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DEVELOPMENT OF A VHF FREQUENCY CONVERTER UNIT FOR THE AN/MKR-4 TELEMETER RECEIVING EQUIPMENT

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DEVELOPMENT OF A VHF FREQUENCY CONVERTER UNIT FOR THE AN/MKR-4 TELEMETER RECEIVING EQUIPMENT

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June 22, 1948

Approved by:

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Abstract

This report describes a VHF frequency converter unit designed for use with the modified RBF-3 FM receiver of the AN/MKR-4 telemeter receiving equipment. The converter unit has been given the designation, X4-CV-4B, and tunes from 215 Mc to 222 Mc providing a voltage gain of approximately 8 decibels with a band width of 500 kilocycles at half power points. The unit can be tuned plus and minus one megacycle from its aligned frequency by one control with a loss of output less than 3 decibels. Instructions for either internal or external attachment to the RBF-3 receiver are included in this report. Complete gain, selectivity, noise, interference, and frequency versus temperature characteristics of the unit are described. Sensitivity and selectivity characteristics of the converted receiver are also given.

Problem Status

This is an interim report representing the completion of the phase of Program R05-27 devoted to the development of a frequency converter unit for the AN/MKR-4 telemeter receiving equipment.

DEVELOPMENT OF A VHF FREQUENCY CONVERTER UNIT FOR THE AN/MKR-4 TELEMETER RECEIVING EQUIPMENT

INTRODUCTION

The frequency band allocated for telemetering was changed by the Federal Communications Commission from 72-76 Mc to 215-222 Mc making it necessary to design and develop a new transmitter to replace the transmitter of the AN/AKT-5 telemeter transmitting equipment, and to convert the modified RBF-3 receiver of the AN/MKR-4 telemeter receiving equipment for reception of signals in the new band. The purpose of this report is to describe a VHF frequency converter unit designed and developed for the purpose stated above, and subsequently given the designation X4-CV-4B. Operating characteristics of both the frequency converter unit and the converter-receiver combination are given. Also detailed instructions for receiver modification, internal mounting (where possible), or external attachment, and operation of the frequency converter with the AN/MKR-4 equipment are included. The transmitter development phase of this work is covered in another report.

Reference (a) requested that NRL perform the work necessary to convert the AN/AKT-5 and AN/MKR-4 telemetering equipments for operation in the newly allocated frequency band. The problem request (S-2163R) was officially accepted by reference (b) and work on the problem was initiated immediately thereafter. Subsequently, cognizance of this problem was transferred from BuShips to BuAer as set forth by reference (c).

In a telephone conference between representatives of the Bureau of Aeronautics and the NRL, it was agreed that the NRL should supply six frequency converter units for modification of the existing AN/MKR-4 receiving stations as a part of the development.

Since no AN/MKR-4 telemeter receiving system was available at NRL, a Navy model RBF-3 frequency modulation receiver was modified in accordance with reference (d) and used in conjunction with performance analysis tests of the X4-CV-4B converter unit. Other information pertaining to the AN/MKR-4 system necessary for the determination of certain design principles of the frequency converter unit were obtained from reference (d) and reference (e).

No detailed dimensions of the modified RBF-3 were available and the converter was designed for internal mounting in the receiver. Later information made it necessary to adapt the unit for external attachment.

TECHNICAL CONSIDERATIONS

No specifications were set forth by reference (a) other than designation of the frequency band. However, since it was originally desired that the converter unit be contained within the modified RBF-3 receiver if possible, its size was at once limited. It seemed also that any additional gain that could be provided by the frequency converter would be desirable since it would permit improvement of the signal-to-noise ratio over that of a converter having only unity gain.

Two expected operating frequencies of the converted receiving station were the 217.55 and 219.35 Mc assigned channels, making it desirable to develop a unit having sufficient selectivity to provide attenuation of undesired signals as well as some discrimination between the two channel frequencies; yet broad enough to permit selection of either assigned frequency by tuning not more than one control in addition to the tuning control of the RBF-3 receiver.

At frequencies above 50 Mc, the performance of the special mixer and converter tubes employed at lower frequencies is greatly reduced because of increased thermal noise due to lower input resistance. Other disadvantages of pentagrid converter tubes are: (1) low oscillator section transconductance, (2) oscillator instability with signal-grid bias variations, and (3) oscillator frequency currents flowing through signal-grid circuits. At frequencies as high as 100 Mc, the high transconductance television pentodes operate satisfactorily, but above 100 Mc, the special high-frequency pentodes are superior, having the capability of successful operation at frequencies as high as 400 Mc. Keeping these special tubes, such as the 9000 series and acorn series, in mind, a still different type of converter tube is preferred from 200 Mc upward because it has a lower noise level and higher conversion transconductance. This is the triode mixer and is the type chosen for use in the X4-CV-4B converter unit. A grounded-grid RF amplifier and a grounded-grid mixer circuit are used to eliminate the necessity for neutrolization, each using a 6J4 triode.

Since ordinary parallel resonant circuits are difficult to construct at frequencies above 200 Mc due to stray and tube interelectrode capacities, a more practical circuit is desired. The tank circuits used are referred to as being parallel resonant - - series tuned because of the use of tube interelectrode capacity in series with the tuning capacitor for resonating the inductor which is in series with tube electrode inductance. Hence, a very small tuning capacitor is advantageous in that it reduces the effects of variations of interelectrode capacity. Also, impedance matching in inductively coupled circuits is facilitated due to the larger, more practical size of the inductors. In general such a circuit is not suitable if it must be tuned over a wide frequency range due to difficulties encountered in tapping the coil at RF ground potential for grid return to ground or for plate supply voltage. However, in the X4-CV-4B frequency converter, the required tuning range is quite small, permitting use of this type of circuit to the realization of its fullest advantages.

DESCRIPTION OF THE CONVERTER

General Description

The X4-CV-4B frequency converter unit is furnished with all necessary parts for either internal mounting in the RBF-3 receiver or external attachment if internal mounting is not possible. Figure 1 shows the unit and associated parts for the internal mounting including mounting brackets, planetary drive tuning assembly, name plates, non-metallic alignment tool, right-angle antenna adapter, interconnecting cables and connectors, plate supply dropping resistor and support, and calibration chart (sample). Figures 2 and 3 show the unit as supplied for external attachment to the RBF-3 receiver.

The converter unit circuit components are mounted on a silver-plated brass chassis-plate 8 inches long by 3 5/8 inches wide by 1/16 inch thick as shown in Figures 4 and 5. The chassis-plate mounts on a silver-plated brass shield-cover 8 inches long by 3 5/8 inches wide by 2 inches deep, constructed of 1/16 inch brass. For the internal mounting, the shield-cover and chassis-plate assembly is secured to the back of the modified front panel of the RBF-3 receiver by means of two aluminum mounting brackets as shown in Figures 6 and 7. This method of mounting was chosen to permit adjustment of alignment controls through ports provided in the receiver front panel, and a vernier adjustment of the converter unit mixer plate circuit. The converter

RF output is fed to the receiver antenna connector from J-602 through an RG-11/U coaxial cable which connects to the receiver antenna jack. The power to the converter unit comes from the receiver power supply through a three conductor power cable to receptacle J-603 on the chassis plate. Plate supply voltage is obtained from a connection between choke L-118 and capacitor C-222 of the RBF-3 receiver, through a 10 watt, 8200-ohm dropping resistor, to an AN type connector mounted on the RBF-3 chassis. Heater supply voltage is taken from the No. 6 terminal of jumper socket X-113 on the RBF-3 chassis. Plate supply current drain to the frequency converter unit is approximately 17 milliamperes, the plate supply voltage being approximately + 135 volts. Heater supply current-drain is 950 milliamperes at 6.3 volts rms.

For external attachment of the converter to a receiver in which the internal mounting is not possible, the unit is furnished mounted in a black crackle finish metal case 10 inches long by 6 1/2 inches high by 4 inches wide. (See Figure 2). The converter shield-cover is attached to aluminum angles which serve as slides and also mount the front panel of the metal case. The planetary drive tuning assembly which is supported by the front panel of the case is identical with that used for the internal mounting except for use of two Millen "truly flexible" couplers in place of the Millen "conventional" coupler. The power cable, RF interconnection cable, and antenna cable enter through the rear of the metal case. The unit and its case may be externally attached in any manner which may be deemed desirable or convenient. A single opening of sufficient size to permit installation of the interconnecting power cable will have to be cut in the RBF-3 cabinet at some convenient location.

Figure 8 is a functional block diagram showing stages of the frequency converter unit and interconnection with the modified RBF-3 receiver.

Oscillator Circuit

The oscillator circuit is of the ultraudion type using a 6C4 triode, V-603, and is intended for fixed frequency operation. Variable air capacitor, C-616 is supplied to permit adjustment of the oscillator frequency to the recommended frequency of 144.71 Mc in order to prevent interfering signals from occurring within the 215-222 Mc band. These interfering signals are caused by heterodyning of the receiver and converter unit oscillators and may be used as approximate band limit markers if the converter oscillator is maintained at 144.71 Mc. Replacement of the 6C4 oscillator tube will

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require readjustment of the oscillator frequency.

The oscillator output voltage is coupled to the mixer input circuit by a special coupling circuit, (See Figure 9), consisting of a blocking capacitor, C-612, and a 1 μh radio frequency choke, L-607, which serves as part of a voltage divider at the oscillator frequency but appears as a parallel resonant circuit to the RF signal frequency, thus preventing loss of the RF signal voltage through the oscillator circuit. Optimum oscillator voltage is applied to the mixer cathode by the inductive voltage divider circuit composed of radio frequency choke L-607 and the 220 Mc mixer input tank circuit which appears inductive at the oscillator frequency. Oscillator plate dropping resistor R-604 further insures proper oscillator signal voltage to the mixer cathode. Normal oscillator plate voltage is approximately + 90 volts.

RF Amplifier Circuit

The RF amplifier is a grounded-grid circuit utilizing a 6J4 UHF amplifier triode, V-601, designed for grounded-grid operation. Both the cathode and plate circuits are of the parallel resonant—series tuned type. The cathode inductance, L-602, is inductively coupled to the antenna loop, L-601, and provides an impedance match to a 50-ohm antenna. Radio frequency chokes were utilized in each heater connection to improve gain and reduce tendencies toward oscillation. The plate inductor, L-605, inductively couples the RF output of the amplifier to the mixer cathode inductor, L-608. Normal amplifier bias is + 1.8 volts at the cathode.

