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APGC-TR-64-72

Test and Evaluation of the A/A 45Y-2 Pressurized Defoliant Dispenser

by Charles L. Flynn, Capt, USAF

October 1964

DEPUTY FOR TEST OPERATIONS
AIR PROVING GROUND CENTER
AIR FORCE SYSTEMS COMMAND • UNITED STATES AIR FORCE
EGLIN AIR FORCE BASE, FLORIDA

TEST AND EVALUATION OF THE A/A 45Y-2 PRESSURIZED DEFOLIANT DISPENSER

by

Charles L. Flynn, Capt, USAF

FOREWORD

The test and evaluation of the A/A 45Y-2 pressurized defoliant dispenser was conducted as authorized in AFR 80-14, and as outlined in the APGC Operations Directive, Project 5957W1 (Revised), dated 13 April 1964; in response to the Detachment 4, RTD, Revised Test Request: "AFSC Project 5957, Dispenser, Defoliant, Pressurized, A/A 45Y-2," dated 5 March 1964. The authority for this Project is Advanced Research Projects Agency Order Number 481, dated 10 May 1963; AFSC Project Number 5957, dated 22 May 1963: and Detachment 4, RTD, "Test Request," dated 5 March 1964.

A C-123 (S/N 540-697) test-bed aircraft and operational and maintenance personnel were supplied by Headquarters, Tactical Air Command.

Testing was conducted from 23 April to 31 August 1964. The author's manuscript was released on 30 September 1964.

Appreciation is expressed for the support provided by the pilots and flight mechanics of the 4500th Aerial Spray Flight, Langley AFB, Virginia. Their experience in defoliation activities in Viet Nam and their many technical suggestions contributed to the timely and successful completion of this project.

Also, acknowledgement is made of the excellent support rendered by TSgt William E. Gensler, Sr., USAF, and his flight of personnel of the 6th Weather Squadron, Tinker AFB, Oklahoma. The efficient gathering and reporting of accurate weather data are most important to the success of grid sampling operations, and this weather crew could always be depended upon for professional performance.

The following is a list of personnel responsible for testing conducted under Project 5957W1:

Project Engineer	Charles L. Flynn, Capt, USAF
Test Designer	John M. Elliott, Maj, USAF
Development Engineer	Richard A. Connors, 1st Lt, USAF
Calibration Engineer	E. J. Krekule
Micrometeorologist	Juri V. Nou, Capt, USAF
Aircraft Instrumentation	Robert Williams, 2d Lt, USAF
Data Reduction	James Coe
Project Pilots	Stanley Swanson, Capt, USAF
Carl Marshall, Capt, USAF	William Bolling, Capt, USAF
Michael Devlin, Capt, USAF	William Bishop, Capt, USAF
Alan R. Kidd, Jr., Capt, USAF	Deane Smith, Capt, USAF
John W. Honnicutt, Capt, USAF	Charles Haggerty, Capt, USAF

This report is not released to the Office of Technical Services, DOC, because it contains information concerning a military system which is not of general interest to the U. S. scientific community.

This technical report has been reviewed and is approved.

JE Roberts

J. E. ROBERTS
Major General, USAF
Commander

ABSTRACT

Project 5957W1 was conducted as a test and evaluation of the A/A 45Y-2 pressurized defoliant dispenser, installed in a C-123 aircraft. Emphasis was placed on an evaluation of the capability of the dispenser to deliver defoliant agent in effective dosages from dissemination altitudes of 50-2000 feet absolute. Inwind releases were characterized by narrow, high-peak-concentration swaths; crosswind releases were characterized by wide, low-peak-concentration swaths. Testing of the C-123:A/A 45Y-2 system revealed the following problems: (1) excessive weight of the filled test item, reducing the operational range of the C-123 to approximately 50 nm; (2) contamination of the aircraft fuselage and tail surfaces with agent during dissemination; and (3) interference with aircraft equipment, i.e., access to aircraft battery compartment for required seven-day inspections and installation of the cargo ramp positioning links, which prevent lowering the ramp below the horizontal in flight. High-altitude dissemination flights (above 500 feet) did not prove feasible due to the lack of aimability of the spray pattern. However, percent recovery values computed from data sampled during these flights showed no degradation of the values experienced with low-altitude releases. Within the test parameters of airspeed, altitude, and flow rate employed during testing at Eglin AFB, the C-123:A/A 45Y-2 system is characterized by small area coverage at minimum concentration levels of 1.5 and 3 gallons per acre. The maximum computed area coverages for these concentrations were .384 and .212 square miles, respectively.

CONTENTS

Section Page

Appendix

ILLUSTRATIONS AND TABLES

3. Power Switch - Set to either AIRCRAFT or BATTERY. Each

ILLUSTRATIONS AND TABLES (Continued)

GLOSSARY OF TERMS

Agent	Defoliant agent, liquid. Code name: ORANGE.
Crosswind	Perpendicular to the wind direction.
Delta-T	Difference in ambient temperature (°F) between two levels above the surface.
Efficiency	Agent recovered at a given minimum concentration level expressed as a percentage of agent disseminated.
Effective Swath Width	The swath width within which the concentration is equal to or greater than the dosage necessary to cause defoliation.
GPA	Gallons per acre
GPM	Gallons per minute
Grid	The defoliant spray test array consisting of six 2000-ft sample lines. Three oriented north-south and three oriented east-west.
Inversion	Meteorological condition where ambient temperature varies directly with altitude.
Inwind	The reciprocal of the wind direction.
MMD	Mass median diameter. One-half of the mass of the disseminated cloud consists of drops larger than the mass median diameter and the other half consists of drops smaller than mmd.
Module	An A/A 45Y-2 module consists of storage tanks, control panel, flow duct, and dissemination nozzle.
Neutral	Meteorological condition where ambient temperature remains essentially constant with altitude.
Position	All positions, e.g., left, right, forward, aft, refer to relative position within the test aircraft.

GLOSSARY OF TERMS (Continued)

Recovery	Agent recovered as a percentage of the agent disseminated.
Spread Factor	Conversion factor which converts spot size to spherical drop size.
Swath Width	The total width of the spray pattern measured perpendicular to the flight path.
Wind Vector	The resultant wind direction and velocity, from dissemination altitude to the surface, calculated by observing travel of a pilot balloon.

SECTION I

INTRODUCTION

APGC Project 5957W1, Test and Evaluation of the Dispenser, Defoliant Pressurized, A/A 45Y-2*, was conducted at Eglin AFB, Florida, to determine dissemination characteristics of the A/A 45Y-2 dispenser and its compatibility with the C-123 aircraft.

This report presents data for the following test objectives:

1. The evaluation of the compatibility of the A/A 45Y-2 dispenser with the C-123 aircraft by investigation of the following:

   a. Adequacy of manufacturer's installation and operational instructions.

   b. Necessity for aircraft modification.

   c. Adequacy of current USAF flight-line equipment and tools used in ground operations.

   d. Effect upon aircraft stability and flight characteristics caused by assymetrical loading.

   e. Possibility of aircraft contamination.

2. The evaluation of the capability of the A/A 45Y-2 dispenser to deliver approximately three gallons of defoliant agent per acre over an area of one-half square mile per C-123 sortie. Spray missions were flown at 50, 150, and 500 ft utilizing flow rates of approximately 150 and 300 gallons per minute (gpm). Releases were made inwind and crosswind and the following data were collected and evaluated:

   a. Ground concentration of defoliant agent (gallons per acre - gpa).

   b. Swath width at various concentration levels (ft)

   c. Droplet size distribution (mass median diameter - MMD).

3. The evaluation of the capability of the C-123:A/A 45Y-2

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*Manufactured by Fairchild Stratos Corp., Hagentown, Md.

system to deposit effective ground concentrations of defoliant agent from dissemination altitudes of 500 to 2000 ft. Higher flow rates (650-800 gpm) were employed during these high-altitude passes.

Slosh and vibration tests were performed on an assembled A/A 45Y-2 pallet, support structure, and fluid tank at Wright-Patterson AFB, 12 November - 13 December 1963. The results of this test are included as Appendix VI.

SECTION II

DESCRIPTION

GENERAL

The A/A 45Y-2 module is a self-contained dispenser (AF SNo. 6625-1-480340), designed for installation in either the C-123 or C-130 aircraft. A two-module installation is designed for use in the C-123, while a four-module installation is planned for the C-130. This report is based on data obtained during testing of the A/A 45Y-2 dispenser as installed in the C-123 aircraft.

Each module (Fig. 1) consists of a stainless steel, 500-gal, trailer-mounted tank; pneumatic and electrical controls; pressurization system; and nozzle deployment assembly. The modules are positioned in the C-123 as shown in Fig. 2, utilizing 34 standard USAF C-2 tie-down devices. System operation, as quoted from the "Preliminary Handbook of Instructions for Internal Modular Defoliation Dispenser System," Fairchild Stratos Corporation, 25 October 1963 (Revised 31 March 1964) is as follows:

> "The defoliant agent, contained in storage tanks in the aircraft cargo compartment, is released under pressure from the aft end of the compartment through dissemination tubes and retractable nozzle assemblies. Each tank is mounted on an individual pallet assembly which is secured in place on the cargo compartment floor. Included with each tank assembly is a rechargeable air storage supply. The pneumatic pressure, after being carefully regulated, is used as the pressure source to pressurize the defoliant fluid tank and to operate pneumatic and fluid shut-off valves. Regulation of pressure is accomplished by use of regulators located at the primary control panel at the forward end of the tank unit. Two regulators to adjust pressures for operation of the fluid shut-off valve are mounted on a secondary control panel on the right side of the unit. Prior to complete release of the main air system pressure, the tank is prepressurized to avoid a surge that might result in opening of the tank relief valve. Following tank prepressurization, main air system pressure is automatically released into the defoliant fluid tank when dissemination is initiated by the operator. A system relief valve, mounted at the top aft end of the tank unit is provided to protect the tank from excessive pressure. On-off control of defoliant dissemination flow is provided by an electrically-controlled, pneumatically-operated fluid shut-off valve, located at the tank outlet."

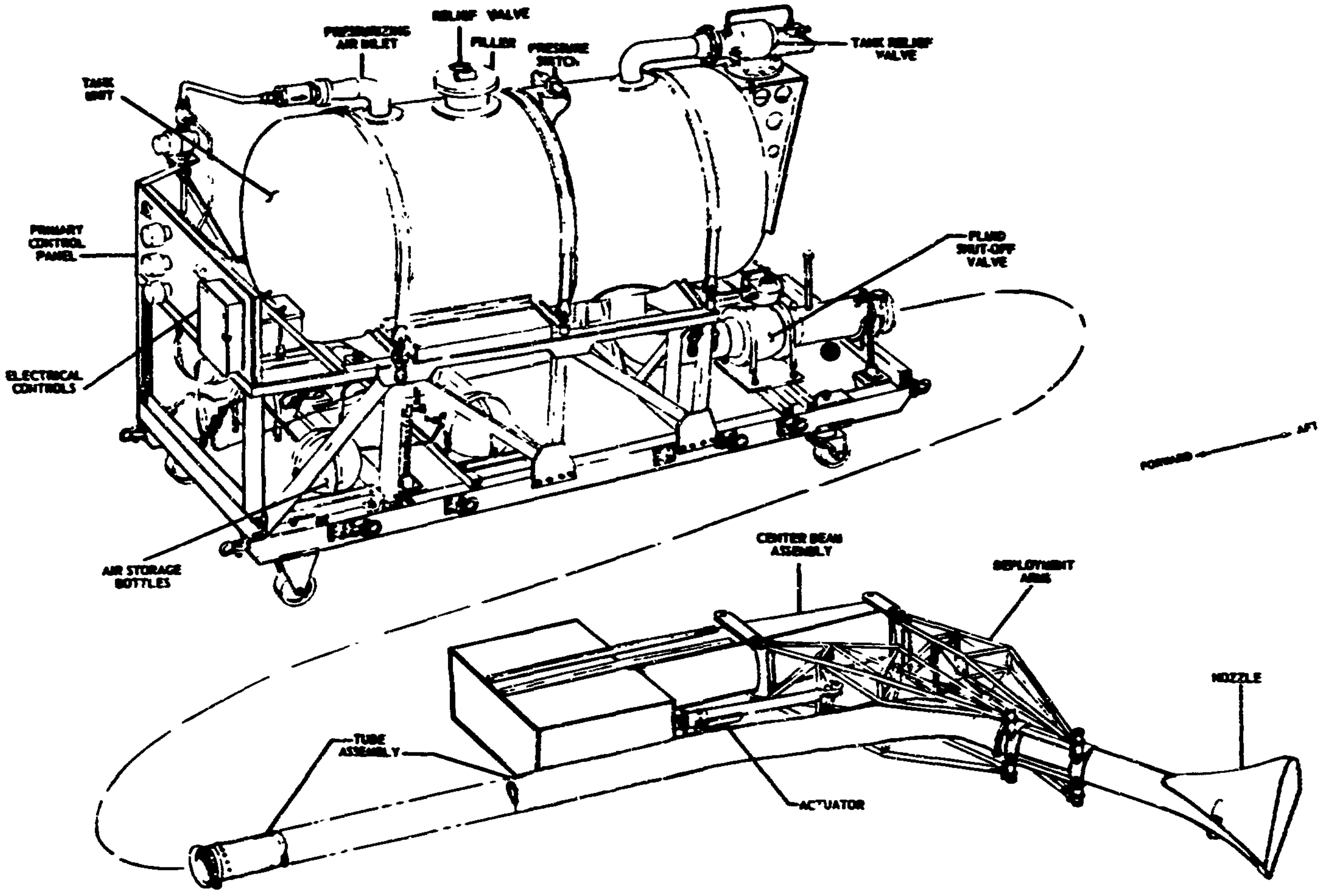

Figure 1. A/A 45Y-2 Dispenser (Left Module).

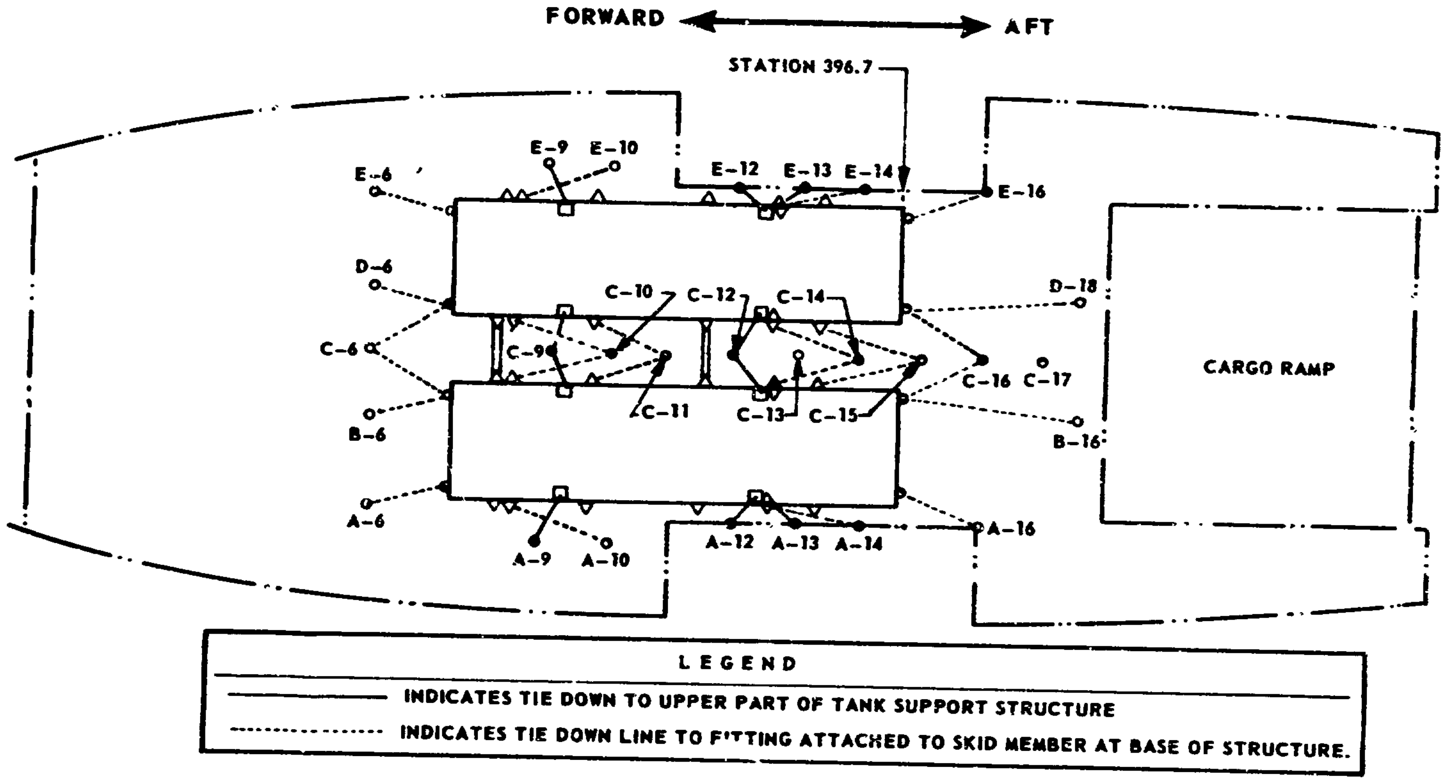

Figure 2. A/A 45Y-2 Placement and Tiedown Schedule for the C-123 Aircraft.

MODULE COMPONENTS

TANK ASSEMBLY (Figs. 3 and 4). The tank assembly consists of the supporting pallet (aluminum), the air supply and associated plumbing, the fluid tank, and the control panel. Four retractable wheels are mounted on the pallet longitudinal beams; the rear wheels are full-swiveling. When the quick-release pin (Fig. 3), located above each wheel is pulled to release the locking mechanism, the wheels may be rotated inward to fold under the pallet frame. When the wheel is rotated to the fully retracted position, the pin is released to engage and lock the wheel in this position. Four T-handle screw jacks (Fig. 4) are provided to support the pallet while retracting the wheels. The pressurization system (Fig. 3) consists of five 3000 psi (1300 cu in.) and one 3000 psi (300 cu in.) wire-wound pressure spheres. The predetermined tank pressure (20 psi) is controlled by manipulation of seven adjustable regulators. A schematic diagram of the pressure system is shown in Fig. 5. The fluid tank, made of 1/8-in. stainless steel, has a capacity of 556 gal. However, allowance for 10% expansion space limits the amount of defoliation fill to approximately 500 gal. The tank contains three baffle plates to limit center-of-gravity shifts due to sloshing of the agent. The tank is held in place by three steel straps with turnbuckles at each end, and maintained in a 4° from horizontal aft-end-down configuration. This tilt insures emptying of the tank during dissemination.

Four openings are provided at the top of the tank: one at the forward end for main air pressure inlet, one at the aft end for the pressure relief valve (set to open at 54 psi), a filler point near the center of the tank, and a port opening for installation of the tank pressure switches. The filler cap, secured by eight 3/4-in. bolts, incorporates a manually-operated pressure relief valve. A fluid strainer is provided in the filler neck. During dissemination the defoliant agent is forced from the tank through an outlet tube at the bottom aft end. Flow through the tube is controlled by an electrically-actuated, pneumatically-operated eight-inch ball valve. The control panel (Fig. 6), mounted on the front of each tank assembly, contains the pneumatic and electrical controls, two test switches, the central pneumatic recharging fitting, main air system pressure gage and a temperature correction chart. The electrical controls are housed in an aluminum frame and consist of:

1. Position Switch - Set according to location of that particular tank assembly, either PORT AFT or STRD AFT.

2. Module Switch - Set to SINGLE or MULTIPLE, depending on whether single-tank or simultaneous dissemination is desired.

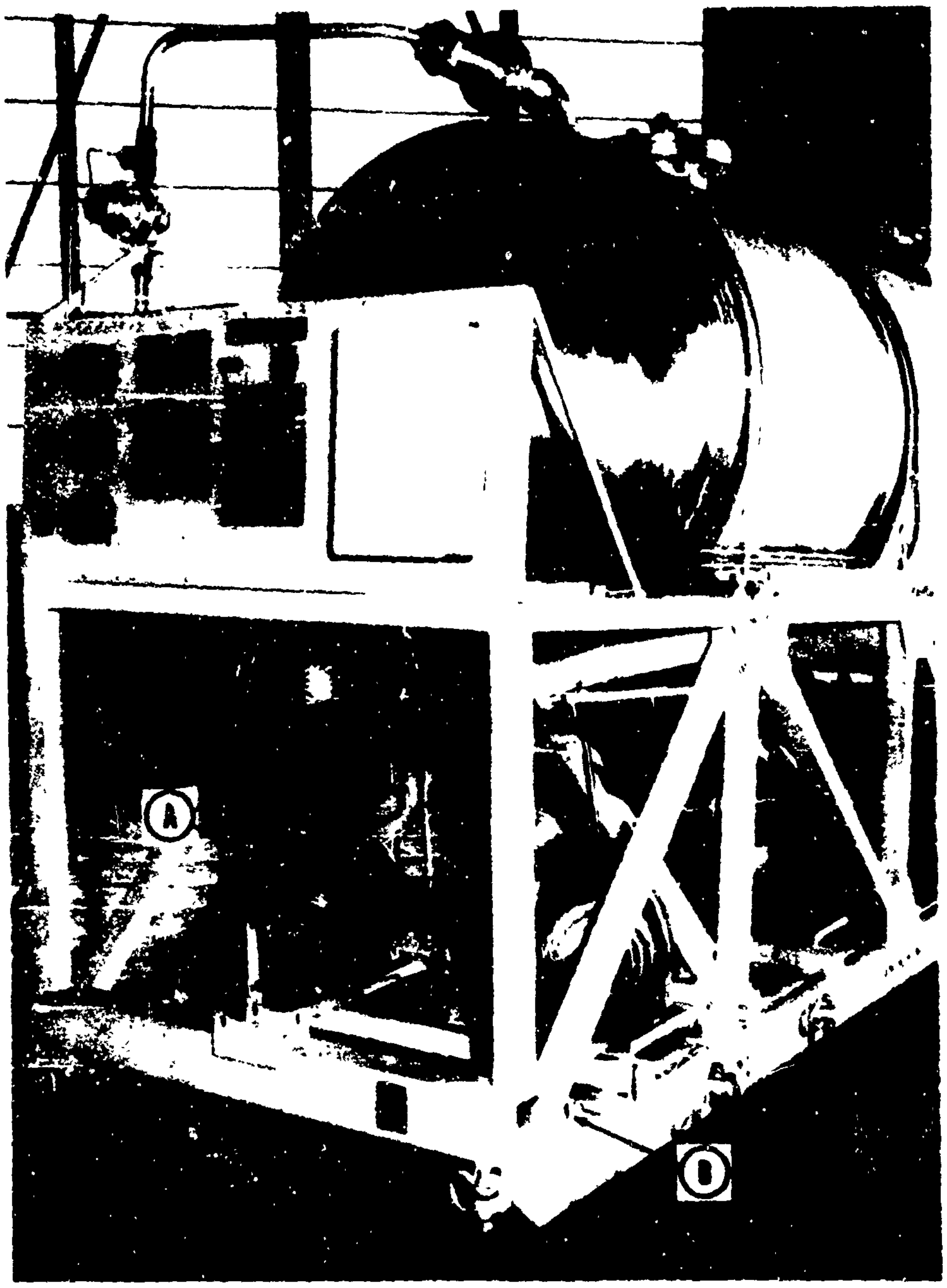

Figure 3. A/A 45Y-2 Dispenser (One Module), Showing (A) Pressure Spheres and (B) Quick-Release Pin.

Figure 4. A/A 45Y-2 Dispenser (One Module) Showing Longitudinal Position Relative to the C-123. Arrows Point to Screw Jacks.

