Ag and Food Interprets . . .

- **Formulators buy over $5 million worth of inerts each year for dusts**
- **Pesticide industry looking to large acreage crops for growth potential**
- **Coke oven operators watch diammonium phosphate closely**
- **Agriculture shows big gains in chemical utilization**
- **Contribution to farm efficiency assures growth of plant food use**

PESTICIDE FORMULATORS spend about $5 million a year for carriers and diluents needed to make dusts and wettable powder concentrates. By far the biggest portion (more than $3 million) of the total goes for fuller's earth (attapulgite). Kaolin and pyrophyllite each take over $600,000. Talc and soapstone together account for half a million dollars, and bentonite alone for $140,000. These figures (from the "Chemical Economics Handbook" for the year 1954) all refer to silicate minerals, but pesticides formulators also use unknown but smaller amounts of synthetic calcium silicate, hydrated lime, calcium carbonate and phosphate, gypsum, magnesium carbonate, diatomaceous earth, and silica. Some of these materials are also used in dusts in small quantities as bulking and anticaking agents.

Normally the term carrier refers to a highly sorptive material that is mixed with the toxicant to make a dust concentrate or wettable powder. "Diluent" refers to the materials used to lower the concentration to a level that can be used in the field. Actually the line between the two is frequently blurred in practice since some materials are usable for either function, attapulgite and kaolin being two examples.

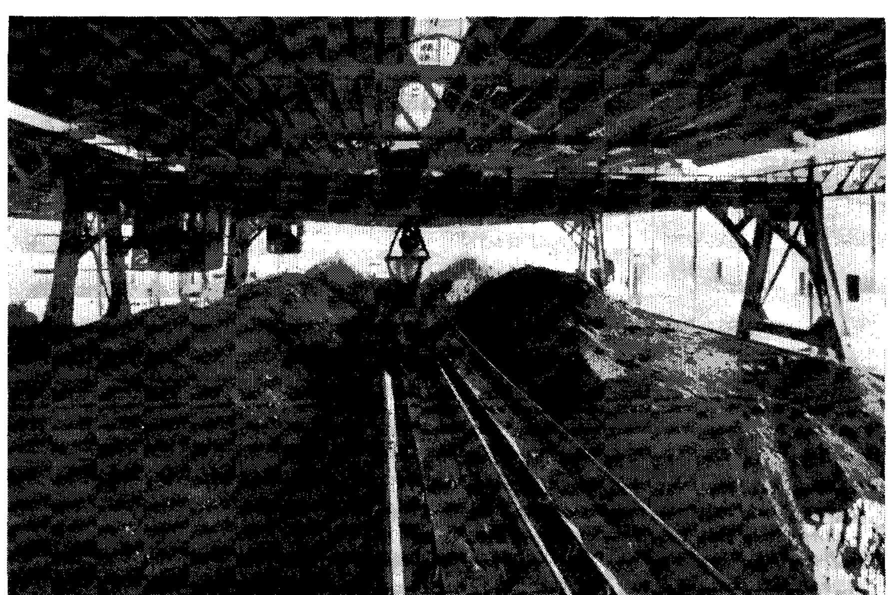
In choosing a carrier, a formulator must consider several factors. Probably at the top of the list is sorptive capacity, but compatibility of the toxicant with the carrier is also important. (Attapulgite, for instance, absorbs malathion nicely, but a formulation of malathion with attapulgite loses its insect-killing power after a few months' storage.)

Flowability, dustability, and low abrasiveness are all necessary to get the best application of the dust in the field. Wettability and suspensionability are important for wettable powder formulations. Low moisture content and small particle size are important from the point of view of the mixing operation itself; some pesticides decompose by hydrolysis if too much moisture is present, while too large a particle size raises grinding costs above the desirable minimum. Density, of course, affects segregation of the ingredients in the dust mixture, and may control the rate of discharge in the dusting equipment. It may also influence package design.

DDT, BHC, dieldrin and lindane are the principal pesticide chemicals made into dust concentrates and wettable spray powders by grinding the solid chemical in a mill (hammer, impact, vertical roller, or fluid energy types) with the carrier. These chemicals are usually mixed with the inert carrier in a ribbon blender before grinding. Chemicals which are liquids or low-melting solids, such as aldrin, heptachlor, or toxaphene, are impregnated on the inert in a ribbon blender equipped with nozzles for introducing the pesticide.

