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A Light Gun for Radar Hand-Off of Aircraft Between Air Traffic Controllers

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by

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A LIGHT GUN FOR RADAR HAND-OFF OF AIRCRAFT BETWEEN AIR TRAFFIC CONTROLLERS

SUMMARY

This report describes the engineering development of an improved light gun for radar hand-off of aircraft between two air traffic controllers. The light gun was designed to provide improved resolution in selecting a target through three Plexiglas overlays, the outer surface of the top overlay being 1 inch from the cathode-ray tube face. The light gun has a shutter system to minimize stray ambient light from affecting the photomultiplier pickup tube, as well as a light marker for positive aiming at the target selected for the hand-off.

INTRODUCTION

The U. S. Air Force TRACALS Branch, Wright Air Development Center, developed a prototype light gun and associated equipment[1] for the transfer of aircraft identification between radar indicators at a radar approach control facility. The aircraft identification mark is triggered by the light output of the cathode-ray tube (CRT) as the sweep passes through the radar target. To evaluate this coordination device for possible FAA application, the light gun was evaluated in the La Guardia Airport radar approach control facility (IFR room).

Undesirable features of this light gun as a hand-off device are listed by the La Guardia traffic controllers as follows:

1. Inadequate resolution, radar targets close together could not be individually selected.

2. Difficulty in aiming the gun at a selected target.

3. Frequent adjustment of amplifier sensitivity controls was required due to blocking of the photomultiplier by the ambient light in the room.

4. The gun would not operate through the three Plexiglas overlays (one of which is a yellow filter) normally provided on an ASR-3 indicator. To use the gun, these had to be removed.

Since the operational use of a light gun as a hand-off device was otherwise favorable, a new light gun was designed to eliminate the problems enumerated above.

[1]Technical Note 55-433, Air Force TRACALS Branch, Wright Air Development Center.

TECHNICAL DESCRIPTION

Figure 1 shows two models of the experimental light guns and associated equipment constructed at the Technical Development Center (TDC). Figure 2 is a functional block diagram for using two light guns between two radar indicators. The gate circuits are used to generate the marker blip and to delay it a desirable distance behind the aircraft target as indicated in Fig. 3. It may be desirable, for example, to generate a marker blip 2 to 5 miles behind the target on a long-range display, whereas on a short-range display, 0.5 to 3 miles may be required. Similarly, the length of the marker can be adjusted by the controller to best suit operational conditions. The marker length adjustment feature also can be used as a means of differentiating between two air traffic controllers handing-off aircraft to a third controller by using different marker lengths for each controller.

Figure 4 is a schematic wiring diagram of the light gun. The signal amplifier for the photomultiplier and all gate-generating circuits are transistorized. A Du Mont Type K1451 photomultiplier was used in the gun. Vacuum tubes were used for the radar video amplification, mixing, and output circuits. It was found necessary to provide a signal voltage gain of approximately 66 decibels (db) to operate adequately through three overlays (including a yellow filter) 1 inch from the CRT face.

Several unique features were provided: (1) to make aiming of the gun easier, (2) to prevent stray light from triggering the marker , and (3) to obtain improved resolution. The gun uses a 35 mm lens and a focusing device to pick up the CRT signal and provide a sharp image on the photomultiplier. The nozzle of the gun is adjustable in length by means of the threaded barrel. When the barrel is adjusted properly and the nozzle is placed against the outer CRT overlay, the phosphor target image is focused on the photomultiplier by the 35 mm lens and mirror No. 1. The nozzle has a very small aperture, 3/64-inch, to provide an optimum compromise between spot resolution and light transmission. Mirror No. 2 is pushed back by the trigger during target detection time, allowing light to pass through the shutter.

A visible light marker is provided to permit positive aiming of the gun. The light source is a General Electric Type 323 grain-of-wheat lamp. When the trigger is pulled through a small portion of its travel, the grain-of-wheat lamp is energized by the switch contact. Its filament is focused on the CRT phosphor by the lens and both mirrors. Since the lamp filament is used as a marker, only a very small amount of light is required. Thus, the voltage on the lamp can be reduced with a consequent increase in the operational life of the lamp. When the trigger is pulled all the way back, the lamp is deenergized and the shutter above the photomultiplier is opened A detent is provided to indicate to the operator pulling the trigger when the light will be deenergized and the shutter opened.