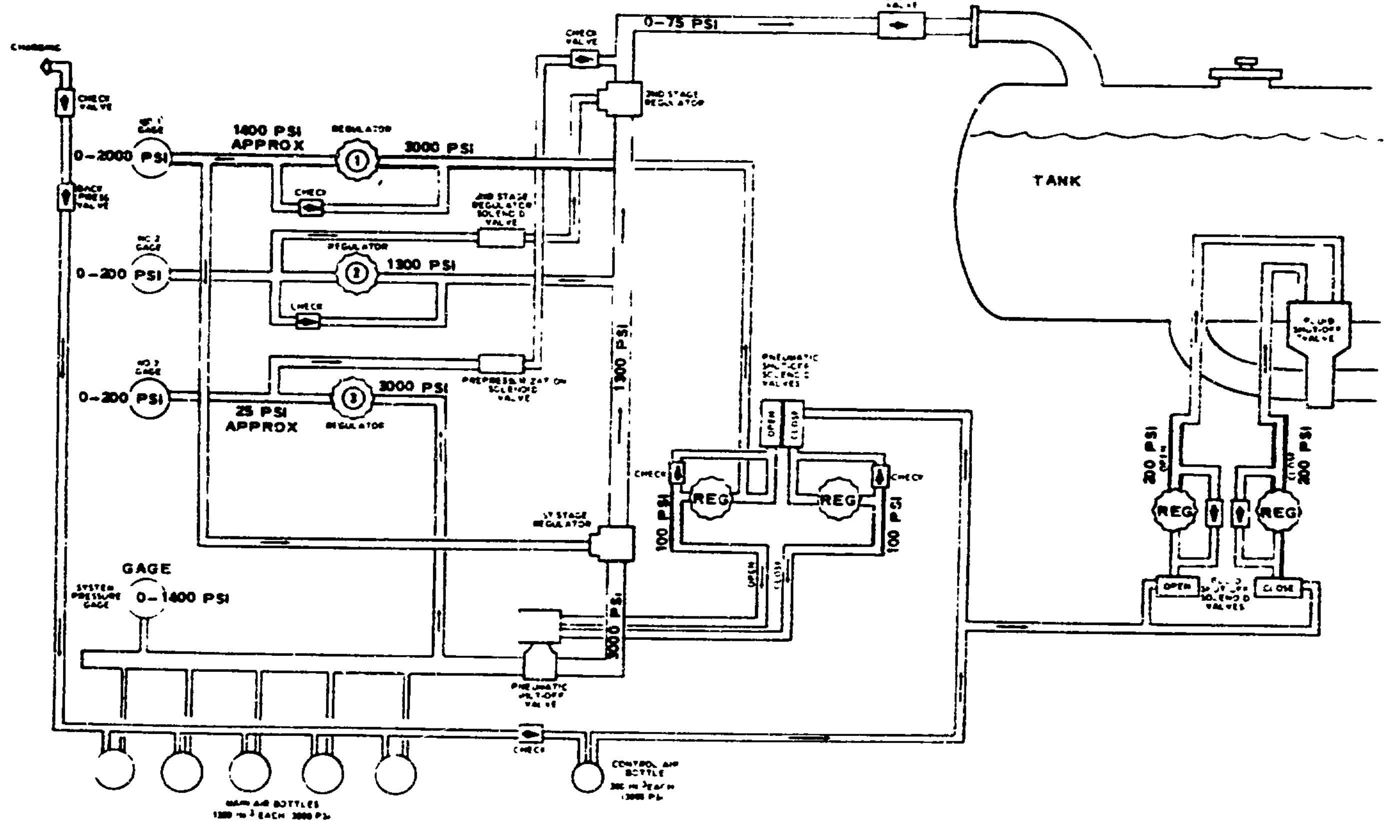

Figure 5. Flow Chart of the Pneumatic System.

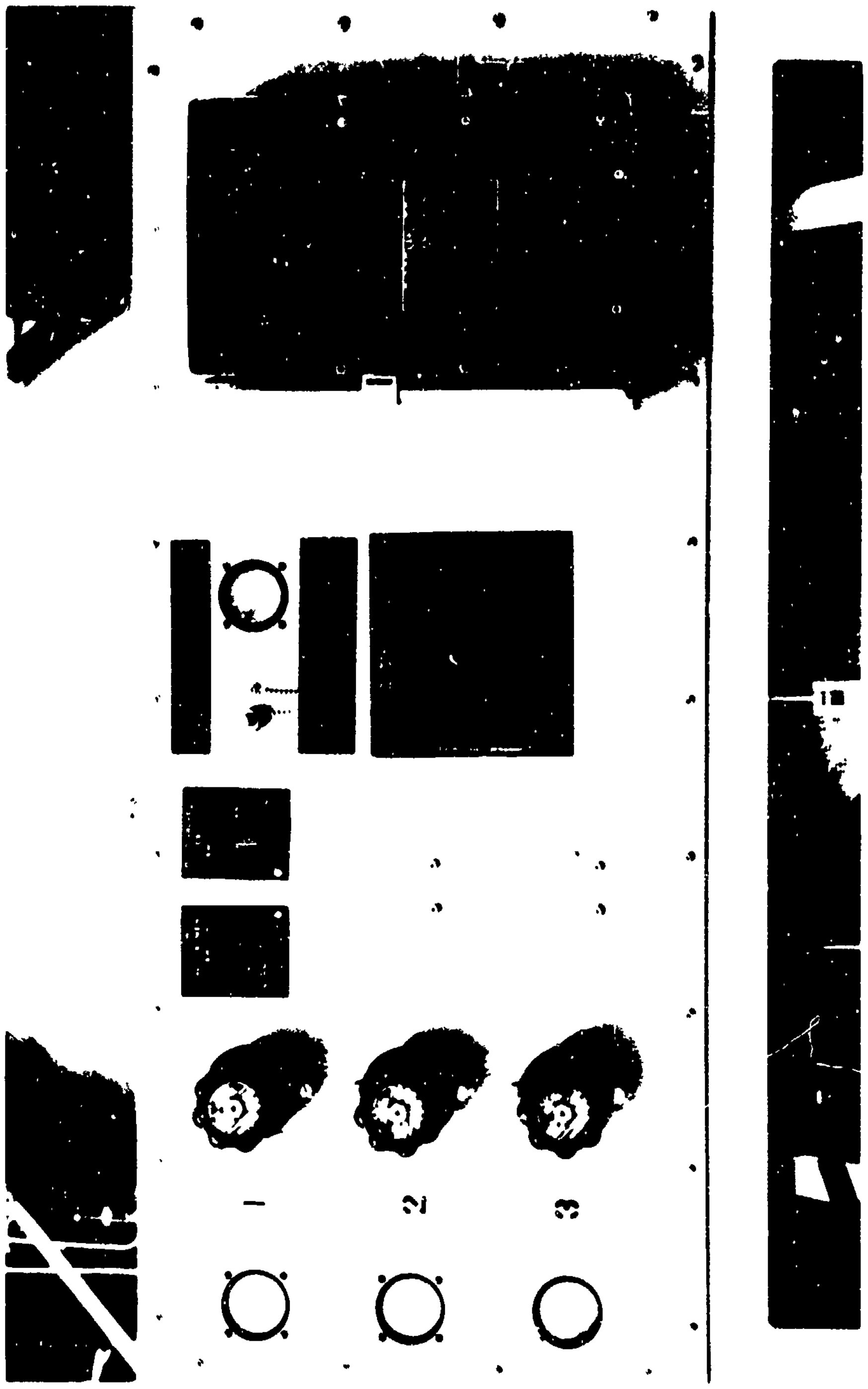

Figure 6. A/A 45Y-2 Dispenser Control Panel.

3. Power Switch - Set to either AIRCRAFT or BATTERY. Each module is equipped with a 28-v battery to provide emergency power. During simultaneous dissemination, the system may be controlled from either control panel. However, the control panel selected must have its Power Switch activated. When the Power Switch is placed in the OFF position, all electrical power, regardless of source, is disconnected.

4. Disseminate Switches -

a. Extend-Retract Switch. Extends and retracts the nozzles after the cargo ramp has been placed in the horizontal position.

b. Arm-Off Switch. When placed in the ARM position, fluid tank prepressurization is initiated. The Extend-Retract Switch must be in the EXTEND position and the nozzles extended, depressing a microswitch, before electrical power is supplied to the Arm-Off Switch. When the tanks are pressurized to 20 psi, green ARMED lights will illuminate for the respective tanks.

c. On-Off Switch. After the tanks are prepressurized, activation of the On-Off Switch to the ON position opens the fluid shut-off valves and fluid flow will commence. Pressure switches (30 psi) actuate the main air shut-off valuves if the tank pressures rise above this setting. Amber lights illuminate as the respective tank is emptied.

DISSEMINATION TUBE AND NOZZLE ASSEMBLY (Fig. 7). Flexible ducts, 8 in. in diameter and 173 in. long, extend aft from the tank assemblies on each side of the cargo compartment terminating at dissemination nozzles. The ducts are supported by eight deployment straps which are attached to the aircraft parachute static cables. The nozzle deployment assembly is attached to the cargo ramp, using existing C-123 support fittings. When the Extend-Retract Switch is placed in the EXTEND position the nozzles move aft and outboard of the cargo ramp to provide the proper fluid dissemination pattern and prevent aircraft contamination. A microswitch on the deployment system prevents opening of the tank fluid shut-off valve and dissemination unless the nozzles are extended. The stainless-steel nozzles are attached to tubular aluminum arms. An electrical worm-gear actuator moves the arms, thereby extending and retracting the nozzles.

The A/A 45Y-2 dispenser (two modules), as installed in the C-123, weighs 5,332 lb empty and approximately 16,000 lb when filled with 1000 gal of defoliant agent.

The nozzles are airfoil-shaped (Fig. 8), and flow is controlled by

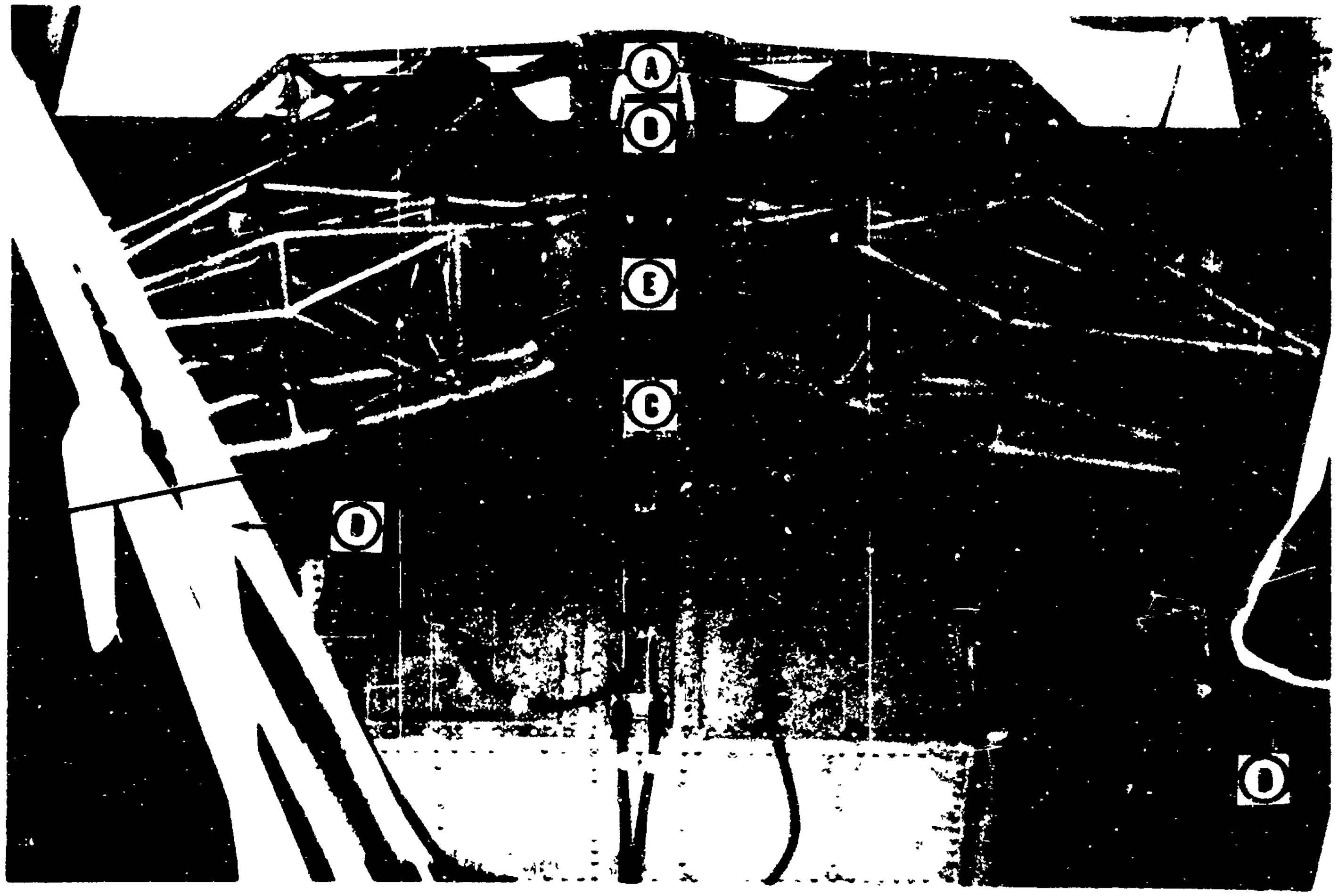

Figure 7. A/A 45Y-2 Dispenser Nozzle-Center Beam Assembly, Showing (A) Extension Arms, (B) Nozzles, (C) Flow Ducts, (D) Support Straps, and (E) Ramp Support Cables.

Figure 8. A/A 45Y-2 Dispenser Retracted Port Nozzle in the C-123 Aircraft, Showing (A) Nozzle, (B) Dissemination Slot, and (C) Cargo Ramp Pad.

manual adjustment, before takeoff, of movable plates on the bottom of the nozzle (Fig. 9). There are two nozzle plates, one with a 24-in.-long slot adjustable to a maximum width of 2 in., and the other with a slot 8.3 in. in length adjustable to a maximum width of 2 in. The rectangular area of the nozzle opening varies from 48 sq in. to approximately 1/2 sq in. Fig. 10 shows the 8.3-in.-slot nozzle plate and teflon gasket.

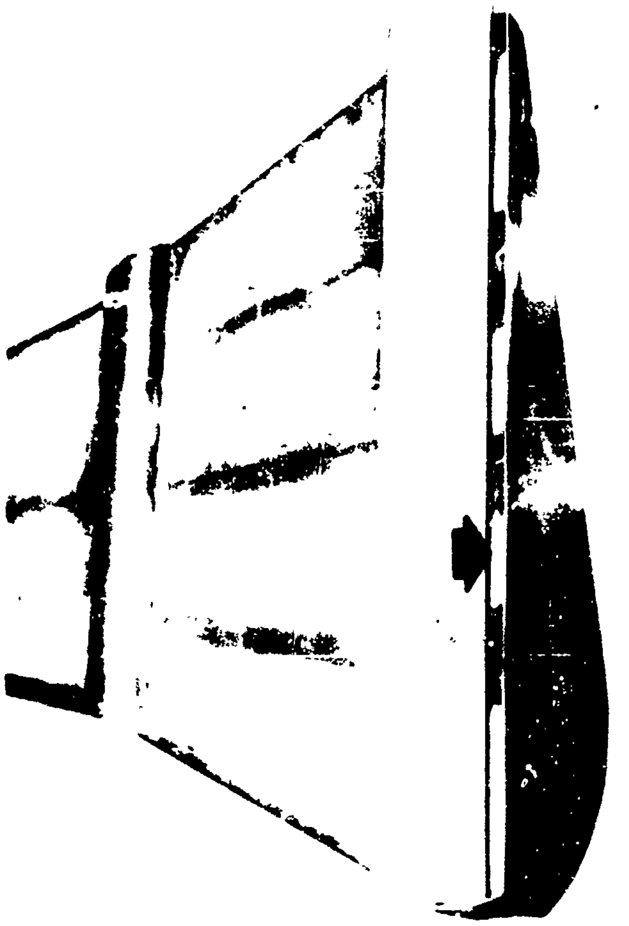

Figure 9. Bottom of Nozzle, Showing Dissemination Slot.

Figure 10. Components of Nozzle, Showing (A) Teflon Gasket, and (B) Nozzle Plate. Cutout in the Gasket and Plate is the Dissemination Slot.

SECTION III

INSTRUMENTATION

A/A 45Y-2 DISPENSER

No special instrumentation other than that already described in Section II was installed by the manufacturer. Two pressure gages, to allow the operator to monitor tank pressure, were provided by the manufacturer and calibrated and installed by the Air Proving Ground Center Instrumentation Laboratory. A 14-channel Midwestern oscillograph was installed by the APGC Instrumentation Laboratory to record the following data:

1. Tank pressure continuously from 15 sec before to 15 sec after dissemination.

2. Spray system shut-off value opening and closing time and degrees of turn from full-closed to full-open.

Agent temperature was measured with a hand-held thermometer before and after each mission. Agent flow rate was determined by extensive ground calibration after each mission.

CB GRID METEOROLOGICAL NETWORK

During the conduct of testing under Project 5957W1, the grid array depicted on the sample worksheet, Fig. 11, was used. The following observed and forecast meteorological conditions were required:

1. Wind direction and velocity, in 50-ft increments, from the surface to 200 ft.

2. Average wind vectors from the surface to 2000 ft.

3. Wind diffusion patterns.

4. Stability conditions.

5. Precipitation and visibility.

6. Surface temperature and relative humidity.

It was necessary that this data be taken as rapidly and as close to

Date ______________________

Pass No. __________ Time ______ CST
Sample Lines ______________________
Wind Condition ____________________
Material __________________________
Temperature (Ambient) ___________°F
Temperature (Fluid) _____________°F
Dissem. Duration __________ Seconds
Tank Pressure _________________ psi
Reg No. 1 _____________________ psi
No. 2 _________________________ psi
No. 3 _________________________ psi

Flow Rate __________ GPM
Airspeed ___________ KIAS
Altitude ___________ Feet
A/C Heading ________ °
Delta - T __________ °F
Trail-Off ______ Minutes:Seconds

Remarks ______________________
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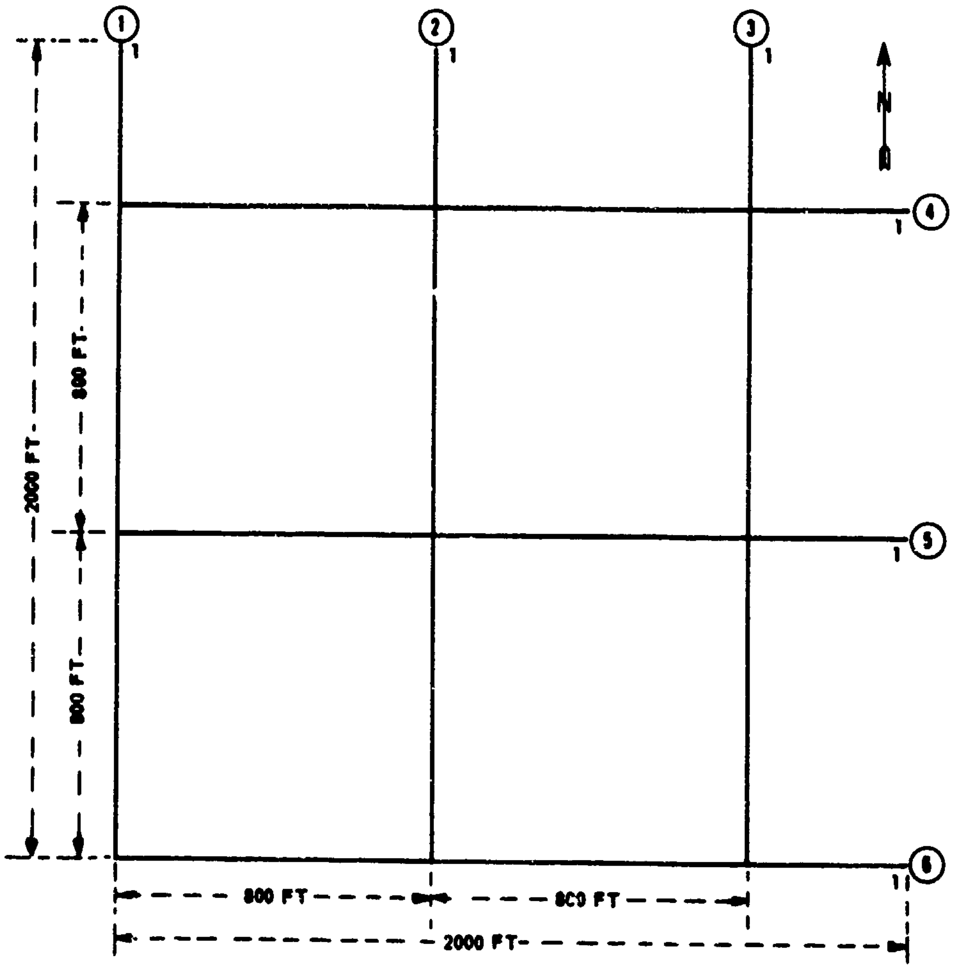


Figure 11. Defoliant Grid Work Sheet.

the time of the spray pass as possible. To accomplish these objectives the equipment array shown in Fig. 12 was employed. Their respective functions were as follows:

1. Jalbert Balloons (Model J-5). Two of these balloons (Fig. 13) were used during the testing cycle to determine wind speed and direction, at 50-ft increments, from the surface to 200 ft. The balloon served two functions: first, as a lifting vehicle for the hot-wire anemometer (Hastings Air-Meter, Model R-2) which measures wind velocity and, second, as a wind direction indicator because of the tendency of the balloon to "weathercock" into the wind.

2. Pilot Balloons (Pibals). Observation of these balloons provided data for computation of average wind vectors from the surface to 2000 ft. Pibals have a known ascension rate and by noting the elevation and azimuth angles of the balloon at predetermined times, the average wind vector from the surface to a desired altitude can be computed. These balloons were released from the northeast corner of the grid array.

3. Delta-T Tower. This mobile, 54-ft tower was used to determine inversion conditions. Temperature and wind velocity and direction were recorded automatically from anemometers located 6 ft and 54 ft from the surface. The tower was located at the control site for the grid spray missions, approximately two miles northwest of the center of the grid. This location provided triangulation for the grid weather data, since the Jalbert balloon pads were located 500 ft from the northeast and southwest corners of the grid array (Fig. 12).

4. A sling psychrometer was used to determine the ambient and dew point temperatures at the surface.

CB DEFOLIANT GRID

The southwest quarter of the square-mile CB grid was designated as the defoliant grid. This grid array was erected as a result of preliminary testing accomplished under Phase I (C-130), APGC Project 2525W3, Development Test of the Hayes Chemical Spray System, Internal. The results of this testing indicated that the single-line sampling employed was not adequate for crosswind tests. Therefore, the six sample lines shown in Fig. 11 were constructed along the already-surveyed sample lines of the CB square-mile grid. Samplers were placed at 20-ft intervals, 4 ft above the ground, along the sample lines. Depending on wind conditions and the type of pass desired, only three of the six lines were used for this pass.

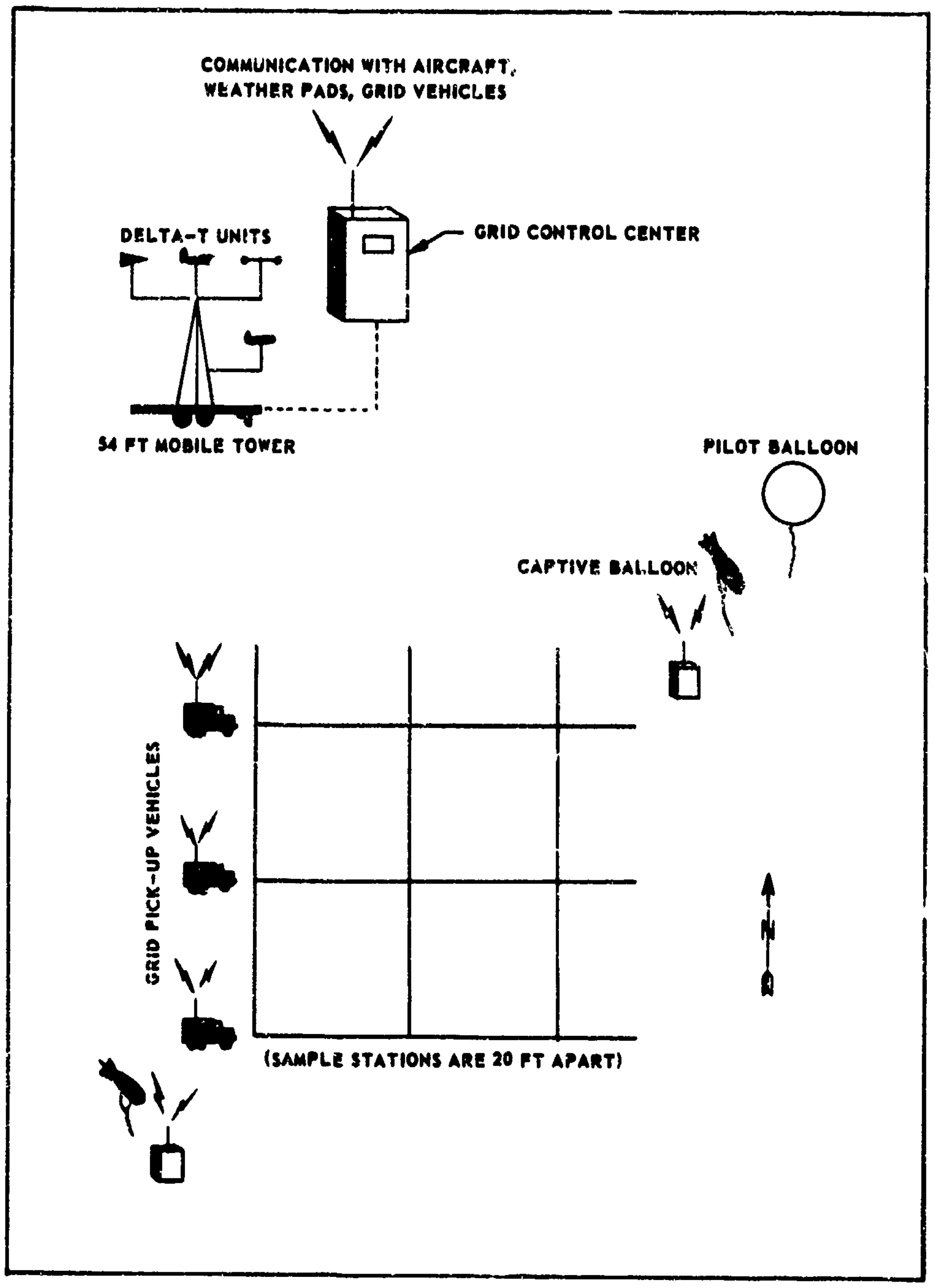


Figure 12. Diagram of CB Defoliant Grid and Meteorological Network.

