DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION

FEDERAL AIRWAYS SERVICE
Technical Development Division

WASHINGTON

NOTE NO. 24

SERVICE TESTS ON SEADROME LIGHTS

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SERVICE TESTS ON SEADROME LIGHTING EQUIPMENT

Summary

This report covers the results of service tests conducted by the Technical Development Division of the C.A.A. on newly developed seadrome lighting equipment designed for permanent installation in transoceanic seaplane operating areas.

The service test installation was made in the Restricted Seaplane Operating Area near Treasure Island in San Francisco Bay. This material covers observations of the test equipment made between August 1 and September 11, 1940. The equipment was left in its original location for further studies.

A complete report on the original development of seadrome lighting equipment is under preparation at this time by the Technical Development Division of the C.A.A., which will contain the material of this note as well as a supplemental coverage of further observations made of the San Francisco Bay and other installations. The purpose of releasing this note at this time is to make the information and experiences gained through the San Francisco test available to all interested Federal agencies and lighting equipment manufacturers and to expedite the further development and use of seadrome lighting equipment.

Introduction

The rapid development of transoceanic transportation created many new problems relative to the design and marking of seaplane operating areas. One of the most outstanding of these problems was the necessity for special seadrome lighting equipment to insure the safe conduct of large flying boat operations. The establishment of restricted areas for seaplane operations and the necessity for the construction of dredged seaplane channels made the development of special marking equipment a matter of extreme importance. The Air Carrier Inspection Section of the C.A.A., responsible by law for the safety of scheduled airline operations, requested that such a seaplane channel marker be developed which would provide a dependable indication of the water's surface during night operations, reduce collision hazards with aircraft operating on the water to a minimum, and be suitable for permanent installation.

As a result of studies of earlier types of seadrome lighting equipment and of consultation with interested Federal agencies, seaplane manufacturers, and operators, a tentative design for such a marker was agreed upon. Development work and testing at Baltimore, Maryland, and Norfolk, Virginia, by the U. S. Navy, Coast Guard, C.A.A., and Pan American Airways resulted in the production of a unit incorporating recommendations of all interested parties. Purchase of the first 24 units by the U. S. Navy Department resulted after completion of the development tests at the Naval Air Station at Norfolk, Virginia, and conferences were held between the National

Electric Manufacturers' Association, Illuminating Engineering Society, the Navy, the Coast Guard, the Lighthouse Service, the C.A.A., and transoceanic operators. These conferences developed a definite list of requirements, and from them the C.A.A. developed standard specifications for seadrome contact light and seadrome boundary light requirements. After completion of these specifications the Airways Engineering Division of the C.A.A. purchased 30 units - 6 boundary units and 34 channel markers - to be installed for service test purposes in the San Francisco Bay restricted area established for the exclusive use of seaplanes.

Test Procedure

The test installation was accomplished through the cooperation of the Pacific Division of Pan American Airways, the Coast Guard, and the Lighthouse Service, at San Francisco. The boundary marker locations were determined after proper clearance through the Lighthouse Service, spaced at approximately one mile intervals, on two sides of the triangular area designated as the restricted area for seaplane operations. The corners of this area had been previously marked by standard Lighthouse Service buoys flashing a red light at approximately 75 flashes per minute. After conferences with the Air Carrier Inspection Section and Pan American Pilots a pattern for the marking of a seaplane operating channel within the restricted area was agreed upon. The light units consisted of gold colored, manually operated, fixed-type seadrome contact lights manufactured by the Westinghouse and Firestone companies. The

channel was 600 feet wide, the lights on the south side being spaced at 250 foot intervals, and the lights on the north side spaced at 500 foot intervals. The total length of the channel was approximately 4,000 feet.

