NATIONAL BUREAU OF STANDARDS REPORT

6554

Lighting Modifications

of Two

Flight-Refueling Drogues for Naval Aircraft

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U. S. DEPARTMENT OF COMMERCE
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THE NATIONAL BUREAU OF STANDARDS

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Optics and Metrology Division

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Department of the Navy
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1. INTRODUCTION

This project was initiated after Navy field evaluation personnel had expressed dissatisfaction with existing drogue-lighting arrangements for in-flight refueling operations. Manufacturers had produced drogues with various lighting arrangements such as flashing neon lights, radioactive sources (Iso-lights), and small incandescent sources placed with filaments facing the receiver aircraft. However, none of the systems was considered entirely satisfactory by the pilots in the receiver planes.

It was requested by the Bureau of Aeronautics that the National Bureau of Standards explore means of improving the lighting characteristics of the collapsible drogue presently used by Naval aircraft. After an investigation of the various lighting systems available, it was decided that the drogues with the incandescent lights had the greatest potential for lighting improvement. All efforts were therefore directed toward the design of a satisfactory system of incandescent illumination.

2. DESCRIPTION

The two drogues used for this investigation were manufactured by the Dalmo Victor Co., Belmont, Calif., and were fitted with Type M-2 reception couplings by Flight Refueling Inc., Baltimore, Md. As initially received, the lighting consisted of four indicator-type light fixtures (Dialco Corp. #4-1930) fitted with Type 328 incandescent lamps and oriented so that the lamps faced the receiver aircraft during refueling operations. A photograph of one of the fixtures is shown in Figure 1. The inner surface of alternate struts of the drogues were coating with red retroreflective adhesive tape, and the remaining ones with white paint. Some receiver planes have a light which illuminates the probe tip, and the purpose of the retroreflective material was to re-direct some of this illumination back to the receiver plane. The balance of the exposed surface of each drogue, except for a black fuel coupling, had a dull gray finish. The only dissimilarity of the two drogues was in the method of powering the lights. One used four series-connected dry cells, and the other a wind-driven Lucas 0.36 ampere bicycle generator. The generator is driven by a small impeller, the blade tips of which protrude through the fuel reception coupling into the air stream. When received, the blades were protected externally by two small pieces of aluminum tubing on each side of the impeller. The installation of the generator, impeller, and aluminum tubing is shown in Figures 2 and 3.

3. TEST PROCEDURE

Visual examination of the original lighting configuration of the drogues revealed several design features which, it was thought, could be improved. The lights were so positioned that they appeared to the pilot in the receiver aircraft as four point sources slightly separated in a dark background. Maneuvering the probe of the receiver aircraft into such a visual field is particularly difficult because of the lack of depth perception afforded. Also, the installation of the retroreflective material rendered it ineffective for redirecting the probe tip lighting to the pilot because of the large angular departure of the incident light from the normal.

It was decided that flood lighting of the internal basket structure of the drogue, combined with retroreflective material appropriately placed, would result in an improved lighting system, and the following modifications were made.

Drogue #1 (Battery powered lights)

a. The entire basket structure was painted white.

b. The inside of each light fixture was coated with white paint, and the light emitting apertures were enlarged. Figure 4 is a photograph of the modified fixture.

c. The light fixtures were oriented with lamps facing away from the receiver aircraft so that they would light the inside of the drogue.

d. Retroreflective fabric #31 silver, manufactured by the Minnesota Mining and Mfg. Co., was sewn to the nylon canopy around the periphery of the drogue.

Modified drogue #1 is shown on the left in Figure #5 along with one of the original drogues. This is a daylight photograph.

Drogue #2 (Generator powered lights)

a. The entire basket structure was painted white.

b. The original light fixtures were used, but the light emitting apertures were enlarged and they were reoriented to face away from the receiver aircraft so that they illuminated the inside of the drogue.

c. Equipment which would permit a measurement of the voltage developed during flight to be read after the plane landed was designed and installed in the outer housing of the drogue. A diagram and description of the equipment are shown in Figure 6. However, this equipment has not yet been used, personnel for making the voltage measurements not being available when the flight tests were conducted.