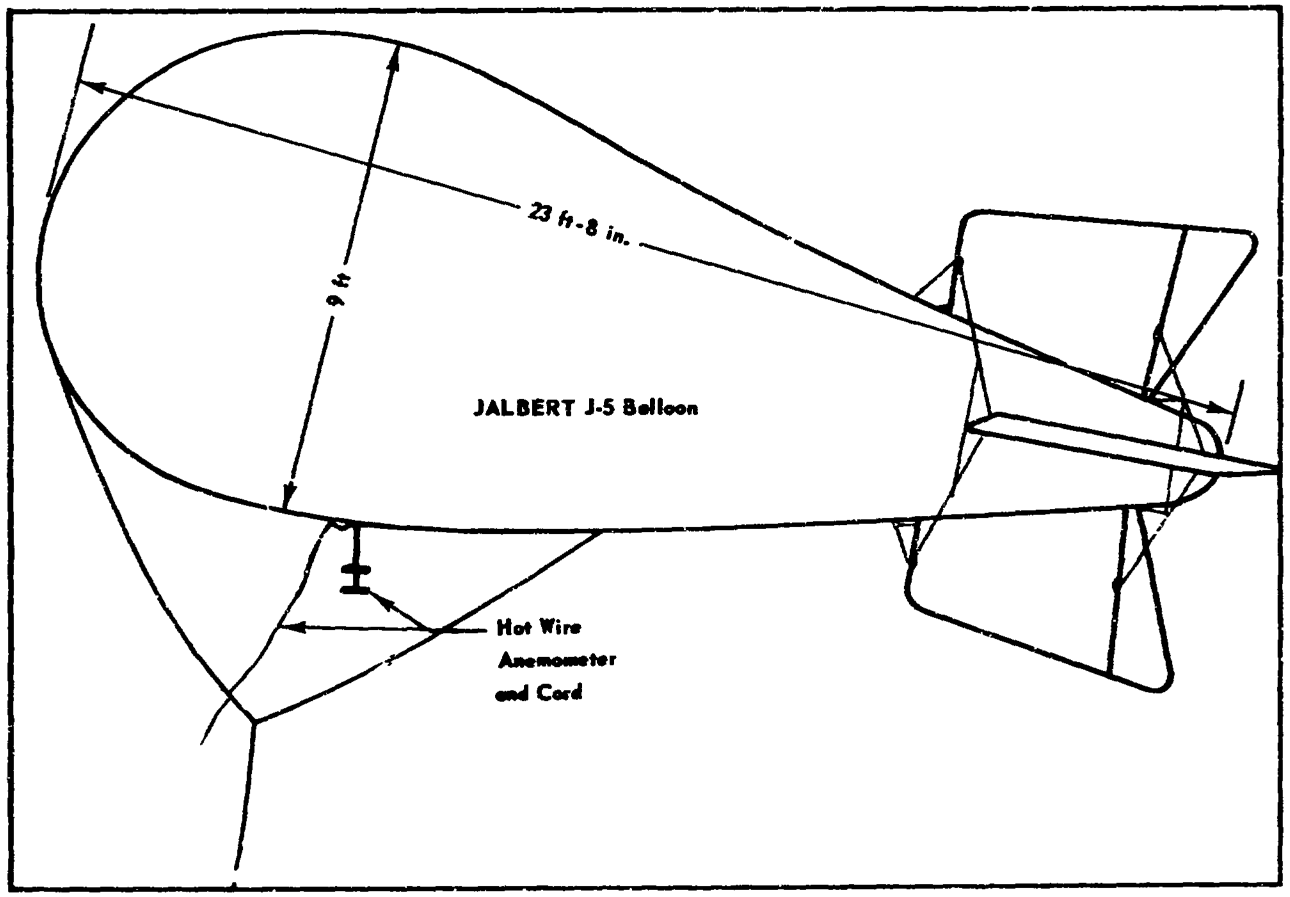


Figure 13. Jalbert J-5 Balloon with Attached Sensor.

The samplers consisted of 5-in. by 7-in. Kromekote cards. Six cards were prenumbered (station and sample line), loaded into a cartridge, and placed on the respective sample station, as shown in Fig. 14. After each spray pass, the top card in the cartridge was removed, yielding a total of 300 sample cards per pass. A detailed description of the sampling and assessment techniques will be given in the test procedure section of this report.

Grid sample pick-up was accomplished by personnel using three four-wheel drive vehicles (one per sample line) equipped with radios.

Communications facilities consisted of:

1. UHF radio communication between the Grid Control Center and the test aircraft.

2. Askania network communication between the grid control center and the grid pick-up vehicles.

3. Portable radio (General Electric "Voice-Commander") communications between the micrometeorologist and the weather balloon crews.

AIRCRAFT

An extra headset and microphone were installed on the pilot's communications jack-box to provide two-way UHF voice communications between project personnel in the Grid Control Center and in the cargo compartment of the aircraft.

Figure 14. Defoliant Grid Sampling Station.

SECTION IV

TEST PROCEDURES

A/A 45Y-2 COMPATIBILITY TESTS

The objective of these tests was to determine if the A/A 45Y-2 dispenser could be installed in the C-123 aircraft and operated in accordance with the contractor's suggested procedures without aircraft modification. All operations were conducted utilizing the procedures outlined in the contractor's "Preliminary Handbook of Instructions for Internal Modular Defoliation Dispenser System," dated 25 October and revised 31 March 1964. These operations included the following:

1. Ground handling and pressurizing tests.

2. Installation in the C-123 and filling of the A/A 45Y-2 with dyed water.

3. Over-water functioning (dyed water) flights at 5000 ft, 130 KIAS to determine:

   a. Aircraft stability and flight characteristics under asymmetrical loads induced by emptying the tanks consecutively at minimum (75 gpm) and maximum (3200 gpm) flow rates.

   b. Aircraft contamination, if any.

Specific analysis of data gathered during the compatibility tests included:

1. Evaluation of the contractor's suggested procedures by considering the following aspects:

   a. Clearness, conciseness, and completeness of procedures.

   b. Adequacy of safety precautions (protective clothing, goggles, etc.).

   c. Action required beyond that indicated by the contractor.

   d. Time required to remove and install the equipment.

2. Evaluation of the suitability of USAF equipment required to

perform installation, filling, and pressurizing operations and a notation of any special equipment required.

3. Evaluation of the capability of the C-123 to safely carry and disseminate the defoliant agent from the A/A 45Y-2. This evaluation included the following:

a. Possibility of exceeding the aircraft center-of-gravity shift limitations through reduction of agent payload and fuel consumption.

b. Review of chase aircraft motion picture film for fluid flow characteristics and contamination.

c. Visual observation relative to aircraft contamination.

d. Correlation of factors b and c above to determine possible reasons for contamination, if any.

For the over-water dyed-water dissemination flights, methylene blue and fluorescein dye were used in the right and left tanks, respectively. The solution disseminated consisted of one pound of dye to 100 gal of water. Aerial photography included motion pictures taken from inside the aircraft and from a T-33 chase aircraft. During these over-water trials, and subsequent grid flights, the aircrews' comments concerning the C-123: A/A 45Y-2 system were documented. These comments are summarized and included in Appendix I.

Throughout the compatibility tests and during flights over the grid array, an assessment of the contractor's day-to-day operating and maintenance requirements was made.

LOW-ALTITUDE GRID AGENT SPRAY FLIGHTS

Grid tests with the defoliant agent, ORANGE, were conducted to determine the capability of the C-123:A/A 45Y-2 system to deliver approximately three gallons of defoliant agent per acre over an area of one-half square mile per sortie. Spray missions were flown at dissemination altitudes of 50, 150, and 500 ft above the terrain at low (approximately 175 gpm), medium (approximately 350 gpm) and high (approximately 650 gpm) flow rates. Spray passes were made inwind and crosswind. Data gathered during the spray flights included:

1. Ground concentration of the defoliant agent in gallons per acre.

2. Swath width at various concentration levels in feet.

3. Droplet size distribution in mass median diameter.

Prior to commencing grid flight testing, extensive flow rate calibrations were conducted to determine the correct nozzle aperture/tank pressure combination to obtain the low, medium, and high flow rates. Since the tank pressure was to remain constant (20 psi) all that remained was to determine the nozzle plate and slot width. Ground calibrations were conducted utilizing the apparatus shown in Fig. 15. The calibration equipment required was:

1. Two 500-gal catch-tanks. (Due to the high cost of the agent and its deleterious effect on asphalt, it was mandatory that the fluid be recovered.)

2. Two stop-watches.

3. One gasoline-powered transfer pump.

4. An MC-1 air compressor.

The calibration procedure and the results are contained in Appendix VII.

After the calibration tests were completed, one orientation flight was made disseminating fuel oil over the grid. The purpose of this flight was to familiarize the test pilots with the physical layout of the grid and adjacent orbit area. Also, this flight provided a shakedown test of the grid procedures and the assessment techniques to be employed by the personnel at the APGC M&O Contractor's CB Laboratory.

All agent spray flights were conducted during the early hours of the day, from approximately 0430 CST to 0730 CST, in order to obtain required weather conditions of:

1. Average wind velocity (surface to dissemination altitude) less than 20 mph.

2. A prevailing inversion or neutral condition.

The initial pass was programmed for 500 ft to take advantage of the lighter wind during the early part of the day. Subsequent passes were directed by the project engineer in accordance with existing meteorological conditions to fulfill project objectives. For a given spray configuration of altitude and flow rate, four passes were programmed under crosswind conditions, and two passes were planned under inwind conditions.

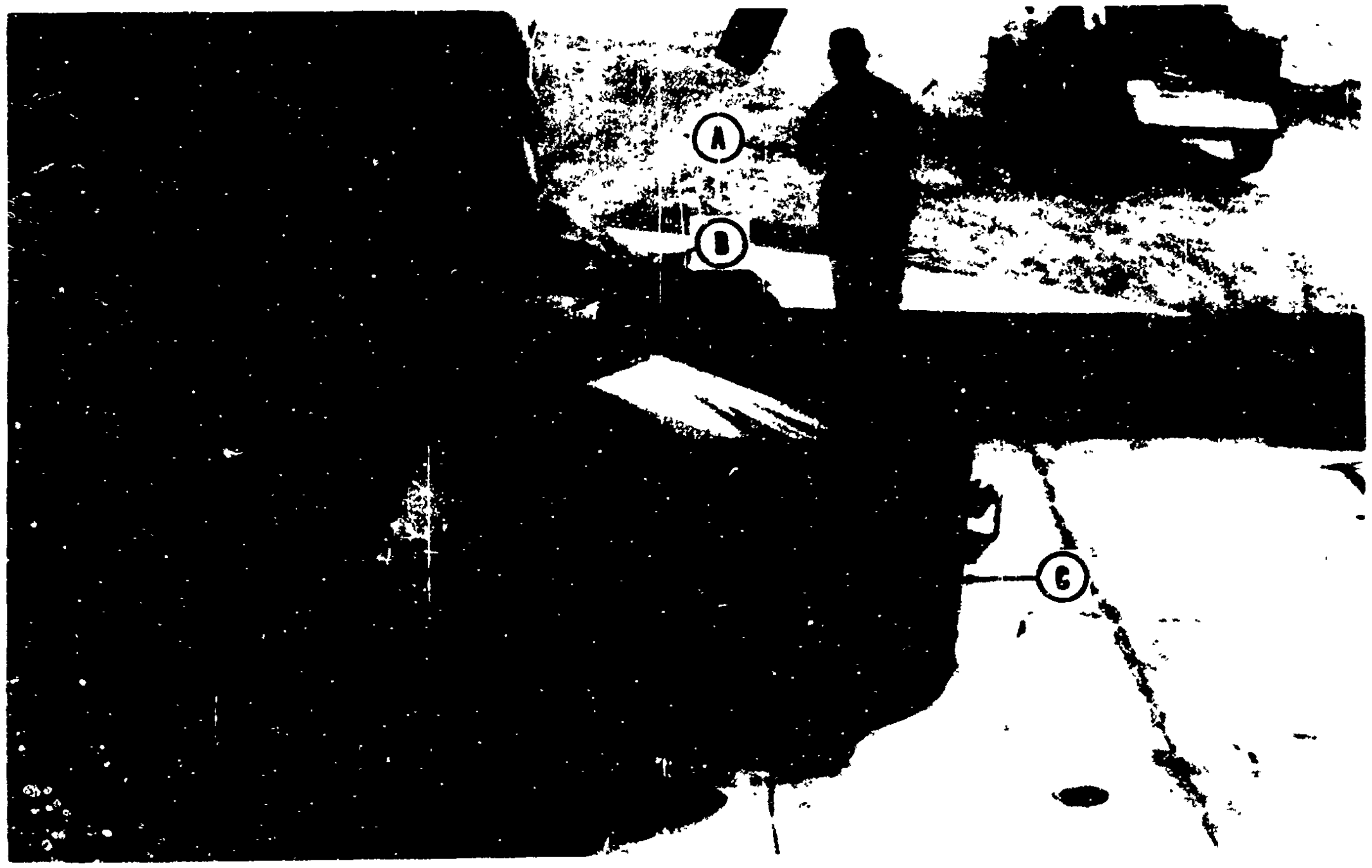


Figure 15. Flow Rate Calibration Equipment, Showing (A) Timer, (B) Nozzle, and (C) Known-Volume Tank.

The crosswind releases were run when the altitude-crosswind vector product was between 500 and 5000 ft-mph. This factor insures proper "shake-out" of the droplets, facilitating assessment of droplet size distribution. The grid flight profile is shown in Fig. 16.

HIGH-ALTITUDE GRID AGENT SPRAY FLIGHTS

High-altitude (500-2000 ft) spray flights were conducted to determine the aimability of such a method of delivery. Preliminary flights were conducted using Class-2 fuel oil as a simulant to determine cloud travel and deposition characteristics. The same meteorological restrictions applied for these flights as for the releases at lower altitudes.

CALIBRATION, COLLECTION, AND ASSESSMENT PROCEDURES

CALIBRATION PROCEDURES. The detailed laboratory procedures established for collection and assessment of the defoliant sample cards are outlined in Reference 4. The general procedure was to collect a sample (one pint) of defoliant agent from each module tank before the mission. This sample was used to prepare Kromekote calibration cards for each mission. Clean cards were weighed, sprayed with a uniform deposition, and reweighed. Hence, the exact amount of defoliant agent, by weight, (milligrams per card) was known. The calibration cards were then placed in the reflectance photometer (Fig. 17) to determine the reflectance reading. From these readings a calibration curve was plotted (Fig. 18), showing deposition (gpa) versus reflectance reading. Since the cards are uniform in size (5-in. by 7-in.) the concentration valves in milligrams per card, are converted to gallons per acre.

COLLECTION PROCEDURES. Six clean 5-in. by 7-in. Kromekote cards were prenumbered (station and sample line) and loaded into a cartridge. The cartridge was then placed in a holder on top of each sampling post. After each spray pass and a 10-min waiting period (to allow droplets to settle), personnel moved down each of the three sample lines and removed the top Kromekote card at each sampling station. Cards which appeared to have liquid agent on the surface were placed in a "wet" box to dry. (This was a problem with the A/A 45Y-2 dispenser because of the large droplets produced—MMD, 400 microns.) Dry cards were placed in the

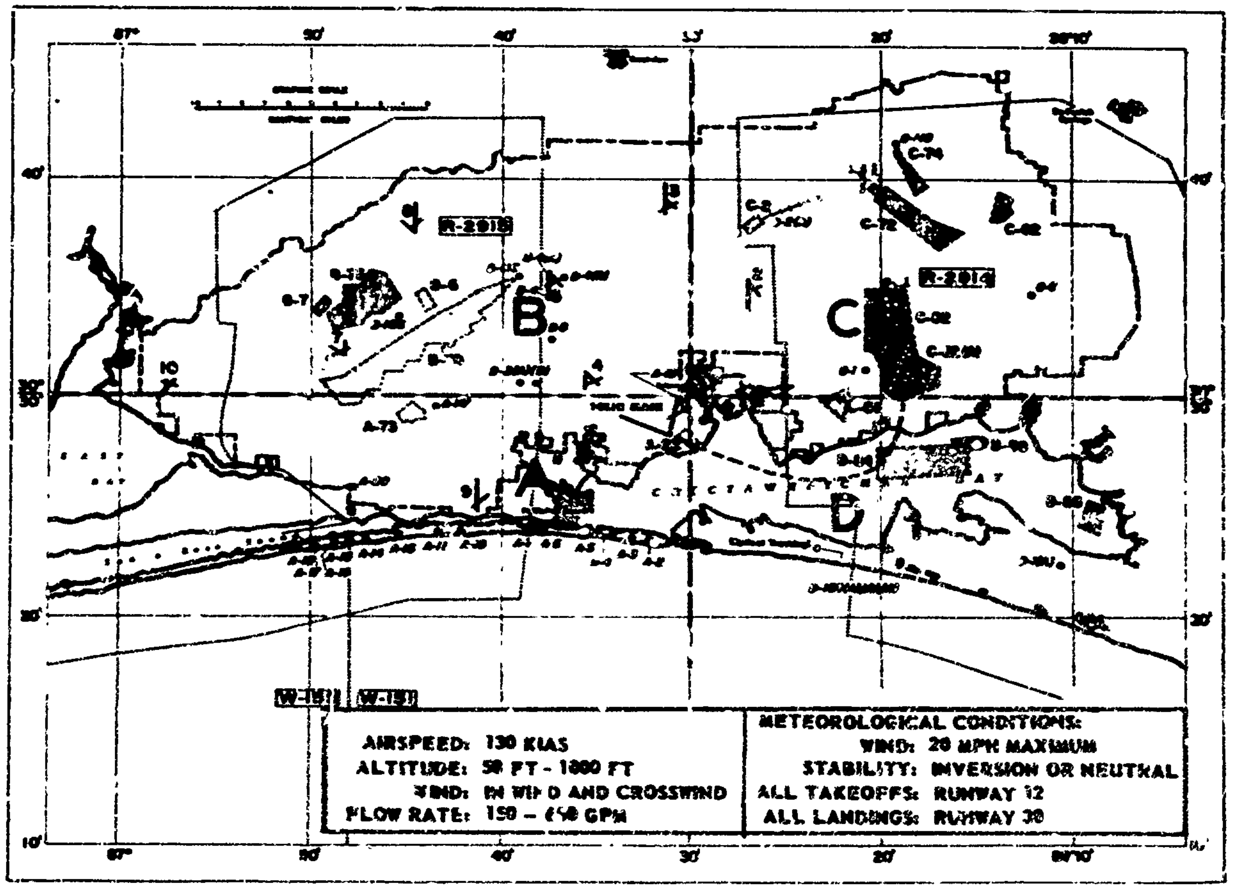


Figure 16. Typical Flight Profile Used During Grid Testing.

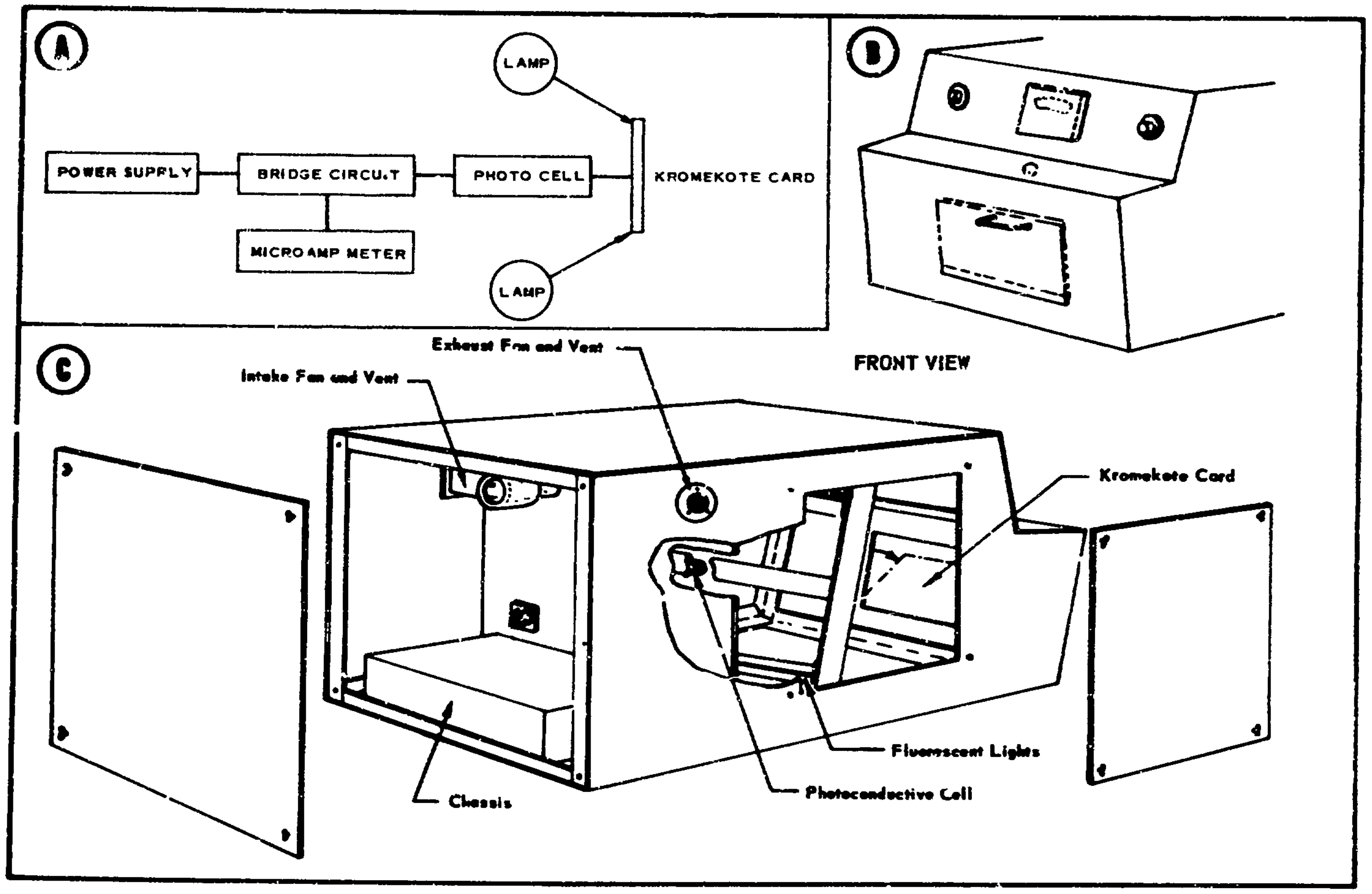


Figure 17. Reflectance Photometer Used to Assess Deposition, Showing (A) Circuit, (B) Front of Photometer, and (C) Cutaway of Photometer.

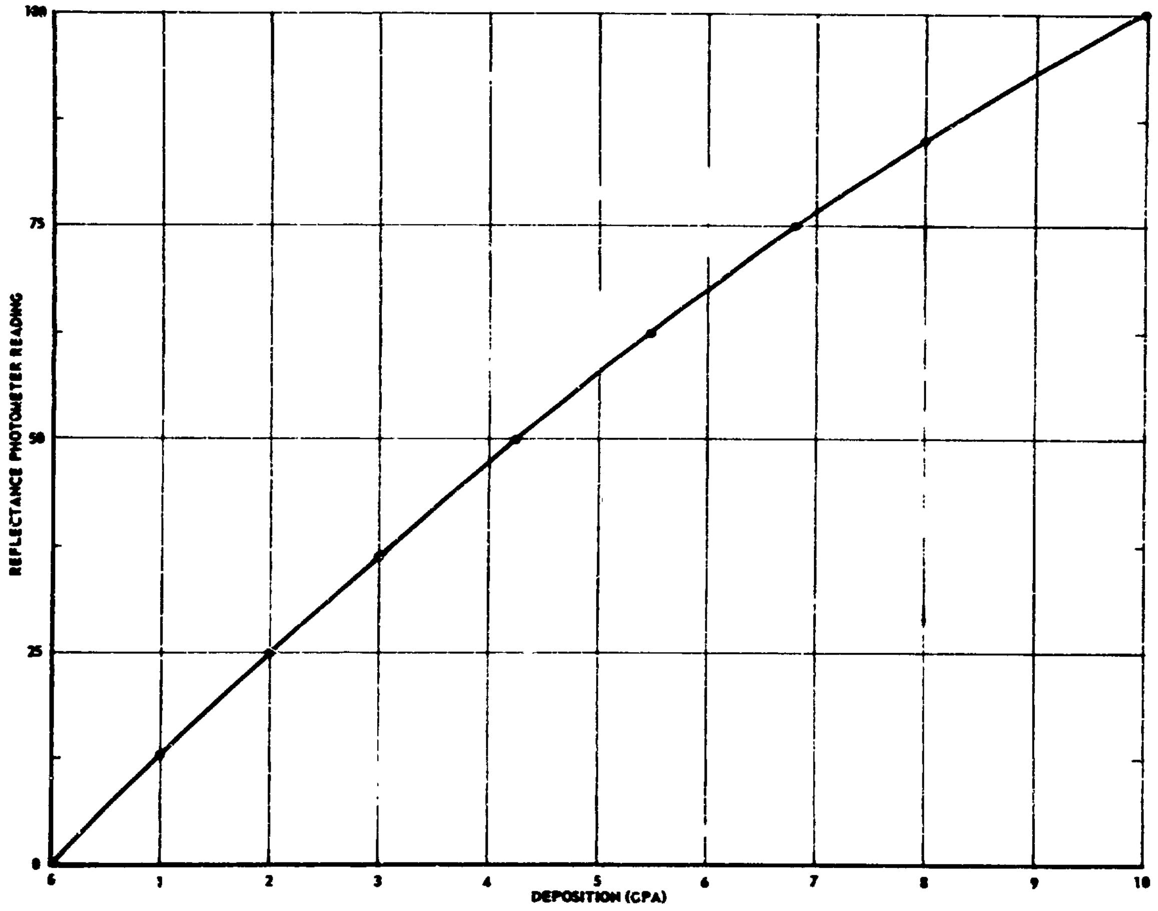


Figure 18. Typical Curve of Reflectance Reading Versus Deposition (GPA).