Mixer Circuit

The mixer circuit is also of the grounded-grid type using a 6J4 grounded-grid triode, V-602. The input cathode circuit is of the parallel resonant—series tuned type, being fixed tuned at approximately 220 Mc. The plate tank circuit of the mixer stage utilizes a balanced stator variable capacitor, C-609, forming a balanced parallel resonant circuit with L-610, which is tunable from approximately 68 to 80 Mc and permits operation of the rotor plates of C-609 at ground potential.

Since the oscillator is fixed tuned at 144.71 Mc, the necessary tuning range of the mixer plate tank is 70.29-77.29 Mc in order to permit reception of the 215-222 Mc band. Mixer RF output is inductively coupled to coil L-602 which connects to output receptacle J-602. Receptacle J-602 is connected to receptacle J-103 of the RBF-3 receiver by means of an RG-11/U coaxial cable, W-601, having a characteristic impedance of 69-ohms.

INSTALLATION OF THE CONVERTER

Necessary Modification of the RBF-3 Receiver

Regardless of whether the X4-CV-4B converter is to be attached externally to the RBF-3 receiver or mounted within the receiver cabinet, certain minor electrical modifications to the receiver are required. It is assumed that the RBF-3 receiver has been previously modified according to instructions given in reference (d). Recommended procedure for the additional modification is as follows:

1. Punch a hole of 3/4 inch diameter in the RBF-3 chassis at a location between J-104 and X-106 for installation of power receptacle J-604. The hole should be positioned so as to allow one edge of the receptacle to be flush with the edge of the chassis. Drill necessary holes for the four mounting screws supplied and secure the receptacle in place.

2. Make a direct connection between terminal D of the receptacle, J-604, and terminal Number 6 of socket X-113 as shown in Figure 10. Use Number 18 insulated wire or larger.

3. Install R-605, the 10-watt 8200-ohm voltage dropping resistor, by connecting one end to the interconnection of L-118 and C-223.

Mount the small insulated terminal provided in a convenient position as shown in Figure 10, and connect the loose end of the resistor. Make a direct connection between the insulated terminal and terminal A of the power receptacle, J-604, using a Number 27 insulated wire or larger.

4. Connect terminal B of the power receptacle, J-604, to a convenient ground lug as shown in Figure 10. This completes modifications to the RBF-3 chassis.

Internal Mounting Procedure

If previous modification of the RBF-3 receiver has been such as to allow sufficient space for installation of the frequency converter on the back of the front panel as shown in Figures 6 and 7, the internal mounting may be made by performing the following additional steps:

1. If the RBF-3 meter switch S-104 has been brought out from the chassis to the front panel as indicated in photographs of reference (d), it will first be necessary to move this switch to a lower position on the front panel. The desired position can best be determined by reinstalling the switch after the converter unit installation has been completed.

2. Lay out the positions of necessary holes on the front panel according to dimensions given in Figure 11. Punch or drill holes as indicated.

3. Install the planetary drive tuning assembly shown in Figure 12 by first mounting the planetary drive unit using the three one-half inch spacers and screws provided. The calibrated dial and brass collet may now be attached to the large secondary shaft by means of the set screw. Attach the dial knob to the small primary shaft by tightening its two set screws. Insert the small coupling shaft in the rear of the secondary shaft and mount the flat Millen conventional type coupler.

4. Mount the two aluminum mounting brackets, A-603 and A-604, on the rear of the RBF-3 panel, placing the one with punched hole on the right hand side (nearest the tuning meter M-101.)

5. With the power cable W-602, and RF coupling cable W-601 connected, the frequency converter (having been removed from the case provided for external mounting) may now be placed in its proper position as shown in Figures 6 and 7. Make certain that the rotor shaft of C-609 is properly engaged by the flexible coupler of the vernier tuning assembly.

6. Attach the small name plates provided, as shown in Figure 13. This completes the internal mounting of the frequency converter.

External Mounting Procedure

If the external attachment of the frequency converter is necessary because of lack of sufficient space or for other reasons, it may be accomplished by the following simple procedure:

1. Removing the unit and sliding rack from the metal case, mount the empty case on either end of the RBF-3 cabinet or at any other convenient location which will permit adjustment of the alignment controls through the ports in the top.

2. Cut a hole of sufficient size for installation of the interconnecting power cable, W-602, at a convenient location on the RBF-3 receiver cabinet.

3. With the frequency converter in its case connect the RF coupling cable, W-601, to the RBF-3 antenna jack mounted on the rear of the receiver cabinet.

ALIGNMENT AND TUNING PROCEDURES

Oscillator Adjustment

Installation of the frequency converter unit having been completed, the oscillator should be accurately set to a frequency of 144.71 Mc as measured by an accurate instrument such as the TS-323/UR heterodyne frequency meter. NOTE: Use the nonmetallic alignment tool for adjustment since C-618 is at a potential above ground. The accuracy of the converted receiver calibration will be dependent on the accuracy of the converter oscillator frequency setting. Hence,

a warm-up period of at least 15 minutes should be allowed before making the final oscillator adjustment. Since alignment of the RF amplifier circuit has a very slight effect on the oscillator frequency, (±25 Kc or less), it is also advisable to make the final oscillator adjustment after alignment of the RF amplifier circuit at the desired signal frequency.

RBF-3 Dial Calibration

A blank calibration chart is provided with the frequency converter. Because of the fact that the converter unit oscillator is fixed tuned at 144.71 Mc, the signal frequency to the RBF-3 input will equal the frequency received minus the converter oscillator frequency. Hence, the RBF-3 input will range from 70.29 Mc to 77.29 Mc as the received signal is varied from 215 Mc to 222 Mc. The receiver may therefore be calibrated by supplying an accurately known signal frequency of 70.29 Mc and recording the RBF-3 tuning dial reading opposite 215 Mc on the chart supplied. Repeat the procedure for each one-Mc interval to 222 Mc, recording the receiver dial reading opposite the proper converter input frequency. Blank spaces are also provided on the calibration chart for specific assigned channel frequencies such as 217.55 Mc and 219.35 Mc. For convenience in operation, calibration should also be performed for such assigned channel frequencies.

RF Amplifier Alignment and Mixer tuning

The converter oscillator frequency having been properly set and the RBF-3 dial calibration completed, the converter unit may now be aligned for reception of any desired frequency in the 215-222 Mc band. This is accomplished by first setting the RBF-3 tuning dial for reception of the desired frequency as indicated on the calibration chart. A signal voltage of the desired frequency is now injected at the antenna connector J-601. Adjust the MIXER PLATE tuning control for a maximum signal amplitude as indicated by the panoramic adapter attached to the RBF-3 receiver. The RF AMP PLATE and RF AMP INPUT alignment controls should then be adjusted in turn, for the same indication, reducing the input signal strength as necessary to insure more accurate adjustment. Repeat the procedure until the alignment is optimum for the desired frequency. Alternate procedures which may be used include adjustment for a maximum indication on the RBF-3

tuning meter M-101 with the meter switch S-104 set to ALIGN position, or on a sensitive very high frequency vacuum tube voltmeter connected to the converter output receptacle J-602. (Note: In some receivers, S-104 has been eliminated and an additional meter provided for the align function).

Summarizing the tuning and alignment procedure, the tuning range of the RBF-3 receiver is 70-90 Mc. The converted receiver has a 7 Mc range from 215 to 222 Mc and the converter oscillator is fixed at 144.71 Mc. Hence, the receiver tunes from 70.29 Mc to 77.29 Mc to cover this band. The receiver calibration chart is calibrated directly in terms of the converter input frequency. After the receiver dial is set for the desired frequency by use of the calibration chart, a signal at the desired frequency is provided and the mixer plate circuit tuned for maximum input to the RBF-3. The input and output circuits of the RF amplifier are also adjusted for maximum input to the RBF-3. With the meter switch S-104 set to TUNE position, a final adjustment of the RBF-3 tuning dial is made by adjusting for zero reading on meter M-101. The receiver and converter combination is now aligned and tuned for reception of a single desired frequency.

In some cases, it may be necessary to receive either of two channel frequencies such as 217.55 Mc and 219.35 Mc without time for realignment of the RF amplifier tuned circuits. If such a circumstance can be foreseen, it is advisable to align the RF amplifier tuned circuits at the median frequency of the two channel frequencies; in this case, 218.45 Mc. With the converter unit so aligned, the combination receiver and converter will provide reception of either channel frequency by adjustment of only the MIXER PLATE control in addition to the RBF-3 tuning dial. Reduction in sensitivity will be less than 3 db if the separation of the channel frequencies does not exceed 2.5 Mc. A channel separation of approximately 4.5 Mc would incur a loss of 6 db in voltage sensitivity if the converter is aligned to the median frequency.

ELECTRICAL CHARACTERISTICS

Converter RF Selectivity

The RF selectivity characteristic of the X4-CV-4B frequency converter is defined as the selectivity of the circuits operating at the converter input frequency. Hence, the RF

amplifier input circuit, RF amplifier plate circuit, and mixer input circuit contribute to the "RF selectivity". Measurements of RF selectivity characteristics are made by aligning the converter circuits at a certain frequency such as 218.5 Mc which is subsequently referred to as F_o. A signal of 0.1 volt rms is injected into the antenna connector, J-601, and the converter output to a 70-ohm resistive load is measured at J-602 by means of a VHF vacuum tube voltmeter. The signal frequency is then varied in steps above and below F_o, the MIXER PLATE tuning control being adjusted for maximum output voltage at each frequency, and the output voltage reduction in decibels recorded. Typical RF selectivity characteristics of the X4-CV-4B are shown in Figure 14. The signal source used was a model LAF-3 signal generator, and an RCA High Frequency Vacuum Tube Voltmeter was used as an output meter. As seen in Figure 14, the RF bandwidth at -3 db is approximately 2.7 Mc.

Converter Overall Selectivity

The converter overall selectivity includes the selectivity of the mixer plate tank circuit. Measurements of overall selectivity were made in the same manner as those of RF selectivity excepting that the MIXER PLATE control was not varied, being left at the setting obtained for F_o. Figure 15 shows typical overall selectivity characteristics.

