1944

Design of a submergible seadrome light--universal type--suitable for military use in all areas and for transportation by aircraft

Frederick Marion Mueller

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DESIGN OF A SUBMERSIBLE SEADROME LIGHT
--UNIVERSAL TYPE--SUITABLE FOR MILITARY
USE IN ALL AREAS AND FOR TRANSPORTATION
BY AIRCRAFT

BY

LT. FREDERICK MARION MUELLER, CEC-V(S), USNR

-------

A

THESIS

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

Degree of

ELECTRICAL ENGINEER

Rolla, Missouri

1944

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Approved by  F. H. Frame
Professor of Electrical Engineering
ACKNOWLEDGMENT

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U. S. Naval Air Station
Corpus Christi, Texas

February 1944
PREFACE

This thesis is made in the interest of the Navy Department for military use and for purposes pertaining to the conservation of materials. It is hoped that substantial aid in the experimentation and sought for "standard design" of a useful seadrome light is contained herein. It has been my experience to see seadrome lighting equipment in use damaged by aircraft and in frequent handling.

It is believed that the design, briefly covered by this report, eliminates in a large part, damages from aircraft and also from handling. In view of the conservation of rubber this new design greatly reduces the use of rubber with no increase in other critical materials over that used in other seadrome lighting sets being manufactured. Probably with further modifications the rubber used for buoys may be entirely replaced by wood, glass or plastics.

From a military point of view, a submerged seadrome light assembly will enhance the security of operations in areas where seaplane bases are secret— for in daylight both lights and buoys remain submerged unobserved by enemy scouts and at night may be turned off from a central control. Since the lights may be supplied electric power from a central source, and not generally from batteries, considerable time is saved in the maintenance of the set. Since the lights may be placed in individual or separate electric circuits, even though some of the lights be damaged, others will continue to operate.

If local operators elect to use the lights surfaced, instead of
submerged, the change is a simple matter and allows a considerable increase in useful light output, thereby making the set suitable for use during flight conditions of extreme low visibility.

Simply by setting the lights on a small cone-shaped mound of earth, or upon light metal cones, the set is useful for landfield operation in even the worst conditions of ground water and low visibility.

The lights offer an inexpensive means of boundary lighting an all-way seadrome and, not being mounted on piles, offer only a minimum hazard—if any at all—to operating aircraft. Seaplanes may land immediately above or taxi over the submerged lights with no ill effects.

Quite possibly other uses of the lights may be found, such as marking reefs, sunken vessels, courses for small vessels plying narrow channels, and taxiway courses for seaplanes.

The lights are easy to transport, install, and maintain and require only one adjustment—the length of the anchor cable. Relamping operations are simple since the lamp head, clipped in place, may be removed from the buoy and line in a few seconds.

Because of the extreme light weight, small size of the buoys and general compactness of the assemblies the set is highly adaptable to transportation by air.

While this is but a semi-official report and does not necessarily reflect the views of the Navy Department or the naval service, it is the writer's desire that the information herein be accepted by the Government for whatever value it may contain and that the writer be permitted to submit this report in its present composition to the faculty of the School of Mines and Metallurgy of the University of
Missouri in partial fulfillment of the work required for the degree of Electrical Engineer and only for that purpose.

U. S. Naval Air Station
Corpus Christi, Texas

February, 1944
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CHAPTER I

Introduction

This thesis was written in consideration of problems arising in present day use of battery operated seadrome lights. The information contained has been compiled to explain the development of a radically new design in seadrome lighting. Use of a selected single lighted strip is the basis of the design.

The seadrome light described is a submersible type and is essentially a modification and combination of the 100 watt beacon lights, used with the Type B-2 portable field lighting set; and the American Gas Accumulator Company Portable Lighting Set PAM-2. The beacon was modified in that it was made waterproof and its base changed to accommodate a centrally placed lamp lead and a small rubber buoy. The PAM-2 seadrome set afforded only the underwater electric cable and generators.

Ease and simplicity of transportation, operation, and maintenance are the essential qualities needed for the type of lighting equipment described. The requirements for rugged military type of equipment have been considered, and while the drawings and photographs included here do not show the optimum design of an underwater marker light, it is contended that the principle involved has merit.

In the beginning of the work it was decided to attempt the design of a portable seadrome light to operate without servicing over prolonged periods. This, of course, meant making a light that would not readily lend itself to damage from small craft or seaplanes. Generally

speaking, seadrome lights in daily use require considerable storage or transportation space and a change of batteries each two or three days, the latter necessitates setting out and retrieving the lights daily unless strict logs are kept on battery life. This nearly endless handling of the lights with buoys attached results in the bending, fracturing and losing of parts. If the lights and buoys are left in the water through daylight operations in heavy traffic, they suffer from rupture of buoys and submersion. In the use of the portable seadrome set not using batteries, it is left in place for extended periods and while it needs little servicing the lights and buoys are continual obstacles on the seadrome surface. The submersible seadrome light operates far enough below the water surface that it offers no obstacle to seaplanes and, when not adapted for battery operation, requires but little servicing. These conditions exist for the portable set about which this paper is concerned.


4. U. S. Naval Air Station, San Diego, California, Commanding Officer’s report to the Chief of the Bureau of Aeronautics, letter N10-12 (20), April 23, 1942, Enclosure (A), (Contract No. C-74978) paragraph 7-(c), with 41 inch buoys; "Due to lack of stowage space on tenders, these lights are not entirely satisfactory for advanced base units because of their bulk. However, it is understood that the size of buoys are being standardized at 33 inches, which will partially remove this objection."

5. U. S. Naval Air Training Center, Corpus Christi, letter from the Commandant to the Chief of the Bureau of Aeronautics, comments on design, "Seadrome Lights for Night Operations of Seaplanes," Serial 6752, File NA47/W59-1, 45/TIW/xx, of June 1, 1943.
Within the scope of future experimentation is the use of a radio signal from a seaplane for control of seadrome lights installed at isolated alternate seadromes where continuous operations are not feasible.

Convenience of operation of underwater lights dictates the desirability of their use in high-intensity illumination of large commercial seadromes. It is likely that underwater seadrome lights of the sodium vapor or mercury vapor type used on series circuits are worthy of consideration.
CHAPTER II
The Underwater Contact Light

The lighting of seadromes is still of an experimental nature\(^6\), of which the first undertakings began ten years ago by Pan American Airways at Miami\(^7\). Various considerations of importance were studied by Navy, Coast Guard, Pan American Airways, Civil Aeronautics Administration, and Westinghouse Electric & Mfg. Co. in tests at the U. S. Naval Air Station, San Diego, California, in March 1942. Results of these tests\(^7\) indicated the desirable qualities needed were rugged seadrome lighting sets controlled from a central point.

The development of materials since the time these tests were conducted indicates the worth of new studies in seadrome lighting design. It is predicted that there will be an extensive use of moulded plastic lenses; photo-electric "on" and "off" control\(^8\) of light lanes in lieu of radio-controlled switching; and underwater or surface airway marker beacons for transoceanic flight aids.

The seadrome light considered here is designed with the intention of overcoming many of the problems introduced in earlier studies. It is hoped that many parts of the light assemblies considered may eventually be made of plastics. There is a possibility of some field of study in the use of a factory-sealed lamp head using a lens to be expended with the lamp at each lamp burnout. If plastics do not prove

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desirable for the major parts of the assembly the metals used in present seadrome lights may well be used in conjunction with plastics. Seadrome lights of the high intensity variety may prove valuable in the growing field of low visibility approach lighting and may even be used, with a vane and an asymmetrical lens to show wind direction. One seadrome studied is a dredged area. Its irregular boundary is marked at night by flare pots mounted on piles. It is considered that a more satisfactory means of lighting could be accomplished by the use of a flexible installation in which case the lights would be used as boundary markers of an irregularly shaped all-way seadrome.

Although experiments concerned with the use of an underwater battery in a waterproof box for a power source have not been started, it is anticipated that a practical seadrome light of low power rating for underwater use is feasible. Such a light as this, following the general assembly structure might use the battery and its container for an anchor. The proposed light for use with a battery might be operated by lighting it before submersion or by operating it by a switch mounted in the anchor location float (Fig. 18, page 54 and Fig. 1, page 53, detail).

The general considerations in the design of the submersible seadrome light are as follows:

(1) The light
   (a) Need bright quality with low wattage
   (b) Need luminary to endure rough handling
   (c) Need lamp and lens combination to produce at about five feet depth in sea water a suitable light distribution--to give low level illumination to a large area of water
and to emit maximum light at low angles

(d) Desire a lamp and lens base suitable for attachment to a pneumatic buoy and completely waterproof

(e) Desire to have a minimum number of parts all suitable for speedy production; and simple to assemble, dismantle, and maintain.

(2) The buoy

(a) Need flexible buoy of displacement sufficient to lift lamp assembly, lamp lead, and maintain a taut anchor cable to minimise light wallowing from wave action

(b) Need material resistant to sea water

(c) Need buoy of proportions to hold clip on lamp base stem and to make complete assembly of proportions to minimise wallowing from wave and tide action and small enough to be readily portable by air

(3) The underwater cable and power supply—(This item was already available and was not modified)

(4) The anchor

(a) Need anchor either easily transported or easily made near the place it is to be used.

(b) Need anchor sufficiently heavy to submerge light assembly and heavy enough so as not to be easily shifted by water movement.

(c) Need anchor of material resistant to salt water.

The design of the light was developed with the aim of making a semi-permanent installation of similar equipment in some area (Fig. 2, page 34)
where indefinitely prolonged operation will prove or disprove its value. It is believed that "Layout D" or "Layout E" (Fig. 2) offer the best arrangement of lights for a prolonged service test. Layout D makes possible an "on course" straight line approach and landing immediately on one string of contact lights which are supplemented on both sides with horizon reference and range lights. This layout is similar in principle with the basic design used by German engineers in the lighting of the Riem Airport at Munich, and was also in use at the E. Forlanini Airport at Milan. Layout E makes use of the customary contact light strip on each side of the landing course. Layout F (Fig. 2) makes use of a single strip for easy handling suitable for changing to correspond with predetermined wind direction and may be called a "wind-line layout."

A comparison of the seadrome light in present use and of two experimental light assemblies is shown in Fig. 23, page 65. Also shown here are the concrete anchors (items 3 and 6); a rough brass casting (item 7) for a Type A assembly; an auxiliary shield (item 5); and a supplementary buoy (item 9). The auxiliary shield is used to change the light distribution and the supplementary buoys are necessary to increase the buoyancy of the assembly to offset additional weight from longer lamp leads and lamp assembly lines should they be needed in installations in water of greater depth. It is intended, in most cases, that the electric distribution circuit be laid on the bottom alongside the anchor.

The complete experimental set is shown in Fig. 22A, page 61, and Fig. 22B, page 62. In Fig. 22A a set of float tie lines are shown as item 5; item 4 is a set of lamp assembly lines (adjustable) complete with galvanized metal.}

snaps and rings for facilitating the set layout. Item 13 is an adapter for use in connecting the underwater electric circuit to a commercial type outlet. Items 14 and 15 show plug seals for the waterproof connectors, item 16, used in providing branch circuits to the assemblies from the main. In Fig. 22B wooden anchor location floats or "bobs" are shown as item 17. Later, in the experiment these "bobs" were made of cork and left in place.

A general purpose layout of the contact light unit is shown in Fig. 18, page 54. In layout of the set a sounding is taken at each light location and the lamp assembly line is adjusted to set the light at the desired depth; then by use of the float tie line the anchor, distribution circuit, and contact light assembly are lowered into position. The equipment is retrieved by lifting the anchor with the float tie line. The seadrome contact light assembly Type G is designed for use without the anchor location float for secret installations where floats would give away the seadrome position.

The Type G assembly (Fig. 21, page 57; Fig. 12, page 46; Fig. 30, page 70) is equipped with horns by which, together with the anchor, it may be lowered into position using a short hand line. The Type G assembly is retrieved by use of a sweep line or net to engage the horns and then by pulling the assembly to the surface.

The seadrome light assembly Type A (Fig. 6, page 42; Fig. 19, page 55; Fig. 24, page 64) is very compact and consists of a Fresnel lens, lamp, lamp base and holder, underwater connector and ring, buoy, buoy retainer plate, and lamp lead. It has overall dimensions of 15 inches by 15 inches diameter. The lamp base (item 7, Fig. 24, page 64) is
made of brass and encloses a soft rubber female receptacle. This base
forms a snug fit to the top of the pneumatic buoy (Fig. 6, section AA),
and is joined to the underwater connector and ring through the center of
the buoy. The underwater connector (Fig. 24, item 9) has a soft rubber
male fitting and is compressed in place with a threaded retaining nut to
form a waterproof connection. The connector is polarized. The buoy is
held in place against the lamp base by a buoy retainer plate (Fig. 24,
item 10) which may be threaded over the lamp lead and compressed against
the buoy to form a clip fit with the underwater connector and ring. Fig.
19 shows the Type A assembly with a lamp lead eleven feet in length. It
is anticipated that the lamp head (Fig. 24, items 1-7 assembled) as a unit
be removed and replaced in servicing a lamp burnout.

