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Development, Testing, and Evaluation of
Visual Landing Aids

Consolidated Progress Report
to
Ships Installation Division
Bureau of Aeronautics
Department of the Navy

For the Period
October 1 to December 31, 1956

For
Bureau of Aeronautics Projects

TED No. NBS-AE-10002
TED No. NBS-AE-10011

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Development, Testing, and Evaluation of Visual Landing Aids

October 1 to December 31, 1956

I. REPORTS ISSUED

Report No.	Title
4947	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for the Period July 1 to September 30, 1956.
21P-11/56	Photometric Tests of an Elfaka Flush Light (USA Model C)
21P-14/56	Qualification Tests of a Fluorescent, Buoy-Mounted Seadrome Channel Marker
Letter Report	Deficiencies in TSM-11 Test Set

II. RESEARCH AND DEVELOPMENT, LABORATORY TESTING, AND CONSULTATION SERVICES IN CONNECTION WITH VISIBILITY, AIRFIELD LIGHTING, AND FOG MODIFICATION PROBLEMS (TED NBS-AE-10002).

a. Visibility Meters and Their Application.

At the request of the Aerology Division a proposal for the development of visual range meters has been prepared. This proposal covers the following points.

1. Study the feasibility of a back-scatter type visibility meter for shipboard installations and construct experimental instruments to determine the type which appears most satisfactory.

2. Conduct field tests of a recently developed prototype slant visibility meter to determine the suitability of the method of transmission determination which is employed.

3. Provide engineering and consulting services in the field of visibility measurements and visibility meters.

If this proposal is accepted, all work pertaining specifically to visibility and visibility meters will be considered as a part of this task. Work pertaining to the performance of visual landing aids in restricted visibility will continue to be treated as a visual landing aids task.

b. Airfield Lighting and Marking.

Runway Lights. Photometric tests of a USA Model C flush light have been completed and a report giving the results of the tests has been issued. Approximately 200 traverses were made during the study of this light. The light, after readjustment by the manufacturer, has a low-angle cut-off at about 0.5° elevation and an axial intensity of 10,000 candles at 1° elevation. The peak axial intensity occurs at 9° elevation and is 57,000 candles. The horizontal beam spread at an intensity of 1000 candles is approximately 4.5° at 0.75° elevation, 6° at 1° elevation, 8° at 3° elevation, and 9° at 8° elevation. (NBS Test Report 21P-11/56)

Photometry of Condenser-Discharge Lights. A method of determining the effective intensity of flashing lights which produce flashes of short duration, e.g., condenser-discharge lights, has been developed. With this method it is possible to record effective-intensity distributions automatically. A report describing the procedure and equipment in detail is being prepared. The method has been used to study the condenser-discharge approach light units being manufactured by Sylvania Electric Products, Inc. and the Westinghouse Electric Corporation.

Materials for Marking Runways. Plans have been formulated for mechanical and thermal tests that will be meaningful in determining how well these materials will withstand service conditions. After these mechanical and thermal tests have been performed, the optical test will be repeated to determine whether the mechanical and thermal tests have affected the optical characteristics of the materials.

Visual Landing Aids Panel. Mr. Douglas has been requested to serve as a technical advisor to the U. S. Representative at the first meeting of the panel on visual aids to approach and landing of ICAO to be held at London, England, starting January 7, 1957, with travel expenses to be paid by the State Department. Since this offers an opportunity to learn of the developments and thinking of other States and to present the viewpoint of U. S. military

aviation, the invitation has been accepted and preparations for the meeting have been made.

Vision Committee Working Group. A working group of the Vision Committee, consisting of Brig. Gen. V. A. Byrnes, Dr. J. J. Gibson, Dr. S. Q. Duntley, Dr. H. W. Rose, and Mr. C. A. Douglas, has been formed to act as advisors on the test procedure used in the tests of narrow-gauge runway-lighting systems. This group met at Andrews AFB on December 13 with approximately 20 representatives of the Air Force, Navy, and CAA.

