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WADC TECHNICAL REPORT 52-167

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RIGID TOW BAR FOR C-82 TYPE AIRCRAFT

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AIRCRAFT LABORATORY

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AUGUST 1952

WRIGHT AIR DEVELOPMENT CENTER

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WADC TECHNICAL REPORT 52-167

RIGID TOW BAR FOR C-82 TYPE AIRCRAFT

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August 1952

RDO No. 458-444-b

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

FOREWORD

This report was prepared by the Stability and Control Section, Aerodynamics Branch of the Aircraft Laboratory under RDO No. R-458-444-b. (Former RDO R-453-297). Contract No. AF 33(038)-9227 was let to the Eastern Rotorcraft Company, Willow Grove, Pennsylvania for services, reports, drawings and actual construction of the tow bar.

Acknowledgement is given to: Mr. A. H. Rosner of the Special Projects Branch of the Aircraft Laboratory as the initiator of the project; Mr. K. W. Zarht of the Mechanical Branch for help in furnishing the electrical brakes and advice on their operation; personnel of the Structures Branch for help in the structural problems involved; the pilots of the glider, Lt. Colonel Rosenfield, Lt. Colonel Sweet, and Major Cecil, and to all others who helped in the development and testing of the rigid tow bar.

Mr. B. A. Hohmann was project engineer and Mr. A. G. Jones acted as assistant project engineer in bringing to a conclusion the project started by Special Projects Branch.

During the flight test, Mr. B. A. Hohmann participated as co-pilot on the C-82 tug and Mr. A. G. Jones acted as technical observer and operator of the instrumentation installed in the glider.

ABSTRACT

Design and flight tests of a "Rigid Tow Bar" for towing a glider by the C-82 type aircraft were conducted at Eastern Rotorcraft Company and Wright Air Development Center, Wright-Patterson Air Force Base from November 1949 to November 1951. This project was started by the Special Projects Branch of the Aircraft Laboratory and concluded by the Aerodynamics Branch of the same laboratory to investigate the feasibility of this type of towing device for all-weather operations.

It is concluded that this towing method has considerable advantages over rope tow in that: it can be used for all-weather flying, the equipment is much easier stored and would outlast rope many times. Flying the G-15 behind the C-82 in rigid tow, in general, requires less pilot technique than flying it behind the C-47 or C-46 in rigid tow, particularly during take-off.

One of the disadvantages of this bar was the necessity of adding ballast to the nose of the C-82 to compensate for the additional weight on the tail.

PUBLICATION REVIEW

This report has been reviewed and is approved.

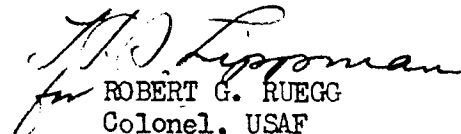

for ROBERT G. RUEGG
Colonel, USAF
Chief, Aircraft Laboratory
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Introduction

The evolution of the rigid tow bar as a method of towing gliders started with the investigation of a tow arrangement for gliders by the Germans. Use of a tow rope angle indicator to aid flight in bad weather conditions proved unsatisfactory because of inaccuracies introduced by the effects of long ropes and false indicator readings while the glider was flying in extreme positions relative to the towing aircraft. Use of a short tow rope, 5 to 7 feet long, was tried in order to maintain visual contact between glider and airplane. This proved to be unsatisfactory for combat because of the poor dynamic stability and angles on short ropes produced a tendency for oscillation, hunting, and over controlling especially about the yaw and pitch axis including a Dutch Roll tendency of the glider. (See Figure No. 1)

A number of rigid tow bars were developed by the Germans, the last one being a ball and socket coupling tow bar developed in 1942. The socket of this unit was equipped with brake lining material which provided damping within a cone of 60°. Damping friction could be varied by tightening or loosening the two half sections of the ball housing or socket.

On 14 November 1949 the Eastern Rotorcraft Company of Willow Grove, Pennsylvania was given a contract to design, fabricate, and test a rigid tow bar for the C-82 type airplane. This project was a continuation of rigid tow bar work started under R-453-279, R-456-46 and AMC Technical Instruction 2096-24. In 1947 the Ninth Air Force fabricated a bar according to the design of two German specialists and installed it in a C-46 airplane. This airplane, with the bar installed, was furnished to the Air Materiel Command for flight tests. Tests proved that the rigid bar method of towing was satisfactory. Since both the C-46 and C-47 airplanes were in limited use for glider towing, further work on the design of these bars were discontinued, and plans were made for the development of a tow bar to be used on a C-82 aircraft.

Design

1. General:

The general arrangement of this bar (Fig 2) as proposed by Mr. Rosner was as follows: a triangular rigid tow bar anchored to the tail booms of a C-82 aircraft, and pivoting about an axis parallel to the horizontal stabilizer. The bar was terminated at each end by an electric brake. A standard glider tow release was mounted at the aft end of the tow bar. The weight of this bar was 186 pounds with 130 pounds for the brakes and arms. The actuator cover and bracket weighed 5.8 pounds and the universal joint weighed 15 pounds.

2. Brake System

The purpose of the electric brakes was to act as a damper of the up and down movements of the bar. (Fig 2) The brake itself was manufactured by the Warner Electric Brake Manufacturing Company of Beloit, Wisconsin (Drawing No. H-2-x-319⁸) and had a shoe three inches wide acting at a five and one-half inch radius. This provided 103.5 sq. in. braking surface per brake.

The operation of this original brake configuration as can be seen in Fig. 3 worked on the principle of an electro magnetic field with a free floating magnet (Fig. 3, Part 2) keyed to the brake shoe by means of a lever system.

When power is applied to the magnet, (Fig. 3, Part 2) the armature, which is attached to the drum, is drawn in and the shoes are expanded into the drum.

In the adaptation of these brakes for use with the rigid tow bar, the contractor incorporated the part known as the armature (Fig 3, Part 3) into the face of the drum (Fig. 3, Part 6) as one piece. The incorporation mentioned above (Fig. 4) would have been satisfactory except, (1) the material used did not possess the magnetic properties necessary, (2) the raised surface of the drum that was to serve as the armature was not wide enough to touch the poles or edges of the "u" shaped magnetic ring, (3) the magnetic flux pattern could not follow the same lines as it did with the thin ring plate (armature) used in the original brake configuration. In correcting this difficulty, annealed boiler plate of low carbon steel was substituted for Armco ingot iron as called for by the brake manufacturer. From this material two 1/8-inch thick rings were machined which were screwed to the drum with a ring of phenolic material between it and the raised section of the drum which had been machined down.

It was originally intended that control of these brakes be done by the use of a single rheostat in the glider, but due to the fact that a rheostat of the desired resistance would have been prohibitive in size, two smaller ones were used. (Fig. 6) Fig. 7 indicates the wiring as used for the operation of the brake. This wiring was so arranged that once the system was turned on (Fig. 6) in the tug cockpit, the brakes were immediately applied full strength. To control the strength of the current passing through the brakes, all that was necessary was to plug in the quick disconnect bringing the rheostats in the glider into the electrical system. To facilitate a possible need for operation of the bar brake from the C-82, a momentary switch was placed in the rear of the cargo compartment which upon operation removed power from the brakes. This switch operated only when the glider was disconnected.

While the brakes did develop considerable resistance to the movement of the bar in moderately rough air, it was concluded that they would not provide adequate braking of the movement in rough air.

The main difficulty encountered in the electric brake system as used on this rigid tow bar installation appeared to be twofold: (1) The resistance of the brakes themselves was not sufficient in view of the long lever arm being applied to them. (2) In this particular configuration there was little rotation of the brake drum, and the brake drum has to rotate to increase the clamping power of the brake shoes. The brakes did not tighten until the arm had rotated about 15° either side of center and in rough air; this is not a desirable feature.

3. Release System

In order to facilitate the quick release of the glider in case of emergency or in preparation for landing, a tow release (14G1545-3) was installed at the vertex of the rigid tow bar.

The operation of this release was controlled from the cockpit of the C-32 aircraft, (Fig. 8 and 11) by an electric switch which operated a linear actuator. (Type DG-SP Drawing No. 25862-12, Air Research Company, Los Angeles, California). Originally it was planned to leave the actuator in the C-32 boom and connect it to the release at the bar vertex by a control cable, but in the actual installation it was decided that better operation could be secured by locating the actuator close to the release (Fig. 12) and that was the final arrangement. Another release, which was installed on the end of a short tow bar extending from the glider, gave the glider pilots a manual means by which they too could disconnect if necessary.

4. Intercommunication System

A two-way intercommunication system was established between the glider and the tug with a quick disconnect at the location of the tow releases.

5. Structural Design of Tow Bar

The structural design of the tow bar as carried out by the Eastern Rotorcraft Company is given in detail in Eastern Rotorcraft Company Report T-105.

Ground Tests

Prior to the installation of the bar on the C-32 aircraft and in accordance with Structures Branch comments, certain structural

modifications were made to strengthen the tow bar. To check the possibility of bar flutter of the horizontal member, the bar was installed on the aircraft and while sitting on the ground the engines of the C-82 were opened up to full throttle and a check was made for excessive vibration. It was noted that what vibration or flutter that did exist was no more than that already present in the tail booms themselves. The ground tests on the tow bar performed by the contractor are reported in Eastern Rotorcraft Company Report T-106, "Report of Tests, Tow Bar Assembly".