Seadrome light assembly, Type B (Fig. 7, page 43; Fig. 20, page 56;
Fig. 25, page 66) is similar in design to the Type A assembly. In the
experiment a beacon light base was modified and extended with a copper
conduit 20 inches long (Fig. 25, item 2). This conduit was added to
lower the center of gravity of the assembly and also to provide for the
use of supplementary buoys which may be threaded onto the conduit and
tied in place by use of a light line passed through the three spaces
in the buoy retainer plate (Fig. 25, item 4). Fig. 20 shows the Type B
assembly with an auxiliary shield in place. The shield shown in Fig. 20
is fifteen inches in diameter.

Seadrome light assembly, Type C (Fig. 8, page 44; Fig. 26, page 66)
is exceedingly simple in design. Fig. 8 shows the unit assembled. A
standard flashing beacon assembly comprises the lamp head. This part is
waterproofed with compound and has attached a waterproof lamp lead ten
feet long. The lamp head (Fig. 26, item 1) placed on top of the buoy is fastened with a thumb screw to the grooved top of the ballast stem (Fig. 26, item 4-8). The disassembled ballast stem shown in Fig. 26 may be made of only one part; here, however, for convenience it was assembled from a rod (item 4) with an annular groove and annular seat at the top and threads inside and outside at the bottom. The outside threads accommodate a nut (item 5) used in applying pressure to the buoy retainer plate (item 3) to hold the assembly together. For the experiment the top of the weight spindle (item 7) was threaded to enter the bottom of the upper piece of the ballast stem (item 4) and held there by a lock nut (item 6). Item 8 is a ballast weight, an integral part of the ballast stem. The buoy retainer plate is dished to add strength and has four large spaces to accommodate the movement of water and to provide a way for servicing air to the buoy through its valve. Pressure by the buoy onto the lamp base and buoy retainer plate holds the buoy in its symmetrical place about the stem.

Seadrome light assembly, Type D (Fig. 9, page 45; Fig. 27, page 67) is similar to the Type C assembly except that a buoy of larger diameter is used and is held symmetrical to the ballast stem through use of a large buoy upper retaining plate (Fig. 27, item 2) of metal and a large buoy lower retaining plate (item 4) made of wood. The ballast stem of the experimental assembly has a welded joint just to the right of the washer, item 5, where it changes in cross section. The assembly is held together with a nut (item 6) and washer (item 5). The buoy lower retaining plate (item 4) has an access aperture through which the lamp lead (item 9) is passed, through which water may circulate, and also through
which air may be serviced to the buoy (item 3).

Seadrome light assembly, Type E, (Fig. 10, page 46; Fig. 28, page 68) is similar to the Type C and Type D assemblies except that the lamp lead, instead of being threaded through an access aperture in the buoy retaining plate, is simply laid into a notched access in the buoy slotted retaining plate (Fig. 28, item 3). The offset joint in the ballast stem (item 6) is brazed. The buoy used in the experiment is a discarded aeroplane tire, without a tube, sealed by patching at its inner circumference (item 2). Fig. 10, section AA, shows the use of supplementary buoys with the assembly.

Seadrome light assembly, Type F (Fig. 11, page 47; Fig. 29, page 69) is an odd design. The buoy lower retaining plate and center block (Fig. 29, item 6) and the buoy upper retaining plate (item 4) are made of wood and assembled with brass screws (item 2). A universal adapter (item 3) (cone adapter from a B-2 set) is centered on top for attachment to the lamp head (item 1). The lamp lead (item 7) is placed over the edge of the buoy and causes an unbalance of the assembly--tilting the buoy to one side.

To prevent the resulting undesirable characteristic in light distribution due to this tilting, the lamp head may be adjusted to a vertical axis by resetting the universal adapter. The lamp lead should be held in place to prevent its assuming a new position once the lamp head has been adjusted. The buoy lower retaining plate has an access aperture through which air may be serviced to the buoy.

Seadrome light assembly, Type G (Fig. 12, page 48; Fig. 21, page 57; Fig. 30, page 70) may be used in conjunction with an anchor location float but is designed primarily for use without an anchor location float. The assembly is composed of a lamp head (Fig. 30, item 1), buoy adapter (item
2), buoy (item 3) made of an aeroplane tire, tube, and wheel, a lamp lead, and retrieving horns (item 6). The retrieving horns are positively attached to the buoy with machine screws (item 4). The lamp head, attached to the buoy adapter with a set screw, when placed on the buoy is secured there with a cotter (item 5) passed part way through the portion of the buoy adapter which extends through the plate atop the retrieving horns. The experimental assembly may be improved by modifying the present design with a larger buoy and a short ballast stem.

Seadrome light assembly, Type H (Fig. 15, page 49, Fig. 31, page 70) is designed for use in deep water and has great buoyancy for overcoming the weight of a long lamp lead and a long lamp assembly line. It is comprised of a lamp head (Fig. 31, item 1), buoy upper retaining plate (item 2), buoy (item 11), buoy lower retaining plate (item 5), lamp lead (item 10), and a ballast stem (item 8). The lamp head seated upon the buoy upper retaining plate is secured in place with a set screw bearing into a notched stem suspended below the buoy upper retaining plate. The buoy upper and lower retaining plates are fastened to each other by use of five wooden columns of length equal to the width of the inflated buoy. These columns are held in place with brass screws and are placed to make the axes of the buoy, light, and assembly congruent. Five large apertures in both the buoy upper and lower retaining plates permit water to circulate through the assembly. Item 8 is a sturdy ballast stem suitable for use in handling the assembly. The ballast stem is fastened to the buoy lower retaining plate with two nuts (items 3 and 7) and washers (items 4 and 6).

Fig. 15 pictures an early study of the possible adaptation of a
Westinghouse-Firestone seadrome light for underwater use. In the experiment no attempt was made to submerge or use a buoy of this size (Fig. 23, item 1).

Fig. 16 represents the writer's first conception of a submerged seadrome light. It was originally held that the lens or lamp cover would be or could suitably be made large enough to have ample buoyancy with no additional buoy. Although the merit of this contention has not been proved, it is thought that further hydrostatic investigation will indicate success.

Fig. 17 is a log sheet form for recording operation and maintenance data relative to seadrome lights now in use at the U. S. Naval Air Station, Corpus Christi, Texas.
CHAPTER III
Development and Experimentation Procedure

Development of the contact assemblies was carried on in the Public Works Shop and at the seadromes of the U. S. Naval Air Station, Corpus Christi, Texas.

After initial construction of the assemblies considerable difficulty arose in sealing and waterproofing the lamp head. The lamp lead terminal in each case was brought into the base of the lamp head through a small aperture and secured by a fiber and metal strain relief and by soldering the wires to the lamp socket. The bowl inside the lamp base was then flame wiped and filled with Low Tension "B" Novoid insulating compound\textsuperscript{10} poured at about 320\(^\circ\) F. This compound formed a watertight seal at the lamp lead entrance and adapter socket in each assembly. Later the use of a very hard sealing compound ("Chico A", Catalog No. Chico A05, Crouse Hinds Company, Syracuse, New York) was successfully introduced in the attempt to overcome difficulties (page 20) encountered with the before mentioned Low Tension Novoid compound.

Fig. 24, page 64, does not show the lamp which should be shown with item 7; item 2 is a paper ring used to distribute the bearing of a brass retaining ring (item 5) onto the pyrex glass seat of the Fresnel lens (item 1). A threaded brass ring (item 6), when tightened, bears upon the retaining ring (item 5) compressing both a stiff rubber gasket (item 3) on which the lens is seated and a soft rubber gasket (item 4) concentric with and outside the stiff rubber gasket. At first it was

\textsuperscript{10} Electric Specialty Co. product, 7780 Dante Avenue, Chicago, Illinois.
believed that two gaskets were sufficient to maintain a watertight seal but submersion tests indicated otherwise. Several types of sealing cements were then tried to make the fixture waterproof. Four types used, all of which proved satisfactory in four day submersion tests in eight feet of fresh water (Fig. 33, page 76) were: (1) Moran's "Seal-Tite" roofing cement - Anchor Paint & Varnish Corp., 88th Street and 73rd Avenue, Glendale, Brooklyn, New York; (2) Hayes Waterproof Cement - Hayes Adhesives Company, St. Louis, Missouri; (3) Vulcatex Calking Compound, knife grade, A. C. Horn Company, Long Island, New York; and (4) "Permatex" --Form-A-Gasket, No. 2, U. S. Patent No. 2217723, Permatex Company, Inc., Sheepshead Bay, New York. The fourth type was the most satisfactory because of the ease of its application and removal. Also tried with the same success was the Novoid hot compound mentioned above. Experience here has proved the desirability of applying a thin coat of hot paraffin over the exterior of the lamp base to protect the interior seal and the metallic parts from salt water. Paraffin was also used on the underwater connector (item 9) in joining it with the lamp base to waterproof and protect the threads. The hot paraffin is easily applied by means of an ordinary oil can with a heated spout and by use of a small heated bath into which the cable splices, at the connectors may be dipped. This latter method was used in making up the connections of the distribution system (Fig. 34B, page 78). Two of the type connectors used were submerged, one in a container of sea water at ambient temperature and the other in a container of sea water at 32 to 34 degrees Fahrenheit temperature without the protective paraffin coat for four months with no visible deterioration and without decrease in operational
efficiency.

The first test conducted on the assemblies was a fresh water buoyancy test and submersion (data--page 35; Fig. 33, page 76) on November 27, 1943. From this test the set buoyancy, Table 1, was found to range from one pound to twenty four and three quarter pounds. From the appearance of the assemblies Types A, B, and C were considered the most desirable. The weight in water of the anchors was also determined.

The next experiment was conducted on January 3, 1944, to determine light output. The experiment was divided into four parts (data--Table 2, page 36), Test A--the light submerged with no shield; Test B--the light submerged with shield; Test C--the light surfaced with no shield; and Test D--the light surfaced with shield. Figs. 32A, 32B, 32C, and 32D show the apparatus set-up used for running the tests. The experiment was interrupted by lamp burn out in Assembly A and Assembly B before these types could be lowered to the water. It is believed that lamp failure was caused by previous rough handling of the assemblies resulting in loosening of the filament in the lamp. At first no effort was made to burn the lamp in only the vertical position--this probably contributed to failure of the filament since in both cases the burn out occurred when the assembly was not vertical. Assembly C was then used in running Test A but, about thirty minutes after it was lighted and underwater, it burned out. Upon inspection at disassembly the cause of the burn out was determined to be due to the entrance of sea water into the lamphead and subsequent short circuit in the lamp base. The lamp base was badly charred and the lamp was shattered. It is believed the water entered around the gaskets. Assembly D was lighted for Test
 but burned out in a few seconds when handling it into position. Evi-
dently there was residual water from a previous submersion that
caused a short circuit in the lamp base. Assembly E with a buoy from
Assembly B was then successfully used in running Test B. Assembly G
was successfully used in running Test C. Assembly H was successfully
used in running Test D after finding that Assembly G overturned with
addition of an auxiliary shield.

Generally the testing was successful and appearance of the light
on the surface as well as submerged was better than had been antici-
pated. The water area, with the light submerged, was illuminated for
a diameter of about seventy five feet and appeared in characteristic
nile green color. Samples of the sea water were taken for determin-
ation of turbidity and color which were found in a test (January 21,
1944) to be: turbidity, 16 parts per million; and color 10 parts per
million, No. 10, nile green. For the photometric distance of ten feet
the light transmissivity was assumed to be 100 per cent. In each case
the light meter was rotated about the lamp at the end of a beam pivoted
on a protractor frame. No underwater readings were attempted. Unfortun-
ately no precise measurements were possible because of the limitations
of the meter and apparatus. It is estimated that the data obtained is
generally accurate within a range of plus or minus ten per cent.

Computations to determine the curves of light distribution are
shown on pages 37, 38, and 39. Only typical calculations are shown.
From equation 1 the candlepower was determined from foot-candle test
data. Fig. 3 shows the interpretation of spherical zones insofar as
they are used in the calculations. Spherical zone mean apparent candle-
power was calculated for all four tests. Spherical zone values of zonal lumens was calculated for all four tests.

The results of Test A and Test B are evidenced by Fig. 4, page 40; a table of values for light distribution in apparent candlepower and zonal lumens, and curves of light distribution. The dotted curve shows apparent candlepower distribution for the lamp alone 5 feet 0 inches below the water surface with values ranging from 75 candles at 125 degrees from nadir to 175 candles (maximum) at 145 degrees. It may be observed from the dotted curve that a reasonably soft illumination occurs directly over the light and one and three quarters this brilliance at 145 degrees. This is not an undesirable curve. The solid curve shows apparent candlepower distribution for the lamp and auxiliary 5 feet 0 inches below the water surface. The peak value on this curve is 150 candles at zenith. This peak is considered as showing a plus error of about 30 to 50 candles. The remainder of the curve levels at 100 candles then attenuates rapidly at 140 degrees. It would be desirable to extend the level portion of the curve to 125 degrees or lower. It should be noted that both curves show the desirable characteristics of reasonably high brilliance and continuity. It is anticipated that future studies will determine the design of a lens which will produce suitable light distribution characteristics without the use of an auxiliary shield. The light has adequate brilliance for underwater use.

