ARTICLES

A LABORATORY THERMAL AEROSOL GENERATOR[1] FOR THE TESTING OF INSECTICIDAL AEROSOLS

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Adulticiding by means of ground thermal aerosols is a major procedure in the control of adult mosquitoes throughout the world. The research needed to determine the dosage rates of the insecticides used in this type of adulticiding has been largely conducted in the field using caged adult mosquitoes. However, the number of tests necessary to arrive at an optimum dosage rate requires considerable time. Also, field testing is at the mercy of unfavorable weather conditions, since the tests must be conducted under rather limited conditions of wind velocity and temperature in order to obtain usable results. Because of these difficulties preliminary laboratory tests are desirable.

Laboratory spray tunnels have been used for many years. (Davis and Gahan, 1961, and McCray and Schoof, 1963.) Sprays, however, may not give results comparable to thermal aerosols for many reasons, the more obvious of which are that the insecticide is not exposed to the possibly destructive heat of a thermal generator and that the droplets to which the insects are exposed are considerably smaller in thermal aerosols than even the finest sprays. Owing to these differences it seemed desirable to construct a thermal aerosol generator which could be used in the laboratory to establish susceptibility levels of various species of insects to various insecticides.

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CONSTRUCTION. Basically the apparatus (Fig. 1) consists of a sprayer, a heater, condensation tube and wind tunnel. The heater (Fig. 2) is constructed of two metal tubes, a 6-inch long, ⅞-inch I.D. stainless steel inner tube and a 5¾-inch long, 3⅜-inch O.D. outer tube. The inner tube is held in place in the center of the outer tube by two transite discs. The forward disc, 5¾ inches in diameter, is drilled to accept the inner tube and ground to accept the outer tube. The rear disc is also drilled to accept the inner tube and is fitted inside and flush with the rear edge of the outer tube. The forward disc is larger than the diameter of the outer tube to prevent the heat radiating from the heater from being sucked into the wind tunnel.

A ¼-inch in diameter hole is drilled 3½ inches from the rear of the outer tube through both tubes to accept the thermocouple shaft, the collar of which is screwed to the ventilated fitting on the outer tube. The tip of the thermocouple contacts the inside surface of the inner tube. The thermocouple is connected to a 2,000° F. pyrometer.

The inner tube is wrapped with a single layer of a 12-foot 400 watt beaded wire heater. The beaded wire is wrapped with 3 or 4 layers of asbestos cloth and the cloth and wire are held in place on the tube by screw clamps. The beaded wire is connected to screw terminals which pass through the forward transite disc. An insulated wire is used to connect the terminals to the powerstat which controls the voltage and the resulting heater temperature. A condensation tube 6 inches long and ⅞-inch in diameter is placed ⅛ inch from the inner heater tube.

The other end of this tube is inserted into the center hole in the wind tunnel cap.

The sprayer (Fig. 2), a De Vilbiss No. 155 atomizer, is mounted so that the movable tip, positioned at a downward angle of 45 degrees, is 2 inches in from the rear of the heater. Because of its inertness nitrogen is used as a propellant. The pressure in the cylinder is reduced to 15 psi by means of a valve and gauge mounted on the cylinder and the volume of gas is further controlled by means of a flowmeter set at 15 liters per minute (lpm). A gas stopcock is used as an on-off valve. The heater, condensation tube and sprayer are mounted on a rack of rods and clamps and are individually adjustable to insure proper positioning of each unit.

The wind tunnel (Fig. 3) is constructed of galvanized duct pipe (6 inches in diameter) and the entrance of the tunnel is covered with an end cap. A series of ⅜ inch holes, ½ to 1 inch apart and arranged in three concentric circles, are drilled in the end cap to reduce the volume of air pulled through the burner which would lower burner temperatures. A 5-bladed fan (5¾ inches in diameter) and a 120V AC variable speed motor are installed 60 inches from the tunnel entrance. The fan motor is connected to a second powerstat used to regulate the fan motor speed and the resulting air velocity in the wind tunnel.

