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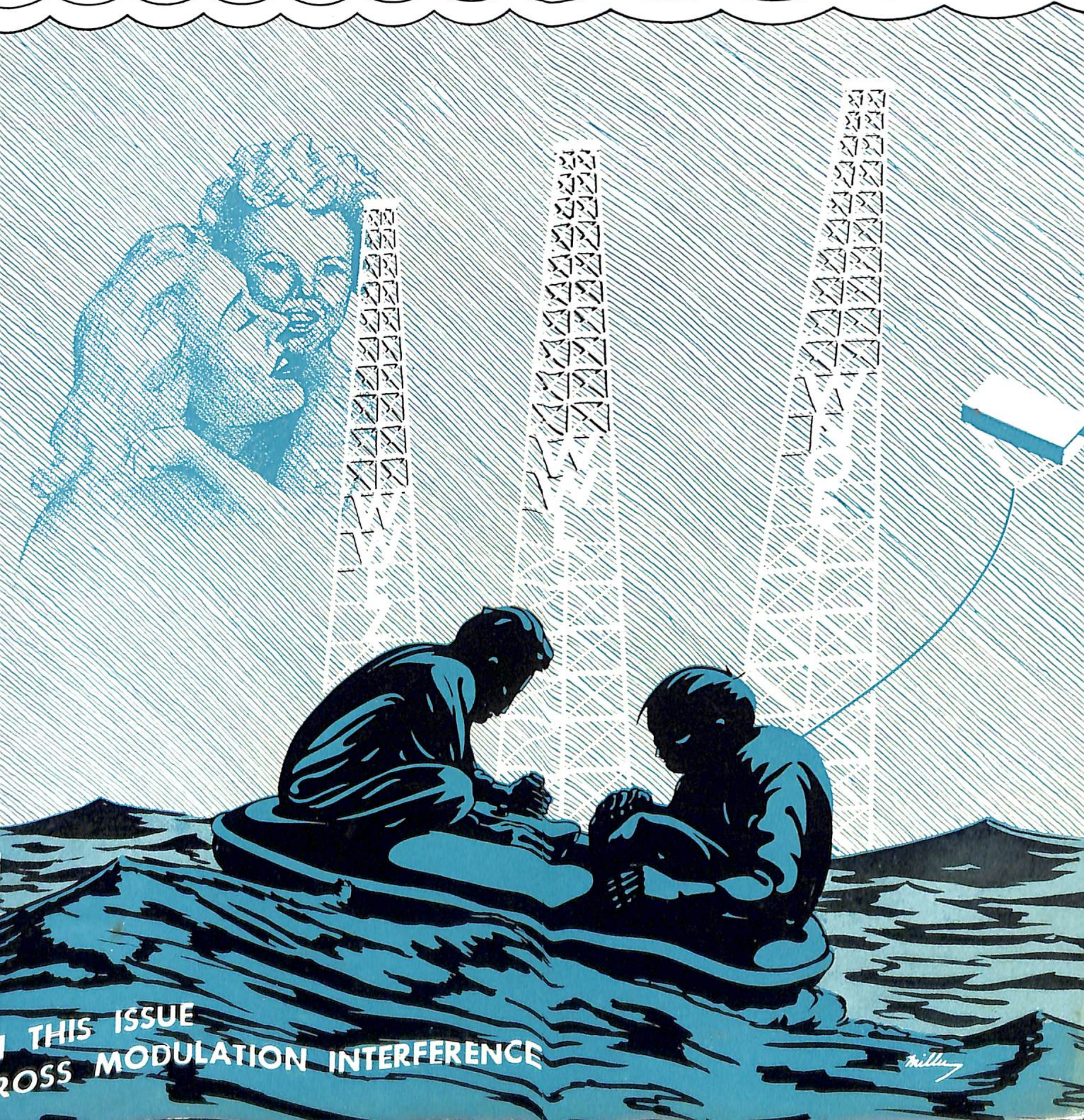

N THIS ISSUE

ROSS MODULATION INTERFERENCE

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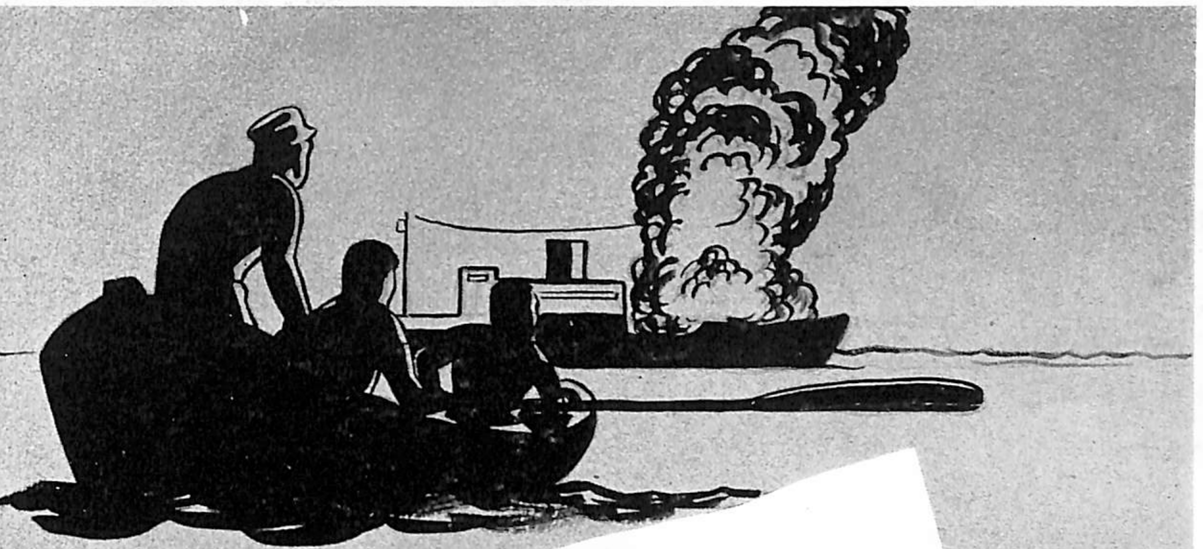


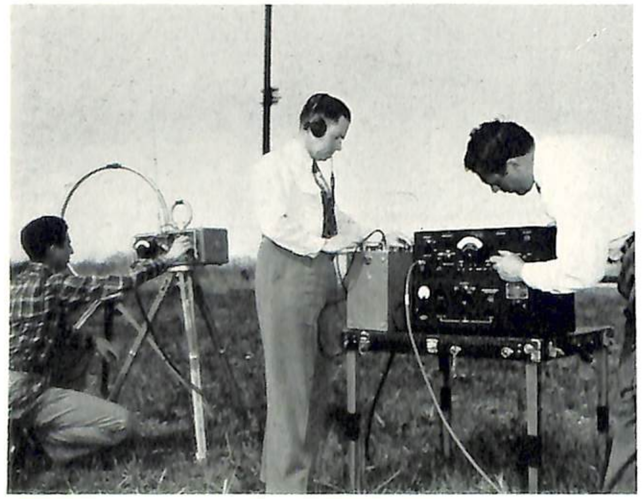
29 DECEMBER 1950............

ON THE NIGHT OF 29 DECEMBER 1950, THE STEAMER S.S. SINCLAIR CAUGHT FIRE IN THE RIVER BELOW NEW ORLEANS. DUE TO THE CROSS MODULATION BROADCAST INTERFERENCE ON THE 500-KC DISTRESS FREQUENCY THE DISTRESS SIGNAL FROM THIS VESSEL WAS NOT HEARD BY THE COAST GUARD RECEIVING STATION AT ALGIERS. ONLY THE FACT THAT THIS MESSAGE WAS PICKED UP BY THE COAST GUARD STATION AT PENSACOLA AVERTED A PROBABLE MAJOR DISASTER.

cross modulation interference

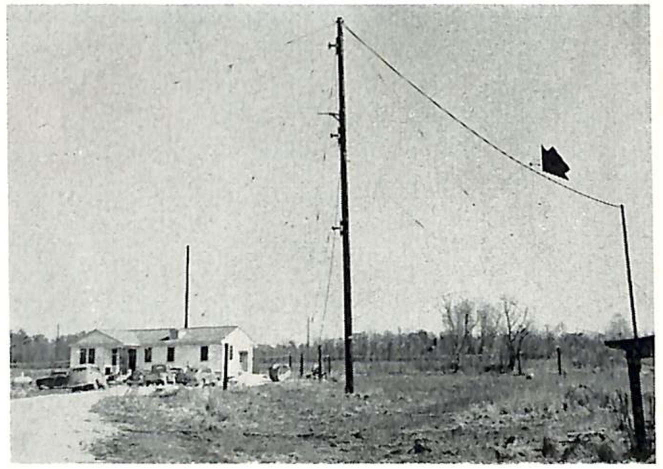
by
William A. Ritz
Electronics Shore Division
Bureau of Ships

Within the past few years the problem of cross-modulation interference has become one of increasing severity at many Naval receiving stations. Cross-modulation interference is of two types. The first type originates in the r-f stages of a receiver and the second type termed external cross-modulation has its source in some point external to the receiver. With the first type the interference is created in the tuned voltage amplifiers of a receiver when the signal being amplified consists of two modulated waves having carriers not too greatly different. Cross-modulation then manifests itself by the fact that during intervals when there is no modulation on the desired carrier, the modulation of the undesired signal may be heard, but if the desired carrier is absent, the undesired program is no longer heard. This cross-modulation, a type of intermodulation distortion, is a result of third-order curvature in the plate-current characteristic of the first or possibly the second r-f tube of the affected receiver. The third-order component of the plate current includes third harmonics and third-order combination frequencies, giving rise to cross-modulation and producing a lack of proportionality between input and output. The last two effects are the most important, particularly as they represent types of behavior not produced by lower order effects. Most of the third-order action usually results from the third derivative of the tube's characteristic curve (i.e., the rate of change of curvature). Hence cross-modulation and lack of proportionality can be reduced by restricting the operating range to regions where the curvature of the tube characteristic is changing only slowly. This means, in general, avoiding the region near cut-off, or using tubes with gradual cut-off (variable-mu type). Third-order effects can also be reduced by making the load impedance to the first order currents high compared with the plate resistance. This condition can be readily obtained with triodes as triode tubes tend to give less trouble from cross-modulation and lack of proportionality than do pentodes. Modern receiver design has incorporated variable-mu type tubes in the r-f stages of receivers and thus minimized cross-modulation in these stages. However, cross-modulation may still exist if signals having an amplitude of a volt or more are induced in the receiving antenna. Under such conditions it is possible to eliminate the interference by making the transfer constant from antenna to the grid of the first r-f tube low, so that the voltage at the grid of the first stage will not be of too great an amplitude for the receiver AVC system to handle. In most cases such as those in which a powerful nearby transmitter is involved, the use of a tuned trap in the antenna circuit will usually eliminate the interfering signal.



Operation of radio interference and field intensity measuring equipment. The AN/URM-6 (14kc-250kc) is illustrated at the left with the AN/PRM-1 (150kc-25Mc) in the center and the TS-587/U (15Mc-400Mc) at the right.

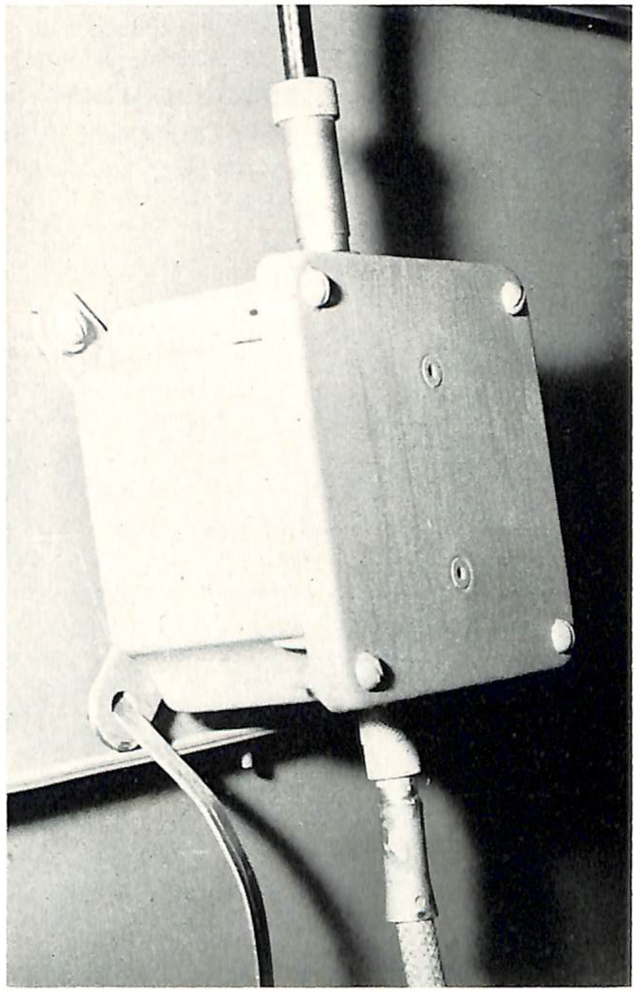
External cross-modulation presents by far the most serious type of interference of the two types to Naval communications today. The term external cross-modulation is applied to spurious frequencies generated by nonlinear contacts in conduit, ground connections, light and power wiring, antenna systems, etc., in the vicinity of the receiver, that carry r-f currents induced by strong signals. When these strong signals are present, such nonlinear contacts develop new frequencies in appreciable amplitude, and these may enter the receiver by means of conduction, or by direct radiation from the point of rectification, causing undesired signals to be heard at unexpected points on the receiver dial. The most common new frequencies produced are harmonics of the transmitted carrier and simple combination frequencies of two carriers of the type $a \pm b$, $a \pm 2b$ and $2a \pm b$, and of three carriers of the type $a + b \pm c$, $a \pm b + c$, etc. Where only one powerful signal is present, the only new frequencies produced by the rectifier are harmonics. In the case where the rectifying contact is on a power line, there is the possibility of strong hum modulation being produced on the carrier frequency of the station. In this case, one of the frequencies is that of the signal carrier and the other that of the power system which is usually 60 cycles. The rectifying action then imposes a 60-cycle modulation on the carrier. External cross-modulation is appreciable only when the



View of some of the antennas at the Navy Radio Station, Belle Chasse, Louisiana. The long wire antenna used with the R-100 receiver is indicated by the arrow.

carriers involved are of high amplitude, i.e., of the order of a volt or more. This fact renders it undesirable to locate transmitting stations so close to each other that their strong signal areas overlap. Many cases are on record wherein the cross-modulation originated in the tuned circuits of the transmitter itself. Cross-modulation originating in the receiver itself can be differentiated easily from that due to external causes by the use of a short antenna, a wave trap tuned to the strongest interfering station or by substituting another receiver. These expedients will eliminate or greatly reduce cross-modulation which originates in the tuned r-f circuits of a receiver but will not affect external cross-modulation.

The problem of external cross-modulation is not new as there has been considerable research work in the past in relation to this subject. Among the first reports regarding this phenomenon are those of van der Pol and Eckersley concerning their observations of ionospheric cross-modulation, more commonly known as the "Luxembourg effect." Many other groups of American investigators have called attention to spurious signals of the external cross-modulation type. Thus in 1935, B. V. K. French and D. E. Foster reported the presence of spurious signals in the vicinity of Newark, New Jersey, the modulation of which associated them with the local broadcast station. A subsequent survey indicated that these spurious signals were created by rectification and radiation along an electrical power line existing within a region of high signal intensity of the local broadcast station. Later similar observations made by Johnson and Kilgour in the Cincinnati area indicated that spurious signals were being created in poorly bonded and grounded electric wiring. Austin V. Eastman and Lawrence C. F. Harle contributed valuable information in a "Proceedings of the Institute of Radio Engineers" article concerning an investigation of spurious signals associated with broadcasting in and about Seattle, Washington. It was found by these investigators that spurious signals of the external cross-modulation type were observed in those locations where a suitably computed product of the field strengths of the associated real signals, termed the "field product" exceeded a critical value. Investigations along these lines indicated that there is a fairly sharp line of demarcation, at a field product of about 0.001 volts-per-meter, above which substantially all computed cross-modulation signals were observed, while virtually none were found below this value. Thus there is a good chance that cross-modulation interference will be created where radio transmitters are so located as to result in the overlapping of the high field strength portions of their service areas. Wherever, in such overlapping areas, the field product exceeds whatever may be the critical value, the generation of spurious signals is, of course, the inevitable result. Most spurious radiations in the field of two or more strong signals are generated in the receiving antenna system. If an a-c receiver is not properly grounded by means of a low impedance grounding system, spurious signals may be generated at points of rectification along the grounding system itself. Such rectification may take place at faulty joints in the receiver case shielding or it may take place in the transmitter case shielding. It may also originate across faulty connections in a transmission line or wherever there happens to be a high r-f impedance across a joint. The rectifying action across such joints is similar to the action of a copper oxide rectifier. Corrosion on the surfaces of the joint may form an oxide, thus introducing a high resistance film at this point. The resistance of such a film is small for currents flowing in one direction and high for currents flowing in the opposite direction, so rectification is assured.



View of the low-pass filter designed to eliminate broadcast station interference on 500 k.c. at the Navy Radio Station, Belle Chasse, La.