The results of Test C and Test D are evidenced by Fig. 5, page 41, a table of values for light distribution in apparent candlepower and zonal lumens, and curves of light distribution. The dotted curve shows apparent candlepower distribution for the lamp alone on the water
surface, with values ranging from 200 candles to 600 candles. The curve shows the desirable characteristic of high luminous intensity at low angles. The solid curve shows apparent candlepower for the lamp and auxiliary on the water surface, with values ranging from 100 candles at near vertical angles to 500 candles at 105 degrees. This curve has the most desirable shape of all the curves considered in this analysis. Under conditions of the light on the surface the luminary tested has a brilliance considerably in excess of that required for contact marking a seaplane landing course.

Test E was started February 9, 1944,\textsuperscript{11} to determine the best installation and operation procedure, and service life of the installation. Six submerged lights were installed similar to the diagrams (Fig. 1, page 33, layout A, plan A; Fig. 34A, page 77; Fig. 34B, page 78; plan D, page 81) on an east-west course parallel to and about 500 feet south from the north boundary of Laguna Madre Basin. The bottom of Laguna Madre Basin is composed of "blue mud." Night flying operations were cancelled because of foul weather and no aerial observations were recorded for this first trial. All lights burned successfully from 1945 o'clock until operations of the set was stopped at 2300 o'clock. The appearance of the illumination at each light was that of a brilliantly lighted area about 50 feet in diameter at each light. The lights were viewed from an elevation of 34 feet on the west beach about 3800 feet away from the lights. The lights were readily visible and appeared quite suitable for use as seadrome contact lights. The large water surface illuminated presented the appearance of a disk of

\textsuperscript{11} U. S. Naval Air Station, Corpus Christi, Texas, Yardraft Detail Dimmit Island Log (of Oct. 23, 1943, date of 9 Feb. 1944).
soft white glow with no surface reflection. During the observations the transmissivity was estimated to be about 80 per cent and the sky was overcast with medium cirrus stratus and cirrus clouds--cirrus clouds predominating. When the lights were first lighted they were observed under conditions of high overcast, average visibility of 5 miles with haze, and visibility of 3 miles to the north. On the morning of February 10 two of the lights were found to contain about one half ounce of water each. The lamp heads of those two assemblies were replaced and then again submerged. Upon opening the lamp heads of the two that had taken on water it was found that the Novoid insulating compound (insulating and sealing the lamp lead and lamp base) had been drawn toward the interior of the fixtures. It is believed that in each case: (1) the compound was warmed and softened by heat omitted by the lamp, (2) a partial vacuum was created by contraction of the air inside the lens upon cooling after the lamp was extinguished, and (3) the vacuum caused the soft compound to flow causing a pin-hole leak and water entered the interior due to the vacuum inside and the pressure head of the water outside.

At 1130 February 10 severe weather set in and continued until 2300 February 12. During this period the submerged assemblies underwent rough treatment from natural causes. Wind velocities for this period averaged 24 knots with gusts to 45 knots creating rough, rugged, and confused sea with wave swells and whitecaps from all directions. The most severe part of the storm occurred on February 11 from 0200 to 0900 during which time winds were at all times over 30 knots. On

12. U. S. Naval Air Training Center, Corpus Christi, Texas, Monthly Aerological Record, Comdr. H. E. Strange, USN.
February 13 thundershowers prevailed throughout the day with winds moderate to 20 knots in the afternoon with gusts to 31 knots at 1600. On the afternoon of February 14 the lights were surfaced and inspected. None of the assemblies showed any effects of the storm and none contained visible moisture. No movement of the anchors was observed. The lights were submerged after inspection and the circuit was tested preparatory to night flying operations and found to be in working condition.

On February 14 the layout was operated from 2000 until night flying was secured at 2330. During this period there was excellent visibility (12 miles or better) with no fog or haze, the sky was clear with no clouds. Winds were generally east southeast averaging 15 knots. The writer made observations aloft from a seaplane from about 1920 until 2115 on a regular flight. The appearance of the submerged lights was studied from all angles and altitudes up to 4000 feet. The lights were visible at a distance of 10 miles and 4000 feet in an estimated atmospheric transmissivity of 90 per cent. Numerous approaches to and passes over the lights were made to ascertain the shape and quality of the light. Each light of the contact strip presented the appearance of a large disk, the entire area of which was equally illuminated to a pleasant soft glow. The lights were easily distinguished from all other lights on and adjacent to the seadrome because they made no surface reflection, whereas surface reflection was observed from all other lights. On approach for landings the lights, observed at low angles, appeared to change from a disk shape to a line normal to the approach path. It is evident that this phenomenon produced an effect which may be used to improve a pilot's judgment.

13. Ibid.
of altitude during landing procedure. Some adverse criticism regarding the use of the phenomenon for determining altitude on the approach was offered. Because the wind was approximately normal to the light strip no landings were attempted immediately on or parallel to the lighted course. Comments, recorded immediately after the flight, typical of those made by five officers and twenty-nine aviation cadets appear in Appendix B, page 88.

On February 15 an attempt was made to secure useful photographic data regarding the new light. In the afternoon the lights were surfaced and inspected for water. None of the lights had acquired moisture so they were again submerged and the circuit tested and found to be in working condition. With each inspection the personnel handling the rearming boat and submerged lighting equipment became more proficient in their task and by this date the "handling time" had been considerably reduced. A small wooden tower was constructed and placed at the west end of the light strip (plan D, page 81, item B) sunk to a solid footing and weighted with sand bags. The camera elevation atop the tower was approximately nine feet above the water surface. The tower was approximately 300 feet due west of the first light of a strip of six submerged lights; approximately 280 feet westerly from a green fluorescent Mazda T-5, 6 watt, General Electric light in a type FPL-N Portable Seadrome Contact Light (with Mark II buoy) (see item 1, Fig. 23, page 63), item D, Plan D, dry battery; and approximately 275 feet from a Westinghouse, red, cold cathode fluorescent, 7\frac{1}{2} watt, 3 mm spiral tube, luminary on Firestone buoy, Item C, Plan D. Both of these conventional floating lights were each fastened to a 61 pound concrete anchor. The weather (Table 6, page
79) was excellent for the problem at hand, with high atmospheric trans-
imissivity prevailing throughout the test.

The underwater contact strip was lighted at 2030 and the photograph-
ing began shortly after 2100. All the lights were plainly visible from
the photographers' tower. High interest was shown by the photographers
when they were told that heretofore no photograph had successfully been
made of more than three seadrome lights in a strip. An "operating
crew" maintained a position in a whale boat; item F, Plan D, moored to
the north of the strip. Two generators were operated continually at an
output of 110 volts throughout the test. All photographs of the layout
were made with an Agfa 8 inch x 10 inch view camera, 12 inch focal length
Bausch and Lomb Protar lens, tripod level. At about 2130 the experiment
was visited by the Naval Air Station Executive Officer and the General
Supervisor of Field Lighting, who commented favorably regarding the layout.

Fig. 351, page 82, is an excellent representation of the submerged
light strip of six lights. The six experimental lights submerged five
feet are shown on the right half of the photograph. The lights are
staggered to prevent apparent superposition and some slack left in the
underwater cable makes the lights approximately 390 feet apart instead
of 400 feet as shown in Layout A. The lights in the strip extend east-
erly in two three light sections away from the camera. The disks of light
ever each contact light appear flat at the small acute angle at which
this picture was taken. The disk therefore gives the impression, at

14. Mr. E. B. Karna (Manager street, aviation and marine lighting, West-
inghouse Electric & Mfg. Co., Cleveland, Ohio) comment in conversa-
tion to Lt. Mueller also mentioned nominal spacing of lights to be
700 feet, February 11, 1944.
the camera elevation, of being a thin line normal to the line of vision. The Neon Products light went dark just before the camera shutter was opened and consequently no record of this light was obtained. The glary line and reflection next left from the submerged strip represents the Westinghouse red, cold cathode fluorescent light floating and drifting on the surface. The small lights above and left from this are the stern and obstruction lights on the whale boat. This photograph was made with an exposure of 20 minutes, f/6.3, and printed on No. 4 Azo paper, time 15 seconds.

Fig. 35B, page 83, is very similar to Fig. 35A, except that the Neon Products light burned for a short interval and is shown just left of the submerged light strip as a bright light with a glary reflection. This photograph was made with an exposure of 5 minutes, f/6.3 opening, and printed on No. 4 Azo paper, time 15 seconds.

Fig. 35C, page 84, is similar to Fig. 35A and Fig. 35B. The Neon Products light burned during the entire exposure. Both the Westinghouse and the Neon Products lights drifted as shown by the print. An extent of approximately 50 per cent more reflection is shown on the negative than is shown on this print. The two small light spots on the horizon between the submerged strip and the Neon Products light show a hand spot light illumination from a boat shortly after it having left the pier to the left. The small beads of light above the Westinghouse light, second left from the submerged strip, are on the pier about 3000 feet from the camera. The two bright stars of lights, at the center of the submerged light strip show a hand spot light directed two times at the camera from a rearming boat plying along the submerged strip. This photograph was
made with an exposure of 10 minutes, with $f/6.3$ opening, and printed on No. 4 Azo paper, time 15 seconds.

Fig. 35 D, page 85, portrays the universal seadrome lighting layout with the assemblies surfaced. In this position the lamp assembly line (adjustable), secured to the anchor, is increased in length to permit the assembly to rise freely to the surface where it remains adrift. In this position the lights appear to have high brilliance and the source is well defined for the light center being near the surface produces only a small amount of light incident to the surface, and hence little reflected light, markedly reducing undesirable glare. When surfaced the light center of each assembly is about 4 to 6 inches above the surface. The new seadrome lights in this position show qualities desirable for use as markers for low visibility flying operations. Both The Westinghouse (left) and Neon Products (middle left) show in the photograph as previously described in the preceding paragraphs. This photograph was made with an exposure of 2 minutes, $f/11$ stop, and printed on No. 4 Azo paper, time 15 seconds.

Fig. 35E, page 86, is similar to Fig. 35D except that the Neon Products light failed just prior to the film exposure and the transmissivity was believed to be slightly reduced. The two egg-shaped spots of light at the upper left indicate a slight drift of the whale boat. The halo effect present in the picture is believed due to chromatic aberration and attendant reflections within the lens. This photograph was made with an exposure of 10 minutes, stop $f/6.3$, and printed on No. 4 Azo paper, time 15 seconds.

In general the photographic data obtained in Test E was entirely
suitable to show characteristics of the layout. On the morning of February 16 the lights were replaced in line and submersed. The lights are aligned in the strip simply by placing the visible anchor location floats in line. One light was added (Plan D) to the extreme west end of the strip to make seven as recommended by the Bureau of Aeronautics.\textsuperscript{15} Seven lights were not used earlier because of the desire to maintain equivalent characteristics in both branches of the electric system during Test E.

CHAPTER IV

Experiment Errors

In general the information obtained by this experiment is sufficiently accurate for practical purposes. Many refinements are necessary for complete studies leading to the optimum design. Needed most are laboratory facilities to study brightness, quantity, diffision, distribution, and color quality of the light. It is intended that these studies be made in a laboratory, such as those at Wright Field, the Bureau of Standards, the Westinghouse Electric and Mfg. Co., Cleveland, and the General Electric Laboratory at Nela Park. The lights in acceptable form should be installed for operational and service life tests at some seadrome or seadromes such as those available at the Naval Air Station, Corpus Christi, Texas, where heavy traffic of patrol and light seaplanes will determine the ultimate practicability of the design.

The buoyancy tests of the assemblies, pages 16 and 35, are accurate to ± 0.25 pounds in fresh water. The difference between fresh water and salt water buoyancy is considered negligible.

Tests A, B, C, and D (pages 16-19; Fig. 1, page 33; Table 2, page 36; Fig. 4, page 40; Fig. 5, page 41; Fig. 32A, page 72; Fig. 32B, page 73; Fig. 32C, page 74; Fig. 32D, page 75) were performed under trying conditions and with very little knowledge of light output testing procedure. Accurate photometric data could not be obtained with the pocket-type light-meter used (errors estimated to be ± 10 per cent) and further testing by the use of the Luckiesh-Taylor, or the Luckiesh-Holliday.

