HOW MAGIC IS DDT?

BY
BRIG. GEN. JAMES STEVENS SIMMONS

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ABOUT THE AUTHOR

There was no one better qualified to write this article than the man who wrote it—Brig. Gen. James Stevens Simmons, Chief of Preventive Medicine, Office of the Surgeon General, United States Army. General Simmons has devoted nearly thirty years to the science of public health, a career which began when, as a graduate of the Medical School of the University of Pennsylvania, he entered the Army's Medical Corps in 1916. He is widely known for his research and teaching in bacteriology and tropical medicine. His achievements in these fields, his contribution to our knowledge of malaria and other insect-borne and virus diseases have brought him numerous honorary degrees and such outstanding distinctions as the Sedgwick Memorial Medal, in 1943, and the Typhus Commission Medal, which was awarded him last spring by the Secretary of War for his nationally valuable service in "protecting the armed forces from typhus fever and preventing the introduction of the disease into the United States."

General Simmons' most recent honor was the Walter Reed Medal, an award that came to him at the time when he was preparing this article for the Post.

—*The Editors.*

LARRY KEIGHLEY

General Simmons (*facing camera*) and other Army medical men watch a demonstration of one of war's few mercy weapons—the Freon-Pyrethrum spray bomb for use against lice, mosquitoes and other disease spreaders.

HOW MAGIC IS DDT?

BRIG. GEN. JAMES STEVENS SIMMONS, U. S. ARMY

Chief, Preventive Medicine Service, Office of The Surgeon General, U. S. Army

The initials DDT are used as a convenient nickname for a jawbreaking chemical term, dichloro-diphenyl-trichloroethane. In everyday language, this high-sounding chemical compound is a stable, almost colorless and practically odorless crystalline solid.

It is not soluble in water, but can be dissolved in many organic solvents, including kerosene and various other oils. It is one of the most powerful insect poisons known, one which affects the nervous system of the insect and produces jittery, spasmodic movements, followed by paralysis and, later, by death.

It is effective when used in infinitely small amounts and can be used highly diluted either as a powder or in oily solutions. It can kill many of our innumerable insect enemies, not only the annoying household pests and many of the plant parasites that ravage our crops and food supplies but also lice, mosquitoes and other dangerous, blood-sucking insects which are responsible for the spread of typhus fever, malaria and other serious diseases.

DDT is of great importance to all of us, both in helping to win the war and in improving the country's health after the war is over. DDT itself is fairly old. It has been known for seventy years, and its ability to kill certain of the insect pests of plants was observed about four years ago in Switzerland. However, its value as a military weapon for the control of insect-borne diseases has been discovered and developed by scientists in this country only during the past two years. At first, the results of the experimental work were blanketed by military secrecy. Recently, however, this secrecy has been lifted; the story of the use of DDT to control typhus in Naples has been announced and statements have been released concerning its effective use against malaria in many theaters.

[Correspondent Allen Raymond told the Naples story in NOW WE CAN LICK TYPHUS in the Post for April 22, 1944. Censorship restrictions in effect at the time prevented him from mentioning DDT by name.—Ed.]

Such reports have fired the popular imagination, and the symbol DDT is acquiring a mysterious, romantic aura. It is coming so rapidly into common use that it bids fair to join the ranks of such well-known war-born Army terms as "jeep," "radar" and "bazooka."

As the experimental work with DDT continues at top speed both in the laboratories and in the field, at home and abroad, the reports of progress which reach the Surgeon General's Office almost daily compete in interest with the war bulletins from the fighting fronts. Meanwhile these reports of the amazing uses of DDT are passed over for yarns telling of its destructiveness which sound like newly created versions of the Arabian Nights. These incredible rumors picture DDT as a substance which may bring complete ruin to both the animal and the vegetable kingdoms. For example, a serious scientific report that DDT has killed millions of malaria mosquito larvae in Gatun Lake may be overshadowed by a fantastic story claiming that particles of the chemical, transported

by the trade winds, have annihilated all the blue butterflies in the Isthmus of Darien.

