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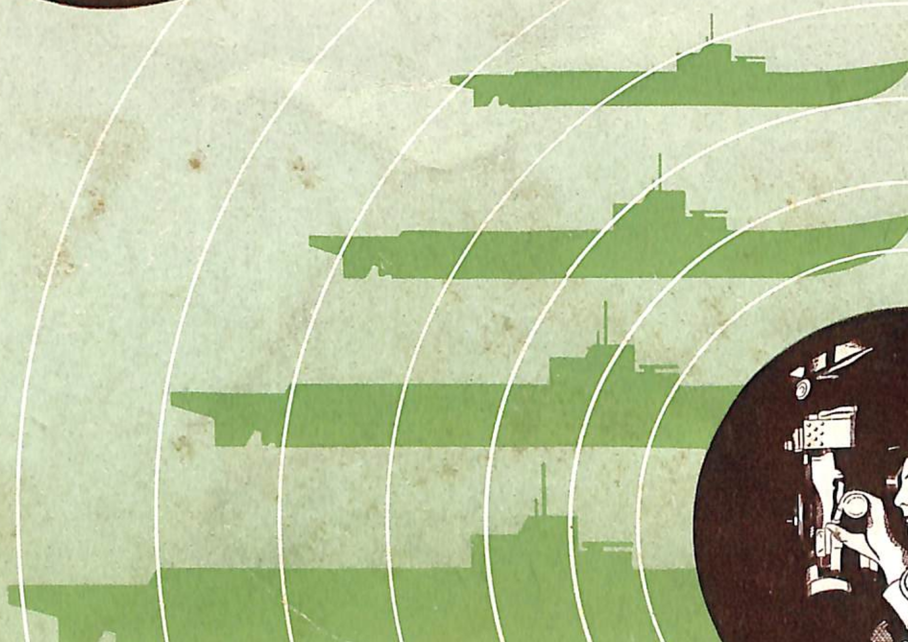

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IN THIS ISSUE
UNDERWATER SOUND

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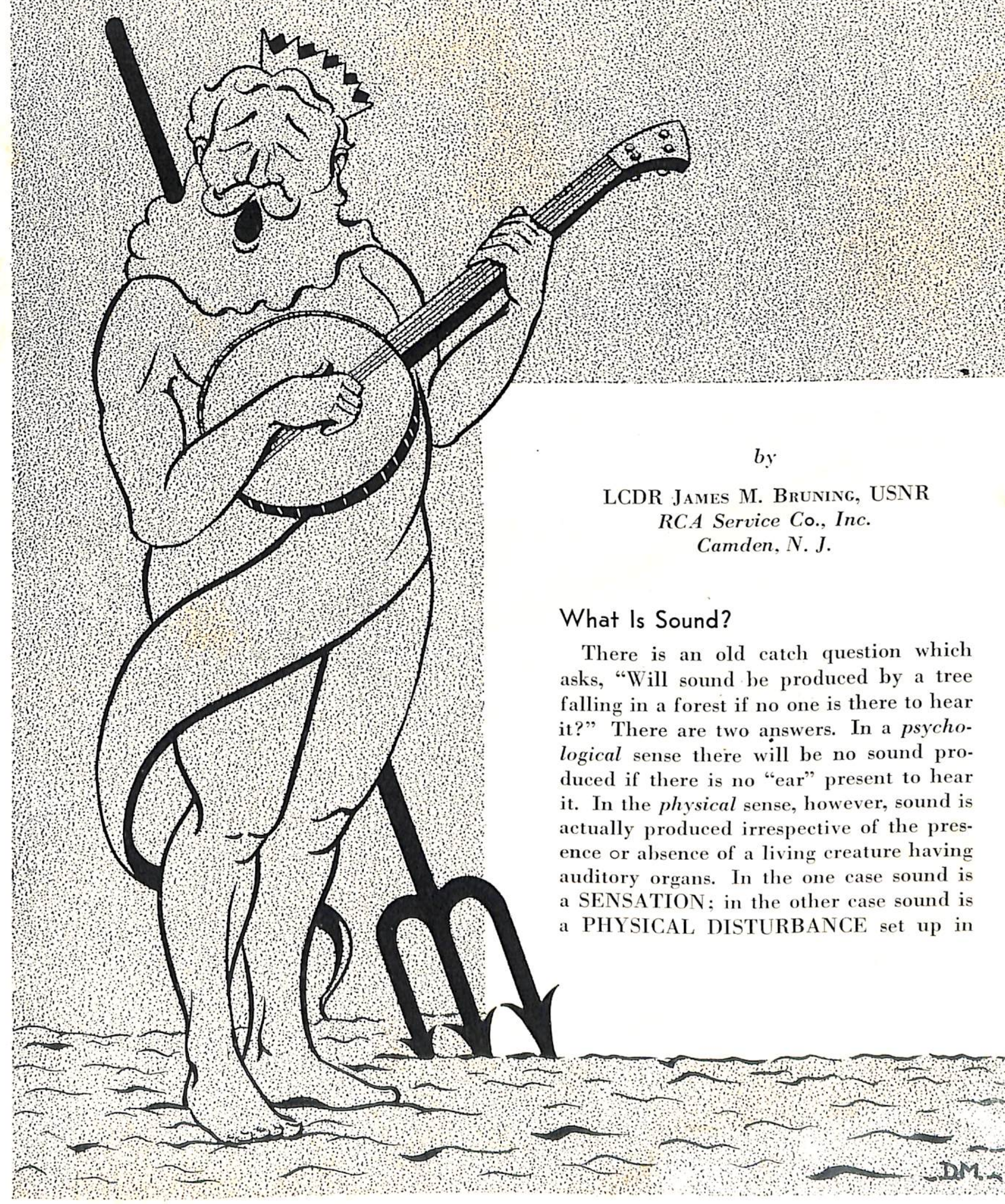
UNDERWATER SOUND



by
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What Is Sound?

There is an old catch question which asks, "Will sound be produced by a tree falling in a forest if no one is there to hear it?" There are two answers. In a *psychological* sense there will be no sound produced if there is no "ear" present to hear it. In the *physical* sense, however, sound is actually produced irrespective of the presence or absence of a living creature having auditory organs. In the one case sound is a SENSATION; in the other case sound is a PHYSICAL DISTURBANCE set up in a material medium, which disturbance may or may not be capable of directly stimulating an auditory sensation.

A Definition

Sound may be defined as being "a longitudinal wave disturbance traveling progressively from particle to particle through a *material* medium."

Sonics and Ultrasonics

A certain newspaper in reporting a lecture on the subject of SOUND once displayed the following remarkable headline, "Bryn Mawr professor proves that inaudible sound can't be heard! The lecturer had used a small tin whistle, the sound of which could not be heard by the audience but was distinctly heard by a pet dog brought along for the occasion—as evidenced by his actions each time the whistle was blown. The reporter's difficulty in describing the event could have been avoided by the use of two words, SONIC and ULTRASONIC. Sonic sounds are those within a frequency range capable of stimulating an auditory sensation in *human beings.* Ultrasonic sounds have a frequency range too high to be heard by human beings. The dividing line between the two is not too sharply defined. By common usage, however, frequencies below 16,000 cycles per second are termed Sonic and frequencies above 16,000 cycles per second are termed Ultrasonic.

Sound Propagation Requires a Medium

Sound will not pass through a vacuum. Only a material substance can serve as the conducting medium. This may be air, gas, water, wood, iron or any other substance so long as it is some material possessing mass and having the properties of elasticity and density. Sound energy is transmitted through a sound medium in the form of *longitudinal* wave motion as shown in Figure 1.

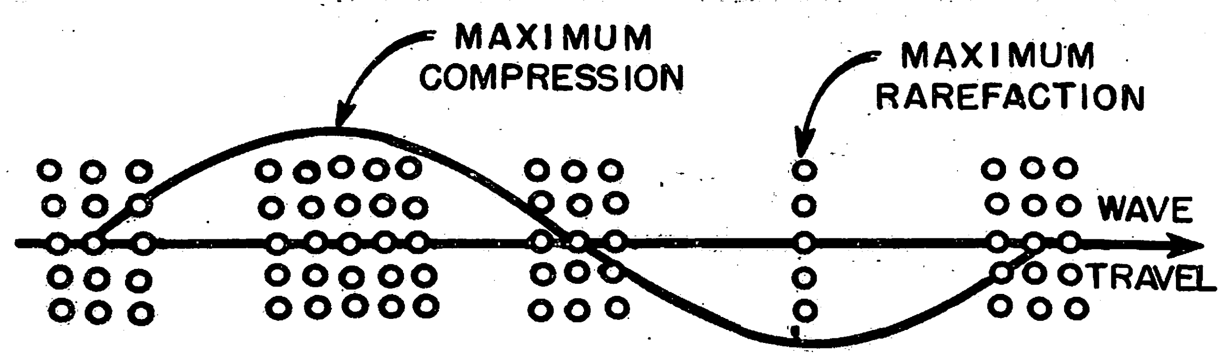


FIGURE 1—Longitudinal Wave Motion.

Disturbed particles of the medium travel back and forth in paths or orbits which are parallel to or along the line of motion of the wave travel. This results in setting up alternate zones of compression and rarefaction in the medium through which sound energy is passing.

The Velocity Equation

We know that sound travels approximately 1100 feet per second in air and 4,800 feet per second in sea water. What accounts for this difference in speed? Many experiments have demonstrated that the elasticity and density of the sound medium are the two most important factors which determine the resulting velocity of sound propagation. These factors are related as shown by the equation.

In which:

$$V = \sqrt{\frac{E}{D}} \qquad \begin{array}{l} V = \text{Velocity} \\ E = \text{Elasticity} \\ D = \text{Density} \end{array} \qquad (1)$$

Density Versus-Elasticity

Density or relative weight is readily explained as being the amount of a substance which can be contained in a unit volume. Elasticity is not what it popularly is assumed to be. Correctly speaking, elasticity is that physical property of a material which enables it to *resist* a force tending to distort or change its shape, and which allows it to return to its original configuration when the distorting force is removed. Strangely enough, rubber and air are not highly elastic substances because they are considerably distorted by a small amount of force. Glass, iron and water, however, by definition are quite elastic.

It is known that sea water is about 800 times as dense as air, and propagates sound waves 4.36 times faster than air. How then does the elasticity of sea water compare with that of air?

$$V_{air} = \sqrt{\frac{E_{air}}{D_{air}}} \quad \text{and} \quad V_{water} = \sqrt{\frac{E_{water}}{D_{water}}}$$

but Water Density = 800 Air Density

$$\text{so:} \quad 1100 : \sqrt{\frac{E_a}{1}} = 4800 : \sqrt{\frac{E_w}{800}}$$

$$\text{or} \quad 1 : \sqrt{E_a} = 4.36 : \sqrt{\frac{E_w}{800}}$$

$$\text{and} \quad \sqrt{\frac{E_w}{800}} = 4.36 \sqrt{E_a} \qquad (2)$$

$$\text{Squaring} \quad \frac{E_w}{800} = 19 \times E_a$$

$$\therefore \; E_w = 15{,}200 \times E_a \qquad (3)$$

Therefore the elasticity of water is about 15,000 times *greater* than the elasticity of air!

The E/D Ratio of Air and Water

As indicated by equation (1) the ratio of elasticity to density of any transmission medium is all important in determining sound velocity. Increasing the elasticity or decreasing the density results in an increased velocity. Any influence which changes either factor has a corresponding effect upon the velocity. Temperature, for example, ordinarily affects density to a greater degree than it affects elasticity. Thus, the higher the temperature of the medium the less the density and the greater the velocity.

An increase in the barometric pressure of air does not have any effect upon the resulting sound velocity because air elasticity and density both increase at the same rate as pressure increases, and the velocity therefore remains constant.

The E/D ratio of the ocean is changed by temperature, pressure and salinity. An increase in any of these factors will increase sound velocity, although this increase is not directly proportional. Temperature has the greatest effect upon resultant sound velocity, with pressure variations (usually) next in importance.

Water has maximum density at 4°C or 39°F. Pressure also affects both elasticity and density. Pressure is a function of and increases with depth. Salinity varies in sea water from near zero at the mouth of large fresh-water rivers to about 5% or more in the more salty areas. Temperature, of course, varies over wide limits depending upon the latitude, ocean current, and the season. From the above it is evident that the E/D ratio and hence the velocity of sound through sea water is subject to considerable variation.

Sound Velocity in Air and Water

In air the speed of sound is about 1,090 feet per second at 32° F., and increases 1.1 feet per second for each degree rise. Thus, in air at 70° F., sound will travel at a velocity of 1,090 + 1.1 (70-32) or 1132 feet per second.

It is generally considered that sound travels 800 fathoms (4,800 feet) per second in sea water. This is a convenient approximation. Actually, the velocity is about 4700 feet per second at 30° F. and increases nearly 10.9 feet per second for each degree rise. At 85° F. a velocity of about 5300 feet per second may be obtained. Recent calculations for newly designed Sonar equipments have used the velocity figure of 4920 feet per second as being more accurate and representative of average conditions.

Calculating Wavelength

Since velocity is equal to the product of frequency times wavelength, one can calculate wavelength by using the equation

$$WL = \frac{V}{F} \qquad (4)$$

$$\text{or} \quad \lambda = \frac{V}{F} \qquad (5)$$

$$\text{and} \quad F = \frac{V}{\lambda} \qquad (6)$$

Thus, the wavelength of a 1,000 cycle note in air is approximately 1.1 feet. The wavelength of the same sound-frequency in sea water is about 4.8 feet. Since wavelength is so directly related to frequency, it is interesting to note the change in wavelength produced by increases in frequency, as shown in Table I.

TABLE I. WAVELENGTHS OF SOUND IN SEA WATER

(V = 4800 ft./sec)

Frequency	Wavelength in Inches
1000 cycles	57.6
10 kc	5.7
20 kc	2.8
30 kc	1.9
50 kc	1.1
100 kc	.57

Since frequency is equal to the ratio of velocity to wavelength, it is evident that the wavelength of the transmitted sound changes with the velocity factor of the medium through which it travels. For example, if sound passes from one medium to another having one-half the velocity, the wavelength will shorten to one-half of its former length. Thus, the wavelength is proportional to the velocity factor of the sound medium.

Beam Formation

A sound source may be any vibrating device which will create a disturbance when in contact with the propagating medium. This source may be in the form of a plate, set in vibration by electro-mechanical means such as crystal oscillators, magnetostriction rods, etc. The vibrating plate or oscillator face is actually a piston. Any sudden displacement of a portion of the surrounding medium by piston movement is transmitted through the medium as a pulse of displacement. This displacement results in a variation in both the pressure and the density of the medium in the immediate neighborhood of the displacement, and through this effect a "sound pulse" is propagated.

If, now, the size of the vibrating sound source is made large in comparison to the wavelength of the transmitted energy, the sound pulses will be propagated in the form of a conical beam. In practice the radiating surface is of the order of eight to ten wavelengths in diameter. From Table I we can see that a 20 kc radiating element should have a diameter of 22 to 28 inches. A larger dimension piston will have a sharper and more intense cone of radiation. The beam from a smaller diameter piston will have a broader or wider angle and will usually be accompanied by many side lobes.

