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DAVID TAYLOR MODEL BASIN
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WIND TUNNEL TESTS ON STABILIZING SHIELDS OF SIGNAL AND HOMING LIGHTS FOR AIRCRAFT CARRIERS

by

J. Norman Fresh

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PERSONNEL

The tests were conducted by J. Norman Fresh of the Aeromechanics Division of the David Taylor Model Basin with the assistance of W.F. Barnett and R.H. Bresk. The report is the work of Mr. Fresh.

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WIND TUNNEL TESTS ON STABILIZING SHIELDS OF SIGNAL AND HOMING LIGHTS FOR AIRCRAFT CARRIERS

ABSTRACT

Tests were made on a sample aircraft-carrier signal and homing light, BuShips Plan 9-S-5430-L, in the 8- by 10-foot Wind Tunnel 2 at the David Taylor Model Basin. The purpose of the tests was to develop a windshield that would protect the light from destabilizing air forces under all conditions of pitch, roll, and yaw usually experienced by the ship. Information was also desired for use in the design of a stabilizing pendulum.

The tests were made with six different types of windshields and with pendulums of two different masses. The maximum angular deflections of the light in both pitch and roll were measured for each windshield and pendulum at two wind speeds.

A combination of a simple 120-degree sector shield and a heavier pendulum proved to be the most effective of the arrangements tested for reducing the deflections.

INTRODUCTION

Signal and homing lights are used during night operational flights to guide returning airplanes to their proper carriers. The light is so designed that, when it is in a level position, the beam will not be visible to surface craft or submarines. It is therefore essential that the light remain in a substantially level position for all combinations of pitch and roll normally experienced by an aircraft carrier, since otherwise it will become visible to enemy ships. For all of these conditions, it is desired that the maximum pitch and roll deflections of the light be limited to approximately one degree.

Two homing lights are located on the superstructure of each carrier. The lights in combination are adjusted to illuminate a 360-degree field. On carriers of the CV, CVB, and CVE classes one light faces forward and the other faces aft, while on carriers of the CVL class the lights face to port and starboard. The location of the lights on the superstructure makes it desirable that the total weight of the assembly be held to a minimum.

A sample signal- and homing-light fixture built to BuShips Plan 9-S-5430-L, five windshield designs, and special stabilizing accessories were obtained from the Bureau of Ships for stabilization tests (1).*

Wind tunnel tests were made to determine which windshield was the best and also to provide pendulum design information. This report gives the

* Numbers in parentheses indicate references on page 17 of this report.

maximum deflections obtained with each of the windshields and detailed data for the best shield, and also the effect of a change in pendulum weight.

TEST APPARATUS AND SETUP

The tests were made in the 8- by 10-foot closed-throat atmospheric Wind Tunnel 2 at the David Taylor Model Basin.

The homing light was supported on Vee-type knife-edge bearings in a gimbal mounting. A method was provided for introducing friction into these bearings by round-pointed set screws pressing against the ends of the pivots; the adjustment was held with a lock nut, as shown in Figure 1.

The light assembly was supported on a closed-bottom cylinder, as shown in Figures 2 and 3. This cylinder shields the stabilizing pendulum from the wind and is referred to as the Straight Sidewall Shield or Basic Support. The stabilizing pendulum was used on all the tests.

The Basic Support and light assembly were mounted in the wind tunnel on a test stand, Figure 4, which could be rotated 360 degrees in yaw, pitched from plus 9 degrees to minus 9 degrees, and rolled from zero degrees to 18 degrees. Any combination of yaw, pitch, and roll angles could be obtained.

The five Bureau of Ships designs for windshields were designated as follows:

1. Straight-Sidewall Shield or Basic Support; see Figure 3,
2. Circular-Lip Shield; see Figure 5,
3. Hexagonal-Lip Shield; see Figure 6,
4. Bremen Shield; see Figure 7, and
5. Norfolk Shield; see Figure 8.

All of these windshields except the Straight-Sidewall type had removable fins. Another type, without fins, designated as the 120-Degree-Sector Shield, was developed by the author and is shown in Figures 1 and 9.

A skirt, which is a standard part of the light, was not available at the beginning of the tests, but it was provided before the tests were completed. The function of this skirt, which fastens to the bottom of the light, is to equalize approximately the exposed area above and below the center of the gimbal ring, thereby achieving partial aerodynamic balance; see Figures 1 and 2. So that this balance will be most effective, the entire skirt should be exposed to the wind. This was accomplished by raising the light 2 1/2 inches for all tests with the skirt in place.

At the oral request of one of the Bureau of Ships representatives, the electric lighting cable was simulated for a majority of the tests; see Figure 2.

The deflections of the light were measured by two levels at 90 degrees to one another on top of the light, one in the pitch direction and one in the roll direction; see Figure 1. The levels were graduated in 10-minute intervals and had a 5-degree range.

(Text continued on page 12)