Selectivity of the Receiver-Converter Combination

The selectivity characteristics of the converted RBF-3 receiver are essentially those of the RBF-3 alone. Selectivity characteristics of the combination are shown in Figure 16. Data for these measurements were taken with all electrical and mechanical connections made between the receiver and converter. A signal frequency of 218.5 Mc was fed into the antenna connector J-601 from an LAF-3 signal generator, and the converter-receiver combination aligned and tuned as previously described in this report. The receiver output was observed on the tuning meter M-101 with meter switch S-104 set to ALIGN position. In this condition, M-101 indicates first limiter grid current which varies linearly with RBF-3 input signal amplitude. The input signal voltage was adjusted to give a reference reading on meter M-101. Each change in input signal frequency was accompanied by an adjustment of the LAF-3 attenuator to obtain the reference indication on M-101. The necessary increases in

signal voltage, as read from the LAF-3 attenuator, were plotted as attenuation in decibels versus frequency to obtain the selectivity curve shown in Figure 16.

Converter Voltage Gain

Typical X4-CV-4B converter gain characteristics over the 215-222 Mc band are shown in Figure 17. A signal of 0.1 volt rms from an LAF-3 signal generator was fed into the converter antenna connector, J-601, at each one-megacycle interval from 215 Mc to 222 Mc and the converter aligned and tuned at each frequency according to the procedure outlined. The converter output voltage was measured across a 70-ohm resistive load at J-602 by means of an RCA VHF Vacuum Tube Voltmeter. With the input and output voltages known, the voltage gain in decibels was computed and plotted versus frequency.

Operational Sensitivity of the Receiver-Converter Combination

Operational sensitivity of the receiver-converter combination is herein arbitrarily defined as the minimum signal amplitude, measured in microvolts, necessary to cause limiting to occur in both limiter stages of the RBF-3 receiver. If meter switch S-104 is placed in TUNE position, M-101 will indicate zero if a signal is properly tuned in. If the signal is detuned slightly a deflection of M-101 will be observed. Change of amplitude of a detuned signal will not change the amount of meter deflection if the signal amplitude is sufficient to cause limiting to occur in both limiter stages. Hence, if the signal amplitude of a slightly detuned signal frequency is reduced an amount just sufficient to cause a perceptible change in the meter deflection, the minimum signal amplitude necessary for limiting in both limiter stages may be observed. Amount of signal detuning should be sufficiently less than one-half of the receiver bandwidth to permit an accurate measurement, that is, 50 kilocycles or less. An alternate procedure is to measure the signal voltage at the plate of the first limiter by means of a vacuum tube voltmeter. This procedure is preferred because it does not require detuning of the receiver.

The above procedures were performed for each one-megacycle interval in the 215-222 Mc band, the converter being completely aligned and tuned for each signal frequency. Typical results are shown in Figure 18 and indicate maximum sensitivity compatible with satisfactory operational performance. An unmodulated signal/peak noise ratio of approximately 10 db was observed with signal amplitude adjusted for maximum operational

sensitivity. Occasional noise peaks did not exceed an amplitude equivalent to a signal amplitude of 0.3 μv and average level of noise peaks appeared to be equivalent to a signal amplitude of approximately 0.1 μv. A test of AFC holding action revealed a holding range of plus and minus 100 kilocycles with an input signal amplitude of 5.0 μv or less. It should be noted that operational sensitivity will be vitally affected by alignment of the RBF-3 receiver and may vary widely from the typical values given herein.

Converter Oscillator Frequency Stability

Tests performed revealed the following information concerning frequency stability of the converter oscillator:

1. After a 15 minute warm-up period, with ambient temperature held constant at +25°C, the oscillator frequency varied less than plus or minus 10 kc over a four hour period as measured by a TS-323/UR heterodyne frequency meter.

2. Over an ambient temperature range of 0°C to +50°C, the oscillator frequency decreases approximately 1.25 kc per 1°C increase in ambient temperature, corresponding to a negative temperature coefficient of approximately 9 parts per million per degree centigrade. At higher ambient temperatures, the change in oscillator frequency per degree of temperature change is much more pronounced as shown in Figure 19.

3. When the 6C4 oscillator tube is replaced, it is necessary to reset the oscillator frequency to 144.71 Mc as previously outlined.

INTERFERENCE SIGNALS

No interference signals originating in the converter-receiver combination exist in the frequency band 215-222 Mc if the converter oscillator is accurately adjusted and the RBF-3 intermediate frequency is 10.20 Mc. Image frequencies are attenuated approximately 40 db or more. Interference signals caused by heterodyning of the fundamentals and harmonics of the two oscillators do exist above and below this

band, the nearest ones occurring at 214.83 Mc and 222.17 Mc, assuming that the RBF-3 intermediate frequency is 10.20 Mc. Other interference signals exist sufficiently above the 215-222 Mc band to be disregarded. The 214.83 Mc interference signal is approximately equivalent in amplitude to a signal of 5 μv and the 222.17 Mc interference signal is approximately equivalent in amplitude to a signal of 15 μv. Equivalent amplitude is herein defined as the magnitude of a signal fed into the converter antenna connector at the same frequency as the interfering signal, and adjusted to give the same amplitude when compared on the associated panoramic adapter. Since these signals are outside the necessary frequency band, their existence is not regarded as being a serious disadvantage. As a matter of fact, they may be used to advantage as approximate band-limit markers. The 222.17 Mc interfering signal is due to a 77.45 Mc difference frequency of the fundamental frequencies of both oscillators. The 214.83 Mc interfering signal occurs as a result of heterodyning action of the converter oscillator second harmonic and the sixth harmonic of the receiver oscillator. These interference signals have been reduced in amplitude by extensive shielding and considerations of circuit design.

CONCLUSIONS

The X4-CB-4B frequency converter unit is considered to be satisfactory as a compact modification to the RBF-3 receiver for the purpose of providing reception of frequencies in the 215-222 Mc band. Its suitability for AN/MKR-4 frequency conversion is considered particularly satisfactory providing it is not necessary, in operation, to make rapid frequency changes over a band of more than plus and minus 2 Mc from the median frequency at which the unit is aligned.

AKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of the following people of the Command and Report Links Section of Radio Division III: Mr. D. S. Powell, who began the work and developed a model similar in circuitry to the final model; Mrs. Martha Powers, who performed most of the developmental construction work and assisted in performance of tests;

Mr. R. R. Mattie and Mr. R. E. Koncen, who assisted in the production and testing of the final models.

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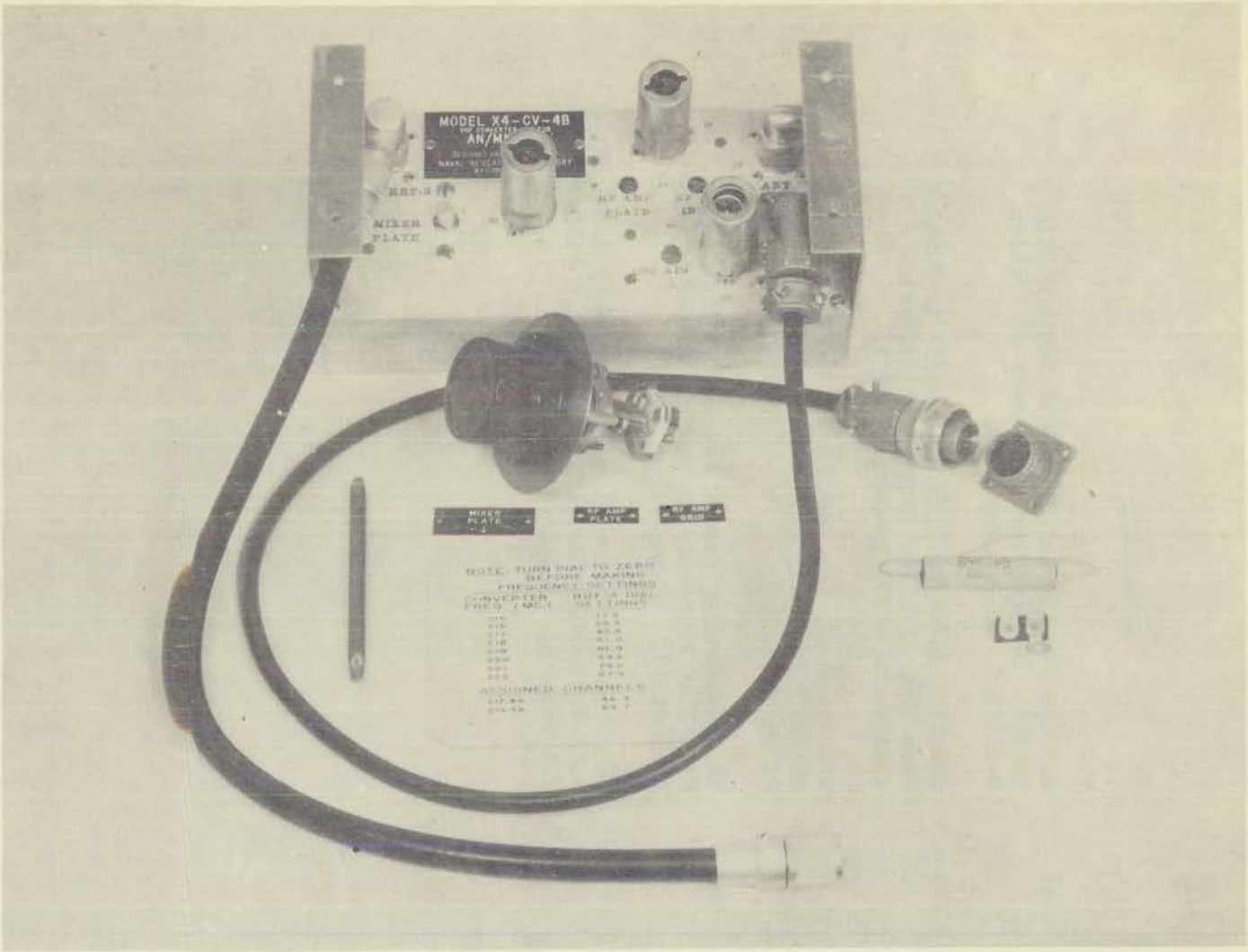

Fig. 1 - Complete frequency converter and accessories for internal mounting in RBF-3