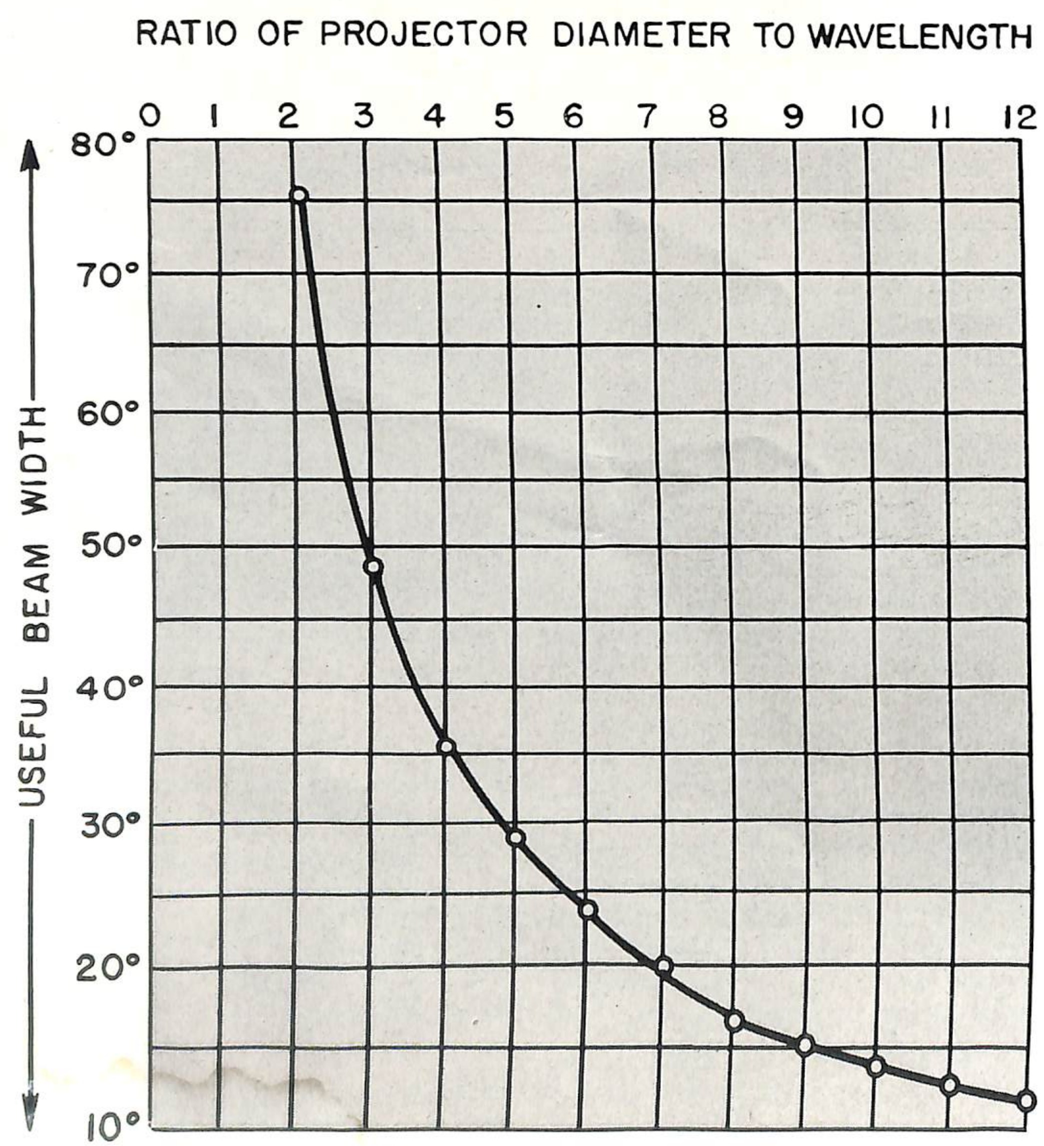


FIGURE 2—Useful beam width is a function of the projector's diameter-to-wavelength ratio.

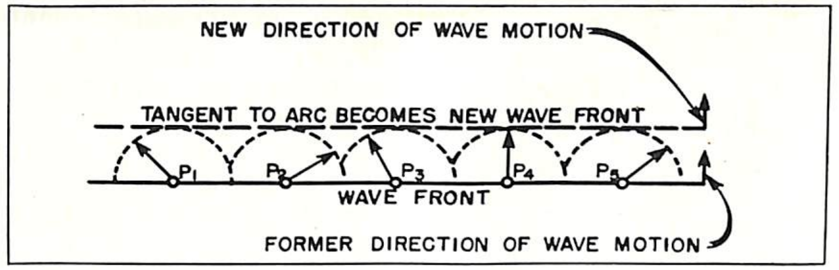


FIGURE 3—Simple development by Huyghen's principle.

Useful Beam Width

We have seen that a narrow diameter piston or projector creates a wide beam and a wide diameter projector creates a narrow beam. The useful beam width of the projected energy can be calculated with a fair degree of accuracy by use of the following equation:

$$\sin \Theta = \frac{1.22\lambda}{D}$$

In which: $D =$ Projector diameter in inches
$\lambda =$ Wavelength in inches
$\Theta = \frac{1}{2}$ beam width
$2\Theta =$ Useful beam width

Assume a 19 inch diameter projector excited at 20 kc. What is the useful beam width of projected energy?

$$\lambda = \frac{V}{F} = \frac{4800 \text{ ft. x } 12 \text{ inches}}{20{,}000} = 2.88 \text{ inches}$$

$$\sin \Theta = \frac{1.22 \times 2.88}{19} = .1847$$

but $.1847 = $ sine of $10° \, 36'$

therefore the useful beam width is
$2 \times 10° \, 36' = 21° \, 12'$

Figure 2 shows the manner in which the useful beam width becomes less, producing a sharper and more intense beam, as the projector diameter-to- wavelength ratio is increased.

The Wave Front

Huyghen stated the principle that the wave front of any moving disturbance may be determined at any instant by drawing the envelope of all the secondary wavelets proceeding from points in the wave front at some preceding instant. A simplified version of this principle is shown in Figure 3.

Each particle in a wave front is considered to be a new re-radiating source. The new wave is found by drawing the spherical wave fronts about these particles at a given instant, and then drawing a line or plane surface tangent to the individual spherical wave fronts.

While this concept may be a little difficult to grasp when thinking in three-dimensional terms, it can be readily comprehended by working an example using only two dimensions. This method is of great utility in determining the bending or refractive effect experienced by a sound wave which travels through a boundary separating two different media, or through two portions of one medium having different characteristics. This is shown in Figure 4.

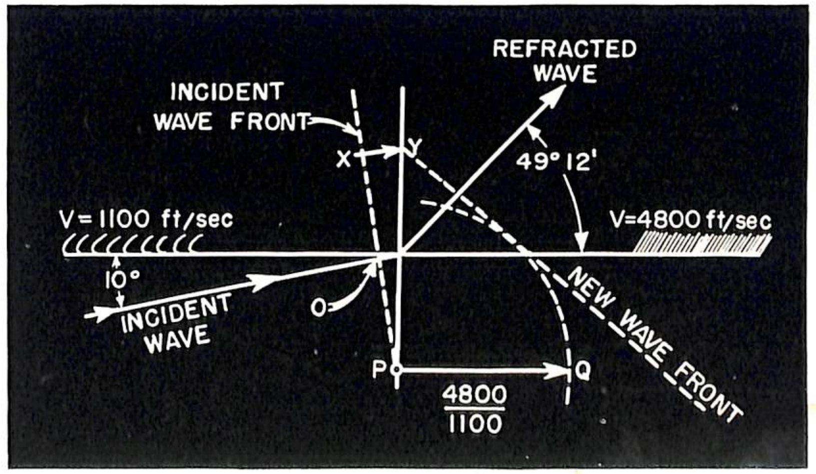


FIGURE 4—Graphical determination of angle of refraction.

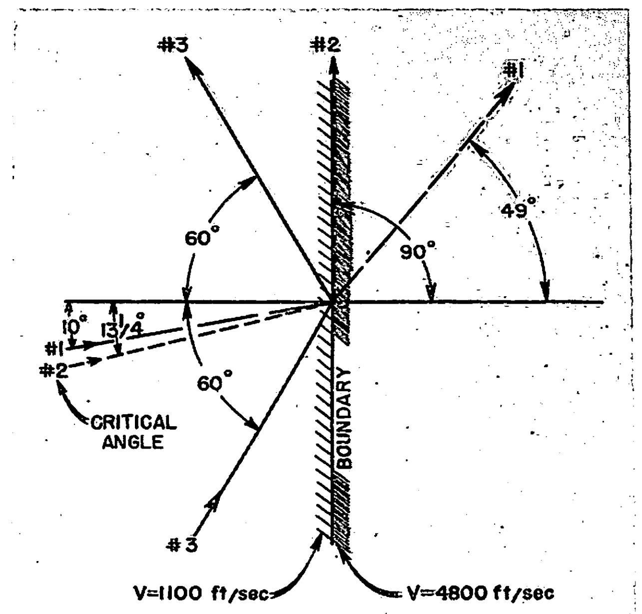


FIGURE 5—Effects of angles of incidence: #1 less than, #2 equal to, #3 greater than the critical angle.

Graphical Determination of Angle of Refraction

To demonstrate Huyghen's principle, let us assume a sound wave traveling through a low velocity medium (1100 ft./sec.) and which enters into a high velocity medium (4800 ft./sec.). If the *angle of incidence* is 10 degrees (nearly right angles or normal to the boundary), the *angle of refraction* will be 49° 12′.

This is graphically determined in the manner shown in Figure 4.

In graphically solving this problem the wave front of the incident wave is drawn perpendicular to the advancing wave at a point conveniently near to the boundary line. This line intersects the boundary at point P. A distance equal to OP is marked off on the incident wavefront as OX. From X a line is drawn parallel to the incident wave until it intersects the boundary at Y. The distance XY is measured carefully and noted.

With point P as a center, a radius PQ is used to swing an arc. The length PQ, compared to length XY, is made greater (or smaller) in the same ratio that the velocity of the second medium bears to the velocity of the first medium. In this example, the velocity ratio is 4800 to 1100 or 4.36 to 1 so PQ is 4.36 times as long as the line XY.

A new line from point Y is drawn tangent to the arc. This line constitutes the *new* wave front. A line erected perpendicular to this new wave front constitutes the new direction of movement of the sound wave in the second medium.

Mathematical Determination of Angle of Refraction

Knowing the angle of incidence and the respective propagation velocities of the two media through which the sound wave will pass, one can readily determine the angle of bending or refraction of the wave. The sine of the angle of the incident wave bears the same relation to the sine of the angle of the refracted wave as the velocity factor of the first medium bears to the velocity factor of the second medium. By formula:

$$\frac{\text{The Sine of the Angle of Incidence}}{\text{The Sine of the Angle of Refraction}} = \frac{V1}{V2} \quad (8)$$

Where V1 is incident and V2 final velocity.

$$\text{Rearranging (8)}: \text{Sin} \angle \text{refr} = \frac{\text{Sin of} \angle \text{inc x V2}}{\text{V1}} \quad (9)$$

Substituting the figures of the problem graphically solved in Figure 4:

$$\text{Sin} \angle \text{refr} = \frac{\text{Sin } 10° \times 4800}{1100} = .1736 \times 4.363 = .757$$

but: .757 is the sine of 49° 12′
so: Angle of refraction = 49° 12′.

The Critical Angle

The critical angle is that angle of incidence which will yield an angle of refraction precisely equal to ninety degrees. At this angle no energy enters the second medium and no energy is reflected back into the first medium. Instead, the refracted beam travels down the boundary of the two media.

We have seen from Figure 4 that refraction takes place when one portion of the wavefront moves faster than another. In Figure 4 a wave having a 10° angle of incidence is refracted to 49° 12′. With an angle of incidence of 13° the angle of refraction would increase to 79°. If the incident angle were increased to 13.25°, the angle of refraction would be (within slide rule accuracy) exactly 90°.

At a refraction angle of 90° it is evident that effectively the wave does not enter the second medium but moves in a line at and parallel to the boundary of the two media. The particular angle of incidence which will produce this effect is indeed quite critical.

At angles of incidence greater than the critical, total reflection takes place. All energy is returned to the incident medium; no energy is passed on to the second medium.

Figure 5 illustrates the effects of refraction, critical angle, and reflection for three different incident waves.

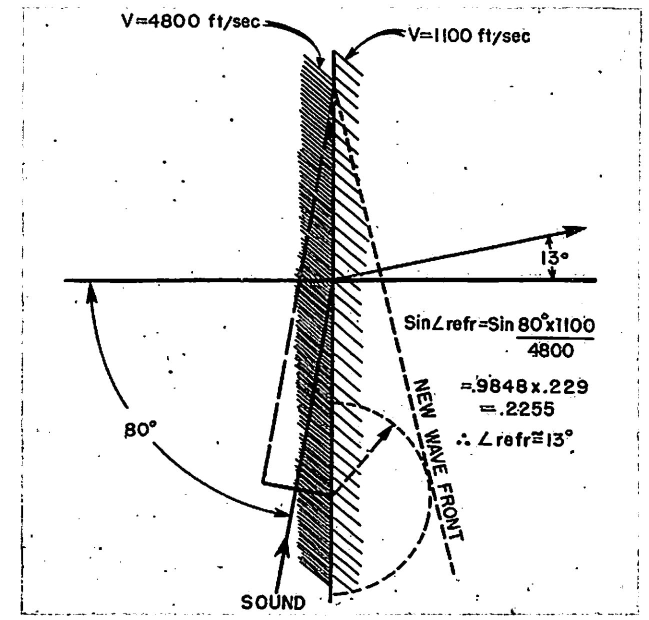


FIGURE 6—A critical angle cannot occur if sound passes from a high velocity medium to a lower velocity medium.

Absence of Critical Angle

Sometimes there is no critical angle. This effect will occur when sound is passing from a rigid highly elastic medium to one that is less rigid. When such a wave passes the boundary between a medium of high velocity into a medium of lower velocity, the angle of refraction (as developed by Huyghen's principle) becomes *smaller* than the angle of incidence.

Since the angle of refraction in such cases is always *less* than the angle of incidence, a refraction angle of 90° cannot be achieved and consequently there can be no critical angle. This is shown in Figure 6.

Phase of Sound Waves

During the passage of one complete wavelength in a sound medium there will be (1) a condition of normalcy followed by (2) a compressional effect, followed by (3) a return to normalcy, then (4) a rarefaction of the medium followed by (5) a return to normalcy. These conditions are shown in Figure 7, which is comparable to the familiar sine curve of electrical theory.

Since TIME is involved in the completion of one cycle of events, the concept of phase may be employed to advantage. Thus, if two sound waves of the same frequency exert their maximum compressional effect upon the same point in space at the same time they are "in phase". If one sound wave exerts a compressional effect and the other a rarefaction effect they are "out of phase".

When waves of the same frequency combine in various phase and amplitude relationships, an abnormal distribution of wave particles in the medium results. This effect is termed "interference". Total destructive interference occurs when two waves of identical frequency and amplitude but of opposite phase combine at the same point. The effects of compression and rarefaction cancel each other so that the medium is not disturbed and the wave motion is not propagated.

Reinforcement occurs if the combining waves have the same frequency and have such phase and amplitude relationships that the resultant wave has an amplitude greater than the original waves.

Phase Changes from Reflection

Some energy is always reflected whenever a sound beam encounters a medium having characteristics different from those of the medium through which the sound has been moving.

When an underwater sound beam strikes a LESS DENSE medium, such as the air boundary at the surface, the reflected sound is 180 degrees OUT OF PHASE with the direct wave. If, however, the sound beam strikes a MORE DENSE medium such as an iron hull or a submerged rock, the reflected sound is propagated IN PHASE with the direct wave.