The Air Force has requested that their project at the National Bureau of Standards, "Development of Optimum Lights for Jet Aircraft", be expanded to include other work in aviation ground lighting. In order to avoid conflict between that project and this, all general work done at NBS in the development of aviation ground lighting will be conducted as part of the Air Force Project. Ground lighting problems peculiar to Navy operation will continue to be studied as a task of this project. This will allow more emphasis to be placed upon seadrome and carrier lighting.

Heliport Lighting. Field tests at Patuxent Naval Air Test Center confirmed the report made as the result of tests at this Bureau which indicated that the lamp being furnished by the manufacturer of the Big Beam 440 lantern would probably not give adequate life. A comparative study of this and three other lamps was undertaken to provide a basis for the selection of a suitable lamp. The lamp being furnished by the manufacturer was found not only to have too short a life but also to be so variable in light-center length that no dependence could be placed upon the vertical angle of the beam. The first lamp studied as a possible replacement gave adequate life and very satisfactory alignment, but it was a relatively expensive lamp and some question exists as to the practicability of using the prefocus base because it is sometimes difficult to insert and remove lamps with this type of base. The same type of lamp without prefocus base would give adequate life but proved as unsatisfactory for alignment as the manufacturer's lamp. A flashlight lamp with a semi-prefocus base was tested and appears to be a satisfactory compromise. Tests were also made to determine what advantage, if any, might result from the use of a single coil, vertical filament. The results of these tests indicated very little advantage, probably not sufficient to warrant the increased costs of such a lamp.

Ten adapters have been made for use in Big Beam 440 lanterns, making it possible to substitute PR12 flashlight lamps for those furnished by the manufacturer. A sample of ten battery cells of recent production has been received and it is found that these cells are too large for satisfactory use in either the Big Beam 440 unit or the approach-angle light. The difficulty can be overcome by the use of a thinner wooden separator in the case of the Big Beam 440 lantern. To adapt the approach-angle light it will be necessary both to substitute a somewhat thinner liner and replace the hinge by some form of clasp so designed that the top can be placed directly over the cells instead of rotating about an axis below the top of the cells. A plastic liner might prove advantageous.

One approach-angle light and ten Big Beam 440 lanterns have been shipped to Ream Field for service tests. Two approach-angle lights have been received from Forway Industries Inc., completing their contract for this unit.

c. Seadrome Lighting.

A preproduction buoy-mounted channel marker, type FMF-6B, received from the Soderberg Manufacturing Company has been checked for conformance to specification requirements. The unit was satisfactory except for a few minor deficiencies. The results of this qualification test have been reported in NBS Test Report 21P-14/56.

An order has been received from the Shore Establishment Division covering the development and procurement of 500-watt, 20-ampere, PAR 56 lamps for test as approach and threshold lights and lenses and lamps for cable-fed, buoy-mounted sea-lane marker lights for use in the new installations planned for NAS Norfolk. Specifications covering these items have been prepared and quotations have been requested.

The corner identification lights ordered for the Norfolk installation have been received.

Further experiments have been made with models of seadrome light buoys but these have led to no improvement in the performance. The study of the relative effectiveness of mercury and incandescent lamps has been completed and showed no great advantage for the mercury lamps unless it is possible to use a super high-pressure lamp which requires either liquid or forced-air cooling. The most difficult problem appears to be the radiation of infrared and

undesirable visible light in a satisfactory way without overheating any part of the lantern. It is believed that the combination of a PAR reflector lamp directed upward along the axis of an inverted cone reflector of the dichroic type should make it possible to use a green plastic filter as a cover for the unit. A report to terminate this assignment is nearing completion. The antenna of the two-antenna buoy which was being tested at Patuxent was damaged in a storm. It is now being rebuilt.

d. Carrier Lighting and Marking.

Lights for Night Field Carrier Landing Practice. The preproduction kit of night field carrier landing practice lights was inspected at NBS at a conference with the manufacturer and representatives of the Bureau of Aeronautics. The kit appeared to be satisfactory for production.