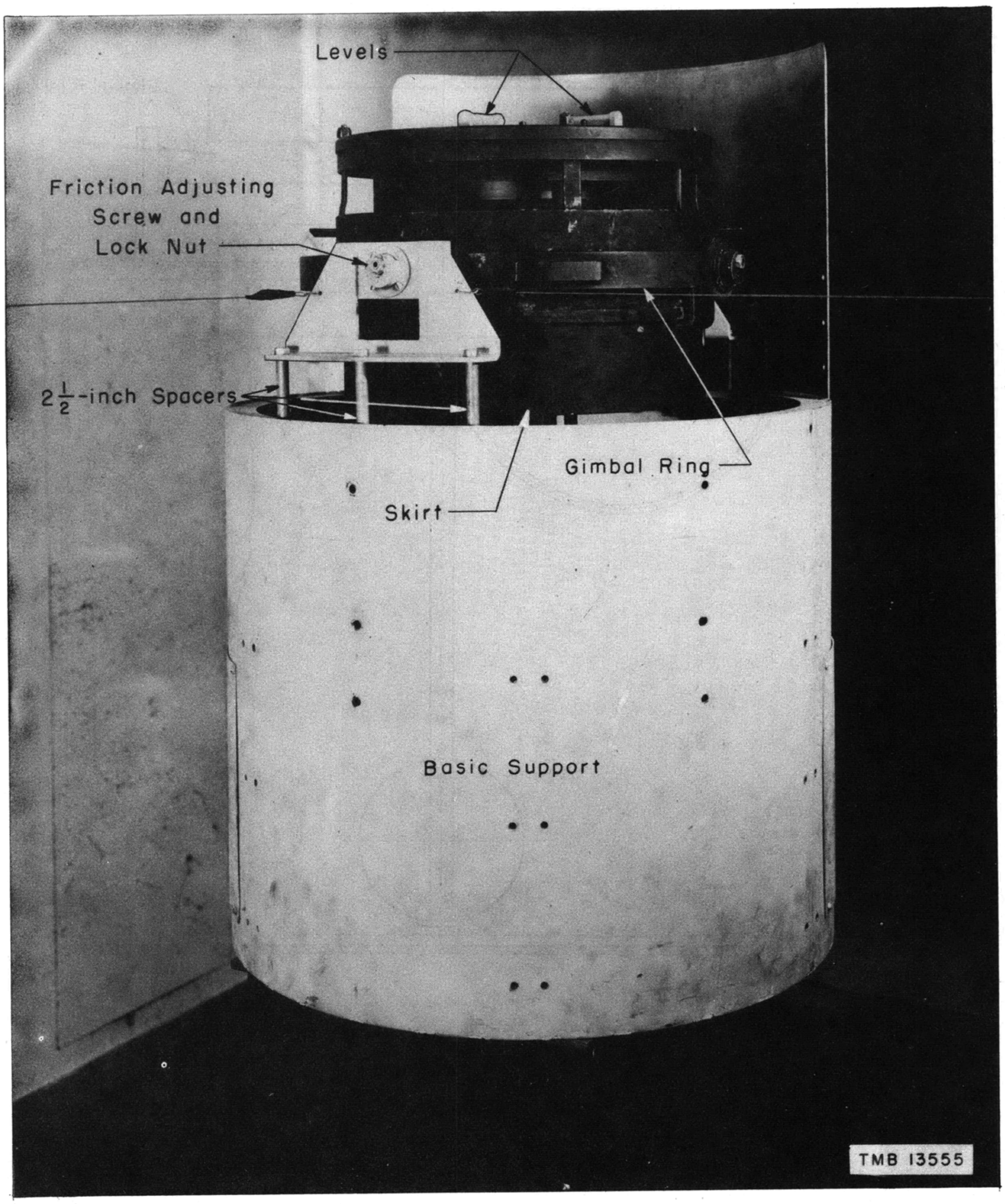

Figure 1 - Close-Up of Signal and Homing Light with 120-Degree-Sector Shield in Place, Showing Details of the Assembly

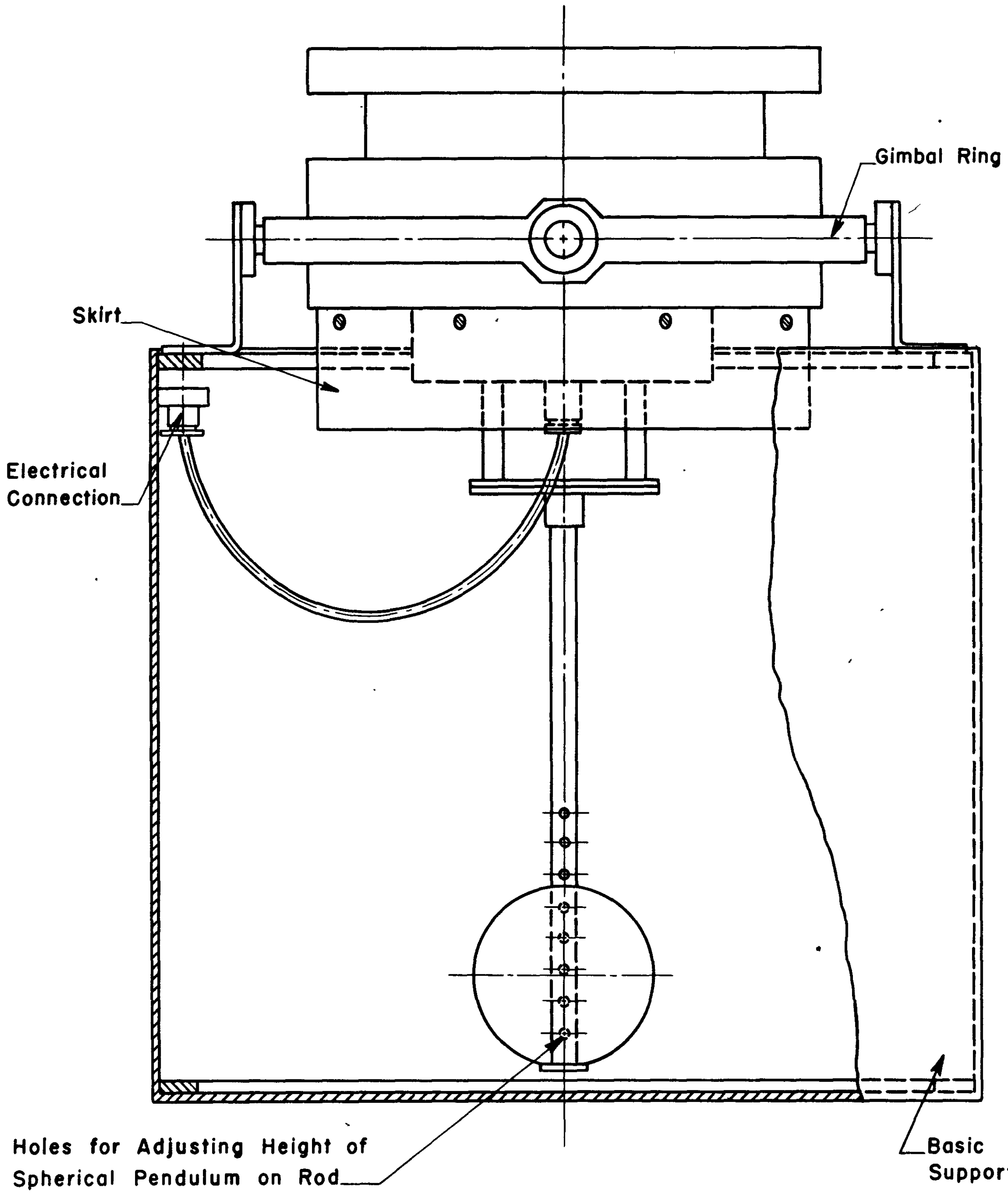

Figure 2 - Sketch of Light Mounted on Basic Support and Showing Pendulum Attachment and Skirt in Place

