ion is easy on the driver, and the :overage of ditches or open water is far .uperior to that obtained in other types of praying.

If the jeep is close to a ditch and the)lower discharge is approximately 7 feet rom the water, the milky colored in- ecticide can be seen to penetrate the water o a depth of about 5 or 6 inches due to he high wind velocity.

A marshy field was pre-treated last Vovember with this mist blower. Only ›ne 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 dorsalis.*

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 dissemi- ıation of insecticides in the Air Force hows a progression of developments in praying equipment and a succession of ·perational aircraft modified to function as ffective vehicles.

Installation of spray kits on aircraft adds ɔ their gross weight, shifts the center of ·ravity, and usually leaves the airplane too luttered for other uses. In addition, those ·arts of the kit which of necessity must ither protrude from within the airplane r be mounted outside the fuselage inter- upt the flow of air around the airplane. 'his in turn affects the control of the ircraft. Spray kits are continually being eveloped, however, for those cases where ontrol of insects affecting the health or ıorale of personnel cannot be achieved ·ith ground control methods or equip- ıent. The researches of the Air Force ı the development of kits for the dis- ɜmination of both liquid sprays and im- ›regnated 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 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 sizes were 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 propellor-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 undivided, contained no baffles, and filler necks were located at the top of either end.

The insecticide flowed by means of gravity through an orifice located in the bottom center of the tank. An 8-inch pipe which conveyed the liquid aft and then vertically through the camera well, terminated beneath and outside the camera hatch in a dome. Two manually-operated 4-inch emergency dump valves were built in to either side of the dome. The pilot actuated these valves by an emergency handle mounted on his control panel.

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

The insecticide dispensers consisted of housings to which supports were attached and through which the insecticide flowed, and a set of propeller-driven wire disseminating brushes. They were located on a line behind and above the landing gear and about 7½ feet out from the T fitting on each side. Each housing was supported by a vertical streamlined pipe bolted to the lower surface of the wing and drag was counteracted by a sway brace which extended from a point at the bottom and aft of the pilot's door to the vertical support pipe.

A wind-driven, wood, paddle-bladed propeller of approximately 15-inch diameter was fixed to the forward end of a straight shaft which passed through the housing. Wire brushes of either 8- or 10-inch diameter were locked to the aft end of the shaft. The brushes were removable and could be lined up in varying combinations.

The insecticide flowed from the housing 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 system depended upon gravity. The only valves 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 propellor housing and were actuated manually by a single operating rod mounted in front and parallel with the horizontal feed pipes. This bar was actuated through a series of linkages and a lever located on the pilot's instrument panel.

The effective swath of this kit was 120 feet and the droplet size was comparatively consistent. The micron range of the droplets varied with the brushes used: the average droplet size varying directly with the gauge of the brush wire.

The rotary brush kit was operationally efficient but was not considered practicable for military use. The rigging was too flimsy; the empennage and the fuselage had to be washed down after each application because the insecticide was blown back over it; the linkage system was too complex for field use; difficulty was incurred in maintaining a stock of rotary brush parts; and the shut-off valves did not function properly. The rubber seals inside these valves expanded due to the action of the insecticide. This expansion resulted in their impeding the movement of the metal discs and being sheared off when the valves were forced closed.

Due to the inefficiency of the venturi kit and the difficulty of maintaining rotary brush parts, these original spray systems were replaced with boom spray kits developed along the principle of the equipment 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 1¼-inch (inside diameter) pipe. One pipe from either 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 1¼-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 to these struts at various points as they passed up and along the trailing edges to the dispersal booms.

The dispersal booms were constructed of 15-foot lengths of 1⅛-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 either 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 replacement 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 ¼-inch steel rods which screwed into tie-down ring holes 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 barely 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 rotary 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 of