Optical Glide-Path Indicator. The model optical glide-path indicator constructed by Burroughs Corporation has been delivered to the Bureau. Rough measurements have been made of the intensity of the signal as a function of the angle of elevation. The results are given in figure I. (Angles of elevation are computed using a point 150 feet behind the unit and in the plane which is perpendicular to the face of and passes through the center of the unit. When the photocell was 156 feet from the light, placing an 8-inch high aperture centered on the flashed area of the light reduced the illumination on the cell to 84% of the illumination incident when no aperture was used. A 6-inch high aperture reduced the illumination to 79% and a 4-inch high aperture to 72%.

Carrier Marking. In cooperation with Comdr. Ogle, a carrier-deck marking system has been designed to overcome the deficiencies of the present system. Points considered were:

All lines were to be either parallel or to intersect at right angles.

Emphasis was to be placed on the markings along the side of the landing area instead of on the center line.

The side markings should provide as much guidance as feasible when only one side is viewed.

Figures 2 and 3 are photographs of a simulated deck showing the old and the proposed markings.

The outermost lines are 40 feet and the inner side lines are 30 feet from the centerline. The centerline dashes are 45 feet long with 30-foot intervals between dashes, and are 18 inches wide. The inner side lines are 3 feet wide and the outer ones are 1 foot wide. The longitudinal dimension of the bars between these lines is 10 feet. The marking of the ramp is of particular importance as it provides a sensitive clue as to alignment and horizon. The line across the ramp must be at right angles to the longitudinal lines, independent of the orientation of the ramp, to obtain satisfactory results.

e. Lights for Carrier Deck Personnel.

A preproduction set of LSO lighted suit equipment has been received from the manufacturer and is undergoing acceptance tests.

A set of lighting equipment for taxi guidance personnel consisting of identifying chest light strips and improved wands is being developed.

f. General Laboratory and Consultive Services.

Cable Test - Detecting Set. A letter report relating the National Bureau of Standards experiences with capacitor failures in the TSM-11 Test Set was prepared. The problem of these failures has been discussed in detail with cognizant personnel of the Navy, the Air Force, and the manufacturer. At the request of the Bureau of Ships, checks have been made of the sensitivity of the amplifier-indicator using type 212N27 transistors in place of the type specified by the manufacturer, since the former is a stock item. No significant changes in sensitivity were found.

Kinorama. The kinorama was sufficiently disassembled so that it could be transported. It was delivered to a truck sent to this Bureau by the Air Force and subsequently packed by them on a cargo-type plane for transportation to the University of the Air at Randolph Field. Unfortunately, the time allowed for preparing the kinorama for transportation was inadequate for any packing and we were informed by the Air Force that it would be properly packed before being placed aboard the aircraft. This was not done and we have received no information regarding the condition in which it was received by the University of the Air.

Color Standards. The work of revising the U. S. Standard for the Colors of Signal Lights has been started. A need arose for

more information on the changes of color and transmittance of filters as the color temperature of the source is changed. A systematic study of this relationship has been started using SEAC computations. The chromaticity coordinates and transmittance have been computed for twelve red and yellow filters for nine color temperatures.

Airfield Lighting Conference. An all-day conference was held the the National Bureau of Standards with representatives of the Visual Landing Aids Branch, the Naval Aviation Safety Center and NBS. Problems in airfield and seadrome lighting and marking, and principles involved in the improvement of these aids were considered in detail.

III. VISIBILITY AND BRIGHTNESS TESTS, SURVEYS, EVALUATION AND ANALYSIS OF VISUAL LANDING AIDS, BASIC TESTS AND EQUIPMENT AS A FIELD SERVICE AT ARCATA, CALIFORNIA (TED NBS-AE-10011).

a. Airport Lighting and Marking.

