

BUSHIPS

# Electron

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RESTRICTED



In This Issue  
**RADIO  
INTERFERENCE**

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BUSHIPS

# Electron

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OCTOBER · VOLUME 5 · NUMBER 4

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# AN ANALYSIS OF RADIO INTERFERENCE SOURCES

by

WILLIAM A. RITZ

*Electronics Shore Division, Bureau of Ships*

*This is the first of a series of articles on the broad subject of radio interference. The growing quantity and increased sensitivity of Naval electronic receiving equipment make this series of articles particularly appropriate.*

## General Considerations of the Problem

Radio reception since its inception has been degraded by interference of various forms.

Satisfactory radio communications between two points is dependent upon the receipt of a signal of adequate intensity from a distant transmitter, and upon the intensity of the prevailing radio interference at the receiver input.

Developments in the techniques of reception have, in recent years, lead to a considerable reduction in the levels of interference generated within the receiving systems themselves.

In most military communication systems and electronic control circuits, "man-made" interference is of major importance, as it is usually the sole limiting factor to their reliable and efficient operation.

The successful performance of the mission of the military forces depends on the adequacy, the effectiveness, and the reliability of communications systems and electronic control equipments. These systems are susceptible, in varying degrees, to radio interference, whether created by equipments of their own type, by other types of equipments employing electrical circuitry, or by natural disturbances commonly known as "static" phenomena.

Radio interference can and does destroy telegraph or voice communications, obliterates the desired indications on radar screens as well as the desired indications both aural and visual of navigational aids. Radio interference impairs the operation of electronic control circuits and causes random triggering of identification equipment and decreased signal-to-noise ratio, reducing the effectiveness of the aircraft identification system. The radio interference problem has increased in complexity in proportion to the number and complexity of modern communications and electronics control equipments in use by the military forces.

Radio interference has the same effect on the limiting of receiver operational efficiency as a poorly designed

antenna system, with high levels of radio interference preventing the reception of low amplitude signals. In the case of receivers designed to operate on a one-microvolt input signal, but due to the presence of a high level of radio interference at the receiver inputs, the receivers require a 10-microvolt input signal in order to deliver an intelligible output signal; this is equivalent to reducing the effective transmitter power in the ratio of 100. Specifically this means that a plane equipped with a 5-watt transmitter, capable of delivering a 1-microvolt signal to the receiving antenna, will require a 500-watt transmitter to deliver a 10-microvolt signal to the receiving antenna, on the basis that the signal level is directly proportional to the antenna current, and the antenna current is proportional to the voltage. Other factors may modify these figures slightly.

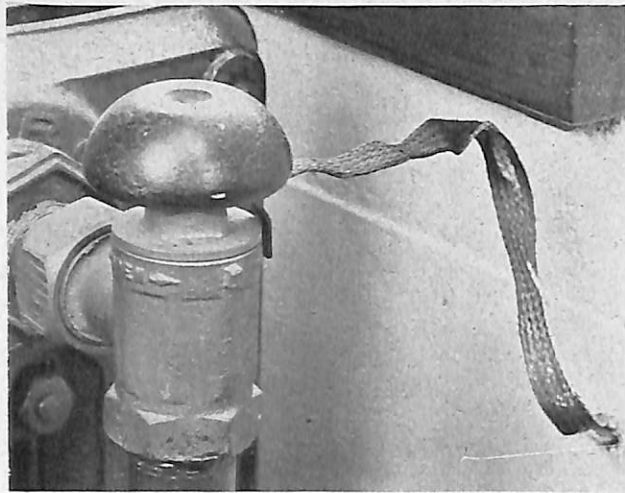
## Terminology and Characteristics of Radio Interference

If the radio interference consists of a succession of identical impulses having a uniform recurrence rate, the frequency components will possess spacing equal to the recurrence frequency with amplitudes determined by the form of each recurrent impulse.

Radio interference may be classified into four general groups as follows:

### 1—Random interference

This type interference consists of a number of elementary voltages not resolvable into discrete disturbances. Fluctuation noise produced in an electrical circuit is an example of random interference, and is caused when a quantity of elementary elements are superimposed with random relationship. Thermal noise in a circuit and shot noise in a tube are examples of fluctuation noise. In both cases the elementary events occur with such rapidity and irregularity that the wave trains set up in a receiver completely overlap and bear



How NOT to do it. Instead of constructing a proper grounding system possessing a low impedance to radio-frequency currents, here the main grounding bus bar to which all receivers terminate, has been painted and terminated to a radiator located on the second floor.

no relation to one another. Such noise has a continuous or smooth frequency spectrum due to the random occurrence of the elementary events.

#### 2—Impulsive interference

This type interference consists of well-separated impulses, distinguished individually, with the spacing and form of the impulses either regular, random or intermediate. In the intermediate type of impulsive interference, the degree of impulse regularity determines whether the interference may be termed quasi-systematic or quasi-random, and thereby whether the frequency distribution is more nearly that furnishing a line or a continuous spectrum.

#### 3—Recurrent wave interference

This type interference consists of a sharply tunable signal of single frequency such as produced by harmonic radiation from transmitters, local receiver oscillators, etc.

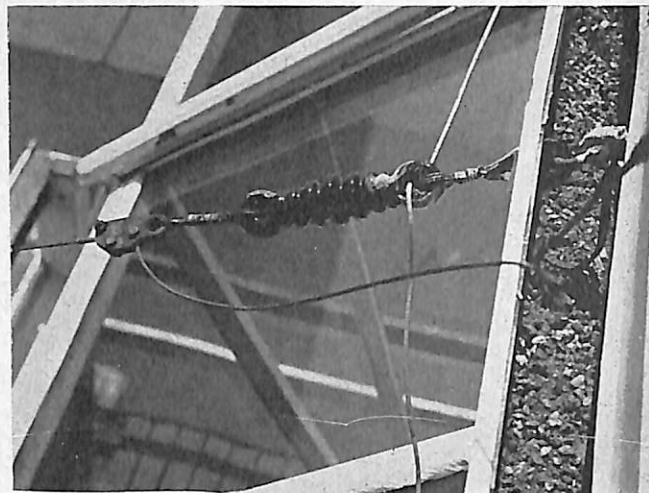
#### 4—Complex radio interference

This type interference consists of a combination of two or more types of interference such as random, impulsive and recurrent wave interference.

### Types of Radio Interference

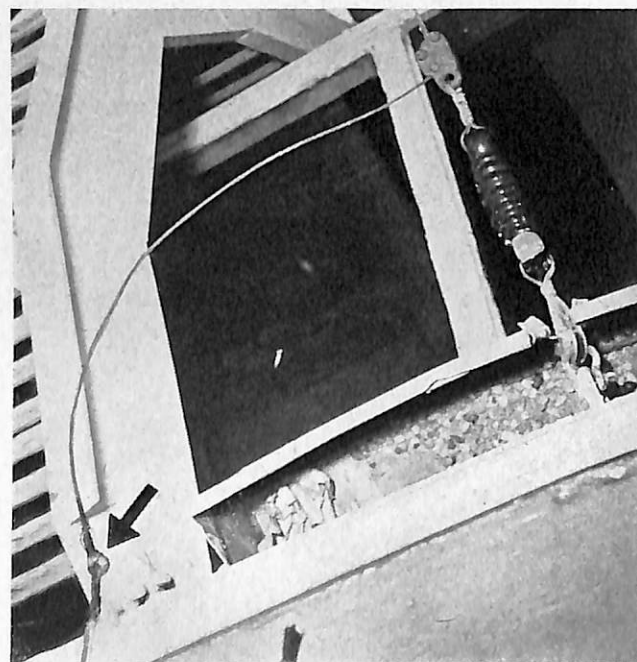
Radio interference, commonly referred to as "noise" may be classified into two main categories as follows:

- 1—Interference from signals other than the desired signal.
- 2—Interference created by sources of radio-frequency energy other than transmitting stations.
  - a—Natural interference

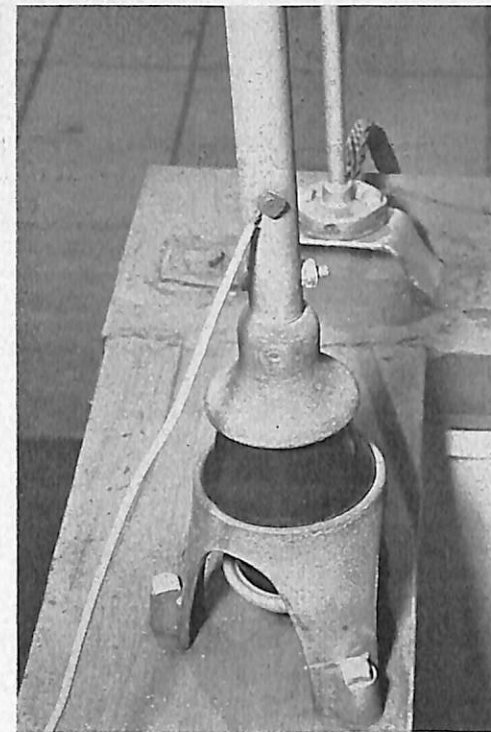


Paint on an antenna insulator, and incorrect routing and poor condition of lead-in wiring on a control tower roof, are shown here.

- (1)—Atmospherics (static)
  - (2)—Cosmic interference
  - (3)—Magnetic disturbances
- b—Artificial interference
- (1)—Man-made (static)
  - (2)—Noise generated in tubes
    - (a) Shot-effect noise
  - (3)—Noise inherent in receivers
    - (a) Thermal agitation, etc.



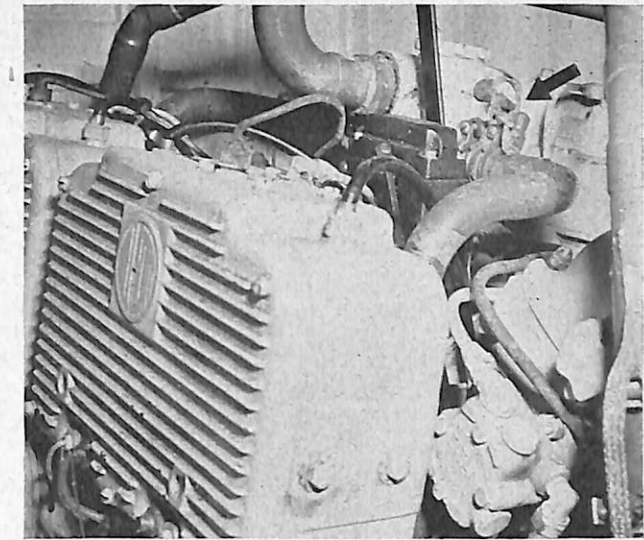
INCORRECT again. Where indicated by the arrow, a receiver lead-in has been connected to an antenna by means of loosely wrapping the two leads together. This type of connection will cause arcing due to intermittent contacts at this point.



POOR INSTALLATION and MAINTENANCE PRACTICE is evident in this installation of a whip antenna on the roof of a control tower. The receiver lead-in is improperly terminated to a rusty bolt on the whip antenna. The arcing created by the intermittent contact at the junction of antenna and lead-in results in a high radio interference level in the receiver connected to the antenna.

Atmospheric (natural static) interference is a natural phenomena caused by lightning discharges and precipitation (rain, snow or sleet) that seriously limit the useful sensitivity of receivers operating on frequencies as high as approximately 25 Mc. The inherent nature of this type of interference makes it impossible to remove or separate it from a desired signal. For frequencies greater than 25 Mc, this interference decreases gradually in amplitude until antenna and the inherent receiver noise predominate. The peak noise voltage may run 13 decibels higher than a measured RMS value and such peaks can be limited to prevent blocking of the receiver. Directional receiving arrays may provide substantial improvement if the majority of the interference is unidirectional. Further improvement is possible by utilizing an optimum bandwidth for a given amount of intelligence. Atmospheric noise is a random type noise, in that the impulses are frequent and overlap with sharp peaks exceeding the average level and with signal strength varying inversely as the frequency.

Atmospherics or static is fundamentally a radio signal containing many frequency components distributed over a wide frequency range, and the static within any fre-



HALL-SCOTT ENGINE aboard a crash boat, showing the incorrect installation of a bonding strap, and the poor condition of the shielded ignition cables. The bonding strap indicated by the arrow is excessively long and constitutes a radiation loop at certain frequencies.

quency range is propagated over the earth in the same way as ordinary radio signals of like frequency.

Static is greatly reduced at frequencies too high to be reflected from the ionosphere. This is due to the limited range of such high frequencies and to the fact that there is little static energy generated at these frequencies.

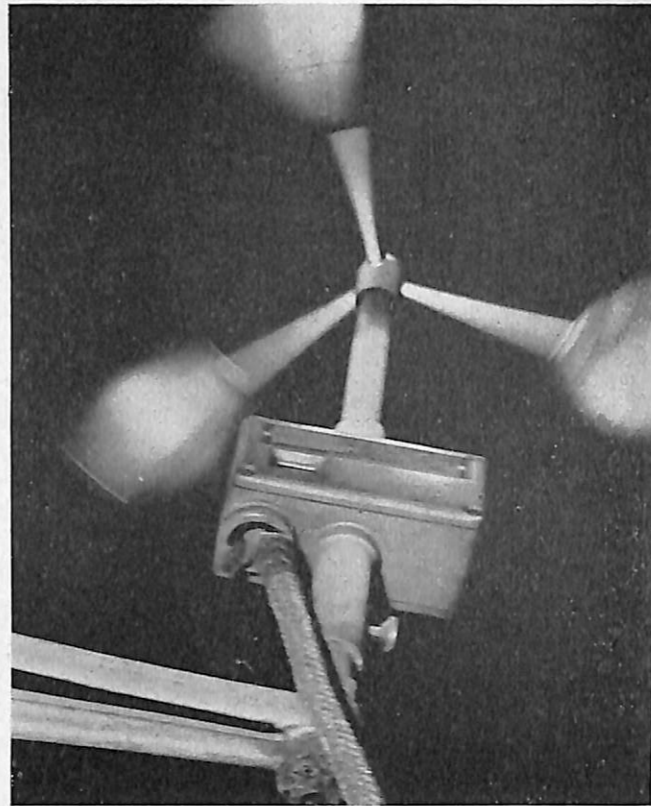
Atmospherics or static may be minimized by the following:

- 1—Designing the receiving system so that the bandwidth is no wider than necessary to accommodate the side bands of the desired signal.
- 2—The use of directional receiving arrays is helpful in eliminating static interference when the desired signal and the static interference arrive from different directions.
- 3—The use of limiter stages in the receiver is helpful in eliminating static interference if this interference consists of crashes of large amplitude.
- 4—Wide band frequency modulation reception is little affected by static, but due to the wide bandwidths required, the use of this type of reception is limited to the higher frequencies (vhf and above) where static is relatively non-existent.

Cosmic noise is caused by the electric field produced at radio frequencies by disturbances outside the earth or its atmosphere. It is a random fluctuating type of noise similar to thermal noise and is characterized by a steady hiss.

Another type of interference is that due to the presence of strong electromagnetic fields about the antenna. For single frequency field selection in the pres-

**POOR INSTALLATION and MAINTENANCE PRACTICE.** This anemometer is mounted on the roof of a control tower in proximity to receiving antennas. There is no cable clamp at the point where the shielded cable enters the anemometer case, and friction tape has been wrapped around the cable at this point to insulate the cable from the case. This break in the shielding and grounding of the anemometer will result in the radiation of high levels of radio interference.



ence of a multiplicity of high level fields, the receiver may not be selective enough, resulting in many combinations of intermodulation products between this field and other frequencies present at the receiver input. A familiar example is the image frequency response of a receiver, or the cross modulation of a weak signal by a stronger signal. The presence of several fields may result in intermodulation products in the first radio-frequency stages or even in non-linear elements external to the receiver. Complete solution of such problems is difficult due to the sensitivity required, but solutions result from increased receiver selectivity in the front end stages, improved shielding, linear operation of tubes and if possible, improved antenna location. Radio receivers and television receivers employing local oscillators and frequency changers are subject to beat interference among themselves.

A type of interference similar to that of atmospherics is known as precipitation static and occurs when an airplane flying through rain, sleet, snow, or dust picks up electrical charges, resulting in high potentials which may produce corona or spark discharges. The same phenomena occurs for an ungrounded stationary antenna during a rain, sleet, dust or snow storm. This precipitation static may be reduced by removing the charge on the antenna or plane gradually. Grounding the stationary antenna or discharging the body of the plane with a soft wick impregnated with a colloidal metal and at the same time utilizing an antenna well insulated with a high dielectric material throughout, are a means of preventing the development of large potentials.

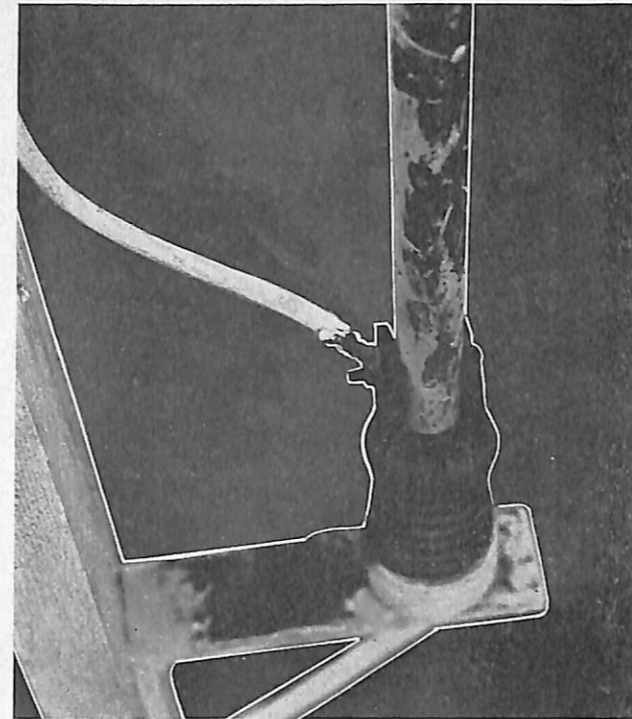
The most serious form of interference to communication stations and electronic control circuits is termed "man-made" interference, which is produced whenever an electrical current is interrupted. The seriousness or magnitude of such interference depends, in general, on the square of the magnitude of the current interrupted, the inductance and damping in the circuit, the rate of occurrence, and the ease with which such interference may reach a sensitive portion of a receiver or electronic control circuit. Devices such as breakers, commutators, and contactors may be shielded and/or filtered. Certain discharge phenomena such as are caused by the unshielded ignition systems of vehicles or of internal combustion engines constitute an intense source of interference. Such phenomena may be considered to be a

charged transmission line representing the high tension cable associated with the spark plug and/or coil, which upon discharging, produces a multiplicity of interference components. Interference from such sources extends from the very-low frequencies through the spectrum to beyond radar frequencies.