16. Loan of the Westinghouse Laboratory facilities were offered to the author for work pertinent to this experiment by Mr. E. B. Karns, Manager--street, aviation and marine lighting, of the Westinghouse Electric and Mfg. Co. during his visit to the Naval Air Station, February 11, 1944.
brightness meter is recommended. It is believed the greatest particular error occurred at the peak of the solid curve (lamp with auxiliary), Fig. 4, in magnitude of +30 to +50 candles. In these four tests only the readings shown in Table 2 were taken. To further eliminate the human error—and error due to slight movement of the light and water the average of a series of 5 to 10 readings should be taken at each angle. The voltage of the electric supply was determined by a small voltmeter, with calibration not verified, on the generator 210 feet from the light. This may have introduced an error of ±3 volts and accurate voltage should have been taken at the light. Any error in the determination of turbidity and color of the seawater is not known since these factors were determined by another agency. This agency used the platinum needle test for turbidity and the Lamonte test for color and has an established reputation sufficient to warrant the belief that the tests are accurate.

The calculations of apparent candlepower, zonal lumens, spherical zone values of apparent candlepower, and spherical zone values of zonal lumens represent the best knowledge available to the author and are believed accurate within their scope.

Test E, pages 19-26, Appendix B, pages 88-97; Fig. 35A, page 82; Fig. 35B, page 83; Fig. 35C, page 84; Fig. 35D, page 85; Fig. 35E, page 86, is a true representation of Layout A, Fig. 1, page 33, and Plan D, page 81, and is in effect the final test by which the underwater contact light may be accepted. For complete information it would be desirable to obtain motion picture data from a seaplane actually flying the light course and in the vicinity of the layout. Due to the extreme difficulties attendant to obtaining such photographic data, this procedure was not attempted.
CHAPTER V

Conclusion

It is concluded that the design of the submergible universal type contact light studied here presents qualities sufficiently promising to warrant further investigation and ultimate adoption of the underwater lighting principle for seadrome and ship channel marking by interested agencies.

The submergible light developed by this experiment is sufficient in size and characteristics for use in its present form at the Laguna Madre Seaplane Basin. The buoys, except the one originally used with Assembly C, are sufficiently large and durable for a temporary installation and the anchors are satisfactorily designed for use in soft mud several feet deep. With careful handling the lamps are satisfactory for continued use.

The high enthusiasm and acceptance regarding the light as shown by aviators and by lighting and maintenance personnel indicates in some measure the desirability of continued efforts to perfect the universal light.

Because of the considerable conservation of materials, particularly the rubber buoys (conventional Mark II seadrome Lighting Buoy, 33 inches in diameter, weights 55 pounds; experimental Type A assembly buoy, 15 inches diameter weights 1 pound, 6 ounces, a saving of approximately 53 pounds of rubber per light), it is concluded that use by the U. S. Navy of the new light will result in a large saving in expenditures for seadrome lighting buoys. The use of rubber covering and rubber insulation of the underwater distribution cable is justified by a different reason—that of making possible control of the system from a central point.

Because of its size the universal lighting set is highly portable and offers itself to be readily moved by air transport.
For use where variation in water depth due to tide is large enough to effect light brilliance at the water surface, it is recommended that the lights be set at low brightness control at low tide and at greater brightness with approaching high tide, in amount corresponding to water depth.

At low voltage and consequent low light output the set may be advantageously used for landfield lighting in all weather, especially in heavy rains and severe ground water conditions.

It is further concluded that this experiment is a suitable beginning of studies to encompass the use of higher voltage underwater electric distribution systems of either parallel, series multiple, or series series circuits for use with high intensity incandescent, sodium vapor, or mercury vapor lighting to be used in permanent installations. In principle the layouts of these systems would be essentially the same as was used in this experiment. In interests of simplicity it is recommended that future designs be incident with the use of series transformers and auxiliaries placed in an "anchor box" laid with the electric cable and used not only for a waterproof box to house the transformer but also to anchor the underwater light. Similarly such a waterproof box may be used to house batteries for operating lights in layouts similar to Layout C, page 33, or for auxiliary lights detached from the main system.
The experiment presented a multitude of very interesting problems the most of which proved both instructive and beneficial to all personnel concerned. Great satisfaction, of the exemplary operation of the experimental lights during the final underwater test, was held by the writer. The successful operation and minimum maintenance needed in the service life test far exceeded expectations. The design, having been proved, is to be improved as time and facilities permit; the service life test is still in progress with the system still being operated in conjunction with light seaplane operations at the Laguna Madre Basin.

It is proposed that the Navy Department put to use the basic principles of underwater lighting outlined in this thesis in the effort to conserve materials and reduce seaplane operational hazards from unsatisfactory lighting and from above water protuberances.
APPENDIX A

Illustrations, Data, and Calculations

Fig. 1; Fig. 2; Fresh Water Buoyancy Data Table 1 and Test B (Installation and Trial); Light Output Data--Table 2; Computations, Table 3, Fig. 3, Table 4; Fig. 4; Fig. 5; Fig. 6; Fig. 7; Fig. 8; Fig. 9; Fig. 10; Fig. 11; Fig. 12; Fig. 13; Fig. 14; Fig. 15; Fig. 16; Fig. 17; Fig. 18; Fig. 19; Fig. 20; Fig. 21; Nomenclature of Parts--Table 5 (page 58); Fig. 22A, Fig. 22B; Fig. 23; Fig. 24; Fig. 25; Fig. 26; Fig. 27; Fig. 28; Fig. 29; Fig. 30; Fig. 31; Fig. 32A; Fig. 32B; Fig. 32C; Fig. 32D; Fig. 33; Fig. 34A; Fig. 34B; Synopsis of Certain Photogrammetrical Data--Table 6 (pages 79-80); Plan D, page 81; Fig. 35A; Fig. 35B; Fig. 35C; Fig. 35D; Fig. 35E.
PROPOSED SEADROME LIGHTING LAYOUT
ALTERNATE PLANS —

10 January 1944 (Portable Sets)
Designed By Lt. F.M. Mueller, U.S.N.R
U.S. Naval Air Station, Corpus Christi, Texas
Areas shown by the plans provide ideal conditions for further experimentation and study because of weather, availability of facilities, and seaplane operations. Layouts considered here are for semi-permanent or permanent installations.

Seadrome lighting layout proposed experimental—semi-permanent installations

10 January 1944
Lt. F.M. Mueller and R.D. Cochran (C.S.)
U.S. Naval Air Station—Corpus Christi, Texas
TEST DATA - SEADROME LIGHT ASSEMBLIES
FRESH WATER BUOYANCY

LOCATION: U.S. Naval Air Station, Corpus Christi, Texas; DATE: 27 November 1943; RECORDER: Lt. F. M. Mueller, CEC-V(S), USNR; APPARATUS: Fairbanks Scales - PA18L, (0 to 600 pounds), two water pans.

<table>
<thead>
<tr>
<th>ASSEMBLY</th>
<th>TANK WEIGHT (a) (FILLED) lb.</th>
<th>TANK WEIGHT (b) (DISPLACED) lb.</th>
<th>GROSS BUOYANCY lb.</th>
<th>WEIGHT lb.</th>
<th>NET BUOYANCY lb.</th>
<th>IMP. LEAD ENTR. ft.</th>
<th>BUOY - SIZE AND TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE A</td>
<td>219.60</td>
<td>195</td>
<td>24.50</td>
<td>11.50</td>
<td>13.50</td>
<td>11</td>
<td>FIRESTONE (TUBE) AIRPLANE 5.00 - 4</td>
</tr>
<tr>
<td>TYPE B</td>
<td>221.50</td>
<td>202.50</td>
<td>19.25</td>
<td>7.25</td>
<td>12.00</td>
<td>10</td>
<td>GOODRICH SILVERTOWN AIRPLANE (TUBE) 3.00 - 4</td>
</tr>
<tr>
<td>TYPE C</td>
<td>221.50</td>
<td>200</td>
<td>21.50</td>
<td>8.50</td>
<td>13.50</td>
<td>10</td>
<td>GOODRICH SILVERTOWN AIRPLANE (TUBE) 3.00 - 4</td>
</tr>
<tr>
<td>TYPE D</td>
<td>221.50</td>
<td>201.50</td>
<td>20</td>
<td>12.50</td>
<td>7.50</td>
<td>10</td>
<td>FIRESTONE SPEEDING 4.00 - 7 (TUBE)</td>
</tr>
<tr>
<td>TYPE E</td>
<td>221.50</td>
<td>211.50</td>
<td>9.50</td>
<td>8.50</td>
<td>1</td>
<td>1</td>
<td>GOODBIRD 10.00 S.C. (TIRE ONLY)</td>
</tr>
<tr>
<td>TYPE F</td>
<td>221.50</td>
<td>201</td>
<td>20.50</td>
<td>8.50</td>
<td>12</td>
<td>10</td>
<td>GOODRICH SILVERTOWN 3.00 - 4</td>
</tr>
<tr>
<td>TYPE G</td>
<td>575.15</td>
<td>552.15</td>
<td>22.50</td>
<td>15</td>
<td>7.50</td>
<td>10</td>
<td>ROYAL 12.50 (TIRE, TUBE &amp; HUB)</td>
</tr>
<tr>
<td>TYPE H</td>
<td>574</td>
<td>509</td>
<td>65</td>
<td>20.50</td>
<td>24.50</td>
<td>10</td>
<td>TUBE - (?) 22.00 - 5.5</td>
</tr>
<tr>
<td>&quot;BOB&quot; J</td>
<td>221.75</td>
<td>212.50</td>
<td>9</td>
<td>4.50</td>
<td>4.50</td>
<td>none</td>
<td>10&quot; x 4&quot; OCTAGON WOOD BLOCK</td>
</tr>
</tbody>
</table>

TEST F - INSTALLATION & TRIAL SUBMERGED CONTACT LIGHT STRIP - LAYOUT "E":
LOCATION: Laguna Madre Seaplane Basin, N.A.S. Corpus Christi, Texas;
TEST DATA - SEADROME LIGHT ASSEMBLY

LIGHT OUTPUT

LOCATION: U.S. Naval Air Station, Corpus Christi, Texas; DATE: 3 January 1944
TIME: start 1950, end 2335; WEATHER: wind from SE - 10 knots, moon - 1st quarter, sea - calm, temperature = 47°F (water) & 62°F (air), tide in - low at 1755 - high at 0001; Two one-gallon samples of water taken; PHOTOMETRIC DISTANCE: 10 feet; CONDITIONS: photometer rotated in vertical plane about lamp - in planes normal to the incident ray. VOLTAGE: 110 volts; LAMP: Westinghouse projection lamp (Airport Signal, 99 watt, 110 volt, T8 bulb, CC13 filament, D.C., prefocus base; Used modified Flashing Beacon Assembly (AN 06-20-4, figure 76, with lens OL-215-8A); PHOTOMETER: General Electric, type DW-48, No. 9641E, used with hood removed, zeroized at start, zero checked at finish.

PARTY: CHIEF - - - - - Lt. F. M. Mueller, CEC-V(S), USNR
ASSISTANT CHIEF - - - - W. D. Dobson, Public Works Lineman
RECORER - - - - Lt. R. L. Goodkind, O(VG), USNR
TACKLE MAN - - - - A. F. Clark, Sea 2/c
PHOTOGRAPHER - - - - R. J. Meagher, PhoM2/c
DECK HAND - - - - A. L. Hollingshead, Sea 2/c
OBSERVER - - - - Lt. Comdr. T. V. Tarbet, CEC-V(S), USNR

LIGHT OUTPUT DATA

<table>
<thead>
<tr>
<th>MID-ZONE ANGLES</th>
<th>PHOTOMETER READINGS (FOOT CANDLES)</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST A SUBMERGED NO SHIELD</td>
<td>TEST B SUBMERGED WITH SHIELD</td>
<td>TEST C ON NO SHIELD</td>
</tr>
<tr>
<td>IB0° ZENITH</td>
<td>1 ft-c</td>
<td>1 1/2 ft-c</td>
</tr>
<tr>
<td>175°</td>
<td>1 ft-c</td>
<td>1 ft-c</td>
</tr>
<tr>
<td>165°</td>
<td>1 1/4 ft-c</td>
<td>1 ft-c</td>
</tr>
<tr>
<td>155°</td>
<td>1 3/4 ft-c</td>
<td>1 ft-c</td>
</tr>
<tr>
<td>145°</td>
<td>1 3/4 ft-c</td>
<td>1 ft-c</td>
</tr>
<tr>
<td>135°</td>
<td>1 1/2 ft-c</td>
<td>3 1/4 ft-c</td>
</tr>
<tr>
<td>125°</td>
<td>3 1/4 ft-c</td>
<td>3 1/4 ft-c</td>
</tr>
<tr>
<td>115°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>105°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>95°</td>
<td>-</td>
<td>4 1/2 ft-c</td>
</tr>
<tr>
<td>90°</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

WATER CHARACTERISTICS:
- Turbidity: 16 parts per million,
- Color: 10 parts per million - nile green.