For dusts, the carrier used most frequently is attapulgite, although certain kaolin clays and diatomaceous

Storage of the attapulgite as it comes from the mines. The pesticide industry uses some 20% of the annual attapulgite output, more than $3 million worth



earth are also widely used. Transportation costs and delivery dates during a busy season may dictate which one of these is used by a particular formulator. The pesticide industry consumed 142 million pounds of attapulgite in 1954, nearly 20% of U. S. production. Most of it is mined in Florida by three companies—Minerals & Chemicals, Floridin, and Magnet Cove Barium.

As it comes from the mine, attapulgite contains about 50% moisture loosely held in the lattice structure of the aluminum magnesium silicate. Drying, after the wet clay is crushed, removes most of the moisture.

Attapulgite and vermiculite are the carriers most frequently used in granular formulations, the growing popularity of which has emphasized the importance of carriers. Particle size must be kept within certain limits for the granular products, and processing and handling must be kept to a minimum to avoid particle breakdown. Impregnation of the liquid toxicant onto the carrier particles (in a ribbon blender or rotating drum) is the preferred technique. In some cases a deactivator such as urea has to be used to prevent decomposition of the toxicant by the acid sites on the carrier surface. Decomposition of the toxicant through catalysis by the acid sites on the carrier surface is an important consideration in dust formulation, also. But this problem can frequently be overcome for heptachlor formulations by use of small amounts of such chemicals as diethylene or triethylene glycol (see page 1038).

In recent years, synthetic carriers have appeared on the market. Among them are synthetic calcium silicate, hydrated silica, and hydrated sodium silicoaluminates. These materials, although highly adsorptive, are much more expensive than the other mineral carriers. The high cost limits their use for the present chiefly to formulations of 75% DDT wettable powders for the export trade.

Letting a dust concentrate down to field strength by diluent addition is frequently accomplished at a small plant in the area in which the finished mixture will be used. The characteristics necessary for a good diluent are: small particle size, low abrasiveness, compatibility with the toxicant chemical, medium bulk density, and low cost. Its function, in addition to diluting the concentrate, is to settle on both upper and lower sides of foliage, to stick to the plant foliage through various weather conditions, and to hold the chemical available for protecting the plant. High sorptive capacity is not so important in diluents. Talc, soapstone, pyrophyllites, kaolins, and the bentonites are the most widely used diluents. Hydrated lime, calcium carbonate, gypsum, and magnesium carbonate are sometimes used as diluents when near-by, low cost sources are available.

The carriers and diluents used in a formulation have been found in recent years to have a great influence on the performance of a particular toxicant chemical in the field. One cause of poor performance of formulations containing an otherwise effective chemical has been found to be decomposition of the toxicant by the inert carrier or diluent. Much research in recent years has been devoted to finding low-cost deactivators. But undoubtedly there are other causes, physical as well as chemical. Continuing research will reveal the answers, for it is being recognized that application and formulation research has lagged behind new chemical development, and that placement has as important an influence on pest control as does the toxicant.

The Pesticide Industry

Nearly 300 chemicals formulated into over 6000 products by more than 300 companies adds up to a complex industry that looks to large acreage crops as its chief growth area

THE PESTICIDE FIELD, like any other facet of American industry, must constantly solve problems in development, manufacturing, and marketing. However, the tremendous growth in pesticide consumption in recent years, coupled with many individual peculiarities, complicates the situation.

As pesticide products become more specialized, more complex and costly, and more varied in formulation and package size—with the continuously present variables of weather and pest infestation—it becomes more difficult for a manufacturer or a distributor to have on hand for the farmer exactly what may be needed at the right time. To avoid the often-prohibitive risk of building large inventories of expensive materials against a market which may not develop, the manufacturer often must accept the burden of building a plant large enough to fulfill a season's requirements in a few months, whereas sound judgment and practical operating experience dictate a smaller plant. This practice compounds his risk by forcing greater capital expenditure, and increases operating costs by virtue of the plant's sitting idle for a substantial part of each year.

In addition to these manufacturing problems, there are many influences that must be carefully considered in pesticide merchandising. State and Federal legislation must be observed and complied with. Competition, price policies, and nature all have their effects. The importance of dealers and distributors cannot be overlooked.

Research and Development

Up to 1939, naturally-occurring extractable organic compounds or easily manufactured inorganics were widely used. Development work during that period consisted largely of improving formulation methods and application techniques.

With the new knowledge that organic compounds could be tailor-made to fit almost any pest control situation, research emphasis shifted to the search for active compounds that would do the particular job more effectively, more economically, and more safely.

