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RADIO POINT LOMA and NEL

RADIO POINT LOMA as it appeared in 1906.

The History of Radio Point Loma is a narrative of the development of Naval communications, for this pioneer station participated in the evolution of modern radio equipment and procedure. Civilian research gave birth to wireless telegraphy and voice transmission over the airwaves, but the development of equipment, particularly in the early years, was largely handled by the military. Commercial entertainment radio as we know it did not exist and radio was used solely for communications.

In 1905 a party from District Headquarters, Goat Island, San Francisco, made the survey for a radio station to be located on the tip of Point Loma. The original installation was made by Chief Electrician R. B. Stuart, now principal civilian assistant to the Electronics Officer, U. S. Naval Shipyard, Long Beach, Cal. The station was commissioned 12 May 1906. Working a Massie type transmitter, R. W. Moore, Electrician 2nd Class, was designated radioman-in-charge.

During the early days it was a long trek by wagon from San Diego to the station. During the construction period, and later, to supply the installation, it was necessary to follow a road through the tule swamp which is now the site of the Navy Training Center. When the river was in flood stage no wagons got through and the men lived meagerly.

In 1909 President Theodore Roosevelt sent the Great White Fleet to show the flag in the seaports of the world. When they visited San Diego, a marvelous new development in the field of radio was tried with Radio Point Loma participating. Doctor Lee DeForest, whose vacuum tube made possible his development of the wireless telephone, was aboard the *USS Connecticut*. One of the first successful tests of voice transmission was made between that ship and Point Loma. Chief Electrician A. R. Rice handled the experiment from the shore end.

In 1912 radio communications had progressed to the point that federal control of traffic became necessary. The former two letter call signs of broadcasting stations were changed to three letter calls, all Navy stations taking the designator *N*. Thus Radio NPL at Point Loma came into existence. The continued use of its call letters from that day to this has perpetuated the memory of the historic station.

A number of the early investigations on atmospheric interference, its source and cause, were conducted at Point Loma by Dr. Louis W. Austin, head of the U.S. Naval Radiotelegraphic Laboratory at the Bureau of Standards from 1908 to 1923.

As the range of radio broadcasting became greater, it was found that the link stations up the coast became superfluous; Point Loma, Mare Island and North Head on the Columbia River became more important as the intervening stations were reduced to the status of compass stations.

Communications with our nationals in private industry in Mexico became a problem of paramount importance. It was the era of tremendous financial boom below the border. In order to keep in touch with American business enterprises in Mexico a complicated radio network was set up starting with Radio Point Loma, who then worked the *USS California*, flag-ship of the Fleet, stationed at Guaymas in the Gulf of California. The *California* in turn communicated with radiomen employed at fabulous salaries by the mines and sugar companies in wild outposts of Central America. Thus Radio NPL aided in the progress of industrial relations with our neighbors below the border.

In 1915 new equipment came to Radio Point Loma. A 500-cycle German Telefunken type transmitter was installed as well as a Danish Poulsen type of 30 kw's. The new arc type installations were gas fed. The flame worked much the same as the old gaslight era street lights. In certain civilian stations the light was fed by alcohol. This fuel was deemed impractical by the Navy. Consequently the personnel at Radio Point Loma kept efficiently sober.

All of the news events of the period were broadcast to the fleet via the facilities of Point Loma. History-making accounts such as the assassination at Sarajevo, the sinking of the Titanic, and the San Francisco earthquake, were picked up by amateurs who tinkered with crystal sets, so the station was known and worked by the early enthusiasts who later became the leaders of the radio industry.

In 1905 a party from Naval District Headquarters, Goat Island, San Francisco, made the survey for a radio station to be located on the tip of Point Loma. The original installation was made by Chief Electrician R. B. Stuart and the station was commissioned May 12, 1906. In this photo Stuart appears third from the left.

Lt. Comdr. Glenn Twiss headed the Point Loma establishment from approximately 1914 to the outbreak of World War I. He built and installed a receiving set using the then-revolutionary vacuum tubes. This set was evolved from experience gained by Mr. Twiss in the making of his first set for the old cruiser *San Diego* (previously named *California*) which was used by that ship until the time of her sinking off New York.

Lt. Comdr. Twiss tells how Radio Point Loma served the city of San Diego during the 1916 flood. The railroads and civilian communications were completely disrupted. The news of the disaster had to get out, but how was a question. Western Union messages were going to Los Angeles via slow boats employed by the company.

Representatives of the press went to Radio Point Loma and requested use of the station's facilities. Permission was granted, and the story of isolated San Diego's disaster went to the outer world at the rate of 5000 words a day. The Navy was credited with rendering a public service. Their stipulation that every news story had to carry the by-line "via Radio Point Loma" assured public recognition of the fact that the U. S. Navy was on the job in spite of wind and high water.

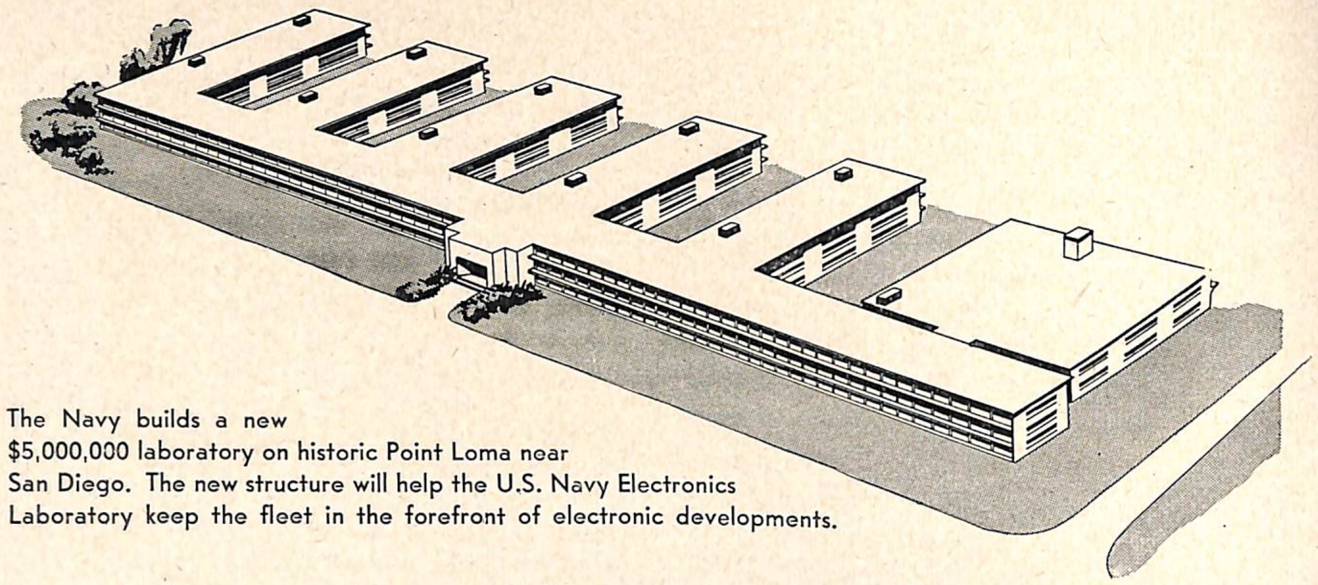
During World War I Point Loma became a busy and vital link in military communications. It served patiently and efficiently.

After the war the Pacific Fleet came to San Diego in numbers, increasing the demands made on the facilities of the Radio Station. Point Loma grew to accommodate the new volume of traffic. In 1919 directional reception was installed at the station and another advance in efficiency was made. In 1917 Point Loma became the first station on the coast to handle trans-continental traffic. Admiral S. C. Hooper came West to inaugurate the service. Admiral Hooper had been an enthusiastic worker of Radio Point Loma as a radio amateur in the crystal-set era, so he had a sentimental attachment for the Pacific Coast station derived from long hours of listening to its early broadcasts. He insisted on tapping out the first transcontinental message to leave Point Loma. This message was addressed to Secnav, Navy Department, Washington, D. C., received by C.E. Rdo M. E. Eason and delivered to LtCdr Lee Noyes, Outlet C Radio Central—State War Navy Bldg.

And so the Station carried on uneventfully but faithfully. In 1940 the new Navy Electronics Laboratory came into being as a facility for housing the research program which resulted in many miraculous developments that played such a part in the winning of World War II. The laboratory was built on ground adjoining the radio station.

December 7, 1941. History was made in the Pacific and Point Loma entered this first day of the war in a major role. During the enemy raid on Pearl Harbor there were many casualties to communication control lines from the navy yard to the receiving and transmitting stations. The high power transmitting station was under attack and for a time doubt was created as to its ability to keep on the air. Radio Point Loma stepped into the breach and for 60 hours served the entire

SCALE MODELS on SIMULATED OCEANS are used by the U.S. Navy Electronics Laboratory's model range for research into antenna characteristics. In the background a 1/24-scale brass destroyer stands on metal webbing and in the foreground a 1/480-scale vessel floats in a pool of mercury. Studies of such models have enabled the laboratory's scientists to originate and develop many devices of permanent value to the Navy communications system.



The Navy builds a new $5,000,000 laboratory on historic Point Loma near San Diego. The new structure will help the U.S. Navy Electronics Laboratory keep the fleet in the forefront of electronic developments.

Pacific Fleet by radio link from the headquarters of the Commander-in-Chief of the Pacific Fleet.

Point Loma continued to serve through another war and the years that followed. The history of the station is an honorable one. Its personnel can be proud of the record. No longer essential as a shore establishment, the historic installation has now been absorbed physically by the ever-expanding Navy Electronics Laboratory.

On 24 June 1949 Radio Point Loma was decommissioned during ceremonies which also included the breaking of the earth for a new building at the Navy Electronics Laboratory. Located on the Laboratory's grounds, the building formerly housing the radio station will be converted to a modern sound-recording laboratory for research purposes.

The ground breaking marks the start of construction of new facilities for the Navy Electronics Laboratory on the grounds of the decommissioned Point Loma Radio Station. The new buildings will permit the Laboratory to continue its mission, assigned in 1939, of serving the fleet in the design, procurement, development, and testing of electronic equipment.

Increasing demands for its services during the war years forced expansion of the Navy Electronics Laboratory from a few small buildings at the southern edge of the radio station grounds into, first, additional temporary structures in the same area, then into barracks-type buildings constructed as troop housing nearby on the Fort Rosecrans military reservation. While useful in the war emergency, these temporary structures soon were found unsuited for the types and extent of research the Laboratory was called upon to perform. The small structures on the radio station grounds soon were overcrowded with personnel and equipment, and the wooden barracks buildings constituted a fire hazard which limited installation of valuable scientific equipment. In addition, the floor loading characteristics of the barracks buildings placed severe restrictions upon the amount of equipment that could be used at any one location. Accordingly, to provide for present and future research needs, plans were drawn in 1945 for the new series of Laboratory structures costing an estimated 5 million dollars.

The project calls for a two-story front structure overlooking San Diego harbor, 650 feet by 50 feet, backed by five wings, each 194 feet by 140 feet. The total gross floor area will be in excess of 183,000 square feet. Completion of the entire project, estimated for 1951, will permit the housing of all Laboratory personnel and facilities now in temporary barracks structures, in permanent modern buildings.

The physical identity of Radio Point Loma will not be lost in the rush of new laboratory construction. Rather the physical assets of the communications center will be incorporated into the overall plans of the research building program. The main radio station building, for example, from which point the Navy communicated with the Pacific Fleet during the Pearl Harbor emergency, is being remodelled to do a new job. It is being converted into a modern sound recording laboratory for continuing investigations in radio and sonar.

NAVY SHIPBORNE RADAR COUNTERMEASURES

by
A. D. Tadde, *Electronics Engineer, Electronics Ship and Amphibious Division, Bureau of Ships*

This article is submitted to acquaint the uninitiated with the basic principles of shipborne radar countermeasures. It has been divided into three parts. In the first part some examples are submitted from actual combat records to illustrate actual useage of this equipment under severe conditions of combat. However only briefly are these conditions mentioned due to the rigorous classification involved. In the second part, the basic aims of radar countermeasures are outlined. The third part contains installation illustrations of this equipment as a system.

Electronic countermeasures encompass the entire frequency spectrum and many types of operations. The extent to which it has grown and specialized under the impact of war is indicated by the following abbreviations adopted by the Joint Countermeasures Committee:

Electronic Countermeasures is composed of two divisions—active and passive:

RADCM—Radar Countermeasures
COMCM—Communication Countermeasures
ROCCM—Guided Missile Control Countermeasures
SONCM—Sonar Countermeasures
NAVCM—Navigational Countermeasures
TORPCM—Torpedo Countermeasures and Deception
Equipments may be either electronic or non-electronic.

Combat Use of RCM

In August 1943 the Germans unveiled a radio-controlled bomb in the Mediterranean and began to take a heavy toll of British and United States ships. After August 1944 the Germans abandoned use of the bombs. Our countermeasures had rendered them completely ineffective.

The key to our success was a pair of special search and intercept receivers produced by the Naval Research Laboratory by a "crash" program. These were rushed to the Mediterranean by two DE's in October 1943, and soon intercepted and revealed the frequencies used by the Germans in controlling the radio bombs. It was by no means easy to develop jammers and tactics to repel the German bombs, once the frequencies were discovered; but the job was done so thoroughly that the Japs made no effort to use this weapon.

As in this incident, the remarkable accomplishments of radar and other electronic weapons in World War II were matched, time and again, by the achievements of countermeasures equipments and tactics. The same process worked for the enemy, of course. Indeed, the Japs brought their countermeasures to a higher stage of development than their radars, and towards the end of the war were utilizing their search receivers in preference to their radars in spotting our radars and homing on our ships.

It was March 1945. From the *USS Franklin* planes took off for Kagoshima airfield, Kyushu, climbed to 19,000 feet, later dropped to 12,000 feet, and pushed over in a glide to drop their bombs at 4,000 ft. The anti-aircraft fire was hot.

But, says a squadron report, "radar jamming was used just before the pushover, using radar jamming planes. The intensity of the anti-aircraft fire was reduced almost immediately. . . ."

