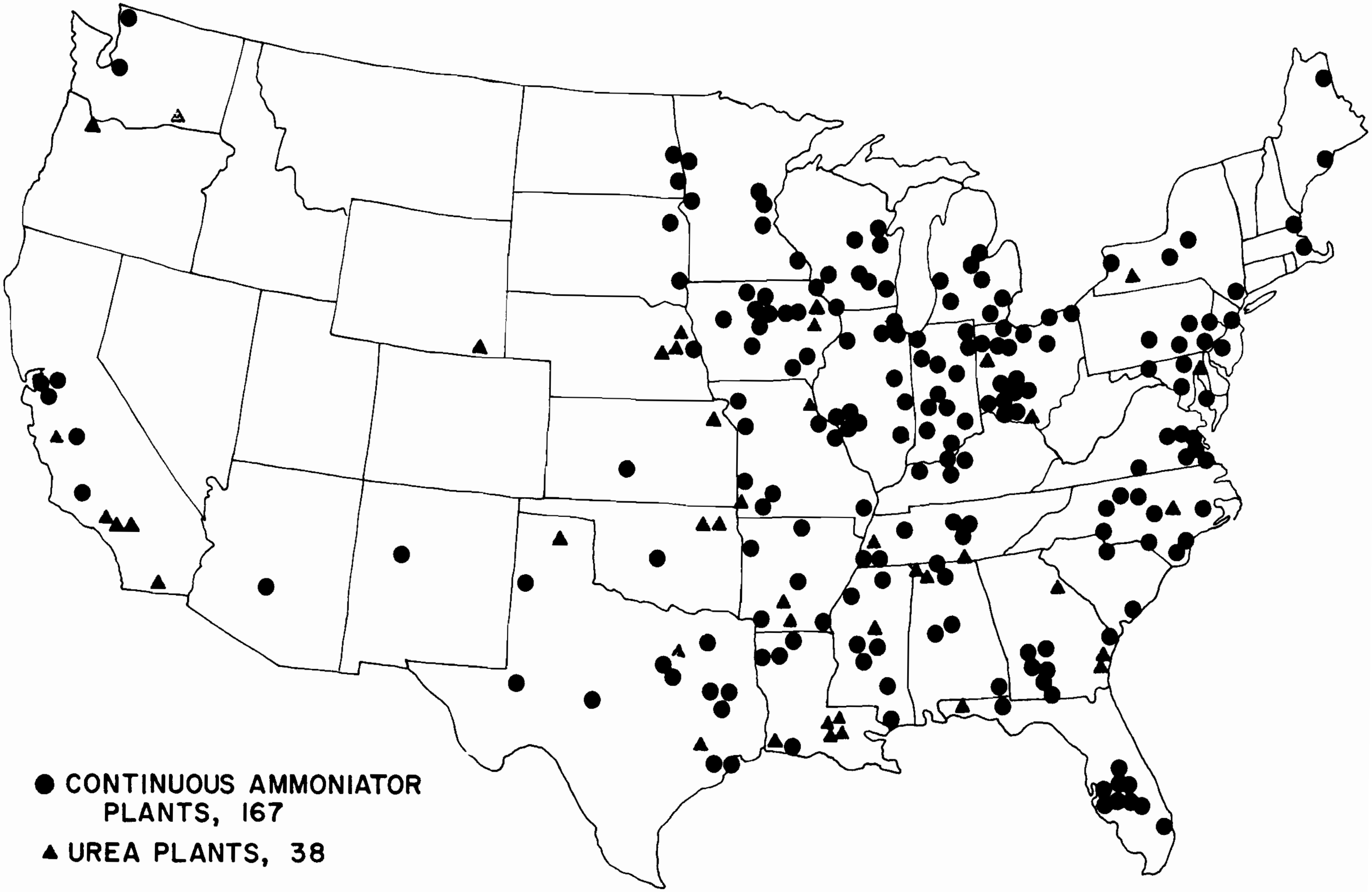

FIGURE 4
Location of Urea and Granulation Plants in Continental United States

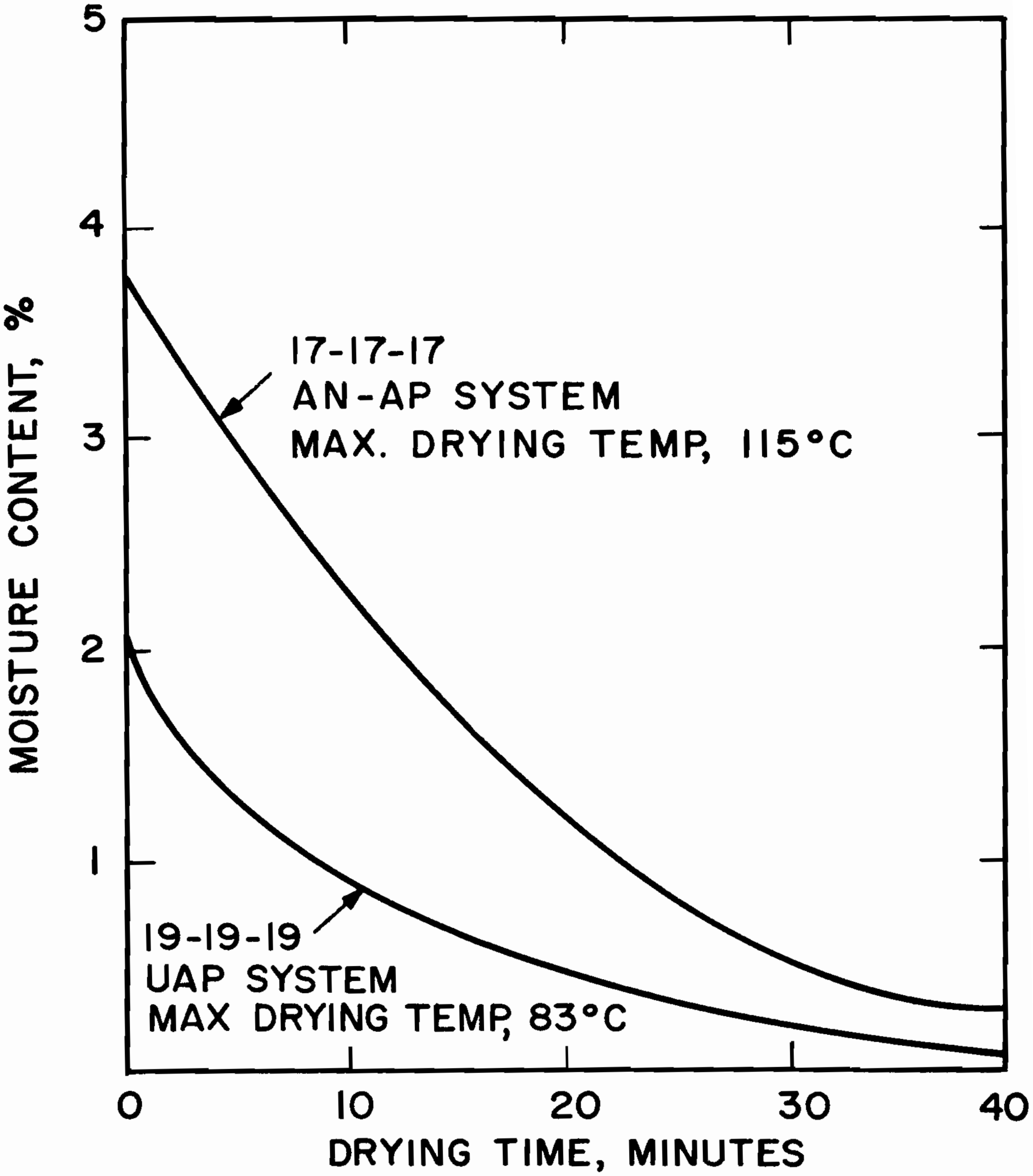

FIGURE 5
Drying Curves for 1:1:1 Fertilizers

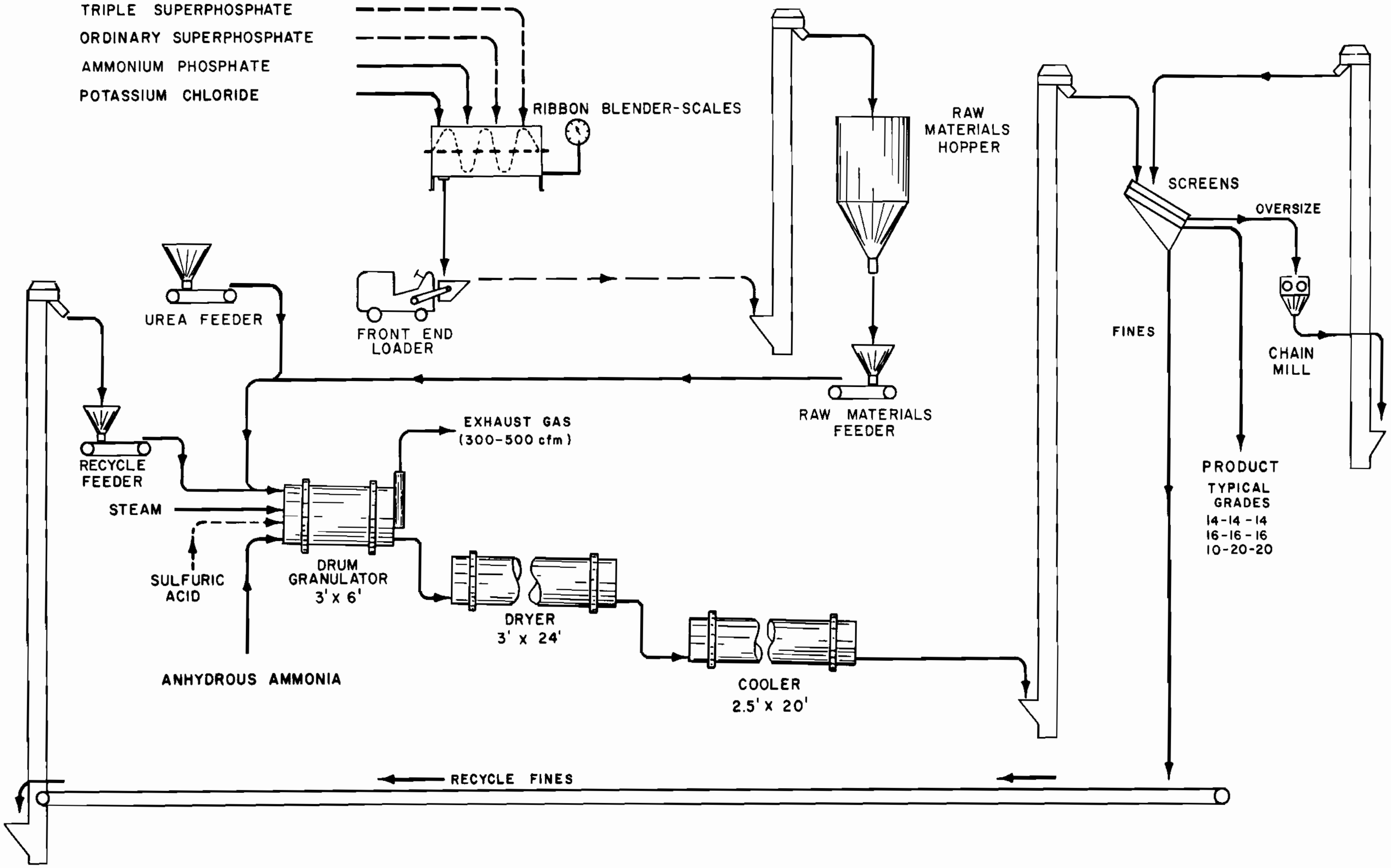

FIGURE 6
Flow Diagram of Granulation Pilot Plant for Producing Granular Mixed Fertilizers Containing Urea

MODERATOR ACHORN: Thank you Bud and thanks to Ronald for that excellent detailed discussion "Urea in Granular Fertilizers".

The next paper will be presented by Mr. John Boyd. John is a Chemist for the Texas Gulf Company. He graduated from Atlantic Christian College. I know John real well. He is one of the young Engineers and one of the young Chemists in our Industry that it is certainly a pleasure to see has entered it. We need young men like him with dynamic force and energy that they put into our Industry. I'm afraid we have been lacking some of this effort in years past and it's a real healthy sign to see them come in. Texas Gulf has always been a strong leader in the fluid fertilizer market and John's talk today, and he wanted me to be sure and say that, John Jernigan helped him to prepare this paper.

Use of Superphosphoric Acid in Fluid Fertilizer

John A. Boyd
John D. Jernigan

Polyphosphates derived from superphosphoric acid play an important role in the manufacture of liquid fertilizer solutions. In 1971-72, 555,000 tons of P_2O_5 derived from superphosphoric acid were consumed in the United States in the liquid fertilizer industry.[1] Liquid mixed fertilizers account for about 10% of the total fertilizer P_2O_5 consumed in the United States and during the past ten years fluid fertilizers usage has grown at a rate of about 14% per year.

Superphosphoric acid is used to produce an ammonium polyphosphate base solution in the field. The base solution is cold, hot, or semi-hot mixed with other ingredients such as soluble potash to produce N-P-K fluid fertilizer clear liquids or suspensions. the term fluid fertilizer includes both suspensions and clear N-P-K liquids. For the past three years the Technical Services Department at our North Carolina phosphate facility has conducted development work on ammonium polyphosphate base solutions, on N-P-K clear liquid systems, and on suspensions manufactured from Texas-gulf super and orthophosphoric acids.

When wet process orthophosphoric acid (54% P_2O_5) is used to manufacture liquid fertilizer solutions, the impurities present in the acid tend to form crystals of phosphate salts and precipitate as bothersome sludges in storage tanks and applicator equipment. Polyphosphates tend to sequester or solubilize these impurities thus keeping then in solution. [2] The increased solubility of polyphosphates over orthophosphates also allows the production of more concentrated liquids

In the manufacture of polyphosphates, orthophosphoric acid is polymerized. Polyphosphates are chains of orthophosphate units liked together. Much like making a chain, heat is used to "link" these orthophosphate units, and to give off water from the linking process. This is pictured in Figure 1.

When these chains of polyphosphates are broken to give the original orthophosphate units, the process is referred to as hydrolysis. Texas-gulf manufactures polyphosphoric, or superphosphoric acid as it is commonly known in the trade, in a two stage falling film vacuum evaporator. the texas-gulf super acid product called Super 49 is typically 69% P_2O_5 with 20-30% conversion of the phosphate to the non-ortho or poly form.

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

In a conventional liquid fertilizer plant, N-P base solutions such as 10-34-0 are produced by reacting aqua or anhydrous ammonia with superphosphoric acid using a large recycle stream of 10-34-0 liquid. the liquids produced by this method are limited in poly level to the maximum poly level present in the super acid used (typically 45-50%). the temperature of the 10-34-0 product has to be rigidly controlled below 90 degrees F. or hydrolysis of the polyphosphates to orthophosphates will occur.

the invention of the TVA pipe reactor [3] permits production of 10-34-0/11-37-0 (N-P) solutions with a polyphosphate level of 70 to 80% using an acid containing only 20-30%. Such solution when stored at temperatures of less than 90 degrees F. have increased storage life as compared to N-P solutions made from superacid with a poly level of 45 to 50%. A typical TVA pipe reactor plant is shown in Figure 2. In the pipe reactor, the heat of reaction of vaporous anhydrous ammonia and superphosphoric acid causes extensive polymerization and yields large quantities of tri, tetra, penta, and higher polyphosphate species. Since this process generates polyphosphates, an acid of low poly content is suitable as a feedstock. Some ammonium polyphosphate analyses from commercial production are shown in Figure 3.

A comparison of poly distribution is shown in Figure 4 for conventional, high-poly and furance ammonium polyphosphate solutions. It indicates that high-poly wet process 10-34-0 is comparable to furnace grade 11-37-0. As you can see, the conventional 10-34-0 has only 10% of its P_2O_5 above the pyro level.

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

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

A thorough description of the pipe reactor process used to produce the base solution has been given in papers by R. S Meline, et all [4]. F. P. Achorn, et al [5], and ____. O. Harwell and L. Hopwood [6]. For this reason I will not attempt today to re-describe this work. For those interested they may refer to these papers.

The second phase of fluid fertilizer manufacture from superphosphoric acid is the utilization of the ammonium polyphosphate base solution to make N-P-K grades. Most of the superphosphoric acid that Texas-gulf produces goes into clear liquid N-P-K mixes, and, therefore, much of our energy has gone into developing clear liquids. The cost of P_2O_5 in 54% acid is usually less than the cost of P_2O_5 in superphosphoric which encourages the blending of 54% orthophosphoric acid with the ammonium polyphosphate base solution in a hot or semi-hot process to yield the finished N-P-K solution.

Development work at Texas-gulf has explored the suitability of both conventional and high poly 10-34-0/11-37-0 to make semi-hot N-P-K grades. Grades of 7-21-7 and 5-10-10 in which 25 to 65% of the P_2O_5 came from the ammonium polyphosphate solution were manufactured with cooling, and stored at temperatures of 75-100 degrees F. These grades were chosen because they approach the concentration limits of clear liquid N-P-K systems. In preparing the 7-21-7 grades, pH's were adjusted to 6.7, while those for 5-10-10 were adjusted to 7.2. Previous studies indicated these pH's gave optimum stability of conventional 1-3-x and 1-2-x grades. Supplemental P_2O_5 was taken from Texas-gulf 54% phosphoric acid. Using 10-34-0 and water as a heel, 54% acid and aqua ammonia were added simultaneously to yield grade. Supplemental nitrogen for the 5-10-10 grades was derived from ammonium nitrate-urea solution. A total of six runs using different high poly 10-34-0 solutions were tested at ambient room temperature, 90 degrees, and 100 degrees F. Storage life was terminated when one (1) percent precipitation by volume accumulated, the sample jelled, or the sample became opaque.

the average storage life of the six samples of 7-21-7 made from high poly 10-34-0 is shown in Figure 5. From these data one can see that when as little as 40% of the P_2O_5 is from high-poly 10-34-0, three (3) months storage is obtained. Storage life is extended to four (4) months when 50% of the P_2O_5 is taken from 10-34-0. Approximately 25 and 35 percent poly P_2O_5 respectfully is contained in these two 7-21-7 formulations.

For comparison, the storage life of 7-21-7 prepared from conventional 10-34-0 is shown in Figure 6. These data show that when as much as 65 percent of the P_2O_5 is taken from conventional 10-34-0, only 2 months of storage is obtained. In this case there was 31 percent poly P_2O_5 in the formulation.

Please note that the storage life of the N-P-K fertilizer at the same poly level is much greater for the fertilizer made from the hi-poly base solution. that the poly levels in the conventional and high poly 7-21-7 grade are similar, indicated the importance of the poly species.

Similar data for 5-10-10 produced from high-poly 10-34-0 are shown in Figure 7. Again you can see that three (3) months storage are obtained when 40 percent of the P_2O_5 is from high-poly 10-34-0; storage stability tends to level out at four (4) months when about 50% of the P_2O_5 is from high-poly 10-34-0. As with 7-21-7, a 10 degrees F. temperature increase decreases storage life by approximately one-half.

Figure 8 shows storage data for 5-10-10 from conventional 10-34-0. When 65% of the P_2O_5 is taken from 10-34-0 to yield 31% poly P_2O_5 in the mix, only one-half of storage is obtained.

Comparison of these N-P-K data from conventional and high-poly 10-34-0 are dramatically illustrated in Figure 9. these N-P-K data illustrate the tremendous increase in storage life when high-poly N-P base solutions are used. the use of the high-poly base solution permits lower formulations costs through increased use of 54% phosphate acid. Raw material savings are calculated to be about $0.20 per ton for 5-10-10 and about $0.60 per ton for 7-21-7. An additional benefit of the high-poly base solution is the opportunity to increase the amount of micro nutrients for a given N-P-K grade.

Conclusions

In summary, a super acid with 20-30 percent of the P_2O_5 as polyphosphate is well suited as a feed stock for the TVA pipe reactor process. The low viscosity of the lower poly superphosphoric acid (600 cps. at 100 degrees F.) makes it easier to haandle than high poly super acid. The new TVA reactor process makes its own polyphosphates so the initial poly level of the feed acid is not critical.

Using the process, high poly 10-34-0 or 11-37-0 can be produced which is comparable to furnace 11-37-0. Because there is a greater abundance of the longer chain species, the ammonium polyphosphate storage life is extended, metallic or trace element sequestration is increased, and clear liquid N-P-K grades of vastly superior storage life can be manufactured. Increased storage life of both the N-P and N-P-K solutions allow off-season production. Formulation costs of N-P-K grades are reduced because larger quantities of P_2O_5 from 54% phosphoric acid can be utilized. Although not discussed in this paper, both base and finished N-P-K suspensions of high quality can be made using superphosphoric acid.

Acknowledgements

We at Texas-gulf are indebted to Mr. R. S. Meline and his associates at TVA for their contribution to the fertilizer industry of the pipe reactor process.

Also, special thanks are given to Messrs. Whitehurst and our associates of Technical Services, Aurora, N.C. and to Mr. A. O. Harwell, Technical Representative of Raleigh, N.C., for their cooperation and support.

Conclusions

1. High poly 10-34-0/11-37-0 can be produced by the TVA pipe reactor process from a low conversion superphosphoric acid.
2. Wet process ammonium polyphosphate solution produced by the TVA pipe reactor process is comparable to furnace 11-37-0 in poly species.
3. N-P-K clear liquid storage life is increased.
4. N-P-K formulation costs are reduced.
5. Long-term storage of both ammonium polyphosphate solution and clear liquid N-P-K grades allow off-season production.

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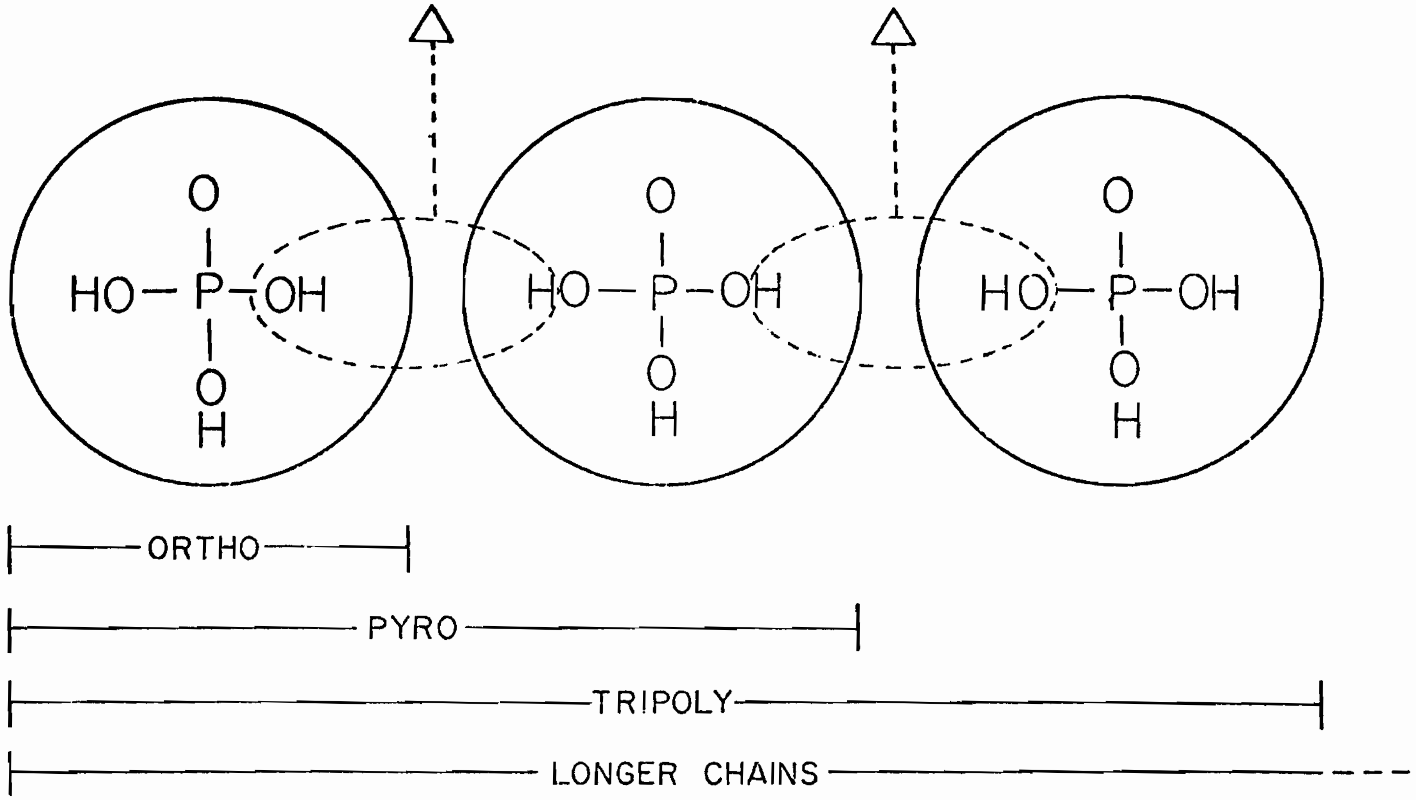
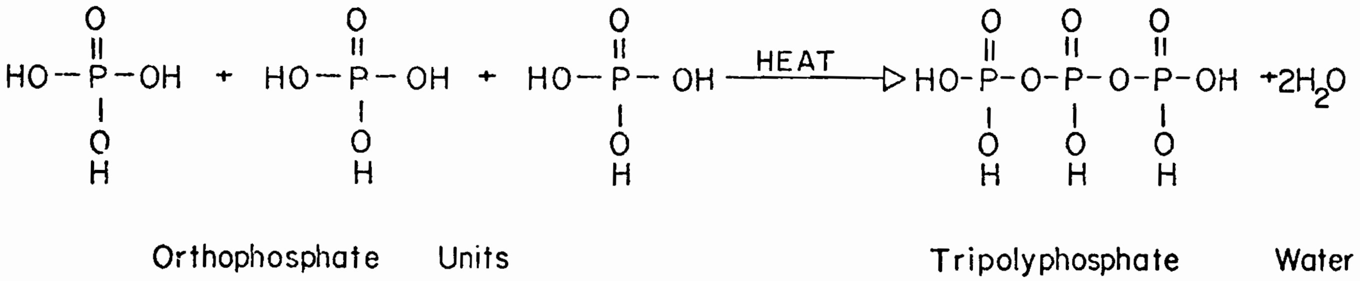
Figure I

POLYPHOSPHATES



Example of forming Tripolyphasphate



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

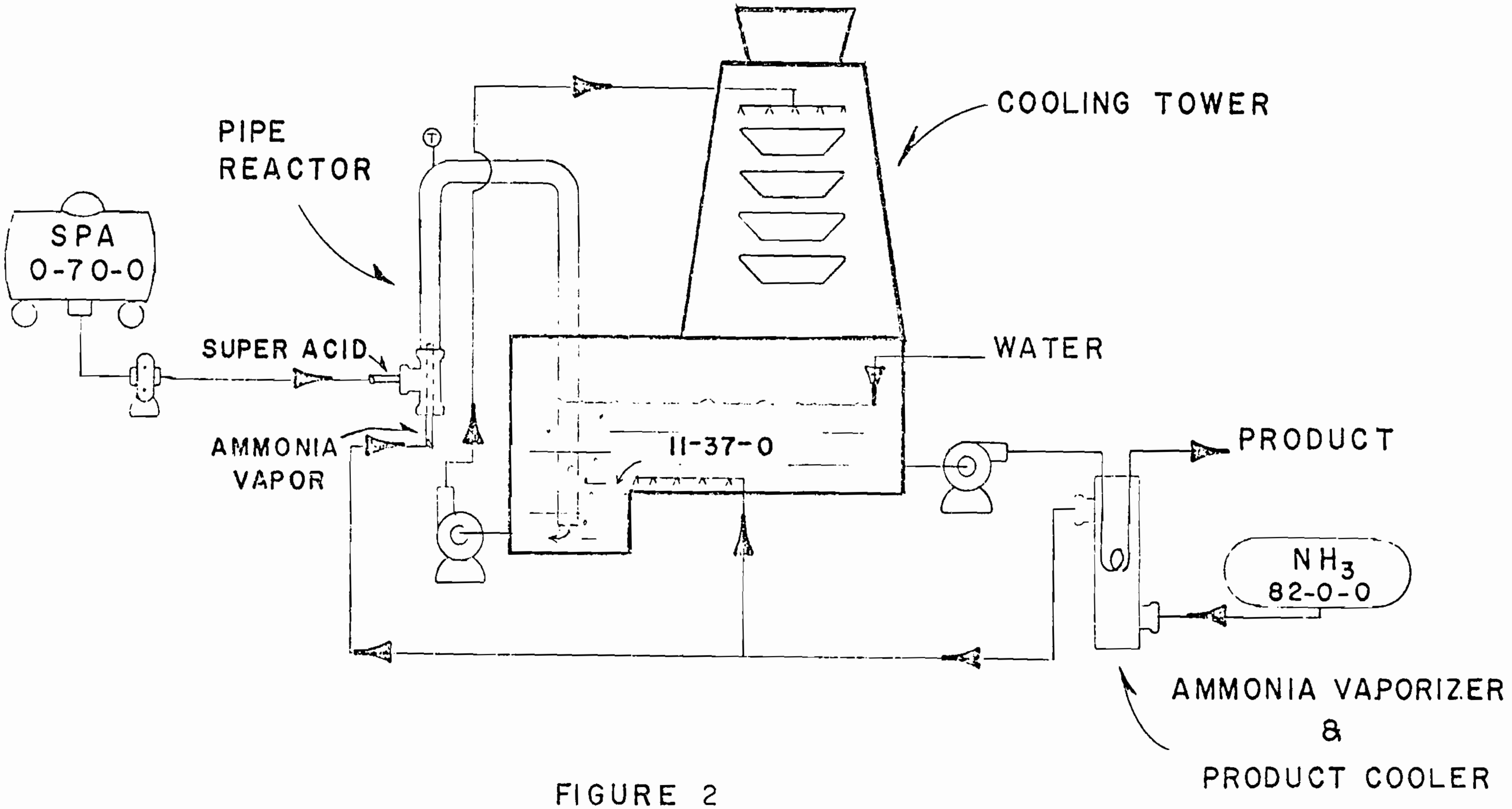


FIGURE 2
DIRECT AMMONIATION PLANT USING A RECYCLE PUMP FOR MIXING AMMONIUM POLYPHOSPHATE MELT

FIGURE 3

Commercial Production Of High-Poly 10-34-0 From Tg Super 49 SPA

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

FIGURE 4

Polymer Profile 10-34-0 / 11-37-0

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

[a] includes tetra

[b] includes penta

FIGURE 5

Average Storage Data For 7-21-7 From High-Poly 10-34-0 and 54% Acid 10-34-0 Contained 65% Polyphosphate

% P_2O_5 From 10-34-0	% Poly P_2O_5	Storage Life in Days vs. Temperature		
		Room Temp.	90 degrees	100 degrees
25	16	16	11	5
30	20	49	25	9
35	22	91	33	10
40	26	100	41	15
45	29	79	35	16
50	33	114	47	19
55	35	119	41	18
65	42	110	40	15

FIGURE 6

Storage Data For 7-21-7 From Conventional 10-34-0 (Polyphosphate 48%) And 54% Acid

% P_2O_5 From 10-34-0	% Poly P_2O_5	Storage Life in Days vs. Temperature		
		Room Temp.	90 degrees	100 degrees
25	12	5	5	5
35	17	7	6	5
45	21	8	7	6
55	26	12	13	8
65	31	56	20	19

FIGURE 7

Average Storage Data For 5-10-10 From High Poly 10-34-0 (Polyphosphate 65%) And 54% Acid

% P_2O_5 From 10-34-0	% Poly P_2O_5	Storage Life in Days vs. Temperatures		
		Room Temp.	90 degrees	100 degrees
25	16	2	1	1
30	20	46	14	2
35	23	68	34	10
40	26	98	48	18
45	29	116	57	24
50	33	117	49	20
55	36	117	48	21
65	42	105	52	24

FIGURE 8

Storage Data For 5-10-10 From Conventional 10-34-0 (Polyphosphate 48%) And 54% Phosphoric Acid

% P_2O_5 From 10-34-0	% Poly P_2O_5	Storage Life in Days vs. Temperatures		
		Room Temp.	90 degrees	100 degrees
25	12	1	1	1
35	17	1	1	1
45	21	3	4	3
55	26	8	8	5
65	31	14	9	5

FIGURE 9

Comparison of 5-10-10 and 7-21-7 Stability Data At Room Temperature

% Poly in Blend (Approx.)	7-21-7		5-10-10	
	Lo-Poly 10-34-0	Hi-Poly 10-34-0	Lo-Poly 10-34-0	Hi-Poly 10-34-0
16 to 19%	7 days	49 days	1 day	2 days
21 to 23	8 days	91 days	3 days	68 days
26	12	100	8 days	98 days
31-33	56 days	114 days	14 days	117 days

MODERATOR ACHORN: Thank you John Boyd. fluids are really growing and John has given us a real good rundown on how to use "Superphosphoric Acid" in fluids.

Some years ago, I believe last year, we presented some information on filters for Phosphoric Acid and we decided we would give a go at it again since there was so much interest in it. Mr. John Roos is the man who is going to present some information, from the Bird Corporation, concerning their type filter. John Roos has been with the Bird Company for 18 years. He is the product manager for the process and equipmment division.

Latest Features and Operating Experience In Phosphoric Acid Filtration

John Roos

In preparing this presentation, which is meant to cover the latest, or at least more recent, developments in phosphoric acid filtration, it is difficult to know exactly what might be construed as old or new for this audience. In this respect and in the interest of not repeating what many of you already know, it will be assumed that you have at least a general knowledge of what a Bird Prayon Filter looks like and how it operates. Many of you undoubtedly have had experience with a Bird Prayon Filter if you have been involved in the operation of a wet process phosphoric acid plant as there are very few of these plants today that do not use one of these filters for the gypsum filtration and washing operation. The design of the filter has, however, been re-evaluated continuously and modifications have been made from time to time to improve its operation. Therefore, it would depend upon the vintage of the Bird Prayon Filter that you are familiar with as to how much of what is presented here is new.

As most of you know, the last major expansion in the phosphate industry started in 1965 and came to a rather abrupt halt in 1968. During this expansion, a demand developed for larger filters. Prior to 1965, the largest size available had an active area of approximately 600 square feet. Before that period of expansion ended, filters having three times that active area were installed. In fact, during the recession in the fertilizer industry which followed the last major expansion, many of the plants with the earlier smaller filters were unable to compete with the later larger filter installations and consequently were taken out of service. Many of the smaller filter installations have recently been put back into service because of the current fertilizer shortage. It is possible however that the same situation could occur again when the new larger filter installations now being built come on-stream.

In developing the larger sizes of the Bird Prayon Filter, it was necessary to consider practically all of the components of the filter. In this respect one of the more important items was the design of the cell vessels. Adequate hydraulic capacity had to be maintained to prevent non-uniform dewatering over the relatively large cell surface areas. Moreover, the cells had to be strong enough without becoming too massive which would result in sacrificing too much of the total area for cell inversion to discharge the filter cake and wash the filter cloth.

One of the more important considerations in the design of the cell vessels was the means used to support the filter cloth and the provisions for draining the filtrate from the cells. In the early '60s it had become apparent that the relatively soft molded natural rubber filter cloth support grids which had been used rather successfully in European practice left much to be desired in North American operations. Unlike many European operations, few Americans are content to operate for very long at the initial design capacity of a plant. However, operating above the design capacity of a phosphoric acid plant invariable means higher operating temperatures and the utilization of foam inhibitors, both of which result in a marked decrease in the life of natural rubber. We then substituted both neoprene and butyl for natural rubber in this service and these helped somewhat. However, it was indicated that even the surface of these materials would deteriorate eventually which not only promotes scale but slso reduces the hydraulic capacity of the drainage chemicals beneath the filter cloth even if scale is not present. It should be appreciated that with these relatively small channels even minor increases in surface roughness will cause an appreciable increase in fluid friction which in turn results in non-uniform dewatering of the filter cake.

As an additional consideration it might be noted that when natural rubber and some of the other more commonly used elastomers are exposed to halogen ions such as F and Cl they rely on the formation of a relatively brittle protective surface formed by a chemical reaction with the halogens. Flexing of these elastomers by the intermittent application of vacuum, cracks this relatively brittle protective surface and accelerates deterioration. Furthermore, this protective surface is usually water soluble and the intermittent application of relatively neutral wash water further accelerates erosion. For this reason some elastomers which give good serv ice used for static application such as tank linings prove to be highly unsatisfactory when exposed to a flexing condition.

From the foregoing it should be recongnized that the use of elastomers for major integral parts of the filter such as the filter cloth supports is important to evaluate. As in the past, satisfactory service can be expected from elastomers in most conventional dihydrate processes today providing the expense of periodic replacement of these parts is not excessive. An evaluation today for a new plant, however, should include future possibilities. With the depletion of the supply of relatively good grades of phosphate rock, many are now considering the use of phosphate rocks having a higher chloride content and/or a greater silica deficiency. The use of such rocks can be expected to have an adverse affect on rubber parts in contact with process material. Many operators are showing now an increased interest in high strength phosphoric acid processes and the direct production of mixed fertilizers by acidulation with acids other than sulfuric. Most of the high strength phosphoric processes operate at temperatures in excess of that normally recommended for natural rubber and even butyl rubber can be a borderline application. Some mixed fertilizer processes such as NPK can contain traces of free nitric acid which rules out the use of any elastomers except for some of the exotic and much more expensive ones such as hypalon.

Bird started to experiment with various forms of metal support grids for the filter cloth in the early 60s. Note slide No. 5. The first metal grids put into service were relatively light gauge corrugated sheets of 316-L stainless steel which provided a configuration similar to that of the butyl support grids which were in use at that time. Several of the filters sold in the early 60s were equipped with this type of metal support grid. A heavier gauge 316-L stainless steel roll form was then developed which was furnished with many of the filters sold in the mid 60s. This overcame some of the difficulities which developed with the lighter gauge corrugated grids and also provided more hydraulic filtrate drainage capacity. It also added more strength and rigidity to the larger filter cells then being manufactured. During this period of time it was observed that we would occasionally get what could be termed as substandard graded of 316-L stainless steel for the support grades which resulted in surface deterioration. This in turn would promote scaling. To eliminate this possibility in the latter part of the last expansion we changed from 316-L to 317-L for the support grids and from reports to date this appears to have solved the problem. It should be noted that 317-L stainless steel is being used for the filter cloth support grids even though in many instances 316-L has been proven to be satisfactory for the balance of the parts of the filter that are in direct contact with process material. In fact, by up-grading the grid material to inhibit surface erosion, the life expectancy is increased substantially and the operator is not faced with periodic costly replacements.

In some of the earlier filters which had either rubber or light gauge 316-L support grids the operators have replaced them with polypropylene grids of several different designs. According to reports we have received, these have given relatively good service compared to either rubber or butyl support grids. Polypropylene has, however, exhibited similar problems with surface deterioration over a period of time, particularly those made by machining the drainage grooves out of a solid block. Machining normally provides a rougher surface than would be obtained with molding or extruding and this accelerates surface deterioration. We have been and are continuing to evaluate polypropylene support grids. However, from what we have learned to date, they are inferior to 317-L for phosphoric acid service and they contribute essentially nothing to the strength and rigidity of the cell vessel.

In developing the design of larger filters it was necessary to consider two of the more important factors which influence the instantanious capacity, namely, filter speed and the applied vacuum level. From the standpoint of dewatering rates only, it can be demonstrated that capacity can be expected to vary approximately in direct proportion to the square root of the speeds, and in direct proportion to the applied vacuum levels. As examples of this, a filter operating at 2 minutes per revolution might be expected to have approximately 40% more dewatering capacity than when operating at 4 minutes per revolution at a given vacuum level. Likewise, assuming constant speed, a filter operating at a vacuum level of 20" Hg might be expected to have 33% more dewatering capacity than when operating at 15" Hg.

High dewatering rates resulting from high speed operation can cause the washing efficiency to deteriorate. The higher speed, the thinner the filter cake and, assuming a fixed ratio of filter cake to wash water, the thinner the filtrate cake, the less thorougly it will be washed. Surface irregularities with thinner cakes result in more non-uniform dewatering. It should also be appreciated that contact time during washing has an influence on washing efficiency, as most filtration washing operating depend to some degree upon leaching which is a function of the contact time. For example, a 2" layer of water penetrating a 2" thick filter cake in 2 minutes would result in the same capacity as a 1" layer of water penetrating a 1" thick filter cake ina 1 minute. However, the contact time for leaching would be twice as long for the 2" thick filter cake. Because of this and although we have designed the larger filters to operate at reasonably high speeds to cope with adverse filtration conditions, we have also provided the capability to operate at relatively high vacuum levels which permits operation at slower speeds and thicker cakes in order to achieve the required capacity without sacrificing washing efficiency.

As noted above there are advantages in operating at a relatively high vacuum level rather than increasing speed to obtain adequate dewatering rates. The filtrate temperatures in most conventional dihydrate processes will permit the application of a least 20" Hg vacuum without "flashing". In fact, thicker filter cakes resulting from slower speeds permit less air passage through the filter cake between wash applications and according to the performance curves for most vacuum pumps used in this service, a higher vacuum level will occur automatically with decreased air flow.

Operating at higher vacuum levels, however, amplifies one problem that has been common to all types of vacuum filtration equipment that have been used in phosphoric acid service, namely, surface wear of the distributor valve or the suction box used to collect the various filtrates. The filtrates will always contain some solids regardless of the filter cloth porosity and these solids can be very abrasive. furthermore, it is difficult to keep the wearing surfaces lubricated due to the temperature and corrosive properties of the filtrates. In fact, lubrication undoubtedly acts to some degree as a cutting oil for the abrasive solids.

Even when operating at a nominal vacuum level the force required to overcome the friction between the wearing surfaces is appreciable. For example, with the Bird Prayon filter which, because of its compact circular valve design, probably requires less force than linear designs, approximately one-half of the force required to turn the filter is consumed by the distributor valve.

Numerous attempts have been made by various filtration equipment manufacturers to solve this problem. In some instances, the wearing surfaces have been maintained with a fixed positive clearance but this arrangement bleeds air into the system which promotes rapid scaling. Others including ourselves have experimented with various materials such as polypropylene and even teflon which have a low coefficient of friction in an effort to reduce the force necessary to overcome valve friction. Unfortunately the materials suitable for phosphoric acid service and having low coefficients of friction also have poor resistance to abrasion. In several instances that we know of with other types of filtration equipment, the operators have installed vacuum level controls to prevent the application of greater than 15" Hg vacuum in order to prevent excessive maintenance.

For the smaller filters we have been providing replaceable wear plates for both valve surfaces to minimize down-time for maintenance. We have also provided sufficient drive capacity to accomodate the friction loads encountered with relatively high vacuum levels. However, as the filters became larger, the distributor valves also had to be larger to provide adequate hydraulic capacity. This increase in size resulted in a disproportionate increase in the load created by the vacuum on the wearing surfaces of the distributor valve.

In order the decrease this load, we redesigned the distributor valve for the larger filters. A hydraulic vacuum load relief system is now incorporated in the new design. this system is activated by the operating vacuum level and provides a force to oppose the load imposed on the wearing surfaces by the application of vacuum. From reports that we have had to date, this has resulted in a marked decrease in valve surface wear even when relatively open filter c loths have been used which permit more solids to get into the filtrates. This same system is also used with a manual control to open the distributor valve when the filter is not operating in order to inspect it or to change a bridge location.

Another disadvantage of relatively high filter speed is that it invariably results in greater dilution of the initial filtrate with the water used to wash the filter cloths. The amount of dilution will be just about proportional to the speed of the filter as a relatively fixed quantity of the water used to wash the filter cloth will be retained by capillery attraction to the filter cloth and other parts of the cell vessel irrespective of the drainage time during cell inversion. this can be illustrated by immersing a piece of filter cloth in water and observing how little moisture will drain from the cloth after the first few seconds of removing the filter cloth from the water.

In conventional phosphoric acid processes it is necessary to return an appreciable amount of the initial filtrate to the digestion section to maintain fluidity. The balance of the initial filtrate is considered product acid. Because of the potential problem of product acid dilution with cloth wash water, it has been recognized that it is advantageous to split the initial filtrate into two fractions at the filter valve, rather than later in the filtrate seal tank as has been the practice in the past. the first fraction is designated for return to digestion and acts as a purge for residual cloth wash water. In addition this first fraction receives a major portion of the solids which report thru the filter cloth with the initial surge of filtrate. This, incidentally, is why the first surge of the initial filtrate is termed the cloudy filtrate and in general filtration practice a cloudy filtrate "cut" is frequently used to achieve acceptable filtrate clarity with relatively open filter cloth.

To date, various devices have been tried for proportioning the flow of the initial filtrate with the Bird Prayon Filter. These have included using a "short" bridge in the distributor valve and a throttle valve in the cloudy filtrate line for flow control. A separate vacuum supply line in the side of the distributor valve has also been provided in an attempt to control the flow by varying the applied vacuum. None of these arrangements have worked very well and have required a fair amount of maintenance to make them work at all. In the case of throttling the cloudy filtrate line, the solids contained in the initial filtrate made it difficult to keep the valve operative. In the case of providing a separate vacuum supply line to the side of the distributor valve, filtrate carry-over into the cacuum line resulted in relatively rapid line blockage. In essence, in the past we had not recognized the potential difficulties involved in proportioning and handling the cloudy filtrate in phosphoric acid filtration. Our experience in this respect just proves again that what may look good on the drawing board and even work well in other applications is not necessarily a good indication that it will perform satisfactorily in a phosphoric acid plant. With the filters now being supplied, we are recommending a separate filtrate receiver for the cloudy filtrate system similar in design and piping to that provided for the other filtrate receivers in the past which has been relatively trouble free. This arrangement will cost more initially but it should pay for itself in reduced maintenance for the cloudy filtrate system.

During the latter part of the last expansion a change was made in the cell turnover design. Prior to this change the cells were tilted in the direction of the rotation of the filter to discharge filter cake and wash the cloth. this is what we term a "forward dump" for cake discharge and this arrangment resulted in the maximum amount of effective filtration area foar the filter. However, it became evident that there were several disadvantages with the "forward dump" arrangment. A cell could only remain inverted for cloth washing for a limited time before it had to be turned out of the way of the filter cake being discharged from the following cell. this resulted in a gap between cells when passing over the cloth wash sprays and made it very difficult to contain the sprays. This problem was compounded in many instances where reclaimed pond water was used for cloth wash and often resulted in extensive corrosion of structural steel parts of the filter. Various means were employed in an attempt to eliminate this problem including a specially designed valve to provide intermittent flow to the cloth wash sprays. This improved the spray control, but it required a fair amount of maintenance to keep the valve operative when using reclaimed pond water for cloth wash. Another problem encountered with the "forward dump" arrangment developed when the filters were operated at rates appreciably higher than design capacity. With this arrangment the overlap extensions of the cell to cover the gap between the cells when upright, must be on the lagging side of the cell and this made it necessary to apply feed slurry in a direction opposite to the direction of rotation of the filter in order to avoid spillage between cells. However, at relatively high rates of feed some of the feed slurry had sufficient velocity to splash over the trailing wall of the cell and report in the cake discharge chute. in some instances, this problem was solved by installing a second slurry feed box, but this usually results in the application of vacuum before the cell has been fed, which causes filtration rates to deteriorate.

Because of the problems associated with the "forward dump"arrangement we revised the design to tilt the cells backwards to discharge the filter cake, and this is what we term a "reverse dump". this arrangment resulted in somewhat less active filtration area but provided solutions for the problems associated with the "forward dump". With this arrangment the cells can be held in an inverted position after cake discharge for more thorough cloth washing, and the cells can be made to overlap in the inverted position in order to contain a continuous flow from the cloth wash sprays. In addition, with the "reverse dump" the overlap extensions of the cells to cover the gap between them when upright is on the leading rather than on the lagging edge of the cells and the slurry feed can be applied in the direction of rotation of the filter. With relatively high slurry feed rates, the slurry splash is directed toward the cell that has already been feed rather than into the cake discharge zone. Refer to Slide 6.

In designing larger filter cells, consideration was given to the potential liquid holdup in the cells during the final cake drying portion of the filtration cycle. during the dewatering of the initial filtrate and the various washes under flooded conditions, the driving force from the vacuum provides a quick and positive purge for each filtrate by the subsequent filtrate. However, in the final cake drying section the air flow through the filter cake does not provide a good purge for the final residual filtrate in either the drainage grooves of the cloth support grids or the central outlet box which collects the filtrate from these drainage grooves. In this respect, it should be appreciated that if this filtrate is not receovered, it reports with the filter cake in the discharge chute and represents a loss in soluable P_2O_5 values. In order to recover this filtrate, each cell is pretilted just prior to inversion for cake discharge in the direction opposite to which it later tilts for cake discharge. This drains the grooves from 1/2 of the cell into the centrally located outlet box. The other half of the grooves are drained into the outlet box just after this when the cell is tilted in the other direction to discharge filter cake. An inverted trough is suitably positioned in the centrally located outlet box to trap and retain this residual filtrate during cake discharge and cloth washing. This filtrate is released from the trough and reports to the distributor valve as each cell is returnedto an upright position. A separate port in the distributor valve is provided to return this residual weak wash filtrate to its respective barometric seal tank. Refer to Slide 7.

Filtration capacity and washing efficiency will be dependent to a large degree upon circumstances prior to the filtration operation such as the source of phosphate rock and the process used. However, for a given set of conditions upstream from the filter and a given filter speed and operating vacuum level there are several items which can influence the filtration capacity which sometimes are overlooked. the ability to dewater and wash any type of slurry is dependent to a large extent upon the percentage of the finer particles present regardless of the size distribution of the balance of the coarser fractions. For example, a filter feed tank having excessive detention and/or agitation can cause particle degradation, and this in turn can cause an appreciable reduction in the filtration rate. It is also important to consider the importance of the fine particles on the filtration rate when initially handling the slurry on the filter. Our experience has indicated that it is advantageous to relinquish some of what might otherwise be used as active filtration area to allow the turbulence in the feed slurry to disipate and permit coarser particles in the slurry to precoat the filter cloth prior to the application of vacuum. Feeding the filter while applying even a very low vacuum on the filter cloth draws the finer particles to the surface of the filter cloth which retards the dewatering rates throughout the entire filtration cycle. In this respect it is important to provide adequate containment for the slurry to permit this and the use of only one point of slurry feed is also an important consideration. Although we do not include this section for presettlement of the feed slurry prior to the application of vacuum in our calculations for active filtration area, its effect on the overall filtration rate invariably results in greater filtration capacity than would be obtained by applying vacuum earlier in this section.

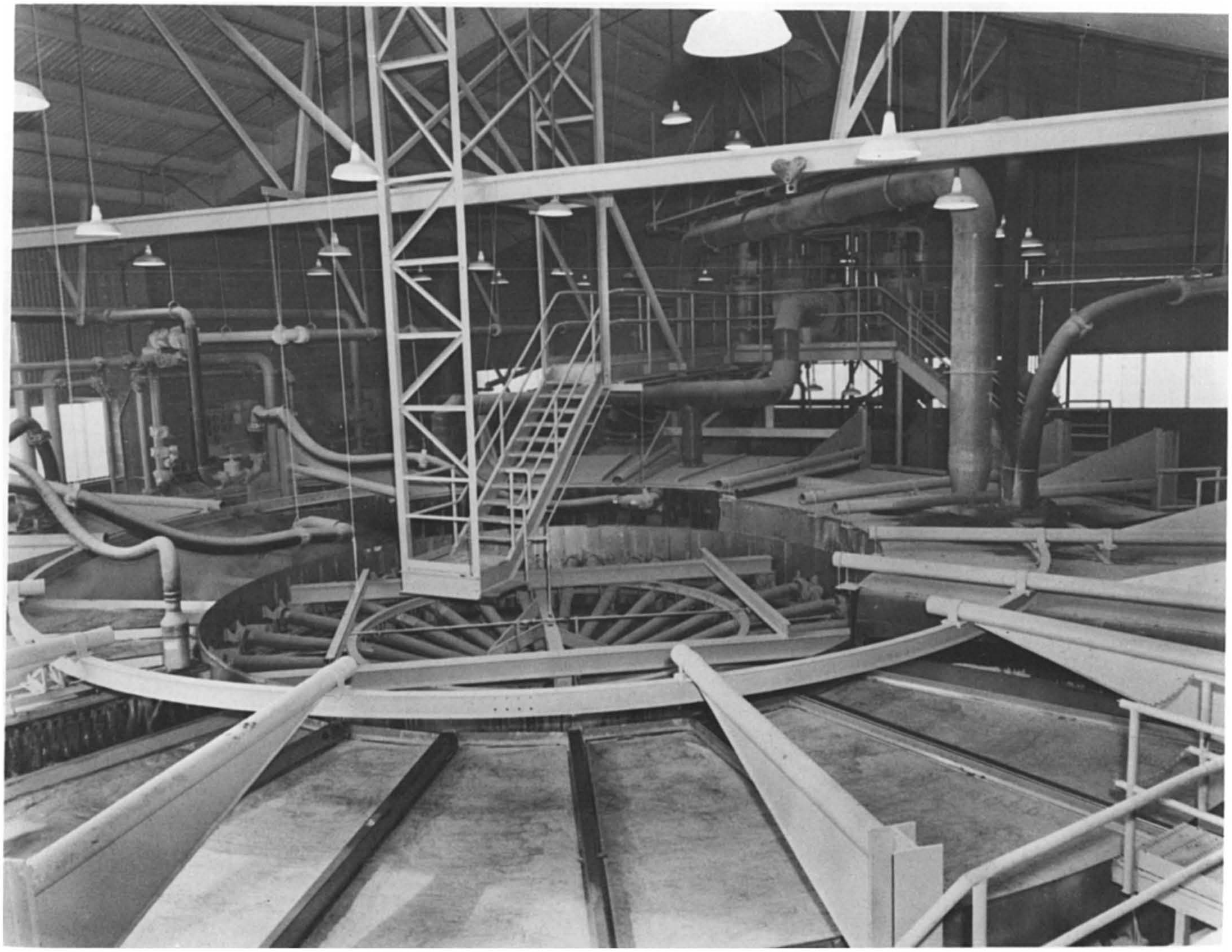
Presettlement of the slurry as just described has another advantage. Precoating the filter cloth coarser particles permits the use of relatively open filter cloth which in turn also helps to improve the overall filtration rate. by using a relatively open filter cloth and taking a cloudy port cut of the initial filtrate as previously described, the finer particles surrounding the presettled coarse particles pass through the filter cloth with the initial surge of filtrate leaving a bed of relatively coarse particles to act as a precoat throughout the entire filtration cycle. At the end of the filtration cycle the filter cake discharges more completely even with relatively sticky cakes and the residual coarser particles adhering to the filter cloth are for the most part rinsed off rather than driven through the filter media during cloth washing. furthermore, by distending the filter cloth during washing with a reverse air blow the pores in the filter cloth are opened up to disengage particles which may have become lodged in the pores.

From the foregoing it should be appreciated that, contrary to what many have been led to believe, speed and even the filtration area subjected to vacuum are not the only factors in determiningfiltration performance. Theoretical filtration equations employing these are frequently used in an attempt to predict filtration performance. However, in order to account for variations that can be expected in actual operation, these equations invariably contain unknown coefficients and/or exponents which can only be quantified by actual operation. Furthermore, although these equations are useful in predicting a trend in filtration dewatering rates, without previous knowledge of a particular slurry, none are able to predict what is necessary to achieve adequate washing efficiency, particularly when countercurrent washing is employed. As a practical matter, it is necessary to first realize and then evaluate all factors contributing to not only instantaneous capacity and washing efficiency but also to both the frequency and expense of maintenance. When these have been evaluated properly with respect to each other, optimum filter performance should be achieved.

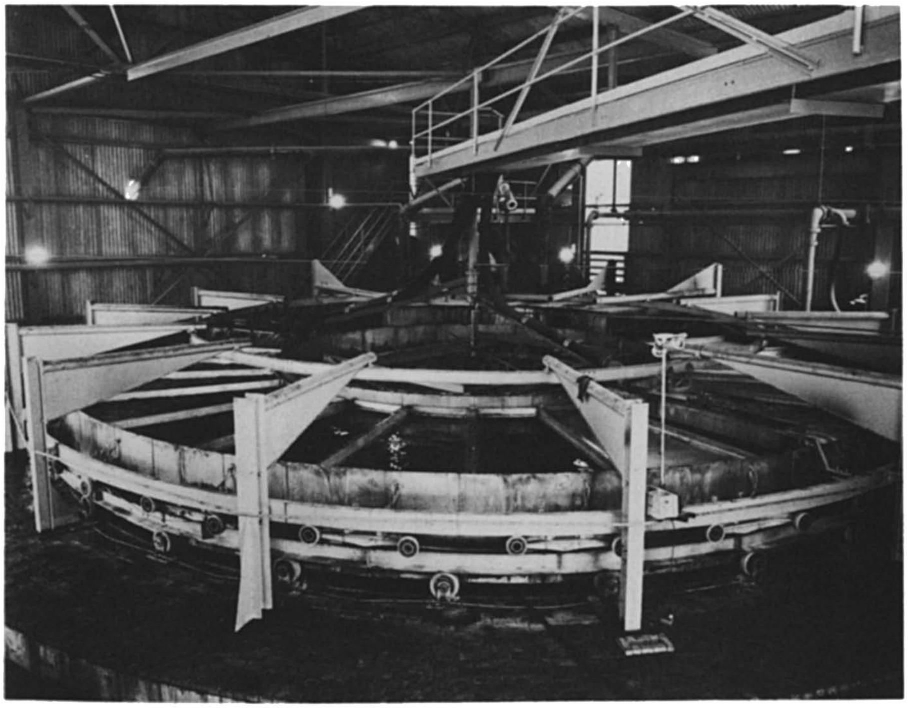
Some of the problems that we have encountered with materials of construction have been indicated already and generally speaking, most of our corrosion problems have stemmed from the use of reclaimed pond water for cloth wash and the difficulties in controlling it. It is believed that our new "reverse dump" design will provide much better control of the cloth wash water. However, it should be appreciated that any spray will produce atomized particles of liquid that can migrate through even rather elaborate splash guard arrangments. because of this we are now offering stainless steel as an alternate in the fabrication of various parts of the filter where mild steel might be construed as acceptable. In this respect it may be of interest to note that even in many instances in the past where either the engineer or his client specified some rather elaborate and expensive coating systems for the structural steel framework, it has been proven that few of these have worked very well and corrosion has been particularly severe with parts that have not been readily accessible for touch-up. In retrospect, we probably should havve learned from the experience of the Giorgini traveling pan filters which were manufactured in the United States some time ago. The original European version of the Giorgini filter utilized stainless steel rather extensively for the framework which might have been considered out of the reach of corrosive moisture and fumes. In an effort to reduce costs, steel was substituted for stainless steel in the U.S. design and appreciable costs were incurred later by the operators in maintaining or replacing steel with stainless steel after the equipment had been installed. However, in a competitive market situation there will always be an incentive to cut costs. In relation to this it should be considered that equipment manufacturers will specify and guarantee the materials of construction which will be used for each component of the equipment that they furnish. Nevertheless, equipment manufacturers are seldom in the position to provide a guarantee for corrosion resistance. Therefore, it is necessary for either the engineer or his client to know enough about ambient corrosion conditions and specify appropriate materials of fabrication accordingly.