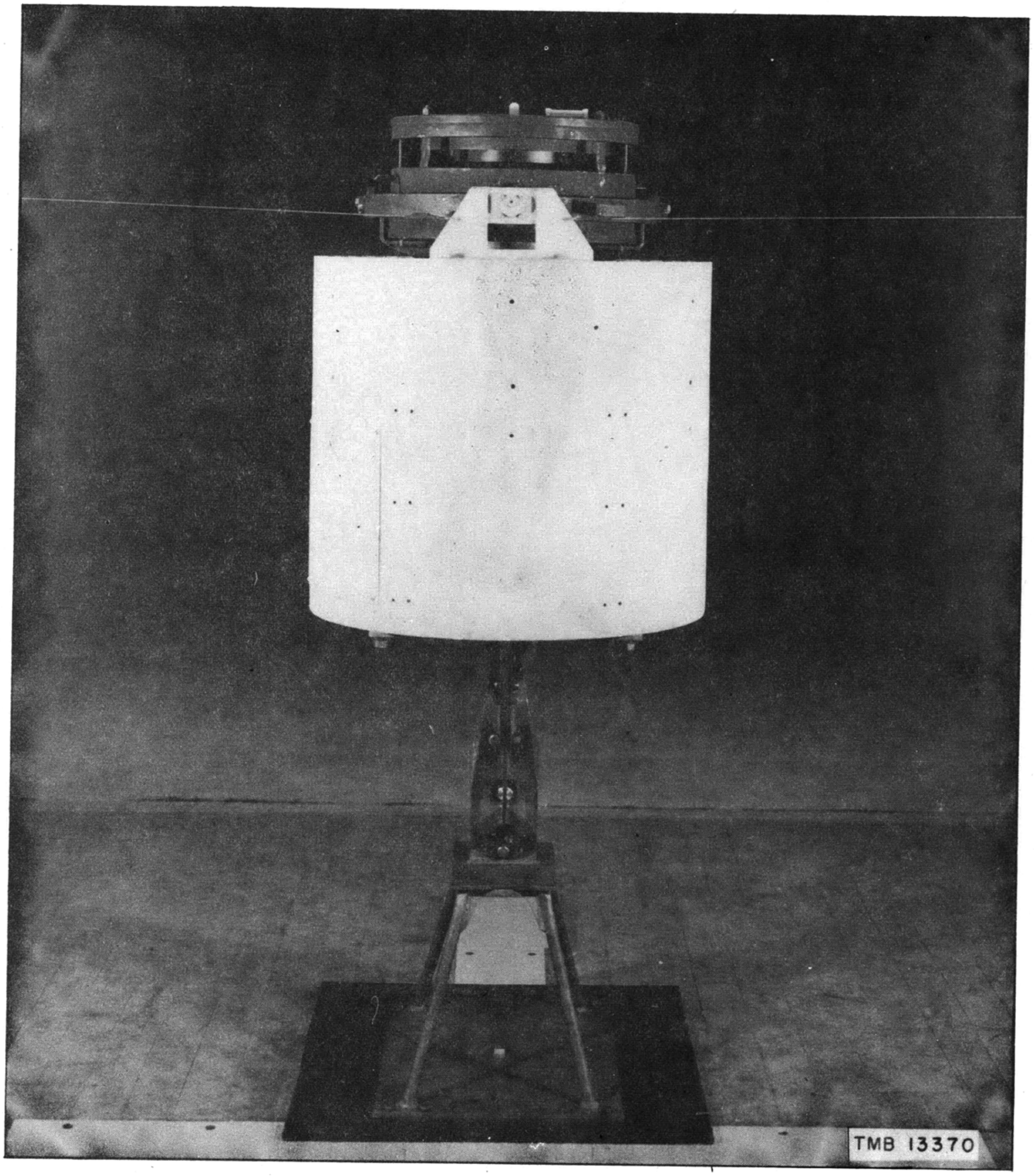

Figure 3 - Front View of Light Mounted in Wind Tunnel
on Straight-Sidewall Shield or Basic Support

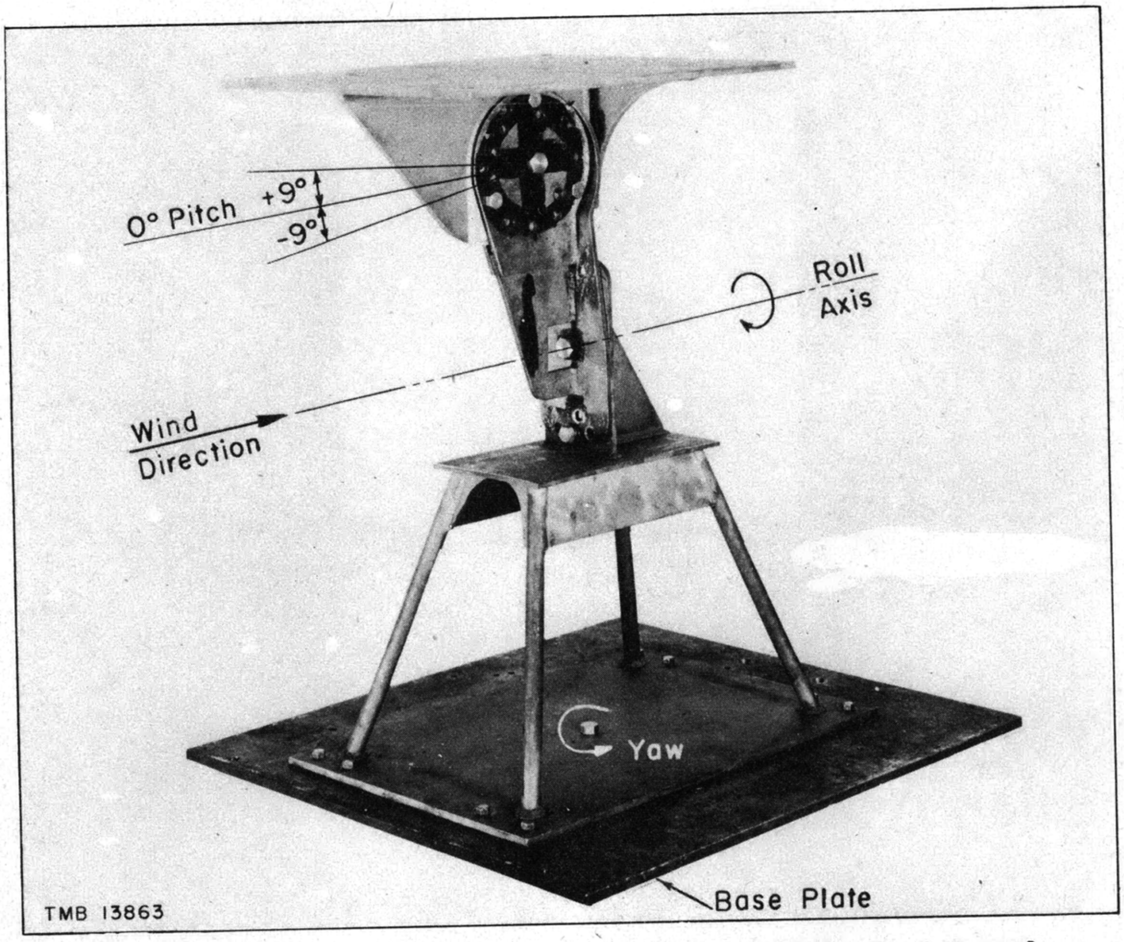

Figure 4 - Test Stand Used for Mounting Light in Wind Tunnel

The base plate was securely bolted to the wind tunnel floor. The basic support which supported the light was then mounted on top of the stand.

