N R L REPORT R-3127

DEVELOPMENT OF AN IMPROVED RADIO-FREQUENCY-FILTER SYSTEM FOR MODEL RDZ/RDZ-1 RECEIVING EQUIPMENT

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NAVAL RESEARCH LABORATORY

Washington, D.C.

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DEVELOPMENT OF AN IMPROVED RADIO-FREQUENCY-FILTER SYSTEM FOR MODEL RDZ/RDZ-1 RECEIVING EQUIPMENT

by

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ABSTRACT

This report covers the development of a substitutive filter system for the RDZ/RDZ-1 receivers in which the major deficiencies have been improved to the extent permitted by existing space limitations and current availability of suitable components. As a result of the modifications described herein, the overall average protection against r-f energy introduced through the remote-line connections to the Model RDZ/RDZ-1 receiver has been increased to 112 decibels; i.e., an overall improvement of 59 decibels has been attained.

PROBLEM STATUS

This report concludes the work on this problem, and unless otherwise advised by the Bureau it will be closed one month from the mailing date of this report.

DEVELOPMENT OF AN IMPROVED RADIO-FREQUENCY-FILTER SYSTEM FOR MODEL RDZ/RDZ-1 RECEIVING EQUIPMENT

AUTHORIZATION

1. Problem S633.3R-C, Investigation of Major Deficiencies of the Model CXHY Equipment, was authorized by reference 1 following submission by the Laboratory of an interim report covering certain stages in the evaluation of the preproduction models (see reference 2). The development of an improved radio-frequency-filter system, as discussed herein, constitutes the final phase of this assignment.

PROBLEM OBJECTIVE

2. The Model TDZ Transmitting Equipment, in conjunction with the Model RDZ Receiving Equipment, comprises a radio communication system for operation in the 225 to 400 megacycle portion of the UHF range. Both equipments are designed for automatic selection of any one of ten pre-set frequency channels; and various circuits of the two basic units are normally inter-connected or mutually coupled at the remote-control stations. Spurious emissions and responses result, respectively, from the crystal-controlled oscillator-multiplier systems of the two basic units. In the case of the transmitter, high levels of noise and c-w energy may be conducted along its power-supply and remote-control cables (see references 5 and 6). Conversely, beyond the attenuation limits of a shielded radio-frequency-filter system for all power-input and remote-control connections, the receiver is responsive to resonant-frequency energy injected into these circuits. The prime objective of this development was to effect a substantial improvement in the attenuation and isolation characteristics of this filter system.

GENERAL DESCRIPTION OF BASIC EQUIPMENT

3. Most of the initial development of the subject receiving equipment was prosecuted at the Naval Research Laboratory, at which time the preliminary units were designated as components of the Model XCS Receiving Equipment. In order to expedite the production-tooling for frozen portions of the design, however, the completion of that development was transferred to the Contractor's plant (National Company, Inc., Malden, Massachusetts). Following completion, the Contractor submitted two preproduction equipments to the Laboratory for evaluation, these units being designated as components of the Model CXHY Radio Receiving Equipment. The production equipments supplied by this Contractor are designated as Model RDZ; whereas identical equipments, produced by the Admiral Corporation, carry the Model RDZ-1 designation. The production type filter system discussed in this report is designated as the Type-53280 R.F. Filter Unit. The respective filter components are assembled on an aluminum panel together with the power-line fuse holders and a formed aluminum shelf which supports the various cable receptacles. The panel of this assembly mounts inside the receiver in such a manner that the component structure, together with an overall shielding cover, project through an aperture in the rear wall of the

cabinet in the form of a streamlined blister. The cover can be removed from the rear, when accessible, or the entire filter unit may be withdrawn through the cabinet after releasing the securing mechanism from the front. The power line fuses are so mounted on the filter panel as to be accessible for replacement from the front of the receiver cabinet only, but without need of removing the filter unit.

ORIGINAL FILTER SYSTEM (XCS)

4. When the filter system for the original XCS Receiver was being laid out, it was recognized that thorough shielding and good circuit isolation were of prime importance, even though the degree of leakage and ground-plane coupling existent in this frequency range might not yet have been fully appreciated. In pursuance of the plan for isolating the input circuits from the output circuits of the Autotune, audio and silencer filters, a U-shaped channel type of construction was employed. This channel was approximately 1 1/2 inches deep and 9 inches long. The individual filter components were mounted along the outer walls of the channel, as were the input connections from the cable receptacles. The output connections of the Autotune filters fed into the center of the channel and thence through the main filter system panel by way of the cabinet cable in which the double-shield coaxial antenna cable was incorporated. Thus, the metal channel interposed a shielding barrier between the input and output circuits, and its construction was such as to permit the addition of a separate cover if more effective shielding was found to be necessary. These filters were simple pi low-pass type, employing conventional 0.01-microfarad molded-mica capacitors and single-layer inductors wound on phenolic forms approximating the size of 1-watt carbon resistors. The power-input filter employed similar components to those employed in the Model RCK and Model RDO receivers, with the parts laid out "in line" to minimize by-passing or input-to-output coupling. As with the Autotune filter assembly, the construction was such as to permit the addition of a separate cover if additional shielding was found to be necessary. The complete assembly of this filter system is shown in Plate 2 of reference 3. Due to transfer of the development to the Contractor's plant, the attenuation characteristics of this filter system were not obtained by the Laboratory.

CONTRACTOR'S EARLY VERSION (CXHY)

5. Upon submission of the Model CXHY Receiving Equipment for evaluation, it was noted that the arrangement of the filter components had been modified considerably. Perhaps due to production considerations, the shielded channel construction of the Autotune filter assembly had been dispensed with and the components were laid out on a metal plate with little or no means of circuit isolation provided. In the case of the power-input filter, the connections were so arranged as to place the lead inductances in series with the capacitive elements rather than in the inductor circuits, and the capacitors were so located (particularly those on the output end) as to provide considerable input-to-output coupling. The Contractor corrected this latter arrangement, in part, as shown in Figure 1. A replacement filter of this type was submitted for use in the CXHY evaluation tests, and a few were furnished with early production units of the Model RDZ Receiving Equipment. As shown in paragraph 6 of reference 2, the receiver sensitivity to signals injected into the power line, with this filter, averaged only 49 decibels below antenna-input standard sensitivity.

CURRENT PRODUCTION TYPE (RDZ/RDZ-1)

6. In further partial compliance with Laboratory recommendations, the Contractor again modified the power-input filter by providing separate terminals between the single and

multi-layer inductor sections, increasing the axial spacing of the inductors, relocating the capacitors between the inductors, and adding a diaphragm shield between this network and that of the Autotune filter. No change was made in the arrangement of the latter. Figure 2 shows the final construction, as currently furnished in the RDZ and RDZ-1 receivers.