If a sound beam is projected horizontally to a target just beneath the surface of the water, some energy will travel a direct path to the target and some energy will strike the ocean surface only to be reflected in an essentially horizontal direction but with a phase change of 180 degrees. The two components will travel nearly identical distances

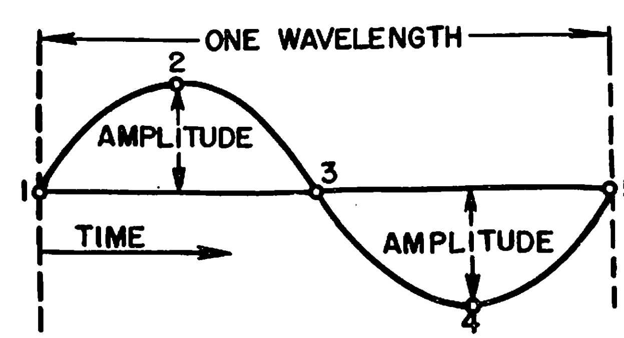


FIGURE 7—1, 3, 5, = conditions of normalcy in the medium. 2 = maximum compressional effect. 4 = maximum rarefaction effect.

and may cancel because of these phase difference. This effect is more pronounced in sonic than in ultrasonic signalling because the difference in path lengths becomes negligible as the wavelength is increased.

Doppler Effect

The doppler effect is the apparent change in frequency or "pitch" of an incoming signal which results when the sound source moves relatively either towards or away from the listener. The relative motion velocity of the listener is added or subtracted from the velocity of propagation, with wavelength remaining constant. Therefore, the frequency of the incoming signal is increased or decreased.

In echo ranging, the sound source and listening device are both mounted in the same ship. The echo returned by an underwater target will show the doppler effect if the target or the ranging ship move relatively either towards or away from each other.

When this relative motion is "towards" or "closing", the returned echo will sound higher in pitch than the outgoing pulse. If the relative motion is "away from" or "opening", the returned echo will sound lower in pitch than the outgoing pulse. These two effects are known as Doppler High and Doppler Low.

The significance of the doppler effect is that it instantly indicates whether the target and search ship are getting closer or whether they are separating. Much more and quite valuable information can be deduced from the doppler effect by a skilled sound operator.

Beam Bending and Blind Spots

We have seen that the velocity of sound propagation is increased by increase of temperature, pressure or salinity, and is reduced by a decrease in any of these factors. If one part of a sound beam moves faster than another, the beam will "bend" as discussed previously. Thus, a sound beam will bend away from levels of high temperature, pressure or salinity.

Normally, the temperature of water is highest at the surface and decreases with depth. In this condition the water is said to have a *negative* thermal gradient. A sound beam near the surface, if transmitted horizontally, will therefore gradually bend downward and may entirely miss a target at or slightly beneath the surface as shown in Figure 8.

During unusual conditions a *positive* thermal gradient may exist and the water is cool at the surface but becomes warmer with depth. In this case a sound beam directed downwards will be bent sharply upward and may entirely miss a submerged target, as in Figure 9.

A third condition, shown in Figure 10, is of interest. If a constant temperature (Isothermal temperature gradient) exists throughout the surface layer of water and the temperature then decreases with depth below this level, a projected sound beam will split. The portion of the beam in the isothermal layer will be bent upwards and the portion below this layer will be bent downward.

The blind spots created by these three types of "beam bending" form "safety zones" in which a target may not be detected. Because of the unpredictability of temperature, pressure and salinity conditions throughout the ocean, the mere fact that target echoes are not heard does not necessarily indicate that a very real target is not nearby!

SOFAR (Sound Fixing and Ranging)

With normal conditions temperature decreases with depth causing a horizontal sound beam to

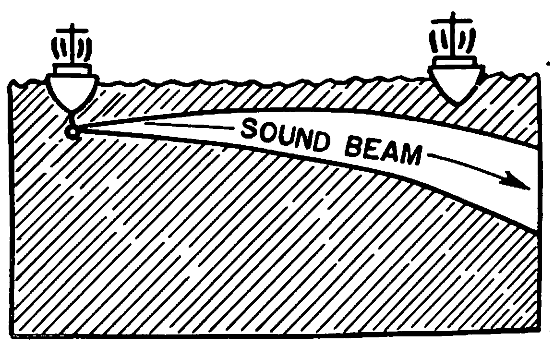


FIGURE 8—A negative thermal gradient bends sound beam down.

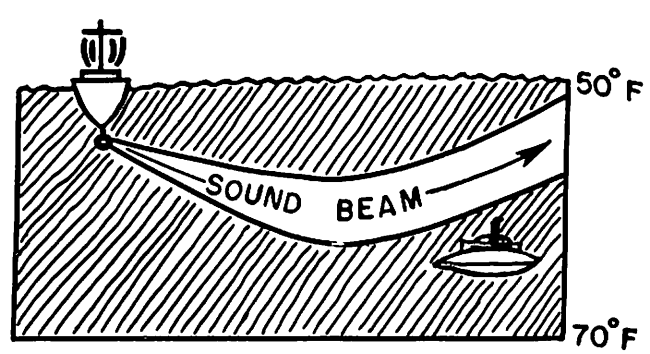


FIGURE 9—A positive thermal gradient bends sound beam up.

bend *downwards.* As the depth increases, the hydrostatic pressure of the water steadily increases. Increased pressure causes a horizontal sound beam to bend *upwards.*

At some definite depth these two opposite effects come into balance. The downward deflection caused by lowered temperature is offset by the upward deflection caused by increased pressure, as shown in Figure 11.

Where this balance is in effect, sound transmission is confined to a "sound channel" almost entirely in the horizontal plane instead of being dissipated by traveling in all directions. Consequently, extreme distances may be reached by a sound of moderate intensity created at this critical depth. The depth of this "channel" varies from place to place but usually will be between 100 and 700 fathoms.

In the operation of the Sofar system, an underwater bomb is exploded within the sound channel. The transmitted sound accompanied by its characteristic reverberations is picked up at widely separated "listening posts". At these stations a comparison of reception times enables the calculation of distance. By triangulation a fairly accurate estimate of the location of the sound source may be made.

This system has certain military possibilities of importance in addition to its value as a means of locating "shipwrecked" personnel.

Underwater Sound Limitations

Probably the most important limitation to the use of underwater sound is its relatively short range. Four possible solutions might be:

(1) change the pulse duration.
(2) increase transmitter power.
(3) change the frequency.
(4) increase receiver sensitivity.

Practical considerations limit the pulse duration. If the pulse is too long reverberations increase, nearby targets may be lost and the transmitter cannot use the pulsing technique to greatest advantage. If the pulse is too short it becomes difficult to deliver sound power to the water and the ability to recognize target makeup by echo characteristics is hindered. Representative pulse lengths are of the order of 12 to 35 milliseconds for Sonar Echo-Ranging equipments.

Considerable research has been devoted to the development of more effective transducers for coupling energy into the water. Again, there is a limit to the amount of power than can be coupled to the water using conventional methods. If the power is increased beyond this amount, cavitation or break-up of the water into bubbles takes place and sound energy cannot be effectively transmitted. It was formerly considered that cavitation would take place if the average sound energy exceeded about one-third (1/3) watt per square centimeter. New Sonar equipments, however, must be capable of delivering an average acoustical power output of at least two (2) watts per square centimeter into the water during a 35 millisecond pulse. In laboratory experiments using pulse techniques and special transducers, peak powers of 60 kw and more have been successfully delivered to the water without any sign of cavitation.

Sonar frequencies from the Sonic range up to 100 kc or more in the Ultrasonic have been tested. The lower frequencies in the band of 10 to 12 kc have greater range but are susceptible to noise interference and have little secrecy. Ultrasonic frequencies in the 20 to 30 kc band possess a fair measure of secrecy but do not have great range. In the still higher frequencies the *noise per cycle* appears to diminish but the greater number of cycles per second gives an overall noise figure that gets worse as the frequency is increased. In one case at 4000 yards range the attenuation over and above the noise level of the water was about 20 db for 24 kc and about 50 db for 60 kc, an anomaly of 30 db or 1000 times greater attenuation at the higher frequency.

An increase in receiver sensitivity appears to hold little promise as modern sonar receivers are capable of operating well into the noise level to the point where an incoming signal cannot be distinguished. The use of TVG (time varied gain) or RCG (reverberation controlled gain) has been found helpful. These systems bias the receiver to a point of insensitivity at the time of the trans-

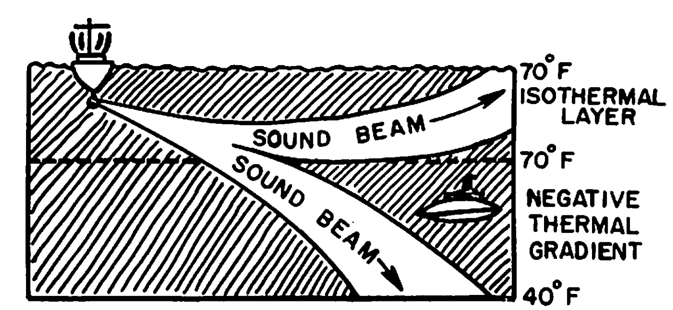


FIGURE 10—An isothermal surface layer above a negative thermal gradient produces beam splitting.

mitter pulse, and then allow the sensitivity to return gradually. Normally, this recovery would take place in less than a second, but if many reverberations are present these undesired echoes prolong the recovery time until the reverberations have diminished appreciably.

Correlation—A Look Into the Future

The present ultimate in establishing maximum range is reached when the returned echo is so weak that it blends with the inherent noise and can no longer be distinguished. But the mere fact that an echo cannot be distinguished does not mean that the echo is not there. The chief difference between a musical note and pure noise is that the musical note has quite definite characteristics such as pitch (frequency), timbre (quality) and intensity (loudness), whereas pure noise represents a random collection of pulses bearing no "pattern" relationship to each other.

If a way could be found to reduce or eliminate those pulses bearing no pattern relationship and to retain those sound pulses having certain predetermined characteristics, it is evident that the noise level—as such—would no longer be the final limiting factor.

This principle is called "correlation". It is the subject of much investigation at present. Its solution may greatly multiply the effectiveness of the Sonar Systems of the future.

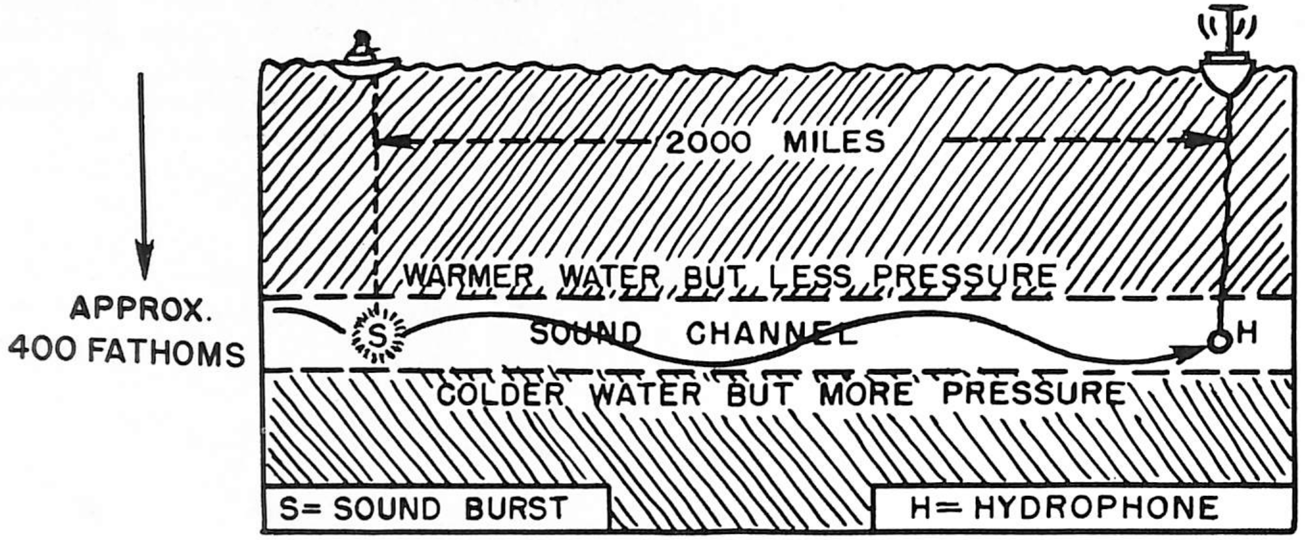


FIGURE 11—A sound channel is formed when the downward refraction due to higher temperature is balanced by the upward refraction due to greater pressure.

SS/SV-1 CONSOLE SWEEP TROUBLES

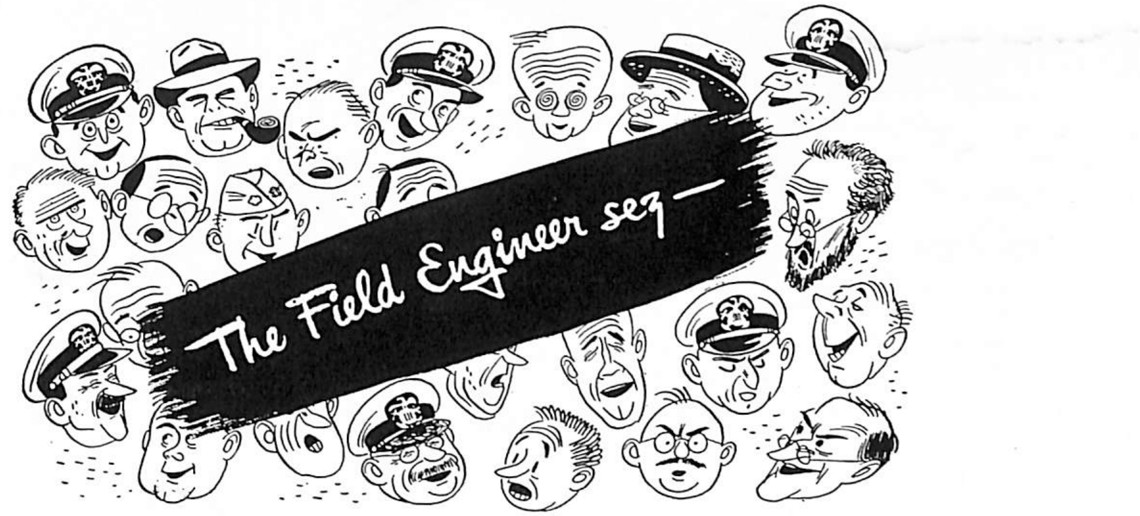
Occasionally the trouble is encountered where *no* sweeps appear on the "A" scope at any setting of the range switch and the "range error warning" light glows. Throw the IFF switch "ON". If a sweep appears and the "range error" lamp goes out the trouble will probably be found in relay contacts K1.1 on the IFF chassis.

To trace this through the indicator console schematic an error in the schematic will have to be corrected as follows: on the schematic, to the left of the range unit chassis, D–156657, will be found the sync cable from the transmitter running up and going into the left of the IFF chassis, D–152660, at J1.

J1 is connected to a movable contact on IFF–K1.1 and when the IFF switch is "OFF" this arm is down and J1 is connected directly to J5, just below. On the schematic the cable from J5 appears to be hanging in thin air. With a pen continue the line straight down to meet the sync cable line going to J1 on the range unit, D–152657 and show *no* connection where it passes over the IFF sync cable.

Now, as can be seen, the sync when IFF is "OFF" goes directly to the range unit and the "A" "B" range sweep generator via the lower contact of K1.1. When IFF is "ON" the sync goes through the upper contact of K1.1 to the sweep delay mbvtr, sync pulse gate, back to J5 and thence to the range unit and the "A" "B" range sweep generator.

This error applies to the SV–1 schematic as well as the SS.



MODEL OKA–1

USS George (DE697)

A field engineer was requested by the electronics shop, Puget Sound Naval Shipyard, to assist in the final check-out of the OKA–1 system. Follow-up checks on the shop's work revealed that although the OKA–1 met the calibration requirements stated in the instruction book, the equipment was not performing satisfactorily.