In order to obtain comparative values, three available types of lighting systems were installed. (1) The Pan American 3-light system superimposed on pontoons, (2) the latest portable unit of Lights, Inc. furnished by Pan American Airways; and (3) the Westinghouse-Firestone boundary and contact lights purchased for test installation. The installation was completed by August 1, 1940 and observations were started in conjunction with Pan American's night flying training program. The equipment used during these night flights consisted of Boeing 314 Clippers, Martin Philippine Clippers, and a Consolidated Commodore training seaplane. Practically all pilots of the Pan American Pacific Division and West Coast members of the Air Carrier Inspection Section had an opportunity to observe the equipment installed for test purposes. The follo ing observations and comments on the three systems are offered for consideration:

(1) <u>The Pan American 3-Light System</u>

This system consists of a series of three incandescent lights suspended on metal posts approximately 7 feet in height, mounted on two metal pontoons and moored by a conventional anchor device. The lights are spaced at intervals of approximately 500 to 1,000 feet and are intended to give the pilot fixed reference points while landing a seaplane.

Performance comments:

(a) The equipment is designed entirely for temporary use and is not suitable for permanent installation.

(b) It is suitable for training purposes and other temporary operations but appears to be unsatisfactory for seaplane channel operations such as those contemplated at Keehi Lagoon, T. H., and North Beach, N. Y.

(c) The equipment in its present condition is not suitable for daymarking purposes.

(d) It constitutes a hazard in case of accidental collision with aircraft maneuvering on the water.

This equipment was not intended to meet the specifications agreed upon by interested Federal agencies, therefore, no further detail is given.

(2) Lights, Inc. System

This system consisted of a series of constant burning white incandescent lights 32 inches in height, mounted on round Balsa wood floats, surrounded by a pneumatically inflated rubber tube, the entire float unit being encased by canvas. Mooring equipment consists of a manila rope and a conventional type boat anchor. Lights were spaced at intervals of approximately 350 feet in a single line.

Performance Comments:

(a) The equipment is suitable for temporary operations only and not adaptable for permanent installation.

(b) Day visibility characteristics are insufficient.

(c) In spite of the inner tube shock protection, this equipment

offers collision hazards to boats and seaplanes maneuvering on the water.

(d) Light performance (14 candle power) is satisfactory, giving visibility of three miles or more from altitudes up to 5,000 feet during 90 per cent transmissivity.

(e) Handling characteristics are unsatisfactory because of fragile construction, particularly the light post attachment. The battery life is too short for average service requirements.

Since this equipment in its present condition was not intended to meet specifications agreed upon by all interested Federal agencies, no further details are given.

(3) Westinghouse-Firestone Boundary and Contact Lights

Basically the boundary lights and contact lights were identical in construction with the following exceptions. The boundary lights were of flashing type, day and night operation of the lights being controlled by sun valves. Boundary lights were installed to identify the limits of the restricted area for seaplane operations in San Francisco Bay, spaced at approximately 5,000 foot intervals. The contact lights were steady-burning and operated by hand whenever required for night operation.

Performance Comments and Recommendations:

(a) Day visibility was good except for operations in sunlight or reflected light on the water's surface.

(b) Flashing boundary lights were not usable because of the low percentage of flash time. The lights became practically

invisible at a distance of 500 yards.

(c) The light intensity of the contact lights was satisfactory near the water's surface and within glide angle. Pilots expressed the opinion that the intensity appeared to be unsatisfactory at an altitude of 1,000 feet, one and one-half miles away, against the background of the lighted San Francisco Bay Bridge and Berkeley Shore Drive. (Sodium lights.)

(d) Five hundred foot spacing of contact lights appeared sufficient for most operating conditions. This is the spacing recommended in the specifications.

(e) In general the equipment appeared to be suitable for permanent service installation when necessary detail changes have been incorporated in the design.

(f) The stability of the lights appeared to be satisfactory even during a sea running as high as 4 feet.

(g) The service life of the battery of the fixed contact light appeared to exceed 300 hours based on actual performance of 10 hours each day for over 30 days. The light was still burning after a 30-day period.

Recommendations

Boundary Light Flashing Characteristics:

Since the service test at San Francisco, the manufacturers have made changes in the flashing unit. This new unit was demonstrated at Aracostia to representatives of the U. S. Navy, U. S. Coast Guard, and the C.A.A., and was given tentative approval. These units, how-

ever, should be given a service test as soon as possible.