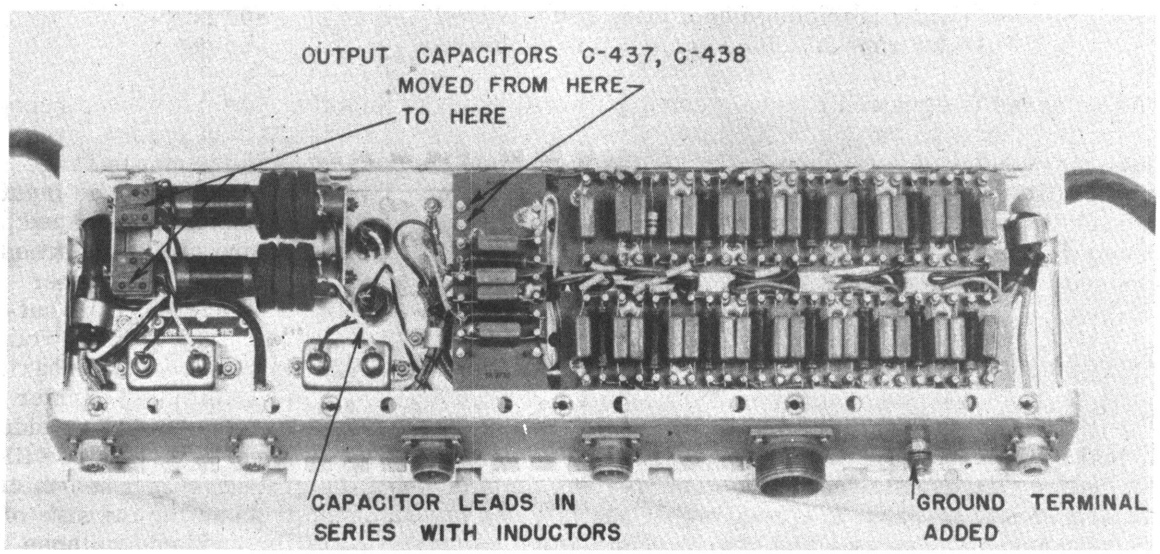

Fig. 1 - Partially-Modified CXHY Filter System
(Also Furnished in Early RDZ Production)

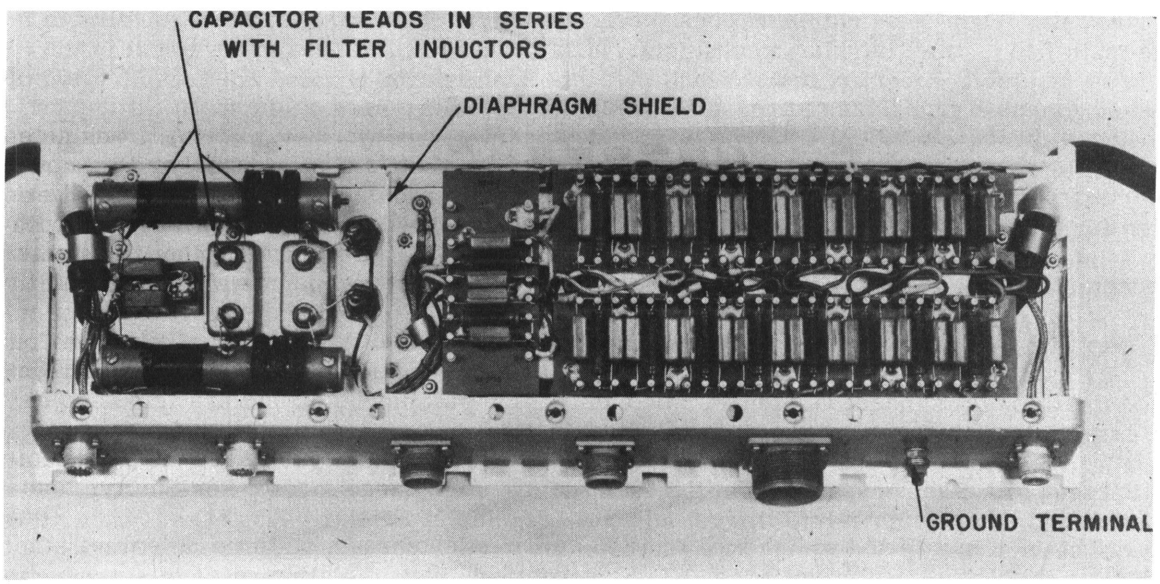

Fig. 2 - Current-Production-Type RDZ/RDZ-1 Filter System

Complete data on the performance of the modified CXHY filter system are given in paragraphs 42 through 45 and Plates 33 through 36 of reference 4. For the purposes of this report, these data and those of reference 2 are summarized as follows:

Average insertion loss of power-input filter:	51 db
Average power-line sensitivity:	-60 db*
Average remote audio line sensitivity:	-61 db*
Average Autotune control line sensitivity:	-56 db*

*As referred to standard receiver sensitivity with antenna injection.

In paragraph 2.4 of reference 3, the average insertion loss of the Autotune control line type of filter was shown to be in the order of 20 decibels. These average values, in general, are for ten measurements approximately equally spaced across the frequency range of the receiver. They show the need for a vast improvement in order to insure minimum interference in the operation of the overall communication system.

ANALYSIS OF FACTORS AFFECTING PERFORMANCE

7. It was shown in paragraph 6 of reference 2, and reiterated in paragraph 45 of reference 4, that the attenuation of Autotune control line sensitivity was increased approximately 30 decibels by the simple procedure of increasing the tension of the grounding springs on the CXHY main filter panel to a point where the latching levers at the front of the cabinet would no longer operate the securing mechanism. Since the principal difficulties encountered in removing the filter system involve the maneuvering of the complete assembly and its connected cables into the receiver cabinet (after the securing mechanism has been released), it was concluded that the overall operation would suffer very little additional inconvenience as the result of substituting a positive-contact securing means. This modification was accordingly decided upon as the basic step in the development of the improved filter system, and all comparative data subsequently reported herein were collected under identical conditions; i.e., eight steel clamping dogs, secured with machine screws, were substituted for the main filter-panel latching mechanism. In addition to a distinct improvement in the overall shielding integrity, it was found that this modification enabled close duplication of measurements regardless of pressures applied at various points on the main filter panel. Aberrant measurements still had to be guarded against when working with the production-type filter system, due to variations in contact between the main filter panel and its cover, which is secured with airplane type spring-tension bayonet fasteners. In laying out the design for the improved filter system, it was therefore planned to isolate the power-line filters and their associated input receptacle, and the remote-line filters and their respective receptacles, by completely enclosing each of the two groups in separate metal shields.

8. As with the initial development, the possible attenuation of the individual filters was largely controlled by space limitations; hence, little improvement could be expected from modification of the inductive elements. However, the subsequent advent of various types of essentially non-inductive capacitors gave promise of considerable improvement in the UHF range. Thus, for the power-line filters, consideration was given to the employment of Sprague "Hi-Pass" capacitors in the 0.01 and 0.1 microfarad sizes. For the Autotune-control and other remote-line filters, advance samples of Erie "Hi-K" ceramic capacitors were obtained in a feed-through type of 1800 micro-microfarads, and in a miniature stand-off style of 2500 micro-microfarads. In a preliminary test, the attenuation of a production-type RDZ power-line filter was increased 10 decibels by adding one of the latter (Hi-K stand-off style) at the input-receptacle terminal.

9. It is obvious that no effective filtering can be expected unless the input and output circuits, exclusive of the filter, have attenuation with respect to each other which is at least greater than that attained with the filter proper. Strong indication of this type of deficiency was noted during evaluation of the CXHY equipments, as was reported in references 2 and 4. Subsequent definite evidence that the Autotune control-line filters were not functioning in the RDZ production equipments was obtained by measuring the change in receiver response to a signal injected into the control line, with its associated filter intact, and with the inductor element removed (filter circuit left open). Since essentially no difference in attenuation could be measured for the two conditions, it was evident that this type of filter was not functioning as such due to by-passing from the filter-input to the antenna-input circuits through various coupling media. The reduction of all types of undesired couplings to the absolute minima therefore gave promise of providing the greatest improvement in the overall performance of the system. It was concluded that the desired degree of isolation would be most nearly attained by: (a) terminal and section compartmentation of the two sub-assembly shields for maximum reduction in electric and magnetic coupling; and (b) direct mounting of all capacitor ground terminals to the shielding structures (i.e., elimination of terminal studs and connecting wires) to minimize lead inductances and provide the nearest possible approach to a unipotential ground plane.