On another strike the same day, 12 planes left the *Franklin* for Izumi airfield on Kyushu. Again they climbed to 19,000, dropped to 12,000 and pushed over in a glide. And again, says the squadron's report, "radar jamming was resorted to, the equipment being turned on just before the pushover. Pilots noted a decrease in the intensity of the AA fire."

Next day the TBM's lined up again, along with fighters and dive bombers, for another strike. Eight VF's and 9 VB's took off before the carrier was shaken by explosions set off by a line Japanese attacker. But

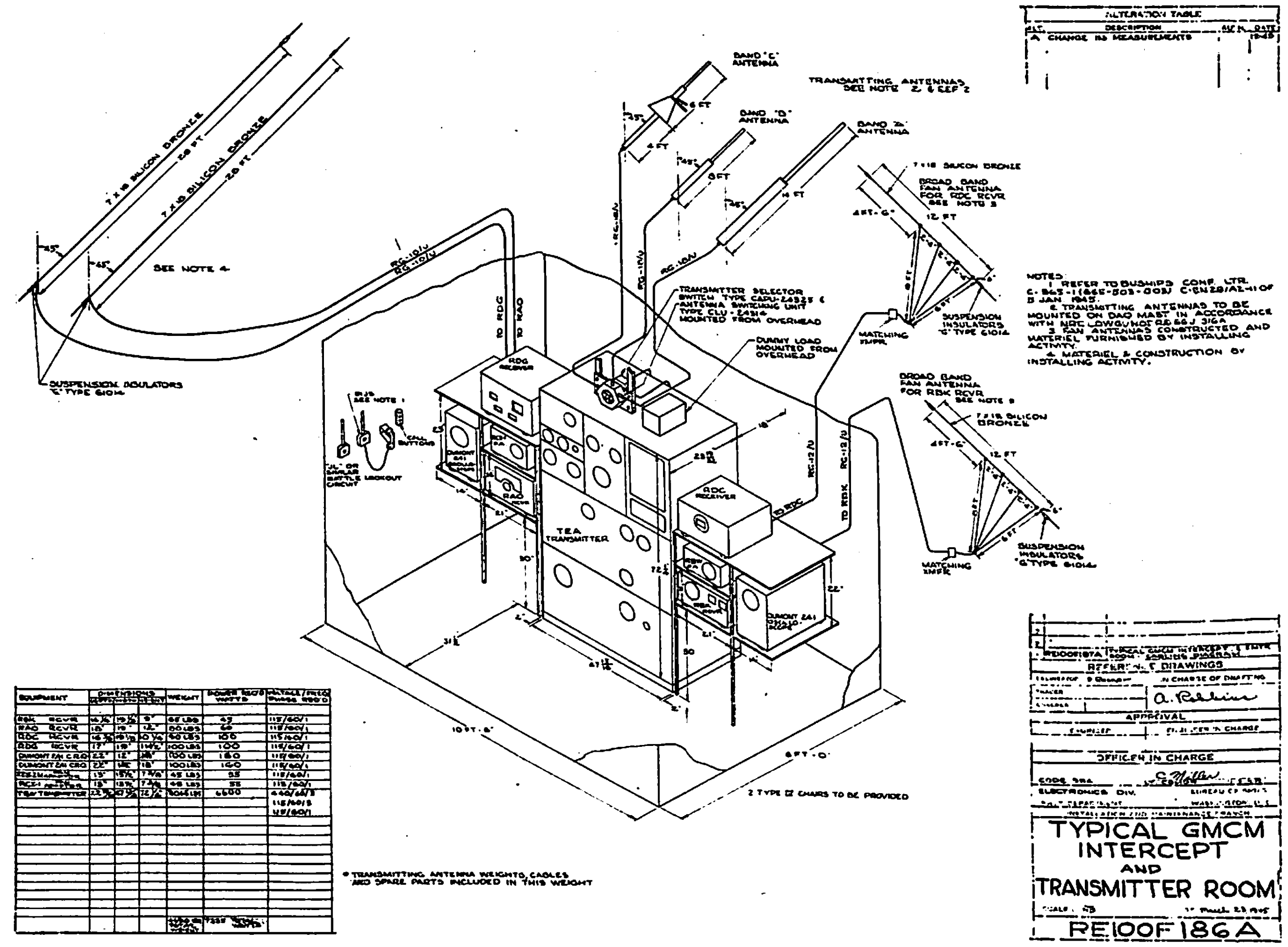


FIGURE 1

the TBM's never got off the flaming deck and the other aircraft had to make their strike without the protection of radar jammers, encountering heavy AA fire.

Whether the TBM jam-makers could have diverted that AA fire cannot be definitely stated, but other reports of successful electronic jamming have piled up as Naval aircraft and ships stabbed into the heart of the Japanese empire. With "Dina," "Rug" and "Web"—formally known as AN/APT-1, AN/APQ-2 and AN/APT-5—available for use, jamming of enemy fire-control and search radar in a wide range of frequencies was possible.

Several jamming missions which apparently succeeded have been reported by the commander of the *Essex*. Commenting on air operations from 1 February to 4 March—a period which included bombing of the Tokyo area, support at Iwo Jima, and a strike at Okinawa—he said:

"Jamming equipment was used, in particular AN/APT-1 transmitters. The equipment was used on five strikes. . . . pilots and aircrewmen believed the equipment caused some confusion to enemy radar controlled fire. Consideration should be given to making this type of jamming equipment available for installation in other planes at an early date."

Additional comment on jamming by some of the *Essex* officers is given in a report: "Radar jamming devices carried may have accounted for some of the inaccuracy." "Occasional bursts from heavy batteries were off altitude, an unusual error factor in Japanese firing. . . ."

When planes struck at the Tachikawa engine plant at Tokyo in February, "both Window and RCM gear were used in the attack," the air group commander has reported. He recommends, as a result of experience in that attack, "that Window and RCM gear be used on all strikes where radar-controlled AA fire is probable.

"One reason for the success of the RCM gear is that the jammers were carefully set on frequency and tuned to maximum power output by squadron personnel who have worked with RCM gear for several years and were therefore aware of the necessity of having the jammer exactly on the frequency to be jammed.

"Another reason is that efficient use was made of the characteristic lobes of the antennas. Sharp lobes are generally considered undesirable, but for use where

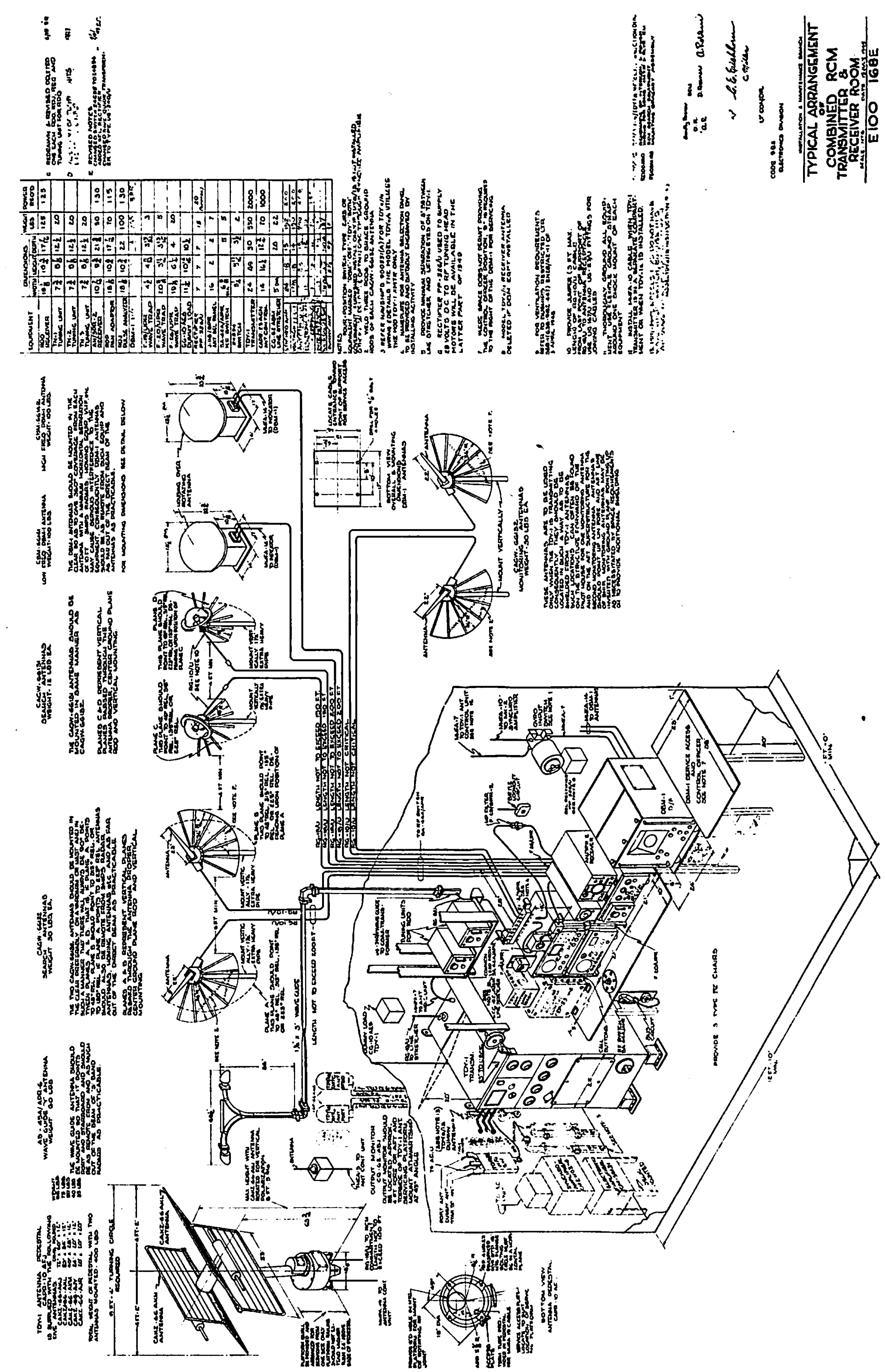


FIGURE 2

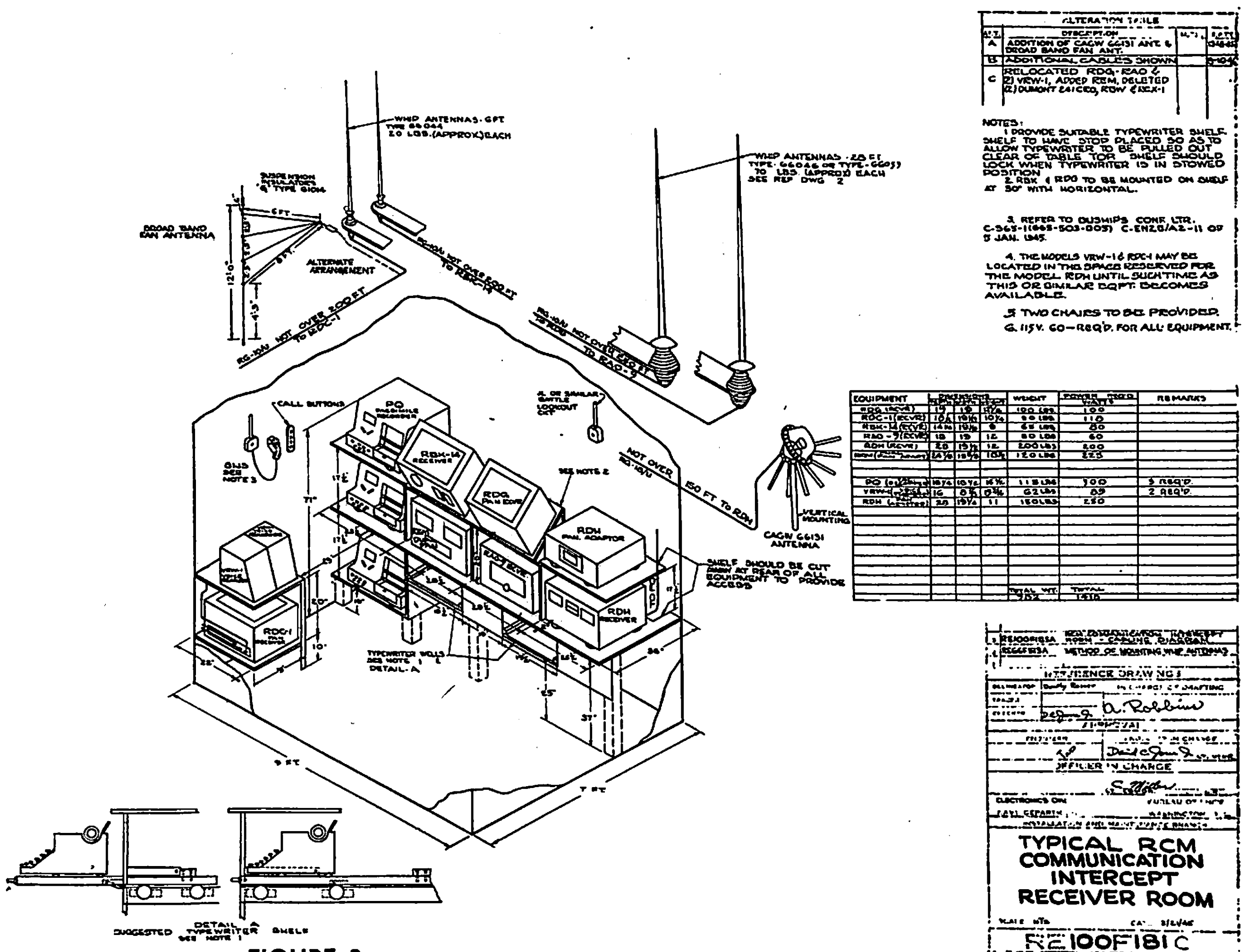


FIGURE 3

jamming is to be employed against known radars, they can be used to considerable advantage, i. e. increasing the effective range of the jamming at certain azimuths. Being able to fly the spiral course, to keep target always at 30 degrees off the starboard bow, insured that the maximum amount of jamming energy was being directed into the enemy radar antenna.

"I believe that intimate knowledge of the equipment and practice in using it are essentials in making the most effective use of RCM. The results of making antenna patterns, studying the limitations of the equipments (and antennas) and spending considerable time in briefing a jamming mission, can make RCM pay big dividends."