4. RESULTS

Visual comparisons of the original and modified drogue, both at the National Bureau of Standards and in actual flight operations at the Naval Air Test Center, confirmed the expected improvement of the flood lighting arrangement. The greatest improvements resulting from the modifications are listed below.

a. Direct light from the lamp filaments was eliminated.

b. Target conspicuity was greatly improved in that the flood lighting arrangement uniformly illuminated a large area.

c. Since the entire interior of the drogue was illuminated significant improvement was noted in ability to determine depth of penetration of the probe.

d. The retroreflective fabric sewn to the canopy of the modified drogue was much more effective than that on the struts of the unmodified drogue.

The lighting of both modified drogues was reported by the Naval Air Test Center pilots to be satisfactory during the flight evaluations. Results of the flight tests are reported in NATC report #1, Project No. PTR-5010 dated July 2, 1959. These results would seem to indicate two things: 1) that the special light fixtures used on drogue #1 are not required to provide sufficient illumination provided the original fixtures are properly modified and oriented, and 2) that the wind-driven generator provides sufficient power for the lamps. It should be pointed out, however, that the voltage developed by the generator in flight has not been determined and, consequently, it is not known at what voltage the lamps operated. When test flights have been made, personnel have not been available to obtain the voltage measurements after landing. Also, insufficient tests were conducted to establish definitely whether retroreflective material is actually needed. It was reported that those aircraft not equipped with probe lights made fueling contact as easily as those that had them. This is probably because of the improved drogue lighting. Indications are, however, that should the drogue lights fail, the retroreflective material would permit refueling contact by aircraft equipped with probe lights, that is, if the lights are mounted near the line-of-sight of the pilot of the receiver plane.

It was further reported that the aerodynamic stability of the drogue had suffered slightly by the addition of the retroreflective material around the canopy. There is no ready explanation for this condition since the material was symmetrically installed except that it possibly decreased the air flow through the nylon canopy. Further tests are being made with patches of retroreflective material sewn at selected spots on the canopy rather than around its entire periphery.

During the flight tests it was found that the tubular aluminum bars (Figure 2) were not adequate to protect the impeller wheel of the generator. Apparently when the drogue is being retracted it sometimes strikes the entrance of the housing with sufficient force to bend the bars. Stouter bars of the type similar to those shown in the upper photograph of Figure 7 were later installed on the drogue, and apparently provided adequate protection.

Later investigations were conducted to determine if the generator and flood lighting arrangement could be equally adapted to the Douglas drogue which uses a Shultz reception coupling. The installation presented no particular difficulty except that it was necessary to mount the generator and impeller wheel assembly on the casting of the reception coupling instead of on the sheet metal cover as was done with the coupling made by Flight Refueling Inc. Figure 7 shows an internal and external view of the modified coupling. The performance of this equipment was reported to have been satisfactory during flight operations, and it is considered to be a more rugged installation from a mechanical standpoint.

5. DISCUSSION

It is concluded that the basic characteristics of a satisfactory drogue lighting system have been achieved but that further engineering and tests are necessary to perfect the system. For example, the paint applied to the drogue for these tests is excellent from the lighting standpoint but is relatively poor from the standpoint of wear, abrasion, stain resistance (oil and grease), and ease of cleaning. Further tests will be required to reconcile all of these features. A porcelain enamel finish or an epoxy polyomide paint appears to offer possibilities, and tests of these materials are proceeding.

Another area of possible improvement is with the generator used for powering the lights. Little is known of the characteristics or reliability of the present generator except that it apparently furnishes sufficient power. No environmental tests have been conducted to date. It is quite probable that a smaller and lighter unit suitable for this application could be designed, and it is therefore recommended that the Bureau of Aeronautics consider such a development.