The cages of insects to be tested are inserted in an opening 4 inches long and half the diameter of the wind tunnel. This opening is 3 feet from the tunnel entrance. A flexible clear plastic sheet is used to close the opening. The insect cages (Fig. 3), made to the exact interior

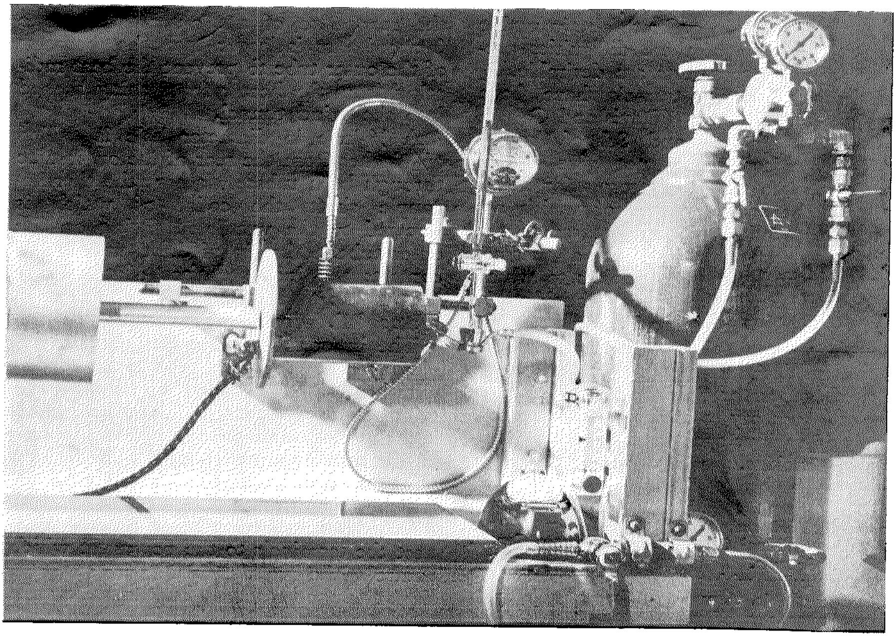

FIG. 1.—A closeup of the assembled units of the laboratory thermal aerosol generator.

measurements of the wind tunnel, are 6 inches in diameter and 1 inch wide. The sides of the cylindrical cages are galvanized metal with 14x18 mesh screen covering the ends. The screen is soldered only to the solid edge of the cages so that there is no lip to block the free flow of the aerosol or to give protection to the insects.

Operation. The volume and pressure of the propellant are adjusted to 15 lpm and 15 psi, respectively. The air velocity in the wind tunnel is adjusted to 3 mph by means of the powerstat. The heater is switched on and the temperature adjusted to 850° F. by means of its controlling powerstat.

One-half milliliter of the material to be fogged is placed in the cup of the atomizer and the cages containing the insects to be treated are inserted in the wind tunnel. The valve is turned on allowing the insecticide to be sprayed into the heater. After all the material has been sprayed, requiring about 3 seconds, the valve is turned off and the test cage is removed from the wind tunnel.

Each dosage level is replicated 2 to 4 times, depending on the accuracy desired, using 25 female mosquitoes per cage. Control tests, with diesel oil only, are conducted with each insecticide test. Before testing each dosage, a "blank" or test without a cage of insects is run to expel from the system any material remaining from the previous dosage. The equipment is cleaned after each dosage series by running 3 or 4 blanks of 0.5 milliliter of No. 2 Diesel through the system.