TRIAL FILTERS

10. Two individual filters were constructed in accordance with the foregoing conclusions, employing the proposed components for the power-line and Autotune types of filters, respectively. Each of these trial filters was completely encased in metal, with the input and output connections brought out through Type "N" concentric fittings. This construction made it very convenient to insert either unit in series with the input cable to the antenna terminal of the Model RDZ Receiver and note the resultant attenuation of an applied signal. Thus, the actual insertion loss, as averaged from measurements taken at ten frequencies in the range of 231.4 to 389.8 megacycles, was 82.1 and 69.0 decibels for the power line and Autotune types, respectively. By comparison with the corresponding values previously measured for the RDZ production types (see paragraph 6), these figures indicate relative increases in actual insertion loss of 31 and 49 decibels for the two types. As was expected from the greater degree of input-to-output isolation obtained in the trial structure of the Autotune type filter, more improvement in actual attenuation was obtained. Since the final value was still relatively low, however, it was decided to employ two-section filters for this type in the construction of the preliminary model.

PRELIMINARY MODEL

11. Figure 3 shows the construction of the first model of the improved filter system, with the two sub-assemblies mounted on a main filter panel and receptacle assembly furnished with one of the original CXHY receivers. The copper cases for the two sub-assemblies and their respective covers were fitted into the space vacated by removal of the original filter components, so that the entire system including the outer cover (not shown) is interchangeable with the production type filter systems currently being furnished with RDZ and RDZ-1 receivers.

12. The case for the power-line filter sub-assembly is fabricated in the shape of the letter "L" in order to tie it in with the shelf at the power-input receptacle and to clear the Scan and Video cables and receptacles. This unit comprises a two-section low-pass filter for

each side of the power line. The original inductor elements were employed, but the forms were sawed in-two between the multilayer input sections and the single layer output sections to permit the insertion of the diaphragm shield. Four 2500-micro-microfarad Hi-K ceramic stand-off capacitors are employed, two mounted on securing screws for the input receptacle (obscured by the shelf lip in Figure 3, but visible in Figure 5) and two mounted on the left wall of the case at the output terminals. The tapped mounting ferrules on this style of by-pass capacitors are common to the ground plate, and double-ended pigtails provide connections to the high-potential electrode in such manner that virtually all the lead-inductance is in series with the inductor elements of the filter. Two 0.1-microfarad tubular "Hi-Pass" capacitors are employed at the inputs and two .01-microfarad units of the same type at the junctions of the inductor elements. These are rolled paper capacitors of the feed-through type employing cylindrical metal shields connected with the ground electrodes and heavy axial busses for the high potential terminals. As shown in Figure 3, the metal shields of these input capacitors are connected direct to the bottom of the sub-assembly case with sweated-on mounting clamps. The cases of the intermediate capacitors project through the diaphragm shield and are sweated to mounting plates which are bolted thereto.

13. The two-stage filter sub-assembly for the remote audio, silencer and Autotune lines is shown to the right on Figure 3. The copper case for this unit is rectangular in plan, with one longitudinal diaphragm shield between the two filter sections, and with only the end baffles and sub-assembly cover projecting forward to the shelf to form a shielding barrier

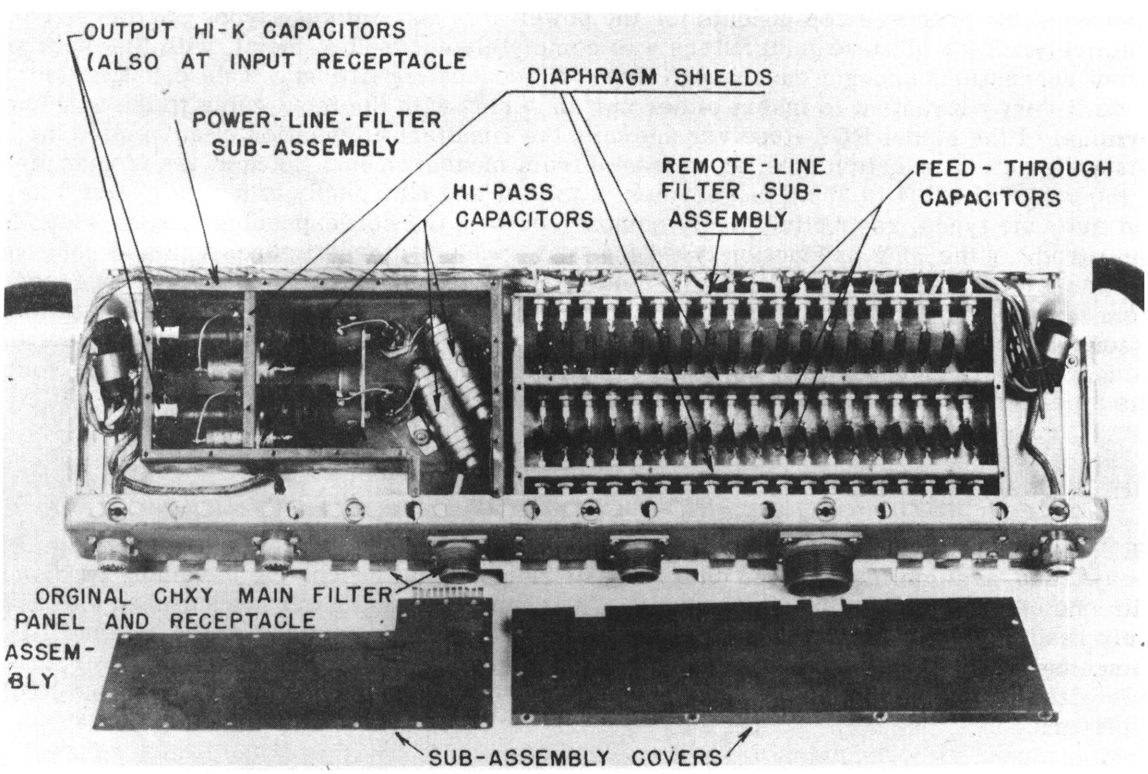

Fig. 3 - Preliminary Model, Improved RDZ/RDZ-1 Filter System
Main and Sub-Assembly Covers Removed

surrounding the audio and remote receptacles and their respective connections to the filter input terminals. The only shielding provided for the filter output terminals is that furnished by the main filter system panel and outer cover, since all other circuits are well isolated within the sub-assemblies. "Hi-K" ceramic 1800-micro-microfarad capacitors of the feed-through type are employed throughout this structure, with the metal bodies grounded directly to the sub-assembly shields so that the inductance of the high-potential feed-through terminals is connected in series with the inductive arms of the respective filters. Although advantage was taken of the height of the enclosure to mount the inductors at an angle, it was still necessary to employ shorter forms than those furnished in RDZ production. The forms in the input sections are close wound for maximum inductance (about 1.45 microhenries), while those in the output sections are space wound for minimum distributed capacity.

14. Initial comparative measurements of this first improved model versus a production type (RDZ/RDZ-1) filter system, when installed in Model RDZ Receiver, Serial No. 5, showed the average relative attenuation of resonant signals injected at the remote line receptacles as compared with the signals applied to the antenna input terminal to be approximately as follows:

AVERAGE ATTENUATION

Filter	RDZ/RDZ-1	Improved Model	Improvement
Power Line	55 db *	115 db	60 db
Autotune	55 db *	85 db	30 db

* These data show attenuation as measured on RDZ Serial 5, whereas the figures for corresponding lines as summarized in paragraph 6 were for sensitivity of the modified CXHY.