Light Fixture # 4-1930
Manufactured By
Dialco Corporation

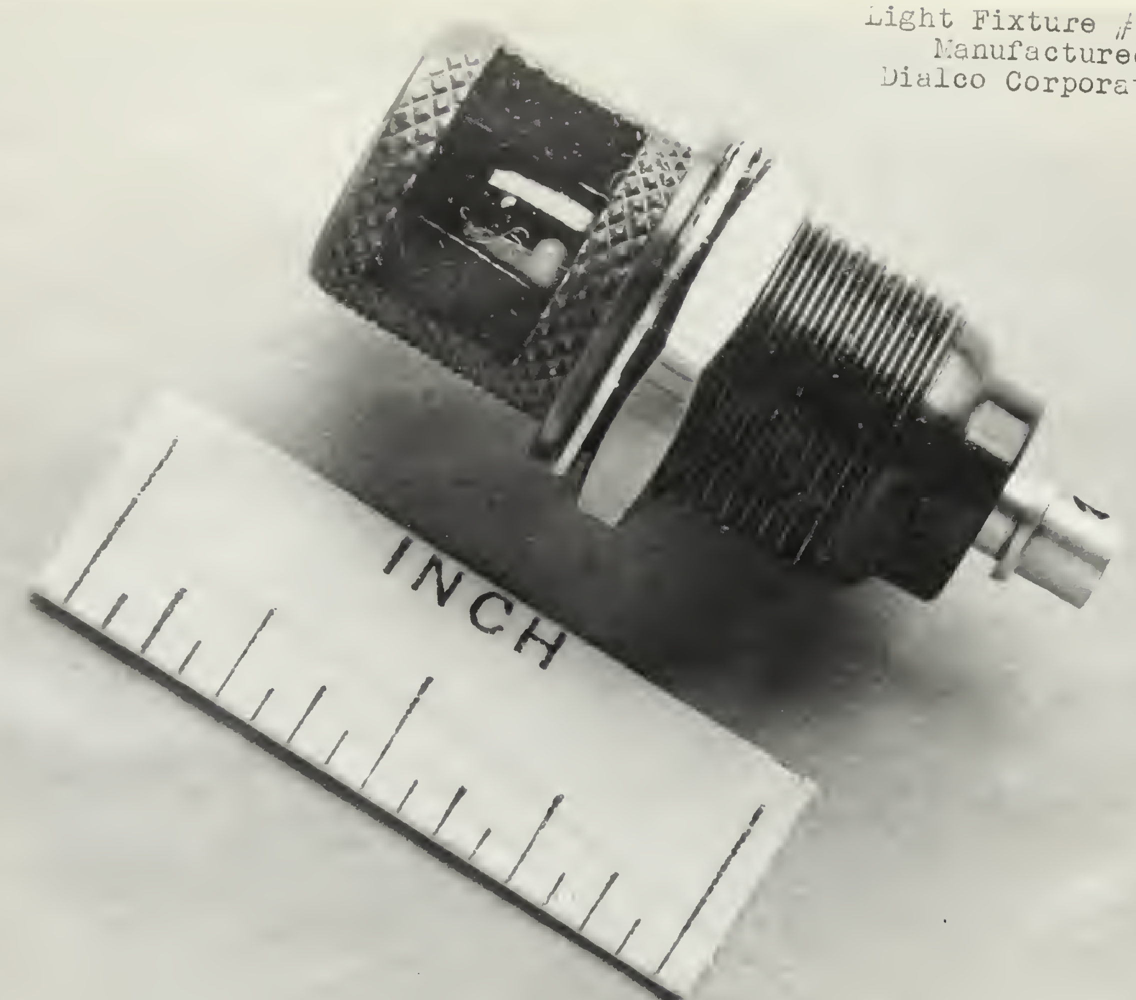

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Figure 1

External Appearance Of
Paddlewheel and Protection Bars