Flight Tests

On 15 October 1951, C-82A, 44-23004 and CG-15A, 44-5276 were flown in rigid tow for the first time. This also is the first time a high-wing aircraft has been used as a tug for rigid tow.

The weight ratio of the towplane-glider combination was 7.1 to 1. The take-off weight of the C-82 airplane was 42,440 pounds with a c.g. location of 25 percent MAC. The glider weighed 5980 pounds with a c.g. of 26.5 percent MAC. The C-82 carried a thousand gallons of fuel and a crew of four. The glider carried a crew of three. To counterbalance the extra weight of the tow bar of the C-82, 800 pounds of ballast were located next to the forward wheel well with 400 pounds on each side.

In the parking area prior to the take-off, the glider was attached to the rigid tow bar, the interphone system connected, and the brakes control hooked up. The tug glider combination then taxied out to the runway avoiding sharp turns. In general, it was possible to turn shorter than with tail wheel aircraft as a tug.

In making the taxi test, the pilots found the configuration so stable that they proceeded to take-off on the very first run. As can be seen in Fig. 9, as power was applied for take-off, the glider arose from the ground and assumed a position on the level of the C-82 boom. It is believed that the glider would not have left the ground so soon, if it had been in a loaded condition. Maneuvers of the configuration during take-off and landing were made without difficulties.

In climbs, the configuration appeared to be no different than other rigid tow combinations except that it was necessary to fly slightly higher to avoid severe buffeting.

In level flight, the area of buffeting was slightly higher than previous rigid tow configurations, apparently the turbulence from the tug engines was not broken up as well. Another possible factor in this higher turbulence could be the location of the engine and wings of the tug in relation to the glider. The best position for the least turbulence seemed to be even with the horizontal tail.

Even in banks of 50°, the combination was easy to handle for both the tug and glider pilot, having low stick forces. In handling tests, simulated CCA approaches were used and the glider was released approximately ten feet off the runway while the C-82 continued to a standard landing.

The IAS for the C-82/G-15 configuration upon landing was approximately the same as the C-46/G-15 configuration. (109-115 mph)

During these flight tests several flights were run with rope tow, and the tow loads, as recorded by an oscillograph, are approximately 200 pounds higher in bar tow than in rope tow.

One flight was made with a single engine (left engine stopped and prop feathered) and altitude was maintained with normal rated power (altitude 4500 feet).

In flights made with the C-46/G-15 rigid tow bar configuration, the glider was held in close proximity to the ground until a speed varying between 80 and 86 miles per hour was attained at which time the tow plane would break ground in the three point attitude without use of the elevator control and with the original tab setting of 14° nose up. If the glider lifted the tow plane's tail wheel, the tow plane became directionally unstable and control could not be recovered until a speed of approximately 100 miles an hour was attained. This was especially true in crosswind take-offs. The technique used on the C-46/G-15 combination was also applied to the C-47/G-15 rigid tow bar tests.

In general, flying the G-15 glider on the tow bar behind the C-82 required less pilot technique than behind the C-47 or C-46, particularly during take-off. It is believed this is due to the tricycle gear configuration of the C-82, which results in less movement of the aft section of the aircraft during the take-off run. In normal flight, the flying characteristics of the glider were generally the same behind all three aircraft, although it seemed that the G-15 could be trimmed to fly "hands off" better behind the C-82.

In rough air, the position of the glider in relation to the tug aircraft was easier to maintain with the tow bar of the G-15 locked in the ball and socket joint, Fig. 2. It is believed that the tug-glider combination even could be landed satisfactorily in the coupled configuration without any difficulties.

In take-off the best pilot technique seems to be to pull the glider into the air and hold a position level with or a little above the horizontal stabilizer of the C-82, keeping the tow bar centered as much as possible. With take-off power on the C-82, this could be accomplished after the tug had accelerated only 10 or 15 mph. The tug pilot was

cautioned, however, not to cut his power abruptly, which would have left the glider in an awkward position.

Comments of the tug pilots indicated that directional and longitudinal stability characteristics during take-off were much better with the C-82 than with either the C-47 or C-46, again probably because of the tricycle gear. They were not aware of any effects of the glider except in the decreased take-off performance of the C-82. All pilots stated they could not tell when the glider had released from the tug during landing approach. Single engine operation of the C-82 tug presented no stability and control problem, the only problem being one of performance, depending on the weight of the glider and/or tug.

Conclusions

In general, the ground handling of this rigid tow bar was considerably simpler than rope-tow. In bar-tow the glider can be connected to the tug in the parking area and taxied into take-off position, flown, and landed without any additional work.

In take-off, the directional control of the C-82/G-15 combination was much easier to maintain than behind the C-46 and C-47. This is attributed to the tricycle gear which remains in contact with the runway until aerodynamic controls are effective.

The flying characteristics of the glider behind the C-82 were very good and it is believed it could be trimmed to fly hands-off.

The horizontal member of the tow bar which was immediately behind the elevator of the C-82 had no effect upon the control of the C-82.

In the C-82/G-15 rigid tow installation, the braking system did not provide much damping of the vertical motion since the brakes did not lock within the 30° deflection range.

The tow bar system has disadvantages in weight, bulk, and additional drag in bar-tow as compared with rope-tow.

It is concluded that the glider rigid-tow method has been developed to a satisfactory stage and has been proved to be a very feasible method for towing gliders or assault aircraft under instrument conditions.

Recommendations

It is recommended that in any future tow-bar design, brakes be

used that will provide a larger braking surface and braking power at zero rotation.

If at some later time a need for towing of assault aircraft or gliders exists, the equipment and techniques developed under this project be considered for immediate use.

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German Document No. F-TS-2694 RE entitled, "Rigid Towing Tests of HE-111 with DFS 230 and HE-111 with G-0242 using a Ball Socket Rigid Towing Attachment".

Memorandum Report No. TSEAC12-45323-2-1 dated 20 June 1947 entitled, "Proof Tests of the AMC Rigid Glider Tow Bar Assembly Installed on C-46 Airplanes".

Memorandum Report No. TSFTE-2107 dated 3 November 1947 entitled, "Rigid Tow Bar for Gliders Flight Test Report on C-46F Towing CG-15A".

Eastern Rotorcraft Company Report T-105, "Structural Design of Tow Bar Assembly".

Eastern Rotorcraft Company Report T-106, "Report of Tests, Tow Bar Assembly".