Alternate designs as well as alternate materials of construction have been developed that can be incorporated in the Bird Prayon Filter to meet specific process requirements. In cases where relatively unstable hemihydrate solids must be filtered, suitable mans may be included in the design to insure that the hemihydrate solids do not have an opportunity to rehydrate and adhere to parts of the filter that they come in contact with. A distributor valve design has been developed which acts effectively as a preseparator for the filtrate and the air which passes through the filter cake. This design may be used to eliminate the need for a multiple filtrate separator arrangment for counter-current washing which is normally located just below the distributor valve.

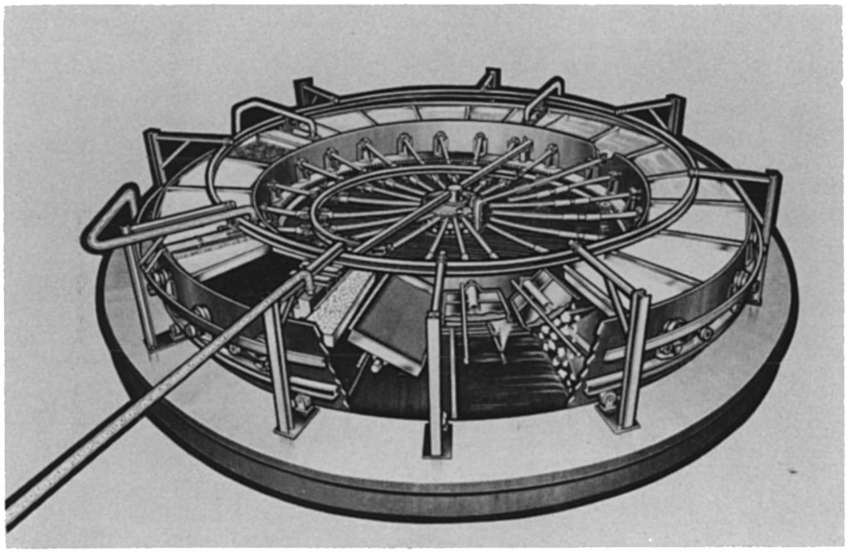
We are continuing to review the design of the Bird Prayon Filter in light of today's operating experience. Further modifications or changes may be expected if current operating experience indicates that it is necessary. In this respect it is interesting to note that the basic design features that were originally incorporated in the design of the Bird Prayon Filter have required few if any modifications to meet the requirements of phosphoric acid filtration.



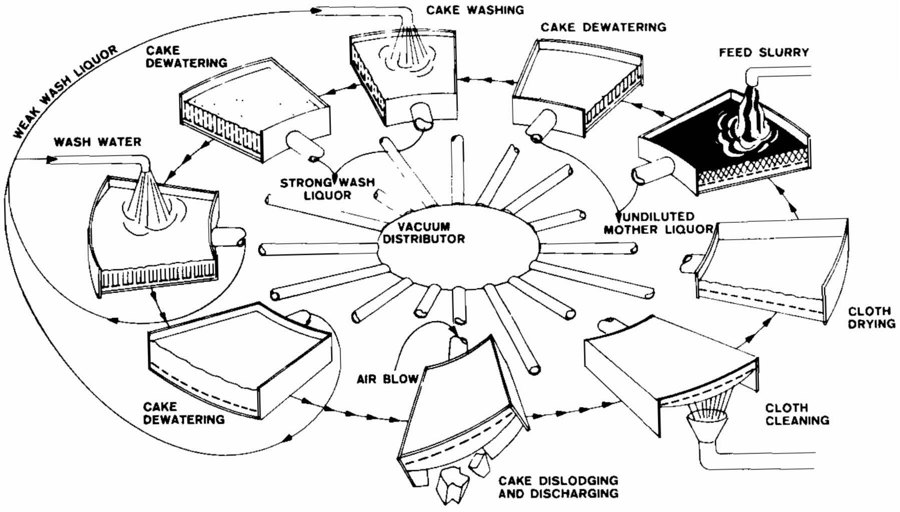
[Slide #1] Model 24-C Bird-Prayon Filter Installation at Coastal Chemical Plant in Pascagoula, Mississippi. An overhead view of the inside of the filter during operation is shown. This installation was engineered by Singmaster and Breyer, New York, N.Y.



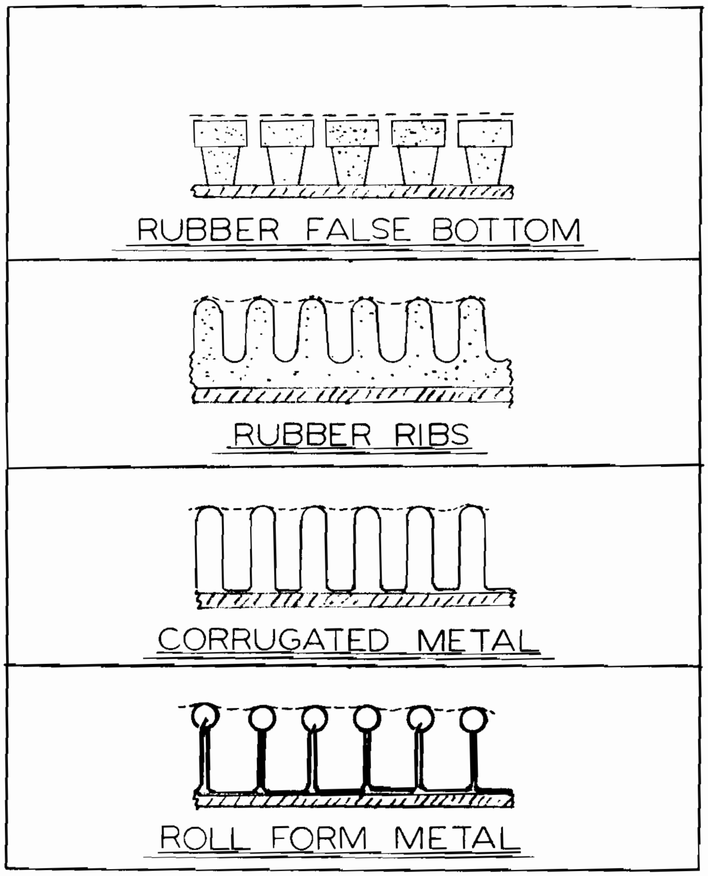
[Slide #2] Model 24-C Bird-Prayon Filter Installation at W. R. Grace and Co.'s plant in Bartow, Florida. An overhead view of the outside of the filter during operation is shown. This installation was engineered by Wellman-Lord Engineering, Inc., Lakeland, Florida.



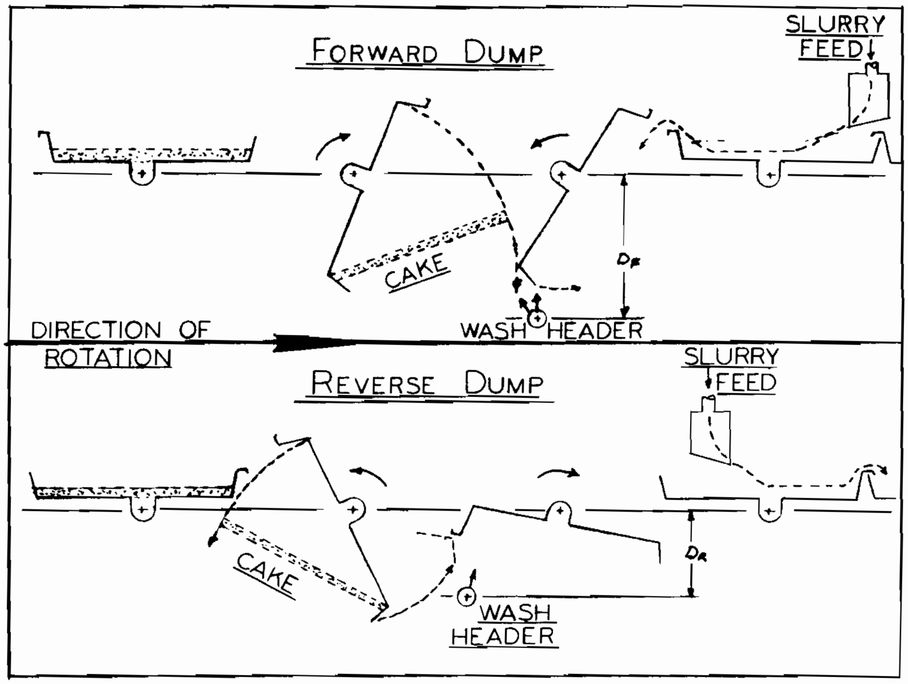
[Slide #3] Cut Away Illustration



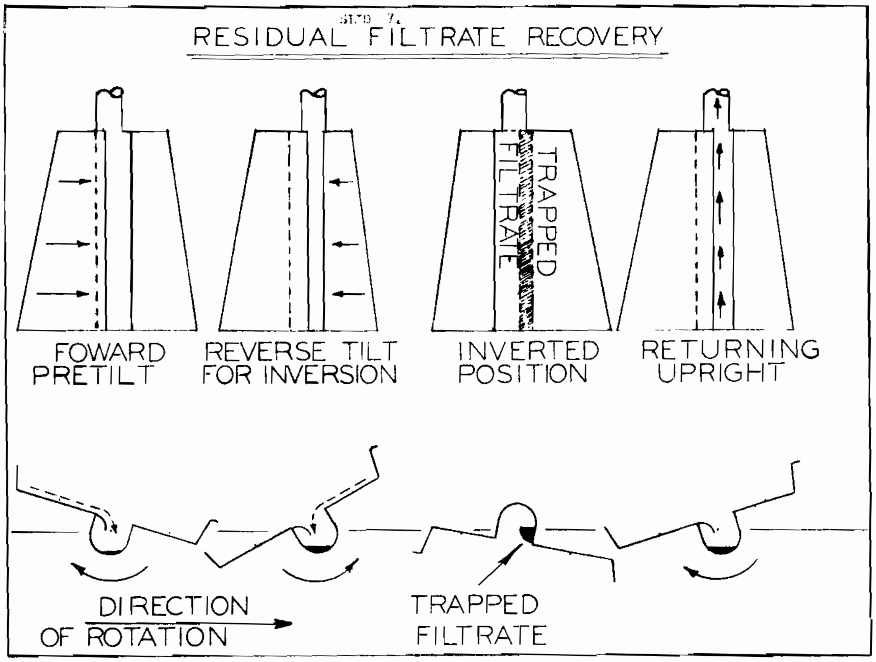
[Slide #4] Schematic Diagram



[Slide #5] Supply Grids



[Slide #6] Forward and Reverse Dump



[Slide #7] Filtrate Recovery

MODERATOR ACHORN: Thank you very much for your most interesting and detailed discussion bringing us up to date on "Phosphoric Acid Filtration".

Our next paper, which I am elected to present, was prepared by my associate at T.V.A., Hubert L. Baley and myself.

We insured that we had some audience because the results presented in this paper are from various ammoniation-granulation plants throughout the country. We obtained formulations and conducted tests in these various plants and we assured all the people that the results would be shown at this meeting. So, we are going to have at least ten guys here, because there were at least ten tests. One thing that was very apparent to us, the past few years, is the increased use of Phosphoric Acid in amoniation-granulation plants. We got some statistics from our economist and we found out that 5.3 million tons of P_2O_5 were produced last year as phosphoric acid.

Phosphoric Acid In Production of Granular Mixed Fertilizers

Frank P. Achorn
and
Hubert L. Balay

The total U.S. production of phosphoric acid in 1972 was 5.3 million tons of P_2O_5 [1]. About one-fourth of this was consumed in the production of either granular N-P-K mixtures or fluid fertilizers. This paper describes the use of phosphoric acid in conventional ammoniation-granulation plants for the production of granular N-P-K mixtures. This year many companies are receiving shipments of phosphoric acid produced from low-grade phosphate rock and containing high levels of solids for use in their ammoniation-granulation plants. Figure 1 is a sketch of a typical ammoniation-granulation plant in which phosphoric acid, anhydrous ammonia, normal or triple superphosphate, potash, and sometimes ammonium sulfate or urea are combined to produce granular N-P-K mixtures.

Orthophosphoric Acid in Conventional Granulation Plant

Most companies formerly used sulfuric acid and ammonia to generate heat and provide liquid phase for the granulation of mixtures. With sulfuric acid, ammonium chloride fumes and fine dust evolved [2]. It was found that when phosphoric acid (either orthophosphoric or superphosphoric acid) is substituted for sulfuric acid, there is a noticeable or complete elimination of ammonium chloride fumes from the ammoniator-granulator and dryer of a plant.

Most conventional ammoniation-granulation plants use between 200 and 400 pounds of phosphoric acid per ton of product to produce various N-P-K mixtures. These plants are the conventional ammoniator-granulator type except for addition of a phosphoric acid handling system such as the one shown in figure 2. A cone-bottom, rubber-lined, mild steel tank is often employed for storage of phosphoric acid. A compressor forces air into the bottom of the tank periodically to agitate the settled sludge; it also supplies air for unloading railway cars. Acid is moved by a positive displacement pump from the storage tank to the granulation unit. Some companies have found that they can use a centrifugal pump for this purpose provided the acid does not become viscous in cold weather. The lines from the phosphoric acid transfer pump to the ammoniation-granulation plant are usually made of polyvinyl chloride.

The usual location of the phosphoric acid sparger in the granulator is shown also in figure 2. This sparger is made of stainless steel pipe (316 series) with 1/8-inch holes on 1-inch centers in the bottom. The streams of acid are directed so that they impinge on the top one-third of the granular bed.

Various formulations are shown in table 1. For the 6-24-24 grade, 300 pounds of phosphoric acid are used typically per ton of product. The degree of ammoniation of the acid is 7.2 pounds of ammonia per unit of P_2O_5. The company that uses this formulation indicates little or no loss of ammonia from the ammoniator-granulator with this degree of ammoniation. Standard degrees of ammoniation are used for the superphosphates in the formulation (5.8 pounds of ammonia per unit of P_2O_5 for normal superphosphate and 3.8 pounds of ammonia per unit of P_2O_5 for triple superphosphate). One company in the Southeast used the formula shown in table 1 for the production of a 10-10-10 grade and reported little or no emission of fumes from its ammoniation-granulation plant, which is equipped with conventional packed-bed scrubbers. It was also reported that when sulfuric instead of phosphoric acid was used for the production of this grade, an excessive amount of white ammonium chloride fume emitted from the plant and local control officials insisted that it be closed because of the resulting atmospheric pollution. When phosphoric acid was substituted for sulfuric, the plant was permitted to operate.

Some companies have found it advisable to operate at degrees of ammoniation lower than 7.2 pounds of ammonia per unit of P_2O_5 from phosphoric acid. they report that when the degree of ammoniation is lowered to about 5.5, a larger quantity of phosphate acid can be added. There seems to be less liquid phase in the granulator as the degree of ammoniation is decreased. Figure 3 shows the solubility of ammonium phosphate in water at various degrees of ammoniation [3]. About 30 pounds of ammonium phosphate salts will dissolve in 100 pounds of water at a degree of ammoniation of 5.5 pounds of ammonia per unit of P_2O_5; this solubility is about three times as great (88 pounds per 100 pounds of water) at a degree of ammoniation of 7.2 pounds per unit of P_2O_5.

This explains why larger quantities of phosphoric acid can be used in the formulation when the degree of ammoniation is 5.5 rather than 7.2 pounds of ammonia per unit of P_2O_5. This is important because phosphoric acid has been more plentiful than run-of-pile triple superphosphate,and most plant operators are looking for ways to replace triple superphosphate. Also, much of the phosphoric acid to be produced next year will be made from low grade rock (62-68 bpl) and probably will contain large quantities of sludge. Plant tests have shown that this acid works well in ammoniation-granulation plants although it may cause some problems in the production of liquid fertilizers and triple superphosphate.

It is also important to note in figure 3 that as the degree of ammoniation is increased above 7.4 pounds of ammonia per unit of P_2O_5, the solubility again decreases. At a degree of ammoniation of 9.6 pounds of ammonia per unit of P_2O_5 (diammonium phosphate) the solubility is 35 pounds per 100 pounds of water. This is about the same as the solubility at a degree of ammoniation of 5.5 pounds of ammonia per unit of P_2O_5. Most companies that produce that produce large quantities of ammonium phosphate take advantage of this lower solubility and higher degree of ammoniation during their production of diammonium phosphate, 18-46-0. However, large quantities (10 to 20 percent) of ammonia are lost from the ammoniator-granulator at the higher degree of ammoniation. Equipment should be installed to scrub exit gases from the ammoniator-granulator with the feed acid, and a preneutralizer is used to further ammoniate the acid before it is fed to the ammoniator-granulator. Large producers of diammonium phosphate usually use this procedure [TVA process for production of granular diammonium phosphate (5(].

Orthophosphoric Acid In Conventional Granulation Plant with Preneutralizer

Companies that prefer to add larger quantities of phosphoric acid than can be added in the conventional plant usually install small preneutralizers but no scrubbers. After preneutralizer installation, as much as 900 pounds of phosphoric acid per ton of product has been used in the formulation. A typical preneutralizer for a small granulation plant (20 tons per hour) is shown in figure 4. this equipment is made of stainless steel (316 series) and is 6 feet in diameter and 12 feet high. It is equipped with a turbine-type agitator driven by a 20-hp motor. The turbine is 26 inches in diameter and has five blades 7 inches long and 5 inches wide. Liquid anhydrous ammonia is added through the 1-1/2 inch stainless steel open-end pipes which have a water wash-out connection and a connection through which the sparger can be rodded. The spargers discharge ammonia to the side and about 6 inches from the ends of the turbine blades.

The slurry recycle line and slurry sparger in the granulator are shown in Figure 5. Slurry is recirculated from the bottom to the top of the preneutralizer by a 300-gallon-per-minute stainless steel centrifugal pump. Recirculation of slurry is continued during periods of plant shut-down to avoid solidification of slurry in the supply lines. The recirculation line is a 3-inch stainless steel pipe into which a 2-inch line is welded. The 2-inch line delivers the slurry to the ammoniator-granulator slurry sparger, and the slurry rate is measured by a magnetic flowmeter. The slurry sparger is a stainless steel pipe 1-1/2 inches in diameter and 5 feet 2 inches long into which 37 holes have been drilled. Two-thirds of the holes are 1/4 inch in diameter, and one-third are 3/8 inch. The holes are equally spaced across the length of the sparger, and every third hole is 3/8 inch in diameter. The sparger dribbles slurry across the center and the top of the bed in the ammoniator-granulator. Liquid anhydrous ammonia is added to the ammoniator-granulator through a drilled pipe-type sparger 5-1/2 feet long. This plant has an ammoniator-granulator 6 feet in diameter and 10 feet long. It has separate ammoniation and granulation sections; the ammoniation section is 6 feet long.

Operating procedure for the preneutralizer is standard and is the same for all grades. The N:P mole ratio in the slurry is usually kept at about 1.5 (7.2 pounds of ammonia per unit of P_2O_5). This degree of ammoniation is close to the Maximum solubility of the ammonium phosphate salts in the slurry, and when the preneutralizer is operated at this ammoniation rate, it is possible to deliver to the granulator a fluid slurry having a solids content of 80 percent or higher. Water is added to the preneutralizer to maintain the solids content. There was no noticeable odor of ammonia from the top of the preneutralizer at this degree of ammoniation.

The apparatus for determination of the N:P mole is shown in Figure 6. Operators usually make this determination by titrating a diluted aliquot of slurry to a pH of 7.8 with a 0.5 normal solution of NaOH and then back-titrating to a pH of 4.0 with a 0.5 normal solution of H_2SO_4. The following formula is used to calculate the ratio:

Formula for Calculating N;P Mole Ratio

$$\text{N:P mole ratio} = 2 - \frac{\text{ml of NaOH to pH 7.8}}{\text{ml of } H_2SO_4 \text{ to pH 4.0}}$$

The perccent of solids is determined by washing a 25-gram sample of slurry with methanol to remove moisture. The slurry is then filtered, and solids are dried by an infrared light. Solids content is determined by weight difference.

Tests were conducted in this plant, and satisfactory results were obtained in the production of 6-24-24, 10-20-

20, and 16-16-8 grades.

6-24-24 Grade

Table 2 shows the formulations and operating data obtained during the production of the three grades. The formula in test No. 1 (6-24-24 grade) gives the most economical raw-material cost; however, the liquid phase in the granulator was high, probably because the N:P mole ratio of the ammonium phosphate in the product was near its maximum solubility point (N:P mole ratio of 1.4). At this degree of ammoniation overgranulation occured, and the plant could not be operated because of insufficient recycle capacity. The plant operated satisfactorily with the formula in test No. 2 (6-24-24 grade), which includes standard-size potash. Some of the phosphoric acid was added to the ammoniator-granulator so that the resulting N:P mole ratio of the ammonium phosphate in the product was 1.2. With potash of this size and at this degree of ammoniation, it was possible to operate the plant at a production rate of 16 tons per hour. Thee resulting product was free of fines and had excellent storage characteristics.

Test No. 3 gave the best operating results for the 6-24-24 grade. Phosphoric acid was added to lower the N:P mole ratio of the ammonium phosphate in the product to about 1.0 (monoammonium phosphate). This is the degree of ammoniation that results in the lowest possible liquid phase in the granulator. Solubility data indicate that in a pure system 22.7 pounds of monoammonium phosphate can be dissolved in 100 pounds of water at 32 degrees F.[4], whereas at the mole ratio of N:P of 1.4 about 60 pounds of mixed ammonium phosphate can be dissolved in 100 pounds of water [3]. The production rate in test No. 3 (table 2) was 18 tons per hour, and probably higher production rates could have been reached. Little or no dust was evolved, and it was easy to see inside the granulator. the recycle rate was about half the quantity required in test No. 1 (1.0 vs. 1.9 pounds of recycle per pound of product).

10-20-20 Grade

Two tests (Nos. 4 and 5, Table 2) were made for the production of a 10-20-20 grade. In test No. 4 the slurry was further ammoniated in the ammoniator-granulator so that the N:P mole ratio of the ammonium phosphate in the product was 1.7 (8.3 pounds of ammonia per unit of P_2O_5). There was a tendency for overgranulation because of high liquid phase in the granulator. the recycle rate was 1.5 pounds of recycle per pound of product. Although the degree of ammoniation in the ammoniator-granulator was higher than normal, there was no odor of ammonia to indicate excessive loss during the test; actual loss of ammonia was not determined.

In test No. 5 phosphoric acid was added to the granulator so that the N:P mole ratio of ammonium phosphate in the product was 1.2. At this lower degree of ammoniation, the required recycle rate was lower than in the previous test, and an excellent granular 10-20-20 grade was produced at a rate of 16 tons per hour.

16-16-8 Grade

One test was made to produce a 16-16-8 grade (test No. 6, table 2). The N:P mole ratio in the product was 1.5. Because of the large quantity of ammonium sulfate in the formulation, it was possible to operate at 16 tons per hour, even at the high N:P mole ratio. Granulation efficiency was excellent. the recycle rate was about 1.3 pounds of recycle per pound of product.

Preneutralizer Design data

Calculations show the ammoniation volume to be between 13.0 and 14.7 pounds per hour of ammonia per cubic foot of fluid for this preneutralizer. These ammoniation volumes are somewhat higher than for the diammonium phosphate plants with preneutralizers in Florida. Data from six of those plants indicate that the ammoniation volume varies from 5.9 to 10.9 pounds of ammonia per hour per cubic foot.

In tests with the small preneutralizer, the evaporation rate varied from 105 to 120 pounds of water per hour per square foot of cross section of the preneutralizer. This evaporation rate is lower than that in the larger preneutralizers for production of granular diammonium phosphate. the larger preneutralization usually evaporate at a rate of about 100 to 200 pounds of water per hour per square foot. the small preneutralizer functioned smoothly at the evaporation rates and ammoniation volumes used in the plant tests. There were no excessive boil-overs or vibrations.

Product Storage

Companies that have replaced sulfuric acid in their formulations with orthophosphoric acid report improved storage characteristics of the products. Products in which the phosphoric acid is ammoniated to N:P mole ratios of about 1.0 or 2.0 usually have characteristics superior to those in which the N:P mole ratio is about 1.5. Most companies try to dry their products to a moisture content of 1 to 2 percent.

Superphosphoric Acid in Granulation Plants

Several companies have used superphosphoric acid in their granulation plants to control pollution; however, the cost of the acid usually has been too high to justify its use instead of phosphate materials of lower cost. Two companies are continuing to use superphosphoric acid to control pollution from their plants because the plants are located near residential areas.

One of the companies has a conventional emmoniation-granulation plant with a TVA-type rotary granulator, a rotary dryer, and a rotary cooler. Two tests were conducted in the plant, and exit gas from the plant stack was analyzed. The formulations and the results are shown in Table 3. Test No. 1 **was** made with sulfuric acid and test No. 2 with superphosphoric acid. Analyses of the exit gas from the plant show that sulfuric acid produced considerable odor and particulate losses. These losses were above the tolerance of the local pollution control laws. The particulate loss from the plant with superphosphoric acid was well below the tolerance. Management of the company reports that the plant can be operated with little or no pollution and below the tolerence if superphosphoric acid is used in the production of their grades, and they plan to continue its use instead of installing venturi-type scrubbers or sophisticated dust-collecting systems such as bag filters.

This company reported some difficulty with the storage of its products containing superphosphoric acid when the degree of ammoniation of the acid was about 7.0 pounds of ammonia per unit of P_2O_5. When this degree of ammoniation was lowered to about 5 pounds of ammonia per unit of P_2O_5, the problems with caking in storage were eliminated. they also report that with superphosphoric acid in the formulation, either no drying or drying with a light burner load is the only requirement to produce a product dry enough to remain free-flowing in storage.

Summary

There has been a significant increase in the quantity of phosphoric acid used in ammoniation-granulation plants. Less particulate loss is reported from plants using phosphoric acid. Phosphoric acid can be used with the simple addition of an acid storage tank and metering equipment. About 200 to 400 pounds of the acid per ton of product is normal. When larger quantities of phosphoric acid are desired, it is partially ammoniated in a preneutralizer.

Some companies have had excellent results with the use of superphosphoric acid to eliminate most of the emission from their ammoniation-granulation plants.

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3. Sohio chemical Company. *Sohiogen Nitrogen Solutions.*

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Table 1

Granulation of N-P-K Mixtures Using Phosphoric Acid in Conventional Ammoniation-Granulation Plants

Grade	**8-32-16**	**8-24-24**	**10-10-10**	**5-15-30**	**6-24-24**	**13-13-13**
Production rate, tons/hr	30	35	20	15-17	20	15
Formulations, lbs/ton of product						
Ammonia	100	—	—	—	82	120
Ammonium sulfate (21%N)	—	—	384	—	—	790
Ammoniating solution 448 (25-69-0)	—	228	279	177	—	—
Diammonium phosphate (18-46-0)	490	350	—	120	350	—
Triple superphosphate (46% P_2O_5)	500	400	—	95	187	213
Normal superphosphate (20% P_2O_5)	—	—	384	325	357	—
Phosphoric acid (54% P_2O_5)	382	260	240	258	300	300
Sulfuric acid, 66 degrees Be.	62	—	—	—	—	150
Filler	—	—	441[a]	—	—	35
Potash (60% K_2O)						
Coarse	—	405	153	—	—	433
Standard	540	405	153	1007	787	—
Operating conditions						
Estimated recycle rate, lbs/lb of product	1.0	0.25	0.2-0.3	0.3-0.4	0.50	2.0
Exit gas temperature from dryer, degrees F.	180	211	250-300	250-300	240	200
Product screen analysis, %						
+6	0.5	—	—	—	—	5
—6 +14	95.8	100	35	40	—	85
—14 +16	2.5	—	60	55	—	5
—16	0.2	—	5	5	—	5
Product moisture, %	0.8	2.9	1-2	1-1.5	1.5	2.0

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[a] One-half limestone and one-half fine limestone

Table 2

Formulations and Operating Data for Ammoniation-Granulation Plant With Preneutralizer

Test **Grade**	**No. 1** **6-24-24**	**No. 2** **6-24-24**	**No. 3** **6-24-24**	**No. 4** **10-20-20**	**No. 5** **10-20-20**	**No. 6** **16-16-8**
Production rate, tons/hr.	14	16	18	15	16	16
Formulation, lbs/ton of product						
Preneutralizer						
Phosphoric acid, 54% P_2O_5	750	696	600	700	603	615
Ammonia	140	130	112	135	116	115
Water	280	260	224	270	232	230
Granulator						
Phosphoric acid, 54% $P_2'O_5$	——	100	189	——	147	——
Normal superphosphate,, 20% P_2O_5	425	300	300	190	——	——
Ammonia	18	8	10	33	——	23
Ammonium sulfate	——	60	114	360	550	1,053
Potash, 60% K_2O	800	800	800	667	667	262
Operating conditions, average						
Preneutralizer						
Solids in slurry, %	80	80	80	80	80	80
Specified gravity	1.5	1.5	1.5	——	——	——
Temperature, degrees F.	240	225-240	240	240	240	240
N:P mole ratio of ammonium phosphate	1.5	1.5	1.5	1.5	1.5	1.5
Ammoniation area, lbs. of NH_3/hr/ft^2[a]	69.5	73.6	71.3	71.8	65.7	65.2
Ammoniation volume, lbs. of NH_3/hr/ft^3[b]	13.8	14.7	14.3	14.3	13.1	13
Evaporation rate, lbs. of H_2O/hr/ft^2	112	120	115	116	106	105
Granulator						
Recycle rate, lbs. of recycle/lb. of product	1.9	1.3	1.0	1.5	1.3	1.3
N:P mole ratio (calculated) of ammonium phosphate[c]	1.4	1.12	1.0	1.7	1.2	1.75
Dryer						
Product temperature, degrees F.	195	205	200	——	——	——
Exit gas temperature, degrees F.	210	210	210	210	210	210
Product moisture, %	1.7	1.5	1.5	——	——	——

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[a] Ft^2 of cross section of preneutralizer.

[b] Ft^3 of fluid in preneutralizer.

[c] The N:P mole ratio was calculated by using feed rates of NH_3 and H_3PO_4.

Table 3

6-24-24 Grade
Plant Tests With and Without Superphosphate Acid

Raw Materials	Test 1 Pounds/Ton of Product	test 2 Pounds/Ton of Product
Solution 448 (25-69-0)	——	268
Solution 530 (49-36-0)	164	——
Auperphosphoric acid (0-70-0)	——	175
Sulfuric acid (66 degrees Be.)	100	——
Triple superphosphate (0-47-0)	684	775
Monoammonium phosphate (11-55-0)	300	——
Potash (0-0-61)	800	800
NH_3 raTE (pounds of NH_3/unit of P_2O_5)	3.34	2.79

Discharges from Plant Scrubber

	Test 1	Test 2
Particulate (grains/standard cubic foot)	0.078	0.006
Odor units/minute*	3,695,000	754,000

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*ASTM D-1391-57
(Reaffirmed 1967)

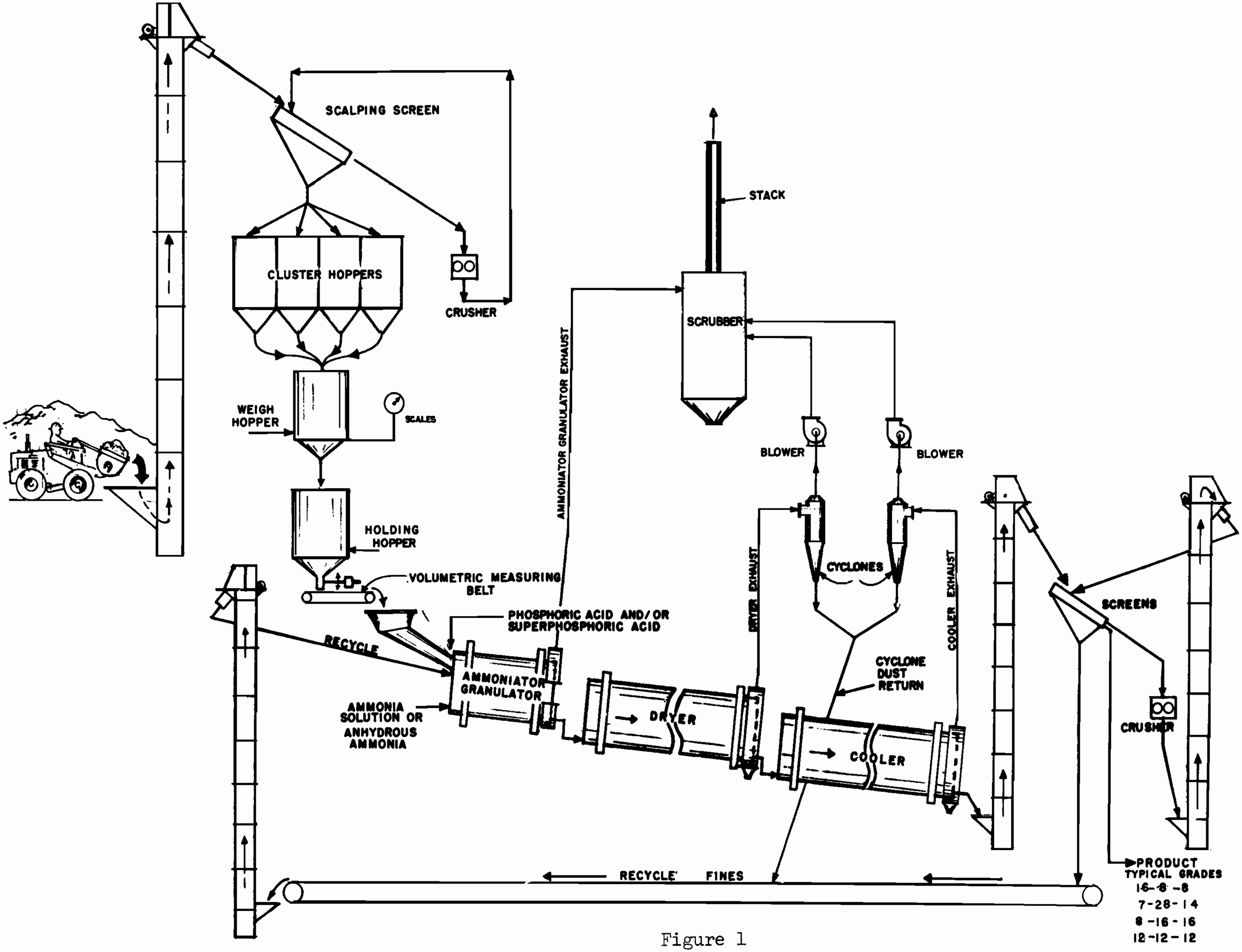


Figure 1

CONVENTIONAL AMMONIATION-GRANULATION PLANT

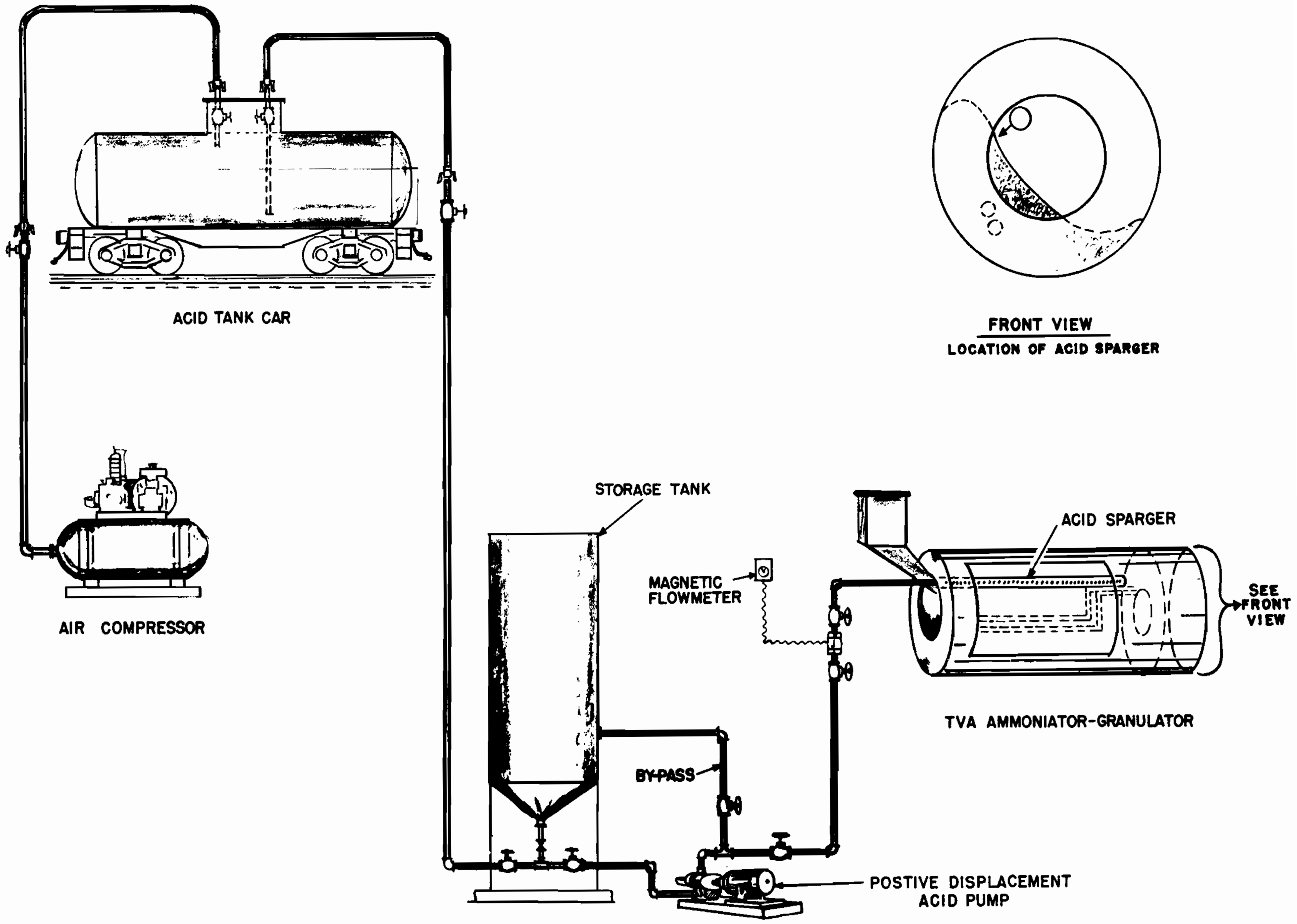


FIGURE 2
PHOSPHORIC ACID SYSTEM FOR GRANULATION PLANT

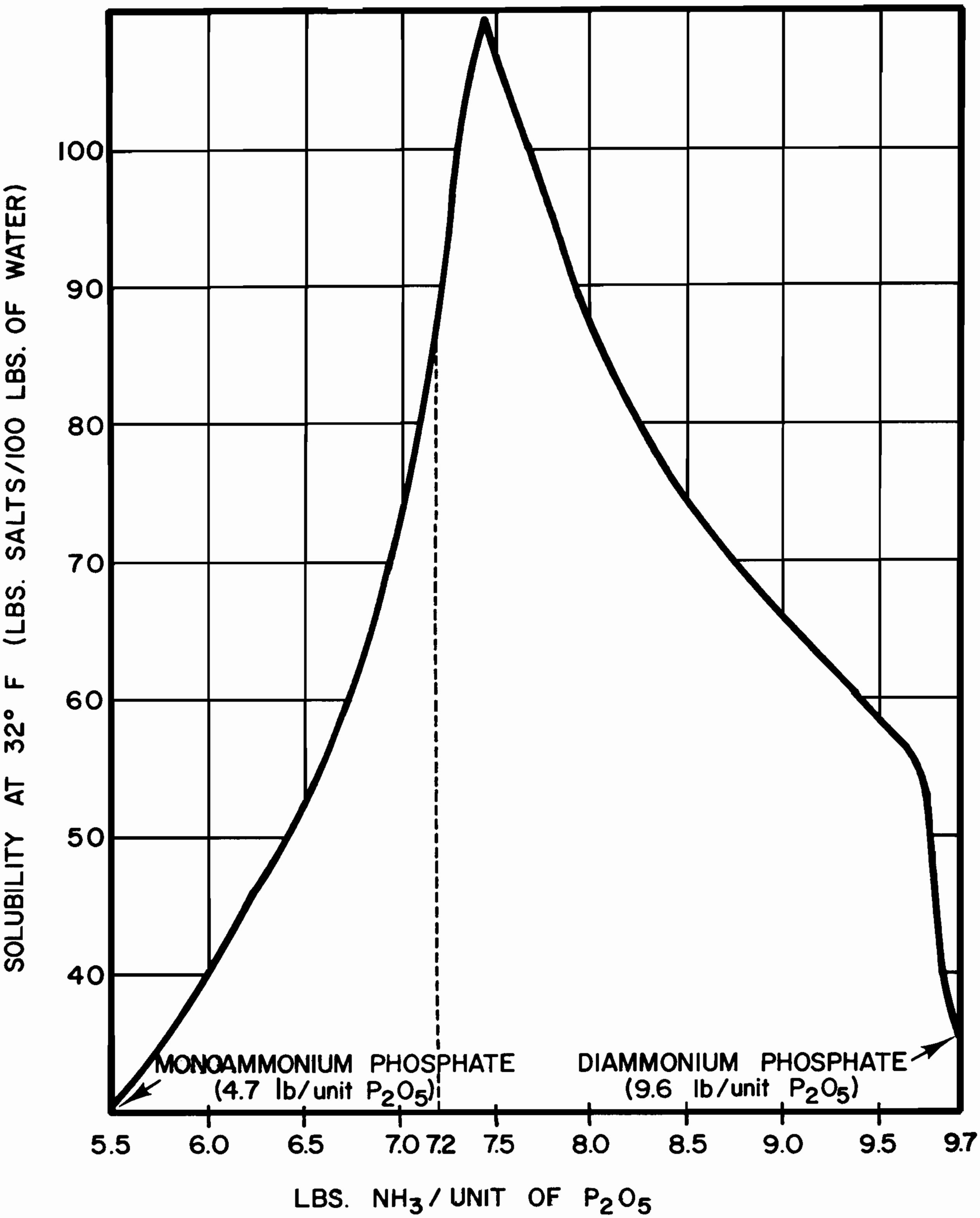


FIG. 3
SOLUBILITY OF SATURATED AMMONIUM PHOSPHATE SOLUTIONS

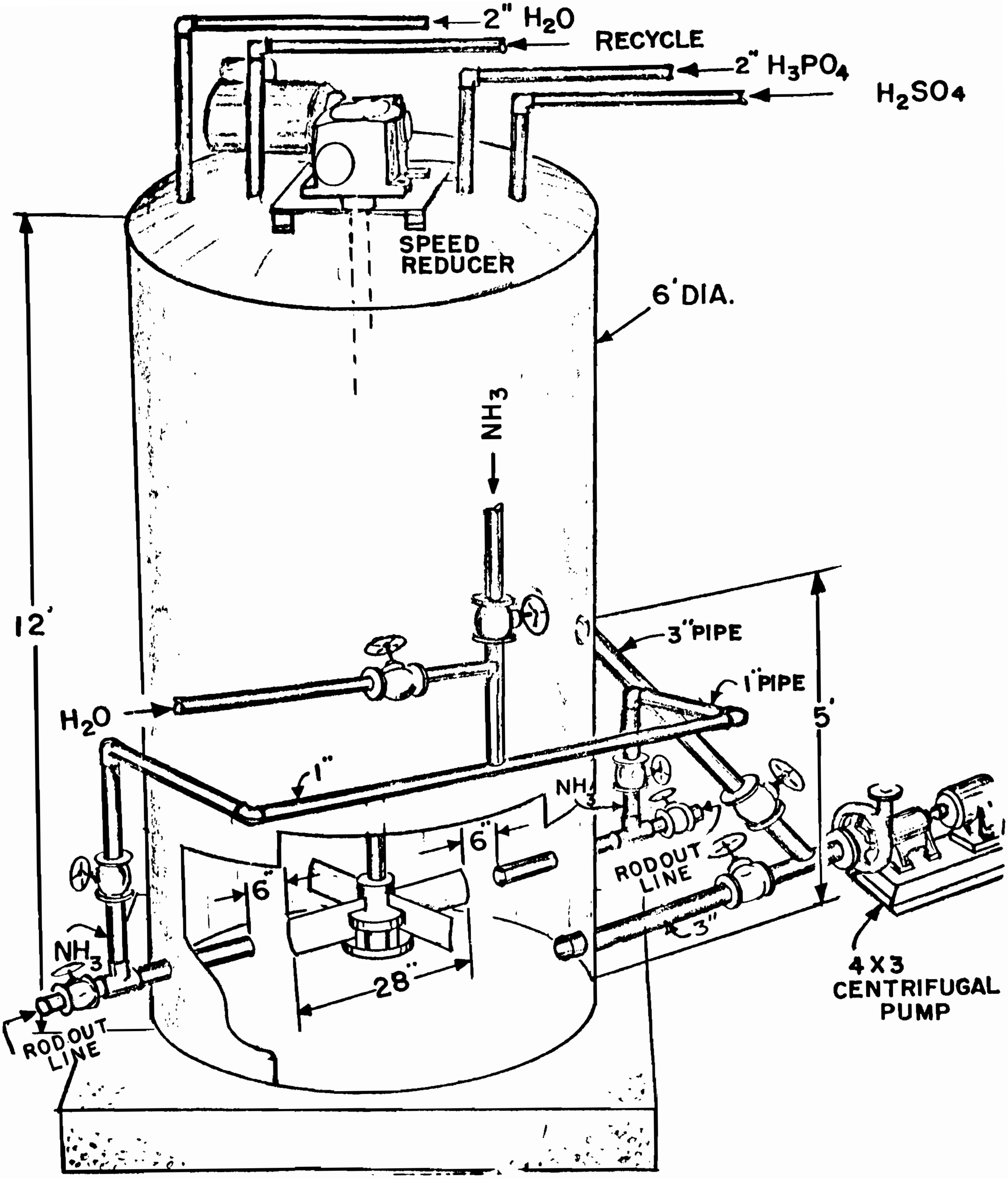


FIGURE 4

PRENEUTRALIZER

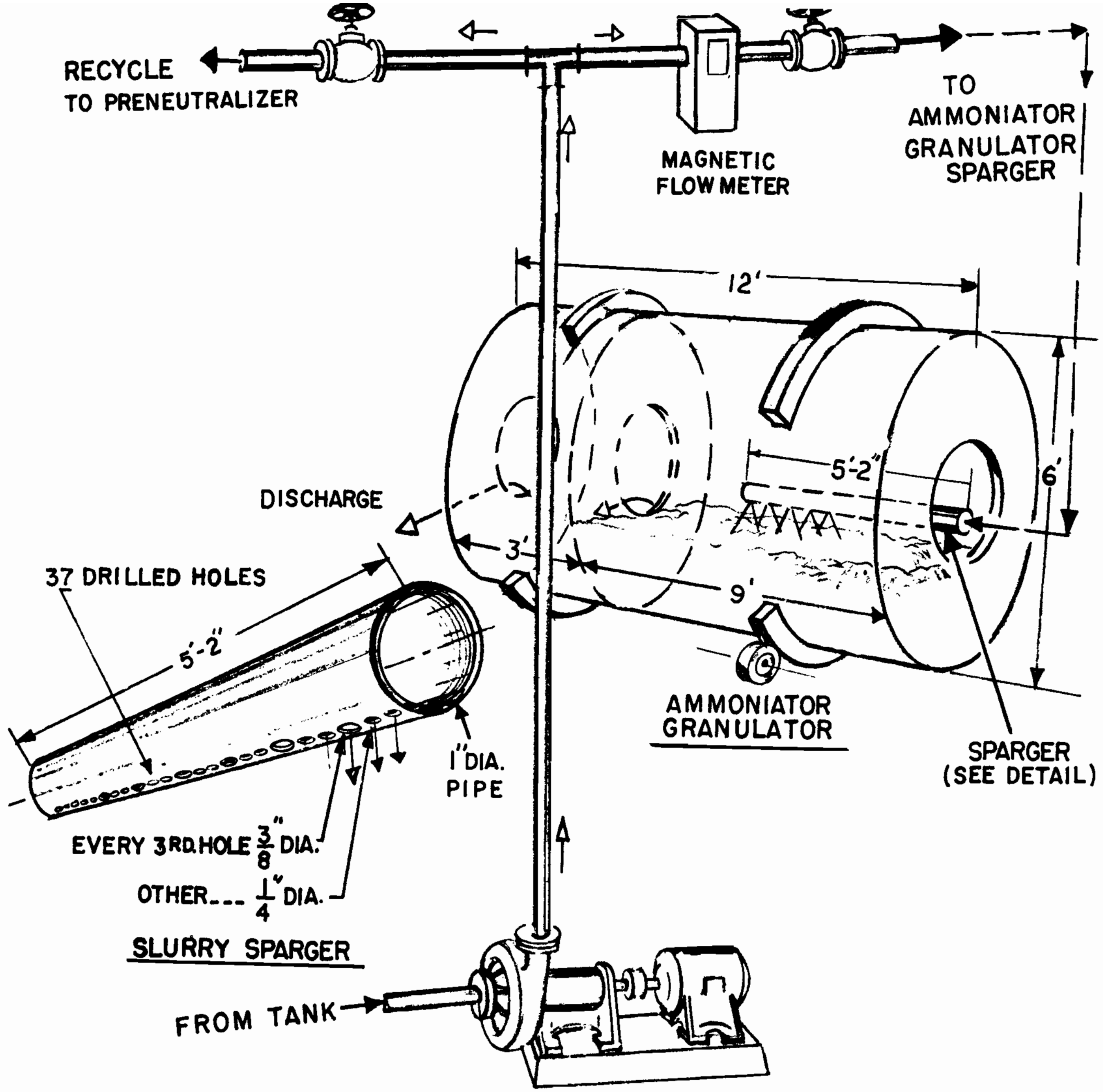


FIGURE 5

SLURRY RECYCLE LINE AND SPARGER FOR AMMONIATOR-GRANULATOR

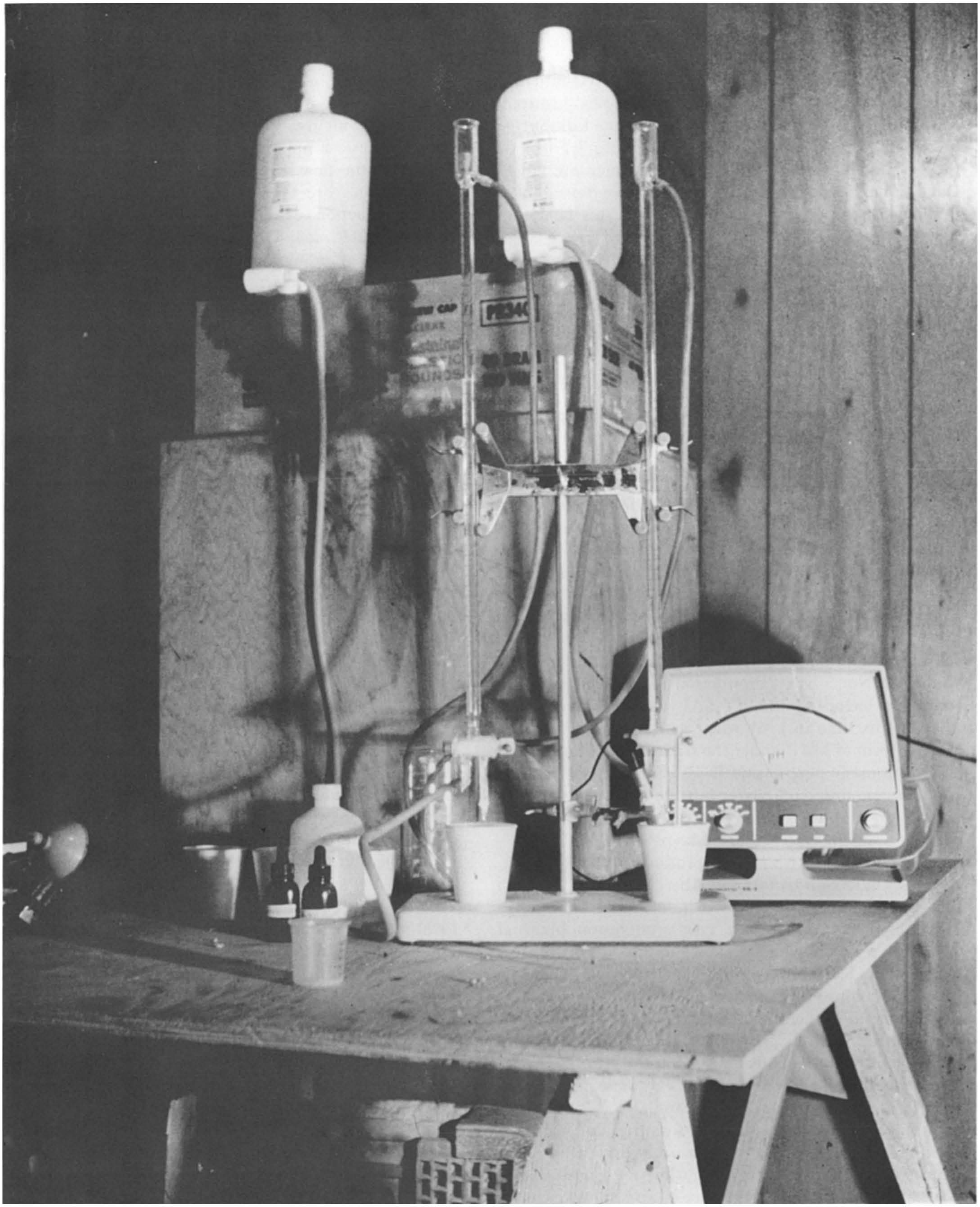


FIGURE 6
APPARATUS FOR DETERMINATION OF N:P MOLE RATIO

MODERATOR ACHORN: I wish to thank Hubert for helping me gather the information covering the up-to-date usage of Phosphoric Acid in the Production of Granular Mixed Fertilizers.

We are particularly honored to have two Gentlemen from the Scottish Agricultural Industries Limited, Research and Development Department, Edinburgh, Scotland, to present a paper on the "Phosai" Form Of Monoammonium Phosphate. The Gentlemen are Dr. E. Davidson and Mr. I.S.E. Martin. Both have done a lot of published work on the research work in this field they have done in the past.

MR. I.S.E. MARTIN: thank you Mr. Achorn for your kind introduction. Ladies and Gentlemen, as you may recall that "SAI" contributed to the 1964 Round Table Conference. At that time we gave two papers, one on the new Double Drum Granulation Process and the other on the "PhoSAI" MAP Process."

The 'PhoSal' Form of Monoammonium Phosphate

Dr. E. Davidson and I.S.E. Martin

1. INTRODUCTION:

It may be recalled that SAI contributed to the 1964 Round Table Conference. At that time two papers were given; one on the new double drum granulation process, the other on the 'PhoSAI' MAP process and the granulation paper was probably regarded as the more important. However, in recent years there has been a great upsurge of interest in MAP and it was interesting to see in the summary of subjects for this year's meeting that Item No. 5 was "Production and use of new raw materials including MAP". SAI was almost certainly ahead of its time in 1961 when it first started selling a powder form of MAP under the trade mark 'PhoSAI'. At that time many people said it was crazy to try to sell a product containing 6% water but the idea seems to have caught on and there are now several other processes making a similar type of material.

Since 1964, SAI has been producing 'PhoSAI' continuously in its own factories at Aberdeen and Edinburgh in Scotland for customers in Britain and in Europe. In 1971, SAI commissioned a new granulation plant at Aberdeen a view of which is shown in Fig. 1. This plant is designed to handle only solid raw materials including 'PhoSAI' and produces a wide range of compounds from organic based horticultural fertilizers to compounds containing urea, such as 20:10:10. The production rate of this type of plant depends entirely on the granulation efficiency obtained and the nature of raw materials used is, therefore, very important. Non-granular MAP has many advantages as an intermediate for granular fertilizer production. Compared with ammonium phosphate slurry, it enables lower recycle ratios to be used with a consequent reduction in capital costs and in fuel costs or, alternatively, higher output can be obtained from the same plant. For instance, one of SAI's licensees in Japan has doubled the production of granular DAP by replacing part of the phosphoric acid feed by 'PhoSAI'. MAP is compatible with all other fertilizer raw materials and is especially useful in the presence of urea. A plant is now being built in Pakistan in which 'PhoSAI' will be granulated with urea prills to produce 27:27:0.

The basic simplicity of the 'PhoSAI' process can be seen from the flow sheet in Fig. 2. Phosphoric acid and ammonia gas are reacted together in an atmospheric pressure reaction vessel to give a slurry containing a mixture of MAP and DAP at the point of maximum solubility of ammonium phosphate. This allows the water content to be minimised while still maintaining a fluid, easily handled slurry. The residence time in the reaction vessel of around one and a half hours ensures steady conditions. The slurry then overflows to a moisture disengagement unit where further phosphoric acid is added to convert the DAP back to MAP. the slurry quickly solidifies and the extra heat of reaction is sufficient to reduce the water content of the product to around 6%. The rest of the flow sheet is screening and milling of product and scrubbing of exit gases. Fig 3 shows the product stored in bulk.

The analysis of the product depends only on the analysis of the phosphoric acid used, which in turn depends on the nature of the phosphate rock and the degree of clarification carried out on the acid. Unclarified acid can be used and there is no need to use any sulphuric acid. The average strength of phosphoric acid required is 41-42% P_2O_5 although this strength can be reduced still further by replacing some of the phosphoric acid by sulphuric acid. In this way, intermediates can be produced ranging from MAP to a 50/50 mixture of MAP and ammonium sulphate. In the extreme case phosphoric acid containing only 25% P_2O_5 can be used to produce an intermediate analysing 16:24. For these products we use the name sulphate 'PhoSAI'.

The use of MAP intermediates is only now becoming established on a worldwide basis although the 'PhoSAI' form of MAP has been used by SAI and its customers for over 12 years. during this time 'PhoSAI' has provided an ideal method of handling, storing and granulating P_2O_5 and it has been transported in bulk by road, rail and sea without any difficulty. Fig. 4 shows a ship loading at Leith Docks in Edinburgh. 'PhoSAI' has a high bulk density of 55 lb per cubic foot. Further drying of the product is quite unnecessary and, in fact, could impair the granulation properties. It was as long ago as 1954 when SAI started to look for a more concentrated intermediate to replace superphosphate. After experimenting with many types of ammonium phosphate, a powder form of MAP was finally produced on a commercial scale in 1961 and SAI's experience since then has shown that the approach adopted in the development of this process was a very good one. 'PhoSAI' was found to have all the good properties required, that is, it was non-caking and easy to granulate, but just how exceptional these properties were not fully appreciated until fairly recently when reports of problems in handling MAP began to appear. SAI therefore, decided to examine MAP product quality more closely to try to find the reasons for the good properties of 'PhoSAI' and in the remainder of this paper some of our work and thinking will be outlined.