as Received

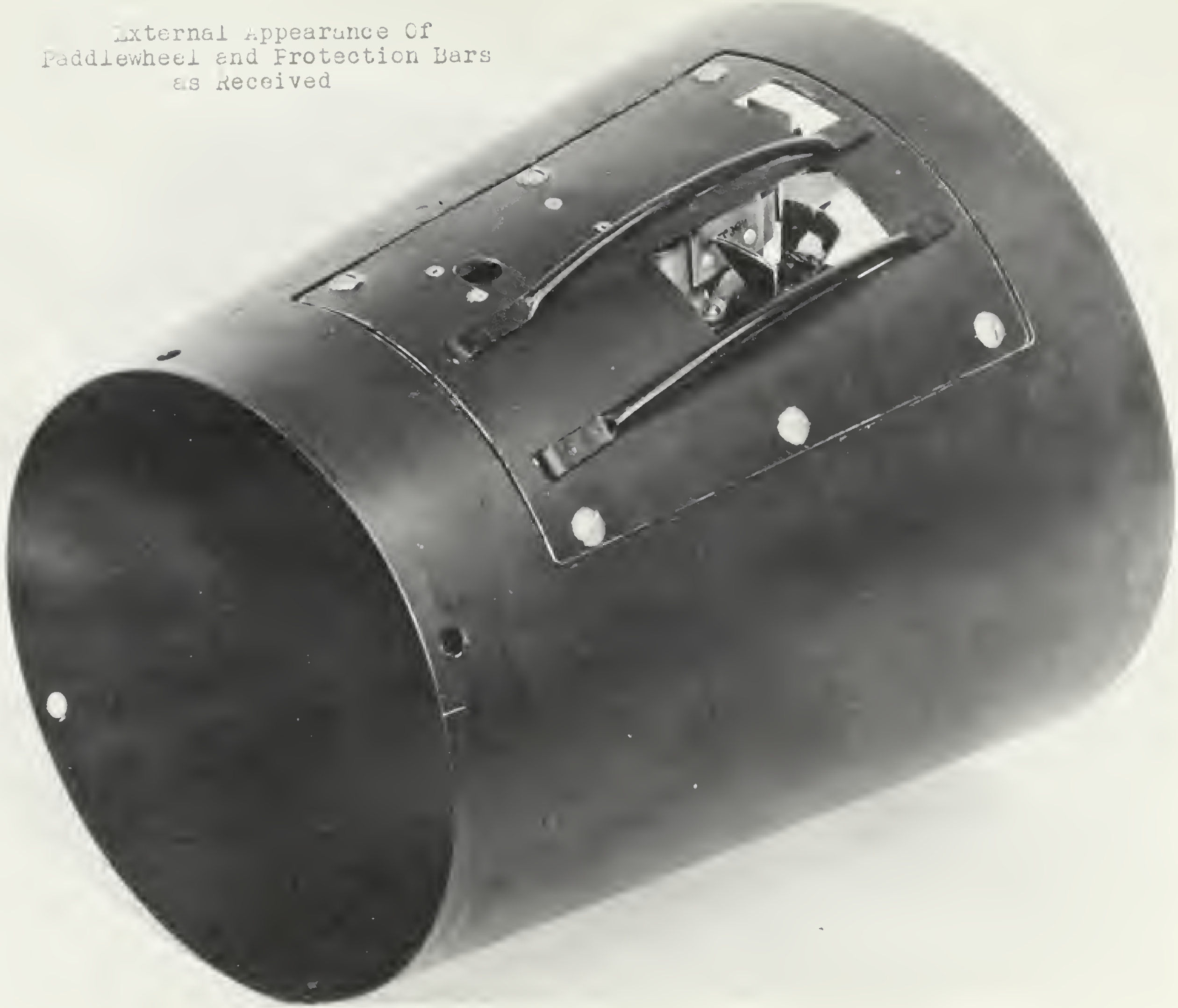

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Figure 2

Internal View of Coupling Cover Showing Generator and Voltage Measuring Circuit.

