THE L-20 AS A VEHICLE FOR AERIAL DISSEMINATION OF INSECTICIDE BY THE U. S. AIR FORCE

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A review of the history of aerial dissemination of insecticides in the Air Force shows a progression of developments in spraying equipment and a succession of operational aircraft modified to function as effective vehicles.

Installation of spray kits on aircraft adds to their gross weight, shifts the center of gravity, and usually leaves the airplane too lumbered for other uses. In addition, those parts of the kit which of necessity must either protrude from within the airplane or be mounted outside the fuselage interrupt the flow of air around the airplane, thus in turn affects the control of the aircraft. Spray kits are continually being developed, however, for those cases where control of insects affecting the health or morale of personnel cannot be achieved with ground control methods or equipment. The researches of the Air Force in the development of kits for the dissemination of both liquid sprays and impregnated granules from the L-20 or Beaver are presented below.

Experience in Korea during the summer of 1951 demonstrated the applicability of employing both large, twin-engine aircraft and liaison-type airplanes to provide coverage of the varied ecological habitats of disease-transmitting mosquito populations present in enormous geographical areas. First the L-5 and later the T-6 were modified through the addition of various disseminating kits to spray front line installations and other areas not readily accessible to the larger C-46 aircraft.

In 1951 the Air Force placed an order with DeHavilland Aircraft of Canada, Limited, for delivery of its newly designed “Beaver.” This aircraft has become subsequently labelled the L-20 by the Armed Services and has been accepted by the Air Force as the light airplane most desirable for aerial dissemination work.

In 1953 the principle of dual coverage learned in Korea was incorporated into the operations of the USAF Special Aerial Spray Unit based at Langley Air Force Base, Virginia. Heretofore all spraying accomplished by this unit, whose mission is easy on the driver, and the coverage of ditches or open water is far superior to that obtained in other types of spraying.

If the jeep is close to a ditch and the slower discharge is approximately 7 feet from the water, the milky colored insecticide can be seen to penetrate the water to a depth of about 5 or 6 inches due to the high wind velocity.

A marshy field was pre-treated last November with this mist blower. Only one part of the field was treated (about 30 acres). In past years the whole field has produced mosquitoes yearly. This year, in January, no mosquitoes were found in the treated portion while the untreated portion produced Aedes squamiger larvae over its entire area (about 40 acres).

Under ideal conditions a 99 per cent kill has been obtained—a distance of 90 feet in open marsh land with one pass of 1¼ per cent DDD against third and fourth instar Aedes aegypti.
was the dissemination of insecticides over all Army and Air Force installations within the continental limits of the United States, was accomplished by means of C-47 ("Skytrain" or "Dakota") aircraft. The L-20 is currently being used in conjunction with the C-47's to cover those areas too small to warrant spraying by the larger aircraft.

The Air Force has developed three separate insecticide dissemination kits for the L-20 during the past two years for use in addition to a patented kit which was procured along with one of the airplanes. Two of these kits, including the patented one, have been discarded and the Air Force is now using a boom-spray system for liquid sprays and a venturi kit for dissemination of impregnated granules.

In May 1953 two "Beavers" which had been assigned to Alexandria Air Force Base in Louisiana and modified for aerial dissemination there, were flown to Langley Air Force Base, Virginia, and attached to the Special Aerial Spray Flight.

These two aircraft were equipped with spray kits consisting of internally-installed tanks and a cylindrical venturi suspended 6 inches beneath the belly of the airplane. The insecticide was borne in a pair of 55-gallon fuel drums installed horizontally and crosswise on the cabin floor. The drums were connected at the forward ends by a single 2-inch feed pipe which carried the liquid aft to a 2-inch manual shut-off gate-valve located behind the drums and just above the camera hatch in the belly of the fuselage. At this point the pipe was fitted with an elbow and a subsequent length which projected vertically through the camera hatch and terminated in a threaded tip to which a union was attached.

The venturi, which consisted of a 5-foot long tapered aluminum cylinder with a 6-inch diameter air-intake orifice, a barrel, and a flattened terminal funnel, was attached to the aircraft through the vertical feed pipe and a series of braces. The braces included a pair of lateral metal flanges riveted to the camera door access plate and four metal straps extending from the belly of the airplane to the venturi.