Light Intensity:

It became evident that for general operating conditions an improved vertical visibility of the seadrome contact lights would have to be obtained. As previously mentioned, the contact lights were not sufficiently visible from a distance of 1½ miles at an altitude of 1,000 feet against an illuminated background. This condition made it difficult for a pilot to locate the lane of lights from the air under normal visibility conditions. In case other aids for locating the area, such as beacons, are available, it will be necessary for the seadrome contact lights to provide only sufficient intensity and vertical distribution as will be needed to mark the channel. If such additional aids are not available, the contact lights must have sufficient visibility to enable the pilot to locate the channel from a distance of at least 5 miles.

Technical Comments and Recommendations Applying to Westinghouse-Firestone Unit.

Mechanical weaknesses of a minor nature, but in some cases of considerable consequence, became apparent prior to and after installation of the equipment. A majority of failures has been caused by water leakage and the causes have been corrected by minor structural changes in some cases and by improved adjustment of operating mechanisms. More serious problems having a definite bearing on the design and proper functions of the unit are as follows:

I. Electrolytic action on mooring gear attachment. In the original test installation a galvanized clevis pin swivel shackle was used for the attachment of the anchor chain to the copper basket

supporting the light unit. It was realized that the life of the galvanized shackle would be very limited, but it was expected that this material would last for at least a period of 3 months, or long enough to complete a reasonable service test. Complete failure of the clevis pin shackle was found within a period of 28 days, because of electrolytic action. In order to arrive at a possible solution to this problem Lighthouse Service and Marine engineers were consulted and the following attachment has been installed for observation purposes. An 18 inch strip of micarta, 2 inches wide and 1 inch thick was fastened by means of a bronze shackle and bolt to the copper basket and by means of a wrought iron swivel shackle to the anchor chain. It is expected that this strip of insulating material will reduce electrolytic action to a minimum and prevent the rapid electrolysis of metal parts.

Further desirable precaution would be the application of nonfouling paint on the copper battery case, specifically a type paint of very high dielectric value.

Recommendations

In all seadrome lighting equipment designed for future installation precautions should be exercised and necessary measures should be taken to insure against ocurrence of rapid deterioration due to galvanic action. The use of bare copper may offer complications in waters of high salt content, since among other effects it might reduce the life of the copper case to an unsatisfactory period. The use of nonfouling paints of high dielectric value such as are now being service tested, may offer possibilities.

All mooring gear should be of material not affected by electrolytic action.

II. Day Visibility Characteristics. It was discovered early during the service tests that while the striped buoy gave satisfactory daytime visibility under normal light conditions, neither the shape of the buoy nor the color combination would provide effective day marking during certain conditions such as light reflection from the water's surface and during operations into the direction of the light. It became evident that during conditions of this kind a silhouette effect was the only means of providing distinctive marking. In order to reach a possible solution of this problem conferences were held with a committee of Pan American pilots and it was recommended that for experimental purposes, triangular and circular markings, similar to those used in connection with inland navigation, be considered for boundary markers. The use of triangular and circular shapes was suggested in order that differentiation between the two sides of a seaplane operating channel could be established. In other words, if an aircraft landed on the water during low visibility conditions such as those encountered during rain squalls in the tropic regions, it would be possible for the pilot to orientate himself and safely proceed to the operating base. Pan American Airways was confronted with a serious marking problem of this nature at Canton Island and immediate action to relieve this situation was strongly urged by the committee. In order to expedite the development of an adequate day marker, two of the rubber buoys shipped to San Francisco were made available to the Airport Engineering Department of Pan American for

experimentation with light weight superstructures and necessary observations by the pilots which could be started immediately.

Recommendations:

Further study should be started immediately to determine what changes can be incorporated in the present design to meet the requirements for unfavorable light conditions, such as those experienced in Canton Island and during conditions when operations against the light are being conducted. The experiments by Pan American Airways, Pacific Division should be followed closely in order that suitable changes may be decided upon without any unnecessary delay.