In an atmosphere made lively by such rumors and tales, scores of sober-minded malariologists, entomologists, engineers, chemists and businessmen convene regularly in Washington to pore over long scientific reports of the insecticidal action of DDT and to arrange for its further investigation and increased production. Distinguished foreign officials fly to the capital to ask for enormous amounts of it with which to save their homelands from immediate destruction by insects.

Meanwhile, harried, hard-working officers sweat over the problem of how to stretch the rapidly increasing but still inadequate supply of DDT to meet the needs of a grasping world.

Many uninformed persons have been puzzled as to why such an old chemical as DDT was not adopted earlier by the Army. The answer is that while this chemical, like thousands of others, has been known for many years, the methods evolved for its use by the armed services are entirely new. They have been developed with phenomenal speed as a part of a streamlined program of wartime medical research. As soon as DDT's effectiveness and safety were established, no time was lost in putting it into use.

Dichloro-diphenyl-trichloroethane was first synthesized in 1874 by Othman Ziedler, a young student at Strasbourg, after which Ziedler was forgotten and his chemical was buried in moldering scientific records as another compound of no practical importance. About four years ago, its bug-killing properties were demonstrated by Paul Muller, of the J. R. Geigy Company, in Switzerland, who reported its value for the destruction of various agricultural-insect pests. The use of DDT as an insecticide is now covered by patents assigned to this company, which made it available in Switzerland, first under the trade name Gesarol, for killing plant-eating insects, and later as Neocid, for use against lice.

In the fall of 1942, a small amount of Gesarol was sent by the parent company to its New York office, along with a report that it had been useful in saving the Swiss potato crop from invasion by our Colorado potato beetle, and also in the destruction of various local plant pests. It was claimed that when painted on the walls of a barn, a single application would kill any flies that chanced to light there for a period of a month or more thereafter.

This sample reached the United States at an opportune time, for the Army was then looking for a new insecticide. On arrival, however, its chemical identity was still hidden under the Swiss trade name Gesarol, and the Army had no information about its value against the blood-sucking insect parasites of man. Nevertheless, because of the fly story, it was welcomed as another preparation of sufficient promise to be tested for its potential value to the armed forces. Thus, recognition of its full possibilities might have been delayed indefinitely, had it not been for the problems posed by a global war.

The Army needed another insecticidal substance, because the war had cut off the normal supplies of rotenone from the Dutch East Indies, and an acute shortage of pyrethrum threatened to cripple its program for the prevention of

insect-borne diseases. This program, which was started before the war by the Preventive Medicine Service of the Office of the Surgeon General of the Army, included an intensive search for better insecticides and repellents. Many American scientific agencies were mobilized to assist in this search. They included the National Research Council, the Committee on Medical Research, the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture, the division of pharmacology of the Food and Drug Administration, the industrial-research laboratories of the National Institute of Health, the International Health Division of The Rockefeller Foundation, the Gorgas Memorial Laboratory in Panama, various universities and several commercial companies.

As a result of this comprehensive research program, a series of excellent new insecticidal agents had been produced for the armed forces. These agents included methyl-bromide gas, which is used throughout the Army as a convenient fumigant for the rapid delousing of clothing and equipment; a louse powder known as MYL, used until recently to delouse the individual soldier; three valuable insect repellents used to protect soldiers against the bites of mosquitoes, sandflies and chiggers; and the popular Freon-pyrethrum mosquito bomb, which is used by our troops in all tropical theaters to kill adult mosquitoes.

While the War Department was making strenuous efforts to speed the production and distribution of these new insecticides to the troops, the supply of the Army louse powder and the mosquito bomb, both of which required pyrethrum, was jeopardized by a combination of temperamental weather conditions, food-crop failure and labor difficulties in far-away Kenya colony on the east coast of Africa. These unpredictable circumstances had reduced the crop of pyrethrum, which is a daisylike flower of the chrysanthemum family. As Kenya was the chief source of our national supply, this accident threatened to cut off the annual flow of millions of pounds of this essential insecticidal material to the United States.

An attempt was made to meet the pyrethrum shortage by conserving the supplies remaining in this country for the armed forces alone, and an unsuccessful effort was made to obtain pyrethrum seeds from Kenya for planting in the Western Hemisphere. However, the supply continued to dwindle and there was an increased demand for it, not only from agriculture but from the troops of the United Nations. Soon it was necessary to ration the Army louse powder and to limit the use of the Army mosquito bomb to our overseas tropical theaters and to the disinsectization of military aircraft. The situation became so serious that a substitute for pyrethrum had to be found.