2. THE CAKING OF MAP:

It is known from over twelve years' experience of manufacture and use of 'PhoSAI' that this product is a non-caking material. This can be illustrated by the results of laboratory caking tests (Fig. 5).

The results shown in Fig. 5 are for samples of typical 'PhoSAI' made from acid derived from seven different phosphate rock sources. All show a slight caking propensity but it is known from correlation of laboratory results with experience on the full scale that a laboratory caking test result of 5 kg. (or less) breaking force is consistent with good storage properties. As shown in Fig. 6, the caking properties of 'PhoSAI' are affected only slightly by variation in moisture content over the range 1-8% and it is worth noting that, even at 8% moisture, the caking test results are acceptly low. Also, the caking properties of 'PhoSAI' are not affected by variation in particle size (cf. Fig. 7)

The behaviour of pure MAP is very different from that of 'PhoSAI'. As shown in Fig. 8, the caking of propensity of pure 'MAP is high and is affected by variation in moisture content. On the basis of the results given in Fig. 8, it is very surprising that the caking tendency of 'PhoSAI' should be low. 'PhoSAI' is, of course, impure but the low caking tendency cannot be attributed merely to the fact that it is impure. This point was established by the results of experiments in which the form of 'PhoSAI' was altered. Samples of 'PhoSAI' were moistened to 15% heated at 165 degrees C. under pressure and flash dried to around 6% moisture by apraying down a tower. The caking propensity of the flash dried products was compared with that of the parent 'PhoSAI' samples and the results are shown in Fig. 9 and 10. Without exception, the flash dried materials had markedly higher caking tendency that tht parent 'PhoSAI'. Furthermore, unlike 'PhoSAI' the flash dried materials were affected by variation in moisture content (cf Fig. 11) and by variation in particle size (cf Fig. 12). These results were regarded as very interesting in the light of reports that commercially available forms of flash dried MAP had unsatisfactory storage properties.

If it is assumed that the caking of MAP is caused by further recrystallisation of the MAP and formation of crystals bridges between adjacent particles, then perhaps clues to the reasons for the difference in behaviour between 'PhoSAI' and flash dried material might be obtained by considering the two processes and types of product. the most obvious difference between the two processes is that flash dried product solidified much more rapidly than normal 'PhoSAI'; flash dried product consists of spheres or flakes of agglomerated MAP crystals whereas normal 'PhoSAI' is a mixture of individual and loosely agglomerated MAP crystals, because in the 'PhoSAI' process the crystals have opportunity to grow. To a large extent crystal growth is governed by the relative proportions of the impurities in the acid. this point is best elaborated by reference to results of laboratory work. It has been found that iron, aluminium, magnesium and fluorine all affect crystal growth and small changes in the concentration of these impurities can have marked effect on the size of the crystals precipitated. For example, in Fig. 13 is shown a photomicrograph (scale is 2000 u x 1500 u) of MAP crystals derived from typical wet process phosphoric acid.

If the MgO content of the acid is increased by only 0.2% the crystals are much smaller (cf Fig. 14). However, not only magnesium has this effect, the effects of aluminum, iron, magnesium and fluoride are interrelated. As an example of this interrelationship, Fig. 15 shows the behaviour observed when using an acid having an iron: aluminium atomic ratio of 2:1. In this system when the fluorine and magnesium contents of the acid were in the clear region, large crystals of MAP were obtained but in the shaded region small crystals were precipitated. The behaviour obtained with acid having an iron: aluminium atomic ratio of 1:2 is shown in Fig. 16. Here again, crystal size varied according to MgO and F content, but the shape of the boundary between the two regions was different. The results of this laboratory work fit in well with general experience of actual 'PhoSAI' production. The size of crystals in 'PhoSAI' vary according to the impurity content of the acid being used. For example, from Senegal acid, as shown in Fig. 17, large crystals are obtained, but (Fig. 18) Moroccan acid typically yields small crystals. the crystals size of Gafsa 'PhoSAI' (Fig. 19) also tends to be small, but thee crystals in Togo 'PhoSAI' (Fig. 20) are large.

Flash dried material derived from 'PhoSAI' looks very different from the parent samples. Photomicrographs of flash dried Togo MAP, flash dried Senega MAP, flash dried Moroccan MAP and flash dried Gafsa MAP are shown in Figs. 21, 22, 23 and 24 respectively. It is noticeable that all four samples of flash dried material resemble each other and that individual, well formed crystals are more or less absent. The flash dried samples are very similar to each other and in each case the material appears to consist largely of fragments rather than well developed individual crystals. This overall similarity demonstrates that the impurities which governed crystallisation in 'PhoSAI' do not have a similar effect in flash dried MAP.

It is well known that under favourable conditions, unstablised small crystals will recrystallise and grow to reduce the interfacial surface area of the system. this is probably why pure MAP has a high caking tendency. Also on the basis of this interpretation, the effect of moisture content on the caking of flash dried material can be understood (Fig. 11) in terms of increased moisture content increasing the mobility of the MAP molecules and hence increasing the tendency for recrystallisation. The lower caking propensity of 'PhoSAI' and lack of effect of moisture content can be attributed to the effect of the impurities. It was shown above that the impurities in the phosphoric acid govern growth of MAP crystals in the 'PhoSAI' process and determine whether large or small crystals are precipitated. It is suggested that these impurities also stabilise the crystals against further recrystallisation. It is believed that in the flash dried MAP such stabilisation does not occur owing to the lack of effect of the impurities on the crystallisation process.

Some recent results obtained by Tennessee Valley Authority (TVA) are relevant to consideration of the caking properties of MAP. Earlier this year the Fundamental Research Branch of TVA expressed an interest in various forms of MAP. We supplied them with some samples of 'PhoSAI' and flash dried MAP and they have kindly given us permission for the results of their examination to be reported at this meeting. It was found that in all samples of 'PhoSAI' examined the impurities were present as amorphous gels and that the gels were distributed in the interstitial void space between the crystals and over the surfaces. this is illustrated in Figs. 25-29, which are copies of scanning electron micrographs prepared by TVA; the descriptions of the photographs are excerpts from TVA's report. Fig. 25 is an electronmicrograph of Senegal 'PhoSAI'. In this case the individual crystals are well developed with amorphous gel being concentrated in localised zones. Fig. 26 is an electronmicrograph of Gafsa 'PhoSAI' and in this case the crystals are smaller and the interstitial space is filled by gel. The MAP can be dissolved out leaving, as shown in Fig. 27, a relic structure consisting of gel phase. Similarly, 'PhoSAI' derived from mixed Florida and Jordan rocks of Fig. 28), when leached, leaves a mass of delicate membranes (cf Fig. 29).

TVA also looked at samples of 'PhoSAI' and flash dried MAP, both made from acid derived from the same phosphate rock source. They showed that in the 'PhoSAI' (Fig. 30) the MAP crystals are fairly large and the insolubles are in the form of an amorphous gel filling much of the interstitial space. In the flash dried material (Fig. 31) the insolubles are only partially present as amorphous gel; mainly they are crystalline. On leaching, the 'PhoSAI' (Fig. 32) left a relic structure but the flash dried material disintegrated ito soft, unconsolidated residue (Fig. 33). Some of SAI's interpretations of TVA's results are as follows.

These results suggest to us the possibility that the good caking properties of PhoSAI' may be due partially at lest to the layers of amorphous gel on the surface of the MAP crystals acting as an anticaking agent. This could account for the fact that pure MAP cakes whereas 'PhoSAI' does not. Similarly the high caking propensity of the flash dried material could be related to the observation that the insolubles were not present, in that product, in the form of membranes.

TVA's observation that some of the insolubles in the flash dried material are crystalline is very much in keeping with Professor Ando's report (ISMA Technical Conference held in Seville, Spain, November 1972) that ammoniation of phosphoric acid at high temperatures and pressure favoured the crystallisation of impurities.

It is to be noted that although variation in the impurities in wet process phosphoric acid affects the size of MAP crystalls in 'PhosSAI', such variation has no discernible effect on the caking and granulation properties of the product.

3. GRANULATION

There is general acceptance of the belief that the good granulation properties of 'PhoSAI' and the MAP slurries derived from wet process acid are due to the presence of the impurities in the form of an amorphous gel. Indeed, it is known that the good granulation properties of 'PhoSAI' can be impaired if the material is dried to such an extent that the gels are dehydrated. This point is illustrated by the results given in Table I. These results were obtained by drying samples of Togo 'PhoSAI' Gafsa 'PhoSAI' and Morccan 'PhoSAI' to a moisture content of about 0.5% H_2O. The dried samples and samples of untreated 'PhoSAI' were then submitted to granulation tests using identical conditions and the same total granulation moisture in each case. After each test the granules were dried and screened; the screen analyses are given in Table I.

It will be observed that in each case the dried samples had inferior granulation properties. The granulation properties of the flash dried MAP (Fig. 33) containing its impurities mainly in a crystalline from were compared with those of the 'PhoSAI' made from the same acid and, as expected, a very large difference in granulation properties was observed. The flash dried material was markedly inferior. To illustrate the extent of the differences more graphically, a film was made of comparative granulation tests.

Table I

Granulation of Dried and Untreated 'PhoSAI'

Sizes	GAFSA		TOGA		MOROCCAN	
	Untreated	Dried	Untreated	Dried	Untreated	Dried
‘2.8 mm	98	35	99	50	86	34
‘2.8 mm 1.2 mm	2	45	1	35	8	37
‘1.2 mm	0	20	0	15	6	29

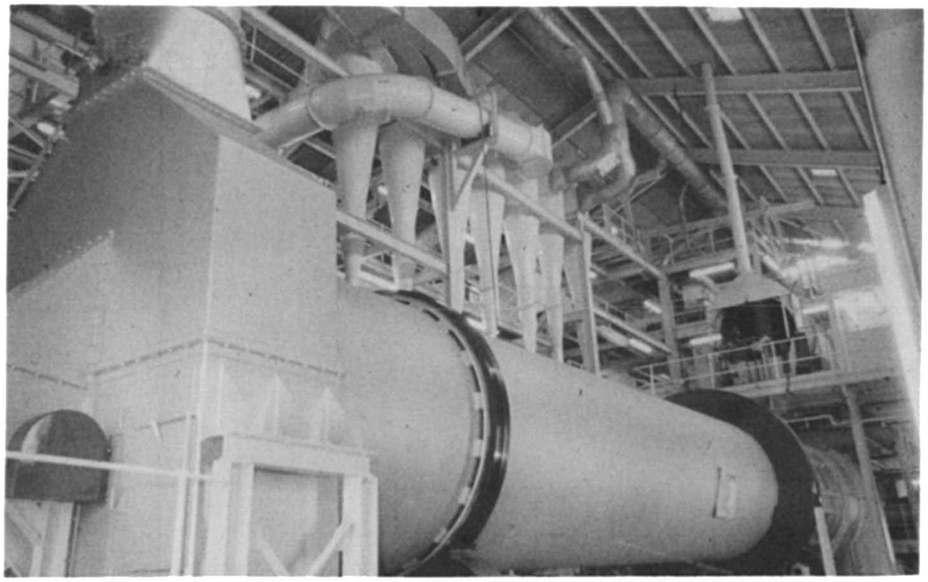


Figure 1
SAI Granulation Plant

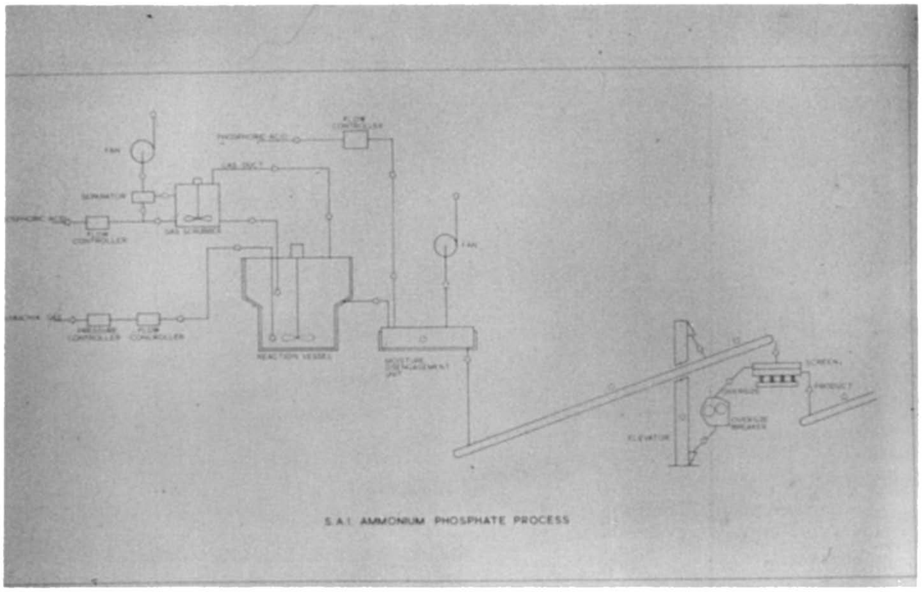


Figure 2
'PhoSAI' Process Flowsheet

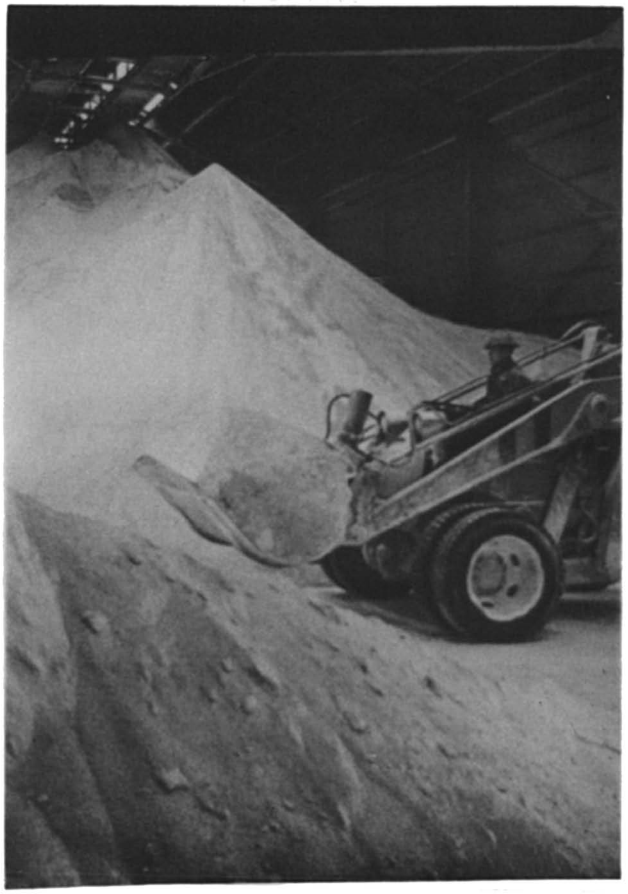


Figure 3
'PhoSAI' Stored In Bulk

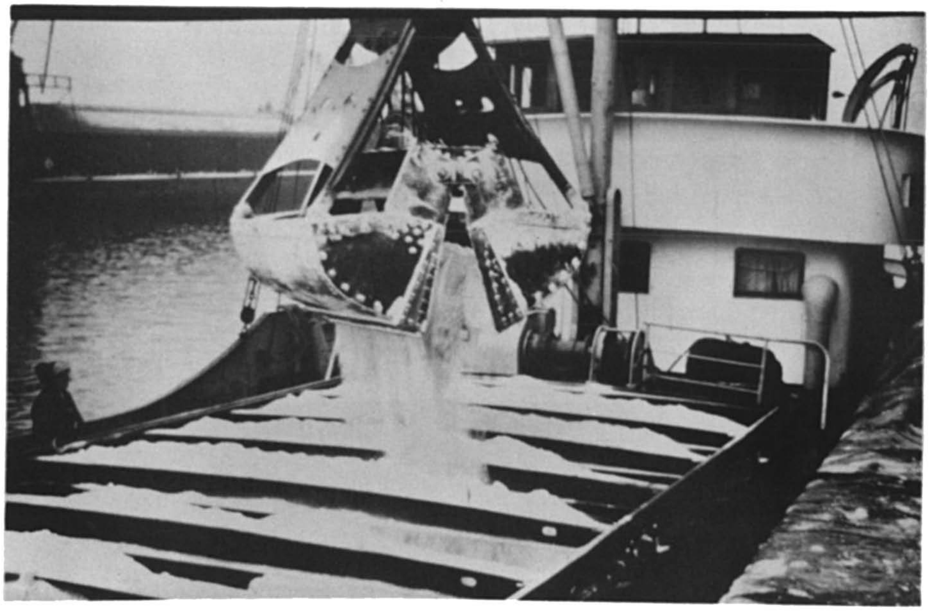
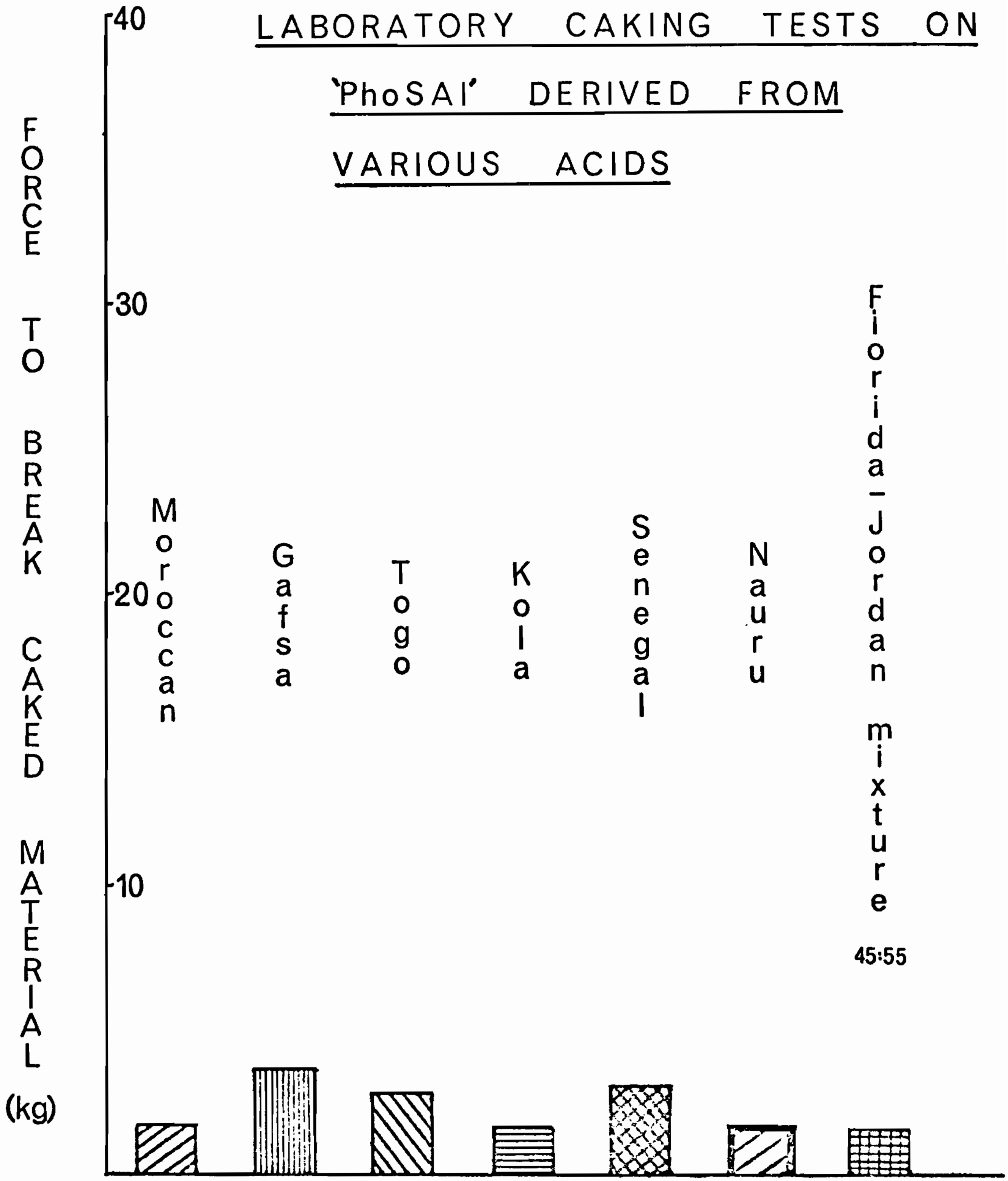


Figure 4
'PhoSAI Being Loaded

Figure 5

LABORATORY CAKING TESTS ON 'PhoSAl' DERIVED FROM VARIOUS ACIDS



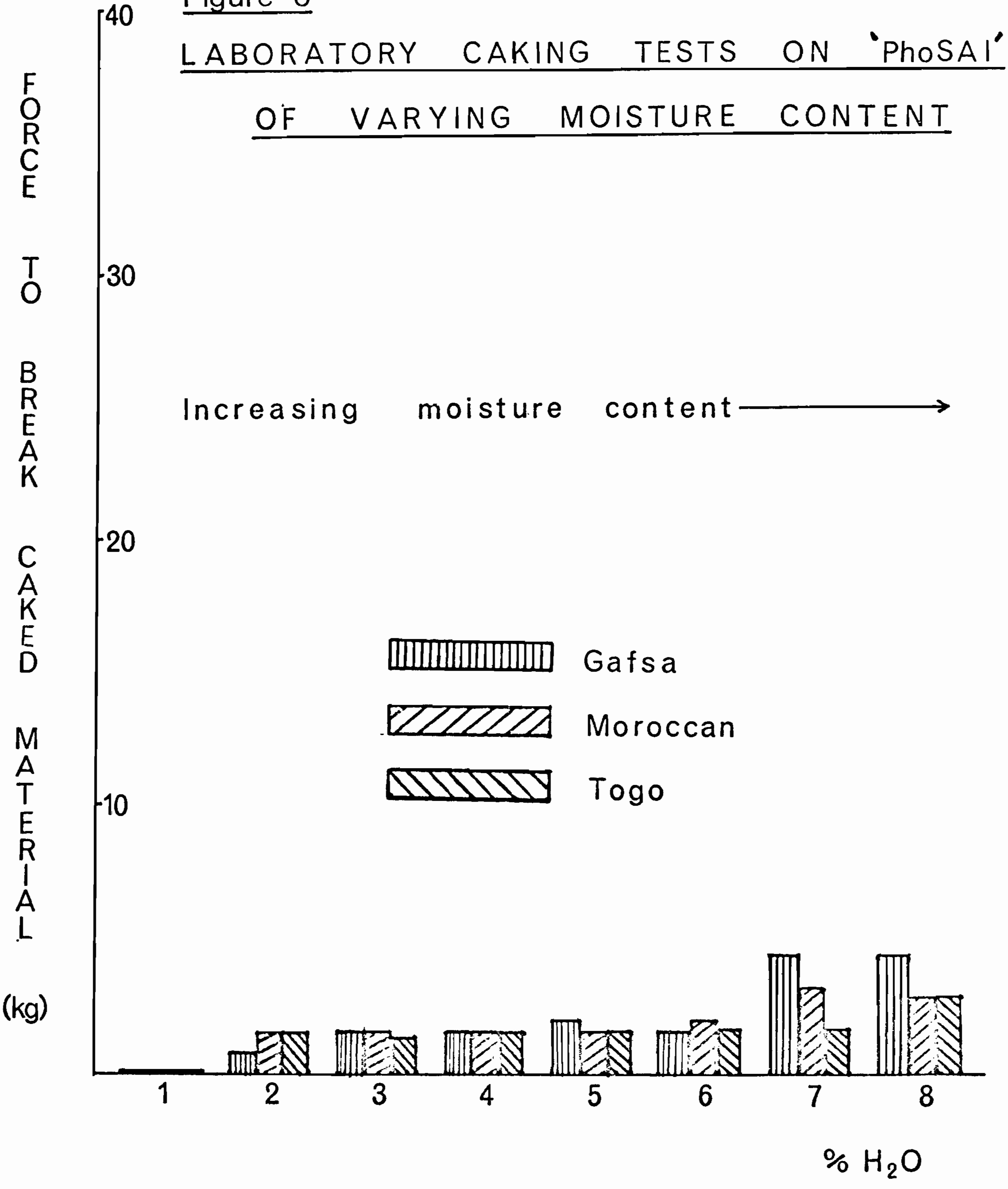


Figure 6

LABORATORY CAKING TESTS ON 'PhoSAI' OF VARYING MOISTURE CONTENT

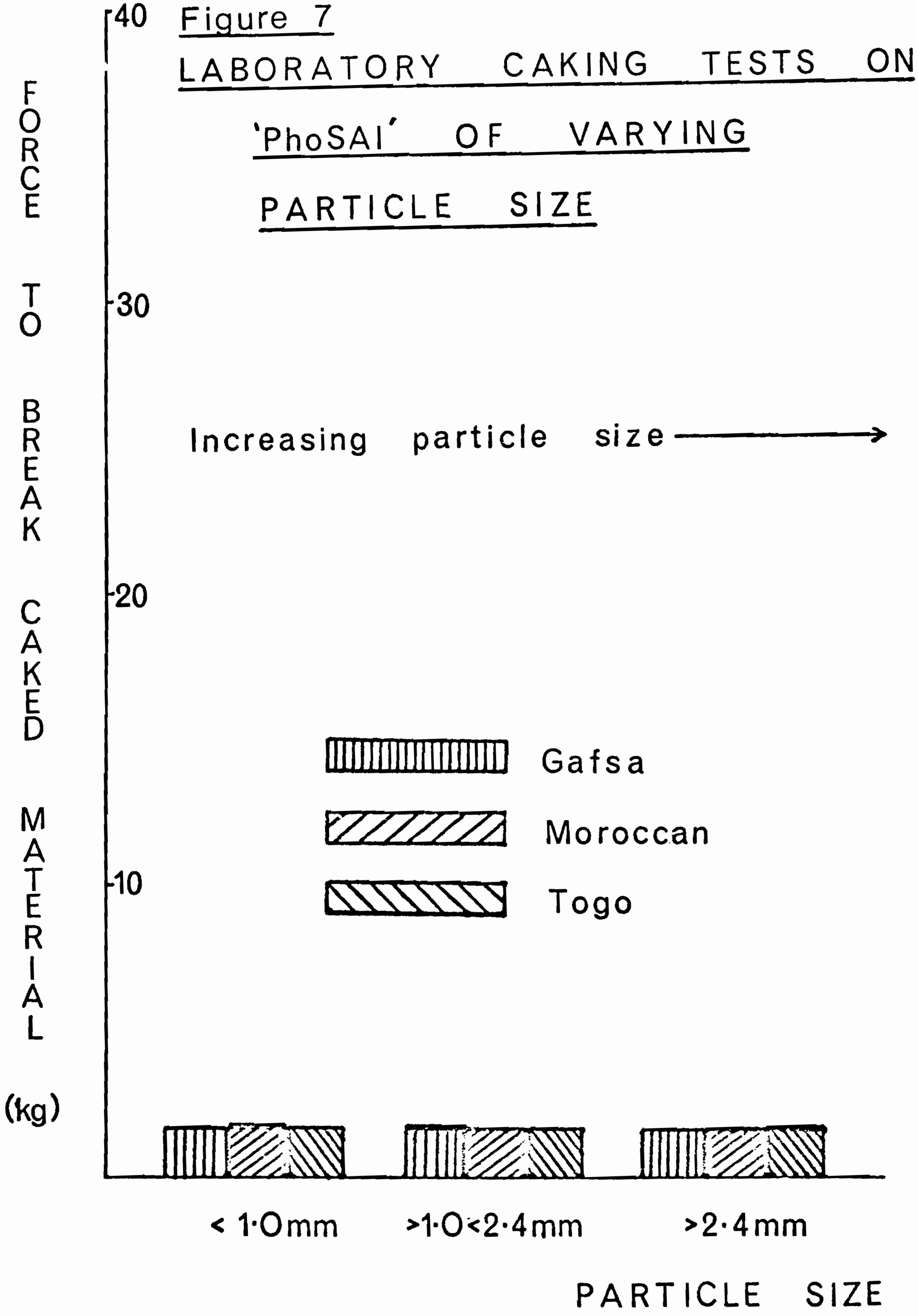
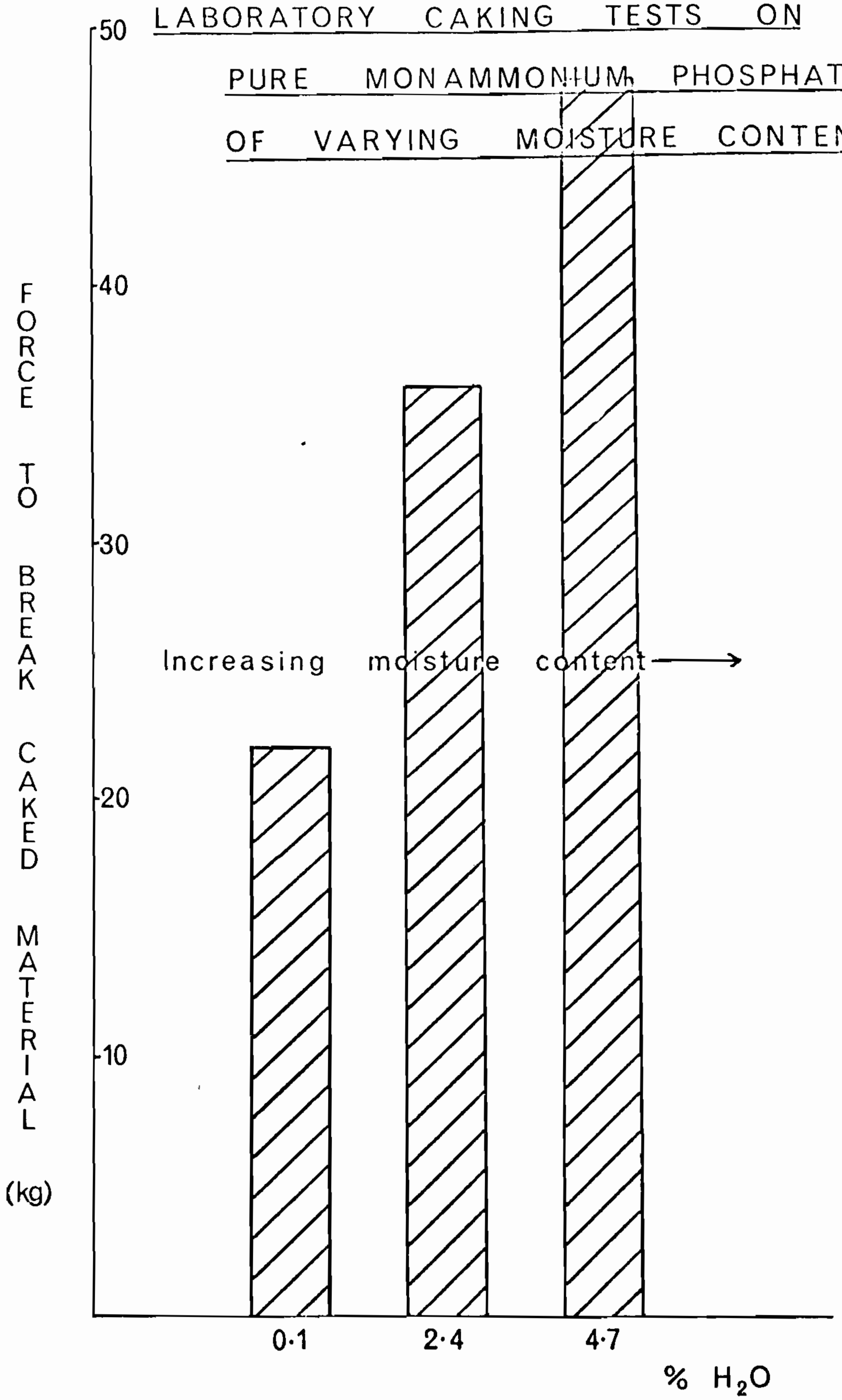


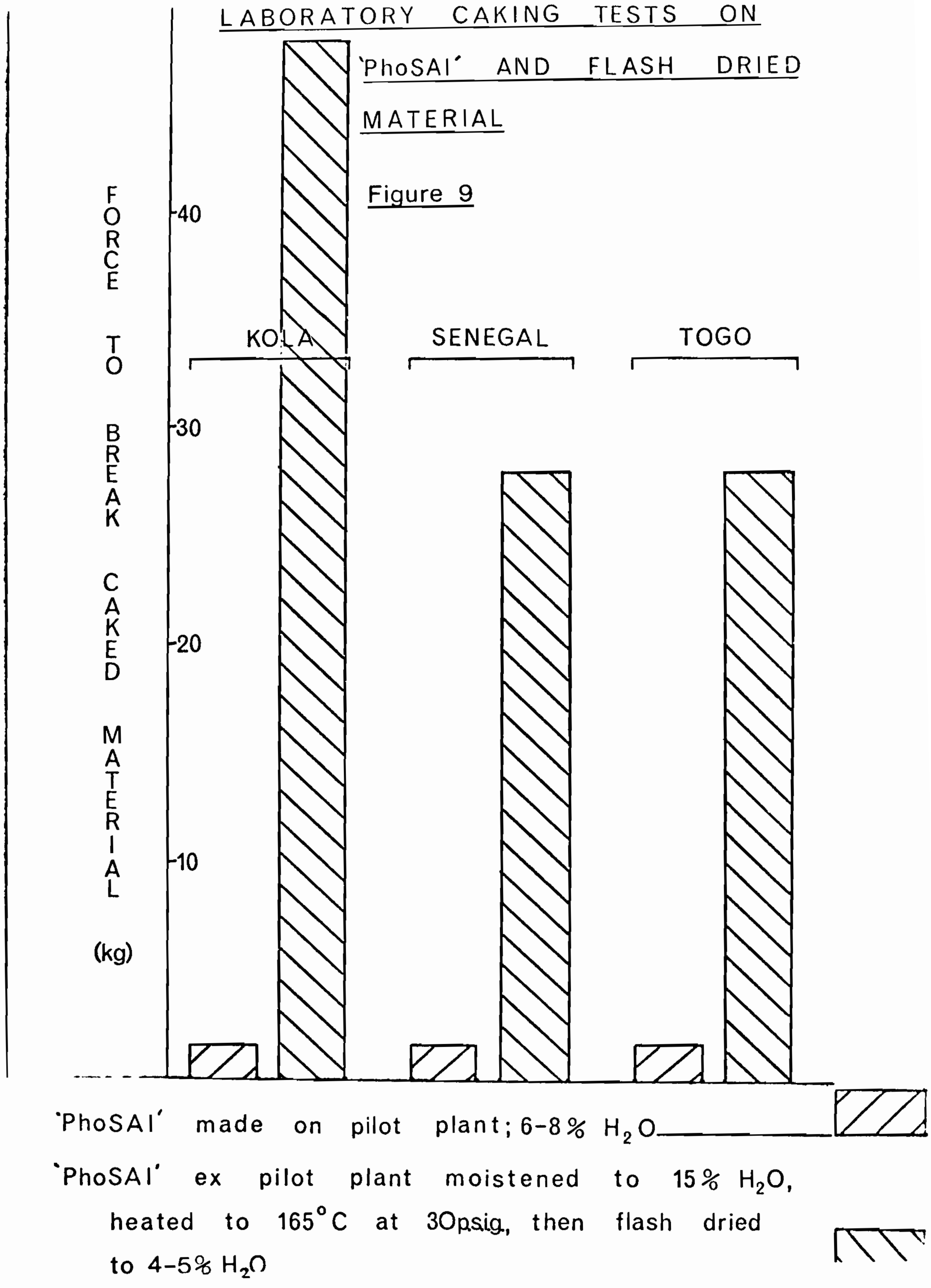
Figure 7

LABORATORY CAKING TESTS ON 'PhoSAI' OF VARYING PARTICLE SIZE

Figure 8

LABORATORY CAKING TESTS ON PURE MONAMMONIUM PHOSPHATE OF VARYING MOISTURE CONTENT





LABORATORY CAKING TESTS ON 'PhoSAl' AND FLASH DRIED MATERIAL

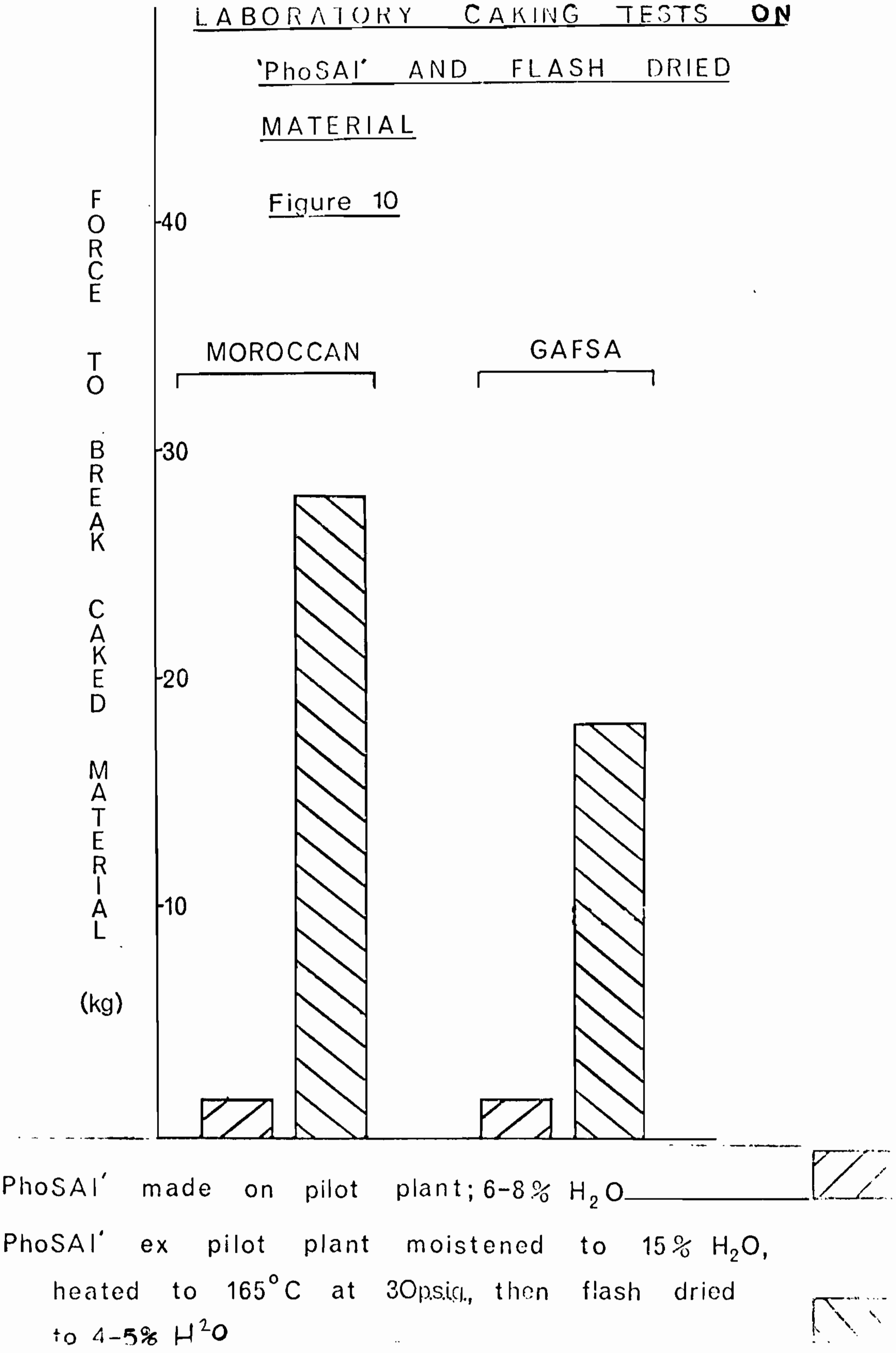
Figure 9

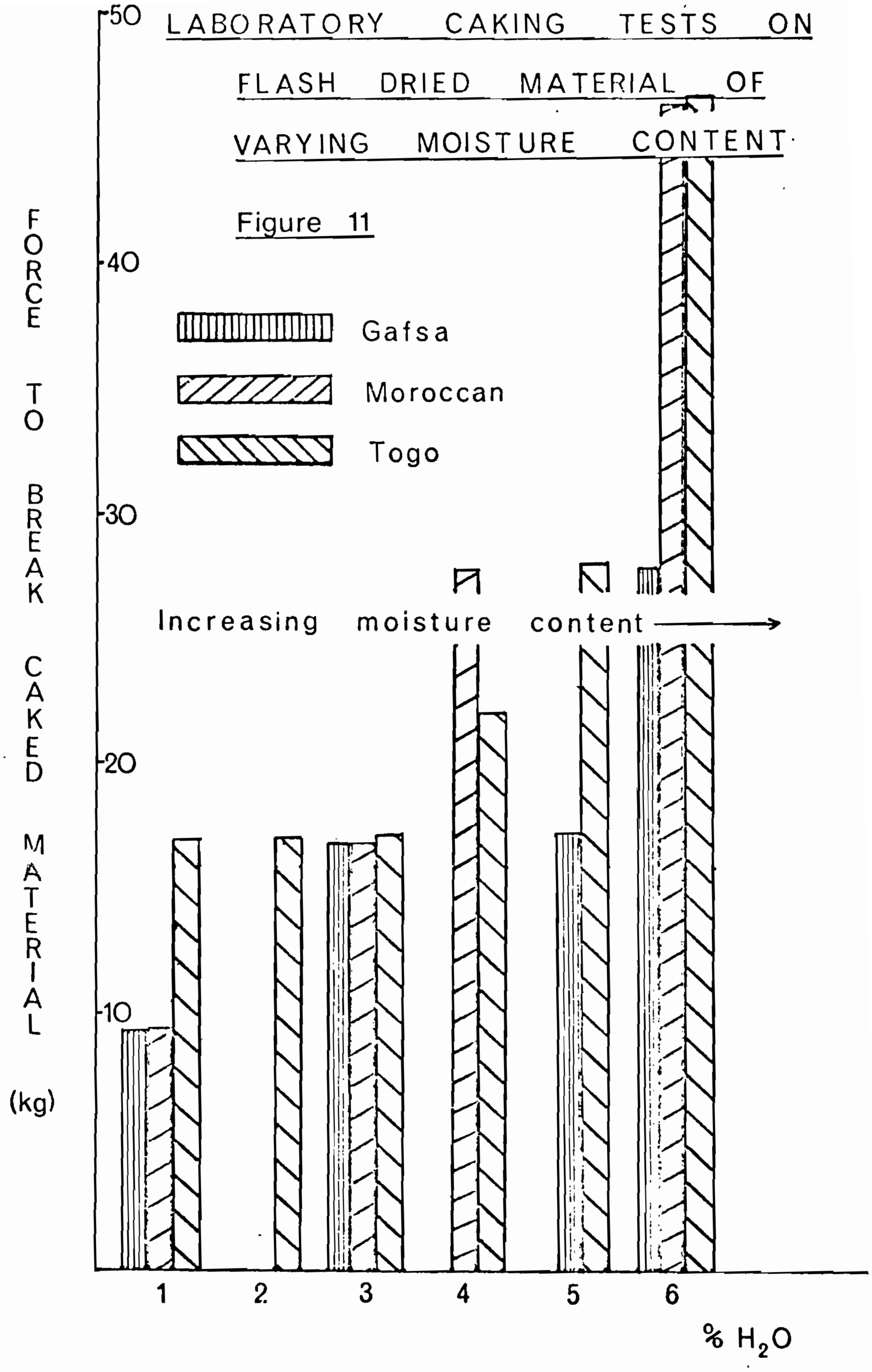
'PhoSAl' made on pilot plant; 6-8% H_2O ▨

'PhoSAl' ex pilot plant moistened to 15% H_2O, heated to 165°C at 30p.s.i.g., then flash dried to 4-5% H_2O ▧

LABORATORY CAKING TESTS ON 'PhoSAl' AND FLASH DRIED MATERIAL

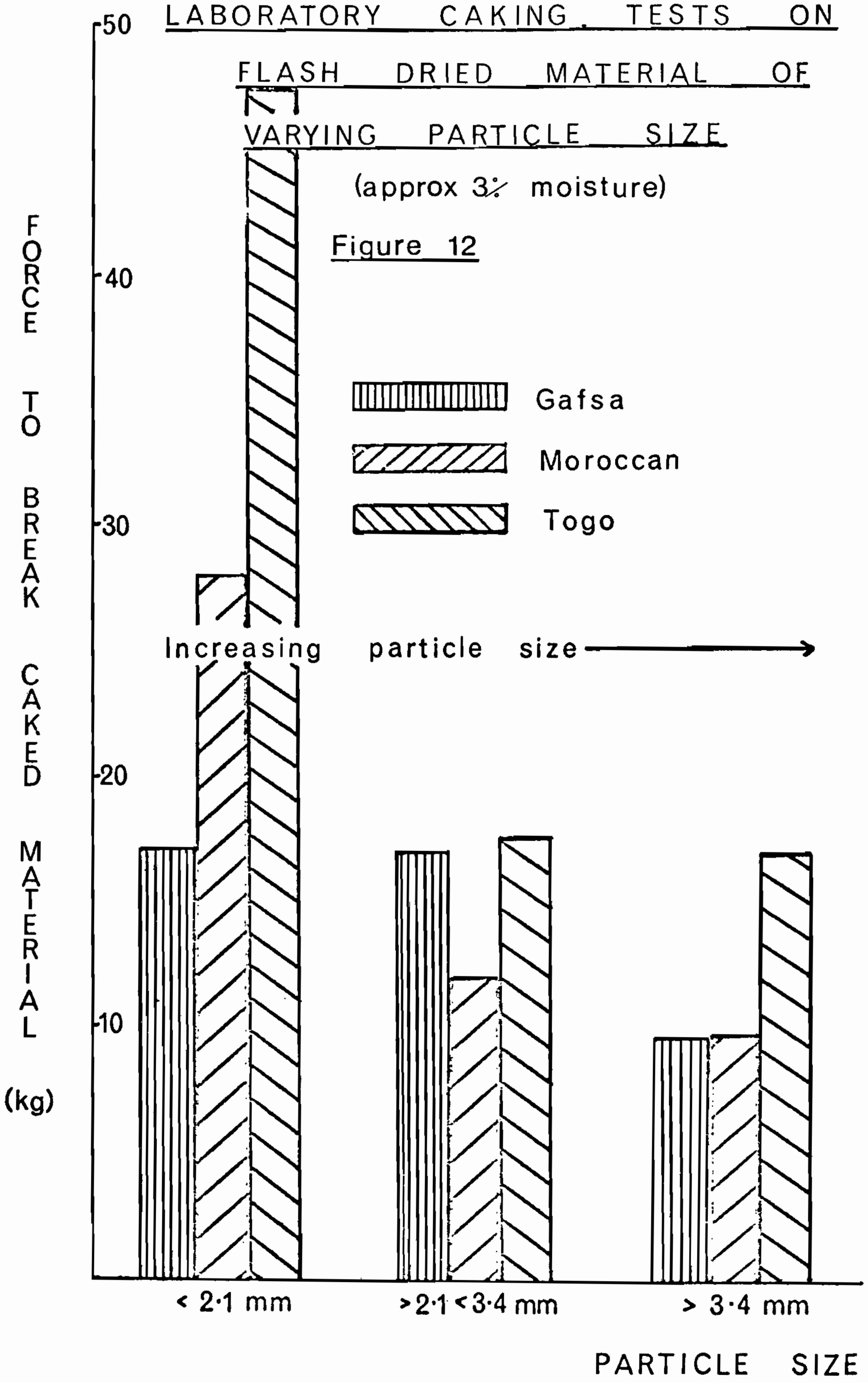
Figure 10





LABORATORY CAKING TESTS ON FLASH DRIED MATERIAL OF VARYING MOISTURE CONTENT

Figure 11



LABORATORY CAKING. TESTS ON FLASH DRIED MATERIAL OF VARYING PARTICLE SIZE

(approx 3% moisture)

Figure 12

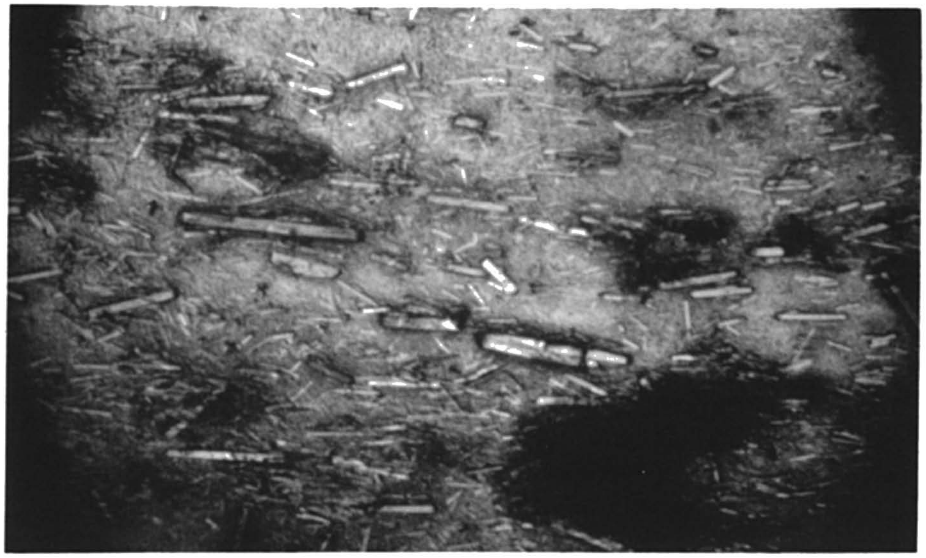


Figure 13
Map Crystals from
Wet Process Phosphoric Acid

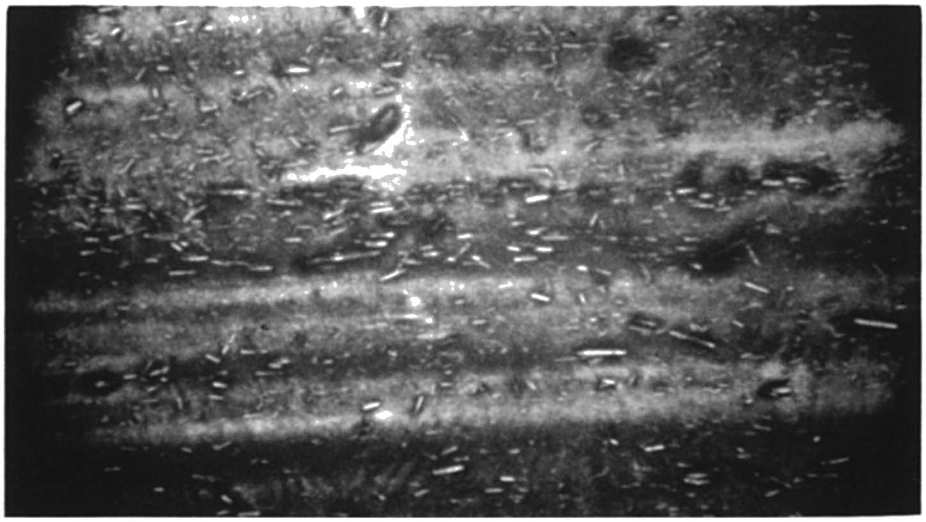


Figure 14
Map Crystals from Wet
Process Phosphoric Acid
(MgO increased by 0.2%)

Figure 15

VARIATION OF MAP CRYSTAL SIZE WITH MAGNESIUM AND FLUORINE CONTENT

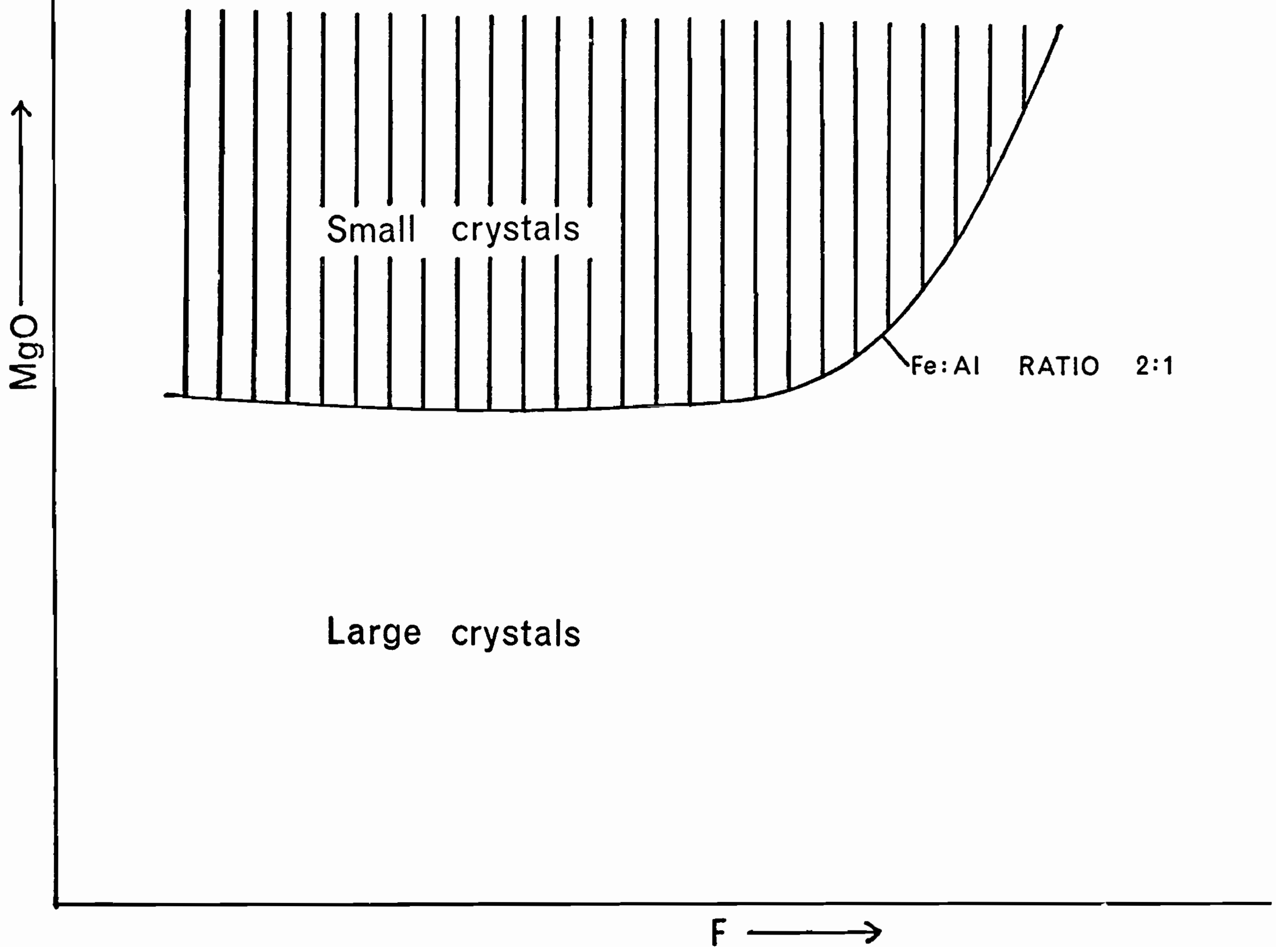
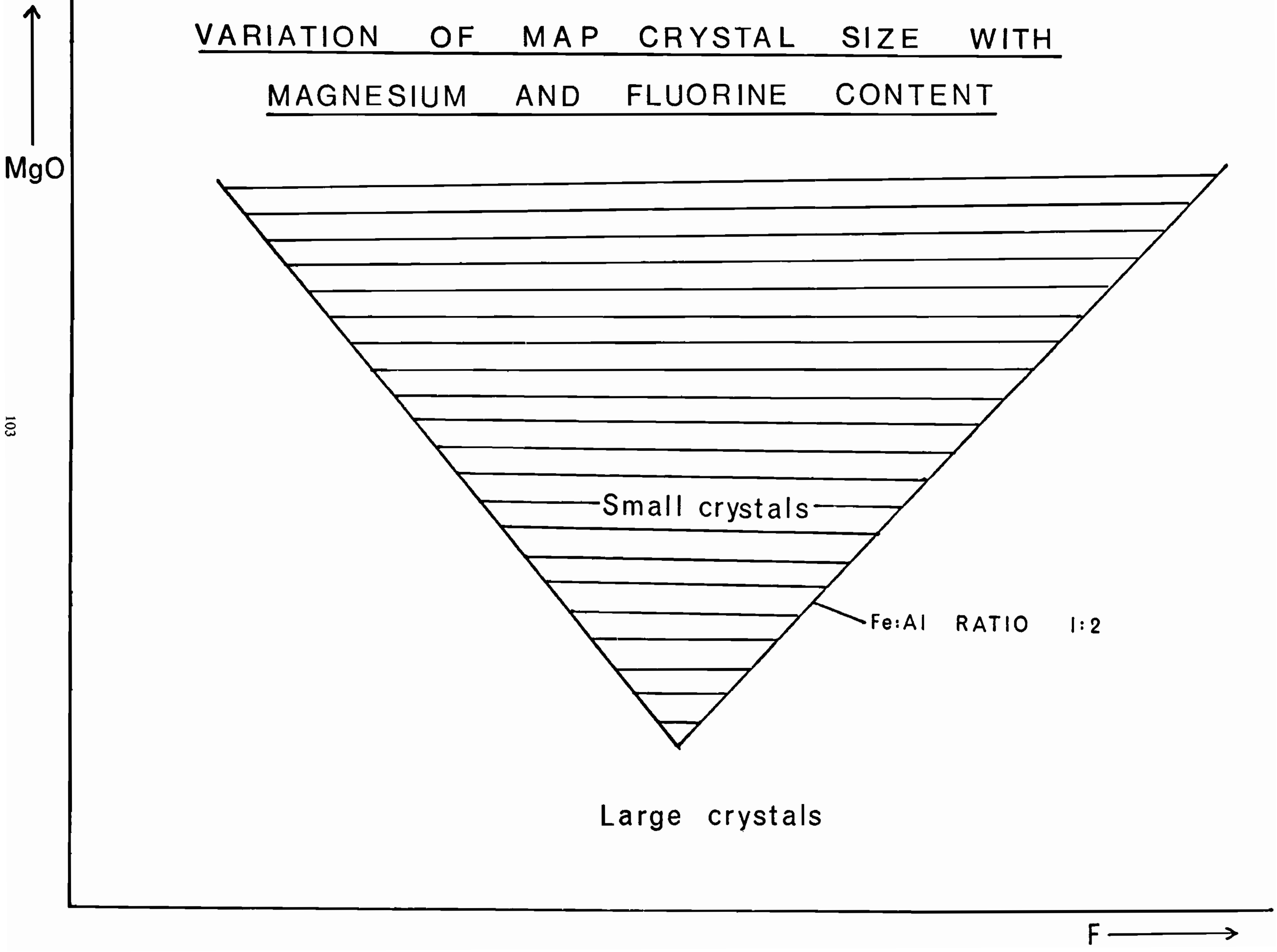