After all cages have been treated the mosquitoes are anesthetized with CO_2

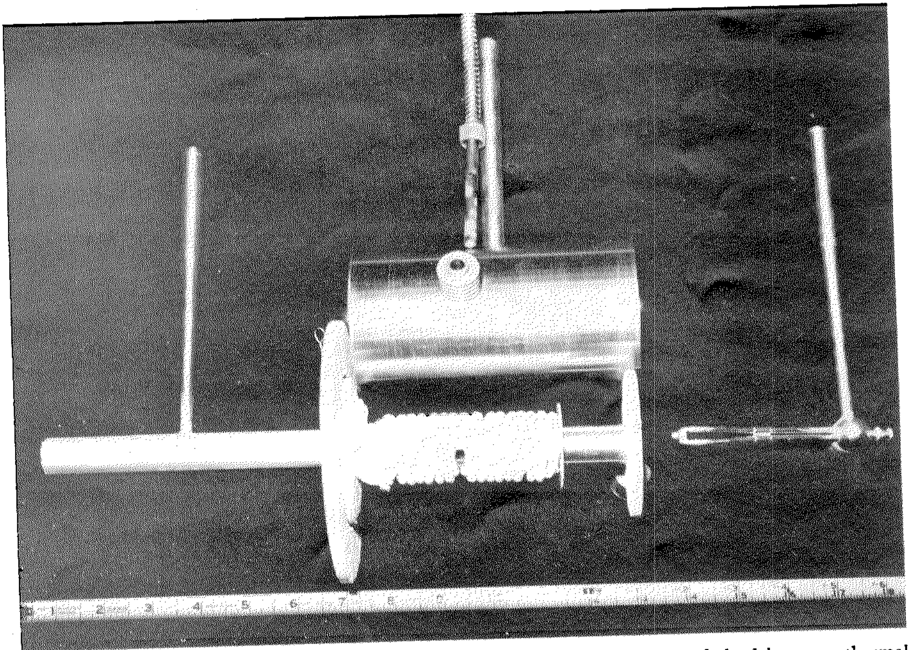

Fig. 2.—The disassembled heater components, condensation tube and sprayer of the laboratory thermal aerosol generator.

and transferred to clean holding cages. A cotton pad wet with a sugar water solution is placed on the top of each cage. Mosquitoes are held for 24 hours for mortality counts. All cages are decontaminated after each use.

The air velocity in the wind tunnel and the heater temperature may be varied if desired. An air velocity of 3 mph was selected as being the average for field conditions. Figure 4 gives the voltage necessary to obtain various heater temperatures. A temperature of 850° F. was selected because at this temperature the droplet size of the fog produced most closely approximated that obtained with large field units. Droplets sampled by use of magnesium oxide coated slides (May, 1950) revealed the presence of an average of 14 droplets greater than 5 microns in diameter per a 1 x 3 inch microscope slide. With this method, however, only droplets larger than 5 microns in diameter can be measured. Data obtained with the cascade impactor (May, 1945) and the aerosol camera (Rathburn and Miserocchi, 1967) showed that, at a heater temperature of 850° F., the average droplet size produced was about 2 microns in diameter. This compares favorably with the large field units as previously determined by the author (In manuscript).

PREPARATION OF STANDARD CURVE. For the purpose of determining dosages of insecticides to be used in the field, a dosage curve for a standard or reference insecticide for a particular mosquito species must first be obtained. In this case malathion was selected as the reference insecticide and *Aedes taeniorhynchus* as the