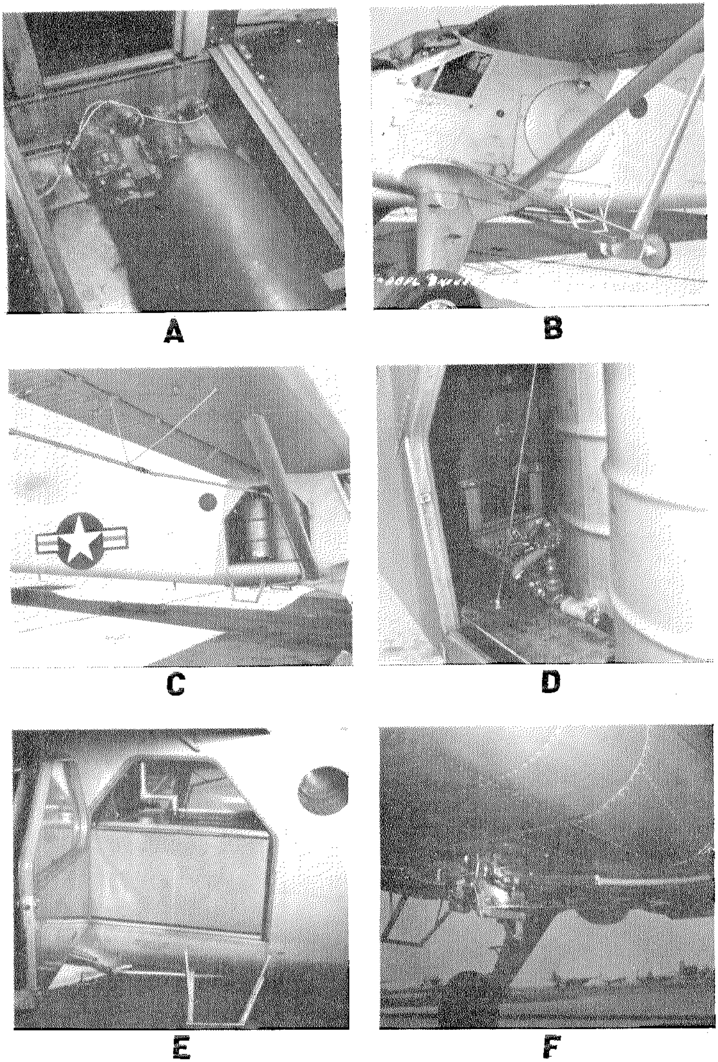

FIG. 1. A—Spray pressure-boost system mounted in the camera well; B—Side view of L-20 with rotary brush liquid spray kit installed; C—View showing fuel drum installation and spray boom with connecting hose; D—View of plane interior showing drum linkage and manual shut-off valve; E—View of internally-mounted 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 the 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 rates 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-tight tank so that the airplane can be used to disseminate either liquid sprays or impregnated granules. Removable spray booms could be alternated with the pellet venturi, and the latter would be replaced by an emergency dump valve.

Other proposed modifications include

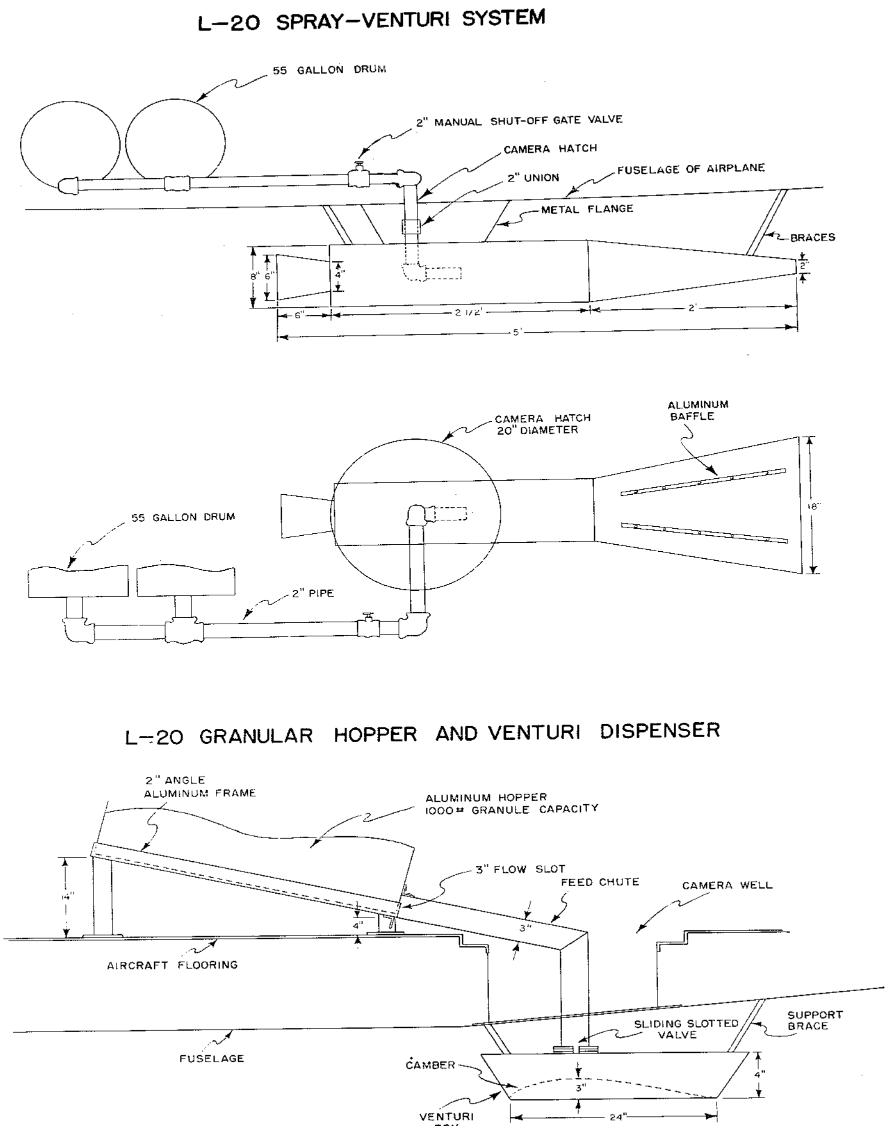

FIG. 2. Construction details of L-20 insecticide dispensing apparatus.

(1) removal of the aft cabin doors and construction of a tank whose ends will form the sides of the fuselage; (2) installation of a pitched bottom inside the tank which will provide for the flow of the granules and eliminate the requirement for the supporting frame; (3) installation of an indicator to show flow of the pellets. This might be a weight gauge mounted in or under the tank to show change in the total weight or an off-pressure switch mounted on the venturi which would indicate flow of pellets through the latter; (4) addition of a dust pan type spreader to the rear of the venturi box which would widen the ejection port from 24 to 50 inches and depress the present slot from 6 to 2 inches. The purpose of this spreader would be to widen the current effective swath of 35 feet to at least 50 feet.

Because of its high degree of maneuverability, its ruggedness, and load capacity, the L-20 "Beaver" was selected as a possible vehicle for the USAF Special Aerial Spray Flight. Development of professional insecticide dissemination kits specifically engineered for installation in this airplane increased its applicability.

Operational experience in the Air Force during the past two years has shown that addition of the L-20 has expanded substantially the operational scope of the Spray Flight and enhanced the value of this unit by insuring its ability to cover all aspects of the terrain.

As a result of effective utilization of the airplane and continuing improvement through modifications of the respective spray kits, the L-20 "Beaver" has come to be a most satisfactory supplementary dissemination vehicle and has indirectly become an integral unit in the over-all Air Force program for the aerial dissemination of insecticides.

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, 1922) 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 (Kuno, 1934).