The Electronics Shore Division, Bureau of Ships, under Captain Hedley B. Morris is presently conducting a comprehensive program for the reduction of electronic interference at all Naval shore stations and Naval air stations. This program includes, among other important features, electronic interference surveys at these activities and a follow-up program for the elimination of all sources of interference that may be disclosed as a result of these surveys. Many cases of external cross-modulation from a great variety of sources have been found during these surveys. Perhaps the most serious instance of this type of interference was that reported at the Naval Radio Station, New Orleans, Louisiana on 14 July 1950. The following letter from the Commander, Eighth Coast Guard District, to the Industrial Manager, Eighth Naval District is self-explanatory:

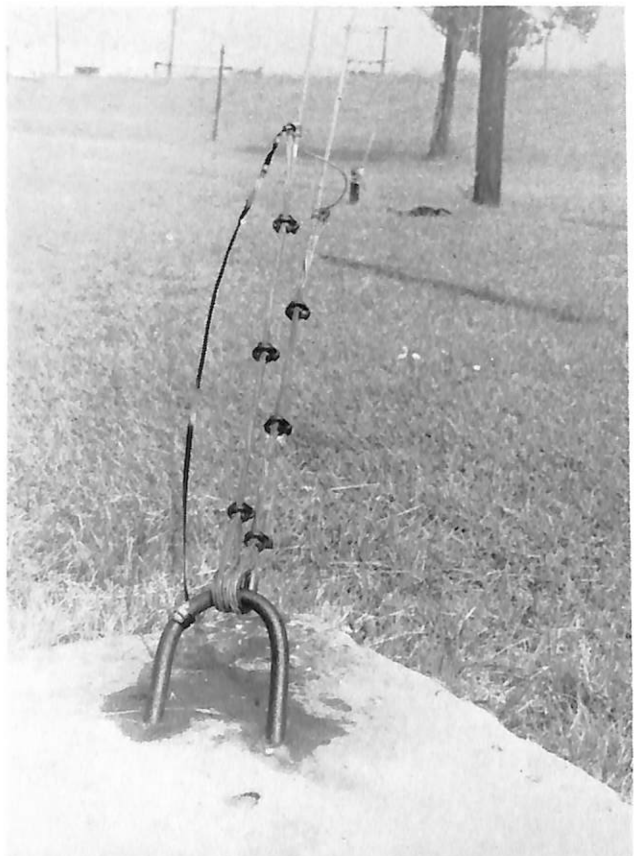
"Commander 14 July 1950
EIGHTH CG District

From: Commander, EIGHTH CG District

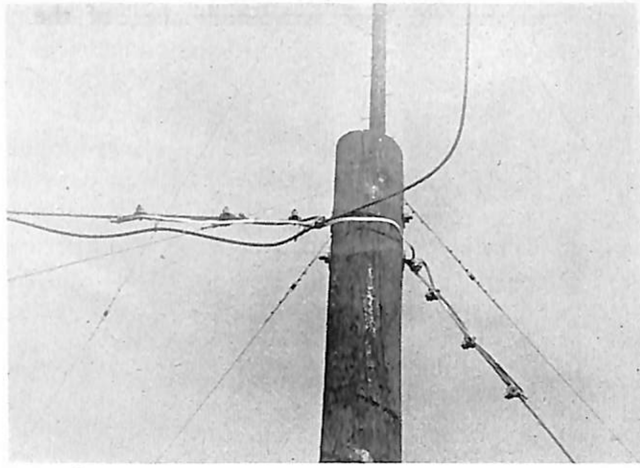
To: Industrial Manager, EIGHTH Naval District

Subj: Interference on 500 kc. at Coast Guard Radio Station (Primary), New Orleans, Louisiana

"1. Subject Radio Station, which uses facilities of the U. S. Navy Radio Station, New Orleans, Louisiana, is experiencing considerable difficulty from broadcast sta-



Bonding of antenna stays to eliminate points of rectification near receiving building at NCS Algiers, Louisiana.



Bonding of points of rectification along the receiving antenna stays at NCS Algiers, Louisiana.

tion interference on 500 kc. The interfering signal consists of three (3) local broadcast stations producing a combined signal on 500 kc. as measured with a type LR frequency meter. The stations have been identified as WNOE (1060 kc.), WWL (870 kc.), and WWEZ 690 kc.). The interfering signal was first heard on 500 kc. when station WNOE began test transmissions on their new frequency of 1060 kc., with a radiated power of 50 kw, about May 19, 1950. They commenced full schedule operations on 1060 kc. on 1 June 1950.

"2. The interference exists only while the three broadcast stations are on the air. It is presumably caused by heterodyne action in the immediate vicinity of the radio station. A possible combination of their fundamental frequencies to produce the interference is as follows:

870 kc. (WWL)
+ 690 kc. (WWEZ)

1560 kc.
—1060 kc. (WNOE)

500 kc.

"3. The interfering signal normally attains strength 5 during dry weather, and at other times is noticeable but not particularly troublesome. During dry weather the interference normally blocks all signals on 500 kc. of strength 4 or less, so that an efficient distress guard for ships at sea is impossible. Various receivers and receiving antennas have been tried, however, the ratio of interference to usable signal remains nearly the same.

"4. Subject station is charged with the responsibility of maintaining a continuous and alert guard of the International Calling and Distress Frequency for the central Gulf of Mexico. The nearest adjacent Navy or Coast Guard shore radio stations maintaining such a guard are located at Pensacola, Florida, and Galveston, Texas.

"5. It is requested that necessary action be taken as soon as possible to improve receiving conditions on 500 kc.

CHAS. W. DEAN

CC: Comdt (OC)
Com8 (DCO)"

Upon receipt of this letter the Office of the Industrial Manager immediately requested assistance from the Bureau of Ships in solving this problem. At this point it is considered advisable to review certain pertinent facts regarding Naval receiving conditions in the New Orleans area. The Naval Radio Station is located in the Administration Building on the Naval Station at Algiers, which is just across the river from the city of New Orleans. Also located in this building is the U. S. Coast Guard Radio Station (primary) which uses the facilities of that station. Several years ago it was deemed advisable to construct a new radio station at Bell Chasse, which is located approximately five miles from the present site at Algiers. This appeared at the time to be an excellent site due to its remote location from sources of interference. The receiver building was completed, underground power wiring was run in, the antennas completed and an interference free emergency power supply was installed. In short, everything was done to insure that the receiving activity would be interference free. However, despite this, a commercial broadcasting station, WNOE, was constructed within approximately 1.7 miles of the new Naval receiving station and commenced operation on May 19, 1950 with a power of 50 kw. The field strength of WNOE at the Naval Receiving Station, Belle Chasse, is approximately one volt and the field strength of the same station at the Naval Radio Station Algiers, is approximately 280 millivolts per meter.

In accordance with the request of the Industrial Manager, Eighth Naval District, electronics engineers, operating under a Bureau of Ships' engineering services contract were sent to the Naval Radio Station at New Orleans in an effort to reduce the external cross-modulation existing at that point. At the conclusion of the preliminary survey by the engineering contractor's personnel the following report was issued by the contractor:

"1—The purpose of this assignment was to eliminate the electronic interference appearing on the international distress frequency channel at 500 kc.

"2—The interfering signal was established as being the beat frequency of three of the local broadcasting stations, namely—WWEZ, which transmits at 690 kc with a 5-kw output; WWL, operating at 870 kc with a 50-kw output; and WNOE, transmitting at 1060 kc with a 50-kw output. The level of interference varied considerably during each day, the highest levels being reported at about 0600 in the morning.

"3—The cross-modulation was observed to exist at many points throughout the New Orleans area. A low level could be observed in the vicinity of the power lines, and was noted as being present on one of the station doublet antennas at the new (still under construction) Navy receiving site at Belle Chasse, as well as radiating from a long wire fence near to station WWEZ's transmitting station. However, it could not be heard near the transmitting antennas themselves, either at WWEZ or at any of the other broadcast stations in the area.

"4—The highest level was observed in the vicinity of the receiving antennas at the Naval station. A level of 300 uv was measured on the #10 long wire antenna on 31 August, before any steps had been taken to eliminate the trouble. On the same day, a level of 350 uv was measured on the #9 E-W doublet, and 60 uv on the #7 N-S doublet antenna.

"5—Detection was found to be taking place at many of the corroded joints between sections of the guy wires supporting the antenna masts. When the joints were shorted across, the interfering signal in the immediate area was eliminated.

"6—The antenna lead-ins and their messengers were observed to radiate the signal. Grounding the messengers effectively reduced the strength of this signal in the vicinity.

"7—Checks made with the radio-frequency line probes across the power line in the radio room of Bldg. 8 and with the rod antenna placed near to the power lines where they enter the building, indicated that the power lines were clear at these points, and, therefore, that the signal was not being conducted directly to the receivers via their power lines.

"8—On 19 September, all of the receivers in the Coast Guard radio room were turned off in order to check for possible detection within the receivers themselves, the rectified signal possibly being then fed back to the antennas of the other receivers. However, no decrease in level could be observed of the signal strength as measured under the antennas, thereby eliminating this possibility.

"9—The interfering signal was observed as being radiated from a transformer bank located about 200 feet northeast of the antenna area. Under the transformers, a level of 50 uv was recorded. Further investigation led to Bldgs. 263 and 271 which are located nearby and fed from this transformer bank. The signal was radiating from wiring and from piping inside and under the building. When the main power switch in the building was thrown off, the signal strength at a point between the building and the transformer bank was reduced from 20 uv to 8 uv. Ground stakes were driven, and the piping and power conduits indicating the greatest levels of radiation were tied to them. Two 0.1-ufd capacitors were placed across the power lines to the building at the main switch box. All of these modifications reduced the signal strength to about 5 uv at the transformer bank, but did not appear to effect the level observed on the #10 antenna.

"10—On 18 September, a 450-foot long wire antenna was strung between two trees at a point miles from any power lines or points of possible detection. The antenna was located between the Naval station and the new Belle Chasse receiving site and ran roughly east-west. The 500-kc cross-modulating signal could not be heard on this antenna, thereby indicating that the signal was not radiated throughout the area.

"—A signal strength of 17 uv was recorded on the long E-W doublet at the Belle Chasse receiving site. The installation here is only two months old, and it is not considered likely that local detection is occurring. The signal could not be heard when using the rod antenna on the test equipment at this site.

"12—During the survey, it was observed that the second harmonic of station WSMB, whose fundamental is 1350 kc, was seriously interfering with the Navy operating frequency at 2698 kc. The field strength of its fundamental, at the Naval station, was measured at 200,000 uv/m; its second harmonic was 600 uv/m; and the third harmonic was 36 uv/m/. It is recommended that the Federal Communications Commission make every effort to have this station reduce its harmonic content.

"13—Measurements made on the doubler antenna at the Belle Chasse site indicate that considerable interference can be expected from WSMB at 2698 kc when the receiving station goes into operation. An indicated level of 3500 uv was recorded at this frequency. Also, WDSU was noted to cause considerable interference at many Navy and Coast Guard assigned channels between 2670 and 2854 kc.

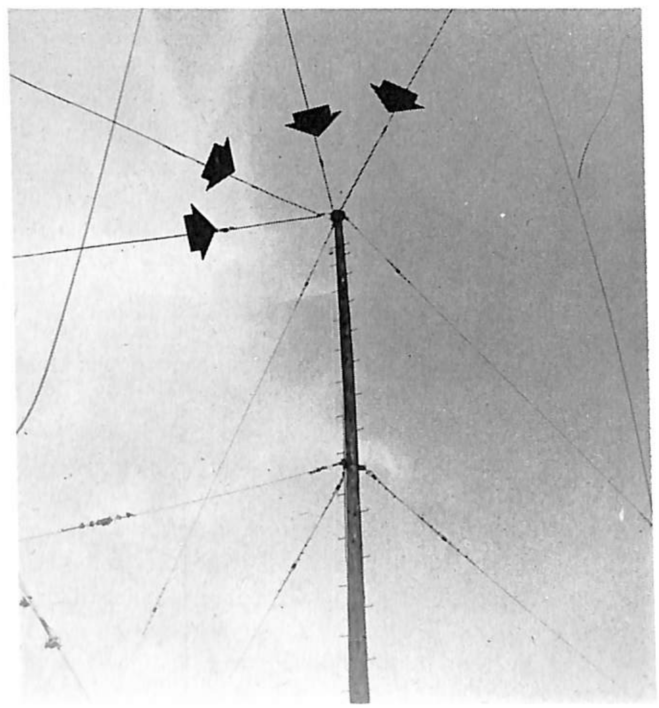
"14—In an effort to eliminate the cross-modulation at 500 kc, all metal-to-metal contact points in the antenna area at the Naval station have been bonded, both on the ground and at the antennas. The metal caps atop the masts have been grounded as have been all the lead-in messengers.

"15—The net effect of all the modifications heretofore mentioned has been a reduction in the level of the cross-modulating signal as measured at the patch panel in the radio room. Measurements made on 25 September on antennas 7, 9 and 10 indicated field strengths of 3, 4, and 35 uv, respectively. These measurements were taken at approximately the same time of the day and under similar weather conditions as the original readings taken on 31 August, and denoted a considerable decrease in level. However, it is reported that at various times, the level still increases to a point where it blocks out signals, and therefore, further steps must be taken to eliminate the trouble.

"16—It is therefore recommended that radio station WNOE be granted its applied-for shift of frequency from its presently assigned 1060 kc to another channel at 1090 kc. This shift would lower the sharply tunable interfering signal from 500 kc to 470 kc which is not a Navy or Coast Guard assigned frequency.

"17—I would like to express my sincere thanks to Lt. Cmdr. R. A. Buck, Mr. J. C. Spencer, Mr. C. F. O'Donnell, F. J. Recely, W. H. E. McCormick, and the many other station personnel, and to the FCC, whose local office lent invaluable assistance in the completion of this survey."

The following data is furnished as a result of the survey: Approximate distances between local broadcast stations and the Naval Receiving Station, Belle Chasse and field intensities existing at that activity:



Arrows point to some of the numerous points of rectification along the receiving antenna system of the Naval Communication Station, Algiers, Louisiana.

STATION	POWER	MILES	NIGHT—MV/M	DAY—MV/M
WWL	50 KW	19	19–22	19–22
WWEZ	5 KW	4.8	32	51
WNOE	50 KW	1.7	10.5	1000

Approximate distances between local broadcast stations and the Naval Radio Station, Algiers, and the field intensities existing at that activity:

Interior of receiving activity located in the Administration Building, Naval Station, Algiers, Louisiana.

STATION	POWER	MILES	NIGHT—MV/M	DAY—MV/M
WWL	50 KW	14.2	35–45	35–45
WWEZ	5 KW	4.5	130	130
WNOE	50 KW	5.3	100	280

The preliminary engineering service report clearly indicates that all efforts were unsuccessful in eliminating the external cross-modulation interference on the international distress frequency channel of 500 kc at the U. S. Naval Station at New Orleans during the survey period due to the location of powerful commercial broadcast stations in proximity to the Naval receiving activity and the impossibility of eliminating the numerous points of rectification surrounding the receiving antennas. During the period of the interference survey, preliminary tests were also conducted at the new Naval receiving station at Belle Chasse which is located within 1.7 miles of the 50-kw broadcast station WNOE, primarily to investigate interference on the international distress frequency, but also to obtain a certain qualitative indication of additional interference which might be encountered at the Belle Chasse receiving location. The results of these preliminary tests indicated that interference caused by local broadcast stations may create appreciable interference to receivers when the receiving activity is placed on an operational basis.

In order to determine more accurately receiving conditions at the Naval Radio Station, Belle Chasse, a Model R100 Coast Guard receiver was installed at that activity and a twenty-four hour watch set on 19 December 1950 for purposes of monitoring the frequency spectrum covered by that receiver. Examination of the log kept by the watch disclosed that broadcast station interference completely blocked reception on 500 kc and seriously interfered with certain other operating frequencies. Radio station WNOE was easily identified as the prime offender on 500 kc. Due to the fact that the Naval Radio Station, Belle Chasse is very soon to replace Algiers as the receiving activity for the New Orleans area, prompt action became necessary in order to eliminate the broadcast station interference which would have nullified the operational value of the station. Accordingly, the Bureau of Ships contacted the Washington, D. C. engineering firm of consulting engineers for radio station WNOE, and requested the cooperation of that radio station in eliminating the interference. The engineering firm consulted the owner of WNOE, who immediately authorized them to proceed to New Orleans at his expense for purposes of coordinating the interference elimination project. Accordisgly, on 13 February, the writer along with two representatives of the engineering firm, proceeded to New Orleans. This engineering project was completed on 22 February 1951 and the following information, taken from a report published upon the conclusion of the project illustrates the corrective measures taken to eliminate the interference, and makes several pertinent recommendations to improve receiving conditions at Algiers and Belle Chasse.

Preliminary Considerations

The original purpose of this work was to eliminate the interference to the international distress frequency of 500 kc at the new receiving station at Belle Chasse. This interference resulted from two causes: inability of the receivers to reject the strong 1060-kc signal from WNOE, and the production of a cross modulation frequency of 500 kc due to a beat between the frequencies 1060 kc (WNOE), 870 kc (WWL), and 690 kc (WWEZ). Since 870 kc + 690 kc — 1060 kc = 500 kc, any non-linear circuit element, either external or internal to the receiver, is a potential source of interference.

The problem at Belle Chasse is particularly severe because of the extremely strong field intensity from WNOE. The measured daytime field intensities at this location were as follows:

Station	Frequency	Field Intensity (mv/m)
WMRY	600 kc	33
WWEZ	690	40
WBOK	800	22
WWL	870	36
WTPS	940	37
WJMR	990	1.75
WNOE	1060	1000
WJBW	1230	8.7
WDSU	1280	56
WSMB	1350	49

The WNOE second harmonic was also measured and was found to be 150 microvolts. This represents an exceptionally good suppression of 76 db below the fundamental.

Certain of these stations do not operate at night, while others reduce power or alter their directive antennas. The measured nighttime field intensities were as follows:

Station	Frequency	Field Intensity (mv/m)
WWEZ	690 kc	79
WWL	870	36
WTPS	940	36
WNOE	1060	24
WJBW	1230	8.7
WDSU	1280	63
WSMB	1350	19.5

The receiving antenna consisted of an inverted "L" approximately 500 feet long with a vertical height of about 90 feet. The measured resistance and reactance of this antenna are plotted in Figure 1. The fact that the antenna resistance varies little with the frequency indicated that most of the resistance is due to losses which in turn are probably caused by an inadequate ground system. This antenna is to be used at two frequencies: 500 kc and 425 kc. In order to effect a partial impedance match, a coil was constructed with a reactance of approximately 150 ohms at 500 kc. This was placed in series with the antenna lead. In addition to increasing the efficiency at the operating frequencies by cancelling a portion of the capacitive reactance, this coil also provided some discrimination against stations in the broadcast band, inasmuch as the antenna is inductive at these frequencies and the coil increases the overall series impedance of the circuit.

