The Insecticide Industry
Lea S. Hitchner

The insecticide industry of today comprises more than 50 basic producers or manufacturers and more than 500 formulators, remixers, and processors. From their plants throughout the country comes a great variety of insecticides and related products.

The products, except those derived from botanical sources, have their origins in the basic chemicals on which the industry is founded, but the processes that turn the raw materials into the finished products applied by farmers are long, highly scientific, and expensive in capital investment and operating costs.

The industry employs thousands of scientists in the fields of entomology, plant pathology, botany, toxicology, medicine, chemistry, and chemical engineering; thousands of skilled and semiskilled workers in the manufacturing plants; and thousands of men responsible for sales, either as employees of industry or dealers who sell directly to farmers and other consumers.

Demand for the products has climbed to the point where annual sales total at least 200 million dollars, the sum paid for the hundreds of products that industry has developed, produced, and distributed to agriculturists in every State and many foreign lands. The products include insecticides, fungicides, weed killers, rodenticides, defoliants, and plant hormones. Never before has the farmer been so well armed to fight insects and other pests.

Some examples of the effectiveness of the products: Growers of peas in Wisconsin in a recent year achieved a return of 6 dollars for each dollar invested in insect control. The insecticides boosted the yields 15 percent and put nearly 2 million dollars extra in the growers’ pockets. In Mississippi at least 75 percent of the 1950 cotton crop would have been destroyed were it not for the control of insects through the use of the industry’s products. Insecticides applied in Nebraska to control grasshoppers in 1949 resulted in savings estimated at 2 million dollars. Insecticidal treatment of alfalfa raised for seed production in various States has doubled the yield.

One factor among others responsible for the high productivity of American agriculture is the cooperative attack that is waged on insects and other pests. The agricultural chemicals industry has welcomed the opportunity to cooperate with Federal and State agencies and with farm organizations in this important work and to carry the responsibility for developing, producing, and delivering the necessary pesticides.

Such a responsibility is a heavy one even in normal times. It becomes acutely heavy in times of national stress, when shortages of raw materials, containers, personnel, and transportation may hamper production and distribution.

The industry has come a long way since the 1880’s, when its development began to have a real impact on American agriculture. To be sure, the use of chemicals to control insects goes back at least a century, and long before that, man had declared war against the insects that had plagued him from time beyond memory.

Among the earliest records of insect control is the Biblical story of the prophet Amos, who was a “dresser of sycamores.” He was one of many who regularly climbed sycamore trees to pinch off the ends of the young fruit, which resembled figs, hoping this would destroy the insect usually found there. For thousands of years the control of insects and diseases was almost entirely guesswork or practically non-existent, with the exception of mechanical control, like that carried on by Amos, supplemented by a rather haphazard system of crop rotation.
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The first record of effective chemical control dates from 1882, when a Frenchman, Millardet, accidentally discovered what is now known as bordeaux mixture. Sixty years ago most of the materials applied for pest control were chemicals, such as paris green and london purple, used primarily in other industries but accidentally discovered to be effective against insects.

Probably the first insecticide resulting from deliberately planned manufacture was calcium arsenate, destined to become one of the most widely used materials throughout the Nation and to play a special role in the control of the boll weevil in the South.

William G. Piver was typical of the enterprising young businessmen in the industry. Within the first 5 years after his graduation from the University of North Carolina, Piver took part in an early campaign to promote lead arsenate. He conceived the possibility of producing calcium arsenate for use as an insecticide. He reasoned that the arsenical insecticides then in use were effective primarily because they contained arsenic—yet the paris green was expensive because it also contained copper and a large share of the cost for lead arsenate was because of its lead content. He therefore set out to find a way to combine the arsenic with a readily available and inexpensive base, such as lime.

Piver's first experimental apparatus was hidden under his bed in a boarding house because his landlady wanted no poisonous or explosive chemicals in her house. He worked at night, and his progress was slow. He found practically nothing in the technical literature to guide him. But he persevered and he finally produced laboratory amounts of calcium arsenate—but only in pound lots. Then followed further study and research, until in 1912 the first commercial batch of calcium arsenate was produced and shipped in powdered form to a dealer in Houston, Tex. The shipment was intended for the control of the cotton leafworm; the boll weevil was not yet the serious pest it became later in the South.

Supplies of calcium arsenate were also sent to potato growers in Virginia and to apple growers in Nova Scotia. On the basis of results obtained by the Virginia growers, Piver began selling calcium arsenate to potato men in New Jersey. Not all the early results were good.