The Army sent out an SOS to its cooperating research agencies, and an immediate search was begun. Many previously disregarded chemicals were re-examined, including some that formerly had been considered unsuitable for military use. During this critical period, DDT arrived in America and began its remarkable wartime career.

The Gesarol sample was examined by experts of the Department of Agriculture, who found that it contained DDT, which they resynthesized and used in

insecticidal studies in the laboratories of the Bureau of Entomology and Plant Quarantine at Orlando, Florida. The Swiss reports of its action on plant pests were found to be true, and our scientists immediately began to study the effect of DDT on various other insects. The results were astounding. Not only was the prolonged killing effect on flies confirmed but it was discovered that even when used in unbelievably small amounts, the material had a similar action against mosquitoes, lice, fleas, bedbugs and other insect parasites that feed on man.

These studies showed that DDT acts as a nervous-system poison and that it kills certain insects either when swallowed by them or when brought into contact with them. For example, when mosquitoes touch an oily solution of DDT, they show no signs of being poisoned for about twenty minutes. Then they become nervous and agitated, take off abruptly, fly about in erratic, drunken circles and finally, after a binge of five to twenty minutes, drop to the floor. Paralyzed and unable to fly again, they die several hours later. These reactions are so typical that laboratory workers often refer to them as the "Gesarol jitters" or the "DDT's." The knockdown effect of DDT is slower than that of pyrethrum, but it retains its lethal power for a much longer time.

DDT is also highly poisonous to lice, and when mixed with certain inert powders, it provides a louse powder infinitely better than the MYL powder previously used by the Army. The MYL powder when shaken into the clothes of a soldier, keeps him free from lice for about a week, but a single application of DDT louse powder is effective for more than a month. During field tests made with this powder among louse-infested natives in various parts of the world, it has been so popular that the investigators were frequently embarrassed by the large numbers of volunteers who demanded attention.

The toxic action of DDT is so strong that some of the scientists who first used it ruined important experiments because they failed to clean their insect cages before using them again, and the small amounts of DDT remaining were sufficient to kill the new insects introduced.

The remarkable results obtained during the early part of 1943 stimulated the hope that DDT might be immediately adopted for use in the Army, thus affording a way out of the pyrethrum dilemma. But before this could be done, a disturbing question had to be answered: Could DDT be used on the millions of soldiers and sailors of our armed forces with safety? The preliminary safety tests, made with full-strength DDT, had been somewhat alarming. When eaten in relatively large amounts by guinea pigs, rabbits and other laboratory animals, it caused nervousness, convulsions or death, depending on the size of the dose.

Further investigations were therefore required to determine its safety for man when small amounts were applied over long periods of time and under the exact conditions of its proposed military uses. It was soon learned that, used as a louse powder, DDT can be safely applied to the human skin, but it was not until the end of the year that it was shown to be safe for use in certain other ways. We now know that, when properly diluted, DDT can be combined with oil and

used in sprays without danger from inhalation. We also know that, when used correctly in small amounts as a mosquito larvicide, it can be added to water without killing fish or game. It must be remembered, however, that like other insecticides, DDT is a powerful poison and has to be used intelligently. It must not be swallowed, and oily solutions of it must not be applied to the skin.

Announcement of the results of the final safety tests late in 1943 precipitated an enormous demand for DDT to satisfy the needs of our Army and Navy and the military and civilian requirements of the United Nations. In an attempt to meet these impatient and sometimes unreasonable demands, the Headquarters Army Service Forces, the Surgeon General, the Quartermaster General and the War Production Board inaugurated a tremendous production program. Within a short time, the supply has increased enormously, but so have the demands. Unfortunately, the production is not yet adequate to meet civilian requests.

Our primary interest in DDT has naturally been concerned with its value as a new weapon for use in the fields of military preventive medicine and public health. The addition of this insecticide to our medical arsenal has forged another vital link in the Army's chain of defense against disease and has materially strengthened the Surgeon General's program for protecting the health of our far-flung forces.