By comparing the above values with those reported in paragraph 10 for actual filter-insertion-loss, it will be noted that the increase in overall attenuation due to indirect signal injection is 33 decibels for the power-line filter, and only 16 decibels for the Autotune type. From this analysis, it was concluded that little gain had been effected by the addition of the second stage to the Autotune-type filter, and that appreciable coupling still existed between its output terminals and the signal-input circuit of the receiver. Accordingly, it was decided to fabricate another model of this sub-assembly, employing single-section low-pass filters throughout, and using the space so gained to provide an additional shielding enclosure for the filter output terminals and the associated cabinet cable terminations from the receiver.

DETAILS OF FINAL DESIGN

15. The final design of the improved RDZ/RDZ-1 filter system is shown in Figures 4 through 6, inclusive. Figure 4 is a similar view to Figure 3, just discussed, which clearly shows the modifications to the remote-line-filter sub-assembly. Figure 5 is a reversed view, looking inward from the upper edge of the panel to show the input-terminal compartmentation and the various component part designations. Figure 6 shows the improved filter system, completely assembled except for the outer cover.

16. It will be noted that the new sub-assemblies are mounted on the main panel and receptacle assembly of the original unmodified CXHY filter system, which is interchangeable

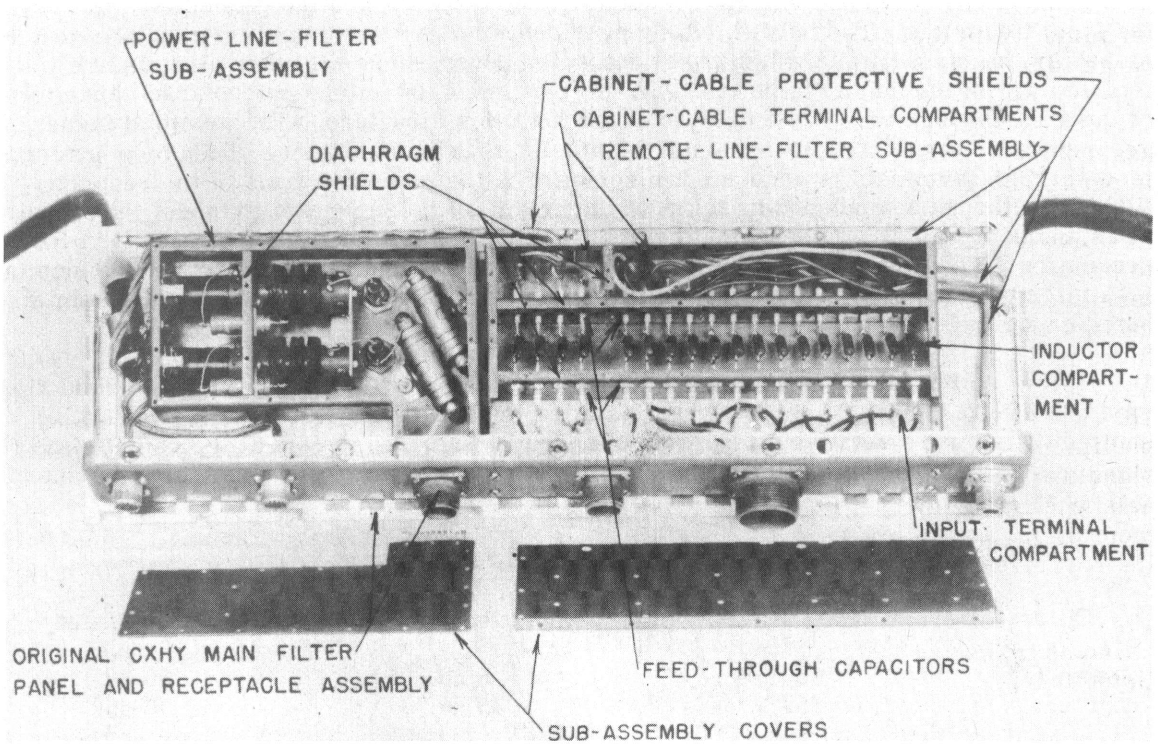

Fig. 4 - Main and Sub-Assembly Covers Removed

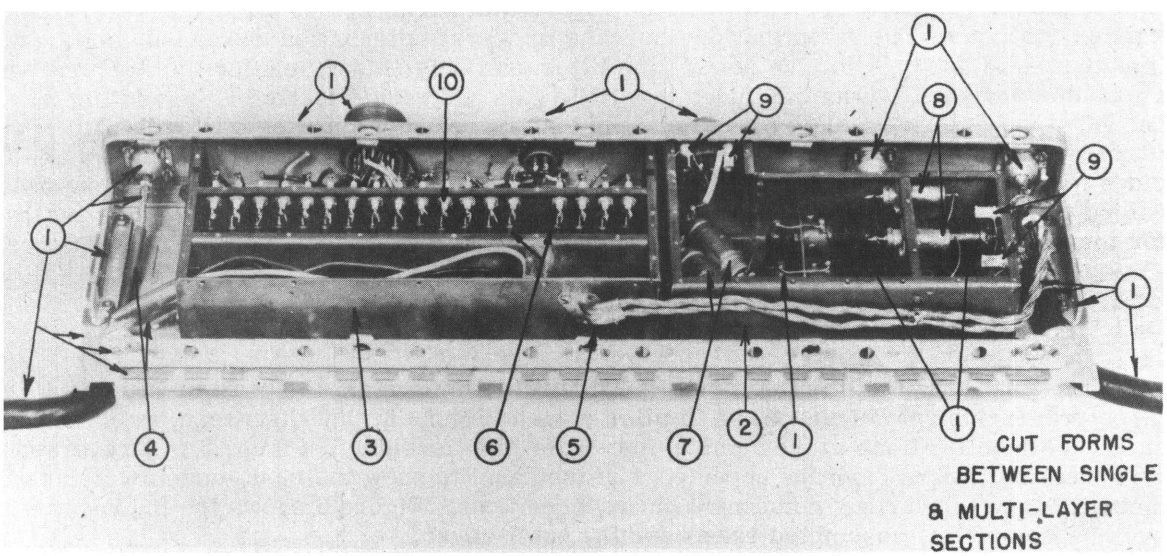

Fig. 5 - Reversed View Showing Input-Terminal Compartmentation and Component Part Designations

with and essentially similar to the current RDZ type except for the omission of the ground terminal. It is therefore possible to fabricate the improved sub-assemblies only, and arrange to substitute them for the original filter components as a field operation.

17. By comparing Figure 4 with Figure 3, it will be seen that the power-line-filter sub-assembly remains unchanged from the arrangement of the preliminary model as described in paragraph 12. The case of the remote-line-filter sub-assembly will be seen to have been substantially altered for the purposes of substituting a shielded output-terminal compartment in lieu of the second-stage filters, and of enlarging the input-terminal compartment to provide more convenient access. Also, an extra diaphragm is inserted in the output-terminal compartment to shield the audio and silencer filter terminations of the IF/AF cabinet cable from the Autotune filter terminations of the preselector cabinet cable, all of these leads being brought out from the case through tubular L-shaped protective shields.

18. Upon reassembling this filter system in Model RDZ Receiver, Serial No. 5, rough preliminary measurements indicated an average of 110 decibels attenuation of resonant signals injected at terminal "G" of the remote receptacle as compared with the same signals when applied to the antenna input terminal. This indicates an approximate improvement of 25 decibels over the two-section filter, as reported in paragraph 14, and 55 decibels improvement over the RDZ production type.