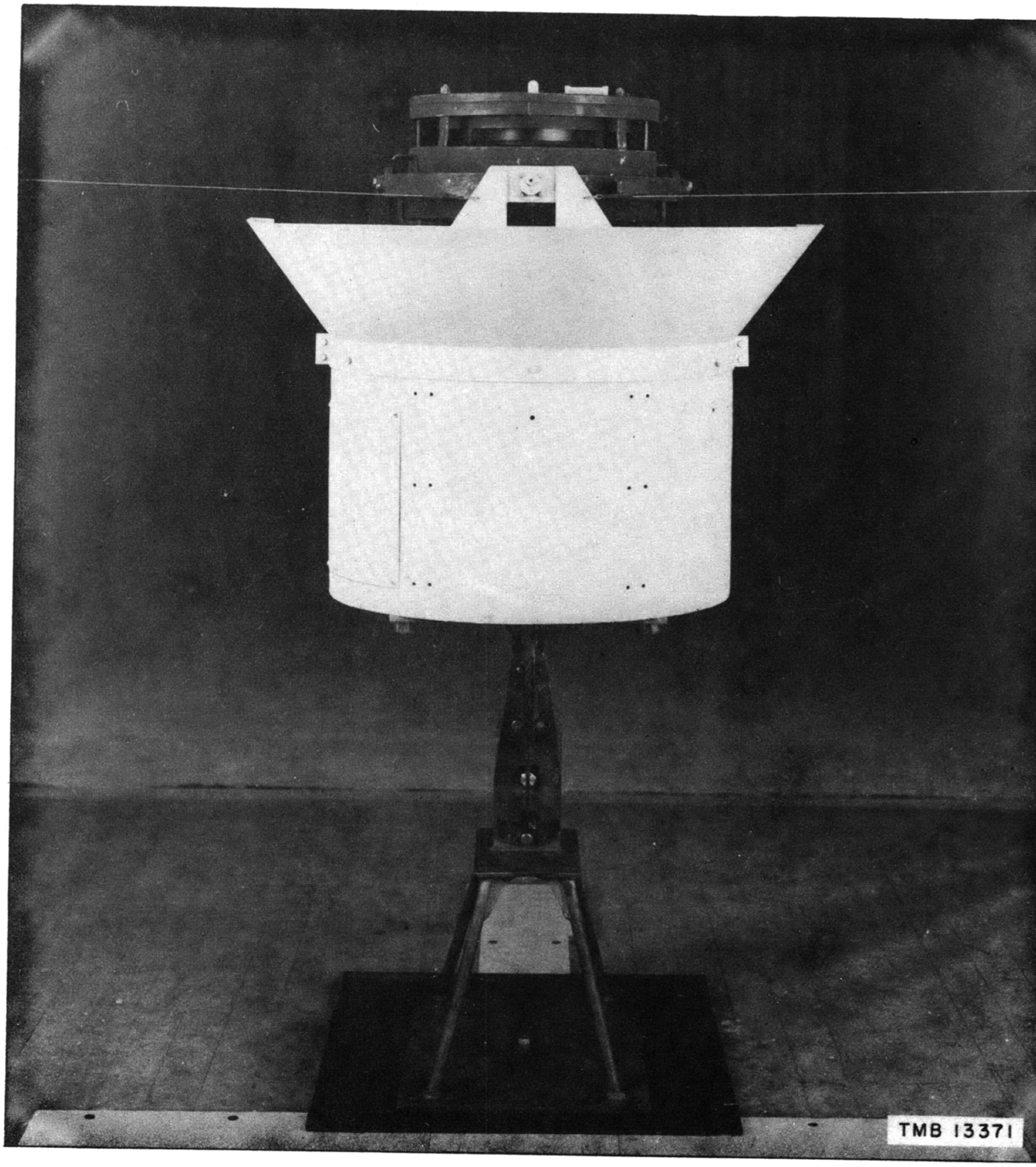

Figure 5 - Light with Circular-Lip Shield without Fins

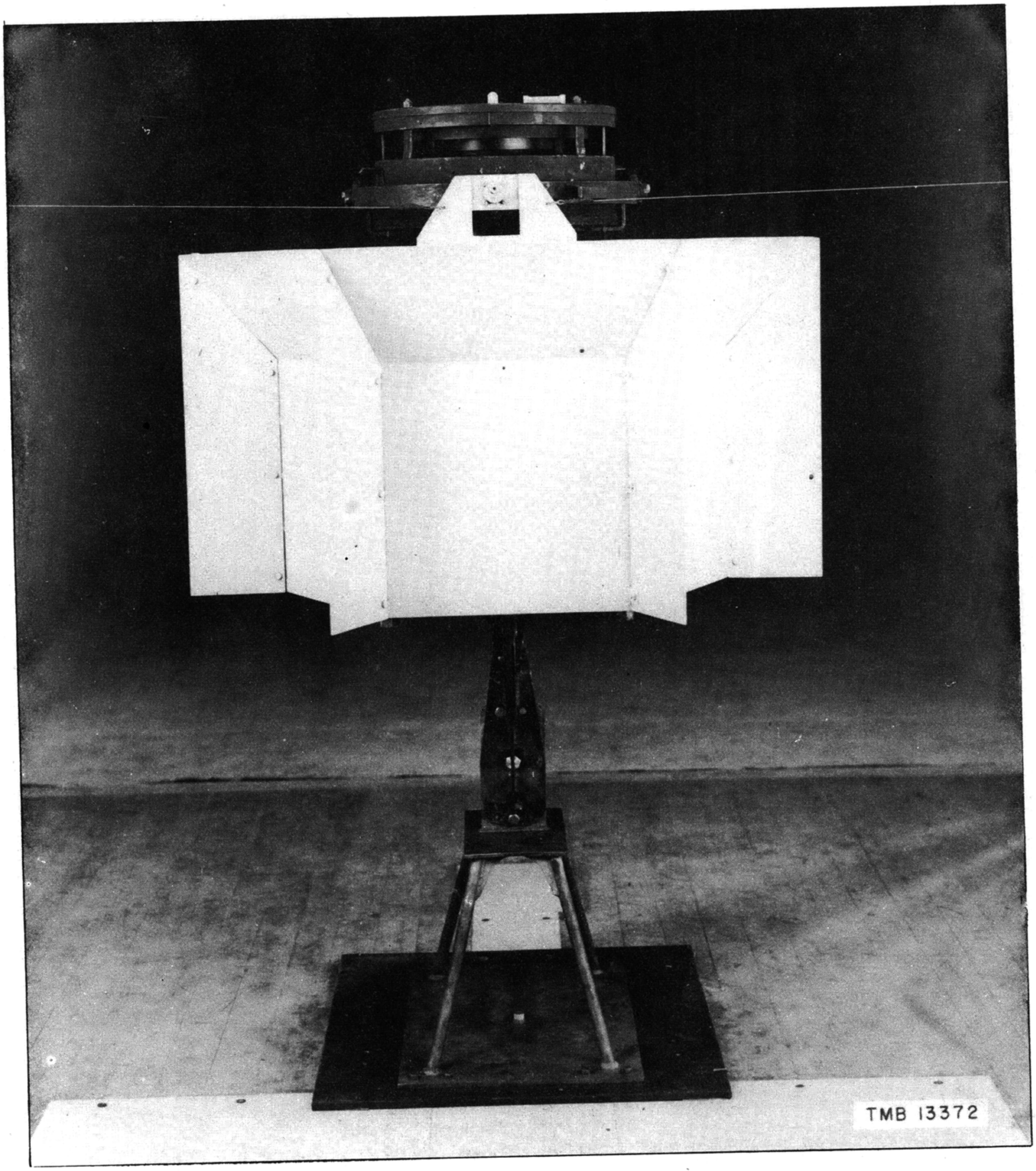

Figure 6 - Light with Hexagonal-Lip Shield with Fins

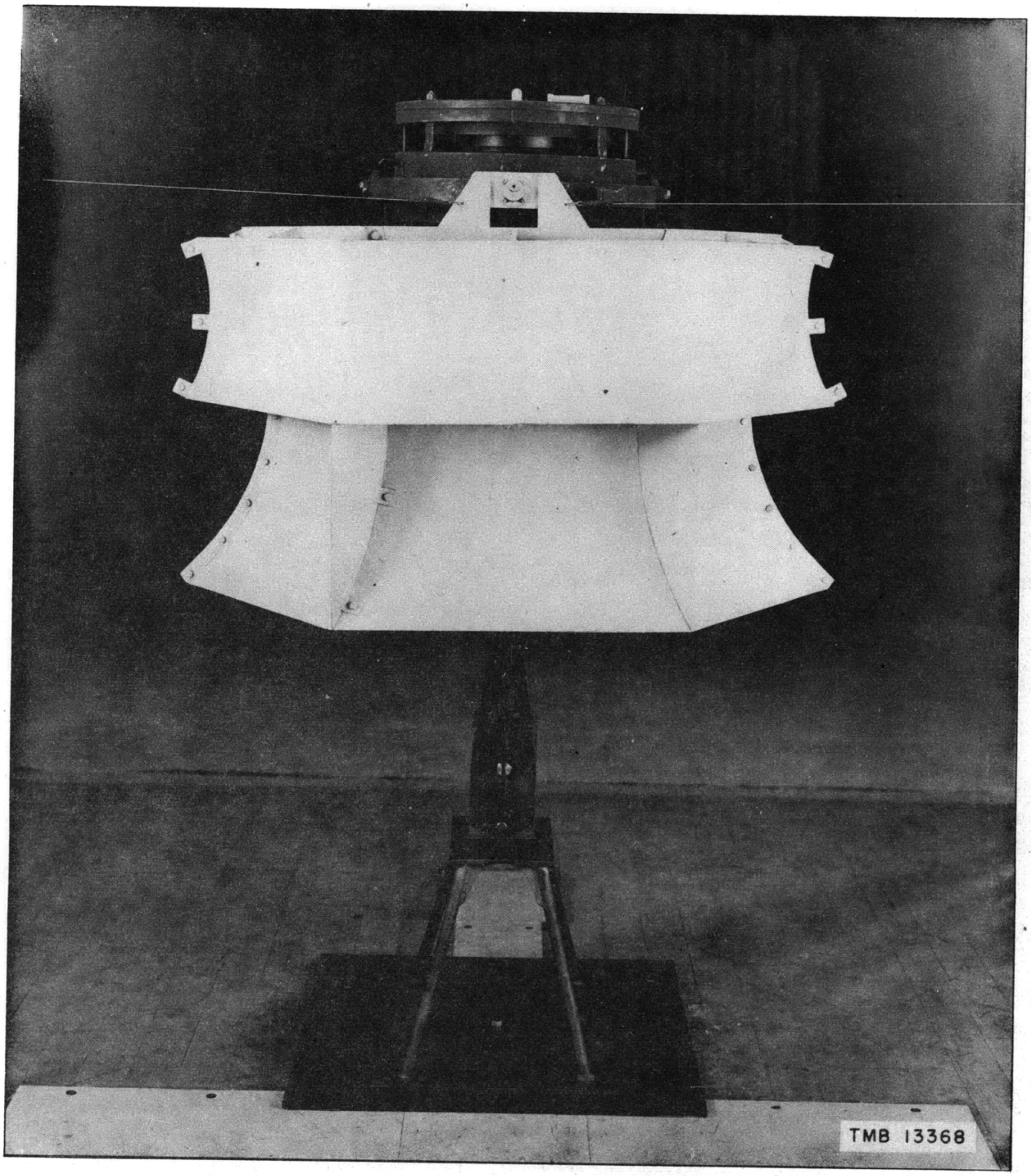

Figure 7 - Light with Bremen Shield with Fins in Place

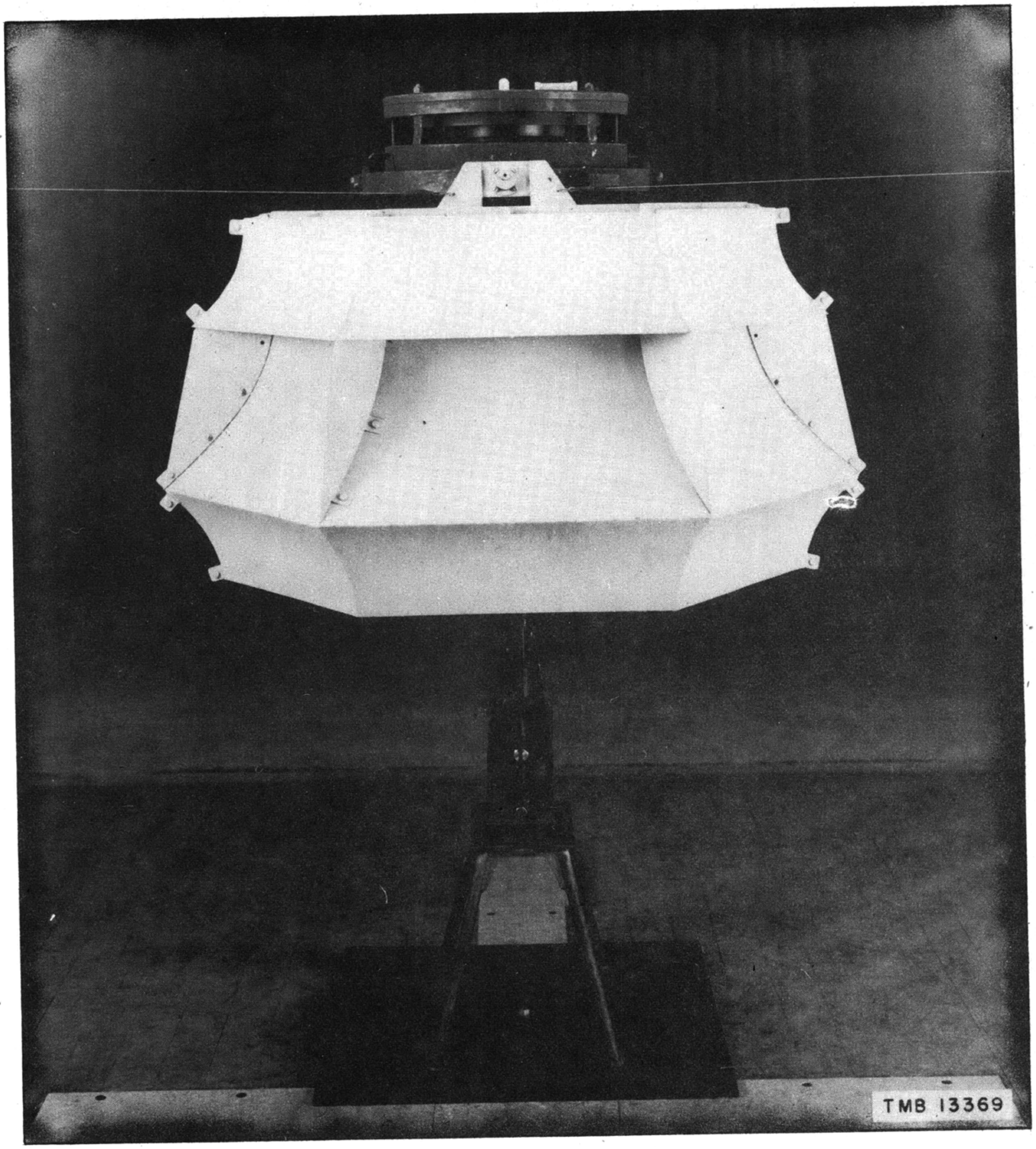

Figure 8 - Light with Norfolk Shield with Fins in Place