As interest in radar countermeasures grows, installations of RCM equipment are becoming more numerous at fleet activities. A basic system of intercept, analysis and direction-finding equipments is now being provided in all new ships. In addition to those equipments, other RCM devices such as jammers can be added or substituted as needed for specific missions. These devices are not always in the ships when delivered but are fleet-installed.

RCM equipments for various purposes are also available for carrier-based aircraft but they, too, are fleet-installed to meet constantly changing needs.

Basic Aims of RCM

The basic aims of radar countermeasures are (1) To obtain combat intelligence of enemy forces from the enemy's employment of radar; and, (2) To prevent the enemy from obtaining through the use of his radar any accurate combat intelligence of our own forces.

For the purposes of this article, the term "Radar Countermeasures" includes radar interception, radar jamming, and radar deception.

All ships should make maximum use of radar intercept equipment in order to obtain all possible information concerning enemy radar.

The entire radar spectrum within the capabilities of the radar intercept equipment installed should be kept under constant surveillance by designated intercept ships in order that new enemy frequencies may be discovered at the first opportunity.

It is essential that RCM personnel be kept fully informed as to the status of all friendly radars, v-h-f and u-h-f radios, and navigational radars and navigational aids to prevent having these reported as enemy radars and to assist in the identification and analysis of spurious radar intercept receiver or signal harmonics.

An RCM operator should be familiar with:

1—Interception of enemy radar signals.
2—Location of enemy radars (if known).
3—Enemy use of radar countermeasures.
4—Own use of radar countermeasures.

There is listed below the information which is pertinent and desired in various cases.

1—Enemy radar reports
- a—Frequency
- b—Pulse repetition rate
- c—Pulse width
- d—Location or bearing
- e—Beam width
- f—Rotation rate
- g—Lobe-switching
- h—Strength of signal (strong, moderate, weak)

2—Enemy radar jamming reports
- a—Frequency
- b—Effective band width of jamming
- c—Type of jamming
- d—Bearing limits
- e—Relative effectiveness
- f—Effectiveness of A/J

3—Enemy radar deception reports
- a—Bearing
- b—Range
- c—Radars affected and to what extent
- d—Appearance of echo

To provide proper intra-ship coordination, all radar countermeasures information shall be communicated promptly and disseminated to the control stations. Adequate internal communications among all countermeasures stations and between each countermeasures station and CIC is desirable.

In general, radar jamming should be employed against specific enemy radars which are known or strongly suspected to be furnishing the enemy combat intelligence of our own forces, and when the use of deception is not practicable or has proved not to have sufficient effectiveness when it is necessary to:

1—Obliterate information on enemy radar scopes.
2—Confuse enemy radar operators and possibly cause them to shut down their radar equipments.
3—Assist in deceptive operations employing electronic deception devices and Window.

Radar jamming is employed most advantageously in darkness, in conditions approaching zero visibility, in conjunction with the use of smoke, or in other circumstances where the enemy lacks visual observation.

The advantages of radar jamming are:

1—Enemy is fully or partially deprived of ability to determine composition, track, direct guns or aim torpedoes by radar.
2—When used in connection with deceptive operations, the enemy may be caused to disperse his forces and lose local superiority where the real attack is launched.

Effectiveness of Jamming:

The criterion of jamming effectiveness is the degree to which radar data is denied the enemy. Jamming should be continued even though the enemy does not turn off his radar. He may leave it in use in an attempt to read through the jamming or to give the impression that the jamming is ineffective. With relation to jamming effectiveness the following factors should be considered:

1—Screening is more effective when the jammer is between the radar and the target.
2—Jamming is most effective when a number of ships jam simultaneously to minimize the possibility of the enemy homing on a single jamming bearing. Spot jamming is preferable to barrage jamming unless sufficient jammers are available to allow pre-tuning, since the operator monitoring the jamming has actual control of the jamming and can follow any shift in enemy frequency. Barrage jamming requires much more equipment, but less trained personnel, and must be carefully monitored by continuously scanning the band covered to insure that the enemy radar is not looking through gaps in the jamming.

Radar jamming should never be conducted indiscriminately simply because the enemy is using a radar. The more frequently jamming operations are conducted against the enemy, the more practice his operators receive in overcoming it, and a greater incentive is provided to his research and development agencies to provide tunable radars or radars on different frequencies than those previously employed. Shipboard fire control radars and shorebased gun-laying radars should be jammed when encountered, especially if visual observation is denied the enemy. Airborne radars should be jammed under conditions similar to the above. Never jam radars when outside their effective range (except in the case of jamming early-warning radars in conjunction with Window and deceptive operations) since this serves no useful purpose and merely alerts the enemy and extends the maximum range of his radar. Also, never jam until the radar in question has picked up the force and steadied on it.

Shipborne RCM Installations

In this paragraph are described various installations with accompanying illustrations.

In the RADCM system equipments such as the following are employed:

Jammer, transmitter

Direction finder
Receiver (all frequencies)
Pulse analyzer
Panoramic adaptors
Recorders

The success of a jamming operation depends upon the use of the associated equipment as shown in the following manner: An enemy radar intercept is made by the search intercept receiver and identified from the panoramic-adaptor and pulse-analyzer displays. From the direction finder the bearing of the enemy radar is found, and this information used to properly orient the jamming transmitter antenna by the use of the antenna-mount control indicator. Meanwhile the transmitter has been fired up and rough tuning adjustments made. Setting exactly on the enemy frequency requires adjustment of the transmitter tuning controls and line stretcher to conform with information given by the pulse analyzer and panoramic adaptor display units.

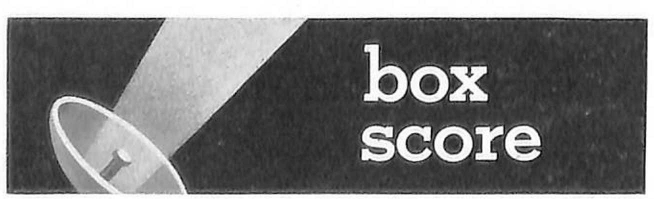
In the majority of cases continuous look-through to check any shifting of the enemy frequency is not possible since there is not generally sufficient electrical separation of the receiving and transmitting antennas.

The installation described and illustrated in figures 1 and 2 is a fully integrated system. It has had extensive operational use and has demonstrated its value both as a defensive and offensive weapon.

Changes in operational requirements have necessitated sending limited numbers of modification kits to the fleet.

Figure 3 illustrates the COMCM intercept system in which receivers covering all frequencies, panoramic adaptors, pulse analyzers, recorders and typewriters are integrated to function as a system.

Type of Approach	Through August	To Date
Practice Landings	13,537	259,242
Landings Under Instrument Conditions	300	10,186



DISPOSITION OF SURFACE VESSEL B/T SLIDES AND LOG SHEETS

Disposition of Surface Vessel B/T Slides and Log Sheets

Attention is again invited to the proper method of turning in surface vessel bathythermograph records. All records should be submitted to:

The Hydrographer
Hydrographic Office
Navy Department
Washington 25, D. C.

These instructions supersede those contained in the following bathythermograph instruction books:

NavShips 943
NavShips 943–A2
NavShips 900,231—IB
NavShips 900,536

To obtain additional log sheets, submit a request directly to the Hydrographer. The form number is OP-Nav–25T–1189. All other accessories, such as smoked slides and lacquer, are available from Navy stock.

DOUBLE-CHECK YOUR TUBE CHECKER

Checking tubes of unknown quality in tube testers is a common procedure. A useful switch is to occasionally run through a varied group of known good tubes with your tube tester, removing the tubes from an equipment known to be in satisfactory operating condition. A tube tester is just another item of electronic equipment, and as such is susceptible to troubles caused by poor connections, cold solder joints, resistance value changes, etc. Such periodic checks may prevent future rejection of good tubes by faulty testers.

BOX SCORE — **BuShips Electronics Repair Parts Program**

Allowances	Type Vessels	Percentage Completed
ELECTRON TUBES	Submarines	100%
	Surface	96%
REPAIR PARTS	Submarines	60%
	Surface	1.1%

SEASONING 5J26 MAGNETRONS FOR RADAR SET AN/SPS-6

Installation activities and ships have reported faulty operation of early production Type 5J26 magnetrons when initially installed in Radar Set AN/SPS-6.

The following procedure for seasoning Type 5J26 magnetrons should be accomplished after initial installation of a new magnetron or after extended periods of non-operation.

Some magnetrons that appear to be defective may only require seasoning. The proper method for seasoning magnetrons is given in Paragraph 11f, Pages 7–34 and 7–35 of the Radar Set AN/SPS-6 Instruction Book (NavShips 91,080). However these instructions require extra equipment which may not be available on all ships in which the AN/SPS-6 is installed. As an alternate method, which has proven very successful during operational evaluation of this radar, the following is recommended since it requires no additional test or other equipment.

First install the magnetron properly in accordance with instructions. Put the BANDWIDTH-PULSE LENGTH switch in the WSP position. Set the transmitter frequency at the high end of the band and apply filament voltage for approximately fifteen or twenty minutes. Next apply minimum plate voltage and observe if the magnetron appears stable. Instability will be indicated by erratic current readings on the magnetron current meter, usually accompanied by audible arcing in the equipment. When this meter indication becomes stable, slowly increase plate voltage until thirty milliamperes of magnetron current is indicated. If instability occurs before full plate voltage is applied, reduce plate voltage until the meter again stabilizes. Wait a few minutes and again increase plate voltage. Continue this process until stable operation is obtained and thirty milliamperes of magnetron current is indicated.

When stable operation is obtained at the high end of the band under full operating conditions, slowly decrease frequency, being alert for erratic meter indications. As frequency is decreased, it is highly probable that erratic operation will appear. When this occurs, reduce plate voltage at that frequency and allow the set to run for a few minutes and then attempt to increase plate voltage, carefully observing the magnetron current meter. When correct stable operation is indicated, continue decreasing frequency slowly. As points of instability appear while decreasing frequency, repeat the process described above. This seasoning should continue until stable operation with thirty to thirty-five milliamperes of magnetron current is obtained throughout the entire frequency range.

If magnetrons will not stabilize after repeated seasoning attempts, as outlined in the preceding paragraphs, they can be considered defective. In such a case they should be reported to the Bureau of Ships on a Failure Report Card, NavShips (NBS–383).

If the magnetron current meter indicates high current with only low plate voltage, gas should be suspected. Also after an equipment has been operating for some time and the magnetron current starts increasing steadily in value with plate voltage retained at the same value, the technician should suspect a gassy magnetron, although such may not always be the case.

"We would have been over earlier only our radar went on the blink and we misplaced our copy of ELECTRON with the necessary radar repair information in it."

The REDUCTION or ELIMINATION of RADIO INTERFERENCE

by
WILLIAM A. RITZ
Electronics Shore Division, Bureau of Ships

The September and October ELECTRONS *carried comprehensive articles on Radio Interference. This article continues the series.*

Once a source of radio interference has been determined and the method whereby the interference is coupled to the affected receiver or electronic device discovered, it becomes necessary to decide on the type of corrective measures necessary, as well as the degree of corrective action required. The corrective action may consist of shielding, filtering, isolation from the source, or a combination of two or more of these measures. The means by which the radio interference is coupled to the receiver or electronic device will be the deciding factor in the choice of the proper corrective measures.

Radio interference may be coupled from a source to one or more receiver circuits by conduction, induction, radiation, or by various combinations of these methods.

In specific cases where the radio interference is coupled to the receiver or electronic device by conduction via common power lines, it is necessary to reduce or eliminate this interference by the use of filters located either at the power line input to the source, or at the power line input to the receiver.

If the radio interference is entering the receiver or electronic device by radiation coupling, and is of high intensity, it is necessary in cases of this type such as radar and ignition interference, to completely shield the source. In some cases it is necessary to place an electrostatic shield between the source and point of radiated interference entry in order to reduce the coupling.

Induction-coupled radio interference is that type interference which is induced in circuits entering a receiver or electronic device. Inductive coupling may take place at all frequencies, with effective coupling of circuits that are otherwise isolated circuits. Shielding or isolation of the source is the usual corrective measure used to reduce inductive coupling. The field intensity of the source of inductive interference may be reduced by bypassing the interference at that point, or by using proper filters. Isolation of circuits carrying radio interference currents from interference-free circuits, constitutes an effective corrective measure.

In many instances the coupling between the source of the radio interference and the receiver or electronic device may consist of various combinations of conduction, induction and radiation. The coupling problem may be further complicated by the fact that intermediate circuits are often involved. In these cases, the coupling may be conduction, induction, radiation, or a combination of these methods, from the source to the intermediate circuit. From the intermediate circuit, the interference may be coupled by any of the above methods to a circuit entering a receiver or electronic device. If the intermediate circuit is resonant to the radio interference frequency, the interference condition may be increased by the presence of parasitic oscillations in the intermediate circuit.

In the reduction of radio interference, the two major corrective measures employed are shielding and filtering. These measures are often found necessary because of the failure to observe proper installation procedures and receiver site selection practices, so that sources of radio interference are isolated from receiving activities by the required distance.

Shielding and Shielding Methods

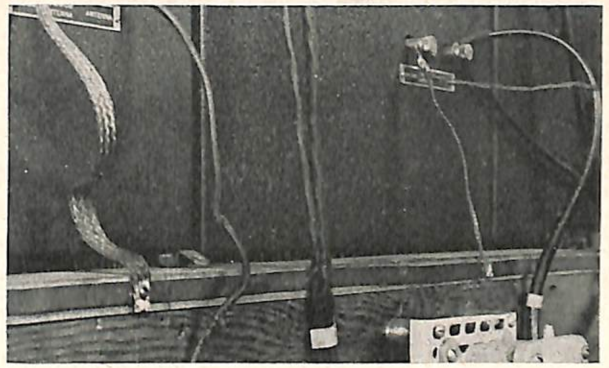
Shielding is an effective means of eliminating direct radiation or induction from a source of radio interference, if the shielded components are correctly installed and thereafter subjected to periodic maintenance procedures.

Radio interference investigations conducted at Naval establishments have disclosed that in general the cognizant personnel at these activities possess a serious lack of appreciation of the magnitude of the radio interference problem to communications and electronic control circuits created by the poor installation and spotty maintenance of shielded systems.