The intake orifice withdrew to a 4-inch throat and then opened abruptly to the barrel within a distance of 6 inches. The barrel was 2½ feet long, cylindrical, and was 8 inches in diameter. The terminal funnel was 2 feet long, flattened dorsoventrally, and tapered to an 18-inch wide dispersion slot with a 2-inch vertical orifice. This funnel was strengthened with two aluminum baffles located inside and riveted to both the dorsal and ventral surfaces.

A threaded length of 2-inch pipe, which projected vertically from the top of the venturi through a hole located 15 inches behind the tip of the intake orifice, screwed into the feed pipe from the airplane. Inside the venturi, the pipe was fitted with an elbow and an additional 4-inch length which allowed the insecticide to flow aft horizontally and pour into the accelerated air stream.

Flow of the insecticide was by means of gravity and the rate was manually-controlled by a crew-member who sat behind the insecticide drums and operated the rotary shut-off valve upon hand signals given by the pilot. The effective swath of this apparatus was approximately 75 feet. The rate of flow was estimated on the ground after landing; the droplet size was variable and uncontrollable.

Operationally, the kit was unsatisfactory because there were no provisions for quick release of the insecticide and no safety precautions for the crew-member who was forced to ride behind the insecticide drums.

In June of 1953 a third L-20 was assigned to the Special Spray Flight. This airplane was equipped with a patented, rotary-brush liquid spray system which consisted of an internal insecticide tank whose ends formed a portion of either side of the fuselage, two feed booms, and a pair of propeller-driven wire disseminating brushes mounted beneath the wings.

The drum-like 250-gallon capacity tank
was mounted on a rack which was bolted to the cabin floor. The tank was un-
divided, contained no baffles, and filler
trcks were located at the top of either end.

The insecticide flowed by means of
gravity through an orifice located in the
dottom center of the tank. An 8-inch pipe
which conveyed the liquid aft and then
vertically through the camera well, termi-
nated beneath and outside the camera
natch in a dome. Two manually-operated
1-inch emergency dump valves were built
n to either side of the dome. The pilot
ctuated these valves by an emergency
andle mounted on his control panel.

A 3-inch pipe which was screwed into
he dome and lay along the centerline of
he belly of the airplane, carried the in-
secticide forward to a point just aft of the
ixed landing gear. A T fitting attached
o the pipe at this point by means of dis-
connect hose fittings diverted the liquid
terally into a pair of 2-inch feed pipes
which projected horizontally on either side
he insecticide dispenser. A bracket at
he T fitting anchored both the central as
vell as the lateral feed pipes to the belly
f the aircraft.

The insecticide dispensers consisted of
ouplings to which supports were attached
nd through which the insecticide flowed,
nd a set of propeller-driven wire dissemi-
nating brushes. They were located on a
me behind and above the landing gear
nd about 7½ feet out from the T fitting
n each side. Each housing was supported
y a vertical streamlined pipe bolted to the
rner surface of the wing and drag was
ounteracted by a sway brace which ex-
ended from a point at the bottom and
ft of the pilot's door to the vertical sup-
sort pipe.

A wind-driven, wood, paddle-bladed
ropeller of approximately 15-inch diam-
ter was fixed to the forward end of a
traight shaft which passed through the
ousing. Wire brushes of either 8- or
0-inch diameter were locked to the aft
nd of the shaft. The brushes were re-
ovable and could be lined up in varying
mbinations.

The insecticide flowed from the hous-
ging to the brushes by means of an opening
bored in the aft section of the shaft.
Rubber seals prevented the insecticide from
dripping from either end of the housing.

Flow of insecticide throughout the
ystem depended upon gravity. The only
alves other than the emergency dump
valves mounted on the pot were a pair
of shut-off valves located on the outer tips
of the horizontal feed pipes. These valves
regulated the flow into the propeller hous-
ing and were actuated manually by a
ingle operating rod mounted in front and
parall el with the horizontal feed pipes.
This bar was actuated through a series of
kages and a lever located on the pilot's
nstrument panel.

The effective swath of this kit was 120
et and the droplet size was compara-
tively consistent. The micron range of
he droplets varied with the brushes used:
he average droplet size varying directly
ith the gauge of the brush wire.

The rotary brush kit was operationally
efficient but was not considered prac-
tical for military use. The rigging was
too flimsy; the empennage and the fuse-
lage had to be washed down after each
plication because the insecticide was
own back over it; the linkage system
was too complex for field use; difficulty was
urrenced in maintaining a stock of rotary
ush parts; and the shut-off valves did
ot function properly. The rubber seals
side these valves expanded due to the
ction of the insecticide. This expansion
esulted in their impeding the movement
f the metal discs and being sheared off
hen the valves were forced closed.