[Signature]
Frederick Marion Mueller
Computations

(d) Calculation of apparent candlepower from foot-candle data:

\[ I = \frac{E \cdot d^2}{\cos \theta} \]  
\[ \text{(candlepower)} \]  
\[ \text{Equation (1)\textsuperscript{17}} \]

where:
- \( I \) = luminous intensity in candlepower
- \( E \) = illumination measured in foot-candles
- \( d \) = photometric distance in feet
- \( \cos \theta \) = cosine of the angle between the normal to the surface of the light meter and the incident ray

for Test (A); at 175 degrees:

\[ I = \frac{1 \times (10)^2}{\cos 0} = 100 \text{ candlepower} \]

(b) Calculation of zonal lumens from candlepower and constants:

<table>
<thead>
<tr>
<th>Midzone Angle From Vertical Axis</th>
<th>Zonal Flux Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>175 deg.</td>
<td>0.0954</td>
</tr>
<tr>
<td>165 deg.</td>
<td>0.2835</td>
</tr>
<tr>
<td>155 deg.</td>
<td>0.4629</td>
</tr>
<tr>
<td>145 deg.</td>
<td>0.6282</td>
</tr>
<tr>
<td>135 deg.</td>
<td>0.7744</td>
</tr>
<tr>
<td>125 deg.</td>
<td>0.8972</td>
</tr>
<tr>
<td>115 deg.</td>
<td>0.9926</td>
</tr>
<tr>
<td>105 deg.</td>
<td>1.0579</td>
</tr>
<tr>
<td>95 deg.</td>
<td>1.0911</td>
</tr>
</tbody>
</table>

\[ \text{Table (3)\textsuperscript{18}} \]

\text{These constants are proportional to the areas of the test zones}

\textsuperscript{17} Standard Handbook for Electrical Engineers (7th ed); Sec.16, 104
\textsuperscript{18} Ibid., Sec.16, 103
where:

$$\text{Zonal lumens} = \text{constant} \times \text{candlepower} \quad \quad \text{Equation (2)^{19}}$$

for Test (A) at 175 degrees:

$$\text{Zonal lumens} = 0.0954 \times 100 = 9.54$$

(C) Calculation of spherical zone values of apparent candlepower:

**note:**

![Diagram showing spherical zones](image)

and,

<table>
<thead>
<tr>
<th>Angles from Vertical at Which Values Were Taken</th>
<th>18 deg. 12 min.</th>
<th>63 deg. 15 min.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31 deg. 47 min.</td>
<td>69 deg. 31 min.</td>
</tr>
<tr>
<td></td>
<td>41 deg. 25 min.</td>
<td>75 deg. 31 min.</td>
</tr>
<tr>
<td></td>
<td>49 deg. 27 min.</td>
<td>81 deg. 22 min.</td>
</tr>
<tr>
<td></td>
<td>56 deg. 38 min.</td>
<td>87 deg. 8 min.</td>
</tr>
</tbody>
</table>

---

19 Standard Handbook for Electrical Engineers (7th ed), Sec.16, 99  
20 Ibid, Sec.16, 100
for Test (A);

At:

<table>
<thead>
<tr>
<th>Angle</th>
<th>Duration</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 deg 12 min.</td>
<td>134 c.</td>
<td></td>
</tr>
<tr>
<td>31 deg 47 min.</td>
<td>168 c.</td>
<td></td>
</tr>
<tr>
<td>41 deg 25 min.</td>
<td>147 c.</td>
<td></td>
</tr>
<tr>
<td>49 deg 27 min.</td>
<td>100 c.</td>
<td></td>
</tr>
<tr>
<td>56 deg 38 min.</td>
<td>68 c.</td>
<td></td>
</tr>
</tbody>
</table>

Σ 617 c.

mean = 617 ÷ 5 = 123 c. (Spherical zone mean apparent candlepower)

(D) Calculation of spherical zone values of zonal lumens:

Spherical zone zonal lumens = Sum of mean zonal lumens

Equation (3)

for Test (A);

Σ Mean zonal lumens = 9.5 × 35.4 + 69.5 + 110 + 96.7 + 67.3

= 388.4 lm. (spherical zone zonal lumens)
Photometric Distance 10 feet
Conditions - Meter rotated about lamp and auxiliary in planes normal to the incident ray.

<table>
<thead>
<tr>
<th>MID-ZONE ANGLES</th>
<th>DISTRIBUTION MEAN VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>APP. CANDLEPOWER</td>
</tr>
<tr>
<td></td>
<td>LAMP ALONE</td>
</tr>
<tr>
<td>180 ZENITH</td>
<td>100</td>
</tr>
<tr>
<td>175</td>
<td>100</td>
</tr>
<tr>
<td>165</td>
<td>125</td>
</tr>
<tr>
<td>155</td>
<td>150</td>
</tr>
<tr>
<td>145</td>
<td>175</td>
</tr>
<tr>
<td>135</td>
<td>125</td>
</tr>
<tr>
<td>125</td>
<td>75</td>
</tr>
<tr>
<td>SPHERICAL-ZONE VALUES</td>
<td>123</td>
</tr>
</tbody>
</table>

Test Showing Light Distribution And Values of Intensity And Flux

Fig. 4
Photometric Test Sheet

Photometric Distance: 10 feet
Conditions: Meter rotated about lamp and auxiliary in planes normal to the incident ray.

<table>
<thead>
<tr>
<th>MID-ZONE ANGLES</th>
<th>DISTRIBUTION MEAN VALUE</th>
<th>APP. CANDLEPOWER</th>
<th>ZONAL LUMENS</th>
</tr>
</thead>
<tbody>
<tr>
<td>180° ZENITH</td>
<td></td>
<td>LAMP ALONE</td>
<td>LAMP WITH AUX.</td>
</tr>
<tr>
<td>175</td>
<td>300</td>
<td>150</td>
<td>28.6</td>
</tr>
<tr>
<td>165</td>
<td>250</td>
<td>100</td>
<td>70.9</td>
</tr>
<tr>
<td>155</td>
<td>200</td>
<td>125</td>
<td>92.6</td>
</tr>
<tr>
<td>145</td>
<td>250</td>
<td>125</td>
<td>92.6</td>
</tr>
<tr>
<td>135</td>
<td>200</td>
<td>100</td>
<td>154.9</td>
</tr>
<tr>
<td>125</td>
<td>200</td>
<td>150</td>
<td>179.1</td>
</tr>
<tr>
<td>115</td>
<td>250</td>
<td>200</td>
<td>248.6</td>
</tr>
<tr>
<td>105</td>
<td>600</td>
<td>500</td>
<td>635.3</td>
</tr>
<tr>
<td>95</td>
<td>450</td>
<td>400</td>
<td>492.7</td>
</tr>
<tr>
<td>SPHERICAL ZONE VALUES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>314</td>
<td>238</td>
<td>2057</td>
<td>1539</td>
</tr>
</tbody>
</table>

Test Showing Light Distribution And Values of Intensity And Flux

Fig. 5

( TEST "C" AND "D" )
SEADROME LIGHT ASSEMBLY TYPE - A
(WITH AUXILIARY SHIELD)

23 Dec. 1943    Scale: 1" = 6"
Designed By Lt. F. M. Mueller, USNR
U.S. Naval Air Station - Corpus Christi, Texas

Fig. 6
SEADROME LIGHT ASSEMBLY
TYPE-B

23 Dec. 1943
Scale: 1" = 6"

Designed By Lt. F.M. Mueller, USNR
U.S. Naval Air Station - Corpus Christi, Texas
SEADROME LIGHT ASSEMBLY
TYPE - C

23 Dec. 1943
Scale: 1" = 6"
Designed by Lt. F. M. Mueller, USNR
U.S. Naval Air Station - Corpus Christi, Texas
SEADRome Light Assembly
Type-D

23 Dec. 1943
Scale: 1" = 6"
Designed By Lt. F.M. Mueller, USNR
U.S. Naval Air Station- Corpus Christi, Texas
SEADROME LIGHT ASSEMBLY
TYPE - E

(WITH AUXILIARY SHIELD & BUOYS)

23 Dec. 1943    Scale: 1" = 6"
Designed By Lt. F.M. Mueller, USNR
U.S. Naval Air Station - Corpus Christi, Texas
SEADROME LIGHT ASSEMBLY
TYPE-F

23 Dec. 1943

Scale: 1" = 6"

Designed By Lt. F. M. Mueller, USNR
U.S. Naval Air Station - Corpus Christi, Texas

Fig. II
SEADROME LIGHT ASSEMBLY
TYPE - G
(WITH AUXILIARY SHIELD)

23 Dec. 1943  Scale: 1" = 6"

Designed By Lt. F. M. Mueller, U.S.N.R.
U.S. Naval Air Station-Corpus Christi, Texas

Fig. 12
Sketch of high-intensity seadrome lighting layout - 7000 foot strip illuminated by underwater mercury vapor luminaries used with reflector, shield, and longitudinal Fresnel lens. Water to appear as a bright silver strip.

Quartz tube mercury lamp 280 watts, 10,000 lumens, air-cooled, instant starting.

Metal buoy

Tie cables vary in length with depth.

Concrete anchor

Not to scale

Lt. F.M. Mueller 17 January 1944

U.S. Naval Air Station, Corpus Christi, Texas
Sketch of Seadrome Light
Adapted for Underwater Use

U.S. N.A.T.O. Corpus Christi, Texas
CONCRETE ANCHOR (about 5 to 8 pounds)

PROPOSED SEADOME EXPERIMENTAL LIGHTING LAYOUT

Fig. 16
<table>
<thead>
<tr>
<th>DATE</th>
<th>HOURS</th>
<th>OPERATION</th>
<th>BATTERY CHANGES</th>
<th>EACH LIGHT</th>
<th>SPARE</th>
<th>SPARE</th>
<th>SPARE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(GO)</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>(RED)</td>
<td>SPARE</td>
</tr>
<tr>
<td>SPARE</td>
<td>SPARE</td>
<td>SPARE</td>
<td>SPARE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

REMARKS
Fig.18  Contact Light Unit - GENERAL PURPOSE LAYOUT

ANCHOR

UNDERWATER LAMP LEAD

LIGHT ASSEMBLY

LAMP ASSEMBLY LINE (ADJUSTABLE)

ANCHOR FLOAT

FLOAT TIE LINE
Seadrome Contact Light Assembly TYPE "B" DETAILS
Fig. 21  Seadrome Contact Light Assembly - TYPE "G" - DETAILS
### Fig. 22A Portable Seadrome Lighting Set

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reel carriage</td>
</tr>
<tr>
<td>2</td>
<td>Two section reel</td>
</tr>
<tr>
<td>3</td>
<td>Float tie lines</td>
</tr>
<tr>
<td>4</td>
<td>Lamp assembly lines (adjustable)</td>
</tr>
<tr>
<td>5</td>
<td>Auxiliary shield</td>
</tr>
<tr>
<td>6</td>
<td>Hand lanterns, weatherproof</td>
</tr>
<tr>
<td>7</td>
<td>Supplementary buoys</td>
</tr>
<tr>
<td>8</td>
<td>Distribution cables</td>
</tr>
<tr>
<td>9</td>
<td>Anchors</td>
</tr>
<tr>
<td>10</td>
<td>Portable generators (500 watts)</td>
</tr>
<tr>
<td>11</td>
<td>Generator cable</td>
</tr>
<tr>
<td>12</td>
<td>Seadrome light assemblies</td>
</tr>
<tr>
<td>13</td>
<td>Adapter cable</td>
</tr>
<tr>
<td>14</td>
<td>Plug seals (female)</td>
</tr>
<tr>
<td>15</td>
<td>Plug seals (male)</td>
</tr>
<tr>
<td>16</td>
<td>Waterproof connectors</td>
</tr>
</tbody>
</table>

### Fig. 22B Portable Seadrome Lighting Set

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reel carriage</td>
</tr>
<tr>
<td>2</td>
<td>Two section reel</td>
</tr>
<tr>
<td>5</td>
<td>Auxiliary shield</td>
</tr>
<tr>
<td>6</td>
<td>Hand lanterns, weatherproof</td>
</tr>
<tr>
<td>8</td>
<td>Distribution cables</td>
</tr>
<tr>
<td>9</td>
<td>Anchors</td>
</tr>
<tr>
<td>10</td>
<td>Portable generators (500 watts)</td>
</tr>
<tr>
<td>11</td>
<td>Generator cables</td>
</tr>
<tr>
<td>12</td>
<td>Seadrome light assemblies</td>
</tr>
<tr>
<td>17</td>
<td>Anchor location float</td>
</tr>
</tbody>
</table>