Further investigation showed that it was possible to have some of the computing components out of adjustment, while still permitting the equipment to be calibrated; thus the two check points indicated by the instruction book were computed perfectly, yet proper operation was not achieved. For example: it was found that the computed target depression angle (cEtq) checked perfectly at 0 degrees and 30 degrees, the two values suggested for calibration, yet the computer would not solve correctly for any other values. Also, it was found that the refracted depression angle (Eqr) checked perfectly at 5 degrees and 15 degrees, the two calibration values, but did not solve correctly for any other values. Consequently the dependent computations of horizontal range (Rhq), depth stylus velocity (Vz), and generated depression angle rate (dcEq) were all in error except at the calibration values.

Assistance was then given to shop personnel in readjusting the necessary components so that they would provide computations that lay well within the tolerance brackets throughout the usable range of values. It was found that the instruction book was vague on some of these adjustments. This necessitated some experimentation in order to perform the calibration. After recalibration, it was noted that the adjustments associated with the depression angle rate servo system operated through a more satisfactory range.

BURTON M. KUCK

TCS–15

U.S.S. Perch (ASSP–313)

The external loading coil of this TCS equipment, when adjusted for optimum loading of the transmitter, was found to so far detune the input to the receiver as to cause a severe loss in signal on the majority of the operational frequencies. The antenna system in use, as well as the other antenna systems on board, checked normal. The substitution of an RBS receiver for the TCS receiver resulted in a loss also but demonstrated that, because of higher gain in the RBS receiver, the loss was not great enough to prevent normal reception. Readjusting of the loading coil on reception each time a transmission was terminated, showed that optimum reception with the TCS could be obtained but at a loss of operator efficiency. Therefore the difficulties are purely operational as full signal can be obtained on RECEIVE by adjusting the loading coil between transmit and receive in each transmission.

As the TCS is intended for standby only, it is recommended that another receiver be used in place of the TCS receiver. The addition of a variable condenser of about 100 micro-microfarads maximum in series with the antenna lead to the receiver and on the receiver side of the antenna relay is suggested, if operation with the TCS receiver is desired. This would tend to retune the system to optimum on receive.

—RAYMOND W. FISHER

maintenance of
ANTENNA ASSEMBLY AS-393(XN-1)/BLR)

The following information regarding the maintenance of the AS-393(XN-1)/BLR antenna installation was submitted by the Philadelphia Naval Shipyard.

Several failures of the antenna AS-393(XN-1)/BLR have been noted at the Philadelphia Naval Shipyard. In three cases, *USS Cutlass (SS-478)*, *USS Tusk (SS-426)*, and *USS Clamagore (SS-343)*, low insulation resistance in the pyrotenax lead was found to be cause of the failure. Replacement of the pyrotenax lead corrected the deficiency.

However, in the cases of *USS Sea Leopard (SS-483)* and *USS Cobbler (SS-344)*, although the pyrotenax lead was faulty, the trouble was more extensive. The complete antenna system, when checked with a megger, showed very low insulation resistance. Removing the antenna from the RG-81/U showed that both the antenna and the lead had very low insulation resistance, the lead being 500 ohms and the antenna less than 100,000 ohms. Examination of the antenna revealed that an attempt had been made to solder the "transmission line" to the "stub" resulting in cold solder connections. In the antenna for the *USS Cobbler*, the solder had dripped across to the "sleeve" and caused a dead short. From the foregoing evidence, it would appear that when trouble developed in the AS-393(XN-1)/BLR system, the antenna was regarded as the seat of the trouble and not the pyrotenax line.

In order to facilitate repairs and also minimize the possibility of damaging the antenna, the following procedure is recommended (reference should be made to BuShips Drawing RE 66F 584B, Sheets 1-3; Antenna Assembly Type AS-393/BLR, Snorkel Mounting, Assembly and Details):

1—If the megger test of the AS-393(XN-1)/BLR indicates low insulation resistance, open the RG-81/U to RG-17/U adapter.

2—Megger the RG-81/U and the RG-17/U transmission lines separately.

3—If the low resistance is in the RG-81/U lead, remove the antenna AS-393(XN-1)/BLR from the snorkel hat and take it to a shop or work space.

4—Remove the polyethylene mound and clean out the petrolatum, washing the petrolatum off the antenna. Care should be observed in handling the antenna because the "subassembly" is easily damaged.

5—Remove the antenna from the "bottom plate" using a wrench on the flat portions of the "supporting stem." The "supporting stem" is threaded into the "bottom plate" and the flats are provided for a wrench.

6—After the antenna AS-393(XN-1)BLR is removed, the RG-81/U can be repaired or replaced. Caution should be observed. The magnesium oxide dielectric of RG-81/U is extremely hygroscopic, and prolonged exposure of unprotected ends of RG-81/U to the air will result in a lowering of the insulation resistance. In order to prevent this, the RG-81/U cable should be sealed as soon as it is cut.

7—No pressure or twisting should be applied to the "subassembly" under any condition, nor should any attempt be made to thread the antenna into the "bottom plate" until the replacement of the RG-81/U is completed.

The presently installed Antenna Assembly AS-393(XN-1)/BLR, as discussed above, has been redesigned. The new Antenna Assembly AS-393/BLR is under procurement. This new antenna employs the same antenna proper assembly, but differs in that a pressure-proof coaxial adapter connector UG-685/U, for connecting an RG-17/U coaxial cable directly to the antenna, replaces the short RG-81/U pyrotenax lead. This adapter connector is mounted directly to the underside of the "bottom plate" of the antenna assembly. Figure 1 shows the new Antenna Assembly AS-393/BLR including the UG-685/U adapter connector. Figures 2 and 3 are the cable fabrication chart for use with the adapter connector UG-685/U.

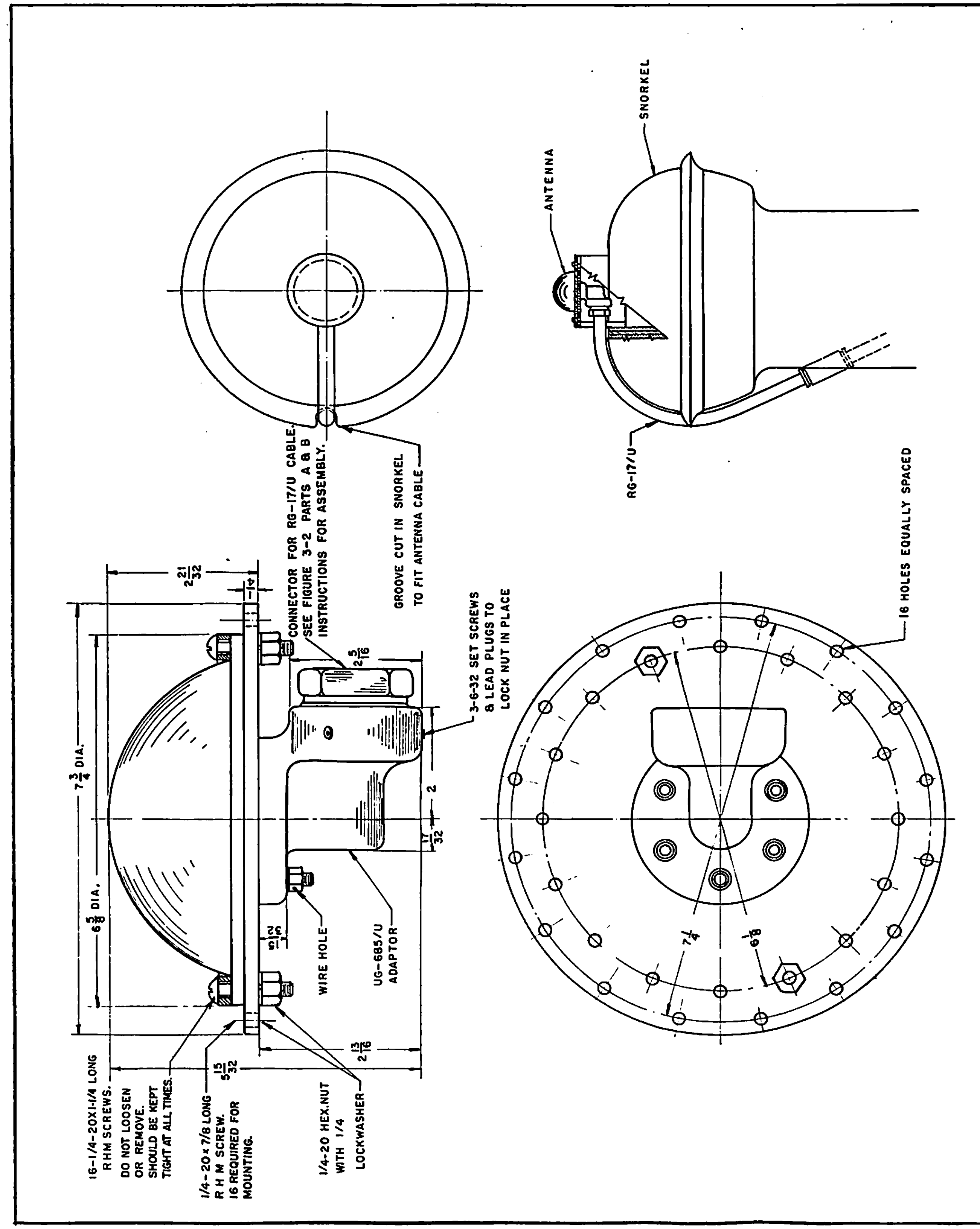


FIGURE 1—Outline and mounting dimensions.

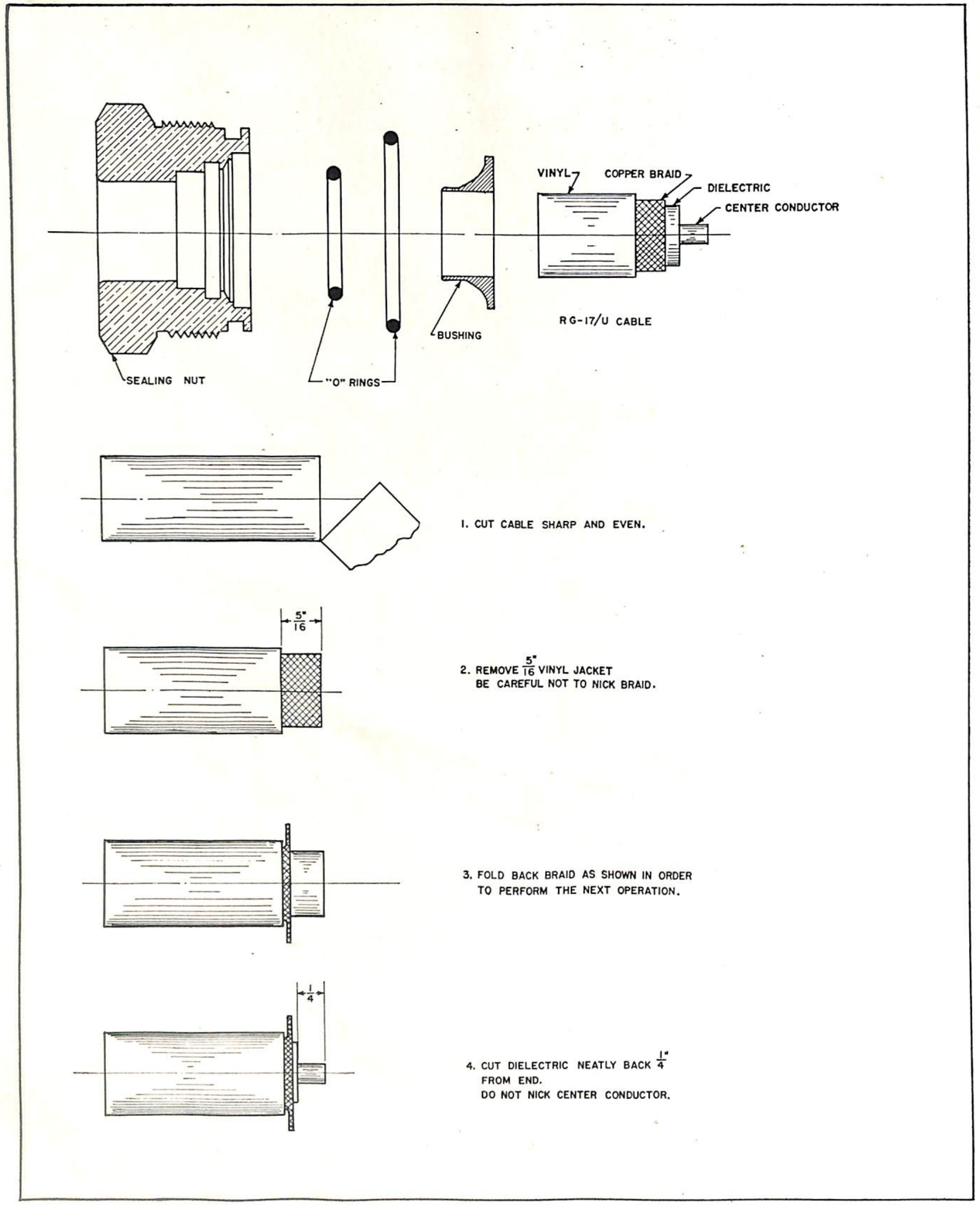


FIGURE 2—Instructions for assembly of RG-17/U cable.

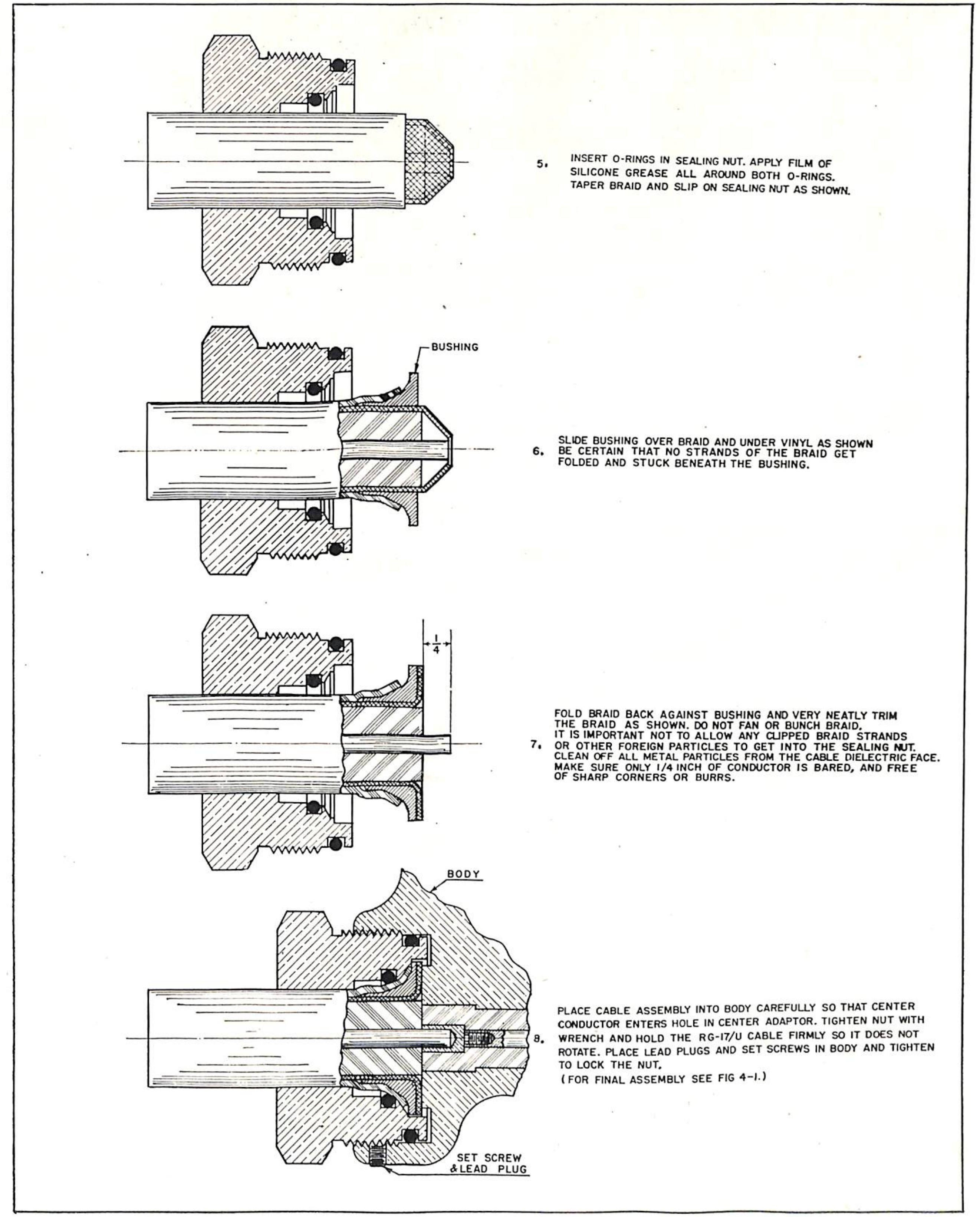
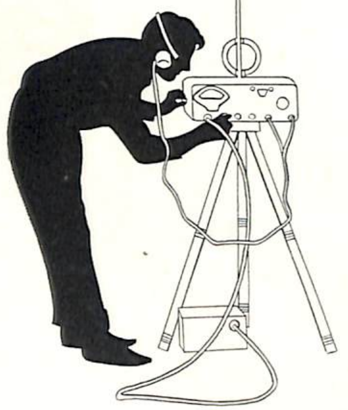


FIGURE 3—Instructions for assembly of RG-17/U cable.