Due to the inefficiency of the venturi kit
nd the difficulty of maintaining rotary
ush parts, these original spray systems
ere replaced with boom spray kits de-
loped along the principle of the equip-
ent used on the C-47.

At first the kit consisted of three 55-
gallon drums standing upright in the
cabin and anchored to the floor by means
of cables. Two of the drums were set
ahead of the third and the three were interconnected by a network of 1½-inch (inside diameter) pipe. One pipe from each side carried the insecticide aft to a pair of electrically driven B-26 fuel-boost pumps which maintained a pressure of 20 PSI. These pumps were installed in the camera well aft of the rearmost drum.

Manual rotary shut-off valves were mounted in each line and just ahead of the boost pumps so that the flow of the insecticide could be regulated from within the airplane while it was in flight.

The insecticide which flowed into the fuel boost pumps was routed under pressure to the two wing booms through a pair of 1½-inch aluminum tubes. These tubes passed out through the camera hatch then forward along the underside of the fuselage to the two main wing struts. They were anchored at these points as they passed up and along the trailing edges to the dispersal booms.

The dispersal booms were constructed of 15-foot lengths of 1½-inch nominal diameter steel aircraft tubing and were supported by three A-frame struts bolted to the lower surface of either wing. Ten spray nozzles were fitted on each side.

The fuel boost pumps were wired through a circuit breaker to a toggle switch on the pilot’s control wheel. A master switch on the control panel turned on the power; the switch on the wheel actuated the pumps. A system of three panel lights informed the pilot that (1) the power switch was on; (2) there was either little (3 PSI) or no pressure in the system; (3) pressure was up.

The effective swath of this kit was 140 feet. The system was considered quite efficient except for one thing: the pumps which maintained 20 PSI did not have capacity for increased flow. The atomization rate dropped in proportion to decreases in pressure and it was found that fourteen nozzles put out almost as much insecticide as the full twenty and produced a finer range of atomization.

In 1954 this kit was modified by re-placement of the three 55-gallon drums with a rectangular stainless steel baffled tank with a capacity of 175 gallons. In addition a vertical stand pipe which vented the tank to the atmosphere, an insecticide volume gauge, and a filler opening located inside the airplane were added.

This new tank was mounted forward of the camera hatch and was held in place by two strips of T bar aluminum which passed over the top of the tank and were bolted to vertical threaded ½-inch size rods which screwed into tie-down rings in the floor.

A 6-inch feed pipe which was welded into the lower center of the aft side of the tank emptied the insecticide vertically through the camera well to an emergency dump. A flat, spring-loaded bottom plate which was hinged to the end of this pipe was the emergency dump valve. During normal flight and spray operations this plate remained locked in the closed position with the release valve cocked and ready for instantaneous release. The release valve was actuated manually by a cable which was routed from the locking arm or trigger, up through the fuselage and into the pilot’s compartment.

The dump orifice was 6 inches in diameter and a full load of insecticide (175 gallons) could be discharged in ten seconds. The pipe, which bared projected from the belly of the airplane passed through a 20-inch plate which fitted into the camera hatch. This plate provided additional support to the system.

No change was made in either the booster pumps, feed tubes, spray booms or the electrical wiring. The two rotor shut-off valves were eliminated with the drum linkage system. The two fuel booster pumps were retained in the camera well and drew the insecticide directly out of the 6-inch dump valve feed pipe through siphon ports.

Recognition in 1954 of the applicability of impregnated granules as a mosquito control measure instigated development o
Fig. 1. A—Spray pressure-boost system mounted in the camera well; B—Side view of L-20 with rotary brush liquid spray kit installed; C—View showing fuel drum installation and spray boom with connecting hose; D—View of plane interior showing drum linkage and manual shut-off valve; E—View of internally-mounted 175-gallon insecticide tank with dorsal vent; F—Emergency dump valve in closed position.
hoppers for aircraft so that these materials could be disseminated from the air. Recognizing its extensive requirement for use of this new medium, the Air Force developed a hopper and a venturi box for the dissemination of granules over Air Force installations with the L-20.