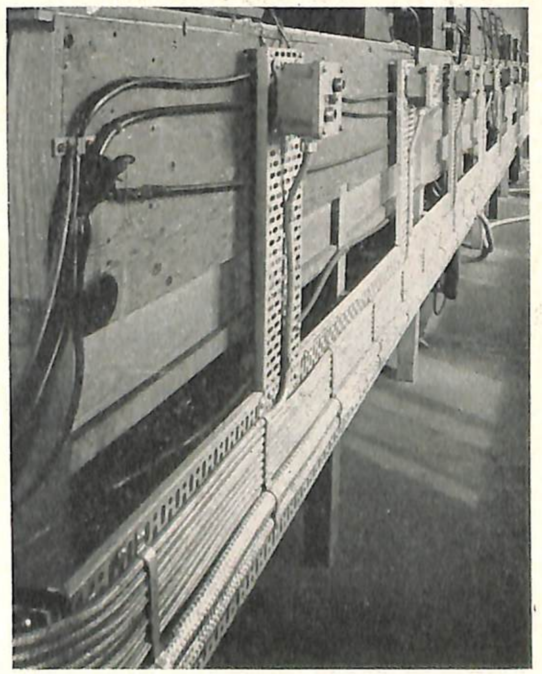
Technical personnel at Naval establishments are often found lacking in the basic concepts of shielding and shielding methods. This is probably due to a lack of understanding of the importance attached to the proper installation and maintenance of shielded systems. Vehicles or craft with shielded ignition systems have been reported as sources of radio interference. Upon investigation it has been found that the vehicle or craft is a prolific source of radio interference due to the improper installation of the shielded ignition harness or to careless maintenance. In working on an engine it is a common occurrence for a mechanic to tear the shielded conduit or to fail to securely tighten the couplings in the shielded system.

To the average mechanic the shielding is just a nuisance which sometimes hinders his work; and not realizing the importance of the shielding he does not bother to report a break in the shielded conduit or to exercise any particular dilligence in assuring that all shielded couplings are tight. A training program covering shielding methods and the maintenance of shielding systems, for all technical personnel who in the course of their regular duty are required to work with shielding, would do much to alleviate this situation. Effective shielding is dependent upon preventing radio interference currents from escaping through breaks in the shielded conduit, or by way of loose or corroded couplings.

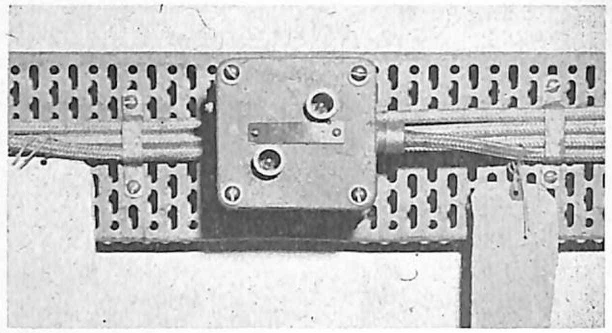
Basically the shielding process may be said to consist of the placing of a closed metal housing around a circuit component to prevent the interaction of its electric and/or magnetic fields with those of adjacent components. Generally speaking, in shielding we are primarily concerned with either confining or restricting electromagnetic fields to a particular area. The problem of shielding arises in electronic equipments, due to the necessity of confining electromagnetic fields of energy within a very limited area around their source. For example, modern communications equipment and electronic control circuits consist usually of many stages, each stage having associated with it, fields of electromagnetic energy. Unless these individual fields are confined to their particular stages, interaction between these separate fields may produce oscillation, intermodulation or interference introduced by electromagnetic fields. With-



POOR INSTALLATION AND MAINTENANCE PRACTICES are shown here by an incorrect method of grounding, and poor antenna connections, which have contributed to the high radio interference levels at this activity. As a result of a radio interference investigation, this condition is in the process of correction by the installation of the proper antenna receptacles, one of which is shown in this photo, and the installation of armored cable, with the armor well-bonded to a metal frame.



COMPARISON between excellent and poor methods of shielding. Rubber covered antenna lead-ins serving this activity were still in use when this photo was made. The new installation employs low-capacity, well-shielded and bonded cables mounted on a metal frame, on which is also mounted the approved type of antenna receptacle boxes.

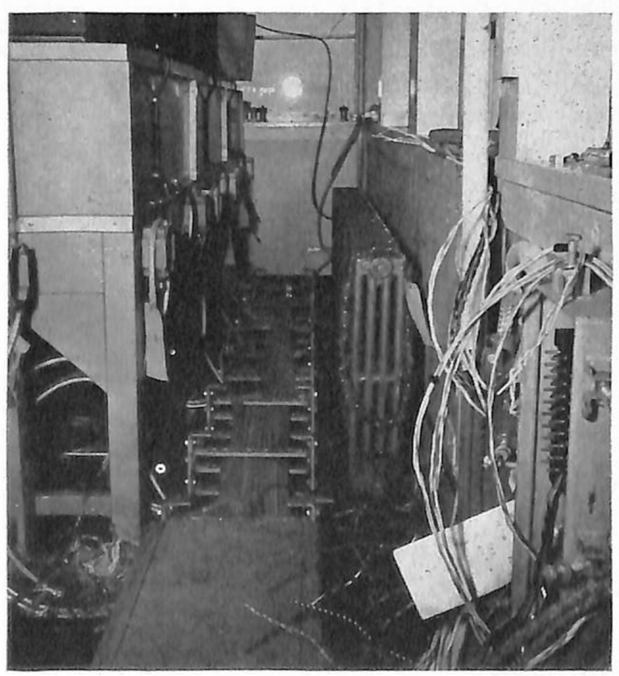


APPROVED TYPE of antenna receptacle installed on a metal frame, with the associated armored antenna cables bonded to the common frame.

out entering into an involved theoretical discussion or complex mathematical study regarding the theory of shielding, some explanation should be given of how shielding isolates circuits and components.

The "wave theory" and the "electromagnetic theory" are commonly accepted as the basis for shielding action. In the case of the electromagnetic theory it is stated that interfering voltages and currents set up interference fields around conductors. These fields of interference are composed of electromagnetic waves of interfering energy which in turn induce currents in the shielding surrounding the wiring. With a perfect shield, the fields set up by the shield currents will be equal in amplitude and opposite in phase to the fields inducing these currents, with resultant cancellation of the fields.

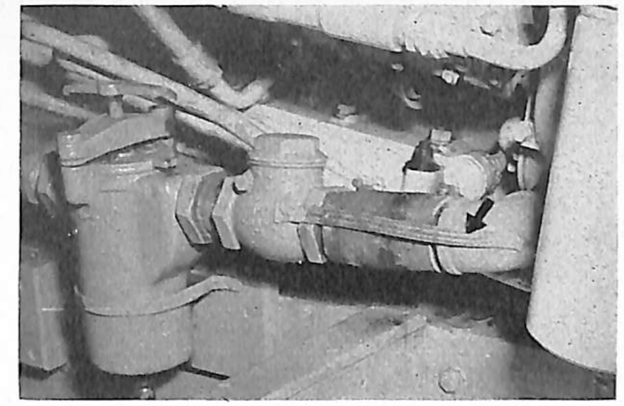
The effectiveness of shielding is explained by the "wave theory" as being due to the reflection of the waves, resulting from an impedance mismatch at the dielectric boundary of the shielding, and also to the attenuation of the wave in passing through the shielding medium. The interfering energy wave in the process of striking the metal shielding surface is greatly attenuated by the partial reflection of the wave at that point. The remaining energy is greatly attenuated while passing through the metal wall of the shielding. Part of the energy reaching the outer shielding wall is then reflected back towards the source of the interfering voltage, resulting in still further attenuation of the wave amplitude during the reflection process. With a shielding medium of adequate thickness and of proper material the total attenuation due to the reflection of the wave striking the metal shield and the loss of wave amplitude while being conducted through the shield will be so large that the energy radiated from the shield will not constitute a serious source of radio interference.



EXTENSIVE radio interference reduction measures are being taken as a result of a radio interference survey at this receiving activity. This photo was taken during the installation of the shielded cable and the antenna receptacle boxes on a well-grounded metal frame.

A perfect shielding medium is one that does not impede current flow. However, there is no perfect conductor possessing this optimum zero impedance, so there cannot be a theoretically perfect shield. Shielding made of the proper low resistance material will be so nearly perfect that for all normal electronic requirements it may be considered a perfect shield.

The best materials available for shielding purposes are silver, copper or aluminum. However, even silver is not a perfect conductor as it offers some impedance to current flow. This impedance of the shielding medium prevents complete cancellation of the interference fields, thereby allowing small amounts of this interference energy to radiate from the source. These statements regarding the escape of interfering voltages from an interfering source due to an increase in the impedance of the shielding medium, will explain the necessity of using proper materials for shielding purposes, along with careful installation of the shielding and periodic maintenance checks to insure that the impedance of the shielding is low and does not increase due to a lack of proper maintenance procedures. In the event of a break in shielding continuity there will be an increase in the impedance of the shielding, due to the introduction of the extra impedance across the break. This does not necessarily mean that part of the shielding is required to be missing, since such a condition may exist if a joint in the shielding does not mate perfectly, thereby not making perfect electrical contact around its entire periphery. This increased impedance at the point where the perfect electrical continuity is broken decreases the effectiveness of the shielding, permitting more interference energy to escape through the shielding. The larger the impedance value at the break of shield-



CORRECT BONDING PROCEDURE is shown in this photo of a Hall-Scott engine aboard a crash boat. The bonding strap indicated by the arrow is short and is properly terminated by low resistance connections, providing a low impedance path for radio-frequency currents.

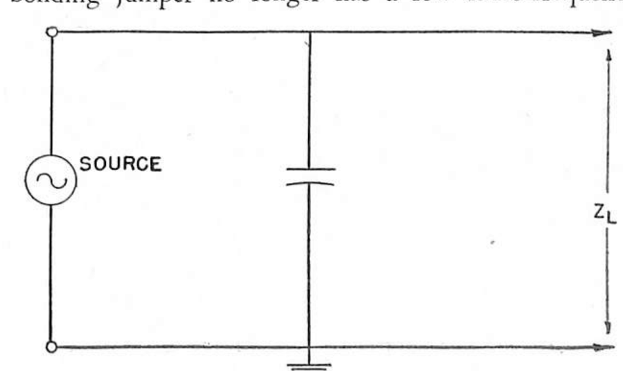
ing continuity, the less effective will be the shielding, since an increase in the shielding impedance at any point permits the fields that are induced in the shielding to travel on the outer surface of the shielding where they may induce interfering voltages in the surrounding conductors, setting up resulting radiated fields of electromagnetic energy. These fields lose amplitude rapidly as the distance from the source is increased, until a point is reached where the electric and magnetic components of the radiated wave are equal and propagation continues in a manner familiar to electromagnetic radiation. The limiting of electromagnetic effects to a particular area can be achieved by enclosing completely the space to be shielded in a housing composed of a material having low electrical resistance such as aluminum, copper or silver or by using a conductor made of a magnetic material. Magnetic shields are used when the field of energy is either of low frequency or unidirectional. This type of shield acts as a magnetic short circuit, preventing magnetic lines of force from penetrating through the shielding medium. To be effective, magnetic shields must possess a high degree of permeability at low flux densities. These magnetic shields should be thick enough so that the reluctance presented to the flux at the point of entry to the shield and also at the point where the flux leaves the shield is of a low value. At the higher audio frequencies and at radio frequencies much better shielding results will be obtained by using a shield of high electrical conductivity such as copper or silver. Magnetic flux passing through a shield that is a good conductor, will induce voltages in the shielding medium, setting up eddy currents, thereby preventing the magnetic flux from passing through the shield.

In the shielding of wires such as those in the ignition system of a vehicle or a craft, thin-wall flexible conduit is used in most cases. The flexible type of conduit is chosen in preference to solid tubing due to its ease of installation and replacement, as well as the ability of this flexible tubing to withstand vibration and shock better than solid type tubing. Flexible shielded conduit is usually fabricated of aluminum or of brass alloys in two sections. The inner section is a thin wall flexible tubing with an outer covering of woven braid shielding. The brass alloy or the bronze flexible tubing is to be preferred over the aluminum type. The brass alloy or bronze tubing has an inner shielding composed of separate convolutions soldered to one another around their entire periphery, with the end ferrules soldered to both the inner tubing and the outer braid. By contrast, the aluminum tubing has its end ferrules crimped to the spiral tubing, which process constitutes a break in the continuity of the metal at this point. A crimped or swaged ferrule cannot make a joint as electrically efficient as a soldered or welded joint.

Bonding

Bonding is a means of tying metal surfaces together in order to provide a low-resistance path for ground-return currents, where the ground return of the electrical system is brought back through the body of the device itself, and to improve the conductivity between metal surfaces which act as a shielding medium against radio interference fields. Bonding is also employed to provide a ground plane to which receivers may be "grounded."

Bonding consists of tying metal surfaces together with jumpers, or connecting them together at their joints by rivets, bolts, or screws. The bonding should be such that the d-c resistance between the bonded parts is less than 0.0025 ohm. Bonding effectiveness does not entirely depend on the ohmic resistance as bonding must possess the required low radio-frequency impedance as well as low d-c ohmic resistance. This requirement is especially true at the higher frequencies where the physical length of the bonding jumper may be an appreciable part of the wavelength of the interference against which it is desired to shield. If this situation occurs, the bonding jumper no longer has a low radio-frequency

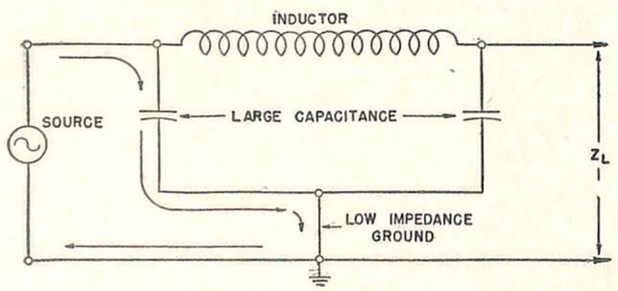


CONNECTION of a simple capacitor type filter.