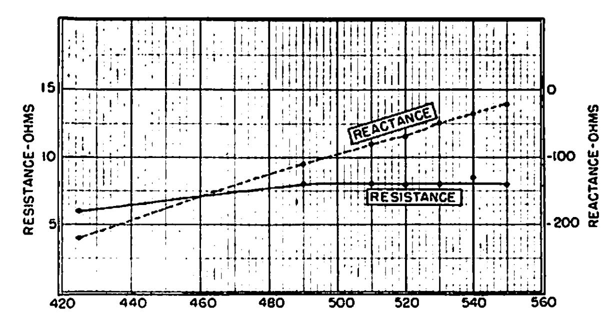


FIGURE 1—Impedance of low frequency antenna, Bell Chasse, Louisiana.

Elimination of Interference at Belle Chasse on 500 kc

It was the opinion of this engineering firm that internal rather than external cross modulation was the major cause of the difficulty. It was determined therefore, that the problem could best be solved by removing the strong 1060-kc signal from the receiver with a suitably designed low-pass filter. Accordingly, an m-derived filter having a cut-off frequency of 850 kc and theoretically infinite attenuation at 1060 kc was designed. The circuit of this filter together with the measured attenuation curve is plotted on Figure 2. This curve was plotted with a Model LP signal generator having a 50-ohm internal impedance and an AN/PRM–1 field intensity meter which was calibrated directly in db.

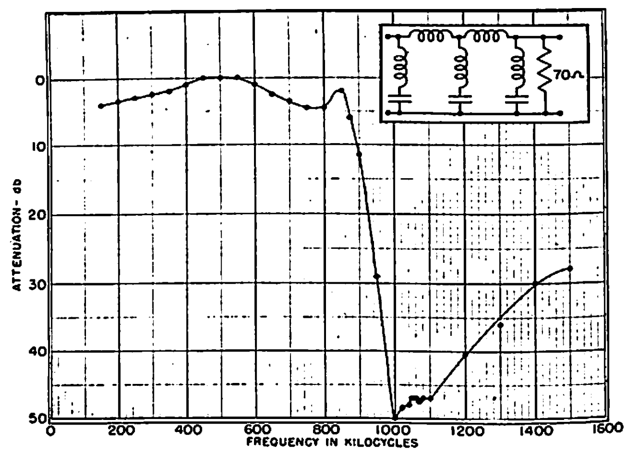


FIGURE 2—Low-pass filter circuit and attenuation curve.

The filter was inserted in the antenna circuit as indicated in Figure 3. The effect of the addition of the filter and loading coil was immediately apparent. Before the addition of these circuit elements the interference, not only at 500 kc but in this entire region of the spectrum, from WNOE and other broadcast stations was such as to make the receiver virtually unusable. When these circuits were added, however, the interference was completely eliminated. A continuous watch was maintained on the receiver by a regular Coast Guard operator for a period of approximately 2 days, during which time no interference was received on any of the frequencies monitored by the Coast Guard on the frequencies below the standard broadcast band. It is believed, therefore, that this problem has been solved at the Belle Chasse receiving station.

Elimination of Interference to High Frequency Receivers at Belle Chasse

The success that was achieved in eliminating interference on the low frequency receivers led the Navy Department representatives to request that a similar attempt be made to eliminate interference that was occurring at various frequencies above the broadcast band, particularly at 2670 kc, and which was due in part at least to WNOE. Accordingly, an m-derived high-pass filter was designed with a cut-off frequency of approximately 1300 kc and theoretically infinite attenuation at 1060 kc. The circuit of this filter and the measured attenuation curve are shown on Figure 4. This filter was inserted in the circuit as indicated in Figure 5.

The antenna which was used for this receiver was a doublet approximately 170 feet long and connected at its center to a coaxial transmission line having a characteristic impedance of 70 ohms. It was suspended approximately 90 feet above the earth. No transformer or other device was used to transfer the circuit from balanced to unbalanced operation. The input impedance of the transmission line was measured at 2670 kc and was found to be approximately 25—j70 ohms. Since an antenna of this length at this frequency would be expected to have an impedance very close to the characteristic impedance of the transmission line itself, this is not the expected value for the input impedance of the transmission line. It is believed that this discrepancy is due to the fact that no circuit was used to convert from balanced to unbalanced operation, and accordingly the vertical portion of the transmission line was acting partly as an antenna and partly as a line, thus resulting in an improper value of impedance at its terminals.

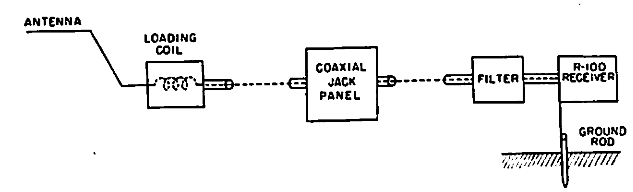


FIGURE 3—Low-frequency receiver circuit.

As the result of the insertion of the filter the interference to various high frequency signals was greatly reduced, and in most cases the interference present from WNOE was well below the noise level, although occasionally audible. In addition, second harmonic interference was noted from WSMB and WDSU.

In the event that a further reduction in the broadcast interference for the high frequency receivers is desired, it is recommended that the following steps be taken:

1—A balanced to unbalanced transformer be installed between the antenna and the transmission line. This will enable the outer conductor of the coaxial line to be maintained at ground potential. This will prevent pick-up of the strong vertically polarized field radiated by the broadcast stations. In addition, it will make the system less sensitive to pick-up of noise from fluorescent lights, automobile ignition, teletype machines, electric typewriters, etc., inasmuch as the doublet itself is removed some distance from these interfering sources and the coaxial line itself will no longer be sensitive to pick-up from them.

2—A suitable ground system should be installed. At the present time the only ground system consists of brass rods driven into the ground at various points. This is not sufficient to maintain an equi-potential surface. This increases the susceptibility of the system to pick-up in the power line leads and makes it impossible to maintain the outer conductor of the coaxial lines at ground potential.

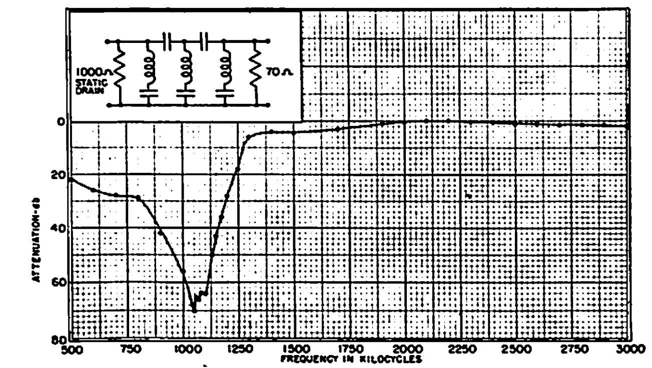


FIGURE 4—High-pass filter circuit and attenuation curve.

3—The filter should be redesigned to reject WSMB and WDSU as well as WNOE. It is believed that the second harmonic pick-up from these stations may be generated inside the receivers rather than being radiated from the station itself. Although these harmonics are measurable on the field intensity meter, there is no way of knowing whether this is due to the generation of harmonics in the meter or to actual radiation. This will also eliminate the possibility of cross modulation due to the signals from these stations. In the event that second harmonic fields are still indicated, the only solution is to solicit the cooperation of the stations in installing proper harmonic filters.

500-kc Interference at Algiers Receiving Station

An attempt was also made to eliminate the interference at the Algiers receiving station due to cross modulation

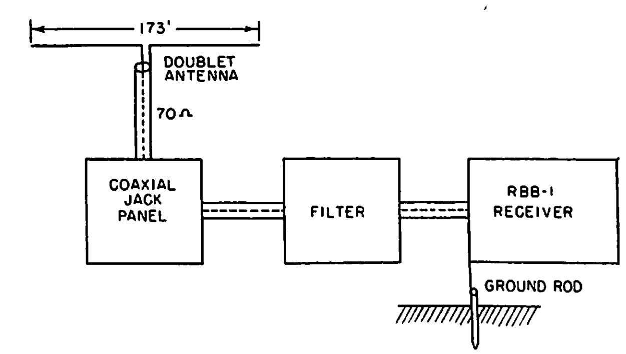


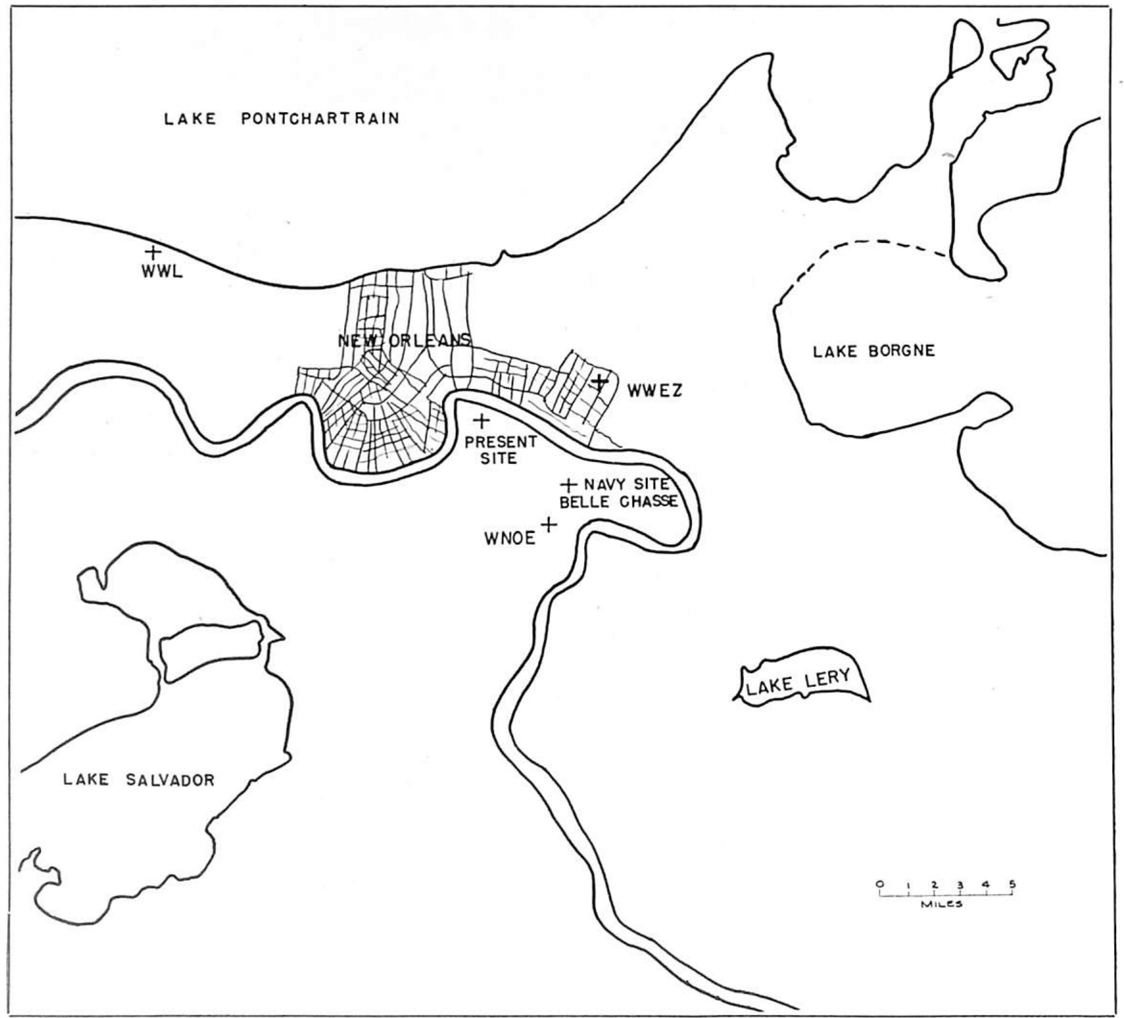
FIGURE 5—High-frequency receiver circuit.

between WNOE, WWL and WWEZ. At this location the signal strength from the three stations was much more nearly equal and was considerably stronger from WWL and WWEZ than at Belle Chasse. Accordingly, a filter which would reject all three frequencies was indicated. A circuit of the filter together with a measurement of the attenuation curve is shown in Figure 6. This was then inserted in series with the receiver as at Bell Chasse receiving station. As in the case of the high frequency receivers at Bell Chasse, this filter greatly reduced the interference at 500 kc but did not completely eliminate it, inasmuch as it could still be heard occasionally at a level comparable to that of atmospheric noise. In order to eliminate this problem completely at Algiers additional steps are indicated as tabulated below:

1—A loading coil should be inserted in series with the antenna in order to cancel out part of the capacitive reactance. A much shorter antenna was used here than at Belle Chasse, and a much higher reactance therefore would be expected. This would perform the dual function of providing additional discrimination against broadcast frequencies and increasing its efficiency at the desired frequency.

2—An adequate ground system should be installed. The ground system of this installation is particularly deficient. The system is for the most part for steam and water pipes which are in themselves a source of cross modulation. While the physical location of this receiving station is not such as to allow the installation of a really adequate ground system, a considerable improvement can be made over the present situation which would also make it possible to eliminate pick-up due to the power cords leading to the receiver.

3—All the receivers in this room should be provided with filters which will prevent strong broadcast signals from entering them. If this is not done, there is always the possibility that cross modulation will occur within the receivers which will be reradiated and picked up by other receivers. Thus, it is not sufficient merely to provide filters for those receivers which are intended to be used at 500 kc.



Map showing the location of the new Navy radio station at Belle Chasse, Louisiana in proximity to the recently constructed commercial broadcast station WNOE approximately 1.7 miles distant. WNOE has a power output of 50 kw and operates on an assigned frequency of 1060 kc. The field strength of the WNOE signal appearing at the Navy radio station is over one volt.

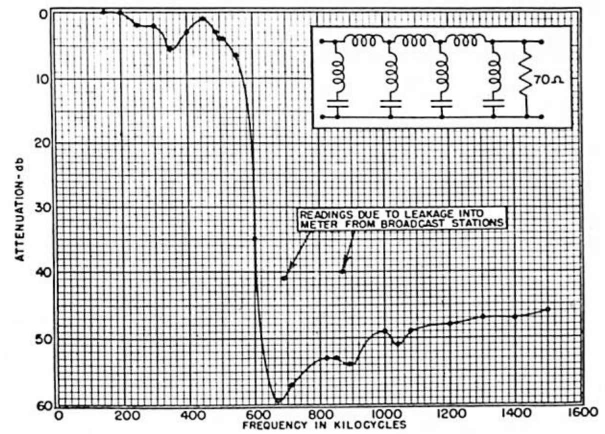
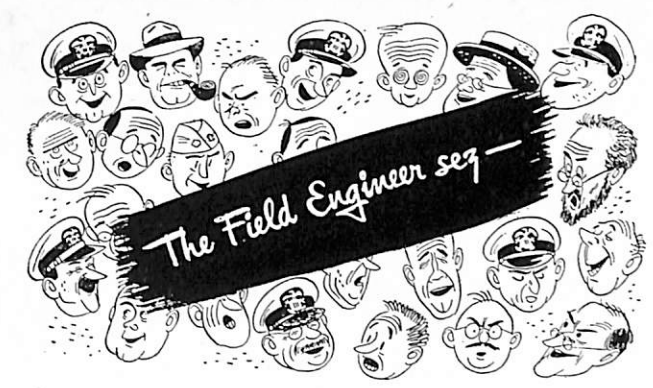


FIGURE 6—Low-pass filter with broad band attenuation.

Possibility of WNOE Moving to 1090 kc

At the present time WNOE has on file an application to change frequency from 1060 kc to 1090 kc and to increase its night-time power from 5000 to 25000 watts. This would eliminate the cross modulation problem between WNOE, WWL, and WWEZ. A new problem would be created in that a 500-kc cross modulation product could be formed between WNOE operating on 1090 kc, WMRY operating on 600 kc, and WJMR operating on 990 kc. This problem would not be nearly as severe, however, first because the signal intensity from WJMR at Belle Chasse is extremely low (only 1.75 mv/m), and second because WJMR operates only during daytime hours, so that the problem does not exist at night. Although the engineering study indicated above shows that the 500-kc problem can be solved by proper engineering means, it does remain constantly as a potential source of interference, and it would be highly desirable to eliminate it if possible. This would be done by moving WNOE to 1090 kc.

Another reason that moving WNOE to 1090 kc would be desirable is that ships in the New Orleans harbor are constantly bothered by this 500-kilocycle interference. It is obviously impossible to equip all ships which might enter the harbor with filters to remove the broadcast interference.



MODEL QHB-a

U.S.S. Ellison (DD-864)

The main power relay, K-405, in the scanning switch assembly would not close. Investigation revealed that the power leads from 7A-1 and 7A-2 in the QHB-a sonar receiver-transmitter to 10-ampere fuses F-401 and F-402 in the scanning switch assembly were reversed. The wires were reversed, restoring operation to the preamplifier circuits, keying circuits and minus 105-volt bias supply.

Arcing in the gyro transfer relay, K-1203, in the data converter was eliminated by inserting insulation between the relay sections and between the relay and the shield can.

It was found that the attacking ship's spot on the attack plotter was 180° out and travelled in the reverse direction. The trouble was found in incorrect wiring of S1 and S3 and R1 and R2 in the remote transmitter in CIC. Reversal of these connections restored proper positioning and travel of the attacking ship spot.