Approach Beacons. The approach beacons use a two-voltage intensity control consisting of a relay in each circuit. Trouble has been experienced with these high - low intensity relays; points on the relays were pitting and sticking because the de-energized relay would not drop out fast enough when changing from high to low intensity or vise versa. Two motor-reversing magnetic contactors were located in the old LAES equipment and used to correct this fault. These contactors are mounted side by side with a rocking lever between the solenoids; the action is such that as one is de-energized and the other is energized, the energized contactor pulls the de-energized contactor open. The linkage is such that only one set of contacts can be closed at one time. Due to long control lines and the resultant induced voltage expected in installations of this type, it is recommended that contactors of this kind be used for rotating beacon and threshold lighting installations where a high - low switch is used. This type of switching is not applicable to intensity controls of series circuits.

A copy of a letter from Southwest Airways to the Air Transport Association has been received. This letter states that Southwest believes these beacons have considerable possibilities for use at intermediate airports and on runways used for approaches in marginal weather, and recommends that consideration be given to their use.

Figure 4 is a photograph of one of the approach beacons installed in the approach to runway 31.

Runway Distance Markers. A runway distance marker with the background painted with fluorescent orange paint has been constructed and installed. NOTE: When applying this paint, two coats are required to obtain the required thickness. If one thick coat is applied, the paint will wrinkle.

b. Electrical Engineering.

Comments recorded during conferences on the survey trip made last quarter are being reviewed. One of the problems emphasized in these comments is the need to get information concerning the purpose and application of new visual aids to the pilots. (This same problem was considered in detail at the conference with the Naval Aviation Safety Center personnel.) Naval Aviation News was considered as the best outlet for this information. Short film strips were also recommended.

Cable Tracing. In using the TSM-11 when the signal-to-noise ratio is so poor because of shielding of the test cable and extraneous noise that usual procedures are not satisfactory, the cable may still be followed by carefully orienting the signal detecting element to reduce the interference to a minimum. Under these conditions some faults cannot be located. Some knowledge of the routing of the cable may be required in order to follow it.

Maintenance Manual. The editing of the step-by-step troubleshooting section of the maintenance manual has been completed and this section is being prepared for reproduction. The survey trip indicated the desirability of an abbreviated step-by-step procedure which would omit instructive material and only outline the procedure. This has been prepared.

Runway Illumination and Brightness. The following data were obtained at night with the runway lights on step 5 (100% intensity) and in visibilities which required this intensity. The illumination on the center of a 150-foot runway equipped with high-intensity runway lights was 0.03 to 0.04 footcandle. This high illumination resulting from the light scattered from the fog is significant when considering the feasibility of using low-mounted floodlights to illuminate the runway. The clear weather illumination is about 0.005 footlambert.

The brightness of the asphaltic-concrete runway when dry was between 0.003 and 0.005 footlambert. The brightness of white runway markings (Nalcrete) 30 months old was about 0.009 footlambert.

When the runway was wet, but with no standing water, the runway and marking brightnesses were 0.0012 and 0.0058 footlambert respectively, giving a contrast of about three. The average reflectances computed from the ratio of the brightness measurements to the brightness of a blotter of known reflectance were as follows:

	Reflectance
Runway, dry	0.16
Runway, wet	0.06
Markings, dry	0.50
Markings, wet	0.28

Thus the average contrast is about two when the runway is dry and three when it is wet. The reflectance of the new Nalcrete samples measured in the laboratory and reported in the Progress Report for June 1 to September 30, 1956 was 58.5%.

c. Research in Visibility and Visibility Measurements.

Sky Brightness. The horizon-sky brightness meters have been calibrated. No significant change was found in the phototube received last year. Considerable difficulty has been encountered in maintaining these units, which were made in the Section shops, because they were made of unanodized dural. The materials used corrode rapidly at Arcata although they give satisfactory results at many locations. In the future brass will be used wherever possible.

Figure 5 shows the horizon sky-brightness meter and the horizontal illuminometer installed in the approach zone. The sky brightness meter scans 360° at 7-1/2 minute intervals scanning clockwise on one scan and counterclockwise on the next so that slip rings are not required for the connections to the photometric head. The shadow arm shown at the left of the horizontal illuminometer rotates on the same type of cycle casting a shadow from the sun on the illuminometer during each scan. This makes possible the determination of the ratio of direct and indirect illumination.