Successful pesticide research requires the coordinated effort of a wide variety of trained people—organic, physical, and analytical chemists, chemical engineers, entomologists, plant pathologists, and other specialists. Specialized facilities also are necessary. Means for rapid dissemination of data within the research organization must be provided.

Industrial research cannot carry out a pesticide development program completely by itself, but it must work in cooperation with the many state and federal agencies. Industry's part may be classified in the following areas: discovery of new compounds; development of superior manufacturing methods for compounds of proved use; and development of new or known compounds for use as pesticides.

Generally, pesticide development programs in industry follow a four-step pattern:

- Continuous evaluation of large numbers of compounds, using representative pests to determine levels of activity
- Applied testing of compounds that show a high level of activity, to determine utility as commercial pesticides

• Development of an economic method for production of a compound if it is potentially salable

• Development of analytical procedures for determining residues of the compound on crops treated, and for maintaining control of formulations containing the compound.

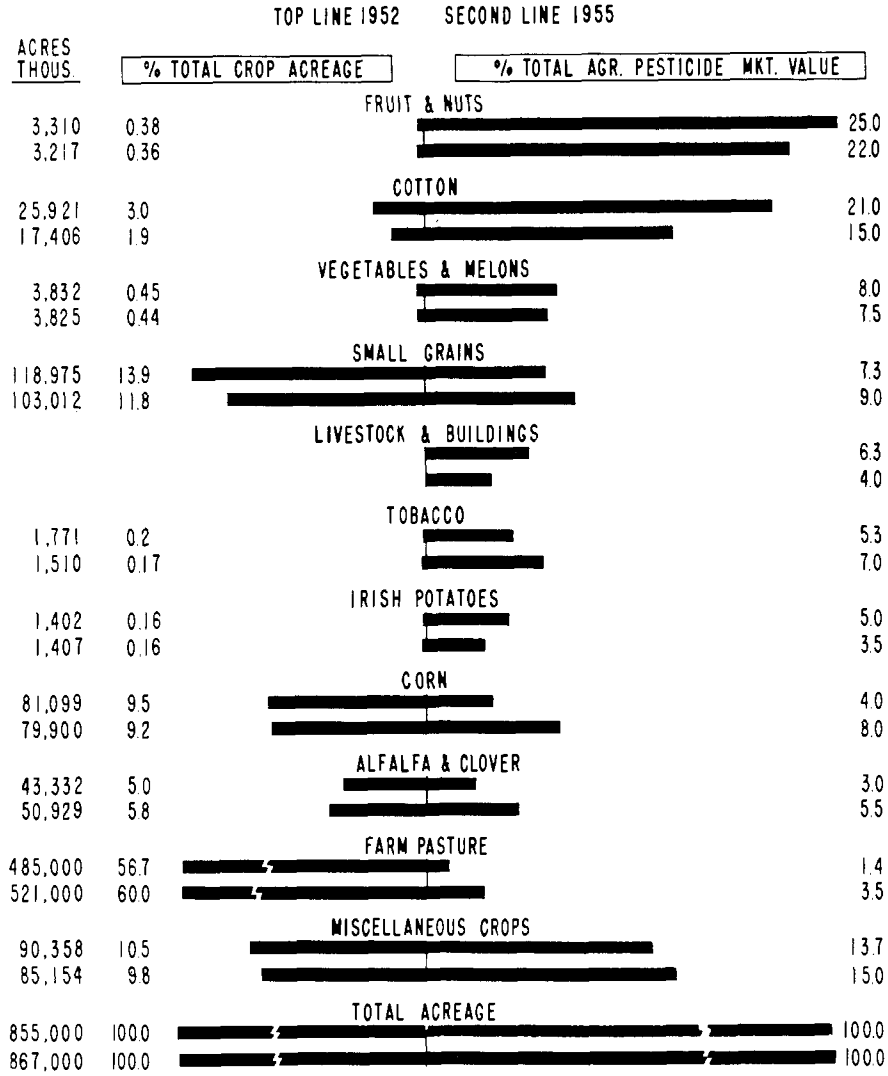
Pesticides End-Use Patterns

Annual production, including imports, of pesticides is worth $200 million at the manufacturers' level. This phase of the chemical industry is composed of about 100 manufacturers of one or more basic chemicals. A recent survey showed that they produce 216 chemical compounds used as pesticides. This number includes 81 fungicides, 66 insecticides, 41 herbicides, 17 fumigants, and 11 rodenticides.

In addition to these active compounds there are about 75 inert chemicals or substances used as diluents in pesticide formulation. These 290-odd chemicals are formulated into more than 6000 tradenamed products by more than 300 companies in the United States.