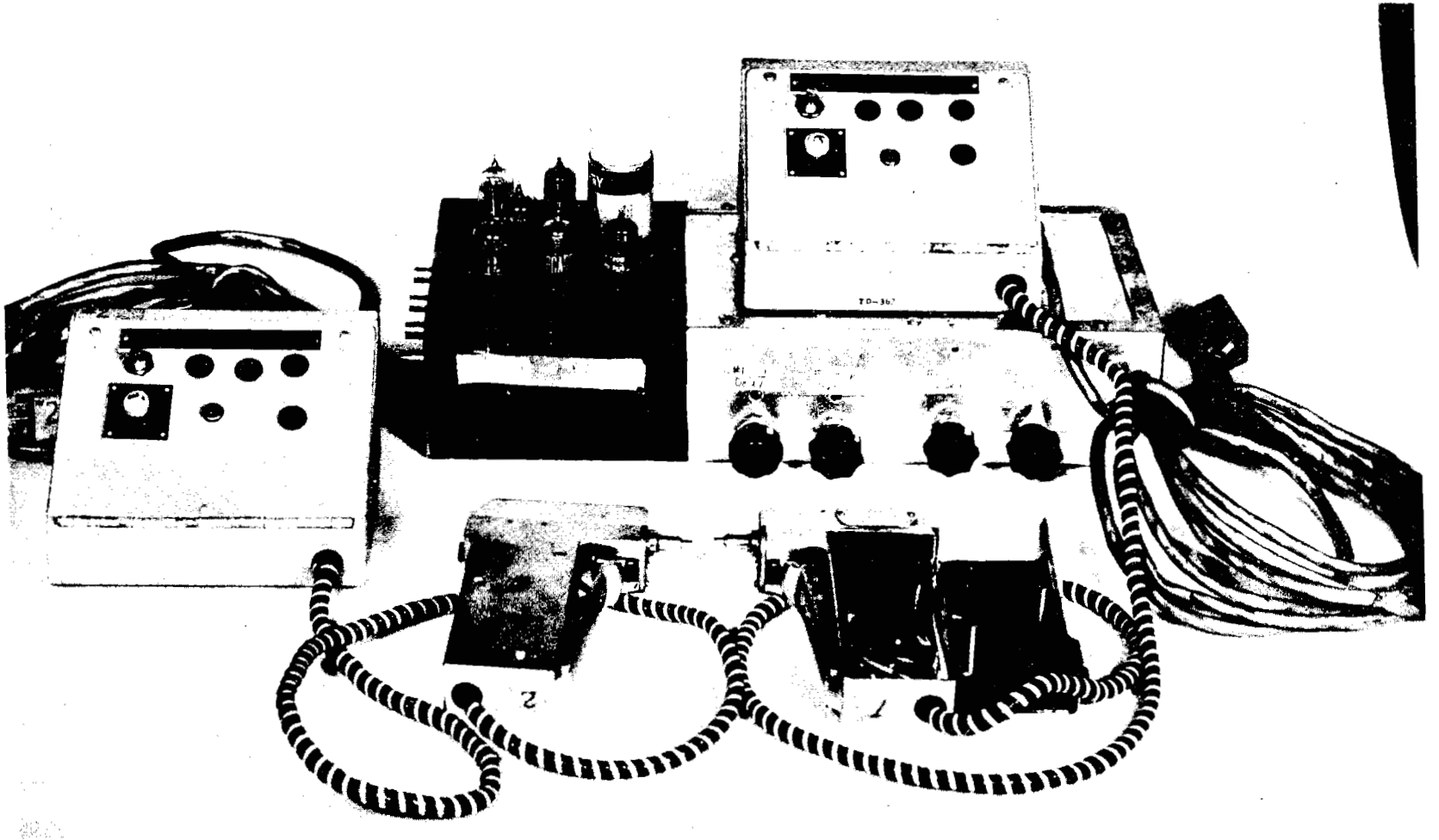


FIG. 1 LIGHT GUNS FOR RADAR HAND-OFF

It should be noted that the same light path is used to transmit the light from the grain-of-wheat lamp to the CRT phosphor as is employed to return the light from the CRT phosphor to the photomultiplier. This prevents any error caused by either optical misalignment or refraction of the light path through the overlay.