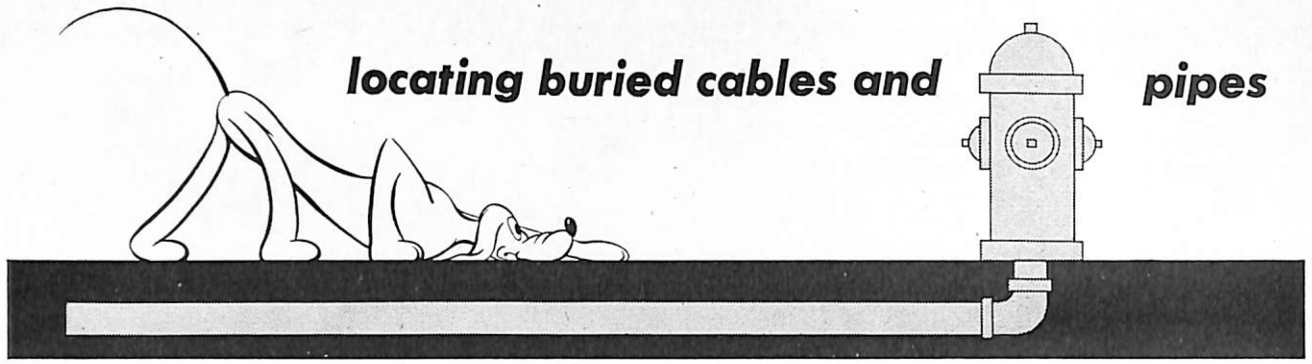
—N. D. Laster, *Fifth Naval District*

MODEL QGA

U.S.S. Ellison (DD-864)

The transducer would hoist until the limit switches were hit and then would immediately reverse direction. Both the upper and lower overtravel switches were found wired in the normally closed position instead of the normally open position. Operation was restored by correctly rewiring these switches.

—N. D. Laster, *Fifth Naval District*



locating buried cables and pipes

by

Lt. Cdr. W. E. Scott, USN

and

Lt. (jg) H. V. McVoy, USN

U. S. Navy Radio Station, Cheltenham, Md.

During the latter part of last year a definite need arose for determining the exact location of buried r-f cables, power cables, telephone cables, water and drainage lines on the Navy's Radio Station at Cheltenham, Maryland. Up-to-date maps of the underground system were not available. The Chief of Naval Operations tentatively modified the station's electronic test equipment allowance and the Bureau of Ships furnished one Model SCR–625 mine detector for this purpose.

The Bureau of Ships was particularly interested in the application of the SCR–625 mine detector for the purpose of locating buried cables and pipes, and requested that the Commanding Officer, U. S. Navy Radio Station, Cheltenham, Maryland report on its usefulness for this purpose. This article is based on the report which was submitted to the Bureau of Ships on 15 December 1950.

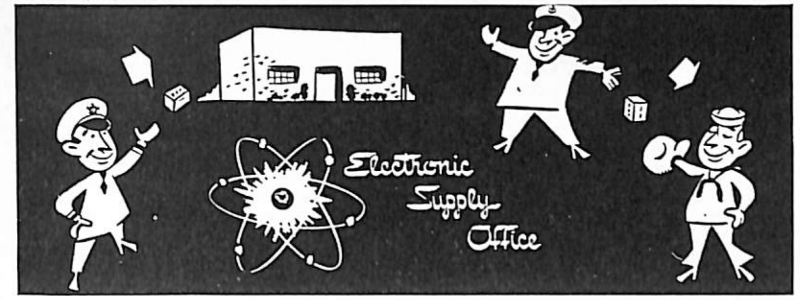
Operation of the SCR–625C is based on the principle of a balanced mutual inductance bridge. A push-pull oscillator circuit supplies a 1,000-cycle voltage to the bridge. The search head of the mine detector contains four coils—two transmitting, one receiving and one for test purposes. When the mutual inductance between the two transmitting coils and the receiving coil has been balanced to the point where there is no difference flux, no voltage is induced in the receiving coil. The presence of metal in the field of the transmitting coils changes their mutual inductance and a signal voltage is induced in the receiving coil. The receiving coil is coupled to an amplifier which drives a resonator for audio indication, and a meter for visual indication.

The equipment was used at intervals over a thirty-day period by the station's Electronics Officer to determine how successfully the mine detector could be used to locate the various buried cables and pipes, particularly the radio-frequency transmission lines (RG–85/U, steel-wire-armored construction), which are required to be buried at least eighteen inches. They are not, however, buried more than three feet.

Tests conducted along the known courses of these buried r-f transmission lines gave a very strong and positive indication of their location. Small lead-covered telephone cables, such as Type DRB–6 were difficult to follow when their depth was greater than eighteen

inches. All water and compressed air lines from one to six inches in diameter, except for one six-inch water main, were located and followed with ease. The six-inch water main which could not be located was buried at least six feet. Other water mains, which were known to be buried about four feet, gave good indications on the meter.

It was determined from the foregoing tests that the Model SCR–625 mine detector could be successfully employed for locating and following the course of most buried cables and pipes at this station and it was recommended to the Bureau of Ships that the Electronic Test Equipment Allowance be modified to include this equipment.



E.S.O. MONTHLY COLUMN

IMPROVED COVER

Development of a special set of parts for use on Teletype Model 15 Printer Covers (either friction or sprocket feed) was announced recently. This new set was devised to provide a longer life for the cover glass, which, in the past, has had to be replaced frequently because of chipping at the tearing edge.

The principal feature of the new assembly is a metal tearing edge mounted by means of existing thumb screws. Associated with this edge is a new cover glass, slightly shorter than its predecessor and adjusted to a minimum opening for the paper to make its exit.

This new set of parts is now being procured and will be available for distribution soon. The stock number is N17–T–350014–744, Teletype Part No. 120685.

Upon initial installation, it will be necessary to requisition the entire assembly. Thereafter, individual parts may be obtained as needed.

Teletype Part No. 120685 consists of the following: two felt strips, TPN 74759; one glass window, TPN 120686; one tearing edge, TPN 120687, and two washers, TPN 125015. Stock numbers are being assigned for component parts.

Past demands for the glass window on the Model 15 Teletype have indicated a need for this improvement. During the past year alone, there were 280 issues of the N17–T–350002–362 window and 635 issues of the N17–T–350011–691 glass, both of which are being replaced by the new assembly.

ELECTRONICS SYMBOL AT LONDON FAIR

If you go to the festival in South Kensington, London, this summer, you will see the same insignia as appears in the masthead of this column being used as a symbol by the Exhibition of Science there. A banner bearing a carbon atom enlarged ten billion times will cover the entrance to this exhibition.

SOLDERING GUN

The December 1950 issue of BuShips Electron contained an article entitled "Tips and Lights—NT 10695 Soldering Guns," stating that many activities had difficulty in obtaining replacement tips and lights for the soldering guns (Standard Navy Stock Number N16–T–3495–600).

These parts may now be obtained through Electronic Supply System activities and should be ordered by stock numbers as follows: tip N41–T–2447–75 or N16–T–3496–150; lamp (2.2 volts as specified by the manufacturer), N17–L–6301.

USE LATEST TUBES

The present international situation makes it more advisable than ever to use the best electron tubes available as maintenance parts for electronic equipments.

Sometimes tubes very similar to those in the Electronic Supply System may be purchased from commercial sources at prices far below the standard price list. Many of these tubes are in excellent condition. Others, such as magnetrons, have deteriorated with age.

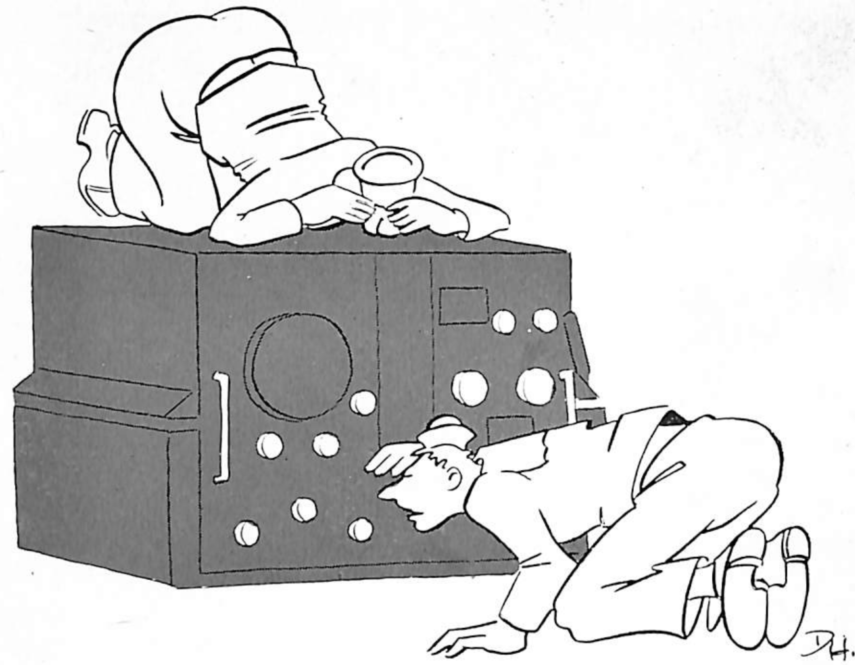
While tubes manufactured in accordance with the latest specifications may cost more than older tubes, military necessity requires that the newer and better tube be utilized whenever and wherever possible. Tubes manufactured under the most recent specifications and procured directly from the factory are more reliable, and the end user will enjoy much more efficient equipment operation if the latest tubes are used.

ORDER MAR KITS BY STOCK NUMBER

In order to facilitate supply operations and expedite delivery, activities are requested to order MAR Application Kits by Standard Navy Stock Number as well as by item name. Ordering solely by item name makes it difficult to locate material stored in warehouses by stock number.

The SNSN for the Field Application Kit is F16–I–73601–1093 and for the Shipboard Application Kit, F16–M–384501–623.

COMMON DAS SERIES TROUBLE



by

A. Cirilli, ETC, *ComServLant*

ServLant technicians have compiled, over a period of time, a list of the troubles most commonly encountered while servicing Model DAS series loran receivers. In line with most electronic equipment troubles, electron tubes were found to be the most common source of trouble. The second main source seemed to be a lack of proper calibration or adjustments and alignment. In all cases with respect to leaky capacitors and blocking oscillator transformers, a megger should be the method of final check since in many cases a standard volt-ohmmeter has insufficient voltage to indicate whether a capacitor is breaking down or not.

In the following tabulated list, considered of value to other fleet technicians, an attempt is made to localize specific troubles although in many cases bad components in a portion of the circuit which appears unrelated to the indicated trouble actually turns up as the indirect cause in the final analysis.

1—Very non-linear slow sweep.
  a—Defective 844 (V122).
  b—Defective (often microphonic) 6SJ7 (V123) sweep amplifier.
  c—Changing value of plate and screen resistors in the sweep amplifier tube (V123). This trouble is quite common.
  d—Distortion of test pattern usually caused by defective video amplifier in the receiver.

2—Jittery sweep or sweeps. Most noticeable on fast sweep.
  a—Improper calibration of the indicator.
  b—Improper setting of the regulated +265 volts.
  c—Defective tubes (usually 6SN7's).
  d—Leaky coupling and divider capacitors in all the counter circuits, especially in the third counter.
  e—In a few cases leaky blocking oscillator transformers. This occurs sometimes between windings and other times between one winding and the case.
  f—Leaky coupling capacitors to the B1 and B2 multivibrators. Also within these two multivibrators.
  g—Changing values of resistors in these two B1 and B2 multivibrators.

3—Critical "A" adjustment. Echoes lost when switching from slow to fast sweeps.
  a—Tubes in the critical oscillator and counters defective.
  b—Improper adjustment of the variable capacitor C111 can make this circuit very erratic and "touchy."

4—Unable to make drift control operate properly in both directions.
  a—After complete calibration, move drift control right and left simultaneously adjusting the "A" adjustment until it drifts in both directions about the same speed.
  b—Leaky slow sweep drift control feedback coupling capacitors.
  c—Dirty drift control switch contacts.

5—Unable to properly focus cathode-ray tube.
  a—Changing in value of the focus resistors R232 and R234.

6—Feedback circuit for different specific rates not all operative.
  a—Shorted air-capacitor plates.
  b—Defective switch contacts.

7—Cathode-ray tube troubles.
  a—Flashing on scope caused by leaky high voltage filter capacitor.
  b—Scope dims out at times and comes back. This was found due to poor socket connection (usually dirty prongs or socket) of CRT.

8—120-cycle ripple on scope especially in slow sweep position.
  a—Nearly all cases found to be defective filter capacitors in the receiver.
  b—Improper grounding of the ground straps between receiver and indicator.

9—Lack of receiver sensitivity on one or more bands.
  a—R-f coils have burned windings. This is usually caused by tuning of nearby transmitters feeding in excessive r-f energy.
  b—Improper tapping of antenna loading coil.
  c—Poor connections from antenna through loading coil to receiver.

—*ServLant Monthly Bulletin*

REPLACEMENT LAMPS FOR NT-10695 SOLDERING GUNS

The December 1950 Electron was in error concerning replacement lamps for the NT-10695 Soldering Guns.

The U. S. Naval Supply Depot, Bayonne, N. J. reports that the proper replacement lamp is a 2.2-volt lamp, Type TL-3 Mazda #222, and is carried in the Electronic Supply System under stock number N17-L-6301, and also in GSK under stock number 17-L-6301.

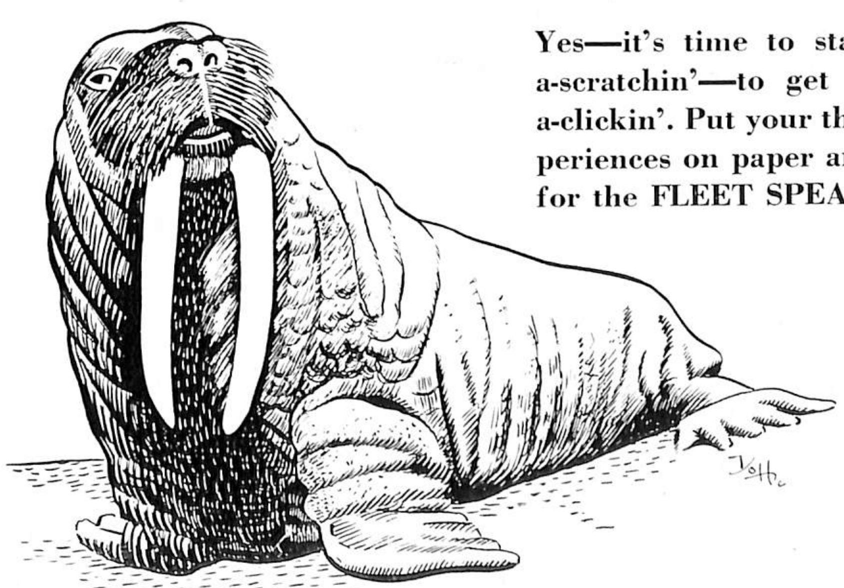
ELECTRON BINDER AVAILABILITY

Binders for Electron magazine Volumes I. II. III and IV are completely out of stock. There is a limited quantity of Volume V binders available. Additional quantities of Volumes I, II, III, IV, and V, as well as a supply of Volume VI, are scheduled for delivery in June. Distribution of binders is limited to Naval activities only, since quantities printed are insufficient for general distribution.

MODEL TCK ALIGNMENT PROCEDURE

On Page TCK:2 of the CEMB is a tuning mechanism alignment procedure for the Model TCK Radio Transmitting Equipment, which differs from the procedure given in the instruction book for the TCK equipments. The CEMB procedure is the preferred one. Revision pages for the instruction books are being prepared by the Bureau.

"The time has come the walrus said . . ."

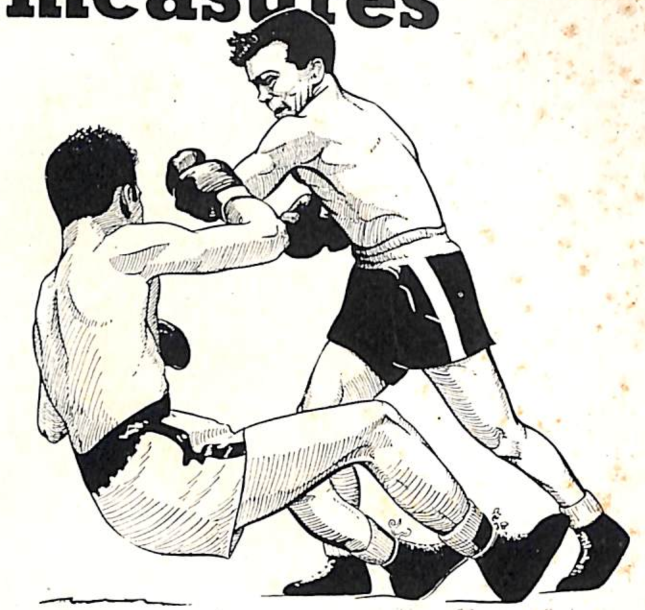


Yes—it's time to start those pens a-scratchin'—to get those "mills" a-clickin'. Put your thoughts and experiences on paper and rush 'em in for the FLEET SPEAKS issue.

Radar Countermeasures

by

S. A. Benson, *ComServLant*



The basic RCM installation consists of the following:
- A receiver
- A panoramic adaptor
- A pulse analyzer

These are the basic units and any individual installation may contain a radar direction finder and some type of jamming equipment. Reference here is made to an article on Page 5 of the November 1949 BuShips Electron, entitled Navy Shipborne Radar Countermeasures.

The units above each perform a specific function as listed here.

Receiver—reception of signal or signals.

Panoramic Adaptor—visual indication of signal being listened to and also composite picture of band conditions plus or minus five megacycles either side of the center frequency.

Pulse Analyzer—this is a relatively important unit since from it we can obtain the pulse width and pulse repetition frequency of the signal to which we are listening.

Radar direction finders and jamming equipment speak for themselves, namely, determination of direction of signal to which we are listening and a potential method of effectively jamming the radiated signal so as to render useless the results obtained with it. The picture thus far developed gives us an audible indication, a visual indication, pulse width and pulse repetition frequency of the signal listened to. This information is valuable in recognition as well as a necessity for effective countermeasures.

This article is not intended to be an operator's guide but rather to give technicians a lead on some common troubles. Needless to say, it would be impossible to list all possible troubles but perhaps this will break the ice and through your own initiative you will become a lot more familiar with RCM equipment. The problem seems to be not lack of interest but lack of familiarity with the equipment. Number one on the list of troubles seems to be antennas. Too much cannot be said about this. Considerable trouble can be avoided by keeping an effective antenna maintenance program in force. This goes for all electronic equipment. Frequent inspection and megging will tell the story. No amount of realignment can remedy the fact that the antenna is bad. The receivers used will vary with the individual installation. For example, you may have an RDO and an AN/SPR–2 or perhaps an AN/APR–1 and an AN/SPR–2 for low and high frequency reception. Antennas used with these are no different than on any other receiving equipment except that they conform to the particular frequency range being used. They will not take to moisture, insulators must be clean, they require preventive maintenance—in other words they are not trouble free.