Slant Visibility Meter. A loose connection at the input circuit breaker was found to have caused sufficient local heating to damage the breaker. In addition, the high voltage to the lamp was arcing over in the fitting connecting the rotating projector to the stationary power supply. These faults are possible causes of the short lamp life which has been experienced.

Transmissometers. Considerable difficulty has been encountered with shifts in the indicator zero of 5-milliampere indicators because of the erratic behavior of the type OC-3 voltage-regulator tubes which are now being obtained. (This problem is much less severe with the 1-ma indicators used in the GMQ-10.) A study is being made of the feasibility of re-designing the bridge in the indicator to replace the type OC-3 tube with a conventional triode.

Effective Intensity of Flashing Lights and Composite Light Sources. The report on the effective intensity of the composite unit will be ready for completion in the next quarter. The equivalent visibility based on the various transmissometer readings has been computed. The ratio of the visual range to the equivalent visibility averages at 2.18 for six lamps at night and 2.19 for 10 lamps at night, and at 3.00 for six lamps at daytime and 3.12 for 10 lamps at daytime. This ratio for the nighttime data increases from about 1.80 at short visual ranges to about 2.35 at the limit of the range.

Lamps for the Westinghouse Krypton flash unit have been received and this unit was installed for testing at the visibility target area. The characteristics of the flash tube ignitor are such that if the ignition voltage is applied too long, secondary flashes will occur, so an electronic timing unit was assembled. The variable flash rate provided covers from 20 to 120 f.p.m. Tests have been conducted on this light in visibilities from 300 feet to 1/2 mile during daylight and night conditions. Preliminary values of effective candlepower of this unit appear to be about 50,000 candles. One of the two lamps shipped for this unit broke when unpacked and was replaced. The first lamp tested lasted for approximately 15 hours and was operated mostly at 60 flashes per minute.

d. Facilities.

An instrument shelter was moved to a location near TD transmissometer receiver for use by personnel from Naval Research Laboratory. Wiring was extended to the shelter to provide power for necessary instrumentation, light and heat. Transportation was furnished to these people to carry out their assignment.

e. Consultive Services.

Naval Research Laboratory. Messrs. Curcio and Knestrick of the Naval Research Laboratory completed tests of their back-scatter transmission meter at this installation during this period. They

were able to make tests under several conditions and encountered a number of difficulties not previously experienced.

Weather Bureau. Mr. Halverson from the Regional Office of the Weather Bureau discussed several problems which they have encountered with their transmissometers.