19. A complete list of the component parts as used in this final design, together with detailed specifications, is given at the conclusion of the report. The part designations as listed therein correspond with those shown in Figure 5.

EVALUATION PROCEDURES

20. Other than actual insertion-loss data, it will be noted that the merit of the respective

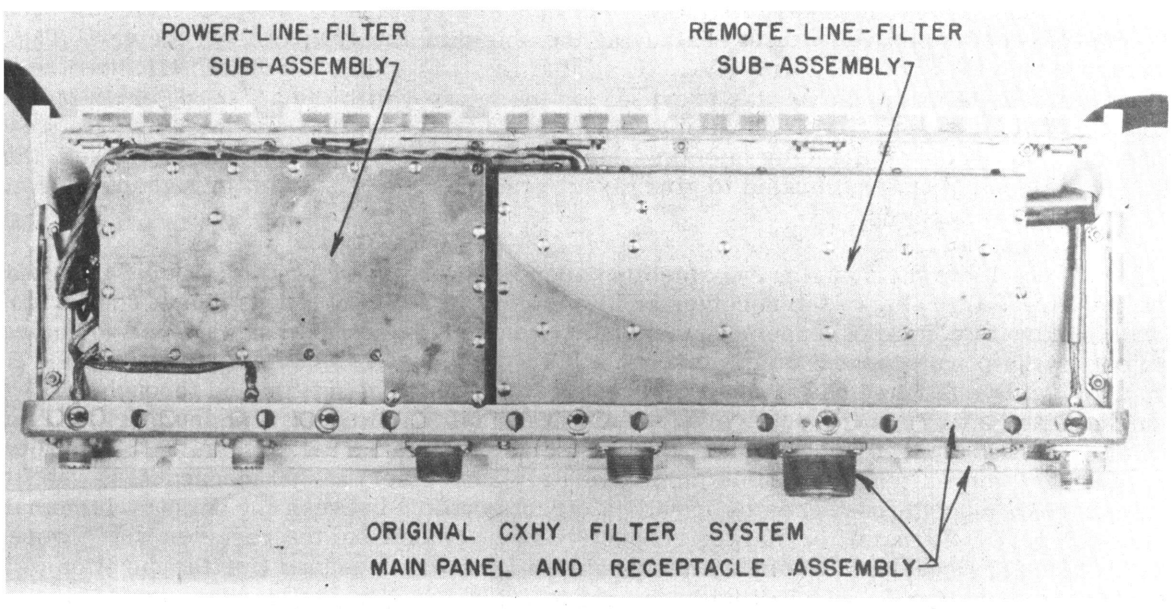

Fig. 6 - Assembly Complete Except Outer Cover

filters was reported in references 2 and 4 in terms of relative power, audio and Autotune-line sensitivity, those measurements having been made on a standard-sensitivity basis. However, that very desirable method of evaluation was made possible only by reason of the relative ineffectiveness of the filter system which was under investigation. Suitable means of measuring the effectiveness of the improved filter system described in this report presented a more difficult problem. No available signal generator covering the range of the receiver was capable of supplying more than 0.1-volt output. Assuming a receiver sensitivity of one microvolt, attenuation measurements would be limited to a maximum of 100 decibels. Since the standard sensitivity of the Model RDZ/RDZ-1 receiver varies across its range between the limits of 3 and 15 microvolts, the practical use of calibrated signal generators was limited to attenuation measurements in the order of 75 or 80 decibels. The one available signal source with adequate output was the Model TDZ Transmitter. It therefore became necessary to develop a suitable means for evaluating the effective voltages delivered to the receiver, in order that attenuation data could be determined with a reasonable degree of accuracy.

21. The first method tested involved the calibration of the input meter of the receiver in terms of micro-volts signal applied to the antenna terminal. Since it was necessary to employ a calibrated signal generator for this purpose, the known values of input were limited to 0.1 volt maximum. To read inputs of higher magnitude required that a curve be plotted (microvolts input vs Input Meter deflection), and that this curve be extended for values beyond the maximum generator output. This method proved to have one very serious disadvantage, in that the calibrated curve was nonlinear and became practically flat for inputs in the order of 0.1 volt, thereby introducing possibilities of large errors for high-input readings. It was also determined that the slope of the calibrated portion of the curve was subject to variation with frequency.

22. To overcome the reading-errors associated with the non-linearity of the input meter, a 0-100-microampere meter was wired in series with the load circuit of the second-detector diode. After determining that metering in this circuit remained quite linear over a suitable range of signal input, this meter was mounted in place of the input meter in order to provide good visibility without destroying the shielding integrity of the receiver. The receiver was then operated with AVC off, so that the R.F. gain control was effective, and a temporary blank-paper scale was provided for the latter. With the aid of a Ferris Model 16-C signal generator (2 volts available output at 15.1 megacycles, the intermediate frequency of the receiver), and by injecting this signal into the grid circuit of the mixer, the R.F. gain control was calibrated to give direct readings of attenuation throughout the range of zero to 138 decibels.

23. To complete the system, two shielding adaptors were fabricated, one being mounted on the Power line plug to the receiver and the other on the Remote line plug. The former was fitted with a Type N connector, the central contact of which was permanently coupled to one of the power-input contacts through a 0.01-microfarad capacitor. Likewise, the Remote adaptor was fitted with four Type N connectors; these being coupled through 0.01-microfarad capacitors, respectively, to audio terminal "J", silencer terminal "R", Autotune common terminal "G", and Autotune channel-selector terminal "H". Also, a 135-foot length of RG-21/U high-attenuation cable (approximately 35 decibels at 300 megacycles) was fitted with Type N plugs at both ends to provide a direct coupling between the Antenna terminal of the Model TDZ Transmitter and the respective input circuits to the receiver which were to be tested. The receiver Autotune clutch-release knob was loosened (for the duration of the tests) and a small hole was drilled in the preselector cover to permit insertion of a trimmer tool for manual operation of the main tuning control. Finally, two Sprague Hi-Pass

radio-frequency filter units were connected in series with each side of the power supply to the Model TDZ Transmitter.

24. As a result of various investigative trials, the following procedure was finally adopted for evaluating the relative merits of the improved filter system vs the RDZ production type:

(a) After suitable warmup, the TDZ transmitter was set to the desired frequency channel and the tuning controls were checked for maximum output with the selector switch in the "Tune" or low-power position (the transmitter was operated unmodulated in all tests, with its output keyed by the "Carrier" switch).

(b) With the improved filter system rigidly mounted in Model RDZ Receiver, Serial No. 5, the transmitter output cable was plugged into the antenna input connector. With the R.F. gain control retarded approximately 50 decibels, and with the transmitter carrier on, the receiver was set to the corresponding frequency channel by means of the Autotune selector and the main tuning control was adjusted manually to produce maximum response (R.F. gain simultaneously readjusted to limit the peak diode current to 40 microamperes or less to ensure against overload).

(c) With the transmitter output cable completely disconnected from the receiver and carrier off, and with full receiver R.F. gain (control set to zero attenuation), note was made of the change in initial diode current reading (due to noise and contact potential) when the transmitter carrier was switched on; i.e., the change in diode current due to poor shielding integrity of the transmitter and/or the receiver, or to conduction between the two units by way of the power-line connections. (Note: Appreciable receiver leakage was found in the first test. This was corrected by the insertion of temporary grounding clips between the front panel and the mounting nuts of the power switch and phones jack, and between the preselector cover and the edge of the recessed sub-panel on which the preselector controls are mounted. No appreciable leakage of this nature was noted during any subsequent tests.)