Another trouble noted is unorthodox arrangement for switching of input from the low frequency receiver to the pulse analyzer and panadaptor, and from the high frequency receiver to the pulse analyzer and panadaptor. Any coupling between these leads can result in the outputs of the receivers getting superimposed on each other in the panadaptor and pulse analyzer. The recommended switch box should be used. This will result in less trouble in obtaining desired information from received signals.

Care should be taken in arrangement of cabling between equipment. Use of line filters and bonding is to be encouraged. Screening equipment where necessary does much to improve operation under unusual operating conditions such as interference from adjacent transmitters, etc. Operators are to be cautioned as to disturbing screwdriver adjustments. This is particularly so on the pulse analyzer. The meter scales are calibrated and set via small pot adjustments and if these are disturbed after calibration, it will require another adjustment by the Electronics Technician.

Common Receiver Troubles

AN/APR–1, AN/SPR–1 and RDO

Trouble	*Probable Cause and Remedy*
Dead Receiver	Faulty controls, fuses, cabling, tuning head or no antenna. Replace or repair as necessary.
Weak Receiver	Faulty crystal, tube or tubes, misalignment, faulty antenna connection, low line voltage.

Alignment of tuning heads requires a test oscillator covering the same range as the head. Defective tubes in the tuning head can cause faulty reception and when these are found and replaced, unit should be trimmed at the high frequency end, to insure accuracy of calibration. IN21B crystals are easily overloaded and this will result in low sensitivity. The only solution here is replacement. Due care is to be taken in replacement—crystals are to be handled carefully.

Alignment of the amplifier strip will require a signal generator capable of output at thirty Mc and attenuation down to about 100 microvolts. A reading of 75 microamps on the tuning meter for 100 microvolts in, should be considered as normal. By modulating the signal, audio performance of the strip can be checked. By feeding in an unmodulated signal, the B.F.O. can be checked and by modulating the signal and feeding it in at a high level the AVC circuit can be checked.

Alignment of the tuning heads is made in conjunction with the receiver i-f amp. strip and a signal generator of suitable range. The signal generator should have an accurately calibrated dial and attenuator. Follow alignment procedure as contained in instruction book.

AN/SPR–2

The AN/SPR–2 common troubles are usually crystal failure, tube failure, and fuses. The meter on the front panel will usually give an indication of trouble and observing this will often help in locating troubles. For instance, no crystal current would mean a defective tuning head. Crystals can be removed and checked easily. No oscillator current or voltage would localize the trouble to the oscillator circuit, etc. The blower motor should run when the power switch is turned on. If this is not so, check motor fuse and motor.

Changing the 2C40 will probably give cause to realign the oscillator; dismantling the unit will mean realignment. There are fifty-five steps listed in the instruction book. These are to be followed to the letter. A wavemeter of suitable range is used in alignment of the oscillator.

Common Panoramic Adaptor Troubles

REJ and RDP

The most common trouble encountered is r-f amplifier misalignment, faulty tubes and misadjustment of sweep limit and synch pots. Defective tubes can easily be found by testing and substitution. Voltage and resistance checks, with information obtained from instruction book, will localize and locate other troubles. Misalignment will cause poor indications on CRT which will show up as low sensitivity, improper bandwidth, etc. A signal generator which will cover a range from twenty to forty megacycles will be satisfactory, but it must be capable of being modulated at 30%, and a calibrated output is desirable. Alignment procedure is simple and best results can be obtained by strict adherence to the instruction book.

Common Pulse Analyzer Troubles

RDJ and AN/SPA–1

The equipment receives a negative pulse input from the receivers and should be checked to see if the input is wired for a negative pulse. It has been found in a number of cases that the pulse analyzer had been wired for a positive input and had never worked.

Observation will give a lead to the cause of most troubles. Where the indication on the scope is normal but the P.R.F. meter shows no indication when the switch is in the "meter on" position, the trouble can be traced usually to one of two sources. First, the most obvious, the 1/200th of an amp. fuse associated with the meter is open, or second, the meter tube is out or weak. Or perhaps with the indication on the scope normal, the P.R.F. meter cannot be set at zero for the desired range with the zero set control. This would mean a faulty tube. If the zero set is normal and the scope shows normal but no P.R.F. reading it would mean that there are no pulses reaching the grid of the P.R.F. meter circuit. All these are common troubles and easily diagnosed if operational theory of the equipment is understood. When the meter shows an indication of going past zero and adjustment of zero set will not move it, this means the meter tube is drawing too much plate current. This could be caused by a faulty tube or poor regulation from the supply, a V.R. tube out.

Checking the accuracy of the pulse width and calibration, a known pulse length is fed in and the accuracy of calibration is checked by taking a reading of pulse input. They should be the same. If not, recalibration of the calibrate coils will probably be necessary.

Most of the troubles listed seem to be about the same as found in other equipment. If a little is known of the operation, the basic principles involved and what is to be expected from the equipment, when trouble occurs it will be relatively simple to diagnose. The instruction book means a lot, your own initiative means as much if not more. *Determine the trouble, localize it and remedy it.*

Bureau Comment: This article includes sound maintenance information for the ET. The following additional information is submitted by the Bureau.

Panoramic Adaptor Functions

The panoramic adaptor may have the ± 5-megacycle bandwidth on each side of the center frequency, but the signal observed on the oscilloscope coming from the receiver will contain only those frequencies passed by the receiver. For example, the receiver bandwidth characteristic at the half-power point is approximately ± 1 megacycle for the Models RDO, AN/SPR–1, and AN/APR–1, and ± 5 megacycles for AN/SPR–2.

Alignment of Amplifier Strip for AN/APR–1, AN/SPR–1, and Model RDO

This information does not apply to the Model RDO receiver. The Model RDO does not have a B.F.O., and for alignment of the amplifier strip reference should be made to the Model RDO instruction book.

Common Troubles of AN/SPR–2

The blower motor comment does not apply if the equipment has been modified by F. C. #1—AN/SPR–2.

RELOCATION OF C–1 IN THE MODEL TDN

Model TDN equipments using crystal control require that the crystal oscillator circuits be retuned periodically due to change in ambient temperature, frequency adjustment and checking. The tuning adjustment for this transmitter is condenser C–1. It is accessible only by drawing the crystal oscillator compartment forward from the transmitter. When the oscillator compartment is reinserted, the flexible cables connected to it do not pass

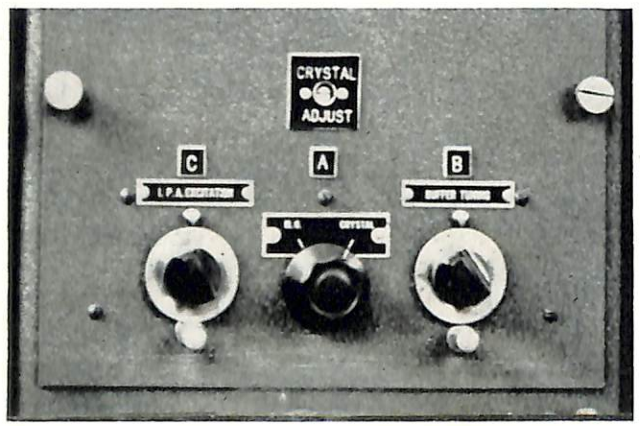


FIGURE 1—Model TDW front panel.

backward readily between the oscillator section and the transmitter frame opening. When this occurs, the cables jam and prevent closing the oscillator section. This necessitates withdrawal of an entire transmitter section to adjust the cables to provide for closing of the oscillator compartment. Safety requirements dictate that all transmitter sections, using the power supply providing power for the transmitter being adjusted, must be secured so that this cable may be properly placed.

The Bureau has authorized a modification to the Model TDN which eliminates the necessity for possible disabling of four circuits when making frequency adjustment on one transmitter section.

This modification consists of relocating the crystal oscillator control condenser C–1, to the inside of the oscillator compartment front panel as shown in Figure 1. This control is presently installed on the oscillator compartment deck. It is required that three holes be drilled in the front panel as shown in Figure 2. The lead from the crystal socket to C–1 is threaded through a grom-

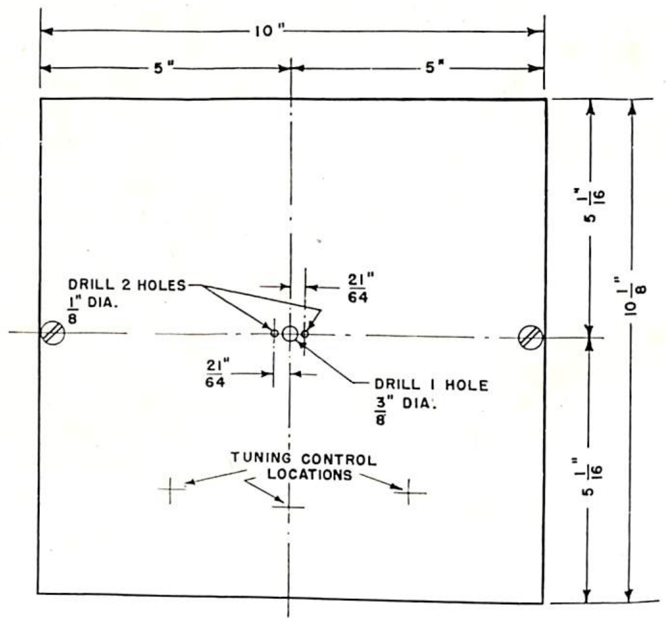


FIGURE 2—Template for relocation of TDN capacitor C–1.

NOTES:

1—Drill 3 holes in panel for relocation of C–1.

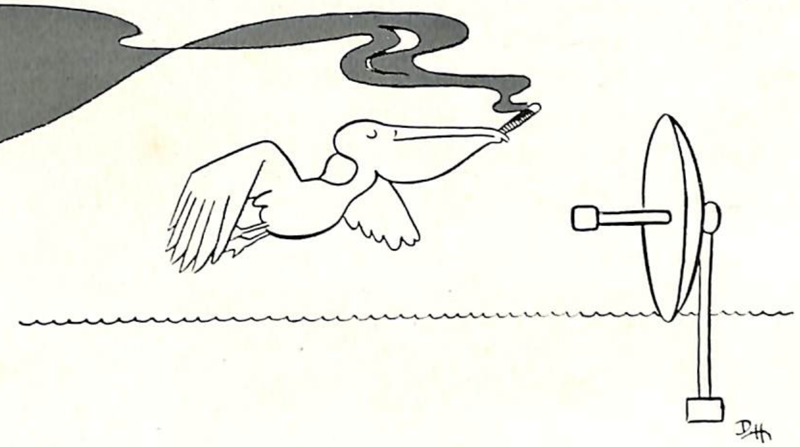
2—Install insulated bushing in shaft hole of original position of C–1 for lead from crystal socket to C–1. Install ground wire direct from C–1 to crystal socket mounting screw.

3—For circuitry see NavShips 900,709 Fig. 2-44.

met inserted in the shaft hole of the original position of condenser C–1. A ground wire is then installed from C–1 to the crystal socket mounting screw.

This modification is to be made on an optional basis. No kits or parts are to be supplied, nor are any special tools required.

spurious radar echoes on L band



by

J. W. GREEN *and* R. U. F. HOPKINS

U. S. Navy Electronics Laboratory, San Diego, Cal.

The frequent observation of spurious echoes (ghosts) on L-band radar sets has currently been a topic of some interest and concern. Reports from the fleet[1] indicate that ghosts are frequently observed on AN/SPS–6 radar sets. Often a source of confusion and concern are the ghosts which are frequently observed on an SR-3b (L-band) (AN/SPS-6A antenna) radar set which is employed for training purposes at the C.I.C. School, Point Loma, San Diego, California.

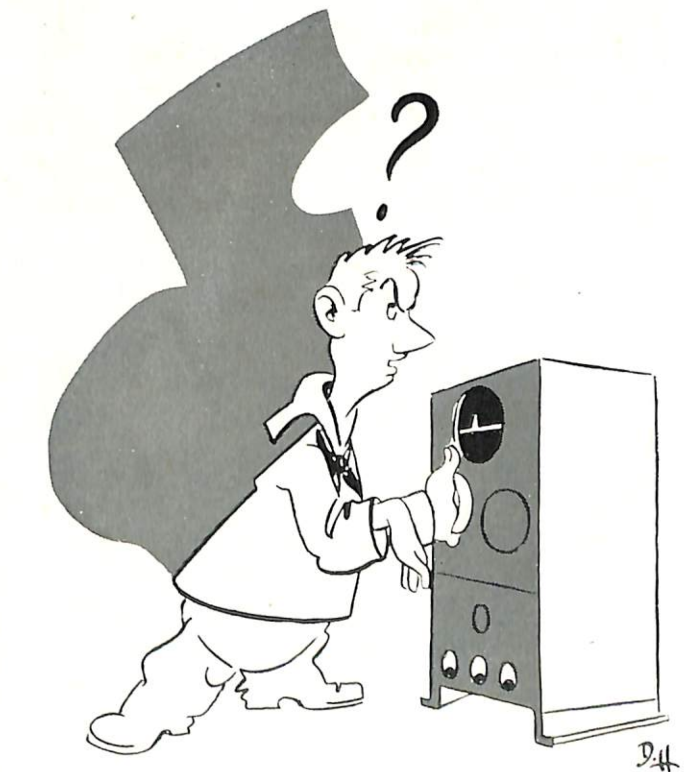
In a preliminary effort to investigate this phenomenon a series of observations were made on the C.I.C. school's SR–3b radar set on the afternoon of 5 October 1950. The set contained a 4J26 magnetron with output power of 500 kw peak, a 4-microsecond pulse length, a repetition rate of 150 cycles/sec. and an antenna sweep rate of 5 rpm.

The prevailing meteorological conditions were marked by the presence of a temperature-humidity inversion layer the base and top of which were at altitudes of 900 feet and 1400 feet respectively. Such non-standard meteorological conditions are frequently observed over the ocean and are conducive to super-refraction. Trapping would be anticipated on all operational radar bands. On the SR–3 set, Guadalupe Isle, 225 miles, 194° T, was showing strongly and the echo may be seen on, for example, Figure 1.

Though propagation conditions were generally excellent, some variability was present particularly on the echoes from the distant island targets to the north. The variability in conditions was probably due to the effect of a front which, during this period, was some 150 miles to the north. Observations on A-scope and PPI were made over a period of three hours. The complete log of observations and photographs will not be given here.[2] It will be sufficient to describe a typical observational sequence.

[1] COMOPDEVFOR report on Project OP/S142/S69–5, Evaluation of the AN/SPS–6B Radar.

[2] Spurious Radar Echoes on L-Band, J. W. Green and R. U. F. Hopkins, Memorandum for File No. 101 (NE 120301) (NEL 1A1), 27 October 1950, U. S. Navy Electronics Laboratory, San Diego, California.



A ghost echo was detected at a range of approximately 80 miles, bearing 214°, see Figure 1. This echo will be referred to as "Ghost 80". Another ghost echo of semi-circular character was observed at 42 miles between the bearings of 244° and 285°, see Figure 1. This echo will be referred to as "Ghost 42". The permanent landscape and island targets may all be readily identified by comparison of the PPI presentation with

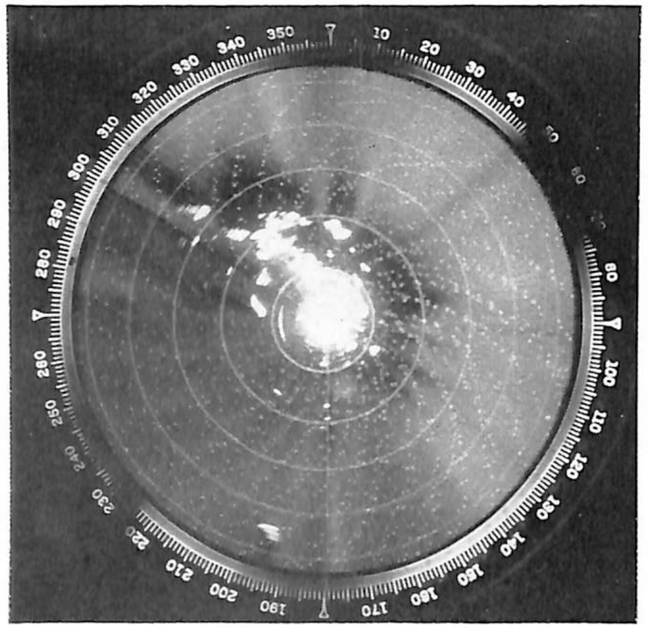


FIGURE 1—L-Band P.P.I. presentation showing a ghost echo at a range and bearing of 80 miles and 214°. Another echo of semi-circular character is shown between the bearings 244° and 285° at 42 miles range.

the map, Figure 2. During an interval of time of nine minutes after detection Ghost 80 had gradually assumed a semi-circular character as shown in Figure 3. The intensity of Ghost 42 was observed to fade slightly. Fourteen minutes after detection the intensity of Ghost 80 was observed to fade and the semi-circular rings were noted to disappear. The intensity of Ghost 42 had faded considerably and the associated semi-circular rings had virtually disappeared. A typical A-scope presentation of Ghost 80 is shown in Figure 4. The range and bearing of the prominent echo is 83 miles, 210°. Figure 5 was taken two minutes later at which time the prominent 83-mile echo had markedly faded. The periodic fading in and out of Ghost 80 and Ghost 42 and their associated semi-circular rings proceeded at intervals of from fifteen minutes to two minutes during the course of the observations. The fading of these ghosts became more frequent and more marked as the course of the afternoon proceeded, during which time the effects of the frontal activity to the northwest was apparently becoming more pronounced. The island targets of Santa Cruz and Santa Rosa (range approximately 140 miles, bearing 300°) were subject to progressively marked fading as the afternoon proceeded and at a time three hours after the start of the observation period, these island echoes had faded beyond recognition.