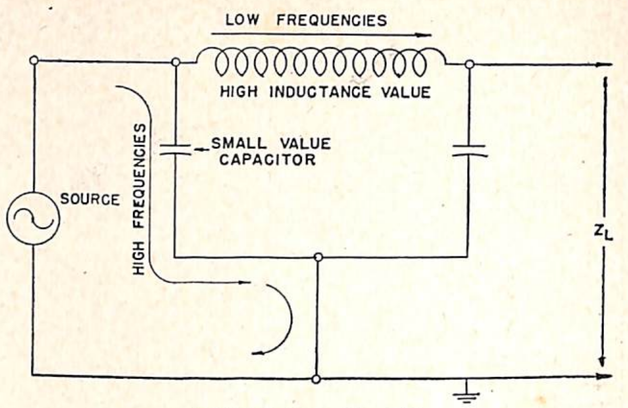
impedance. The radio-frequency currents induced in one section of a shield by a source of interference can then flow across the high impedance path between the bonded parts, causing a voltage drop at that point with the result that the two surfaces will be at different radio-frequency potentials and will no longer act as efficient radio-frequency shields. The bonding jumper may act as a radiator of radio-frequency energy, due to the radio-frequency current flowing through it and the radio-frequency voltage drop across the bonding jumper. Bonding jumpers are effective only at low and medium-high frequencies. Wherever possible bonding should be done by actual metal-to-metal contact of low ohmic resistance between the two metal surfaces to be bonded together, rather than by the use of bonding straps. Proper and efficient bonding is made difficult by the effects of corrosion and the protective finishes on metallic surfaces. Aluminum is usually anodized to prevent corrosion, and many other metals are given various forms of chemical treatment for the same reason. All these protective treatments increase the resistance at the surface of the metal and decrease the surface conductivity. The resistance between the mating surfaces of the treated metals in contact is high and the bonding of the parts is accomplished by bolts, screws, or rivets only if they properly "bite" through the chemical treatment and make actual contact to the metal underneath.

Corrosion is the result of a chemical action wherein the metal is slowly eaten away, and may occur on bare metals not in contact with other metals or result when dissimilar metals make contact due to electrolysis. The most common type of corrosion is rust, found usually when objects containing iron are exposed to a damp atmosphere. Many other metals are oxidized by contact with air in a similar manner. Precious metals such as gold, silver and platinum resist oxidation and therefore are excellent bonding mediums due to the maintenance of very low contact resistance by these metals. However, their great cost and weight prevent the extensive use of these metals for bonding or shielding. It is necessary to use the lighter, cheaper metals and to design joints so that mating metallic surfaces will be protected from corrosion.

When dissimilar metals make contact, and there is



INDUCTOR-CAPACITOR TYPE FILTER.



LOW-PASS FILTER.

moisture containing impurities or conductive liquids present, the dissimilar metals form "galvanic couples," and electrolysis takes place at the point of contact. There is a potential difference between the dissimilar metals, and current flows from one metal, through the conducting liquid, to the other metal. Through this electrolytic action one of the metals will corrode quickly, while in the other metal the effects of corrosion are light. Corrosion of either type in connection with bonding or shielding surfaces will seriously impair their usefulness as a means of reducing radio interference.

Correct bonding procedures must be used in connection with shielded systems to insure optimum efficiency. The common bonding procedures employed at many Naval establishments in connection with flexible conduit, consist of using cable clamps and bonding jumpers of various lengths. This procedure is unsatisfactory in connection with the reduction of radio interference. The clamp exerts a high unit pressure on the flexible conduit, compressing the conduit around the area of contact. With the vibration encountered during periods of use, the clamp has a tendency to loosen, causing high resistance or intermittent contacts. The approved method consists of the use of a flared split sleeve under the standard clamps. This method is superior, in that the clamp exerts a low unit pressure over a large area in a uniform manner. It is advisable to solder the flared split sleeve to the flexible conduit.

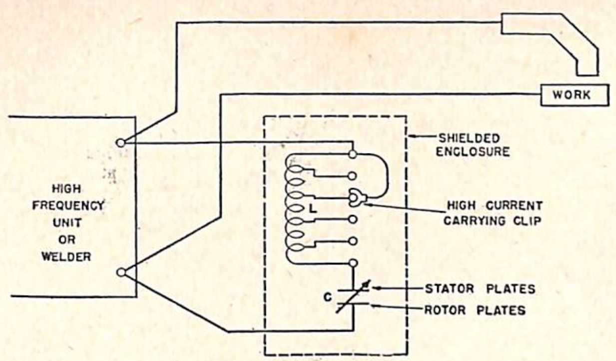
In connection with the joints existing in shielded systems the following are very important:

1—Low resistance, metal-to-metal contacts must be made around the entire periphery of the mating surfaces.

2—The joint must be oil and pressure tight.

3—Maximum uniform unit pressure at the contacting surfaces of the joint must be exerted in order that the joint present a low contact impedance to radio-frequency currents.

4—The contact area at the joint must be equal to or



ABSORPTION TYPE FILTER commonly used to eliminate harmonic or spurious frequencies generated by an inert-gas shielded arc welder.

greater than the cross sectional area of a thin wall possessing identical shielding effectiveness.

Filters and Filtering Procedures

Radio interference as radiated or conducted from a source may be of a single frequency or may cover an extended band of frequencies. When shielding or isolation of the source proves ineffective as a means of reducing radio interference, it becomes necessary to employ filters to accomplish this reduction. The size of a filter may vary widely, depending on the voltage and current requirements as well as the degree of attenuation desired. Filters are usually incorporated in electronic equipment known to generate radio interference, but these filters are often inadequate, and in many cases it is necessary to add filters external to these equipments. This is especially true if the source is coupling interference to paths of entry to a receiver other than the power line.

The simplest of all filters is a single capacitor which provides sufficient attenuation of radio interference in many cases. In many other applications it becomes necessary to use filters composed of resistance and capacitance or of capacitance and inductance. In the case of filters employing capacitance and inductance, the filter effectiveness depends on the ratio of shunt impedance of one element with respect to the series impedance of the other for attenuation of the interfering frequencies. Capacitors play an important roll in filtering, having the property of low impedance at certain radio frequencies, while allowing the desired direct current or power frequency to flow on to the load. Capacitors may be used alone, or in combination with inductances or resistors to form a filter unit. All capacitors possess inductance and resistance as well as capacitance, and due to these properties there is no "ideal" capacitor. In large paper capacitors the internal inductance is high. This fact is of considerable importance when the capacitor is used as a filter, because if it is not properly installed, or the inductance calculated and consideration given to the lead lengths, the filter will be less effective.

Kinds of Filters

1—*Band-Pass Filter.* This filter is characterized by negligible attenuation at all frequencies within the band between two frequencies and relatively high attenuation at all other frequencies.

2—*Band-Rejection Filter.* This filter introduces negligible attenuation at all frequencies outside a specified range, and relatively high attenuation at all frequencies within a specified range.

3—*Low-Pass Filter.* This filter introduces low attenuation at all frequencies below a certain frequency, called the "cut off" frequency, and relatively high attenuation at all higher frequencies.

4—*High-Pass Filter.* This filter introduces low levels of attenuation at all frequencies above a specified frequency, called the "cut off" frequency, and relatively high attenuation at all lower frequencies.

The normal characteristics of a filter are obtained only when the filter is properly terminated in its characteristic impedance.

Filter Selection

The choice of a filter for a specific application is usually governed by the following requirements:

1—Current, capacity, voltage and frequency limitations.

2—Temperature and humidity and other factors involved in the installation.

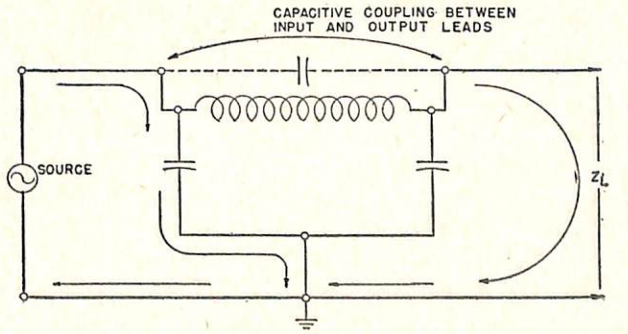
3—Amplitude and frequency range of the interference to be attenuated.

4—Degree of attenuation desired.

5—Space and weight limitations.

6—Costs.

The filter must be rated to carry the desired current without overheating or introducing an excessive voltage drop. If an inductor having an iron core is used, it is important that the filter be operated within current limitations in order to avoid the detrimental effects of core saturation which will impair the effectiveness of the filter. In connection with the use of a capacitor, the voltage rating is the important factor. In choosing a filter, considerable thought should be given to constructional details. The filter should be shielded with the output leads isolated from the input leads. The shielded



METHOD whereby interfering currents may be coupled between input and output leads that are unshielded and routed in close proximity to one another.

IMPROPER SITE SELECTION. This receiving activity is located on the second floor of this building directly over a commissary containing the usual assortment of radio interference sources including coffee grinders, electric adding machines, etc. A parking area is located around the building directly under the receiving antennas. High levels of ignition interference are radiated to the receiving antennas by the unshielded ignition systems of vehicles using this area. Numerous other activities containing prolific sources of radio interferences such as radar and link trainers are located in proximity to this receiving activity. It is considered impractical, in view of persons in this photo laden with bags of groceries, to exclude vehicles from a 1000-foot radius of this building.

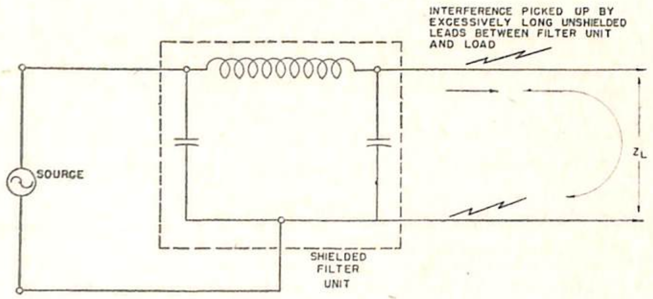
cover must make perfect electrical contact with the rest of the shielded enclosure. The filter terminals should be of sufficient size to carry the required current. When capacitors are used, the leads should be as short as possible. All grounds must be of low impedance to radio frequencies. Coupling between leads should be avoided by routing all leads close to the ground plane, in opposite directions, never looped together. Filters should always be mounted as close as possible to the filtered apparatus with well shielded leads used as a coupling medium. Both the filter and the filtered apparatus must be well grounded through low radio-frequency impedances. This means bare, clean, low conductivity metal-to-metal contacts around the periphery of doors or removable panels or where this is impracticable, short grounding straps should be used at all mounting surfaces. The use of electrolytic capacitors as filter components is not recommended due to the danger of dielectric breakdown. Oil-filled paper or mica capacitors are generally employed in Navy approved types of filters.

Location of Filters

The physical location of a filter unit plays an important part in the degree of radio interference attenuation that may be obtained by its use. The filter may be located at the source of interference, somewhere along the power line between the source and the receiver, or at the power line input to the receiver.

The location of the filter at one or more of the possible locations will be determined by the method whereby radio interference is coupled to the receiver. In cases where the interference is coupled directly via the power lines, the most effective means of eliminating the interference is to install the filter at the power line input to the receiver. If the radio interference is conducted from the source and then radiated from the power lines between the source and the receiver and thence into the receiver at points of entry other than the power line input, the most effective means of eliminating this type of interference is to locate the filter at the source itself. It is considered good practice to locate a radio interference filter at the power line input of each receiver. This procedure is necessary due to the usually impossible task of filtering separately all sources of radio interference that may be interfering with receivers. Locating filters at the receivers also reduces the number, weight and size of the filters that may be required at a Naval activity. This reduction in filter size and weight is due to the fact that network filters located at the receiver are required to carry only the current required by the receiver itself. The reduction in the number of filters, is due to the necessity of attenuating only the range of frequencies to which a particular receiver is interfered with. In most cases, a simple series capacitor filter located in the receiver power line input will serve to provide the required degree of radio interference attenuation. In general such a filter is provided in most present day radio receivers.

In cases where it is found that a single source of radio interference is interfering with several or more receivers, it is best to install a filter directly at the source as well as filters at the receivers. This procedure will often eliminate the necessity of installing additional filters at each receiver. The connection of a filter at the source will sometimes eliminate the coupling of interference to a receiver by a means other than the receiver power line input. This is illustrated in cases wherein interference from an unfiltered source is conducted out through the power lines with subsequent radiation by these lines and resultant pick up of this radiated interference by the receiver antenna input or at other points of entry into the receiver.



METHOD whereby interfering current may be radiated by excessively long unshielded leads between a filter unit and load.

IMPROPER RECEIVER SITE is shown in this photo of a control tower located on one end of an airship hangar. The v-h-f antennas, indicated by an arrow, are located below the roof level of the hangar, with resultant poor communications between the control tower and any airships that may be operating in the areas shadowed by the hangar.

Capacitors

In general, the use of simple capacitor filters is to be preferred over that of the more complicated network filters in cases where this type of filter provides the required degree of radio interference attenuation. Radio interference currents are conducted by a-c power lines as well as d-c power lines. The filtering action of a capacitor may be applied to either type of power line in order to reduce or eliminate the conducted radio interference. In connection with the use of capacitors as filters on generators, it is necessary to observe a few precautions in the selection of the proper capacitor for filter use. These precautions are necessary because of the following reasons:

1—Generator excitation is increased by the leading current drawn by a capacitor when connected in parallel. The automatic voltage regulation of the generator will tend to offset this increase in excitation, by varying the generator field current. If more field resistance is required than the voltage regulator is capable of providing, the voltage regulator action will be impaired, with resultant over-voltage output from the generator.

2—If a parallel connected capacitor resonates with the internal reactance of the generator, currents and voltages much higher than the rated output of the generator will result, with the attendant danger of capacitor failure or flash over.

3—If the parallel capacity increases the generator current materially so as to increase the generator heating, the safe output rating of the generator will be decreased.

The above detrimental effects may be minimized by the use of as small a value of capacitance as possible, consistent with attaining the required degree of attenuation of the radio interference. Usually it is possible to employ capacitors possessing low enough capacity to have little or no effect on the performance of a-c generators and at the same time furnish the required attenuation of interference on the power lines. The filter capacitors should be located inside the case of the generator, near the output terminals.