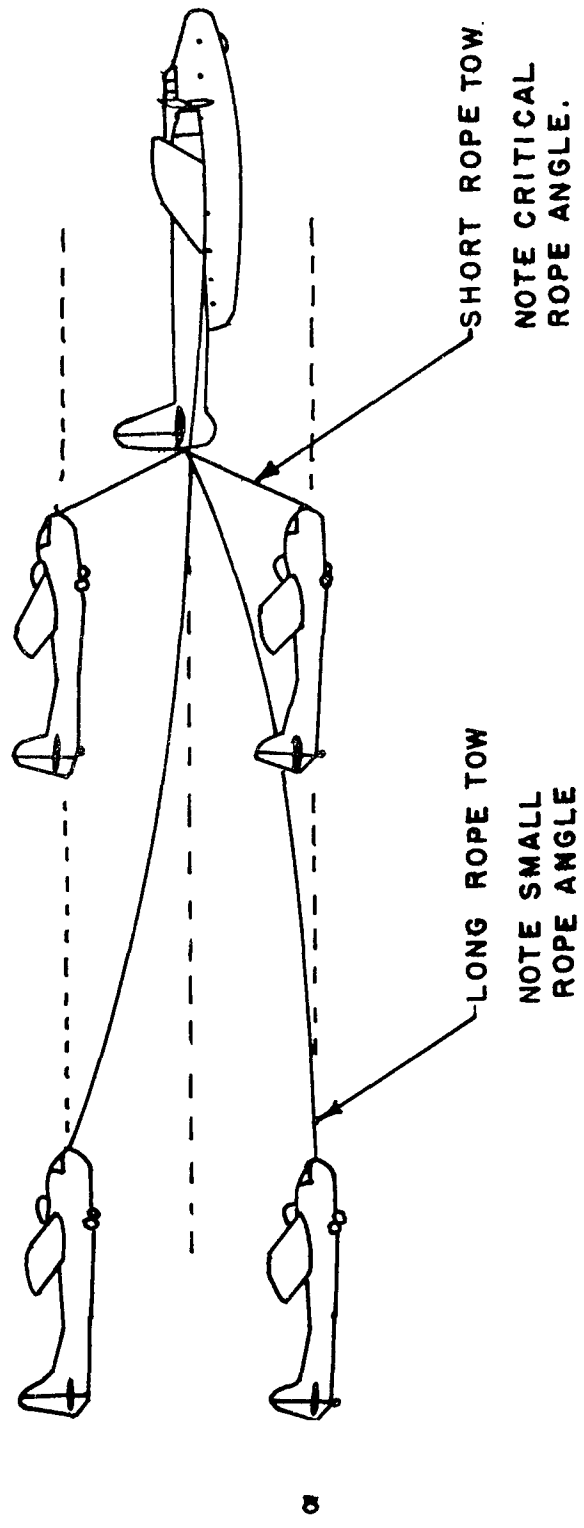


FIG. 1 Short and Long Rope Tow

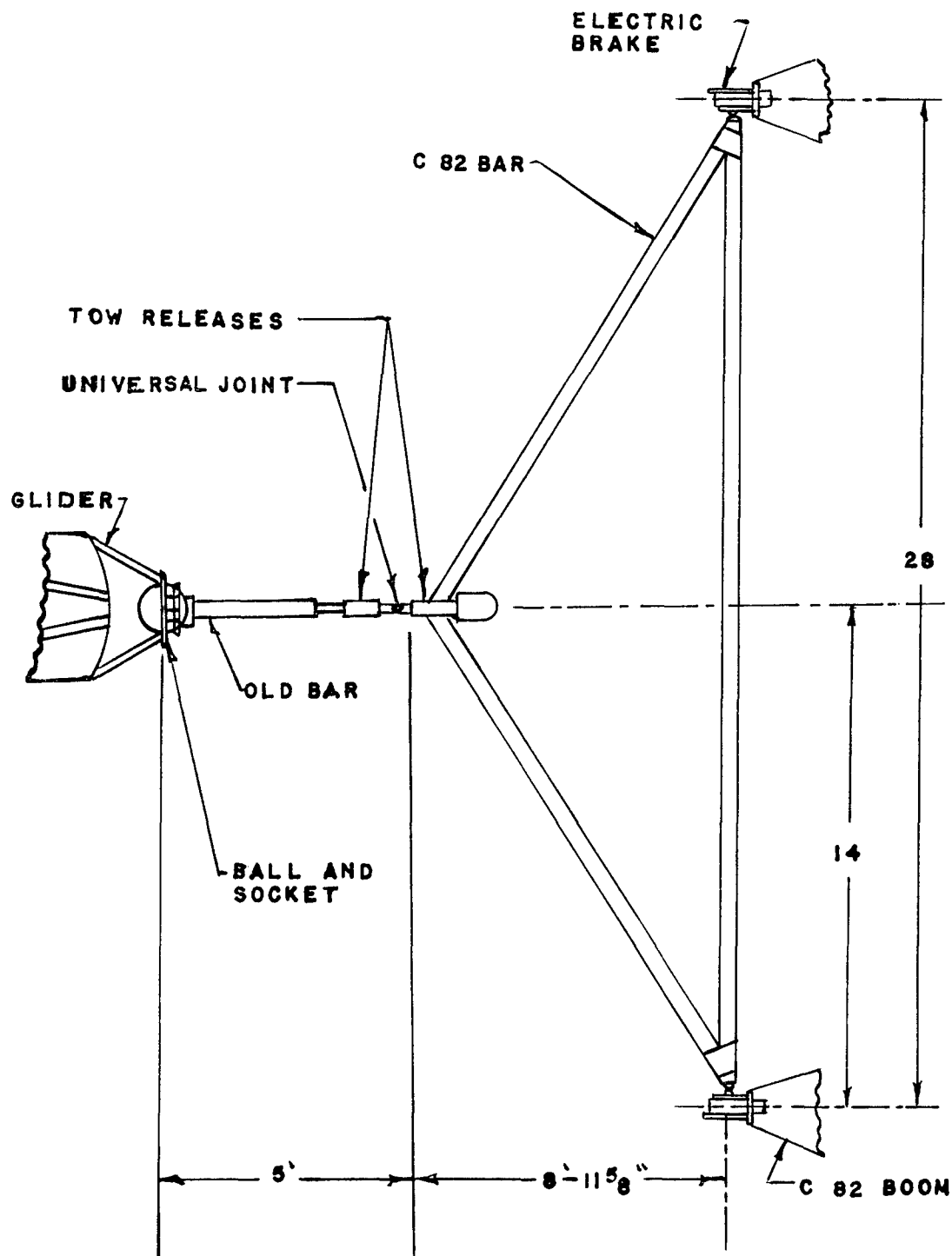
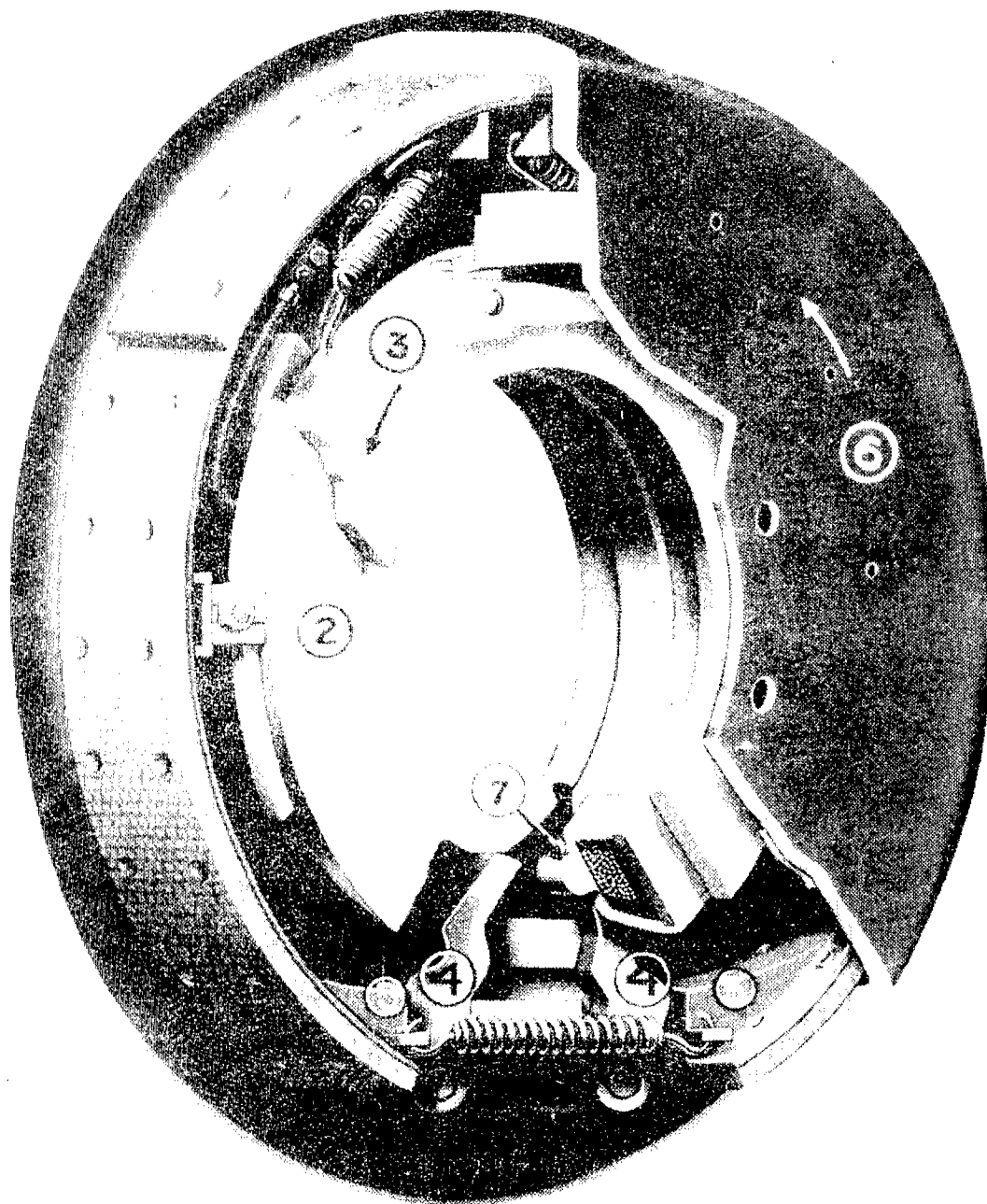