The Ghosts which are shown in these photographs, particularly the semi-circular rings, are rather unusual and have been only occasionally observed. Though not definitely confirmed, it is probable that such semi-circular type echoes are in evidence only when meteorological conditions are strongly super-refractive. The more commonly observed ghosts are those which suddenly appear as a distinct echo similar to a ship or plane, remain for a limited time, possibly only a few sweeps, and then vanish again. This type seem to be associated with con-

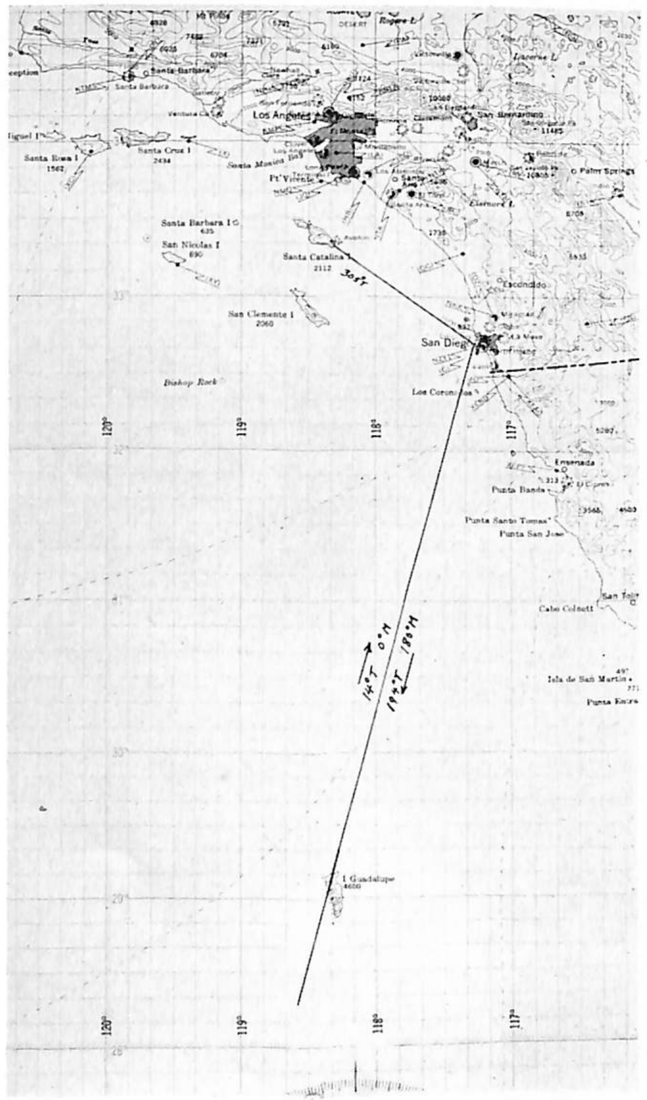


FIGURE 2—A map of the Southern California and Mexican region showing the coast and the islands.

ditions which are variable and only moderately super-refractive.

The semi-circular character of the ghost echoes is immediately suggestive of antenna side lobe radiation. If, indeed, Ghost 80 and Ghost 42 were caused by side lobe radiation, it would seem that spurious echoes should be observed from several of the more prominent island targets, as for example from Santa Catalina (range 63 miles, bearing 305°) and San Clemente (range 55 miles, bearing 278°). However, no spurious echoes were observed at the ranges of 63 miles or 55 miles and off-bearing with respect to these islands. It may be seen from the photographs that prominent landscape echoes are prevalent at a range of approximately 80 miles and a bearing of 320°. An exploratory investigation with an A-scope revealed that an extremely strong echo did in fact come from a bearing of 320° and range 83 miles.

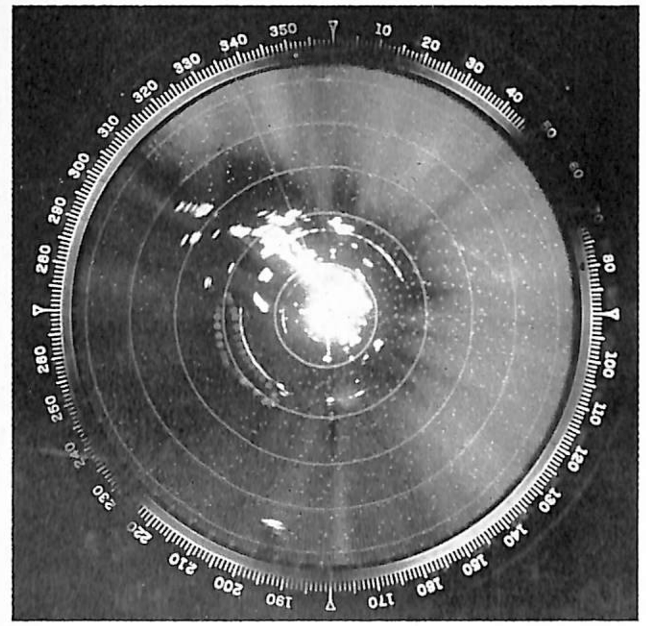


FIGURE 3—L-Band P.P.I. presentation 9 minutes after that shown in Figure 1, showing a semi-circular ghost echo at 80 miles range between the bearings of 210° and 275°, between 340° and 65°, and between 155° and 165°. The semi-circular ghost echo is shown at 42 miles range and between the bearings 245° and 310°.

This range and bearing corresponds to an area around Long Beach and Terminal Island which abounds with oil wells, oil tanks and Navy installations, all of which understandably make an excellent radar target. With the main lobe directed on bearing 320° and the receiver gain control set so that this 83-mile echo was just equal to the saturation amplitude, the antenna was then rotated so that the main lobe was directed on the bearing of San Clemente Island. The echo from San Clemente Island was below detection at that same gain setting. This would seem to explain why side lobe spurious echoes from the islands were not in evidence.

It was observed that the character of the A-scope echo from Long Beach, on the main lobe, resembled that of the ghost echo at 83 miles range and bearing 214°, which gave further credence to the supposition that Ghost 80 was caused by side lobe radiation. For the presumably representative AN/SPS-6A antenna, AN specifications[3] state that the minor lobe maximum is 22 db. down from the main lobe maximum. No mention is made of the angle between the main lobe and the minor lobe maxima. If the strong target at 320° is indeed responsible for the semi-persistent ghost at 214°, then side lobe radiation would have to be received at 320°-214° or 106° from the main lobe. Measurements made at the Navy Electronics Laboratory on a particular AN/SPS-6A antenna indicate the minor lobe maxima to be within approximately 90° of the main lobe maximum. The radiation pattern of the particular AN/SPS-6A antenna employed in these tests is not known. Presumably, however, some variation among individual antenna patterns would be expected, in which case the side lobe maxima might well extend as far as 106° from the main lobe, and thus account for the semi-persistent ghost echo at bearing 214° and range 83 miles.

The likely source of the spurious echo at 42 miles is believed to be a wire screen structure approximately 30 feet by 50 feet which was erected on the top of San Onofre Mountain (elevation 1735 feet) as a radar target for radio wave propagation experiments conducted in the past. The radar echo from this screen and from the mountain itself is of much greater amplitude than the neighboring landscape. The bearing and range of the screen target are 341.5° and 41.6 miles respectively, hence the range of this target corresponds very closely to the range of the spurious echo, Ghost 42.

It should not be concluded that all ghost echoes are to be attributed to side lobe radiation. It seems possible that flocks of birds, unusual sea wave structure, and possibly certain types of clouds may be responsible for some ghost echoes. However, with the high power employed at L-Band, particularly in conjunction with super-refractive propagation conditions and in the presence of strongly reflecting radar targets, the reception of spurious echoes on side lobe radiation should be recognized as a distinct possibility.

The results of this preliminary investigation indicate that in the presence of strongly reflecting radar targets and super-refractive meteorological conditions, spurious echoes (ghosts) may frequently be the result of side lobe radiation.

Acknowledgement

The authors would like to express their appreciation

[3] Navy Radar Specifications, BuShips Code 915, March 1949.

to the C.I.C. School, Point Loma, for use of the SR-3b radar set and for the cooperation of all members of the C.I.C. school staff, in particular for the helpful assistance of Lt. (jg) D. D. Butler.

Appendix

The following analysis demonstrates the possibility of the reception of strongly reflecting radar targets on antenna side lobe radiation. It will be observed in

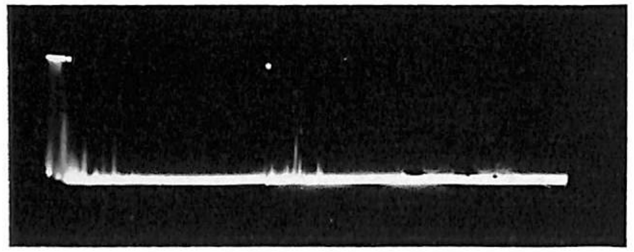


FIGURE 4—An A-scope presentation recorded two minutes after showing the structure of the ghost echo at 83 miles range and bearing 214°.

Figure 1, for example, that the intensity of the ghost echo (range and bearing of 83 miles, 214°), is at least as great, if not greater than the intensity of the echo from Guadalupe Island (range and bearing 225 miles, 195°). The ghost echo (83 miles, 214°) is postulated to arise from side lobe radiation illuminating a target at range and bearing, 83 miles, 320°. Hence, the received (side lobe) echo power P^{83}(S. L.) from the target at 83 miles, 320°, is at least as large, if not larger than, the received (main lobe) echo power P^{225} from the target at 225 miles, 195°, or $P^{83}(\text{S. L.}) \Rightarrow P^{225}$. Let us compare the received echo power P^{225} from Guadalupe Island, 225 miles distant, on the main lobe

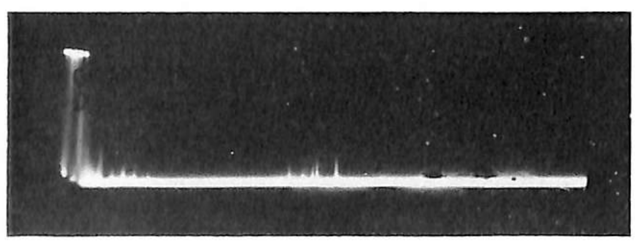


FIGURE 5—An A-scope presentation of the ghost echo at 83 miles range and bearing 214°. This echo structure is strikingly similar to that received on the main lobe from the terminal Island—Long Beach area (range 83 miles, bearing 320°).

(27 db. above an isotropic radiator) with the received echo power P^{83}(S.L.) from the Long Beach area, (83 miles, 320°) on a side lobe (equal to an isotropic radiator). Let the effective radar target area of the Long Beach target be T^{83} and that of Guadalupe Isle be T^{225}. We have, then, from the radar equation $P = K\dfrac{G^2T}{R^4}$

where P is received power in watts
G is power gain of the antenna
T is the effective target cross section
R is the target distance
K is a constant involving the wavelength squared and the power transmitted, both of which will be constants in the following considerations. For the power received, P^{225}, from the 225 mile target, T^{225}, we have:

$$P^{225} = K\,\frac{(500)^2\,T^{225}}{(225)^4} = 0.975 \times 10^{-4}\,KT^{225}\ \text{watts},$$

$$\text{since } G\ (\text{main lobe}) = \log^{-1}_{10}\left(\frac{27}{10}\right) = 500.$$

We have assumed the conservative value of unity for the antenna side lobe gain. For the power received, P^{83}(S.L.), from the 83 mile target, T^{83}, on a side lobe we have:

$$P^{83}(\text{S.L.}) = K\,\frac{1 \cdot T^{83}}{(83)^4} = 0.211 \times 10^{-7}\,K\,T^{83}\ \text{watts},$$

$$\text{since } G\ (\text{side lobe}) = \log^{-1}_{10}\left(\frac{10}{0}\right) = 1.$$

Then:

$$\frac{P^{225}}{P^{83}(\text{S.L.})} = \frac{0.975 \times 10^{-4}}{0.211 \times 10^{-7}}\ \frac{T^{225}}{T^{83}} = 4.62 \times 10^{3}\ \frac{T^{225}}{T^{83}}$$

Thus for $P^{83}(\text{S.L.}) \Rightarrow P^{225}$, it is required that

$$T^{83} \Rightarrow 4.62 \times 10^{3}\,T^{225}.$$

From quantitative radar measurements made on an FC L-band radar on Guadalupe Isle, T^{225}, and Long Beach, T^{83}, under strong super-refractive propagation conditions, it has been determined that the received echo power P^{83} from Long Beach is at least equal to or greater than 60 db. above the received echo power, P^{225}, from Guadalupe Isle under conditions of strong super-refraction. From these measurements it is possible to derive a value of the ratio T^{83}/T^{225}. Thus, if we assume the conservative value of 60 db., $P^{83}/P^{225} = 1 \times 10^{6}$, and since the antenna gain is the same for these measurements,

$P \propto \dfrac{T}{R^4}$, we have:

$$\frac{T^{83}}{T^{225}} = \frac{P^{83}}{P^{225}} \times \frac{R^{4}_{83}}{R^{4}_{225}} = 1 \times 10^{6} \times \frac{(83)^4}{(225)^4}$$

$$= 1.85 \times 10^{4}$$

$$\text{or} \quad T^{83} = 1.85 \times 10^{4}\,T^{225}$$

Thus we have shown from quantitative L-band radar measurements that indeed $T^{83} > 4.62 \times 10^{3}\,T^{225}$

and hence $P^{83}(\text{S.L.}) > P^{225}$, or

more specifically ,

$$10\log_{10}\frac{P^{83}(\text{S.L.})}{P^{225}} = 10\log_{10}\left(\frac{1.85 \times 10^{4}}{4.62 \times 10^{3}}\right) = 6\ \text{db}.$$

Thus the intensity of radar echoes from the Long Beach target on the side lobe radiation are at least 6 db. higher than echoes from Guadalupe Island on the main lobe radiation. This confirms the qualitative observations from Figure 3 for example. It is then entirely possible to receive radar echoes from strongly reflecting (metallic) targets on antenna side lobe radiation which are at least as great, if not greater in intensity, than echoes received from island or landscape (non-metallic) radar targets on the main lobe radiation.

DISCONTINUE REQUESTS FOR FORM NAVSHIPS 3550

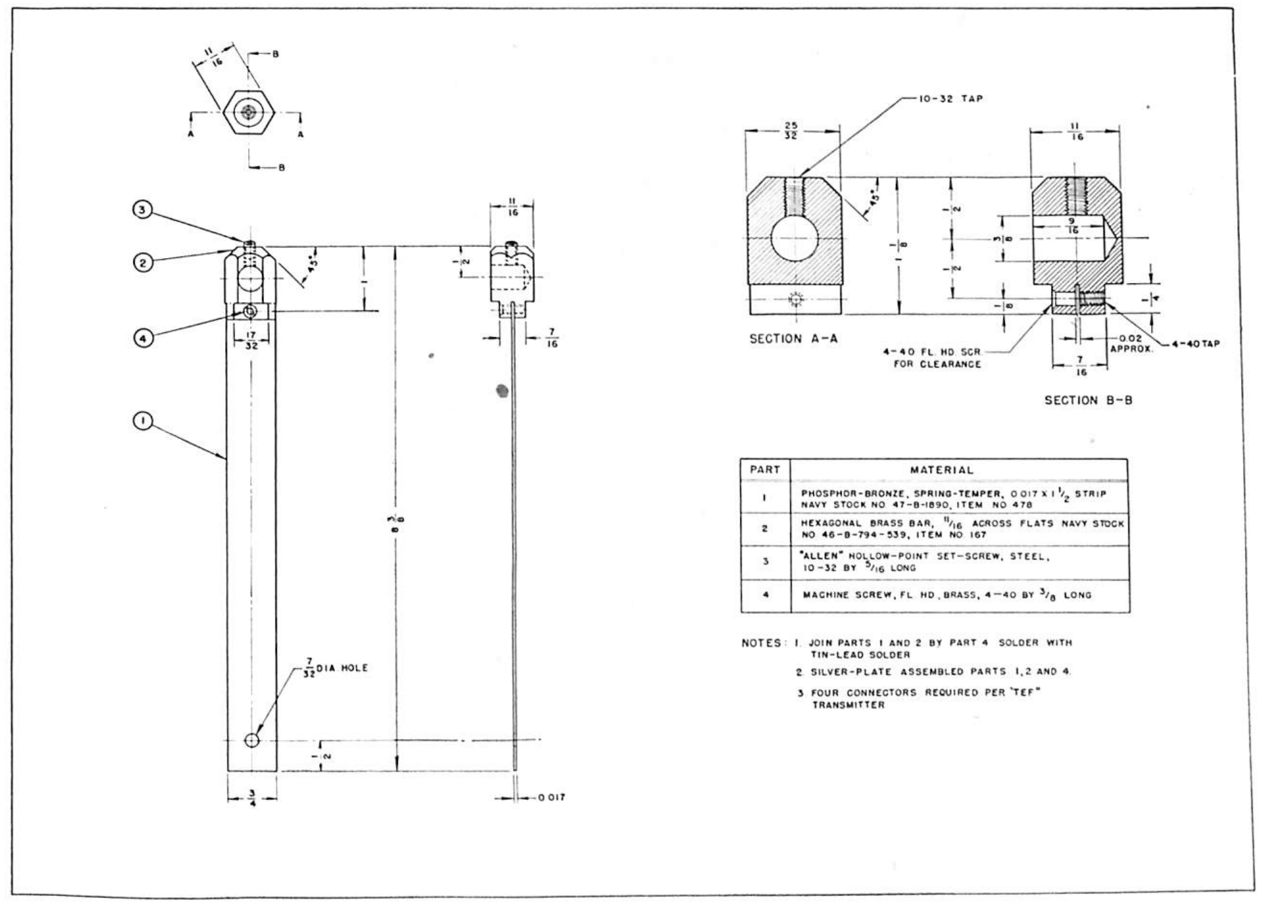
It has been brought to the attention of the Bureau of Ships that several ships have submitted requisition for copies of Form NAVSHIPS 3550 (Rev. 9-50), Electronic Equipment Maintenance Parts Allowance, from various District Publication and Printing Offices. This form is not stocked by any activity for general issue. It is prepared by the Bureau for each individual ship on a continuing basis. *Ships are requested to discontinue requisitioning Form NAVSHIPS 3550 from any field activity or from the Bureau.*

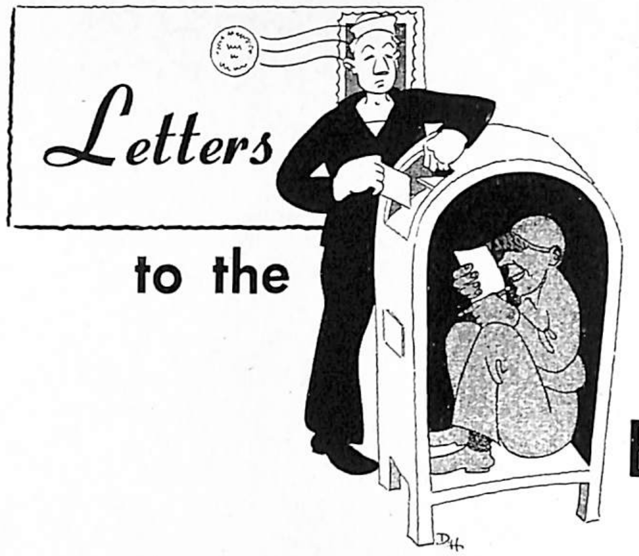
MODIFICATION OF TEF FILAMENT CONNECTORS

The Bureau has been notified that deficiencies exist in the power amplifier tube filament connectors of the Model TEF single side-band transmitters. The connector material is flat, tinned copper braid, used as flexible connectors. Both ends of the braid are filled with solder for about one-half inch to make them stiff. Holes are drilled in each stiffened end, for securing one end to a screw terminal, and for attaching a split cylindrical terminal to the other end. The cylindrical terminal is designed to fit over the tube filament prongs, relying on friction for mechanical and electrical contact. After prolonged usage the connectors show two deficiencies. The terminal screws loosen at both ends, due to cold flowing of the soldered braid, and the cylindrical sleeves overheat, discolor and lose stiffness due to insufficient metallic contact area for the filament current.