Figure 16

VARIATION OF MAP CRYSTAL SIZE WITH MAGNESIUM AND FLUORINE CONTENT



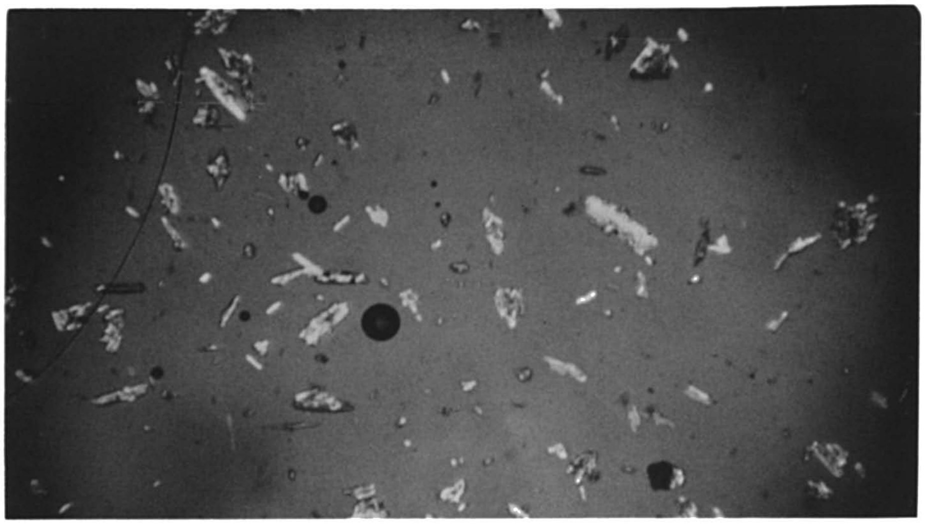


Figure 17
Senegal 'PhoSAI'
(Scale 2000 u x 1500 u)

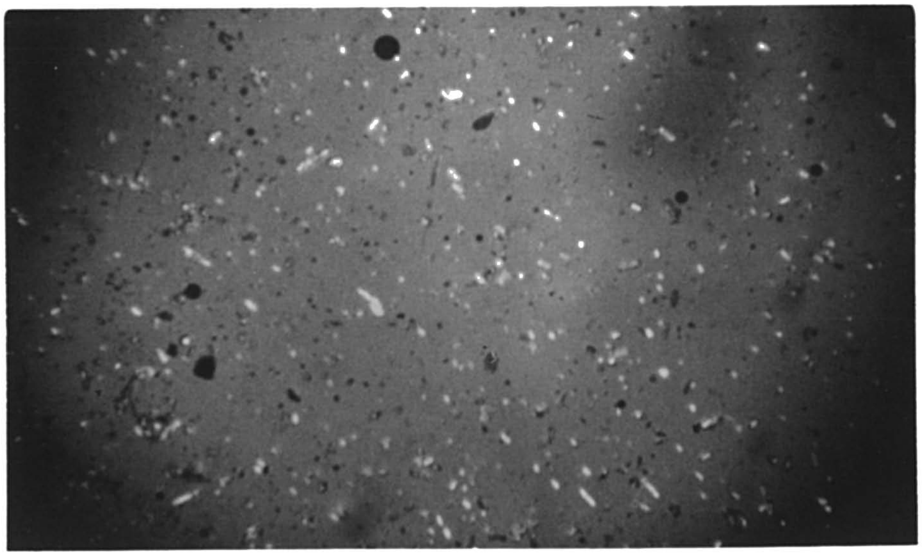


Figure 18
Morocco 'PhoSAI'

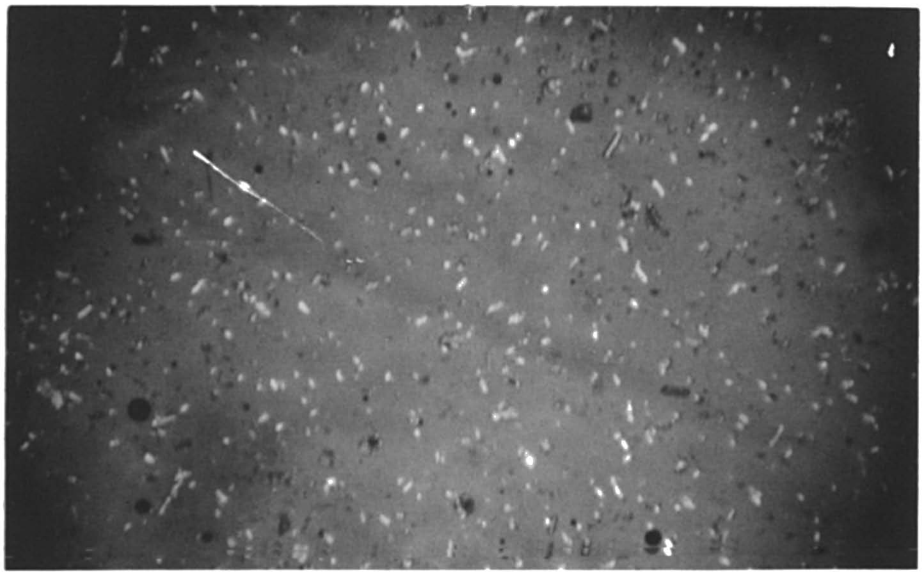


Figure 19
GAFSA 'PhoSAI'

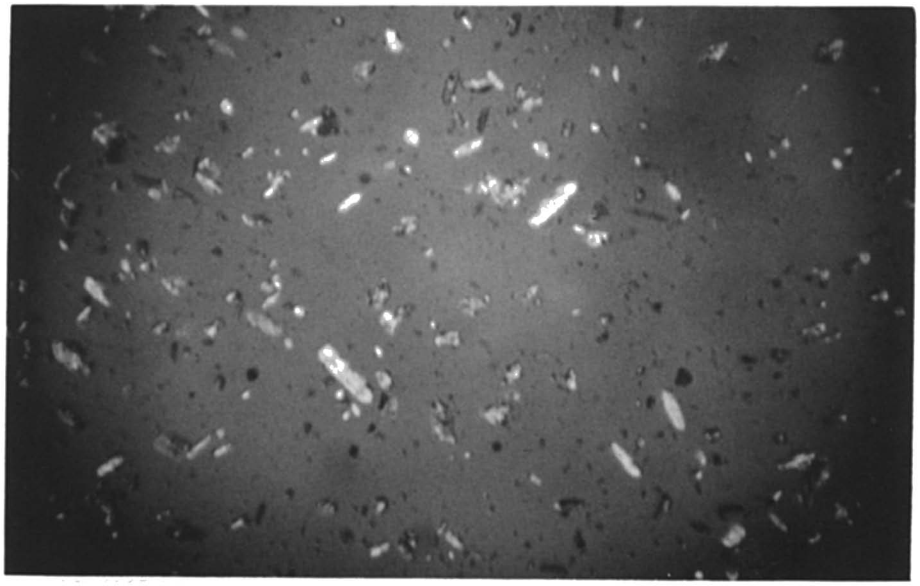


Figure 20
TOGA 'PhoSAI'

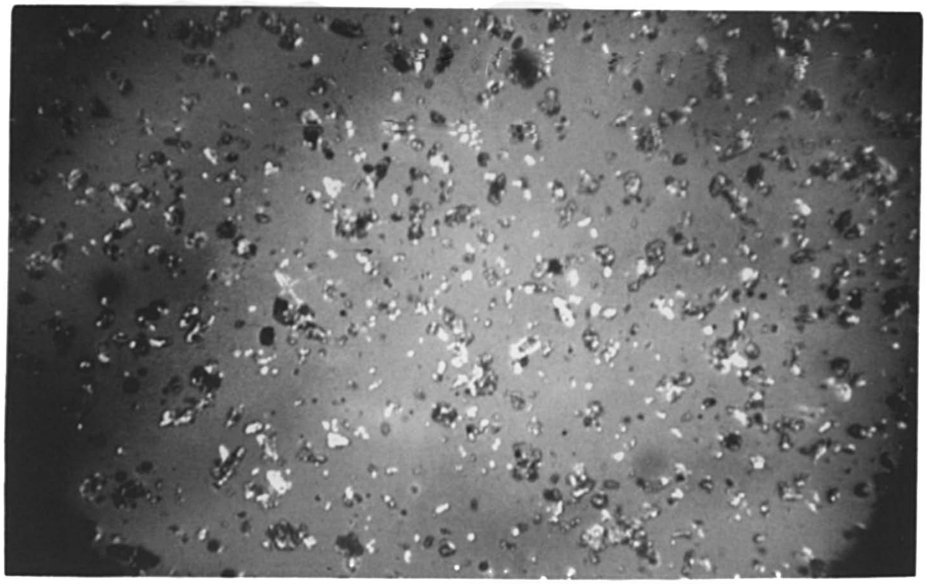


Figure 21
TOGO Flash Dried MAP

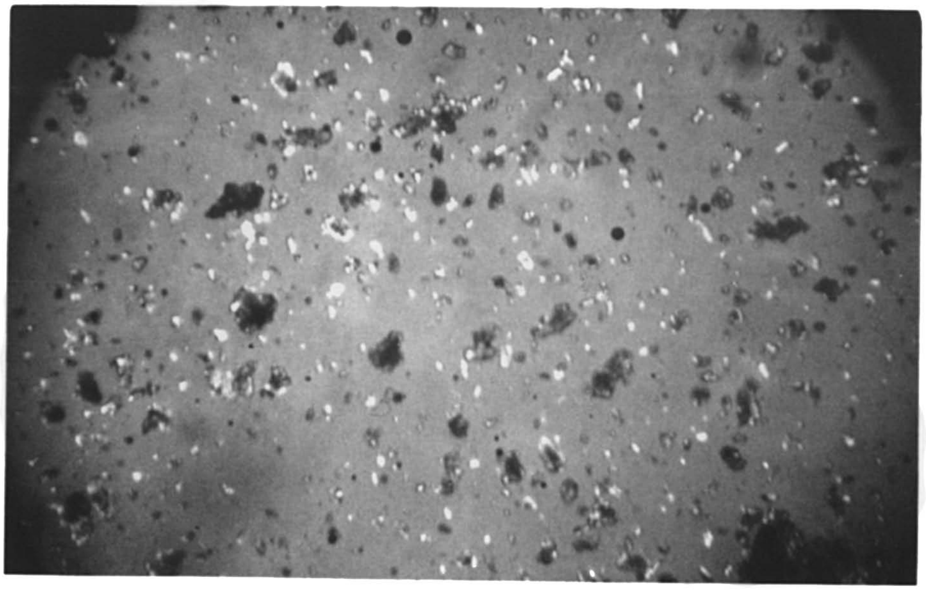


Figure 22
SENEGAL Flash Dried MAP

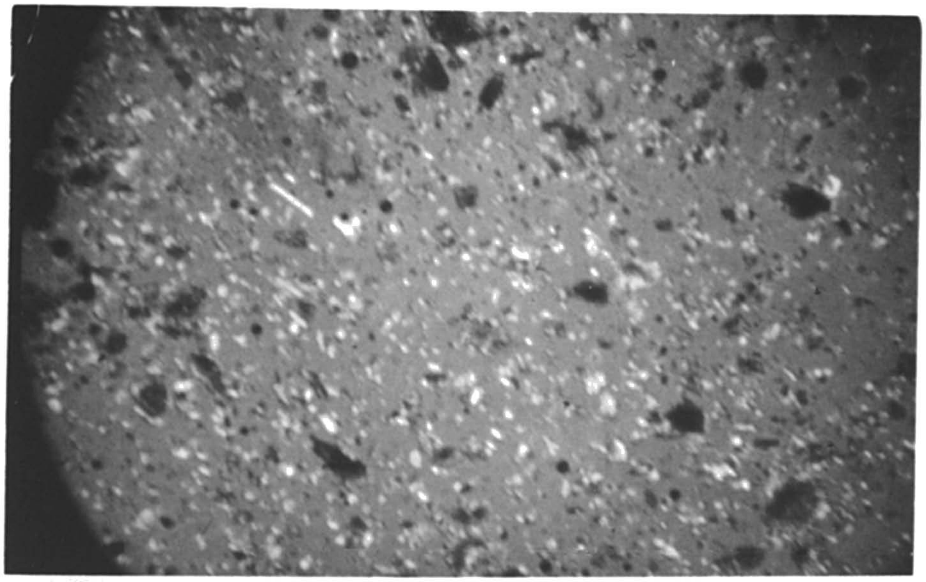


Figure 23
MOROCCO Flash Dried MAP

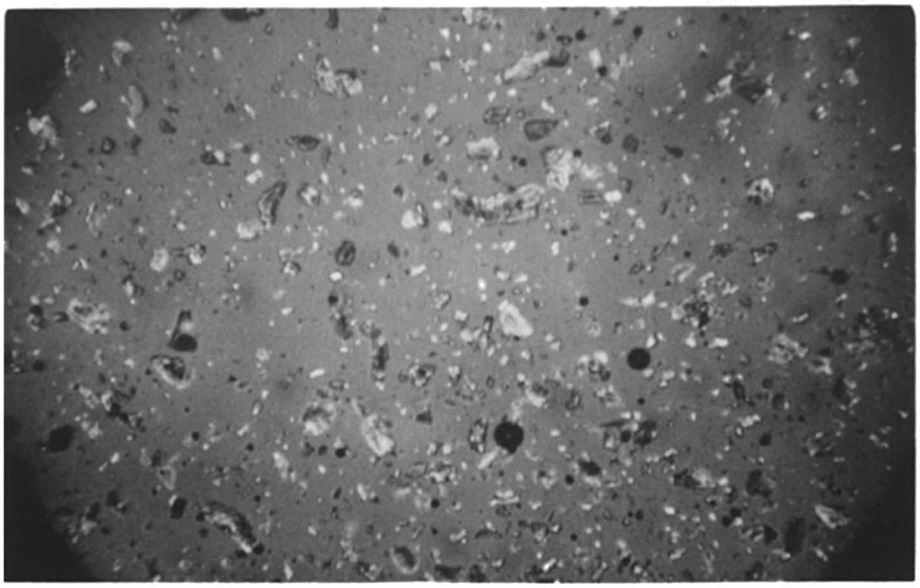


Figure 24
GAFSA Flash Dried Map

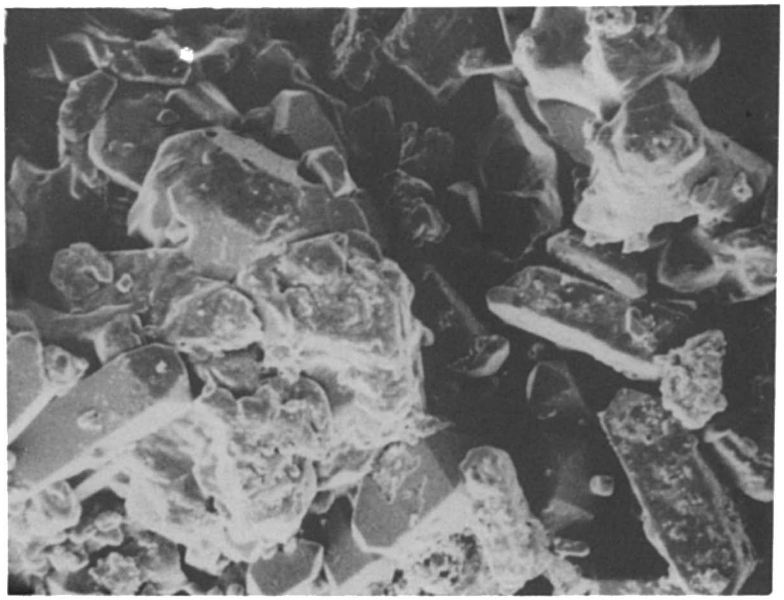


Figure 25
Electronmicrographs of SENEGAL 'PhoSAI'

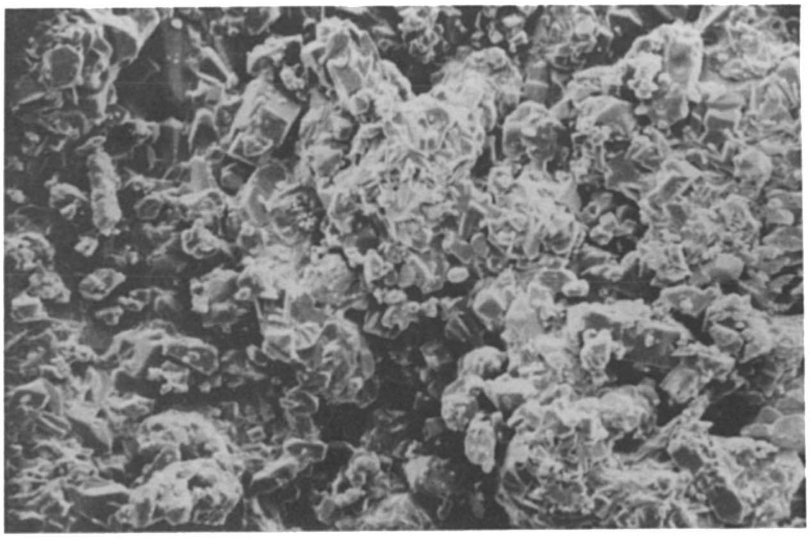


Figure 26
Electronmicrographs of GAFSA 'PhoSAI'

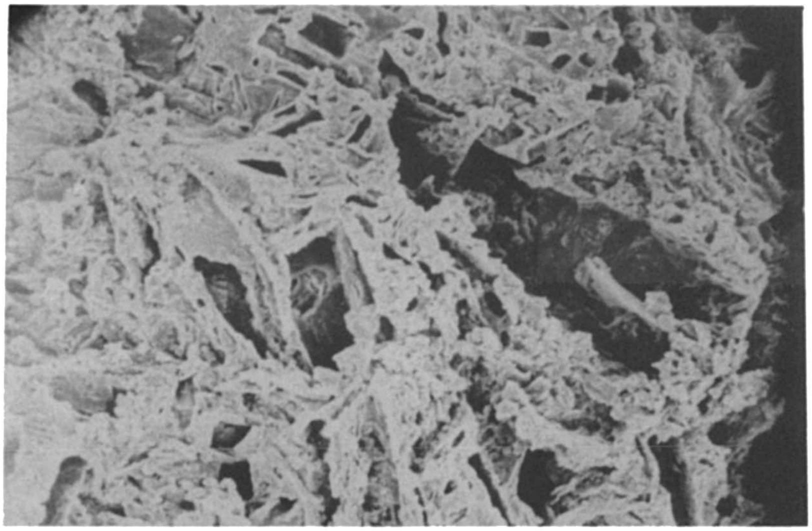


Figure 27
Electronmicrograph of GAFSA
'PhoSAI' Relic Structure

Figure 28
Electronmicrograph of
Florida/Jordan 'PhoSAI'

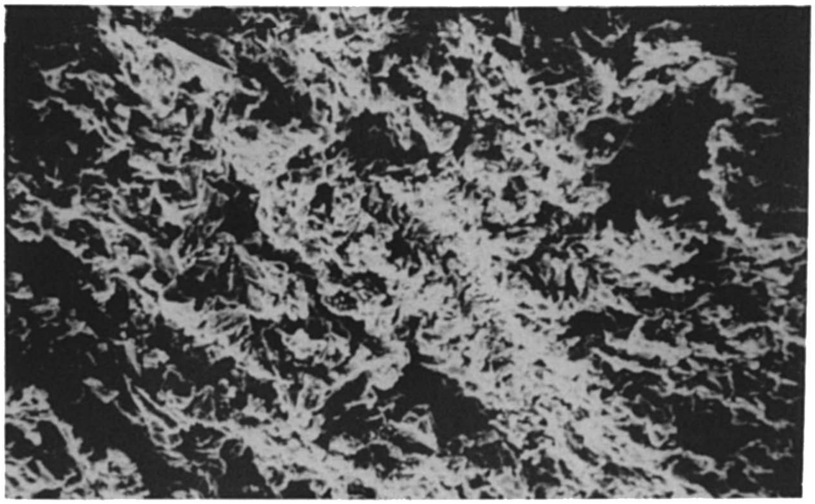


Figure 29
Electronmicrograph of
Florida/Jordan 'PhoSAI' Relic Structure

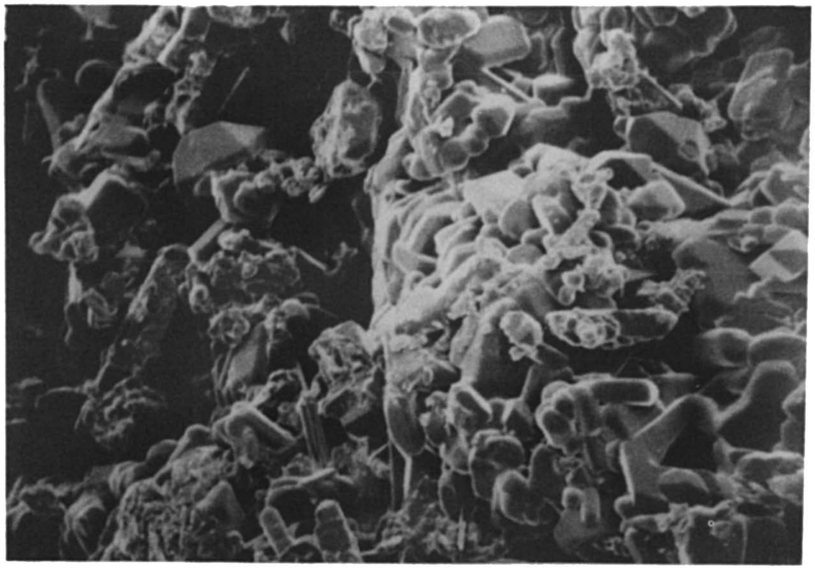


Figure 30
Electronmicrograph of 'PhoSAI'

Figure 31
Electronmicrograph of
Flash Dried MAP
(Derived from same acid as for Figure 30)

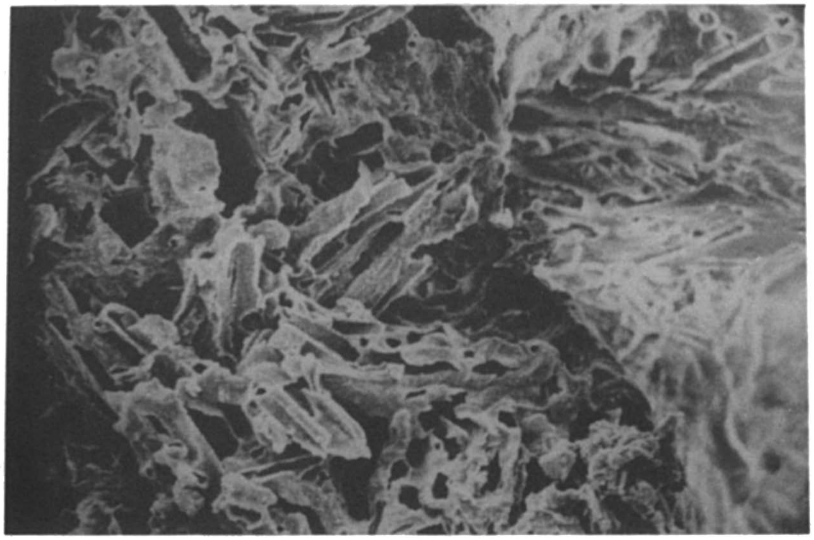


Figure 32
Electronmicrograph of Leached 'PhoSAI'

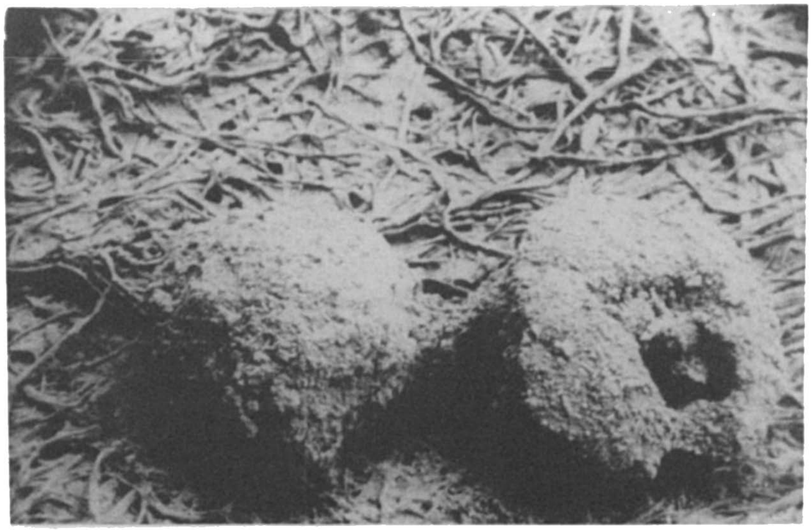


Figure 33
Electronmicrograph of
Leached Flash Dried MAP

MODERATOR ACHORN: Dr. Davidson and Mr. Martin: thank you so much for coming to our meeting this year and especially for bringing with you that outstanding paper - "The 'PhoSAI Form of Monoammonium Phosphate" and your slides and illustrations in great detail. You did an outstanding job when you were with us in 1964 on the two papers you discussed on the "PhoSAI and MAP Process". And you have done it again. Thank you so very much.

It is our pleasure to have with us a good friend, Mr. Earl L. Downen, Director of Project Planning and Development for F. S. Services, Bloomington, Ill. I have known Earl for a number of years and have known him to be a very good exponent and a good promoter of "Bulk Blending". I think Earl probably knows more about "Bulk Blending", which is probably our major marketing system now, and is continuing to show rapid growth.

EARL DOWNEN: Thank you Frank. It seems like this year has been a year when we have really taken bulk blending apart and spent a good deal of time talking about it. T.V.A. just completed, in August, a rather extensive seminar on Bulk Blending, on various phases of it, so I am not going to try today to spend a lot of time on technical details of bulk blending. Instead I will try to talk a little bit about what has happened in the Mid-West market and some of the things we see in the future affecting bulk blending.

The Practice of Bulk Blending N.P.K's Present and Future

Earl L. Downen

I want to begin by talking about the Illinois-Iowa market — what has happened here and then talk about the future.

We are most familiar with this section of the market and its development. it is the place where bulk blends started and developed to the dominant method of distribution. It is the heart of the area where a vast amount of capital has been invested in facilities. It is an area where adjustment in the marketing system is now moving rapidly.

The make-up of the market in 1972 by USDA figures was as follows:

Total Tons Sold —	5,851,301	**tons**	**% Total**
Dry Bagged Fertilizer —	646,600	”	11
Dry bulk Fertilizer —	2,784,500	”	48
Liquids —	2,096,200	”	36

the liquids are broken down as follows:

Anhydrous Ammonia —	872,500 tons = 59% N market.
Nitrogen Solutions —	465,000 tons = 12% N market.
Liquid Mixtures —	689,000 tons

(N in liquids — 4% — P_2O_5 — 11.8% — K_2O — 8.3%)

It is difficult to determine form the statistics how much of the dry bagged fertilizer and dry bulk is ammoniated N-P-K grades and how much is blended from granular straight materials.

By deductions from the statistics the dry bagged and dry bulk forms of fertilizer account for 25% of the total N, 88% of the total P_2O_5 and 91% of the total K_2O in 1972.

Some of the dry bagged fertilizers were blended and bagged in a blending plant. Some bulk materials were N-P-K ammoniated mixtures.

From the number of central mixing plants which have been converted to blending plants or closed down, it is evident that a high percent of the dry materials are going through the blending plants.

The first plants built specifically to blend product and sell it directly to the farmer appeared in the late 1940's after World War II. they were an outgrowth in Illinois of the bulk handling of rock phosphate. The farmer began to ask to have potash mixed and spread with the rock phosphate. This increased to include other materials.

In the 1950's blending of N-P-K materials became a dominant form of distribution in the midwest. During the 1960's the number of blending plants increased to about 1000 units each in Iowa and Illinois.

the 1970's now appear to be a decade of adjustment again. Some of the major companies have withdrawn from the market, ownership of many outlets has changed hands, many have closed. Emerging is the locally ownded enterprize whether it be cooperative or private ownership.

So much for the history — I would like to move to the future and talk about blending.

If we take the present philosophy prevailing in agriculture, we have to be optimistic that over a 10-15 year period agriculture begins to move more into an era when optimum production is the goal and that agriculture will be encouraged to produce all it can.

The size of the farm operation will continue to grow and management of these operations will continue to improve.

As the farmer goes to bulk handling of his starter fertilizer, he really does not care whether it is a blend or an ammoniated N-P-K grade. this blender does not want to tie up space for storage of ammoniated N-P-K grades; consenquently, the bigger farmer moves away from materials which have gone through the N-P-K mixing plant. Since the blender enjoys greater margins on the blends we can expect a greater volume to move through the blending plants.

As fertility levels go up, the timing and kinds of fertilizers are less important and can affect the operation of the distribution system more in the future than at present. For example, it is not uncommon today to find P & K soil tests in the midwest far above the recommended levels of P & K. On this land, we are no longer really concerned with applying P & K fertilizers every year or with plowing down P & K fertilizer. Except for extremely early planting, row fertilizer becomes unimportant. There are enough reserves to produce optimum yields. In many of these situations, we will be modifying our methods to an application of P & K every other year or every third year to compensate for crop removal to maintain the high level of reserves. This means higher rates per acre than now being used but less times over the land to accomplish the same results — more efficiency for the farmer and the dealer.

The present transportation dilemna will not disappear. Labor contracts with Guaranteed Annual Wage clauses and other high fringe benefits make it difficult for any industry to really cope satisfactorily with SEASONALITY.

The railroads and trucking industry will be hard pressed to provide adequate equipment for movement of product on an even monthly basis — seasonal movement will be difficult to come by.

In the midwest, one of the biggest problems facing the trucking industry is to provide enough drivers to keep all of the ammonia bottles rolling during that 10-day period when every dealer wants to turn his inventory 1½ times every day. No one knows when it will happen. We are moving in the direction of the same kinds of problems on solutions and dry products as we go to increased intermediate storage points on the water and pipeline.

The successful blender will recognize that he will have to provide enough storage of the products which he distributes to be ble to take delivery on an equal monthly basis throughout the year. the lowest cost transportation system will operate on this basis — the uncertainty as to when the product will move is at retail where the flexibility must exist to supply the customer when he can take delivery.

Volume of products to be handled will increase substantially at the same market penetration level. In spite of the high level of available P & K in many midwest soils, there are still many acres which require substantial quantities of P_2O_5 and K_2O to bring them to optimum yield levels. As these fields move into strong management hands, these levels go up rapidly. furthermore, if the political atmosphere continues to put emphasis on agricultural exports, more acres will go under row crops and average yields will continue to climb creating an increasing demand for P & K. Nitrogen will be used on pasture lands in increasing quantities as well as the higher rates on row crops. Because of the locations of future nitrogen production, urea appears to be the carrier for increasing quantities of nitrogen available to the market. Even in the midwest where ammonia now supplied as much as 59% of the total nitrogen, we see the growth taking place as urea rather than ammonia. As we handle larger volumes and need to store more product, blend plants will increase in size significantly.

This will increase the capital requirements for the business operation. Who is going to supply this? Traditionally the good dealer has been the one who supplied a greater portion of his capital. Will the basic supplier industry get back into the business of supplying capital and product? To operate successfully is going to require more capital.

Mixtures will contain more than N-P-K. In addition to these elements, micro nutrients such as zinc manganese, copper boron, etc., will be included where needed. TVA has published the procedures to stick micro nutrients to granular fertilizers. This procedure, although not popular, will probably be used when micro nutrients become critical and need to be properly dispersed. In some areas sulfur will be added.

The addition of pesticides to dry fertilizer has only begun to be exploited. There is no real reason why a broad range of pesticides cannot be applied as effectively with dry fertilizers as with liquid fertilizers. It will require some attention to product quality and spread patterns, both subjects which are long overdue in the industry.

What are the other opportunities? In southern Illinois, a great deal of the wheat is now blended with N-P-K mixtures and broadcast on the land with the fertilizer spreader. The seeding rate is increased ½ bushel per acre and the seed is then disced or harrowed in after broadcast. As chemical weed control becomes more precise, maybe we will be combining fertilizer, herbicides, m icro nutrients and seed corn into one broadcst operation?

Product Quality — As we talk about these various combinations and supplying the N-P-K needs, we must become concerned more with product quality. We are well aware of the needs of the industry but have been a long time in coming to grips with it. The current discussions going on in the potash industry have been encouraging. The announced production of Agrico and CF Industries of urea processes to produce granular urea which meets the needs of the industry indicates greater concern on the part of the supplier industry.

Air Pollution is another consideration which the industry faces. It now appears to us that we are well on the way to meeting these requirements through the production of dust-free products. Recent work by some of the suppliers with dust suppression coatings have been helpful to the basic supplier in meeting air standards at warehouse transfer points as well as providing the dealer with products which can be handled without the heavy investment in air pollution control equipment. Equipment will become more sophisticated at the blending plant. As plants increase in size, the daily demand for product increases, requiring more capacity to blend and ship to meet the highly seasonal needs of the farmer.

In the early days of blending, product was moved to the farm and applied by custom spreader trucks. From here we moved to the 4-6-8 ton pull-type spreaders which the farmer pulled behind his tractor to apply product. Some blenders have concluded it is less costly to deliver the product and spread it for the farmer than it is to leave the spreader and go back and pick it up. We are now seeing a trend back to custom application. As we add the pesticides, micro nutrients or other services with the fertilizers, the move will accelerate.

The Big Floater and High Flotation trucks are now popular but present some real problems. They are over legal width and lack the flexibility of the truck to move product. Much of the future in movement of product hinges on the legislatures. The industry has had special exemptions on much of its equipment. The present move to Federal guidelines on highway safety will probably remove some of these exemptions in the future. This could mean higher license fees and higher investments in safety equipment. The long term answer appears to be trucks to move product on the highway to the farm and then a combination of specialized equipment at the farm for spreading or trucks equipped with spreading devices.

In summary, we believe that farms will continue the trends of the past — that is, to get larger, to substitute capital for labor and to be concentrated into the hands of strong managers. These people will have a better understanding of their crop-input requirements and will utilize them to produce optimum results.

These managers will not be as concerned about who the dealer is, how he parts his hair, etc., but will expect him to provide them with seeds, fertilizer, pesticides and other crop production inputs and services which he decides he needs.

Phosphates and potash fertilizers will be applied every two or three years in quantities which will maintain a high level of fertility. Newly acquired lands will be brought rapidly up to these standards. More solid nitrogen carriers, such as urea, will be used to supply the nitrogen requirements.

The farmer will require more precision in the mixing and application of materials on his lands. He will expect the dealer to do more of this for him.

Blend plants will take product on a more uniform equal monthly basis and accumulate it where it will be used in order to assure the farmer that the product will be available when needed. The dealer will be under pressure to provide more of the needed capital for his operation.

His facilities will need to be equipped with mixing and service equipment to provide much larger quantities of material to be delivered per day. In some areas his facilities may not have rail service available to him so that all product will be trucked either from nearby railroads or river terminal points or both.

The mixing of minor elements, pesticides, sulfur, seeds, etc., in addition to N-P-K materials will be commonplace. He will be dealing with essentially dust-free materials in his operations.

The dealer will be forced to keep better cost records and price his services on the basis of his cost for that particular service. We believe he will be pricing his product on an F.O.B. basis with cost of the various services which he offers added to the invoice after the farmer has had an opportunity to decide what services he wants to provide for himself.

The people employed by the dealer will require more training and supervision to adequately provide the services which the farmer needs and wants.

MODERATOR ACHORN: We certainly wish to thank you Earl. I think we need more communications between those that work close to the "Use" and those that are close to the "Production" end. We are going to have to see to it that we have more of it at the Future Round Tables. I am sure we had planned to have some questions and answers for our Speaker this morning, however, we had a long session and are running late. I am sure all of our Speakers this morning will be around during the remainder of our 3 day program and will be happy to answer any questions you may have. Please contact them. Again thank you Speakers. Have a good lunch and return here by 2 P.M. We have another interesting discussion of major items this afternoon.

Wednesday, November 7, 1973

Afternoon Session
Moderators: Billy E. Adams and Wayne W. King

MODERATOR ADAMS: Our first discussion this afternoon will be by Borden Chronister. Since his retirement, from Allied Agricultural Division, Borden has joined A & L Agricultural Laboratories, Memphis, Tennessee, as an Agricultural Consultant. He is well equipped to discuss his paper on that "Most Important Subject 'Sulphur'".

Sulfur — It's Time Has Come

Borden S. Chronister

SURFUR HAS GROWN UP

Among the essential plant food elements, sulfur is the *Champion Piggyback Rider* of them all. For decades it has been carried along as the uninvited guest in our fertilizer and pesticide materials. It has sneaked into our soils through normal superphosphate, ammonium sulfate, potassium sulfate, dusting sulfur and other materials. It has performed a yeoman's service for the farmer, yet, because it was free, it has gone unnoticed and its need unregognized.

Times have changed. A new day has dawned for sulfur. Piggybacking has been sacrificed in the name of higher analysis fertilizers and organic pesticides. Consequently, sulfur is getting short in many of our soils.

THE NEED IS CRITICAL

It is fair to say that the need for sulfur in many areas is very critical and the deficient areas are growing, year by year. The cry for sulfur by our growing crops is still going unheeded to a great extent. Where this is the case, yields go down, crop quality is reduced and the farmer's profits are cut back. As I mentioned above, sulfur has been mainly a piggyback rider. It may get into the fertilizer end it may not. It just rides along on whatever sulfur containing materials that may be used in the mix.

Gentlemen, this haphazard application of sulfur can't continue to go on. The sulfur levels in our soils are falling too fast. We must have all the agricultural production we can get to continue to feed our growing population.

A recent report indicated that some progress is being made. Slowly, but surely the need for sulfur is being recognized on a much wider scale. The Sulphur Institute is working hard, through many channels, to help sulfur find its place in the family of plant nutrients.

SCOPE OF PRESENT DEFICIENT AREAS

Deficiencies are appearing with increasing frequency all over the United States. East of the Mississippi River, deficient areas are concentrated in the Coastal Plains soils of the South Atlantic States and the coarse textured soils of Alabama, Mississippi and Tennessee. In addition to these areas, sulfur deficiencies have been mapped in Wisconsin, Indiana, New York and Pensylvania. The coarse textured soils of the Mid-Atlantic states are showing severe signs of sulfur shortages. The atttached map indicates the areas where the most serious shortages are now located in the United States.

My company, the A & L Agricultural Laboratories in Memphis, Tennessee, processes thousands of soil and tissue samples each year. A check at the lab on Monday, November 4, 1973 indicated that 65 percent of all samples analyzed were low to medium in sulfur. In localized areas of the Southeast and in many other areas of the west, the percentage of sulfur deficiencies is even much higher than this.

SULFUR INCREASES CROP YIELDS

Yields of crops have been increased by sulfur fertilization in at least 30 U.S. states and five Canadian provinces. Some of the crops responding to sulfur applications are legumes, grasses, small grains, oilseeds, peanuts, cotton, sugar beets, sugar cane, tobacco, vegetables and field peas and beans. Although yield increases exceeding 1000 percent have been recorded, responses from 10 percent up to 50 percent are more common.

THE ROLE OF SULFUR IN PLANT GROWTH

In addition to increasing the yields of crops, sulfur plays many other roles in plant growth and crop quality. It is component of the amino acids, Cystine, lysine and methionine. As much as 90 percent of the total sulfur in plants may be present in these amino acids. Sulfur is required for the synthesis of chlorophyll and for this reason, it is understandable why sulfur deficient plants uusually lack the vigorous green appearance of healthy plants. Sulfur is present in ferredoxin which plays an important role in all photosynthetic processes in plants.

Sulfur serves as an activator for certain plant enzymes. Some vitamins, such as biotin and thiamin (B_1), and other important substances, like glutathione and coenzyme A, all contain sulfur. Sulfur is also important in the formation of nodules on legume plants and their ability to fix nitrogen from the atmosphere. We can readily see that sulfur is one of the greatest work horses in the realm of crop production as well as in crop quality. Farmers can no longer afford to disregard its importance in their crop production programs. It's status must be upgraded from that of an incidental piggybacking element to one of major importance.

the causes of sulfur shortages in the soil

In recent years, the amount of sulfur removed from the soil in grazed and harvested crops, and through leaching is greater than the quality being added. In order for us to establish a course of action, it is necessary for us to understand the reasons for this changing picture. To do this, one must first consider some of the ways through which sulfur has been added to the soil and what has been happening to these sources in recent years.

DECREASED USE OF SULFUR CONTAINING FERTILIZERS

Normal Superphosphate has been the predominate source of phosphorus in fertilizers for years and the principal base material for the manufacture of mixed fertilizers. the sulfur content of Super is about 12 percent, while the P_2O_5 will run about 18 to 20 percent. The normal rate of use for Superphosphate has, in general, been enough to take care of the sulfur needs. As you know, the use of Super in a mixed fertilizer has been chiefly superseded by higher analysis, more economic phosphate materials containing little or no sulfur. Consequently, this source of soil and sulfur has diminished and can no longer be considered adequate in the future.

Ammonium Sulfate for many years has been a common nitrogen source in mixed fertilizers, both bulk blends and in ammoniated goods. It carried 24% sulfur. It is still sporadically used depending on the price relative to other nitrogen sources. the availability is also sporadic; hense, another reason for our present soil sulfur shortage.

Potassium Sulfate and Potassium Magnesium Sulfate which are used in relatively small quantities constitute a good source of sulfur in areas where used. The scope of usage is small.

Concentrated Superphosphate, Dianmonium Phas phates and other materials now in wide use have had most of the sulfur removed. Most liquid fertilizers are formulated from high analysis materials and contain very little sulfur.

LESS ATMOSPHERIC SULFUR

Most fuels that are used for heat, power and transportation are fossil fuels and contain some sulfur. Coal smoke is especially high in sulfur. Now, under programs sponsored by the EPA, most all sulfur is refined from petroleum products. Other campaigns to reduce air pollution are taking the sulfur from coal smoke and restricting further the atmospheric supply.

DECREASED USE OF SULFUR CONTAINING PESTICIDES

Dusting sulfur and other sulfur containing materials such as lime-sulfur have been widely used as pest control chemicals, and at one time were the most widely used fungicides. Residues from these dusting and spraying supplied considerable sulfur to the soil.

In recent years, newly-developed organic pesticides have been replacing sulfur and sulfur-based formulations. Another reason sulfur is short.

GREATER CROP REMOVAL OF SULFUR

Crop yields have been on the increase everywhere due to the use of more fertilization, better plant varieties and other improved farming practices. This means that more of all plant nutrients, including sulfur, are being removed from the soil each year. this is another reason that soil sulfur is short. This means the long time trend is for greater sulfur consumption.

It is an "eye opener" to many people to know that the crop requirement for sulfur is almost as great as for phosphorus. this fact has not been taken into consideration in the manufacture of complete fertilizers, as a general rule. Our fertilizers today, manufactured with high analysis materials, do not contain the needed sulfur.

To more graphically point out the need for sulfur, the amount removed from the soil by several crops is given below:

CROP	YIELD/ACRE	POUNDS SULFUR REMOVED	POUNDS P REMOVED
Corn	150 bu. grain & stalks	25	40
Cotton	2 bales — seed, lint & stalks	20	24
Wheat	60 lbs. — grain & straw	15	19
Alfalfa	5 tons	25	23
Coastal Bermuda	6 tons	20	32
Soybeans	50 bu. beams & straw	22	27
Cabbage	20 tons	25	35
Tobacco	2,000 lbs.	15	10
Peanuts	3,000 lbs.	20	14

The information above will give some idea of the magitude of the sulfur requirement. In most cases, the sulfur requirement for a crop is almost as much as the requirement for phosphate (elemental basis). Who would think about trying to grow a crop without adequate phosphorus? As the reseves of sulfur in our soils go down, there will be a steady rise in the demand for sulfur by farmers over a wide area of our country.

SUGGESTED PROGRAM OF ACTION

It is of utmost importance that everyone in the fertilizer industry be concerned with the efficient utilization of plant nutrients. Shortages are already a reality, especially niitrogen and phosphates. No doubt, there will be other shortages coming along in the future. Every pound must be made to serve a good purpose.

There is only one answer to this problem. It is simply this. A prescriptionized fertilization program for all crops. this can be done by a complete soil analysis and the use of tissue tests. Apply only the plant foods that are needed in the proper balance — no more or no less. Presently, there are millions of dollars spent for certain nutrients that are not needed and other millions lost because of the lack of sufficient nutrients to feed the crops in the correct balance. A complete soil test will point out the low stave or staves in the barrel and will recommend corrective action. A yield can be no higher than the level of the lowest stave in the barrel.

As fertilizer manufacturers, plant operators and technical service representatives, you should take the necessary steps to insure that your Management is aware of this sulphur problem and that all field representatives and dealers are equipped to take soil and tissue samples so that the sulfur problems as well as other imbalances may be corrected. You will save your customers a lot of money and make a lot of friends.

SCOPE OF POTENTIAL DEMAND

The magnitude of the potential demand for sulfur in crop and forage production in the next decade is staggering. Millions of acres of crop land are already mapped as sulfur deficient and other millions are on the borderline.

Below is a list of the South Atlantic States and Albama along with some of the principal crops grown. these figures should give us some idea of the sulfur potential in this area:

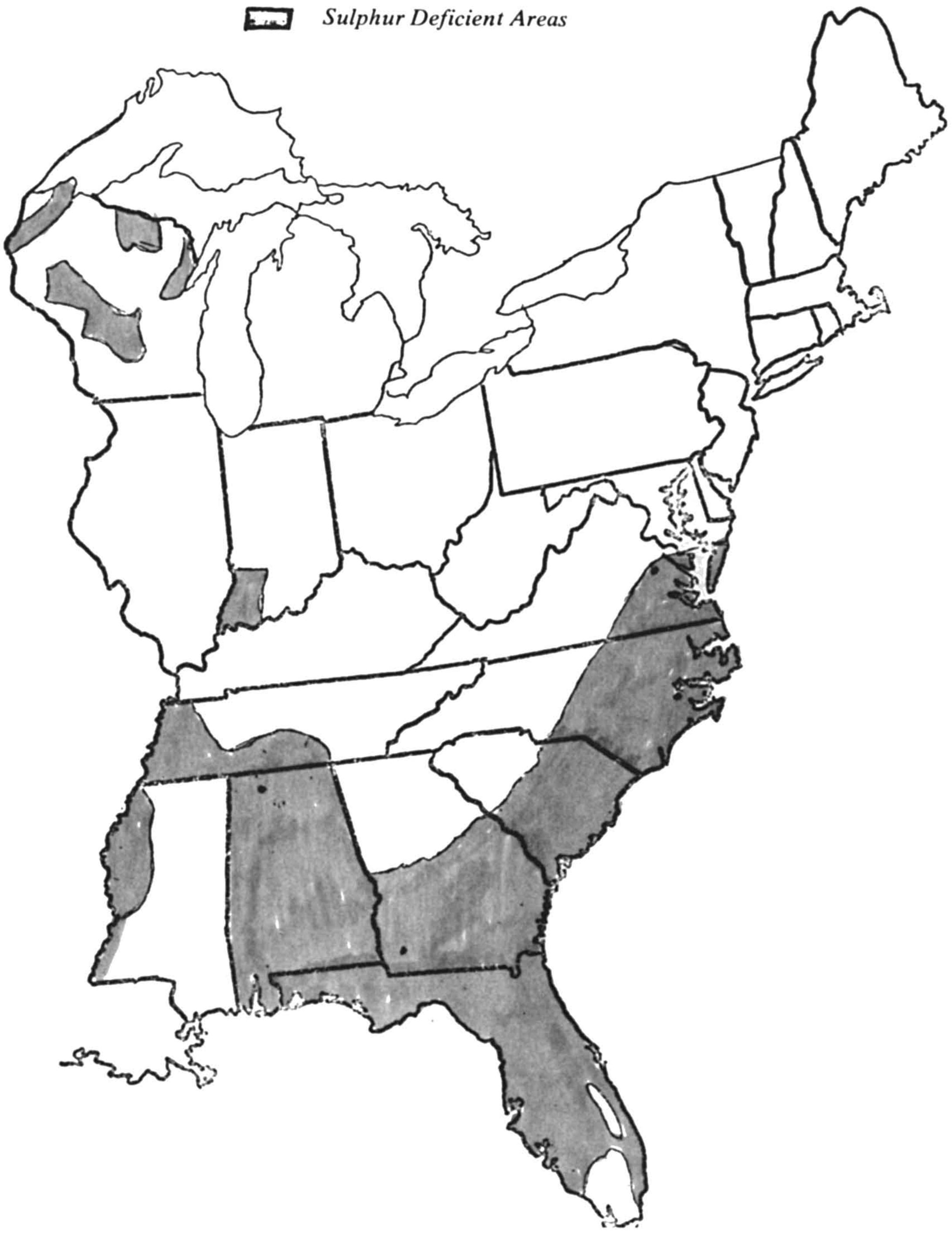
STATES — ACRES OF CROPS

CROPS	N.C.	VA.	S.C.	GA.	FLA.	ALA.	ACRES NEEDING S.
Corn	1,489,600	636,000	429,000	1,478,000	335,000	570,000	2,962,000
Cotton	165,000	4,300	290,000	380,000	12,000	540,000	1,391,000
Soybeans	876,000	339,000	997,000	528,000	184,000	609,000	2,473,000
Peanuts	164,000	102,000	13,000	507,000	51,000	189,000	1,026,000
Coastal Bermuda	80,000	10,000	300,000	900,000	175,000	400,000	1,865,000
Citrus	———	———	———	———	150,000	———	150,000
Truck	23,000	25,000	10,000	———	75,000	———	133,000
							10,000,000

It is estimated that each acre of these crops needing sulfur would require the addition of approximately 15 pounds of sulfur per acre per year for good production. Based on the acres listed above, the sulfur potential in this group of states alone is approximately 75,000 tons, equivalent to 300,000 tons of Amthio.

Gentlemen, sulfur for crop production is here to stay. Its use will be growing. We should learn the technology of incorporating it in both dry and liquid fertilizers. With 10 billion people to feed by the year 2000, we have no time to lose. With a united effort, we can get the job done.

Thank you for your kind attention.



MODERATOR ADAMS: Thank you Borden for your excellent, down to earth and thorough discussion on "The Importance of Sulphur Requirements Now". I think I will dust a little "Sulfur" in my drink tonight because of "Importance it seems to be"!

Our next Speaker is a graduate of Texas A. M. University. He has a BS in Chemical Engineering. He also attended the University of Pittsburg. His professional activities are: American Men of Science, American Chemical Society, American Institute of Chemical Engineers, Professional Engineer, Chemist club of New York, Who's Who in the East and many, many more Professional Activities. The Gentleman, Mr. Norwood K. Talbert, Director of Environmental Quality and Engineering, Agway Inc., Syracuse, N.Y.

A New Dimension In The Business World Environmental Quality and the Fertilizer Industry

Norwood K. Talbert.

Thank you very much Billy for that kind introduction. It is a real pleasure for me to be here today. I have been an "Ecologist" for about as far back as I can remember.

In this day and age of ecological experts, it has occured to me that speakers on the subject should be required to state their qualifications. To support this concept, let me give you some of my qualifications with the expressed hope that you will pardon the personal reference.

I have been an ecologist for as long as I can remember — personally and professionally. One of my earliest recollections was accompanying my father to the potato patch when the potatoes "had to be dusted". In an entirely manual operation, he would put several pounds of aresenic dust in a used flour bag and with short, abrupt, vertical "shakes" of the bag over the bug-infested potato plant, sprinkle the arsenic on the plant, and, I suppose, the bugs, too. It was my pleasure to take an empty bottle along and see how many potato bugs I could catch and put in the bottle while he was applying the toxicant. I was practicing good ecology; my father was not.

I can also remember shoveling the manure dumps around the barnyard and stacking it in a covered open-sided shed for drying and later spreading on the fields. As you recognize, when manure is dry there is very little odor and, of course, recycling is the "in" thing — so I was practicing good ecology. Occasionally, however, my brother would spread some "damp and ripe" manure on the fields and get a few odor complaints from the neighbors — he was a bad ecologist. But the ducks and chickens who used to follow the cows as they grazed practiced "instant recycle" — they were the best ecologist of all around the Talbert family farm.

Let's skip a few years and stop in the early 1950's. As a young chemical engineer, I was involved in the development of a process for the production of "Lindane", the game (active) isomer of benzene hexachloride. As it turned out, the good Lord structured the chemistry of benzene hexachloride such that for each pound of active gamma isomer produced, there were four pounds of inactive isomers. I observed that the political and legal interest involved in project commercialization were considerably more interested in knowing how long before the project would be commercialized than in finding an ecologically acceptable way to dispose of the inactive isomers. When will the plant be in operation? How long before the payroll starts to pump income into the town's economy? It was a lonesome problem for the young chemical engineer — a concerned ecologist — and, by a strange turn of the screw, a member of a profession that other professions like to target as an ecological scapegoat!

While you may think I am biased if I go from those personal observations to the generalization that chemical engineers, because of their intimate responsibility in the processing industries, have been aware of environmental abuses resulting from short-sighted or incomplete economic analyses, I do think that you will agree with me that the ecological movement has reached an emotional and political climax within the past several years, particularly, in the Clean Air Act and Federal Water Pollution Control Act amendments. Just today, I was reading in the November, 1973, issue of *Environmental Science and Technology,* it is estimated that we are going to have to spend $272 billion to comply with present mandates: $120 billion for water, $40 billion for solids, and $112 billion for air pollution, with all kinds of exclusions and contingencies in those figures. I also read in the same issue that "EPA" has eased some of the sulphur oxides standards after reviewing the initial bases for setting those economically-sensitive standards. along with these current observations, it is to be noted that, according to a news release, the Air Pollution Research Center is launching a $2 million *panic* program to study the observation that the automobile catalytic exhaust converters proposed for use on automobiles may result in pollutants even more dangerous than the original pollutants which they were designed to remove. And, cyclamates may be coming back after having been suddenly removed from the marketplace after 20 years of use without, as I understand it, a single documented human injury or illness. Even some DDT uses are being touted. Perhaps running that old ammoniator may not be so bad after all when we look at some of the moving targets other industries are required to hit! I want to make this point: some very important "Legislative and Regulatory Actions" have been based more on emotion and, perhaps expediency, than on sound economic and scientific principles.

We don't want this to happen in the "Fertilizer Industry". and we must be vigilant to emotional and arbitrary inroads. It seems to me that this wonderful Industry, so necessary to our national well-being with its basic tie-in to food production, does not deserve to be boxed in just as it is emerging from a half-decade of economic despair. In this age of consideration for our natural resources, it seems to me that the "Fertlizer Industry" is poised to move our "Nation" into the position of capitalizing on it's greatest natural resource — food production from a God-given soil nurtured in a God-given climate — an *unlimited* natural resource (made more abundant by fertilization) — a resource to be felt, tasted, savored, and always in demand. Box it in'? Never. I say "Let her rip!"

We, in the "Fertilizer Industry", might listen advisedly to what Lynn Townsend of Chrysler Corporation had to say as that corporation, along with the other automobile manufacturers, struggled with implementation of the Clean Air Act, an extrememly difficult struggle for a public corporation operating in a free capitalistic system where rewards are placed upon research and development through a patent system:

> "Perhaps everyone has concentrated too much on the question of how these standards are to be met instead of raising the more relevant question, "Why should they be met?" In the light of . . .; we believe the country is headed for an economic and technological confrontation which nobody needs or wants and which would do nothing for the cause of clean air."

While we cannot even begin to get into the *very serious,* but not so obvious, implications of "research and development by government fiat", we can dig a little deeper into what pollution is all about and perhaps sharpen and simplify the perspective.

We do only three things in this country:

1. Convert one material or substance into another material or substance. For example, iron ore into steel, sand into glass, crude oil into plastics and synthetic fibers, nitrogen of the air into fertilizer, etc.
2. Convert one energy form into another energy form. For example, oil or coal into electricity, gasoline into the kinetic energy of moving vehicles, natural gas into chemical explosives.
3. Perform services to support the first two.

And nothing else.

I am sure that it is obvious to this rather sophisticated audience that there are some fairly fundamental laws of nature that prevent us from carrying out those conversions with 100% efficiency and that these physical limitations result in geometrically increasing costs as we strive for 100% conversion (or "zero" pollution). Finding that economic optimum is what industrial chemistry and engineering are all about. What has happened historically is that by and large an infinite set of economic optimums has evolved based on the key assumption that there is no negative value to leftovers; "the environment is a free dumping ground."

Now society has come to a new and simple resolve that the environment can no longer be a free depository. Although we are having a very difficult time communicating that simple message politically and professionally, the conclusion that we must find new optimums is inescapable. This presents a different and vitally important concept; it is truly "A NEW DIMENSION IN THE BUSINESS WORLD." Each of our almost infinite conversions must now find a new economic cutoff point that will equilibrate within a delicate and extremely complex technical-economic balance.

The dilemma now before us is that we have legislated a regulatory solution to a problem derived from an infinite set of parameters which can only respond to an economic incentive approach. To continue on the present approach will be to lose our nation in a legalistic mire that is tantamount to what might happen if we suddenly tried to adjust our income tax laws to a basis that regulated not only by quantity, but by source (or activity) generating the income. Can you visualize such an impossible situation?

Let us illustrate the economic incentive approach by two examples. First, take the automotive exhaust problem that is generating corporate and professional schisms never before seen in the United States. Suppose, government would say to the automobile manufacturer, "We do not know exactly how damaging each of these pollutants are to society but we do know that, in general, the more pollutants emitted, the more damaging they are to society. The air is no longer a free dumping ground. Effective a certain date, you must pay society, in the form of an effluent fee, an amount based upon the toxicity of the material and the amount emitted. And, we sure hope you wind up competitive."

Wouldn't that be a great day for the free enterprise system. And can you imagine the response! Right now, if we had followed this approach from the beginning, it is my humble opinion that our competitive system would have already produced engines with greatly reduced environmental emissions.

Take another example — at the other extreme. Suppose the Federal Government had followed the economic incentive approach and had enacted legislation that would have prmitted it to say the local municipality: "Mayor, the trout stream is no longer a free dumping ground for your raw effluent and effective a certain date, we will be imposing a fee upon your community based upon the quantity and type of discharge." Can you see that Mayor scrambling for engineers *to solve the problem!!/* The economic incentive approach is result-oriented — diametrically opposed to the beaureaucratic approach. It is a "normal" capitalistic approach. It is my opinion that such an approach would create a vast array and concentration of opportunities never before encountered in our country. After all, we never before set out to change an infinite set of economic optimums.

To continue on the present approach is dangerous. Regardless of vested professional and beaureaucratic interests, America must face up to some emotional miscues.

Let's get after those new opportunities created by the "new dimension in the business world."

MODERATOR ADAMS: Thank you Norman Talbert for your down-to-earth frank discussion. I am sure, when the "Proceedings" covering this three day meeting are printed and delivered to our Membership, they will read your message a number of times to be sure they have digested the awareness of your "Positive Comments." I agree with you that "Legislative and Regulatory Actions" cannot be based on "Emotion and Expediency" rather than on "Sound Economic and Scientific Principals" using your words, which are so emphatically correct. And, I thank you again for your "frankness".

The remainder of this meeting will be taken care of by my good friend Moderator Wayne W. King.

MODERATOR KING: I just had a double "gin cocktail" — Hydrogen and Oxygen. I asked the Chairman what they wanted me to talk about and he said "3 minutes"! I will condense all that I wanted to say because the messages will come direct from the "speakers".

Our next speaker, Rick Renninger, is a long time and very close friend of mine. He is Director Technical Services, National Crushed Stone Association, and is a Graduate Engineer from Rennsselaer Polytechnic and George Washington University.