#### Methods of Coupling

Radio interference energy which is conducted into the receiver is said to be conductively coupled to the receiver. All radio interference sources impress some part of their interference output on the power wiring connected to them, unless these sources are completely filtered at this point. The radio interference currents impressed on the power wiring by such a source of radio interference are conducted to other points of the wiring system.

All metallic materials, whether used nominally for electric systems or other purposes may conduct radio interference currents into the receiver via remote control wiring, antenna, and antenna lead-ins. These circuits are not necessarily common to both receiver and interference sources. The interference currents must first be coupled to them by some means other than conduction. An example of this occurs in the use of an inert-gas shielded arc welder using a spark-gap oscillator wherein radio interference radiated by the welding leads or the high-frequency stabilizing unit is electromagnetically coupled to unshielded wiring such as power lines or telephone lines located in proximity to the welder,



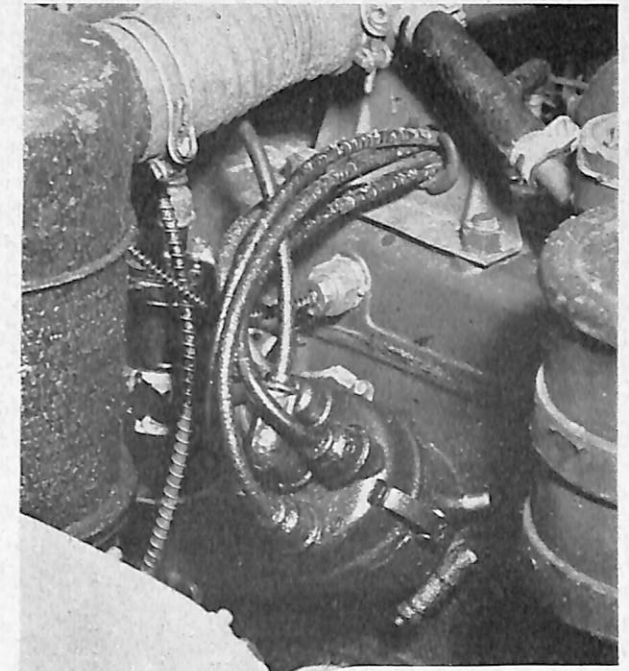
This whip antenna on a control tower shows the need for better installation and maintenance practices. The deterioration of the shielded cable is evident and the antenna as well as the insulator has been painted.

then conducted and radiated by these power lines and telephone lines.

Radio interference currents coupled into a receiver cause undesired outputs from the receiver by coupling to some impedance element in the low level stages of the receiver. A common ground impedance is an example. It includes the antenna, the lead-in, the receiver input circuit and the ground return circuit. The impedance presented by the ground path is a complex one. It may be inductive or capacitive depending upon the frequency and installation. The radio interference voltages developed across the ground impedance are dependent upon the radio interference currents flowing through it. Hence the lowest possible ground resistance is essential. These voltages are in series with the antenna circuit, resulting in a lower signal-to-noise ratio so that the noise may even override the signal.

#### Radio Interference Investigations

The Bureau of Ships is presently conducting radio interference investigations at several Naval Shore Communication Stations, and Naval Air Stations as an important phase of the Bureau of Ships comprehensive long-range program for the reduction of radio interference existing at these activities. The radio interference surveys conducted to date have conclusively demonstrated that radio interference is the major limiting factor to efficient and reliable communication systems

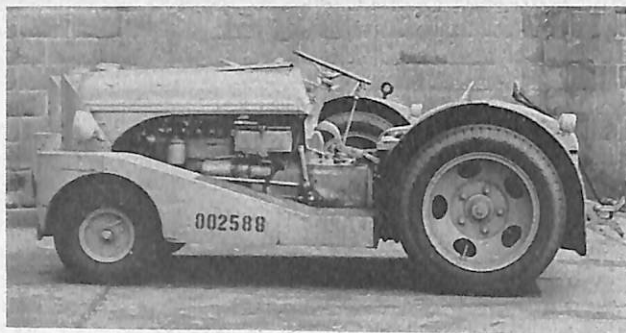


**UNSHIELDED IGNITION SYSTEM** of a jeep. Jeeps are a prolific source of radiated ignition interference because of their being normally operated within 1000 feet of control tower receiving antennas.

and electronic control circuits. It has also been found as a result of these investigations that cognizant personnel are generally lacking in appreciation of the magnitude of radio interference. In far too many instances personnel concerned either fail to recognize radio interference as such, or resign themselves to its presence as an annoyance they must "put up with."

The following is a listing of the most prolific sources of radio interference which have been disclosed by these surveys as existing in whole or in part at several Naval Shore Communication Stations and Naval Air Stations:

- 1—Overhead unshielded power lines located within approximately one mile or less of a receiving antenna.
- 2—Vehicles and internal combustion engines having unshielded ignition systems and operated within 1000 feet of a receiving antenna.
- 3—Unfiltered motors and generators.
- 4—Fluorescent lighting.
- 5—Poor grounding systems.
- 6—Defective shielding and bonding.
- 7—Link trainers operated in proximity to a receiving activity. Radio interference is created by the turbo-compressors and the type NSF-11 Bodine motor located in the link trainer.
- 8—Inert-gas shielded arc welders, diathermy apparatus and induction heating equipment.
- 9—TXC facsimile recorders.
- 10—Unfiltered and unshielded oil burner ignition systems



This AIRCRAFT TOWING TRACTOR, also normally operated in proximity to control tower receiving antennas, is another major source of radio interference to communications due to a lack of shielding on the ignition system.

- 11—Universal ac-dc electric motors in photographic laboratories such as are used in the PDX-30 photo developing equipment.
- 12—Painted insulators on antenna systems.
- 13—Taxiway lighting systems at Naval Air Stations.
- 14—Proximity of radar and transmitter installations to receiving activities.
- 15—Teletypewriters using gaseous rectifier power supplies and/or series motors.
- 16—Electromatic typewriters, electric coding machines, electric adding machines and other miscellaneous electric office equipment.
- 17—Flashing signs and thermostats.
- 18—Electric razors and electric erasers.
- 19—Rotary converters used for battery charging or as a source of direct current.
- 20—Electric drills, vacuum cleaners and floor waxing machines.
- 21—Power supplies using gaseous rectifiers.
- 22—Leaky lightning arrestors on power distribution poles.
- 23—Dirty, painted, or cracked insulators on power distribution poles.
- 24—VRF-1 film recorders.
- 25—Dry disc rectifier power supplies built by Raytheon Manufacturing Company under the trade name "Rectifilter" Catalogue 1082, Specification Number W-2529A.

Radio interference investigations have disclosed the following as representative of poor installation and maintenance procedure in connection with shielded systems:

- 1—A general lack of proper cable and equipment bonding.
- 2—Shielded cables found depending on loose clamps for bonding.
- 3—Cable securing clamps having friction tape between the securing clamps and the flexible cable.

- 4—Bonding straps of excessive length, constituting possible radiation loops.
- 5—Securing clamps having surfaces painted at points of contact with the shielded cable.
- 6—Bonding jumpers terminating to poor grounding surfaces.
- 7—One bonding jumper used to ground a quantity of shielded cables.
- 8—Breaks in cable shielding and loose couplings.
- 9—Corroded bonding and joint mating surfaces, creating a point of high radio-frequency impedance.

Poor installation and maintenance practice in connection with receiving activities has also been found responsible for the existence of high levels of radio interference even though the activity itself was not originally located in an area of high radio interference levels. This condition is caused by the subsequent installation and operation of radio interference sources in proximity to a receiving activity, without taking corrective action towards rendering these sources ineffective, by means of shielding, bonding, and/or filtering. The radio interference investigations conducted to date have disclosed a general lack of proper and periodic maintenance procedures. This lack of maintenance is manifested by broken or corroded shielding, ineffective grounds, bonding straps excessively long or not properly terminated, and insulators painted.

The radio interference investigations conducted by the Bureau of Ships at specific Naval Shore Communication Stations and Naval Air Stations have resulted in an appreciable improvement in the signal-to-noise ratios at the activities surveyed. Whenever installation methods or maintenance procedures have been disclosed as faulty, the cognizant personnel have taken prompt corrective action. A vigorous program has been initiated in every case to reduce radio interference levels at these activities, by means of eliminating sources of radio interference, checking all installations carefully for conformance to radio interference reduction practices, and instituting radio interference reduction projects whereby shielding is checked, defective wiring replaced, insulators cleaned of paint, and effective ground systems installed.

The illustrations presented in connection with this article depict typical conditions at receiving activities, such as the poor location of receiving activities, faulty installation and maintenance procedures, and the corrective actions taken as a result of radio interference investigations conducted at Naval Shore Communication Stations and Naval Air Stations.

### Sources of Radio Interference

#### Power Line Interference

Unshielded aerial high-voltage transmission lines are a major source of radio interference to communications and electronic control circuits at Naval Shore Communi-



### IMPROPER RECEIVING ACTIVITY SITE SELECTION

TOP: The control tower with its associated receivers and receiving antennas is located in proximity to the two major sources of radio interference—power lines and unshielded ignition systems of vehicles.

BOTTOM: This overhead power line with power distribution pole and transformers is located within 60 feet of the nearest receiving antenna. A radio interference survey disclosed this power line as the major source of radio interference to control tower communications.

cation Stations and Naval Air Stations if located within a general distance of three miles from these activities.

Receiving activities should not be located within approximately three miles of high-voltage aerial power transmission lines as a general policy in order to minimize the interference to communications caused by radiated interference from these power lines. Radiation from high-voltage transmission lines is very difficult to suppress, since the interference is largely generated by corona discharge on the wires and insulators, especially under conditions of high humidity. On frequencies in the 1- to 20-megacycle band, it has been found that the radio interference level in wet weather may be as much as 20 decibels higher than in dry weather.

Sparks created by high-voltage arcing between two points of potential difference along the high-voltage transmission lines will generate radio waves covering various portions of the radio-frequency spectrum, and extending to approximately 20 megacycles.

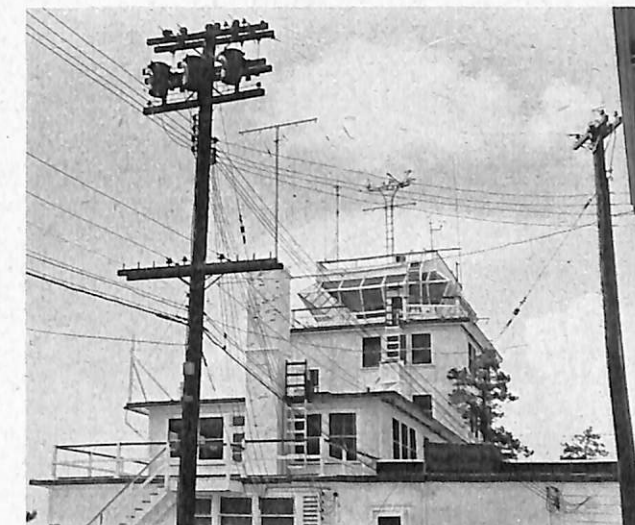
Radio interference conducted from a source of radio interference forming part of the load of unshielded aerial power lines will be efficiently radiated and conducted for miles, while similar interference loading of shielded or buried power lines will be conducted for miles and radiated to a lesser degree. Appropriate power line filters should be installed at the receiving activity to eliminate the interference to communications that may be conducted from these power lines.

#### Ignition Interference

Radio interference surveys conducted at Naval Shore Communication Stations and Naval Air Stations have established spark ignition systems and overhead power lines as the two major sources of radio interference existing at these activities.

Ignition interference is probably the easiest type of interference to identify and to eliminate.

Ignition interference is easy to identify due to the "machine-gun" type of interference produced in the output of receivers, which varies in pitch with the speed



of the motor causing the interference. The radio interference generated by the ignition systems of vehicles and various types of auxiliary power supplies is of a very high level unless the entire ignition assembly of each motor is effectively shielded to prevent the radiation of interference to receiving antennas located in a radius of approximately 1000 feet.

The generation of high voltages by ignition systems and subsequent discharge of this electrical energy across spark plug gaps produces a radiated interference rich in harmonics due to the steep front of the resultant pulse wave train, with harmonics covering many portions of the radio-frequency spectrum. These transient pulses of high amplitude "shock excite" the affected receiver even though the interference impulses may not have a component at the resonant frequency of the receiving circuit. The radio-frequency wave produced by the ignition system may be an ultra-high-frequency wave, modulated at the oscillating frequency of the arc created by the spark action. The amplitude of this ultra-high-frequency carrier wave may be so high that the first stage of the receiver becomes saturated, resulting in rectification of the received impulses, permitting the

**ANTENNA INSTALLATION** on control tower roof, showing proximity of this antenna to vehicles having unshielded ignition systems.

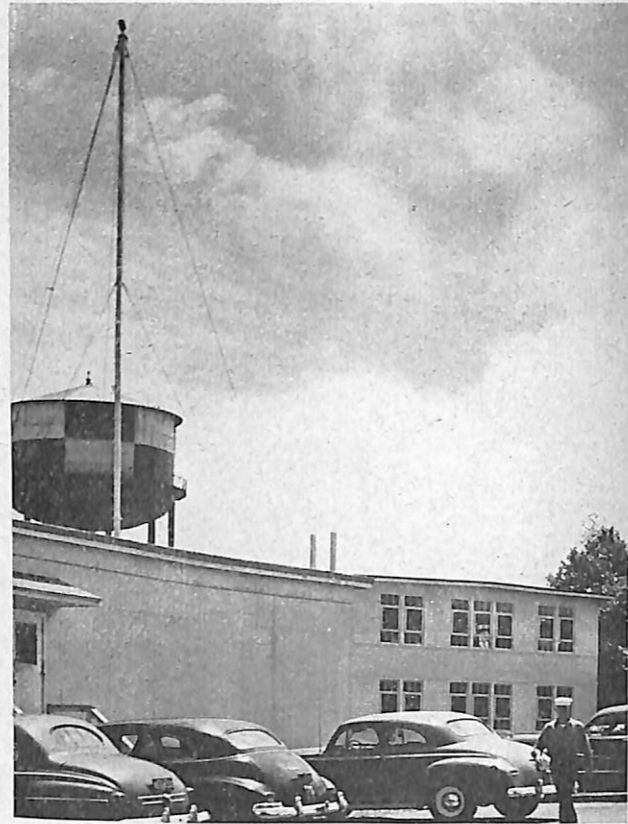


low-frequency modulation component of the arc to appear in the receiver. The resultant noise heard in the output of communication receivers is at the spark repetition rate of the interfering ignition system, changing in pitch with changes in engine speed.

Ignition interference from vehicles and certain auxiliary power supplies is effectively radiated at high amplitudes up to approximately 1000 feet. A distinguishing characteristic of motor ignition interference is that the intensity increases with an increase of frequency (up to 400 megacycles), which is at variance with the usual decrease of interference intensity with an increase of frequency, characteristic of other common sources of radio interference, with the possible exception of high-frequency medical equipment. Ignition interference increases also as the bandwidth of the receiver is increased, and is regarded as the major source of interference to television receivers due to the high frequencies and wide bandwidths presently used in these receivers.

Past practice in reducing radiated ignition interference consisted of placing suppressors on spark plugs and in series with the high-tension lead to the distributor. These suppressors were made in many different types, but were usually carbon or wirewound resistors, designed to suppress interference by changing the wave shape of the radiated wave. These suppressors were only partially effective in reducing ignition interference and have been discarded generally in favor of shielded ignition harnesses, which if properly installed, will completely eliminate ignition systems as a source of radio interference to communications and electronic control circuits.

At the present time, there are several approved



**This receiving antenna has been installed directly over a parking area and a well-traveled road, causing high levels of ignition interference at the inputs of the receivers served by the antenna.**

types of shielded ignition harnesses which completely encase the ignition system in a continuous metallic shield. The word "continuous" used in this connection is very important, as a very small break anywhere in the shielding system will often completely nullify the shielding effectiveness of the harness and permit the radiation of high levels of radio interference from ignition systems to nearby receiving antennas. All parts of the shielding system must have an extremely low radio-frequency impedance between themselves and also between all parts of the shielding system and "ground." The main structure of the vehicle or auxiliary power supply is to be considered as the ground.

#### *Inert-Gas Shielded Arc Welders Interference*

The operation of inert-gas shielded arc welders at, or in proximity to, Naval Shore Communication Stations and Naval Air Stations has created a major radio interference problem at these activities.

Inert-gas shielded arc welding is known under several trade names including "Heliwelding," and Heliarc." By means of this process welding heat is supplied by a concentrated arc between a non-consuming electrode and the work, while the electrode, arc, and the weld



**CRASH BOAT (above) and UNSHIELDED IGNITION SYSTEM (at right).** Due to the high levels of radio interference radiated by this unshielded ignition system, it is impossible to receive messages from the air station control tower with any degree of reliability.

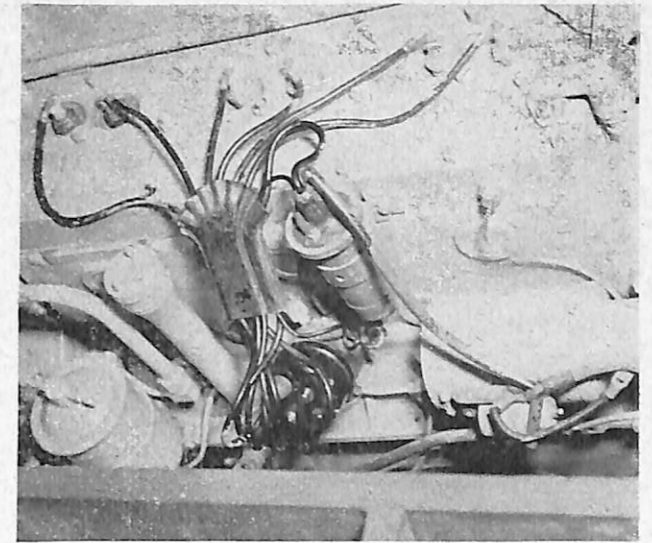
area are blanketed by a monatomic inert gas such as helium or argon.