FIG 2 General Arrangement, Tow Bar



51-15132 WADC-1 27 DEC 51 GROUND TESTING C-82 RIGID TOW BAR

FIG 3 Brake

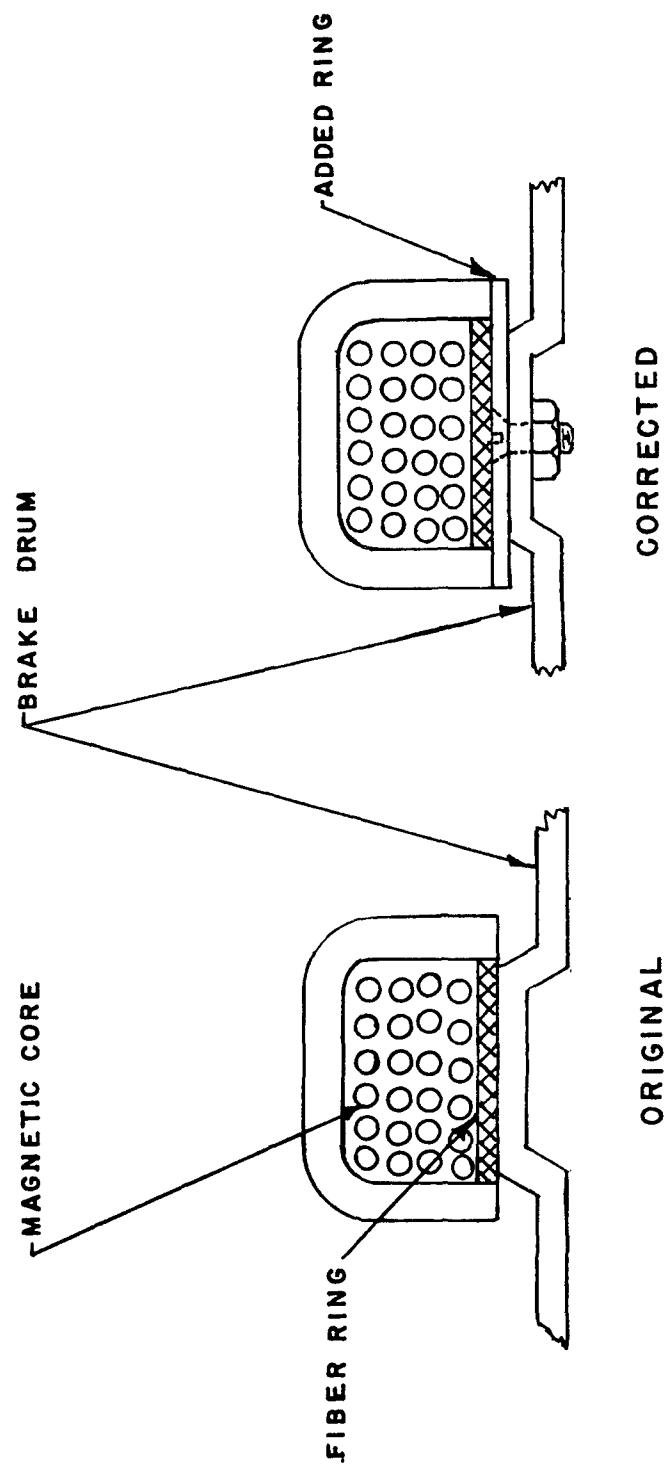


FIG 4 Brake Cross Section