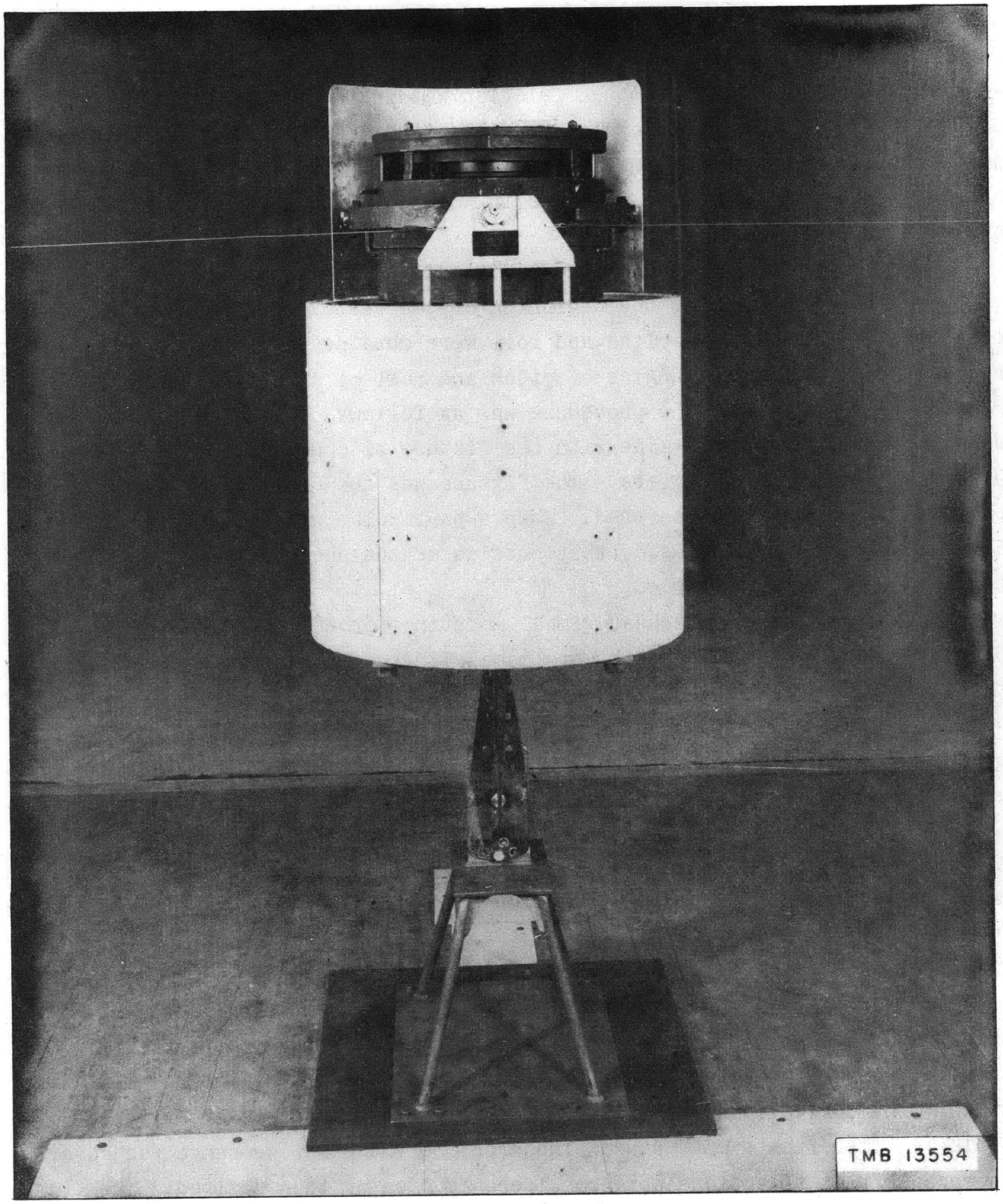

Figure 9 - Light with 120-Degree-Sector Shield in Place and with Light Raised 2 1/2 Inches

TEST PROCEDURE

Preliminary tests with only normal friction in the bearings, and with the wind blowing, showed that after an initial disturbance the oscillations of the light remained undamped or increased in magnitude. Frictional damping was found to be necessary for proper functioning of the light. To keep the tests comparable, enough friction was introduced to damp out a 5-degree deflection in three complete oscillations in still air. Frequent adjustments were necessary to maintain a constant amount of friction. New bearings, however, are being designed in which it is expected that this trouble will be eliminated.