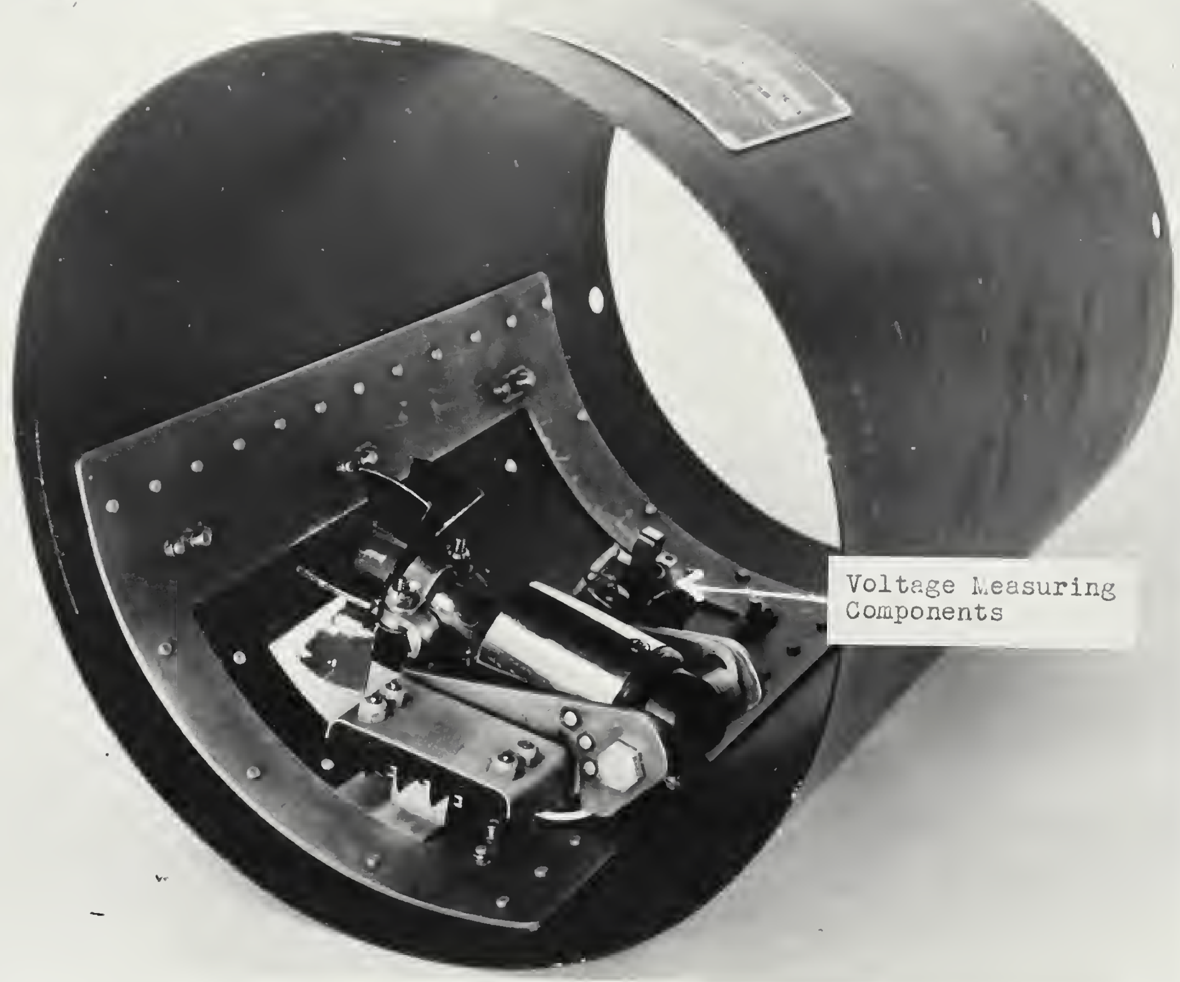

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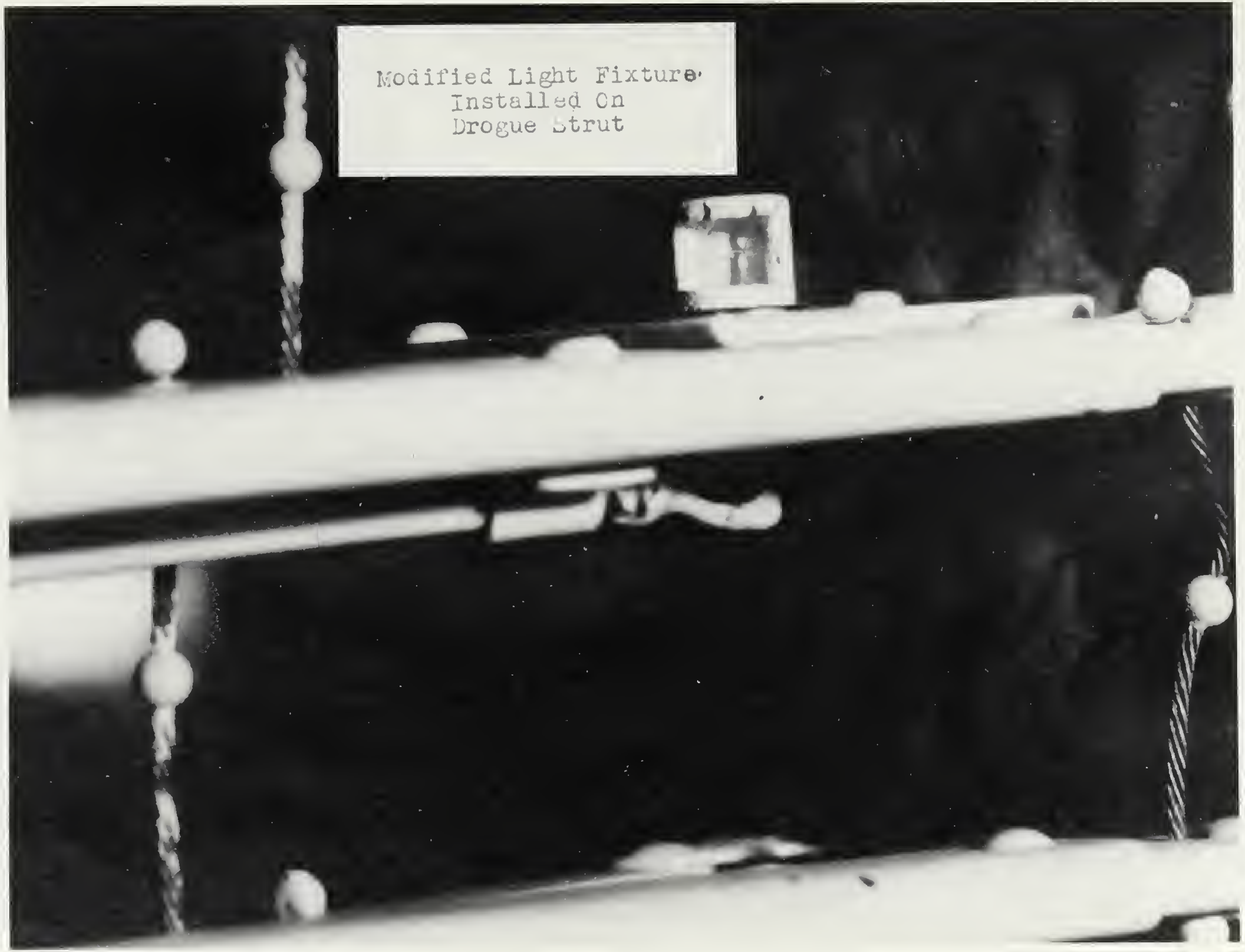
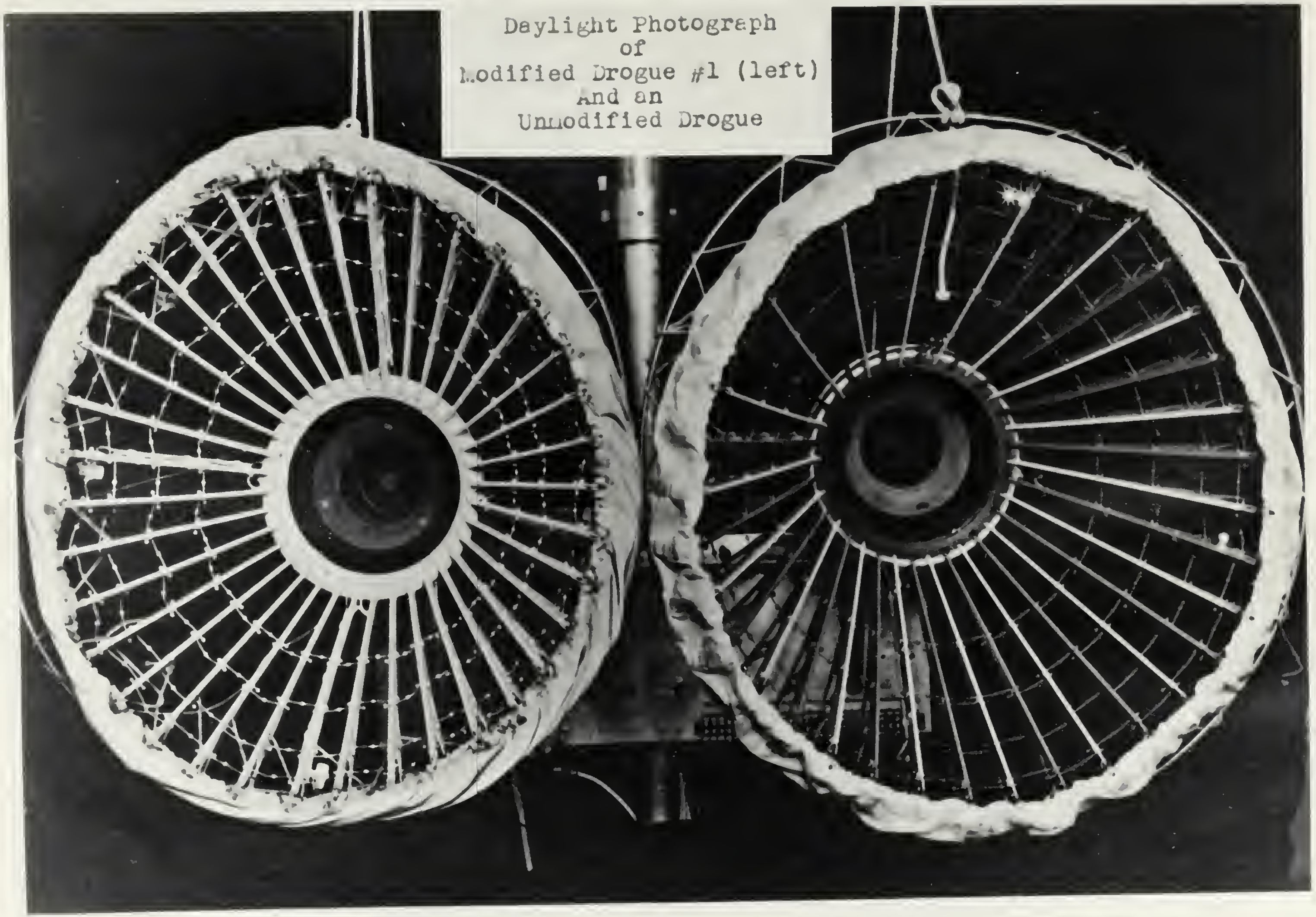
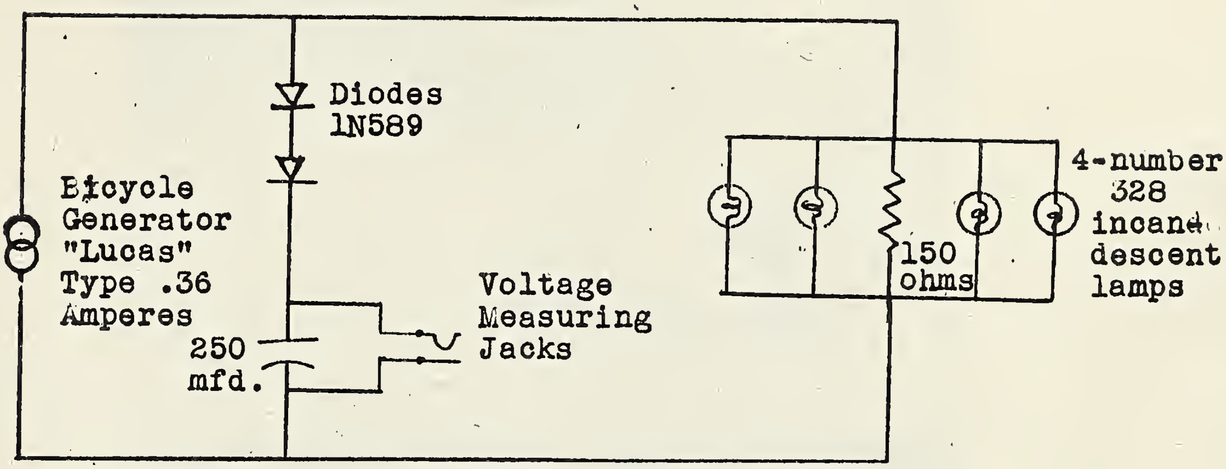
Figure 3


Modified Light Fixture
Installed On
Drogue Strut



Daylight Photograph
of
Modified Drogue #1 (left)
And an
Unmodified Drogue

Voltage Measuring Circuit Installed
in Drogue To Permit
The Maximum Voltage Attained
in Flight
To Be Determined After The Aircraft Lands



Circuit Operation.

During flight the voltage developed by the generator is impressed across the lamp load as well as the two diodes and series capacitor. The rectified voltage through the diodes charges the capacitor to peak voltage. The capacitor remains charged for several hours after the drogue has been retracted from the wind stream but the charge slowly leaks off through the high inverse resistance of the diodes and the dielectric of the capacitor. From previous calibration of voltage leakage versus time, and knowing the elapse time between retraction of the drogue and time of measurement of the remaining voltage in the capacitor, the maximum voltage attained in flight can be computed. The voltage measurement should be made with a VTVM to eliminate discharging the capacitor through the voltmeter.

NBS Report #6554 Figure 7

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Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

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Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

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Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation. • Office of Weights and Measures.

BOULDER, COLORADO

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Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

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Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Ultra High Frequency and Super High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.

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