EQUIPMENT EVALUATION

The light guns and associated equipment were installed in the IFR room of the Washington National Airport control tower. See Fig. 6. No difficulty was encountered in this installation. The equipment was operational from August 13 to September 16, 1958, for a total of 768 hours of continuous operation. A minor equipment failure was reported when a front-surface mirror in one of the light guns came loose. It was cemented with a better adhesive and no further difficulty was encountered. An operational evaluation of this gun in the Washington IFR room is described in a separate report.[2]

CONCLUSIONS

The light gun described in this report is a much improved design over the original prototype. The mechanical and electronic designs have been time-tested and the gun was found to be stable and reliable. There are no alignment errors between the aiming marker and the detection area. The gun works satisfactorily through three Plexiglas overlays (including a yellow filter) and is not adversely affected by stray ambient light.

ACKNOWLEDGMENTS

To design and fabricate the light gun described in this report, many suggestions and a considerable amount of assistance were received. The author wishes to thank the air traffic controllers at La Guardia tower, New York, and the TDC controllers for their many helpful suggestions. For the final design of the light gun, credit goes to Mr. John F. McGinley and Mrs. Jeannette L. Sharp of TDC Engineering Services Branch. For the excellent machine and fabrication work on the light guns, credit goes to Mr. Willard W. Gigerich of the TDC Machine Shop.

[2]Frederick H. Ottersberg, "Evaluation of Radar Light Guns in the Washington National Airport IFR Room," FAA Technical Development Report No. 383, January 1959.