TENTATIVE PROCEDURE FOR CONDUCTING INTERFERENCE SURVEYS AT NAVAL SHORE ESTABLISHMENTS



by
William A. Ritz
Electronic Shore Division
Bureau of Ships

Introduction

The Electronics Shore Division under the direction of Captain Hedley B. Morris has been vigorously engaged during the past several years in conducting an electronic interference reduction program at Naval Shore Communication Stations and Naval Air Stations. That this comprehensive program has been eminently successful in improving Naval Communications is attested by reports concerning the hundreds of sources of electronic interference eliminated to date, and the prevailing highly satisfactory receiving conditions at many Naval Shore Stations where previously high electronic interference levels had created intolerable operational conditions.

The Bureau of Ships' electronic interference reduction program based on the highly beneficial results obtained, has been continually expanded to encompass more and more Shore Activities. Acting on the known fact that electronic interference once reduced at a Naval Shore Station can be held in check only by continual vigilance and persistent efforts, the Bureau of Ships has established the program on a permanent basis as an integral part of the Communication plan, functioning as a combined electronic interference reduction and preventative program.

As an integral part of the Bureau's program, electronic interference field surveys are continually in progress at Naval Shore Stations. Most of these surveys to date have been conducted by engineering services contractors, operating under Navy Contracts. The engineering services Contractor's personnel, all experienced engineers, specializing in the measurement and elimination of electronic interference, have as a phase of their duty during surveys at Naval Shore Stations, provided instruction to assigned personnel at these activities, in the techniques of locating, measuring, and eliminating sources of electronic interference. Improved measurement techniques and methods of compiling and reporting interference data have been developed as a result of these many surveys.

The major problem involved in the measurement of electronic interference has been to obtain a true picture of a given interference condition. This difficulty stems from the highly complex nature of the electrical disturbances which constitute electronic interference. These electrical disturbances vary so greatly and so rapidly in phase, amplitude, frequency distribution and rate of repetition that they are often exceedingly difficult to measure. It is therefore a difficult task to select from the many measurements that might be made, the ones that are most significant for the desired purpose. It is comparatively easy to obtain numerical values of electronic interference, but the difficult part lies in understanding just what measurements mean. This can be particularly confusing, especially when analyzing the results of multiple electronic interference surveys at Naval Shore Communication Stations and Naval Air Stations, unless the measurements are obtained in a standard manner, using identical measuring instruments and techniques. In order to clarify these survey techniques and the method of reporting the results obtained, so that cognizant personnel in the various Naval Districts may conduct electronic interference surveys in the most effective and efficient manner, the following tentative procedure for conducting electronic interference surveys at Naval Shore Establishments has been developed by the Bureau of Ships, and is printed here, as promised on Page 16 of the January 1952 Electron magazine.

General

A radio interference survey at a Shore Station is conducted for the following reasons:

1—To locate, wherever possible, all sources of electronic interference.

2—To determine the method by which the interference reaches the receivers affected.

3—To determine the best practical method for the reduction of the interference, within the limits of the present state of the art, so that appropriate action may be taken.

It should be noted that all electrical units or items of equipment do not produce radio interference energy, but unless this energy is transferred, by some means, into circuits used for the reception of information, it does not constitute radio interference. In the absence of any energy transfer, the radio interference energy becomes merely a harmless voltage, current, or electromagnetic field.

A scientifically conducted radio interference survey, designed to secure meaningful and interpretable results, must be carefully planned. Any necessary schedules should be arranged and coordinated with all participating units and personnel well in advance of the proposed tests.

In planning for, and carrying out, the procedure outlined below, it is suggested that full use be made of station maps. This will enable the survey personnel to correlate the sources of interference and the affected receivers and antennas.

It is expected that remedial measures will be applied, during the course of the survey, insofar as is practical, whenever discrepancies are noted, or whenever the need for radio interference elimination arises.

Survey Procedure

1—Make a List of Equipment installed

At the location being investigated (control tower or communication center, a list should be made of all communication equipment (radio and radar receivers) installed therein. This list should contain model, type, serial numbers, and other identifying information.

2—Check the Electronic Ground System

The electronic ground system, (not the power circuit ground system), at any survey location should be visually inspected for good engineering practice. No other circuits should be grounded with the receivers. No braid of any kind should be used in any electronic ground system. The system should terminate at the nearest good earth ground and not at a steam radiator, gas pipe, water pipe, electrical conduit, or steel structural member. The electronic ground system should not be tied to the power circuit ground system.

3—Check All Antenna and Antenna Sites

A thorough visual inspection should be made of all antennas and antenna sites used by receivers at the survey location. Included in the inspection should be the following points of interest:

a—Proper physical construction and condition of all antennas.

b—Fences in the area.

(1)—Type.

(2)—Construction.

(3)—Materials.

(4)—Height.

(5)—Extent.

(6)—Ownership.

c—Power lines, telephone lines and telegraph lines.

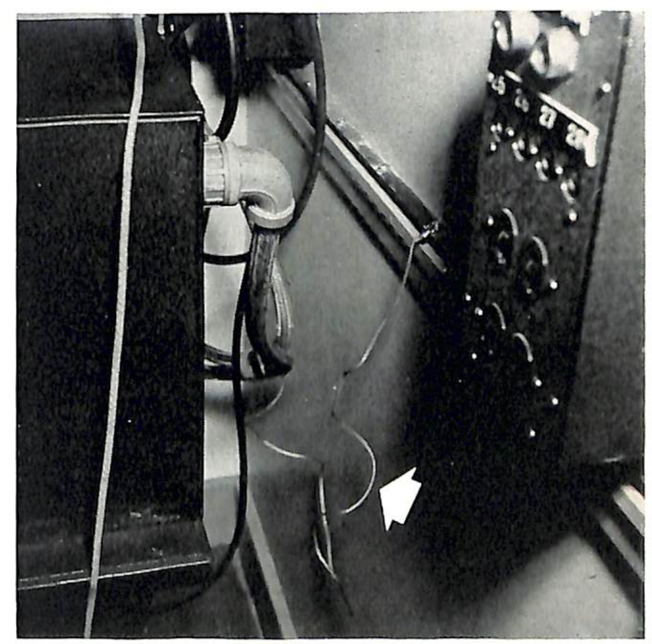
(1)—Type of pole or other support.

(2)—Height.

(3)—Number of lines.

(4)—System of pole grounding.

(5)—Transformers and other units.



A visual inspection of the electronic ground system will reveal obvious defects such as the use of braided looped wire.

Check for power lines and transformers in proximity to antennas.

(6)—Voltage on power lines.
(7)—Extent of lines.
(8)—Ownership.

d—Highways and roads in the area.
(1)—Distance from antenna.
(2)—Type of construction.
(3)—Number of traffic lanes.
(4)—Ownership or control of road.
(5)—Ownership of vehicles using road.
(6)—Amount of traffic on a 24-hour basis.

e—Railroads near the antenna.
(1)—Distance from antenna.
(2)—Number of tracks.
(3)—Type of train and locomotives running on tracks.
(4)—Extent of traffic based on a 24-hour period.

f—Buildings near the antenna.
(1)—Type of construction.
(2)—Size.
(3)—Ownership or control.
(4)—Special features such as:
(*a*)—Tin roofs.
(*b*)—Underground metal surfaces.
(*c*)—Lightning rods and cable.
(*d*)—Windmills.
(*e*)—Rotating machinery.
(*f*)—X-ray and diathermy units.
(*g*)—Other equipment that might cause interference.

g—Pipelines under the antenna.
(1)—Type of pipe.
(2)—Material carried by pipeline.
(3)—Depth underground.
(4)—Distance from antenna.
(5)—Extent of pipeline.
(6)—Ownership or control.

h—Lack of good engineering practice such as:
(1)—Underground shield on coaxial downleads.
(2)—Cracked insulators.
(3)—Painted insulators.
(4)—No weather guards on MHF whip antenna.
(5)—Dirty antenna insulators.
(6)—Antenna located so that direct radiation is received from radar antennas.
(7)—MHF antennas too close together.
(8)—Corrosion on towers or guy wires.
(9)—Loose, unused wiring near antenna.
(10)—Any others that may be noted.

4—Check All Antenna Downleads

A visual inspection should be made of all antenna downleads installed at the survey location.

Included in the inspection should be the following:

a—Type of wire or cable.

b—Lack of good engineering practice, such as:
(1)—Ungrounded shield on coaxial downleads.
(2)—Antenna downleads wrapped around insulators.
(3)—Downleads painted.
(4)—Downleads loose, not secured by clamps.
(5)—Improper cable connections at coaxial junctions.

5—Check the Type and Location of Filters Installed in Any Equipment listed in Paragraph 1 Above

The visual inspection should include a careful check of any filters that may be installed on any of the equipment located at the survey site. Complete information on each filter should be recorded.

6—Check the Aural Noise Level

If the activity being surveyed is a control tower, the inspection portion of the survey should include engineering observations on the general aural noise levels existing in the tower and the intelligibility of the received signals as heard by the inspecting engineer. It is not expected that measurements will be made.

7—Completion of Inspection

At this point, the inspection portion of the radio interference survey should be complete. Before proceeding further, all information and notes concerning the visual inspection should be assembled ready for inclusion in the final report. Corrective action taken by station personnel, action to be taken by station personnel, and additional recommended corrections should be included after each item which did not conform to good interference reduction practice.

8—Make Resistance Measurements on Electric Ground System

In order to check the quality of the electronic ground system, complete resistance measurements should be made. These measurements should be made by some standard method; and the information thus obtained should be included in the final report. One of two methods is suggested: either a low-reading megger-type instrument, or a Wheatstone Bridge may be used. In either case, complete information should be given regarding the method and the equipment used.

The d-c resistance, or the equivalent audio-frequency resistance, should not exceed 0.001 ohm between any receiver ground terminal and the

Check for the presence of metal fences in proximity to receiving antennas.

Aircraft hangar lightning rods and cable in the vicinity of receiving antennas.

point at which the electronic system enters the earth.

9—Check the Interference Coupling to Each Receiver

a—Through the power wiring.

The next step in the measurement portion of the interference survey is to check the levels of interference entering the receiver through the power wiring. This check should be made at the receiver power terminals. The measurements should be made in accordance with the procedures contained in Section (4) of the following instruction books:

(1)—NAVSHIPS 91196, Radio Test Set AN/URM-6.

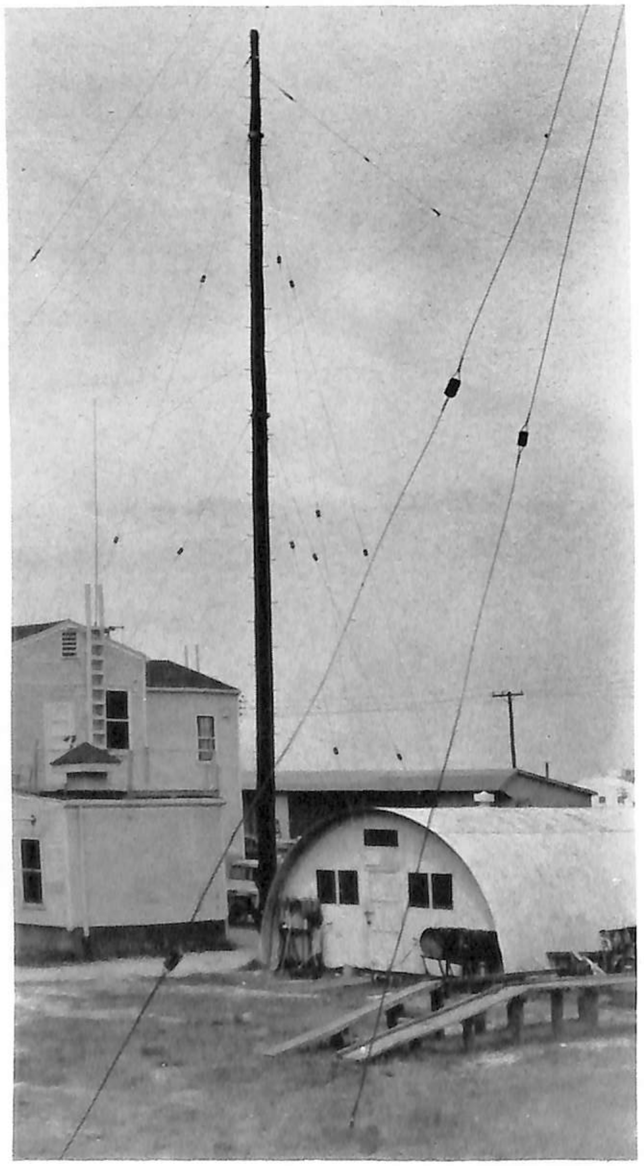
(2)—NAVSHIPS 91255, Radio Test Set AN/PRM-1.

(3)—NAVSHIPS 900,990, Noise Field Intensity Meter TS-587/U and TS-587A/U.

(4)—NAVSHIPS 91388, Radio Test Set AN/URM-17.

To insure that accurate information is obtained on the power line interference, curves of interference versus frequency should be plotted on a graph. This graph should show the average, quasi-peak, and peak values on the same sheet plotted as follows:

2-kc intervals from 14-30 kc
5-kc intervals from 30-50 kc
10-kc intervals from 50-100 kc
20-kc intervals from 100-300 kc
50-kc intervals from 300-500 kc
100-kc intervals from 500-1000 kc
200-kc intervals from 1-3 Mc
500-kc intervals from 3-5 Mc
1-Mc intervals from 5-10 Mc
2-Mc intervals from 10-30 Mc
5-Mc intervals from 30-50 Mc



Report all buildings with tin roofs located in proximity to receiving antennas.

Check for the presence of television receiving antennas in proximity to other receiving antennas as television receivers are a prolific source of radiation interference.

10-Mc intervals from 50-100 Mc
20-Mc intervals from 100-300 Mc
50-Mc intervals from 300-500 Mc
100-Mc intervals from 500-1000 Mc

In addition, other points should be plotted near any peaks or dips in order to insure accurate curves.