Sales value of the basic ingredients at the manufacturers' level had an interesting distribution in 1955: insecticides—59%; fungicides—20%; herbicides—16%; nematocides—3.5%; and rodenticides—1.5%. Pesticide distribution according to consuming lines was estimated to be: domestic agricultural uses—60%; domestic nonagricultural uses—20%; export—20%.

END-USE PATTERN OF AGRICULTURAL PESTICIDES WITH RELATED ACREAGE PERCENTAGE PATTERN FOR 1952 AND 1955.



Export Patterns

With one fifth of all domestically produced chemicals going to the export market, much attention is being given to recent trends. About one third of the exported insecticides go into world health programs, financed by various national and international agencies.

The major export market for American pesticides lies in the western hemisphere. In 1955 this area took two-thirds of all our pesticide exports (including both formulated and unformulated materials).

While the export market should steadily expand, United States producers may expect to meet increasing competition from Europe, particularly West Germany, where excellent research chemists and a revitalized chemical industry are rapidly gaining recognition in this field. However, if one speculates that per capita consumption of insecticides outside the United States may some day reach that already attained here, then world production outside this country, as well as our exports, must rise several fold over present levels.

Nonagricultural Domestic Use

Over 80% of our people are nonfarmers, and 38% of the land in the United States is non-farmland. This market comprises a wide variety of end-uses. Pesticides are used in grain and space fumigation, and weed and brush control along rights-of-way (railroads, highways, power lines, and drainage canals). An important segment is weed, insect, and disease control in ornamental turf (home lawns, parks, golf courses, institutional grounds, and airports). Also included are compounds sold for household and industrial pest control by professional control operators. Forest insect control in our 311 million acres of forest and 202 million acres of farm woodland provides an expanding and attractive market. Pest control around urban dwellings, industrial plants, and military reservations has become routine practice.

Several recent developments point to rapid growth of this pesticides market. A sum of $100 million has been allocated to purchase chemicals for roadside beautification in the new federal highway program. FHA and VA are now insisting on chemical termite proofing of every building in most major urban areas of our country. Sales of products for lawn beautification have skyrocketed in recent years, and it is predicted that sales growth will continue so long as general prosperity prevails.

Agricultural Pesticides

While we had 1158 million acres of U. S. farms in 1954, only 332 million represented acres from which crops were harvested. USDA figures show that in 1952 70% of all agricultural pesticide applications were carried out by farmers, and 30% by custom applicators. Today's estimate is 40% for the latter figure, indicating a strong trend toward custom application.

The chart emphasizes that crops utilizing less than 3% of our farm crop and pasture land accounted for the use of more than 56% of all pesticides in 1952 and over 47% in 1955. The change of 9 percentage points is significant, and represents a marked increase in the use of chemicals for pest control and prevention on the large acreage crops—small grains, corn, and forage legumes. These constitute 25% of today's farm acreage being considered, and are a vast, almost untapped, potential market.

Farm pasture, excluding woodland and other grazing areas, totals 521 million acres (1954), of which 17.3 million are listed as improved pasture. In view of invested capital and production potential this acreage deserves every protective measure industry can offer. It is obvious that farm pasture and the large acreage crops, together with a shift in outlook toward preventive chemical application, constitute the chief areas of growth for the U. S. pesticide market.

Developed from material presented by Jack T. Thurston, American Cyanamid Co.; J. Steele Brown, General Chemical Division; F. W. Hatch, Shell Chemical Corp.; and Ernest Hart, Food Machinery & Chemical Corp. before the Division of Chemical Marketing and Economics, 130th National American Chemical Society Meeting, Atlantic City, N. J., September 1956.

LAST YEAR'S concern by coke oven operators about ammonium sulfate's future (AG AND FOOD, April 1955, page 283, and May 1955, page 374) has extended through 1956. Of three coke oven ammonium sulfate makers that have converted to diammonium phosphate manufacture in the last two years, two of them—Ford Motor and Kaiser Steel—went into DAP this year. Colorado Fuel & Iron, which converted in 1955, recently made a major improvement in its process, indicating that CF&I is in DAP to stay.

Ammonium sulfate, an old stand-by as a fertilizer, is slowly but surely being displaced or reduced in mixed goods, partly because of the rising demand for high analysis fertilizers. In AG AND FOOD's midyear fertilizer survey (June, pages 508–15), the trend toward high analysis fertilizers was visible in every part of the country. A good share of the money being spent for high analysis material is going for DAP. Granular mixed goods also provide competition for coke-oven ammonium sulfate (AG AND FOOD, September, page 737). As sales of granulated materials rise, ammonium sulfate will suffer accordingly. In addition, sulfate is more costly on a unit basis than are some other forms of nitrogen.