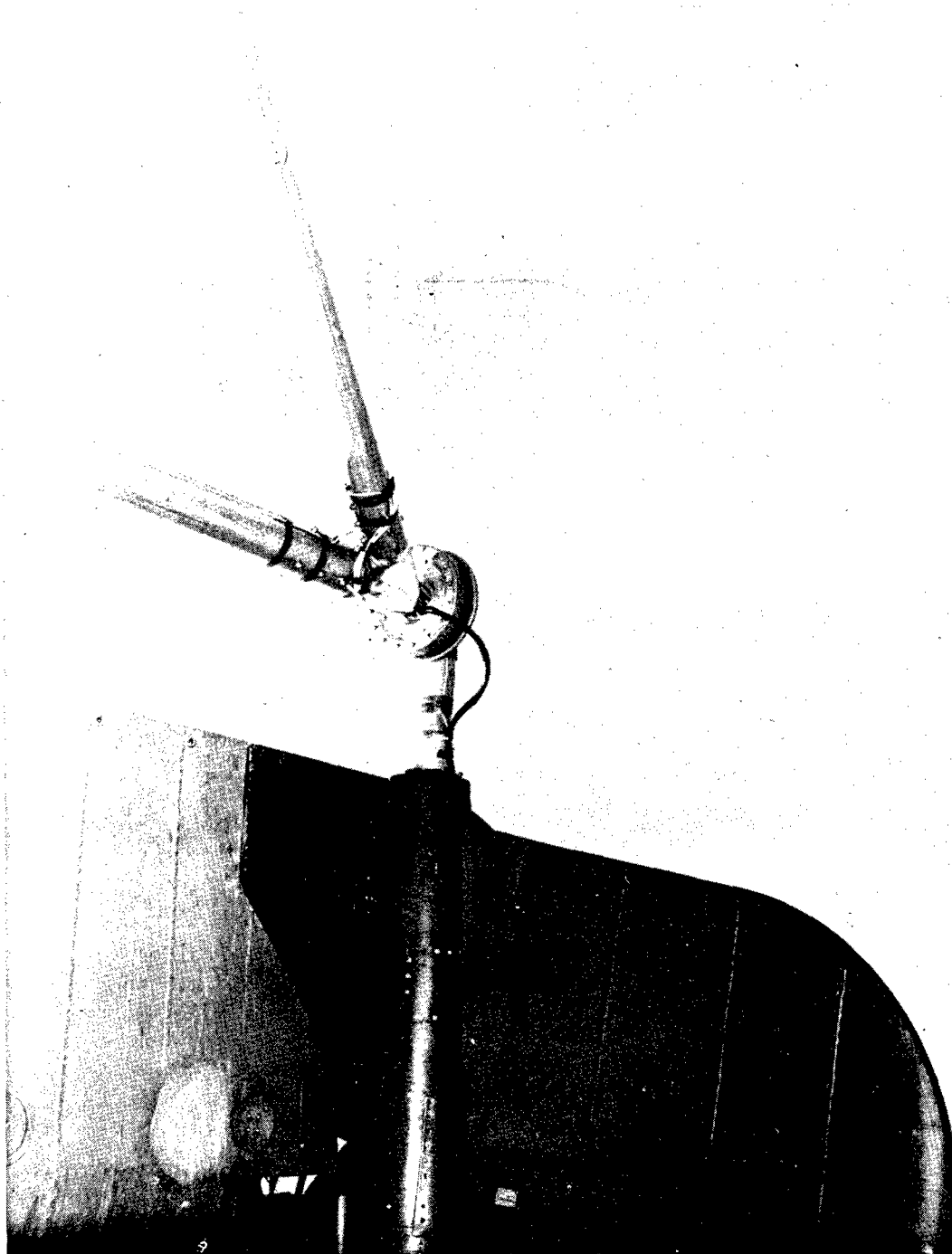


FIG 5 Altered Brake Drum Installed

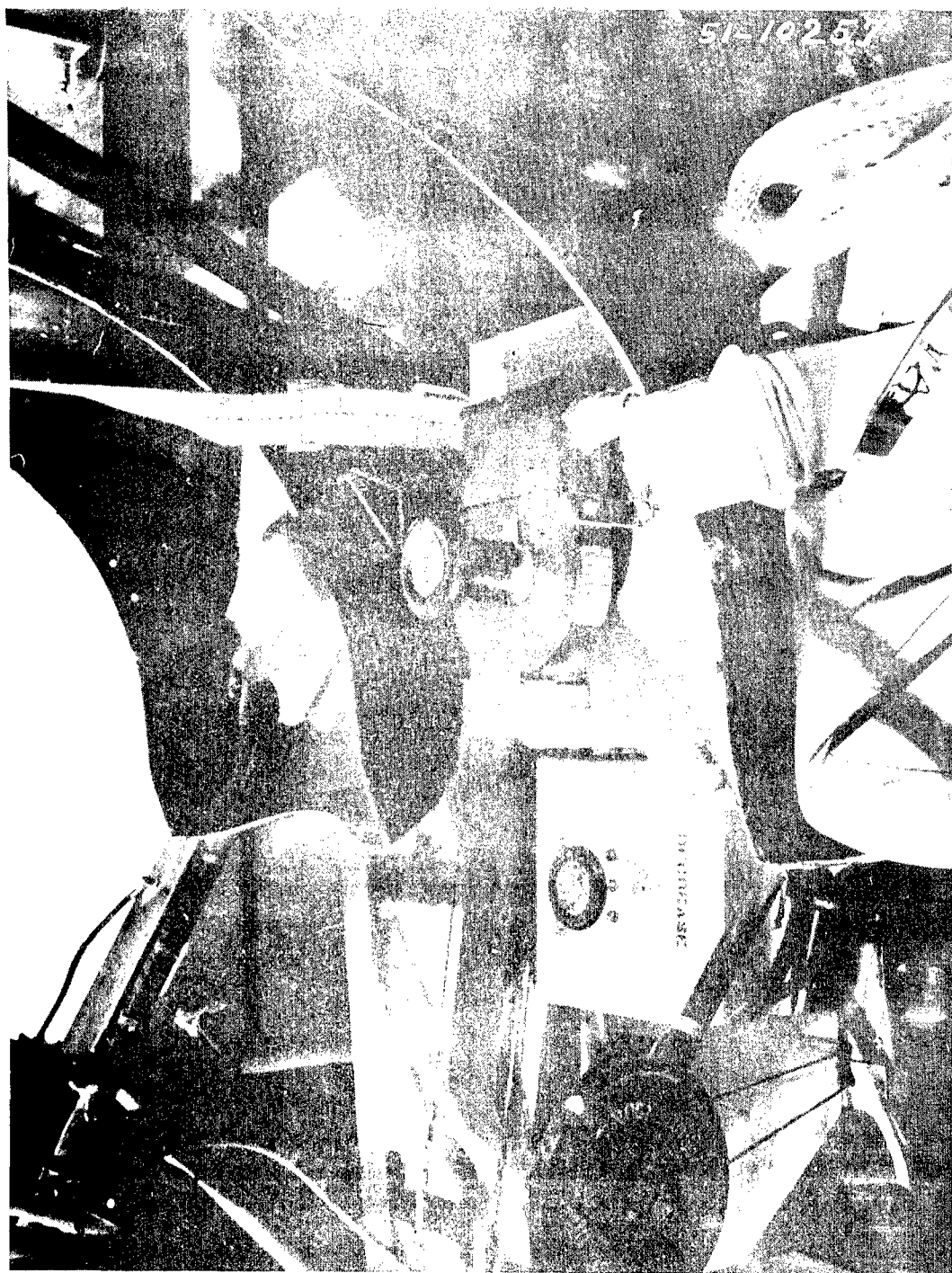


FIG 6 Rheostats

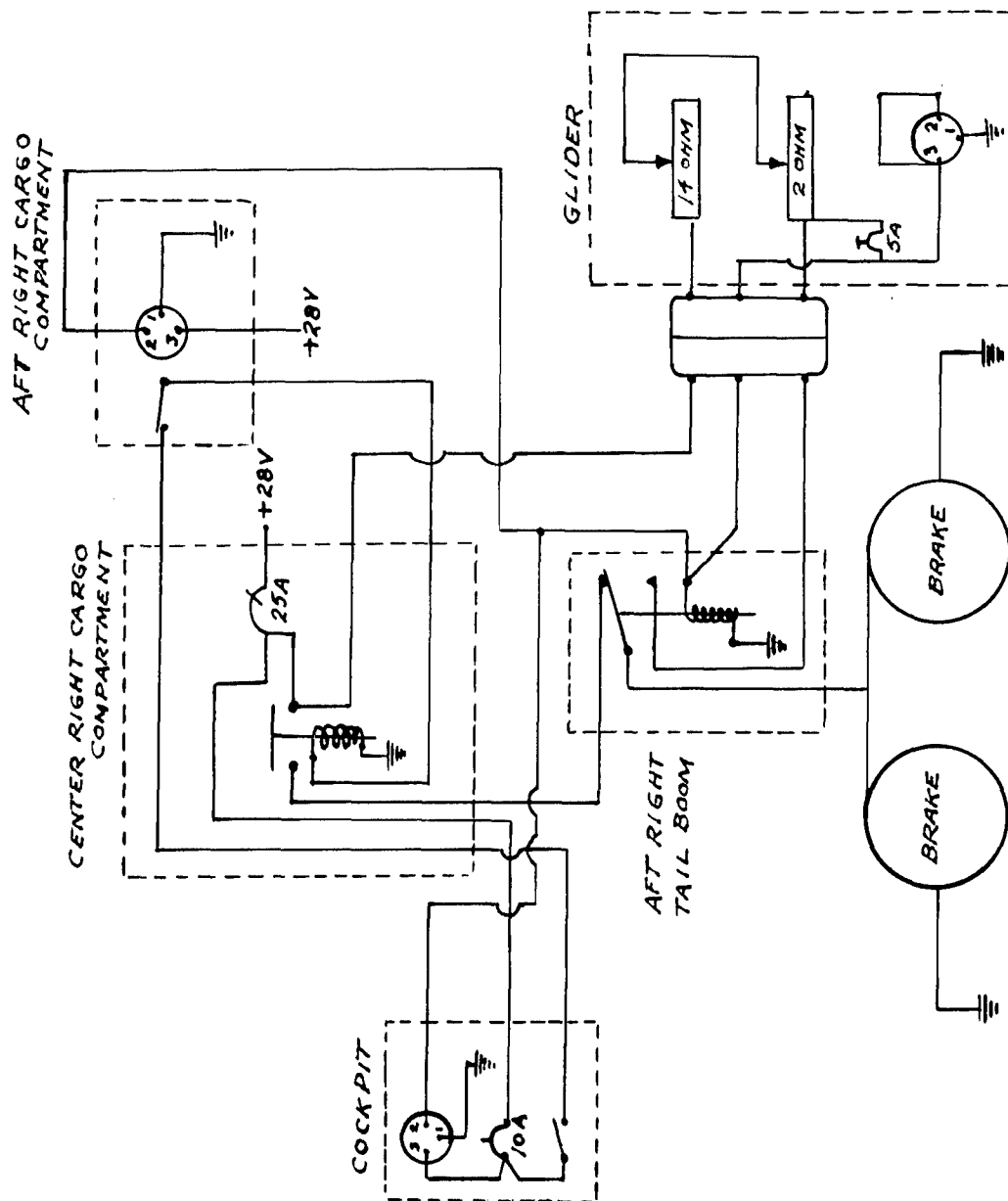