In 1915, Piver's company had 21 customers; in 1916, 55 customers. By then the boll weevil was serious in cotton. Entomologists accepted the challenge by carrying on extensive experiments with calcium arsenate. In 1918, on the basis of Government tests, a Federal entomologist telegraphed Piver for 40 tons of calcium arsenate—the largest single order he had ever received and a third larger than his highest yearly production. The order nearly floored him. He had to get special permission from his company's board of directors to make up so large a single batch because factory production at that time produced so many failures that the factory back yard was knee deep with the discarded mixes run out from the tanks and dried in the sun. He was "wasting assets of the company," they said, but he won his point. The shipment was made up and sent south. Professional entomologists were quick to realize the potentialities of calcium arsenate as an insecticide.

About the time Piver's company started to manufacture, W. D. Hunter, in charge of southern field crops investigations of the Department of Agriculture, and B. R. Coad, in charge of the laboratory in Tallulah, La., began extensive studies on the use of calcium arsenate for cotton insects. The experimental work continued many years, and much of the development and use of calcium arsenate may be attributed to their efforts.

Typical of the development of other products by industry is the research in the early 1920's that led to the commercial sale of summer spray oils, now widely used on fruit crops.
The late William Hunter Volck is considered by many as one of the greatest contributors to this field. He first started work on spray oils in 1902 in collaboration with C. W. Woodworth, of the University of California; from then on he continued to study petroleum oil products. Volck developed a series of spray oils, including in 1924 the summer oils, which can be used on foliage. He also developed quick-breaking emulsions and, in collaboration with Hugh Knight and others, summer oils plus poisons and emulsive oil products.

To list all the names of industrial companies, scientists, and university and Government workers who have contributed to the development of petroleum oil pesticides would be to list the names of many of the leaders of research development in the United States. Today approximately 85 million gallons of petroleum oil products are used in agriculture to control pests and weeds.

The growth of the industry can be divided into two periods—the first dates from the development of calcium arsenate through the early period of the Second World War, and the second from that time until the present.

During the first period, the industry developed several effective products, adaptable to a wide range of crops and insects—calcium arsenate, lead arsenate, sulfur, nicotine, rotenone, pyrethrum, cryolite, and various copper compounds. The number of manufacturers grew to more than 35, and they hired entomologists, plant pathologists, and toxicologists. Cooperative work between industry and Federal and State entomologists proceeded. Sales of insecticides reached 75 to 100 million dollars annually. The quality of agricultural products was remarkably improved, further concentration of crop production became possible, and the area available for crop production was enlarged.

Many look back on this period as one of pioneer contributions to a more efficient agriculture. Among the early pioneers were A. P. and David Ansbourger and Fred L. Lavenburg, who worked with paris green; James A. Blanchard, also with paris green; B. G. Pratt, miscible oils; and Thomas Grasselli, Arthur Kent, Frank Hemingway, C. D. Vreeland, and George A. Martin, lead arsenate. Besides Piver, Theodore Dosch, Ernest Hart, and Fred Moburg were identified with the development of calcium arsenate; George F. Leonard and Charles Taylor, with nicotine sulfate; William Rose, Edward Mechling, Herbert Dow, Gerald Cushman, R. W. Scott, Arthur Stern, and others, with arsenicals and other products.

The second phase sometimes is called the era of organic insecticides. It was stimulated by wartime research and necessity and resulted in a tremendous increase in the number of products available to growers.

The development of DDT exemplifies the telescoping in a short time the research that might well have taken years. Some authorities have said the major discoveries in curative and preventive medicine during the war were DDT, plasma, and penicillin.

In recognition of his outstanding work in the development of DDT as an insecticide, Dr. Paul Muller of J. R. Geigy, S. A., of Basle, Switzerland, was awarded the 1948 Nobel Prize in Physiology and Medicine. In 1939 the potato crop of Switzerland was seriously threatened by the Colorado potato beetle. The Swiss firm made available to the Swiss entomologists a sample of DDT for testing. Results of the first tests against the Colorado potato beetle confirmed the company's findings and culminated in the control of this destructive insect. The effectiveness of DDT against other destructive insect pests was soon discovered.

A good example of how the insecticide industry developed a product to fill a particular need lies in the story of toxaphene. The toxaphene dusts and sprays are used to kill cotton insects, grasshoppers, and scores of other pests. A chemist of Hercules Powder Co. con-
ceived the idea that insect toxicants might be found in the highly chlorinated terpene products. Chlorinated terpenes of relatively low chlorine content were rather well known, but little was known about chlorinated terpenes of high chlorine content.

By synthesizing a number of different chlorinated terpene materials of varying degrees of chlorination, and submitting them to routine tests against house flies, he discovered that when camphene, a bicyclic terpene hydrocarbon of the formula $\text{C}_{10}\text{H}_{16}$, was chlorinated to above 60 percent, a unique waxlike product of excellent stability and high insecticidal activity against house flies resulted. When his tests were extended to include agricultural pests, he found that the high activity was even more pronounced.