The welding arc may produce considerable radio interference, but the greater part has its source in the high-frequency stabilizing unit which converts power supplied as 60-cycle alternating current into high-voltage high-frequency current. To obtain high-frequency power in a simple manner, spark-gap type oscillators have been commonly employed in most commercial welders of this type with resultant high levels of radio interference. While these machines are designed to operate at some fundamental frequency, no attempt has been made to hold them to close frequency tolerances. Therefore, various high-frequency units of identical make and model may cause radio interference on many frequencies since the radiated signal is broad and may cover a wide band of frequencies rather than a single sharply defined frequency.

The h-f stabilizing unit may radiate many frequencies at lower amplitude than the fundamental, these being harmonic or spurious frequencies. The harmonic frequencies are multiples of the fundamental frequency, always higher in frequency than the fundamental. The spurious frequencies have no particular relation to the fundamental and may be either higher or lower in frequency than the fundamental. The fundamental, the harmonics and spurious frequencies are all capable of creating radio interference to receivers tuned to any of those particular frequencies.

Lighting, power lines and telephone lines in proximity to the welder, unless shielded or in conduit will pick up the radiated interference from the welder, then conduct and re-radiate this radio interference over great distances.

In an installation wherein all of the power wiring, lighting wiring and telephone lines are shielded or isolated from the high-frequency unit, the major portion of the radiation will be from the welding leads. These welding leads carry a high-frequency current which is transferred by electromagnetic coupling to unshielded power wiring, intercommunication lines, telephone wires or lighting circuits. These wires will in turn act as



antennas and also radiate the high-frequency currents. Since these wires are usually much longer and higher than the welding leads, they are much more efficient as radiators of radio interference than the welding leads themselves. As appreciable coupling between the welding leads and shielded wires takes place when these unshielded wires are within a 50-foot radius of the welding leads, all of the wiring within this distance from the welding equipment should be shielded or placed in conduit.

The power line feeder to the welder should be shielded to a point at least 50 feet from the welder and a suitable line filter installed at that point.

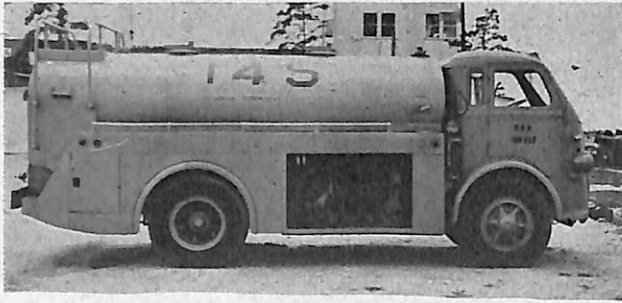
If the radio interference attributed to the welder is of a frequency higher than 2.5 megacycles, the interference is probably resulting from harmonics or spurious frequencies. Some form of wave trap or absorption circuit may be applied to the welder to eliminate the interfering frequency without interfering with the fundamental frequency.

An inert-gas shielded arc welder using a vacuum tube oscillator in place of the spark-gap type oscillator now used has been developed by Glen Roberts and given type approval by the F.C.C. The fundamental frequency of the oscillator is 27 megacycles.

It is indicated that this new type of inert-gas shielded arc welder meets the radio interference requirements of the F.C.C., and that shortly the Commission will require that all inert-gas shielded arc welders be of this approved type or that welders of a type capable of creating radio interference be operated within shielded rooms, the work area to be included in the shielded enclosure.

#### *Rotating Equipment—Generators, Motors and Rotary Converters*

The level of radio interference created by a single electric motor is usually low at distances over 600 feet from the motor, but the cumulative levels of several or



**AIRCRAFT REFUELING TRUCKS** with UNSHIELDED IGNITION SYSTEMS are a constant source of radio interference to control tower communications due to their being normally operated within 1000 feet of receiving antennas.

more motors often constitute a serious source of radio interference. Devices associated with rotating equipments such as speed or voltage regulators, relays, etc. also create radio interference of varying levels.

Commutator motors (dc or ac) create appreciable radio interference while a-c induction motors cause little or no interference.

Rotary converters when used for battery charging or as a source of direct current create radio interference similar to that caused by commutator motors.

Generators create radio interference of a type similar to that of motors.

Rotating equipments create radio interference due to one or more of the following sources:

1—Brush interference

This type is usually the major source of interference. It occurs due to imperfectly machined commutator, dirt on commutator, uneven brush wear, or incorrect brush pressure. The wave form of the arc produced by the brushes is a square wave, containing harmonic frequencies extending through a wide portion of the radio-frequency spectrum.

2—Voltage regulators

Contacts are continually opening and closing during the regulating process, creating radio interference producing arcs at these contacts.

3—Shaft interference

Originates in armature shaft. It is a static type interference created by the discharge of the shaft through the bearings and surrounding grease to ground. It is irregular in nature and is only found in equipments using ball or roller bearings and is never found where sleeve bearings are used on the shaft.

4—Interference created by a nonsinusoidal waveform of the output voltage generated by a-c equipments.

Caused when the output waveform is not a pure sine wave, but is an irregular wave shape approximating a sine wave. Resultant harmonics

of the fundamental frequency thereby appear in the voltage output, with the number of harmonics depending upon the actual shape of the waveform.

5—Ripple frequency from the commutator and resultant harmonics.

This ripple is the audio-frequency component of the direct-current output, with the frequency dependent on the number of commutator bars and the speed of rotation.

6—Iron interference

This type of rotating interference is produced by loose laminations in the armature and is due to changes in the field reluctance, caused by vibration of the loose laminations.

7—Relays

The interference created is due to arcing across the relay contacts. It takes place during current surges caused by the making and breaking of the relay contacts.

### Fluorescent Lighting

Fluorescent lighting units, when installed in proximity to a radio receiver, constitute a major source of radio interference.

There are three ways whereby the radio interference created by fluorescent lighting may reach a receiver and interfere with reception:

1—Direct radiation from the fluorescent lamp to the receiving antenna circuit.

2—Direct radiation from the power input line to the receiving antenna circuit.

3—Conduction from the lamp through the power lines to the receiver.

The interference produced by fluorescent lighting is a 60- and 120-cycle complex pulse type covering a wide portion of the radio-frequency spectrum.

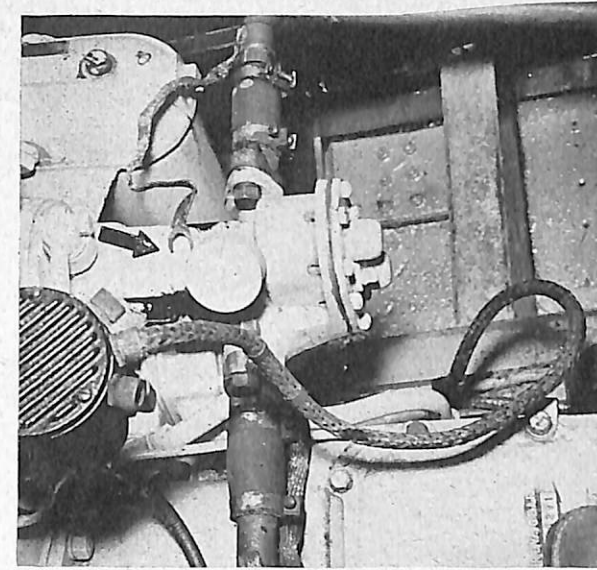
An interference-free type fluorescent lamp fixture is presently available in a 15-watt size, designed for ship-board use. This fixture employs conducting glass as a cover over the illuminating area of the fixture to prevent the radiation of radio interference.

A power line filter is incorporated in the lamp fixture housing, to prevent the conduction of radio interference from the lamp to nearby receivers via the power lines.

This interference-free fluorescent lamp fixture has not been widely used or larger fixtures of this type developed at present, due to the high cost and greatly increased weight of the fixture, caused by the addition of the heavy conducting glass.

### The Link Trainer and Associated Turbo Compressor

In the Link Trainer there are a small Bodine brush-type motor, multiple switch contacts, and several slip rings with brush contacts, all of which create severe radio interference.



**IMPROPER INSTALLATION** and **MAINTENANCE PROCEDURES** are evident in this Hall-Scott engine aboard a crash boat. The shielded lead to the tachometer is in poor condition, and as indicated by the arrow, one bonding strap is not terminated. This bonding strap is excessively long, and even if properly terminated, would constitute a radiation loop at certain frequencies due to its length. High levels of radio interference exist aboard this craft, making reliable reception impossible when the motors are running.

The radio interference from the Bodine motor is created by the brushes; the switch contacts generate radio interference on each make and break of the contacts; and dirt on the slip rings or incorrect brush pressure cause radio interference at this point.

The turbo compressor is driven by a high speed ac-dc universal type motor which generates the greatest portion of the radio interference created by the Link Trainer. The radio interference generated by Link Trainers and turbo compressors may be reduced to permissible levels by the proper installation of filters on the Bodine Motors and the turbo drive compressors.

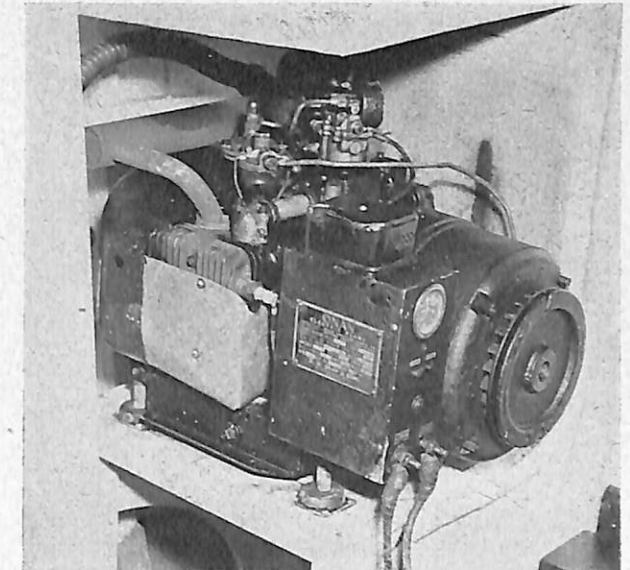
### Diathermy Apparatus and High Frequency Heating Equipment

High-frequency diathermy equipment is of two main types as follows:

1—"Violet Ray" apparatus containing a discharge tube excited at a high voltage by a spark coil and a high-frequency transformer. The voltage is applied to the patient by means of a single electrode, the return current flowing through the ground capacitance.

2—The larger type of electrotherapy apparatus using a spark coil or vacuum tube generator, together with a radio-frequency transformer. In this type the voltage is applied to the patient by two electrodes.

For the spark type the radio interference is broadly tunable, whereas for the vacuum tube type, the inter-



**AUXILIARY POWER SUPPLY** on a **CRASH BOAT**. High levels of radio interference are created by this power supply due to a complete lack of shielding or filtering.

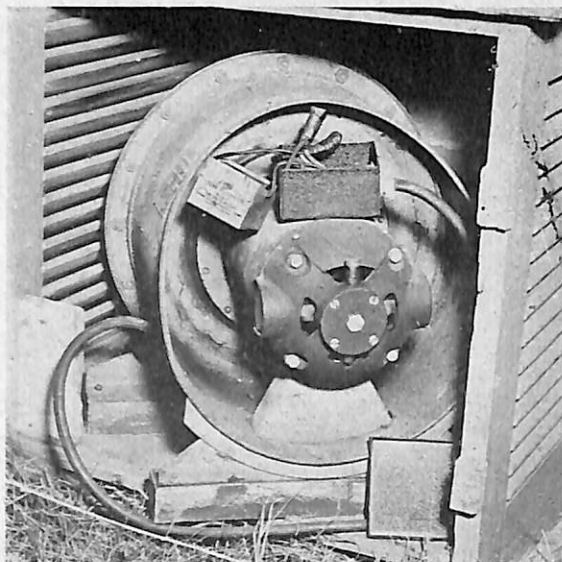
ference is mainly concentrated around the fundamental and harmonic frequencies with sidebands corresponding to the frequency of the power supply lines. Therefore concentration of energy on one frequency can be greater with the vacuum tube type than with the spark type.

All high-frequency heating equipment can be split into two classes based upon its load circuit. The first class, induction heating, provides a large high-frequency current through a coil of few turns causing a field with a predominant magnetic component in its immediate vicinity. The work placed in this field is a metal or other electrically conducting object, which becomes heated by induced currents which circulate near its surface.

Dielectric heating provides a large high-frequency voltage across two electrodes causing a field which is predominantly electric in its immediate vicinity. The work placed in this field is a nominal insulator or other electrically semi-conducting material, which becomes heated by hysteresis losses from the dielectric voltage stresses set up in the material.

Industrial heating units employ induction heating in the lower frequency ranges from power frequencies up to about 500 kilocycles, and dielectric heating for frequencies from about two megacycles up to the microwave region, with no upper limit in sight at the present. Industrial load circuits are frequently enclosed in metal boxes, sometimes of perforated or screened construction, primarily for high voltage safety reasons but also for shielding to reduce radiation. The power output used runs from several hundred watts to over a hundred kilowatts.

High-frequency heating generators are often subject



**IMPROPER FILTERING PROCEDURES** in connection with a motor installation. The filtering is ineffective due to: first, the motor housing is not grounded; second, the input and output leads are looped together, thereby providing a path for interference currents to pass from the filter input to the filter output. This condition will usually nullify the filtering action as the filter itself is effectually bypassed. Third, no effective shield is provided for the filter unit; fourth, the filter leads are excessively long, constituting possible radiation loops.

to frequency jumping. If the load circuit is tuned separately from the oscillator tank circuit and the tank circuit is the frequency determining circuit, it is frequently found that the frequency of the oscillator will jump discontinuously as the oscillator or the load circuit is tuned or the coupling between these circuits is changed. This is the chief reason why in most heating generators the load is made part of the oscillator tank circuit and is not separately tuned. As the load circuit is tuned or the coupling is increased the load circuit will "pull" the frequency of the oscillator toward that of the load circuit. When the reactive power drawn by the load circuit becomes sufficiently large, the oscillator jumps to another frequency at which the load draws little power.

Generators operating at lower frequencies below 200 megacycles can cause considerable interference with microwave equipment because of the large amount of radiation of such generators at high harmonic and parasitic frequencies. The 2450-megacycle diathermy machine radiates 125 watts. When used on a ship, this diathermy machine will black out the screen of a radar set installed on a nearby ship so that nothing in that direction can be detected.

Conducted radio interference from diathermy machines and high frequency heating equipment is of a high level and the radiated interference from these equipments has been detected at distances up to several hundred miles, the interference increasing in intensity with an increase in frequency.

The frequency of 2450 megacycles was made available for industrial, scientific and medical services by the Federal Communication Commission's order of 26 December 1946. This order provides for use of this frequency for industrial, scientific and medical purposes upon a non-exclusive basis and without a license upon the following conditions:

1—That all radio-frequency energy resulting from such

operation shall be confined between 2400–2500 megacycles.

2—That the energy radiated and the bandwidth of emissions of such equipment shall be reduced to the greatest extent practicable.

3—That no interference shall be caused to authorized communication services from spurious or harmonic radiations.

4—That use of this frequency shall be subject to such future regulations as may be found by the Commission to be appropriate.

5—In the event of interference from spurious or harmonic radiations, operation of the equipment causing such interference shall cease and shall not be resumed until steps necessary to eliminate such interference have been taken.

Pursuant to the Atlantic City Radio Regulations, the frequencies 915, 2450 and 5850 megacycles may be used for industrial, scientific and medical operation.

As no international table of frequency allocation was adopted above 10,500 megacycles, no changes in 10,600- and 18,000-megacycle frequencies allocated by the Commission for these services are now contemplated.

The frequencies available for industrial, scientific and medical use are summarized as follows:

Assigned Band	Center Frequency of Channel	Tolerance From Center Frequency
13,553.22–13,566.78 kc	13,560 kc	± 6.78 kc
26,960.00–27,280.00 kc	27,120 kc	±160.00 kc
40,660.00–40,700.00 kc	40,680 kc	± 20.00 kc
890.00– 940.00 Mc	915 Mc	± 25.00 Mc
2,400.00– 2,500.00 Mc	2,450 Mc	± 50.00 Mc
5,775.00– 5,925.00 Mc	5,850 Mc	± 75.00 Mc
10,500.00–10,700.00 Mc	10,600 Mc	±100.00 Mc
17,850.00–18,150.00 Mc	18,000 Mc	±150.00 Mc

In addition to the frequencies specified above, an unspecified frequency in the vicinity of 6 megacycles for industrial, scientific and medical purposes is expected to be made available pursuant to the action taken by the Provisional Frequency Board of the International Telecommunications Union when the first International Frequency List is completed.

The emission of radio-frequency energy generated by operation of industrial, scientific and medical equipments, including spurious and harmonic emissions shall

not exceed a strength in excess of 15 microvolts per meter at a distance of 1000 feet or more from the medical diathermy equipment other than at those frequencies specified in the table above.

Operation of industrial heating equipment outside the bands specified in the above table is permissible provided the general operating conditions are as follows:

1—The equipment used in such operation shall be operated within a room or space with sufficient shielding and power line filtering so that the emissions of radio-frequency energy generated by such operation, including spurious and harmonic emissions will not exceed a strength of 10 microvolts per meter from the industrial heating equipment on frequencies other than those listed in the table. The radio-frequency field from power lines due to radio-frequency energy originating with such equipment at distances beyond one mile must be less than 10 microvolts per meter when measured at one mile from such equipment and 50 feet from the power line.

#### *TXC Facsimile Recorders*

During the course of a radio interference survey at a control tower, a sharp click at approximately one-second intervals was heard in the earphones used for aural monitoring of the measuring equipment. The source of this radio interference was traced to the facsimile machines in aerology. High levels of conducted interference from these machines were also measured across the 115-volt a-c input power lines with the major portion of the interference arising in the radio-frequency spectrum above 10 megacycles.