These curves will indicate what filtering, if any, will be required in order to reduce the conducted interference to an acceptable level. If the receiver has an internal power line filter, measurements should be made, if practical, to check the adequacy of the filter.

It is important to monitor the interference aurally at all times during the course of the measurements in order to obtain information which may later be used to identify and locate the sources of interference.

b—Through the control and audio wiring.

The next step in the survey is to measure the interference reaching the receivers by means of the control and audio wiring. These measurements should be made at the receiver terminals in accordance with procedures noted in Paragraph 9a above. The information obtained thereby should be presented in graph form as specified previously.

c—Through the antenna lead-in.

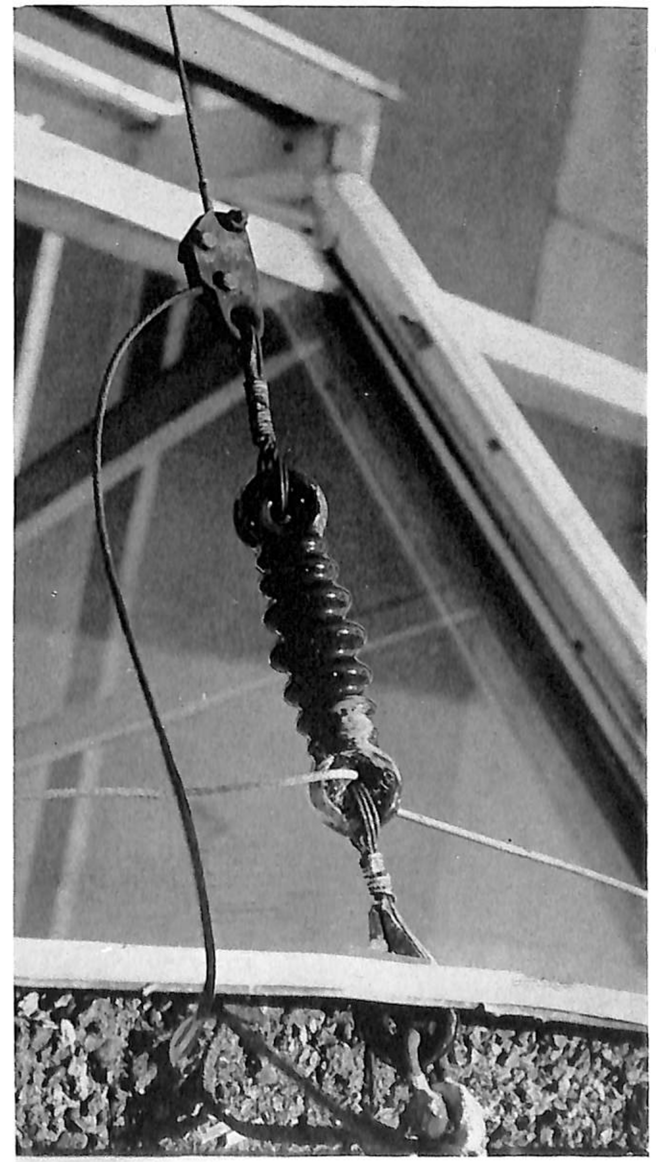
In order to make the next measurements required on the survey, the following steps should be taken:

(1)—Disconnect the antenna lead-in from the receiver.

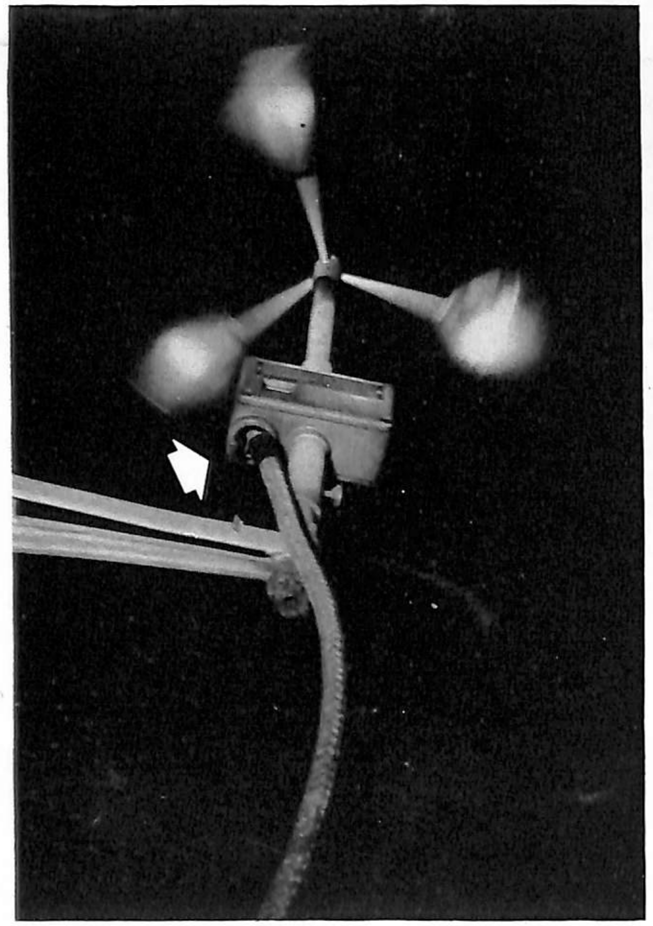
(2)—Disconnect the lead-in from the first normally available jack inside the building (antenna patch panel).

(3)—Ground the patch panel end of the lead-in.

(4)—Connect the test equipment to the receiver end of the lead-in and make required measurements.



Report all painted insulators.



Report all improper cable connections such as this taped anemometer cable.

Particular care should be exercised in accomplishing Step (4). It is important that the correct accessories are used, and that complete information on all test equipment and accessories be included in the data.

Sufficient spot checks should be made, throughout the range of frequencies covered by the test equipment, to determine the need for complete measurements. Any indication of leakage or coupling into the cable should be cause for complete measurements. The data resulting from the spot checks may be presented in tabular form, but the data derived from complete measurements should be presented in the form of curves, with values plotted at the intervals and over the frequency range specified in Paragraph 9a above.

d—Through the antenna system.

To make the final checks on the receiver, connect the test equipment to the first normally available jack inside the building (antenna patch panel), and measure the interference present on the antenna and antenna downlead. Plot curves of interference level (throughout the range of the antenna) as specified in Paragraph 9a above. In every case, the radio interference levels existing on the *operating frequencies* of the particular receiving activity should be measured and reported along with the measurements on other frequencies.

10—Locate All Sources of Interference

By means of the measurements specified in Paragraph 9 together with aural monitoring done during those measurements, information should have been gained which would assist in pin-pointing all sources of interference. If the interference is conducted, the source may be located more easily by laying out the immediate area into sections according to power line installation. By checking each section in order, the location of the interference source may be determined. If the interference is radiated, three-point triangulation may be used to determine the area in which the source lies. When the location has been narrowed down to a small area, the loop probe may be used to determine the offending equipment.

11—Data Required on Interference Sources

Each source of interference, except those subsequently listed, should be described completely by means of the following information:

a—Date measurements were made.

b—Time measurements were made.

c—Description and location of source.

(1)—Manufacturer's nameplate data.

(2)—Indication of actual use.

(3)—Cognizance of source.

(4)—Distance and bearing from nearest receiving antenna on which the interference was noted.

d—Curves of interference versus frequency, obtained before suppression is applied. Graph should show the average, quasi-peak and peak values on the same sheet, plotted as follows:

2-kc intervals from 14-30 kc
5-kc intervals from 30-50 kc
10-kc intervals from 50-100 kc
20-kc intervals from 100-300 kc
50-kc intervals from 300-500 kc
100-kc intervals from 500-1000 kc
200-kc intervals from 1-3 Mc
500-kc intervals from 3-5 Mc
1-Mc intervals from 5-10 Mc
2-Mc intervals from 10-30 Mc
5-Mc intervals from 30-50 Mc
10-Mc intervals from 50-100 Mc
20-Mc intervals from 100-300 Mc
50-Mc intervals from 300-500 Mc
100-Mc intervals from 500-1000 Mc

In addition, other points should be plotted near peaks and dips in order to insure accurate curves. The following information should be included on the graph:

(1)—Title.

(2)—Distance from source to location where measurements were made.

(3)—Description of exact location at which measurements were made.

(4)—Specific test equipment and accessories used in measurements.

(5)—If conducted interference, state type of wiring serving the source.

(6)—Date measurements were made.

(7)—Signature of engineer making measurements.

e—Notation, based on weather conditions, regarding present or predicted atmospheric noise.

f—Photograph(s) showing details of the interference source before suppression methods, or components, are applied. These would not normally be required on common sources such as fluorescent lights, telephone equipment, business machines and ignition systems.

g—Corrective measures.

(1)—Details of suppression methods applied.

(2)—Recommendations in detail as to further corrective action.

(3)—Explanation of failure to take corrective action.

h—Sketches or circuit diagrams giving values and types of components, or items, used in reducing the interference caused by the source.

i—Curves as in Paragraph 11d above, with data taken after corrective measures have been applied (if any were applied).

12—Interference Caused by Ignition

In the event that vehicle ignition interference (except as noted below) is recorded at such locations as control towers, communication centers, and antenna farms, the following information shall be included in the report:

a—Distance from measurement site to nearest road, highway, parking area, apron or ramp.

b—Number of traffic lanes or parking spaces.

c—Ownership of vehicles using the road.

d—Amount of traffic based on a 24-hour period.

All plane-handling equipment, crash vehicles, emergency power units, and other such sources of ignition interference are to be listed separately with the following information supplied on each unit:

a—Complete manufacturer's data including engine number.

b—Distance to the nearest active receiving antenna.

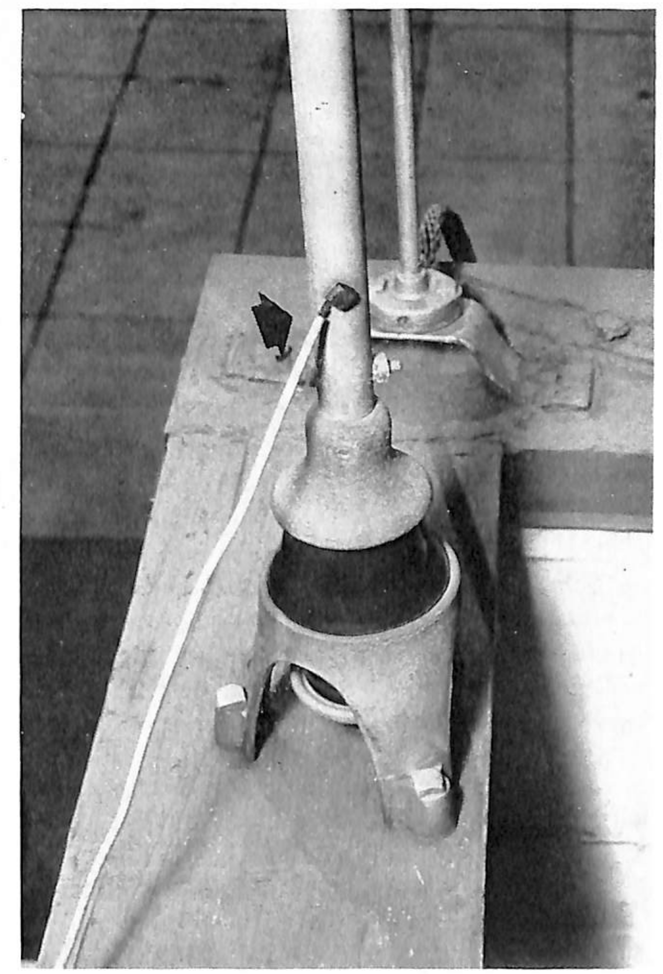
c—Type and extent of interference suppression applied, if any.

d—Indication of the extent to which the unit interferes with communications (spot checks on frequencies in the range of interest).

13—Interference Caused by Non-Navy Transmissions

Transmitters located outside the Naval Activity being surveyed may cause interference of one type or another. Such transmitters may be any of the following:

a—Commercial land communications.
b—Commercial marine communications.
c—Frequency-modulation.
d—Television.
e—Amplitude-modulation.
f—Amateur.
g—Civil Aeronautics authority.
h—Loran.
i—Coast Guard.



Report all examples of poor engineering practice such as this whip antenna with the downlead termination to a rusty bolt.

j—Army.
k—Air Force.

If interference is noted, the following information should be furnished on each transmitter involved:

a—Description and exact location of measurement site at the activity.
b—Complete description of interference and suspected causes.
c—Sky conditions (movement of cold front, warm front, or occluded front).
d—Tidal height referred to high and low tide values and average mean level (if in tidewater area).
e—Transmitter identification.
f—Latitude and longitude of transmitter site.
g—Operating frequency.
h—Power.
i—Type of emission.
j—Type of antenna and directivity.
k—Distance of transmitter from measurement site.
l—Fundamental field intensity.
m—Second harmonic field intensity.
n—Third harmonic field intensity.
o—Date measurements were made.
p—Remarks as necessary.

Technical information concerning commercial transmitters, and measurable signals thereof, may be obtained from any office of the Federal Communications Commission.

14—Make a Noise Level Recording

A 24-hour recording of noise level should be made at such sites, and on such frequencies, as may be specified by the Bureau of Ships or the Industrial Manager.

15—Obtain Data for a Noise Level Contour Map

At such activities as may be determined by the Bureau of Ships, or the Industrial Manager, noise levels should be plotted in contour form on a separate station map and included in the report. This map may be a photostatic reduction, but the size should not be so small as to render the information undecipherable.

16—Assemble Data in Final Report Form

All information resulting from this survey should be prepared in final form for transmission to the Bureau of Ships (Code 910) in accordance with established procedure. If the survey has been conducted by Navy personnel, it is desired that fifteen (15) copies of the report be forwarded to the Bureau. If the survey has been conducted by contract engineers, the reports should be submitted as specified by the applicable contract.

It is expected that the security classification, engineering content, and such other matters, will be approved by the Industrial Manager. Only when the engineering data is complete and presented in a form suitable for forwarding to the Chief of Naval Operations, Bureau of Aeronautics, Bureau of Yards and Docks, and other departments within the Department of Defense, should the reports be approved for transmission to the Bureau.