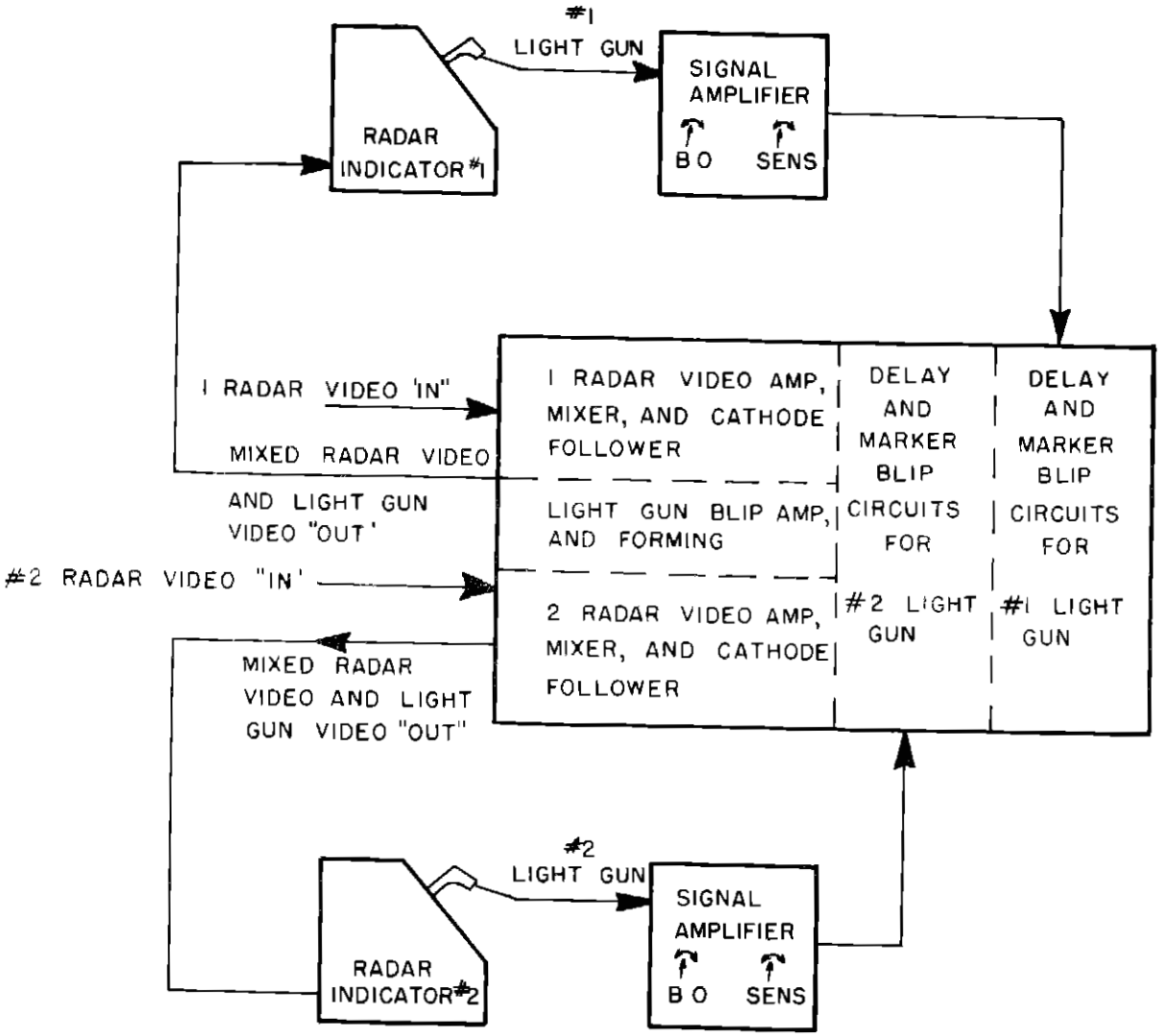


FIG 2 BLOCK DIAGRAM FOR FUNCTIONAL OPERATION OF LIGHT GUNS