FIG 7 Wiring Diagram

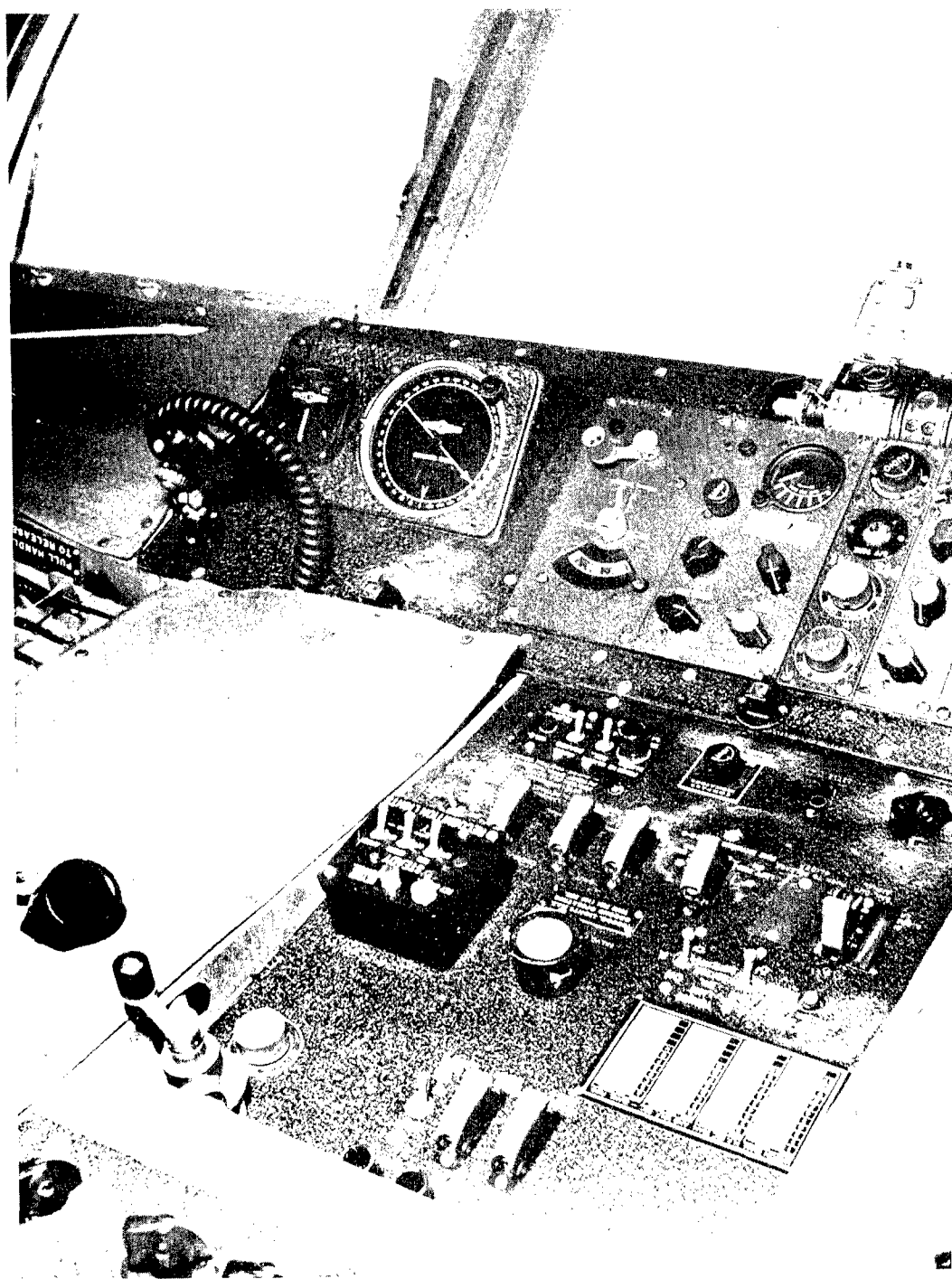


FIG 8 Cockpit Control

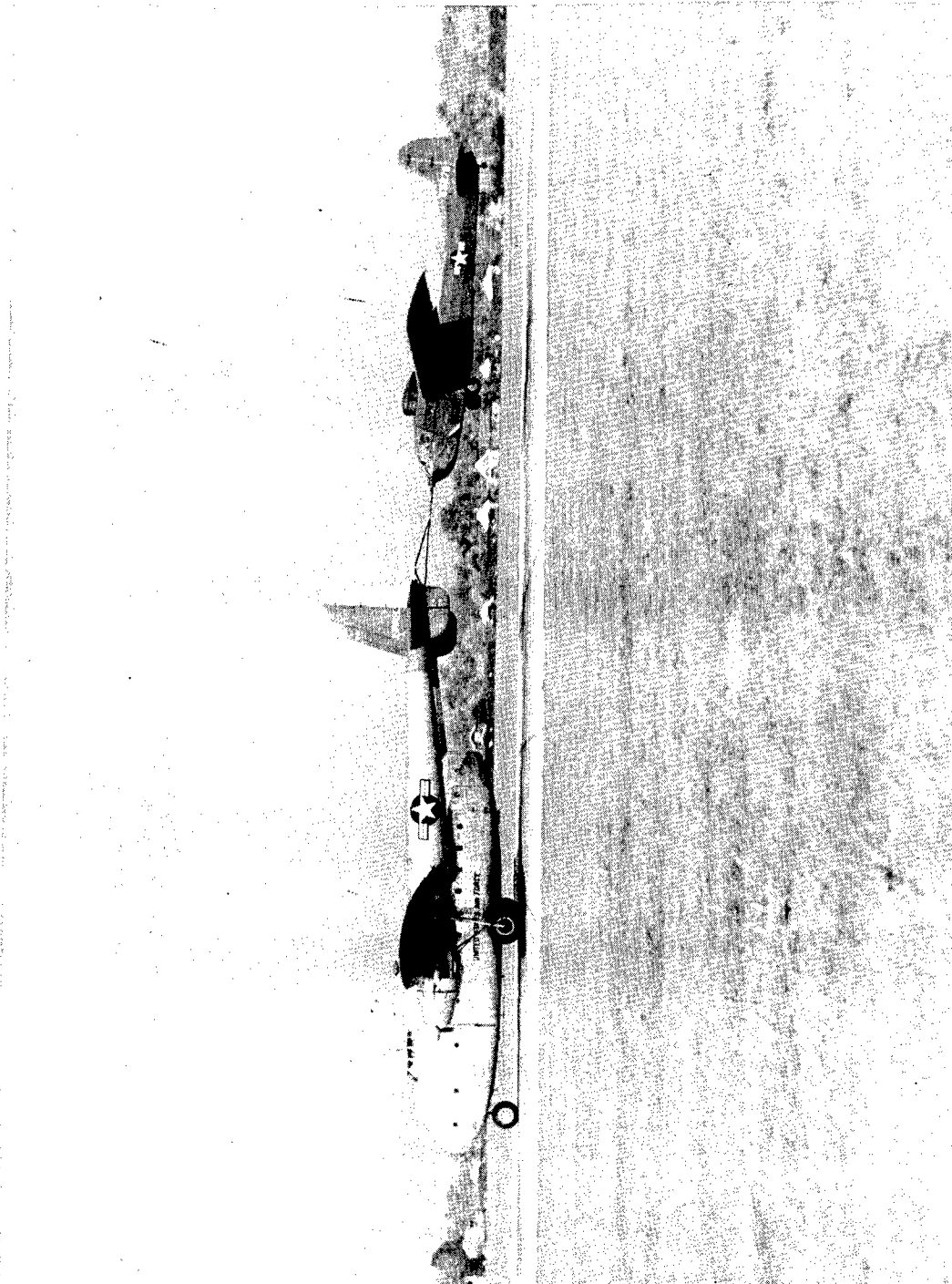
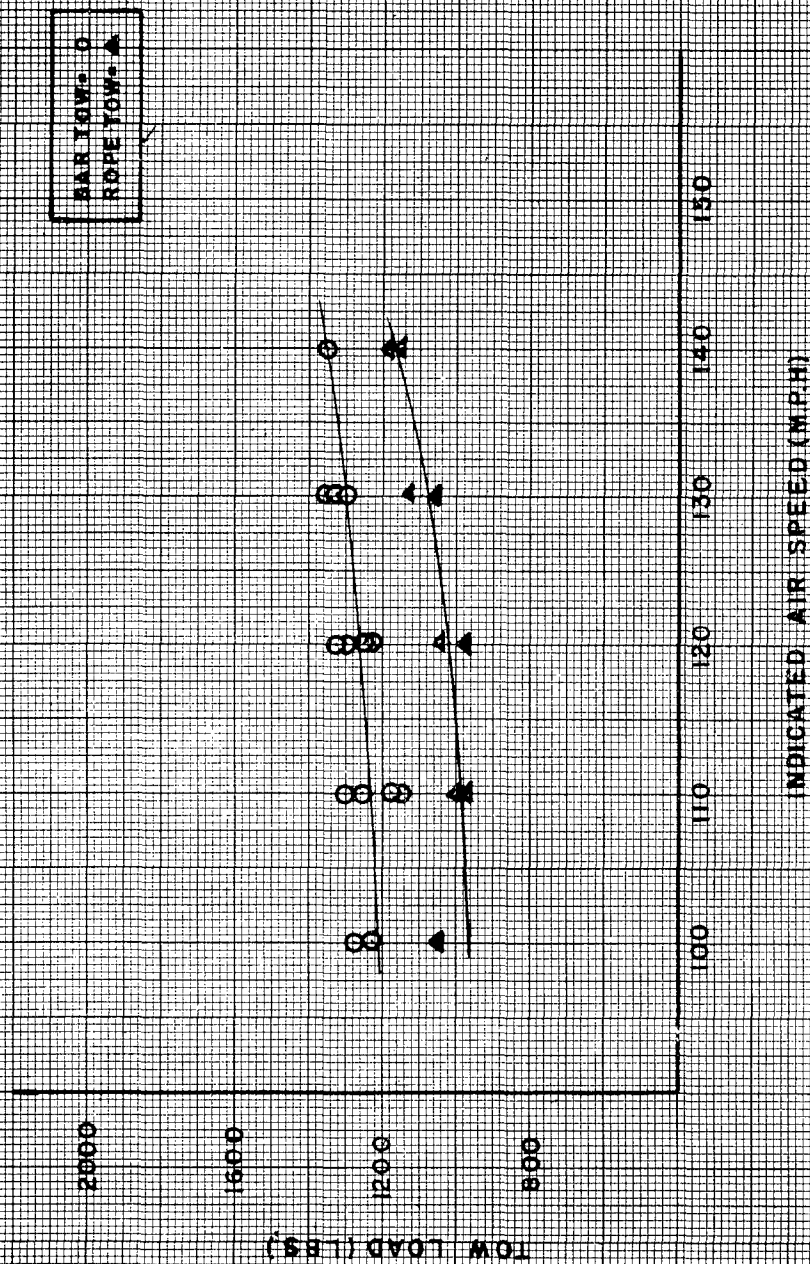