If a survey is conducted on an air station, communication station, remote receiver location, or in a large building, the formal report should be submitted. This type of report should contain the following elements:

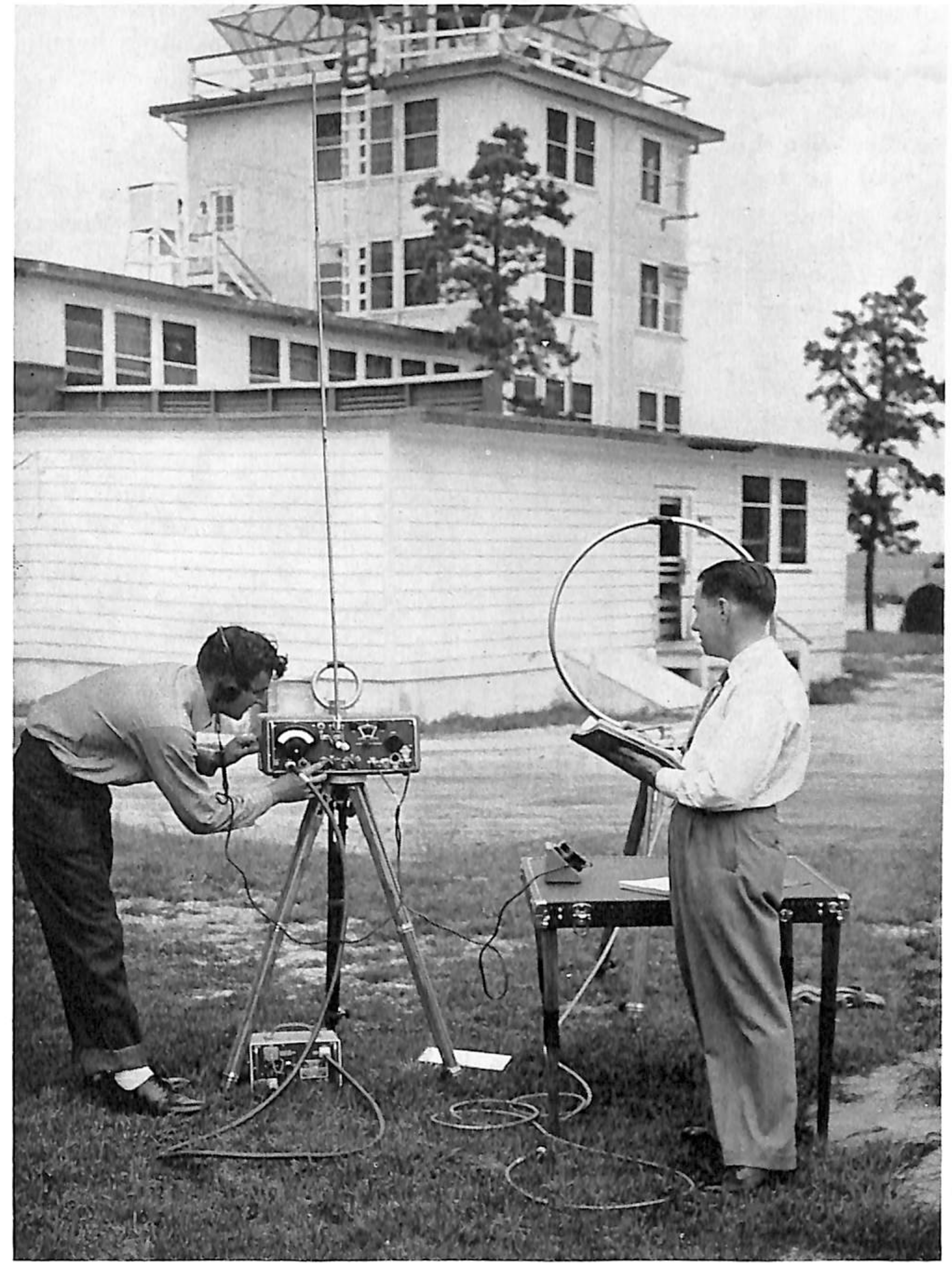
a—Title Page.
(1)—Subject of report.
(2)—Number of report (optional).
(3)—Name of organization for whom report is made.
(4)—Name of organization submitting the report.
(5)—Date.
(6)—Signature of approving officials.
(7)—Other statements required by Navy Security Manual.

b—Distribution List: (separate page).
(1)—Number of report.
(2)—Organization or individual receiving report.
Note: This page is to be used for all reports classified "Confidential" and higher.

c—Letter of Transmittal: (Separate page).
(1)—Authorization—references to all documents bearing on the contents of the report.
(2)—Purpose—brief statement of the object of the report. Any assumptions should be stated.
(3)—Scope—a statement of the degree of comprehensiveness of the report: what considerations are included and what have been excluded.
(4)—Acknowledgments—the personnel engaged in the work covered by the report may be listed; assistance from all cooperating agencies and parties should be mentioned.

d—Table of Contents: (separate page).
A list in the order of appearance, of the divisions and subdivisions of the report together with their respective page numbers. Figures, tables, and material in the Appendix should be listed.

e—Summary: (separate page).



Measuring and locating sources of radiated electronic interference using the AN/URM-6 radio interference and field intensity measuring equipment.

(1)—Abstract—a boiled-down version of the entire report in the smallest possible space without sacrifice of clearness or completeness.
(2)—Conclusions—brief, concise statements, based on the facts revealed by the survey.
(3)—Recommendations — short statements concerning future work as a result of the survey.

f—Survey Procedure:
(1)—List of equipment.
(2)—Visual inspection.
(a)—Ground system.
(b)—Antennas and antenna sites.
(c)—Antenna downleads.
(d)—Filters.
(3)—Measurements.
(a)—Ground system resistance.
(b)—Interference coupling.
(4)—Sources of interference.
(5)—Other information.

This section of the report is devoted to a discussion of the work done on the survey. It should be sufficiently detailed to enable anyone at some future date to reproduce the measurements insofar as is possible. No information should be left out and no assumptions should be made. No general statements and meaningless phases should be used. FACTS ARE DESIRED. Adequate data should be presented with no inconsistencies. Correct references should be made to all material in the appendix.

g—Conclusions.

The findings and results of the survey should be presented in the order of their importance. The information presented in this section deals with the past and present; and must be drawn from unquestionable premises, and based on adequate data. In contrast to the information presented in the summary, the conclusions here should be detailed and explicit.

h—Recommendations.

The information presented in this section has to do with the future treatment at an activity. All improvements that are considered necessary should be presented in the order of their importance. In contrast to the brief statements in the summary, the recommendations given herein should be detailed and complete.

i—Appendix:

(1)—Graphs.
(2)—Tabulated data.
(3)—Diagrams and drawings.
(4)—Maps.
(5)—Recordings.
(6)—Photographs.
(7)—Copies of Data Sheets.

If the survey is of brief duration (trouble calls, "quickies", et cetera) a letter-type report may be submitted, provided the engineering content is satisfactory. This type of report should include the following elements listed above:

a—Survey procedure.
b—Conclusions (optional)
c—Recommendations (optional).
d—Appendix (applicable material).

NOTE: All electronic interference work on shore establishments should be reported to the Bureau by one form or the other.

AN/URM-25 DEFECTIVE WIRING

A recent Failure Report from the *U.S.S. Mountrail (APA 13)* to the Bureau of Ships reported a case of improper operation of a newly received R-F Signal Generator AN/URM-25. A routine check showed that all tubes were good, and no apparent cause for failure existed. After a short time, however, the set started to blow the line fuses.

Upon investigation, the source of trouble was traced to defective wiring. It was found that the lead supplying filament voltage to the audio compartment (this lead is encased in braid and is covered with transparent plastic insulation) had shorted out where the braid terminated in the audio compartment and had melted back the plastic insulation for five inches. This action also caused the insulation on the filament supply leads in the power supply to melt and short all the wires served together leading to the four-prong connection plug. It was also found that the serving twine was so tightly bound around the wires that the soft plastic insulation was severed in many places.

The Bureau of Ships suggests an inspection of all braided leads covered with plastic insulation be made upon receipt of the signal generator and approximately quarterly thereafter. Particular attention should be given to braid terminations, melted plastic insulation and tightly bound serving twine.

This situation has been brought to the attention of the manufacturer and modifications are being made to prevent recurrence of the aforementioned unsatisfactory conditions. An insulating heat resistive sleeving is being substituted for the plastic insulation. A new type of plastic lacing cord is also being used which will not cut the insulation.

The Index to Volume 6 in the December 1951 ELECTRON covers the period July 1950 to December 1951, numbers 1 through 18 respectively. The articles are listed alphabetically and by classification according to the issue number (inside front cover) and page. For instance an article that is listed as 16-11 is on page 11 of the number 16 (October 1951) issue. Starting with the January 1952 ELECTRON each new volume will cover one calendar year.

Letters to the EDITOR

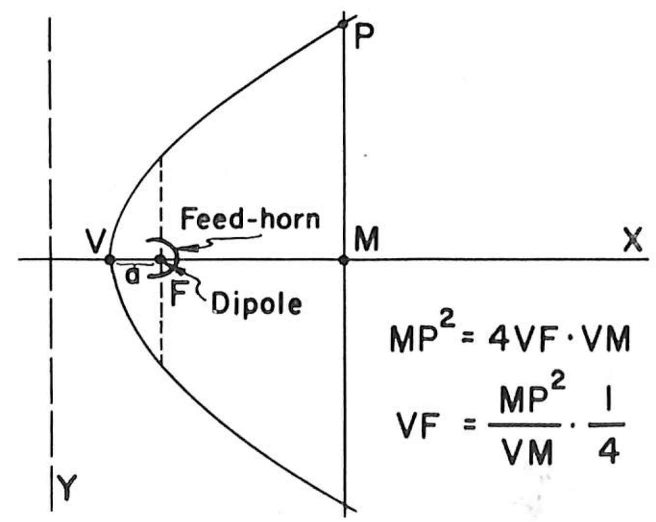
Editor
BuShips Electron
Sir:

Several times the problem of radiation pattern change, variation, etc. caused by slight changes of Feed-Horn positioning at the focus of a parabolic reflector has occurred on AS-120/TPS-1B antenna; therefore I desire answers to the following questions:

A radar parabolic reflector of the equation $(y\text{-}k)^2 = 4a\,(x\text{-}h)$ is fed by a horizontal dipole surrounded by a parabolic reflector of the equation $(y\text{-}k)^2 = -4a(x\text{-}h)$, both axis parallel to the x axis as per sketch below:

a. Would the distance VF be measured to the center of the dipole or to the edge of the feed-horn?

b. Frequency is in the Lk band. What effect on the radiation pattern does moving the feed-horn and dipole up or down on its y axis cause?



$$MP^2 = 4VF \cdot VM$$

$$VF = \frac{MP^2}{VM} \cdot \frac{1}{4}$$

c. If the feed-horn is moved angulary along the y axis (i.e. dipole held fast at focus and the horn rotated up or down on the y axis) would the center of the beam as reflected from the large parabola be raised up and down, if so, how much.

L. C. H.

The specific answers are as follows:

(a) The distance VF, according to the enclosed sketch, is known as the focal length of the parabola and is measured to the center of the dipole.

(b) There may be a slight change in gain between the side lobes and the main desired lobe or the main lobe may be decreased. Further, there may be a shift of the main lobe. This is a very general question as are the following and a specific answer cannot be given.

(c) If the fud or dipole is held constant and the parabolic reflector tilted upwards or downwards, the beam shift will be affected correspondingly. The amount of tilt of the reflector will determine the amount of shift of the beam.

Normally, a parabolic dish will have a definite focal distance when manufactured. When a fud or dipole is placed at this stated focal point and free-space patterns taken, it may be found that optimum conditions will be obtained at a focal point slightly more or less than this distance. To restate, the main parameters to consider in dealing with parabolic reflectors and which will have to be varied to obtain desired conditions are:

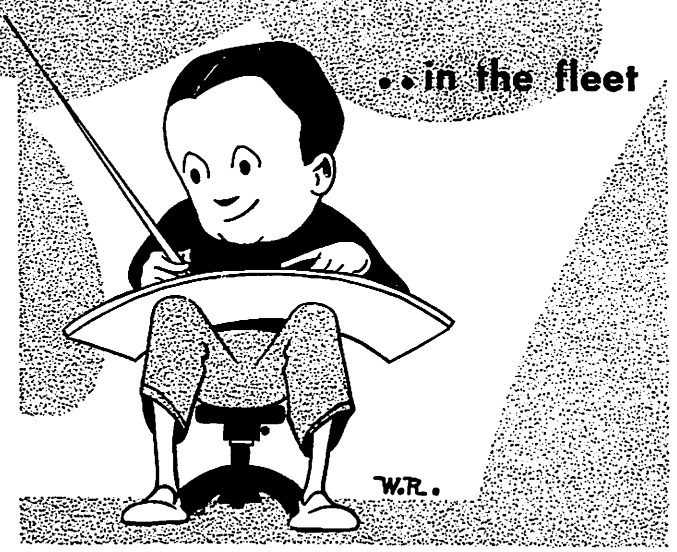
(1) The focal distance.
(2) Length of dipole.
(3) Distance between dipole and parasitic reflector.

Editor

some notes on

ELECTRONIC RELIABILITY . . .

. . in the fleet



by
LCDR. F. G. SCARBOROUGH *and*
LT. D. W. TOMLINSON
Fleet Training Group
Guantanamo Bay, Cuba

Introduction

The Naval Operating Base at Guantanamo Bay, Cuba, has for many years been the scene of a large part of the Atlantic Fleet Training. Since World War II, the Fleet Training Group, Guantanamo Bay, which is a part of the Training Command, Atlantic Fleet, has coordinated exercises and furnished instructors for ships in training. All Atlantic Fleet battleships, cruisers, carriers, destroyers, most of the destroyer escorts, and some other miscellaneous small craft have their shakedown and refresher training at Guantanamo Bay, hence, in Guantanamo Bay, there is afforded an excellent opportunity to evaluate the strength of the fleet. The strength of any fleet has, in recent years, become increasingly dependent upon electronics both in performance and reliability. To observe the electronic reliability of fleet units in Guantanamo, is to evaluate the strength of one of the contributing factors to the operational readiness of the fleet. These notes are written in hopes that the facts presented here will benefit fleet planning by highlighting a current fleet weakness.

Since effective training depends upon a high electronic reliability the Chief of Naval Operations has, through the Chief of the Bureau of Ships and Commander Service Force, Atlantic Fleet, assigned civilian electronic technicians to the Ship Repair Unit, Guantanamo Bay. These men apply their skills when the ships have exhausted their capacities in electronic repairs. The civilian engineers work at night and over the weekends to avoid interfering with daily operations. It is "patching while the troops are marching".

In an effort to understand the inter-relations of the factors effecting the performance of search radar, considerable information obtained from the ships in training was examined. Most of the data available was qualitative in nature and did not lend itself to a quantitative analysis of the ships electronic performance. Some of the items were educational and practical background of the officer and enlisted personnel, age and estimated material condition of the equipment, vigorous pursuit of a preventive maintenance program, and the final evaluation of the Operational Readiness Inspection. The only data which produced any meaning was "days of operation" and the amount of electronic assistance required from the Ship Repair Unit. Since this data did seem useful it has been assembled and is presented here. By dividing the number of days a ship was in training with the Fleet Training Group by the man-hours of Ship Repair Unit outside help required, an index of electronic reliability was developed by types of radar and types of ships. These notes are written to show something of the electronic reliability as observed in Guantanamo both in continuous active ships and ships re-activated from the reserve fleets.

Data

The data presented below is recognized to be a limited sample. However, to wait until a larger sample can be obtained is to wait until the military importance of the results has vanished. In the seven-month period, 1 November 1950 until 26 May 1951, the following ships have been considered:

36 ships on continuous active duty
1 new ship in shakedown
31 ships re-activated from the reserve fleets

Since the new ship had new gear and had not been in "moth balls", it was considered as a continuous active duty ship. This number of ships has produced some reliable indexes, and some which may not be conclusive, though generally a guide of some value.

Table I covers the seven-month period and all the ships. It organizes the data by types of search radar. The index is the days of training divided by the number of man-hours of the Ship Repair Unit civilian engineers time devoted to the equipment, producing an index of *days of operation per man-hour of Ship Repair Unit work.* This index could be called an index of electronic reliability.

Comments on Table I

SA — In the continuous active ships, four of the equipments required no outside assistance. One equipment required eighteen Ship Repair Unit man-hours and thus reduced the index. A larger sample would probably produce a higher index.

SL — In the reactivated ships, five equipments required no outside assistance. One equipment required ninety-three and a half man-hours and thus drastically reduced the index. Since one out of six equipments was in such poor condition, the index is not considered significant. In the continuous active ships there was only one equipment and the index is meaningless.

SC — The continuity of data on the re-activated ships was satisfactory and the index is considered significant. There were insufficient continuous active cases to be considered significant.

SR–a — There were no reactivation cases and few continuous active cases. However, these few did not require outside assistance.