### Fig. 23 Contact Lights (Conventional, Experimental, Auxiliaries, & Parts)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PPL-6, Neon, 6 watt, Portable Seadrome Light with Mark II</td>
</tr>
<tr>
<td></td>
<td>Seadrome Lighting Buoy</td>
</tr>
<tr>
<td>2</td>
<td>Seadrome light assembly (deepwater type)</td>
</tr>
<tr>
<td>3</td>
<td>Concrete anchor, 101 pounds</td>
</tr>
<tr>
<td>4</td>
<td>Seadrome light assembly, experimental</td>
</tr>
<tr>
<td>5</td>
<td>Auxiliary shield, 15 inches diameter</td>
</tr>
<tr>
<td>6</td>
<td>Concrete anchor, 51 pounds</td>
</tr>
<tr>
<td>7</td>
<td>Rough casting for lamp head base (Type A)</td>
</tr>
<tr>
<td>8</td>
<td>Experimental &quot;floating lens&quot;</td>
</tr>
<tr>
<td>9</td>
<td>Supplementary buoy</td>
</tr>
</tbody>
</table>

(continued on page 59)
## Nomenclature of Parts—Table 5

### Seadrome Light Assembly, Type A, Component Parts

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lens, clear, Fresnel, pyrex, OL-215-3A</td>
</tr>
<tr>
<td>2</td>
<td>Paper gasket, pressed</td>
</tr>
<tr>
<td>3</td>
<td>Stiff rubber gasket</td>
</tr>
<tr>
<td>4</td>
<td>Soft rubber gasket</td>
</tr>
<tr>
<td>5</td>
<td>Brass retaining ring</td>
</tr>
<tr>
<td>6</td>
<td>Brass threaded retaining nut</td>
</tr>
<tr>
<td>7</td>
<td>Brass lamp base (seat for lens and for connector)</td>
</tr>
<tr>
<td>8</td>
<td>Pneumatic buoy</td>
</tr>
<tr>
<td>9</td>
<td>Underwater connector and ring</td>
</tr>
<tr>
<td>10</td>
<td>Buoy retainer plate</td>
</tr>
<tr>
<td>11</td>
<td>Lamp lead</td>
</tr>
</tbody>
</table>

### Seadrome Light Assembly, Type B, Component Parts

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamp head</td>
</tr>
<tr>
<td>2</td>
<td>Conduit and connector</td>
</tr>
<tr>
<td>3</td>
<td>Pneumatic buoy</td>
</tr>
<tr>
<td>4</td>
<td>Buoy retainer plate</td>
</tr>
<tr>
<td>5</td>
<td>Underwater connector and ring</td>
</tr>
<tr>
<td>6</td>
<td>Lamp lead</td>
</tr>
</tbody>
</table>

### Seadrome Light Assembly, Type C, Component Parts

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamp head</td>
</tr>
<tr>
<td>2</td>
<td>Pneumatic buoy</td>
</tr>
<tr>
<td>3</td>
<td>Buoy retaining plate</td>
</tr>
<tr>
<td>4</td>
<td>Ballast stem—upper piece</td>
</tr>
<tr>
<td>5</td>
<td>Buoy retaining plate nut</td>
</tr>
<tr>
<td>6</td>
<td>Ballast stem weight spindle lock nut</td>
</tr>
<tr>
<td>7</td>
<td>Ballast stem weight</td>
</tr>
<tr>
<td>8</td>
<td>Ballast stem weight</td>
</tr>
<tr>
<td>9</td>
<td>Lamp lead</td>
</tr>
</tbody>
</table>

### Seadrome Light Assembly, Type D, Component Parts

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamp head</td>
</tr>
<tr>
<td>2</td>
<td>Buoy upper retaining plate</td>
</tr>
<tr>
<td>3</td>
<td>Pneumatic buoy</td>
</tr>
<tr>
<td>4</td>
<td>Buoy lower retaining plate</td>
</tr>
<tr>
<td>5</td>
<td>Buoy lower retaining plate washer</td>
</tr>
<tr>
<td>6</td>
<td>Buoy lower retaining plate nut</td>
</tr>
<tr>
<td>7</td>
<td>Ballast stem</td>
</tr>
</tbody>
</table>

(continued on page 60)
### Nomenclature of Parts—Table 5 (Continued from page 59)

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Ballast stem weight</td>
</tr>
<tr>
<td>9</td>
<td>Lamp lead</td>
</tr>
</tbody>
</table>

**Fig. 28**  
 **Seadrome Light Assembly, Type E, Component Parts**

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamp head</td>
</tr>
<tr>
<td>2</td>
<td>Atmospheric pressure buoy (tire—heavy)</td>
</tr>
<tr>
<td>3</td>
<td>Buoy slotted retaining plate</td>
</tr>
<tr>
<td>4</td>
<td>Buoy retaining plate nut</td>
</tr>
<tr>
<td>5</td>
<td>Buoy retaining plate washer</td>
</tr>
<tr>
<td>6</td>
<td>Ballast stem</td>
</tr>
<tr>
<td>7</td>
<td>Ballast stem weight</td>
</tr>
<tr>
<td>8</td>
<td>Lamp lead</td>
</tr>
</tbody>
</table>

**Fig. 29**  
 **Seadrome Light Assembly, Type F, Component Parts**

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamp head</td>
</tr>
<tr>
<td>2</td>
<td>Buoy upper retaining plate screws</td>
</tr>
<tr>
<td>3</td>
<td>Universal adapter</td>
</tr>
<tr>
<td>4</td>
<td>Buoy upper retaining plate</td>
</tr>
<tr>
<td>5</td>
<td>Pneumatic buoy</td>
</tr>
<tr>
<td>6</td>
<td>Buoy lower retaining plate and center block</td>
</tr>
<tr>
<td>7</td>
<td>Lamp lead</td>
</tr>
</tbody>
</table>

**Fig. 30**  
 **Seadrome Light Assembly, Type G, Component Parts**

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamp head</td>
</tr>
<tr>
<td>2</td>
<td>Buoy adapter</td>
</tr>
<tr>
<td>3</td>
<td>High pressure buoy (tire, tube, and wheel)</td>
</tr>
<tr>
<td>4</td>
<td>Retrieving horn screws</td>
</tr>
<tr>
<td>5</td>
<td>Buoy adapter cotter</td>
</tr>
<tr>
<td>6</td>
<td>Retrieving horn</td>
</tr>
<tr>
<td>7</td>
<td>Lamp lead</td>
</tr>
</tbody>
</table>

**Fig. 31**  
 **Seadrome Light Assembly, Type H, Component Parts**

<table>
<thead>
<tr>
<th>Item</th>
<th>Part Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lamp head</td>
</tr>
<tr>
<td>2</td>
<td>Buoy upper retaining plate and separator column</td>
</tr>
<tr>
<td>3 &amp; 7</td>
<td>Ballast stem nuts</td>
</tr>
<tr>
<td>4 &amp; 6</td>
<td>Ballast stem washers</td>
</tr>
<tr>
<td>8</td>
<td>Ballast stem</td>
</tr>
<tr>
<td>9</td>
<td>Ballast stem weight</td>
</tr>
<tr>
<td>10</td>
<td>Lamp lead</td>
</tr>
<tr>
<td>5</td>
<td>Buoy lower retaining plate</td>
</tr>
</tbody>
</table>
Fig. 24  Seadrome Light Assembly  TYPE "A" - COMPONENT PARTS
Fig. 25  Seadrome Light Assembly  TYPE "B" - COMPONENT PARTS
Seadrome Light Assembly — TYPE "D"

COMPONENT PARTS

Fig. 27

Lt. F. M. Mueller, CEC-VIS, USNR

U.S. Naval Air Station
Corpus Christi, Texas
Fig. 28: Seadrome Light Assembly TYPE "E" - COMPONENT PARTS
Fig. 31. Seadrome Light Assembly TYPE "H" - COMPONENT PARTS
Apparatus Set-up—Photometric Test
Lamp Submersed 5 feet, 0 inches;
Without Shield

Fig. 32B
Photometric Test
Preparation For Raising
Protractor (Lamp Assembly Type "G" in Position)
Photometric Test
Seadrome Lamp Assembly
Type "H" With Shield
FIG. 33 FRESH WATER BUOYANCY TEST & SUBMERSION
27 NOV. 1943
SYNOPSIS OF CERTAIN PHOTOGRAMMETRICAL DATA  

(Information refers to Test E; Layout A; Plan D)

TYPES: Photographs taken between 2030 February 15, 1944, and 0100 February 16, 1944, from photographers’ tower shown in Plan D. Tower located about 300 feet from submerged light as shown; about 280 feet from green fluorescent Mazda T-5, 6 watt, General Electric light in Type PPL-N Portable Seadrome Contact Light – Dry Battery; about 275 feet from a Westinghouse, red, cold cathode fluorescent, 7½ watt, 3 mm spiral tube, luminary, on Firestone Buoy. Camera 9 feet above water surface. Voltage constant at 110 volts. Light centers average approximately 5 feet below surface.

WEATHER: Atmospheric transmissivity 100 percent estimated for photographs: Fig. 35A, Fig. 35B, Fig. 35C; 98 percent estimated for Fig. 35E. At about 2245 a very light fog approached the basin from an easterly direction but reached no appreciable intensity before completion of the photographic work. However, on 16 February at 0220 the Naval Air Station Aerological Tower, one and one-half miles due west of test location, reported heavy fog with no visibility (1/8 mile); no ceiling. From Naval Air Station Aerological Tower report: 2030 to 0100 clouds, completely overcast, stratuscumulus average height 3000 feet, no restrictions to visibility – 6 miles to 10 miles. Wind east north east average 3 knots. Sea (lagoon) calm, at 2030 barometer 29.98 inches; tide in, tide reached high of + 0.3 feet at 2106; at 0100 (16 February) barometer 29.96 inches; tide out, tide reached low of – 0.3 feet at 0356, water characteristics: turbidity Q parts per million, color 17 parts per million, No. 17, mulberry. A40

CAMERA: Agfa 8 inches x 10 inches View Camera, 12 inch focal length, lens Bausch & Lomb Protar, tripod level.

FILM: Eight inches x 10 inches – Triple "S", Panchromatic Film.

PHOTOGRAPHS: Fig. 35A, "Experimental Seadrome Lighting Strip, Layout A, Assemblies Submerged (Plan D), Test E," exposure 20 minutes, f/6.3, printed on paper No. ½ Azo, time 15 seconds.

Fig. 35B, "Experimental Seadrome Lighting Strip, comparison with Conventional types, Layout A (Plan D), Test E," exposure 5 minutes, f/6.3, printed on paper No. ½ Azo, time 15 seconds.

Fig. 35C, "Experimental Seadrome Lighting Strip, comparison with conventional types, Layout A (Plan D), Test E," exposure 10 minutes, f/6.3, printed on paper No. ½ Azo, time 15 seconds.

(continued on page 80)
SYNOPSIS OF CERTAIN PHOTOGRAMMETRICAL DATA—Table 6 (Continued from page 79)

Fig. 35D. "Experimental Seadrome Lighting Strip, Assemblies Surfaced, Layout A (Plan D), Test E," exposure 2 minutes, f/11, printed on paper No. 4 Azo, time 15 seconds.

Fig. 35E. "Experimental Seadrome Lighting Strip, Assemblies Surfaced, Layout A (Plan D), Test E," exposure 10 minutes, f/6.3, printed on paper No. 4 Azo, time 15 seconds.

The following is a list of file numbers for negatives of photographs included in this thesis filed in the U.S. Naval Air Station Photographic Laboratory Files, Corpus Christi, Texas:

<table>
<thead>
<tr>
<th>Illustration</th>
<th>File No.</th>
<th>Illustration</th>
<th>File No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig. 18</td>
<td>13677</td>
<td>Fig. 31</td>
<td>13691</td>
</tr>
<tr>
<td>Fig. 19</td>
<td>13678</td>
<td>Fig. 32A</td>
<td>13690</td>
</tr>
<tr>
<td>Fig. 20</td>
<td>13679</td>
<td>Fig. 32B</td>
<td>12089</td>
</tr>
<tr>
<td>Fig. 21</td>
<td>13680</td>
<td>Fig. 32C</td>
<td>12091</td>
</tr>
<tr>
<td>Fig. 22A</td>
<td>13681</td>
<td>Fig. 32D</td>
<td>12092</td>
</tr>
<tr>
<td>Fig. 22B</td>
<td>13682</td>
<td>Fig. 33</td>
<td>13699</td>
</tr>
<tr>
<td>Fig. 23</td>
<td>13683</td>
<td>Fig. 34A</td>
<td>13698</td>
</tr>
<tr>
<td>Fig. 24</td>
<td>13684</td>
<td>Fig. 34B</td>
<td>13697</td>
</tr>
<tr>
<td>Fig. 25</td>
<td>13685</td>
<td>Fig. 35A</td>
<td>13692</td>
</tr>
<tr>
<td>Fig. 26</td>
<td>13686</td>
<td>Fig. 35B</td>
<td>13693</td>
</tr>
<tr>
<td>Fig. 27</td>
<td>13687</td>
<td>Fig. 35C</td>
<td>13694</td>
</tr>
<tr>
<td>Fig. 28</td>
<td>13688</td>
<td>Fig. 35D</td>
<td>13695</td>
</tr>
<tr>
<td>Fig. 29</td>
<td>13689</td>
<td>Fig. 35E</td>
<td>13696</td>
</tr>
<tr>
<td>Fig. 30</td>
<td>13690</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

Endorsements, Comments, Correspondence

<table>
<thead>
<tr>
<th>Source</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comments--Seadrome Lighting Demonstration</td>
<td>88</td>
</tr>
<tr>
<td>Naval Air Station Air Traffic Coordination, Plate 3-3A</td>
<td>98</td>
</tr>
<tr>
<td>Naval Air Station Air Traffic Coordination, Plate 3-3B</td>
<td>99</td>
</tr>
<tr>
<td>Naval Air Station Air Traffic Coordination, Plate 3-3C</td>
<td>100</td>
</tr>
<tr>
<td>Naval Air Station Air Traffic Coordination, Plate 3-3D</td>
<td>101</td>
</tr>
<tr>
<td>Sketch--Hydroplane for Seadrome Utility Work</td>
<td>102</td>
</tr>
<tr>
<td>Letters</td>
<td>103</td>
</tr>
<tr>
<td>Application for Professional Degree, Missouri School of Mines and Metallurgy, Rolla, Missouri</td>
<td>109</td>
</tr>
<tr>
<td>Letter of Transmittal--Application for Professional Degree</td>
<td>110</td>
</tr>
<tr>
<td>Acknowledgment of Receipt of Application, M.S.M.</td>
<td>111</td>
</tr>
<tr>
<td>Vita, Frederick Marion Mueller</td>
<td>112</td>
</tr>
</tbody>
</table>
From: Lt. Comdr. T.V. Tarbet, CEC-V(S), USNR.