FIG 9 Take-off Start

TOW LOAD MEASUREMENTS C82 AND G15 10-24-61



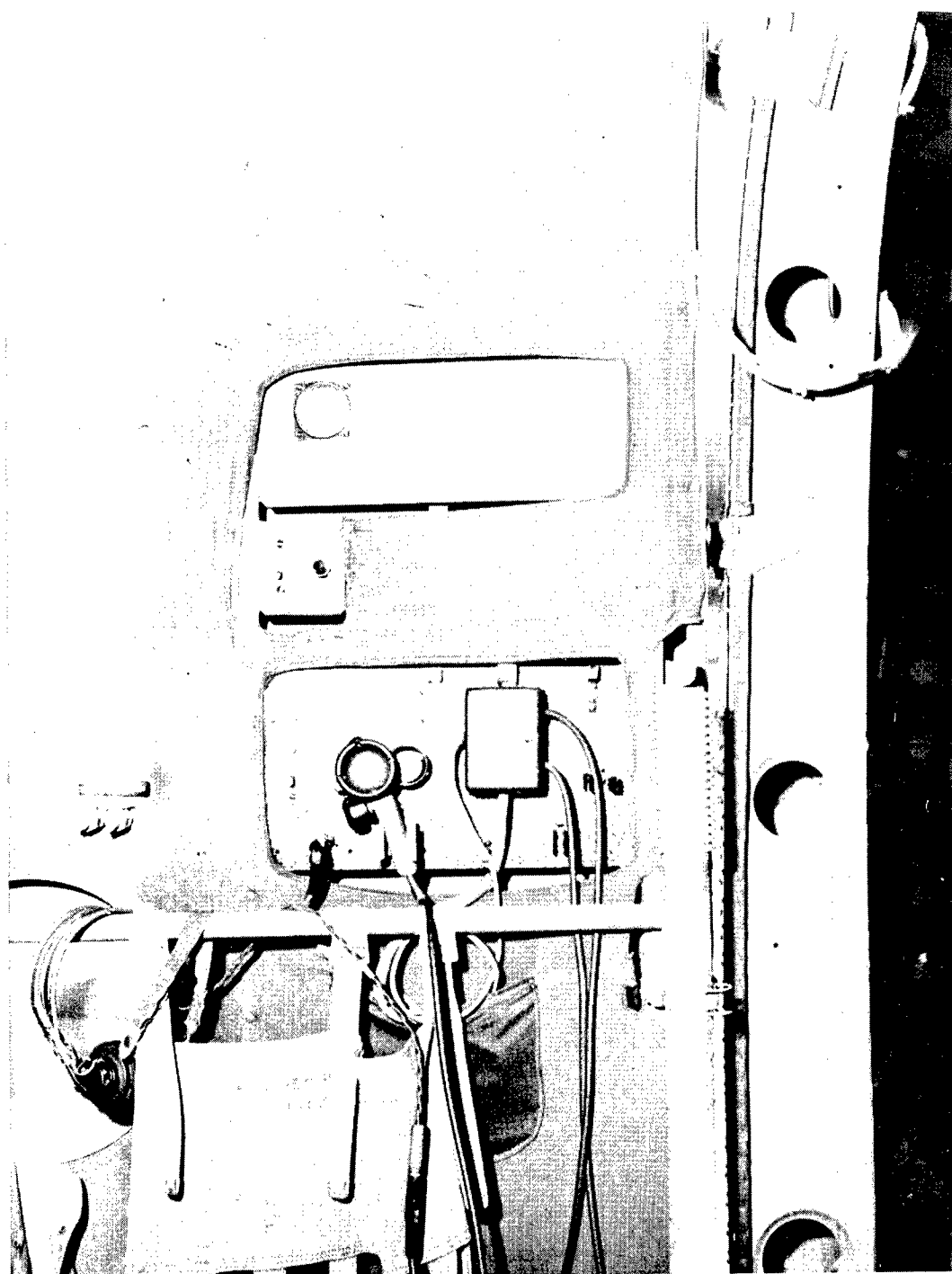


FIG 11 Rear Control Panel

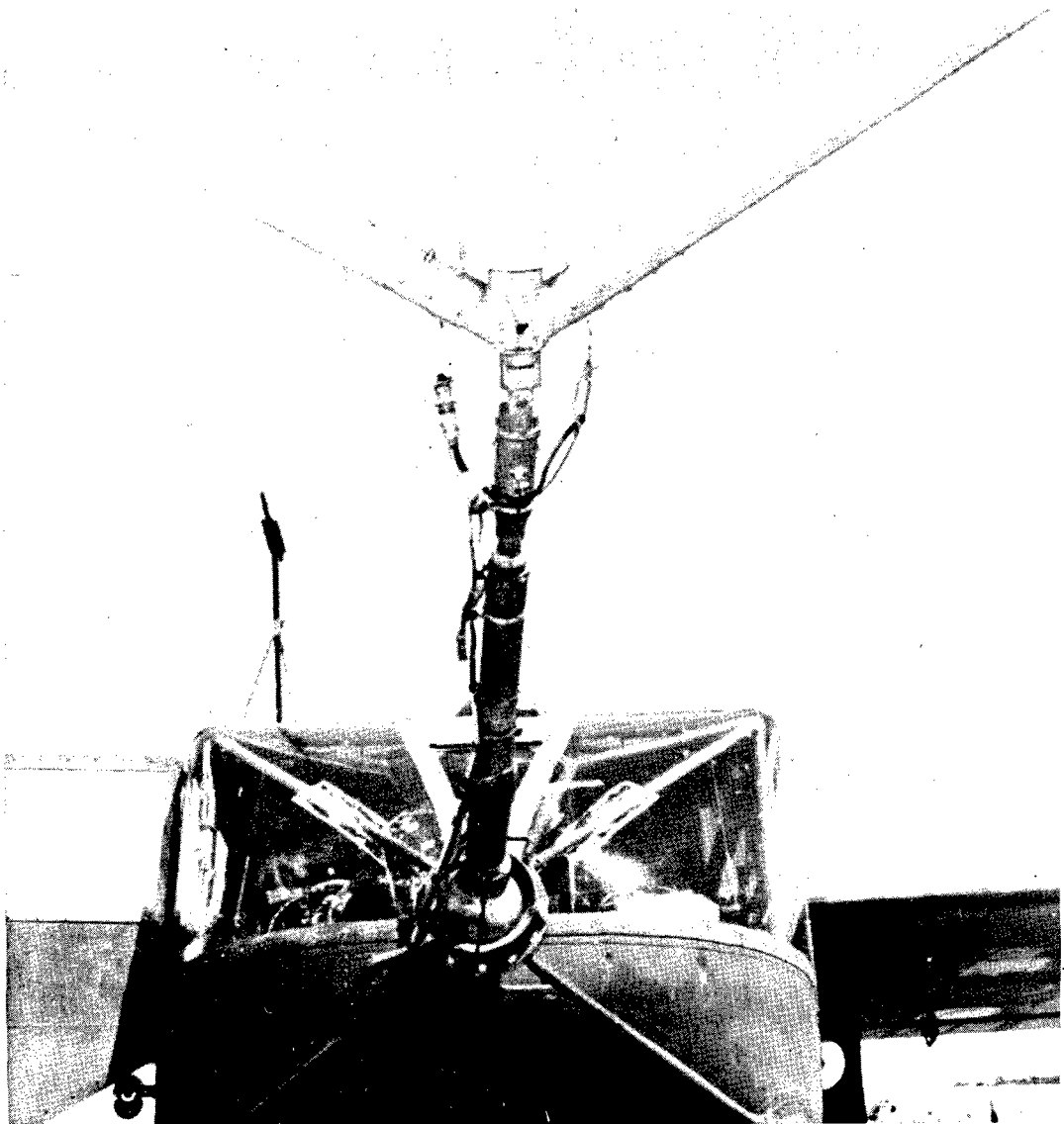


FIG 12 Tow Releases

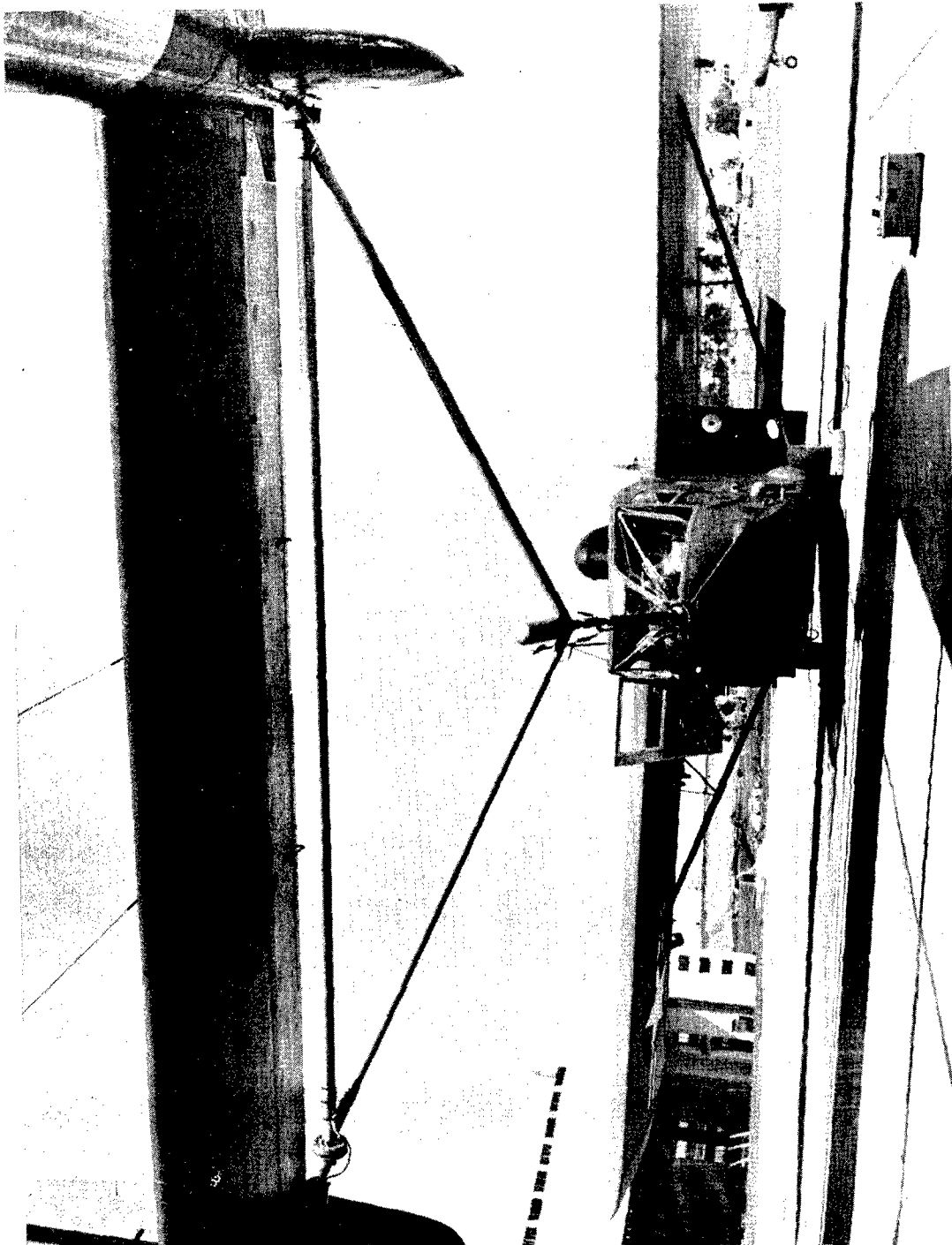