(d) With the transmitter output cable plugged into the connector on the receiver power-input-plug adaptor, with transmitter carrier switched off, and with full receiver R.F. gain (zero attenuation setting of the control), note was made of the diode-current indication resulting from noise and contact potential (Note: For the ten frequency channels employed throughout the tests, the noise readings varied between the limits of 7 and 11 microamperes). The R.F. Gain control was then retarded until the diode current due to noise was reduced to zero. The transmitter carrier was then switched on and the R.F. Gain control was <u>further retarded</u> to produce a convenient diode current indication, due to signal, preferably in the range of 10 to 50 microamperes. If such a convenient reading could not be obtained by retardation of R.F. Gain below the zero-noise-current setting, the transmitter output was increased by throwing its selector switch from the "Tune" to the "Operate", or high-power, position. If the desired R.F. Gain control setting was obtained with the low-power output from the transmitter, a check was nevertheless made in the high-power condition to insure (by observation of the proportionate increase in diode current) that the receiver was not being overloaded. Wherever possible, these measurements were made with low-power output (transmitter selector switch in "Tune" position). Having obtained the desired adjustments, the resultant diode current and R. F. Gain control setting were jotted down. The transmitter carrier was then switched off, the transmitter-output cable was transferred to the antenna input connector of the receiver, and the R. F. Gain control was retarded approximately half-way. The transmitter carrier was then switched on (with the same power-output as employed in obtaining the above-described desired adjustments), and the receiver R.F. Gain control was again adjusted to duplicate the previously noted diode-current indication. The previously noted setting of the R.F. Gain control was then subtracted from that obtained by this final adjustment; and the difference, in decibels, was logged as the effective attenuation of the receiver, at the frequency employed, to signals injected into the power line.

(e) With no other change except that the transmitter-output cable was transferred, successively, to the four connectors on the remote-line-plug adaptor, operation (d) was repeated in its entirety to complete the collection of data applicable to the frequency employed for each of the four remaining circuits selected for these tests.

(f) Operations (c), (d) and (e) were repeated for each of the nine remaining frequencies selected for the tests.

(g) With the exception that the RDZ production type filter system was substituted for the improved model, operations (a) through (f) were repeated in their entirety in order to ascertain the relative merits of the two filter systems. It should be noted that the data so collected show the production system to be somewhat better than it actually is, as these tests were also made with the panel rigidly clamped rather than with the quick-release system furnished in production equipments.

PERFORMANCE CHARACTERISTICS

25. The data collected by the aforedescribed procedures are shown graphically in Figures 7 through 11 inclusive (compared with signals applied to antenna input terminal, RDZ receiver, constant output basis). Since all these curves show the usual standing wave effects common to measurements taken at these frequencies, the average value for each plot has been indicated in the associated note in order to facilitate comparison. A more detailed summary of the relative merits of the two filter systems is set forth in Table I.

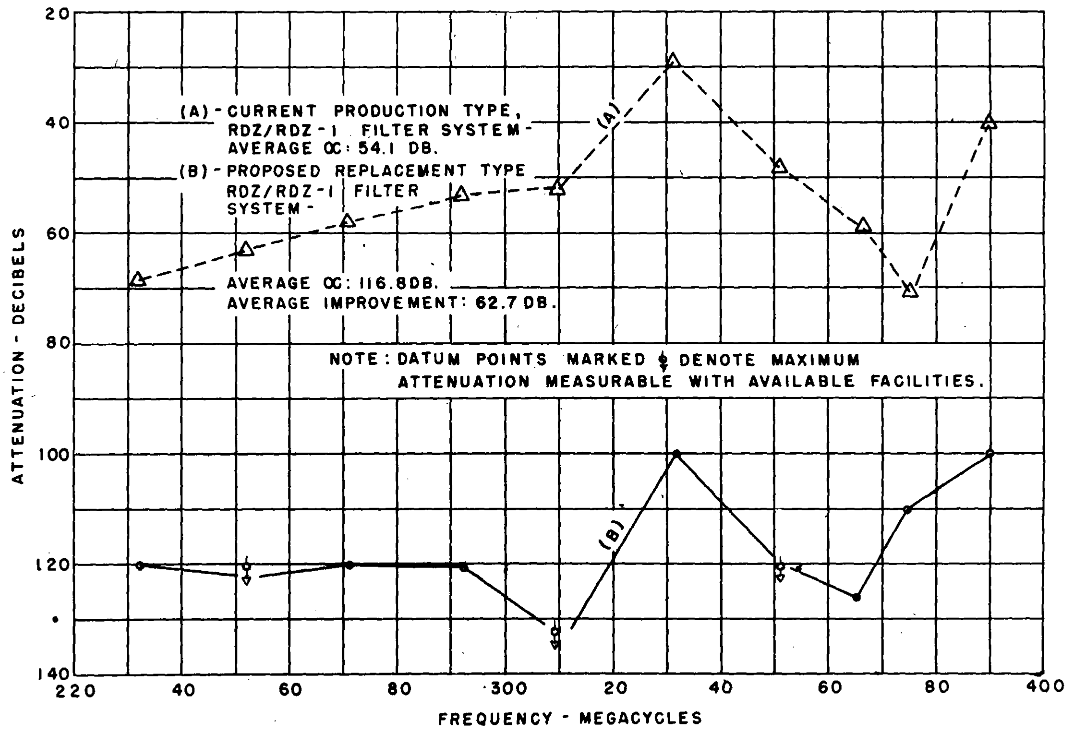

Fig. 7 - Relative Attenuation of Signals Injected at the Power Line Receptacle

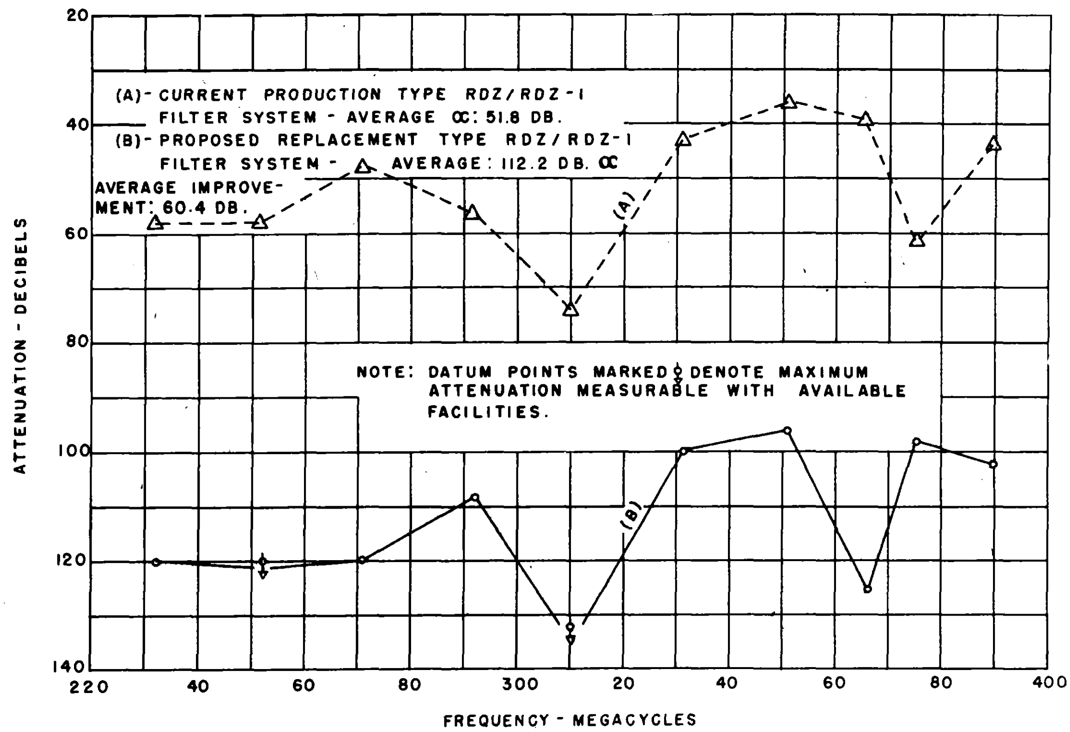

Fig. 8 - Relative Attenuation of Signals Injected at the Remote Receptacle Audio Terminal "J"