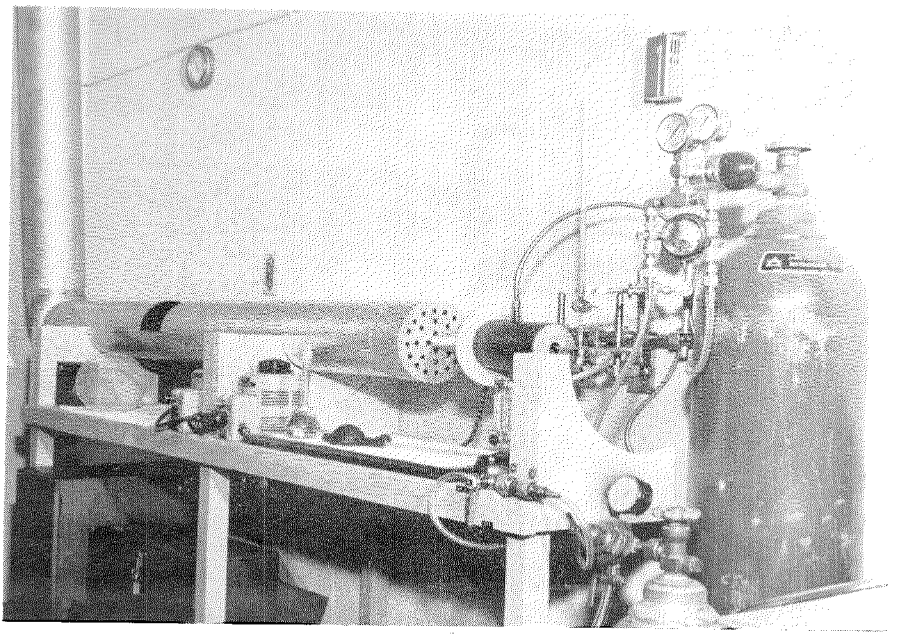

FIG. 3.—The laboratory thermal aerosol generator including wind tunnel and testing cage.

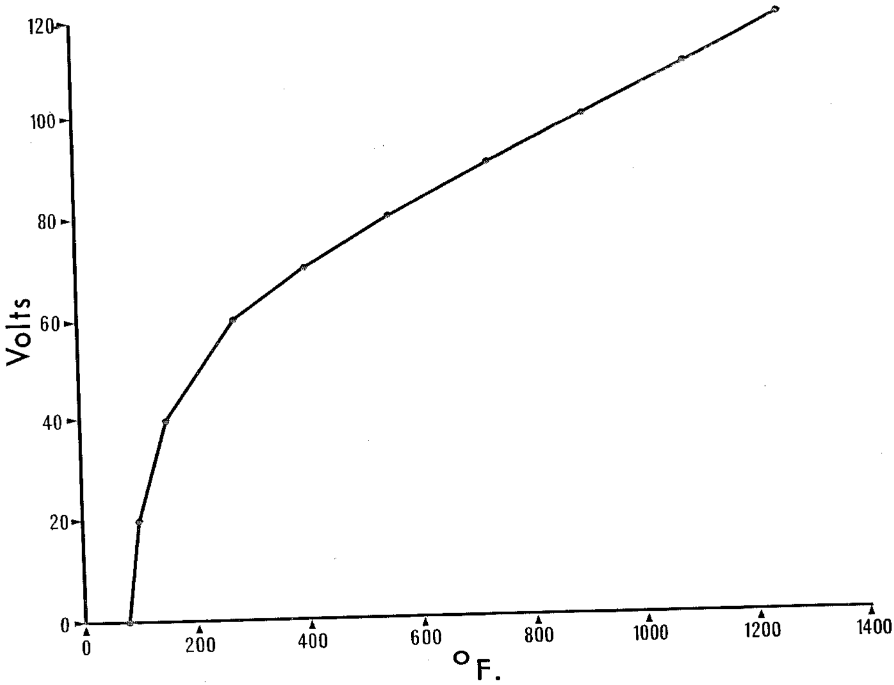

FIG. 4.—A curve showing the voltage necessary to obtain the desired heater temperatures.

reference mosquito species although other insecticides and insect species could be used. Initial tests indicated that a kill between 5 and 95 percent could be obtained with malathion dilutions ranging from 3.5 to 5.8 milligrams per milliliter of No. 2 diesel oil. The results, an average of 20 replications at each dosage, are shown in Fig. 5. Check mortalities for all tests averaged only one percent. The LC_{90} dosage of 5.4 milligrams per milliliter represents about one-eighth of the dosage required to effect the same degree of kill in the field using 6 weight ounces of malathion per gallon of No. 2 diesel oil discharged at 40 gph and a vehicle speed of 5 mph.