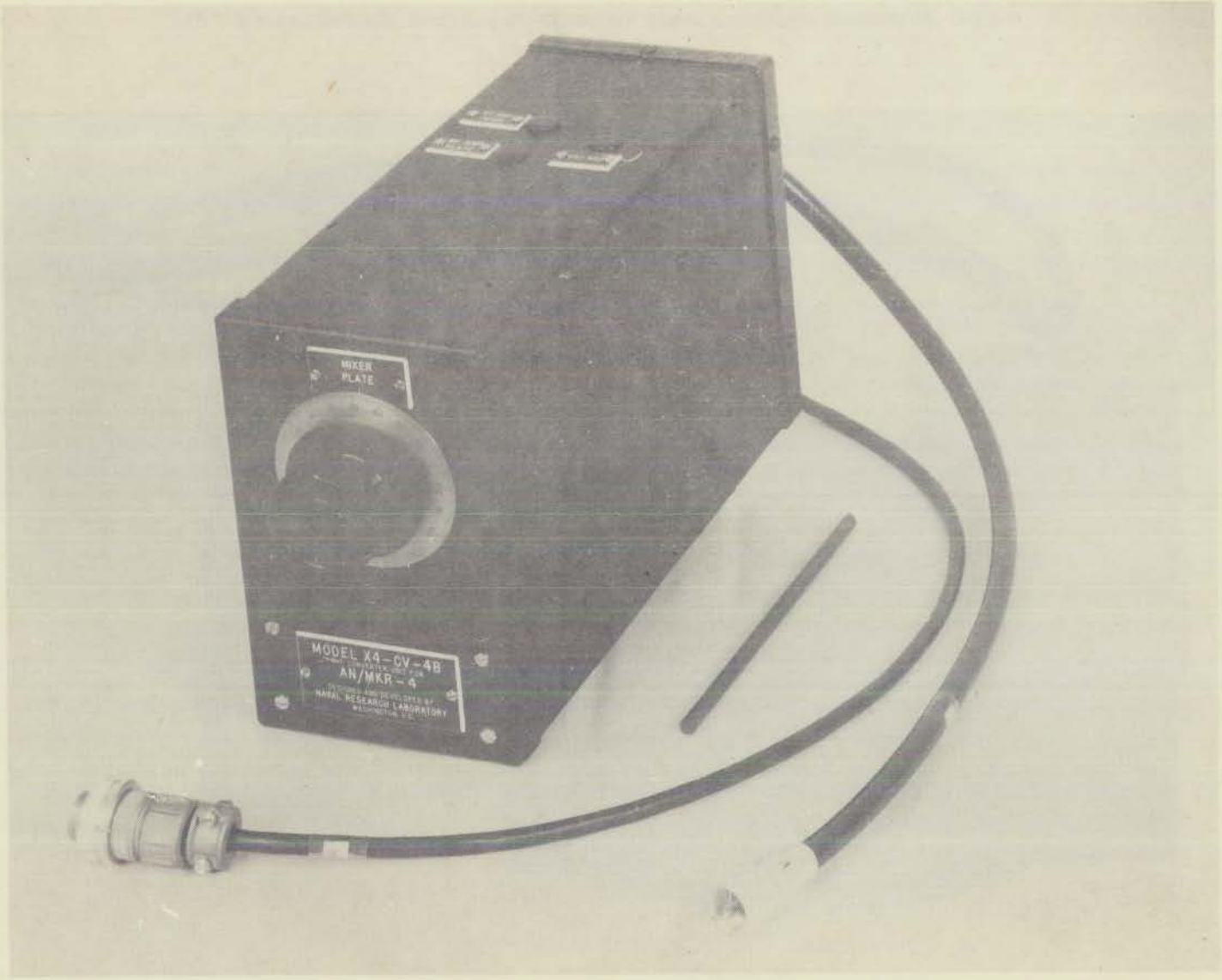

Fig. 2 - Frequency converter in case for external attachment to RBF-3.

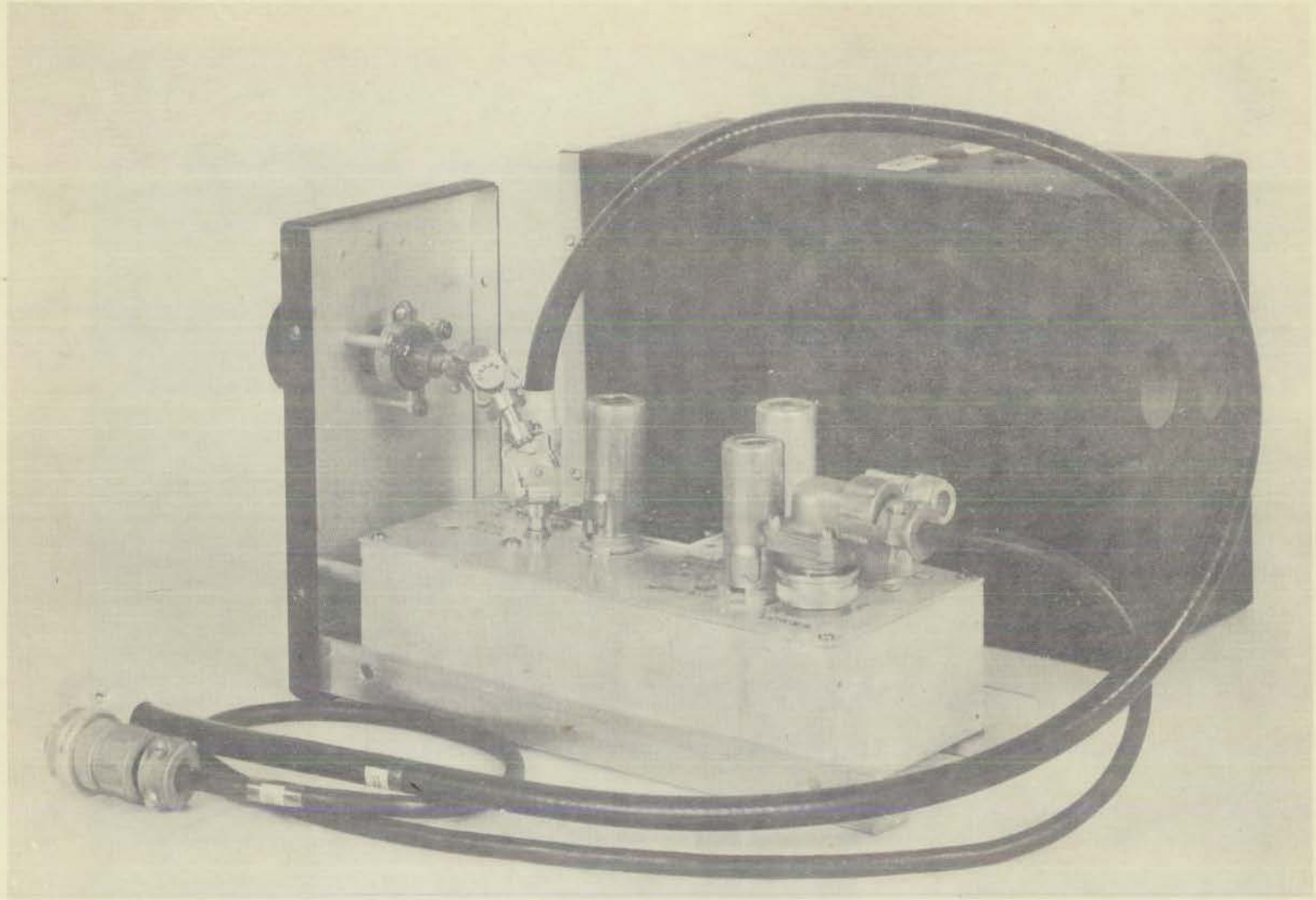

Fig. 3 - Frequency converter removed from external mounting case.