By mid-1956 (before the steel strike), ammonium sulfate sold for about $10 per ton less than during 1955. Faced with a diminishing market, coke oven operators will be watching closely to see how coke oven DAP makes out.

CF&I Switch

CF&I, first to make the switch, made a smooth transition from sulfate to phosphate manufacture in early 1955. CF&I's production of DAP is about 10,000 to 15,000 tons per year. Electric furnace phosphoric acid from Monsanto replaced sulfuric acid in the standard ammonium sulfate saturator units. This year, Monsanto constructed a phosphoric acid unit (AG AND FOOD, August, page 657) at CF&I's Pueblo, Colo. plant. The new unit, reported as the first one of its kind and size, has been engineered specifically to meet the needs of CF&I's coal chemicals operation. Monsanto and CF&I officials describe the installation as unique and pioneering.

For operation, electric furnace elemental phosphorus from Monsanto's plant in Soda Springs, Idaho, is shipped to Pueblo. Phosphorus is burned in the new unit to phosphoric acid. For use in the production of diammonium phosphate, the acid is pumped directly into the CF&I plant system. The plant, although built on CF&I property and operated by its personnel, is owned by Monsanto.

In the Midwest, at a time when high analysis fertilizer is in greater demand than ever, Ford Motor Co. has converted its coke oven operations from sulfate to phosphate. Ford, a long time producer of agricultural fertilizers, makes its DAP at the Rouge plant in Dearborn, Mich. In its new ammonia removal process, Ford also uses electric furnace phosphoric acid instead of sulfuric acid solution for washing coke oven gas. The conversion—again installed with technical assistance from Monsanto—produces about 80,000 pounds of DAP daily. According to Ford's F. M. Winnie, the phosphoric acid gas washing process may present an entirely new vista to coke oven operators.

Ford's conversion is significant in light of the fact that the company has been marketing ammonium sulfate since 1919. During its 37 years in the business, Ford has sold more than 470,000 tons of the fertilizer.

Kaiser Can Alternate

On the West Coast, particularly in California, a growing western interest in phosphate fertilization is evident. Kaiser Steel, at its Fontana, Calif. plant, began test runs on coke-oven DAP during the spring of 1955. Since then, Kaiser is reported to have installed a system which permits alternate production of sulfate and DAP without interrupting production, basing production on the dictates of current markets.

Together with existing and new producers of DAP, the three coke-oven sources should make a sizable increase in the amount of DAP available, primarily in their respective regions. Whether or not other coal chemical operators will also undertake phosphate manufacture is uncertain, but it seems certain that they are taking a long look at the ammonium sulfate *versus* DAP market outlook.

Farm Use of Chemicals

Pesticide volume is now four times as great as in 1947—expansion in fertilizer led by nitrogen

SOME OF THE most striking gains in the use of chemicals in the past few years have been shown by agriculture. While industrial consumption of nitrogen has declined, the amount employed in the form of anhydrous ammonia for direct application in the soil has more than doubled. Also striking is a gain of 117% in the use of potassium salts for fertilizer purposes, when 1955 is compared with 1947.

The quickening steps of technology are shown most dramatically in the

expansion that has taken place in organic pesticides. Last year their production attained a volume of 506,376,000 pounds, or more than four times the total reported for 1947. In many industrial chemicals, exports amounting to 5% or 10% of domestic production are considered normal; in pesticides we export as much as 20% of our production, and in one product (copper sulfate) the share runs as high as 40%.

These and other important data for the chemical and chemical processing industries are presented, along with discussion by government authorities and ACS staff editors, in the Facts and Figures Issue of *Chemical & Engineering News,* Nov. 19, 1956.

Rising Nitrogen Capacity

Fertilizer supply of nitrogen for 1955–56 is estimated at 2,303,000 short tons in terms of N, an increase of 28% over 1954–55, and 150% over 1947. Actually, there are nearly 50 plants in operation with an aggregate capacity of 3.7 to 3.9 million tons. Several things explain the over-extension of ammonia facilities. Increased use of plant foods, spurred by advancing technology, has encouraged many producers to expand. Petroleum and coal processing plants are partly responsible, by seeking an outlet for byproduct hydrogen and by erecting units to serve promising local markets.