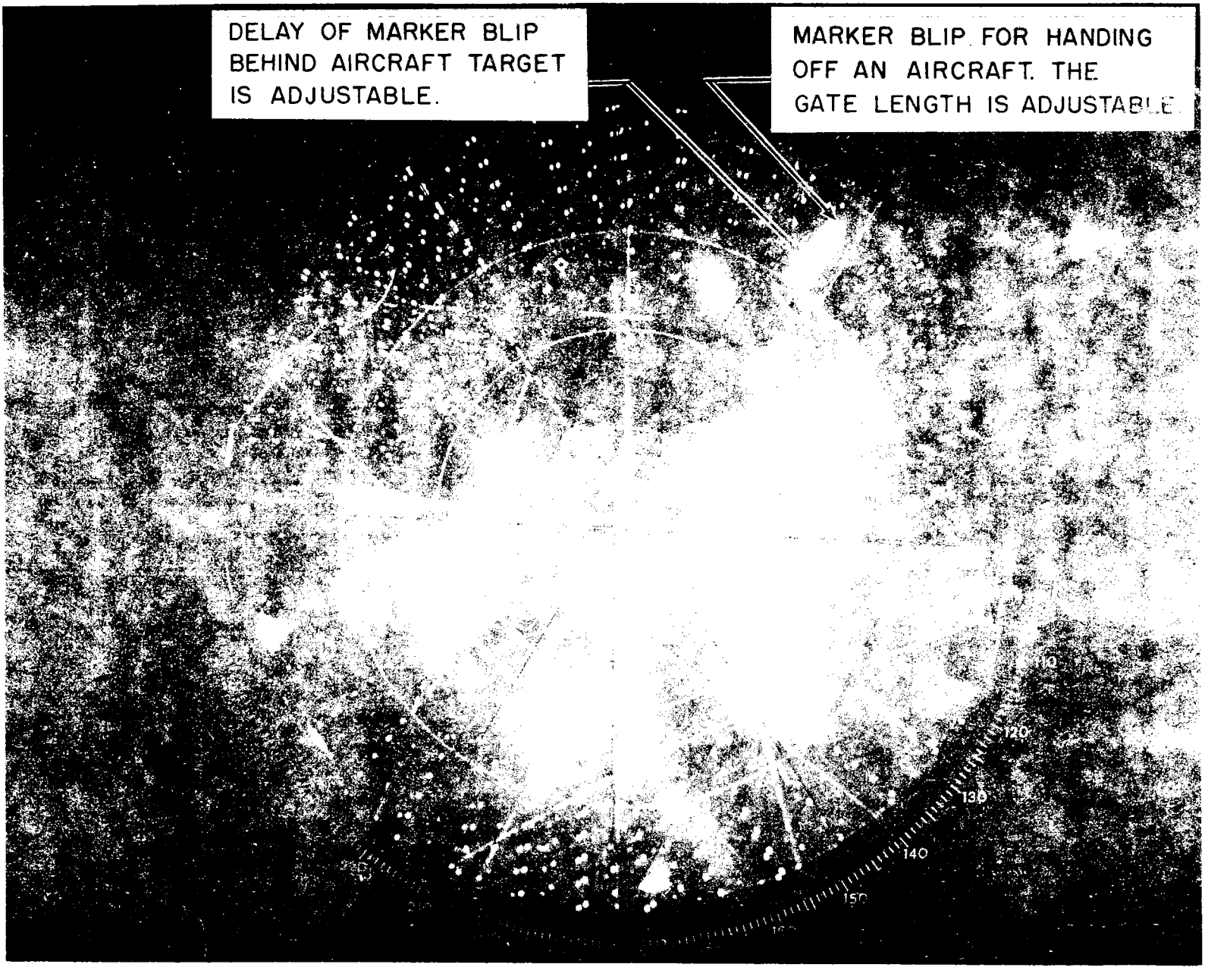
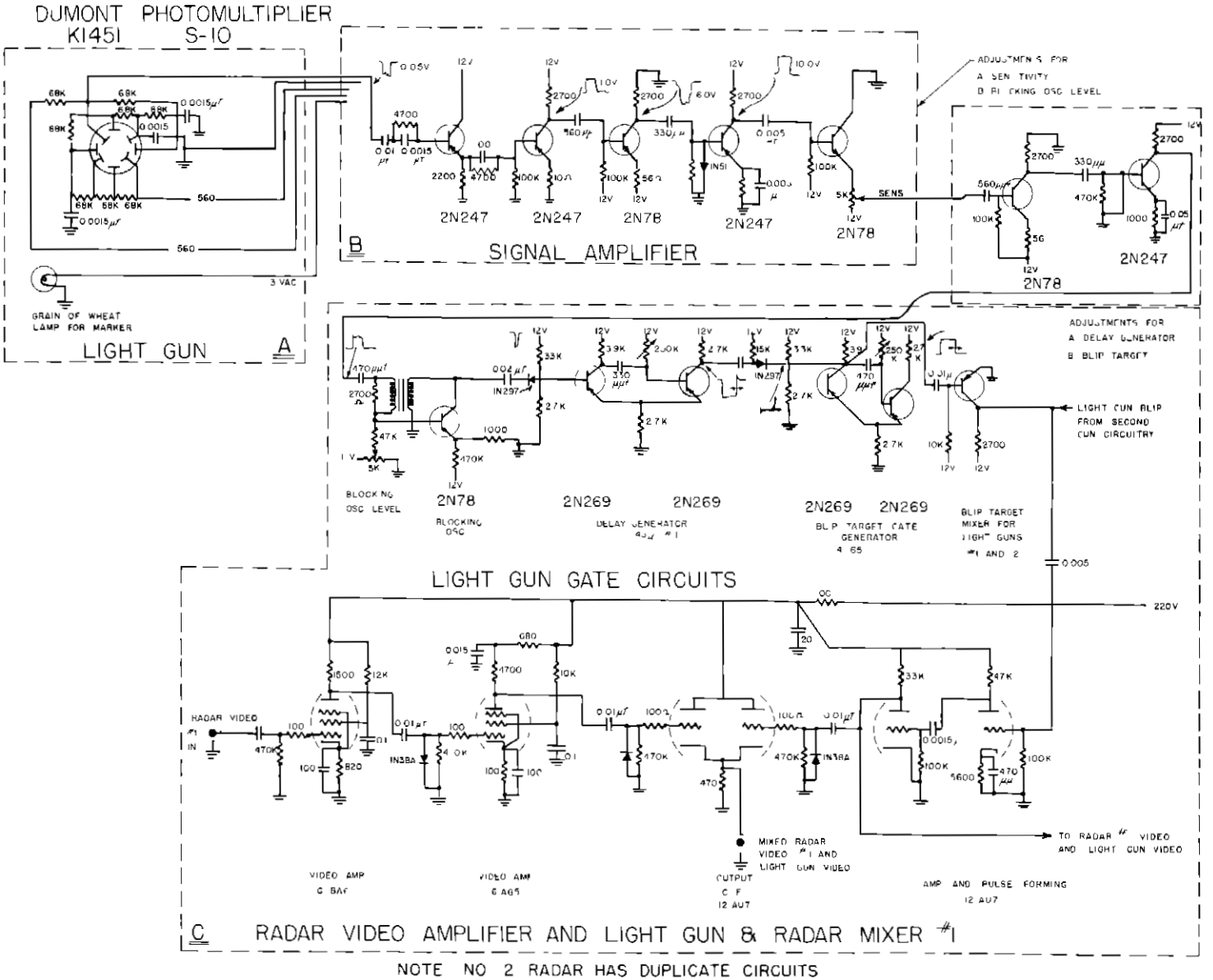