#### *Radar and Transmitter Radio Interference*

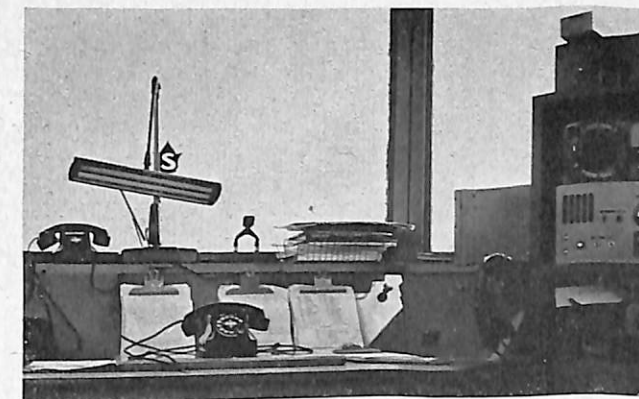
Usually radar equipment does not create appreciable radiated interference except when beamed directly at the radio receiving antenna. However any defect in the shielding, such as that on the modulator pulse cable, will allow the radar to become a prolific source of radiated interference.

The radiation of harmonics by transmitters creates a type of radio interference known as recurrent wave interference, which is a sharply tunable single frequency signal.

#### *Teletypewriters Using Gaseous Rectifiers or Series Motors*

Teletypewriter power supply REC-30 is a gaseous power supply designed to operate from 60-cycle power at various voltages and furnish regulated 110 volts direct current and adjustable a-c voltage output. The d-c output of this power supply contains high levels of conducted radio interference created by the gaseous rectifier tubes when these tubes go from the nonconducting to the conducting state, setting up transient voltages.

In the case of series motor power supplies, the radio



**FLUORESCENT LIGHTING** should never be used at or in proximity to a receiving activity due to the high levels of radiated and conducted interference created by this type of lighting.

interference is caused by the motor brushes or worn and pitted commutators.

#### *Office Machines*

Office machines such as electromatic typewriters, electric coding machines and electric adding machines are prolific sources of radio interference due to one or more of the following causes:

- 1—Worn and pitted commutators.
- 2—Worn, inadequate and improperly fitting brushes.
- 3—Dirty speed regulator contacts.
- 4—Deterioration of electrical insulation in motor field and armature, between commutator segments and in wiring between motor and external line connections.

#### *Flashing Signs, Thermostats and Other Contact Breakers*

Many types of electrical equipment include circuits in which intermittent contact is made at intervals ranging from seconds to hours; flashing signs and thermostats are examples of this type.

The radio interference created by such equipment has the characteristics of a succession of isolated impulses; usually the interrupted current is small and the normal range of the created radio interference is less than 400 feet.

#### *Dry Disc Rectifiers*

Dry disc type rectifiers usually do not create appreciable radio interference, but one that does is the rectifier built by the Raytheon Manufacturing Company under the trade name of "Rectifilter," Catalogue 1082, Specification No. W-2529-A. Conducted radio interference measurements made on the 115-volt a-c power input to this rectifier revealed the presence of a strong 120-cycle hum voltage

Measurements made on the 115-volt a-c power line input to a low-voltage disc type rectifier Model CLG-20341 revealed a high level of 60-cycle pulse type radio interference at the lower frequencies.



# MODIFICATION TO THE MODEL RDE

by

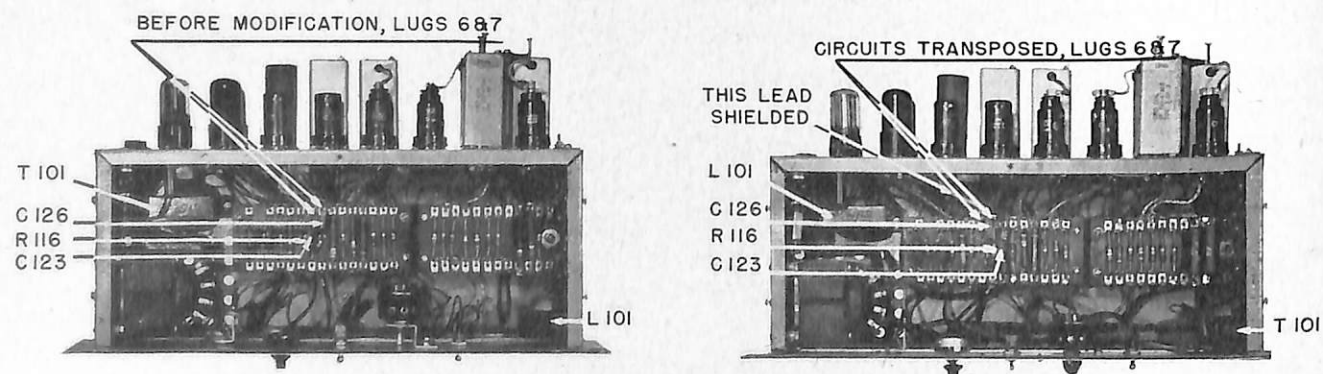
R. MENDEZ

Office of the Industrial Manager, Tenth Naval District

At the new installation in Roosevelt Roads, Puerto Rico, three Model RDE Radio Receiving Equipments were installed as part of the equipment assigned to the air traffic control tower. These receivers are located approximately 1.8 miles away and their output is sent to the tower over  $2\frac{1}{2}$  miles of telephone cable. In order to suppress possible crosstalk, the levels permissible are of the same level as those normally encountered in standard telephone practice, and they are amplified at the tower to loudspeaker level by means of an amplifier-compressor in each channel. These amplifier-compressors are designed to maintain a fairly flat level output to compensate for the wide variations of signal strength since the operator has no way of controlling the receiver's gain and a line attenuator is not a good substitute. An automatic-volume-control circuit is therefore incorporated in the amplifier circuit and is so designed that it will operate from the speech modulated voltages. Any sustained voltage input regardless of its frequency or origin will impair this a-v-c action since it will create a steady voltage and thus bias the first amplifier tube to the point where it will rectify any further variable signal input and introduce intolerable distortion. The unwanted input will furthermore introduce an output at the loudspeaker which can be exceedingly annoying to the tower operators. It follows then, that any hum, tube noise or any disturbance having the receiver as its point of origin will greatly impair its use in this type of installation to the point where it will be entirely unfit and unusable.

The Model RDE's already mentioned, although having features highly desirable for tower operation, proved to have a hum content in their output which disqualified them for the installation under consideration. This hum appeared even when all the tubes, including the rectifier, were removed from the receiver. On further investigation it was determined that it was due to the close proximity in which the power and output transformers are mounted and the consequent coupling between them. By removing the filter choke and interchanging its place with the output transformer, the hum disappeared. The choke and the output transformer have identical dimensions, making this transposition very easy. However, when the tubes were replaced in the receiver, a new noise appeared which had been masked by the stronger hum. This was a frying type sound and persisted even with the audio gain at its minimum setting, which clearly indicated that it originated in the audio amplifier of the receiver. This turned out to be correct, and the cause of it was feedback caused by the lugs supporting the leads to the plates of tubes VT-104 and VT-105 being of sufficient size and close enough to transfer enough energy to cause an obnoxious hiss which appeared at the output. The lugs and associated resistors have been relocated as shown in the photographs, and the cause for the unwanted noise eliminated. The receivers are now being re-installed and no further difficulties are anticipated.

MODEL RDE before and after modification.



# STORAGE TUBES

by

FRANCES R. DARNE

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Bureau of Ships

## What Is Meant by Storage Tubes

The term "storage tube" or "memory tube" is used to designate an electron tube in which a charge of electricity, usually deposited by an electron beam, is stored or remembered by elements of a dielectric surface, and taken off or observed after a lapse of time by the same or a different electron beam, or by visual observation.

## How They Work

The principle of electrostatic storage on an insulating surface is based on the fact that the secondary emission ratio of the surface varies with the energy of electrons bombarding it, according to a curve of the general shape illustrated in Figure 1. If the voltage is high enough that the secondary emission ratio is greater than unity, then the target surface under bombardment will emit more electrons than it receives, and the potential will become increasingly positive until the net number of secondaries leaving the surface is exactly equal to the number of primaries arriving there. This point is one equilibrium potential. If the surface is struck by an electron beam of lower than the critical value, so that the secondary emission ratio is less than unity, the surface will gain electrons, and the potential will become increasingly negative until it reaches a negative equilibrium point close to cathode potential. Thus by adjusting the voltage of an electron beam each element of the target surface can be established at one or the other of two stable points representing "charge" and "no charge," called "plus-zero" or "yes-no" elements or "1-0" in binary digital numerical systems.

Although the principle is well established, many technical problems are involved in putting it into practice. To obtain a tube which will be useful, critical requirements must be met for resolution (total number of "yes-no" elements and separation between them), writing speed needed to place a charge on an element, time of storage, prevention of leakage, prevention of destruction of charges by repeated readings, problems of registration (returning the beam to a specific spot), and other factors pertinent to particular applications.

## Why They Are Wanted

There are all sorts of ways in which a device which can store charges could be used to advantage. Navy applications reported to date have fallen into four general categories, outlined here with an indication of the approximate requirements for specific characteristics for each group.

*Moving Target Indicators*—Signal comparison or cancellation, and reduction of noise are included in this category. Storage tubes are needed with resolutions in the order of 100 elements, writing speeds equal to radar scan rates, storage time of at least one scanning period, dynamic range to cover varying amplitude of received signals, and cancellation ratios in the order of 30 to 40 db.

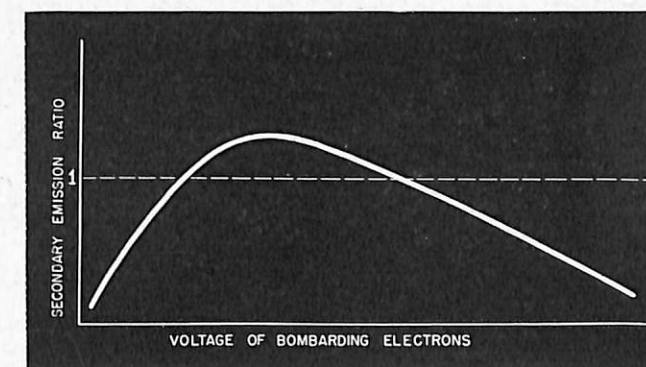


FIGURE 1

*Radar Display*—Radar repeaters and daylight viewing PPI tubes are forms of radar displays. The resolution required is equal to that of a radar system, and is in the order of 250,000 elements. Moderate writing and reading speeds are needed, and a dynamic range is desirable. The storage time must be equal to that of one radar scan period, and provision should be made to erase the signal at the end of the scan period.

*Recording*—Electrical transients and unknown signals are examples of requirements for recording, for later analysis, of signals which are too rapid or too short to be recorded by other means. At least a million separate elements of resolution are wanted for this use, as well

as a recording speed of one microsecond per element or faster. Dynamic range is also desired, and ability to track the writing and reading scans. Time of storage and repetition of playbacks are not critical for this application, as signals can be re-recorded on a slower device if necessary.

*Electronic Computers*—The prime requirement for a storage tube to be used in computers is practically perfect reliability with an indefinite time of storage, not affected by repeated readings. Tubes are needed which are capable of erasing and rewriting one element, which requires a high degree of registration. A comparatively small number of elements of resolution will suffice and there is no need for dynamic range as only "1-0" binary digits are to be stored. Reading and writing speeds of 1 microsecond per element are desired, but somewhat slower rates would still be useful.

### What's Being Done About Storage Tubes?

The storage tube field has been the subject of an intensive development program by service and commercial laboratories over the past several years. A few types of storage tubes are just beginning to emerge in practical form and are finding their way into experimental Navy equipments. A brief description of some

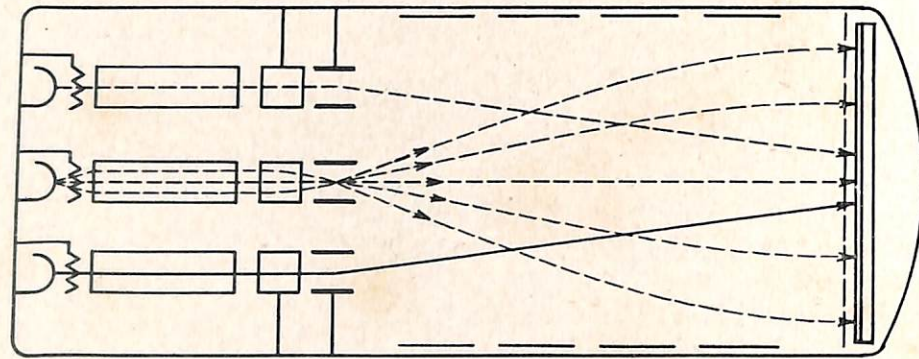


FIGURE 2

of the leading developments and their proposed applications is given below, in alphabetical order of their current nomenclature.

*The Barrier Grid Storage Tube*, recently christened "radechon," was developed by RCA under a Signal Corps contract, primarily for MTI purposes, although it appears that this tube may also be useful in computers. The tube has been described in detail in the March, 1948 issue of "RCA Review." It is based on the storage of signals on an insulating target backed with a conducting signal plate, and uses a single electron beam which may be magnetically or electrostatically focused and deflected. A grid or screen is placed on or near the target surface, and operated at a potential which prevents the return of electrons to the surface. There is also a means of collecting the secondary electrons emitted

from the surface. The surface is scanned by a repetitive pattern, such as a spiral, and the signal is impressed on the signal plate. The beam deposits a charge pattern on the target, which varies in intensity as a linear reproduction of the time variation of the impressed signal. If the surface is again scanned over the same path with no signal impressed, the beam will remove the charge, reading off a signal reversed in polarity to the written signal. Both writing and reading signals appear on the collector as a modulation of the secondary beam. If the same signal is impressed upon the tube in successive scans, the target is instantaneously at equilibrium potential when the beam reaches it, so no additional charge will be deposited, and no signal appears on the collector in the case of steady input signals. Any variation in input signals causes a charge to be placed on the spot. This effects cancellation of steady signals while varying signals are passed by the tube. The amount of cancellation, writing speed, and number of elements attainable are interdependent, and one of these characteristics may be improved only at the expense of the others. Typical experimental results reported give cancellation ratios of 100 db for about 600 elements, with storage time of about 1/50th of a second.

*The Graphechon* is an RCA development for "Teloran,"

a proposed system wherein planes are equipped with television receivers, through which an airport transmits data received from a radar on the ground. It is a scanning converter, whose purpose is to convert a slow PPI scan rate to a rapid television rate. The light output is improved, because each element of the screen of the viewing tube is bombarded at a faster rate, receiving energy more often so it gives off more light. This tube has potentialities for use in radar display systems and daylight viewing PPI's. The storage surface is placed in the center of the tube. A charge is written on one side of the surface by an electron beam modulated by a PPI type of scan. A reading beam on the reverse side of the storage plate is deflected by a television type of scan, and is modulated by the signals stored on the storage surface. The electrical output from the reading

beam may be transmitted through an amplifier or sent by radio to a television type of cathode-ray tube, scanned in synchronism with the Graphechon reading beam. The storage time is adjustable by varying the voltages and currents in the writing and reading beams, up to a maximum of about two minutes. The signal-to-noise ratio goes down with increased storage time, and is about 2:1 at two minutes and 10:1 at 20 seconds. The resolution is approximately equal to a 525-line television picture (about 250,000 elements), and the light output is dependent only on the characteristics of the viewing tube and system.

*The Haeff Memory Tube* was developed at the Naval Research Laboratory as a general purpose storage tube, and has been written up in some detail in the September, 1947 issue of "Electronics." The novel feature of this type is the use of three electron guns: a writing gun which places a pattern on the storage surface by using a beam of relatively high current density; a reading gun which can be made to scan the surface in any desired manner; and a holding gun. The latter retains the

electrical picture written on the surface of the storage tube can thus be viewed on the face of the indicator tube. The resolution presently attainable with the Haeff Memory Tube is in the order of 10,000 elements. Writing and reading speeds are in the order of several kilometers per second. The erasure and persistence time are controllable over a wide range by suitable adjustment of the holding beam. Figures 2 and 3 show a block diagram and a photograph of a typical Haeff tube.

*The Image Amplifier Storage Tube* is a development being carried out by Raytheon Manufacturing Company for the Bureau of Ships for recording applications, and is based on the principles of the Farnsworth image amplifier television pickup tube. An insulating storage surface is coated on the back of a perforated conducting screen electrode. Signals are written by an electron beam which passes through the screen and is reflected by an electron mirror to scan the dielectric coating on the reverse side of the screen. Reading is accomplished by means of the same electron gun and deflection system,

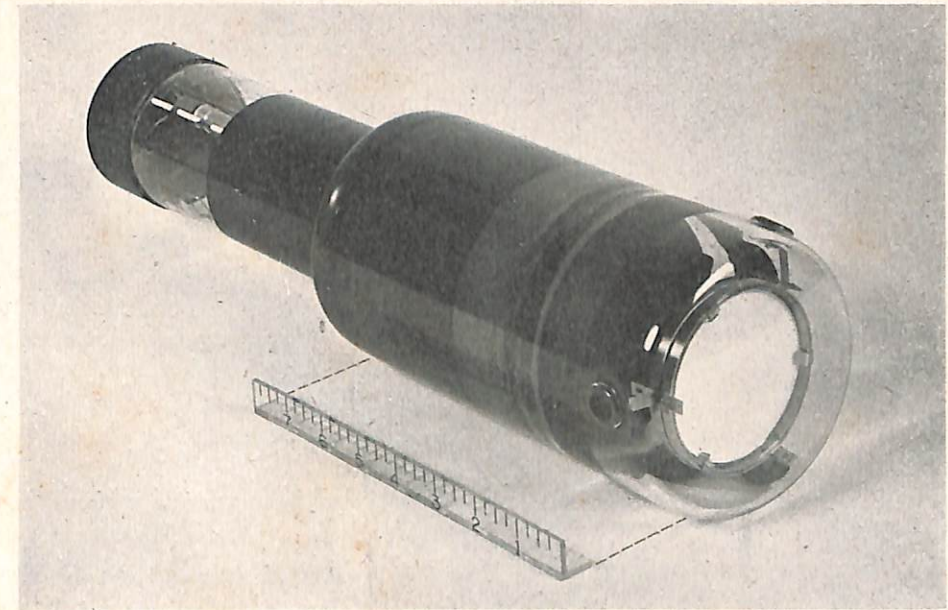


FIGURE 3

written pattern for any desired period by spraying a stream of electrons to regenerate continuously the stored charge, making the length of time of storage indefinite, and the number of readings of a charge pattern unlimited. The storage surface is a phosphor powder, and the stored signal can be observed visually directly on the screen, or it can be read out electrically. This is accomplished by scanning with the reading beam and using the signals collected by a metal screen in front of the dielectric target, fed through a suitable amplifier, to modulate the grid of an ordinary cathode-ray tube, scanned in the same manner as the reading beam. An

by permitting the beam to pass through the screen, where the charge pattern on the dielectric controls the passage of the beam to an output electrode, to give an electrical output signal. This tube is capable of dynamic range, since a varied amount of charge can be placed on a screen storage element. The objective of the development is a resolution of a million elements with a writing speed of 1 microsecond per element. These objectives have not yet been reached. The writing speed is dependent on the amount of current in the beam and the charging time of an element. Resolution is to some extent dependent upon the fineness of the beam, thus

limiting the amount of current. These contrary factors must be solved before the desired results can be attained.