In recent years nitrogen entering fertilizer as ammonium nitrate and ammonium sulfate (coke-oven and synthetic) has leveled off, while ammonia for direct application, ammonia for ammoniation, and nitrogen solutions for direct application have been increasing in use quite rapidly.

Phosphate Expansion

Growth in use of phosphate for fertilizer has been slower than that of either nitrogen or potash. Phosphate enters the industry in the form of normal superphosphate, triple superphosphate, defluorinated phosphate rock, ammonium phosphates, and similar materials. In comparison with 1947, the 1955 crop year consumption of P_2O_5 was 31% higher. Consumption during 1954–55 was 2,284,362 tons as P_2O_5, a record, but this total was considerably below capacity. The production capacity goal set by the Government for phosphatic fertilizers was apparently much in excess of actual needs.

Record Potash Output

Potash consumption in the United States has been growing very steadily over the years as have the other basic fertilizer materials. With the bulk of production still emanating from New Mexico, agricultural potash use set a record during the crop year ending with June 1955 at 1,874,943 tons, up 120% from 1947. Production in 1955 on a K_2O basis was 2,064,808 tons, and the upward trend in output and consumption is being continued this year.

In the matter of foreign trade, we are still importing more fertilizers than we are exporting, although the dollar balance favoring imports is narrowing. Fertilizer exports were outstanding in 1955 when they gained 47% to an approximate total of 4,119,000 short tons valued at $91 million. Fertilizer imports were 2,418,000 tons valued at $110,197,000, major items being Chilean nitrate of soda, ammonium nitrate and mixtures, and ammonium phosphates.

New Construction

"Facts and Figures" shows that fertilizer chemicals were responsible for a good portion of all chemical industry construction in 1955, probably because of new facilities for ammonia and phosphatic materials. The amount completed or under construction at the end of that year for all fertilizers was $433 million out of the total of $2.4 billion for all chemical plants and laboratories.

Pesticides Growth

The growth of the pesticides branch of the agricultural chemicals industry is described as phenomenal. As noted, output of pesticides and other organic farm chemicals, fertilizers excluded, was 506.4 million pounds. Sales were 415.3 million pounds valued at $152.8 million. As against a year earlier, the 1955 performance was 23.6% higher in quantity and 22.7% higher in value. Pesticides growth is attributed to development and wider application of plant hormones and organic insecticides and fungicides. The output of cyclic herbicides increased substantially in 1955 to 76.7 million pounds.

The low-cost fungicide copper sulfate leads in the Department of Agriculture's volume breakdown of 1955 sales. Copper sulfate's total was 78 million pounds; the amount sold has been declining since 1950 when the figure was around 125 million pounds. Sales of DDT last year were 61,800,000 pounds; here the volume has been increasing since 1952. The herbicide 2,4-D follows with a sales total of 29 million pounds, highest since its development. Data covering 1955 sales are lacking for ground sulfur, which amounted to as much as 312 million pounds in 1952, as well as for TEPP, pyrethrum and its extract, and parathion. The latter sells at a level of 3 to 4 million pounds per year.

The Federal Reserve Board index of industrial activity does not reflect business conditions in all segments of the agricultural chemicals industry. It is of interest, however, to note that the board's index of activity (base period 1947–49) shows a rise in fertilizer manufacture from 98 in 1947 to 148 for the first six months of 1956.

Employment in the fertilizer industry is likewise at a high (40,900) on the basis of data issued by the Bureau of Labor Statistics for the first half of 1956. Last year it was 36,900, and five years ago the employment total was 36,000. Average weekly earnings in the same industry this year are at a peak of $67.21. The average has been rising almost constantly since 1951 when the figure was $52.33.