III. Accumulation of Marine Growth.

Upon removal of all seadrome lights after a service period of 28 days, it became evident that the effect of marine growth upon the service-requiring portions of the buoys was a problem requiring serious consideration. The effect of marine growth on the rubber floatation may be of minor importance since according to rubber manufacturers chemical treatments can be perfected which will retard such accumulations. The use of synthetic rubber is reported as a possible solution to this problem. However, the effect of marine growth on the battery case offers a more serious problem since excessive accumulation on the case would tend to make the unit unserviceable within two or three months. The paint used for the original coating of the entire light unit was a silver enamel of a very high quality. However, this material evidently was not resistant to marine growth. After considerable study of the availability and uses of various types of nonfouling marine paints, it was dis-

covered that a product of the local office of the Chemical Corporation of America, gave very promising performance. In order to obtain further comparative information on the behavior of this new product, four light unit battery cases were buffed and installed in a portion of the San Francisco Bay offering the most severe water conditions. Two of the units were coated with the product of the Chemical Corporation of America while the other two were left in bare copper. The same material was applied to two of the rubber floats for test purposes, to determine whether this type paint will be usable as a protective coating for rubber.

Recommendations:

As mentioned under recommendations on mooring gear attachment, the use of nonfouling paints or other protective means on all parts of any seadrome lighting equipment to which it is applicable, particularly to those parts constantly submerged, is imperative. The performance records of the product now under service test at San Francisco indicate that it may offer a solution and results of present testing should be followed closely by interested agencies.

IV. Construction of Switch Used on Channel Marker.

The type of control switch used incorporated a plunger. As the switch is continually immersed, the packing allowed leakage and consequent deterioration of the aluminum base plates and enclosed mechanism. It is impractical to control this by tightening the packing gland, as it makes the plunger action stiff and difficult to operate from a boat.

Recommendations:

A new location of the switch should be given consideration. Placing the switch directly under the light bulb attachment would facilitate operations of the manually controlled unit. A rotary type or a pneumatic pressure switch may accomplish the same results.

V. Difficulty in Handling Light Units During Servicing.

Frequent removal of the various light units necessary for battery replacement or mechanical adjustments made it evident that certain changes in the design of the light unit should be considered because of the possibilities they offer to facilitate servicing operations. After two weeks of servicing, ten out of 24 light extension posts were bent. It became extremely difficult—in some cases impossible—to disengage the light units from the floatation devices in waves three or four feet in height. Variation in sizes of servicing boats did not seem to result in material improvement. The problem became sufficiently acute to offer possibilities of serious injury to service personnel.

Recommendations:

Light extension posts should be made out of heavier material to avoid bending. Evidently there is no necessity for the use of light material as a collision preventive, since the yield strength of light aluminum or other types of light tubing would be higher than the force in foot pounds necessary to upset the buoy. Provisions should be made for more simplified servicing of buoys by means of a bridle or eye bolts. The possibility of using an eye-hook attachment directly above the light unit or the possibility of rubber-lined, self-clamping tongues providing a straight lift should

be given consideration.

VI. Design of Lens Hold-down Plates

The present design of the lens hold-down plate securing the Fresnel lens to the light base plate, calls for a thin rubber gasket between the base and the lens. It became evident that after a short service period the thin rubber gaskets would be compressed to such an extent that the hold-down plate reinforcements and the lens plate would be caused to meet, destroying proper sealing of the Fresnel lens and permitting possible leakage.

Recommendation:

Reinforcement of the lens hold-down plate at the hold-down bolt holes should be omitted, the thickness of the gasket should be increased, and the material should be of superior quality.

The clamping lugs should be replaced by a pressure clamping ring, bearing evenly on the shoulder of the lens.

VII. Servicing Requirements and Cost

In view of the information gained at San Francisco, it is evident that the proper servicing equipment such as suitable boats and hoisting equipment will be necessary to make efficient servicing possible under varying weather and sea conditions. A Lighthouse Service tender of approximately 150 ton capacity was used for the original installation. However, this type of boat was entirely unsuitable for servicing purposes because high free board clearance, and in some cases the actual removal of the light units from the buoys had to be accomplished through the use of a small skiff.

Equipment such as the double-ender 28 foot power boats used by the Coast Guard appear to be ideally suited for service purposes. From the information available at this time it appears that seadrome boundary units will require complete servicing at least every 3 months and a 30 day performance inspection. For a 3 month complete servicing operation the following personnel will be necessary: 3 men exclusive of boat crew. Time required, based on the handling of 20 buoys, 3 days for pick-up, servicing, and installation—or 9 men days for 20 buoys for routine servicing. Monthly inspections could be handled by one man and a boat crew. Cleaning of buoys every 3 months requires 2 men for 1 day for every 20 units.