At very high frequencies a capacitor cannot be regarded as a pure capacitance due to the inductance of the capacitor and leads thereto. The capacity existing between the capacitor and its associated leads and the sides of the filtering enclosure must be considered in determining the choice of capacitors for use as filters at these frequencies. The proximity of the metal walls of the filter enclosure will in many instances act to tune the filter coil. However, modern design methods have produced many types of capacitors possessing low values of inductance. One widely used capacitor of the non-inductive type is known as a "spark plate." This capacitor has found extensive use commercially in the reduction of radio interference from motor ignition systems. This spark plate capacitor usually consists of two parallel plates, separated by a thin insulating material. The filter case usually forms one of the capacitor plates. The lead being filtered is connected to one side of the insulated

SITE SELECTION SURVEYS are an important phase of the Bureau of Ships comprehensive program for the elimination of radio interference at future Naval receiving activities. This photo shows a Bureau of Ships radio interference field engineering survey party checking the suitability of proposed receiving station sites. These sites are thoroughly analyzed from the standpoint of existing radio interference, signal strengths and the ground conductivity of the area.

plate with the output taken from the other side of the same plate.

Site Selection

Naval shore communication stations and Naval air-stations should be relatively free from the degrading effects of man-made interference. This condition is realized by locating receiving activities in areas remote from interference sources. Unfortunately this condition exists only at major shore communications stations. At smaller stations and air stations these receiving activities are usually located with regard to other factors such as convenience or the availability of space.

High levels of radio interference will be evident in the output of a radio receiver, if certain types of radio interference producing equipment are located in the vicinity of the receiver.

In the initial planning for a receiving activity it is important that good antenna design and installation practices be observed and that the receiving activity be located in an area of low radio interference levels.

Improper planning of receiving activities in the past has contributed largely to the high radio interference levels presently existing at many Naval shore communications stations and Naval air stations. Many receiving activities have been installed with little regard for the principles of proper receiver site selection, as evidenced by the location of many receiving activities in close proximity to known sources of radio interference such as transmitter stations, power lines, industrial areas, housing developments and highways or parking areas.

The following material forms a part of a tentative specification governing the site selection of United States Naval shore radio receiving stations, stressing the factors pertinent to the fundamental suitability of a site for radio reception.

1—*Noise level at the site.* It will be necessary to determine the undesirable noise peculiar to the site since the ability to communicate is a direct function of the signal-to-noise ratio at the receiver. The noise level (other than true atmospheric) of a desirable site should not exceed two microvolts per meter in the 10-kc to 140-Mc frequency range. This figure is the maximum allowable at the undeveloped site and only in extremely rare instances can it be expected to diminish. Rather, it will increase.

2—*Isolation.* The site should be isolated by these minimum distances from the nearest antenna to the following sources: High-power, very-low-frequency and low-frequency transmitter stations of 50 kw or over —25 miles; other transmitter stations—5 miles.

As regards non-Navy transmitting stations, the limitations desired by the Bureau of Ships are as follows: Five-mile distance between Navy radio receiving stations and non-Navy transmitting stations not employing v-l-f and l-f transmitters of 50 kw or over. The signal level from the non-Navy station shall not exceed ten millivolts per meter at the Navy site.

While realistic consideration must be given existing stations, a major deviation from the above limitations will be reflected in a reduced operating efficiency of the Navy station concerned. Also to be considered are:

1—*Air fields and glide paths.* For general communications receiving—5 miles; For aeronautical receiving at air stations—1500 feet.

2—*Teletypes and other electro-mechanical systems.* When installed in shielded room—no requirement; when installed in an unshielded room, a large installation such as a communication center—2 miles, or a small installation (one to six instruments)—200 feet.

3—*Main highways*—1000 feet.

4—*High tension power lines (overhead).* Receiving station feeders—buried within a distance of 1000 feet from the nearest antenna; high tension transmission lines and sub and transformer stations—3 miles.

5—Habitable areas—1½ miles.

6—Areas capable of industrialization—2 miles.

Clearances from local transmitters should be reviewed from a realistic viewpoint, as rigid interpretation of specifications will unnecessarily hamper receiver site selection. Certain transmitters such as links and emergency communications equipment must be tolerated at the receiving station. An overmodulated amateur transmitter located on a housing development, close to the radio reservation, can cause more interference than a 50-kw transmitter several miles away, while a foreign non-regulated, over-modulated broadcast transmitter just across the border can completely jeopardize the operations of a nearby receiving station by spurious radiations over a wide band. In evaluating the amount of interference to be anticipated, the effective transmitter power (beamed antenna, etc.), type and efficiency of emission, frequencies, etc. should be considered. These estimates must be confirmed by actual field measurements before a final decision on the site is reached.

The measurement of radio interference levels, and the signals from radio transmitters is a necessary procedure for determining definitely and accurately the most desirable location in a given area for a receiving activity or a transmitter activity.

Field intensities of both radio interference, and the signals from transmitters may be accurately measured by the use of the following radio interference measuring instruments, all of which will be available to field activities in the near future:

1—AN/URM-6, frequency range 14 kc to 250 kc.
2—AN/PRM-1, frequency range 150 kc to 25 Mc.
3—TS-587/U, frequency range 15 Mc to 400 Mc.

NOTES ON MODEL QHB SERIES TROUBLE SHOOTING

Defective Leak Detectors Furnished With QHBa Transducers

Difficulty has been encountered with the leak detectors furnished with the Model QHBa transducers scheduled for installation aboard the *USS Blue* (*DD-744*), the *USS Hubbard* (*DD-748*), the *USS Cunningham* (*DD-752*), and the *USS Evans* (*DD-754*).

Trouble was first encountered with the leak detector installed in transducer #111. During and after the first pressure test the leak detector reading was approximately 5,000 ohms. Hot silica gel was installed and two hours later the leak detector reading was 4 megohms. The cap was removed again and the transducer was purged with dry nitrogen, bringing the leak detector reading to 10 megohms. Inside an hour, however, the reading dropped to around 200,000 ohms. New silica gel was installed and at this time it was necessary to install the transducer aboard the *USS Blue* in order to meet a rigid undocking date. Just previous to installation and immediately after resealing the transducer the leak detector reading was 22,000 ohms, and although a slow rise in reading was anticipated, the leak detector reading has remained at this value. At no time during these tests could any moisture be found in the transducer. Megger readings made on this transducer were all in excess of 500 megohms.

Tests have also been made on other leak detectors available at the San Francisco Naval Shipyard. These tests were made by mounting the leak detectors in their respective transducers, using hot silica gel, and immediately sealing the transducers. The one mounted in the QHBa transducer #114, which is now installed on the *USS Hubbard* is the only one that has proved satisfactory. The leak detector readings on other transducers tested were all less than 10,000 ohms, excepting one reading on transducer #112 of 33,000 ohms.

The *USS Catfish* was recently drydocked (for reasons other than sonar) and the QHB-1 transducer was inspected, since the leak detector reading has been around 40,000 ohms for some time. No moisture could be found anywhere in the transducer. The silica gel was removed, but even after considerable baking, the leak detector reading could not be brought above 40,000 ohms. A new leak detector was installed and it is now reading 10 megohms.

Inoperative QHBa Audio Scanning Switch Caused by Gear Train Defect

In a test of the QHBa serial #83 at San Francisco Naval Shipyard, the audio scanning switch was found to be inoperative. It was determined that there was a mechanical defect in the gear train. Upon removal and disassembly of the scanning switch it was found that the gear on the main shaft had sheared off about six teeth. One of the gears mated to this gear, the brass gear on the counter shaft, had several teeth bent. There is no perceptible bind in the main shaft. It is believed that this trouble started with a burr or bent tooth on one of these gears. New gears were manufactured at the shipyard.

During check-out of the QHBa equipment on the *AVP-30*, it was found that the audio scanning switch was not training properly. Investigation disclosed that the Meehanite metal gear on the rotor of the audio scanning switch had several teeth partially missing. Damage was also in evidence on the brass pinion gear in contact with the rotor gear. However, it was also noted that the scanning switch rotor and the associated training mechanisms were all perfectly free with no evidence of binding that might have caused the broken teeth to have sheared.

A similar failure was noted during the QHBa installation check-out on the *DD-866*.

Oil Leakage From Power Transformer T-708

After several deep dives the *USS Catfish* reported a large amount of oil leakage from power transformer T-708. The unit was removed and inspected at Mare Island Naval Shipyard, and it was found that a poor job of soldering had been done. The transformer was refilled with oil, resealed and reinstalled in the equipment, and is now operating satisfactorily.

Arcing in the QHBa Preamplifier Tubes During Keying

During the final stage of a Model QHBa check-out it was discovered that considerable arcing occurred within the preamplifier tubes at the instant of keying. The trouble was positively isolated to be in transducer stave #25. The resistance of the stave as measured at terminal board 4B in the scanning switch assembly was 1.6 ohms. This is approximately the resistance of the transducer cable less the transducer element and although it seemed entirely feasible to make the repairs without removing the transducer, it was decided by the activity to replace the transducer and inspect the defective unit upon its arrival at the shop. Upon inspection it was found that the blue lead on terminal 25 in the transducer had been pressed hard against the "common" lug of element 25, thus shorting stave 25 out. (The plastic on the blue lead was ruptured without the least signs of arcing.)

Incorrect Bearing Information From QHB Result of Incorrect Cable Connections

The following Model QHB trouble was experienced by a Naval vessel. It is considered to be thoroughly representative of the results of an insufficient and improper initial check out of a sonar installation.

As a measure designed to eliminate incorrect interconnections between the Model QHB scanning switch assembly and the transducer, all transducers should be checked with an OCP/OCP-1 sonar monitor after the vessel is waterborne as described on Page 22 of the March 1949 ELECTRON.

The Model QHB sonar equipment installed in the vessel was inspected in response to a request. The ship reported that it had recently taken part in ASW exercises and had been unable to track down targets. It believed the bearing information indicated by the QHB was incorrect.

An engineer made a series of tests with a sonar monitor, and found that when the monitor hydrophone was hung from the bow of the vessel, at relative bearing 000, two wedge patterns appeared, one at bearing 305 and one at 060 relative. When the monitor hydrophone was placed at relative bearing 090, a single wedge appeared at relative bearing 255. The hydrophone was then placed successively in positions that should have been along the bearings of the centers of the sectors connected to transducer cables Nos. 1, 2, 4, and 5. From the indications received it appeared that the transducer cables were connected at the terminal board in the scanning switch cabinet in reverse order; that is, cables Nos. 5 and 1 were interchanged, and Nos. 4 and 2 were interchanged. This was confirmed in the case of No. 5 cable by obtaining an ohmmeter reading of 4 ohms between the pair of leads connected to terminals 9 and C indicating that they were connected to the MCC ring, and a reading of only 2 ohms between the pair on terminals 49 and 50 indicating that this pair was connected to a single stave. The transducer cables were then reconnected in the correct order as determined from the above tests and a series of monitor checks was made. It was found necessary to make a correction of approximately 5 degrees to the video bearing by resetting sweep generator B–405. After making this correction, normal bearing indications were obtained. The transducer cables apparently had been incorrectly connected when the equipment was installed approximately a year before. The ship's sonar personnel reported that they had not been changed since installation.

MODEL TDH SHOCK HAZARD

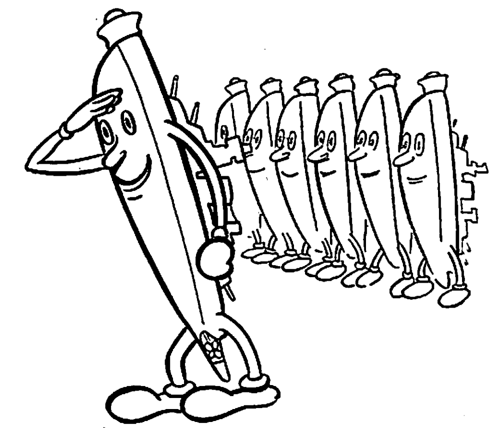
The District Communication Officer of the Eleventh Naval District, San Diego, California, in a conference held on 11 October 1948, pointed out that a dangerous situation exists in the Model TDH Radio Transmitting Equipment as a result of a field modification for RATT (Radio and Teletype) operation of the TDH transmitters.

The RATT coupler unit is so installed that when an operator or technician opens the access door to tune the coupler, his hand must pass within three inches of the 500-volt bias circuit which is not deenergized by the interlock on the access door. This voltage is required in order to adjust the oscillator and coupler unit.

The Collins Radio Company, manufacturer of Model TDH equipment, was contacted and "recommended that a strip of 3/16″ Bakelite approximately 6″ wide and of a length equal to the front-to-back width of the chassis be bolted to the chassis lips at the front and back of the power amplifier chassis. The conditions hazardous to operating personnel would then be essentially eliminated and this would not have a detrimental effect on the ventilation of the transmitter."

All activities using the Model TDH equipment please note that such a hazard exists and initiate action to eliminate this dangerous condition.

THE U.S.S. JUNEAU REPORTS ON THE MODEL TCZ



The following report covering the operation of Model TCZ Radio Transmitting Equipments aboard the *USS Juneau (CLAA–119)* is published to assist personnel of other vessels and activities in improving performance of their equipment:

1—The *USS Juneau (CLAA–119)* reported that the performance of the equipments installed in Radio I and II was poor to unsatisfactory and that the transmitter installed in Radio III had not been used because of completely unsatisfactory performance.

2—Several checks were made on the equipment installed in Radio I. The transmitter was tuned to 2716 kc. It appeared to tune normally, except that the settings of dials "C," "D" and "E" did not correspond to the data supplied in the instruction book. An operational check was conducted with poor results. A further check was made at a frequency of 4235 kc. Again the dial settings did not correspond to instruction book data, although tuning appeared normal. At this frequency, the operation was excellent at the short range check.