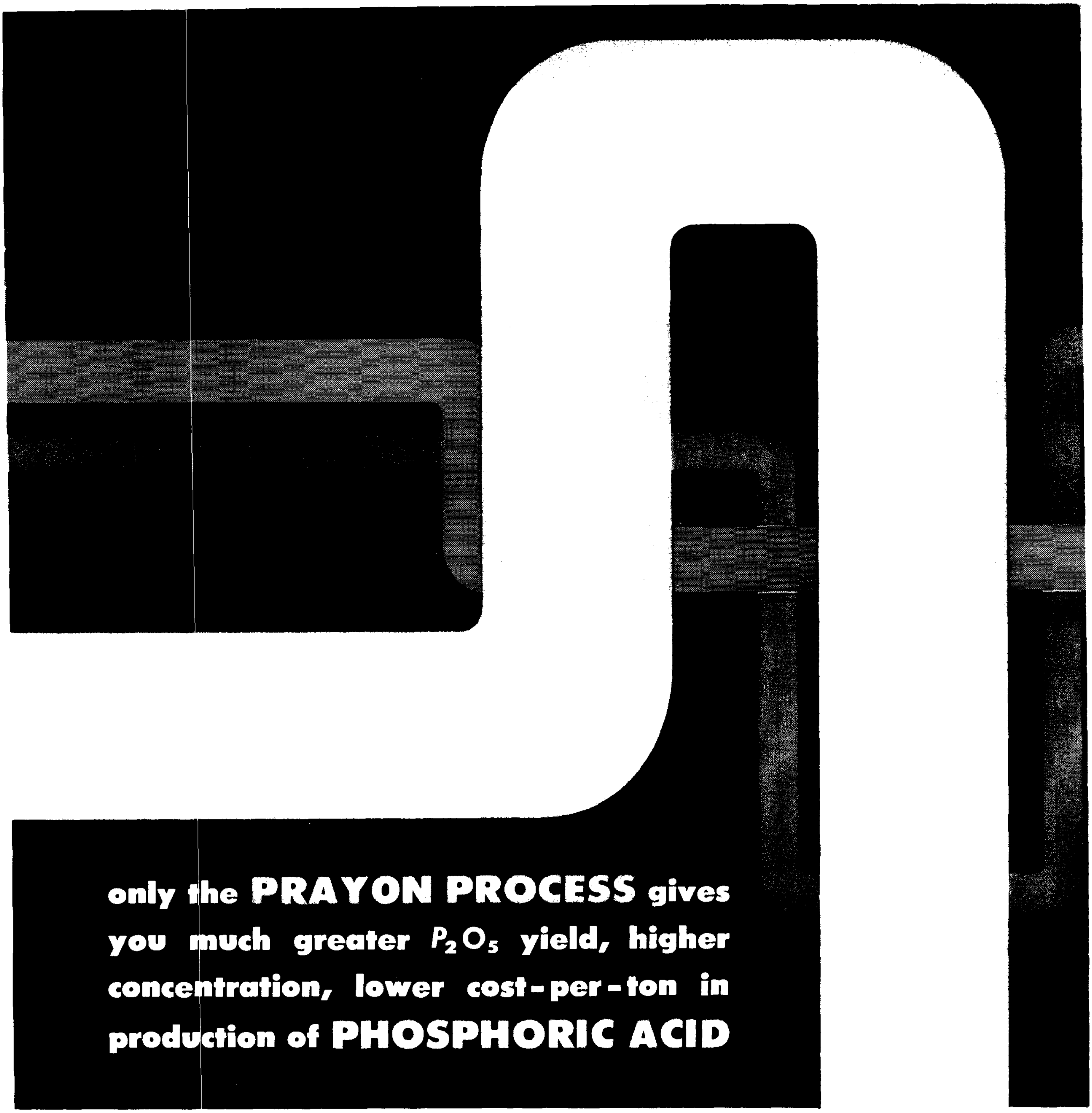
Chemical Fertilizers

Plant foods are more important than ever, and will play a major part in reducing farm surplus and raising farm profits

THE OVERABUNDANCE of food in the United States is focusing new attention on the future of chemical fertilizers. Why should crops be fertilized for greater yields, when surpluses are huge and mounting? The answer lies in efficiency. The vast industry which supplies the nitrogen, phosphorus, and potash that enable food production to keep pace with a constantly increasing world population now has another task—that of enabling the individual farmer to operate at a satisfactory profit. This consideration alone is sufficient to assure chemical fertilizers of continuing growth.

Nitrogen, No. 1 in Growth

In an industry where spectacular growth is almost standard, nitrogen stands out as the No. 1 growth product. U. S. capacity for synthetic ammonia, the source of over 90% of our nitrogen supply, has jumped to around 4 million tons annually (from 0.5 mil-


only the PRAYON PROCESS gives you much greater P_2O_5 yield, higher concentration, lower cost-per-ton in production of PHOSPHORIC ACID

lion 15 years ago), and will reach 5 million tons by the end of 1957. Wide dispersal of the industry's 55 separate plants will then place virtually every area in the nation within about 400 miles of a producer.

"When will demand catch up with supply?" is probably the number one question on the minds of both ammonia producers and ammonia users. Excess capacity is now around 25%, and construction of new plants continues. Consequently, excess capacity will continue to increase rather than decrease in the months ahead, and it looks as though at least four years will be required before demand and supply will be in balance.