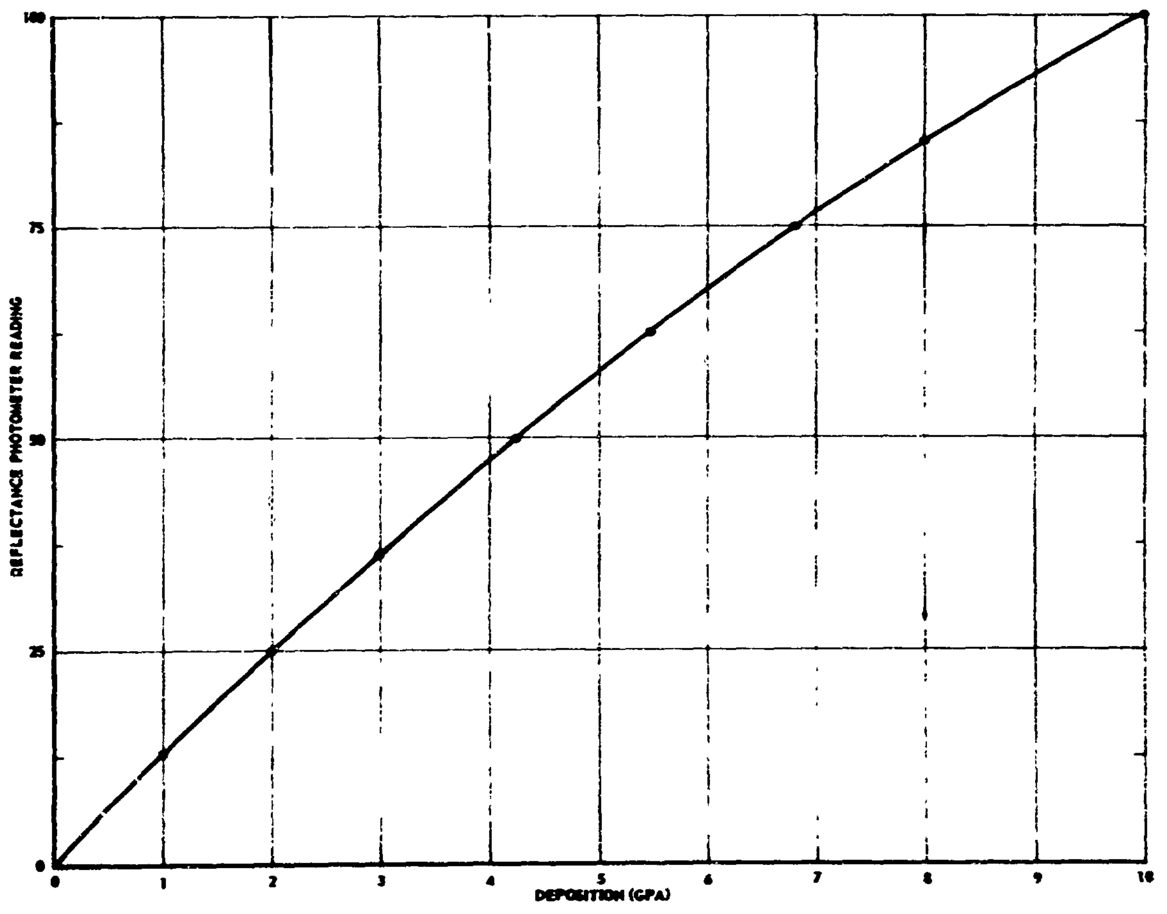


Figure 18. Typical Curve of Reflectance Reading Versus Deposition (GPA).

shoulder-boxes carried by the grid pick-up crew. Removal of the top card uncovered a sample card for the next pass. At the end of the mission, all the cards (300 per spray pass) were returned to the APGC M&O Contractor's CB Laboratory for assessment.

ASSESSMENT PROCEDURES. Concentration. After the photometer had been calibrated, each sample card was placed in the photometer and the reflectance reading recorded. This reading was applied to the graph shown in Fig. 18, to obtain the concentration (gpa) of agent at each sample station.

Droplet Size Distribution. The droplet size distribution, expressed as mass median diameter (MMD) was determined utilizing the method developed by B. Maxsymiuk (Ref. 8). Mass median diameter is the size of the droplet which divides equally the mass deposition. Half of the mass deposition consists of droplets larger than MMD, and half of the mass deposition consists of droplets smaller than MMD. The procedure is to select from the sample cards the five largest spots in the swath collected on each pass. One of the droplets is designated as D-max. Beginning with the smallest spot, D-max is the droplet which is no more than 200 microns larger than the previous spot. For example, if the five largest spots in a swath are 3500 microns (1 micron = 10^{-6} meter) 3000 microns, 2800 microns, 2700 microns and 2600 microns, the 2700-micron size droplet is designated as D-max. D-max is then converted to spherical droplet size by dividing by a spread factor (S.F.). This spread factor will vary directly with droplet size. An illustration of this variation is shown in the graph, Fig. 19. This spherical droplet size is divided by a conversion factor, CF (also developed by B. Maxsymiuk, Ref 8) to determine MMD. The conversion factor is primarily a function of airspeed. The conversion factor of 2.5 for airspeeds of 150-180 mph was used for these tests.

$$\text{MMD} = \frac{\text{D-max}}{(\text{S.F.})\ (\text{C.F.})} = \frac{\text{D-max}}{(\text{S.F.})\ (2.5)}$$

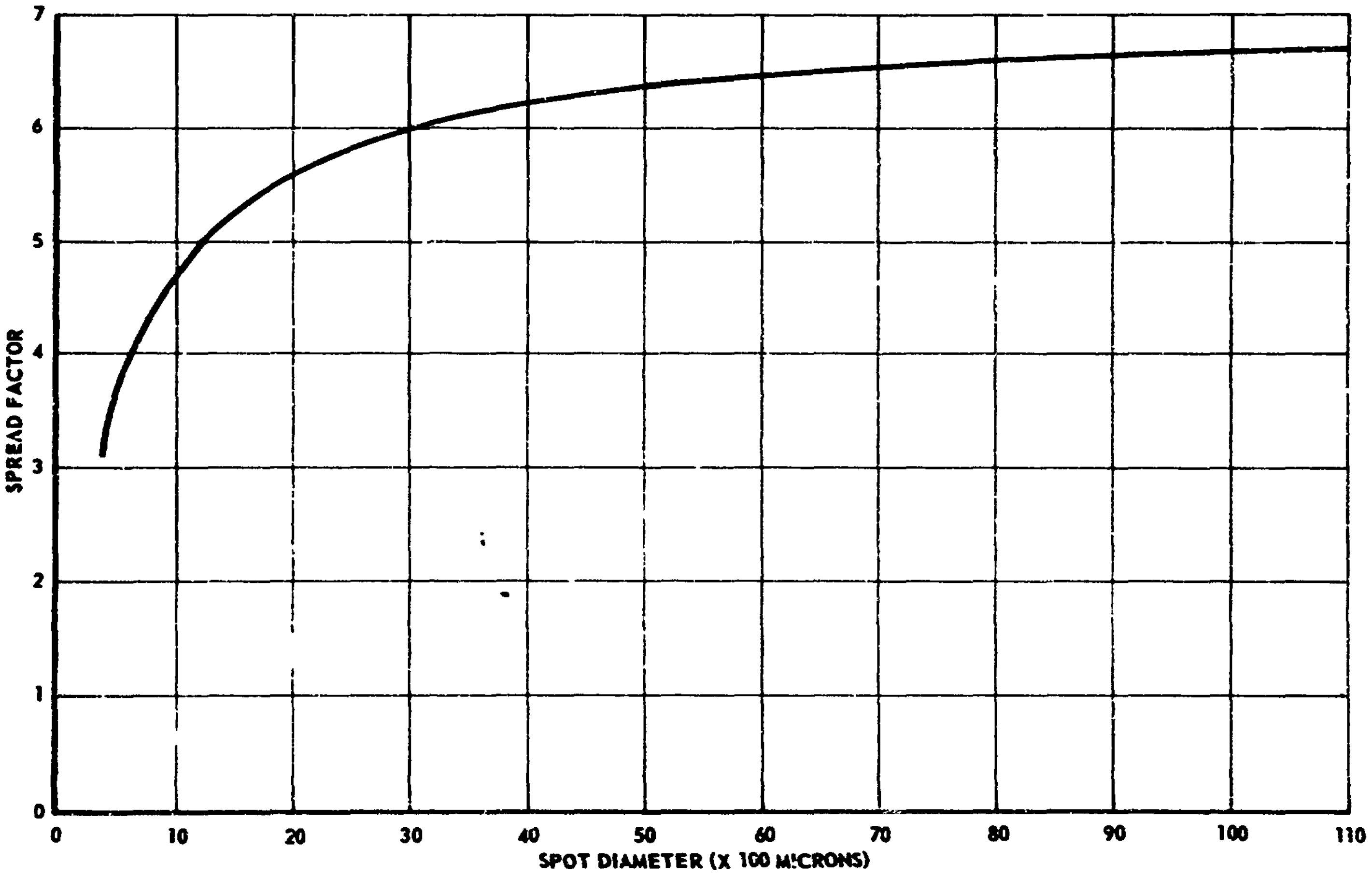


Figure 19. Plot of Spread Factor Versus Spot Diameter.

GRID DATA ANALYSIS

Tabluated grid data was presented by the APGC M&O Contractor and distributed to the APGC Mathematical Services Laboratory and the project engineer. These data were plotted by the Mathematical Services Laboratory on grid worksheets and forwarded to the project engineer for analysis. The project engineer determined the swath widths at minimum concentration levels of 0.5, 1.5, and 3.0 gpa. To determine these swath widths for each pass, the peak depositions on the three sample lines were aligned and an average station-by-station deposition was determined for each pass. This mean deposition is shown as the abscissa on the swath-width charts in Supplement I of this report. This data was also analyzed for projected area coverage (Appendix IV) and MMD variations and percent recovery (Appendix III).

SECTION V

TEST RESULTS AND DISCUSSION

COMPATIBILITY

INSTALLATION. The A/A 45Y-2 dispenser was installed and extracted three times, following the contractor's suggested procedures. All installations were performed by the same four personnel assigned to the Field Maintenance Section, Deputy for Materiel, Eglin AFB. This test item cycling was accomplished in order to evaluate the manufacturer's recommended installation procedures and the ability of average flight-line personnel to follow these procedures. The following standard USAF equipment was used during the installations:

1. M-246 winch.
2. Load assist pulley (C-123).
3. Assorted hand tools.
4. Standard automobile jack.
5. Forklift (6000-lb capacity).
6. 100 ft of 1/2-in. steel cable.

The contractor's suggested procedures were clear and concise. The first installation required approximately eight hours. The following observations were made:

1. Due to limited work space, minor deviations were made from the tie-down diagram suggested by the contractor.

2. The extended nozzles prevented installation of the ramp positioning links (Fig. 20).

3. Closure of the cargo ramp and door, with the nozzle assembly installed showed no interference, but the clearance was small, approximately 1/4 in. (Fig. 8).

4. With the system installed, it is impossible to gain access to the aircraft battery compartment.

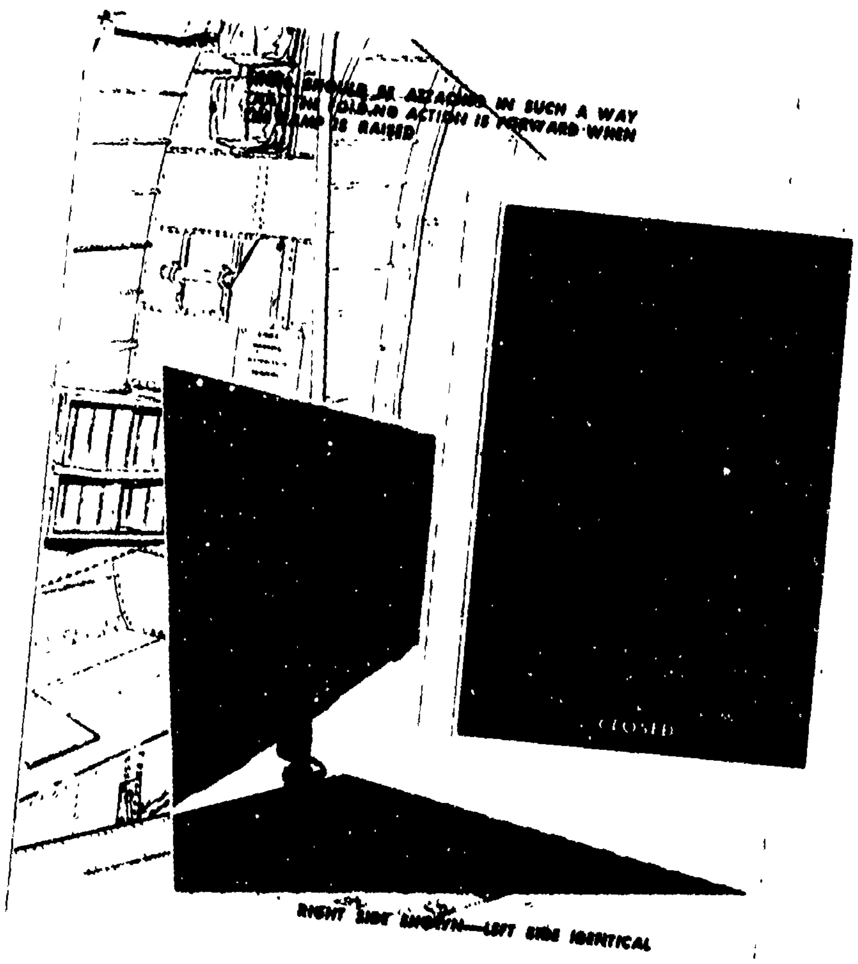


Figure 20. Ramp Positioning Links Installed on C-123 Cargo Ramp.

5. The majority of the time spent accomplishing the first installation was used assembling and installing the center beam assembly. This was due to the complexity of design, numerous small parts, and the close tolerances between these many small parts.

6. The passageway between the front and rear cargo compartment is reduced to approximately 15 in. (Fig. 21) with the dispenser installed. The side clearance between each module and the main gear well bulkhead is approximately five inches (Fig. 22).

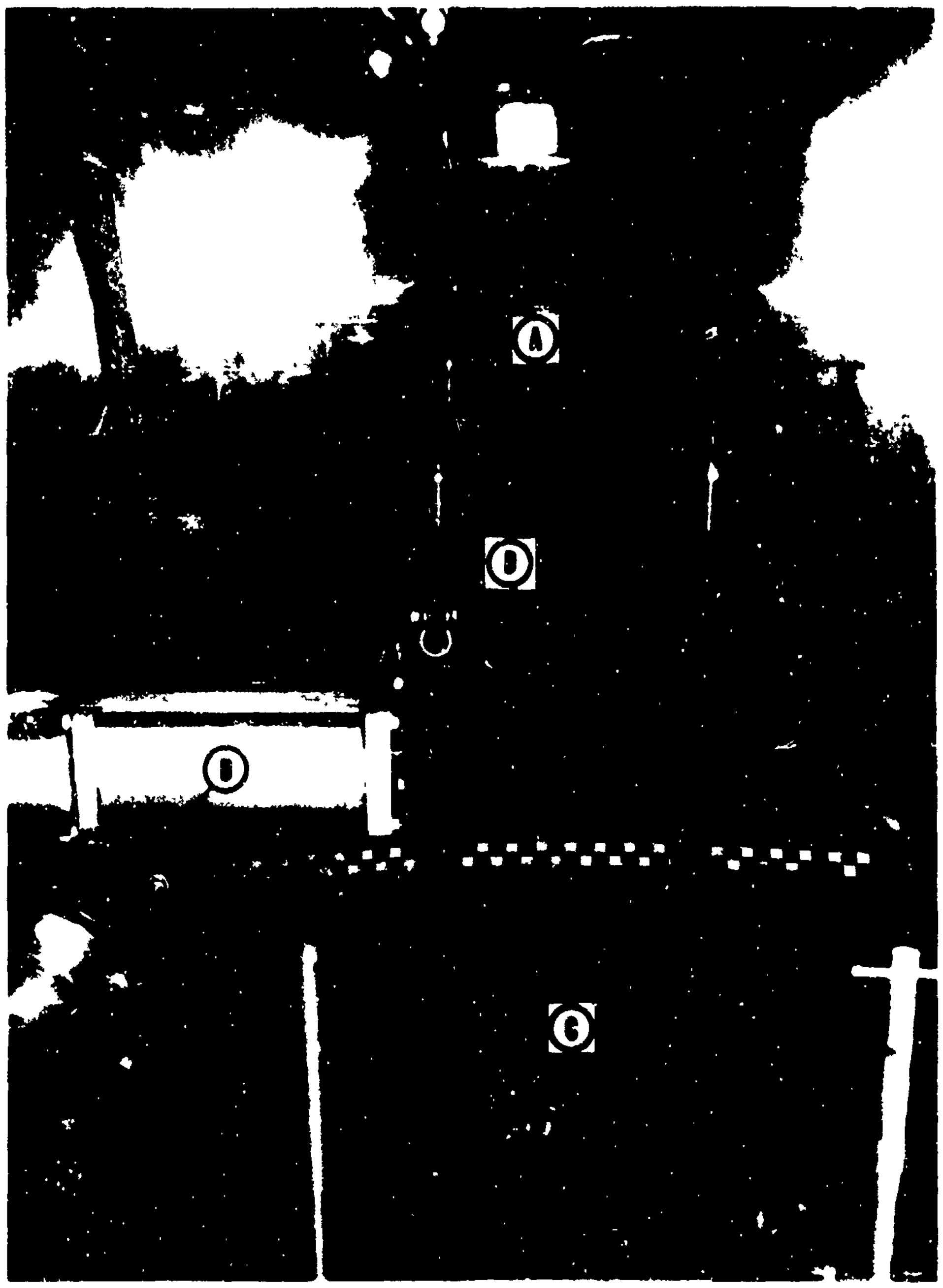


Figure 21. A/A 45Y-2 Dispenser (Two Modules) Installed in C-123 (Rear View), Showing (A) Tanks, (B) Shut-Off Valve, (C) Jacks, and (D) Spreader Bar.

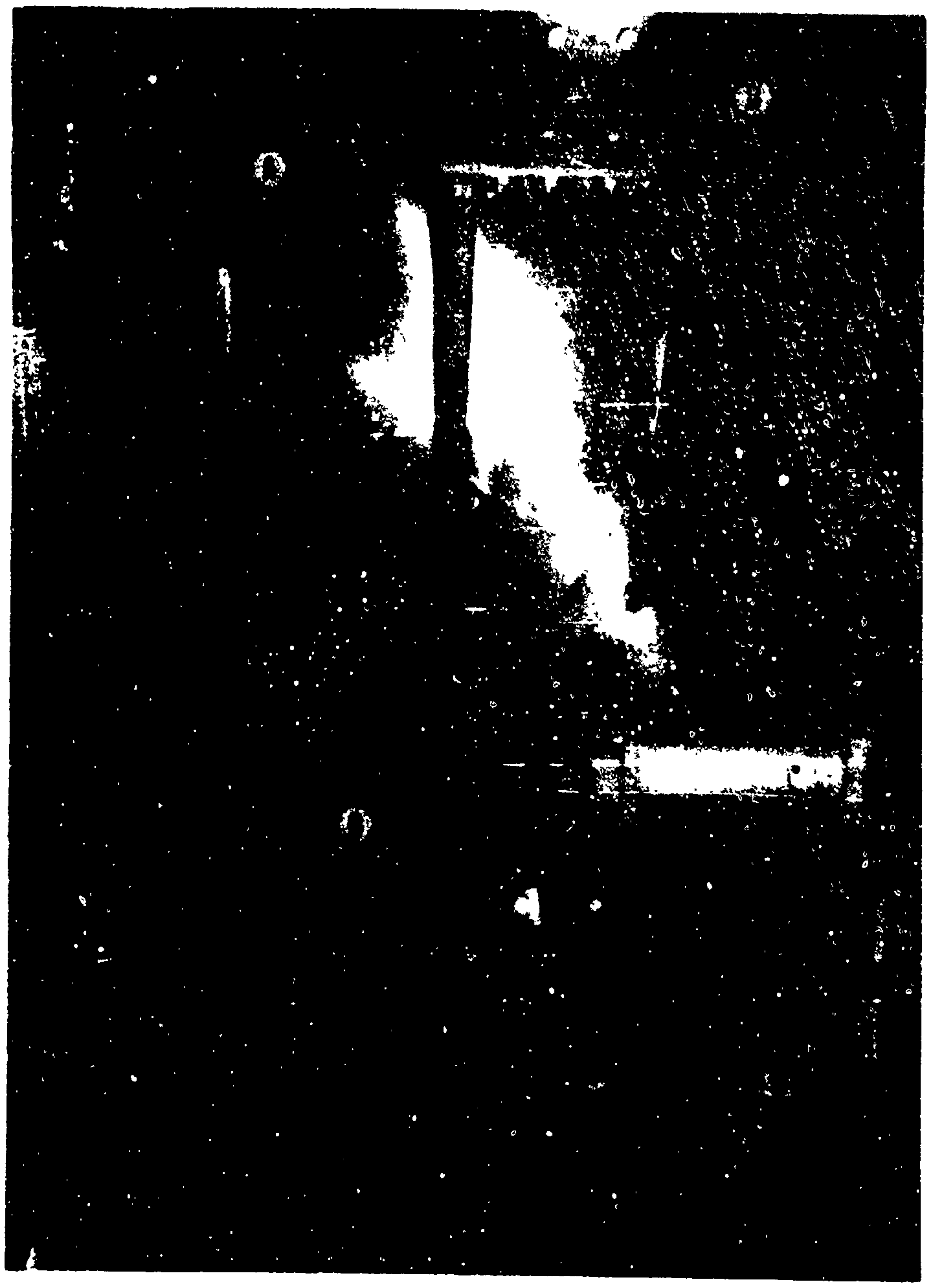


Figure 22. Left Module of the A/A 45Y-2 Dispenser Installed in C-123 (Rear View), Showing (A) Voltage Regulator Compartment, (B) Pressure Relief Valve, (C) Shut-Off Valve, and (D) Flow Tube.

Subsequent installations and extractions made later in the testing period yielded the following results:

1. Installation time was reduced from eight hours to two hours, and removal required approximately two hours. The reduction in installation time was effected by pre-assembling the center beam assembly. This assembly was placed on a pallet and placed in position on the cargo ramp using a forklift.

2. The A/A 45Y-2 dispenser was easily loaded and positioned in the C-123 by use of a steel cable, pulley, and a vehicle to provide the pulling force. Once the modules were up the cargo ramp and on the cargo compartment floor, they were easily manhandled into position. An automobile jack was used for exact positioning to facilitate installation of the spreader bars (Fig. 21) between the modules.

3. Installation and removal of the A/A 45Y-2 dispenser requires no special training or qualifications on the part of the loading crew. Average flight-line personnel can perform these tasks with a minimum of instruction. No special tools or equipment are required. (The standard automobile jack is not a required item since the modules can be manhandled into final position after the wheels are retracted.)

The system was designed to operate with the cargo ramp in the horizontal position, and since the position of the extended nozzles precluded the installation of the ramp positioning links, an alternate method of support was devised to maintain the ramp in a horizontal position in the event of hydraulic failure. Since the parachute static line cables were installed to provide support for the flexible flow ducts (Fig. 23), it was decided to support the cargo ramp by cables attached to the static line system (Fig. 7). This modification was approved by the APGC Airborne Test Flight Safety Board and proved adequate throughout the test period.

OVER-WATER FUNCTION FLIGHTS

Two over-water function flights were conducted on 28 April and 1 May 1964 to determine flight characteristics, assymetrical load parameters, and possible aircraft contamination. Prior to these flights, the anticipated lateral center-of-gravity shift due to consecutively functioning the tanks was computed and considered insignificant.