3—A wavemeter was obtained to check the transmitter output frequency. It was felt the π network used to tune the final amplifier, while completely satisfactory when properly tuned, might easily be tuned to the second harmonic of the desired output frequency. The transmitter was dialed to the original frequency of 2716 kc. and the output checked with the wavemeter. This check revealed that there was no output at 2716 kc., but that the output frequency was 5432 kc., the second harmonic. Checks made at other frequencies confirmed that the final power amplifier was tuned to twice the desired frequency. Attempts to tune the transmitter using data from the instruction book for the settings of dials "C", "D" and "E" gave harmonic output frequencies in this range.

4—At 4235 kc. the wavemeter check indicated that the output frequency was correct. This accounts for the satisfactory check previously made on this channel. By variation of controls "C" and "E", it was found that the output frequency could be doubled and normal tuning indications, including good current, would be present.

5—At 215 kc., the oscillator settings on the low-frequency range were normal. However, after tuning the loading coil, it was found that the transmitter was actually tuned to the second harmonic again, 430 kc. By further adjustment of the loading coils, the transmitter was set at the desired frequency and very satisfactory communication checks were made. A check indicated that in the 200- to 575-kc. range, the highest frequency that could be doubled by the loading coil tuning was 285 kc. Above this frequency the range of the loading coil was not sufficient to tune to a second harmonic.

6—Checks conducted in a similar manner on the TCZ installed in Radio II indicated that the same conditions existed as were previously found in Radio I.

7—Conditions in Radio III, insofar as the equipment was concerned were the same as in the other two spaces. However, satisfactory checks could not be held at 215 kc. even when the transmitter was properly tuned. Investigation of the antennas revealed the following conditions: In the original installation in Radio III, there had been two transmitters and consequently two individual lines. Since only one transmitter, the TCZ, was now in use in this space, one of the lines had been sealed. However, it was found that the trunk line connected to the ship antenna supposedly connected to the TCZ was actually the sealed one, and that the TCZ was connected to a trunk line which did not terminate in an antenna. Correcting this error resulted in operation of this equipment comparable to the other two.

8—It was found that the tuning information for Dials "C", "D" and "E" and for the low-frequency loading coils was not reliable. It is believed that the reason for this unreliability is that the TCZ is designed for aircraft, where the structure surrounding the antenna is similar in all installations and the approximate settings given would be satisfactory. However, in a shipboard installation, the capacity reflected into the π network because of trunk lines and superstructure surrounding the antenna permits this network to be tuned to the second and sometimes the third harmonic of the desired frequency. Many times there is no indication at the transmitter that doubling, or tripling is occurring. Since this reflected capacitance will vary from ship to ship, it is recommended that a calibration curve for each equipment be taken, using the tuning methods in the Communication Equipment Maintenance Bulletin and the instruction book, and covering the entire transmitter range. A rough curve was made for the equipments installed in the *USS Juneau (CLAA–119)*, using the wavemeters previousy mentioned.

The Bureau of Ships desires that all activities and vessels report operating deficiencies and remedial measures taken in order that such may be disseminated to the field for the benefit of all concerned. These reports should be forwarded to the Chief of the Bureau of Ships, Code 983, Washington 25, D. C.

BATHYTHERMOGRAPH SENSITIVE ELEMENT REPLACEMENT BY DIVERS

The *USS Amberjack (SS–522)* reported her Model CTB–40131A Bathythermograph was inoperative following operations in early January, 1949.

A request for docking disclosed that the marine railway at the Naval Station, Key West, was under heavy demand and no date was available to accommodate the *Amberjack*. In view of this, the divers of the *USS Howard W. Gilmore (AS–16)* were interrogated to determine the feasibility of replacing the sensitive element with the ship waterborne.

Master divers R. L. Stevens and R. J. Melton, both TMC, USN, studied the instruction book (NavShips 900,234–IB) and the layout of the ship inside and out, and reported that it was practicable.

The work required a total of 53 man hours by 8 divers submerged, and consisted of the following steps:

1—Drilling and retapping all buttons for holding the sensitive element. (This constituted the majority of the divers' work.)

2—Diver entered No. 2D main ballast tank and removed clips holding copper tubing.

3—He then went to the pressure hull and unscrewed packing gland nut. The control room was sealed, and personnel were standing by to put air pressure in the compartment, if necessary.

4—Diver rapped on hull and man stationed in the control room pulled copper tubing into ship. Diver installed blank plug in packing gland.

5—Control room attendant rapped on hull and diver removed plug. New tubing was fed through the pressure hull to diver who inserted packing gland nut over tubing. When the proper amount of tubing had been fed through, man in control room rapped on hull and diver tightened packing gland nut. Diver then ran new tubing through all clips and through Class B stuffing tube in outer hull, and secured in place.

6—The remaining tubing was then coiled on the sensitive element frame in accordance with the diagram contained in NavShips 900,234–IB, figures 9 and 12. The sensitive element and protective shield were then screwed into place.

7—On completion of the installation, a diver's light and a standard mercury thermometer were placed adjacent to the sensitive element to determine calibration and reaction. A portable waterproof sound-powered telephone was run into the ballast tank where the diver could communicate directly with calibration personnel in the control room by entering the ballast tank instead of surfacing.

This installation has performed satisfactorily during at least two months of strenuous operations since renewal of the sensitive element.

CHANGE IN DIAGRAM OF FIELD CHANGE NO. 4–SS

Western Electric Co. has reported receipt of a marked print from the Bell Telephone Laboratory showing some changes which should be made on the SS Radar Field Change No. 4 Interconnecting Wiring Diagram, BR–79925. This is one of the drawings supplied in the kits for Field Change No. 4 as part of the set of maintenance prints, and is referred to in Paragraph 7.92 as a drawing to be used in wiring the field change after mechanical work is completed.

The issue of BR–79925 which is furnished in the kits is probably Issue 4, (12-11-47). This issue assumes that O.S.C. information is available from a 36-speed synchro circuit in the torpedo data computer junction box (usually called the GT box) and therefore shows an MCOP–14 cable from the D–153810 electronic control amplifier, Terminals 101 to 110, into the TDC junction box, picking up three synchro circuits carrying 36-speed change-of-range, 1-speed change-of-range, and 36-speed O.S.C. (9 conductors active). However, O.S.C. data is not available in the GT box. Note 4 on the drawing anticipates this condition and states that, in this case, a separate cable from Terminals 101, 102 and 103 of the electronic control amplifier (Unit 23) should be run to the 36 O.S.C. terminals of the gyro termination box. This is not convenient, however, and a better way to get the data is from the SS console where it is already available on Terminals 7, 8 and 9.

Accordingly, BR–79925 is being reissued to show an MHFF–6 running from Unit 23 to the T.D.C. junction box, carrying change-of-range data only (6 conductors active), color coded as follows:

Electronic Control Amplifier Term No.	*Conductor Color*
104	BL) 1-speed
105	GR) Delta-R
106	OR) Synchro input
108	RD) 36 Delta-R
109	WH) Synchro
110	BLK) Input

The O.S.C. data is then obtained with a TCOP–3 cable, Circuit 1–C–23, 2R–ER–150, connected as shown in figure 1. On this same drawing another circuit is omitted entirely which should be shown for SS–1 installations, but not for SS–a (field conversion of SS). This circuit is a connection for the heater in the electronic control amplifier. No provision for space heaters was made in the design of Model SS Radar Equipment, but in the production models of SS–1 various units were equipped with heaters according to later Navy specifications. The power distribution unit for SS–1 is provided

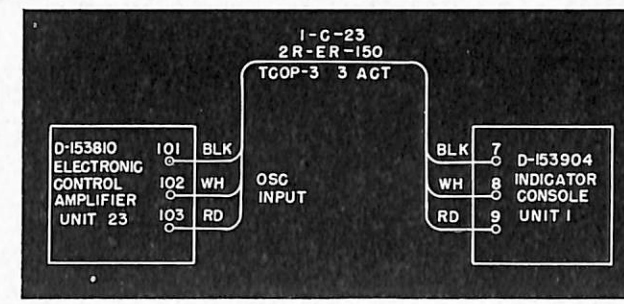


FIGURE 1

with a heater supply circuit which arranges to cut the power from all space heaters when the equipment is turned on.

There is presently specified on BR–79925 an MCOP–14 cable, 2R–ER–148, which brings various kinds of power from the power distribution unit (Unit 4) to the new electronic control amplifier (Unit 23) and which has ten conductors active. MCOP cables are superseded by MHFF cables so this should be changed to an MHFF–14 in which twelve conductors will be active in SS–1 installations when the control amplifier space heater is connected. For this purpose, Terminal 77 of the power distribution unit is connected via the BLK–WH wire to Terminal 162 of the control amplifier; and Terminal 78 of the P.D.U. connected via the RD–WH wire to Terminal 161 of the control amplifier.

ELECTRONIC FIELD CHANGE INDEX

The Electronic Field Change Index is a tabulation of pertinent information and data required by field activities concerning all authorized changes and modifications to ship and shore electronic equipment. The index will provide a convenient reference source for operating personnel, maintenance and repair technicians, inspectors, etc., wherein the information essential to the orderly progression of the field change program will be concentrated.

The index will ultimately be published as a permanent feature in the three maintenance bulletins, the Communication Equipment Maintenance Bulletin, Radar Maintenance Bulletin and Sonar Bulletin, according to the category of the equipments involved. Additions and corrections to the index will be included in the regular supplements to the bulletins which are presently issued on a quarterly basis.

In addition to the Bulletins, the entire original issue of the Field Change Index will be published on the installment basis in ELECTRON Magazine in order to expedite dissemination of the important information and data. The following is the first installment of the index. All activities concerned with these equipments should check both the equipments and the equipment records to ascertain if they are up-to-date. If not, the proper action should be initiated to accomplish the necessary changes.

1—The dates of December 1945 and January 1946 are indicated for many changes. These represent the dates on which serial numbers were assigned to previously unnumbered changes or modifications authorized or issued prior to the initiation of the present field change system.

2—The preferred activity to accomplish each field change is indicated by "SF" (ship's force) or "YF" (yard force).

ELECTRONIC FIELD CHANGE INDEX

Field Change Number	Field Change Title	Date of Field Change	Serial Numbers of Equipment Affected	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Contract Number
RAK Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna		Not applicable						
RAK-1 Radio Receiving Ekuipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna		Not applicable						
RAK-2 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna		Not applicable						
RAK-3 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna		Not applicable						
RAK-4 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None

Field Change Number	Field Change Title	Date of Field Change	Serial Numbers of Equipment Affected	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Number Contract
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna		Not applicable						
RAK-5 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna		Not applicable						
RAK-6 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack	Dec. '45	All	YF	3	Kit	——	CEMB & Supplement to 1B	NOs -95022
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna	Mar '47	All RAK-6, equipts. aboard submarines	YF	8	Kit	——	With kit	NObsr -37148
RAK-7 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204		Not applicable						
3	Fusing of the Equipments	Dec. '45	All	SF	8	Non req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna	Mar '47	All RAK-7 equipments aboard submarines	YF	8	Kit	——	With kit	NObsr -37148
RAK-8 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204		Not applicable						
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
4	Modification for use with Navy Type -66097 Loop Antenna	Mar '47	All RAK-8 equipments aboard submarines	YF	8	Kit	——	With kit	NObsr -37148
RAL Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
RAL-1 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipment	Dec. '45	All	SF	1	None req'd	None	CEMB	None
RAL-2 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
RAL-3 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	A..	SF	1	None req'd	None	CEMB	None
RAL-4 Ralio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
RAL-5 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R-202, R-203 & R-204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
RAL-6 Radio Receiving Equipment									
1	Providing Concentric Antenna Jack	Dec. '45	All	YF	3	Kit	——	CEMB &	NOs -95022

Field Change Number	Field Change Title	Date of Field Change	Serial Numbers of Equipment Affected	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Contract Number
								Supplement to IB	
2	Replacing Power Supply Resistors R–202, R–203 & R–204	Dec. '45	All	SF	2	Stock	None	CEMB	None
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
RAL–7 Radio Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R–202, R–203 & R–204		Not applicable						
3	Fusing of the Equipments	Dec. '45	All	SF	1	None req'd	None	CEMB	None
RAL–8 Radio Equipment									
1	Providing Concentric Antenna Jack		Not applicable						
2	Replacing Power Supply Resistors R–203, R–203 & R–204		Not applicable						
3	Fusing of the Equipment	Dec. '45	All	SF	1	None req'd	None	CEMB	None
RBA Radio Receiving Equipment									
1	Installation of Type –49059 Plug Adapters	Dec. '45	All	SF	2	Kit or Stock	——	CEMB	NXsr–39245 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBA Receivers with NT–20130 power supplies having the following serial numbers:						

1– 451, incl.	2018–2021, incl.	2245–2246, incl.	2298–2299, incl.	
488– 492, incl.	2025	2249	2303–2305, incl.	
801– 802, incl.	2028–2033, incl.	2251–2253, incl.	2307	
804– 844, incl.	2038	2255–2257, incl.	2309–2310. incl.	
846	2041	2261–2263, incl.	2313–2314, incl.	
848– 850. incl.	2050–2051, incl.	2265	2316–2317, incl.	
852– 901, incl.	2058	2267–2269, incl.	2320–2321, incl.	
907	2062	2270	2323–2326, incl.	
1601–1695, incl.	2069	2272–2274, incl.	2328–2336, incl.	2404–2416, incl.
1800–1819, incl.	2071–2075, incl.	2276–2279, incl.	2340–2341, incl.	2418–2471, incl.
1821–1872, incl.	2078–2079, incl.	2281	2345	2473–2499, incl.
1874–1899, incl.	2172	2286	2347–2351, incl.	2500–2527, incl.
1900–1998, incl.	2213	2289	2353	2529–2548, incl.
2000–2008, incl.	2238	2293	2355–2399, incl.	2550–2589, incl.
2012–2016, incl.	2241	2295–2296, incl.	2400–2402, incl.	2591–2600, incl.