Equipment and Material

Battery replacement cost on a basis of 20 units every three months at $4.50 per unit replacement will amount to $90 or $360 annually. Lamp replacement cost will be negligible since the lamp bulbs are guaranteed for 5,000 hours' operation. Spare parts and unit replacements as well as spare flash mechanism transformers and mooring gear should be provided for.

General Recommendation

Because of numerous variables entering into the estimation of boat cost, it was impossible to determine accurate information on this subject, which really lies outside the scope of this report.

For moorings over 30 feet in depth, the chains should be supported by underwater floats.

Some of the difficulties encountered during the service test at San Francisco caused considerable concern to some of the recognized

authorities on marine and other types of lighting. As a whole, it is evident that further observation of, and experimentation with, this new typed of seadrome lighting equipment is imperative in order that all concerned may profit by such service testing.

Past experience indicates that flashing lights would not be practical for landings of aircraft on water. Flashing lights, previously tried in Department of Commerce emergency fields, proved to be unsuitable for visual reference purposes. However, seadrome boundary lights with a flashing characteristic of 120 flashes per minute, similar to the unit submitted to all interested Federal agencies in Anacostia, D. C., during October 1940, appear to be practical for a twofold purpose. First, as a guide to mariners and surface water craft and, second to outline to the airmen the boundaries of the seaplane operating area. Seadrome boundary lights are not intended to be used for seaplane landing purposes.

Further studies and coordination of many varied interests will doubtless be necessary, and should be undertaken immediately, since the development of seadrome lighting equipment suitable for uniform marking of commercial and naval seaplane operating areas is essential to the safe conduct of air commerce and National Defense.

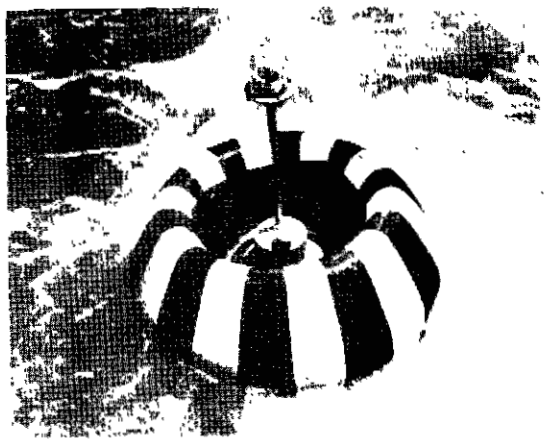
Conclusion

The first period of the service tests at San Francisco, although of short duration, has produced valuable information. The results indicate that some of the equipment tested shows definite promise and may be considered as the first step toward the

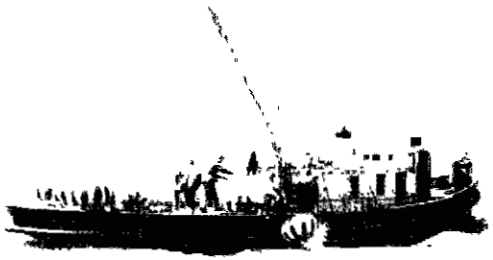
ultimate development of seadrome lighting equipment suitable for permanent installation. Considering the rapid increase in the establishment of restricted areas for seaplane operations, it is evident that the proper facilities for the marking of such areas must be developed without further delay. Additional service testing will contribute greatly to the perfection of acceptable seadrome markings and will accelerate the recognition and avoidance of restricted seaplane operating areas by surface water craft.

It is recognized that other manufacturers are engaged in the development of similar or improved types of seadrome lighting equipment and it is hoped that the service test experiences at San Francisco will be of material benefit both to the Federal agencies interested and to the manufacturers engaged in and contemplating the design of permanent seadrome marking facilities.