Experiences With Fugitive Dust Problems In the Crushed Stone Industry

F. A. Renninger

Several months ago Wayne asked me about discussing this subject at your round Table Meeting this year and to pass on to you some of our experiences in the "Stone Industry" with regard to "Fugitive Dust Problems."

I have attended several of your round Table Sessions during the past ten years and at one of the meetings I talked to your group about "Air Pollution Problems" in the stone industry. Some of the problems in the stone industry are about the same as in The Fertilizer Industry and some of the problems in the fertilizer Industry are substantially different from the crushed stone industry. In either case I am sure that both the Stone and the fertilizer Industries are always on the alert to try to eliminate, by careful study, air or plant dust problems, pollution, etc.

Just in the way of background I would like to describe to you, generally what the Stone Industry produced in 1972 (1.6 billion dollars worth of materials or about 922 million tons of rock products.)

EDITOR'S NOTE: At this point, by error or by misunderstanding, the tape recorder stopped operating. Apparently the operator was under the impression that Mr. Renninger was discussing his paper from a prepared talk and that this would finally go into the records. Mr. Renninger advised that he discussed his entire message from short notes and had no further record. Sorry.

MODERATOR KING: Thank you Rick. I appreciate your message. You know in our trade we refer to Rick as the fellow that does his crossword puzzles in "ink".

Now we come to another fellow here. His people and I have been associated together for many, many years. His name is Jack Nuttal. He is from Salt Lake City, Utah. He is a CSP which means "Certified Safety Professional", Manager of Occupational, Safety and health, Envirotech Corporation. Prior to his affiliation with Envirotec he worked as Safety Engineer for Hercules, Kennecott Copper and American Smelting and Refining. He currently serves as President of the Utah Chapter of the American Society of Safety Engineers and is a member of American Industrial Hygiene Association. He has also served as a Director of the Society for the Prevention of Blindless. He is a native of Salt Lake City, Utah, and has had many years experience as Safety Engineer in the Western Mining Industries. Now, Mr. Nuttal will you take over. Thank you.

Occupational Safety & Health
What do you do when The "OSHA" Man Arrives?

J. A. Nuttall

GENTLEMEN: It is a pleasure to be here today. My topic is "What to do when the "Osha" man arrives. I am sure that you people have Safety-Engineers, Safety Inspectors, Safety directors, Corporate Safety Managers, or What Have You and that they are all familar with "OSHA".

In beginning my discussion of "OSHA", I would like to identify what OSHA applies to. OSHA applies to any manufacturing operation, to any construction work and to agricultural work. It applies to any trade and service activity. It even applies to any office of any company whose business affects interstate commerce. Yes, you cannot go into the drug store and buy anything without entering a premises that is covered by this law. You cannot drive your car into the corner gas station, unless it is a small operation that is operated by the owner and only by the owner, without entering premises covered by the law.

The law, as it is written, imposes more duties on the employer than it does on the employee. As far as employers are concerned, there are two duties that are imposed. One is known as the general duty, that is, to maintain "A workplace that is free of recognized hazards"; and a specific duty, which is to be in complete compliance with all standarrds, rules and regulations that are promulgated under this act.

There is a very significant difference between the duties that are applied to the employer as opposed to those that are applied to the employee. Under the law, violations as far as employers are concerned are subject to some very stringent penalties. However, there are no such provisions written into the law for penalizing employees. Many of you may be asking yourselves why not penalize the employee just the same as the employer.

Employees are required by the law to obey all standards, rules or regulations that have been established by the employer and that apply to their jobs. Enforcement of safety rules is part of the responsibility of the employer.

The importance of safety rules should not be minimized in the context of the employer's duty to furnish a safe work environment. If the employer would avoid being cited under the general duty clause, he must necessarily enforce his safety rules. It is a matter of common knowledge that many workers are careless, even to the point of indifference, about matters affecting their personal safety. A welder may use only his face shield and keep his safety goggles in his pocket. A worker in an area of high sound levels may not use ear plugs because it is more comfortable to work without them. Seeing to it that workers use the protective equipment made available to them by the employer is a problem that has long aggravated management. the problem has now become a legal obligation.

Some employers have adopted the rule that violation of company safety rules is punishable by reprimand for a first offense and by discharge for a subsequent offense. The review commission has on several occasions pointed to this practice as supportive of the employer's intention to make the workplace safe.

In enforcing work rules, you should take care to inform the employees of what their responsibilities are, what is expected of them, and then you must uniformly apply your disciplinary programs. You cannot be selective and ferret out one person. Managment itself must also live by the same rules. If you do this, you will find the law will strengthen your ability and your capability to carry through on the disciplinary procedures.

The most direct effect the law has had on industry is in regards to compliance. You know compliance is nothing but a polite and palatable word for "enforcement." I feel they were very conscious in Washington about public relations so they decided that rather than call it enforcement, they would call it compliance. But any way you hide it, it is still enforcement.

I would like to summarize for you what to expect and how to prepare for an OSHA inspection.

Prior to a visit by our OSHA inspector, you should decide how to handle such a visit and who you want to handle it. Then, alert your receptionist to watch for the OSHA inspector and provide her with a list of people to contact when he presents himself. (see atttached form). Be sure to ask for proper identification.

The inspector, prior to his visit, should have familiarized himself with as many known factors of your operations as possible and have determined which OSHA standards are pertinent.

Inspections may be made during the regular working hours only, except as special circumstances require. For an inspection at other than daytime working hours, the area director's approval must be obtained prior to entering your business, except where obtaining approval would cause undue delay.

The inspection begins with an opening conference. this is to inform you that the purpose of his visit is to make an investigation to ascertain whether you are in compliance with the requirements of the act. The inspector will outline in general terms the scope of the inspection including records he may desire to review, employee interviews, physical inspection of the worksite or workplaces. The CSHO should then give you copies of laws, standards, regulations and promotional materials, as applicable, and advise where additional copies of other applicable materials may be obtained. At this time he should furnish a copy of the complaint if one has been filed, or inform you that it is a general or random type inspection.

At an appropriate time during the opening conference, the CSHO will discuss the walkaround provisions under the act. You should be asked to designate your company representative for walkaround purposes. In addition, the CSHO* should determine if there is a certified or recognized union in the plant, or any other authorized employee representative and they should be contacted.

Ordinarily, the selection of an employer representative will cause no difficulty. However, the selection of an employee representative will require the exercise of discretion and judgment of the CSHO. The purpose of this provision is to provide "an appropriate degree of involvement of employees themselves in the physical inspection of their own places of employment" and to give them an opportunity to point out hazardous conditions.

If employees are represented by a certified or recognized bargaining representative, the union ordinally would designate the employee representative. Similarly, if there is a plant safety committee, the employee members of that committee would ordinarily designate the employee representative for walk-around purposes.

Where employees are not represented by a bargaining representative or a safety committee, there may be situations where employees will select their own representative for walkaround purposes, even though there is no union or safety committee in the plant. Such selection may be made only by the employees not by the employer or the CSHO. The regulations provide that the CSHO shall have authority to resolve all disputes as to who are the representatives authorized by the employer and by the employees for walkaround purposes.

After the authorized employee representatives are designated at the beginning of the inspection, the CSHO should review with them the scope of the walkaround.

There are restrictions on walkaround rights however. The CSHO may deny the right of accompaniment to any person whose conduct interferes with a full and orderly inspection. 29 CFR Section 1903.7(d) of the regulations provides that the conduct of inspections, including the walkaround, shall be such as to preclude unreasonable disruption of the operations of your establishment. While some degree of interference may be inevitable, any large-scale disruption of normal operations will hamper the inspection and the CSHO should use his judgment as to whether to suspend the inspection or to take other action.

In addition, the CSHO must take special measures during inspections when trade secrets or security matters are involved. Upon the request of an employer, any authorized representative of employees in an area containing trade secrets shall be an employee authorized by the employer to enter that area.

The compliance safety and health officer's responsibilities are necessarily extensive. The primary responsibility is the conduct of effective inspections to determine whether you are (A) complying with safety and health standards and regulations promulgated under the act, and (B) furnishing places of employment free from the recognized hazards that are causing or are likely to cause death or serious physical harm to employees.

The conduct of effective inspections requires identification, professional evaluation, and accurate reporting of safety and health conditions and practices. Inspections may vary considerably in scope and detail, depending upon the circumstances in each case.

The CSHO is instructed to take the time necessary to inspect all aspects of the operations. the time involved may vary from one hour to more than a day, depending on the size of your establishment and the complexity of its operations.

The primary objective of the inspections is the enforcement of standards issued under the act. However, the CSHO will also ascertain whether you have posted the notice informing employees of their rights and obligations under the act in accordance with the requirements of 29 CFR section 1903.2 and complied with the recordkeeping requirement under the act.

During the course of an inspection, the CSHO's primary concern will be determining whether you are complying with safety and health standards promulgated under the act. However, attention will also be directed to whether you are complying with the general duty clause in section 5(a)(1) of the act which applies to every workplace. the clause provides that each employer "shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees."

During the inspection the CSHO shall use discretion in discussing apparent violations with either the employer representative or the employee representative. However, he may be generally responsive to inquiries without indicating his conclusions as to whether a citations will be issued. He may indicate to an employee representative that if a citation results from the inspection, the citations may be mailed within a short period of time.

It will be found that numerous apparant violations such as blocked aisles, unsafe floor surfaces, hazardous projections, unclean toilets and deficiencies of a similar nature can be corrected immediately. In many instances, the employer representative will voluntarily point out to a foreman the apparent violations detected, so that the foreman may take immediate steps to correct the hazards. In any such situations, the conditions and corrections shall be recorded to help judge good faith, compliance, etc. Although corected, the apparent violations shall be the basis for a citation or proposed penalty.

Records voluntarily provided by the employer can be received by the CSHO and considered by him in evaluation of conditions in the workplace. For example, you may want to voluntarily give the CSHO copies of correspondence between you and a manufacturer of equipment that you have for the purpose of complying with a standard. Such records are not required, however, this type of record may be in your best interest as an aid to the CSHO and the area director in determing a reasonable time for abatement of a particular violation. If such correspondence contains projected delivery dates, etc.

Before the CSHO man leaves the plant, he will confer with the owner, operator, or employer representative and advise him of all conditions and practices disclosed by the inspection whic h may constitute safety or health violations. Under the new procedure, area directors are granted the authority to empower "qualified" inspectors to issue citations at the worksite. Normally, citations are to be issued as a second part of the closing conference.

The inspector may issue citations for *serious* violations without conferring with the area director, except in the following instances:

1. Where laboratory analysis results must be obtained prior to determining whether there is a violation.
2. Where the professional advice of other specialists such as industrial hygienists or construction specialists is needed prior to determing

whether the violation exists.

3. Where advice of the legal staff is needed.
4. Where there are serious questions regarding the jurisdiction of OSHA to enforce compliance with the OSHA standards.
5. Where reference to documents not available to the inspector at or near the worksite is needed prior to preparation of the citations.

Inspectors may also issue citations for *nonserious* violations. However, the inspector is not empowered to issue citations for repeated, willful, or general duty clause citations without first conferring with the area director. The directive also indicates that where any citation must be issued by the area director, then *all* citations have to be issued by the area director, rather than onsite by the inspecting officer. OSHA directive 200-20 provides the procedures for developing and issuing citations at the worksite. It also provides guidance on the amendment of citations by area directors. this new directive is intended to speed up the citation process. The department of labor has indicated that they believe the new procedure will work to the advantage of employers since employers will know of the violations charged against them before the compliance officer leaves the worksite. Whether or not this new procedure will, in fact, work to the employer's advantage may be too early to tell at this time.

To give you an idea of the most frequently cited standards, the last quarter of 1973 reveals the electrical violations are still the most frequently cited OSHA standard. Compliance officers cited 7,456 electrical violations (1910.309[a]) during the three-month period, and 5,043 such violations in the previous three-month period. As has been the pattern, pulley guarding was cited 1,666 times (1910.219[d][1]) and gas cylinders (1910.252[a][2]) cited 1,585 times were the next most frequently cited OSHA standards.

Improper work rests for abrasive wheel machinery (1010.215[a][4]) brought 1,461 citations and machine guarding violations (1910.212[a][1]) were cited 1,397 times. there were 1,235 citations issued for the improper guarding of fan blades (1910.212[a][5]) and 1,187 infractions of the guarding standard for open-sided floors (1910.023[c][1]). Housekeeping failures accounted for 1,139 citations (1910.022[a][1]).

Whether a company has a safety program is always determined during an OSHA inspection of a workplace and, if such a program does exist, inquiry is made to learn the extent ot which it is enforced. the failure of a company to adopt a safety program, or to enforce strictly the safety program which it has, can weight heavily against an employer's chance in a citation contest. The converse is also true. the employer with a safety program who insists that it be observed and who backs up his insistence with reprimands and discharges, may well prevail on the basis of this fact alone in a close case before the review commission.

**"OSHA" Occupational Safety
And Health Act**

**"CSHO" Compliance Safety
And Health Act**

OSHA Inspection Contact List

1st________________________ **Ext**______

2nd________________________ **Ext**______

3rd________________________ **Ext**______

4th________________________ **Ext**______

5th________________________ **Ext**______

RECEPTIONIST: Upon the OSHA Inspector identifying himself with proper credentials and announcing an inspection, you will promptly notify the persons listed in order.

MODERATOR KING: Thank you Jack. You gave us a lot of food for thought, what to do when the "OSHA" man arrives. I shall now turn the meeting back to billy Adams.

MODERATOR ADAMS: We have time for Questions:

QUESTION: It occured to me, while listening to the Speaker talking about "Sulphur Scarcity" and the increase in "Fertility" if the needed "Sulphur Content" is maintained. Maybe we have a solution to the "Overall Population" in some of the undeveloped areas. What about using "Gypsum for putting Sulphur back into the soil?

ANSWER — CHRONISTER: Gypsum is a very good source of "Sulphur". If the level in the soil is very low, sometimes the solubility of "Gypsum" is not sufficiently fast enough to meet the "Sulphur" requirements unless it is applied in the "Fall" or sometime before planting. The more acid in the soil will speed up the availability of the "Gypsum" to some extent, however, the solubility of "Gypsum" is not very high. Gypsum is a good source if you have a medium to a high level of "Sulphur" already and just want to use it as maintenance. There also is another problem with "Gypsum". If you already have a very high calcium, you will add a lot of "Calcium". This is the case in a lot of instances.

QUESTION: In the line of "sulphur" the control samples that you displayed. Your slides. What was the "Sulphur Form" used for comparison?

ANSWER — CHRONISTER: In some of these slides that I had, if the soil was acid where it was used or where the demonstrations were run, about 25% to 50% of the sulphur was in the "Sulphate Form." If the Ph was above 5½ and if the "Sulphur" was applied in the fall before, or in the very early Spring, or the winter, it would be just the "Elemental Sulphur or if 'Liquid Fertilizers". "The Ammonia-Tri-Sulphate".

QUESTION: Is this a common test?

ANSWER — CHRONISTER: Ammonia-Tri-Sulphate is the liquid form of "Sulphur" that is very popular especially with the liquid fertilizer manufacturers. It is an all Sulphate form and it is compatable with just about all the ingredients that they might put in a liquid fertilizer and it's analysis is 12% nitrogen and about 26% sulphur.

MODERATOR ADAMS: there seems to be no further questions at this time. I am sure "our speakers" will be contacted in the Halls here or at the lunch period, by our members, for answers to questions that will come into their minds later.

Thanks again to our speakers for their messages and to our members for listening.

Thursday, November 8, 1973

Morning Session
Moderator: Herman G. Powers and Rodger C. Smith

MODERATOR POWERS: Like any other "Business Enterprise" your Round Table has to have a business session.

Business Meeting
Secretary—Treasurer Report

Paul J. Prosser, Jr.

Good Morning! Last night, at the cocktail party, one or two Gentlemen were inquiring about the basic Organization of the Round Table. For their benefit I would like to take about one minute and try to explain the fundamentals. Basically we are obviously a non-profit "Organization".

During the past year there were a fantastic amount of contributions made in time and energy and talent by a number of people who organized the program and who assembled what we all believe is one of our best programs. To accomplish that, we had two or three meetings of The Directors in Baltimore, at which time the mechanics of the program for this meeting were ironed out.

During the year the "Clerical—Secretarial Work" was handled, not only thru our Office, The Sackett People also do a great deal of that, particularily with the "Magazines" and the "News" media and the Chairman's Home Office also made a lot of contributions in time. There were, during the past year, no expenses to the round Table for any Secretarial or Clerical labor at all. The only expenses that were put in the budget were out-of-pocket costs: Like postage, printing and things like that.

I would like to take one second and congratulate and thank Chairman Herman Powers, who has done, in our judgment, an outstanding organizing job over the past two years.

I would like to request that if any of you on our mailing list are incorrectly listed, if you will try to drop us a line, this will help to keep our mailing list up-to-date. We have about 1200 names on our mailing list and it is about 90% accurate apparently.

I would also like to request, on behalf of Joe Reynolds, that any items for topics, to be discussed at the next Round Table Meeting, be sent to us as soon as possible. I am sure that we will again have a couple of Organizational Meetings in Baltimore thru the year. the attendance at this meeting, when I came in, was approximately 262.

FINANCIAL STATEMENT

November 1, 1972 to October 31, 1973

CASH BALANCE — November 1, 1972		$691.03
Income 1972 — 1973		
Registration — 1972 Meeting	$5,550.00	
Sale of Proceedings 1972 and Prior	648.50	
Total Income November 1, 1972 to October 31, 1973		$6,198.50
Total funds Available November 1, 1972 to October 31, 1973		$6,889.53
Disbursements 1972 — 1973		
1972 Meeting Expenses	$1,003.72	
Expenses — Directors Meetings	600.46	
Membership Letters — Including Postage	378.68	
1972 Meeting Proceedings including Printing, Postage, Envelopes, etc.	3,189.31	
Miscellaneous Expenses including office supplies, postage for mailing back issues, etc.	93.73	
1973 Meeting Expenses — preliminary	100.53	
Total Disbursements		$5,365.93
CASH BALANCE October 31, 1973		$1,523.60

Nominating Committee Report

Wayne W. King, Chairman

For the period starting (Our 24th year) November 4, 1973 your Nominating Committee recommends election of the following officers:

Joseph E. Reynolds	Chairman
Billy E. Adams	Vice Chairman
Rodger C. Smith	Vice Chairman
Frank T. Nielsson	Vice Chairman
Paul J. Prosser, Jr.	Secretary-Treasurer
Albert Spillman	Past Chairman
Herman G. Powers	Past Chairman

By Unanimous Vote the membership voted "Aye".

WAYNE KING: Will Walter Sackett and Albert Spillman come to the rostrum, please.

Presentation of Plaque
to
Herman G. Powers

By Walter J. Sackett, Jr and Albert Spillman

HERMAN: For a job well done, we are privileged and delighted, on behalf of our Board of Directors and Members, to present to you this "Plaque" which you well deserve and which reads as follows:

Fertilizer Industry
Round Table
Herman G. Powers
Chairman
1972 — 1973

And we thank you again for your excellent Stewardship.

HERMAN G. POWERS: Gentlemen, I certainly appreciate this. My job was relatively easy. The core of this thing is that you Gentlemen come here and dedicate your time as Speakers. We have a group of real dedicated "Directors" and "Members" who put in a lot of hours, have a lot of discussions, meetings, correspondence, and finally we all agree and get the job done. It is interesting to note that some of our Directors come from long distances. You will notice on your program that we have a "Director" from England, a Director from Mexico, a Director from Canada and a number of Directors from far-away places in States, East, West, North and South.

These Gentlemen come to most of our planning meetings in Baltimore and also attend most of our Annual Meetings. They are the life line of our Round Table. That is what makes the whole thing possible.

I have enjoyed "Chairing" our round Table for the past two years and I thank you for the privilege. I shall continue as your "Past Chairman" to help keep our Round Table successfully operating.

Entertainment Committee

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. We all enjoyed your "Hospitality".

"HOSTS"

ATLANTA UTILITY WORKS
COMMONWEALTH LABORATORY, INC.
DAVY POWERGAS, INC.
DORR-OLIVER, INC.
EMISSION CONTROL
DIV. OF EVIROTECH
FERTILIZER ENGINEERING
AND EQUIPMENT CO., INC.
FESCO, INC.
HOWE RICHARDSON SCALE COMPANY
KIERNAN-GREGORY CORP.
THE PROSSER COMPANY, INC.
EDW. RENNEBURG & SONS CO.
ST. REGIS PAPER CO.
THE A. J. SACKETT & SONS CO.
STEDMAN FOUNDRY
AND MACHINE CO., INC.
WEBSTER INDUSTRIES, INC.

Meeting Dates and Place
24th Annual Meeting

Joseph E. Reynolds, Chairman
Tom Athey, Committee Member
Report given by Tom Athey

We have all decided to come back to Washington next year. We are making arrangments with The Shoreham American Hotel to be here sometime in November, 1974. We will let you know the exact dates. Note: Mr. Athey advised at a later date that Our 24th Annual Fertilizer Industry Round Table Meeting will be held at The Shoreham American Hotel, Washington, D.C. and the dates confirmed are as follows:

Tuesday, December 2, 1974
Wednesday, December 3, 1974
Thursday, December 4, 1974

CHAIRMAN POWERS: Any other business Gentlemen? I wish to thank all the Committees and their Chairmen and our Membership for an outstanding job, well done. We shall now proceed with the remainder of this morning's program. To be honest the last day is always a challenge for the "Speakers". You no doubt noted that this year we arranged to have the Round Table on Tuesday-Wednesday-Thursday and not windup on Friday, realizing, transportation problems.

Our Program will now continue with Rodger C. Smith, Moderator.

MODERATOR RODGER C. SMITH: Thank you Herman. Good morning, Gentlemen. Nice to see all of your bright, shining faces after two days of hard seats and three evenings of Washington. During this Round Table we have so far considered primarily, Formulation, Processing and Distribution. These subjects have been the basis of The Fertilizer round Table since it's inception. this morning we address ourselves to topics related to "Environmental Control" which by "Regulations" has been a very important part of Production, Management and Technical Development. Most of you allocated substantial budgets and time to the measure and control of "Effluents". On the positive side it can be said that marked progress has been made in coping with "Effluents" and also that "Effluents" recovered have some value, partially off-setting the added "Capitol" and "Operating Expenses" required.

Various committees have calculated that 1% to 3% material shrinkage, in the Fertilizer Industry, has for many years exceeded average Fertilizer Industry's earnings. the subject is both a very necessary and important one.

This morning we are priviledged to have "Speakers" well known for their accomplishments. the first Speaker has had twenty-three years experience in Fertilizer and Pollution Control Industries. He is a Chemical Engineer. He has held positions with C. F. Industries, Engineers Corporation of America and is now Manager of Processing and Development Engineering for The Purity Corporation. Mr. John Rodgers will discuss "Particlate Control". John, please cone to the platform.

Particulate Control

John L. Rodgers

This discussion is intended to introduce a new development in air pollution control technology that affects the fertilizer industry. The whole field of particulate control is, of course, the subject of books, not twenty minute discussions, because so much fine work has been and is being done on particulate control in all industries. So rather than trying to merely outline the broad field of dust collection as it applies to fertilizer manufacture, this discussion will add to that broad field some information on a new approach to air pollution control which was given birth commercially in fertilizer dust control application and which, we hope, will have a far larger role to play in your future. We call it the PENTAPURE.

Over a year and a half ago, a fertilizer manufacturer, Farmers Chemical Company, purchased the first commercial unit to be scaled up from our pilot plant model. An experimental unit, it was made to work through the cooperation of Purity and Farmers Chemical. The initial test results so closely matched those achieved under less rigorous conditions in the pilot plant, that it is justified a research and development program to improve the basic concepts. Since that time the unit has evolved to four models, each of which is superior to this original one.

Every commercial unit fabricated and installed has been made to comply with the regulations in force, and we are now making an effort to get these less costly to purchase, less costly to install and less costly to operate than others presently available on the market.

The first fertilizer unit has multiple agglomeration cones. Since then we have found that we could scale up a single cone, thus eliminating the chance of plugging. Most of our present units are being sold with no moving parts, which eliminates a motor and drive. But in spite of the improvement achieved in more than one and a half years, it is still worth talking about the performance of this original model. Since its start-up, the device has been collecting all but an average of 5 pounds of an hourly input of 60 pounds of reusable dust. More important than that, because the dust is fairly easy to catch, the PENTAPURE has been doing its job with little power or water input.

The PENTAPURE has sone advantage inherent in its technology which will have a bearing in many potential applications. current forms of particulate control devices, all of which have been performing well for many years, boast specific characteristics — wet operation, dry operation, gas removal, low pressure drop — each to be weighted plus or minus in specific applications. It is important to add more options to any decision about pollution devices, not to multiply the confusion, but to further insure success in light of the fact that most processes demand individual attention.

Farmers Chemical Company operates a standard chemical fertilizer granulator with preneutralizer. Their potential air pollution problems are contained by the PENTAPURE, capturing what comes off the cooler, and a pair of other scrubbers, which take dust from the dryer, granulator and screens, and the steam from the preneutralizer. Cyclones get the coarse particles prior to all of these collectors.

Engineers at Farmers Chemical Company are faced with the need to obtain reasonably high efficiency of particle collection because recovered material is money saved and because State codes have to be met. PENTAPURE stack tests conducted by Farmers Chemical Company engineers in April and May of 1972 were found to be in accordance with existing codes.

Good efficiencies on this kind of dust don't take miracles to achieve. A large benefit of the PENTAPURE promises to be in the maintenance aspect. Most scrubbers require periodic attention to prevent plugging or overflow. Even with such attention, clogging of the scrubbers frequently necessitates a shutdown of the entire operation. During certain seasons, the plants run all day every day, and a shutdown for unclogging costs them in production time.

The water input to the PENTAPURE is a fraction of what it is to scrubbers of similar duty, and this has proven to be valuable at most PENTAPURE installations.

The PENTAPURE Impinger has a good potential of paying for itself quickly, including operating and maintenance costs, because it can salvage previously lost dust and enforces little downtown in the process. For this reason, it is often profitable to investigate improved models of the PENTAPURE for all steps in the process.

Now, to examine the PENTAPURE Impinger itself. the PENTAPURE utilizes the existing energy in a gas stream to cause agglomeration and collection of particles, including many in the sub-micron range.

The PENTAPURE takes the gas stream through the inlet. Particles of all sizes are mixed in the air. The smaller pollutants, less than a micron in diameter, tend to behave like gases. Slightly larger particles respond to velocity changes in the surrounding gas — but do so to a lesser extent as their size increases. this is what the PENTAPURE takes advantage of.

The stream enters the agglomeration cone where gas will accelerate. So will the tiniest particles. The larger pollutants will be affected mostly by drag forces in the gas and will accelerate to lesser and varying degrees, depending upon size.

Now, the relative velocity difference induced between the small and large particles is sufficient, when they collide in the narrowing cone, to cause binding. We have found, through electron microscopy, that some of the tested materials agglomerate extremely well.

One thing the unit must do is guarantee that all the sub-micron particles find targets. The PENTAPURE increases the probability of collision by injecting an agglomerating agent, usually a fine water mist with known diameter droplets, just upstream of the cone. Also, the proper ratio of inlet to outlet diameters in the cone affects the collision rate.

Once the particles have been agglomerated, they are removed in the impingement section. Here, the agglomerates collide with a target and their gravitational dorces direct them downward, out of the stream. An additional spray on the target can assist this. The spray, where applicable, presents a three dimensional impingement surface of almost infinite area, thus increasing the efficiency of removal by impingement. The unit can be tailored to the application — most demand wet impingement, a very few, dry.

One model of the PENTAPURE uses a moving belt to further direct the agglomerates downward to the collecting bin. The standard model has a curved stationary surface, which means no moving parts within the flange-to-flange section. (This is the type now installed at _farmers Chemical.)

Finally, the collected particles can be disposed of or recycled or used as raw material for other products. The cleaned air passes out the top of the unit.

Compare this to the operation of other equipment. All collectors cause some variation of agglomeration in order to remove the smallest pollutants. Some apply large amounts of kinetic or electrical energy to force agglomeration and removal. A filter agglomerates by causing particulate to adhere to a fibrous medium. A characteristic of the PENTAPURE Impinger is that it uses the energy already in the gas stream to generate the agglomerating turbulence.

The pressure drop across the PENTAPURE, flange-to-flange, is 3.5 to 5 inches of water. Since the unit has few internal organs — a belt or strike plate, nozzles — it seldom calls for the expense and effort of parts replacement or even the power needed to shake anything free of dust. The impingement belt and inner surfaces are self-cleaning.

Avoiding the use of interior parts and providing for low liquid flow when running wet are key reasons behind the PENTAPURE's light weight. Large input impingers, up to 50,000 CFM, can be installed without drastic modification in the plant or its foundation.

The simplicity of the unit also surfaces as versatility.

It has been tested both wet and dry. Two units, operating in series, can capture a dry, recycleable material without sacrificing the high efficiency of the wet spray.

A sanitary unit, designed for the grain industry, has no sharp corners, no places for bacteria to hide from cleaning agents. Its construction design lowers the initial cost of the unit by reducing the number of welds.

Significantly, like any wet collector, the PENTAPURE has the potential capability to remove gaseous pollutants with the same basic unit with which it collects particulates. No dry particle collector can hope to touch gases.

From data obtained on gases in several installations it is evident that when it comes to capturing water soluble gases, the PENTAPURE rivals scrubbers that use far more water. This can be attributed to the efficiency of the turbulence induced in the cone and the quality of contact on the impingement surface.

The PENTAPURE has established a record in several other industries, and much of the information in these case histories is of value to the fertilizer industry.

The PENTAPURE is presently operating on the cupolas of four foundries and will soon be starting up at three others. A routine nozzle change at the first PENTAPURE installation, in Tippecanoe, Indiana, cut the emission in half, although the stack was well within the State code originally. Tests on SO_2 at that installation showed good removal efficiency.

The PENTAPURE is doing well on particles on a coal fired boiler at a textile manufacturing company in North Carolina. the 25,000 CFM PENTAPURE captures all but about 6 lbs./hr. of the particulate. The State code allows 18 lbs./hr.

The PENTAPURE was installed on an asbestos mixer, and an operating permit was granted. The allowable emission for asbestos is 2.0 fibers per cc of air and the PENTAPURE test results show .24 fibers per cc. the unit uses less than 10 HP. The small amount of water needed for this installation allows them to recycle everything collected directly back to the mixer, which eliminates the normal problems of clean out and disposal.

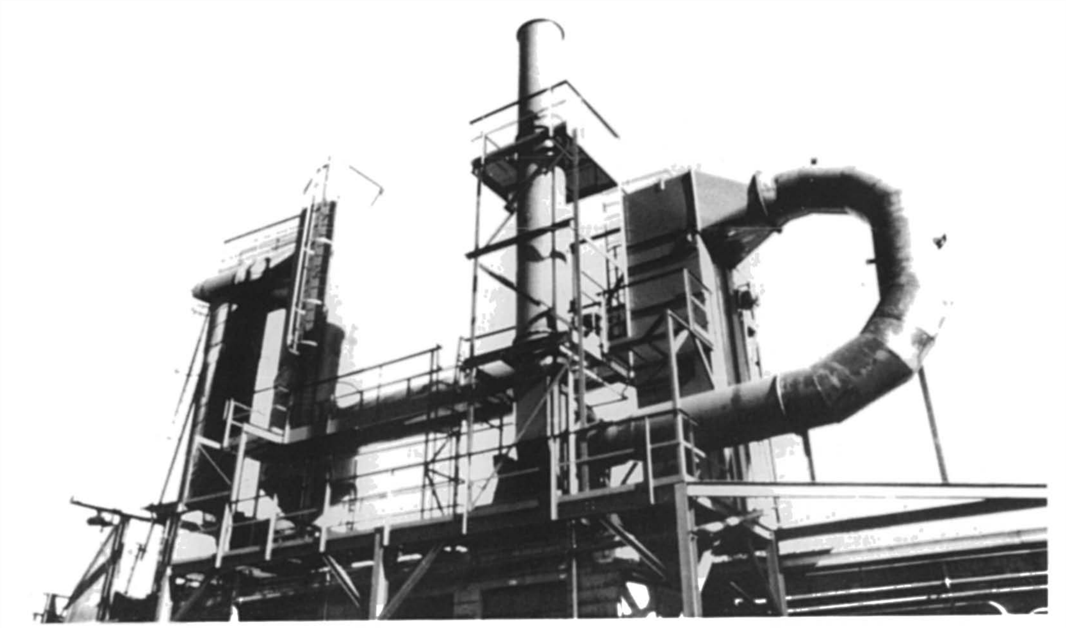
Two 40,000 CFM PENTAPUREs in series are tackling a trickly pollutant on a brass smelter. The first unit has the moving belt because of the quantity and nature of the larger pollutants. The second unit uses the static target, increasing the efficiency on smaller particles, many of which are metallic oxides.

No industry has been unaffected by the increased stringency of Federal, State, and local laws regarding stationary source air pollution. the fertilizer industry has been fortunate in that some of its pollution prevention activity can be rather profitable by virtue of materials recovered, and in these areas the fertilizer industry is well ahead of others in meeting the proposed emission deadlines.

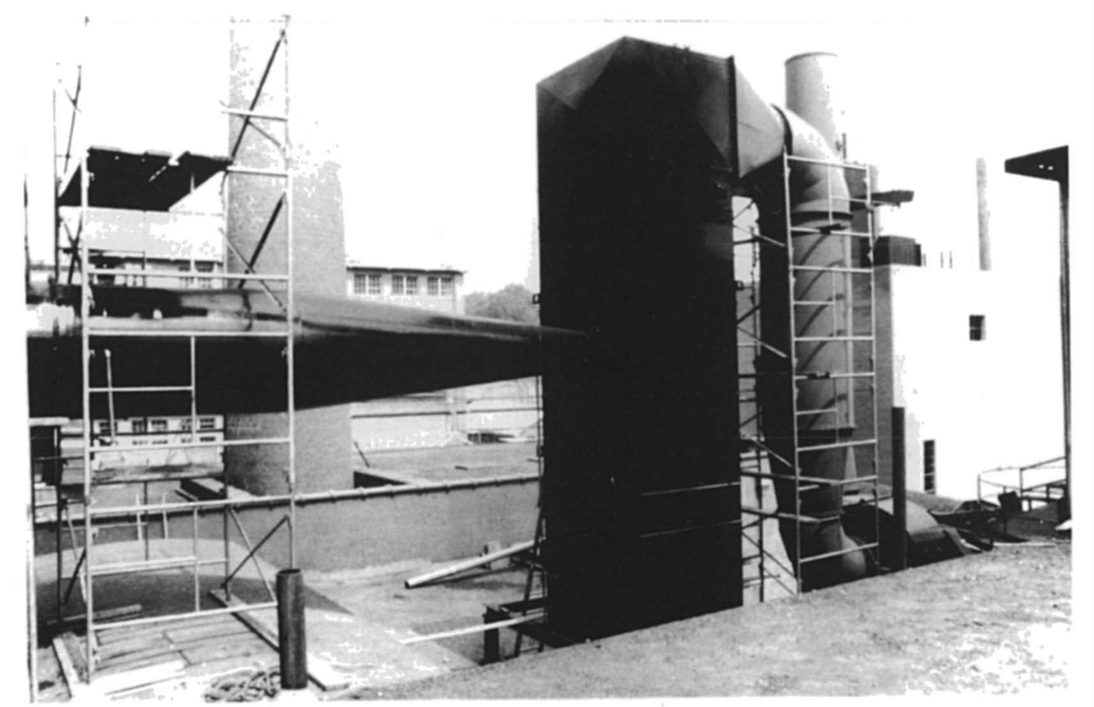
This observation surely does not exempt fertilizer producers from an obligation shared by all industries with pollution control responsibility. the obligation is this — new forms of dust collection devices must be sought and evaluated. the reason is cost.

Several reports — from the E.P.A., McGraw-Hill, and the Industrial Gas Cleaning Institute, for example — outline the massive expenditure by industry in control of stationary sources of air pollution in this decade. Whatever the variation in forecasted figures, these studies all agree that most of the expense to industry will not be for the particle collection device. Eighty percent or so will be to construct, maintain, and operate the system. In other words, it is far too little to create an inexpensive dust collector. It is essential to find control devices that cut back power and water consumption, maintenance time, plumbing, structural support, or any of the material or activity related to the operation of the flange-to-flange unit.

Current technology must, therefore, be geared to improving the performance of particle collectors in all the related areas needed to achieve high efficiency. Bigger and more is not necessarily better when all the details are considered. The Pentapure Impinger is one new approach that should be granted attention both by virtue of its newness and of its performance.



Slide number 1: Is of a 20,000 CFM Pentapure at J. M. Bruce Foundry in Cedar Grove, Wisconsin. This unit has been in operation for eight months and has kept the output from their stack well within the State Code. The system includes a vertical chamber for cooling the hot gas before it enters the particle collector. This system is mounted on the foundry roof, and you will note that the outlet is curved back from the "Pentapure" in order to conserve space.



Slide number 2: Is of 25,000 CFM Pentapure system at Chatham Mfg. Co. in Elkin, North Carolina. the Purity device captures both fly ash particulates and sulfur dioxide gas from a pulvertized coal fired boiler. Output has been reduced to 5 pounds per hour of fly ash for a removal efficiency of nearly 99%. This data was obtained by the North Carolina State Testing Agency in determining that Chatham's stack met the 18.5 pounds per hour code. Also Purity tests showed Sulfur Oxides removal of over 50% using only plan water as the collecting agent.

MODERATOR RODGER C. SMITH: Thanks John for your excellent paper discussing "Particulate Control".

Our next speaker, Mr. Harold B. Coughlin, is presently serving in "The Chief Guidelines Implementation Branch, Office of Water Planning And Standards, Environmental Protection Agency, Washington, D.C.".

This division is responsible for the development of National and Industrial Effluent Limitations And Guidelines for control of "Point Sources" of "Water Pollution".

Mr. Coughlin has served with the Los Angeles "Air Pollution Program" for five years and has served 3 years with the North Carolina "Air Pollution Program" and for sometime now has been serving "E.P.A." here in Washington. His Paper will cover discussions on "Development of Industrial Effluent Limitations".

Development of Industrial Effluent Limitations

Harold B Coughlin

Thank you Mr. Smith. Alan Cywin, who is the Division Director of the Effluent Guidelines Division. was the scheduled speaker. He wanted me to express to you the fact that he was sorry he cannot be here. He is up on The Hill now talking to both the House and the Senate Public Works Committee Staff on the "Guidelines Program". As you all know, "The Federal Water Pollution Control Act" was amended last October and part of the amendment required that several provisions of the "Act" be implemented.

Industries discharge into our Nation's waters a broad range of pollutants. In the aggregate, they form the largest and most toxic of all concentrated sources of pollution. On the average, industry discharges about three times the amount of waste that is discharged by all the sewered private residences in the United States, and the volume is increasing several times as fast as that of sanitary sewage.

The 1972 amendments provide for a vigorous attack on industrial water pollution, with set deadlines for a number of specific control actions. Guiding the control program will be two salient requirements: (1) existing industries discharging pollutants into the Nation's waters must use the best practicable water pollution control technology currently available by July 1, 1977; and (2) they must employ the best available technology by July 1, 1983.

EPA is publishing effluent limitations guidelines to define the "best practicable" and "best available" technologies for various industries. The development of the effluent limitations guidelines takes into account adjustments for several factors, including the cost of pollution control, the age of the industrial facility, the process used, and the environmental impact (other than water quality) of the controls. EPA is also identifying where possible pollution control measures for completely eliminating industrial discharges.

In addition, new sources of industrial pollution must use the best available demonstrated control technology which is being defined by EPA in the form of standards of performance for various industries. Where practicable, EPA may require that there be no discharge of pollutants from new industrial facilities.

EPA is also promulgating pretreatment standards for new sources and proposing regulations stating the application of effluent limitations to users of publicly owned treatment works which are subject to pretreatment standards under section 307(b) of the Act.

Review of the legislation revealed that most of the required industrial pollution control regulations are closely interrelated. Because of the close relationship, these activities were performed simultaneously for each industry that was studied.

Contracts were negotiated with responsible contractors to perform the necessary studies and analyses of the 28 industrial categories listed in section 306 of the FWPC Act. A tabulation of the Group I, Phase I industrial categories are shown in Table 1. The legislation directs that additional categories be identified and added to the mandatory listing already provided by Congress. Twenty additional categories (Group I, Phase II) have been identified (Table 2). Sixteen more categories (Group II) have been identified for remaining industries. The lists may be expanded as work progresses in identifying permit applications and as pretreatment and cost recovery requirements are implemented.

Guideline Development Methodology

In the development of effluent limitations guidelines EPA obtained technical input and obtained critical review comments from other Federal agencies, the States, industry, citizen groups, and the Effluent Standards and Water Quality Information Advisory Committee. Public hearings were held by ES & WQIAC and the information obtained these made available to EPA. The steps required to develop effluent limitations guidelines for existing sources of industrial pollution, and performance standards for new sources of such pollution are outlined as follows:

Industrial categorization

A listing of industries by categories was developed. Industries were subcategorized based on raw material used, product produced, manufacturing processes employed, and other factors such as age or size of plant.

Waste characterization

Raw waste characteristics for each category and/or subcategory were identified. A waste and waste-water material balance was performed, indicating the source, flow, and volume of water and wastewaters. Constituents (including thermal) and the chemical, physical, and biological characteristics of all wastewaters (including toxic and other constituents causing taste, odor, and color effects) were identified.

Identification, documentation and verification of control and treatment technology.

This step included consideration of the following items:
— In-plant control techniques
— All existing and potential treatment and control technologies (including in-plant and end-of-process technologies)
— Limitations and reliability of each treatment technology and required implementation time
— Effects of application of each treatment technology on other pollution problems
— Resulting solid wastes and solid waste control technologies
— Intake structure technology

Development of cost information

For each treatment technology cost information was developed for investment costs and annual costs (including capital costs, depreciation, operating and maintenance costs, and energy and power costs).

Evaluation of data

Data was evaluated to determine the best practicable control technology currently available (Level I), the best available technology economically achievable (Level II), and the best available demonstrated control technology (Level III).

The effluent limitations and guidelines for existing sources and performance standards for new sources of pollution were developed and proposed for 26 of the 28 industrial categories (listed in Table 1) in 1973, in accordance with the steps outlines above.

Published Guidelines

Effluent limitations guidelines for existing sources, performance standards for new sources and pretreatment standards for new sources were published for the following categories in the *Federal Register* as proposed regulations during 1973:

Pulp and paper mills, paperboard and board mills, meat products and rendering, dairy products processing, grain mills, canned and preserved fruits and vegetables processing, canned and preserved seafood processing, sugar processing, cement manufacturing, feedlots, electroplating, organic chemicals manufacturing, inorganic chemicals manufacturing, plastics and synthetic materials manufacturing, soap and detergent manufacturing, fertilizer manufacturing, phosphate manufacturing, petroleum refing, nonferrous metals manufacturing, ferroalloy manufacturing, leather tanning and finishing, glass manufacturing, asbestos manufacturing, rubber processing, timber products processing, and textile mills.

Guidelines Under Development

Effluent limitations guidelines, standards of performance and pretreatment standards for the remaining Group I, Phase I categories will be proposed during January and February 1974. The categories are: iron and steel manufacturing and steam electric power plants. Promulgated regulations covering all of the Group I, Phase I categories will be published in the *Federal Register* during the Spring of 1974.

The Group I, Phase II categories of point sources will be published in the *Federal Register* as proposed regulations and republished as promulgated regulations during 1974.

Effluent limitations guidelines and performance standards for seven of the 16 Group II industrial categories are currently being developed and will be published during 1974. the categories are: paint and ink formulation and printing, converted paper products, fish hatcheries and farms, transportation industries, paving and roofing materials (tars and asphalts) and wooden furniture and fixtures manufacturing.

Future Guidelines

It is anticipated that effluent limitations guidelines and performance standards for all or most of the remaining Group II industrial categories will be developed during 1974 within the capability of existing resources. these include machinery and mechanical products manufacturing, coal mining, petroleum and gas extraction, mineral mining and processing, water supply, miscellaneous foods and beverages, miscellaneous chemicals, ore mining and dressing and steam supply.

TABLE I

Major Industrial Categories Listed in FWPC Act (Group I, Phase I)

Category

pulp, paper and paperboard mills
builders paper and board mills
meat product and rendering processing
dairy product processing
grain mills
canned and preserved fruits & vegetable processing
canned and preserved seafood processing
sugar processing
textile mills
cement manufacturing
feedlots
electroplating
organic chemicals manufacturing
inorganic chemicals manufacturing
plastics and synthetic materials manufacturing
soap and detergent manufacturing
fertilizer and phosphate manufacturing
petroleum refining
iron and steel manufacturing
nonferrous metals manufacturing
steam electric powerplants
ferroalloy manufacturing
leather tanning and finishing
glass manufacturing
asbestos manufacturing
rubber processing
timber products processing

TABLE 2

Major Industrial Categories Requiring Additional Study (Group I, Phase II)

Category
pulp, paper and paperboard mills
meat products and rendering
grain mills
canned and preserved seafood processing
sugar processing
electroplating
organic chemicals manufacturing
inorganic chemicals manufacturing
plastic and synthetics manufacturing
fertilizer manfacturing
iron and steel manufacturing
nonferrous metals manufacturing
phosphate manufacturing
ferroalloy manufacturing
glass manufacturing
asbestos manufacturing
rubber manufacturing
timber products processing
canned and preserved fruits and vegetable processing

TABLE 3

Additional Industrial Categories (Group II)

Category
paint and ink formulation and printing
converted paper products
fish hatcheries and farms
transportation industries
paving and roofing materials (tars and asphalts)
auto and other laundries
machinery and mechanical products manufacturing
coal mining
petroleum and gas extraction
mineral mining and processing
water supply
miscellaneous food and beverage processing
miscellaneous chemicals manufacturing
ore mining and dressing
steam supply
wooden furniture manufacturing

MODERATOR: RODGER C. SMITH: Thank you Mr. Coughlin. We are sorry Mr. Alan Cywin, your Division Director, could not be with us this morning. Please convey to him our thanks for his help and for you coming here to enlighten us on what your office is doing on "The Guidelines Progress". the information you have given us will be valuable and helpful.

We have a change from the printed program. Our next discussion will be given to us by Robert W. Riddle. He is a graduate from The University of Miami. He was with I.M.C. for approximately 20 years in their Florida operation. He is now employed as Process Chemist in the same operation by C.F. Industries at the Bartow, Florida plant. Mr. Riddle please come to the rostrum and we thank you.

Emission Sampling And Analysis For Fertilizer Plants

Robert W. Riddle

When this "Chore" finally filtered down to me, I really did not know what to prepare on the subject of "Sampling", that had not been said before. I will try to survey some of the methods available for testing in Fertilizer Plants and how there is an objective to show that emission testing can be done to give meaningful results at a reasonable cost.

Introduction

Sampling stacks and ducts for gaseous and particulate matter was originally done more for obtaining design and operation data than for pollution control.

The equipment and procedures currently being used have been developed over several decades, with recent emphasis toward instrumental and continuous methods.

The measurement of the gas flow remains the biggest source of error, and the basic method has changed little during the past fifty years.

This paper is not meant to be an instant course in stack sampling, but rather to give a survey of some methods available for emission testing at fertilizer plants, and its objective is to show that emission monitoring with less elaborate procedures can give meaningful results at a reasonable cost.

General Sampling Methods for the Fertilizer Industries

The Sampling technique employed will usually be determined by the analysis required plus whether gases or particulates are present. Particulates may be either liquids or solids.

If only gases are to be considered, then the sampling procedure can be less complicated than if particulates are to be measured. Gases may be sampled at any point within the duct or stack at any convenient rate. This presupposes that all of the input streams have had sufficient time for complete mixing. For the majority of these cases, an absorption train is used. This train may consist of bubbler tubes, immersed in a liquid or impingement tube, which are essentially small nozzles directed at a target to break up the gas stream into very fine bubbles. Normally, two or three of these absorption bottles will be connected in series to provide stage scrubbing. The scrubbing medium is usually water, although acids and bases are used in some cases. Analyses of the solutions are made in the lab. In a few instances some other medium, such as alcohol, may be used. An example of this is the EPA method of SO_2 — SO_3 determination.

For some types of gases, the familiar Orsat or chromatographic techniques are used. For these procedures, the sample may be withdrawn directly from the stack into the apparatus or withdrawn into an evacuated container and then fed into the apparatus. Analyses from the Orsat and chromatograph give results in percent by volume while the results from an absorption train are usually determined on a weight per volume of gas basis. Instrumental analysis of the continuous or semi-continuous type is finding increased use and may be required by regulatory agencies for specific types of operation.

Particulate sampling will normally require a more involved procedure. This is because of the need for multipoint samples at an isikinetic rate. For particulate sampling, several types of equipment may be used. The oldest and probably most frequently used collector is the filter. this filter may be the paper thimble type (figure 1), an alundum thimble type, circular paper type, or a packed fiber type such as glass wool. The thimble type is frequently used right after the nozzle in the stack and operates at the stack temperature. In other procedures, the filter is placed after the probe outside of the stack. In this case, the filter may or may not be heated. Paper thimbles, of course, are not suited to those locations with high moisture content and even the alundum thimble may present problems in this case. The paper thimble will fail when wet and the alundum thimble will have an excessive pressure drop. a circular paper filter with backing screens may work with light particulate loadings. In case of liquid particulates, the packed fiber filter will be satisfactory. Wet collectors similar to the impinger absorption train may also be used for collection of wet and dry particulate. he use of a wet collection train depends upon the type of particulate present and the available means of analysis. Inertial collectors are also used for particulate collection. These collectors depend upon the kinetic energy of the particle to separate it from the gas stream. Cyclones and cascade impactors (figure 2) are examples of this type. Inertial collectors are followed by a filter to collect the smallest size particles.

Particle size distribution for dry solids may be obtained by two general schemes:

1. Separation into size fractions during sampling. This method is also useful for liquid particulates.
2. Size analysis of sample after collection.

Inertial collectors are used to separate size fractions while sampling. Being inertial devices, they do not give a sharp cut-off point at each size fraction like test screens. They are useful, however, in determining the relative size distribution of a dust or mist.

Solids collected in the thimble or circular type of filters may be sized by microscopic counting or air elutriation. Air elutriation is essentially the separation of sizes by varying the air velocity in a column to remove different size particles. Low velocities will carry out fine particles and as the velocity is increased, larger particles are carried up and out of the column.

Instruments are available for determination of gaseous and particle concentration. For gases, there are two general classes of instruments, those that depend on some special physical property of the gas and those that are essentially adaptations of wet chemical methods. For particulates, there are instruments that mount directly on the stack and detect the solids by interference with the light transmission across the stack. Others remove a sample stream from the stack and filter this sample usually on a moving tape. The amount of solid may be measured by radiation absorption or the frequency shift of an oscilator caused by the change in mass of the tape.

Sampling Scheme

The choice of sampling procedure and equipment used will be determined by the following:

1. The purpose of the sample
2. The type of material to be sampled
3. The flow conditions under which the sample may be taken

The purpose for taking the sample can be considered to fall into three broad areas:

1. Compliance tests
2. The sources may be sampled to obtain design data or for troubleshooting
3. A monitoring program to insure the continued satisfactory operation of the pollution control equipment

    For compliance tests, the choice of sampling method is frequently one; namely, the method specified by the regulatory agency requiring the test. Fortunately, in Florida, as far as the State is concerned, we are able to use the same train that most of the phosphate companies have been using for a number of years. However, a number of states have simply adopted the train recommended by the EPA. Procedures for compliance tests are usually, and of necessity, more involved than those that would normally be used for a monitoring situation.

Sampling for design data may require even more involved procedures than sampling for compliance tests. The degree of difficulty will depend on the type of material and flow conditions.

A monitoring program will require much less time and effort per sample than compliance tests or testing for design data.

The type of material to be sampled has a great effect on the sampling method no matter what the purpose.

As mentioned earlier, sampling for gaseous components is usually the simplest operation. Normally, withdrawing a sample from any point and at any rate is considered adequate. Sub-micron particles behave as a gas in a flowing stream and may be sampled as such. In most cases, absorption trains will be used for gaseous samples in fertilizer plants.

For particulate sampling, more involved procedures are required. Because particles tend to classify themselves by size in an air-stream, due to turns, entrances, and even gravity, multi-point sampling is necessary. this is normally done at the same points as the velocity traverse for flow rate was made. A velocity traverse is made so that each point of measurement represents an equal area of stack or duct. Even this procedure may be inadequate if very large particles are present and the flow distribution is very irregular. In addition, particulate sampling requires an isokinetic sampling rate: that is, the velocity of the gas entering the sample probe must be at the same velocity as the gas in the duct at the point sampled. If the sampling velocity is low, high results will be obtained because the gas will deflect around the probe while the particles will tend to continue in a straight line and enter the probe. A high sampling velocity will give low results because the gas will be pulled in from outside the probe area while the particles continue on past the probe.

Surface filters, such as paper, are usually used for solid particulate and the change in weight of the filter medium used for determination of dust loadings. For liquids, a deep bed-type of filter, such as a tube packed with glass wool, may be used. Cyclones and cascade impactors are also useful for mists. Analyses for mists are usually made by chemical means. Impingement scrubbers, identical to those used for gas absorption, are also used for both solid and liquid particulates.

The temperature and humidity conditions in the stack will also influence the selection of equipment to be used. High humidity when sampling solids may eliminate the use of paper-type filters and with severe conditions will eliminate any filter except the packed type.

As indicated for particulate sampling, the flow pattern in a duct is a very important consideration in determining the sampling procedure. Elbows and side entries will cause larger particles to classify themselves by size. In long, horizontal runs, larger particles will tend to gravitate towards the bottomof the duct. If we are sampling under these conditions to determine the inlet loading for a collection device, the normal multi-point sampling procedure used by the EPA may be inadequate. For this condition, it will be necessary to sample several additional points to determine a solids flow profile.

Comparison of Specific Equipment and Procedures

Attached you will find a rough sketch of the sampling trains used by the EPA (Figure 3), the State of Florida (Figure 4), and CFCI (Figure 5) for sampling of particulate matter. You will notice the Florida train and the CFCI train are essentially identical. The EPA train uses the same type of impingers but is all glass and has ground glass connections.

As you can see, the Florida train and CFCI train have easy portability and adaptability to various types of sampling requirements; while the EPA train, having all solid connections, must have the sampling point built for their equipment. The EPA has now decided to count only that particulate collected in the filter preceding the impinger train. In the Florida procedure, the solids are caught in the impinger train and the entire sample evaporated to dryness and the remaining solids weighed. At CFCI, we measure particulate by two different methods. If we are sampling from rock collectors, we collect the dust in our regular impinger train using water, filter the water sample, dry and weight the residue. For ammonia and calcium phosphates, we measure the P_2O_5 captured. This is based on the fact that no volatle P_2O_5 would exist at the temperatures we normally encounter. This latter method, of course, would measure any solid material that is carried through the scrubber and any liquid entrainment from the scrubber as particulate matter. Florida and the EPA require multi-point sampling; that is, each point of the velocity traverse is sampled at an isokinetic rate for the same length of time. At CFCI, we sample it at the point nearest the average velocity at isokinetic rate. There can be little argument that the multi-point sampling should give better results; however, since we normally sample following a collector and only the finer particles remain and I feel, that for these cases, multi-point sampling is not needed. Several of our stacks have a cyclonic flow, and representative particulate sampling for these is not attainable at this time. This upward spiraling also makes flow rate measurements most difficult. With a monitoring program, this problem is not as difficult as it may appear. By sampling frequently we have established a rough, normal operating range and operational problems in the control equipment are detected by a twofold or greater increase in emission rates.

The fluoride sampling train for each group is identical to the particulate train, except the EPA train does not require the filter ahead of the impingers but after them. The State of Florida and the EPA use distilled water to capture the fluorides; at CFCI, we use a weal caustic solution to capture the fluorides. The reason for this being that our normal sampling period will run from three to six hours and the caustic will minimize the chance of the scrubbing media becoming acid and the possibility of a fluoride loss. For fluorides the EPA maintains a multi-point sampling procedure as they did for particulate. The State of Florida requires isokinetic sampling, which is really not necessary, at the point of average velocity unless a considerable amount of particulate material is present in the gas stream. At CFCI, we sample for fluorides in the same manner we do for particulates. Table I gives a step-by-step comparison of the EPA and CFCI's sampling procedures, as they were done in December of 1971. the comparative results obtained by the EPA and CFCI sampling group were quite good and as might be suspected, the points of greatest disagreement occurred in those inlets to the scrubber with high dust loadings of the larger particle sizes. I have made a tabulation of the comparative results in Tables 2 and 3. Also shown in these tables are comparative flow rates and moisture content of the streams measured. It can be seen (even though they made special sample runs to condense the moisture) while we simply take a wet and dry bulb reading, good comparative results were obtained.

In Table 4 you will find a comparison of the analytical results on samples taken by the EPA at CFCI using a fluoride electrode and a modified Willard-Winter volumetric method. As you can see, the results are quite comparable. Also, a comparison of the Willard-Winter method and the EPA method, which is the colorometric procedure, may be derived by comparing in Tables 2 and 3 the results listed under column EE which is the EPA analysis and the column EE/CFCI which are the same samples analyzed by CFCI. The main difference is due to the analysis. These results also compare favorably, although not quite as good as those comparing the Willard-Winter and the Electrode.

Arthur D. Little made a study for the EPA comparing sampling method and analysis. In this report, the A.D. Little people could find no reason for using a glass probe or all glass equipment. Their work, comparing what was essentially the Florida train and the EPA train, gave no really significant differences. They did state that the stainless steel probe had a greater variation in the collection efficiency. However, it also showed a better overall collection of fluorides.

As far as analysis is concerned, the A.D. Little report recommends the use of the fluoride electrode following a perchloric acid or sulfuric acid distillation. They did acknowledge that direct reading of samples could well be possible and advisable for fertilizer plants. In fact, some of the favorable comparisons shown, with other methods in their report, were made by the direct method.

At CFCI, we have changed to using the ammonia electrode in place of the conventional distillation-titration method from the modified Kiedahl procedure. A considerable amount of work has been done by the CFCI lab and has shown that the ammonia electrode analysis in the concentration ranges normally encountered for stack and effluent sampling to be at least as good as the distillation-titration procedure.

I will close with a brief description of the CFCI emission monitoring program. This program was designed on the premise that those stacks with the highest potential emissions should be checked most frequently. The resulting program is outlined below:

Monday and Friday:

1. The three phosphoric acid plants for fluoride only
2. The three DAP plants for fluoride and ammonia

Stack flow rates at these units are taken only ance per month since the change in flow rate is usually less than the normal flow measurement error. Not having to measure the flow will cut the operator time to one-half or one-third the time required when the flow is measured. The samples are allowed to run unattended for three to five hours allowing the technicians to perform other duties while taking the samples.

Tuesday:

The three stacks at the super acid plant are taken in a more conventional manner with a flow measurement preceding each sample. Flows are measured more frequently here because of the greater percent flow change experienced. While in operation, the three samples are monitored by two technicians.