FIG. 3 LIGHT GUN MARKING AN AIRPLANE TARGET FOR TRANSFER TO ANOTHER SCOPE AT WASHINGTON NATIONAL AIRPORT



NOTE NO 2 RADAR HAS DUPLICATE CIRCUITS

FIG 4 SCHEMATIC DIAGRAM OF CIRCUITS FOR ONE LIGHT GUN

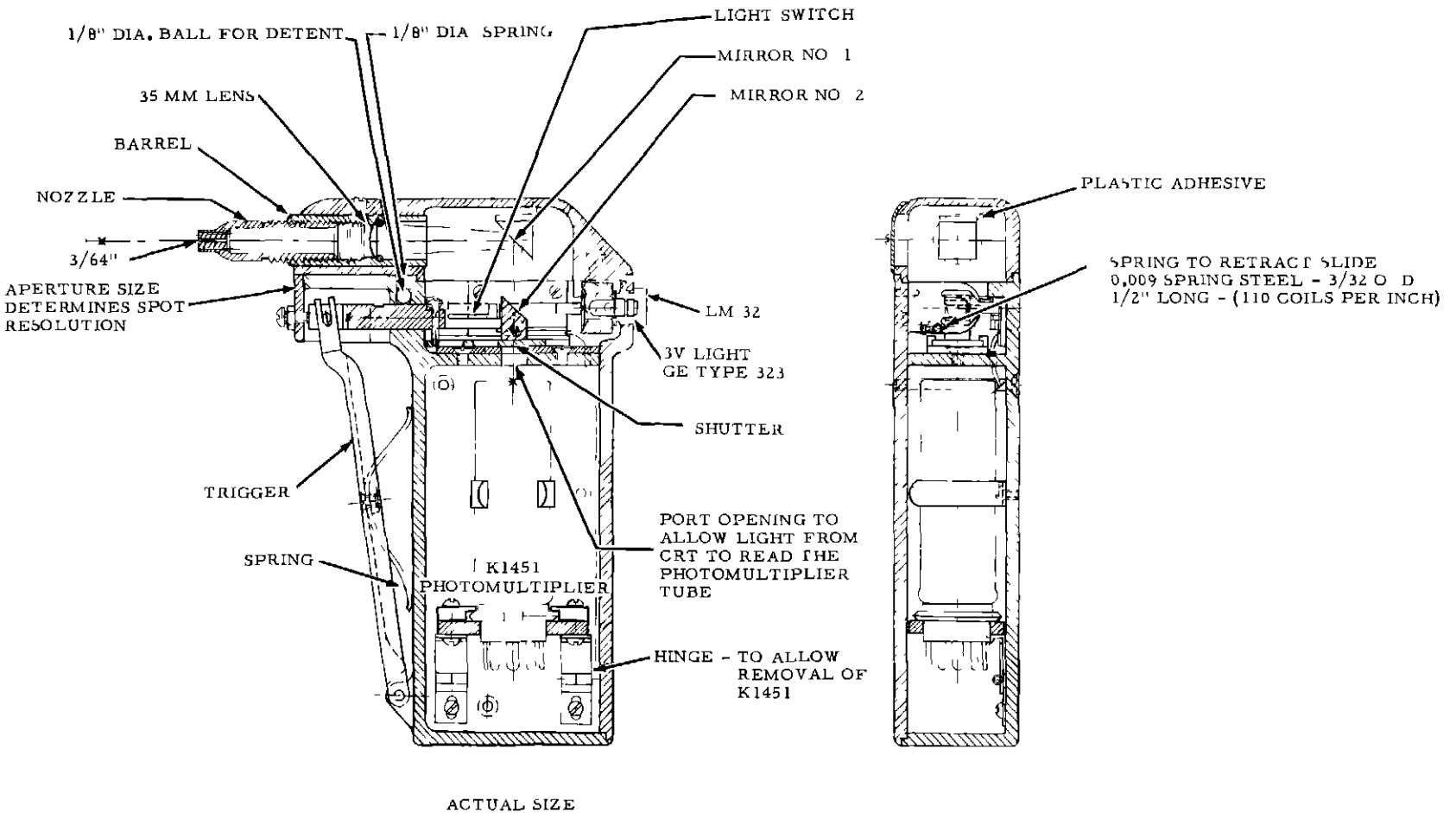


FIG 5 LIGHT GUN ASSEMBLY

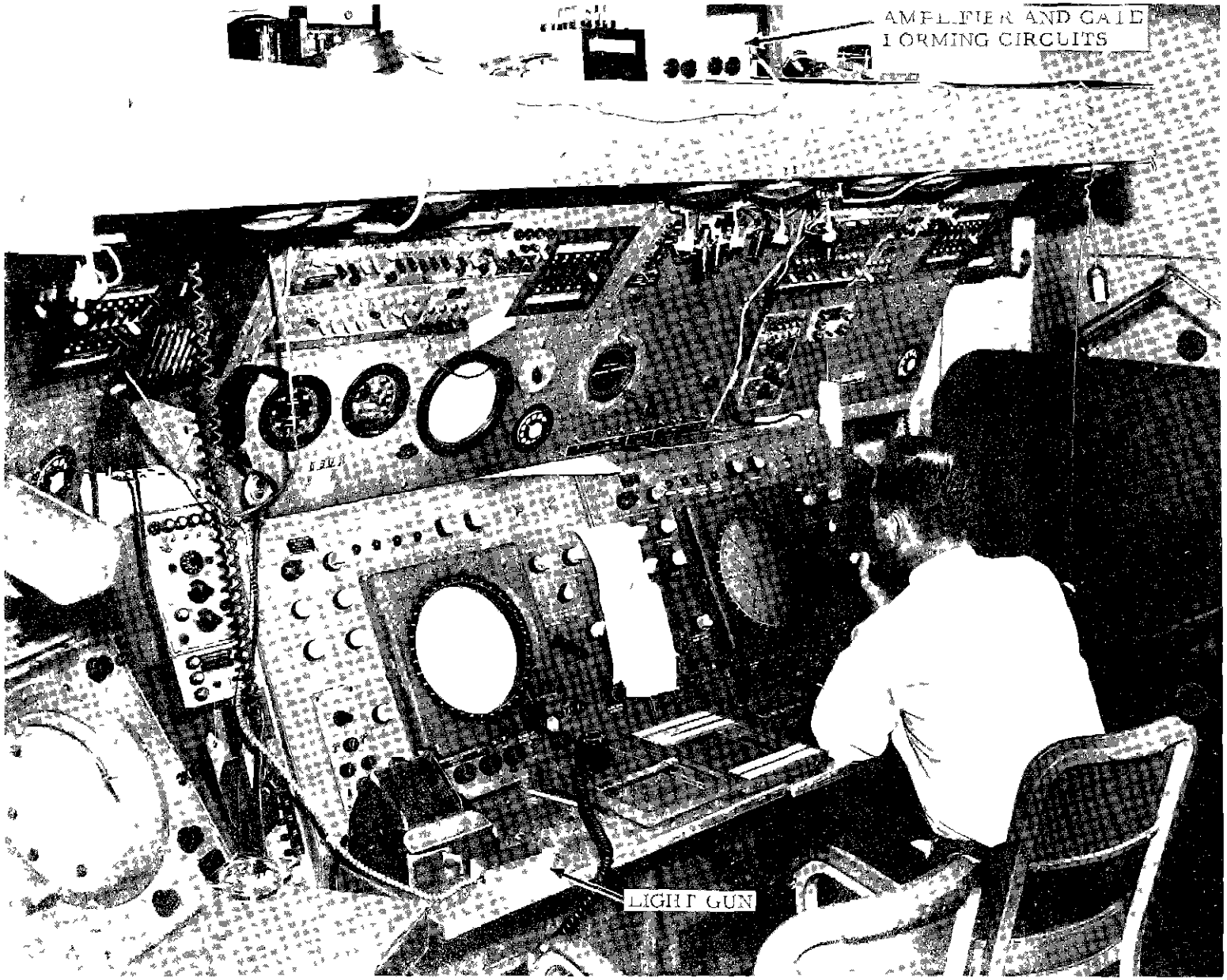


FIG. [illegible] INSTALLATION OF LIGHT GUNS AT WASHINGTON NATIONAL AIRPORT