FIRST OVER-WATER FLIGHT (28 May). The dispenser was loaded with 1000 gal of demineralized dyed water. A water truck, type A/S 32-A-2,

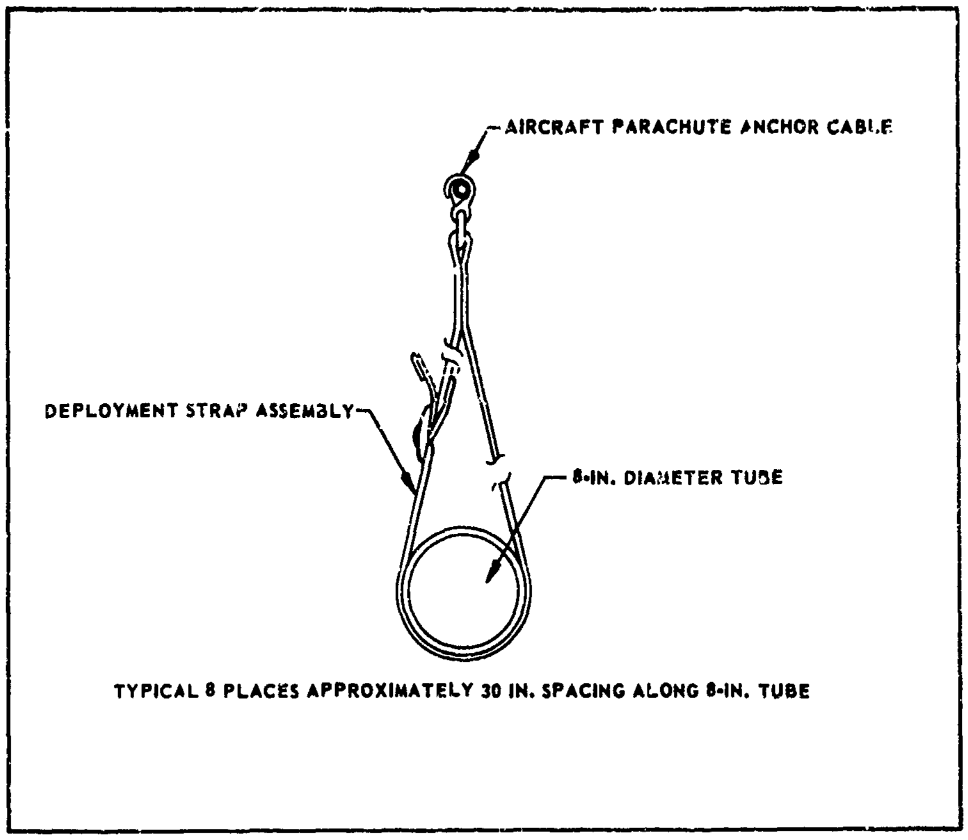


Figure 23. Flow Duct Support Strap.

provided fill for the dispenser. The left module contained fluorescein (yellow) dye and the right module contained methylene-blue dye. Motion picture coverage was provided by a T-33 photochase aircraft and hand-held motion picture camera inside the cargo compartment of the C-123. The dispenser was functioned at a low flow rate of approximately 150 gpm to afford maximum flow time for motion picture coverage. Operation was normal throughout the extension of the nozzles and subsequent series of 30-sec functionings. The trail-off time for cessation of fluid flow after valve closure, was approximately 32 min. During retraction of the deployment system, the cargo ramp pad which had raised up approximately two inches due to airflow loads, jammed both nozzles. This caused rupture of the nozzle actuator motor fittings on the center beam assembly (Fig. 24). An uneventful landing was made with the nozzles extended. Visual examination of the aircraft aft-fuselage belly and tail surfaces showed heavy concentrations of dye. Flight time was 1 hr 45 min.

SECOND OVER-WATER FLIGHT (1 May). Prior to this flight, three metal restraining straps (1 in. by 6 in.), Fig. 25, were installed to keep the cargo ramp pad from rotating up and into the path of the retracting nozzles. Also, manually-actuated purge valves were installed on stand-pipes downstream of the shut-off valves to reduce trail-off time. During the flight, the left module was functioned at maximum flow rate to determine assymetrical load characteristics. The module emptied in approximately one minute with a 30-sec trail-off. No lateral aircraft trim changes were required. Longitudinal trim was changed from three degrees nose-down to three degrees nose-up. The right module was functioned for 30 sec and the purge valves opened to determine the effect on trail-off time. Trail-off was reduced from approximately 32 min to 5 min. During a second functioning, the right flow duct came off at the tank outlet end, contaminating the cargo compartment with a large quantity of dyed water. An uneventful landing was made after an elapsed flight time of 1 hr 15 min.

GROUND CALIBRATION (AGENT)

Further flight-testing was cancelled pending redesign of the duct and connectors. Prior to receipt of the new ducts, 19 May 1964, extensive ground calibration runs were made using defoliant agent ORANGE to determine the correct nozzle setting to attain the required flow rates to be used during grid flight testing. Due to the lack of a recording flowmeter, the following method was used to determine flow rate. The agent was recovered in two 500-gal tanks. The modules were functioned consecutively at a tank pressure of 20 psi and a given nozzle setting. Elapsed time was kept with a stopwatch. The watch was started as soon as fluid appeared at the nozzle and stopped on the second burst of air. (As the tank emptied, a burst of air would come out of the nozzle, then fluid, then air again after one or two seconds.) The amount of fluid in the recovery tanks was then measured with a dip-stick, and the number of gallons which had flowed was calculated. Dividing by the elapsed time gave the average flow rate on each run. Approximately 50 flow-rate checks were made throughout the test period.

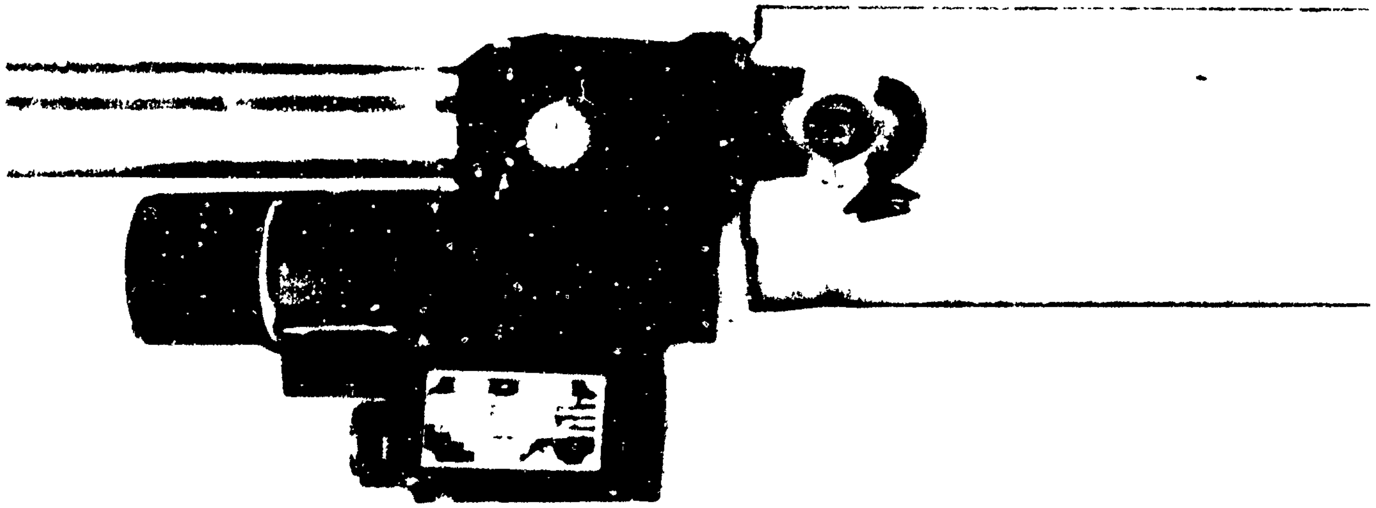


Figure 24. Nozzle Extension Arm Actuator. Arrow Points to Broken Bracket.

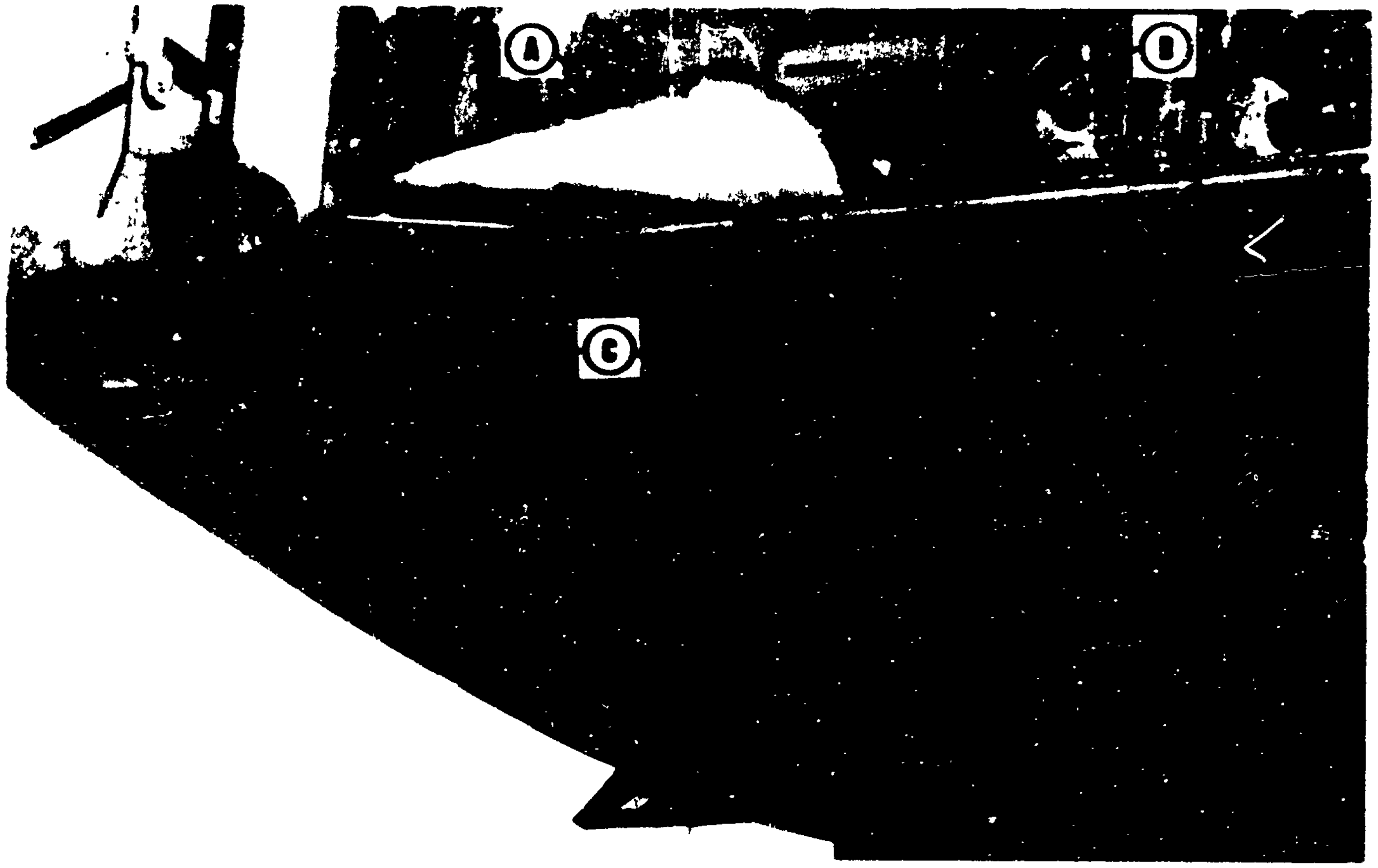


Figure 25. Rear of C-123 Cargo Ramp, Showing (A) Nozzle, (B) Cameras Used to Photograph Dissemination, and (C) Restraining Strips on Ramp Pad.

FILLING PROCEDURES (AGENT)

During the calibration runs, the filling procedures (agent) were evaluated. The following equipment was used for servicing of the A/A 45Y-2:

1. Gasoline-powered centrifugal pump.
2. Two sections of rubber hose, 20-ft and 50-ft.
3. Forklift, 6-ton capacity.
4. 500-gal recovery tank.

The 55-gal drums of agent were moved using the forklift and emptied into the 500-gal catch-tanks. Then the agent was pumped into the dispenser using the portable centrifugal pump. This method was used because the pump provided was not self-priming and therefore had to be primed often when attempting to transfer directly from the drums. Constant priming resulted in spillage and excessive servicing time. Using the recovery tank method, servicing required approximately one hour, 15 min of which were consumed removing and replacing the dispenser lids from the two tanks. During all agent servicing operations, the armament personnel wore protective rubber aprons, gloves, and boots. The empty agent drums were turned over to the base civil engineer for secure storage and subsequent destruction.

AGENT-GRID SPRAY FLIGHTS

On 20 May 1964 the first flight over the CB defoliant grid was made using fuel oil as a simulant. The purpose of this flight was to familiarize the air crew with the grid arrangement and provide CB laboratory personnel an opportunity to shakedown their collection and assessment procedures. Three passes were made at altitudes of 50, 150, and 500 ft. Agent spray flights began on 21 May and ended 13 June 1964. During this period, 53 passes were made across the grid, resulting in 159 sample lines of data. The flights were made in varying conditions as follows:

1. Altitude - 50, 150, 500, 750, 1000 ft.
2. Flight direction - inwind and crosswind.
3. Wind speed - up to 20 mph.

4. Flow rate - low, medium, high.

5. Airspeed - 130 KIAS (constant).

Since it is nearly impossible to obtain a truly inwind flight, crosswind components were accepted; however, the wind speed was on the order of 1-5 mph for these flights. Complete grid data appears chronologically in Supplement I. In order to present the capabilities of the A/A 45Y-2 dispenser, an attempt has been made to summarize this magnitude of data in a few small tables. It should be pointed out that these summaries are only indicators of the system's dispensing capability and should not be construed as firm, accurate values. The tables are presented in the appendices by altitude of dissemination, both inwind and crosswind. The material sprayed was the defoliant agent, ORANGE.

The latter portion of grid testing, 10-13 June 1964, was devoted to high-altitude dissemination aimability studies. Initial spray passes were made from altitudes of up to 2000 ft, disseminating fuel oil as a simulant. Later flights were made disseminating agent from altitudes of up to 1000 ft. The system flow rate was set at approximately 600 gpm to compensate for the higher delivery altitude. It was found that disseminations above 500 ft are not feasible due to the poor aimability of this technique. Even with known meteorological conditions, the travel of the agent could not be predicted due to wind shift and shear. These high-altitude missions concluded flight testing on 13 June 1964.

During testing conducted under APGC Project 5957W1, the test-bed aircraft was flown a total of 41 hr 5 min.

During the grid testing phase of this project a number of incompatibilities and deficiencies were noted concerning the A/A 45Y-2 dispenser. Listed in relative order of importance, they are:

1. Gross weight limitation. When the dispenser is filled with 1000 gal (10.7 lb/gal) of defoliant agent, ORANGE, the C-123 aircraft must be operated with a reduced fuel load to remain within aircraft design gross weight limitations. The total weight of the filled dispenser (two modules) is approximately 16,000 lb. This payload restricts the aircraft fuel load to 1,950 lb (Table I), or 1 hr 15 min flying time, or a radius of action of approximately 50 nm. This limited duration did not affect the conduct of grid testing since the test pilots would reduce power to a maximum endurance setting during the interval between spray passes (approximately 20 min). The agent-empty weight of the dispenser ratio is 1.983:1.

2. Aircraft Contamination. Extensive aircraft contamination

TABLE I. C-123 WEIGHT AND BALANCE DATA. (A/A 45Y-2 Dispenser [two modules] Filled with 1000 gal of Defoliant Agent, ORANGE.)

Item	Weight (lb)
Basic Aircraft Weight	34,332
Oil (80 gal)	600
Fuel	1,950
ADI Fluid	210
Aircrew (3)	600
Test Item and Miscellaneous Equipment	16,870
Total	54,562
Correction:	
Fuel Burn-Off During Taxi and Runup	562
Maximum Gross Weight (Standard Day)	54,000

occurred during spray flights due to the "rooster-tailing" effect induced by the airflow around the fuselage. Contamination was measured by placing Kromekote cards at selected positions on the underside of the fuselage and tail surfaces as shown in Figs. 26 and 27. Deposition on the cards was assessed by APGC M&O Contract personnel and is presented in Fig. 27. Fig. 26 also shows the effect of the defoliant agent on the fiberglass tail cone. Agent contamination also caused deterioration of the paint on the underside of the aft fuselage, as shown in Fig. 28.

3. Flexible Ducting. The flexible flow ducts showed evidence of internal deterioration at the completion of testing (Fig. 29). The exact cause of this deterioration is unknown, but it was probably due to the deleterious effect of the agent as well as the pressure forces exerted on the walls of the duct by the surging liquid agent. External deterioration occurred due to the abrasive action incurred when the ducts were dragged across the aircraft floor during extension and retraction of the nozzles. The original duct length was 173 in. The ducts were measured after the grid flights were completed and the left and right ducts had stretched to 177.5 and 179.5 in., respectively. The final ducts used were bonded to the clamp at the inlet end and glued to the nozzle end. These ducts deteriorated to an unusable condition after approximately one hour of "switch on" time.

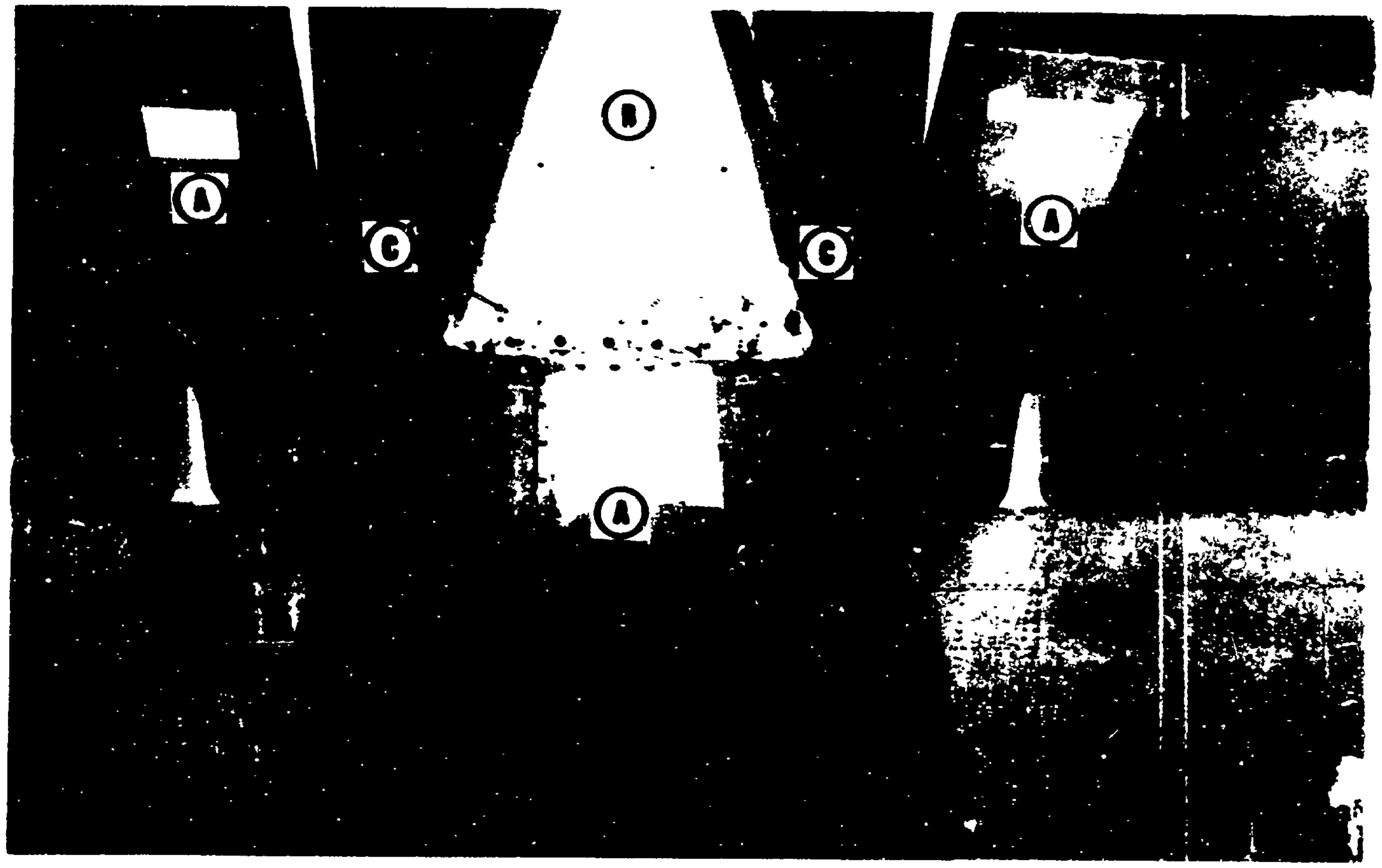
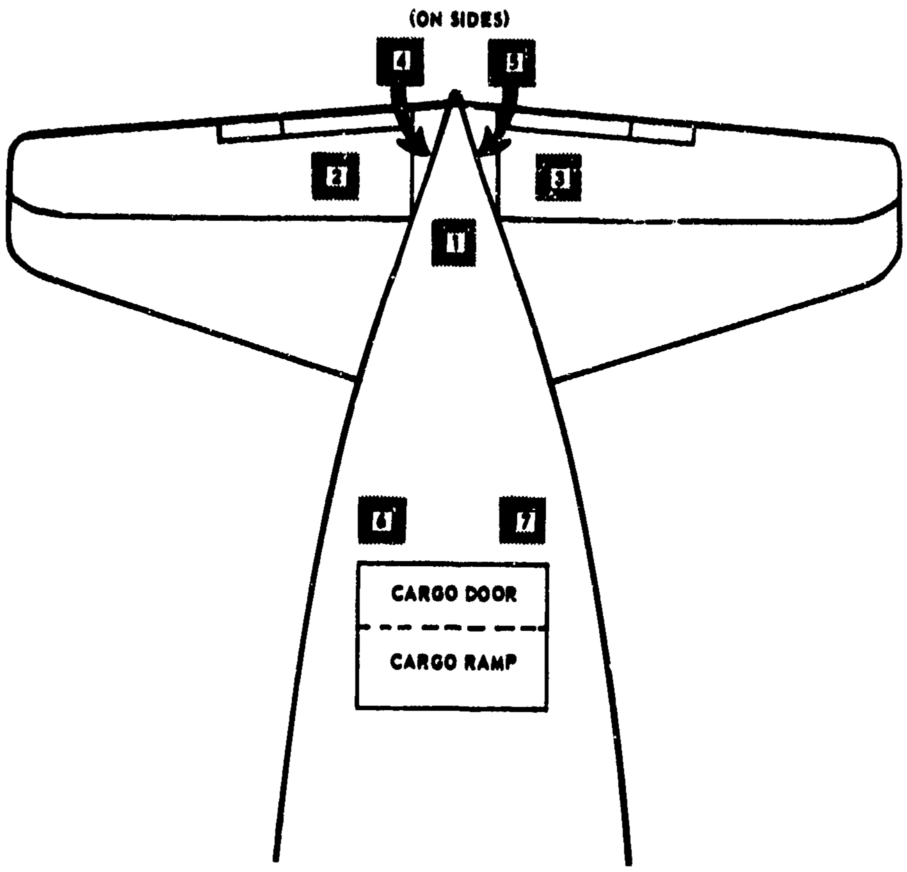


Figure 26. Underside of the Fuselage/Tail Surfaces of the C-123, Showing (A) Locations of the Kromekote Cards, (B) Fiberglass Tail Cone, and (C) Some of the Evidences of Contamination and Deterioration of the Paint.



The cards located above were assessed by the APGC M & O Contractor as follow:

STATION NO.	GPA (approximately)
1	10
2	5
3	5
4	10
5	8
6	0.1
7	0.1

Figure 27. Drawing of Underside of the C-123 Showing Kromekote Card Stations.

Figure 28. C-123 Cargo Door Showing Peeled Paint Due to Action of Defoliant Agent.

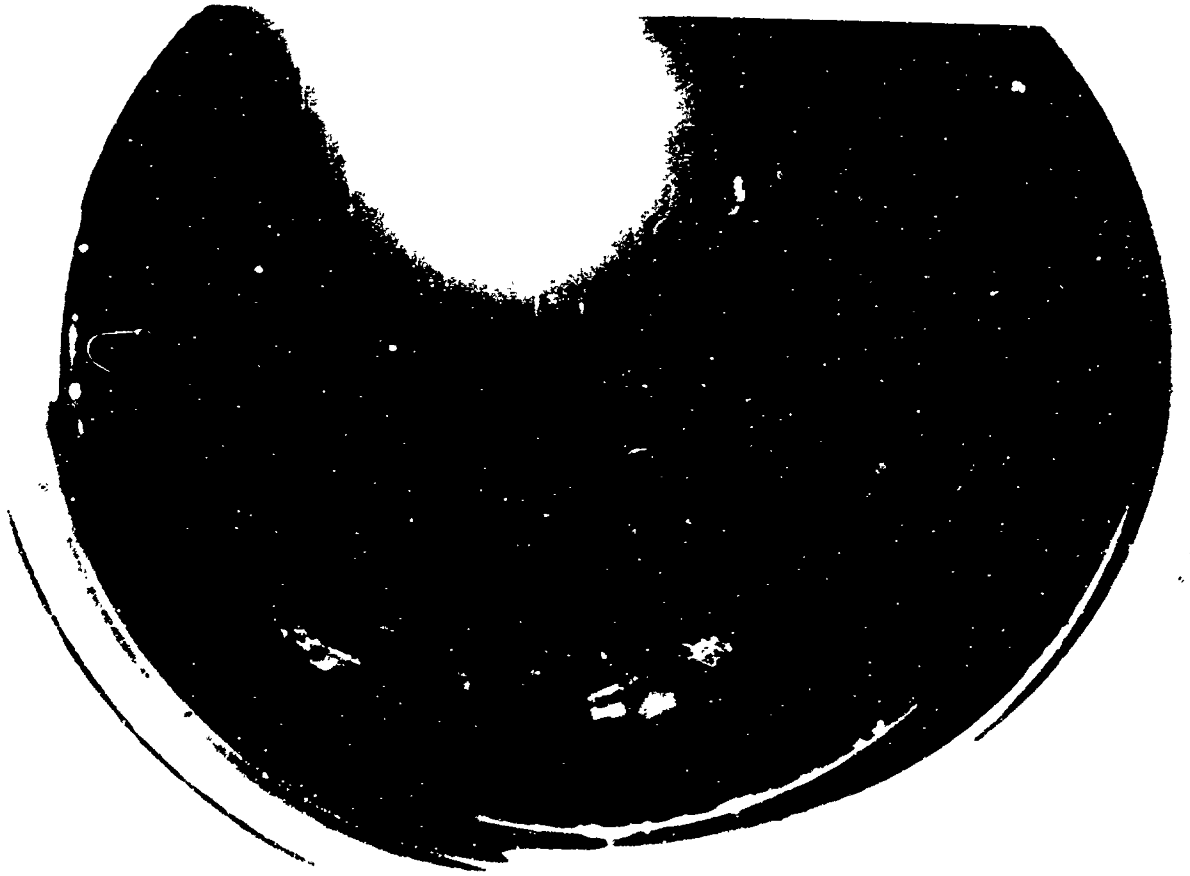


Figure 29. A/A 45Y-2 Flow Duct Showing Internal Deterioration.