FIG 13 Rear View - Ground

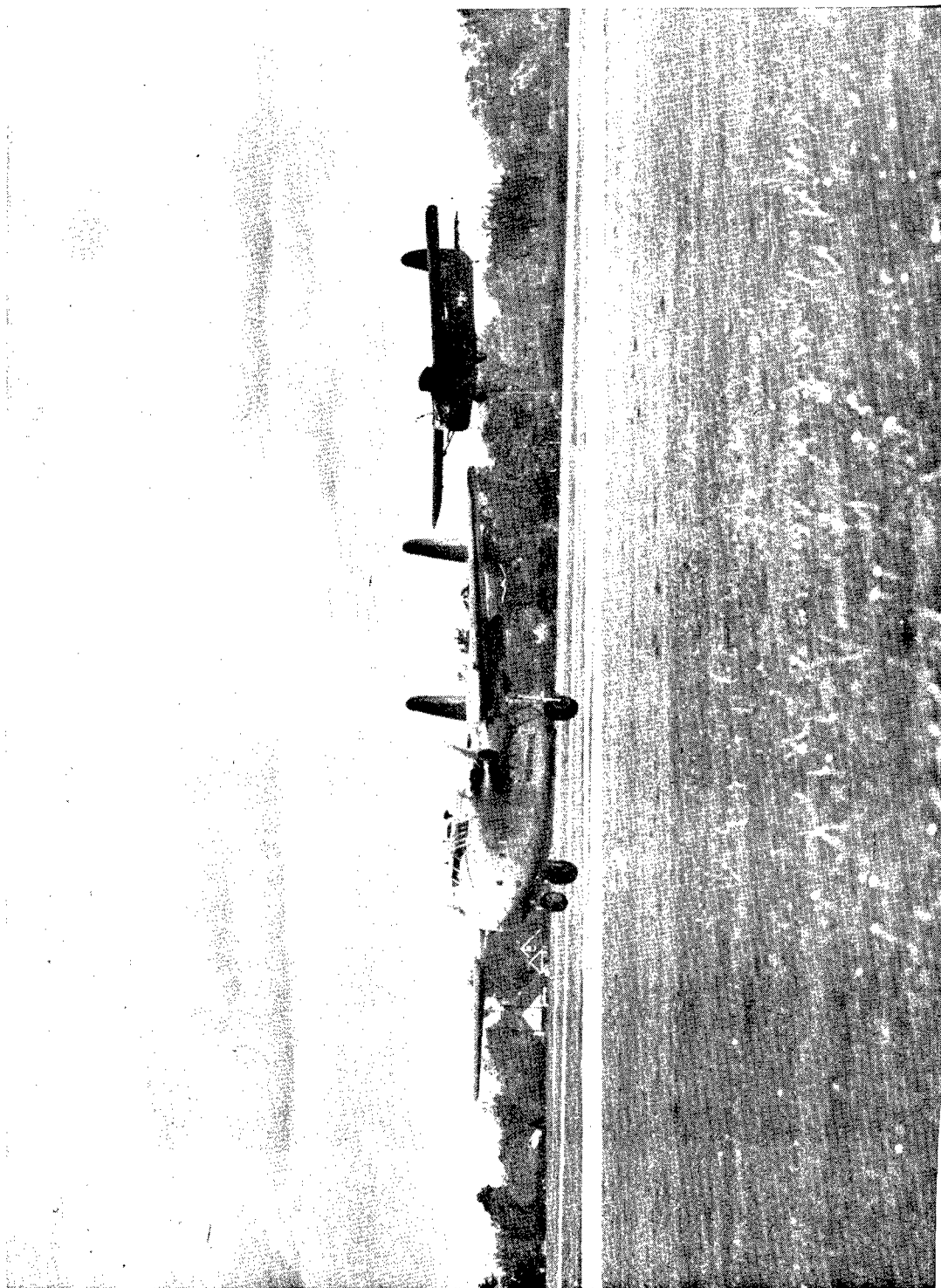


FIG 14 Landing Release

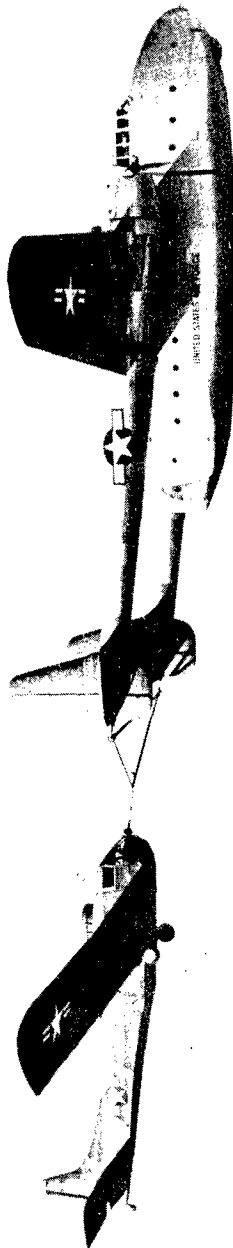


FIG 15 Left turn

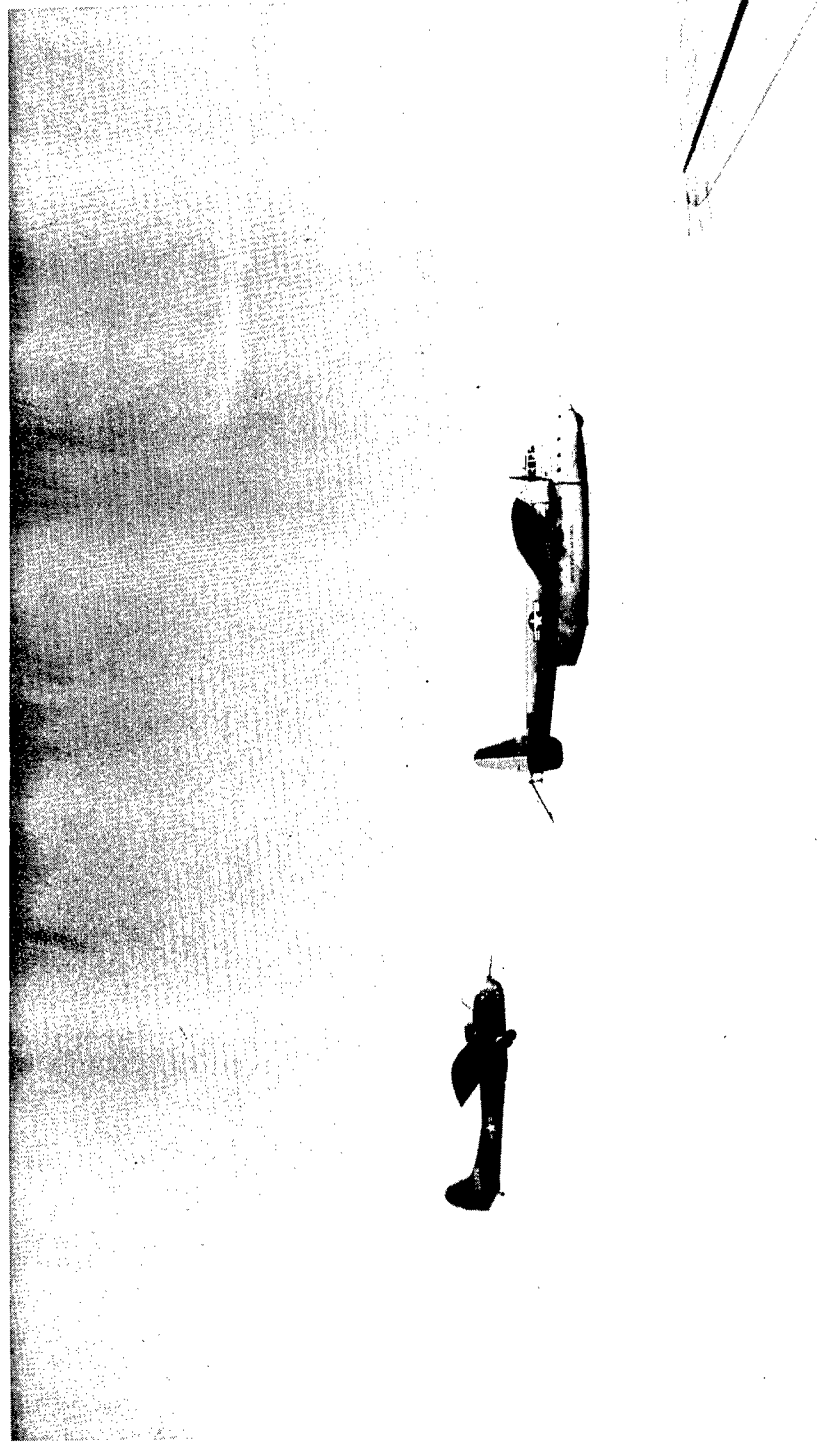


FIG 16 5,000 Ft. Altitude Release