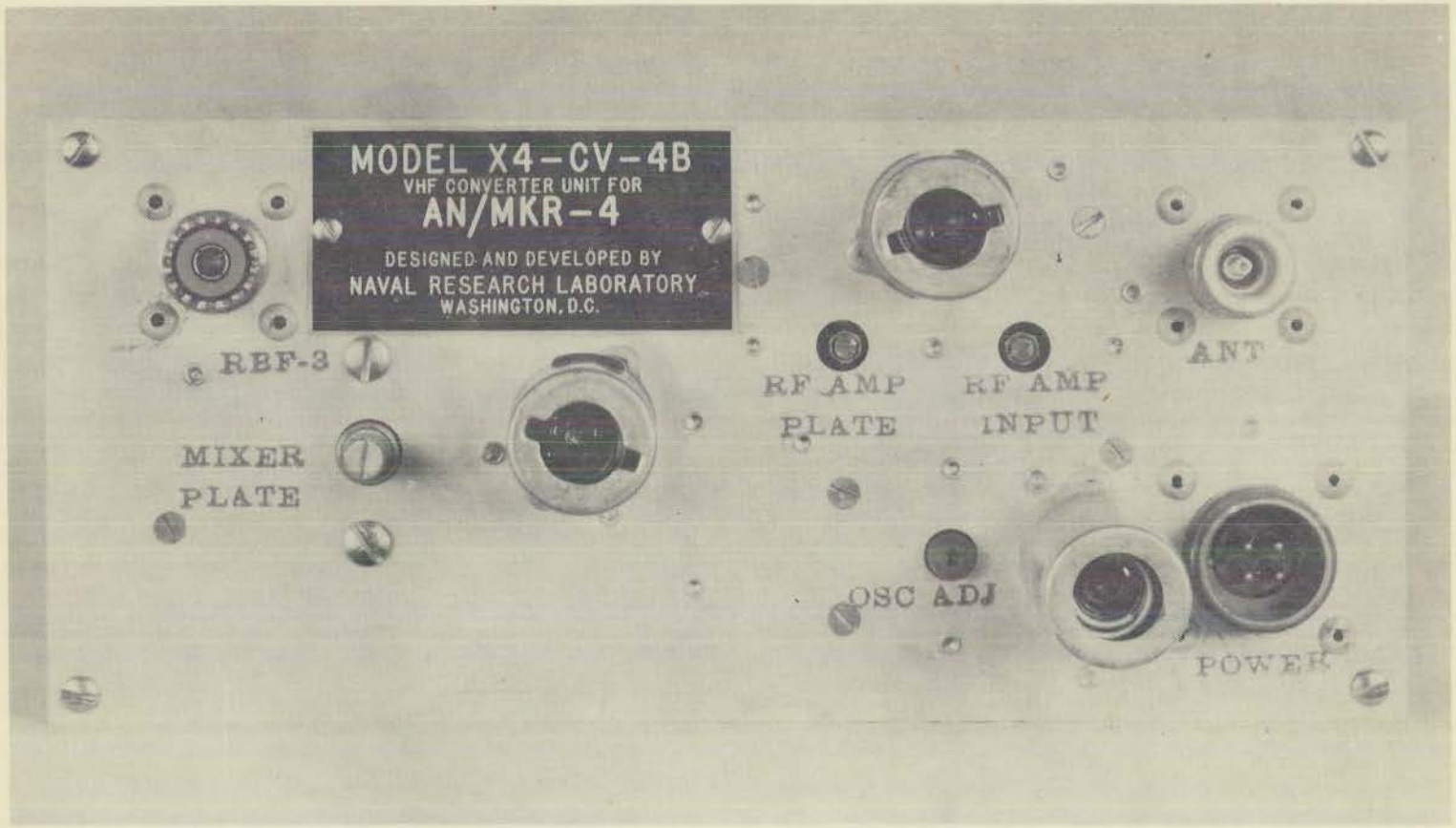

Fig. 4 - Top view of converter chassis-plate

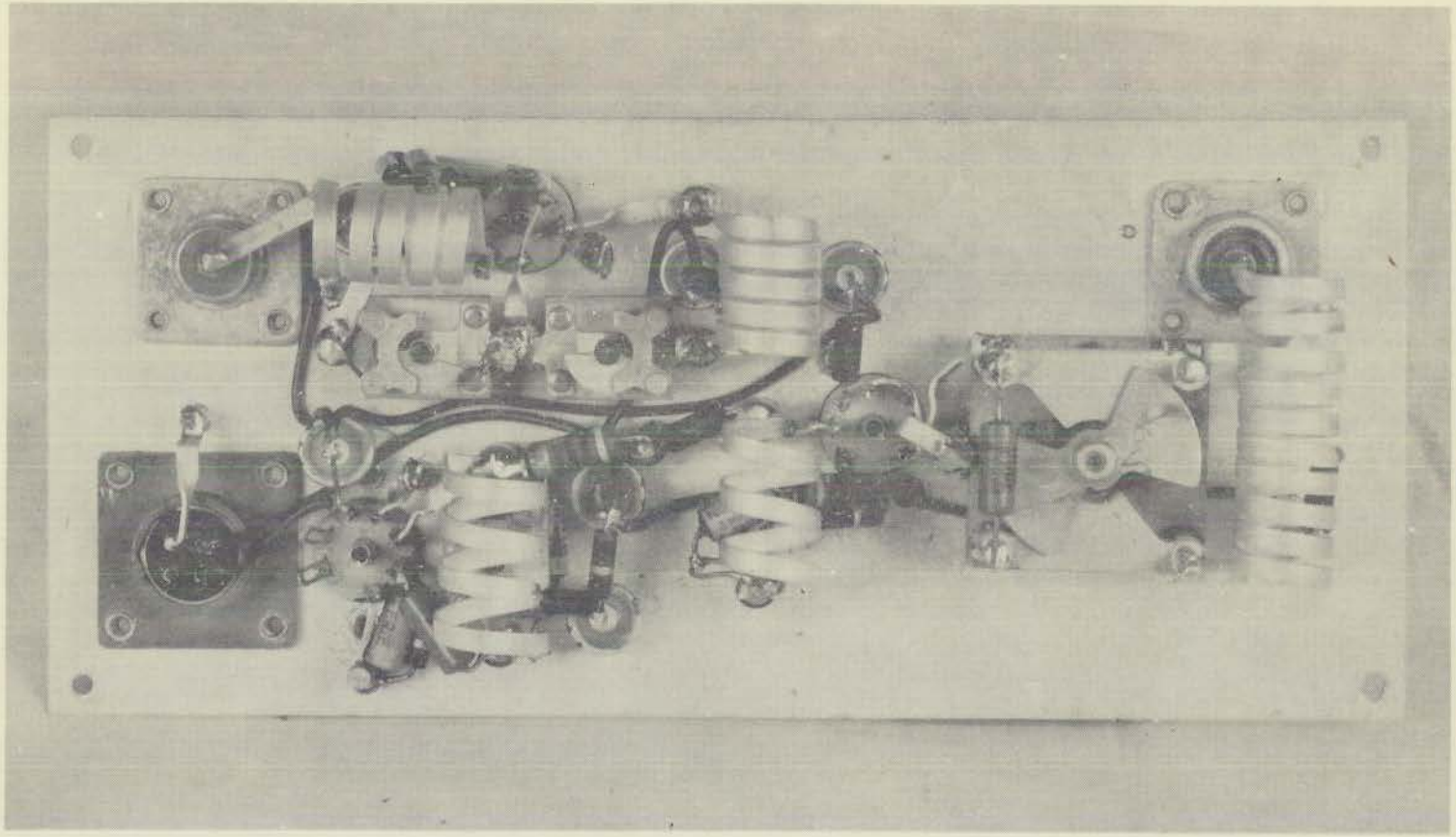

Fig. 5 - Bottom view of chassis-plate showing circuitry.

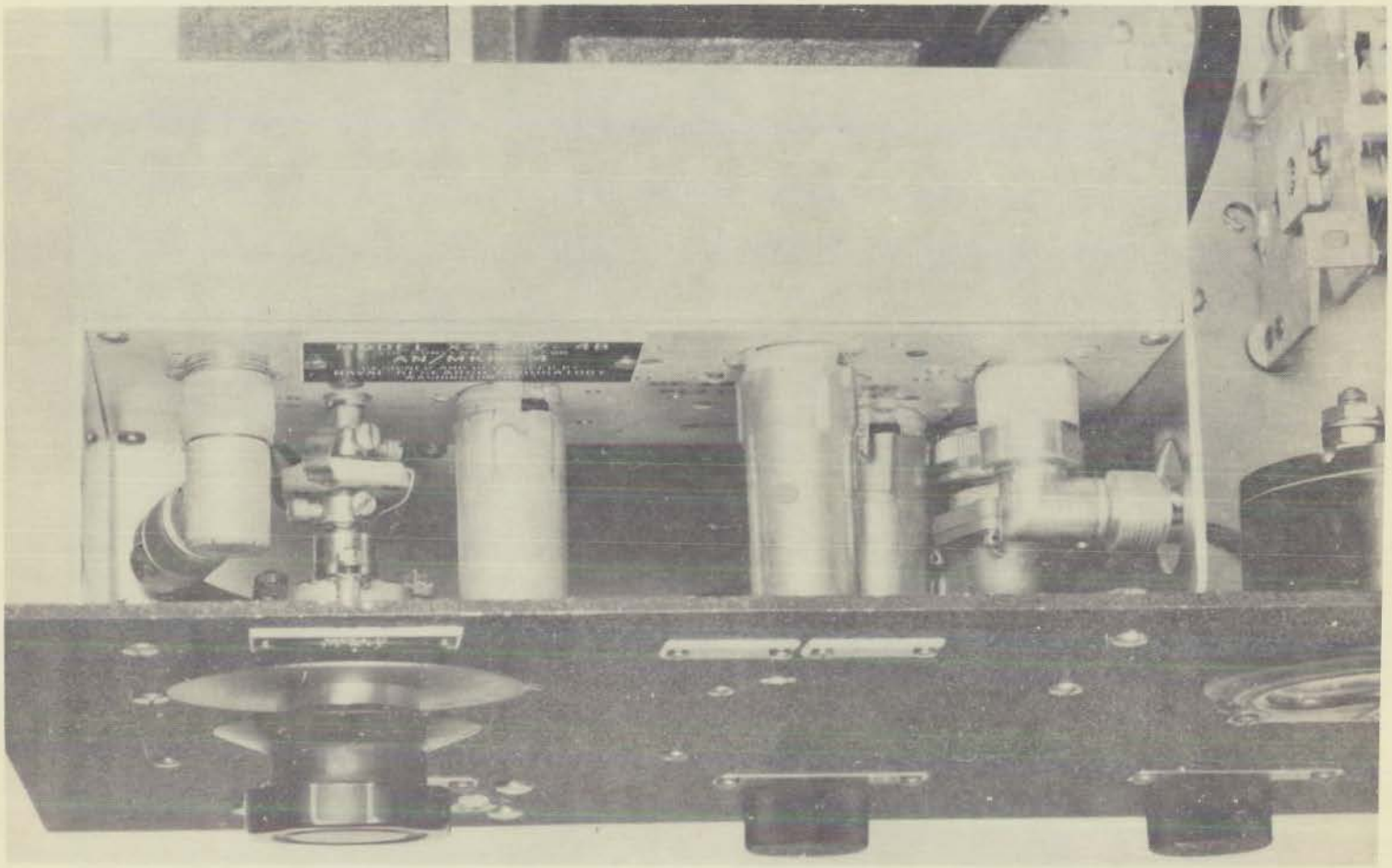

Fig. 6 - Close-up view of converter internally mounted in RBF-3.