*The Selectron* is a tube under development at RCA for use in electronic computers. It differs from all the other tubes described in that it is not a scanning device, but has a cylindrical storage surface with cathodes in the form of posts near the center of the cylinder emitting electrons in all directions simultaneously. At its present stage of development this tube has 256 storage elements in the form of metal eyelets embedded in a sheet of mica surrounding the cathodes. The eyelets act as windows which may be opened or closed by positive or negative charges deposited on the surrounding mica. Between the cathodes and the storage elements is a mesh grid composed of a network of crossed wires separated from each other, with each wire individually connected to an external control circuit. These form 256 open meshes. When all four sides of a particular mesh opening are positive, electrons from the cathode can pass through it and charge the storage element behind the opening. Each mesh is gated open in sequence for a complete writing or reading operation. By this arrangement, during writing, the electrons from the cathode lay down a charge pattern, element by element, on the mica surface surrounding the eyelet. When there is a negative potential on the eyelet the storage window is effectively closed, and the electrons cannot pass through it during the reading operation. If there is a positive potential on the eyelet the reading electrons will pass through it, striking a phosphor dielectric deposited on the walls of the glass tube surrounding the structure. Secondaries emitted by this phosphor are collected by wires for electrical signal take off. The signal is not damaged by reading, as it is regenerated by electrons sprayed on the entire storage surface between each writing or reading operation. The Selectron is more complicated than the other types of storage tubes, but since it is a gating device rather than a beam deflection tube, it gives exact and positive registration to the particular element desired, an important point in computers. The signal may be read an unlimited number of times, and erasure of one point and rewriting in the same spot may easily be carried out.

*The Williams Tube.* A standard cathode-ray tube with the addition of an external metal backing plate has been used by F. C. Williams of the University of Manchester, England, for electronic computers. The tube uses a single gun, and writes positive and negative signals by digging a "potential well" in the form of dots and dashes on the phosphor surface. The same gun can differentiate between the two types of signals when used for reading. The information is destroyed when it is read, but is regenerated in an external circuit and continuously fed back into the tube. Approximately 1000 dots can be stored at writing and reading speeds of 2 to

5 microseconds. Although production type cathode-ray tubes must be carefully selected for uniformity and absence of screen defects, the use of such a tube for storage would offer great advantages in simplicity, availability, and low cost. An article "A Storage System for Use in Binary Digital Computing Machines" by Williams and Kilburn is being published in the British Journal of the Institution of Electrical Engineers.

*Miscellaneous Storage Tubes.* Several other storage tube developments are presently under way or have been carried out. These include:

- 1—Repeller Storage Tube developed by Raytheon under a War Department contract and described in the August, 1948 "Electronics." This was a cancellation device and has been discontinued in view of the apparent greater suitability of the Haeff and Barrier Grid Tubes.
- 2—Whirwind Tube being developed at MIT for a Navy electronic computing project. This tube is somewhat similar to the Haeff Memory tube and the Barrier Grid tube. It has a back plate behind the storage target and a mesh grid in front. It uses two guns, one for writing and reading and one for holding. This tube shows possibilities of being able to solve the computer problems, but fabrication difficulties have been encountered.
- 3—Krawinkel Storage Tube was developed in Germany during the war, and is described in Air Material Command technical report F-TR-2205-ND, dated June 1948. The tube is quite complicated, using an insulating storage material interspersed with a photoemissive surface, the emission of which is controlled by the charge on the insulating material.
- 4—Dark Trace. National Union has recently proposed the development of a storage tube based upon the principles of the difference in secondary emission between the dyed portions of a dark trace cathode-ray tube screen and the portions on which no traces have been written. This tube has interesting possibilities, but no work has started to date.

### When Will They Be Available?

Models of the Haeff Memory Tube, the Barrier Grid Tube, and the Graphochon have recently been made available for experimental use in certain Navy equipments. The Institute for Advanced Science at Princeton is working with models of the Williams tube and the Selectron for the electronic computers they are designing as a joint service project. The other tubes mentioned have not yet reached the stage where tubes have been fabricated for use outside the laboratories where the development is under way, but their progress is being followed closely by the Bureau of Ships Electron Tube Section. As soon as justified by results, data and tubes will be supplied to Navy laboratories and contractors.

# REACTANCE STARTING OF HIGH POWER FILAMENTS

by  
 LT. CDR. JOHN C. WALTER  
*Electronics Design and Development Division,  
 Bureau of Ships*

Certain large tubes, particularly those having pure tungsten filaments, require reduced voltage starting in order to prevent damage to the filament structure. Tube manufacturers usually specify the maximum permissible starting current for tubes in this category. As a general rule, preventing the starting current from exceeding a maximum of 150 percent of the normal operating current may be considered as a satisfactory design value.

When the cold resistance is not known it may be safely estimated at 1/12 of the hot resistance for tungsten filaments. Where filaments are oxide or thorium coated there will be less difference between the hot and cold resistance because of the lower operating temperatures required for adequate emission. In the following example, a special filament consisting of tungsten bars with one side thoriated by a carburizing process has a hot/cold resistance ratio of approximately 4 to 1.

*Example:* Determine the series reactance and filament transformer primary voltage to limit starting current to 150 per cent of normal for a tube having the following filament characteristics:

Hot resistance  $R_h = 0.002185$  ohms  
 Cold resistance  $R_c = 0.00050$  ohms  
 Filament power  $E_f I_f = 10,000$  watts  
 $R_h/R_c = 4.037$

On a per-unit basis:

Operating condition	Starting condition
$E = 1.0$	$E = 1.0$
$I = 1.0$	$I = 1.5$
$Z = 1.0$	$Z = 1/1.5 = 0.67$

Solving for reactance X:

$$\left. \begin{aligned} R^2 + X^2 &= (1.0)^2 \\ R^2/(4.037)^2 + X^2 &= (0.67)^2 \end{aligned} \right\}$$

$$\left. \begin{aligned} R^2 + X^2 &= 1.0 \\ R^2/16.32 + X^2 &= 0.448 \end{aligned} \right\}$$

$$\left. \begin{aligned} R^2 + 16.32X^2 &= 7.32 \\ -R^2 - X^2 &= -1.00 \end{aligned} \right\}$$

$$15.32 X^2 = 6.32$$

$$X^2 = 0.4125$$

$$X = 0.6425$$

Percent reactance required = 64.25%

Power factor of system =  $(1 - 0.4125)^{1/2} = 0.767$

For a 10-kw filament load and a 460-volt single-phase, 60-cycle supply, we may obtain the transformer primary voltage and series reactance value as follows:

Line voltage	$E_L = 460$ volts
Reactance drop	$E_x = 0.6425 \times 460 = 296$ volts
Primary voltage	$E_p = .767 \times 460 = 353$ volts
Line current	$I_L = 10,000/353 = 28.3$ amperes
Reactance	$X = 296/28.3 = 10.46$ ohms
Inductance at 60 cycles	$L = 10.46/(6.28 \times 60) = 0.277$ henry.

From the foregoing we see that the 10-kw filament transformer primary should be wound for 353-volt oper-

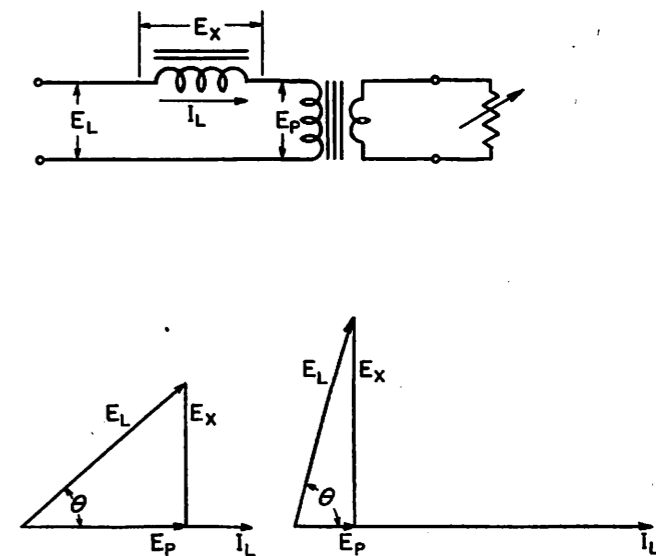


FIGURE 1

ation and that the series reactor should have a 60-cycle rating of 27.7 mh at 28.3 amperes.

The vector diagrams of figure 1 illustrate start and run conditions for the circuit:

RUN	START
$E_L = 460$ volts	$E_L = 460$ volts
$I_L = 28.3$ amperes	$I_L = 1.5 \times 28.3 = 42.4$ amperes
$VA = 13,030$	$VA = 19,500$
$X = 10.46$ ohms	$X = 10.46$ ohms
$E_X = I_L X = 296$ volts	$E_X = 42.4 \times 10.46 = 444$ volts
$E_p = (E_L^2 - E_X^2)^{1/2} = 353$ volts	$E_p = (E_L^2 - E_X^2)^{1/2} = 122.5$ volts
$P = E_p I_L = 10,000$ watts	$P = E_p I_L = 5,200$ watts
p.f. = $\cos \theta = 10,000 / 13,030 = 0.768$	p.f. = $5,200 / 19,500 = 0.267$

Experience has shown that it is better to use the external reactor method in preference to building the required leakage reactance into the transformer. High leakage transformers usually require the use of air-gap cores and split windings that are wedged in place. Magnetic vibration and dehydration cause loosening of the wedges, and result in noisy operation and voltage variations caused by coil displacement. In a typical application using several high power tubes of the type considered in the example, taps were provided on the reactors to permit adjustment of filament voltage for individual tubes so that standard bus voltage could be maintained by induction regulators. Power factor improvement was also obtained by means of standard power factor correction capacitors. The reactance starting method is considered superior to the familiar resistance starting in that filament shock is practically eliminated and smooth automatic operation is obtained without the use of moving parts.

**BOX SCORE**

**BuShips Electronics Repair Parts Program**

Allowances	Type Vessels	Percentage Completed
<b>ELECTRON TUBES</b>	Submarines	100%
	Surface	91%
<b>REPAIR PARTS</b>	Submarines	50%
	Surface	0.9%

## MARK 25 MOD 2 RADAR, FIELD CHANGE NO. 5

Field Change No. 5 to Radar Equipment Mark 25 Mod 2 is accomplished by replacing the unmodified range sweep chassis with one that has been modified at the factory. The modified range sweep chassis is shipped as Field Change Kit No. 5. The number of Field Change Kits that are available for installation depends upon the prompt return of the unmodified range sweep chassis to the factory.

Of the first 30 kits shipped out, only 11 have been reported installed and only 9 unmodified chassis have been returned. To expedite the accomplishment of Field Change No. 5 those activities which have received Field Change Kit No. 5 should install the modified chassis and return the unmodified one promptly. The returned chassis can then be modified and reshipped to enable another activity to accomplish Field Change No. 5.

## THE NAVY NEEDS YOU . . . ALIVE

ET's are scarce. Those DANGER HIGH VOLTAGE signs are there for a reason. Be careful, or the next large charge you get may be your last. If you get shorted out, you can't always be repaired! Naval Supply Depots do not stock components for ET's. Only recently an ET was permanently discharged forever.

To learn more about the dangers that surround you, read "Effects of Electric Shock" in the March 1948 ELECTRON and "You Too Can Be a Dead Technician" in the December 1946 issue. Even if you "know all about high voltage precautions" it would be wise to read and reread those articles and study the safety precautions and shock treatment measures described in the front section of every equipment instruction book.

And remember, under the right conditions, 110 volts can cook you as well done as 20 kv. Please be careful fellahs! ET's are scarce.

## ELECTRONIC CLEARANCE INDICATOR

In a general program for streamlining weight and speed requirements on rotating machinery, a device was needed to measure clearances of internal rotating parts operating in close proximity to the case or frame. To calculate running clearances certain assumptions may be made by the designer that are not sufficiently borne out in actual operation, resulting in changed clearances of an unknown degree after assembly. If this remains undetected after installation, continued operation near a point of failure may result. For certain applications where, for example, a differential internal expansion occurs under varying temperatures it is desirable to have an indication of internal clearances during test runs, to check the possible need of redesign. An electronic micrometer principle has been employed in the development of an indicator for this purpose.

A number of systems for internal clearance measurement have been devised including mechanical, optical, electrical and electronic methods that have been de-

scribed before. The mutual inductance type of electrical distance measuring equipment appears to be the most satisfactory, due to linearity of response, response to vibration frequencies as well as to straight expansion, operation in oil spray or steam, and stability. To apply this principle in a typical instrument the coupling between two air core coils at radio frequency is varied by the proximity of a metallic surface such as a shaft coupling or turbine blade disc. Since no electrical contact to the rotating shaft is necessary this represents a distinct advance in design over many electrical instruments where brush contacts and slip rings are needed for operation. By feeding a radio-frequency voltage to the primary coil and impressing the signal from the secondary coil on a crystal diode rectifier, a d-c millivolt output is derived proportional to the mechanical displacement of the rotating part. The millivolt output is capable of showing a full scale deflection on a balancing bridge type recorder with clearance changes of the order

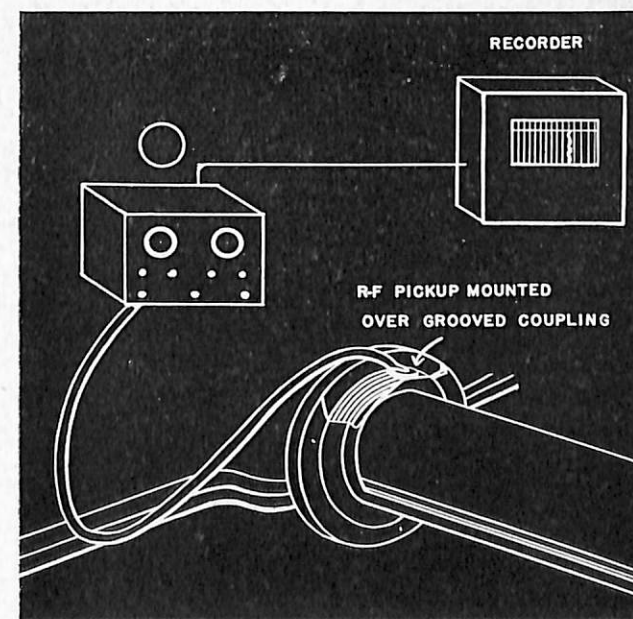


FIGURE 1



Type of Approach	Last Month	To Date
Practice Landings	11,411	245,705
Landings Under Instrument Conditions	226	9,886



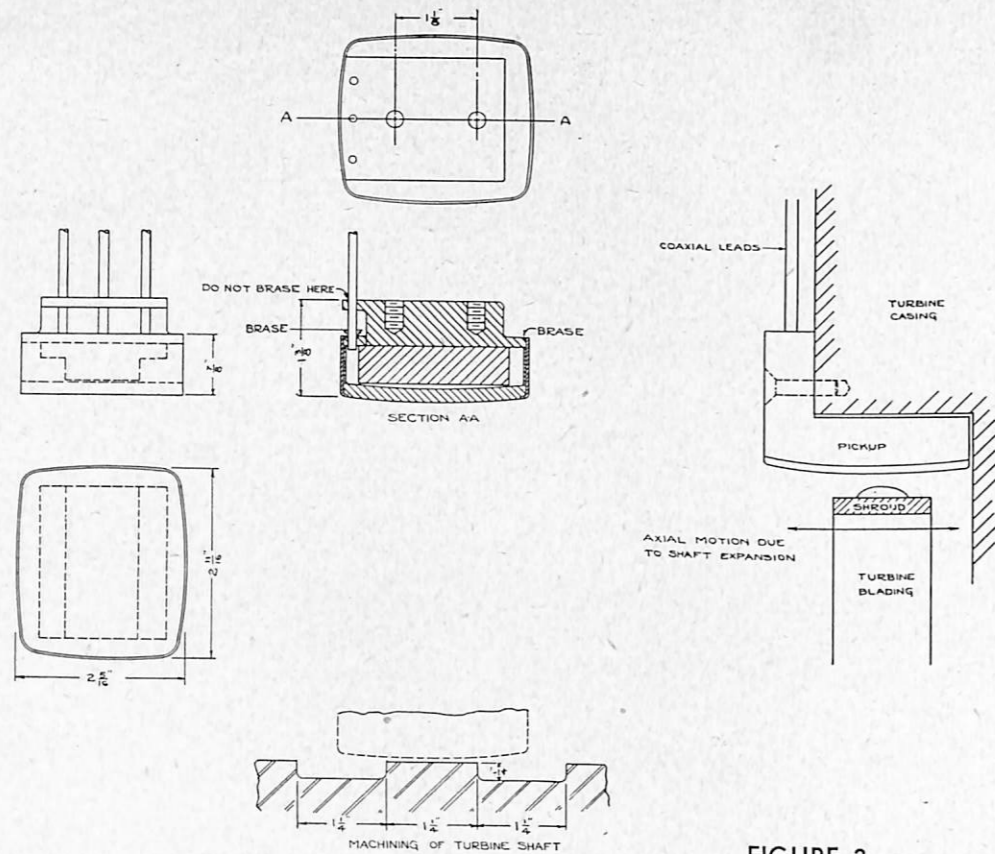


FIGURE 2

of 0.2 inch, so that any changes of .001 inch or less are easily recorded on such an instrument. For a study of vibration or eccentricity, further amplification can be effected and the pattern shown on a cathode-ray tube.

**Design of Distance Sensing Elements**

In the specific application of the mutual inductance micrometer principle it is necessary to obtain clearance measurements at four different points, three installations being internal and the fourth mounted externally to reference the indications of the internal pickups.