This broad program is directed by a special staff of Medical Department officers trained in all the complex phases of preventive medicine who maintain a hard-hitting, streamlined military-health department within the Army. Every aspect of health conservation is covered, and it is the constant objective of the Preventive Medicine Service to keep every soldier strong and well, and fit to fight. The Army's health campaign is translated into action by the thousands of Medical Department officers and soldiers who go wherever the troops go. They have done a good job and, in spite of the exposure of American troops to great hazards and handicaps, there has been relatively little serious illness and there have been no severe epidemics in the Army. The proportion of deaths caused by disease has been reduced to an all-time low.

However, as was anticipated, the war has spread to tropical countries, resulting in an unprecedented exposure of our soldiers to the tropical diseases, many of which are spread by the creeping, crawling, flying hosts of biting insects that infest such regions. As the war progresses to its final stage against Japan and greater numbers of our men are exposed to tropical diseases, the importance of DDT and the other individual protective agents will become even greater.

As our tropical frontiers enlarged, first through acquiring the Caribbean bases during 1940, and later through the dispatch of troops to many of the hot regions of the world, the Army's campaign against all the diseases of these regions has been steadily improved and expanded. On the whole, the campaign has been extremely successful. Many of the dreaded tropical scourges, such as African sleeping sickness, have not occurred. New vaccines have been used for the control of three of the most fatal diseases—yellow fever, plague and cholera. Scrub typhus, or Japanese river fever, with a case mortality of 3 to 10 per cent, has occurred in a few areas in the Southwest Pacific and in the China,

Burma, India Theater. Dengue, sandfly fever and filariasis have been annoying in certain regions, but all these are non-fatal diseases and they have caused no permanent disability.

The No. 1 hazard of this war is malaria, which has been a serious problem in every tropical theater. Another exotic, insect-borne disease which is not tropical, but was feared at the beginning of the war because of its notorious past, is typhus fever. Armed with DDT, the Army has conquered the fear of typhus. For the first time in history, this ruthless companion of disaster, famine and poverty has lost all right to its murderous title of champion of the ancient plagues of war.

Army preventive medicine is also smashing ahead on all fronts in the stubbornly resisted fight against malaria. Both typhus and malaria are charter members of the ancient order of wartime diseases, but they differ in their techniques and spheres of influence. Typhus prefers cold and temperate climates, and it burrows about in its filthy endemic lairs until disaster affords a chance to attack; then, through its loathsome intermediary, the louse, it preys on the miserable and the weak. Malaria, on the other hand, is a disease of hot, humid regions, and strikes out directly; its fleets of air-borne mosquito carriers hit with the fury of robot bombs, attacking both the weak and the strong.

It wages a continuous offensive against man throughout its great tropical domain which encircles the earth on both sides of the Equator. During the warmer months of the year it expands the borders of its empire as far north as Southern Sweden and Lake Ladoga; and as far south as Johannesburg and Argentina and, in rare instances, to Queensland. A complete world census of its victims has never been made, but in 1932 more than 17,000,000 patients were treated in sixty-five countries. In India alone, only one tenth of the annual toll of 100,000,000 malaria cases received treatment, and several million people died.

Moreover, chronic malaria has weakened and enslaved a large part of the earth's population and has played an important and often decisive role in most of the great wars fought within its jealously guarded empire. It is claimed that malaria was largely responsible for the decline of the ancient Greek and Roman civilizations. Alexander the Great, dreaming of new worlds to conquer, was cut off in his mighty youth by what was probably the plasmodium of malignant malaria slipped into his skin through the bite of a vagrant anopheline mosquito.

During World War I, relatively few American troops were exposed to malaria. Other forces, however, suffered severe casualties, and this disease interfered with military activities in several theaters including East Africa, the Levant and Macedonia. In the latter area, large British, French and German forces were immobilized for three years.

The plans made by the Army to protect soldiers against malaria in this war may be considered in two main categories: first, the group-control measures which can be employed in permanent or semipermanent fixed installations to destroy the mosquito vectors or to prevent their invasion of buildings; and, second, the individual-control measures which are necessary to protect the soldier during exposure to mosquitoes under field conditions. The group-control measures

have been highly successful. The gigantic antimosquito campaign which has been carried on by the Army on military reservations in this country at the cost of millions of dollars, supplemented by an extramilitary campaign by the United States Public Health Service, has reduced the prevalence of malaria among soldiers in the United States to the lowest rate ever recorded.