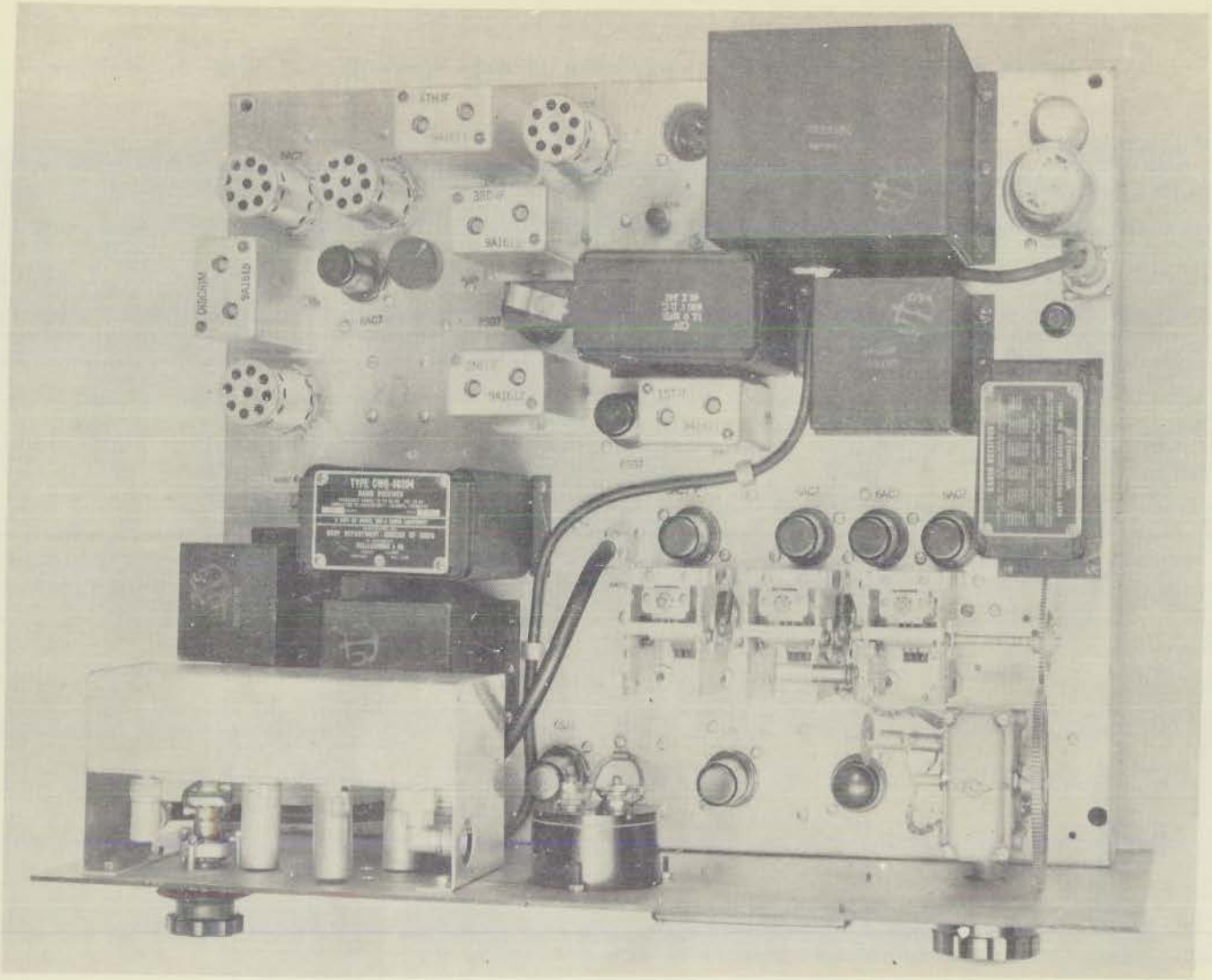

Fig. 7 - Converter and cable installations in RBF-3. (Internal mounting)