To: The General Supervisor of Field Lighting, - - - LT. F.W. Mueller, Public Works Department, Naval Air Station. CEC-V(S), USNR

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration:

2. Comments regarding visibility of marker light used - eye reaction:

   [Handwritten: Very good - observed from tower to be a very definite and unusual marker.]

3. Suggestions for improving contact light and strip:

   [Handwritten: Shields or lenses for greater horizontal dispersion may improve markers.]

4. Miscellaneous remarks:

   [Handwritten: Try colored lights. Add shields or lenses for greater horizontal dispersion may improve markers.]

Observed from flight? (Mark one)

   Yes
   No

SIGNED: [Signature]

TITLE: Lt. Comdr. T.V. Tarbet, USNR

(GENERAL SUPERVISOR OF FIELD LIGHTING, U.S. NATC, Corpus Christi, Texas)
NAVAL AIR TRAINING CENTER
U. S. NAVAL AIR STATION
CORPUS CHRISTI, TEXAS

RESTRICTED

Naval Air Station, Laguna Madre
Seaplane Basin

February 14, 1944

From: Lt.(jg) J. W. Johnson, A-V(N), USNR

To: The General Supervisor of Field Lighting,
   Public Works Department, Naval Air Station.

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the
demonstration:
   Appears to be an excellent idea from
   a practical as well as theoretical standpoint.

2. Comments regarding visibility of marker light used - eye reaction:
   I was able to see the marker from 3 or
   4 or miles away at 5,000 ft.

3. Suggestions for improving contact light and strip:
   Would suggest placing one light at end of
   strip to line up on it after dark take off.

4. Miscellaneous remarks:
   The present power of the light appears to be
   ideal. Stronger light would tend to blind a pilot
   coming into the groove in a dark night.

Observed from flight? (Mark one)
Yes  x  No

SIGNED: J. W. Johnson, Lt.(jg) USNR
TITLE: 354th Squadron
Naval Air Station, Laguna Madre
Seaplane Basin

February 14, 1944

From: F. A. Yochem 1st Lt. USNR (NAV)

To: The General Supervisor of Field Lighting,
Public Works Department, Naval Air Station.

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration: A very good idea, but to be practicable will have to be improved.

2. Comments regarding visibility of marker light used - eye reaction:
   Visibility of light is 8-10 miles. As you move the water light seems to flatten out. Are invisible when on surface of water.

3. Suggestions for improving contact light and strip:
   Put light at each end of surface to be used as a guide.
   Intensity light without increasing phase

4. Miscellaneous remarks:
   Needs a more stable securing device.
   Anchors will shift with sand on bottom. In my estimation a short pile is should be driven into bottom instead of using anchor.

Observed from flight? (Mark one)

Yes X
No

SIGNED: Flt Engr. CTR Base
TITLE: Flight Instructor
From: 1st.Lt. J. L. Boyd, USMCR

To: The General Supervisor of Field Lighting, Public Works Department, Naval Air Station.

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration:

2. Comments regarding visibility of marker light used - eye reaction:

3. Suggestions for improving contact light and strip:

4. Miscellaneous remarks:

Observed from flight? (Mark one)
Yes No

SIGNED: __________________________
TITLE: __________________________
From: [Signature]
To: The General Supervisor of Field Lighting,
Public Works Department, Naval Air Station.

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration:
   "From the layout was very rough."

2. Comments regarding visibility of marker light used - eye reaction:
   "S - S. M. L. Good."
   "S - S. M. L. Fair."

3. Suggestions for improving contact light and strip:
   "A 400 light was ideal both in clarity and size at great point in the scheme of navigation. Lamps for cooperation with the light should be rugged and good."  
   "In less visibility as the pilot approaches the water. And the light which is used for the purpose of being visible in the water is nearly invisible when most needed."

4. Miscellaneous remarks: For clear overwater. As they near the 200 foot mark the light begins to rise and becomes visible as the pilot approaches the water. And the light which is used for the purpose of being visible in the water is nearly invisible when most needed.

Observed from flight? (Mark one)
Yes [X] No [ ]

The light cannot be seen on the water at all from a distance of 50 ft.

SIGNED: [Signature]
TITLE: [Title]
NAVAL AIR TRAINING CENTER
U. S. NAVAL AIR STATION
CORPUS CHRISTI, TEXAS

RESTRICTED

Naval Air Station, Laguna Madre
Seaplane Basin

February 17, 1944

From: [Signature]

To: The General Supervisor of Field Lighting,
Public Works Department, Naval Air Station.

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration:
   These lights are a great improvement in night flying;
   their main feature is safety.

2. Comments regarding visibility of marker light used - eye reaction:
   Light can be seen easily from the air. However, the eye reaction time is slower due to
   the softness of the light.

3. Suggestions for improving contact light and strip:
   Underwater lights are ideal for marking areas, but regular "glow water" lights
   must be used at the ends of runway to mark the end of safe deep water.

Observed from flight? (Mark one)
Yes 
No

SIGNED: [Signature]
TITLE: [Signature]

SPD. 17
From: The General Supervisor of Field Lighting, Public Works Department, Naval Air Station.

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration:

2. Comments regarding visibility of marker light used - eye reaction:
   Easily distinguished from any altitude light diffused by water does not bother eyes.

3. Suggestions for improving contact light and strip:

4. Miscellaneous remarks:
   Since light shines to top of water and no further, it may be used to some extent to judge height above water just prior to landing.

SIGNED:  
TITLE: 

EAST COURSE
From: H. F. Ahmann
To: The General Supervisor of Field Lighting,
Public Works Department, Naval Air Station.

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration:
   The lights are well placed, making it extremely easy to line up on the run way. They are situated just right from the beach so as to use as a judging mark for the landings.

2. Comments regarding visibility of marker light used - eye reaction:
   In my case they were easy to distinguish. They showed clearly down to about 50 ft. altitude above them. No glare!

3. Suggestions for improving contact light and strip:
   I would suggest having a longer string, running to the ends of the runway. So the other marker lights are new, you can not tell who you are running off the side, but with a string, you could tell them.

4. Miscellaneous remarks:
   All the runways should be equipped with the lights.

Observed from flight? (Mark one)
Yes [ ]
No [ ]

SIGNED: H. F. Ahmann

PREVIOUS COURSE
NAVAL AIR TRAINING CENTER
U. S. NAVAL AIR STATION
CORPUS CHRISTI, TEXAS

RESTRICTED

Naval Air Station, Laguna Madre
Seaplane Basin

February 14, 1944

From: J. C. Sommerson

To: The General Supervisor of Field Lighting,
Public Works Department, Naval Air Station.

Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration:
   The course for the demonstration was ready to use all to see practical.
   But if more depth were used the three section method would be less success
to proper lighting. Have felt around.

2. Comments regarding visibility of marker light used - eye reaction:
   The marker lights that were placed were visible to one at about 1/2 mile
   under the visibility. The goal in fact
   landed - duplicate time again not delivered.

3. Suggestions for improving contact light and strip:
   Passing the lights would be much
   better if they were stronger and greater in number.

4. Miscellaneous remarks:

   The idea is adopted here for the VC
   squad in the tropics that follow me through
   will have a much easier time with their
   conditions and judging the flight - long.

   Observed from flight? (Mark one)
   Yes /
   No ___

SIGNED: J. C. Sommerson
TITLE: ___
From: MC IRVIN S. COOPER  
To: The General Supervisor of Field Lighting, Public Works Department, Naval Air Station.  
Subj: Seadrome Lighting Demonstration.

1. Comments regarding practicability of course layout used in the demonstration:

   SEADROME LIGHTING WOULD ELIMINATE CONSTRUCTION OF PILING ON CONSEQUENTLY ADD TO THE SAFETY FACTOR IN THE AREA.

2. Comments regarding visibility of marker light used - eye reaction:

   VISIBILITY WAS EQUAL TO BETTER THAN FLARE POIS AT A DISTANT, AND MUCH BETTER THAN FLARE POIS AT A CLOSE RANGE. IT LIT A LARGER AREA.

3. Suggestions for improving contact light and strip:

   IF EACH LIGHT IS KEPT AT A CONSTANT DEPTH, THEN THE EFFECT OF THE MARKERS WOULD BE EQUAL AROUND THE WHOLE AREA. (SOME LIGHTS SEEMED BRIGHTER THAN OTHERS.)

4. Miscellaneous remarks:

Observed from flight? (Mark one)
Yes  
No  

SIGNED:  
TITLE:  
MC S. COOPER  
V-5
NAVAL AIR STATION AIR TRAFFIC COORDINATION

AREA 1

CORPUS CHRISTI BAY

AREA 2

AREA 8

UNSAFE FOR SEAPLANES

AREA BOUNDARIES

O SEAPLANE RUNWAYS - AREA B

SEAPLANE CONTROL TOWER - YELLOW FLAG

AREA B CONTROL TOWER - 2 YELLOW FLAGS

SEAPLANES LANDING IN AREAS 1 AND 2

SEAPLANES LANDING IN AREA B

SEAPLANES TAKING OFF IN AREA B

LANDPLANE TRAFFIC

PLATE 3-3B
NAVAL AIR STATION AIR TRAFFIC COORDINATION

AREA 1

CORPUS CHRISTI BAY

AREA 2

AREA 3

O30 BAY

UNSAFE FOR SEAPLANES

AREA BOUNDARIES

SEAPLANE RUNWAYS - AREA B

CONTROL TOWER - YELLOW FLAG

CONTROL TOWER - RED FLAG OVER

SEAPLANES LANDING

IN AREAS 1 AND 2

SEAPLANES TAKING

OFF IN AREA B

SEAPLANES LANDING

IN AREA B

LANDPLANE TRAFFIC

PLATE

3-3 C

PAGE 100
SKETCH

HYDROPLANE

About 8 inch draft

Air Rudder

water rudder (on hinge)

JUNE 10 1943

FIRE, RESCUE, UTILITY

GENERAL SUPERVISOR OF
FIELD LIGHTING

DRAWING GA2
November 30, 1943

Lt. Mueller
Public Works Office
Naval Air Training Station
Corpus Christi, Texas

Subject: Seadrome Contact Lights

Dear Lt. Mueller:

I have had a reply from the factory regarding this proposition, and they express very keen interest in the matter which you now have under consideration. While they feel that it may be difficult to get enough light through from a depth of 8' to reach the pilot's eyes at sufficient intensity to be of assistance to him in guiding him for a landing, too, they feel that the idea has possibilities.

They also question the matter of depth perception, which we understand is a very definite factor in successful night landings on water.

In checking over our stock of under-water equipment, we find that it is practically depleted. There is, however, one 66240849 Type CF-14 Aqualeux flood light still in our stock. While this unit is manufactured of aluminum and would not be recommended for continuous emerging in salt water, it probably would be satisfactory for tests running over a relatively short period of time. This unit has a swivel base for mounting on 1-1/2" pipe and uses either a 1000 or 500 watt C-40 mogul screw base lamp.

We have not been able to procure this unit as yet on a no-charge basis, and we are, frankly, pretty well stopped because of the matter of priorities. Samples have been practically a thing of the past for some time. We are wondering if it might be possible for you to procure this unit through some of your regular channels and give us a regular purchase order with priority. If such is the case, the unit could be supplied at a net price of $55.40.

We trust that you may find this unit suitable for the test, and then we may be permitted to supply your requirements in this line.