SR–6 — The indexes indicate poor reliability in both continuously active and re-activated ships. Most of the trouble centered around the antenna, and much of the Ship Repair Unit time was spent trying to improve performance by adjusting and cleaning the r-f section. The index is therefore of little consequence.

TABLE I

7-MONTH PERIOD (1 November 1950–26 May 1951)

EQUIP	Number	Re-activated Days Training	Ship Repair Unit Hours	Index	Number	Active Days Training	Ship Repair Unit Hours	Index
SA	13	439	88	5.0	5	117	18	6.5
SL	6*	192*	93.5*	2.1*	1*	29*	—	∞*
SC2, 3, 4, 5	6	203	29.5	6.9	3*	82*	9*	9.1*
SR–a					4*	130*	0*	∞*
SR–6	7	257	67	3.9	4*	95*	18*	5.3*
SG–1b	13	456	29	15.8	17	507	44	11.5
SG–6	7	269	14	19.2	7	181	7	25.8
SK	2*	78*	36*	2.2*				
SPS	5	213	8	26.6	15	479	67.5	7.2
SO					7*	83*	8*	10.4*
SU	7	247	28	8.8	4*	88*	2*	44*
SP	3*	103*	—	∞*	7	171	6	28.6

NOTE: Items marked * may not be significant.

SG–1b — The data is good and is generally uniform in all ships. This is one of the two cases in which the continuous active gear had a lower reliability than the reactivated gear. The only explanation offered is that the gear is relatively old and is used much of the time when ships are at sea. It may be wearing out.

SG–6 — The data is good and generally uniform. This equipment has one of the highest significant indexes or reliability. Yet the ships are not self sufficient for one month.

SK — The data is not considered significant since the sample is so small.

SPS–6 — In the continuously active ships one of the fifteen equipments required forty-four man hours which is considered unusual. If this equipment were eliminated the index would be raised to 18.9 which is probably near a true evaluation.

SO and SU — The continuous active ship indexes are not considered significant since the number of days is low.

SP — The reactivated index is not considered significant due to a very few equipments.

It must be borne in mind that no adjustment has been made for the supposition that the size ship will have an effect on reliability, i.e., an SG–1b on a CVB will normally prove more reliable on this basis than one on a DD, insufficient data existed for an analysis of type equipment on different classes of ships.

Table II, an accumulative tabulation of the data, was developed to evaluate the improvement in the reactivation work on ships from the reserve fleets. The periods selected were arbitrary and reflect no wave of mobilization nor any other time schedule. The indexes were developed in the same manner as in Table I.

Comments on Table II

The comments from Table I apply here also. In addition it is interesting to note that there is a definite improvement in the reactivation reliability index in data which is considered significant. The only exception is in the SG–1b. The difference between the 5½–month period and 7–month period is in the order of 7½% and probably has no meaning. It may be a reasonable assumption to say that Table II indicates that reactivation work is improving and ships are joining the fleet better able to sustain themselves electronically. Even so the indexes of electronic reliability are very low.

Table III was developed to evaluate the electronics reliability by ship types. It should be realized that the size of the sample in each type, with the exception of the DD class, is so limited that detailed conclusions drawn from the data should be viewed with considerable skepticism. The low index of reliability obtained by the reactivated CV and BBs can be attributed to the defects in the equipment when inactivated, many of which could have been corrected through adequate reactivation and test of the equipment. It is felt that continued operation of the vessels will bring them to the same index of reliability as the continuously active ships of those classes. The inability of the DD class vessel to maintain its own equipment for more than approximately one week indicates a real weakness in that class.

TABLE II

EQUIP	1 Nov 1950 to 1 Feb 1951 (3 Mos)		1 Nov 1950 to 16 Apr 1951 (5.5 Mos)		1 Nov 1950 to 26 May 1951) (7 Mos)	
	Reactivated	Active	Reactivated	Active	Reactivated	Active
SA	2.12	4.17	3.90	6.5	5.0	6.5
SL	1.18*	∞*	1.47*	∞*	2.1*	∞*
SC	3.40*	∞*	4.45*	9.0*	6.9	9.1*
SR–a	—	—	—	∞	—	∞*
SR–6	2.9	—	3.83	7.2*	3.9	5.3*
SG–1b	7.6	12.4	17.2	16.5	15.9	11.5
SG–6	9.5	∞*	15.5	∞	19.2	25.8
SK	—	—	6.5*	—	2.2*	—
SPS	∞*	2.4	9.6*	6.3	26.6	7.2
SO	—	9.13	—	9.0*	—	10.4*
SU	∞*	45.5	15.3*	44.0*	8.8	44.0*
SP	∞*	—	∞*	20.3	∞*	28.6

NOTE: Items marked * may not be significant

TABLE III

$$\text{Index} = \frac{\text{Equipment Days Training}}{\text{Ship Repair Unit Hours}}$$

CLASS	ACTIVE	REACTIVATED
Small Craft (AM, PC, PCS, ARS)	14	∞
APD	—	7.4
DE & EDE	7.7	5.8
DEC	—	1.0
DMS	∞	∞
DD	7.6	5.8
DDE	—	∞
DDR	13.5	—
CVE	—	26.2
CVL	∞	—
CV	∞	7.4
CL	∞	—
CA	—	31.5
BB	—	8.3

Discussion

TABLE I—It is painfully obvious that the electronic reliability in the fleet is at a very low level. Not one single piece of equipment is effective one month without help outside the ship. The only exception is SU radar on which the data is not considered significant.

A further detailed statistical study of this problem using data primarily accumulated for the purpose would produce some factual causes for the deficiencies in electronic reliability afloat. A representative sample could be obtained from destroyer types and the lessons learned there applied to larger units as well as to the destroyer classes.

The following points though based on experience are hypothetic:

1—One of the major causes for a lowering of the electronic reliability is the widespread lack of an effective preventive maintenance program. Many of the electronic failures are caused by the accumulation of simple minor derangements, none of which are individually vital. Dust and dirt are constantly noted to gather in such proportions as to short out and disable the equipment. Since tube failures are frequently progressive, many electronic failures from this cause could be intercepted by a preventive maintenance program.

2—Another of the important reasons the electronic reliability is low is the lack of an administrative organization and a lack of leadership. Few ships have a working administrative organization in electronics of bills, procedures, records and publications. There are no specific instructions and directives for electronics administration as there are in the Bureau of Ships Manual and USF 82 for engineering.

The leadership problem in electronics is most acute. The technical aspect of the work has an unfortunate effect on leadership. Probably the best answer is plain ordinary Naval discipline. Some officers feel that this problem of leadership is, in a large part, the key to electronic difficulties.

3—Another detraction to electronic reliability is lack of confidence and lack of knowledge of the capabilities of the equipment. Often a radar capable of reliable detection of air targets at one hundred (100) miles will be accepted when producing ranges of forty (40) miles. This satisfaction with less than optimum results, further imposes an unwarranted handicap on the operational performance of search radar.

4—Probably the greatest single item which lowers electronic reliability is the requests for technical assistance before the electronic men on board have exhausted their ability to fix the defective gear. The Ship Repair Unit engineers on one occasion responding to a call for assistance found the difficulty was a blown fuse. Such calls for outside help afford no training or development of the enlisted electronic ratings and they soon lose pride and desire to be self-sufficient.

5—Most often the blame for poor electronic reliability is placed on design. This is not true! Admittedly some few pieces of inferior design have reached the fleet, but the vast majority of the radars are well designed, well built, and well inspected before they ever reach the installation stage. The poor results lie in the laps of the operators and the maintenance men of the fleet.

These five items may not be a magic formula to cure all electronic ailments, but they will help a tremendous amount. Ships which have seriously applied themselves to correcting these faults, have impoved while in Guantanamo Bay.

TABLE II—There is, without any doubt, a marked improvement of the electronic readiness of the ships reporting for duty from the Atlantic Reserve Fleet. It is obvious the Reserve Fleet personnel have made a conscientious effort to improve and they have succeeded.

TABLE III—It is clear that the larger ships are more self-sufficient than the smaller ships. It is true that larger ships have more electronic ratings, but they also have more gear. Probably the answer is in the better organization and administration of electronics in larger ships where one officer can devote more of his time to electronics. In smaller ships there is often exchange of talent on particularly difficult problems, but that is only partially effective. The answer seems to be in better administration and leadership.

In all the discussion above, the term electronics has applied to search radar, but similar problems and results appear in the fire control radar, sonar gear, and communications equipment.

Conclusions

1—The ships are not electronically self-sufficient. The electronic reliability is very low.

2—The reactivation program is improving in electronics.

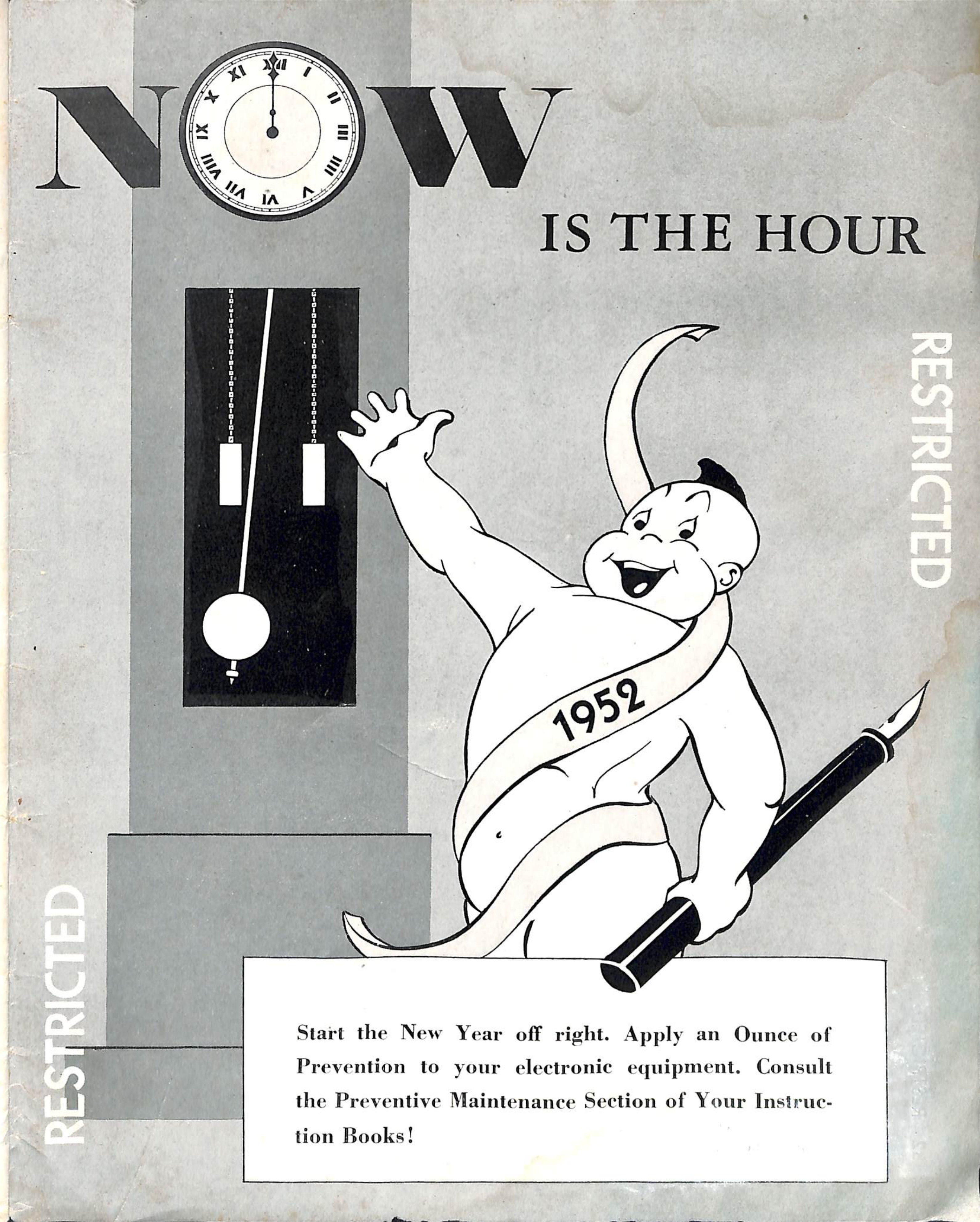
3—Larger ships have a higher electronic reliability.

SV MODULATION NETWORKS

The following is the Bell Telephone Laboratory's recommended method of measuring the mod.nets. and the tolerances to be expected:

MEASURE BETWEEN TERMINALS	MAXIMUM OHMS	MINIMUM OHMS
1 and 2	5.0	3.5
NOTE: When this measurement is made, Terminals 4 and 5 must be connected together—measures coil L3 in the filament circuit of the magnetron.		
3 and 8	2.30	1.60
NOTE: This measures the resistance of coils 9 and 10 of L1 in series with coil L4. L4 is the coil which usually fails.		
6 and 9	485	435
NOTE: Gives resistance of all secondary coils of L1 and L2 in series with the thermistor. The thermistors resistance varies inversely with temperature and this measurement should be made at 70 deg. F.		
7 and 9	360	310
NOTE: Same measurement as above but excluding the thermistor.		

SUBFLOT ONE Electronics Newsletter



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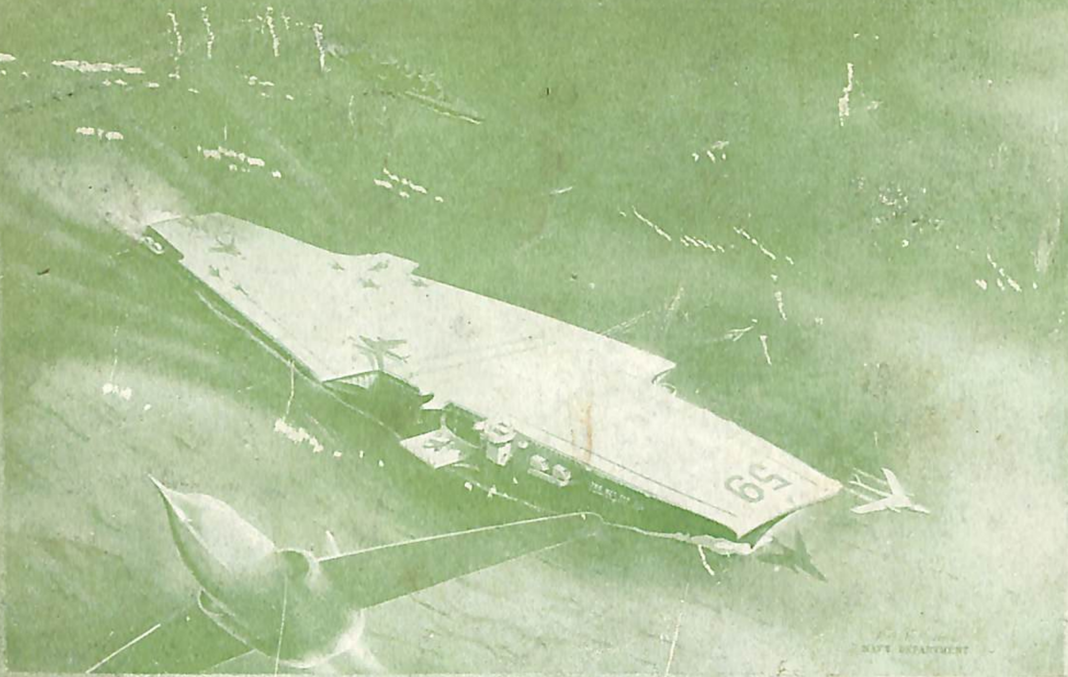

Artist's conception of our newest and largest "flat-top", the USS FORRESTAL (CVB-59) now under construction. Without Electronics, she could not fulfill her mission as one of our finest combatant ships.

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OUR PRIDE — OUR RESPONSIBILITY