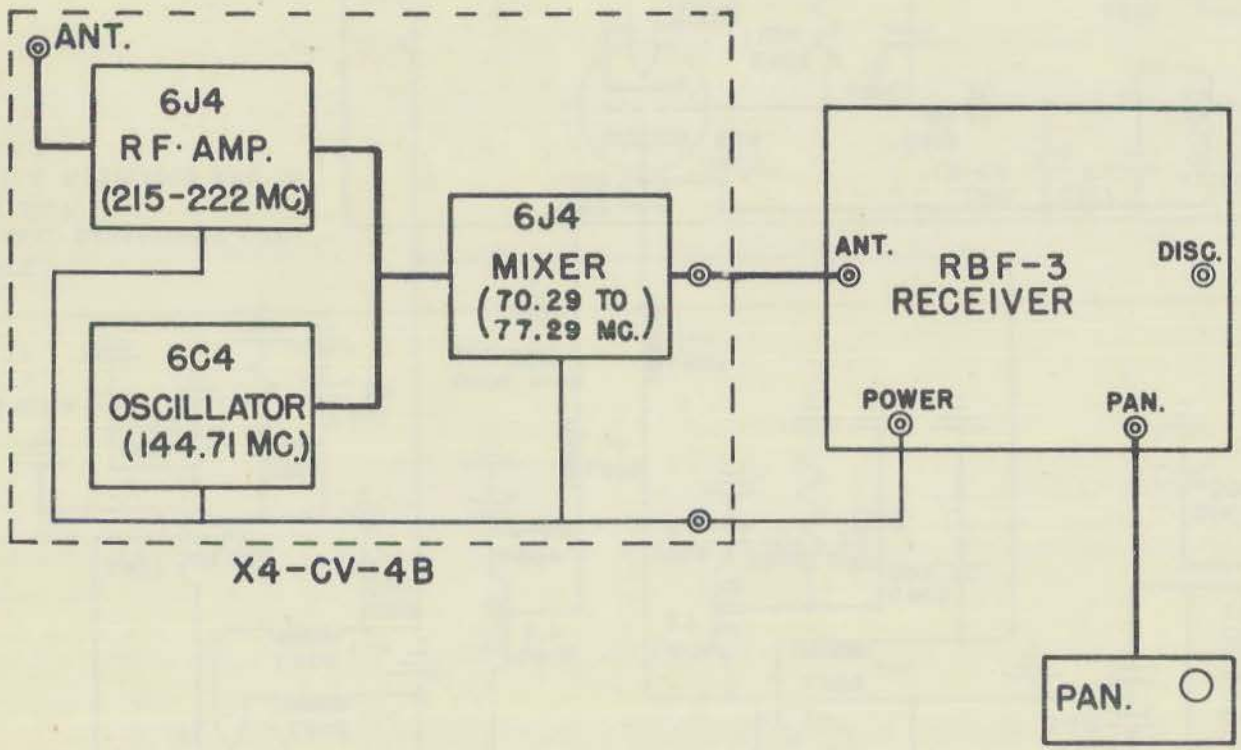

FIG. 8 — BLOCK DIAGRAM X4-CV-4B CONVERTER & RBF-3 RECEIVER

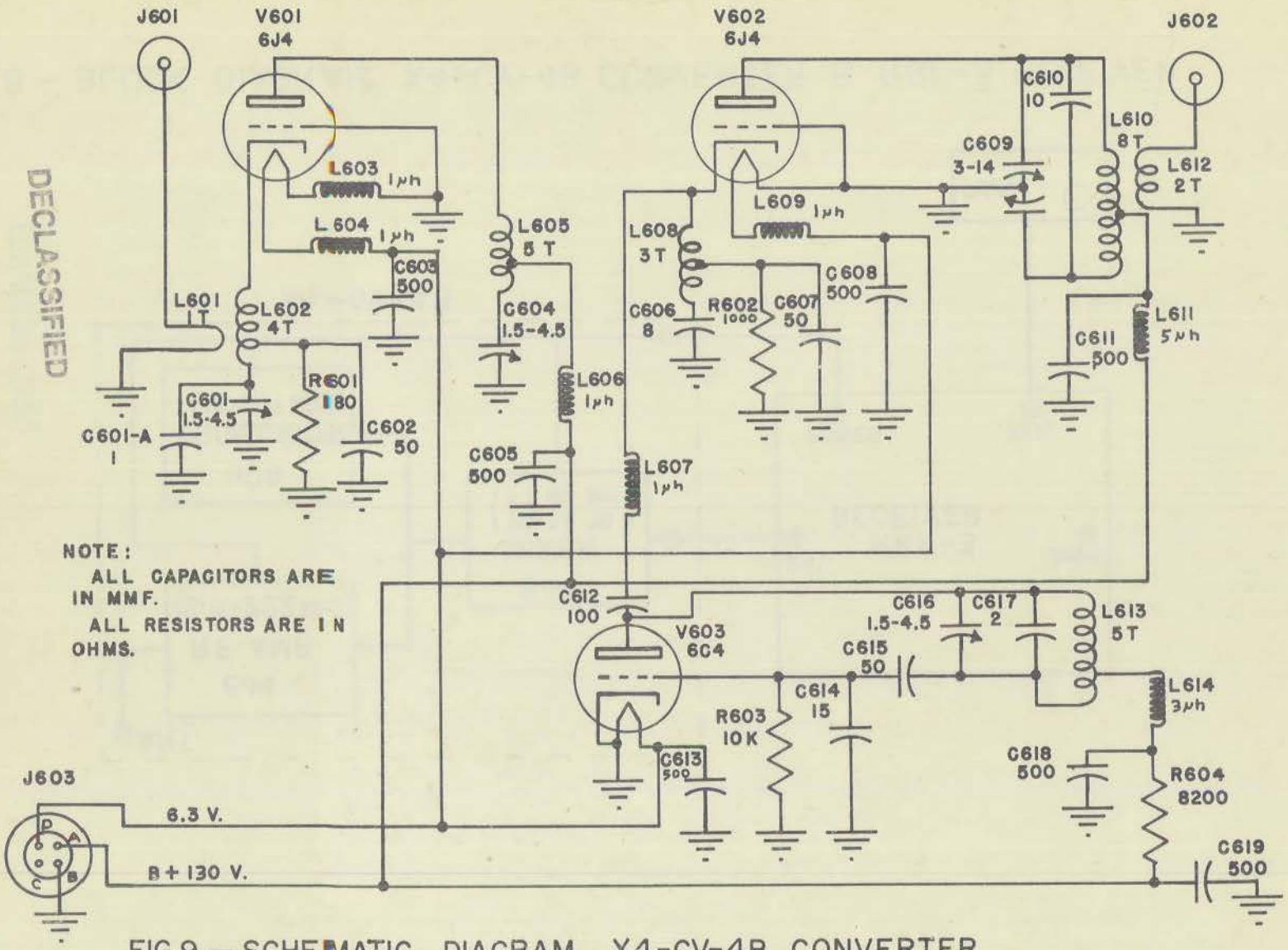

FIG.9 — SCHEMATIC DIAGRAM X4-CV-4B CONVERTER

FIG.10— DIAGRAM FOR MODIFICATION OF RBF-3 POWER SECTION

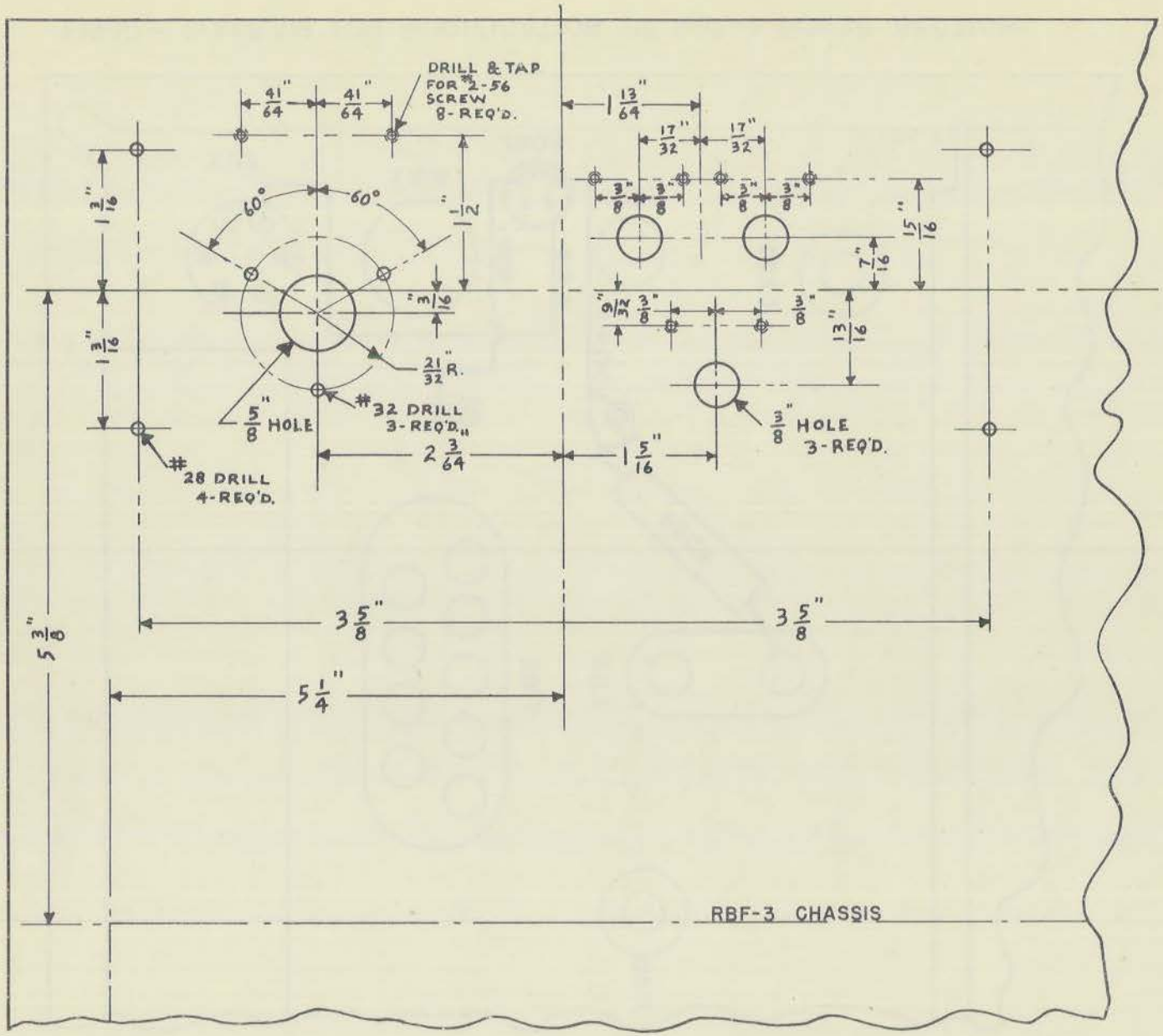

FIG. 11 — DETAILS FOR MODIFICATION OF RBF-3 FRONT PANEL

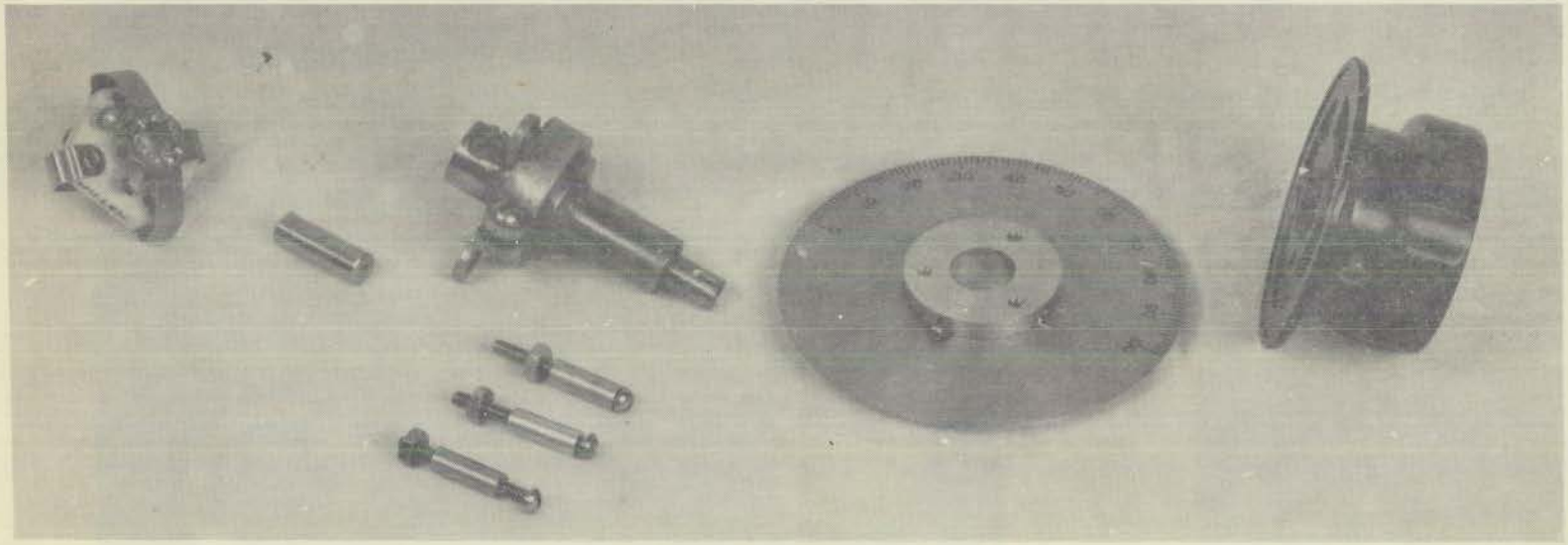

Fig. 12 - Parts of the planetary drive tuning assembly.

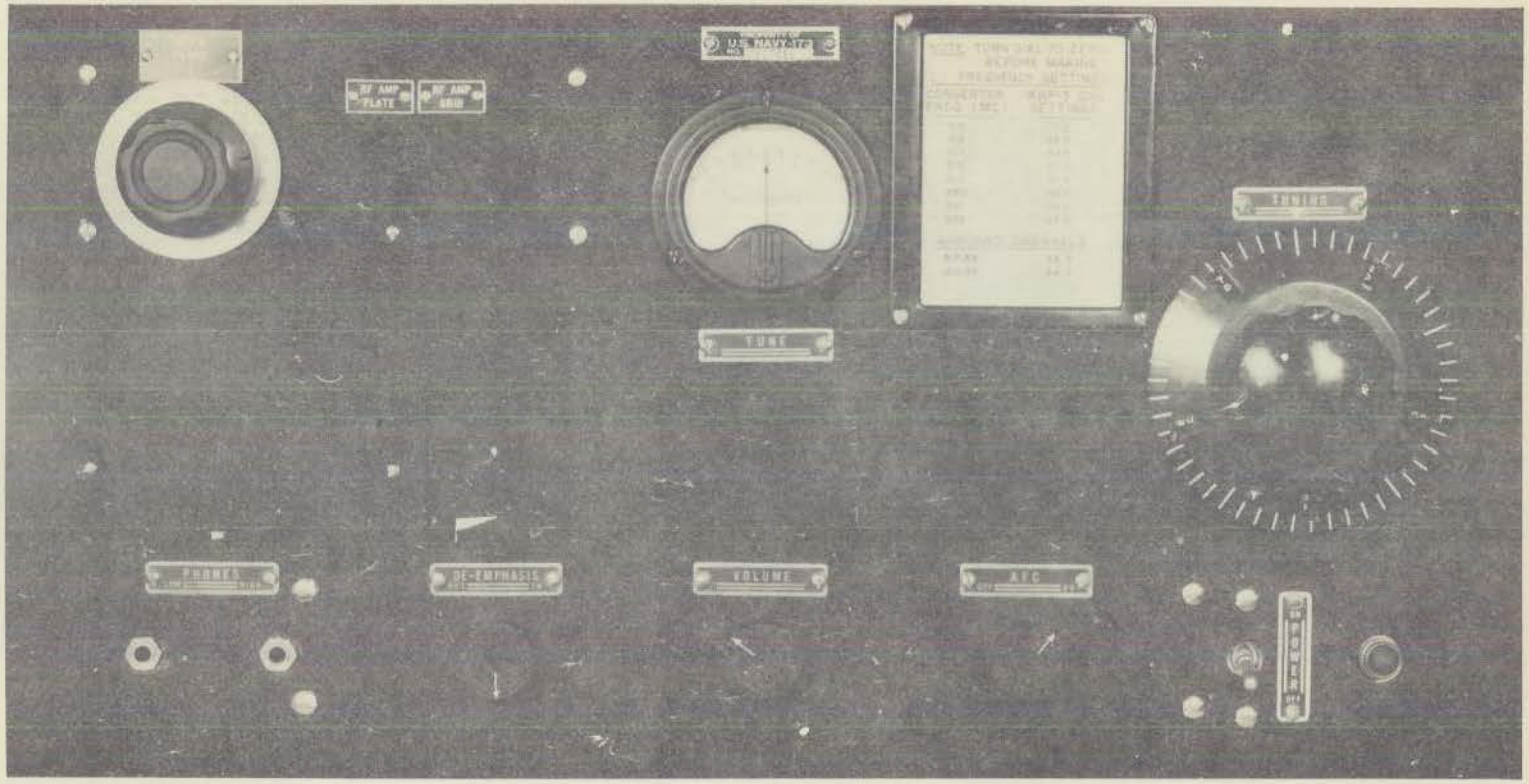

Fig. 13 - Front view of converted RBF-3 with converter mounted internally.