Wednesday and Thursday:

1. Sulfuric acid plants are sampled for the following:
   a. SO_2 (By Reich Test)
   b. Stack mist and total sulfur

The AFI Plant is sampled for fluoride emissions once a week on any convenient day.

Other special tests run on request are:

a. Dust loadings to and from the rock dust collectors
b. Dust and fluoride emissions from the shipping units
c. Individual scrubbers are sampled for entrainment and fluoride emissions
d. Super Acid feed acid tank scrubbers are sampled for fluorides
e. Special tests afor moisture and mist on gases leaving the drying tower at the sulfuric acid plants
f. Regularly scheduled samples that may have been missed

In order to maintain this schedule and to minimize costs, the following steps have been taken:

1. Since the Phosphoric Acid, DAP, and AFI Plants are sampled at the rooftop level, vacuum pumps and gas volume meters are stored at each of these points to save the time and effort needed to transport them.
2. Flow rates are not measured for every sample.
3. Samples are taken at a single point instead of a multi-point traverse.
4. A simplified calculation procedure is used.
   An example of this may be seen by comparing the attached forms 1 and 2. Form 1 is an example of the type form used for the conventional calculations. The data is all recorded on the 5 lines at the top. The 19 numbered lines are used to calculate the emissions rate.
   Form 2 is the one in use at CFCI. The blanks with letters are used to record the date. The first 5 numbered blanks are obtained from graphs using recorded data. Blanks 6 and 7 are simple multiplication and division. The one final calculation to obtain the emissions rate is at the bottom.

The purpose of this shortened procedure is more frequent sampling. Taking three or four times the number of samples, even though they may be slightly less accurate, will still provide:

1. A better picture of the average emission rate
2. Faster detection of scrubber or plant operating problems that affect emissions
3. Allow the technicians to monitor the effluent and make special tests for production and engineering

This is all to be accomplished at a cost that would be approximately equal to having an outside firm sample each of our 16 main stacks two or three times per year.

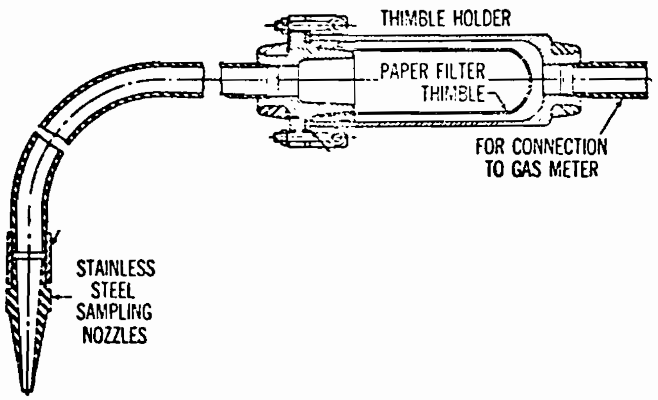


Figure 1

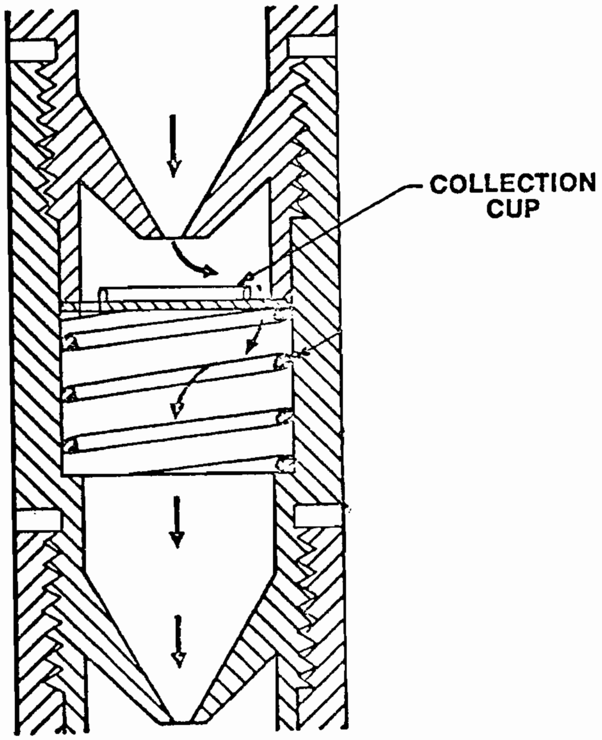


Figure 2

Figure 3

4.2 Gas volume.

$$V_{mc}=V_m\left(\frac{P_m}{P_{std}}\right)\left(\frac{T_{std}}{T_m}\right)=17.71\,\frac{°R}{\text{in. Hg}}\left(\frac{V_mP_m}{T_m}\right)\quad\text{equation 4–2}$$

where:

V_{mc} =Dry gas volume through meter at standard conditions, cu. ft.

V_m =Dry gas volume measured by meter, cu. ft.

P_m =Barometric pressure at the dry gas meter, inches Hg.

P_{std}=Pressure at standard conditions, 29.92 inches Hg.

T_{std}=Absolute temperature at standard conditions, 530° R.

T_m =Absolute temperature at meter (°F+460), °R.

4.3 Moisture content.

$$B_{wo}=\frac{V_{wc}}{V_{wc}+V_{mc}}+B_{wm}=\frac{V_{wc}}{V_{wc}+V_{mc}}+(0.025)\quad\text{equation 4–3}$$

where:

B_{wo}=Proportion by volume of water vapor in the gas stream, dimensionless.

V_{wc} =Volume of water vapor collected (standard conditions), cu. ft.

V_{mc} =Dry gas volume through meter (standard conditions), cu. ft.

B_{wm}=Approximate volumetric proportion of water vapor in the gas stream leaving the impingers, 0.025.

5. *References.*

Air Pollution Engineering Manual, Danielson, J. A. (ed.), U.S. DHEW, PHS, National Center for Air Pollution Control, Cincinnati, Ohio, PHS Publication No. 999–AP–40, 1967.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, Calif., November 1963.

Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases, Western Precipitation Division of Joy Manufacturing Co., Los Angeles, Calif., Bulletin WP–50, 1968.

METHOD 5—DETERMINATION OF PARTICULATE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and applicability.*

1.1 Principle. Particulate matter is withdrawn isokinetically from the source and its weight is determined gravimetrically after removal of uncombined water.

1.2 Applicability. This method is applicable for the determination of particulate emissions from stationary sources only when specified by the test procedures for determining compliance with New Source Performance Standards.

2. *Apparatus.*

2.1 Sampling train. The design specifications of the particulate sampling train used by EPA (Figure 5–1) are described in APTD–0581. Commercial models of this train are available.

2.1.1 Nozzle—Stainless steel (316) with sharp, tapered leading edge.

2.1.2 Probe—Pyrex[1] glass with a heating system capable of maintaining a minimum gas temperature of 250° F. at the exit end during sampling to prevent condensation from occurring. When length limitations (greater than about 8 ft.) are encountered at temperatures less than 600° F., Incoloy 825[1], or equivalent, may be used. Probes for sampling gas streams at temperatures in excess of 600° F. must have been approved by the Administrator.

2.1.3 Pitot tube—Type S, or equivalent, attached to probe to monitor stack gas velocity.

2.1.4 Filter Holder—Pyrex[1] glass with heating system capable of maintaining minimum temperature of 225° F.

2.1.5 Impingers / Condenser—Four impingers connected in series with glass ball joint fittings. The first, third, and fourth impingers are of the Greenburg-Smith design, modified by replacing the tip with a ½-inch ID glass tube extending to one-half inch from the bottom of the flask. The second impinger is of the Greenburg-Smith design with the standard tip. A condenser may be used in place of the impingers provided that the moisture content of the stack gas can still be determined.

2.1.6 Metering system—Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 5° F., dry gas meter with 2% accuracy, and related equipment, or equivalent, as required to maintain an isokinetic sampling rate and to determine sample volume.

2.1.7 Barometer—To measure atmospheric pressure to ±0.1 inches Hg.

2.2 Sample recovery.

2.2.1 Probe brush—At least as long as probe.

2.2.2 Glass wash bottles—Two.

2.2.3 Glass sample storage containers.

2.2.4 Graduated cylinder—250 ml.

2.3 Analysis.

2.3.1 Glass weighing dishes.

2.3.2 Desiccator.

2.3.3 Analytical balance—To measure to ±0.1 mg.

2.3.4 Trip balance—300 g. capacity, to measure to ±0.05 g.

3. *Reagents.*

3.1 Sampling.

3.1.1 Filters—Glass fiber, MSA 1106 BH[1], or equivalent, numbered for identification and preweighed.

3.1.2 Silica gel—Indicating type, 6–16 mesh, dried at 175° C. (350° F.) for 2 hours.

3.1.3 Water.

3.1.4 Crushed ice.

3.2 Sample recovery.

3.2.1 Acetone—Reagent grade.

3.3 Analysis.

3.3.1 Water.

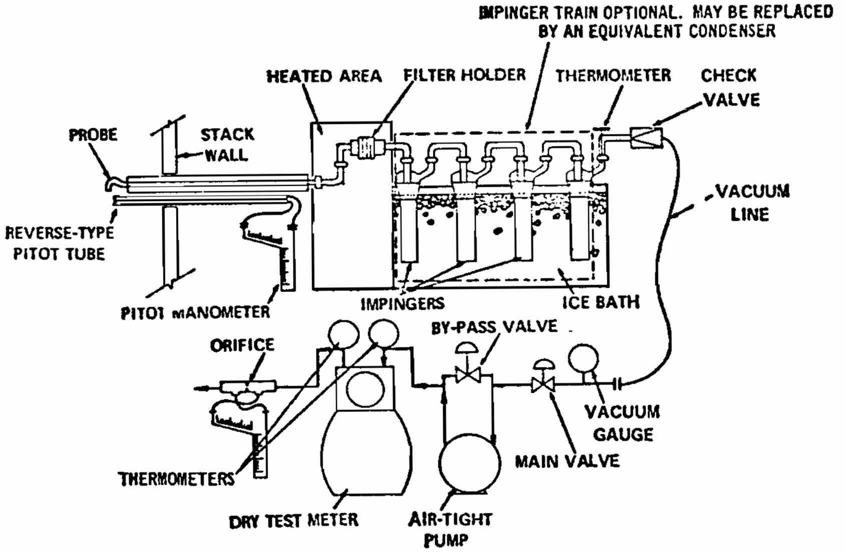


Figure 5-1. Particulate-sampling train.

3.3.2 Desiccant—Drierite,[1] indicating.

4. *Procedure.*

4.1 Sampling

4.1.1 After selecting the sampling site and the minimum number of sampling points, determine the stack pressure, temperature, moisture, and range of velocity head.

4.1.2 Preparation of collection train. Weigh to the nearest gram approximately 200 g. of silica gel. Label a filter of proper diameter, desiccate[2] for at least 24 hours and weigh to the nearest 0.5 mg. in a room where the relative humidity is less than 50%. Place 100 ml. of water in each of the first two impingers, leave the third impinger empty, and place approximately 200 g. of preweighed silica gel in the fourth impinger. Set up the train without the probe as in Figure 5–1. Leak check the sampling train at the sampling site by plugging up the inlet to the filter holder and pulling a 15 in. Hg vacuum. A leakage rate not in excess of 0.02 c.f.m. at a vacuum of 15 in. Hg is acceptable. Attach the probe and adjust the heater to provide a gas temperature of about 250° F. at the probe outlet. Turn on the filter heating system. Place crushed ice around the impingers. Add more ice during the run to keep the temperature of the gases leaving the last impinger as low as possible and preferably at 70° F., or less. Temperatures above 70° F. may result in damage to the dry gas meter from either moisture condensation or excessive heat.

4.1.3 Particulate train operation. For each run, record the data required on the example sheet shown in Figure 5–2. Take readings at each sampling point, at least every 5 minutes, and when significant changes in stack conditions necessitate additional adjustments in flow rate. To begin sampling, position the nozzle at the first traverse point with the tip pointing directly into the gas stream. Immediately start the pump and adjust the flow to isokinetic conditions. Sample for at least 5 minutes at each traverse point; sampling time must be the same for each point. Maintain isokinetic sampling throughout the sampling period. Nomographs are available which aid in the rapid adjustment of the sampling rate without other computations. APTD–0576 details the procedure for using these nomographs. Turn off the pump at the conclusion of each run and record the final readings. Remove the probe and nozzle from the stack and handle in accordance with the sample recovery process described in section 4.2.

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[1] Trade name.

[1] Trade name.

[2] Dry using Drierite[1] at 70° F.±10° F.

PARTICULATE SAMPLING APPARATUS

NORMAL STACK SAMPLING TRAIN

Figure 4

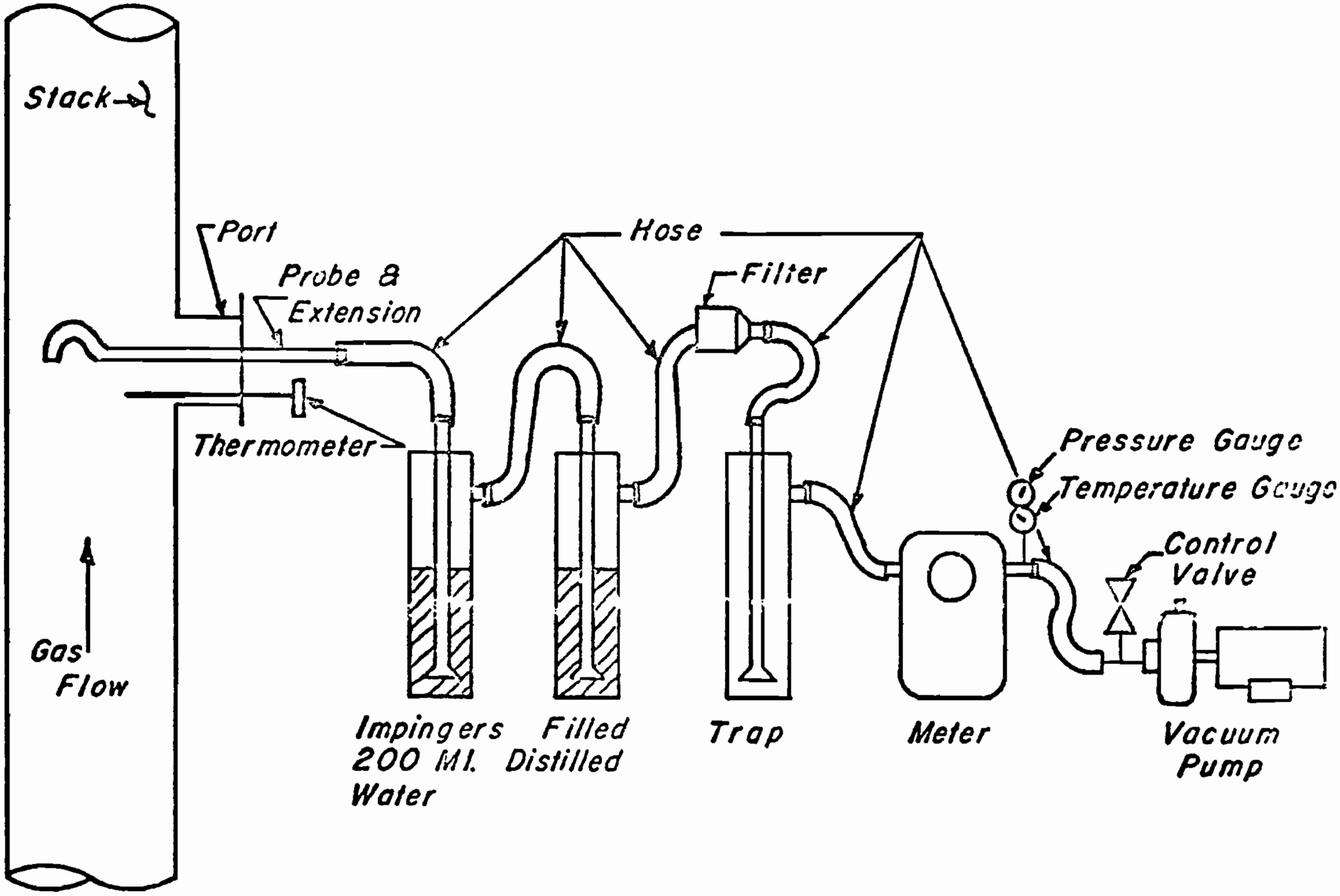
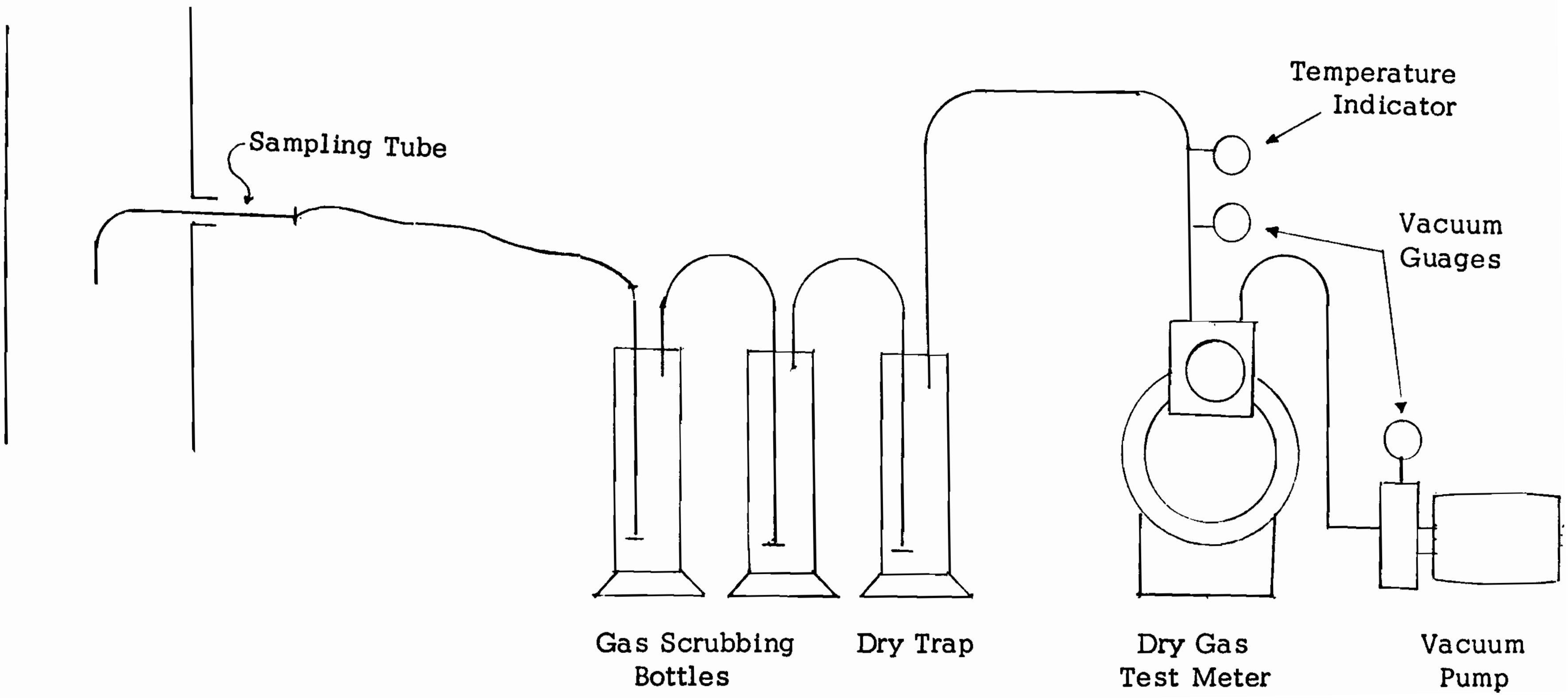


FIGURE 5

GAS SAMPLING TRAIN



EPA PROCEDURE	CFCI PROCEDURE
1. The probe, sample train and connecting tubing are glass with ground glass joints.	1. We used a 316 S.S. probe with rubber tubing connection to the sample train. Rubber tubing is also used to connect each scrubber in the sample train.
2. The sample train consists of four Smith Greenberg impingers in series. The first two impinger contains distilled water, the third is a dry trap and the fourth contains silica gel. This train is used to sample fluorine and particulate only. For the preliminary moisture run and ammonia sample at DAP, midget impingers are used. These impingers are similar in design to Smith-Greenberg impingers but are about 1/10 the size and can pass about 1/10 the flow. For the moisture run water is used and for the ammonia sample .1 N H_2SO_4 is used.	2. The sample train consists of three or four Smith-Greenberg impingers in series. For the DAP Plants four impingers are used. The first impinger contains 20% H_2SO_4 to capture the ammonia. The next two impingers contain .1 N NaOH to capture fluorine. The fourth impinger is a dry trap. The sample train for all other plants is identical to the one used for DAP except the first impinger with H_2SO_4 is not used.
3. Stack or duct flow rates are determined with a type S pitot tube and inclined manometer. Velocity readings are taken at intervals so that each reading represents an equal area of the stack or duct.	3. The same type of equipment and the same procedure is used by CFCI as the EPA.
4. Before sampling the EPA make a moisture run using midget impinger in a ice bath. The amount of condensate is weighed to determine the moisture content of the stack gas. This moisture is used with the temperature of the stack gas to calculate the stack gas density which is used with the pitot tube reading to calculate stack velocity and gas volume.	4. CFCI takes wet and dry bulb temperature to find the relative humidity of the gas. From this the density of the stack gas is determined (by a graph). The gas velocity is then calculated (actually read on a graph) from the density and pitot tube reading.
5. The EPA takes the velocity readings and samples simultaneously. A portion of the total sample is taken at each velocity point measurement. The sampling rate is adjusted at each point to make it isokinetic with the stack flow rate.	5. CFCI determines the velocity first and samples at the point nearest the average velocity at a isokinetic rate.
6. Total sample volume is measured with a dry test meter. However, their sampling rate is determined with an orifice meter. Their dry test meter is located after the vacuum pump which eliminated a volume correction for a vacuum at the meter. Since a silica gel column is used after the water scrubbers no volume correction for moisture is needed. The only correction for meter volume is temperature.	6. Total sample volume is measured with a dry test meter. Sampling rate is determined by noting the volume taken for one minute on the dry test meter. Our meter is located between the vacuum pump and the sample train since in some cases our flow rate is controlled by an air bleed on the suction side of the pump. Our meter volume is corrected for vacuum, moisture and temperature. This correction is done in one step by graph.
7. The stack flow rate and gas sample volume are related to each other by correcting both the air standard conditions (70°F, one atmosphere, dry).	7. The metered sample volume is corrected to stack conditions to relate it to the stack flow rate.
8. Since their train has no flexible connections a platform six to ten feet long at the correct distance below the sample port (about 20 inches) must be provided to accomodate their sample train.	8. Our train allows the sampling of almost any point that can be reached and has a sample port large enough to accept a sample probe.

TABLE 2

COMPARISON OF ENVIRONMENTAL ENGINEERING & CFCI SAMPLING AND ANALYSES

RUN NO.	Point	Fluoride Rate			SCFM			% MOISTURE		
		E.E.	E.E./CFCI	CFCI	E.E.	E.E/CFCI	CFCI	E.E.	E.E./CFCI	CFCI
CFCI	1	-	-	34.4	-	-	25,400	-	-	13.1
1	1	28.65	-	-	23,146	23,100	-	12.6	12.8	-
2	1	25.93	28.7	-	24,303	24,200	-	13.0	13.2	-
CFCI	1	-	-	26.2	-	-	-	-	-	-
3	1	14.27	14.1	-	23,657	23,600	-	14.2	14.4	-
CFCI	2	-	-	0.21	-	-	3,316	-	-	3.3
1	2	0.08	-	-	2,446	-	-	3.4	3.4	-
2	2	0.09	-	-	2,533	-	-	4.6	4.6	-
CFCI	2	-	-	0.19	-	-	-	-	-	-
3	2	0.13	-	-	2,369	5,000	-	3.6	3.6	-
CFCI	3	-	-	0.24	-	-	5,861	-	-	4.6
1	3	0.21	0.31	-	7,090	7,090	-	3.1	4.0	-
2	3	0.15	-	-	7,200	7,200	-	2.7	2.7	-
CFCI	3	-	-	0.18	-	-	-	-	-	-
3	3	0.18	0.28	-	7,640	7,640	-	3.2	3.2	-
.CFCI	4	-	-	0.22	-	-	35,900	-	-	4.0
1	4	2.02	2.08	-	34,327	34,500	-	3.8	3.8	-
2	4	0.35	0.42	-	33,384	33,400	-	4.1	5.0	-
CFCI	4	-	-	0.55	-	-	-	-	-	-
3	4	0.59	0.75	-	34,635	34,600	-	3.8	3.9	-

NOTES: E.E. - Samples taken and analyzed by Environmental Engineering, Inc.
E.E./CFCI - Portion of above samples analyzed by CFCI.
CFCI - Samples taken and analyzed by CFCI.

TABLE 3

COMPARISON OF ENVIRONMENTAL ENGINEERING (EPA) AND CFCI

Run No.	Point No.	Fluoride Rate			SCFM			% MOISTURE	
		E.E.	E.E./CFCI	CFCI	E.E.	E.E/CFCI	CFCI	E.E.	CFCI
1	1	3.74	3.88	----	36,019	43,100	----	2.6	----
CFCI	1	----	----	12.1	- 0 -	- 0 -	----	----	----
2	1	2.65	1.78	----	34,373	35,400	----	2.1	----
3	1	3.07	----	----	41,447	41,100	----	2.5	----
CFCI	1	----	----	8.0	- 0 -	- 0 -	----	----	----
1	2	.19	.33	----	46,921	45,800	----	11.4	8.3
CFCI	2	----	----	1.3	- 0 -	- 0 -	44,608	----	----
2	2	.31	.28	----	52,423	53,100	----	9.5	----
3	2	.18	.38	----	60,675	59,300	----	7.5	----
CFCI	2	----	----	.55	-- 0 -	- 0 -	----	----	7.6
1	3	9.29	8.6	----	30,655	30,300	----	19.5	----
CFCI	3	----	---	19.5	- 0 -	- 0 -	----	----	----
2	3	7.25	5.08	----	36,665	38,100	----	10.4	----
3	3	1.93	1.59	----	34,855	34,700	----	9.0	----
CFCI	3	----	----	11.1	- 0 -	- 0 -	----	----	----
1	4	.15	.22	----	39,130	37,300	----	11.7	----
CFCI	4	----	----	.61	- 0 -	- 0 -	36,400	----	15.5
2	4	.51	.54	----	36,103	39,600	----	11.7	----
3	4	.08	.23	----	31,979	38,700	----	14.3	----
CFCI	4	----	----	.65	- 0 -	- 0 -	----	----	----

TABLE 4

COMPARISON OF ANALYTICAL PROCEDURES

DATE SAMPLED	PLANT LOCATION	LABORATORY PROCEDURE (WILLARD-WINTER) PPM F	EMISSION CONTROL FLUORIDE ELECTRODE PPM F
12-14-71	NO. 3 PAP		
	Stack (impingers)	1.6	2.2
	Stack (probe)	1.6	N.S.
	Hot Well Duct (impingers)	2.8	1.8
	Hot Well Duct (probe)	81.6	94.0
	Filter Duct (impingers)	3.6	2.7
	Filter Duct (probe)	80.0	76.0
	From Attack (impingers)	510	420
	From Attack (probe)	720	820
12-15-71	NO. 3 PAP		
	Stack	9.3	6.6
	Hot Well (impingers)	2.2	4.0
	Hot Well (probe)	98.1	124.0
	Filter	22.1	17.2
	Attack	441	410
12-16-71	NO. 3 DAP		
	Between R-G Scrub.	11	12.8
	From R-G Scrubber	25.2	21.6
	S and M Scrub. Inlet	23.2	24.0
	S and M Scrub. - Outlet	1.6	1.4
	Dryer Scrub. - Inlet	39.4	35.2
	Dryer Scrub. - Outlet	1.8	2.2
	Stack	13.8	14.0
12-20-71	NO. 3 DAP		
	Between R-G Scrub.	13.0	12.0
	From R-G Scrubber	14.2	15.2
	S and M Scrub Inlet	15.4	14.4
	S and M Scrub Outlet	2.6	2.6
	Dryer Scrub Inlet	26.0	22.4
	Dryer Scrub Outlet	4.0	3.7
	Stack	7.6	4.8

FORM 1

PARTICULATE TEST CALCULATIONS

Plant________________________, Stack________________________, Date______________

Bar. Press.________in.Hg, Stack Press.________in.Hg, Stack Dia.______in., C_p__________

Ave. Stack Temp.______F, Ave.$\sqrt{h}$______in.H_2O, Ave. Meter Temp.______F, Nozzle Dia.________in.

Meter Volume______________cu. ft., Moisture plus Silica Gel_______ml, Sample Time ______ min

Orsat Analysis: CO_2_______%, O_2_______%, CO_______%, N_2_______%

1) $V_{wv} = (0.0474)\times(\underline{\quad\quad}\text{ ml}) = \underline{\quad\quad\quad\quad}\text{ scf}$ = ____________scf

2) $V_{stpd} = (17.71)\times(P_o + \frac{\Delta H}{13.6})\times(V_m)\times(1/T_m+460)$ = ____________scf

3) $V_t = V_{wv} + V_{stpd} =$ = ____________scf

4) $W = V_{wv} / V_t =$ = ____________

5) $FDA = 1.0 - W =$ = ____________

6) $M_d = (0.44)\times(\underline{\quad}\%CO_2)+(0.32)\times(\underline{\quad}\%O_2)+(0.28)\times(\underline{\quad}\%N_2+\underline{\quad}\%CO)$ = ____________

7) $M_s = (M_d)\times(FDA) + (18)\times(W) =$ = ____________

8) $G_s = (M_s)/(28.99) =$ = ____________

9) $$EA = \frac{\left[(\underline{\quad}\%O_2) - (\frac{\underline{\quad}\%CO}{2})\right]}{\left[(0.264)\times(\underline{\quad}\%N_2)\right] - \left[(\underline{\quad}\%O_2) - (\frac{\underline{\quad}\%CO}{2})\right]} \times 100$$ = ____________%

10) $\bar{U} = (174)\times(C_p)\times(\overline{\sqrt{h}})\times(\frac{T_s + 460}{G_s})^{\frac{1}{2}} \times (\frac{29.92}{P_s})^{\frac{1}{2}} =$ = ____________fpm

11) $Q_s = (\bar{U})\times(A_s) =$ = ____________cfm

12) $Q_d = (Q_s)\times(FDA) =$ = ____________cfm

13) $Q_{stpd} = (Q_d)\times(\frac{70 + 460}{T_s + 460}) =$ = ____________cfm

14) $V_i = (\bar{U})\times(A_n)\times(FDA)\times(T)\times(\frac{70 + 460}{T_s + 460}) =$ = ____________scf

15) Percent Isokinetic = $\frac{(100)\times(V_{stpd})}{V_i} =$ = ____________%

16) $E_{stp} = \frac{(15.43)\times(Y)}{V_{stpd}}$ 17) $E_{12} = \frac{(12)\times(E_{stp})}{(CO_2\%)}$ 18) $E_{50} = \frac{(100 + EA\%)\times(E_{stp})}{150}$

19) $E_m = (E_{stp})\times(Q_{stpd})\times(0.00857)$

Particulate Lab Analysis	Y	Particulate concentrations, grains/scf E_{stp}	E_{12}	E_{50}	Emission Rate, lbs/hr E_m
Probe	______gm	______	______	______	______
Filter	______gm	______	______	______	______
Imp. H_2O	______gm	______	______	______	______
Organics	______gm	______	______	______	______
After Filter	______gm	______	______	______	______
Total	______gm	______	______	______	______

FORM 2

PARTICULATE TEST CALCULATIONS

DATE ____________ TIME ____________ TO ____________

VELOCITY READINGS

POINT NO.	VEL. PRESS. (Pv)	$\sqrt{Pv}$
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		

AVG. $\sqrt{Pv}$ ____________
AVG. Pv ____G____

SAMPLE ____________

STACK TEMP. DRY BULB ____A____ °F
WET BULB ____B____ °F
RELATIVE HUMIDITY ____1____ %
STACK PRESSURE ____________ IN.HG
STACK GAS DENSITY ____2____ LBS/FT

METER TEMP. __C__ ______ ______ ______ °F
METER VAC. __D__ ______ ______ ______ IN.HG
TIME ______ ______ ______ ______

METERED GAS VOLUME ____E____ FT^3

LIQUID SAMPLE VOLUME ____________ ml.-Start
____________ ml.-Finish

CONDENSATE VOLUME ____________ ml.

TOTAL SAMPLE AND WASH VOLUME ____F____ liters

STACK GAS SPEC. VOL. ____3____ FT^3/LB. DRY AIR

METERED GAS SPEC. VOL. ____4____ FT^3/LB. DRY AIR

STACK GAS VELOCITY ____5____ FT/MIN

STACK FLOW RATE __6 = 5 x area__ ACT. CFM

METERED GAS VOLUME __7 = E x 3 ÷ 4__ FT^3, AT STACK CONDITIONS

0.132 ____F____ SAMP. VOL. (L) x $\frac{6}{7}$ ACTUAL CFM / FT^3 METERED

x ____________ Analysis gm/L= ____________ F LBS/HR
x ____________ Analysis gm/L= ____________ N LBS/HR
x ____________ Analysis gm/L= ____________ P_2O_5 LBS/HR

3/9/73

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MODERATOR: RODGER C. SMITH: Thank you Bob. This area of these procedures have certainly advanced considerably since some of us made an attempt in this direction some fifteen years ago.

Continuing our search for ways to be at peace with our neighbors and to minimize loss of materials, we turn to another corner of the United States, Worcester, Mass. Our next speaker was formely Dean of Cooper Union School Of Engineering and Science. He holds a PhD in Chemical Engineering from the Case Institute of Technology, holds 20 patents, has received the Business Week award in 1970 for leadership in the "Enviroment" and was elected "Lecturer" by the American Institute of Chemical Engineers in 1972. Dr. Aaron Teller, President, Teller Environmental Systems, will discuss "Scrubbers."

Scrubbers In the Fertilizer Industry Their Success, Near Future And Eventual Replacement

Dr. Aaron J. Teller

I've been asked to give a paper on scrubbers in the fertilizer industry. I will comply with the request, but extend the subject to the essence of effective performance and regrettably indicate why the success of these scrubbers is leading to their eventual replacement by more effective transfer mechanisms.

It is patently outrageous to tell a fable to a distinguished audience. But it appears that this may be the only effective way to explain the success of some of these scrubbers, and the failure of others.

The fable is all about a fluoride molecule. He has had a lowly origin and is universally despised by plants, animals, environmental groups, and corporate profit centers. He has never had an opportunity to go to college. This is a blessing since he has not been misled by half-baked theories published in learned journals. By following his natural instincts instead of textbook admonitions, he has often escaped to brown the gladioli, cause arthritis in cattle, and defoliate trees.

What he has ignored is equilibrium. Equilibrium studies under controlled conditions, with exposure time available only to universities, indicates that the fluoride atom in its most popular associations as HF or SiF_4 is extremely soluble in water. These "data" implied to most that mere contact with water and most certainly with water containing basic materials would result in the essentially total removal of the fluoride. This "knowledge" brought joy to the gladioli, the citrus, the cattle, and the environmentalists, but not necessarily to the corporate profit centers.

As a result of this "knowledge", the investment in scrubbers rose throughout the land, but although his numbers were reduced, the fluoride somehow escaped in sufficient numbers to continue his harassing of the plants, trees, cattle, and corporate profit centers. For he had a knowledge that had escaped the knowing ones. He knew kinetics in addition to equilibrium. He knew local thermal release effects on solubilization. He knew the slow rates of diffusion of neutralizing agents that could destroy him. And he had the wisdom to permit his enemies to attempt to overwhelm him with energy and sprays while harassing them with flanking attacks of deposition, plugging, and corrosion, then slipping enough of his numbers through to scourge the land.

In the early 1960's there came a group who although respecting the "knowledge" of the learned ones of the college lands of equilibrium and the admonitions of the practical proponents of plugging promises, surreptitiously decided to learn from the enemy. They learned his use of temperature, of relative rates of diffusion, and of encapsulating the weapon water with silica. And once his superb practical knowledge was learned he was almost destroyed. He still lingers in the ponds, multiplies in the mists,, and scourges the life in proximity to his storage. But he is contained.

The moral of the story — Respect the theorists and the practical ones, but mostly learn from your enemy — He can be as smart as you.

So now we have learned of kinetics and thermal phenomena and equilibrium and in some scrubber systems, this knowledge has been applied to effectively reduce the emissions to tolerable levels.

However, knowledge of the behavior of molecules does not, in itself, provide a total solution. The secondary effects of recovery, the accompanying emissions, and the emissions created during recovery, vitally affect the design for reliable, economic, and efficient operation. The use of the EPA train imposes an additional restriction on emissions, the complete removal of entrained scrubbing liquors.

The new emission standards and the escalating ambient air standards further impose new restrictions on the performance of recovery systems. It is projected that permissible emissions will be

F — 1.5 — 3 PPM out of stack
0.08 — 0.15 lb/ton P_2O_5
Particulate 0.02 gr/SDCF (closer to 0.01)
Opacity 10%

These objectives can be fulfilled by the present state of the art.

The emissions from the various operations in fertilizer manufacture, their characteristics, and the potential problems in recovery systems are tabulated in TABLE I.

Although these emissions can be and are considered by the authorities to be pollutants, there is economic justification for recovery of these materials as products for process recycle or sale. Assumption of this objective is significant, if only psychologically, in the approach to design, operation, and maintenance.

In the chart noted, the ammonia and the entrained phosphoric acid or product fines can and should be recovered and recycled to process. The fluoride compounds are slowly achieving marketability in the water treatment, secondary aluminum, metals, glass, and chemical industries as a result of shortages of natural fluorides. Thus recovery processes should and, to a degree are, designed to accomplish the recycle or use objectives.

However, although there are economic objectives in the overall view, there are real problems in the implementation of recovery.

As indicated in Table I, the recovery or abatement of emissions by scrubbing is plagued by the secondary effects of absorption.

1. The recovery of ammonia by phosphoric acid results in the formation of compounds of various levels of ammoniation. Although the statistical concentration of ammonia in the phosphoric acid may be regulated to maintain the liquor mass in the liquids zone, in the ternary equilibrium diagram, the boundary layer concentration is most probably in the solidus zone. As a result a metastable equilibrium exists where deposition to rock like matrices of ammophos compounds in phosphoric acid can occur as a result of thermal or mechanical shock or rapid changes in gas feed composition.

2. In the recovery of ammonia by phosphoric acid the boundary layer temperature can rise as much as 50 degrees F. above the temperature of the bulk liquid due to release of the heat of neutralization. As a result, stripping of gaseous fluoride compounds will occur during the absorption process. the degree or quantity of the fluorides stripped during the process is a function of the concentration of the phosphoric acid used in the absorption process and the termperature of absorption.

It should be noted that the partial pressure of gaseous fluorides will rise an order of magnitude when the concentration of phosphoric acid increases from 30% P_2O_5 to 40% P_2O_5.

The release of gaseous fluoride compounds in the presence of ammonia creates an additional pollutant. This is ammonium bifluoride. Similar to the behavior of ammonium chloride, it dissociates at elevated temperatures and recombines on gas cooling. This submicron particulate presents a major problem for recovery systems in the DAP and NPK processes.

3. In the recovery of fluorides with water, significant deposition of silica can occur when the F-Si ratio is of the order of 2.8 or less. Deposition can occur, as a function of pH conditions in the absorbing liquid with ratios as high as 3.1. thus, equipment design must consider the potential of deposition and system design must seek to circumvent this potential.

4. Tail gas scrubbing using water results in an additional hazard. Although the partial pressure of fluorides over the pond are minimal and in and of itself presents no hazard, the accumulation of fluorides in mist under adverse atmospheric conditions can result in a fluoride hazard.

The solution to these problems rests in both system and equipment design. system design is, however, not independent of equipment capabilities. Thus, successful types of equipment in the specific services are first evaluated.

1. In the case of acidulation, or storage building effluents, the exhausts consist primarily of SiF_4 carrying small quantities of HF and entrained particulate. The most generally applied equipment is the spray-cross flow scrubber first installed at Borden, Plant City in 1963

(continued on page 153)

TABLE I

PROCESS	EMISSIONS	SCRUBBING LIQUOR	POTENTIAL PROBLEMS	SECONDARY EMISSIONS POTENTIAL	SCRUBBING LIQUOR	POTENTIAL PROBLEMS	TERTIARY EMISSIONS
ACIDULATION	S_iF_4	POND WATER	SILICA DEPOSITION PLUGGING	ENTRAINMENT			HF-POND MIST
DAP OR NPK RG	NH_3 S_iF_4-HF	P_2O_5	DEPOSITION OF METASTABLE AMMOPHOS GROUP PLUGGING LOSS OF P_2O_5	NF, NH_4F $NH_4F.HF$ (FUNCTION OF P_2O_5 CONC. AND TEMP.) P_2O_5	POND WATER	PLUGGING (FUNCTION OF pH CHANGE IN POND WATER)	HF-POND MIST
DRYER	NH_3 S_iF_4-HF PARTICULATE	P_2O_5	DEPOSITION OF METASTABLE AMMOPHOS GROUP PLUGGING LOSS OF P_2O_5	NF, NH_4F $NH_4F.HF$ (FUNCTION OF P_2O_5 CONC. AND TEMP.) P_2O_5	POND WATER	PLUGGING (FUNCTION OF pH CHANGE IN POND WATER)	HF-POND MIST
COOLER	PARTICULATE HF	P_2O_5	PLUGGING LOSS OF P_2O_5	HF, P_2O_5	POND WATER	PLUGGING (FUNCTION OF pH CHANGE IN POND WATER)	HF-POND MIST
GTSP RG	S_iF_4-HF PARTICULATE	POND WATER OR P_2O_5	INCOMPLETE ABSORPTION OF S_iF_4-HF LOSS OF P_2O_5	HF-S_iF_4 P_2O_5	POND WATER	PLUGGING	HF-POND MIST
DRYER	S_iF_4-HF PARTICULATE	POND WATER OR P_2O_5	INCOMPLETE ABSORPTION OF S_iF_4-HF LOSS OF P_2O_5	HF-S_iF_4 P_2O_5	POND WATER	PLUGGING	HF-POND MIST
COOLER	S_iF_4-HF PARTICULATE	POND WATER OR P_2O_5	INCOMPLETE ABSORPTION OF S_iF_4-HF LOSS OF P_2O_5	HF-S_iF_4 P_2O_5	POND WATER	PLUGGING	HF-POND MIST
GTSP STORAGE BUILDING	S_iF_4-HF PARTICULATE	POND WATER	EXCESSIVE AIR HANDLING RESULTING IN INCREASE IN FINAL SCRUBBER EMISSIONS. INADEQUATE AIR-PERSONNEL DANGER.	HF-POND MIST			
ACID CONCENTRATION	S_iF_4-HF P_2O_5	FLUOSILICIC ACID	PLUGGING	S_iF_4-HF	CONDENSER POND WATER		HF-POND MIST
GTSP DEFLUORINATION	HF SO_x PARTICULATE	RECYCLE ACID	THERMAL DAMAGE	HF	NEUTRALIZED POND WATER	PLUGGING	POND WATER MIST

(Fig. 1) and the spray cocurrent scrubber first installed at IMC Bonnie in 1961.

Although both perform effectively, the cross flow design permits higher flows, is modular in design, and has a maximum capability for particulate feed or deposition. As reported by EPA, the emissions for well designed Teller scrubber ranges from 1-3 PRM of fluorides, essentially in equilibrium with the pond water, in the order 0.003 to 0.010 lb F/ton P_2O_5.

The cross flow packed section is designed for high mass transfer efficiency but also as a solids handling system. As a result of its geometry the liquid flux can be varied as a function of depth of packing. thus the liquid can be concentrated in the zones where the maximum deposition potential exists. For example, maximum deposition in the packed bed will occur in the first foot of packing. thus, the liquid irrigation rate can be maintained at 20-30 GPM/ft_2 in the first foot of packing whereas it can be as low as 5 GPM/ft_2 at the back portion of the packing.

By proper design, the overall circulation of liquid can be as low as 20% of the liquid recycle rate for a counter-current or cocurrent scrubber for the same gas rate.

A major advantage in this design is that separate support plates exist for liquid and gas flows such that support plate buildup is minimal.

The absorption capability is a function of the height-depth relationships in the packed section. The particulate separation cut is 3-5 microns with ordinary design and down to 0.1 micron under nucleation (proprietary) conditions.

The cross flow scrubber is limited in operation to low viscosity liquid irrigation. Where ammonia absorption is required and phosphoric acid is the scrubbing medium, the danger of heavy precipitation inhibits the use of this type of equipment.

Specific for this service is the coaxial venturi (Teller Rockett) (Fig. 2). the major objective of this design is minimizing of deposition and a high degree of separation of phosphoric acid entrainment. The liquid flow pattern is linear from inlet to outlet. No turning is required. Thus the liquid is not subjected to mechanical shock that could result in deposition of ammophos. Liquid distribution is primarily achieved by underflow weirs with safety overflow weirs provided in case of blockage. The liquid is not dispersed by liquid pressure devices that could plug. the throat of the venturi is generally of diamond design to minimize scale up requirements since it provides the same efficiency of contact independent of overall capacity.

One of the major problems often encountered in large flow systems including venturi contact is that the pollutants are merely shifted from gas borne to liquid entrainment. this is a result of the low efficiency of entrained particle separation by large diameter cyclones. The design of the coaxial is such that the definition of flow patterns is far more precise than in cyclones of the same diameter. thus the entrained liquid cut is of the order of 10-15 microns compared with 40-60 microns for a cyclone of equal diameter.

Thus the loss of the phosphoric acid product is minimal.

A major problem encountered in ammonia scrubbing by phosphoric acid is the stripping of fluorides. The degree of stripping is highly dependent on the temperature, acid concentration, a concentration of sulfates in the scrubbing liquor. The fluoride partial pressures at constant temperature is a direct function of the pH of the acid and an order of magnitude difference is encountered with increase in P_2O_5 concentration from 30% to 40%. the problem is further exacerbated by the generation of high boundary layer temperatures as a result of ammonia absorption and reaction.

Thus the coaxial must be followed by a cross flow or other secondary scrubber to recover the fluorides in pond water or another aquerous medium.

The other secondary problem resulting from ammonia absorbtion is the production of ammonium fluoride and ammonium bifluoride. this occurs in the RGN and Drier primary scrubbers. Inasmuch as these particulates are in the submicron range, the alternatives for capture are the baghouse, high energy venturi (order of 50 in. w.g.) and the nucleator.

The nucleator is the lowest cost and most reliable unit for this service. Mechanically, the appearance is similar to the cross flow scrubber. However, the conditions of operation are established such that submicron ammonium fluorides are recovered at a pressure drop of the order of 2 in. w.g.

The emissions from an operating system in DAP production consisting of primary and secondary scrubbers produce a final emission of the order of 2 PPM fluoride total representing an exhaust of 0.03 lb F/ton P_2O_5.

In the case of GTSP, the emission control system can be identical to that used in DAP or NPK manufacture. However, the danger from deposition of reaction products from scrubbing is much less that that encountered in DAP or NPK scrubbing. this integrated venturi scrubbing for solids recovery and finishing tail gas scrubbing for fluoride reduction can be used representing a lower capital cost.

The only concern is loss of P_2O_5 product to the pond liquid in the scrubbing section for fluorides. Advantage is taken of the ability to achieve multiple scrubbing sections in a single cross flow shell. In this case particulate is recovered by phosphoric acid wash in the diamond venturi and the entrained acid above 50 microns in size separated in the baffle section. The smaller entrained particles to the 3-5 micron level are removed in a water recycle packed bed with the liquid overflow providing makeup to the phosphoric acid scrubbing liquor. the gas then passes through the final packed section for fluoride reduction to the permissible levels. This plant representing half the capital cost of the "old style" units is under construction (Fig. 1 and 3).

The "conventional" TESI system in GTSP service is providing emissions in the order of 2-2.5 PPM Fluoride equivalent to 0.04-0.06 lb F/ton P_2O_5.

In the case of acid concentration, the Swift scrubber design, a spray chamber design positioned between the evaporator and barometric condenser, provides 80-90% recovery of the fluoride emitted during the concentration process. Although this recovery is economically acceptable, the projection of restriction of pond emissions requires significant improvement in recovery. the major restrictions to increasing recovery of the fluorides is the deposition of silicates requiring recycle liquor with excess HF, obtained only from the 54% acid evaporator effluent. thus the equilibrium partial pressure of the recycle liquor is too high to permit effective recovery in first and second stage evaporation. We are now in the process of total system — scrubber design to recover in excess of 95% of the effluent fluorides.

With the success achieved with modern scrubber design, we have achieved the position of the expected dilemma. We have converted our air pollution problems into a polluted water source, the pond, that in turn is creating an ambient air hazard.

We have looped the system.

The real problem that is emerging is the pond. The solution is obvious. We will have to remove the pond as a component of our system design. this is difficult since the pond serves two purposes:

1. to remove thermal energy from the system from 1.8 — 2.5 x 10_6 Btu/ton P_2O_5
2. to provide low temperature scrubbing liquor necessary to efficient fluoride absorption and for condensing the concentrator system vapors

There are two ways to obviate the use of the pond. One is already on the design board. One is conceptual but already in practice in other industries.

The first uses conventional recovery previously described and now being recognized by EPA as the highest state of the art, coupled with a modified scrubbing liquor and non-effluent cooling.

The second, experimental in concept for the fertilizer industry, uses no water in tail gas scrubbing and can be modified to a completely water-less system.

The first system does not use pond water in any of the cross flow scrubbers or barometric condensers. Instead a sodium based aqueous solution is circulated through the system. An advantage in this type of design is that fluoride emissions can be reduced as much as 75% below present achievement levels, or to 0.04 lb F/ton P_2O_5 for the entire complex. The fluoride rich water exerting no fluoride vapor pressure can now be cooled in a cooling tower. A duty of 130,000,000 Btu/hr. for a 700 TPD NPK operation requires a cooling tower with land area of the order of 3000 ft_2 (Fig. 4).

A continuous slipstream is removed and neutralized with lime to form a silica rich calcium fluoride solid product and is regenerated to form a fresh caustic solution that is recycled to process.

The second process now operating in the glass, secondary aluminum, and copper industries uses a chromatographic absorbent called TESISORB. It has the capability of absorbing fluorides and sulfur oxides in a gas-solid reaction to form thermally stable products. the system simultaneously removes all particulates down to the 0.1 micron range.

It is capable of removing fluorides to an emission level of the order of 1-2 PPM and has been operational for a year in the glass industry and for 3 years in the secondary aluminum industry. The significant advantage to the process is that no thermal energy removal is required inasmuch as it operates efficiently up to 250 degrees F. (Fig. 5;.

Thus the setting has been established for the new generation control systems. the scrubbers are serving well and can be modified to achieve our new objectives and have served in the additional capacity of teaching us how to contain the fluoride mole ule since they gave us the substantiation of the theory, that few believe, to design their eventual replacement.

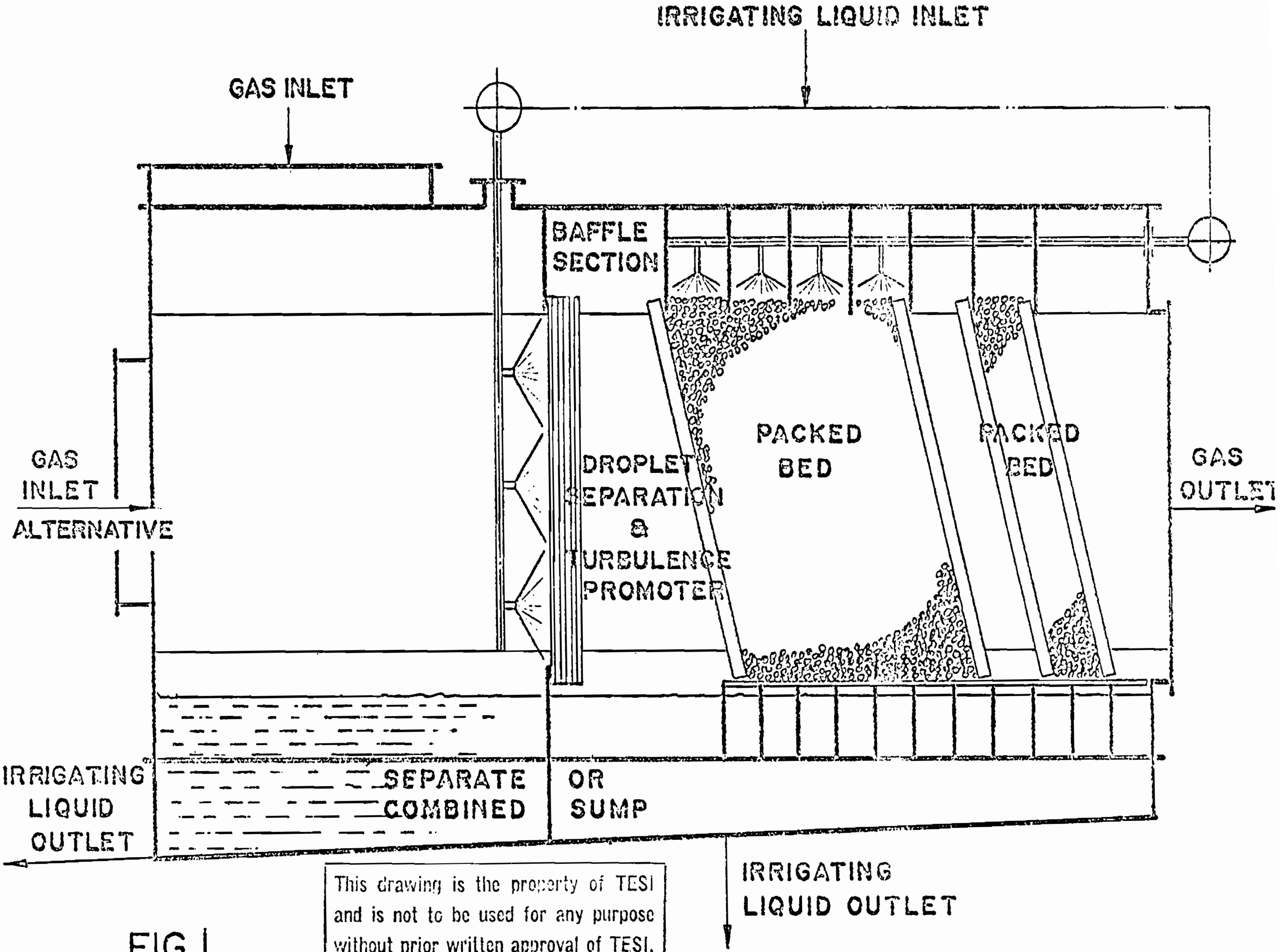
IRRIGATING LIQUID INLET
GAS INLET
BAFFLE SECTION
PACKED BED
PACKED BED
DROPLET SEPARATION & TURBULENCE PROMOTER
GAS INLET ALTERNATIVE
GAS OUTLET
IRRIGATING LIQUID OUTLET
SEPARATE OR COMBINED SUMP
IRRIGATING LIQUID OUTLET

FIG.1

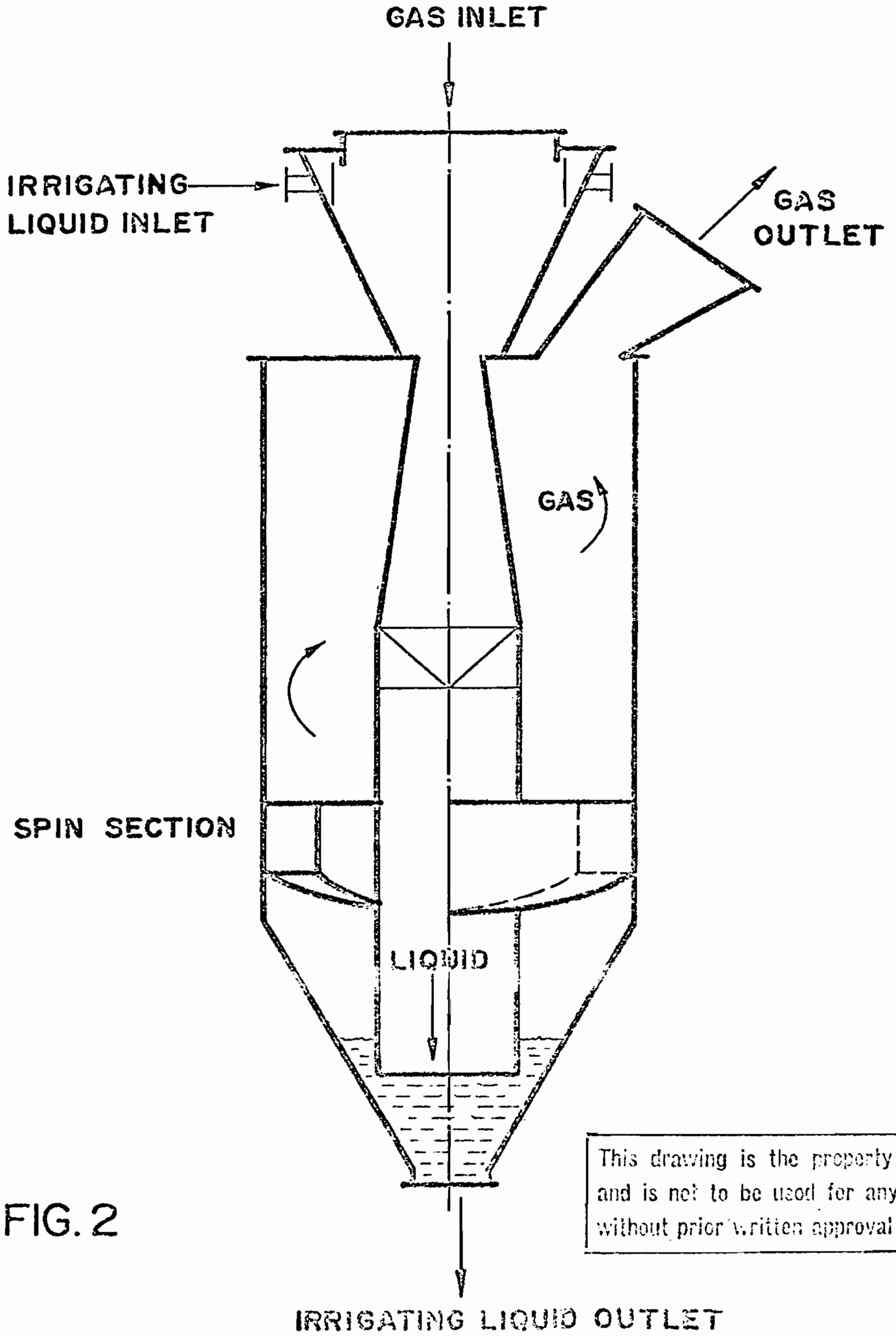

FIG. 2

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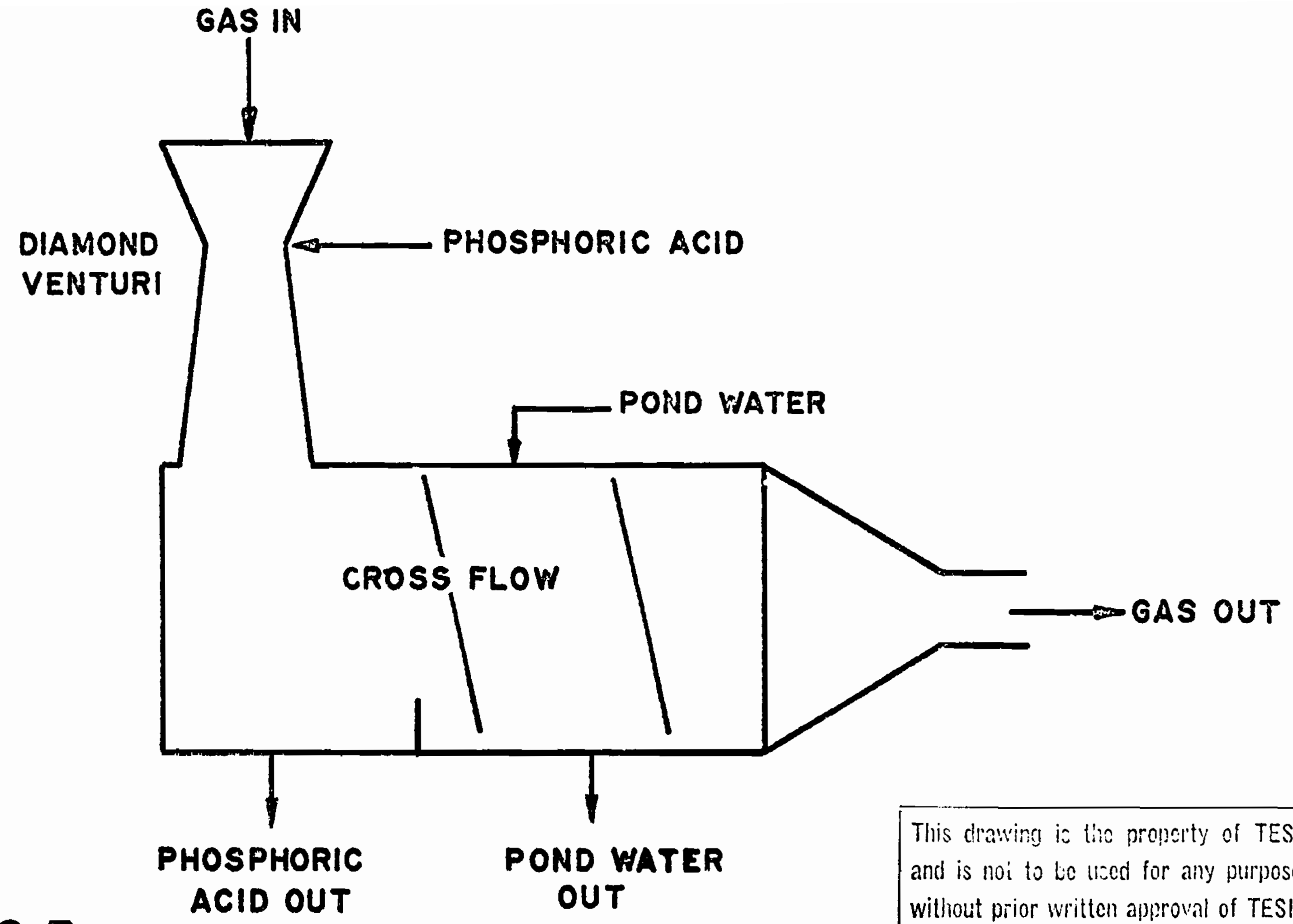

GAS IN
DIAMOND VENTURI
PHOSPHORIC ACID
POND WATER
CROSS FLOW
GAS OUT
PHOSPHORIC ACID OUT
POND WATER OUT

FIG. 3

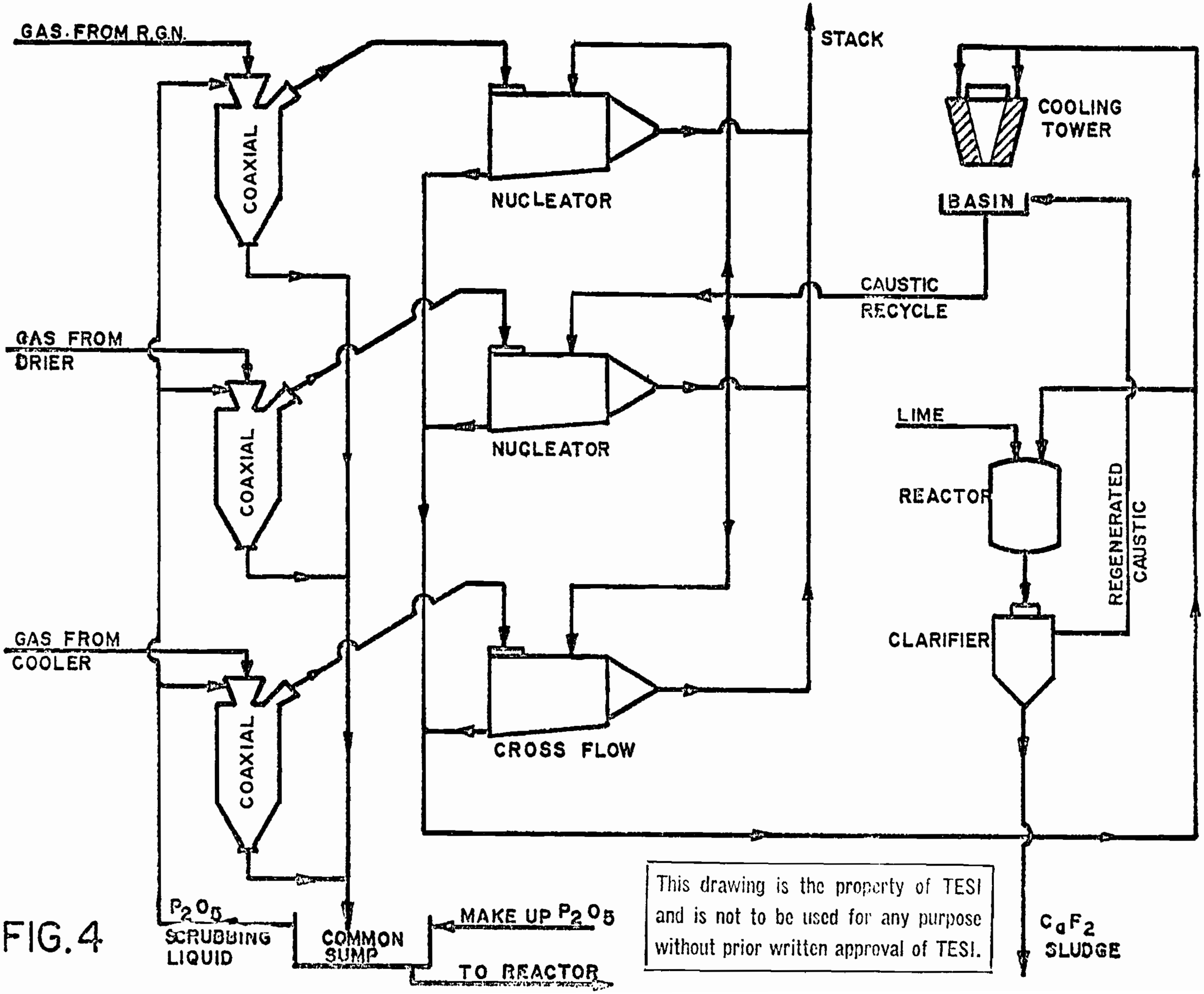


FIG. 4

This drawing is the property of TESI and is not to be used for any purpose without prior written approval of TESI.