The tests were made with wind speeds of 30 and 50 knots.

It was found, at the beginning of the tests, that the maximum deflections of the light in pitch and roll were obtained under conditions representing the largest angles of pitch and roll of a carrier. For the remainder of the tests, the procedure was as follows: With the roll angle equal to zero, tests were made with the fixture pitched zero degrees, plus 9 degrees, and minus 9 degrees. The fixture was then rolled 18 degrees and the same pitch range was covered. When a particular windshield produced light deflections which were considerably outside of the acceptable range, the tests on it were discontinued.

An alternate overhead gimbal mounting for the light was also supplied; see Figure 10. No tests were made with this mounting, however, since there was no way of introducing friction into the bearings.

Two different pendulum bobs were used during the tests: a 42-pound spherical bob which was supplied with the light, and a 50-pound bob which was obtained by wrapping 8 pounds of sheet lead around the original bob.

The time and number of oscillations required to damp out an initial 5-degree deflection, and the equilibrium deflection assumed by the light for both wind-off and wind-on conditions were recorded.

TEST RESULTS

The data are presented in tabulated form for the various windshields and accessories for the 50-knot wind speed. Since the deflection of the light increased with wind speed, the data for only the higher speed are given. The deflections for the five Bureau of Ships designs are given in Table 1. These tests were discontinued before the complete range was covered because the deflections were considerably greater than desired. The effects of increasing the pendulum weight and the addition of the skirt are given in Table 2 and Table 3 respectively. Results of the tests with the 120-degree sector shield are summarized in Table 4.

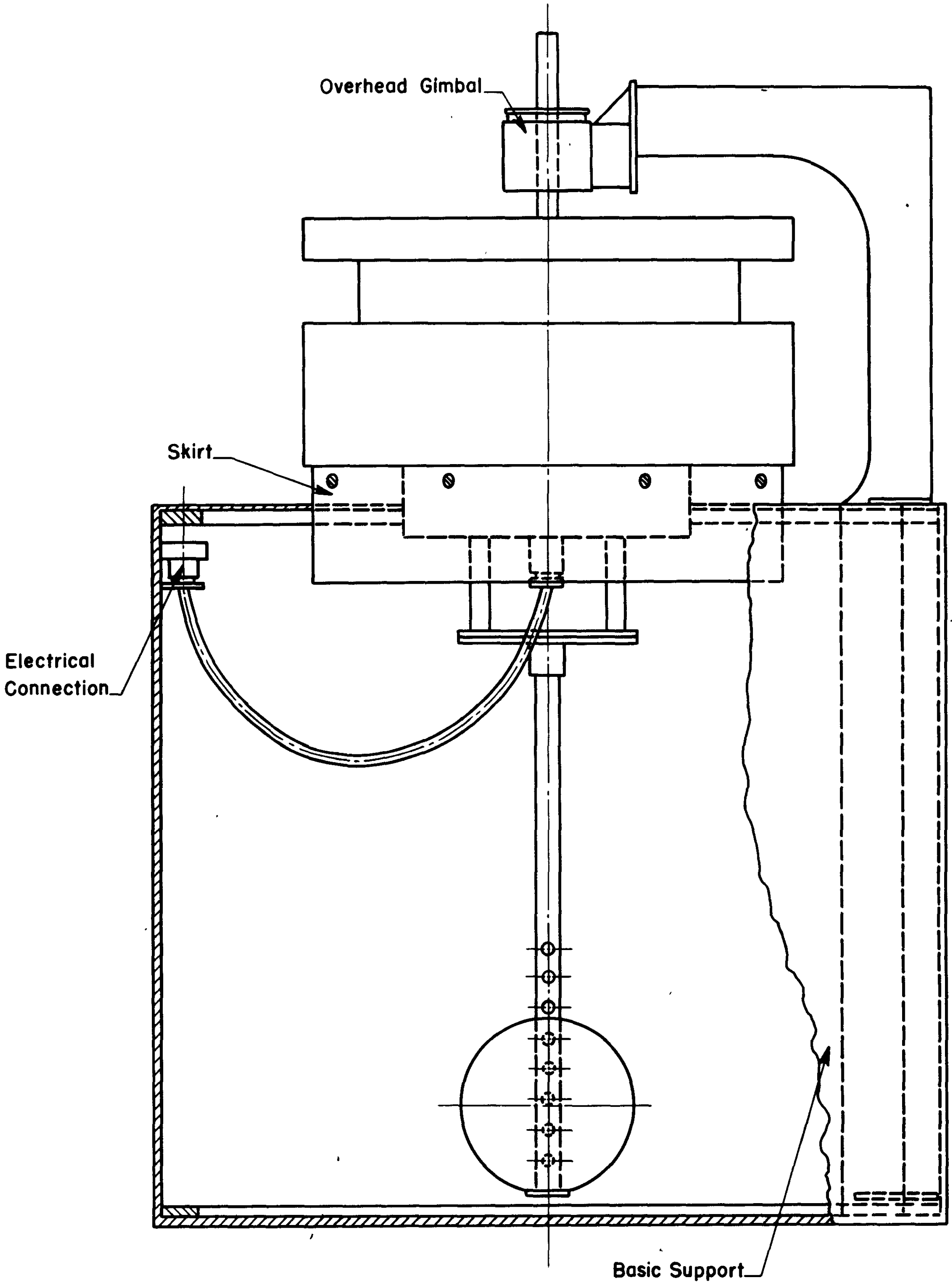

Figure 10 - Sketch Showing Proposed Overhead Gimbal Mounting

TABLE 1

Maximum Deflections of the Light for Various Types of Windshields

Angle of yaw, 0 degrees   Pendulum Weight, 42 pounds   No skirt   Wind speed, 50 knots

The basic support, or straight-sidewall shield, was present in all tests. The other types of windshields were fastened to the basic support.