4. Nozzle Design. The airfoil-shaped nozzles used did not extend far enough out from the fuselage to preclude contamination of the aircraft. Flaps were lowered (20°) during trail-off on one mission in an attempt to eliminate contamination. As flaps were lowered, the "rooster-tail" progressed from the rear of the tail to the cargo door, aggravating rather than eliminating the contamination.

The original neoprene gasket (Fig. 30) was unsatisfactory due to deterioration, presumably caused by the agent, and subsequent distortion. The first seven grid passes were made using these gaskets, after which 1/8-in. teflon gaskets were substituted. The teflon gaskets were satisfactory during the remainder of the tests.

When using the nozzle plate with a 24-in.-slot width, it was found that the plate distorted under pressure of the fluid and resulted in

Figure 30. Nozzle Gaskets, Showing Distortion of Neoprene Material Due to the Effect of the Agent.

unacceptable variations in flow rate. Therefore, the 24-in.-slot plate was discarded and the 8.5-in.-slot plate modified to provide the required higher flow rate of 300 gpm.

The test pilots noted a slight aircraft buffeting when the nozzles were extended. The drag produced by the extended nozzles and lowered cargo ramp reduced cruising airspeed by approximately 8 KIAS.

5. Safety. Some safety factors noted during testing were:

a. The position of the extended nozzle precluded installation of the ramp support scissors. These scissors are a safety device to insure that, in the event of hydraulic failure, the cargo ramp will not drop any lower than horizontal.

b. The cramped quarters and passageways in the cargo compartment of the C-123 produced by installation of the A/A 45Y-2 necessitates use of the bailout hatch in the forward end of the compartment in the event of emergency bailout.

c. There is no manual method to quickly dump the agent load during an inflight emergency condition.

6. Aircraft Fit.

a. As mentioned earlier, installation of the A/A 45Y-2 denies access to the aircraft battery compartment.

b. It is also difficult to gain access to the voltage regulator compartment, located on the left side on cargo compartment.

c. In order to operate the nozzle extension and retraction assembly, the cargo ramp pad (Fig. 25), must be secured to prevent interference during flight.

7. Trail-off Time. The A/A 45Y-2 dispenser has an undesirable trail-off feature in that after each functioning of the system approximately 80 gal of defoliant agent dribbles from the nozzle. The time for this trail-off will vary according to the nozzle slot area. During grid testing, the time to empty the ducts varied from 4.5 to 10 min, depending on nozzle opening.

SUMMARY

This test was unusual for the following reasons:

1. Dissemination was attempted from relatively high altitudes (up to 1000 ft).

2. New, rapid assessment techniques allowed multiple-line sampling, and as a result, a new grid was constructed to permit comprehensive crosswind testing.

3. The nozzle used for dissemination was of unusual design, featuring a large slot rather than the boom/small-nozzle arrangement normally associated with spraying.

4. The meteorological data used was gathered by means other than those employed on earlier spray tests. Pilot balloons, augmented by two Jalbert captive balloons were used to determine weather data. The pilot balloons provided more useful information in that the reduced data illustrated the average wind effect on the spray droplets from dissemination altitude to the surface.

5. Disseminations were made under less stringent wind restrictions. It was found that depositions could be efficiently controlled from a spray altitude of 500 ft with effective crosswind velocities of up to 15 mph. However, the combined effect of higher altitude releases (500 to 1000 ft) and the inherent variable wind conditions, made it difficult for experienced spray pilots to judge their release points in order to hit the 2000 ft square grid. Thus, even with accurate meteorological data, high-altitude dissemination with the defoliant agent did not prove feasible for the Eglin AFB test situation. Since the A/A 45Y-2 dispenser was designed primarily for high-altitude (2000 ft)/high-flow-rate (6000 gpm) operation, this test item was not tested to its maximum capability.

It had been anticipated that high-altitude/high-wind-velocity crosswind flights would result in a more uniform spray deposition by reducing the peak concentration expected with agent spray flights using tail-mounted nozzles. This did occur to a certain extent on some passes, but to have a predictable effect on these peak concentrations, the meteorological conditions must be perfect. That is:

1. The wind velocity must not be too high so as to spread the spray too thinly over the target area.

2. There must be a strong inversion to reduce the possibility of convection effects and possible drift.

An increase in dissemination altitude requires a commensurate increase in flow rate to produce a given concentration on the ground, all other things being equal. The swath widths and reduced area coverage (Appendices II and III) illustrate that, within the parameters selected for this test, defoliant spraying becomes less efficient at higher altitudes and flow rates.

Aerial delivery of defoliant agent is affected by many variables. e.g., release altitude, airspeed, flow rate, nozzle configuration, etc. Although the number of variables was held to a minimum, there is one variable which cannot be controlled: the meteorological condition. Therefore, each pass differed from the others. The tables presented in Appendices II and III give a summary of swath widths and projected area coverage associated with these data. These values for swath width were derived by taking the mean of the three deposition lines sampled on each pass. Further, this mean was not taken station-by-station on the respective lines. The characteristic concentration peaks were shifted (Fig. 31) to allow for variation in flight path across the grid, and then the mean was taken. In the interest of simplicity, this liberty is taken to give an idea of the approximate swath widths experienced during testing of the A/A 45Y-2 dispenser.

The programmed high flow rate of 600 gpm, for dissemination altitudes below 500 ft, was deleted after two grid missions because of the excessive variation in flow rate using this nozzle configuration. This variation ranged from 10% to 35% above the required flow rate. A medium flow rate of 300 gpm was substituted. The spray passes scheduled to be flown at the dissemination altitude of 50 ft and flow rate of 600 gpm, and later 300 gpm, were deleted because of the inability of the APGC M&O Contractor to assess the high depositions involved. These peak depositions exceeded 10 gpa, which was the upper limit of the assessment technique employed.

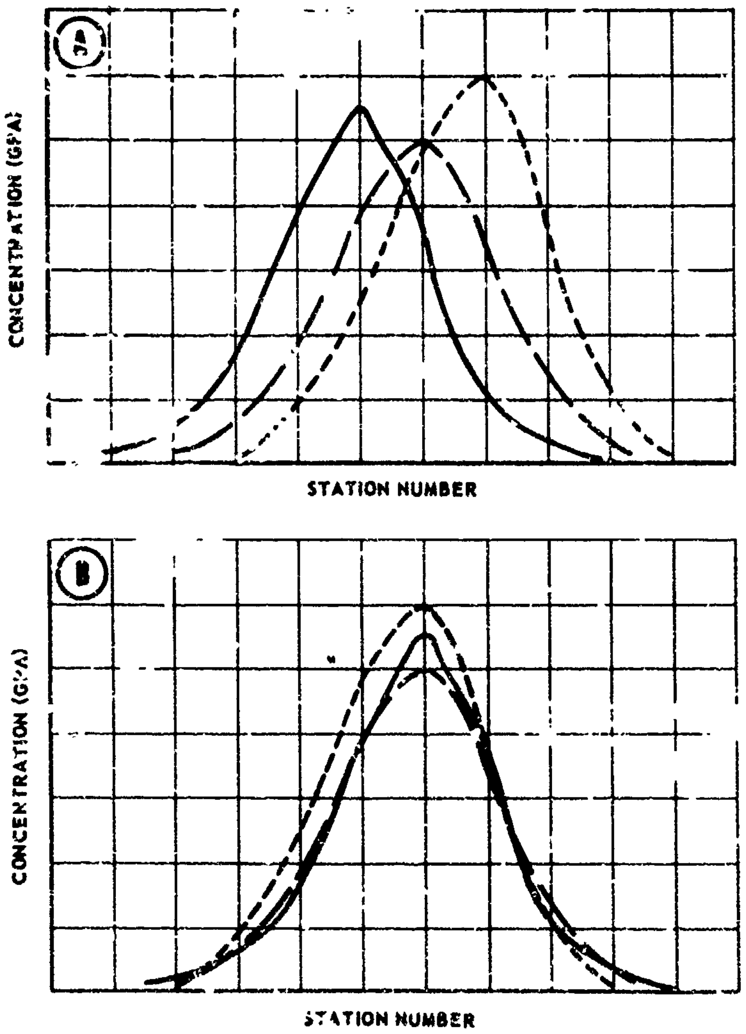


Figure 31. (A) Typical Graph of Deposition Versus Sample Stations. (B) Typical Graph of Deposition Versus Sample Stations After Normalizing Peaks

SECTION VI

CONCLUSIONS

1. Evaluation of the compatibility of the A/A 45Y-2 dispenser with the C-123 aircraft yielded the following results:

a. The installation and servicing of the A/A 45Y-2 dispenser is simple, requiring no special tools and approximately 10 man-hours.

b. The contractor's installation and operational instructions are satisfactory.

c. Operation of the system inflight produces a slight aircraft buffet and a reduction in airspeed of [illegible] KIAS.

d. Inflight operation of the A/A 45Y-2 negates the use of the ramp support scissors and requires tie-down of the cargo ramp pad.

e. Heavy contamination occurs on the aft fuselage and tail surfaces during spray dissemination.

f. The operation of the A/A 45Y-2 dispenser requires constant attention and monitoring by the operator in the cargo compartment. (Throughout the flight testing phase of this project, the second-stage regulator on the left module leaked air which pressurized the storage tank above the desired pressure.)

g. The system regulators have an excessive recovery time after turn-on, which makes it difficult to spray specific targets, such as the defoliant grid.

h. After the shut-off valve is closed, there still remains approximately 88 gal of agent, downstream of the valve, which trails-off for 4.5-10 min.

i. The fully-serviced (1000 gal) A/A 45Y-2 dispenser restricts the allowable aircraft fuel load, reducing the operational radius of the C-123 to approximately 50 nm.

j. The location of the A/A 45Y-2 precludes access to the aircraft battery compartment. (Technical Orders require a weekly inspection.)

k. Installation of the A/A 45Y-2 in the C-123 poses the following safety problems:

(1) Egress System. The position of the spray tank in the cargo compartment restricts movement of personnel due to small clearances. In the event of a bailout situation, all personnel forward of the spray tanks would have to leave the aircraft by means of the bailout hatch in the floor at the forward end of the cargo compartment.

(2) High-Pressure System. During testing, the adequacy of the contractor's safety measures associated with the high-pressure (3000 psi) lines was questioned. The pressure-line system did not conform to appropriate military specifications with regard to suggested spacing of tie-downs. This spacing varies with line diameter and pressure sustained within the line. The contractor felt that arbitrarily-spaced tie-downs could create a hazardous situation and, therefore, suggested that the high-pressure lines be observed during engine run-up, taxi, and flight to determine the requirement for additional and/or movement of, tie-downs. The line system was observed during the above operations and deemed to be adequately secured with no evidence of abnormal vibration.

2. The C-123:A/A 45Y-2 defoliant dispenser system is not capable of delivering defoliant coverage of three gallons per acre over one-half square mile. The limiting factor is the narrow swath width at this minimum concentration level. The maximum computed area coverage at this minimum concentration level was 0.212 sq mi. (MMD-400 microns).

3. High altitude (>500 ft) delivery techniques proved not feasible due to the lack of aimability of the disseminated cloud.

RECOMMENDATIONS

APGC Recommends:

GENERAL

The A/A 45Y-2 disperser should be redesigned to eliminate the [illegible] bilities of excessive [illegible], aircraft contamination, interference with aircraft [illegible]ments, and reduced area coverage.

SPECIFIC

1. The high-pressure air system capacity should be reduced since depletion of the fluid supply, at storage tank pressure of 20 psi, required approximately one-third of the total pressure available. This would require substitution of step-down pressure regulators of lower operating ranges. This reduction in system capacity would mean a reduction in total weight since some of the air storage bottles could be eliminated from each module.

2. The size of some of the hardware associated with the disperser should be reduced, thereby resulting in a further reduction in gross weight, specifically:

a. Pressure relief valve on the rear of the storage tanks.

Det 4, RTD Comments:

A redesign of [illegible] system is necessary to provide an effective defoliation system utilizing this concept; however, development funds for such an effort are not available. Until such time as funds are made available, this organization will pursue an in-house [illegible] of the system.

(1 through 2). These items will be included in any further effort to redesign the system.

b. Fluid shut-off valve and fluid flow duct.

c. Filler neck lid.

d. Tank supporting structure (height and length).

3. The nozzle configuration should be redesigned to eliminate the aircraft contamination and trail-off problems, and increase the swath widths at minimum concentration of 1.5 gpa and above.

4. The A/A 45Y-2 should be modified to provide an in-flight flow rate control capability, including a flowmeter and indicator, to allow for changes in viscosity/flow rate of fluid and to provide operational flexibility.

5. The flexible fluid ducts should be reduced in size and fabricated of a more substantial material, particularly if the retractable nozzle feature is retained.

6. A manually-controlled emergency fluid-dump valve, controlled from the cockpit, should be installed..

7. Control of the fluid flow valve should be remoted to the cockpit to reduce the possibility of inadvertent dissemination.

8. Further vibration studies should be conducted on the high-pressure air system to determine resonant vibration frequencies which might rupture the high-pressure line.

9. To eliminate the possibility of personnel injury and aircraft damage due to severance of these high-pressure lines by ground fire, a safety shield should be installed around the lines.	
10. A study should be initiated to determine a spectrum of possible agents which could be disseminated from the A/A 45Y-2. Since the projected area coverage of the A/A 45Y-2 at lower concentration levels is fairly good (Appendix V), more potent agents could be employed.	10. A study of this type is a continuous effort pursued both in-house by Det 4 and by US Army Biological Laboratories at Ft. Detrick, Maryland.

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APPENDIX I

TEST PILOT'S CRITIQUE OF THE C-123;A/A 45Y-2 SYSTEM

As pilots of the C-123 aircraft we feel that this system would be very limited in its application to aerial spray missions in all areas such as Viet Nam. We are not thoroughly clear as to the expected capabilities of the system, but defoliation of a large area was mentioned. We feel that a high flow rate from all altitudes between 500 and 1000 feet would attain satisfactory results with a good crosswind. We have found from our experience in defoliating in Viet Nam that it takes approximately three gallons per acre applied in two equal segments (1½ gallons per acre each time) with about a 10 day waiting period between sprays to attain desired kill. This allows the first application to kill the dense cover layer of jungle foliage opening up the bottom layer for a successive application.

This system can give the high flow rate desired, but the weight of the system itself and the restricted agent load (1000 gallons) pretty well nullify any desirable results. The weight of the system and weight of defoliant (1000 gallons) allow only 2,000 pounds of fuel, which limits the total flying time of the aircraft to approximately one hour and fifteen minutes, which would give an effective range of approximately 50 nautical miles from the departure point. The majority of our targets in Viet Nam were from 100 to 180 nautical miles from the departure point and our fuel requirement was 5000 pounds.

This system if used for standard spraying of roads and canals, etc., from 150 feet would be far inferior to our present system which delivers 1½ gallons per acre in a 300-foot swath for approximately 12 miles. A system giving three gallons per acre in a 300 foot swath would be very desirable in the low mangrove foliage of the Mekong delta where the enemy concentration is high and ground fire is a definite hazard on the second trip back to a spray area. This low mangrove can be very effectively killed with one application of three gallons per acre, whereas the deep jungle growth of the rest of the country takes two separate applications.

Two other comments on the system are the bulkiness in the C-123 where access to important electrical apparatus in the area adjacent to the system is made impossible, without the removal of the system. Also, any emergency dump capability and a method of cockpit control of the system would be very desirable. Since the pilot is responsible for what he defoliates, we feel that a cockpit control would be necessary.

/s/ Alan R. Kidd, Jr.	/s/ John W. Honnicutt
ALAN R. KIDD, JR.	JOHN W. HONNICUTT
Capt, USAF	Capt, USAF

APPENDIX II

SWATH WIDTH SUMMARY

The following is a tabular presentation of the swath widths determined by analysis of the mean deposition plots presented in Supplement I of this report. The data are presented chronologically by altitude of dissemination.

The altitude-crosswind component product is determined by multiplying the dissemination altitude by the crosswind component of the average wind vector experienced during the spray pass. Correlation of the effect of this parameter on deposition characteristics is being made with effects experienced during testing conducted under APGC Project 2525W5, Development Test of the Hayes Chemical Spray System, Internal and the Advanced Research Projects Agency-sponsored defoliation tests conducted at Eglin during the summers of 1962 and 1963. The latter project is described in Technical Report Number 46, United States Army Biological Laboratories, Fort Detrick, Maryland.[2] The results of this correlation will be published at a later date.

Date 1954	Pass	Altitude (ft	Flow Rate (gpm	Type of Pass	Altitude-Crosswind Component Product (mph	Mean Swath Widths (ft At Indicated Dispersion Levels (gpa		
						0.5	1.5	3.0
27 May	2 3 4	50 50 50	182 182 182	Crosswind Crosswind Crosswind	450 400 500	90 140 120	60 75 90	25 60 60
28 May	–	50	181	Crosswind	490	215	65	55
29 May	3	50	185	Crosswind	575	740	75	55
12 June	1	50	152	Crosswind	375	90	60	30
21 May	3 4	150 150	150 150	Crosswind Crosswind	770 300	100 110	45 20	— —
22 May	1	150	150	Crosswind	740	220	40	—
25 May	1 2	150 150	* *	Inwind Inwind	150 —	80 90	45 60	20 35
27 May	1	150	182	Crosswind	1650	635	140	20
28 May	2 3	150 150	180 180	Crosswind Crosswind	1950 1365	880 160	— 80	— —
29 May	1	150	185	Inwind	—	155	105	65
1 June	2	150	185	Crosswind	410	140	80	60
2 June	2	150	155	Inwind	650	155	110	70
4 June	1 3	150 150	650 650	Crosswind Crosswind	1230 660	275 300	185 170	145 130
5 June	2 3	150 150	600 500	Crosswind Crosswind	770 1495	270 335	150 190	110 140
8 June	1 4	150 150	336 336	Crosswind Crosswind	725 455	230 275	120 120	90 80
9 June	1 2	150 150	324 324	Inwind Inwind	305 —	160 175	110 130	80 60
[illegible] June	[illegible]	15[illegible]	[illegible]	[illegible]	[illegible]	225	145	110
11 May	1 2	500 500	150 150	Crosswind Crosswind	4550 2[illegible]	— 750	— —	— —
28 May	1	500	15[illegible]	Crosswind	6100	1040	220	—
29 May	1	500	185	Inwind	—	240	60	—

28 May	1	500	180	Crosswind	6100	1040	220	—
29 May	2	500	185	Inwind	—	240	60	—
27 May	1	150	182	Crosswind	1650	635	140	20
28 May	2 3	150 150	180 180	Crosswind Crosswind	1950 1365	880 160	— 80	— —

27 May	1	150	152	Crosswind	1650	695	140	20
28 May	1 3	150 150	160 160	Crosswind Crosswind	1950 1365	560 160	— 50	— —
29 May	1	150	185	Inwind	—	155	125	65
1 June	2	150	185	Crosswind	410	140	80	60
2 June	2	150	185	Inwind	850	155	110	70
4 June	1 3	150 150	630 630	Crosswind Crosswind	1230 660	275 300	185 170	145 130
5 June	2 3	150 150	800 800	Crosswind Crosswind	970 1495	270 335	150 190	110 140
8 June	1 4	150 150	336 336	Crosswind Crosswind	705 255	230 275	120 120	90 90
9 June	1 2	150 150	324 324	Inwind Inwind	318 —	160 175	110 130	50 60
10 June	3	150	321	Inwind	647	225	145	100
21 May	1 2	500 500	150 150	Crosswind Crosswind	4860 2350	— 780	— —	— —
28 May	1	500	160	Crosswind	6100	1040	220	—
29 May	2	500	185	Inwind	—	240	60	—
1 June	1	500	185	Crosswind	1950	295	110	—
2 June	1	500	185	Inwind	—	695	150	—
4 June	2	500	630	Crosswind	4225	1100	100	—
5 June	1	500	800	Crosswind	4410	840	310	—
8 June	2** 3	500 500	336 336	Crosswind Crosswind	3320 1435	210 465	110 190	60 120
9 June	3 4	500 500	324 324	Crosswind Inwind	950 —	170 200	110 135	75 90
10 June	1 2	500 500	321 321	Crosswind Crosswind	5600 4920	140 420	— —	— —
11 June	2 3	500 500	152 152	Crosswind Crosswind	4380 4810	140 600	— —	— —
13 June	1 3 4	750 750 750	670 670 670	Crosswind Inwind Inwind	4000 645 —	490 320 —	260 190 —	150 145 —
13 June	2	1000	670	Inwind	400	250	180	120

* Unknown Flow Rate - Nozzle gasket failures.

** Spray deposition was maximum at Station 1, beneath aircraft.

APPENDIX III

AREA COVERAGE SUMMARY

Area coverage is derived by determining the length of a given swath for various conditions of airspeed and flow rate and multiplying the swath width by this distance.

Therefore,

$$A = \frac{P}{F} \times V \times S .$$

where

A = Area coverage (sq ft)

P = Agent payload (gal)

F = Flow rate (gal/min)

V = Airspeed (ft/min)

S = Swath width (ft)

Dividing by $1/(5280)^2$ yields area in square miles: therefore

$$A = \frac{1}{(5280)^2} \times \frac{(P)(V)(S)}{(F)}.$$

Since, for these tests

P = 1000 gal

V = 150 mph = 13,200 ft/min

$$A = \frac{1}{(5280)^2} \times \frac{(1000)(13{,}200)(S)}{(F)}$$

which reduces to

$$A = .473 \frac{S}{F}.$$

This area coverage data represents maximum values, since they were computed assuming a constant flow rather than "burst-type" dissemination, which would be less efficient due to amount of agent (88 gal) lost during trail-off.

AREA COVERAGE SUMMARY

Indicated Minimum Deposition Level (GPA)						0.5	1.5	3.0
Date (1964)	Pass	Altitude (ft)	Flow Rate (gpa)	Type of Pass	Altitude-Crosswind Component Product (ft/min)	Area Coverage (sq mi)		
27 May	2 3 4	50 50 50	182 182 182	Crosswind Crosswind Crosswind	430 400 300	0.234 0.364 0.312	0.156 0.195 0.234	0.065 0.156 0.156
28 May	4	50	180	Crosswind	490	0.565	0.171	0.145
29 May	3	50	185	Crosswind	575	1.890	0.1915	0.1405
11 June	1	50	152	Crosswind	375	0.280	0.1860	0.0935
21 May	3 4	150 150	150 150	Crosswind Crosswind	770 900	0.315 0.347	0.142 0.0631	— —
22 May	1	150	150	Crosswind	[illegible]40	0.694	0.126	—
25 May	1 2	150 150	* *	Inwind Inwind	150 —	Not Calculated		
27 May	1	150	182	Crosswind	1650	1.650	0.364	.052
28 May	2 3	150 150	180 180	Crosswind Crosswind	1950 1365	2.310 0.420	— 0.210	— —
29 May	1	150	185	Inwind	—	0.396	0.269	0.212
1 June	2	150	185	Crosswind	410	0.358	0.204	0.153
2 June	2	150	185	Inwind	830	0.306	0.281	0.179
4 June	1 3	150 150	630 630	Crosswind Crosswind	1230 680	0.207 0.226	0.130 0.128	0.109 0.0825
5 June	2 3	150 150	800 800	Crosswind Crosswind	970 1495	0.1595 0.198	0.090 0.1125	0.065 0.0828
8 June	1 4	150 150	336 336	Crosswind Crosswind	705 255	0.324 0.387	0.169 0.169	0.127 0.1125
9 June	1 2	150 150	324 324	Inwind Inwind	308 —	0.234 0.256	0.161 0.190	0.117 0.117
10 June	3	150	321	Inwind	297	0.331	0.214	0.1475
21 May	1 2	500 500	150 150	Crosswind Crosswind	4880 2350	- No 2.460	Plot —	- —

10 June	3	150	321	Inwind	297	0.331	0.214	0.1475
21 May	1 2	500 500	150 150	Crosswind Crosswind	4880 2350	- No 2.460	Plot —	- —
21 May	1 2	500 500	150 150	Crosswind Crosswind	4880 2350	- No 2.460	Plot —	- —

[illegible] May	[illegible]	150	162	Crosswind	1650	[illegible]	0.384	.052
[illegible] May	 3	150 150	[illegible] 180	Crosswind Crosswind	1955 1305	[illegible] 0.420	— 0.210	— —
29 May	1	150	185	Inwind	—	0.395	0.269	0.212
1 June	[illegible]	150	185	Crosswind	410	0.358	0.264	0.153
2 June	2	150	185	Inwind	650	0.396	0.281	0.179
4 June	1 3	150 150	630 630	Crosswind Crosswind	1230 680	0.207 0.226	0.139 0.128	0.109 0.0825
5 June	2 3	150 150	800 800	Crosswind Crosswind	970 1495	0.1595 0.198	0.090 0.1125	0.065 0.0828
8 June	1 4	150 150	336 336	Crosswind Crosswind	705 255	0.324 0.387	0.169 0.169	0.127 0.1125
9 June	1 2	150 150	324 324	Inwind Inwind	308 —	0.234 0.256	0.161 0.190	0.117 0.117
10 June	3	150	321	Inwind	297	0.331	0.214	0.1475
21 May	1 2	500 500	150 150	Crosswind Crosswind	4880 2350	- No 2.460	Plot —	- —
28 May	1	500	180	Crosswind	6100	2.740	0.0577	—
29 May	2	500	185	Inwind	—	0.614	0.153	—
[illegible] June	1	500	185	Crosswind	1950	0.755	0.282	—
2 June	2	500	185	Inwind	—	1.780	0.384	—
4 June	2	500	630	Crosswind	4225	0.825	0.075	—
5 June	1	500	800	Crosswind	4410	0.497	0.183	—
8 June	2 * 3	500 500	336 336	Crosswind Crosswind	3320 1425	0.296 0.655	0.155 0.267	0.0845 0.169
9 June	3 4	500 500	324 324	Crosswind Inwind	950 —	0.248 0.292	0.161 0.197	0.119 0.1315
10 June	1 2	500 500	321 321	Crosswind Crosswind	5600 4920	0.206 0.620	— —	— —
11 June	2 3	500 500	152 152	Crosswind Crosswind	4380 4810	0.435 1.870	— —	— —
13 June	1 3 4	750 750 750	670 670 670	Crosswind Inwind Inwind	4000 645 —	0.346 0.226 - No	0.1835 0.1345 Plot	0.106 0.104 -
[illegible] June	2	1000	670	Inwind	400	0.177	0.127	0.0846

* Unknown Flow Rate - Nozzle gasket failures.