MODERATOR RODGER C. SMITH: Thank you Dr. Teller. Florides have certainly been a problem in the Fertilizer Industry and we are glad to know that progress is being made in their recovery and also the economics of their recovery has something on the plus side.

Just a side-note, if any of you care for copies of the papers in advance of the printed "Proceedings" coming out, if you would leave your business cards or a note with your names and which papers you wish, we will be glad to funnel them to the appropriate Speaker and we would be glad to supply you with a copy.

For our next discussion this morning we address our attention to "Nitrogen Production", which is undergoing another round of expansion in the United States and in other Countries including China. With the spiraling cost of feed stock, any new efficiencies become increasingly important. Our speaker is James A. Finnerman, Assistant Director of Process Engineering, M. W. Kellog company, Houston, Texas. Mr. Finnerman holds numerous "Patents" and has published many technical papers concerning "Chemical and Refining Processes". Mr. Finnerman please come to the rostrum. Thank you.

Steam Stripping Of Process Condensate In Annonia Production

J. A. Finnerman and L. J. Buividas

Most ammonia manufactured in the U.S. today is produced from natural gas as the raw material, and in most cases the steam-methane reforming process is used to convert natural gas to ammonia synthesis gas. In this process, natural gas is partially reacted with an excess of steam in a primary reformer to produce hydrogen and carbon monoxide. The mixture is then combined with air, the source of nitrogen, and the remaining natural gas is reacted in a secondary reformer. The resulting gas, a mixture of hydrogen, carbon monoxide, carbon dioxide, nitrogen and steam, is introduced into a shift coversion step for reaction of carbon monoxide with steam to produce additional hydrogen. The shift reactor effluent, still containing an excess of steam, is cooled. Most of the unreacted steam is condensed and separated from the synthesis gas; this condensed process steam is termed "process condensate".

The process condensate from a 1,000 ton per day ammonia plant represents a substantial quantity of water, — approximately 300,000 gallons per day. The process condensate contains approximately 1,000 ppm of ammonia, in the form of ammonium bicarbonate, and in the range of 2,000 to 4,000 ppm of organic materials, principally methanol. Other organic compounds are present in lesser quantities, and small amount of various metals are present in trace concentrations.

The ammonia contained in process condensate is formed largely in the first stage of shift conversion. In this shift conversion step an iron catalyst is used to promote the reaction of carbon monoxide and water vapor to produce additional hydrogen. However, in the presence of iron catalyst, a small quantity of hydrogen and nitrogen react to form ammonia. It is this ammonia, formed as a by-product of shift conversion, which dissolves in water as the mixture of gases and water vapor are cooled, and which eventually appears as an impurity in process condensate.

The synthesis gas contains approximately twenty percent carbon dioxide. Because of the fairly high pressure at which synthesis gas production is conducted, carbon dioxide tends to dissolve in small quantities, in the liquid process condensate. Carbon dioxide in solution reacts rapidly with the ammonia in solution to produce ammonium bicarbonate, a highly soluble ammonium salt.

The organic matter is largely formed in a second stage of shift conversion, in which a copper-based catalyst is used. This type of catalyst promotes the reaction between hydrogen and carbon monoxide to form small quantities of methanol and certain other organic compounds. These organic chemicals, which are highly water soluble, appear in the process condensate.

The condensate also contains small quantities of mineral matter, principally sodium, iron, calcium, copper, zinc, magnesium, and silca. These inorganic impurities are introduced into the flowing stream by contact at high temperatures with catalysts and with refractories and to a lesser extent by contact with the steel walled vessels and piping.

Past practice in the ammonia industry has been to discard process condensate. The chemicals contained therein are such dilute concentrations that chemical recovery has not been economic. Ammonia plant process condensate is certainly not among the most objectionable industrial effluents; it is not even the worst offender in the fertilizer industry. Discharge of process condensate has not been generally considered a major nuisance, and such dischage has been tolerated.

Today however, the state of the art permits a reduction in the concentration of objectionable chemical components of process condensate, and we anticipate such reduction will become common practice in new ammonia plants as well as in existing plants. It is the purpose of this paper to describe the current state of the art, with particulat emphasis on steam stripping as a means for purifying the process condensate effluent.

This subject is of interest to the ammonia manufacturing industry, as it may help the industry to achieve reasonable effluent conditions at moderate costs for equipment and operation. The subject is of interest to the community as a whole because it provides a basis for definition of what can be achieved, based on the present technology and reasonable economics.

It may be of interest to mention first the several methods for handling process condensate which do *not* involve stripping. In addition to the previously mentioned discharge to the nearest stream, a practice which is less likely to be considered acceptable in the coming years, some of the alternate disposal methods which have been considered are: (1) Process condensate discharge to underground disposal wells is a practice which has been utilized in at least one instance.

This practice is of very limited application because of the special geological conditions required for safe dee-well disposal.

2. Process condensate utilization as cooling tower make-up water has been adopted to several instances. This has been practiced particularly in some of the older ammonia plants, in which because of different operating conditions the process condensate contained only 300 or 400 ppm of ammonia and virtually no organic matter. In an experimental test of this concept, we have found that the ammonia concentration tends to equilibrate in the recirculating cooling water at a concentration of about one-half of the ammonia concentration of the make-up cooling water. While no measurements of the cooling tower plume were made during this test, it is safe assumption that the cooling tower plume carried ammonia into the atmosphere. Cooling water systems operated in this manner require extra acid treatment to maintain pH control, and particular attention is required in regard to any cooper-bearing metals used in the cooling water circuit.

3. Process condensate can be used in certain chemical processes, provided that the process is not adversely affected by the chemical content of ammonia and organic matter. Process condensate has been used, for example, as make-up water for the CO_2 removal system within an ammonia plant. The process condensate has also been used as process water for formulation of liquid fertilizer solutions, an application for which it is obviously ideally suited. There has been some consideration of use of process condensate as process water for nitric acid manufacture; this practice involves certain inherent hazards however, and is not generally recommended.

Steam stripping is a technique for handling process condensate which is of far broader application than the various non-stripping nethods discussed above. Steam stripping can remove most of the ammonia and most of the organic material; in many instances such stripped condensate, containing acceptably low concentration of impurities., is discharged into the community drainage system. Discharge of stripped condensate is considered to be a reasonable and acceptable practice in communities where discharge of raw condensate would not be tolerated. A simple steam stripper, using about 0.1 to 0.2 pounds of steam per pound of condensate, can achieve reduction of ammonia to a level less than 50 ppm, and generally in the range of about 20 ppm. This latter concentrations corresponds to a discharge of about fifty pounds per day of ammonia from a thousand ton per day plant. A similar degree of reduction of organic material can be achieved.

The equipment for steam stripping of three hundred thousand gallons per day of ammonia plant condensate is relatively simple and inexpensive. For example, a carbon steel tower, approximately four feet in diameter, and approximately fifty feet tall would suffice. Both packed towers and tray towers ahve been used for this service. In some instances the condensate is preheated prior to introduction to the stripper, thereby achieving a steam economy. Steam for stripping can be utilized directly in the form of open steam to the bottom of the stripping tower; on the other hand, in some instances it is advantageous to use indirect steam reboiling for stripping. The stripping operation is most effective and most efficient if conducted at low pressure, for example one or two psig.

The stripped process condensate can be discharged in many instances to a drainage system, as mentioned above. However, stripped condensate is of such purity that it represents a valuable source of water, and consequently it is of economic merit to consider industrial utilization of the material, by the following methods for example:

1. Stripped process condensate has been utilized as cooling tower make-up. this is much preferble to using raw process condensate for this purpose. As mentioned above, raw condensate has been used for cooling tower make-up in some of the older, low pressure ammonia plants; the newer, high pressure plants produce a condensate with considerably higher concentration of ammonia, and therefore stripping is preferable in the new plants. It is advisable, even with stripped condensate, to pay particular attention to any cooper-bearing metals in the cooling water cirucit.

2. Stripped process condensate has been used as boiler feedwater. This practice has been used for several years in low pressure boilers and more recently in medium pressure and high pressure boilers. The stripped condensate requires further treatment for this purpose, in order to further reduce the cation concentration to satisfactory levels. Ion exchange is the preferred emthod to achieve the required cation reduction. The use of stripped process condensate as feedwater for the high pressure steam system of an ammonia plant has the added advantage that, in addition to complete elimination of process condensate as an effluent stream, it tends to reduce discharge from the plant demineralizer, since the quantity of raw water to be demineralized is reduced proportionately.

This discussion of ammonia process condensate stripping has considered to this point only the question of removing ammonia and organic matter from process condensate, to achieve a process condensate purity such that the material may be discarded or may be reused. Of equal importance is the aspect of safe disposal of the ammonia and methanol thus separated.

In many instances the stripper overhead vapor, consisting of steam, ammonia and methanol, is discharged to the atmosphere. The ammonia and methanol are dilute even in the stripper overhead vapor, and a well-designed vent system, one which discharges at a high elevation and remote from any operating area, is acceptable. The discharge of a few pounds of ammonia at a remote discharge point in an ammonia plant creates no known problems. It is not possible to even detect an ammonia odor from such discharge.

It is recognized that discharge of ammonia to the atmosphere is not a universally acceptable practice, even though it is considered much preferable to discharge to a small stream. In those instances in which atmospheric discharge of perhaps fifty or one hundred pounds per day of ammonia is not considered acceptable, a more complex, and more expensive, stripping system can be designed.

The ammonia and organic matter separated from the process condensate can be concentrated into a liquid stream. This would be accomplished by addition of an "enriching" section to the condensate stripper. The enriching section entails additional tower height, as well as a reflux condenser, accumlator and pump. these features add to the cost of the condensate stripper, and add to the steam consumption, to achieve the same degree of stripping. the ammonia can be concentrated by this means to about 5 or 10 percent concentration, and the resulting liquid will amount to approximately three thousand gallons per day. This of course, is not insignificant amount of material for disposal; it is however a significant reduction in volume, considering that the initial process condensate was approximately three hundred thousand gallons per day. The resulting ammonia-containing stream can be utilized, or disposed of, in several different ways:

1. The material can be utilized for UAN or other liquid fertilizer solutions. The effect of the organic content would require considerations. However, we believe that this technique would be acceptable practice.

2. The material could be incinerated, perhaps in the radiant section of the primary reformer, or in an auxiliary boiler. We are not sware that this disposal method has been tried in a commercial ammonia plant. If this technique were adopted, it would be advisable to monitor NOX emissions during initial operations. However, it is common practice to burn ammonia purge gas, which contain significantly higher quantities of ammonia, in primary reformers without particular NOX emission problems, and therefore we anticipate that no particular NOX problem would be encountered with this approach.

3. It has been suggested that the concentrated ammonia-methanol solution could be pumped to a sufficiently high pressure, vaporized, and injected into the radiant tubes of the primary reformer. Again, this practice has not, to our knowledge, been attempted in a commercial ammonia plant. The known impurities in the stream, — ammonia, methanol, and amines — would not be expected to have any adverse effect on the performance of the primary reformer or the catalyst. This technique would achieve the desirable and result of "total recycle" of the impurities contained in process condensate.

Process condensate strippers are in service in many ammonia plants throughout the world today, plants ranging in capacity up to 1500 metric tons per day. Several methods for handling or disposal of stripped condensate, are in use. The process condensate stripper can reduce chemical content of process condensate to levels which are generally acceptable for discharge. The process condensate stripper could be utilized as one element in a recycle system in which stripped condensate is re-used in the plant, and in which the chemicals stripped from the condensate are incinerated or otherwise safely disposed.

MODERATOR RODGER C. CMITH: Thank you Mr. Finnerman. With the great increase in sizes of "Hydrogen Plants" in the last few years, and the many efficiencies that have been built into these "Plants", we begin to think of the "Plateau" and we are glad to know that progress is still being made as we move into the period having to consider other sources of "Hydro-Carbons". No doubt there will be a lot happening in the near future in "Hydrogen Technology".

This concludes my job as Moderator and I wish to express to all of you our appreciation for the contributions yo have made. All of you presented well the pertinent information on Dynamic Subjects" which is becoming more important every day to all of us.

This Afternoon Session will start promptly at 1 P.M. Please be present because we have some interesting, important papers to discuss.

Mr. Ed Lantz, International Minerals and Chemical Corp., will be our Moderator.

Have a good lunch and I thank you.

Thursday, November 8, 1973

Afternoon Session
Moderator: E. L. Lantz

MODERATOR LANTZ: We would like to start this Afternoon Session promptly, hopefully, we can get through by 2:30 P.M., or shortly thereafter, so that any of you who have not yet checked out from the Hotel will still have time to do so by 3:00 P.M.

In selcting the topics for today's presentation on "Enviromental Technology, in the Fertilizer Industry", we have tried to come up with a cross-section which would provide something of interest to everyone attending. My own impressions have been based on the programs this morning, and I am sure the presentations this afternoon too, that we have a fairly good selection. Again, as was mentioned by Rodger Smith this morning, any of you that have topics that you would like to have presented at the next year's Round Table, please submit your suggestions as quickly as possible. I think it might be in order to start off this afternoon's Program with a little different type of Environmental Story".

We are fortunate to have with us a tandem of Speakers to start off this Session and representing that well known Chemical Company "Union Carbide". The Gentlemen who will be making the presentations are: First, Joe Collins, who has a Bachelors and Masters in Chemical Engineering and an Engineering Degree from New York University. Mr. Collins has been with Carbide for the past sixteen years. He is currently responsible for "Development and Design of Processes for Air Pollution control", that is, Pollution control and Hydrocarbon Separation and Conversion. Our other Speaker from Union Carbide is William C. Miller, National Sales Manager, Industrial systems, Environmental Systems Department. Mr. Miller has a Bachelors Degree in Chemical Engineering and a Masters Degree in Chemical Engineering. Bill worked for that small Company called "Exxon" from 1959 to 1962 and has been with "Union Carbide" since 1962. He served in a number of managerial positions and is presently "Market Manager Purasiv Systems".

Molecular Sieves
PuraSiv Process

J. J. Collins and W. C. Miller

Joe Collins will be talking about some of the "Technical Items" and I (Bill Miller) will be giving you some of the Economic background.

Both Mr. Collins and Mr. Miller gave a complete discussion on the following Slides showing Figures 1 thru 8.

Figure 1.

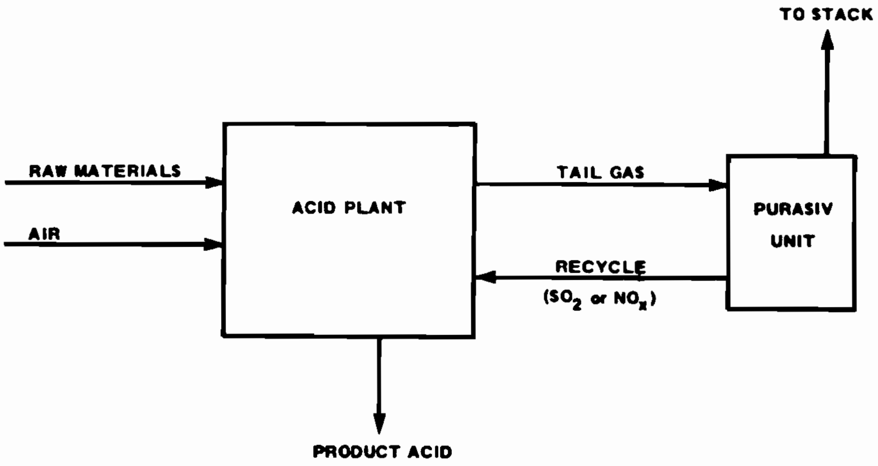
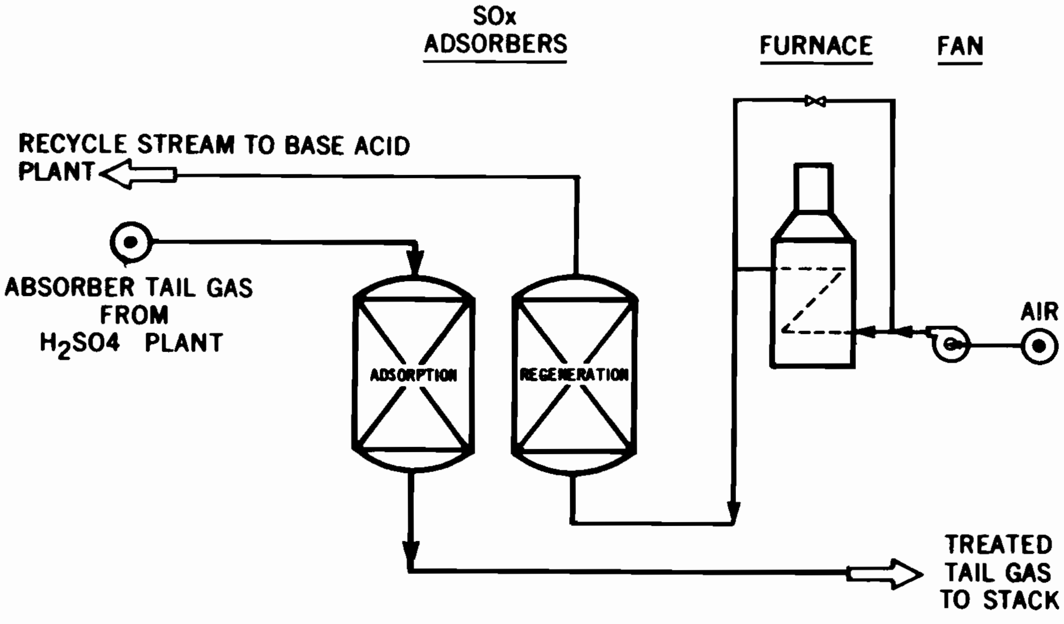


Figure 1. shows a basic PuraSiv S or N retrofit situation. SO_2 or NO_x are returned to the acid plant for conversion into additional product acid.

Figure 2.

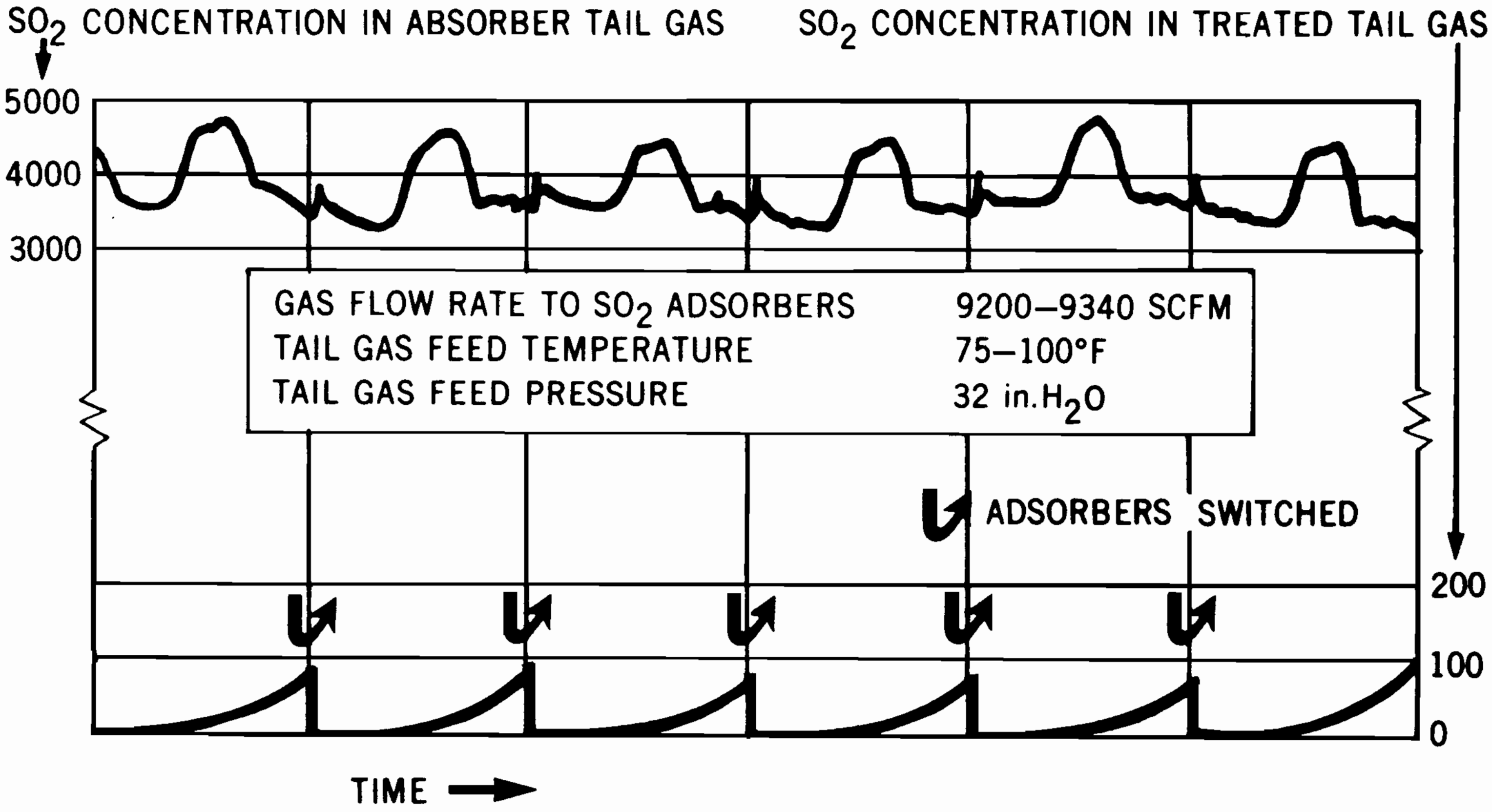


SCHEMATIC FLOW DIAGRAM FOR MOLECULAR SIEVE

PURASIV S UNIT AT COULTON CHEMICAL CORPORATION, OHIO.

Figure 2. is a simple schematic of the Coulton Chemical PuraSiv S Unit. Tail gas from the acid plant enters the molecular sieve bed that is presently in the adsorption mode. The SO_2 (plus acid mist vapor, and SO_3) is trapped and concentrated in the sieve. Just before SO_2 "break through" (several hours) the bed is switched to the recovery mode and regenerated. This is accomplished by passing dry hot air in the reverse direction through the vessel. The concentrated SO_2 is stripped out of the sieve and recycled back to the front end of the acid plant, for subsequent conversion into additional H_2SO_4.

Figure 3.



TYPICAL SO_2 CONCENTRATION PROFILES IN INLET AND TREATED TAIL GAS

Figure 3. illustrates typical operating data from the Coulton PuraSiv S Unit. The curves at the top show the feed SO_2 concentration, which varies from 3300 ppmv to 4800 ppmv. The rather large swings in concentration are typical in a sludge plant of this type and are caused primarily by the final acid stripping operation in the plant — not by the PuraSiv S Unit. Despite the swinging feed concentration the PuraSiv S remains very stable — producing effluent gas with SO_2 peaks in the 80 ppmv range and average values of 25 ppmv. The peaks can be lowered by a simple readjustment of the cycle time — cutting off the "breakthrough".

Figure 4.

PERFORMANCE OF COULTON PURASIV S UNIT
(DAILY AVERAGES) 1973

TIME PERIOD	Feb. 4-28	March	April	May	June	July
SO_2 in Effluent						
Typical ppm/v	15	25	20	25	25	35
Range ppm/v *	5-30	5-45	5-35	5-50	10-60	10-80
SO_2 in Feed						
Typical, ppm/v	2,600	3,250	3,200	2,700	2,600	2,800
Range, ppm/v*	1,700-5,000	1,900-6,500	2,200-6,000	2,200-3,000	2,200-3,000	2,200-3,500
Tail Gas Flow						
Typical, scfm	8,800	9,400	9,550	10,400	10,400	10,400
Range, scfm	8,500-9,300	8,500-9,800	9,200-10,000	10,000-10,500	10,000-10,500	10,000-10,500
Design, scfm	9,500-10,500	9,500-10,500	9,500-10,500	9,500-10,500	9,500-10,500	9,500-10,500
Acid Mist In Feed						
Average, Mg/scf	<0.08	<0.10	< 0.10	< 0.10	<0.10	< 0.10
Design, Mg/scf	<0.10	<0.10	< 0.10	<0.10	<0.10	<0.10

* Includes acid plant start-up and upset conditions. The high end of this range existed only for short periods after a start-up. Some of the high feeds were generated to test the PuraSiv S system.

Figure 4. summarizes the operating data obtained during the first 6 months of operation at Coulton. Effluent SO_2 concentrations averaged between 15 and 35 ppmv, despite large swings in feed concentration and the flow rates. this data includes acid plant start-up and shut down periods.

Figure 5.

PURASIV ECONOMICS
500 TPD SULFUR BURNING H_2SO_4 PLANT

TAIL GAS FLOW RATE	30,000 SCFM	
SO_2 CONCENTRATION IN TAIL GAS	3000 ppmv SO_2 +SO_3, ACID MIST, ACID VAPOR	
TOTAL BATTERY LIMITS CAPITAL INCLUDING MIST SEPARATOR	$1,150,000	
DIRECT OPERATING COSTS (350 SD PER YEAR)		
Power: 725 KW @ 1¢ per KWH	$60,900/yr	
20°F Rise Cooling H_2O: 620 gpm @ 4¢ per 1000 gals	$12,500/yr	
Indirect Heat: 51 MM BTU/Day @ 90¢ per MM BTU	$16,000/yr	
Chemical Operators:	None-Fully Automatic	
Molecular Sieve Supply And Performance Contract		
@ 100 ppmv Maximum SO_2 Emission Guarantee	$96,000/yr	
@ 500 ppmv Maximum SO_2 Emission Guarantee		$63,000/yr
Total Direct Operating Costs Without Acid Credit:	$185,400/yr	$152,400/yr

ACID CREDITS: 16.8 TPD of 100% H_2SO_4 From Recovered and Recycled SO_2

Acid Valued @ $10/Ton = ($58,800/yr)
Acid Valued @ $20/Ton = ($117,600/yr)
Acid Valued @ $30/Ton = ($176,400/yr)

BATTERY LIMITS SPACE REQUIREMENTS	3000 FT^2
DELIVERY TIME, AFTER RECEIPT OF PURCHASE ORDER	16 MONTHS

Figure 5. summarizes PuraSiv S capital and direct operating costs for a 500 TPD brimstone unit. It lets you "plug-in" your own utility cost factors and acid values to see how retrofit PuraSiv economics look in an individual plant situation. For new plants with *integrated* PuraSiv S systems, both capital and operating cost factors would be significantly lower.

Figure 6.

PURASIV N PROCESS FLOWSHEET

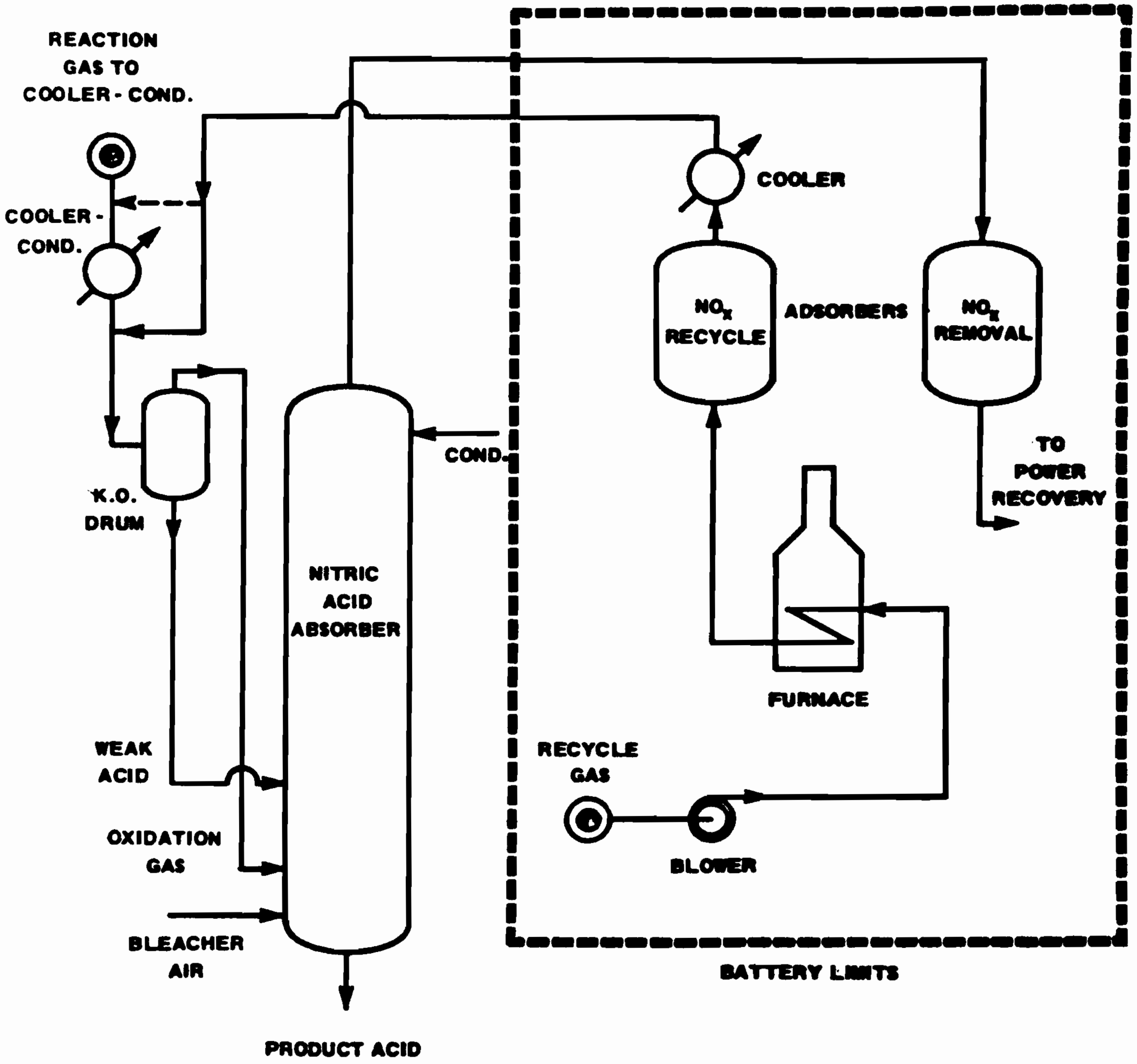


Figure 6. is a schematic flowsheet of a PuraSiv N System retrofitted to a nitric acid plant. Operation is quite similar to the PuraSiv S unit described in Figure 2. the major difference is the fact that the molecular sieve acts as an adsorbent and a *catalyst.* NO in the tail gas (typically 50% of the total NO_x) is converted completely and instantaneously to NO_x in the top section of the bed. The NO_x is then adsorbed and concentrated — returning back to the acid plant absorber during the regeneration cycle.

Figure 7.

PURASIV ECONOMICS
300 TPD HNO_3 PLANT

TAIL GAS FLOW RATE	24,000 SCFM
NO_x CONCENTRATION IN TAIL GAS	3,000 ppmv
TAIL GAS TEMPERATURE	90°F
TAIL GAS PRESSURE	90 psig

TOTAL BATTERY LIMITS CAPITAL FOR A FULLY ASSEMBLED PURASIV N UNIT	$755,000

DIRECT OPERATING COSTS (350 SD PER YEAR)		
Power: 400 KW @ 1¢ per KWH	$33,600/yr	
20°F Rise Cooling H_2O: 585 gpm @ 4¢ per 1000 gals	$11,800/yr	
Indirect Heat: 43 MM BTU/Day @ 90¢ Per MM BTU	$13,500/yr	
Chemical Operators:	None-Fully Automatic	
Molecular Sieve Supply and Performance Contract		
@ 50 ppmv Maximum NO_x Emission Guarantee	$34,000/yr	
@ 250 ppmv Maximum NO_x Emission Guarantee		$23,000/yr
Direct Operating Costs Without Acid Credit:	$92,900/yr	$81,900/yr

ACID CREDITS: 8.6 TPD of 100% HNO_3 From Recovered and Recycled NO_3	
Acid Valued @ $20/Ton	($60,200/yr)
Acid Valued @ $30/Ton	($90,300/yr)
Acid Valued @ $40/Ton	($120,400/yr)

BATTERY LIMITS SPACE REQUIREMENTS	1900 FT^2
DELIVERY TIME, AFTER RECEIPT OF PURCHASE ORDER	14 MONTHS

Figure 7. itemizes retrofit PuraSiv N economics for a typical 300 TPD HNO_3 plant. Again, the cost factors are set up to allow the individual plants to plug in their own values for utilities and acid credit.

Figure 8.

PURASIV STATUS SUMMARY
AS OF NOVEMBER 8, 1973

UNITS ON-STREAM OR CONTRACTS RECEIVED FOR FULL SUPPLY (ENGINEERING, HARDWARE, ADSORBENT).	ADDITIONAL UNITS WITH PROCESS ENGINEERING CONTRACTS
14	9

Figure 8. summarizes the status of Union Carbide's PuraSiv program as of 11/8/73. Twenty three units are either on-stream or committed.

MODERATOR LANTZ: Thank you Mr. Collins and Mr. Miller for that most interesting discussion and your clean-cut "Slide Demonstration" showing your "Molecular Sieves — PuraSiv Process". I have known our next Speaker, Mr. Lee L. Beck, for about a year. I have had a number of contacts with him and have a very high regard for his capabilities. He is a Chemical Engineer and has had over five years of experience in various "Industrial Pollution Control Applications". He has been with the "Environmental Protection Agency" for the past two and half years. It is my pleasure to present to you Mr. Lee Beck of the Environmental Protection Agency. He will discuss with you Federal Standards of Performance.

Federal Standards of Performance

Lee L. Beck

Thank you Ed, I do not know how many of you were here yesterday when Mr. Norwood K. Talbert made the comment that the Clean Air Act and the Water Pollution Standards are very difficult to understand, I think I am going to have to second that comment.

I. The Clean Air Act.

In order to understand the intent of Congress regarding pollution control, one must have at least a cursory understanding of the Clean Air Act. As last amended in December 1970, it established the pattern for a new national priority to reduce air pollution.

One provision of the Act of key importance to your industry requires the Environmental Protection Agency, or EPA, to establish standards of performance for new stationary sources of air pollution. These standards are to be based on emissions achievable with the best systems of emission reduction which the Administrator of EPA determines has been adequately demonstrated when he takes into account the cost of achieving such control.

Standards for new sources become effective as depicted on the first slide (Figure 1). As you may know, a regulation becomes Administrative Law after being published twice in the *Federal Register.*

1. A list of "source categories," or sources of pollution, is published in the *Federal Register.*
2. Within 120 days after a source category is listed, standards of performance must be proposed in the *Federal Register.*
3. For 45 days thereafter, EPA receives comments from interested parties regarding the standard.
4. An additional 45 days are provided for EPA to review the comments and incorporate any changes into the standard.
5. Ninety days after publication, the proposed standards of performance, modified as deemed appropriate based on the comments, are promulgated by publication a second time in the *Federal register* and thereby become law. It is interesting to note that the Act specified that any affected facility, the construction of which is begun after proposal, becomes subject to the emission limitation as finally promulgated.

As you can see, the time achedule starts when EPA publishes the list for which it intends to establish standards of performance. Actually, our development of data on a source category usually begins several months to a year prior to formal announcement of the list.

II. Rationale for Development of Standards Performance for the Phosphate Fertilizer Industry

I'm certain that many of you wonder, "Why develop standards for phosphate fertilizer plants?"

The "National Standards Study," a 1970 report to the U.S. Congress by the Secretary of HEW, identified phosphate fertilizer plants as an example of specific plants whose air contaminants, and I quote, "due to the amount or nature of emissions from such facilities, constitute a danger to public health or welfare." Documented evidence has shown that fluorides emitted by phosphate fertilizer plants have been responsible for damage to commercially-grown flowers, fruits, and vegetables. Also, low concentrations of fluorides are absorbed by grasses and plants and have caused fluorists in animals feeding upon such forage. This disease affects bone structure, retards growth, and adversely affects general health. Other effects of fluorides on plants and animals are well documented in a publication titled "Fluorides" by the National Academy of Science.

As we began to study your industry, we identified 15 major processes. Due to limited manpower and time, we selected only six for standards. Present plans call for development of standards for the other pro cesses in the future. Selection of the six processes in the current program were based on:

1. The quantity of their emissions.
2. Their anticipated growth rate (remember that standards developed under section 111 are applicable only to new plants).
3. The data available on which to base standards.
4. The impact a fluoride standard would have on existing sources, since States will be required to set fluoride standards for existing sources in accordance with section 111(d) of the Act.

The six processes selected for the current program are:

1. The production of wet-Process phosphoric acid (WPPA).
2. The production of superphosphoric acid (SPA).

3. The production of diammonium phosphate (DAP).
4. the production of granular triple superphosphate (GTSP).
5. Granular triple superphosphate storage.
6. The production and storage of run-of-pile triple superphosphate (ROP-TSP).

The next slide (Table 1) presents some of the parameters which originally influenced our decision to choose these processes for standards. We have been informed by your industry that even these dramatic growth rates may be conservative. Realization of the world's grain shortage may be one reason.

There are two other sources of emissions in the industry which, nationwide, are at least as significant as the six selected. The first is plants which mix various quantities of nitrogenous, phosphatic, and potassium pertilizers to produce "blends" of fertilizers. Your industry refers to these as NPK plants. Because of the large number of plants (6000-8000) and the variation of emissions with various formulas and blends, a study of this process was delayed and only now are we beginning to work on it.

The second major source is gypsum ponds, possibly the industry's greatest single emitter of fluoride (F). Though no figure has been widely accepted, it has been estimated that from 0.16 to 5.0 pounds of F evolves per acre each day. For a 200 acre pond, this could amount to as much as 1000 pounds F per day, up to several hundred times the controlled emissions from WPPA plants. Unfortunately, there is no known technology for measuring or controlling these emissions. EPA is now supporting a study by North Carolina State University on the chemistry and emissions from gypsum ponds.

Since the common control mechanism in the industry is water scrubbing, we considered promulgation of one fluoride emission standard for all processes. this approach was found to be impractical. The great variation of fluoride concentrations and gas volumes from each process precluded selecting a single standard which would require best demonstrated control for all processes.

Table 2 shows some of the major differences in the six processes. As you can see, gas volumes vary 300 fold, from 1,500 scf per ton P_2O_5 for SPA plants to 450,000 got GTSP plants. Concentrations of inlet gas range from 0.001 grains F per scf for GTSP storage facilities to 0.6 for ROP-TSP plants. Although the concentrations of fluorides out of the control devices were similar for all processes, we did not recommend a concentration type standard for reasons to be discussed later. A more equitable measure of actual emissions is pounds of F per ton P_2O_5. Outlet emissions range from 0.0005 lb F per ton P_2O_5 for SPA plants to 0.3 for ROP-TSP plants.

After obtaining the emission data, we began to comtemplate the form of the standard. Units of both concentration and mass were considered. Concentration units have the advantage of being simple and are measured directly. It is also the basis used to design the air pollution control system. However, concentration units would not necessarily provide strict control of the total mass of emissions. To control the total mass of emissions with a concentration standard, we must also control the volume of gas emitted since, at a constant concentration, the quantity of pollutants will vary directly with the effluent gas volume. Our investigation revealed that gas volumes do indeed vary significantly even for two plants making the same product. For WPPA plants, gas volumes varied six fold, from 50,000 to 300,000 scf per ton of P_2O_5.

A standard based on mass of allowable pollution per ton of production requires plant operators to be cognizant of and minimize effluent gas volumes (thereby minimizing total fluorides emitted). Unfortunately, the industry does not always accurately measure production rate. They do, however, weigh their raw materials and analyze for P_2O_5. As a result, the units for which the required data are most easily obtained and which provide strict control of mass emissions are "pounds of fluoride per ton of P_2O_5 fed."

III. *Data Base for Development of Performance Standards in the Phosphate Fertilizer Industry*

A. *Wet-Process Phosphoric Acid (WPPA) Manufacture*

The next slide (Figure 2) presents the results of our investigation of emissions from the WPPA process. For those not familiar with the process, a brief description is presented in the reprint.

Basically, WPPA is produced by acidulation of phosphate rock, a process which renders the phosphate in the rock soluble. Though a wide variety of acids can be used to leach these phosphates from the rock, the most common acid is sulfuric because of its wide availability and low cost.

The production of WPPA is depicted in Figure 3. The process consists of a reaction step where the acidulation of the rock occurs, a filtration step where the solids are separated from the acid, and an evaporation step where the acid is concentrated.

At the beginning of the process, measured quantities of 93-percent sulfuric acid, weak phosphoric acid from the filter cake washing process and pulverized phosphate rock are introduced into a reactor. The highly exothermic reaction that ensues is cooled by a vacuum cooler, which also serves to degasify the slurry of dissolved air, carbon dioxide and fluorides. After a retention time of five to eight hours the slurry is pumped to a filter where the acid is separated from the resultant gypsum. The gypsum is reslurried, with effluent process water and pumped to the gypsum pond. The acid containing about 30-percent P_2O_5, is concentrated by evaporators to about 54-percent P_2O_5 phosphoric acid, which is the product of the process.

Figure 2 shows fluoride emissions from WPPA plants in lb F/ton P_2O_5 plotted on the ordinate and the various plants from which we have data on the absicissa.

Emissions tests performed by operators of plants A, B, and C show average emission levels of 0.013, 0.014 and 0.010 respectively. Two plants tested during a joint study performed by our predecessor organization, the National Air Pollution Control Administration, and the Manufacturing Chemists Association, labeled D and E, revealed average emissions of 0.011 and 0.008.

EPA measurements at the three best controlled plants, labeled A, B, and C, show average emission levels of 0.015,0.006, 0.002 and 0.012. The data bars labeled C_1 and C_2 indicate emission levels from two tests of the same plant measured six months apart.

The standard which we have recommended for WPPA plants is 0.02 pound of fluoride per ton of P_2O_5.

B. *Superphosphoric Acid (SPA) Manufacture*

The development of standards of performance for SPA plants presented us with a particularly challenging situation. There are two predominant processes; the submerged combustion or direct fixed process and the vacuum evaporation process. Production of SPA by vacuum evaporation is depicted in Figure 4. Clarified 54-percent P_2O_5 phosphoric acid is continuously fed to a vacuum evaporator. The hot off-gases, which contain water vapor and fluorides, are condensed in the water-cooled barometric condenser. The fluoride-laden condenser water flows to the hotwell where it cools before draining to the gypsum pond. The concentrated acid is continuously drawn from the evaporator to product cooling tanks where it is cooled before being pumped to storage. In the submerged combustion or direct-fired process (Figure 5), hot gases are forced below the surface of the 54-percent P_2O_5 phosphoric acid in a direct-fired evaporator. Water vapor, fluorides, and phosphoric acid mist are driven from the solution and concentrated acid is drawn off as product.

The products produced by the two processes are essentially the same, but the direct-fired process has at least 100 times more emissions. The Clean Air Act commissions us to develop standards in accordance with "best systems of emission reduction." Its legislative history, which we use for guidance, indicates that EPA should use process changes where applicable to show demonstrated control technology. These facts coupled with a suggestion within the industry that the direct-fired process was obsolete, led us to recommend a standard based solely on emissions from the vacuum evaporation process, the less polluting. Such a standard would be sufficiently stringent that it would essentially preclude any growth of the direct process. When the strategy contemplated received greater exposure, we learned that some companies consider the direct process the more desirable. Furthermore, they maintain that the quality of the Nation's phosphate rock reserves are continually decreasing and the vacuum evaporation process cannot utilize poor grades of phosphate rock. Although the alternatives have not yet been submitted to the Administrator for a decision, it may not be in the best interest of our national resources to force obsolence of the direct-fired process.

In our judgment, none of the existing direct-fired SPA plants utilize the best methods of air pollution control. Consequently, the standard may ultimately be based on emission levels achievable with control devices not now used on the process.

A possible standard which permits both processes would be calculated using a conventional mass transfer equation which takes inlet and outlet gas concentrations into account. Such calculations show that emissions from the direct process can be limited to 0.01 pound F per ton P_2O_5, with pond water as the scrubbing medium. 0.01 is now being considered as the recommended standard.

C. *Diammonium Phosphate (DAP) Manufacture*

Development of a standard for DAP was more conventional. Many plants were inspected and certain ones selected from which to measure emissions and determine the best control technology that has been demonstrated.

Diammonium phosphate, or DAP, is manufactured by reacting wet-process phosphoric acid with ammonia. The resultant solid product contains about 18 percent N and 46 percent P_2O_5.

The production of DAP begins, as depicted in the flow diagram in Figure 6, by introducing measured quantities of phosphoric acid and anhydrous ammonia into a prereactor. The reaction forms a slurry which flows to a rotary dryer where the reaction is completed and the DAP is dried. The hot DAP is then screened, cooled, and conveyed to storage.

DAP plans incorporate venturi scrubbers as an integral part of the process to improve product yield. They use phosphoric acid to collect particulates and ammonia from the prereactor, the reactor-granulator, the dryer, and the cooler. Unfortunately, phosphoric acid is not an efficient scrubbing medium for fluorides. Consequently, a number of DAP plants have a second scrubber, a spray-crossflow packed scrubber which uses gypsum pond water to remove fluorides.

The operator of plant B reports average fluoride results of 0.041 pounds F per ton of P_2O_5 (Figure 7). Notice the range of the 23 measurements obtained. Although some of the observations vary sufficiently to be discarded with 99-percent confidence, all are included. Most of the results fell in the lower third of the data bar. EPA measured average emissions of 0.036 lb F per ton P_2O_5.

Plant A was tested twice by EPA. Results averaged 0.040 and 0.028 pound F per ton P_2O_5. Measurements by the operator on the same day as one of the EPA tests yielded results of 0.034 pound F per ton P_2O_5. The recommended standard for DA'P plants is 0.06 pound F per ton P_2O_5..

D. *Granular Triple Superphosphate (GTSP) Manufacture*

Granular triple superphosphate, or GTSP, is produced by reacting phosphate rock with phosphoric acid.

GTSP production is very similar to DAP production. In fact, many operators use the same production train for both products by changing the feed materials and making a few simple adjustments to the equipment.

In the production of GTSP (Figure 8), measured amount of phosphoric acid and phosphate rock are introduced into the reactor. The resultant slurry is pumped to the granulator where it is mixed with undersized product. From the granulator the GTSP drops into a rotary dryer where the reaction is forced to near completion. The GTSP is then screened and onsize product is cooled by a product cooler before being conveyed to storage where the reaction continues for three to five days.

Some plants produce GTSP by granulating cured ROP-TSP. These plants have basically the same equipment as the direct-slurry granulation process except for the reactor.

Operators of best-controlled GTSP plants also use spray-crossflow packed scrubbers to control fluoride emissions. These scrubbers are preceded by venturi scrubbers which remove particulates with process acid in much the same way as for DAP plants.

Six reportedly well-controlled plants were visited to obtain information on the process and control equipment. Four were judged not best-controlled because either excessive fluoride fumes were emitted in the processing area or the equipment was not suitable for testing (e.g., ductwork configuration). Emissions were measured at the remianing two locations.

EPA conducted two tests at plant A (Figure 9). Average emissions were 0.182 and 0.063 pound F per ton P_2O_5. The operator of plant A measured emissions of 0.120 pound F per ton P_2O_5 the same day as the first EPA test. Average emissions at plant B were 0.206 pound F per ton P_2O_5.

The recommended standatd for this process is 0.2 pound F per P_2O_5.

E. *GTSP Storage*

The production of granular triple superphosphate, or GTSP, is not considered complete until the GTSP has been stored for three to five days. during this storage period, the phosphate rock and residual acid are still reacting and fluorides continue to evolve. In addition to the gaseous fluorides evolved during storage, particulates are generated during the loading of GTSP into the storage building and the unloading of the product for shipment.

Figure 10 illustrates some of the activities which produce particulates in the storage building. The GTSP is distributed to a predetermined area in the building by conveyors. After three to five days the product is considered cured and ready for shipping. In shipping an order to a customer, front end loaders move loads of the GTSP to elevators or hoppers. The GTSP is sized by screening. Oversized material is pulverized and sent back to the screens; undersized material is sent to the GTSP production plant where it is reclaimed; and onsize material is shipped as product.

GTSP storage is the only of the six processes for which units of "pounds of fluorides per ton of P_2O_5 input" were not considered applicable. Quantities of fluoride evolved from the storage pile depend primarily on the quantity and age of the GTSP stored. Units for a standard based on the age of the product in the storage building were considered since fresh GTSP will evolve more fluorides than cured GTSP. These units would be cumbersome, though, and enforcement would rely heavily on records kept by the manufacturer. Units of "pounds of fluoride per hour per ton of P_2O_5 stored" permit fluoride emissions based on the quantity of GTSP in the storage building.

Best controlled GTSP storage facilities control fluoride emissions with packed scrubbers using gypsum pond water.

EPA engineers visited six GTSP storage facilities and judged two to be superior to the others. One of these was tested twice.

The next slide (Figure 11) shows measured emissions from GTSP storage facilities.

EPA measurements showed average emissions at plant B to be 0.000058 pound F per hour per ton P_2O_5 stored. The plant operator measured emissions of 0.00015 pound F per hour per P_2O_5 stored the same day as EPA's test. The second EPA test at plant B showed average emissions of 0.00042 pound F per hour per ton P_2O_5 stored. EPA found fluorides at plant A to average 0.00036.

The standard we recommend for GTSP storage buildings is 5 x 10^{-4} pound of fluoride per hour per ton of P_2O_5 in storage.

F. *Run-of-Pile Triple Superphosphate (ROP-TSP) Manufacture and Storage*

The manufacture of ROP-TSP is depicted in Figure 12. Measured quantities of ground rock and 54-percent P_2O_5 phosphoric acid are combined in a mixer. The resultant viscous slurry drops onto a slow moving belt, called a den, where it solidifies. When the porous mass reaches the end of the belt it is reduced to small chunks by the cutter. The ROP-TSP is then conveyed to a storage pile where the reaction continues. After approximately 30 days the product is considered "cured" and is ready for shipping.

ROP-TSP plants presented us with an interesting situation regarding units for the standards. Initially, separate standards were considered for ROP-TSP manufacture and ROP-TSP storage since one of the major sources of fluoride emissions, the storage pile, releases fluorides irrespective of production rate. However, most manufacturers control emissions from these two sources with a common control system, so this approach could not be pursued. Units based on the age of the product in the storage building were also considered. Fresh or "green" ROP-TSP evolves more fluorides than cured ROP-TSP. These units would be somewhat cumbersome, though, and enforcement would rely heavily on records kept by the manufacturer. Concentration units were not selected because units based on production rate would more readily encourage process changes to reduce emissions. Although information on emissions from production and storage is contradictory, it appears the bulk of the fluoride is emitted during production. Therefore, units of pound F per ton P_2O_5 were recommended.

Currently, best-controlled ROP-TSP plants use cyclonic or venturi scrubbers to control emissions of particulates and fluorides. Packed scrubbers would probably provide more efficient fluoride control. Unfortunately, no ROP-TSP plant currently utilizes packed scrubbers such as those typically used by other phosphate fertilizer processes.

Six plants were visited and two were judged to represent existing best control.

Results of three EPA emission tests (one plant was tested twice) show average emissions of 0.188, 0.213 and 0.124 pound of fluorides per ton of P_2O_5 input (Figure 13). Results of two tests conducted by the operators of these plants show emission to be 0.084 and 0.151.

The recommended standard for ROP-TSP plants is 0.2 pound F per ton P_2O_5. As you can see, this standard is the most stringent with respect to the data base. However, the standard can be easily met at a new plant that uses a well-designed packed scrubber as part of their control system.

V. *Future Standards Development in the Fertilizer Industry*

As mentioned earlier, EPA is currently developing data for standards for NPK fertilizer plants. Many of you may have already been contacted by EPA and questioned about pollution control for these fertilizer production processes. Your hospitality and spirit of cooperation are appreciated. We plan to investigate particulates, ammonia, and fluorides from these processes. Standards should be proposed in about one year.