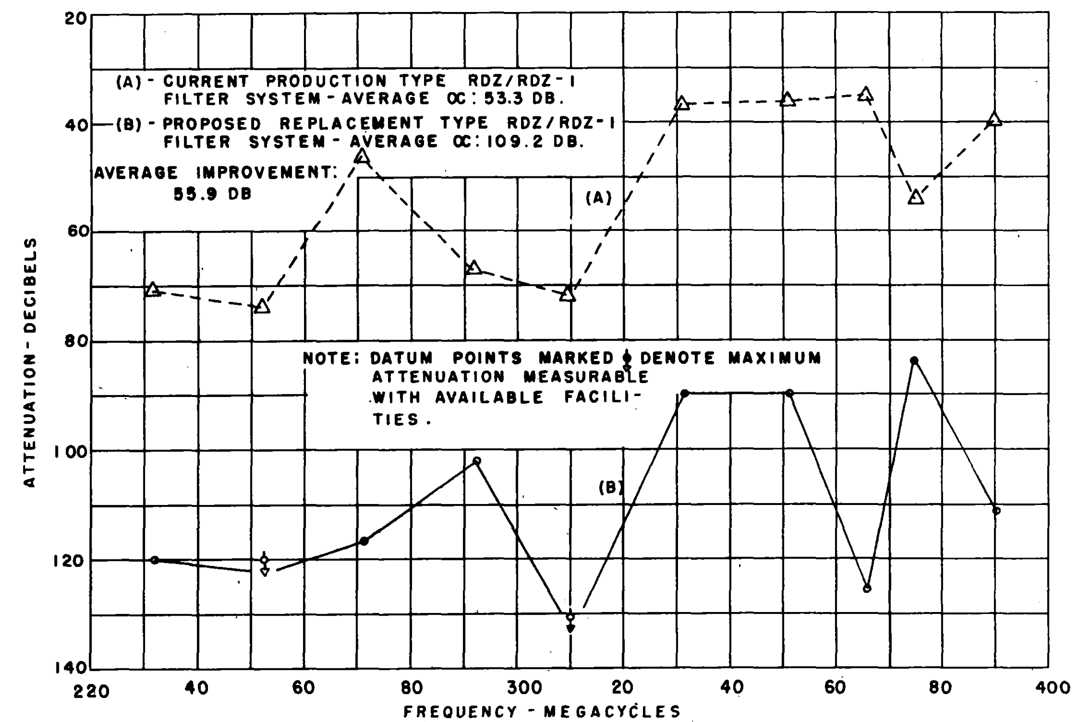

Fig. 9 - Relative Attenuation of Signals Injected at the Remote Receptacle Silencer Terminal "R"

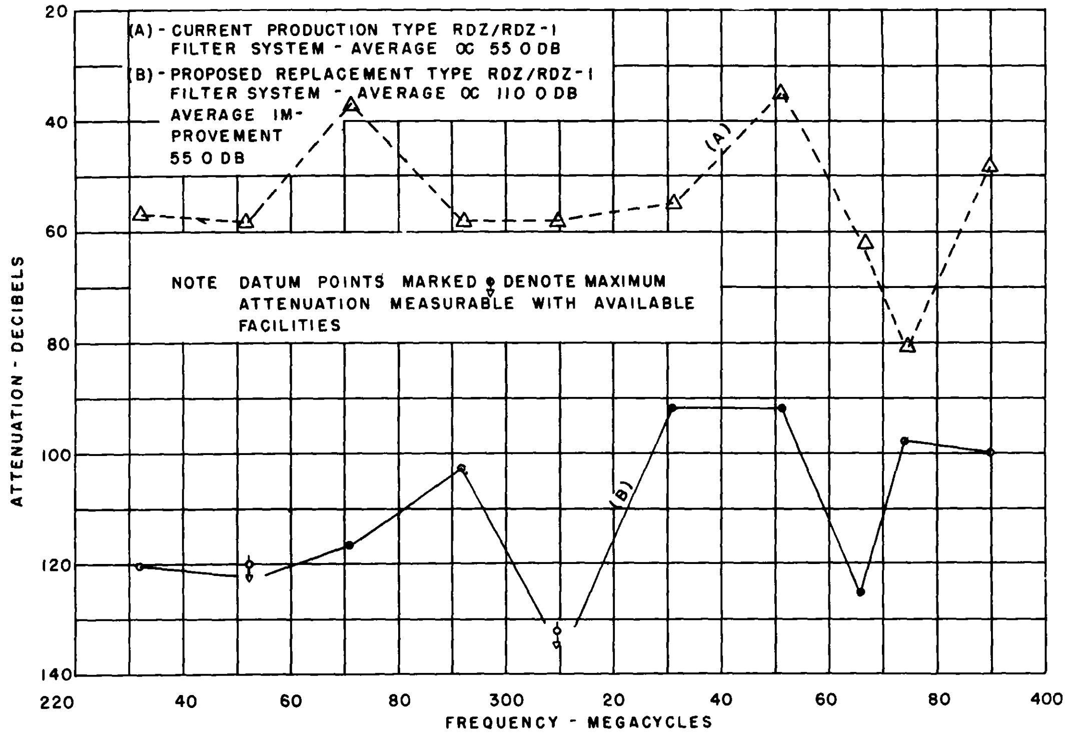

Fig. 10 - Relative Attenuation of Signals Injected at the Remote Receptacle Autotune Terminal "G"