Windshield	Fins	Fixture Attitude		Maximum Deflection Pitch degrees-minutes	Maximum Deflection Roll degrees-minutes
		Pitch Angle degrees	Roll Angle degrees		
Basic Support		0	0	1-50	0
Basic Support		-9	0	1-50	0
Norfolk	On	-9	0	1-45	0-10
Norfolk	Off	-9	0	1-40	0
Circular-Lip	On	0	0	2-15	0-10
Circular-Lip	Off	0	0	1-55	0-05
Hexagonal-Lip	On	0	0	2-25	0-15
Hexagonal-Lip	Off	0	0	2-05	0
Bremen	On	0	0	1-45	0
Bremen	Off	0	0	2- 0	0-05

TABLE 2

Effect of Increased Pendulum Weight on Deflections of the Light

Angle of yaw, 0 degrees   No skirt   Wind speed, 50 knots

Windshield	Pendulum Weight pounds	Fixture Attitude		Maximum Deflection Pitch degrees-minutes	Maximum Deflection Roll degrees-minutes
		Pitch Angle degrees	Roll Angle degrees		
Basic Support	42	0	0	1-50	0
Basic Support	42	-9	0	1-50	0
Basic Support	50	0	0	1-30	0-10
Basic Support	50	-9	0	1-30	0
Circular-Lip without Fins	42	0	0	1-55	0-05
Circular-Lip without Fins	50	0	0	1-30	0

The accuracy with which the tests could be repeated is of the order of 10 minutes of arc. This deviation is partly attributable to the small variations in the amount of friction in the bearings.

DISCUSSION OF RESULTS

The data of Table 1 show that none of the windshield designs furnished are satisfactory because with them the maximum deflections of the

TABLE 3

Effect of Skirt on Deflections of the Light

Angle of yaw, 0 degrees Wind speed, 50 knots

Windshield	Light Position	Skirt	Pendulum Weight pounds	Fixture Attitude		Maximum Deflection Pitch degrees-minutes	Maximum Deflection Roll degrees-minutes
				Pitch Angle degrees	Roll Angle degrees		
Basic Support	Normal	Off	42	0	0	1-50	0
Basic Support	Normal	On	42	0	0	1-25	0
Basic Support	Raised*	On	42	0	0	1-15	0-10
120-Degree-Sector Shield, 4 inches above top of light	Normal	Off	50	0	0	0-35	0
120-Degree-Sector Shield, 4 inches above top of light	Normal	Off	50	9	0	0-50	0-05
120-Degree-Sector Shield, 4 inches above top of light	Raised*	On	50	0	0	0-25	0
120-Degree-Sector Shield, 4 inches above top of light	Raised*	On	50	9	0	0-45	0

* The light was raised 2 1/2 inches above the normal position.

TABLE 4

Summary of Tests with 120-Degree-Sector Windshield

Pendulum weight, 50 pounds Wind speed, 50 knots

Light Position	Height of Shield Above Top of Light inches	Skirt	Fixture Attitude			Maximum Deflection Pitch degrees-minutes	Maximum Deflection Roll degrees-minutes	Pitch Damping		Roll Damping	
			Yaw Angle degrees	Pitch Angle degrees	Roll Angle degrees			Oscillations	Time seconds	Oscillations	Time seconds
Normal	0	Off	0	9	18	1-05	0				
Normal	4	Off	0	9	0	0-50	0-05	3	4.5	3	4.6
Raised*	4	On	0	9	0	0-45	0	3	4.5	3	4.7
Normal	0	Off	45	9	18	1-10	1-05				
Normal	4	Off	45	0	18	1-10	1-00	3	3.8	3	4.0
Raised*	4	On	45	9	18	0-50	0-55	2 1/2	4.0	6	9.0
Normal	4	Off	90	9	18	0	1-25	3	4.3	3	4.5
Raised*	4	On	90	0	18	0	1-35	3	4.6	5	7.7
Normal	4	Off	180	9	0	0	0-25	3	4.4	2 1/2	3.8
Raised*	4	On	180	9	0	0-10	0-05	3	4.5	3	4.8

* The light was raised 2 1/2 inches above the normal position.

light greatly exceeded the desired limit of about one degree. The addition of fins to these shields had very little effect on the deflections.

Increasing the weight of the pendulum bob from 42 pounds to 50 pounds reduced the angular deflection of the light in the order of 1/3 to 1/2 degree.

The 120-degree-sector shield was tested at two heights: level with the top of the light, and 4 inches above it. The shield was more effective in the raised position, when the fixture was yawed, and was used in this position for the remainder of the tests; see Figure 1. This shield was the only one that consistently reduced the light deflections to one degree or less, for normally expected angles of pitch and roll. Roll deflections were negligible until the fixture was yawed 45 degrees or more, reaching a maximum at 90 degrees yaw.

With 90 degrees yaw and 18 degrees roll, the maximum deflections were approximately 1 1/2 degree for the full pitch range. This is not considered serious since it is unlikely that an aircraft carrier would ever attempt taking airplanes aboard in this attitude, especially during night operations.

The 120-degree-sector shield was located symmetrically at the back of the light during the tests. This is considered satisfactory for a fore-and-aft arrangement of the lights on an aircraft carrier since the foreward light would, in effect, be at zero yaw and the aft light would be at 180 degrees yaw as tested. Small light deflections were obtained at both of these angles.

For a port and starboard installation, conditions would be more critical since the lights would be mounted in a position corresponding to a yaw angle of 90 degrees where the test deflections were a maximum. Placing the shield around the light as far aft as possible without entering the field of light would be equivalent to reducing the angle of yaw of the light as tested; this would act to reduce the maximum deflections.

Since the Basic Support is used in combination with each of the other windshields, the total weights of the individual light assemblies may be compared by noting the difference in weights of the various shields. The shields designed by the Bureau of Ships ranged from 33.7 pounds to 92.8 pounds while the 120-degree shield weighed only 9.3 pounds. The combination of the 120-degree shield and the heavier pendulum not only produced the lowest test deflections but resulted in a substantial saving in weight when compared with the Bureau of Ships designs.

CONCLUSIONS AND RECOMMENDATIONS

1. The 120-degree-sector shield is the most effective of all the windshields tested for reducing the deflections of the light.

2. For a port and starboard mounting of the homing lights, it is recommended that the shield be moved around the light as far aft as possible without entering the field of light.

3. It is further recommended that the pendulum weight be increased to 50 pounds.

REFERENCES

(1) BuShips letter C-CV/S64-5(449-332) of 25 July 1944 to TMB.