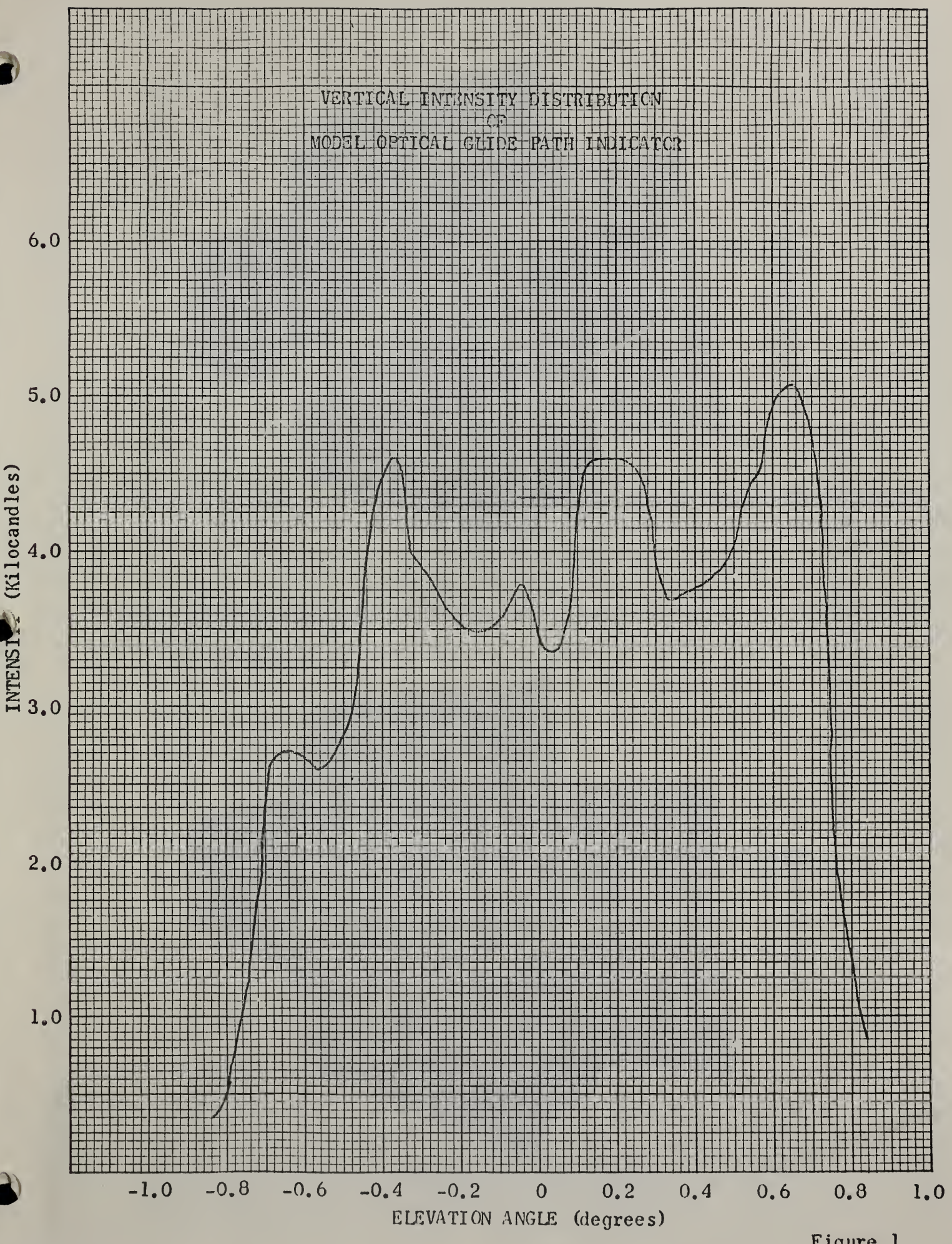
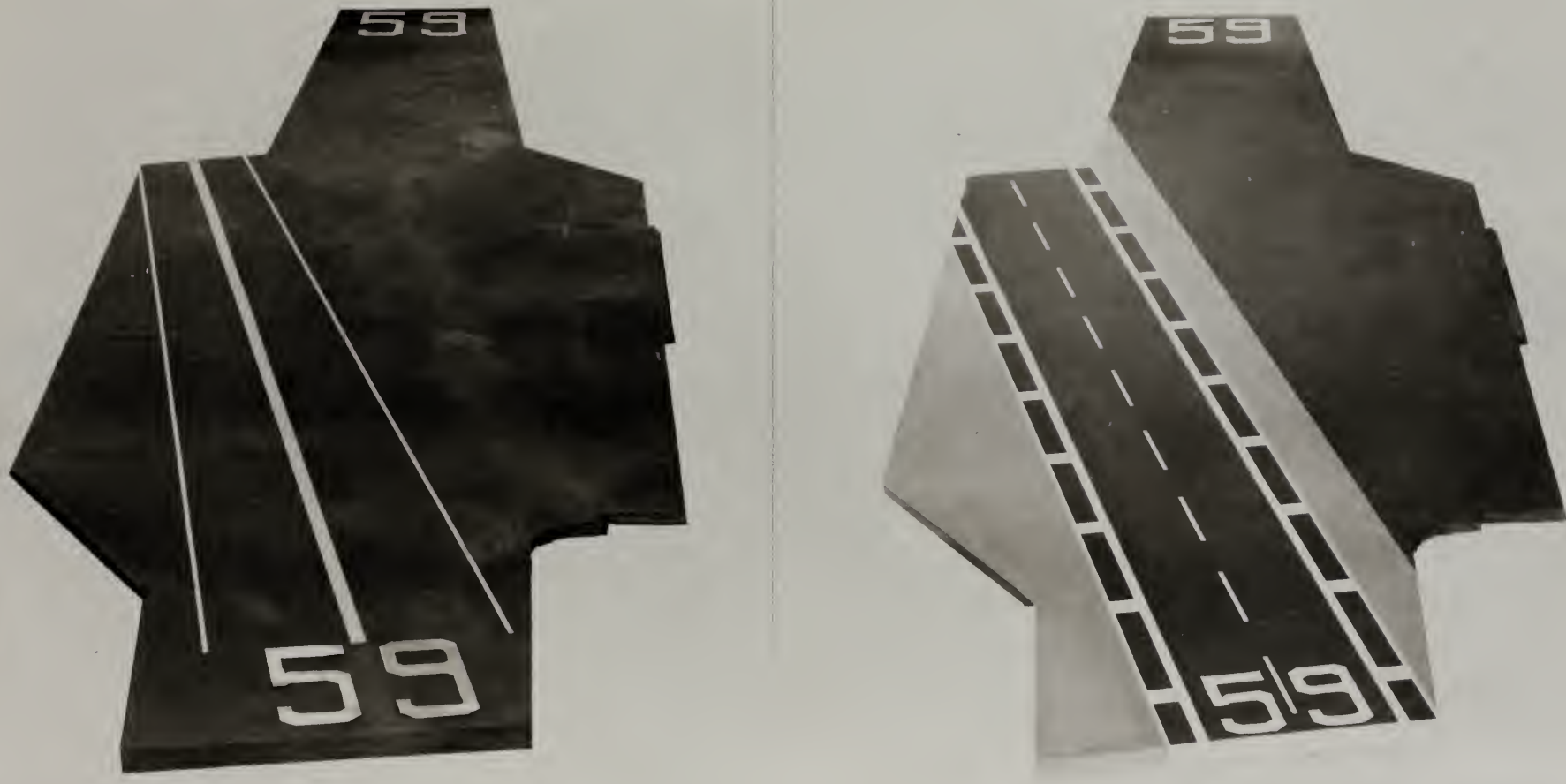