Navy Communication Station, Annapolis, has designed a connector which has overcome these deficiencies. The drawing shows this connector together with a list of materials and instruction for assembly.

The Bureau approves this modification to be made on an optional basis. No kits are to be provided. Materials may be obtained from Navy stock.





Letters to the EDITOR

Continuing a new, and it is sincerely hoped, a permanent feature of your magazine—ELECTRON. This new feature is the answer to numerous suggestions and requests from fleet and shore personnel for a medium of presenting their individual problems, gripes and questions on electronics matters and obtaining answers to such queries. This section is not to be confused with the FORUM which has been a regular part of the ELECTRON since its inception in 1945. The continuance of this new feature depends entirely on you—the personnel in the field—since we must first receive correspondence from the field before we can search out the answers and print them. As a matter of convenience, it is suggested you write directly to:

The Editor
BuShips Electron
Code 993
Bureau of Ships
Navy Department
Washington 25, D. C.

The following is typical of the type of letters received to date for inclusion in this column:

Editor
BUSHIPS ELECTRON
Sir:

We have two purposes in mind in writing in to you. The first is to ask for information on a specific problem and the second is to tell you of an improvement we have made.

First comes the problem. We seem to be having a lot of trouble with magnetrons. We are referring to their use with an SG–1B radar serial number 1194.

Our trouble is one of double moding. We generally get satisfactory performance for a period of about two weeks continual operation. We then shut down for a periodic maintenance check which takes perhaps three to four hours. Upon energizing the equipment after these checks the double moding will appear. We thought at first that we were not allowing sufficient time before going into "radiate" but we have discarded this because of the time delay in the equipment itself.

The type and serial number of one magnetron that was used for sixteen days successfully is 706–AY, C 18212, Feb. 22, 1948. We noticed double moding to appear upon re-energizing the equipment. We have also had this same condition when using Type 706–BY magnetrons.

Perhaps this is a common trouble and you can suggest a remedy for it.

Next comes the improvement. We have noticed that the RMB recommended that the 446A tubes in the Mark 12 Mod 2 be replaced by 2C40's. Our ship also has an SC–3 radar and we replaced the 446A's in the receiver with 2C40's and then realigned it. We noted a definite increase in sensitivity and have been operating with them in for over two months.

We have consulted all our sources of information to see if this is a recommended change but can find nothing referring to it. The question is, "Have we done right or wrong?"

C. A. K., ET1
G. E. S., ET2

First, the phenomenon of double moding can be the result of several conditions—any one or all of which may exist in your equipment. A search through the Bureau's files of information on the subject discloses the following six major reasons for double moding:

1—Poor magnetron or series of magnetrons.
2—Weak magnet or magnet pole.
3—Incorrect voltages in the pulse forming network.
4—Defective pulse line or pulse forming network.
5—Improper tuning of the klystron, TR or ATR.
6—Bad voltage standing wave ratio.

As we all know, improper operation, such as you have described in your letter, can not be accurately pinned down in some cases. Apparently the condition is of an intermittent nature since it seems to appear only when the equipment is first energized and disappears after a few hours operation. This would indicate that a mismatch due to misalignment in the r-f section can be strongly suspicious. Such a condition could be caused by poor coupling between magnetron and waveguide which, after a few hours operation and perhaps mechanical vibration, will clear up. It is suggested that you check the positioning of the magnetron carefully when inserting. Also check to insure that the waveguide protective relay switch is functioning correctly and that the waveguide shutter is opening fully when the equipment is energized. If a portion of this shutter is protruding into the waveguide, standing waves will be set up which will cause a mismatch and consequent pulling of the magnetron.

Second, you stated that the RMB (Radar Maintenance Bulletin) recommended that the 446A tubes in the Mark 12 Mod 2 be replaced by 2C40 tubes. A search through the RMB, which is also published by this office, does not reveal these instructions. However, a check of the history of the Type 446A indicate that it was a wartime development. The Type 2C40 tube is an accepted improved replacement for the Type 446A tube in the equipment under discussion, and the bureau has no objection to your continued use of the 2C40's in the equipment.

Such inquiries and information as you have presented are always welcome and will be given prompt attention. Initiative on the part of technicians such as yourself is gratifying and indicates interest and willingness among the men who keep our equipments operating.

Editor

Corrections:

Concerning the April 1951 ELECTRON *"Letters to the Editor", the following information applies:*

1—In answer to J. T. W. Lt (jg) USNR, a typographical error occurred. Copies of the Service and Repair Manuals were sent to various EO's for reference use, but these manuals are to be ordered in the same manner as all other electronics publications—through the local District Printing and Publications Office.

2—In answer to G. B. McF., ET3, in accordance with a recent change in policy, the Bureau is planning to distribute Stock Number Identification Tables (SNITS) to ships not yet converted to "bin stowage" to use as a requisitioning aid and to assist in identification of material by Standard Navy Stock Number. Requests for SNITS should be forwarded to the Electronic Supply Office, 2B, Great Lakes, Illinois.

Editor

REPLACEMENT OF TYPE AB–146/SPS–6 ANTENNA MOUNTING MAIN DRIVE GEAR

Reports received by the Bureau of Ships indicate that many main drive gears (symbol 0–1350) for Type AB–146/SPS–6 Antenna Mounting are being replaced as soon as they begin to show signs of wear.

The manufacturer of this equipment advises that this gear should not be replaced until the amount of wear, as shown in Figure 1, amounts to 3/64th of an inch. As wear in this gear is discovered, it can be compensated by the backlash adjustment described below. When a replacement is made, only a gear (symbol 0–1350) from spares should be used. Any substitution with gears manufactured locally will endanger the warranty provision of the contract for this equipment.

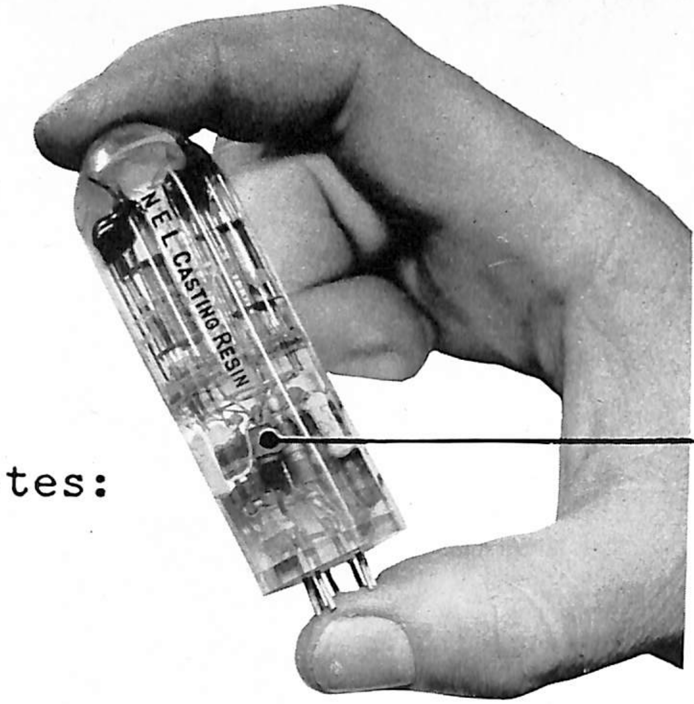
Since spare main drive gears (symbol 0–1350) are available upon request to Bureau of Ships Code 882, substitution of this part will be authorized for emergency situations only. It is possible to use the gear until it is

WEAR OF TEETH AS SHOWN BY DOTTED LINES IS REASONABLE AND CAN BE EXPECTED. DECREASE THICKNESS OF SHIM O-1351 TO REDUCE BACKLASH AS WEAR INCREASES WHEN "W" ABOVE APPROACHES 3/64. GEAR O-1350 SHOULD BE REPLACED. WORN SURFACE SHOULD REMAIN SMOOTH AND POLISHED.

well worn by compensating as described in the following paragraps. A gear with a scored or torn working surface should be replaced regardless of the depth of wear.

Wear in the gear is compensated in the following manner—If the backlash is greater than 0.003″, the thickness of shim 0–1351 must be decreased. Remove the motor from the mounting and examine shim 0–1351. It appears to be made of solid sheet, but it is actually made up of 0.002″ thick laminations which can be peeled off after one spot is loosened with a jack knife. Removal of one such lamination (0.002″) will decrease the backlash by about 0.0018″. Remove the number of laminations required to bring the backlash within the specified limits of 0.001″ to 0.003″. Re-install the motor and again check the backlash. Repeat this process until a suitable reading of backlash is obtained.

If the difference is less than 0.001″, the thickness of shim 0–1351 must be increased. To do this laminations peeled from a shim taken from spare parts must be added to shim 0–1351 until the proper backlash is obtained. The same procedure for measuring backlash as that outlined above should be followed.



nel notes: nel casting resins

FIGURE 1 — Complete multivibrator circuit, containing two 6K4 tubes, potted in NEL casting resin.

A series of new casting resins with outstanding advantages over present commercially available compounds has been developed by the U. S. Navy Electronics Laboratory during the past two years. The new resins have been successfully used in a wide variety of applications at NEL, and the indications are that they may fill a widespread need for a resin for casting or potting subminiature circuits and components. For Navy use, cast subminiature circuits would provide small size and portability, features particularly desirable on submarines and aircraft. From the point of view of the maintenance man, such circuits would be a tremendous asset. Instead of laboriously repairing a defective unit of an equipment, the maintenance man would simply replace the unit as a whole from a block of cast amplifiers, oscillators, etc., which would be manufactured on a production-line basis. Also, such cast circuits would require less servicing because of their superior ability to resist damage from vibration, shock, or salt-water corrosion.

The development of the new resins was started because the commercially available materials were unsatisfactory in electrical or physical properties, or their manufacture involved chemicals either not easily obtainable or prohibitive in cost. On the other hand, the NEL resins afford the following advantages:

1—The ingredients are inexpensive.

2—Compounding and processing are simple.

3—Solidification is accomplished without the application of heat.

4—The resins are transparent in both liquid and solid form.

5—The cast resins are chemically stable, resisting attack by the atmosphere, sea water, solvents, acids, and alkalies.

6—They are more stable to heat than other casting resins and will stand up to the highest temperatures normally reached by subminiature tubes.

7—The cast resins are hard, durable, machinable, and mechanically strong.

8—The resins have satisfactory electrical properties.

A variety of circuits have been cast in the NEL resins and put to practical use in the Laboratory. A typical circuit is illustrated in Figure 1. Of course, before such circuits appear in the equipment of the ship's radio room many problems will have to be solved and probably new and unusual techniques will have to be worked out in circuit design.

One important advantage of cast circuits is the reduction of microphonics in the high-gain amplifier circuits. During the NEL study, two circuits were constructed with identical components; one was cast in NEL resin, and the other constructed conventionally. Both circuits were mounted on a plate attached to a vibration test machine (Figure 2) and the outputs connected to an oscilloscope. Figure 3A shows traces of both amplifiers with the vibration machine turned off. Figure 3B shows the traces with just the bearing noise of the machine transmitted to the table. Figure 3C shows the traces when the table of the machine was vibrated at 55 cycles per second with a 0.06-inch horizontal excursion.

FIGURE 2—High-gain amplifiers used in comparative microphonics test. Amplifier at left is mounted conventionally; amplifier at right is cast in NEL resin.

Apart from their use in the casting of subminiature circuits, the NEL resins have potential applications in other fields. Insects, plants, and small animals have been cast in them (Figure 4), and they could be used for casting organs or tissues for instruction purposes. Because of technique limitations, only small and medium-size castings have been made up to the present, but if problems of bulk processing can be solved the resins could be used for preserving large animals or even human bodies.

A good deal of work still remains to be done on these resins. For example, comprehensive data on the resins need to be compiled, and to do this, new test methods and techniques will have to be devised. This is unfortunately necessary because most of the relevant standard tests are designed for thermoplastic resins, while the NEL materials are thermosetting in type. Improved resins of the same general chemical constitution could undoubtedly be produced and such are being actively sought. Future work will also include a study of the fundamental molecular structure of this type of resin, knowledge of which would help in the production of optimum properties.

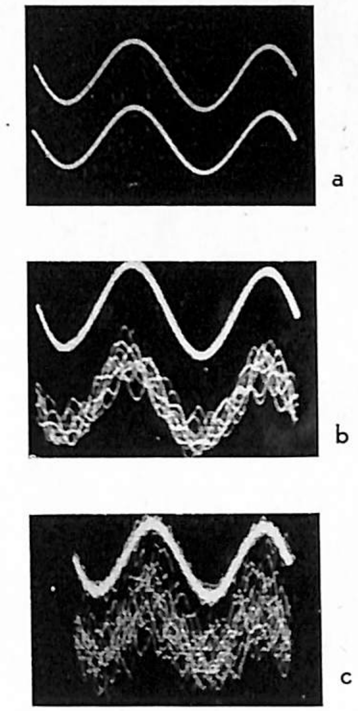


FIGURE 3—Oscillograms recorded under three conditions of operation in microphonics test. Top trace in each oscillogram shows output of potted amplifier; bottom trace is output of conventional circuit. (a) Traces recorded with vibration test machine turned off. (b) Traces recorded with vibration machine motor turned on, but table not in motion. (c) Traces recorded with vibration table in motion at 55 cps, excursion distance 0.060 in. horizontally.

FIGURE 4—Delicate tissues such as this rose can also be cast in NEL resins.

audio amplifier systems

by

L. G. CRUMBAKER, ETC, USN

This article is written in an attempt to be of help not only to ships that have standard Navy public address systems, but also to smaller vessels which have had to rely on civilian-manufactured amplifiers for communication. While it is intended as a guide for microphone and speaker hookup on smaller craft, a few of its points may be of interest to others.

It has been noticed during routine repair work on various vessels, that the usual shipboard RBO amplifier system leaves much to be desired in its performance. While the RBO receiver does pick up broadcast stations and the amplifier does amplify them, the audio quality is extremely distorted. A number of factors causing this trouble are listed below:

1—Improper tuning of receiver to station.

2—Excessive volume out of receiver, causing peak clipping and severe limiting in remote amplifier.

3—Receiver distortion due to infrequent maintenance or improper r-f or i-f lineup.

4—Weak tubes or improper circuit voltages in amplifiers.

5—Incorrect matching of the amplifiers to the receivers.

These units are not designed for high fidelity, and cannot be expected to perform as if they were $500 consoles. However, a check through the system with reference to the five points listed above should easily place the RBO and its amplifier in a class with an average, good quality broadcast receiver. (It may be of interest to know that an inexpensive crystal microphone with fairly high output can be connected to the PHONO terminals of the RBO and the system used as a small public address amplifier. For this use, the receiver band switch must, of course, be thrown to the PHONO position. Volume may be controlled with the receiver gain control.)

The first thing to do when checking the RBO system is to remove all amplifier and receiver tubes and test them in a good tube tester. Replace those reading low, doubtful, shorted or microphonic. Second, replace the tubes in their correct sockets and after disconnecting the leads from the speaker-amplifiers used, tie in a temporary speaker to the output terminals, and listen at normal volume for distortion. Be sure the speaker matches the RBO output impedance. If distortion is present, the receiver needs a checkup for adjustment or repair. Assuming little distortion is present, the job narrows down to one or both of two things: Distortion in the amplifier, or improper amplifier matching to the receiver output terminals. Distortion in the amplifier may be localized by using a pair of high impedance phones in series with a .05-mf, 600-volt paper capacitor, listening at the points listed below:

1—Input tube grid to ground.

2—Input tube plate to ground.

3—Output tube grid to ground.

4—Output tube plate to ground.

5—Across voice coil of speaker, if sufficient volume is present to operate headphones.

If the incoming signal is clean at the grid of a tube, but is distorted at the plate, either the tube is weak, plate or screen voltages are abnormal (low rectifier tube, shorted filter capacitor, changed value of plate load resistor, screen bypass (if used) shorted or open, screen-dropping resistor changed value or open, etc.) or in the case of an output tube, the speaker transformer windings may be shorted. In this case, check with a low range ohmmeter and compare ohms in primary and secondary with the d-c ohm value given in the instruction book for that particular transformer.