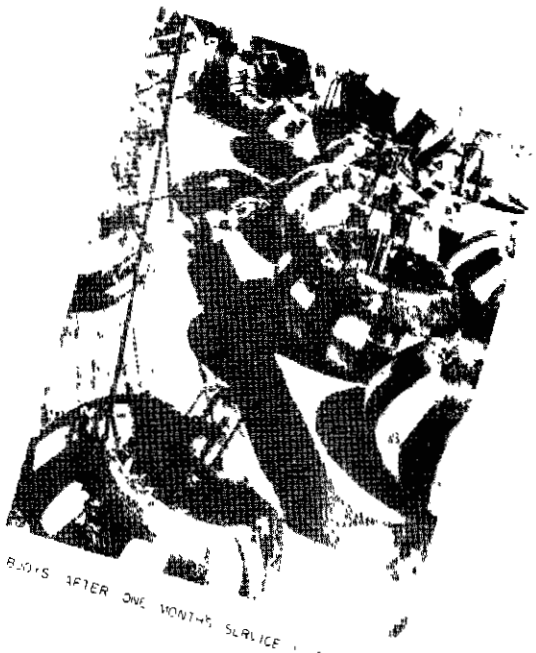
INSTALLING LIGHT UNIT IN RUBBER BUOYS



COMPLETE ASSEMBLY OF SEADROME CONTACT LIGHTS



PLACING OF BUOYS IN SEAPLANE OPERATING CHANNEL



BUOYS AFTER ONE MONTH'S SERVICE IN TROPICAL WATERS

STERN VIEW OF COAST GUARD CUTTER DURING INSTALLATION OF RUBBER BUOYS

MARINE GROWTH ACCUMULATION ON RUBBER BUOY

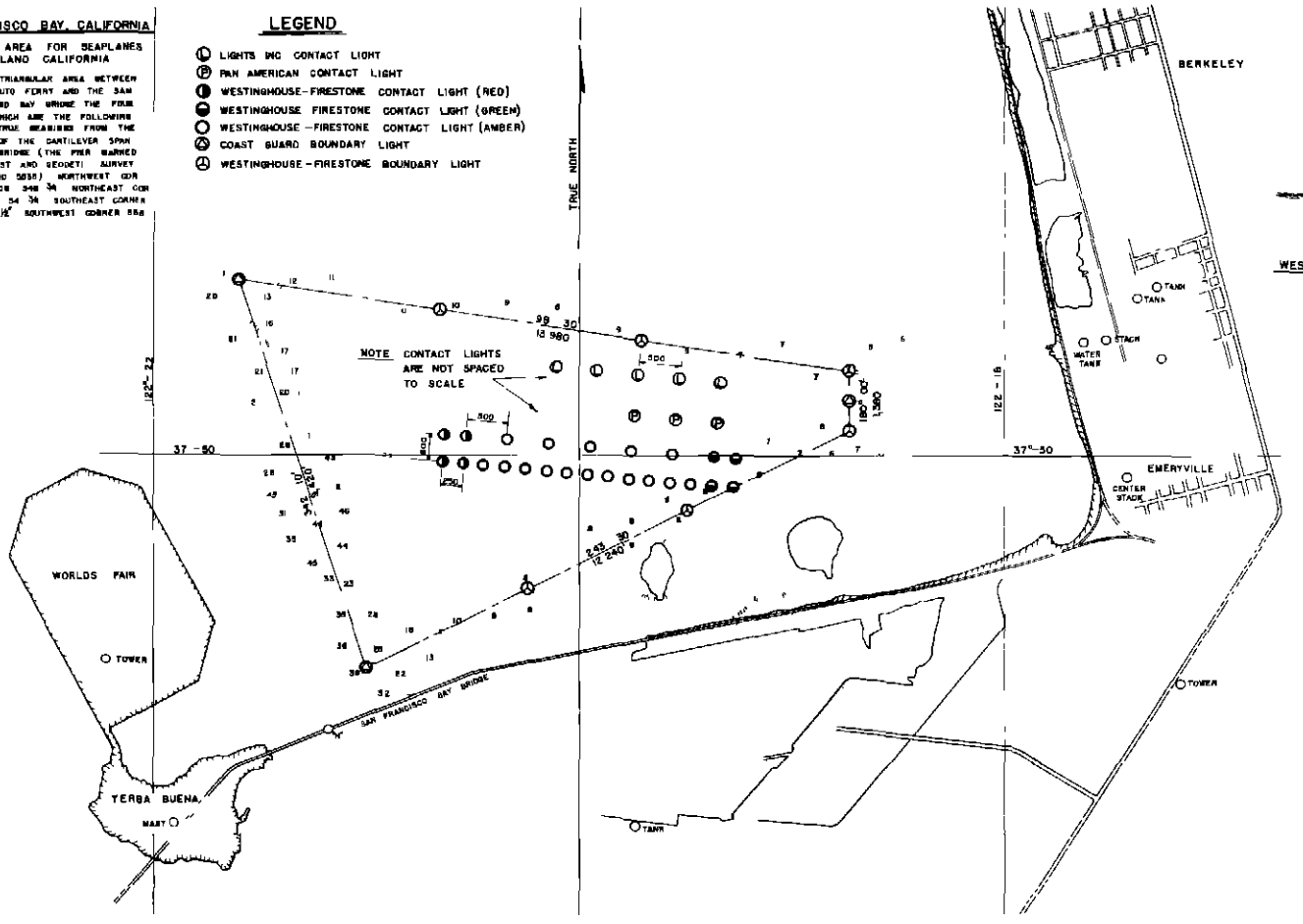
SAN FRANCISCO BAY, CALIFORNIA

RESTRICTED AREA FOR SEAPLANES AT OAKLAND CALIFORNIA

THE TRUNCATED TRIANGULAR AREA BETWEEN THE BERKELEY AUTO FERRY AND THE SAN FRANCISCO - OAKLAND BAY BRIDGE THE FOUR CORNERS OF WHICH ARE THE FOLLOWING DISTANCES AND TRUE BEARINGS FROM THE EASTERLY PIER OF THE CANTILEVER SPAN OF THE ABOVE BRIDGE (THIS PIER MARKED R ON U S COAST AND GEODETI SURVEY CHARTS 555E AND 5038) NORTHWEST CORNER 3 882 YARDS 348 ½ NORTHEAST CORNER 4 815 YARDS 54 ½ SOUTHEAST CORNER 4 980 YARDS 58 ½° SOUTHWEST CORNER 556 YARDS 91 ½°