Formulation of the material into dusts, wettable powders, emulsions, and oil-soluble concentrates became important. A considerable amount of application work was undertaken. It was estimated that 150,000 pounds of toxaphene would be required for extensive field tests. A pilot plant was set up to make it at Brunswick, Ga.

Quantities of toxaphene for commercial consumption first were produced in 1947. Testing has continued since, and the insecticide has been found effective against many pests. Construction was started on another toxaphene-manufacturing unit in the South.

In 1949 at the request of the Department of Agriculture, the trade name toxaphene was released, so that the word could be used commonly for chlorinated camphene having a chlorine content of 67–69 percent.

In the wartime research, many chemicals were screened for efficacy, and several phosphorus compounds were found to have insecticidal activity. Hexaethyl tetraphosphate, tetraethyl pyrophosphate, and parathion were soon on the market. They are effective against many pests not controlled by earlier materials. They therefore have been marketed even though they require special precautions in their manufacture and use.

In the production and marketing of parathion, for instance, a notable job has been done to insure proper handling. The technical material is shipped in welded, specially designed drums. For further protection of the handlers, the drums were reduced from a 500-pound size to 280 pounds as further assurance against accidents. Companies manufacturing the material limited its sale to processors who proved themselves properly equipped to formulate parathion. Their departments of industrial hygiene took an active interest in the handling of the chemical from then on and continued to cooperate with the processors to insure continued safety in handling and distribution.

Beyond that, the companies worked closely with the various Government agencies and devised a model label to be followed by formulators of the finished insecticide. They also prepared manuals for growers and safety precautions in the use of the chemical.

I give only a meager outline of what the insecticide companies undertake to insure safe use of a product. The toxicological studies, laboratory and field tests, chemical analyses, and many other costly and laborious activities are involved. Yet the consumer gets the materials cheap enough to pay him to apply them.

Many of the companies test 10,000 chemicals or more a year in the search for effective new products. Often several tens of thousands of chemicals are screened before one or two of real promise are found. When such a material is discovered, it is scrutinized immediately by a battery of scientists. If it appears that the insects to be controlled and the cost of production will create a new field of use or improve the control resulting from the use of existing products, the material undergoes a series of intensive tests. It may be tested in the manufacturer's greenhouses and experimental farms for its insecticidal effectiveness and for the reaction of the crop being treated. At the same time it
is studied by company toxicologists and by toxicological laboratories throughout the country. Entomological and toxicological testing are coordinated so that data showing the insects that are controlled, and precautions to be observed in use, are available at as nearly the same time as possible. Often years are required to obtain adequate data.

Because of the competitive nature of the industry, most of this information is not published. I have no count of laboratories engaged in research on the toxicity of agricultural chemicals. Toxicologists have estimated that there are nearly 25 such laboratories and that their facilities are now being used to capacity.

It is also estimated that 10 to 20 new agricultural chemicals are thoroughly studied for toxic hazards each year in the United States. Not all finally reach the market in quantity. Probably 500 to 1,000 products each year receive some study through the early stages of development but later are abandoned for various reasons. Toxicological research on a chemical that presents no hazards of food residues probably costs not less than 5,000 dollars, but sometimes, when residues of the chemical may occur on food products, the cost often exceeds 20,000 dollars.

A sampling of 20 manufacturers showed that the yearly expenditures for their research, including toxicological studies, is nearly 4 million dollars. Such studies represent fundamental work directed toward the protection of the health of all concerned—workers in the manufacturing plant, farmers who apply the product, and consumers who buy and consume the commodities that have been sprayed or dusted.

For that reason, too, the industry has supported State and Federal legislation to regulate the distribution and use of insecticides, fungicides, and related products.

The industry is regulated at the State and the National level. Many State laws, some of them conflicting, present something of a problem to an industry whose members often sell their products throughout the country. Many States have tried to enact uniform legislation; in that effort, the industry has cooperated with the Council of State Governments, the Department of Agriculture, the National Association of Commissioners, and Federal and State regulatory officials. The combined efforts of those groups have produced the Uniform State Insecticide, Fungicide, and Rodenticide Act, which has been enacted into law in 19 States. Twenty-one States have other pesticide laws. The industry believes public interest will be served by the enactment of a uniform act in more States. The industry also actively supports a proposed Uniform Custom Applicators' Law, which was drafted by the Council of State Governments and other interested groups. Its purpose is to insure the safe application of pesticides from the air and by other means.

The agricultural chemistry industry has made noteworthy achievements, but it is not content merely to think of them. Its research is being intensified, with increased emphasis on fundamental studies. Substantial capital investments have been made in new plants. Manufacturing and processing techniques are being improved constantly. More efficient methods of distribution are being instituted. Toxicological studies and educational programs more and more seek to safeguard users of its products and the general public.

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