Field Change Number	Field Change Title	Date of Field Change	Serial Numbers of Equipment Affected	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Contract Number
RBA–1 Radio Receiving Equipment									
1	Installation of Type –49050 Plug Adapters	Dec. '45	All	SF	2	Kit or Stock	——	CEMB	NXsr–29345 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBA–1 Receivers with NT–20130 power supplies having the following serials numbers: See Field Change #2 For RBA	SF	1	None req'd	None	CEMB	None
RBA–2 Radio Receiving Equipment									
1	Installation of Type –49059 Plug Adapters	Dec. '45	All	SF	2	Kit or Stock		CEMB	NXsr–39245 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBA–2 receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 For RBA	SF	1	None req'd	None	CEMB	None
RBA–3 Radio Receiving Equipment									
1	Installation of Type –49059 Plug Adapters	Dec. '45	All	SF	2	Kit or Stock		CEMB	NXsr–39245 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBA–3 Receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 For RBA	SF	1	None req'd	None	CEMB	None
RBA–5 Radio Receiving Equipment									
1	Installation of Type –49059 Plug Adapters		Not applicable						
2	Inversion of Power Supply Filter Choke	Dec. '45	RBA–5 Receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 for RBA	SF	1	None req'd	None	CEMB	None
RBA–6 Radio Receiving Equipment									
1	Installation of Type –49059 Plug Adapters		Not applicable						

ELECTRONIC FIELD CHANGE INDEX—Continued

Field Change Number	Field Change Title	Date of Field Change	of Equipment Affected Serial Numbers	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Contract Number
2	Inversion of Power Supply Filter Choke	Dec. '45	RBA–6 Receivers with NT–20130 power supplies having the following serial numbers: See Fied Change #2 for RBA	SF	1	None req'd	None	CEMB	None
RBB Radio Receiving Equipment									
1	Installation of Type –49509 Plug Adaptors	Dec. '45	All	SF	2	Kit or Stock		CEMB	NXsr–39245 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBB Receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 for RBA	SF	1	None req'd	None	CEMB	None
3	Improvement of Band Switch	Dec. '45	All	SF	3	Stock	None	CEMB	None
RBB–1 Radio Receiving Equipment									
1	Installation of Type –49509 Plug Adaptors	Dec. '45	All	SF	2	Kit or Stock		CEMB	NXsr–39245 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBB–1 Receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 for RBA	SF	1	None req'd	None	CEMB	None
3	Improvement of Band Switch	Dec. '45	1 thru 1000	SF	3	Stock	None	CEMB	None
RBB–2 Radio Receiving Equipment									
1	Installation of Type –49509 Plug Adaptors	Dec. '45	All	SF	2	Kit or Stock		CEMB	NXsr–86317 NXsr–76317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBB–2 Receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 for RBA	SF	1	None req'd	None	CEMB	None

3	Improvement of Band Switch		Not applicable						
RBC Radio Receiving Equipment									
1	Installation of Type –49509 Plug Adaptors	Dec. '45	All	SF	2	Kit or Stock		CEMB	NXsr–39245 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBC Receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 for RBA	SF	1	None req'd	None	CEMB	None
3	Improvement of Band Switch	Dec. '45	All	SF	3	Stock	None	CEMB	None
RBC–1 Radio Receiving Equipment									
1	Installation of Type –49509 Plug Adaptors	Dec. '45	All	SF	2	Kit or Stock		CEMB	NXsr–39245 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBC–1 Receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 for RBA	SF	1	None req'd	None	CEMB	None
3	Improvement of Band Switch	Dec. '45	1 thru 1000	SF	3	Stock	None	CEMB	None
RBC–2 Radio Receiving Equipment									
1	Installation of Type –49509 Plug Adaptors	Dec. '45	All	SF	2	Kit or Stock		CEMB	NXsr–39245 NXsr–86317
2	Inversion of Power Supply Filter Choke	Dec. '45	RBC–2 Receivers with NT–20130 power supplies having the following serial numbers: See Field Change #2 for RBA	SF	1	None req'd	None	CEMB	None
3	Improvement of Band Switch		Not applicable						
RBC–3 Radio Receiving Equipment									
1	Installation of Type –49509 Plug Adaptors		Not applicable						
2	Inversion of Power Supply Filter Choke		Not applicable						
3	Improvement of Band Switch		Not applicable						
RBC–4 Radio Receiving Equipment									
1	Installation of Type –49509 Plug Adapters		Not applicable						

Field Change Number	Field Change Title	Date of Field Change	Serial Numbers of Equipment Serial Numbers	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Contract Number
2	Inversion of Power Supply Filter Chokes		Not applicable						
3	Improvement of Band Switch		Not applicable						
RBM Radio Receiving Equipment									
1	Shock-Mounting		Not applicable						
RBM–1 Radio Receiving Equipment									
1	Shock-Mounting		Not applicable						
RBM–2 Radio Receiving Equipment									
1	Shock-Mounting		Not applicable						
RBM–3 Radio Receiving Equipment									
1	Shock-Mounting		Not applicable						
RBM–4 Radio Receiving Equipment									
1–RBM	Shock-Mounting	15 Mar. '48	All the HF receivers and power supplies that are to be installed aboard ship	YF	6	Kit	——	NAVSHIPS 98066	Project Order 396/47
RBM–5 Radio Receiving Equipment									
1–RBM	Shock-Mounting	15 Mar. '48	All the HF receivers and power supplies that are to be installed aboard ship	YF	6	Kit	——	NAVSHIPS 98066	Project Order 396/47
RBO Radio Receiving Equipment									
1	Modification of the Audia Circuit	Superseded by Field Change No. 3							
2	Replacing Power Transformer and Rectifier Tubes	Dec. '45	1 thru 3799	SF	2	Kit	——	——	NXsr–56772 NObsr–30032 NObsr–37960
3	Connecting for Balanced Line Speaker Connection	Dec. '45	All	SF	3	Kit	——	——	NXsr–69250
RBO–1 Radio Receiving Equipment									
1	Modification of the Audio Circuit	Superseded by Field Change No. 3							
2	Replacing Power Transformer and Rectifier Tubes		Not applicable						
3	Connecting for Balanced Line Speaker Connection	Dec. '45	All	SF	3	Kit	——	——	NXsr–69250
RBO–2 Radio Receiving Equipment									
1	Modification of the Audio Circuit	Superseded by Field Change No. 3							
2	Replacing Power Transformer and Rectifier Tubes		Not applicable						
3	Connecting for Balanced Line Speaker Connection	Dec. '45	All	SF	3				NXsr–69250
RCK Radio Receiving Equipment									
1	Additional Tuning Set-UP System	Dec. '45	All	SF	2	Stock	None	CEMB	None
2	Noise Suppressor Wiring Correction	Dec. '45	All	SF	1	Stock	None	CEMB	None
3	Installation of Type –49509 Plug Adapters	Dec. '45	All	SF	2	Kit or Stock	——	CEMB	NXsr–86317 NXsr–39245
4	Increased Audio Band Width for CCL Service	July '49	RCK receivers when used in CCL service, provided increased audio band width response is required	SF	½	Stock	None	CEMB	None
REA Radio Receiving Equipment									
1	Receiver Output Line Connections	Jan. '46	All	SF	2	Stock	None	CEMB	None
2	AVC Circuit Modification	Jan. '46	All	SF	2	Stock	None	CEMB	None
REA–1 Radio Receiving Equipment									
1	Receiver Output Line Connections	Jan. '46	All	SF	2	Stock	None	CEMB	None
2	AVC Circuit Modification	Jan. '46	All		2	Stock	None	CEMB	None
REK Receiving and Reproducing Equipment									
1	Installation of Automatic Record Player	Aug. '47	All	YF	40	Kit	——	IB–39242–1A	NXsr–62358
TBA Radio Transmitting Equipment									
1	Modification of Meter M–111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						
4	Modification of the O–5/FR Exciter Unit	Dec. '45	All using O–5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA–1 Radio Transmitting Equipment									
1	Modification of Meter M–111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						

Field Change Number	Field Change Title	Date of Field Change	Serial Numbers of Equipment Affected	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Contract Number
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-2 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying	Dec. '45	All when high speed keying is used	SF	3	Stock	None	CEMB	None
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-3 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation	Dec. '45	All when used with double ended antennas	SF	3	Stock	None	CEMB	None
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-4 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-5 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-6 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit	Dec. '45	All	SF	1	Stock	None	CEMB	None
2	Balanced Output Operation	Dec. '45	All when used with double ended antennas	SF	3	Stock	None	CEMB	None
3	High Speed Keying	Dec. '45	All when high speed keying is used	SF	3	Stock	None	CEMB	None
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-7 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-8 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-9 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-10 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit	Dec. '45	All	SF	1	Stock	None	CEMB	None
2	Balanced Output Operation	Dec. '45	All when used with double ended antennas	SF	3	Stock	None	CEMB	None
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-11 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						

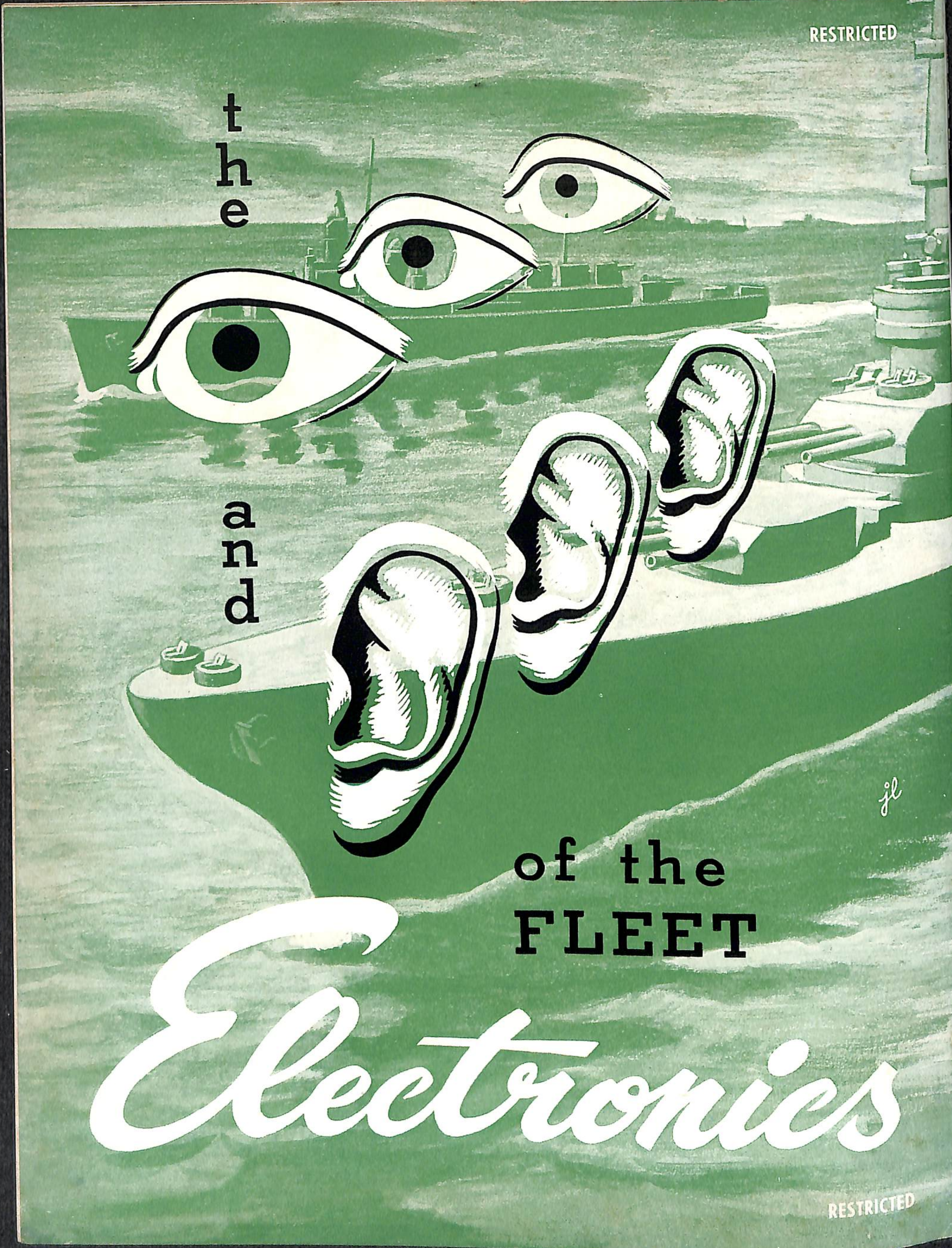
Field Change Number	Field Change Title	Date of Field Change	Serial Numbers of Equipment Affected	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Contract Number
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-12 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBA-13 Radio Transmitting Equipment									
1	Modification of Meter M-111 Bypass Circuit		Not applicable						
2	Balanced Output Operation		Not applicable						
3	High Speed Keying		Not applicable						
4	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK-1 Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK-2 Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None

TBK-3 Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK-4 Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK-5 Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK-6 Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK-7 Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK-8 Radio Transmitting Equipment									
1	Meter M-107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O-5/FR Exciter Unit	Dec. '45	All using O-5/FR Exciter Units	SF	2	Stock	None	CEMB	None

Field Change Number	Field Change Title	Date of Field Change	Serial Numbers of Equipment Affected	Modifying Activity	Man-Hours Req'd	Source of Material	Stock Number of Kit	Instruction Bulletin	Contract Number
TBK–9 Radio Transmitting Equipment									
1	Meter M–107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O–5/FR Exciter Unit	Dec. '45	All using O–5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK–10 Radio Transmitting Equipment									
1	Meter M–107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O–5/FR Exciter Unit	Dec. '45	All using O–5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK–11 Radio Transmitting Equipment									
1	Meter M–107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O–5/FR Exciter Unit	Dec. '45	All using O–5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK–12 Radio Transmitting Equipment									
1	Meter M–107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O–5/FR Exciter Unit	Dec. '45	All using O–5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK–13 Radio Transmitting Equipment									
1	Meter M–107 Erroneously Labeled		Not applicable						
2	Paralleled High Speed Keying	Dec. '45	All using parallel and high speed keying	SF	3	Stock	None	CEMB	None
3	Modification of the O–5/FR Exciter Unit	Dec. '45	All using O–5/FR Exciter Units	SF	2	Stock	None	CEMB	None
TBK–14 Radio Transmitting Equipment									
1	Meter M–107 Erroneously Labeled		Not applicable						

GOT SOME FIELD CHANGE TROUBLE?

LET THE FIELD CHANGE INDEX HELP YOU. THE FIRST SECTION APPEARS IN THIS ISSUE. WATCH FUTURE ELECTRONS FOR MORE OF THE INDEX.



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