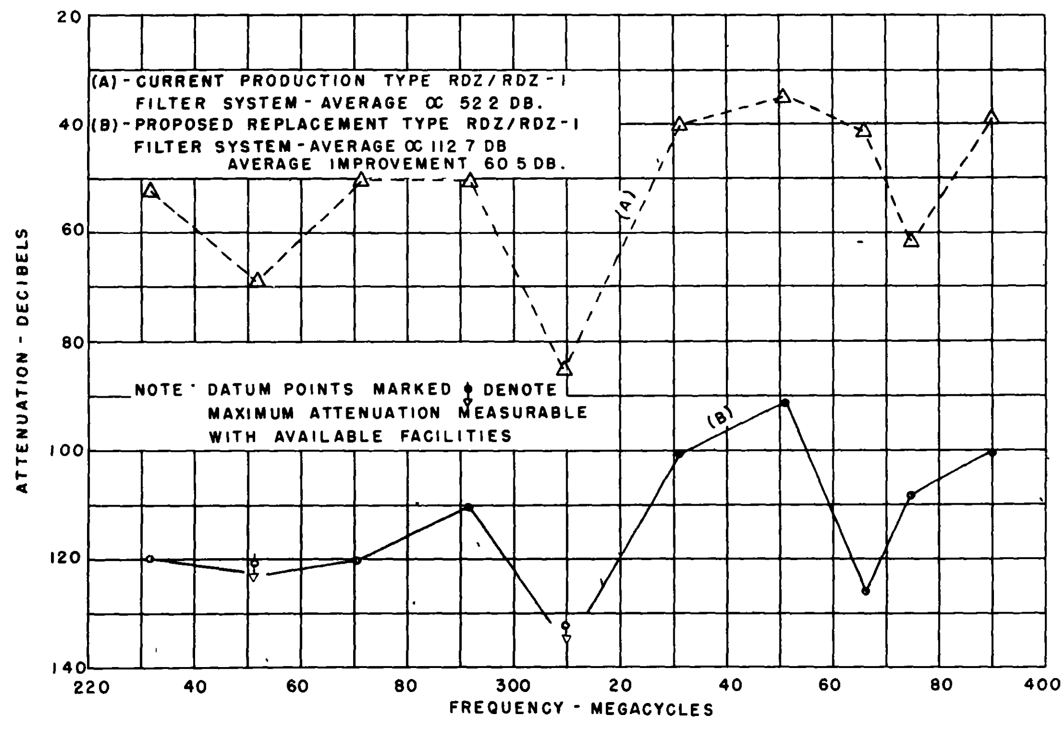

Fig. 11 - Relative Attenuation of Signals Injected at the Remote Receptacle Autotune Terminal "H"

TABLE I

SUMMARY OF RELATIVE MERITS
IMPROVED vs CURRENT PRODUCTION RDZ/RDZ-1 FILTER SYSTEMS

(See Figures 7-11 for detailed characteristics)

Signal Injection Circuit	Attenuation	Production Filter	Improved Filter	Improvement
Power Line	Minimum	29 db	100 db	----
	Maximum	71	132 +	----
	Average	54.1	116.8	62.7 db
Audio Line (J)	Minimum	36	96	----
	Maximum	74	132 +	----
	Average	51.8	112.2	60.4
Silencer Line (R)	Minimum	35	83	----
	Maximum	74	131 +	----
	Average	53.3	109.2	55.9
Autotune Line (G)	Minimum	35	92	----
	Maximum	81	132 +	----
	Average	55.0	110.0	55.0
Autotune Line (H)	Minimum	35	91	----
	Maximum	85	132 +	----
	Average	52.2	112.7	60.5
	AVERAGE OVERALL IMPROVEMENT			58.9 db

CONCLUSIONS

26. In view of the adverse conditions outlined in paragraph 2 of this report, it is concluded:

(a) That the Type-53280 R.F. Filter Units furnished with current-production Model RDZ/RDZ-1 receivers provide insufficient protection (within the range of 225 to 400 megacycles) against interference introduced through the power-input and remote-control lines.

(b) That the deficiencies of the Type-53280 R.F. Filter Units result from the combined effects of input-to-output coupling of the respective filter terminals, direct coupling between the power and remote-line terminals and the antenna input circuits of the receiver, non-suitable capacitive elements in the respective filters due to excessive series inductance, high-impedance ground paths in the respective filters, and poor contact between the main filter-system panel and the receiver cabinet.

(c) That the phones jack, power switch, and preselector-control sub-panel are inadequately grounded to the external shielding structure in current RDZ/RDZ-1 production.

(d) That an average improvement of approximately 60 decibels in the overall degree of protection can readily be attained by application of the techniques herein described.

RECOMMENDATIONS

27. It is recommended that consideration be given to:

(a) The advisability of stocking limited quantities of power and remote-line filter sub-assemblies to permit field modification of the main filter-system assemblies of such RDZ/RDZ-1 receiver installations as may be affected by interference from associated TDZ transmitters.

(b) The advisability of stocking limited quantities of suitable spring contacts for grounding the phones jack, power switch, and the preselector-control sub-panel to the outer shielding structure to permit field modification of those RDZ/RDZ-1 receiver installations which may be affected by strong-field interference from TDZ or other nearby transmitters.

* * *

REFERENCES

1. BuShips ltr. Serial 1935(925C) of 26 June 1945 to NRL: Request for Assignment of Problem S633.3R-C.

2. NRL 3rd. Int. Rpt. C-S67/46(353:JWK), C-350-196/45 of 8 June 1945 to BuShips: Advance Notes on Deficiencies Found in Preproduction Model CXHY (RDZ) Receiving Equipment (Problem S633.2 R-C).

3. NRL ltr. Rpt. C-S67/46(353), C-350-539/45 of 6 January 1945 to BuShips: History of Model XCS Receiver Development (Problem S633R-C).

4. NRL Report No. R-2667, 23 October 1945: Test of Model CXHY(RDZ) Radio Receiving Equipment (Problem S633.2R-C).

5. NRL ltr. Rpt. C-S67/L5(1210-ARR), C-1210-217/46 of 30 September 1946 to BuShips: Interference Characteristics of Model TDZ Transmitter.

6. NRL ltr. R-S67/1(1225), R-1220-38961/46 of 9 January 1947 to BuShips: Extension of Comment on Systems Sketch Plan RE 101F 100.

Original data recorded in NRL Log Book No. 2783.

PARTS LIST

IMPROVED RDZ/RDZ-1 FILTER SYSTEM
LIST OF COMPONENT PARTS USED IN FINAL DESIGN

(See Figure 5 for Relative Locations)

Part No.	Description	No. Required
1	Main Filter Panel and Receptacle Assembly, current RDZ/RDZ-1 production type, including 2 cabinet cables and clamps, 2 fuse holders and fuses, 2 power-line-filter inductors and mounting brackets, and 1 outer cover.	1
2	Power-Line-Filter Sub-Assembly Case, 7" x 3 1/2" x 1 11/16" approximate, with L-shaped offset at right end (to accept internal projection and mounting screws of Power receptacle) and 1 diaphragm shield, 1/16" sheet copper, complete with 1/32" sheet copper cover plate and necessary mounting and securing screws.	1
3	Remote-Line-Filter Sub-Assembly Case, 9 5/8" x 3" x 1 11/16", with end baffles extended 1 1/2"(for attachment on receptacle shelf to form input-terminal compartment) and 2 diaphragm shields, 1/16" sheet copper, complete with 1/32" sheet copper cover plate and necessary mounting and securing screws.	1
4	Protective Shield for Preselector Cabinet Cable, fabricated "L", 9/16" I.D. x 5/8" O.D. brass tubing, with 3/16" I.D. x 1/4" O.D. antenna cable outlet and mounting flange.	1
5	Protective Shield for Audio and Silencer Cables, dual fabricated "L", 3/16" I.D. x 1/4" O.D. copper tubing, with mounting flange.	1
6	R.F. Chokes for Remote-Line Filters, 33 turns No. 26 A.W.G., S.S.E. covered, wound close on 3/16" O.D. x 11/16" phenolic forms, molded-in pigtail leads.	18
7	Hi-Pass Capacitors, 0.1 μf, 200 V.D.C.W., Sprague Electric Co. Cat. No. 48P-1.	2
8	Hi-Pass Capacitors, 0.01 μf, 400 V.D.C.W., Sprague Electric Co. Cat. No. Y-6097.	2
9	Hi-K Ceramic Capacitors, 2500 $\mu\mu$f, stand-off type, grounding bushings tapped No. 4-40, dual-ended hi-pot pigtail leads, Erie Resistor Corp. Cat. No. EX-258.	4
10	Hi-K Ceramic Capacitors, 1800 $\mu\mu$f, feed-through type, Erie Resistor Corp. Cat. No. 2325-000.	36

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