The external pickup is of the most simple design as the external mounting requires no consideration other than operation in an oil spray. Since the mutual inductance type pickups are inherently unaffected by the presence of oil or vapors this requirement is met for all points of operation in the machine. The pickup is designed to be mounted over a grooved section of a coupling as shown in figure 1. The two coils are mounted with their centers spaced apart along the direction of coupling motion and are surrounded by an exciting winding. The mutual inductance between the exciting winding and each of the two coils is altered by the proximity of the metal. Motion of the coupling decreases the induced voltage in one coil while increasing it in the adjacent coil so that output voltage is derived from the difference voltage of the two coils. The coils

are assembled in an open metal case with leads brought out in 1/8" stainless steel tubing to a terminal block, and the case is filled with a plastic potting resin to prevent damage in use, completing the construction of the pickup.

Of the three internal pickups, the first position requires installation in a high temperature steam atmosphere, with the other two installations operating at somewhat lower temperatures. With the coil designs established for all pickups, the major problems are the temperatures encountered along with eroding action due to steam velocity. Since the face of the coil case must be non-metallic, preliminary attempts at sealing were made on ceramic forms coated with vitreous enamel. Silicone coatings were considered but are not sufficiently rigid. A final design for the form was determined using unfired lava for machining to final form and firing after coils were placed. In this construction it was found necessary to use ceramic coated wire on the forms.

A test of the pickups sealed with vitreous enamel or plastics showed that erosion in high speed steam was too severe to permit the use of such materials with any degree of success. Mycalex, a mixture of powdered mica and glass was considered but was not actually used due to machining and casting difficulties. An acceptable design was determined using a glass cover sealed to a metal housing. The glass is specially heat and shock

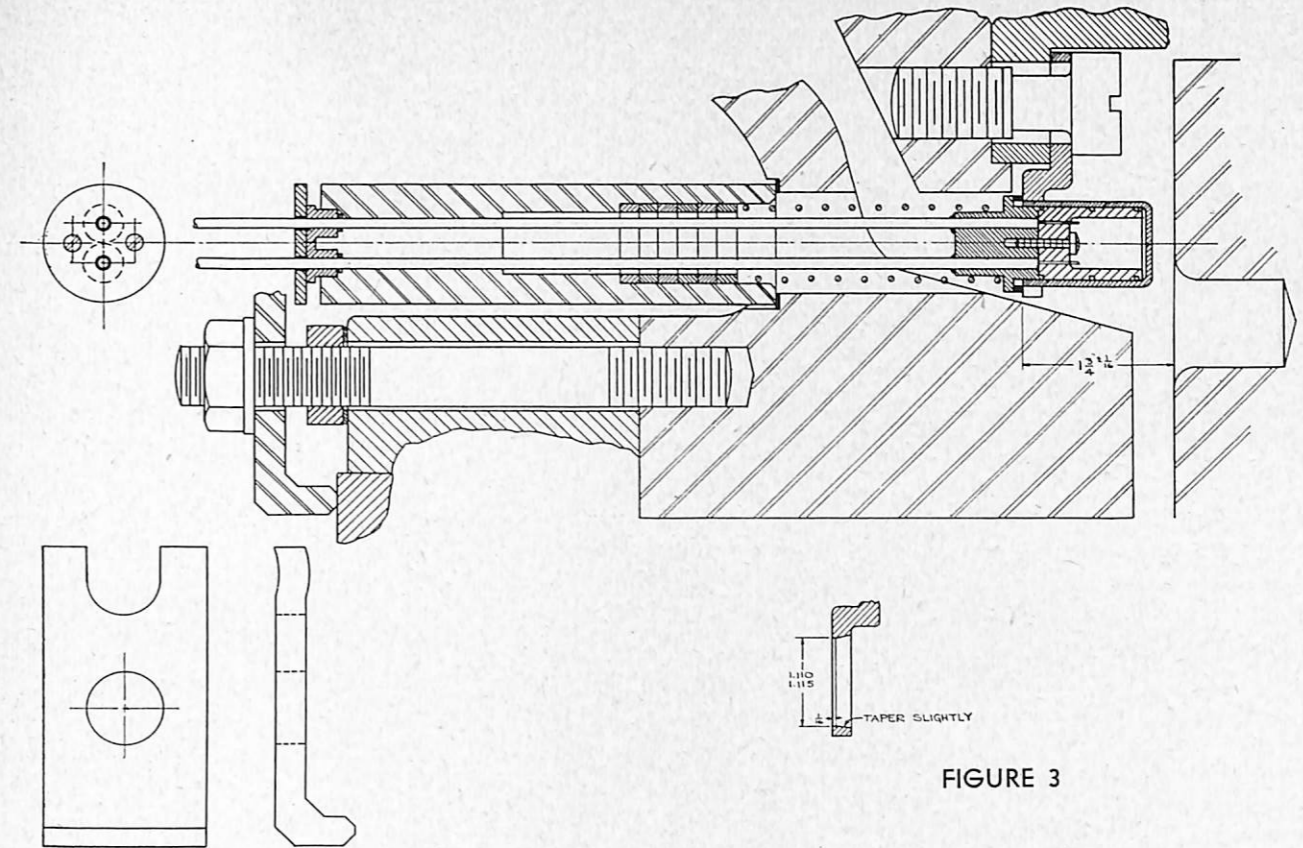


FIGURE 3

proof tempered, having metallized edges sealed to the case with high temperature solder. Since the coils are contained in a sealed case, the leads can be brought out in stainless steel tubing, obviating the necessity for pressure seals around the conductors. The location of this pickup to measure expansion laterally to the face makes the design similar to that of the external pickup. The design of the second pickup is also similar in all details to position 1, except for mounting lugs and position of leads. The drawings of these two types are shown in figures 2 and 3.

The fourth position pickup requires a different method for sensing clearance changes, as the pickup must be mounted normal to the face of a turbine blade wheel. This necessitates an "end-on" installation. The same materials are used on this pickup as those on positions 1 and 2, except that the glass cover is made in the form of a cylindrical cup, fused to the metal base which is of Kovar, to match as nearly as possible the thermal expansion of the glass seal. Figure 4 shows the details of this pickup.

**Chassis**

The radio-frequency power to drive the probe output is obtained from an oscillator circuit that is designed to maintain a stable output to the probe coil. The power is obtained from a Type 6L6 beam power oscillator tube in a circuit utilizing the probe output winding

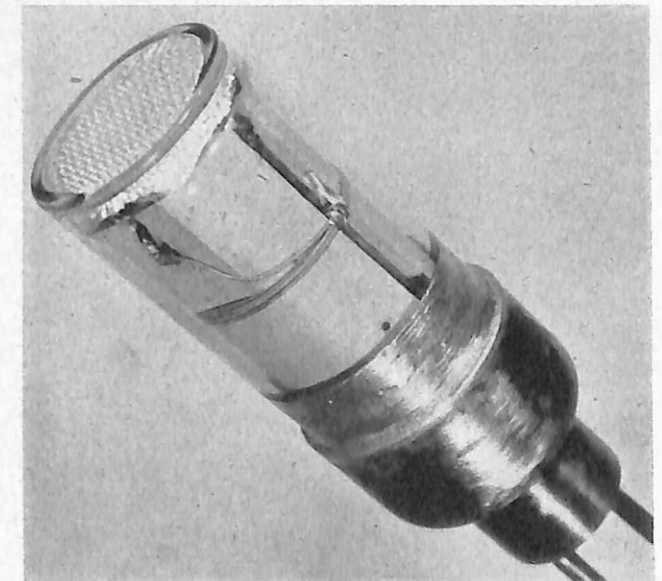


FIGURE 4

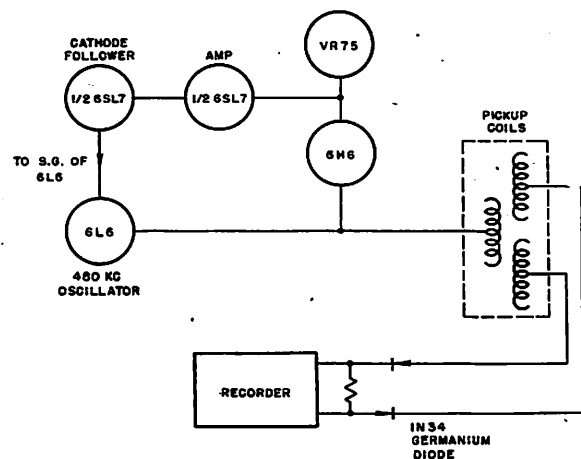


FIGURE 5

then fed through a cathode follower to the screen grid of the 6L6 oscillator. The result is a very close regulation of the output to the pickup. A block diagram of the system is shown in figure 5.

The power supply is obtained from a full wave rectifier circuit and is similar in all respects to standard radio receiver supplies. The crystal diode rectifiers to convert

## COUNTERMEASURES INFORMATION

It is essential that the countermeasures equipment presently installed in the fleet be properly maintained in the operating condition required for fleet readiness. It is also essential that this equipment be used whenever possible for both training purposes and observance of equipment operating conditions. Maintenance procedures outlined in the instruction books of the specific equipments should be followed.

Periodic system inspections should be made to locate loose, dirty and corroded cable connections at antennas; loose cable connections in the countermeasures compartment; damaged antennas; and poor ground connections due to the absence of bonding straps or the painting of such straps.

The lack of proper maintenance of the Model DBM series equipments is causing an excessive number of failures and a critical shortage of spare parts. Following the maintenance schedule as listed in the instruction book, greasing the rotary antenna joint (use clean grease Navy Type O.S. 1350), and inspecting the contact fingers for deformation and wear at least once every two weeks if the equipment is subjected to continuous operation, may reduce the number of failures.

The Variac used for antenna speed control should be checked for voltage output. The voltage range should be from 30 to 87 volts but will vary from 0 to 135 volts if the low- and high-range stops on the Variac have

the r-f output from the probes to d.c. suitable for measurement are also installed on the chassis with terminals for connection to a recorder.

### General

The development of this instrument for measurement of clearances will also open other possibilities for making internal measurements and associated tests that were previously accomplished only by mechanical and optical methods. It is thought that a new field will be opened for the study of vibration of rotating parts, that could not previously be attempted with other methods. The instrument is presently in the evaluation stage where it has shown a degree of accuracy comparable to or surpassing that of mechanical methods, with the further advantages of stability beyond previous attainments in electronic measurement circuits, imperviousness to destructive atmospheres and, most important, response to vibratory motion. It is expected that improvements in rotating machinery will result from new information obtained by the use of this device as its potentialities become known.

broken. The low voltage will damage the antenna drive motor; the high voltage will cause excessive antenna rotation speed with abnormal vibration and eventual antenna failure.

It is known that the crystals in the Model AN/SPR-2 receiver are damaged by high-frequency currents such as are produced by radar and other high power transmitters if the AN/SPR-2 antennas and the transmitting antennas are in close proximity to each other. The Bureau of Ships has received no failure reports on AN/SPR-2 crystals. All such failures should be reported on the failure report card NavShips 383 and information on antenna location with respect to nearby radar or other transmitting antennas should be noted thereon.

The Bureau is endeavoring to improve the electronic countermeasures equipment presently installed in the fleet. A number of field change kits are being prepared for issuance to the fleet within the next few months. Poor operation due to interference from other electronic and electrical equipment is being investigated. All reports from the fleet regarding these equipments are evaluated and action taken as required.

Don't forget, failure reports are the best means by which the Bureau can determine the need for improvement to your equipment. *Report Your Equipment Failures on Form NavShips 383.*

## A SONIC DEVICE FOR UNDERWATER SEDIMENT SURVEYS

by

E. C. LAFOND, ROBERT S. DIETZ, and J. A. KNAUSS  
U. S. Navy Electronics Laboratory

It is sometimes desirable to establish the character of the sea floor in a limited area in sufficient detail to permit the construction of an accurate sediment chart showing the distribution of mud, sand, stony, and rock bottom. For example, a detailed bottom-sediment chart is occasionally required for geological information or in connection with marine ecological studies such as those relating to the distribution of fish. Also, detailed sediment information is sometimes required in connection with the installation of equipment on the bottom or with the construction of marine engineering structures. To meet such requirements, a new sonic "sampler," which has been nicknamed the "soundfish," has been developed and successfully tested by the writers. The device utilizes the sound emitted by a metal cylinder dragged along the bottom to determine the continuous character of the sea floor along the course of the ship.

The soundfish, as presently developed and used, consists of a Brush C-23 hydrophone encased in a watertight metal cylinder, which is 22 inches long, four inches in diameter, and weighs 25 pounds (see figure 1). The metal case serves as a sound source as it scrapes along the bottom and also furnishes protection for the hydrophone. Circular ridges are used on the outside of the case to increase the frictional sound developed. The metal case does not necessarily have to be watertight, but this type of construction increases the depth to which the device may be used, since the hydrophone will only safely withstand a pressure equivalent to about 60 fathoms. However, the difficulty of the dragging operation and other considerations probably limit the usefulness of this device to continental shelf areas where depths are generally less than 100 fathoms.

The sound emitted by the metal case as it is dragged along the bottom is picked up by the encased hydrophone and transmitted up an electric conductor cable to the ship, where it is monitored with suitable listening equipment. For this purpose, a battery-operated audio amplifier proved satisfactory. If the conductor cable is of a high-tensile-strength type, it may be used for towing. If it is of the usual low-breaking-strength type, it must be lowered along with a steel cable which serves to withstand the stress of towing.

The type of sound emitted by the soundfish is specific for rock, gravel, sand, and mud bottom. Under good conditions, a trained observer can even differentiate with some success between fine, medium, and coarse sand. Rock makes continuous loud bongs or clangs, sand makes a heavy scraping or rasping noise, and mud makes a quiet swishing noise. In a mixture of coarse and fine material, the noise made by the coarse fraction dominates. It is not possible to describe accurately the noises, and they vary with the sensitivity of the audio amplifier, the speed of the ship, and the resonance of the metal case, so that it is necessary for the observer to train his ear by listening while the equipment is dragged at constant speed over known types of bottom, as determined by grab sampling.

An especially useful function of the soundfish is to establish the boundaries between areas of different types of sediment. Such boundaries cannot be accurately located by spot-sampling methods. Also positive identification of rock bottom is difficult to obtain by grab sampling methods, as the snapper usually comes up empty.

A bottom sediment survey made with the soundfish gives best results when it is supported and checked by occasional bottom sampling. Also, it is useful to correlate the survey with detailed profiles made with a recording echo sounder, as the type of bottom sediment is usually closely correlated with topography. For example, rock bottom is almost invariably irregular whereas sand and mud bottoms are smooth.

A simpler variation of this method of using the noise of an object dragged along the bottom to determine sediment type has been fairly successful. This technique consists of dragging a resonant metal object such as a hollow metal pipe along the bottom with a small-diameter wire rope. Some of the noise made by such an object is transmitted up the wire to the boat, where it may be picked up by a contact microphone which is connected to a suitable audio amplifier. The sounds produced by various types of bottom are similar to those detected by the "soundfish" sampler. With this technique, however, the sound signals are weak and it is difficult to eliminate extraneous noises.

In order to give the soundfish a thorough field test, a detailed bottom sediment survey was recently made

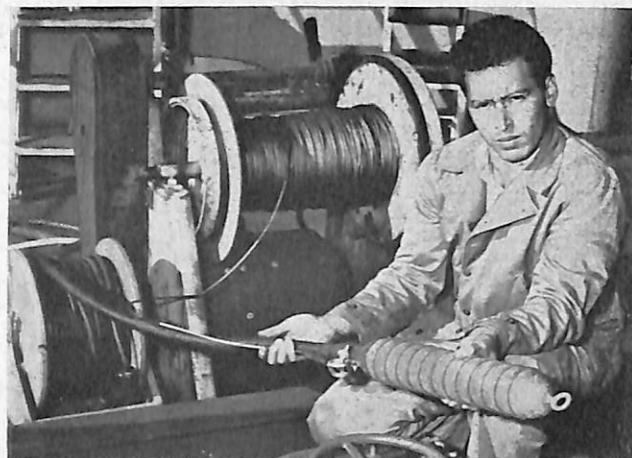


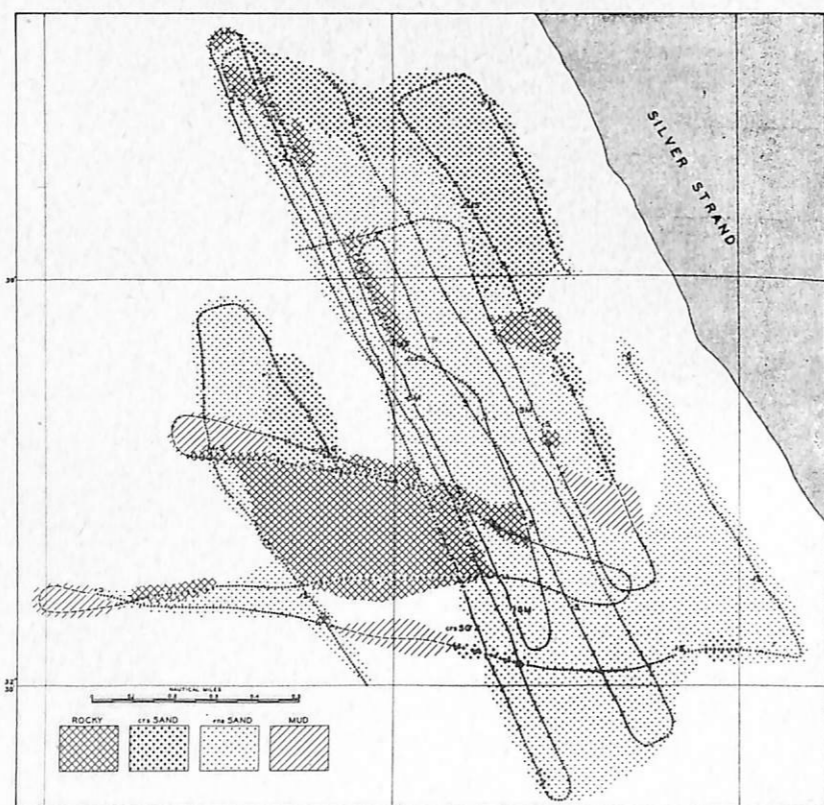
FIGURE 1—Photo showing the "soundfish." Note also the winch containing wire rope and the smaller reel of conductor cable both of which are used to lower the device to the sea bottom.

was operated at a speed of from two to four knots, so that the soundfish moved by saltation along the bottom. An observer monitored the audio amplifier and attempted to differentiate between mud, fine sand, medium sand, coarse sand, pebbles, cobbles and rock. Another observer obtained bottom samples at intervals with an underway sampler. It was found that good agreement was obtained between the actual bottom samples and the bottom character interpreted by the observer listening to the soundfish. Also, the boundaries between different types of bottom could be located with considerable accuracy. With the data obtained from this survey, a sediment chart was constructed showing the distribution of mud, fine and medium sand, coarse sand, and rocky or stony bottom (see figure 2). It was not practical to attempt to make finer discriminations, such as differentiating between fine and medium sand.