VERTICAL INTENSITY DISTRIBUTION
OF
MODEL OPTICAL GLIDE PATH INDICATOR
INTENSITY (Kilocandles)
6.0
5.0
4.0
3.0
2.0
1.0
-1.0
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1.0
ELEVATION ANGLE (degrees)

Figure 1

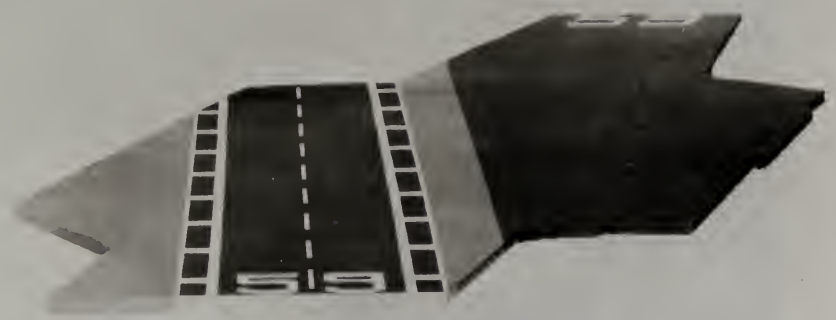


PRESENT

PROPOSED

CARRIER-DECK MARKINGS

FIGURE 2



PRESENT

PROPOSED

CARRIER-DECK MARKINGS

FIGURE 3

APPROACH BEACON INSTALLATION

FIGURE 4

HORIZON SKY-BRIGHTNESS METER

HORIZONTAL ILLUMINOMETER

FIGURE 5