But the battle overseas has been a tough one. In certain tropical areas, the malaria rates during some of the early campaigns were excessive because of the unusual exposure of combat troops, difficulties in supplying them with malaria-control materials, and, in some instances, failure of commanders to appreciate the importance of enforcing sanitary discipline. During the last year this situation has been strikingly improved, and considered as a whole, the prevalence of malaria in the Army is not alarming. In June, 1944, the American minister to Australia, Mr. Nelson Trusler Johnson, following a visit to New Guinea, wrote the Surgeon General that "amazing things have been accomplished, so that malaria is no longer the threat to success of our mission in this area of war."

The insect repellent which is now supplied to troops in all theaters repels mosquitoes for about four hours and is a boon to the soldier exposed at night under combat conditions. Mosquito-proof clothing impregnated with various repellents is being tested for use in certain regions. The spray of the Freon-pyrethrum bomb is used to kill adult mosquitoes in planes, barracks, tents and foxholes.

These measures for individual control are now being supplemented byDDT. Solutions in oil may be used as sprays. Applied to the walls of buildings or tents, such solutions, for periods of several weeks, kill all adult mosquitoes that light on them.

DDT is also so effective as a mosquito larvicide that it is replacing the methods formerly used. When a small amount of oily solution is dropped on the water at the edge of a pond, it spreads rapidly over the entire surface and kills all the mosquito wrigglers present. One pound of DDT in a 5 per cent solution of Diesel or fuel oil is sufficient for five acres of water.

Examples have been reported of ducks that, after swimming on water treated with DDT, moved on to untreated ponds and carried on their feathers enough of the chemical to kill the mosquito larvae in the second pond. The most exciting development with DDT has been its experimental distribution from airplanes in the form of smokes and sprays to destroy mosquitoes in large inaccessible areas. Preliminary tests with slow-flying planes gave excellent results; both adult and larval mosquitoes were killed in areas covered.

This led to field experiments with fast combat aircraft which are now in progress in every tropical theater. The reports from all these tests indicate that, as already anticipated, DDT is the greatest weapon now available for continuing the fight of the armed forces against malaria.

During the last few years, many new agricultural uses of DDT have been discovered and its great military value for the control of typhus and malaria has been demonstrated. However, we have only scratched the surface of its potentialities. We now know that DDT is effective against the Japanese beetle,

various cabbage worms, the coddling moth and many other destructive plant pests, but poor results have been obtained in experiments with the Mexican bean beetle, the red spider and the cotton boll weevil. It can be used to kill such domestic pests as flies, ants and cockroaches, although the German cockroach is more resistant than the American.

Also it is useful against many biting insects, including lice, mosquitoes, flies and bedbugs, and, to some extent, against ticks and chiggers. To those of us who believe that when a magic key to world peace is discovered, this key can work only in a lock well lubricated with the magic oil of world health, these potentialities are interesting. Therefore, the increasing production of DDT continues at full speed and the program of experimentation is being intensified and expanded in order to obtain answers to the innumerable questions which arise concerning its future uses.

The Army now has sufficient DDT louse powder to protect the louse-infested liberated populations of Europe against typhus; and plans have been made for the delousing of approximately 18,000,000 persons displaced by the war. There is enough DDT for emergency malaria-control work in certain combat areas, and the supply will soon be adequate for expanding the agricultural studies.

It is fully realized that such a powerful insecticide may be a double-edged sword, and that its unintelligent use might eliminate certain valuable insects essential to agriculture and horticulture. Even more important, it might conceivably disturb vital balances in the animal and plant kingdoms and thus upset various fundamental biological cycles. In order to investigate all phases of these broader problems as well as to give additional help to the armed forces during the present emergency, an important new board on insect control has recently been established by the Office of Scientific Research and Development.

The possibilities of DDT are sufficient to stir the most sluggish imagination, but even if all investigations should cease today, we already have a proud record of achievement. In my opinion it is the War's greatest contribution to the future health of the world.