LEGEND

- LIGHTS INC CONTACT LIGHT
- PAN AMERICAN CONTACT LIGHT
- WESTINGHOUSE-FIRESTONE CONTACT LIGHT (RED)
- WESTINGHOUSE FIRESTONE CONTACT LIGHT (GREEN)
- WESTINGHOUSE -FIRESTONE CONTACT LIGHT (AMBER)
- COAST GUARD BOUNDARY LIGHT
- WESTINGHOUSE-FIRESTONE BOUNDARY LIGHT



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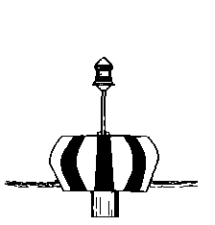
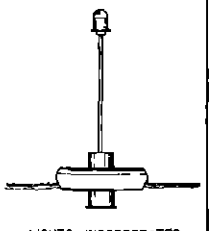
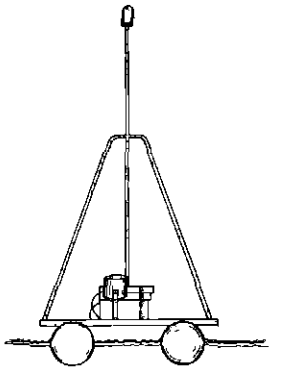
GRAPHIC SCALE IN FEET



WESTINGHOUSE – FIRESTONE



LIGHTS INCORPORATED



PAN-AMERICAN

TYPES OF SEADROME LIGHTS

NO SCALE

DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION
FEDERAL AIRWAYS SERVICE
TECHNICAL DEVELOPMENT DIVISION – AIRPORT SECTION

LIGHTING PLAN
SEAPLANE OPERATING AREA
SAN FRANCISCO BAY

REVISED	APPROVED Frederick Brown SECTION CHIEF
	SUBMITTED
	DRAWN R.C.M. DATE 11-7 40 DR NO. 2