Some instances have been noted where the signal through the amplifier was clean all the way to the speaker voice coil, but distortion was noted on the louder passages of music. This was found to be due to the voice coil rubbing on the magnet core in its center. If the speaker cone can be replaced or adjusted, the rubbing may occasionally be cured by re-centering the voice coil and cementing the cone in place. In most cases, however, it will be necessary to junk the speaker and replace it with a similar unit from spares.

Where the amplifier units are connected to the wrong RBO outlet terminals, it becomes necessary to try various terminal combinations for correct impedance match. In most cases this can be done by ear, using the taps that produce the best quality audio with the best volume. The human ear is, after all, the final judge, and as long as results sound good by ear, there is little need for splitting hairs to satisfy the requirements of some technical formula or other. In the case of connecting a single amplifier to the RBO, the 600-ohm terminals are used and no trouble should be experienced as most amplifiers have 600-ohm inputs. When two or more amplifiers are used, connecting to the same receiver, it may be necessary to parallel the amplifier inputs and connect them across the 600-ohm terminals of the receiver in series with a 300-ohm, 5-watt resistor to keep the load as seen by the receiver at 600 ohms.

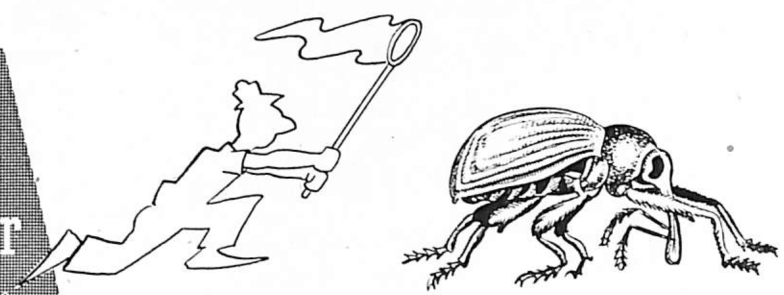
With a little care and occasional checkup as dictated by your shipboard maintenance routine, once an RBO amplifier system is put in good working order and adjusted properly, the only troubles should be minor.

Heavy-handed shipmates, who occasionally have been known to twist the knobs completely off the amplifiers in a desperate search for music on more than one channel of the input switch, are growing fewer. Trouble of this sort should not be encountered very often, but it should be kept in mind.

It is suggested that should an ET start on an RBO amplifier overhaul, he be cautious enough to remember that the RBO high voltage circuits have a distressing tendency to deplete the number of active ET's, should he prove careless. The amplifier units, while not quite so deadly, pack a good wallop with their 115-volt a-c input and equivalent d-c output from their rectifiers. Never decide you are so familiar with your equipment that it can't kill you, or at least leave you with a good case of the shakes and those little white spots on your hands where you acted as your own low resistance bleeder for a second or two. High voltage is *always* dangerous, and a little caution can go a long way toward preventing trouble.

—*ServLant Monthly Bulletin*

removing the BUGS from your SP radar



by

R. G. WALKER *and* EDWARD J. WIRTZ, JR.
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Does your SP radar hunt or creep? Does your stable element topple? Are you missing your "R" sweep? If you have been encountering these troubles you will find the material covered in this article to be helpful in future servicing. It is a compilation of recent actual cases of trouble encountered in the SP.

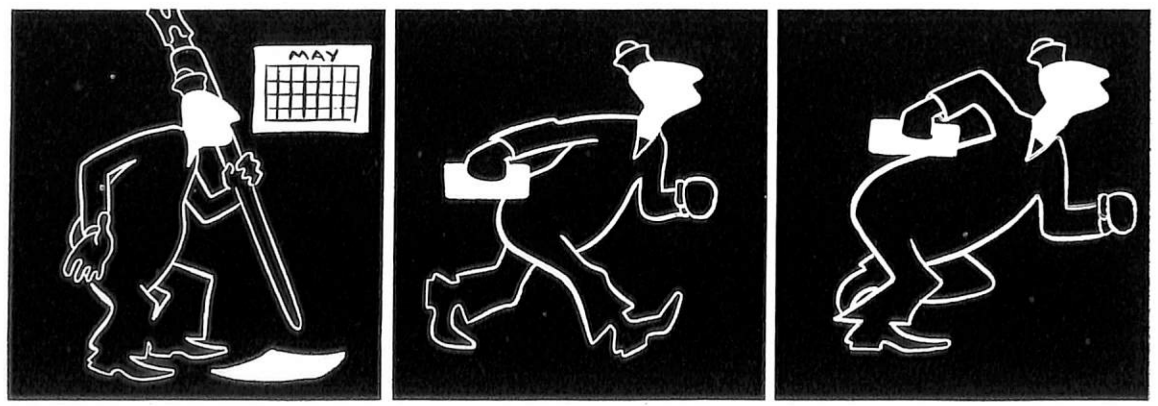
The most common prevalent troubles include failure of the TR and ATR tubes and the 1N21B crystal. Two types of tubes have been used for the TR and ATR. The 721–A is the least rugged and averages from 50 to 150 hours of useful life. The 721–B averages 200 to 500 hours, when used in the TR circuit, and is good for approximately 1000 hours as ATR. 721–A's are issued occasionally due to the scarcity of the 721–B's. It is suggested that the A's be used for ATR service and the B's for TR service. The life of the crystal is parallel with the life of the TR since TR failure always means that the crystal is ruined.

Hunting of the antenna in train and creeping in elevation are frequent troubles which are usually caused by incorrect adjustment of the train control and elevation control amplifiers. Another frequent trouble in the AFC circuit is due to incorrectly adjusting the oscillator 30 megacycles above the magnetron frequency. This should *always* be 30 megacycles *below* the frequency of the magnetron for proper AFC action.

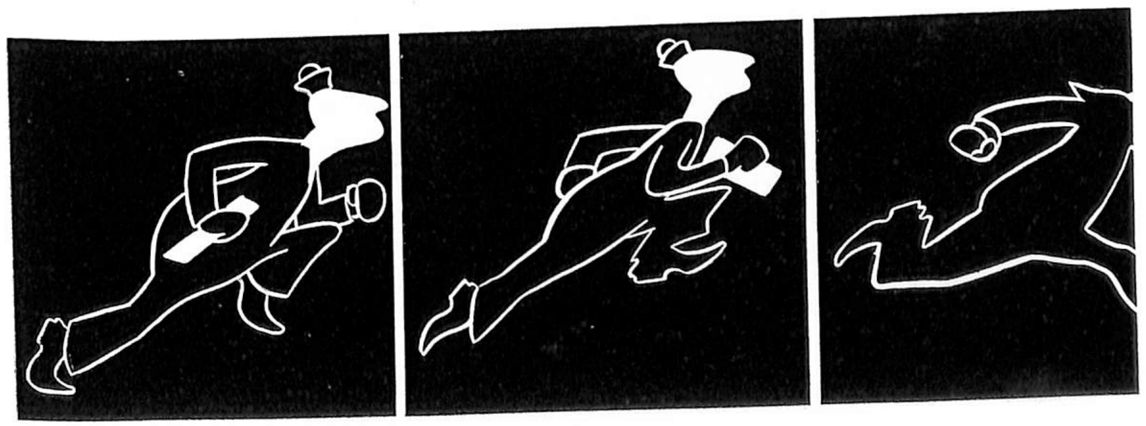
The following "cases of trouble" are based upon actual equipment failures gleaned from equipment failure reports submitted by the Field Engineers assigned to the Bureau of Ships and under the Administrative Control of Commander Service Force, U. S. Atlantic Fleet. It is prepared in a "complaint" and "solution" form so it may provide you with a quick reference in helping solve your future problems.

COMPLAINT—Line stub tuning was inoperative.
SOLUTION—The field winding in the line stub drive motor was open. The motor was replaced.
COMPLAINT—The standing wave probe was not functioning properly.

SOLUTION—The circuit to the probe was open and there was no ground.
COMPLAINT—No echo presentation.
SOLUTION—Replaced a defective local oscillator tube. Oscillator, TR and ATR cavities were retuned for maximum ringtime. Tuned the line stub for minimum standing waves.
COMPLAINT—Indistinct and blurred presentation on the 100-mile PPI range.
SOLUTION—The trouble was caused by the sweep amplifier tube (807) being gassy.
COMPLAINT—Antenna was tilted in cross-level.
SOLUTION—The cross-level synchros in the antenna required re-zeroing. The use of a VTVM to zero a synchro is preferred. This prevents loading of the CT which might cause an inaccurate zero setting, resulting in antenna hunting. If an a-c voltmeter must be used a range providing 15,000 ohms or more should be selected to prevent CT loading during the zeroing process.
COMPLAINT—The load stub tuner was inoperative.
SOLUTION—The load stub limit switch (S–3142) had failed to operate. This caused the worm gear shaft to break.
COMPLAINT—Erratic sweep lengths on the "A" and "R" scopes.
SOLUTION—A lump of solder lying across the sweep length potentiometer was intermittently shorting.
COMPLAINT—Antenna was hunting in both azimuth and elevation.
SOLUTION—Readjusted the gain, stabilizing and bias controls on the train and elevation amplifiers.
COMPLAINT—Poor ranges on air target.
SOLUTION—Replaced weak magnetron, TR and ATR tubes.
COMPLAINT—The synchroscope was inoperative.
SOLUTION—R–4529 and R–4532 had increased in resistance. Replaced weak 3BP1 and 3B24 tubes.
COMPLAINT—No video being received from the associated Model BO–1 IFF interrogator.
PRELIMINARY CHECK—Checked for video output at the BO–1 and found it to be proper.
CAUSE OF TROUBLE—The video and trigger cables had been crossed at the console due to incorrect numbering of the cables.
COMPLAINT—No control of antenna rotation.
SOLUTION—Re-adjusted the low-speed cut-in relay potentiometer and the stabilizing 1 and 2 potentiometers which control the low and high speed anti-hunt circuits.
COMPLAINT—No echos being received.
SOLUTION—Replaced defective TR and ATR tubes (721–B's) and the 1N21B crystal.
SECONDARY TROUBLES—The local oscillator tuning shaft coupling was broken. The magnetron (4J47) was acting very erratic and unstable. No echoes being received from the echo box.
SOLUTION—The shaft coupling was mechanically repaired aboard ship. The magnetron was replaced. The echo box probe had become detached from the waveguide.
COMPLAINT—No "R" sweep, no 5-mile sweep and the "A" scope had a sweep but no range marks.
SOLUTION—No output was being obtained from the selector gate tube (V–311). Trouble symptom in this stage was found to be low plate voltage. Resistance checks disclosed that the 0 to 5 mile range switch (S–301) was incorrectly wired. Rewired this switch and immediately received range marks again. (It was assumed that incorrect wiring of S–301 occurred when the coarse range potentiometer was replaced by the ship's ET).
RESULTS OF PRELIMINARY WORK ACCOMPLISHED—The range marks were restored to the "A" scope. The "R" scope sweep was present but unstable. The 0 to 5 mile sweep was present.
SOLUTION—R–425, selector gate control, was out of adjustment. This control restored normal "R" scope sweep and corrected the range marks on the "A" scope.
ADDITIONAL REMAINING TROUBLE—In adjusting the coarse range potentiometer the range step would jump 10 miles instead of 5. Varying the ditch width control showed that the output of V–301 (6SN7) was not normal.



SOLUTION—V–301 was replaced. Operation now normal.
COMPLAINT—The stable element level ring was oscillating at a fast rate.
SOLUTION—The trouble was due to excessive gear backlash. One of the gear mounting brackets was adjusted to bring the two associated gears into closer mesh.
COMPLAINT—The level ring would not lock in.
SOLUTION—At an earlier date the ship had been experiencing trouble with the antenna 'hunting". A temporary solution was to reduce the amplifier gain. Readjustment of the amplifier gain control to the correct value allowed the level ring to lock in properly.
COMPLAINT—The gyro would not straighten up after tumbling.
SOLUTION—The erecting magnet was not operating. Trouble was due to a broken lead which connected to the coil of the erecting magnet.
COMPLAINT—The spark gap motor-generator was running too slow.
SOLUTION—The impeller blades were fractured. Centrifugal force was causing them to rub against the stator windings.
COMPLAINT—The "A" and "R" scopes were flashing intermittently.
SOLUTION—This was caused by severe arcing occuring at the magnetron filament leads. The modulator input voltage was very low. Modulator voltage was raised to a point which allowed normal magnetron current of 28 milliamperes to flow.
COMPLAINT—Antenna would hunt in train and creep in elevation.
SOLUTION—The train control amplifier was out of adjustment. Adjusting according to the instruction book procedure cured the hunting trouble. Adjusted the elevation control amplifier so that antenna would not creep without excitation from the elevation hand-crank.
ADDITIONAL REMAINING TROUBLE—The cross-level control amplifier could not be properly aligned due to controls being in their extreme rotation positions.
SOLUTION—Replaced V–3306 and V–3307 (6L6's) which were weak.
COMPLAINT—The standing wave load stub tuner would only operate "out".
SOLUTION—Voltage checking in the antenna pedestal disclosed that the lower limit switch in the load stub tuner was inoperative. This was replaced.
COMPLAINT—Low signal and AFC crystal currents.
SOLUTION—Both 1N21B crystals in the mixer line sections were weak.
COMPLAINT—Receiver not tuning up properly.
SOLUTION—The coarse tuning control of the local oscillator cavity was broken, causing a very limited tuning range which covered an incorrect mode. The control coupler, which was broken, was repaired by soldering.
COMPLAINT—The stable element toppled easily.
SOLUTION—The cross-level and level amplifiers were not adjusted for proper gain. This was accomplished by control adjustments.
COMPLAINT—Stable element trained continuously in a CCW direction when in "local" control of stable element.
SOLUTION—Replaced defective 6L6 d-c servo amplifier tube in the stable element train amplifier.
COMPLAINT—Antenna hunts in "true" position but normal in "relative" position.
SOLUTION—This was due to an intermittently shorting 2nd 6H6 in the stable element train amplifier.
COMPLAINT—Antenna cross-level movement very sluggish.
SOLUTION—Oil had leaked from the gear box into the motor of the cross-level drive assembly. Motor was replaced.
COMPLAINT—The AFC unit would not remain steady for any length of time.
SOLUTION—The coaxial couplings which connected to the crystal unit were loose. Tightening these by hand cured the trouble.
COMPLAINT—Antenna hunted in elevation.
SOLUTION—Trouble was due to improper alignment of the elevation amplifier.



COMPLAINT—Range unit could not be aligned. Insufficient tuning range in "R" sweep multivibrator.

SOLUTION—R–380 had increased in value from 1300 ohms to 1500 ohms. This was replaced.

COMPLAINT—Antenna hunted in train when in stabilized operation.

SOLUTION—V–405 (6L6) in the stable element train amplifier was intermittently shorting.

COMPLAINT—Receiver responded too slowly to any change made in the "main gain" control.

SOLUTION—R–145 (4.7 megohms) in the gain control circuit had greatly increased in resistance.

COMPLAINT—Erratic magnetron pulsing.

SOLUTION—Replacing the fixed and rotating electrodes in the spark gap. Adjusted the spacing and phasing of the gap.

COMPLAINT—Trigger not visible on the monitor scope.

SOLUTION—R–4534 (2,000 ohms) was open. Repaired the delay line, Z–4501, in the synchroscope.

COMPLAINT—Scanner motor inoperative.

SOLUTION—Scanner motor, B–3189, burned to a shorted condition. Lubrication appeared to be sufficient. Failure believed due to the centrifugal starting switch not operating properly.

COMPLAINT—Rough rotation of antenna in stabilized or unstabilized operation.

SOLUTION—The train handwheel on the console was binding. The bearing surface of the handwheel was rough and scored. The slot in the coupling between the bearing handwheel and the 36 speed gears was also binding due to someone having forced the bearing handwheel through the bearing resulting in bending of the gears and the coupling.

COMPLAINT—Standing wave stub tuners inoperative.

SOLUTION—F–2011 would continue to blow out. Moisture and fungus had collected in the antenna pedestal. The trouble was due to moisture in the motor (B–137).

COMPLAINT—Stable element and antenna not following sweep properly.

SOLUTION—The OSC reference voltage was down to 75 volts. When this voltage was restored to 115 volts at the radar distribution board the stable element followed the sweep normally.

COMPLAINT—There was an overload indication in the synchro power system.

SOLUTION—Overload relay, K–3227, was remaining in a closed position.

COMPLAINT—Antenna not operating in elevation.

SOLUTION—The Type 1CT synchro was shorted.

COMPLAINT—When energized, the antenna drives into the limits of the cross-level axis and remains in that position.

SOLUTION—The armature of the cross-level amplidyne was grounded at point A1.

THEORIZED CAUSE OF TROUBLE—When the armature became grounded it placed a ground on the number one grid of the current limiter tube V–3305 (6SL7). This caused V–3305 to conduct very heavily and develop a high positive bias on the grid of V–3306. (The bias network was effectively grounded at the junction of R–3381 and R–3377, thereby reversing the polarity of the bias developed across R–3381.) The positive bias was therefore being applied to the 6N7 low-speed cut-in tube, V–3306.

COMPLAINT—Weak presentation of close in targets and poor ranges on air targets.

SOLUTION—The TR and ATR tubes (721–A's) were weak. The duplexer needed cleaning. The contact arm supplying keep alive voltage to the TR tube required replacement. The crystal mixer, 1N21B, was weak. The oscillator, preamplifier and duplexer were then tuned up for maximum response.

COMPLAINT—At low speeds the antenna hunts in the train axis.

SOLUTION—The 36-speed CT rotor was shorting, requiring replacement. The train control amplifier was adjusted for a 2-4 volt error signal at 6 RPM.

COMPLAINT—The AFC would not sweep or lock in.

SOLUTION—The 6AC7 video amplifier tube in the AFC strip was shorted.

The Fleet Speaks

ON THE INSIDE

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With the utmost contempt for his personal safety, The Editor of ELECTRON has gathered from the wildest regions of the globe these amazing reports on the newest happenings in the great field of Amplifiers.

You cannot, you must not, permit any officer or man in your command to be denied the opportunity to imbibe of this knowledge. Go away, boy, you bother me—Step right up—Hurry, hurry—The show is just be-ginning—in the next issue. What am I talking about—? Why the article on Magnetic Amplifiers of course!!

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