** Spray deposition was maximum at Station 1, beneath aircraft, no upwind sample.

APPENDIX IV

MMD AND PERCENT RECOVERY SUMMARY

MASS MEDIAN DIAMETER

The average mass median diameter for each pass is shown in the attached tables. These means were computed by averaging the three MMD values measured on the three sample lines on each pass. The tables are arranged according to delivery altitude. Due to the large spots experienced during grid testing of the A/A45Y-2 dispenser, APGC M&O Contractor's laboratory personnel extrapolated the required spread factor from existing data to determine the proper MMD. Also, when the sample card received a heavy agent dosage, it was impossible to determine the five largest droplets. Therefore, MMD was based on the five largest droplets discernible. These extrapolated and minimum limiting values are noted as follows:

* Extrapolated value

\+ Minimum limiting value

X Extrapolated, minimum limiting value.

For a given flow rate, height of dissemination did not seem to influence the magnitude of the MMD. Therefore, for these tests, since airspeed was held constant at 150 mph, the MMD varied directly with flow rate.

PERCENT RECOVERY

Percent recovery is defined as the ratio of amount of agent recovered during a spray pass to the amount disseminated during that pass. This value is determined by the following formula:

$$\% \text{ recovery} = \frac{.202 \times S \times D \times I}{F}$$

where

.00202 is a constant representing the portion of an acre covered in one minute at one mile per hour with a swath of one foot. Multiplied by 100 to convert to percentage, the constant becomes .202.

S = Speed of the disseminating aircraft (mph)

D = Total deposit collected on one sample line (gpa)

I = Interval between sample stations (ft)

F = Flow rate of agent (gpm).

NOTE: At times, the percent recovery values may exceed 100%. This can occur due to turbulent air or wind shifts which would distrub the assumed uniform distribution.

MMD AND PERCENT RECOVERY SUMMARY

Date (1964)	Pass	Altitude (ft)	Flow Rate (gpm)	Mean MMD	Recovery (%)
27 May	2 3 4	50 50 50	182 182 182	276+ 350+ 331+	41.8 73.0 78.8
28 May	4	50	180	284	101.0
29 May	3	50	185	337+	166.0
11 June	1	50	152	243+	48.2
21 May	3 4	150 150	150 150	365 363	47.5 34.6
22 May	1	150	150	[illegible]73	56.3
25 May	1 2	150 150	? ?	298+ [illegible]21+	40.8 65.0
27 May	1	150	182	299+	124.3
28 May	2 3	150 150	180 180	387 403	107.7 112.0
29 May	1	150	135	276+	97.0
1 June	[illegible]	150	185	404	77.7
2 June		150	185	381	81.2
4 June	1 3	150 150	630 630	516 553	70.8 [illegible]
5 June	 3	150 150	800 800	486 [illegible]	36.9 [illegible]
[illegible] June	3 4	150 150	336 336	[illegible]* [illegible]13x	79.[illegible] 65.0
9 June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	514	48.6
8 June	1 4	150 150	336 336	164* 413x	79.6 65.0
9 June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

| 29 May | 1 | 150 | [illegible]5 | 276+ | 97.0 |

29 May	2	150	185	[illegible]	[illegible]
1 June	2	150	185	404	77.7
2 June	[illegible]	150	185	381	51.2
4 Jun	1 3	150 150	630 630	516 553	70.0 62.4
5 June	2 3	150 150	800 800	466 514	36.9 48.6
8 June	1 4	150 150	336 336	464* 413x	79.6 65.0
9 June	1 2	150 150	324 324	352x 406x	51.2 59.8
10 June	3	150	321	457x	68.2
21 May	1 2	500 500	150 150	361 355	204.0 [illegible]
28 May	1	500	180	385	182.0
29 May	2	500	185	453+	67.4
1 June	1	500	185	440	77.7
2 June	1	500	185	[illegible]	127.6
4 June	2	500	630	535	54.5
5 June	1	500	800	520	44.5
8 June	2 3	500 500	336 336	298 531	37.2 87.3
9 June	3 4	500 500	324 324	444x 411x	57.8 52.2
10 June	1 2	500 500	321 321	487x 461*	24.3 36.8
11 June	2 3	500 500	152 152	404* 412*	66.5 132.5
13 June	1 3	750 750	670 670	491x 484x	56.5 60.2
15 June	2	1000	670	390x	47.8

\+ Minimum limiting value. x Extrapolated, minimum limiting value
* Extrapolated value

APPENDIX V

CALIBRATION PROCEDURES AND DATA

Measurement of Flow Rate of Pressurized Spray System, 25 May 1964

These tests include manual adjustment of spray nozzles and time measurements to determine rate of flow.

The spill tanks used to catch the solution known as ORANGE were measured and calculated for U.S. gallons per foot. The solution was timed from the instant of flow until the lines were cleared by the second blast of air. A stop watch was used to time the flow of liquid.

The nozzle sizes were varied to flow 150, 300 and 600 gpm when both nozzles were discharging.

The following data were taken at hardstand No. 10. Because of spillage and blowing vapors, it is estimated that the loss is within -1 to -5 U.S. gallons.

Data

Starboard Spill Tank:
Diameter 65 1/4 in.
Height 36 in.

Port Tank:
Diameter 65 1/4 in.
Height 36 in.

Diameter: 5.4375 ft

1 cu ft = 7.481 U.S. gal

$$\frac{\pi D^2}{4} \times 7.481 = \text{gal/ft of height}$$

$$\frac{3.1416 \times (5.4375)^2}{4} \times 7.481 = 173.78 \text{ gal/ft}$$

(1)

Pre-Test Runs

Friday, 8 May 64

Port Tank Run No. 1: Water Solution
PSI: 18 No. 2 Regulator: 50
Time: 3.315 min.
Spill Tank: 2.79 ft
Nozzle Size: 1.253 sq in.
Total Gal: 484.85
Flow Rate in gal/min: 146.26 Error: -.3 to -1.5 gal/min

Friday, 8 May 64

Starboard Tank Run No. 1: Solution ORANGE
PSI: 18 No. 2 Regulator: 50
Time: 1.102 min
Spill Tank: 2.5 ft
Nozzle Size: 2.4 sq in.
Total Gal: 434.45
Flow Rate in gal/min: 394.24 Error: -.9 to -4.5 gal/min

Test Data Port Tank

Run No. 1 Monday, 11 May 64

PSI: 19 No. 2 Regulator: 50
Time: 5.272 min
Spill Tank: 2.46 ft
Nozzle Size: 0.6142 sq in.
Total Gal: 427.50
Flow Rate in gal/min: 81.1 Error: -.19 to -.95 gal/min

Run No. 2 Tuesday, 12 May 64

PSI: 20 No. 2 Regulator: 55
Time: 6.017 min
Spill Tank: 2.41 ft
Nozzle Size: 0.6142 sq in.
Total Gal: 418.81
Flow Rate in gal/min: 69.6 Error: -.17 to -.85 gal/min

Run No. 5 Tuesday, 12 May 64

PSI: 20 No. 2 Regulator: 55
Time: 5.935 min
Spill Tank: 2.33 ft
Nozzle Size: 0.6142 sq in.
Total Gal: 404.9
Flow Rate in gal/min: 68.4 Error: -.15 to -.75 gal/min

Run No. 1 Tuesday, 12 May 64

PSI: 17 No. 2 Regulator: 50
Time: 1.102 min
Spill Tank: 2.42 ft
Nozzle Size: 2.40 sq in.
Total Gal: 420.55
Flow Rate in gal/min: 381.6 Error: -.91 to -4.55 gal/min

Run No. 2 Tuesday, 12 May 64

PSI: 16.5 No. 2 Regulator: 52
Time: 1.119 min
Spill Tank: 2.41 ft
Nozzle Size: 2.40 sq in.
Total Gal: 418.81
Flow Rate in gal/min: 374.3 Error: -.90 to -4.50 gal/min

Run No. 3 Tuesday, 12 May 64

PSI: 16 No. 2 Regulator: 52
Time: 1.204 min
Spill Tank: 2.44 ft
Nozzle Size: 2.4 sq in.
Total Gal: 424.02
Flow Rate in gal/min: 352.2 Error: -.84 to -4.20 gal/min

Run No. 1 Monday, 11 May 64

PSI: 18.5 No. 2 Regulator: 50
Time: 3.170 min
Spill Tank: 2.45 ft
Nozzle Size: 1.253 sq in.
Total Gal: 425.76
Flow Rate in gal/min: 134.31 Error: -.32 to -1.60 gal/min

Run No. 2 Monday, 11 May 64

PSI: 20 No. 2 Regulator: 50
Time: 3.026 min
Spill Tank: 2.51 ft
Nozzle Size: 1.253 sq in.
Total Gal: 436.19
Flow Rate in gal/min: 144.15 Error: -.33 to -1.65 gal/min

Run No. 3 Monday, 11 May 64

PSI: 19.5 No. 2 Regulator: 50
Time: 3.068 min
Spill Tank: 2.50 ft
Nozzle Size: 1.253 sq in.
Total Gal: 434.45
Flow Rate in gal/min: 141.61 Error: -.33 to -1.65 gal/min

Test Data Starboard Tank

Run No. 1 Monday, 11 May 64

PSI: 18.5 No. 2 Regulator: 50
(No Test 8 in. Flexline burst)
Nozzle Size: 1.253 sq in.

Run No. 1 Re-run Monday, 11 May 64

PSI: 20 No. 2 Regulator: 46
Time: 2.850 min
Spill Tank: 2.54 ft
Nozzle Size: 1.253 sq in.
Total Gal: 441.40
Flow Rate in gal/min: 154.9 Error: -.36 to -1.80 gal/min

Run No. 2 Wednesday, 13 May 64

PSI: 19 No. 2 Regulator: 45
Time: 3.408 min
Spill Tank: 2.46 ft
Nozzle Size: 1.253 sq in.
Total Gal: 427.50
Flow Rate in gal/min: 125.4 Error: -.29 to -1.45 gal/min

Run No. 3 Wednesday, 13 May 64

PSI: 19.5 to 21 No. 2 Regulator: 47
Time: 3.374 min
Spill Tank: 2.48 ft
Nozzle Size: 1.253 sq in.
Total Gal: 430.97
Flow Rate in gal/min: 127.7 Error: -.29 to -1.45 gal/min

Run No. 4 Wednesday, 13 May 64

PSI: 20 No. 2 Regulator: 45
Time: 3.085 min
Spill Tank: 2.42 ft
Nozzle Size: 1.253 sq in.
Total Gal: 420.55
Flow Rate in gal/min: 136.32 Error -.33 to -1.65 gal/min

Flexline burst Tuesday, 12 May 64 No info

Run No. 1 Wednesday, 13 May 64

PSI: 20 No. 2 Regulator: 46
Time: 5.544 min
Spill Tank: 2.44 ft
Nozzle Size: 0.6142 sq in.
Total Gal: 424.04
Flow Rate in gal/min: 76.5 Error: -.18 to -.90 gal/min

Run No. 2 Wednesday, 13 May 64

PSI: 22.5 No. 2 Regulator: 46
Time: 5.102 min
Spill Tank: 2.42 ft
Nozzle Size: 0.6142 sq in.
Total Gal: 420.55
Flow Rate in gal/min: 82.4 Error: -.20 to -1.00 gal/min

Run No. 3 Wednesday, 13 May 64

PSI: 20.5 No. 2 Regulator: 46
Time: 5.306 min
Spill Tank: 2.42 ft

Run No. 3 (Continued)

Nozzle Size: 0.6142 sq in.
Total Gal: 420.55
Flow Rate in gal/min: 79.3 Error: -.19 to -.95 gal/min
NOTE: Flexline slipped off nozzle about 1 in. but did not break.

Run No. 1 Thursday, 14 May 64

PSI: 20 No. 2 Regulator: 46
Time: 0.986 min
Spill Tank: 2.42 ft
Nozzle Size: 3.0 sq in.
Total Gal: 420.55
Flow Rate in gal/min: 426.53 Error: -1.03 to -5.15 gal/min

Run No. 2 Thursday, 14 May 64

PSI: 14 No. 2 Regulator: 42
Time: 1.238 min
Spill Tank: 2.40 ft
Nozzle Size: 3.0 sq in.
Total Gal: 417.07
Flow Rate in gal/min: 336.89 Error: -.81 to -4.05 gal/min

Run No. 3 Thursday, 14 May 64

PSI: 20 No 2 Regulator: 50
Time: 1.102 min
Spill Tank: 2.42 ft
Nozzle Size: 2.4 sq in.
Total Gal: 420.55
Flow Rate in gal/min: 381.6 Error: -.92 to -4.60 gal/min

Measurement of Flow Rate of Pressurized Spray System, 3 August 1964

This report supplements the interim report dated 25 May 1964. The following data and comments are submitted for analysis:

1. During the performance of tests, it became necessary to reevaluate the flow nozzles of the spray system due to deterioration of the rubber gaskets between the nozzle housing and the adjustment plate. It soon became apparent that the solution known as "purple" caused rubber gaskets, as well as rubber sole shoes, to literally fall apart. Teflon gaskets were used in lieu of rubber, and the nozzles were modified and recalibrated. This modification consisted of welding a half inch square strip the length of the orifice of the nozzle plate and the installation of teflon gaskets. However, welding of the metal strip to the nozzle plate produced warping which made the measurement of an exact nozzle size rather ambiguous.

2. The portion of this task which relates to determining differential rate of flow was cancelled because of supply difficulties in acquiring two pitot tubes. The items were received two days prior to completion of the test program.

Test Data Starboard Tank

Run No. 1 Tuesday, 26 May 64

PSI: 19.5 No. 2 Regulator: 45 (Temperature 80°F)
Time: 2.986 min
Spill Tank: 1.45 ft
Nozzle Size: 0.614 sq in.
Total Gal: 252
Flow Rate in gal/min: 97.7 Error: -.39 to -1.95 gal/min

Run No. 2 Tuesday, 26 May 64

PSI: 19.5 No. 2 Regulator: 45 (Temperature 80°F)
Time: 3 (20 second bursts) 5 min delay between bursts
Spill Tank: 1.40 ft
Nozzle Size: 0.614 sq in.
Total Gal: 243
Flow Rate in gal/sec: 4.05 Error: -.02 to -.1 gal/sec

Run No. 1 Wednesday, 27 May 64

PSI: 20 No. 2 Regulator: 47 (Temperature 84.3°F)
Time: 4.272 min
Spill Tank: 2.15 ft
Nozzle Size: 0.614 sq in.
Total Gal: 373.6
Flow Rate in gal/min: 87.5 Error: -.2 to 1.0 gal/min

Test Data Port Tank

Run No. 1 Tuesday, 26 May 64

PSI: 19.5 No. 2 Regulator: 55 (Temperature 80°F)
Time: 3 min
Spill Tank: 1.65 ft
Nozzle Size: 0.614 sq in.
Total Gal: 286
Flow Rate in gal/min: 95.3 Error: -.33 to -1.65 gal/min

Run No. 2 Tuesday, 26 May 64

PSI: 20 No. 2 Regulator: 55 (Temperature 80°F)
Time: 3 (20 second bursts) 5 min delay between bursts
Spill Tank: 1.56 ft
Nozzle Size: 0.614 sq in.
Total Gal: 271
Flow Rate in gal/sec: 4.52 Error: -.017 to -.09 gal/sec

Run No. 1 Wednesday, 27 May 64

PSI: 19.75 No. 2 Regulator: 52 (Temperature 87.8°F)
Time: 4.068 min
Spill Tank: 2.25 ft
Nozzle Size: 0.614 sq in.
Total Gal: 387.5
Flow Rate in gal/min: 95.3 Error: -.25 to -1.25 gal/min

Test Data Starboard Tank

(420.5 U.S. Gallons pumped into tank)

Run No. 1 Tuesday, 2 June 64

Run started with pressure regulator at 12 psi. When pressure was increased, the rear of the nozzle began to leak increasingly. No Test.

Run No. 2 Tuesday, 2 June 64

PSI: 19.5 No. 2 Regulator: 48 (Temperature 82°F)
Time: 1.187 min
Spill Tank: 2.29 ft
Nozzle Size: 2.16 sq in.
Total Gal: 398
Flow Rate in gal/min: 335.2 Error: -.84 to 4.2 gal/min

Run No. 3 Tuesday, 2 June 64

Cancelled due to change of gaskets and modification of nozzle.

Test Data Port Tank

(427.8 U.S. Gallons pumped into tank)

Run No. 1 Tuesday, 2 June 64

PSI: 20 No. 2 Regulator: 55 (Temperature 82°F)
Time: 1.374 min
Spill Tank: 2.375 ft
Nozzle Size: 1.56 sq in. (* observation)
Total Gal: 412.7
Flow Rate in gal/min: 300.4 Error: -.73 to -3.65 gal/min
*NOTE: Spray from rear of nozzle leaking almost equivalent to the flow of the nozzle.

Run No. 2 Tuesday, 2 June 64

PSI: 20 No. 2 Regulator: 55 (Temperature 82°F)
Time: 1.04 min
Spill Tank: 2.271 ft
Nozzle Size: 1.56 sq in. (approximately)
Total Gal: 394.7
Flow Rate in gal/min: 379.5 Error: -.96 to -4.80 gal/min

Run No. 3 Tuesday, 2 June 64

Cancelled due to change of gaskets and modification of nozzle.

Test Data Starboard Tank

Run No. 1 Wednesday, 3 June 64

PSI: 20 No. 2 Regulator: 47
Time: 1.289 min
Spill Tank: 2.27 ft
Nozzle Size: (approx. 1.671 sq in.)
Total Gal: 395
Flow Rate in gal/min: 306.4 Error: -.78 to -3.9 gal/min

Run No. 2 Wednesday, 3 June 64

Three 15 sec bursts were made and time was allowed between each burst to let all the solution drain from the 8 in. flex pipe.

PSI 20
1st 15 sec plus run off: 9.750 in.
2nd 15 sec plus run off: 18.250 in.
3rd 15 sec plus run off: 26.750 in.

1st 15 sec total gal: 141.4
2nd 15 sec total gal: 264.6
3rd 15 sec total gal: 387.9

A lapse of about 5 sec time from arming the system to flow from the nozzle was observed.

Test Data Port Tank

Run No. 1 Wednesday, 3 June 64

PSI: 20 No. 2 Regulator: 55
Time: 1.298 min
Spill Tank: 2.292 ft
Nozzle Size. (approx. 1.675 sq in.)
Total Gal: 398.3
Flow Rate in gal/min: 306.9 Error: -.77 to -3.85 gal/min

Run No. 2 Wednesday, 3 June 64

Three bursts - 20 sec, 15 sec and 10 sec were made and time was allowed between each burst to let all the solution drain from the 8 in. flex pipe.

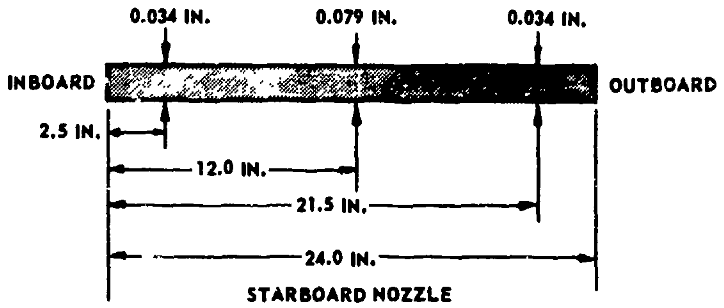
PSI 20
1st 20 sec plus run off: 12.25 in.
2nd 15 sec plus run off: 10 in.
3rd 10 sec plus run off: 4.75 in.

1st 20 sec total gal: 177.6
2nd 15 sec total gal: 145.0
3rd 10 sec total gal: 68.9

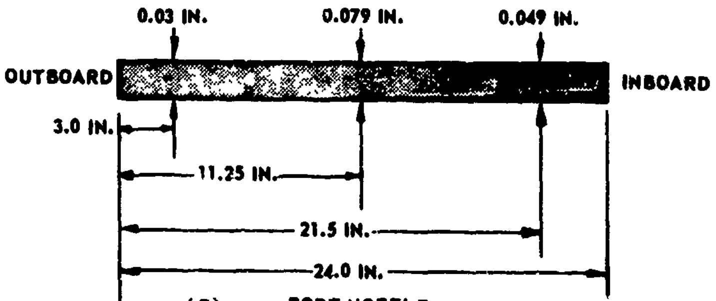
A lapse of about 4.5 to 5 sec time from arming the system to flow from the nozzle was observed.

Information on modification of nozzle and gaskets:

The modification (welding) described in paragraph 1 above resulted in the following nozzle configuration:



STARBOARD NOZZLE



PORT NOZZLE

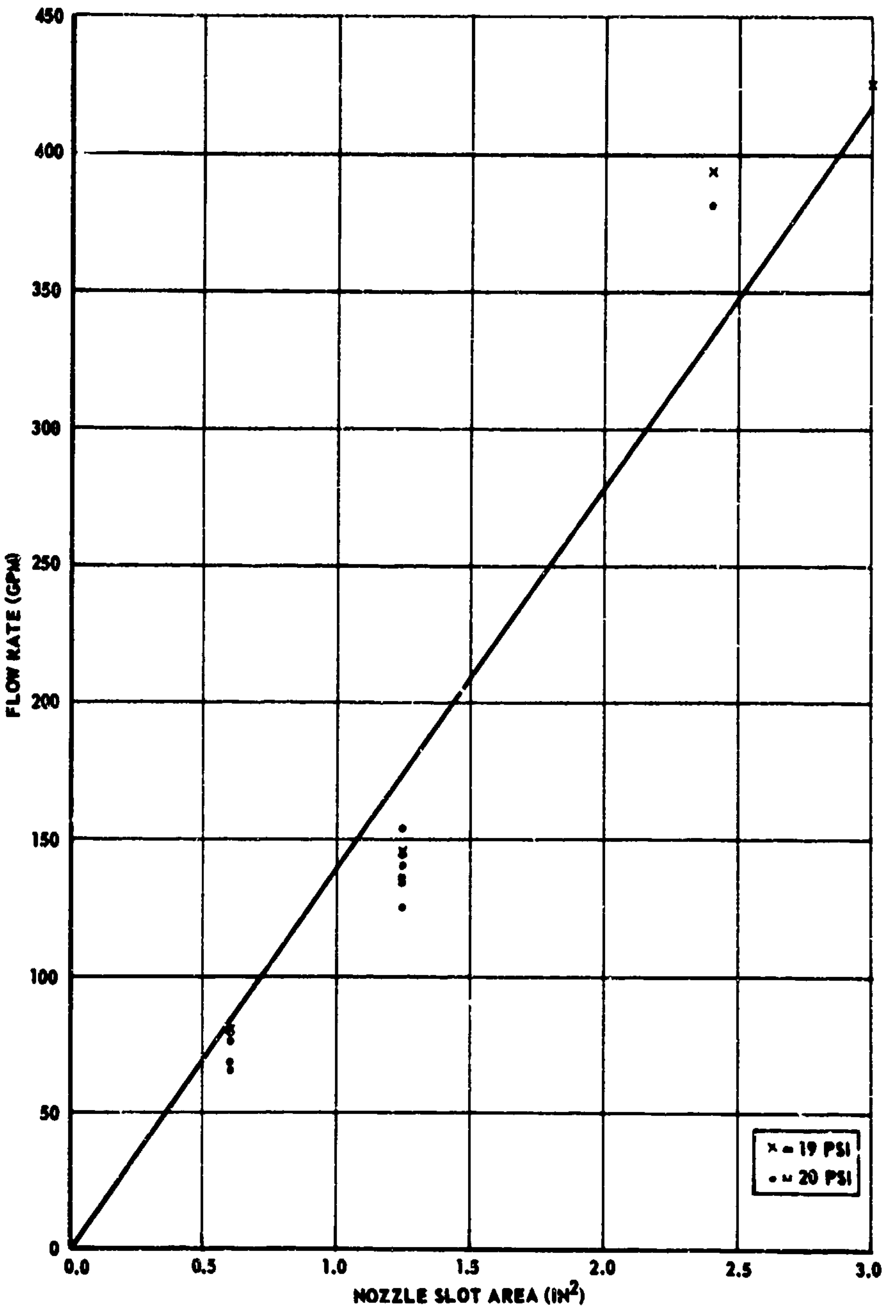


Figure V-1. Flow Rate (GPM) Versus Nozzle Slot Area (In.^{2}). 18-20 PSI Tank Pressure (One Module). (6)

APPENDIX VI

A/A 45Y-2 SLOSH AND VIBRATION TEST RESULTS

SUBJECT: A/A 45Y-2 Dispenser Defoliant, Pressurized
Slosh and Vibration Test

DATE OF TEST: 12 Nov - 13 Dec 1963

PURPOSE: To determine the structural integrity of the A/A 45Y-2 tank assembly being developed under ARPA ORDER 481, AFSC Project 5957. The test was performed in accordance with Mil-T-6396B.