In conclusion, the writers believe that the soundfish is a useful tool for rapidly determining the detailed distribution of bottom sediment types on the continental shelf. The less satisfactory method of dragging a piece of metal on the bottom and listening to the wire with a contact microphone and an audio amplifier is a useful alternative.

from the research schooner *E. W. Scripps* of the Scripps Institute of Oceanography in water of about ten fathoms depth off the Silver Strand beach near San Diego, California. The soundfish was dragged with a 5/32-inch wire rope back and forth over an area of about three square miles which was known to have a variety of bottom types. A conductor cable, through which the sound from the hydrophone was transmitted to the ship, was taped at approximately 20-foot intervals to the steel cable with sufficient slack so that the steel cable alone accumulated the stresses. Fixes were obtained about every two minutes by triangulation, using a sextant aboard ship and measuring the horizontal angles to suitable shore points of known position. The vessel

FIGURE 2—Bottom sediment chart made with data obtained by the "soundfish" of an area off the Silver Strand Beach at San Diego, California. The lines on the chart represent the track of the observing vessel. Each "soundfish" observation along the track is represented by a symbol as follows: a cross equals rock or gravel; an open circle equals coarse sand; a dot equals medium or fine sand; and a dash equals mud. The sediment chart is constructed on the basis of these observations. Letter symbols such as fSM (fine sand with mud) etc. indicate identifications made on the basis of bottom samples.



## MARINE CORPS NOTES



The Marine Corps Ground Control Intercept Squadron 21 of NAS Squantum, Mass. reports periodic fading of information of the Model VK Radar Indicating Equipment. The trouble has been traced to excessive line voltage fluctuations of shore power.

Marine Corps Ground Control Intercept Squadron 17 of NAS Willow Grove, Pa. reports that a great deal of noise and interference was noticed in Model AN/TPS-1B presentations, and the source of trouble was found in the i-f stages of the receiver. When wire mesh was used for shielding, the trouble disappeared. It is believed that local television stations were producing interference in the unshielded r-f section of the 1B modulator.

Squadron 17 also reports one failure of the Model AN/TPS-1B in which the targets disappeared completely. The trouble was traced to the converter cavity in the r-f section. The plating on the cavity had begun to corrode and chip and all mixing action had been lost. Since local facilities for replating were inadequate, the converter cavity was sent to the District Electronics Officer for repairs. The equipment had been in operation for 1,000 hours over a two-year period at the time of the failure.

### MODELS DBM/-1 ROTATING ANTENNA JOINTS

A number of reports of rotating joint failures and noisy receiver operation due to the rotating joints of the Models DBM/-1 Radar Direction Finder Equipment antennas have been received by the Bureau of Ships. The results of an investigation have indicated that in 90 percent of the cases, the trouble occurred because the equipment was not properly maintained. By (a) following the equipment maintenance schedules as listed in the instruction book, (b) greasing the rotary antenna joint every two weeks if the equipment is subjected to continuous duty, and (c) inspecting the contact fingers for deformation or excessive wear and taking appropriate action, the number of failures occurring in these antennas should be reduced.

## NEW TIPS FOR THE TYPE -10695 SOLDERING GUN

A quantity of new improved tips for the Type -10695 soldering gun has been procured for issue. These new tips, manufacturer's part number 7300, and known as "Duratips," should be requisitioned and used in the Type -10695 soldering gun. The original tips (Long-life) furnished with the guns should be discarded upon receipt of the new Duratips.

The new tips have been assigned the stock number N16-T-3496-150 and have been stocked at NSD, NBA, Bayonne, N. J. and at SSD, NSC, Oakland, Cal.

The new tips are not tinned. Therefore, personnel using the gun with new tips should tin the working area before heating to a high temperature. The new tips are preshaped with a spaded focal soldering point. This design allows for increased heating capacity, decreases the chances of breakage at the soldering point and increases the tip life substantially.

Retaining nuts are not included with the new tips. The old nuts should be used with the new tips. Before use, the retaining nuts should be tightened securely to assure proper operation. Frequent checks to insure nut tightness will eliminate possible casualties.

It is requested that all vessels and activities using the Type -10695 soldering guns include information on the performance of the new tips in their operational reports stating whether a Duratip or Longlife tip was installed in the gun reported on.

### DISTRIBUTION OF ELECTRONICS CONFERENCE FINAL REPORT

The final two-volume report of the Electronics Conference held at the Bureau of Ships, Washington, D.C. on 16-20 May 1949 has been completed and distribution to cognizant and interested fleet, field, and departmental activities was initiated during the last week in July.

Special consideration will be given to a limited number of requests for additional copies of the complete report. Additional copies of the papers presented at the conference are available in very limited quantities and may be obtained by addressing requests to the Chief of the Bureau of Ships, Attention Code 950, Navy Department, Washington 25, D. C.

# BI-DIRECTIONAL RHOMBIC ANTENNAS AT NSS

by  
 Personnel of Naval Communication Station,  
 Annapolis, Md.

The ground area available for radio transmitting antennas at the Navy Communication Station, Annapolis, Md., is limited by Chesapeake Bay and adjoining inlets, and the proximity of other Naval activities. In spite of this limitation, and because of the unique position which the Station occupies as the primary transmitting station for the Navy Department in the Washington Area, all practicable steps have been undertaken to provide omnidirectional antenna coverage. Such coverage will soon be obtainable due to expansion of directional antenna facilities over the last two years and the design and use of an effective bi-directional rhombic antenna installation.

As far as known, the practical use of high-power bi-directional transmitting rhombic antennas has not been attempted at other transmitting stations, although Navy radio receiving stations have used bi-directional rhombic

antennas, as has been done at Cheltenham, Md. In the case of receiving antennas, the low power carried by the antenna simplifies the problem. A bi-directional switching installation, located at the antenna, was designed for rhombic transmitting antennas by this station's Electronics Engineer, Walter W. Goodhue. The initial full-scale model has been in use for 6 months. The illustrations indicate the principal features of such an installation.

The "bi-directional switch" structure is illustrated in figure 1. By use of this structure and some modification of transmission lines and the rhombic antenna terminating network, it is possible to transmit efficiently in either direction of the rhombic major axis. The time required for two men to change bi-directional switch connections to reverse the direction of transmission is about 15 minutes. Bi-directional switches are being incorporated in four new transmitting rhombic antennas, in addition to the initial installation on rhombic RA 090/270, as shown in figure 2. When rhombics under construction are completed, there will be five transmitting rhombic antennas at Annapolis which may be used for transmitting in either of two opposite directions. This allows

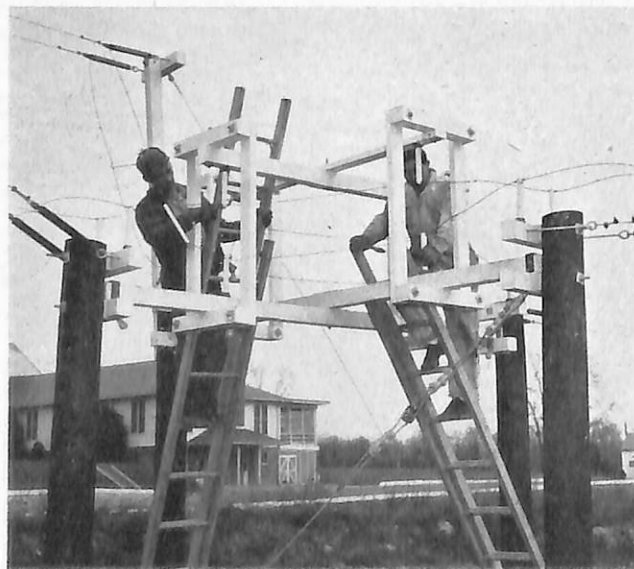


FIGURE 1

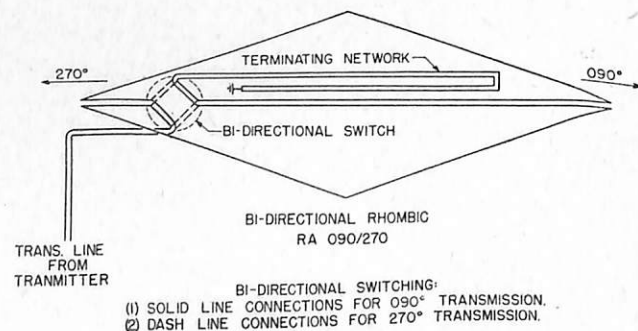


FIGURE 2

several antennas, which normally bear toward the southwest, to be reversed 180 degrees in their transmission for additional service to Atlantic areas where traffic is heavy.

Where the bi-directional switch is used, the transmission line from the radio transmitter, the input transmission line to the terminating network, and the transmission lines from both ends of the rhombic antenna all terminate at the switching structure in the field. (See figures 3 and 4). The structure performs the function of two double-pole, double-throw switches. This permits the transmission line from the transmitter to be connected to either end of the rhombic antenna. Similarly the input line to the terminating network can be connected to either end of the rhombic antenna. The switching effect is accomplished by short lengths of transmission line bolted in place for the direction desired. This use of line conductors eliminates the capacity effects and maintenance difficulties of switch-blades and jaws, and assures tight reliable connections through the structure. It also avoids any unused or dead-ended line terminals, regardless of the direction of transmission. The line connections are held by "Kearney" clips or "Con-nec-tites," which are special slotted bolts used in radio transmission line construction. The switch structure requires a minimum of fittings and insulators, and

should withstand sleet and snow conditions as well as standard transmission line construction.

The electrical performance of a transmitting rhombic installation is indicated by the ratio of standing-wave currents along the transmission line feeding the antenna. A low ratio of standing-wave currents indicates a good impedance match, hence efficient uni-directional transmission. Ratios between 1.0 and 2.0 are common over the high-frequency range. Standard rhombics at Annapolis, without the bi-directional switch, show a standing-wave current ( $I_{\text{maximum}}/I_{\text{minimum}}$ ) between 1.15 and approximately 2, over a frequency range of 20 Mc. to 4 Mc. respectively. The transmitting rhombic on which the first bi-directional switch was installed was measured for its standing-wave characteristics before the switch was added. The standing-wave ratios for three specific frequencies in the range of 12-18 Mc. were 1.16-1.19 for the original installation. After the bi-directional switch was added, the standing wave ratios for transmission on the original bearing were 1.12-1.19, and on the reversed bearing 1.22-1.39. This shows an increase in standing-wave ratio of only 10 to 20% on the reversed bearing. The increase in standing-wave ratio for the reversed direction of transmission is attributed to the transmission line passing over the top of the terminating network before reaching the rhombic. This is shown

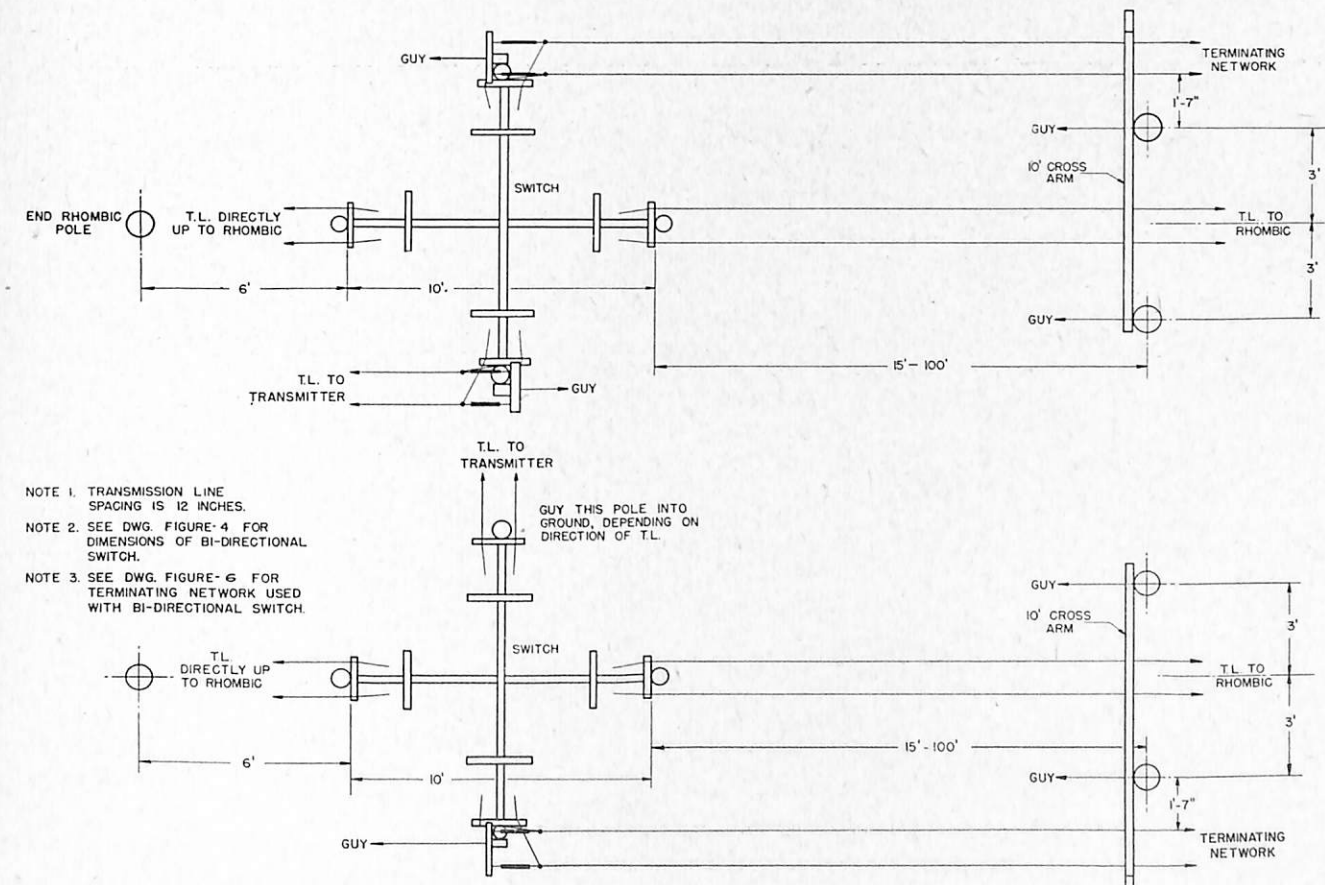
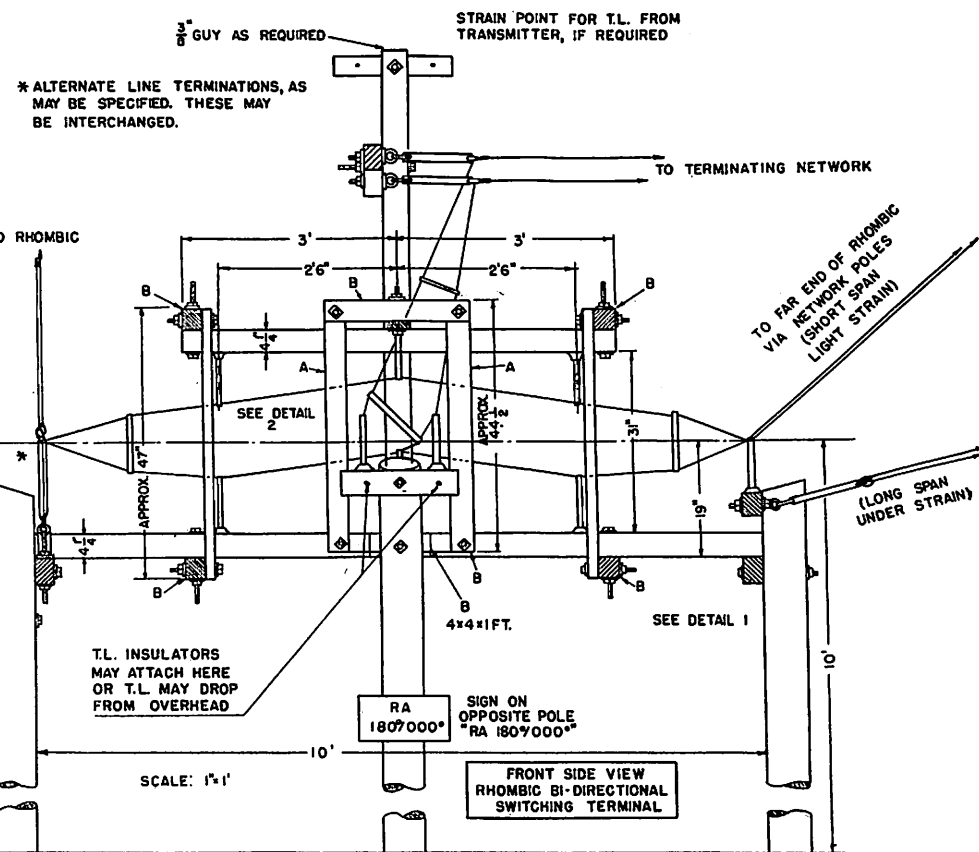
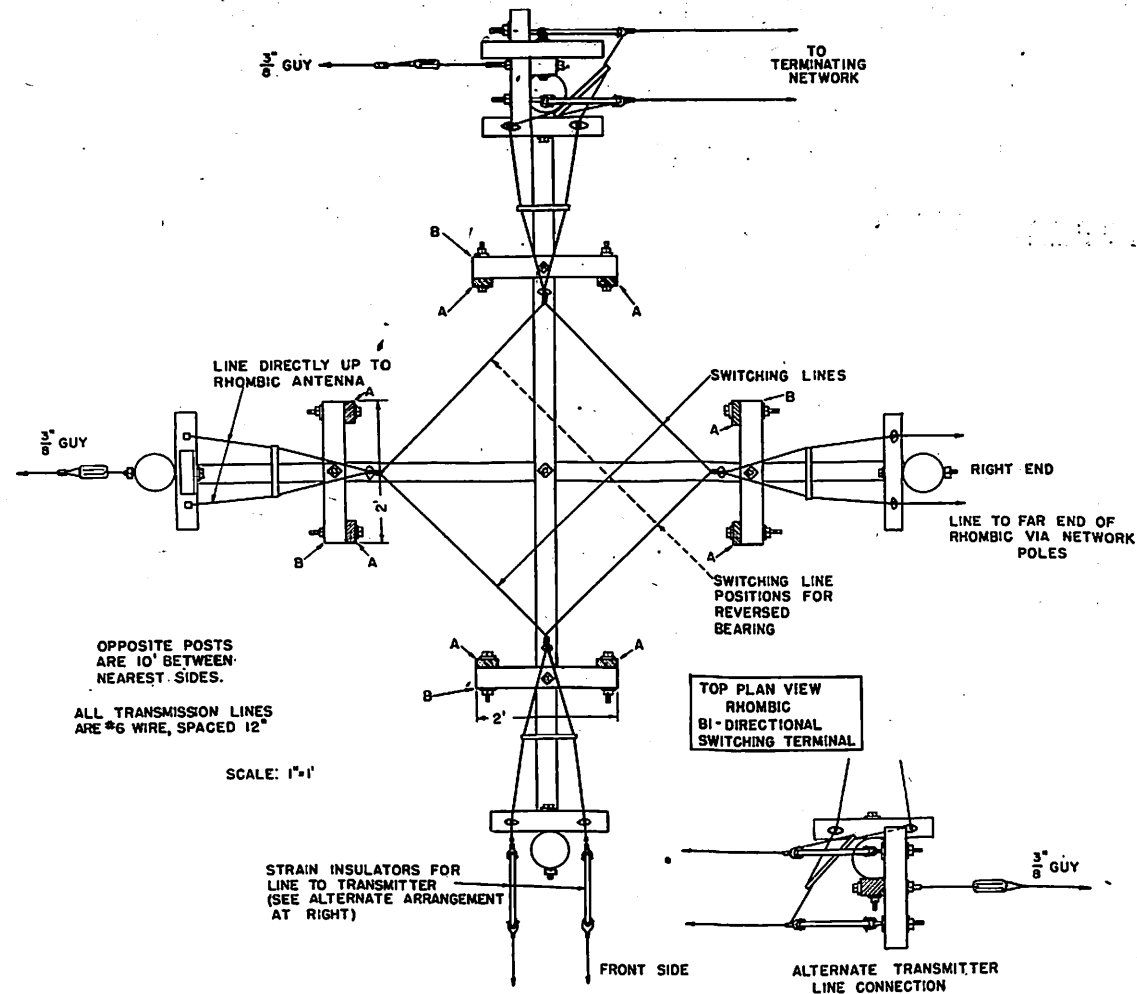