Results with other species of mosquitoes, as for *Culex nigripalpus* shown in Fig. 5, may not be the same due to susceptibility variations among species. Also the laboratory-field toxicity ratio may not be the same with all insecticides because of different dosage requirements and field meteorological conditions. In addition to laboratory thermal aerosol screening of new insecticides, this equipment can also be effectively used to test susceptibility levels of various species and also the same species from various areas which is necessary in determining resistance levels.

SUMMARY. The apparatus described consists of a sprayer, a heater, a condensa-

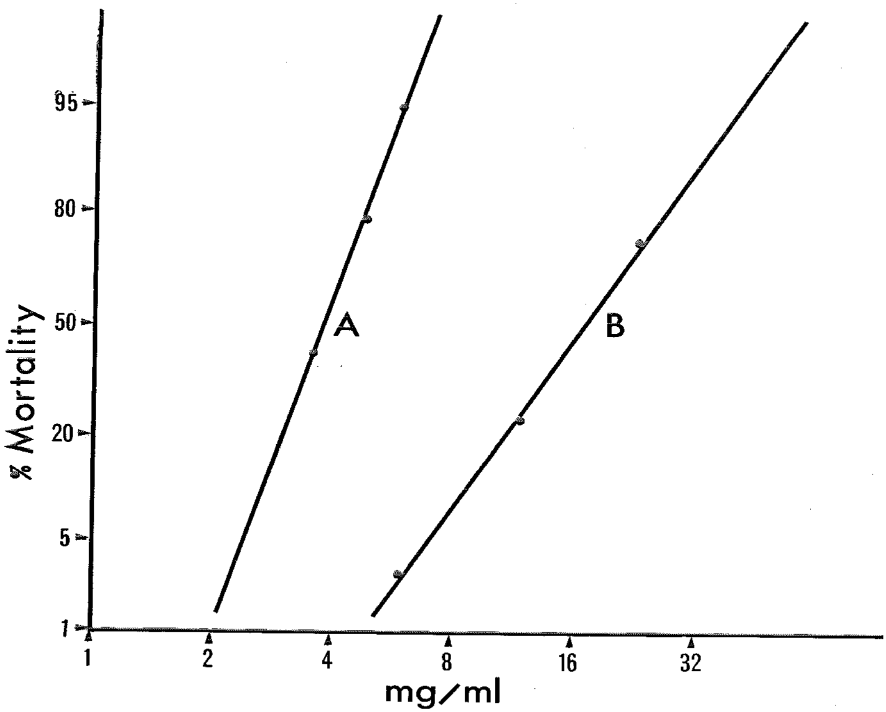

Fig. 5.—Standard curves for malathion as obtained with the Laboratory Thermal Aerosol Generator. A—*Aedes taeniorhynchus*, B—*Culex nigripalpus*.

tion tube and a wind tunnel. Cages containing the test insects are placed in the wind tunnel and momentarily exposed to an aerosol produced by spraying one-half milliliter of a diesel oil solution of the toxicant into the heater. The equipment affords a quick method for the laboratory testing of insecticidal thermal aerosols. It may be used to determine the relative effectiveness of an experimental insecticide by comparing it to one of known effectiveness and also to compare the susceptibility of different species of insects to various insecticides.

References Cited

Davis, A. N., and Gahan, J. B. 1961. Wind tunnel tests with promising insecticides against adult salt-marsh mosquitoes, *Aedes taeniorhynchus* Wied. Mosq. News 21(4):300–303.

McCray, E. M., Jr., and Schoof, H. F. 1963. The use of a modified Hoskins-Caldwell spray chamber for mosquito insecticide resistance studies. Mosq. News 23(4):286–291.

May, K. R. 1945. The Cascade Impactor: An instrument for sampling coarse aerosols. Jour. Sci. Instrum. 22:187.

——— 1950. The measurement of airborne droplets by the magnesium oxide method. Jour. Sci. Instrum. 27:128–130.

Rathburn, C. B., Jr., and Miserocchi, A. F. 1967. Direct photomicrography of air-borne droplets. Jour. Econ. Ent. 60(1):247–254.