TEST REQUESTED BY: Detachment 4, RTD (ATCB), Eglin Air Force Base, Florida.

TEST CONDUCTED BY: Propulsion Laboratory, APTT, Wright-Patterson Air Force Base, Dayton, Ohio.

SUMMARY OF RESULTS:

1. Slosh and Vibration Test

Vibration Amplitude: 0.017 inches (average double amplitude)

Vibration Frequency: 2000 + 0 -60 cpm

Slosh Angle: 30° (total)

Slosh Frequency: 16 cpm

Duration of Test: 25 hours

Tank pressure: 5 psi

Tank Fill: 367 gal. water

Visual examination of the tank assembly following the slosh and vibration test revealed no structural damage.

2. Vibration Portion of Test

Vibration Amplitude: 0.027 inches (double amplitude)

Vibration Frequency: 2000 +0 -60 cpm

Duration of Test: 10 minutes

Tank Pressure: 5 psi

Tank Fill: 543.2 gal. water

Examination of the tank assembly following the slosh and vibration test revealed no physical damage. A blackening occurred on the edges of the pallet members that withstood primarily vertical loads which might indicate fatigue. Further examination of these members is recommended.

EQUIPMENT USED:

1. 20,000 lb. capacity slosh and vibration table at Wright-Patterson AFB, Dayton, Ohio.
2. Six (6) vibration meters (double amplitude)
3. Three (3) vibration recorders (double amplitude)
4. C-130 tie-down chains and turnbuckles.
5. Pressure line and gage.
6. Air Compressor

TEST SETUP: See Fig.'s 1*,2,3, pp. 5,6,7.

TEST PROCEDURE:

The tank assembly was mounted on the test fixture using 10,000 lb. chains and turnbuckles from a C-130 aircraft. Mounting braces were fabricated and bolted to the table platform. The pallet extended beyond the table on each end, which made the end tie-down points inaccessible and necessitated the use of steel cables on the lower-side tie-down points to prevent horizontal motion. The mounting simulated actual aircraft installation.

The 6 vibration pickups were attached to phenolic blocks and mounted (using epoxy glue) on the tank at the supporting bulkheads. Initial pressurization (12 psi) of the tank through the valve on top revealed leaks in the main filling port and drain port. Liquid rubber was used to seal these ports.

The tank was filled to 2/3 full (367 gal.) with red water and pressurized to 5 psi. Vibration was started and trouble in the hydraulic valves of the control panel was encountered. This was repaired and the screw jacks were removed from the pallet due to their excessive vibrations. The test was resumed.

The test was stopped after 4 hrs. and 15 min. of slosh and vibration to secure tie-downs. After 14 hrs. 10 min. of testing, the main filling port bolts loosened and were retightened. A main table support bolt broke off after 18 hrs. of testing and was repaired. After 25 hours of testing, the tank was inspected revealing no physical damage and 176.2 gallons of water were added to the tank and 10 min. of pure vibration followed. Total time - 25 hours, 10 minutes. Fig. 4 Page 8 is a graphical representation of the test. Readings were taken twice every hour and readings from meters 1, 2, 3, 4, 5, and 6 were averaged to obtain the average tank displacement (See Fig. 5 Page 9).

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*Fig. 1 is not reproducible.

A mean tank displacement of 0.017 inches (double amplitude) at a vibration frequency of 2000+0-60 cpm, a total slosh angle of 30°, and a slosh frequency of 16 cpm was maintained throughout the slosh and vibration portion of the test.

A mean displacement of 0.027 inches (double amplitude) was maintained during the 10 minute vibration portion of the test.

The minimum tank displacement of 0.032 inches as required by Mil-T-6396B was not maintained due to the fact that the pallet absorbed on the average approximately 0.008 inches of the vibration with an average table displacement of 0.025 inches. Also, the pallet did not lie completely flat on the table which did not allow for the total table displacement to be transmitted to the test specimen. Another reason for not running the test table at maximum amplitude was due to the fact that at these upper limits, the test table has a tendency to "run away" with increasing amplitude which is detrimental to the test table and specimen.

CONCLUSIONS:

The A/A 45Y-2 spray tank was tested in accordance with Mil-T-6396B. Visual examination of the tank assembly following completion of the test failed to indicate evidence of structural damage. No functional or operational checks were performed.

Even though the required tank displacement of 0.032 inches was not maintained, a valid test was performed. In many instances the vibration table was well over the required displacement and yet the tank was subjected to only one-half of this vibration amplitude which indicates that the pallet was absorbing a certain amount of the vibration. It is safe to assume that in actual operation of the system in the aircraft, the assembly will not be subjected to a greater vibrational displacement than was placed on it in the test, and the pallet assembly does absorb as much as 50% of the vibration which will insure structural integrity of the tank.

Suggested modifications of the tank assembly are as follows:

a. The horizontal section of the pallet that houses the retractable wheels is bolted to the remaining superstructure except for two (2) welds. These welds seem unnecessary and if eliminated would provide for complete dismantling of the pallet.

b. The plexiglass gasket used on the drain on the underside of the tank leaked when pressurized to 12 psi. A more flexible gasket material is required for proper sealing.

c. The top filling port leaked under 12 lbs. pressure due to the hard, brittle gasket material being used. Also, the self-locking nuts on this port were not easily removed and required strenuous effort. Another type of sealing device should be investigated such as an "O" ring seal or screw-type mechanism along with suitable gaskets.

d. The bushings used in the pallet tie-down rings seemed unnecessary and would be easily lost with removal of the tie-down eyelets.

The tank assembly was returned to the manufacturer following the test.

PREPARED BY: JAMES E. BURDA
2/Lt, USAF

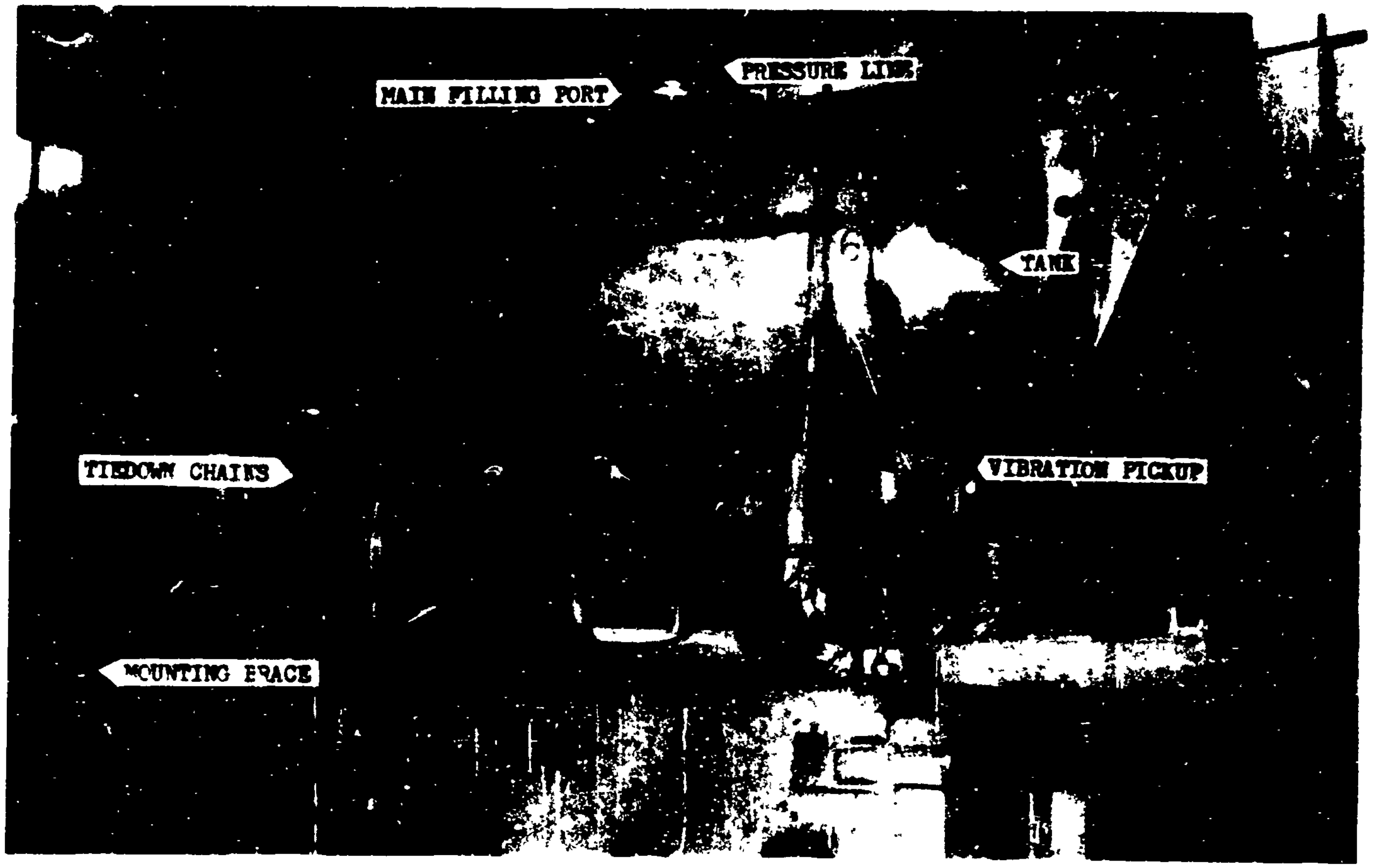


Figure 2: Test Setup

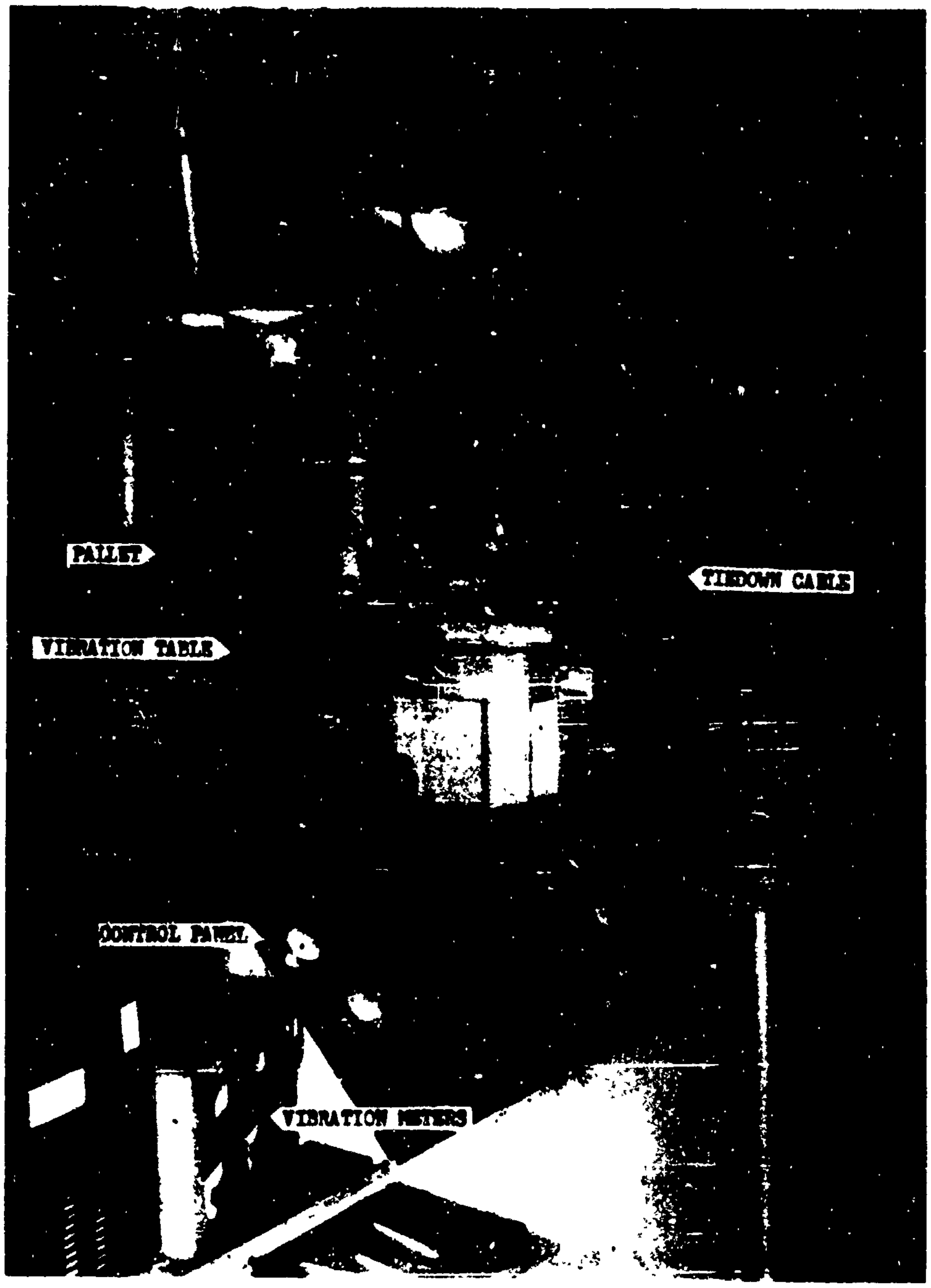


Figure 5: Control Panel Test Setup
(6)

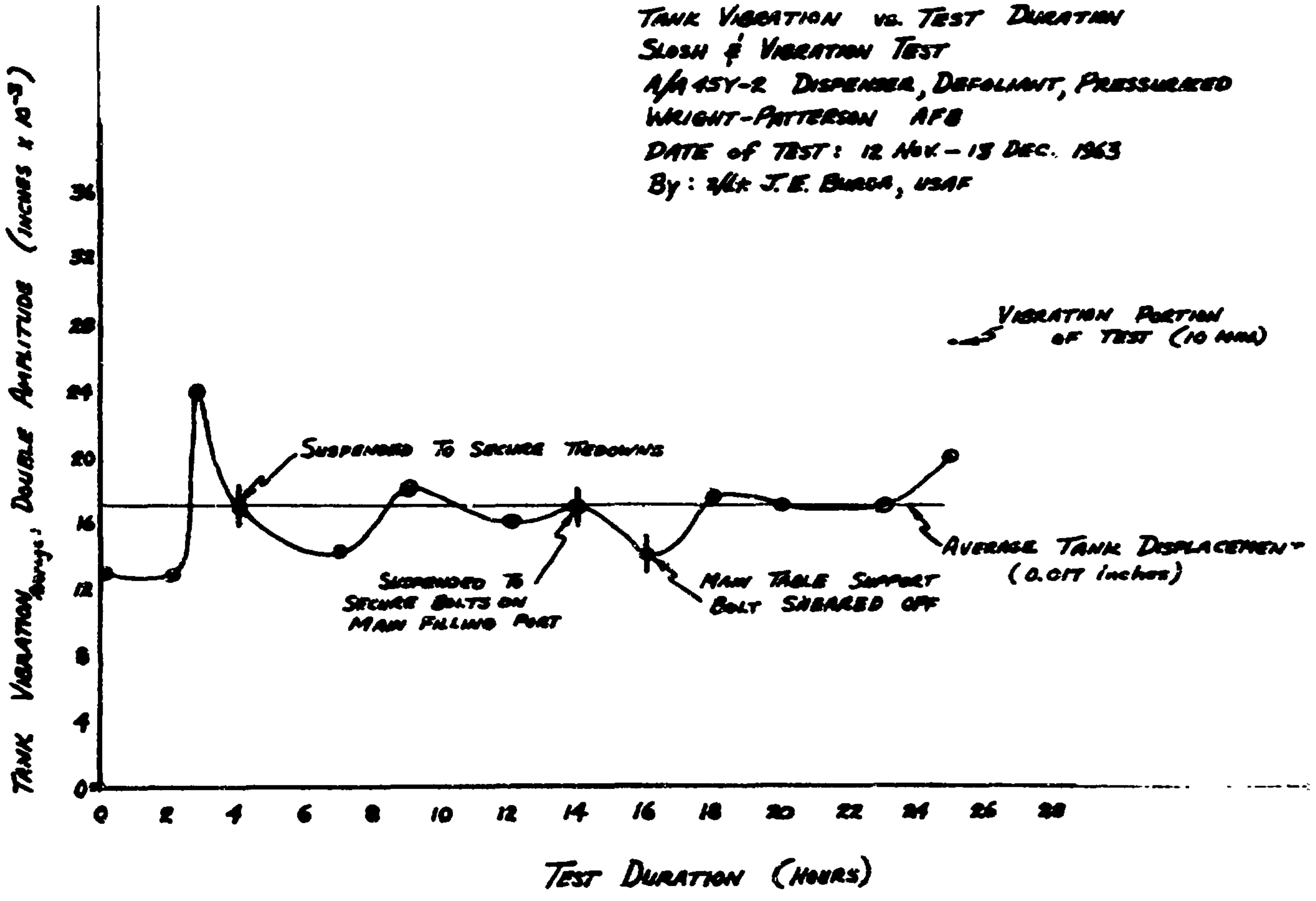
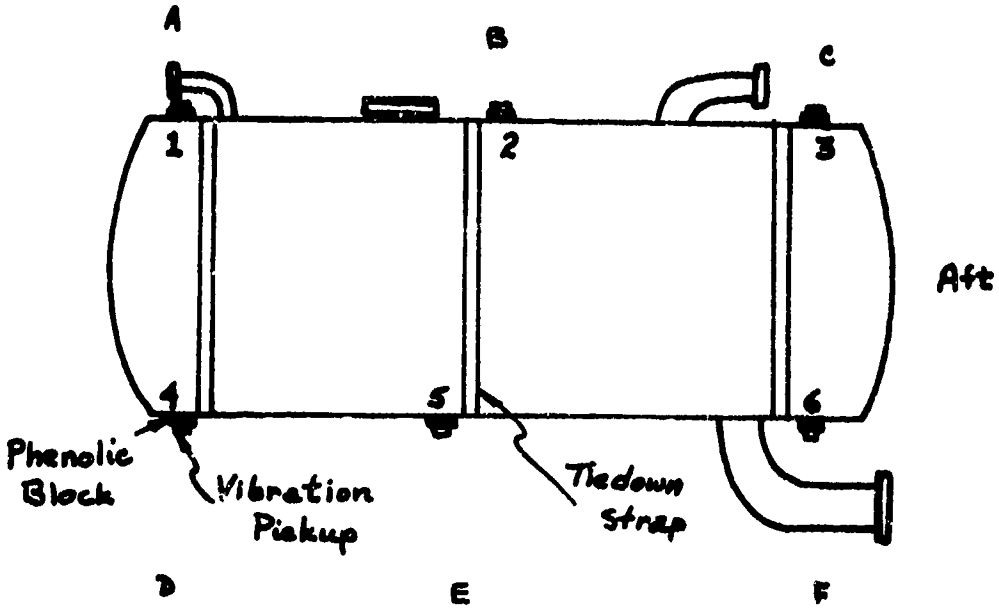


FIGURE 4: GRAPHICAL REPRESENTATION
TANK VIBRATION vs. TEST DURATION
SLOSH & VIBRATION TEST
A/A 45Y-2 DISPENSER, DEFOLIANT, PRESSURIZED
WRIGHT-PATTERSON AFB
DATE of TEST: 12 NOV. – 13 DEC. 1963
By: 2/Lt J. E. BURGA, USAF

Slosh & Vibration Test

A/A45Y-2 Tank



$$\text{Tank Displacement}_{\text{Average}} = \frac{\overset{\text{Readings:}}{1+2+3+4+5+6}}{6}$$

FIGURE 5 : TANK DISPLACEMENT

INITIAL DISTRIBUTION

2	Sec/AF (SAFOI)
2	Sec/AF (SAFRD)
2	Sec/AF (SAFRR)
1	Hq USAF (AFCIN-3K2)
2	Hq USAF (AFRDDF)
2	Hq USAF (AFORZTS)
2	Hq USAF (AFORQ)
1	Hq USAF (AFORZTA)
2	Hq USAF (AFRAEC)
1	Hq USAF (AFRODE)
1	Hq USAF (AFMSG)
1	Hq USAF (AFXPDK-NI)
2	Hq USAF (AFOSR)
2	OAR
2	AFSC (SCS-6)
1	AFSC (SCT)
1	AFSC (SCCPR)
3	RTD (RTNW)
2	ASD (ASJ)
2	ASD (ASCPT)
2	ASD (ASUSR)
1	ASD (ASZFM)
1	ASD (ASZB)
6	FTD (TDEWA)
1	SEG (SETSF)
1	AFLC (MCSWT)
2	AMD (MRMPD)
2	AMD (AMR)
1	AFMTC (MTBAT)
2	SSD (SSAPD)
2	BSD
2	ESD (ESO)
1	AFCRL
5	TAC (DORQ)
2	TAC (DPLTR)
1	TAC (DOOP)
5	TAC (DORQ)
1	TAC (TFW-R&D)
1	SAC (DM4E)
1	SAC (DORQA)
1	SAC (DOPLT)
1	AUL
1	AU (Warfare Sys Sch)
1	AU (Army-Navy Mil Advis Gp)
2	ADC (ADORQ)
3	USAFE (Dir Ops)
3	PACAF (PFORQ)
1	OOAMA (OOY)
1	OOAMA (OOYP)
1	OOAMA (OOYPP)
1	OOAMA (OOYS)
1	OOAMA (OOG)
1	OOAMA (OOYDP)
1	SAAMA (SANUSE)
3	ATC
1	ATC (TSOR)
1	3415 Tech Sch (TS-OS)
1	ATC (ATTAT-S)
2	9AF
2	12AF
5	AFSC STLO, Edgewood Arsenal
2	AFSC STLO, USNOTS
1	US Army Mat Command (AMC PM-NBC)
2	USA Foreign Science & Tech Ctr
2	Edgewood Arsenal
2	Edgewood Arsenal (Commodity Eng Div)
2	CRDL
1	Combat Dev Command
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4	BUWEPS (Code RM-379)

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1	USMC Ln Off
2	The Rand Corp
20	DDC
	Eglin AFB
	APGC
4	PGBAP-1
3	PGEH
1	PGLPM
10	PGOW
3	PGGW
	Det 4, RTD
2	ATC
1	ATG
4	ATC (CCLO)
1	ATW
2	SAWC
2	SAWC (DOI)
2	TACLO
2	TAWC
1	ATTEG

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13. ABSTRACT

Project 5957W1 was conducted as a test and evaluation of the A/A 45Y-2 pressurized defoliant dispenser, installed in a C-123 aircraft. Emphasis was placed on an evaluation of the capability of the dispenser to deliver defoliant agent in effective dosages from dissemination altitudes of 50-2000 feet absolute. Inwind releases were characterized by narrow, high-peak-concentration swaths; crosswind releases were characterized by wide, low-peak-concentration swaths. Testing of the C-123:A/A 45Y-2 system revealed the following problems: (1) excessive weight of the filled test item, reducing the operational range of the C-123 to approximately 50 nm; (2) contamination of the aircraft fuselage and tail surfaces with agent during dissemination; and (3) interference with aircraft equipment, i.e., access to aircraft battery compartment for required seven-day inspections and installation of the cargo ramp positioning links, which prevent lowering the ramp below the horizontal in flight. High-altitude dissemination flights (above 500 feet) did not prove feasible due to the lack of aimability of the spray pattern. However, percent recovery values computed from data sampled during these flights showed no degradation of the values experienced with low-altitude releases. Within the test parameters of airspeed, altitude, and flow rate employed during testing at Eglin AFB, the C-123:A/A 45Y-2 system is characterized by small area coverage at minimum concentration levels of 1.5 and 3 gallons per acre. The maximum computed area coverages for these concentrations were .384 and .212 square miles, respectively.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Aircraft defoliant dispenser						
Grid tests						
Depositions						
Concentrations						
C-123: A/A 45Y-2 system						
Flight data						
Capabilities						
Defoliant spray systems						
Herbicide spray tests						
High altitude tests						
Biological spray system						
Warfare, biological						
Anti-crop aspect						

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