Very truly yours,


Subject to the terms and conditions on the back of this quotation

WESTINGHOUSE—THE NAME THAT MEANS EVERYTHING IN ELECTRICITY
18 October 1943

Dear Lt. Comdr. Simpson,

I suppose you are finding yourself quite busy with the coordination. Since the Atlanta Conference I have been away on temporary duty. In a few days the report to BuAero regarding portable lights--training in use of, will be released.

What I hope you will do for me is to help make it possible for me to collect data with which to complete a thesis on "The Development, Use, and Projected Use of Airport and Seadrome Lighting Facilities at the U. S. Naval Air Training Center, Corpus Christi, Texas," which I have begun.

I should like for you to send me a bibliography from the library you have, or use, on field lighting. Also please send me names of one or two libraries which may have information on field lighting. I would be interested in any literature you can spare--data tables, or otherwise.

I hope to submit this thesis here for planning a manual for squadrons and operators of the field lighting facilities, and also, with the Commandant's permission, will use it in partial fulfillment of work for a graduate professional degree of Electrical Engineer at my university.

A stamped envelope is enclosed. Thank you.

Sincerely yours,

Fred. M. Mueller
Lieut. CEC-V(S), USNR

Lt. Comdr. Lester C. Simpson, USNR (Ret)
c/o Eq. AAF, AC/AS, KH&D, B&G Sect., Washington
Field Lighting, Bureau of Aeronautics
Washington, D. C.
Dear Lieut. Warskow:

By now you have probably received my request which I had sent to the Bureau of Standards.

I am planning that the thesis: "The Development, Use and Projected Use of Aviation Lighting Facilities for Airfields and Seadromes at the U. S. Naval Air Training Center, Corpus Christi, Texas" may, upon its completion, be suitably revised for use as a manual as operations here may require. The initial purpose of the thesis, however, is to obtain a professional degree in electrical engineering from my university and to record a history of the work done here.

Any information which you may release for this purpose will be greatly appreciated. I also would like information on type PAM-2 (Portable Seadrome) sets. Are these sets now available?

I have just invented a new type light which will probably interest you. Because it is still in the development stages, details must wait.

Cordially yours,

Lt. F. M. Mueller, CEC, USNR
Dear Sirs:

I am seeking information regarding the standardization of aviation field lighting facilities which may have grown out of the Army-Navy Conference held at the Aeronautical Board, Washington, D. C., 6 November 1941, relative to the Standardization of Airport and Seadrome Lighting. Please send to me any pertinent information available through the National Bureau of Standards.

Any data received will be used in writing a thesis: "The Development, Use and Projected Use of Aviation Lighting Facilities for Airfields and Seadromes at the U. S. Naval Air Training Center, Corpus Christi, Texas," which I have begun.

Sincerely yours,

Frederick M. Mueller
Lieut. CEC-V(S), USNR
Civil Aeronautics Administration  
Washington, D. C.

Dear Sirs:

I am interested in obtaining information on C.A.A. policy relative to the standardization of airport and seadrome lighting facilities. In addition to this, if C.A.A. publications are available regarding accepted practice in airport lighting, they are welcome. The information requested will be used in writing: "A History of the Development, Use, and Projected Use of Airport and Seadrome Lighting Facilities at The U. S. Naval Air Training Center, Corpus Christi, Texas.

Sincerely yours,

Fred W. Mueller  
Lieut. CBC-V(S) USNR
I am seeking information regarding the standardization of aviation landfield and seadrome lighting facilities; and other pertinent information from which a permanent policy of lighting airfields for night flying may be developed.

Please advise me where I may obtain the desired information or send any that is available through the Illuminating Engineering Society.

Information received will be used in writing a thesis: "The Development, Use, and Projected Use of Airfield and Seadrome Lighting Facilities at the U. S. Naval Air Training Center, Corpus Christi, Texas."

Sincerely yours,

Frederick M. Mueller
Lieut. CEC-V(S) USNR
APPLICATION FOR PROFESSIONAL DEGREE

I, Frederick Marion Mueller, hereby make application to the faculty of
Missouri School of Mines and Metallurgy for the degree of
ELECTRICAL ENGINEER
and ask that the degree be granted at the regular Commencement exercises in 1944
I graduated in SPRING 1938 with the degree B.S.in E.E.

My experience since graduation has been as follows:

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<td>(For this information please refer to three attached sheets)</td>
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I propose to submit a thesis with the title "SEADRONE LIGHTS - PORTABLE"
which will consist essentially of

DESCRIPTION OF THE DESIGN OF A UNIVERSAL TYPE SEADRONE LIGHT SUITABLE FOR MILITARY USE IN ALL AREAS AND FOR TRANSPORTATION BY AIRCRAFT.

I understand that this thesis must be submitted to the Department Head concerned by January 1 of the year in which the degree is to be granted, and must be in final form by March 15 of the same year.

I understand that at any time prior to March 15 of the year specified above I have the privilege of withdrawing this application, or of asking that it be extended for a year.

I enclose herewith five dollars ($5.00) to cover my Diploma Fee, with the understanding that if this application is withdrawn by me as covered by the paragraph above, this amount will be refunded to me; if I request an extension as covered in the same paragraph the fee will also be extended; but that no refund will be made if this application remains in effect after March 15 of the year specified above.

I will pay $2.00 for the use of the cap and gown, if I attend the Commencement exercises.

Title and outline approved

Department Head

Fee received

Business Manager

Final thesis approved

Department Head

Degree Granted

Registrar
IN REPLY REFER TO
NO. ................

U.S. NAVAL AIR STATION
CORPUS CHRISTI, TEXAS
PUBLIC WORKS DEPARTMENT

14 December 1943

Dean Curtis L. Wilson,
Missouri School of Mines and Metallurgy,
Rolla, Missouri.

Reference: Dean Wilson's letter 12 October.

Dear Sir:

I am forwarding herewith my application for the Professional Degree of Electrical Engineer; and by this letter request an extension of time until the information in my thesis now considered confidential, can be released by the Navy Department. It is anticipated that this release will be after 1 January 1944, but before 15 March 1944.

The experimental and development work involved in my investigation has been long drawn out due to the urgency of other demands. Before long, however, weather permitting, the field work will be completed. I shall forward the thesis to the Department Head immediately upon release.

Sincerely yours,

[Signature]
FREDERICK MARION MÜLLER,
Lieutenant, CMC-V(S), USNR.
Lt. F. M. Mueller, CEC, USNR
Public Works Department
U. S. Naval Air Station
Corpus Christi, Texas

My dear Lt. Mueller:

In response to your request of December 14, we are happy to grant an extension of time for your thesis for the professional degree of Electrical Engineer at Missouri School of Mines and Metallurgy.

I am handing your money order for $50.00 to our Business Office and I am notifying Professor F. H. Franze, Chairman of our Department of Electrical Engineering, of the extension of time granted you. We wish to do everything we can to help you and trust that we may have the pleasure of greeting you at the Commencement in May.

With best wishes and kindest regards, I am

Faithfully yours,

Curtis L. Wilson
Dean

MISSOURI SCHOOL OF MINES & METALLURGY
ROLLA, MISSOURI

CAP & GOWN, and DIPLOMA FEE

Name: Frederick Marion Mueller
Amount: $5.00
This receipt is for the student's use.

No: 691

12/21/43
V I T A

FREDERICK MARION MUELLER: Born, Urich, Missouri, May 25, 1916, of Mr. Edgar H. Mueller and Alice E. Mueller. Received grammar school education in Holden, Missouri. Age 10 to 14 developed interest in electrical phenomenon and mechanisms. Received high school education in Adrian, Missouri. Age 12 to 16 was active Boy Scout. Began university training in 1934 at the Missouri School of Mines and Metallurgy, Rolla, Missouri, and pursued the work for the degree of Bachelor of Science in Electrical Engineering, which was granted in 1938. In the School of Mines was granted a curators' scholarship for year of 1934-35 and upon graduation was nominated as candidate for the Rhodes Scholarship. In the School of Mines was member U.S. R.O.T.C. Band; professional engineering fraternity, Theta Tau; student member American Society of Electrical Engineers. In Rolla was member Little Theater Guild, Rolla Community Chorus, and Engineers Club.

At the present time is a member: The Society of American Military Engineers; The American Association for the Advancement of Science; The American Institute of Electrical Engineers; and is a Registered Professional Engineer in the State of Missouri.

From October to February 1944, in U. S. Navy, under Lt. Comdr. T. V. Tarbet, CEC-V(S) USNR, Public Works, U. S. Naval Air Station, Corpus Christi, Texas. Experimental studies in seadrome and landfill illumination, special assignment to conference; Bureau of Aeronautics; General supervision of field and seadrome lighting installations, maintenance, development of policy and indoctrination of personnel, inclusion of a standardization program, also part time given to superintending public utilities; especially electric generation, transmission, and distribution. This work covers one air station, six auxiliary air stations, and minor jobs at 34 practice fields.

From 18 September 1943 to 2 October 1943, in U. S. Navy, under Capt. F. F. Rogers, USN (Ret), Commanding Officer, N.C.T.C., Davisville, R. I. Indoc­trination in Naval Construction Battalion Activities.

From 12 May 1943 to 18 September 1943 same as from 2 October to 15 December 1943.

From 1 January 1943 to 12 May 1943, in U. S. Navy under Lt. Comdr. Tarbet. Assistant supervision in operation of electric utility facilities, general maintenance shop administration at N.A.T.C., Corpus Christi, Texas.

From 15 December 1942 to 1 January 1943, in U. S. Navy, indoctrination in Naval Construction Battalion Activities.

From November 1941 to 15 December 1942, in U. S. Navy, under Lt. Comdr. C. M. Herd, CEC-V(S) USNR; Assistant to Design Superintendent, Public Works, U. S. NAS, 18 Civil Service, mapping, field surveying, planning.
construction equipment specifications, transportation inventories, streets, buildings, utilities, landfields, seadromes, waterfront facilities, contract checker, theater stage equipment, hurricane preparation studies, blackout studies, camouflage studies, general development.


From May 1941 to August 1941, in U. S. Navy, under Lt. Comdr. R. W. Oliver, USN. Pratt and Whitney Aircraft Corporation, East Hartford, Conn. Aircraft engine overhaul, inspection, and testing.

From June 1940 to May 1941, Stone and Webster Engineering Corporation, under Mr. W. D. Marich, S&W Engr. Corp., Venice, Illinois. Electrical checker, assistant to the electrical supervisor. Supervision of electrical construction; field electrical design; installation of electrical machinery at Union Electric Company of Illinois, steam-electric generating station. Coordination construction activities, design and layout of underground and overhead transmission and distribution facilities; drafting--hydraulic systems; drawing sketches, maps, railroad curves, excavation analysis; assistant first-aid man; electric drawing checker; material requisitions; conduit schedules; wiring schedules; terminal box locations; temporary power facilities. While working with Stone and Webster was offered jobs with: Missouri General Utilities Co., Union Electric Co. of Illinois, Tennessee Valley Authority, U. S. Civil Aeronautics Authority, U. S. Navy (aviation machinist), U. S. Marine Aviation Corps, U. S. Army Aviation Corps, U. S. Navy Air Corps, U. S. Naval Reserve, Class A-V(S).

From May 1940 to June 1940 and from May 1938 to June 1938, made both conducted and personal industrial tours of Commonwealth Edison Company; Tennessee Valley Authority; Potomac Electric Power Co.; Consolidated Edison Company; Sanderson & Porter, Engrs.; E. J. White, Engrs.; Western Electric Company; General Electric Company (Chicago); and others.

From January 1940 to May 1940, in U. S. Navy, under Major W. O. Brice, U.S.M.C., Commander Aviation Cadet Battalion, U. S. NAS, Pensacola, Florida. Intense ground school and flight training--finished ground school but was dropped from flight training after 90 hours.

From September 1939 to January 1940, Electrical Transmission Lineman, 132,000 volt lines of Union Electric Company of Missouri; sag sighting; survey of line clearances; map making, member of emergency squad. Mr. Geo. Couch, Superintendent of Transmission, Union Electric Company of Missouri, Rivermines, Missouri.

From December 1938 to August 1939 with A. Y. Taylor & Company, Consulting Engineers, under Mr. A. Y. Taylor, 2 South Central Avenue, Clayton, Missouri. Design of rural electric distribution lines; voltage regulation studies on 33 and 44 kilovolt lines and lower voltage lines; pole strengths, code application, Grade A railroad crossings; supervised drafting in map making division; made automobile surveys of approximately 1,000 miles of lines; executive field trips.

From May 1937 to September 1937 and from January 1938 to December 1938, with Missouri General Utilities Company, Mr. C. J. Koetting, Ste. Genevieve, Missouri. Field surveying; rights-of-way procurement and records; construction 2.3, 4.5, 6.9, 33 kilovolt transmission systems; R.E.A. reports; material records; map making; schematic diagrams, line routing.

Frederick Marion Mueller
Lieutenant, CEC-V(S) USNR
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