An aluminum hopper of 1,000-pound granule capacity, designed to conform to the shape and size of the cabin door and the inside width of the cabin was constructed. This box-like carrier was placed inside the cabin, then tilted aft and supported in that position by means of a frame into which it was bolted.

The frame, built of 2-inch angle aluminum, was constructed so as to elevate the hopper 14 inches in the front and 4 inches off the floor in the rear. The vertical flange of the aluminum bar welded on the back of the frame was turned down so as not to close off the flow slot.

Loading of the hopper was accomplished through a hatch located on the upper surface. The granules were poured through this opening by means of a feeder suspended above the airplane. The feeder consisted of a 55-gallon drum with the bottom cut out and replaced with a large funnel which channeled the pellets into a rubber loading hose.

The granules flowed out of the hopper by means of gravity through a 3-inch slot which extended the width of the hopper and was located along its base.

A feed chute, bolted to the top and sides of the flow slot, directed the flow of the pellets aft and outward through the camera well. The lower edge of this chute slid under the tank so as not to impede the flow of the granules. The feed chute was 3 inches deep and 44 inches wide at its mouth. It tapered to a width of 16 inches over the first 10 inches, then projected aft for another foot at which point it dropped vertically through the camera hatch. The dimensions from the point of taper to where the feed chute joined the venturi box outside the airplane were 3 x 16 inches.

The venturi box was suspended 6 inches beneath the fuselage. It was 6 inches deep, 24 inches wide and 31½ inches long. The venturi consisted of a 3-inch rise or camber in the forward half of the box. The top of the venturi box fitted over the end of the rectangular feed chute and was bolted to it. In addition, it was supported by four braces attached to the fuselage of the airplane.

The rate of drop of the granules was controlled by a sliding-slotted cut-off valve located between the top of the venturi box and the end of the feed chute. This valve was actuated by an arm hooked onto an electric jack screw. A pair of adjustable micro-switches were built into this jack screw. One of these switches was set for open position and the other for closed. The size of the opening required to produce the effective rate of flow was pre-set on the ground by adjusting the position of the micro-switches. The jack screw was actuated by a switch on the pilot's control panel.

This original kit has already been modified slightly, and more changes are pending.

The actual dispensing mechanism was found to be unsatisfactory during the first operational missions flown by this airplane at Robins Air Force Base, Georgia. The slot in the sliding slotted shut-off valve was widened from ½ to 1 inch to provide increased rate of drop of pellets into the throat of the venturi. In addition to this, the actuating arm on the electric jack screw was eliminated by hooking the jack screw itself to the center-aft section of the sliding-slotted valve.

A formal inspection to determine the structural soundness and aerodynamic suitability of the granule dispensing kit is being conducted at Wright Air Development Center in Ohio. One of their recommendations has been the development of a liquid-filled tank so that the airplane can be used to disseminate either liquid sprays or impregnated granules. Removable spray booms could be added with the pellet venturi, and the latter would be replaced by an emergency dump valve.

Other proposed modifications include
L-20 SPRAY-VENTURI SYSTEM

L-20 GRANULAR HOPPER AND VENTURI DISPENSER

FIG. 2. Construction details of L-20 insecticide dispensing apparatus.
THE ATTRACTIVENESS OF HUMAN SWEAT TO MOSQUITOES AND THE ROLE OF CARBON DIOXIDE

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Although human sweat has long been suspected of being attractive to mosquitoes, early investigations (Howlett, 1910; Crumb, 1922; Rudolfs, 1923) found little to substantiate this belief. However, more recent experiments (DeLong et al., 1949; Willis, 1947; Parker, 1948) have yielded evidence that sweat can be attractive. Furthermore, field experiments with robots (Brown, 1951) showed that sweat-soaked clothing was almost twice as attractive to Canadian Aedes mosquitoes as equally moist clean clothing. Moreover, laboratory experiments with an olfactometer (Brown, Sarkaria and Thompson, 1951) showed that the vapour from an aqueous solution of human sebaceous sweat would bring approximately 40 per cent more females of A. aegypti to the experimental port than to the central port which carried only water vapour.

Human sweat is comparable to a weak solution of sodium chloride in water and contains, at least in traces, practically all of the non-colloidal constituents of blood plasma. It is produced in large part by the sudoriferous glands, which are simple tubular structures distributed over the entire body surface, being most abundant on the palms of the hands, the soles of the feet, and the forehead (Kuro, 1934).