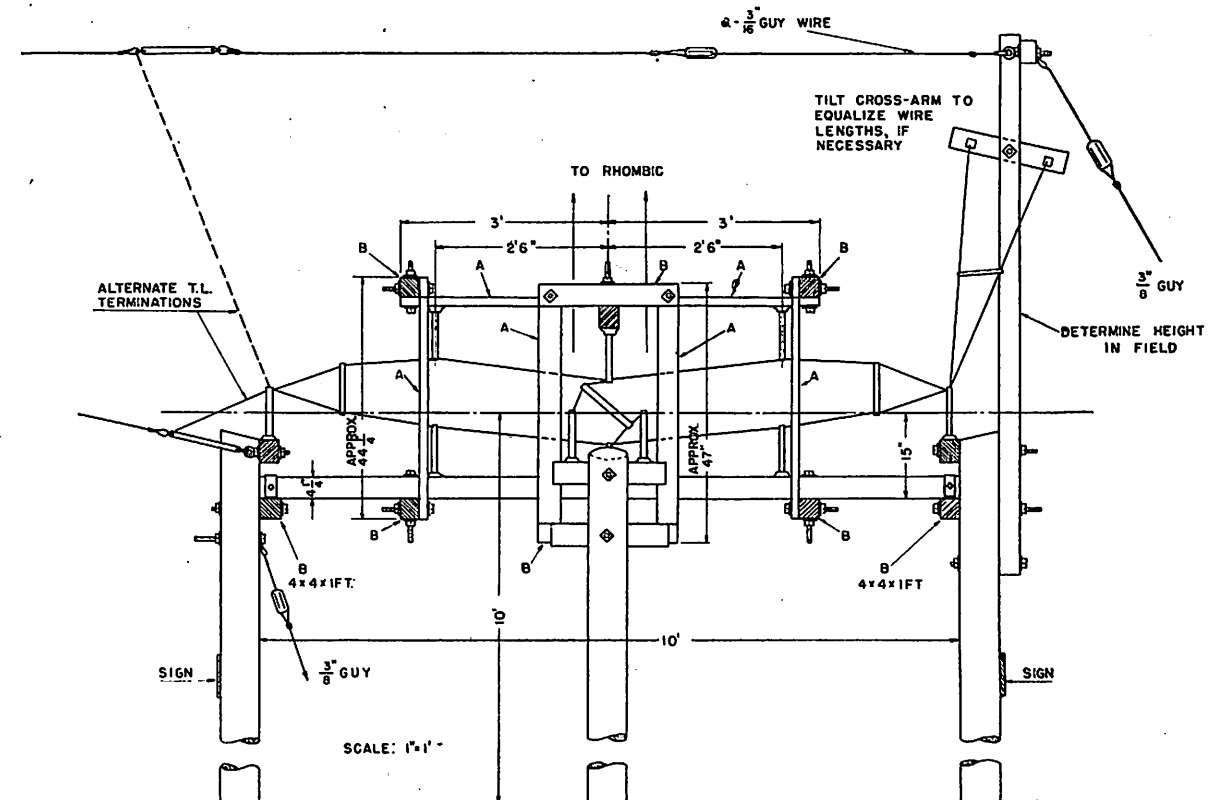
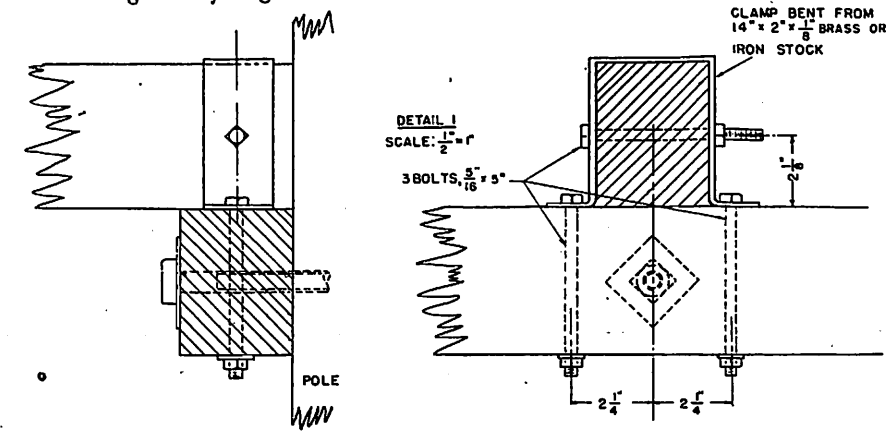
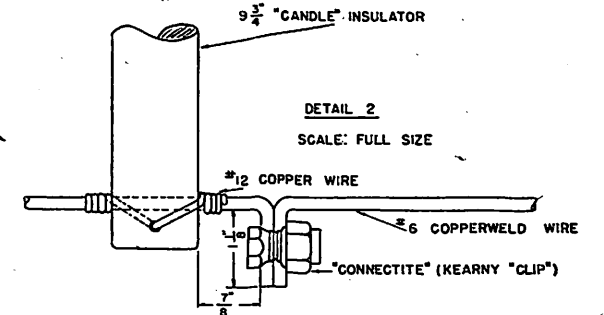
FIGURE 3



FIGURE 4



- NOTE 1: Set all poles to measure 10 feet from ground to top of pole. Saw pole tops to correct height as determined in field, and creosote pole tops.
- NOTE 2: Pole gains to be used with all cross-arms and 4 x 4s attached to round posts.
- NOTE 3: Galvanized hardware used in sizes below:  
 3/8-inch diameter—through all poles and cross-arms and 4 x 4s.  
 1/2-inch diameter—through all 2 x 4s.  
 5/16-inch diameter—through "candle" insulators and cross-arm end clamps.
- NOTE 4: All finished lumber is standard cross-arm stock except 2 x 4 marked "A" and 4 x 4 marked "B" all to be finished with 2 coats of white paint.
- NOTE 5: Standard 12-inch bar strain insulators, 12-inch spreaders, and 9 3/4-inch "candle" insulators used as indicated.
- NOTE 6: Guying is subject to requirements of each installation. Guy as necessary to prevent each of the poles from moving out of alignment.



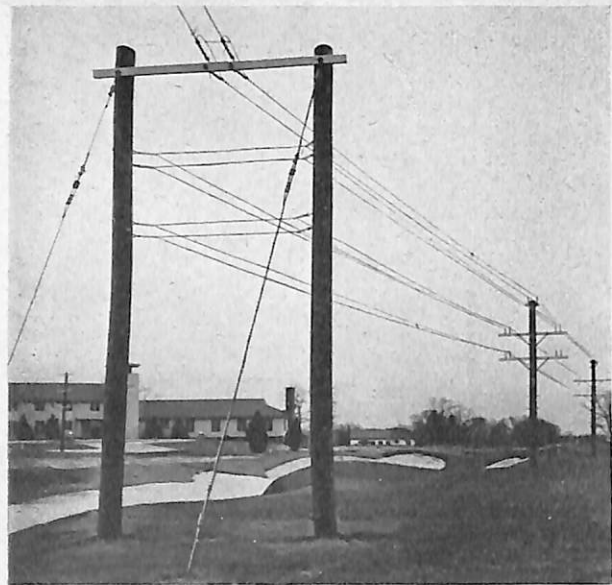


FIGURE 5

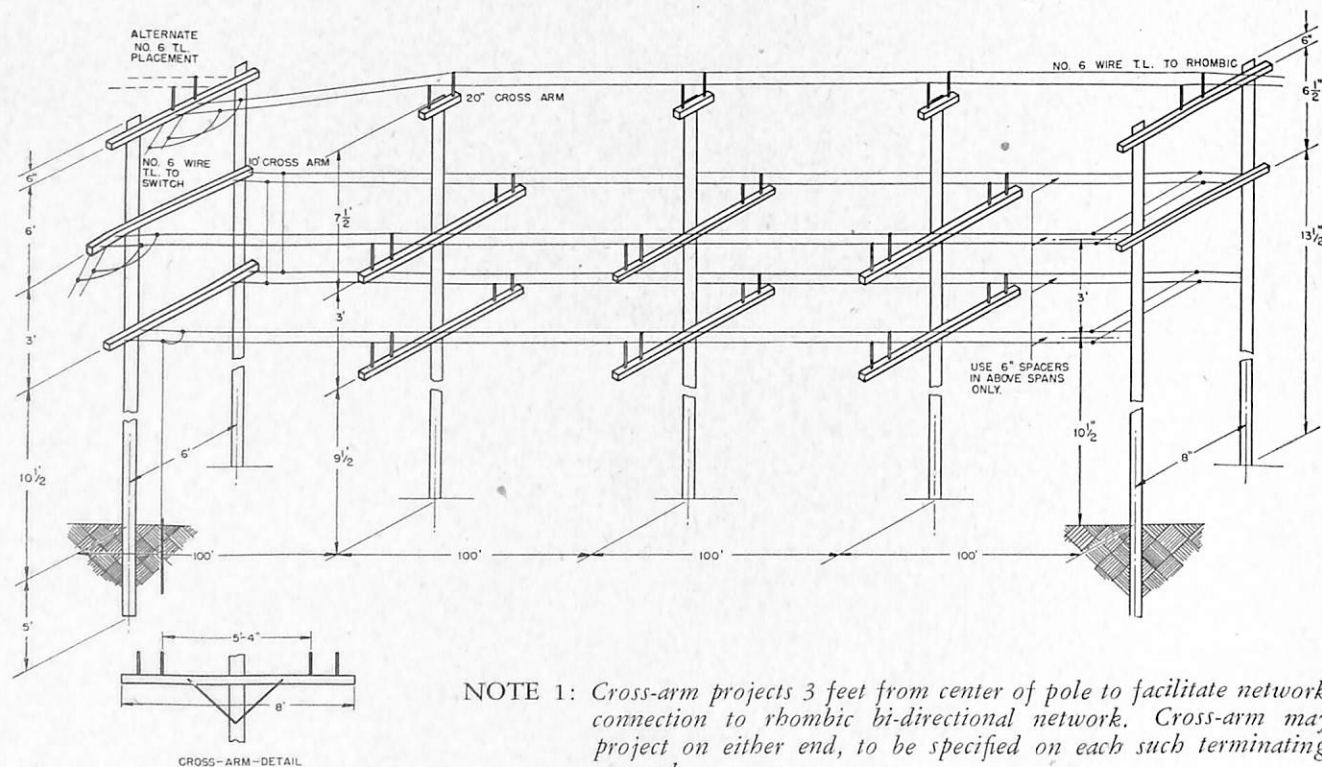
in figure 5. The vertical separation between the network wires and the transmission line was 5.8 feet on this installation. On subsequent installations the separation is increased to 7.5 ft. to reduce capacity between the

transmission line and the terminating network. Figure 6 shows construction details of the terminating network used with the bi-directional switch.

The initial bi-directional transmitting rhombic has been in use at this station on its reversed bearing (090°T), as compared to the bearing for which originally designed (270°T), since July, 1948. Communications have been carried on reliably using this antenna since that time. The adoption of the bi-directional transmitting rhombic installation increases the flexibility and service capabilities of the station to the Navy Department. This report is submitted for the consideration of the Bureau of Ships as to application to other radio stations where space is limited.

*Bureau Comment:* This system has limited application, being of value only where a geographic coincidence occurs, so that the reverse direction of the antenna is the direction desired. It definitely increases the flexibility of the antenna system when it can be used, however, and exemplifies the ingenuity that can be exercised by Naval personnel.

Other stations desiring to use these principles in modifying their own rhombic antennas should get prior approval from the Bureau of Ships or CNO.



NOTE 1: Cross-arm projects 3 feet from center of pole to facilitate network connection to rhombic bi-directional network. Cross-arm may project on either end, to be specified on each such terminating network.

\* Space No. 6 wire 12 inches, No. 8 wire 9 1/2 inches.

# Space No. 8 wire 8 inches.

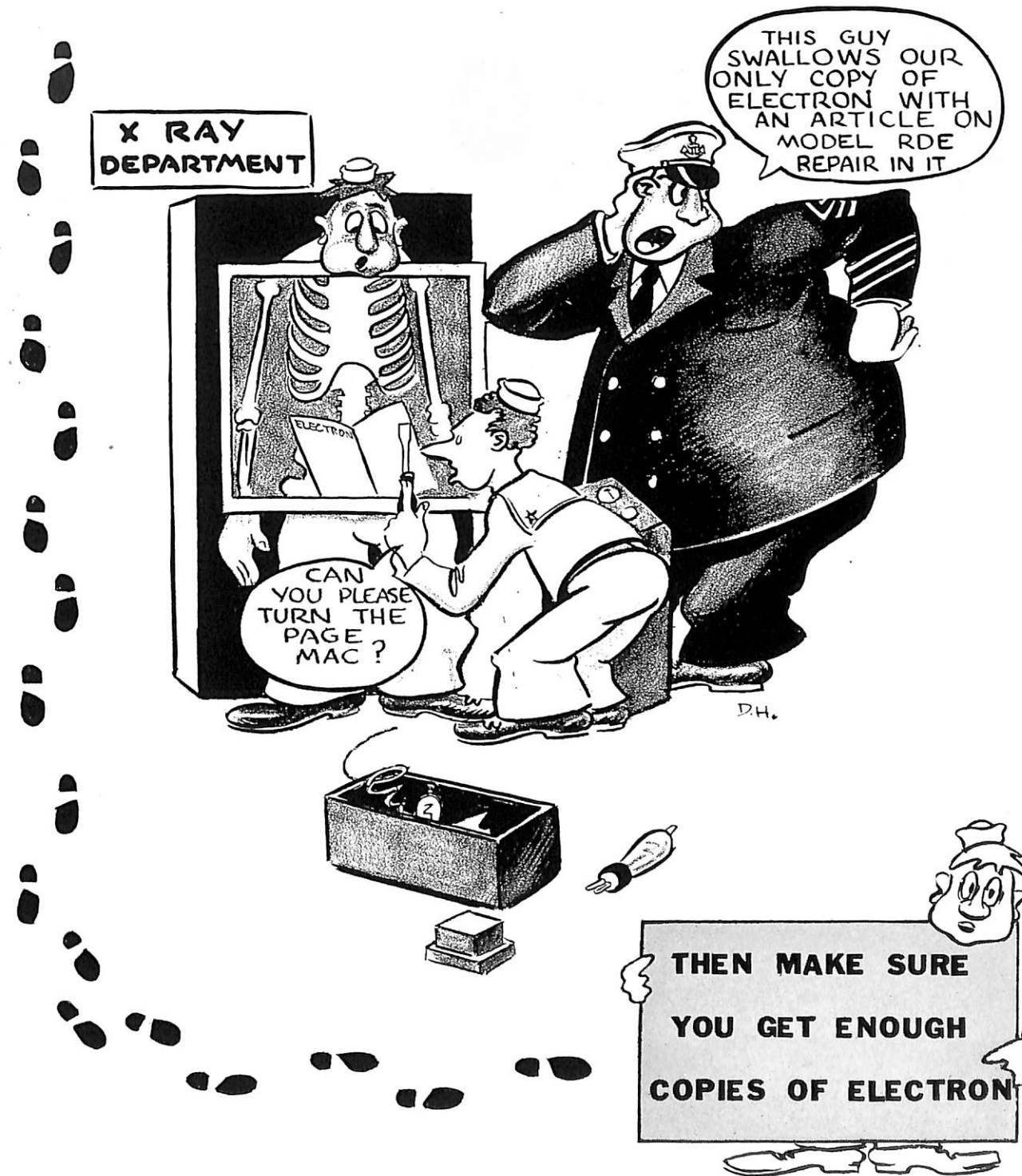
Space 6 1/2 inches at all other insulators.

NOTE 2: All poles are 2.5 feet, set 5 feet in the ground.

NOTE 3: Guy end poles at cross-arms, height 13 1/2 feet above ground.

FIGURE 6

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