Phosphorus, the Oldest

Phosphorus—second of the big three minerals supplied by chemical fertilizers—is perhaps the oldest. Commercial use of natural phosphatic materials began in the 19th century when enterprising Frenchmen undertook the gruesome task of recovering bones from the Napoleonic battlefields to restore fertility to European soils.

The phosphate industry shares the constant trend toward more concentrated forms of plant foods. Superphosphate, although still the largest source of P_2O_5 (about 1.6 million tons or 69% of the total in 1956) is now losing ground to the higher analysis materials: concentrated superphosphate, ammonium phosphates, calcium metaphosphate, and phosphoric acid. Fertilizer materials now consume 81% of the wet process phosphoric acid and 12% of the elemental electric furnace phosphorus; future expansion is envisioned largely in products from phosphoric acid and phosphorus.

In some instances, liming and other cultural practices can do more to restore phosphate fertility in a given soil than can the additions of phosphatic fertilizers. However, man has too often preferred the seeming shortcut of adding fertilizers, with the result that after heavy and continuous phosphate applications the soil remained deficient in available phosphates. The complexity and variability of soil and the need for sound soil management are problems in phosphatic fertilizer usage that must be considered in order to obtain economic returns.

Potash Unique

Potash, the third major nutrient, is unique in that it apparently is not used directly in construction of any vital plant constituents. Its very important role in fertilizers is usually considered chiefly a regulatory or catalytic action.

The steady increase in agricultural potash production since its beginning in the 1850's has been marked by a sharp upward trend in the last 15 years. Increased realization of the importance of potash for efficient plant growth and the depletion of available potash in the soil of some sections of the country, particularly the Midwest, were major factors in pushing usage to 2 million tons of K_2O last year. A strong reason to expect further increases is the fact that potash is still being removed from our soil at a much faster rate than it is being returned.

It might seem improper to predict a continuation of increased chemical fertilizer production in view of current farm surpluses, especially since the crops in greatest surplus are the same ones that use more than 50% of all the plant food sold in the U. S. However, the picture is not nearly so dark as it looks. Many facts point toward increased use of fertilizers as the key to alleviating crop surpluses and resulting low farm income. That fertilizers can do the trick can be shown, at least theoretically, by using state experiment station data on corn as an example.

50% Profit Gain

A fair figure for average corn yield is 37 bushels per acre, which may be assumed to sell at $1.40 per bushel, including about $0.40 profit for the farmer. Research shows that larger use of fertilizer could push yields up to 70 bushels per acre. This increase, researchers say, could be obtained while at the same time the unit cost of producing each bushel would be reduced from $1.00 to $0.80. Thus, proper use of fertilizer would increase the farmer's corn profit by one-half. Advocates of this program do not suggest, of course, that our total corn crop be increased during this time of surplus. The stepped-up use of fertilizer would go hand in hand with a program of reducing corn acreage so that ultimately the nation's needs could be grown on less than half the land now devoted to corn.

AVERAGE PLANT FOOD CONTENT OF MIXED FERTILIZERS

	—PERCENT—			
	TOTAL	N	P_2O_5	K_2O
1920	13.9	2.3	9.2	2.4
1930	17.9	3.1	9.8	5.0
1940	19.9	3.8	9.6	6.5
1950	23.6	4.1	11.0	8.5
1955	27.7	5.4	11.7	10.6

The effect of using more fertilizer on less land would benefit both the farmer and the fertilizer manufacturer. Since both yields per acre and profit per bushel would be higher, the farmer's net income would increase even though he would actually be farming considerably less land. Similarly, the total amount of fertilizer used would increase since up to three times as much fertilizer per acre would be required to obtain the higher yields. This plan has not been proved, nor can it be expected in itself to solve all the farmer's difficulties. However, it does seem to be a logical course to follow.

Chemical fertilizers are definitely an integral part of the long term development of our agricultural resources. Available cropland per person in the U. S. dropped from 3.8 acres in 1920 to 2.7 acres in 1950, and is expected to continue to decline so that by 1970 only 1.9 acres will be available to feed each person. Despite current surpluses, feeding our constantly rising population presents a real challenge to agriculture—a challenge that must be met by more efficient use of farm land. Chemical fertilizers are almost synonymous with efficient land use.

Developed from material presented by C. Y. Thomas, Spencer Chemical Co.; Edwin Cox, Virginia-Carolina Chemical Co.; J. Fielding Reed, American Potash Institute; and Russell Coleman, National Plant Food Institute, before the Division of Chemical Marketing and Economics at the 130th National Meeting of the American Chemical Society *at Atlantic City, N. J., September 1956.*