EPA is also gathering data on emissions from gypsum ponds and phosphate rock grinders, dryers, and calciners. Though no dates have been set, standards will be developed for these processes.

VI. *Summary*

In summary, standards of performance for the phosphate fertilizer industry are being developed by EPA in accordance with section III of the Clean Air Act. The six process for which data have been obtained and the recommended standards for these processes are presented on the following slide (Table 3).

Emission data will shortly be obtained for NPK fertilizer plants and standards for these plants will be recommended in the coming year. Other emission sources in the fertilizer industry for which standards may later be developed are gypsum and rock grinders, dryers, and calciners.

I will be happy to answer questions during the question period immediately following Dr. Bromwell's presentation.

Thank you for your interest and attention.

FIGURE 1.

TIMETABLE FOR PROMULGATING STANDARDS OF PERFORMANCE UNDER SECTION III OF THE CLEAN AIR ACT

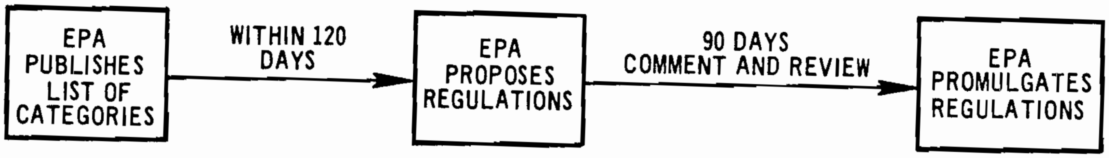
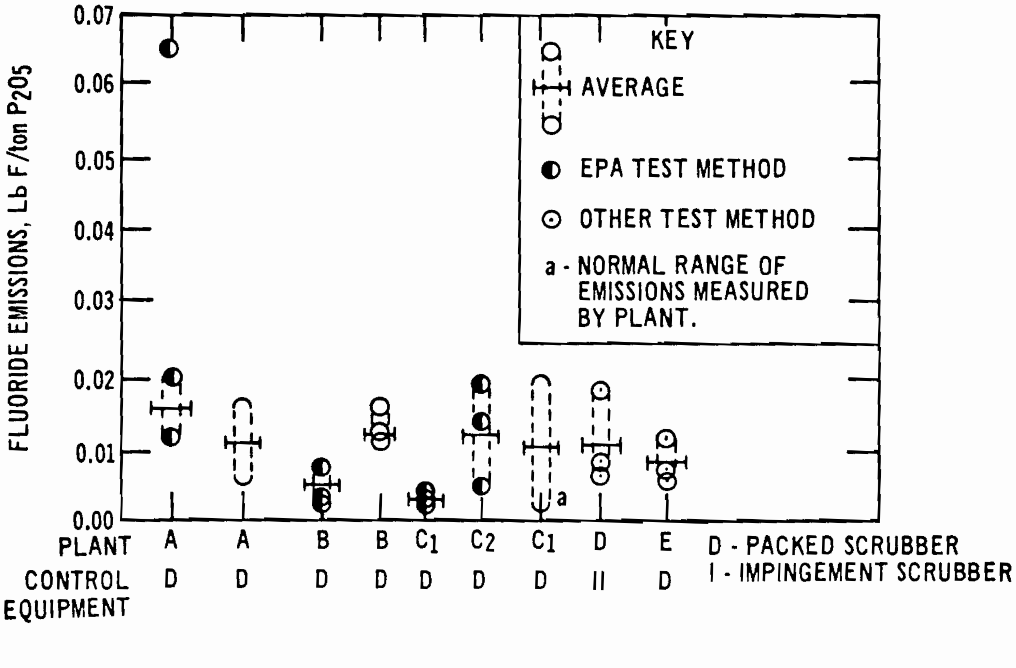


FIGURE 2.

FLUORIDE EMISSIONS FROM WET-PROCESS PHOSPHORIC ACID PLANTS



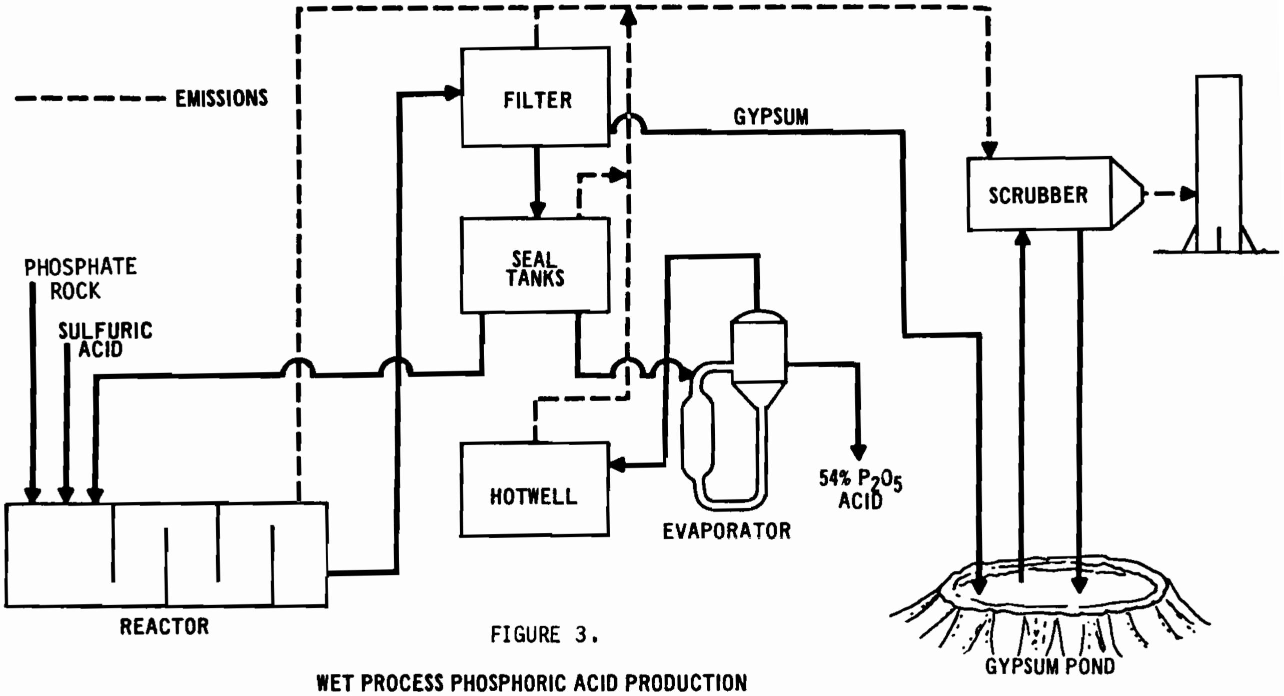


FIGURE 3.

WET PROCESS PHOSPHORIC ACID PRODUCTION

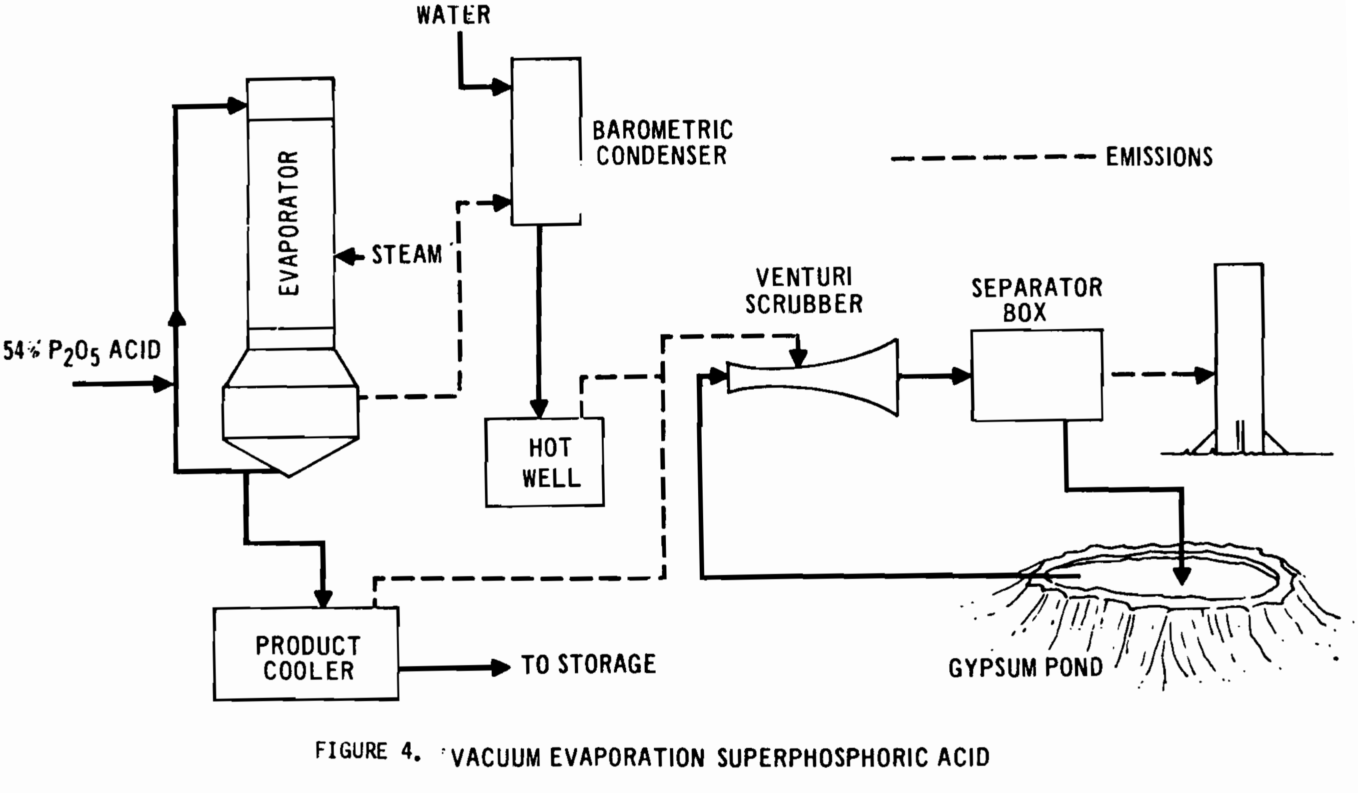


FIGURE 4. VACUUM EVAPORATION SUPERPHOSPHORIC ACID

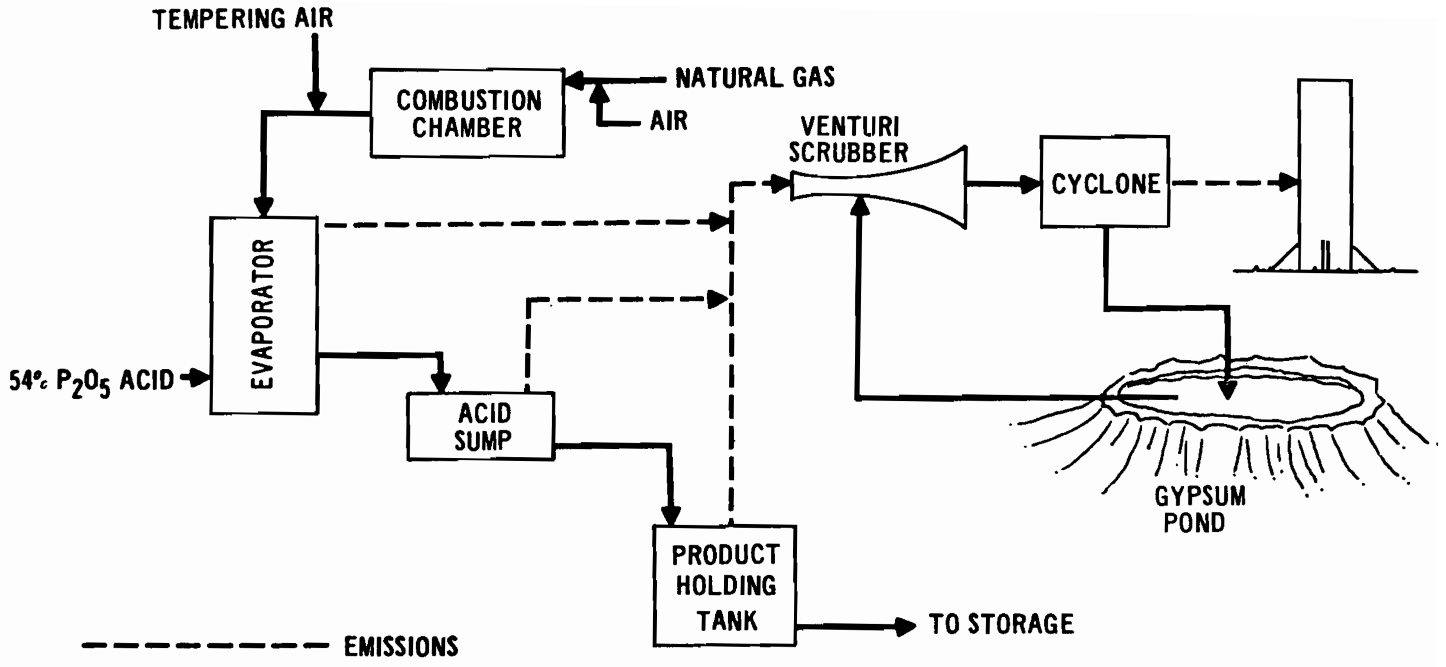


FIGURE 5.

SUBMERGED COMBUSTION SUPERPHOSPHORIC ACID PRODUCTION

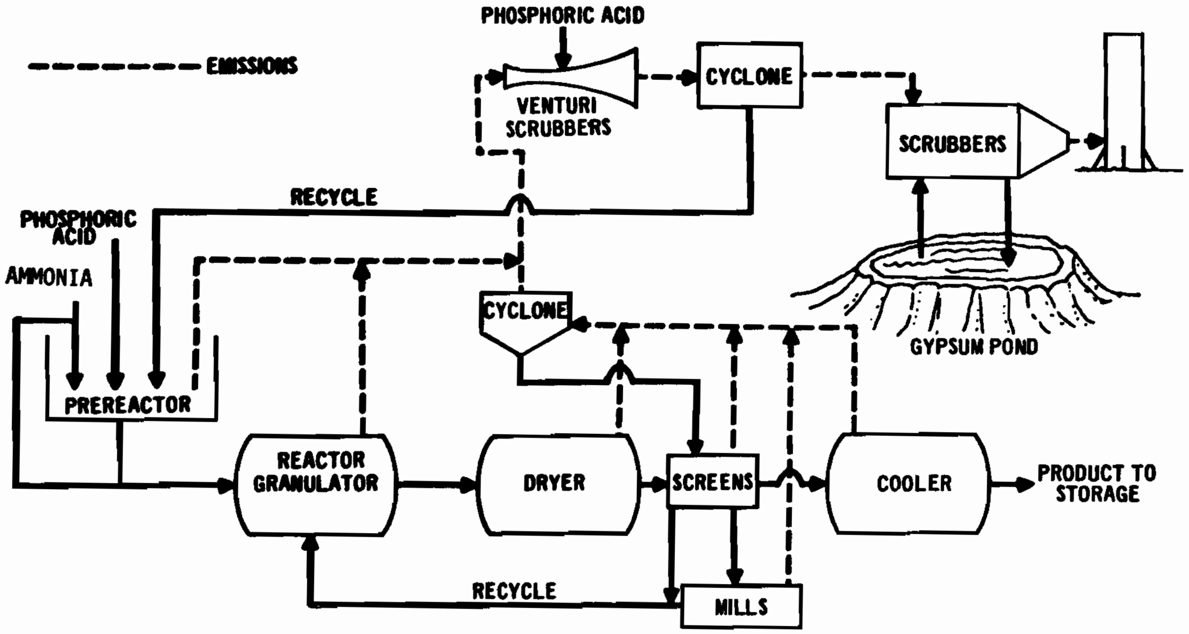
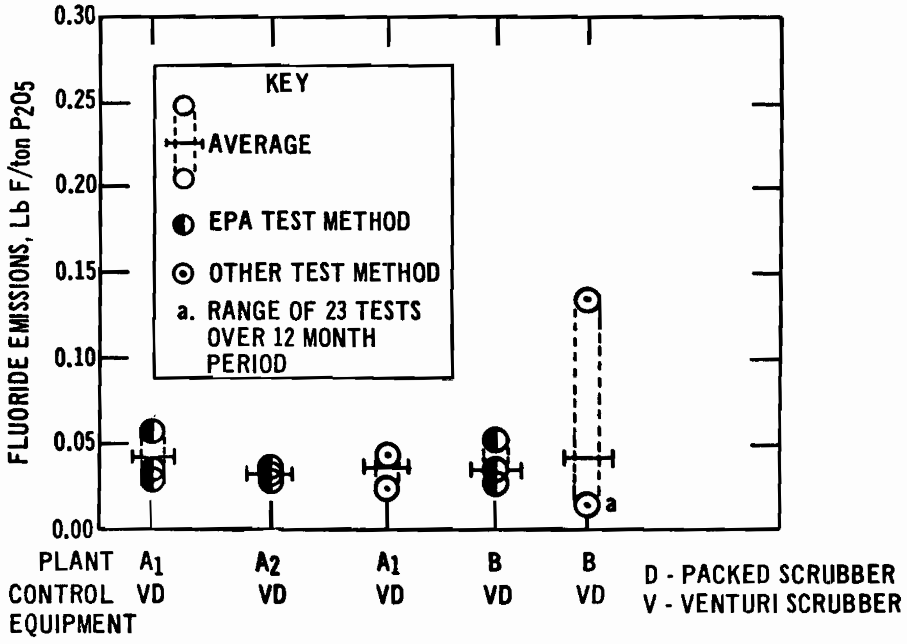


FIGURE 6. DIAMMONIUM PHOSPHATE PRODUCTION

FIGURE 7.

FLUORIDE EMISSIONS FROM DIAMMONIUM PHOSPHATE PLANTS



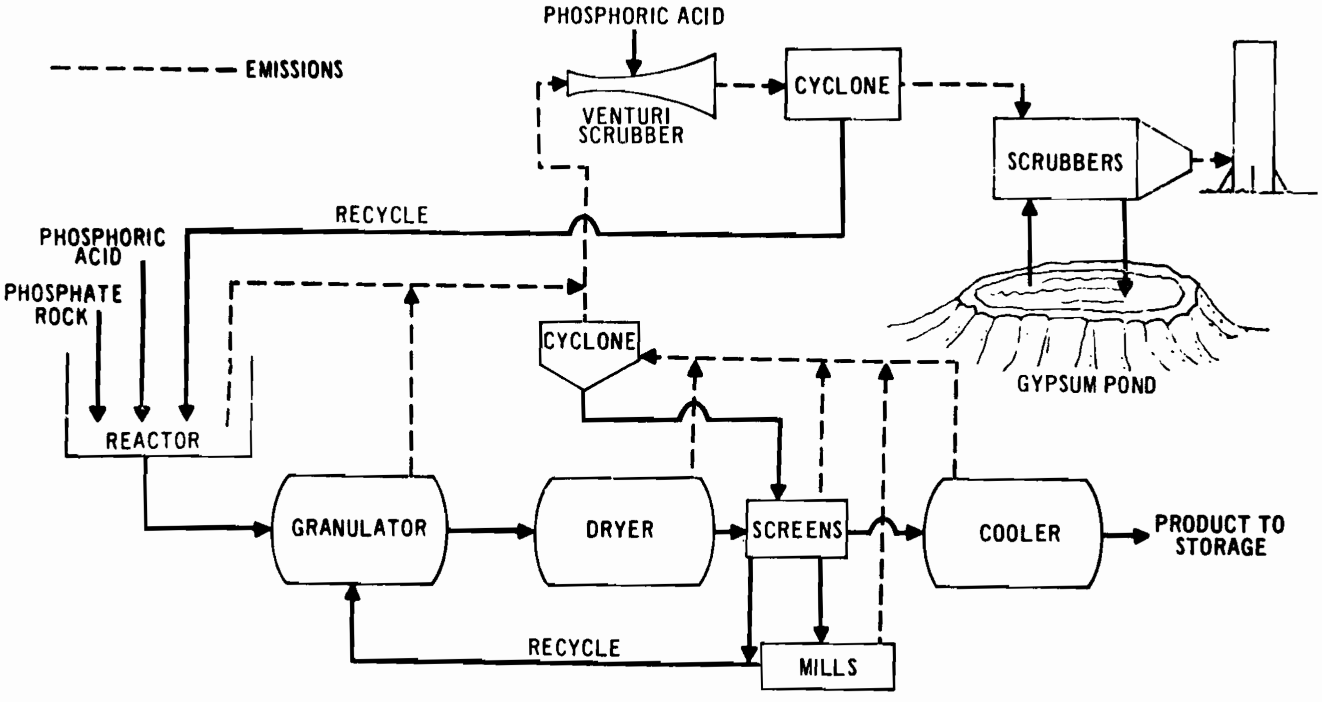
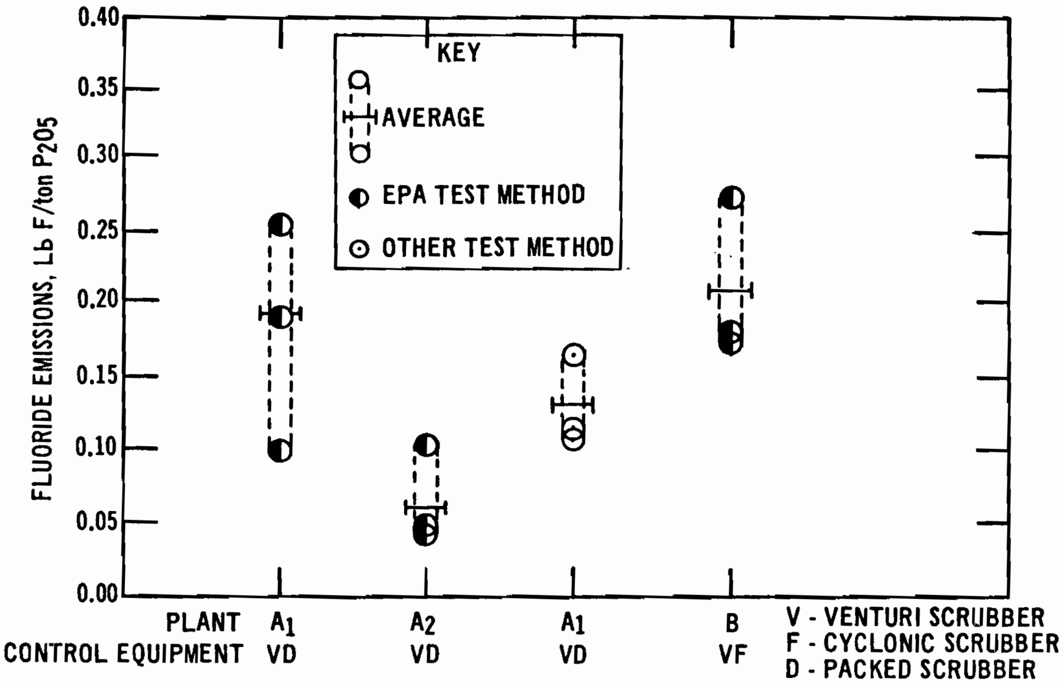


FIGURE 8. GRANULAR TRIPLE SUPERPHOSPHATE PRODUCTION

FIGURE 9.

FLUORIDE EMISSIONS FROM GRANULAR TRIPLE SUPERPHOSPHATE PRODUCTION PLANTS



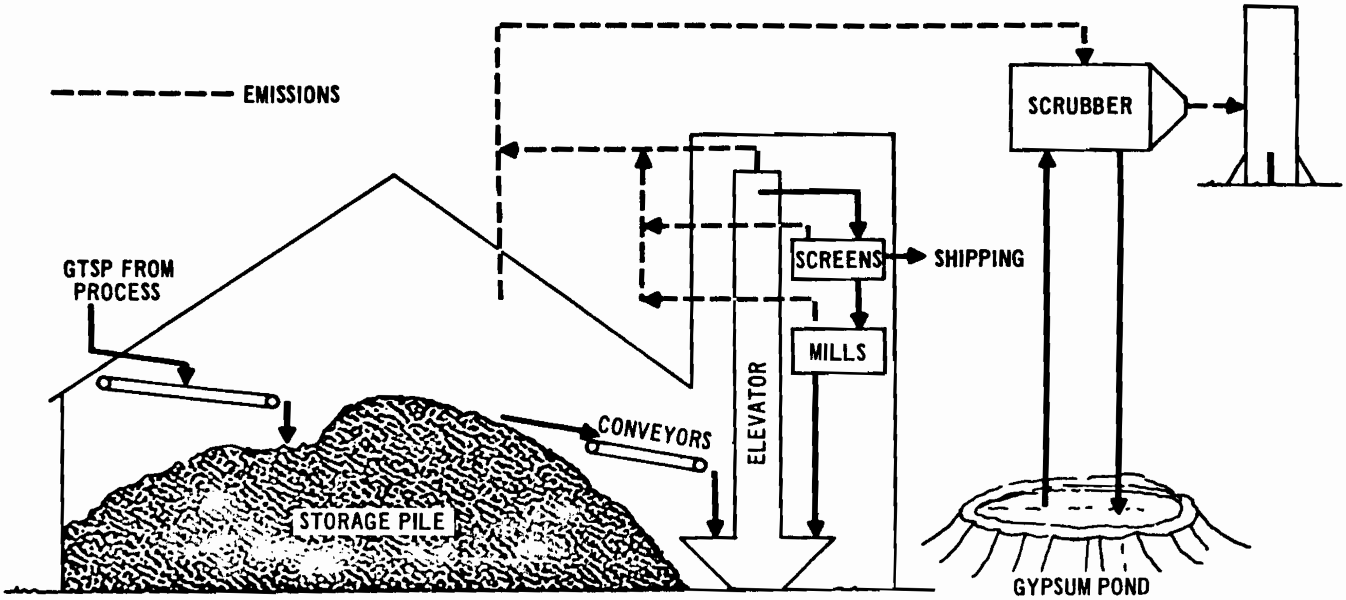
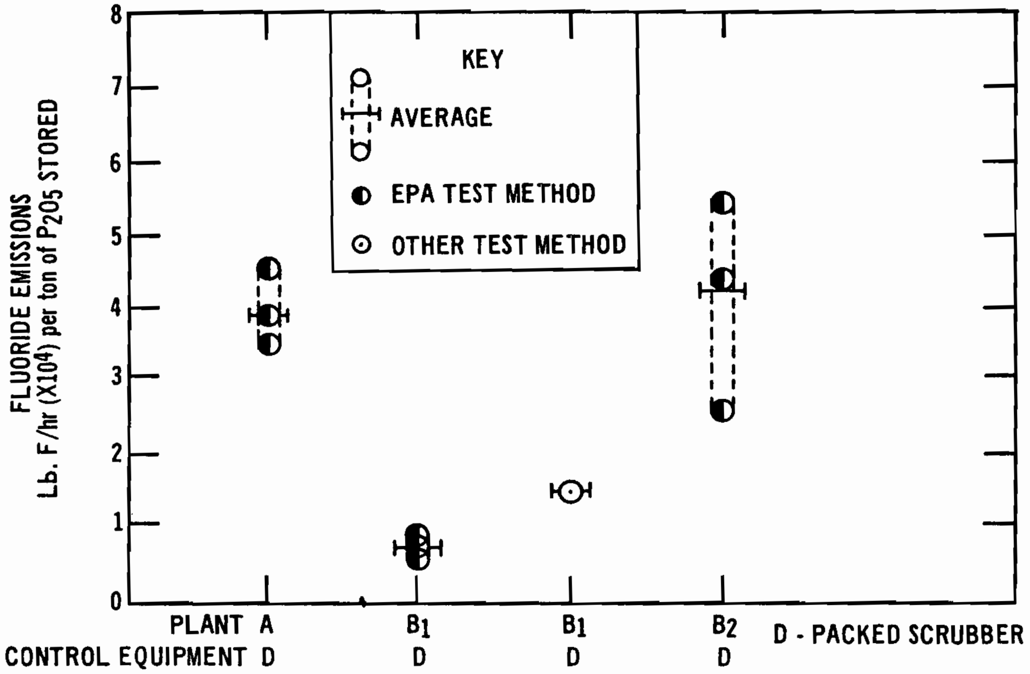


FIGURE 10. GRANULAR TRIPLE SUPERPHOSPHATE STORAGE

FIGURE 11.

FLUORIDE EMISSIONS FROM GRANULAR TRIPLE SUPERPHOSPHATE STORAGE FACILITIES



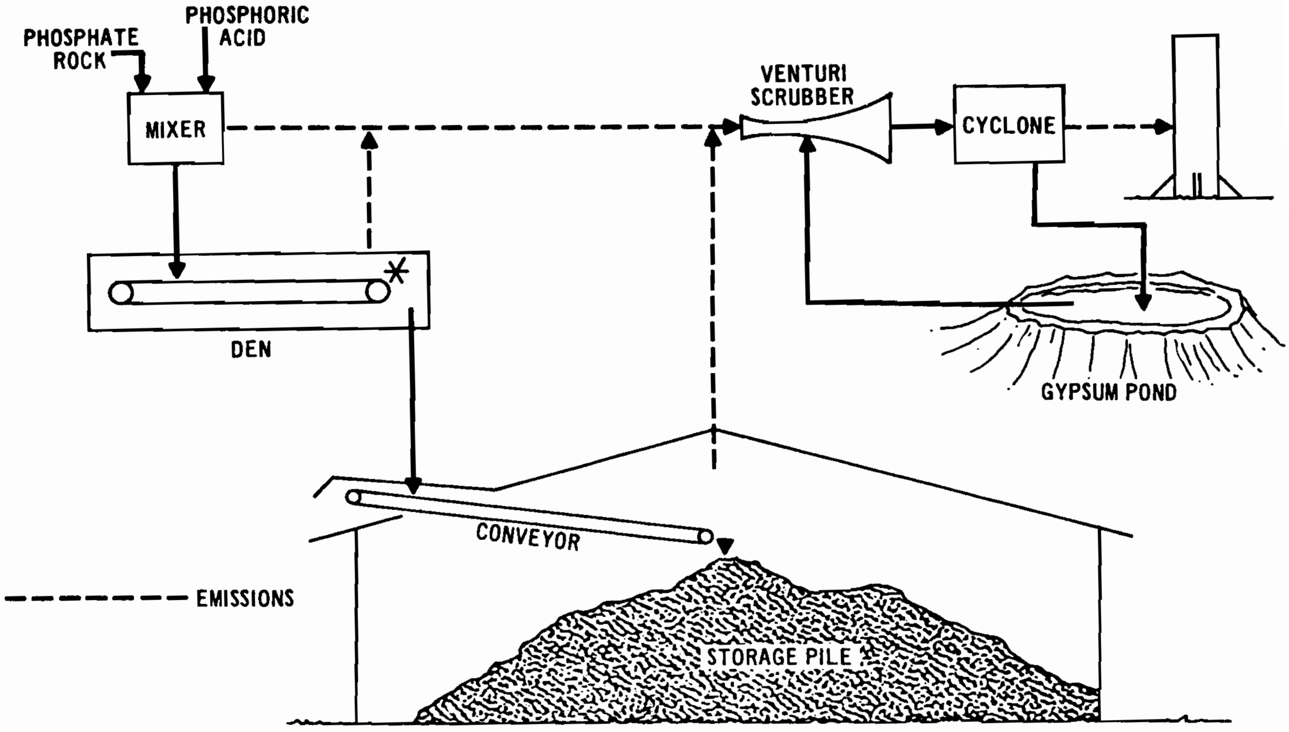


FIGURE 12.

RUN-OF-PILE TRIPLE SUPERPHOSPHATE PRODUCTION AND STORAGE

FIGURE 13.

FLUORIDE EMISSIONS FROM RUN-OF-PILE TRIPLE SUPERPHOSPHATE PLANTS

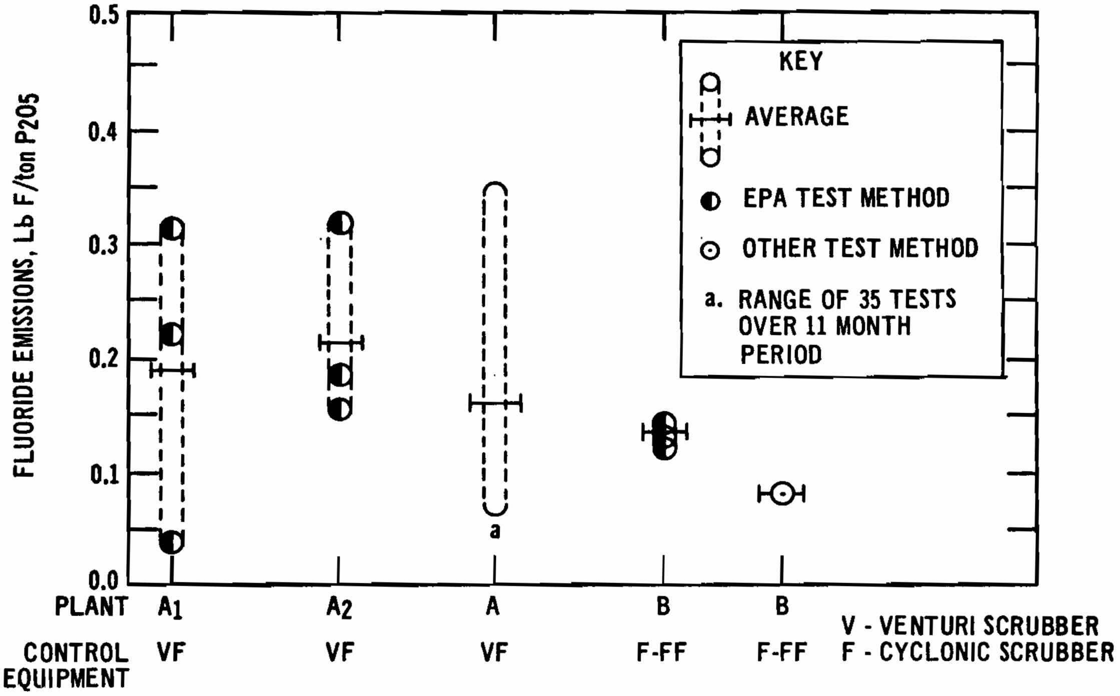


TABLE 1.

ANNUAL PRODUCTION, EMISSIONS, AND GROWTH RATES

PROCESS	PRODUCTION MILLION TONS P_2O_5/YEAR		TOTAL 1970 FLUORIDE EMISSIONS TONS/YEAR	ANTICIPATED GROWTH PERCENT (1)
	1970	1980		
WET-PROCESS PHOSPHORIC ACID	4.4	7.5	90-100	70
SUPERPHOSPHORIC ACID	0.4	1.0	20- 35	150
DIAMMONIUM PHOSPHATE	2.4	4.6	100-110	92
TRIPLE SUPERPHOSPHATES	1.4	1.7	300-330	21

(1) FOR PERIOD 1970-1980.

TABLE 2.
GAS CHARACTERISTICS IN AND OUT OF THE CONTROL DEVICE

PROCESS	TYPICAL GAS FLOW, (scf/ton P_2O_5)	INLET GAS CONCENTRATION (grF/scf)	EMISSIONS	
			(grF/scf)	lbF/ton P_2O_5
WET-PROCESS PHOSPHORIC ACID	50,000	0.02-0.1	0.001-0.002	0.01-0.02
SUPERPHOSPHORIC ACID	1,500	NO DATA	0.002-0.003	0.0005-0.0015
DIAMMONIUM PHOSPHATE	300,000	0.005 (1)	0.001	0.04
RUN/OF/PILE TRIPLE SUPERPHOSPHATE AND ROP-TSP STORAGE	350,000	0.3-0.6	0.003-0.006	0.2-0.
GRANULAR TRIPLE SUPERPHOSPHATE	450,000	0.02	0.001-0.003	0.05-0.25
GTSP STORAGE	30 (2)	0.001-0.003	0.0008-0.001	0.0003-(3) 0.0005

(1) GAS CONCENTRATION INTO PACKED SCRUBBER.

(2) scfm/ton P_2O_5 STORED.

(3) lb. F/Hr. P_2O_5 STORED.

TABLE 3.
RECOMMENDED STANDARDS FOR PHOSPHATE FERTILIZER PROCESSES

PROCESS	RECOMMENDED STANDARDS (lb F/TON P_2O_5)
WET-PROCESS PHOSPHORIC ACID	0.02
SUPERPHOSPHORIC ACID	0.01
DIAMMONIUM PHOSPHATE	0.06
RUN-OF-PILE TRIPLE SUPERPHOSPHATE AND ROP-TSP STORAGE	0.2
GRANULAR TRIPLE SUPERPHOSPHATE	0.2
GTSP STORAGE	0.0005 (a)

(a) lb.F/Hr. P_2O_5 STORED.....

MODERATOR LANTZ: Thank you very much Lee for your minute discussion covering "Federal Standards of Performance" and I too, am sure most of us here, agree with Norwood K. Talbert and you that the "Clean Air Act" and the "Water Pollution Standards" are very difficult to understand. I am sure, after we study and analyze what Talbert and you have outlined to us, we will have more understanding of "Clean Air Act, Enviromental, Water Pollution", etc.

The last presentation, and by no means the least, we have today, I believe, is probably one of the most important from the standpoint of long range "Phosphate Activities". The Phosphate Chemicals Operation, as you all know, start way back with the "Phosphate Rock Production and Processing". One of the biggest problems that the Industry has encountered is in the disposing of "Phosphate Slimes" which are generated on about an equal tonnage basis, pound for pound, with Phosphate Rock. Consequently, we are very fortunate to have with us Dr. Leslie G. Bromwell, ScD., Project Director, Florida Phosphatic Clays Research Project, Lakeland, Florida. Dr. Bromwell has a Bachelor of Science in chemical Engineering, A Doctorate in Civil Engineering from M.I.T. He has been on the Faculty at MIT for the last five years teaching various courses in "Soil Mechanics", "Physical Chemical Soil Properties" and certain other "Consulting Projects". He has been a Consultant for "Nasa" and also the U.S. Army Corps of Engineers. Currently he is the Project Director of the Florida Phosphatic Clays Research Project. It is with a great deal of pleasure that I present Dr. Deslie G. Bromwell.

The Florida Phosphatic Clays Research Project

Dr. Leslie G. Bromwell

I. INTRODUCTION

Phosphate mining, centered around Polk county in Central Florida, is one of the state's major industries, with annual production exceeding 30 million tons of phosphate rock. According to a recent Bureau of Mines study, the industry is responsible for some 54,000 jobs in Florida, and contributes $1.3 billion annually to the state's economy.

The phosphate ore ("matrix" occurs as shallow deposits of clayey sands and gravels. Separation of the phosphate from the ore body is accomplished by washing and flotation processing. When the phosphate is removed, the remaining components of the matrix, silica sand (sand tailings) and phosphatic clays (slimes) become waste products.

Disposal of the sand tailings is not a problem, and in fact the sand is quite useful as a construction material for dams and as fill for land reclamation. Disposal of the phosphatic clays, however, is a major environmental problem for the industry.

II. PROBLEMS WITH PRESENT DISPOSAL METHOD

The phosphatic clays, or slimes, leave the plant in a water suspension containing about 3% solids by weight. The only economically feasible means of disposing of this material has been in large impoundments or settling areas.

In the settling areas, the clays gradually consolidate, releasing water which is recirculated for plant use. After several years of settling the clays reach an equilibrim solids content of about 20%. In other words, each ton of clay solids retains about 4 tons of intersticial water. When one realizes that the industry produces some 30 million tons of these waste clays (dry basis) annually, the magnitude of the disposal problem is readily appreciated. At the present time, some 40,000 acres of active and inactive settling areas exist, surrounded by more than 300 miles of earth dams. About 2500 acres of new settling areas are being constructed each year.

The most pressing problems caused by the use of settling areas for clay disposal are: (1) the ever-present threat of a dam failure releasing large quantities of semi-fluid clays, resulting in extensive water pollution; (2) the unavailability of large land areas for reclamation. another problem that is likely to become more serious in the future is the loss of significant mineral values in the slimes.

Earth Dam Failures

Since 1942, twenty dam failures have been recorded in the industry, as shown in Figure 1. Most of these failures accourred prior to the existence of any regulations or codes regarding dam construction. Following the last dam break, in December 1971, a group of experts in earth dam construction, representing both government and industry, developed a comprehensive set of regulations to control the design, construction, and operation of earth dams. This cooperative effort, in which the industry was commended by the State Department of Pollution control, is expected to minimize the likelihood of future failures.

Neverless, the possibility of another dam failure is ever-present. If such an unfortunate event should occur, the consequences to the industry in terms of restrictive legislation, adverse public opinion, and resistance to future mining, could well prove catastrophic. Hence, the urgent need for a clay dewatering process that will eliminate earth dams.

Land Reclamation

The florida phosphate industry has an enviable record of land reclamation. However, the burgeoning population of Central Florida coupled with increasing governmental concern for the environment is putting increasing pressure on the industry to reclaim higher percentages of the land mined each year.

The major limiting factor on land reclamation in the industry is the need for clay settling areas. As previously mentioned, these areas remain semi-fluid for many years, and are unavailable for reclamation. Given sufficient time — 10 to 15 years — even settling areas can be reclaimed. But time to handle environmental problems is becoming increasingly difficult for industry to obtain.

The Acreage available for land reclamation can be increased only by confining the clay into smaller areas, which requires that higher dams be built to provide adequate storage volume. Figure 2 shows the dam height required in order to have various percentages of the land that is mined available for reclamation. For a typical ore deposit of twenty feet depth, a reclamation ratio greater than 50% would require the construction of dams greater than 40 feet high, which would cause even greater concern regarding possble dam failures. Clearly the only feasible way for the industry to achieve increased land reclamation is to find an alternative method of clay disposal.

Loss of Mineral Values

Appreciable phosphate values remain in the waste clays, which typically contain 25% to 30% apatite (12% to 15% P_2O_5). In this regard, the clays are almost as high-grade an ore as the original matrix, which typically contains 15% to 20% P_2P_5. At the present, no feasible technique for recovery of the phosphate values in the clay exists. However, an economical dewatering process may well facilitate additional processing of the clays for phosphate recovery. Even if the major use of the dewatered material is as landfill in reclamation of mined-out areas, agricultural usage will be enhanced by the phosphate values in the clay.

III. OBJECTIVE AND SCOPE OF RESEARCH PROJECT

In 1972 the industry initiated a joint research project with the U.S. Bureau of Mines to study new methods for dewatering phosphatic clays. The primary objective of the project is to eliminate the need for above-ground storage behind earth dams. If the clays can be dewatered to about 35% solids, disposal can be accomplished below-ground in mined-out areas. Also, at 35% solids, the clays no longer behave as a fluid.

Clay at 35% solids can be combined with sand tailings to produce excellent landfill. Therefore, dewatering of the clays would also permit additional land reclamation, perhaps enabling the industry to reach the highly desirable goal of 100% reclamation.

Potential by-product uses of the clays, such as lightweight aggregate, ceramic products, soil conditioners, etc., all await an economical process for water removal. a list of possible by-product uses for the clays is shown in Table I. Although a sufficient market for the volume of clays produced does not currently exist, the long-range projection for utilization of the dewatered clay material is very favorable.

The research now underway is along two lines: laboratory research, being done by the Bureau of Mines and university research groups; and plant testing, being done under my direction. the annual budget for the project is $540,000, with funds contributed equally by the Federal Government and Industry.

Universities now participating in the research include the University of Florida, Florida State University, and the University of South Florida. Numerous other research groups and commercial firms are participating in the testing and avaluation of various dewatering methods.

Guidance for the research is provided by a Steering Committee composed of 5 members form government and 5 industry representatives. the organizational structure of the project is designed to enhance communication between the industry and those doing the research, thereby speeding the flow of promising concepts to the field for testing and evaluation.

IV CHARACTERIZATION OF PHOSPHATIC CLAYS

One of the first objectives of the research project was to determine the chemical, mineralogical, and mechanical characteristics of phosphatic clays. Although the work is still in progress, a great deal of basic information regarding material properties has been collected. The chemical and mineralogical composition of phosphatic clays has been investigated using chemical analysis techniques, x-ray diffraction, and scanning electron microscopes. Samples from all operating mines havve been studied in order to investigate the range of materials involved.

The composition of phosphate slimes is quite variable, but the main constituents are as follows:

1. *Clay minerals,* primarily montmorillonite, attapulgite, and kaolinite, with occasional small amounts of illite.
2. *Phosphate minerals* (primarily fine-grained carbonate-fluorapatie, with smaller amounts of aluminum phosphate such as wavellite).

3. *Quartz,* which occurs as sand or silt-size particles.

In addition to the above components, minor quantities are found of other minerals, including dolomite, calcite, chert, muscovite, feldspars, and heavy minerals such as ilmenite, staurolite, zircon, and rutile.

Grain size analyses indicate that approximately 50% of the material is in the colloid range, less tha 1 micron in diameter. No correlation between sedimentation behavior and grain size distribution has been found, however.

The colloidal-sized clay particles are primarily responsible for the slow settling behavior and the high water retention of the material. Of the clay minerals, attapulgite has been shown to exhibit the slowest settling rate and the lowest ultimate solids. A close correlation has been obtained between attapulgite content and settling behavior. Other properties such as viscosity, filtration characteristics, and response to floocculants also appear to be strongly correlated with attapulgite content.

Attapulgite particles are fibrous in appearance, having a length several times their diameter. Clusters of attapulgite particles have the appearance of haystacks under the electron microscope, and the poor settling behavior is caused both by the mechanical interference between particles (similar to "tangling" of polymers) and the large specific surface area of the particles. The poor response of the high attapilgite clays to most chemical flocculants is also attributable to the mechanical hindrance between particles, and possibly also to low surface charge. the fibrous character of the attapulgite appears to aid in filtering the material, although a practical process to take advantage of this characteristic has not yet been developed.

V. EVALUATION OF POTENTIAL DEWATERING SCHEMES

Table II gives a partial listing of potential dewatering schemes that have been considered. The list is not complete, and may not even prove to be accurate at some future date, as new concepts develop or as additional research puts a previously unfavorable concept in a more favorable position. The number of schemes that have been shown to be technical solutions — that is, are capable of consistently dewatering slimes to an acceptable degree — are very few.

A major consideration in the evaluation of any potential scheme is the projected unit cost of handling, treatment, and disposal. The present method of disposal costs on the order of \$0.35 per ton of slimes (dry basis), with major cost components being dam construction and maintenance, and pumping costs. To be economically feasible for the industry, an alternative method must exhibit the same order-of-magnitude cost. Disposal schemes that result in increased land reclamation can justify additional expenses as the industry currently spends an average of about \$650 per acre to reclaim previously-mined land.

At the present time, three dewatering techniques have passed the laboratory testing stage and have been subjected to field tests. All of these techniques involved mixing the clays with tailings sands.

One technique, developed during the past several years by Brewster Phosphates (partnership of american Cyanamid Corp. and Kerr-McGee Corp.), involves natural settling of the clays to a desired consistency, and then spreading of sand tailings over the slimes. If the sand is uniformly distributed, and of the slimes have the proper consistency, appreciable quantities of water are released as the sand filters through, and is entrained within the clay. Uniform distribution of the sand is not easily achieved, and Brewster has devoted a great deal of effort to the development of this concept.

Although flocculation of the clays has been tried numerous times over the years, significant success in terms of attaining a higher solids content than is eventually reached in the settling areas, has not been achieved. the flocculated clay settles more rapidly than the natural material, but the loose floc structure generally occupies a larger ultimate volume than the unflocculated material. However, flocculation does render the material more susceptible to other treatments — such as filtration — and additional research on flocculated clay is underway.

One chemical treatment that appears promising both from a technical and economic standpoint is a coagulation procedure using tailings sands and chemical flocculant. the mechanism of dewatering is not completely understood at present. However, mixtures of slimes and sand in ratios of 2 parts sand to 1 part slimes will dewater to greater than 50% solids by gravity drainage when treated with modest amounts of flocculant — on the order of 0.5 lb. of flocculant per ton of dry slime. Field testing of this technique is now in progress.

The University of Florida has successfully dewatered alimes on a laboratory scale using various types of drains, both internal and external, and allowing natural seepage to reduce the water content. Previous research in filtering of slimes was stymied by the problem of preventing clogging or blinding of the filter media. However, use of specially designed drains may avoid this problem, and field testing of the concept is planned for the near future.

In the short time the research project has been in existence, substantial progress has been achieved. We now have a much improved knowledge of the properties of the material that we are working with, which provides a rational basis for correlating observed behavior with material properties. also, we have been able to evaluate many potential dewatering concepts and select those few that appear most promising for intensive testing. During the coming year we plan to focus on those methods that appear to offer promise for a short-term solution. At the same time, laboratory research into new areas will continue in order to evaluate all possible concepts for a practical solution to the phosphatic clays dewatering problem.

Figure 1

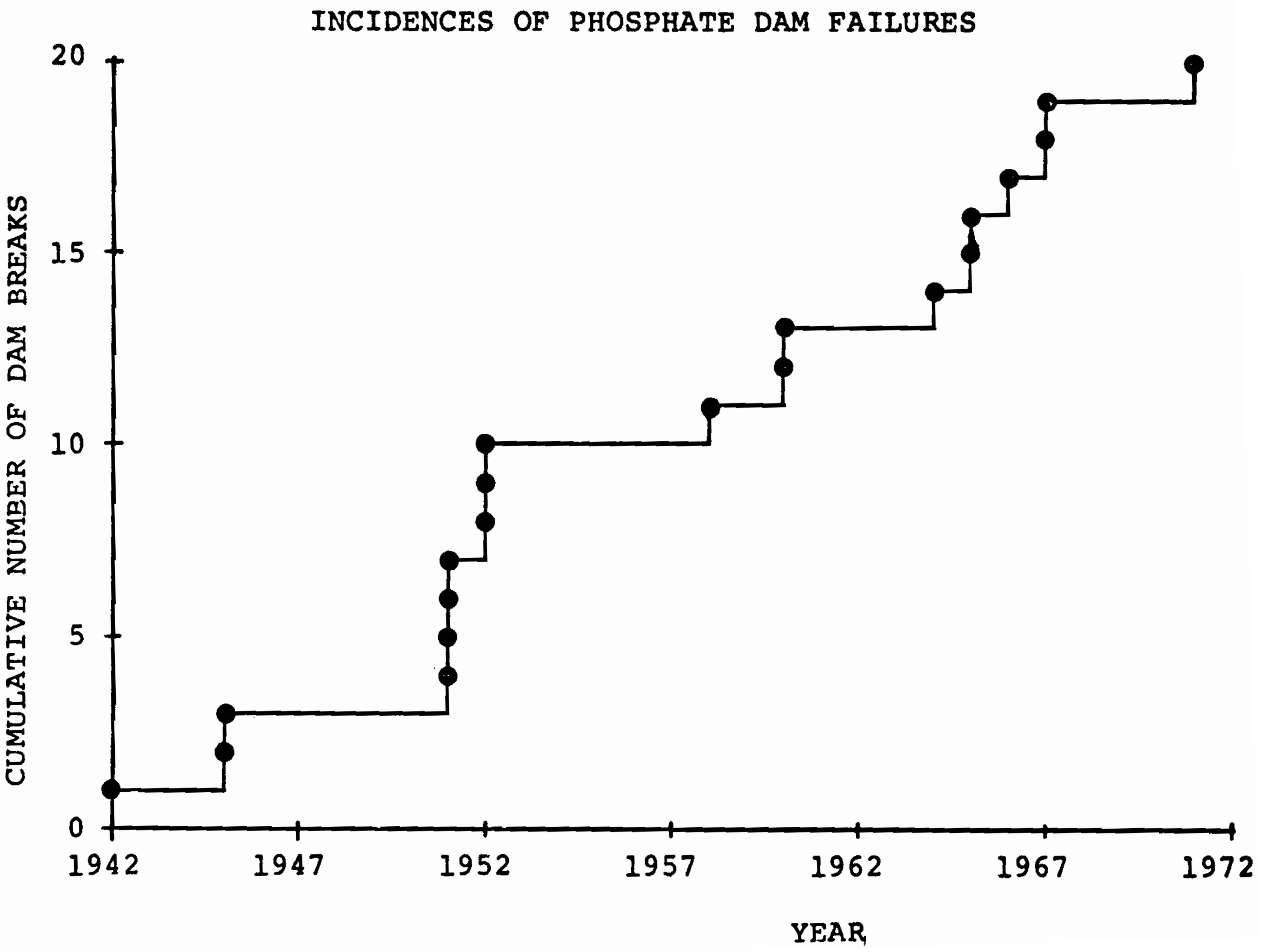
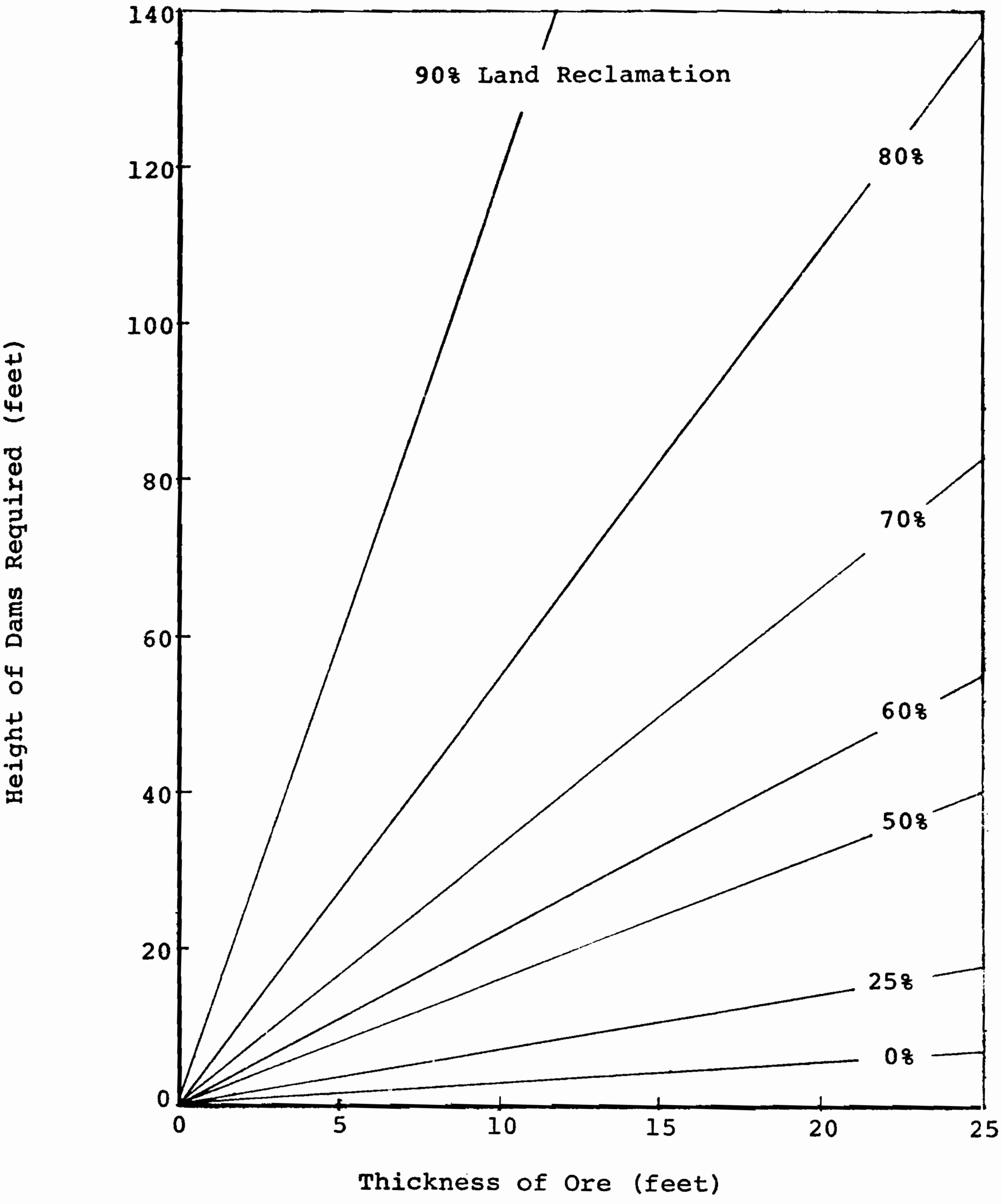

INCIDENCES OF PHOSPHATE DAM FAILURES
CUMULATIVE NUMBER OF DAM BREAKS
20
15
10
5
0
1942
1947
1952
1957
1962
1967
1972
YEAR

Figure 2

Height of Slimes Dams Required for Varying Percentages of Land Reclamation



Assumptions:

1) Final solids concentration of slimes = 20%
2) Ratio of slimes to rock product is 1:1

TABLE I

POTENTIAL UTILIZATION OF PHOSPHATIC CLAYS

EXTRACTION OF P, Al, Fe, U VALUES

CERAMIC PRODUCTS

DESSICANTS AND ABSORBENTS

SOIL CONDITIONERS

LIGHT-WEIGHT AGGREGATES

DRILLING MUDS

INERT FILLERS

EMULSIFYING AGENTS

MEDICINES AND COSMETICS

CROP IRRIGATION

CROP PROTECTION

TABLE II

POTENTIAL CLAY DISPOSAL TECHNIQUES

A. TECHNICALLY FEASIBLE -- ECONOMICS NOT SATISFACTORY
   - FREEZING
   - DRYING
   - SPHERICAL AGGLOMERATION
   - SOLAR EVAPORATION

B. NEITHER TECHNICALLY NOR ECONOMICALLY SATISFACTORY AT PRESENT
   - ELECTRICAL DEWATERING
   - FILTERING
   - ULTRASONIC VIBRATION
   - EVAPO-TRANSPIRATION
   - BACTERIALOGICAL DECOMPOSITION
   - MAGNETIC SEPARATION
   - MECHANICAL COMPRESSION
   - CENTRIFUGATION
   - ULTRA-FLOTATION
   - DRY PROCESSING OF ORE
   - CHEMICAL FLOCCULATION

C. TECHNICALLY FEASIBLE -- ECONOMICS APPEAR PROMISING
   - MIXING WITH TAILINGS SAND
   - CHEMICAL FLOCCULATION - COAGULATION WITH TAILINGS SAND
   - SEEPAGE THROUGH TAILINGS SAND

MODERATOR LANTZ: Thank you Dr. Bromwell for your detailed discussion on your "Research Project Florida Phosphatic Clays". You gave us the "Full Package". We appreciate the time and effort you gave to this important project.

This completes our 3 day — six session meeting.

On behalf of our "Chairman" Herman G. Powers, who has already given us his "Summary", our Directors, our Officers and our Members, we thank you all for attending this 23rd Annual Meeting.

As soon as you get home please make your "Reservation" for our next round-Table, 24th Annual Meeting, to be held here.

Shoreham—American Hotel
Washington, D.C.
Meeting Dates
Tuesday, December 3, 1974
Wednesday, December 4, 1974
Thursday, December 5, 1974

We take this opportunity to thank "The Fertilizer Institute" for helping us jointly to arrange the Friday Morning and Afternoon Discussions on "Environmental Control Developments".

We had an outstanding 3 day meeting. Each session was fully attended. Hope to see you at our next meeting. Have a safe trip home. Meeting adjourned at 2:30 P.M.

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