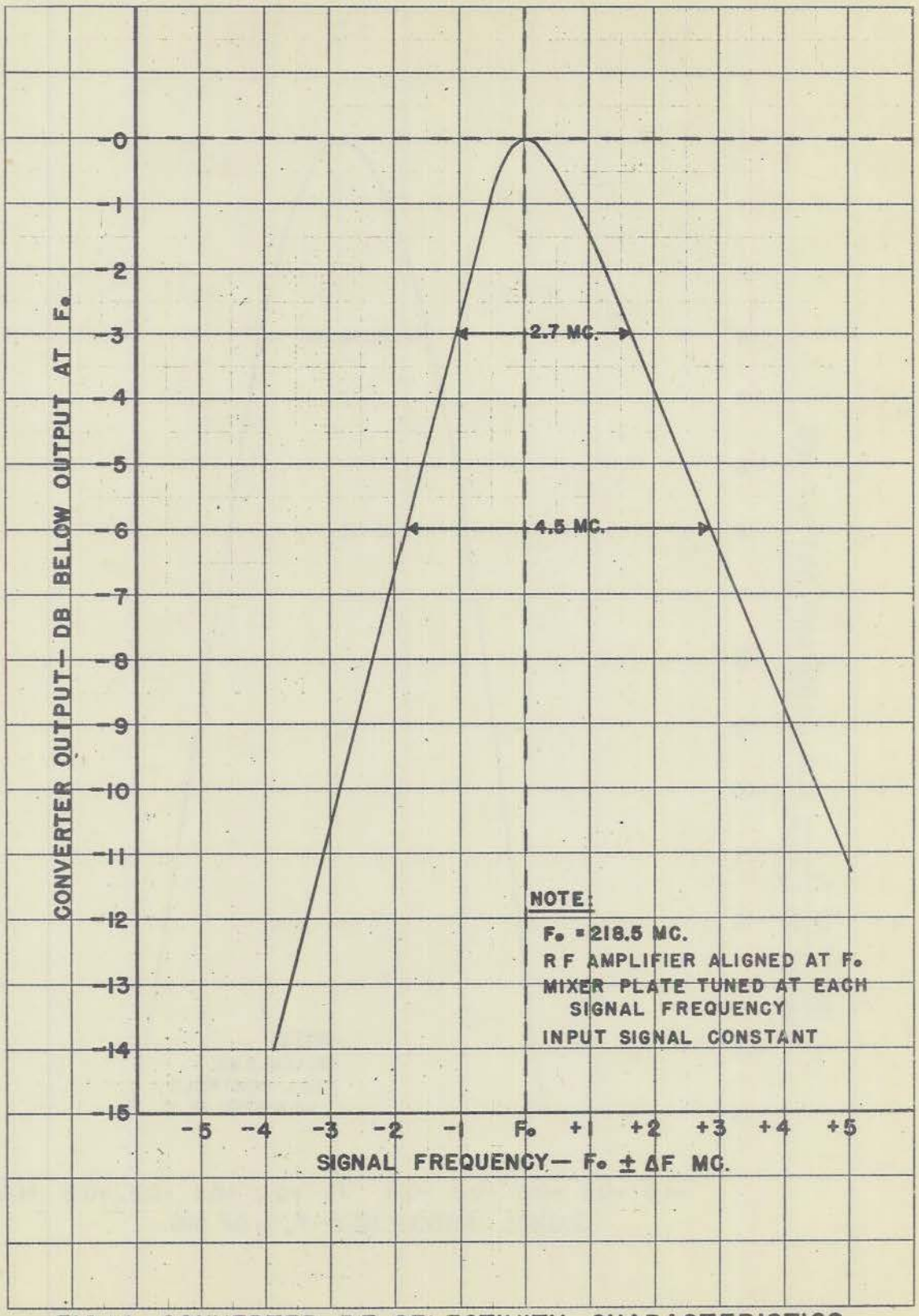

FIG.14 — CONVERTER RF SELECTIVITY CHARACTERISTICS

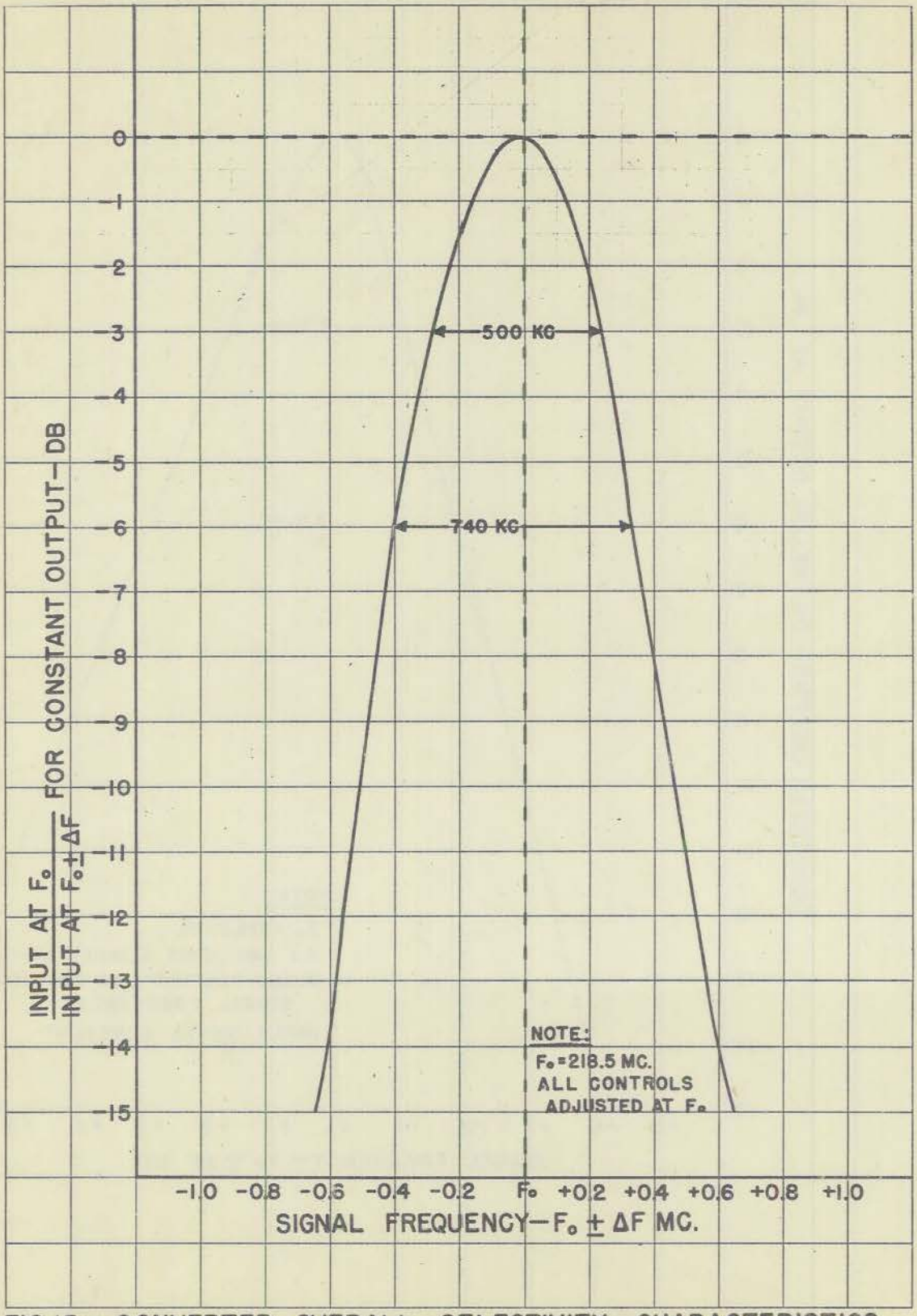

FIG.15— CONVERTER OVERALL SELECTIVITY CHARACTERISTICS

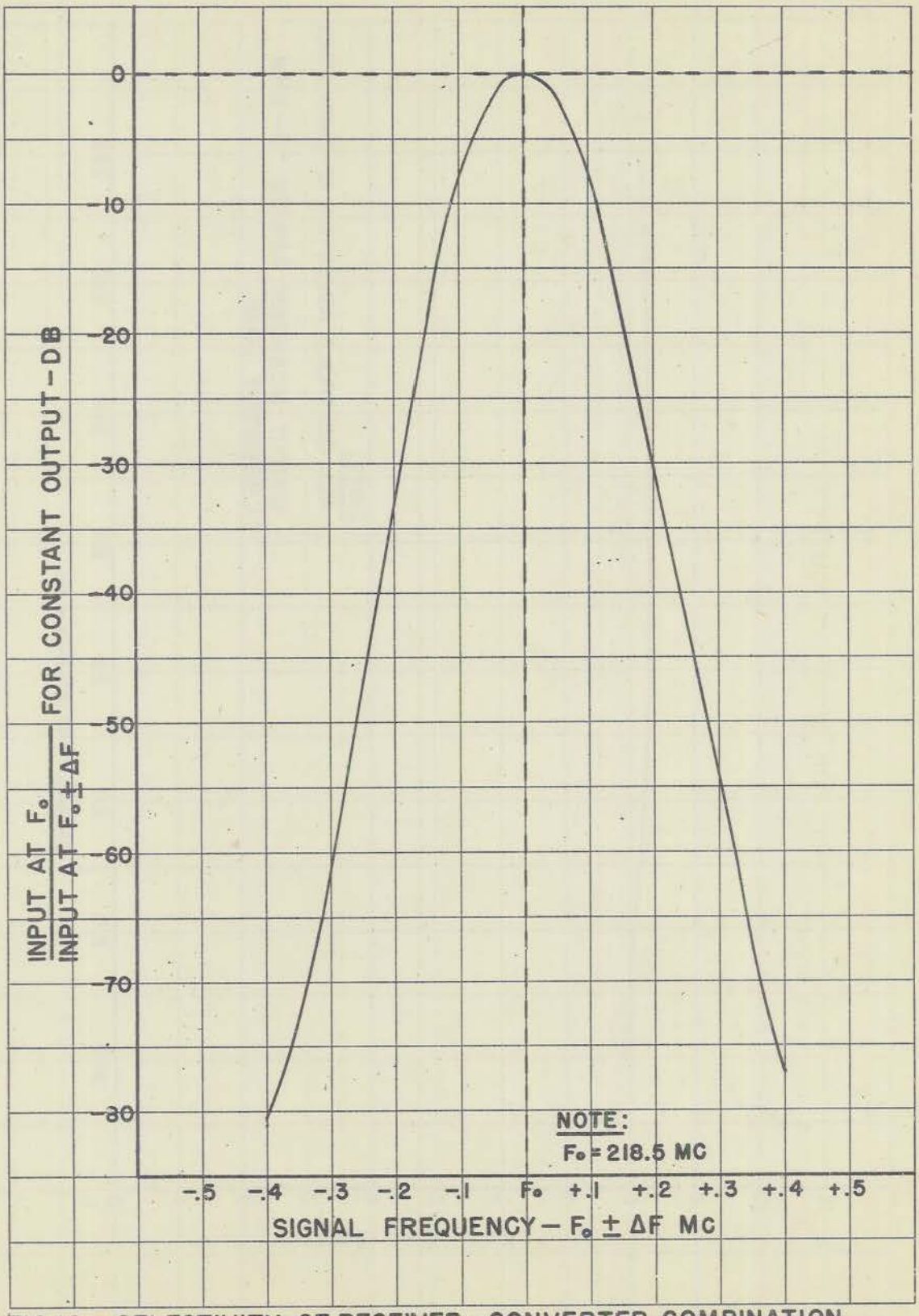

FIG. 16 — SELECTIVITY OF RECEIVER — CONVERTER COMBINATION

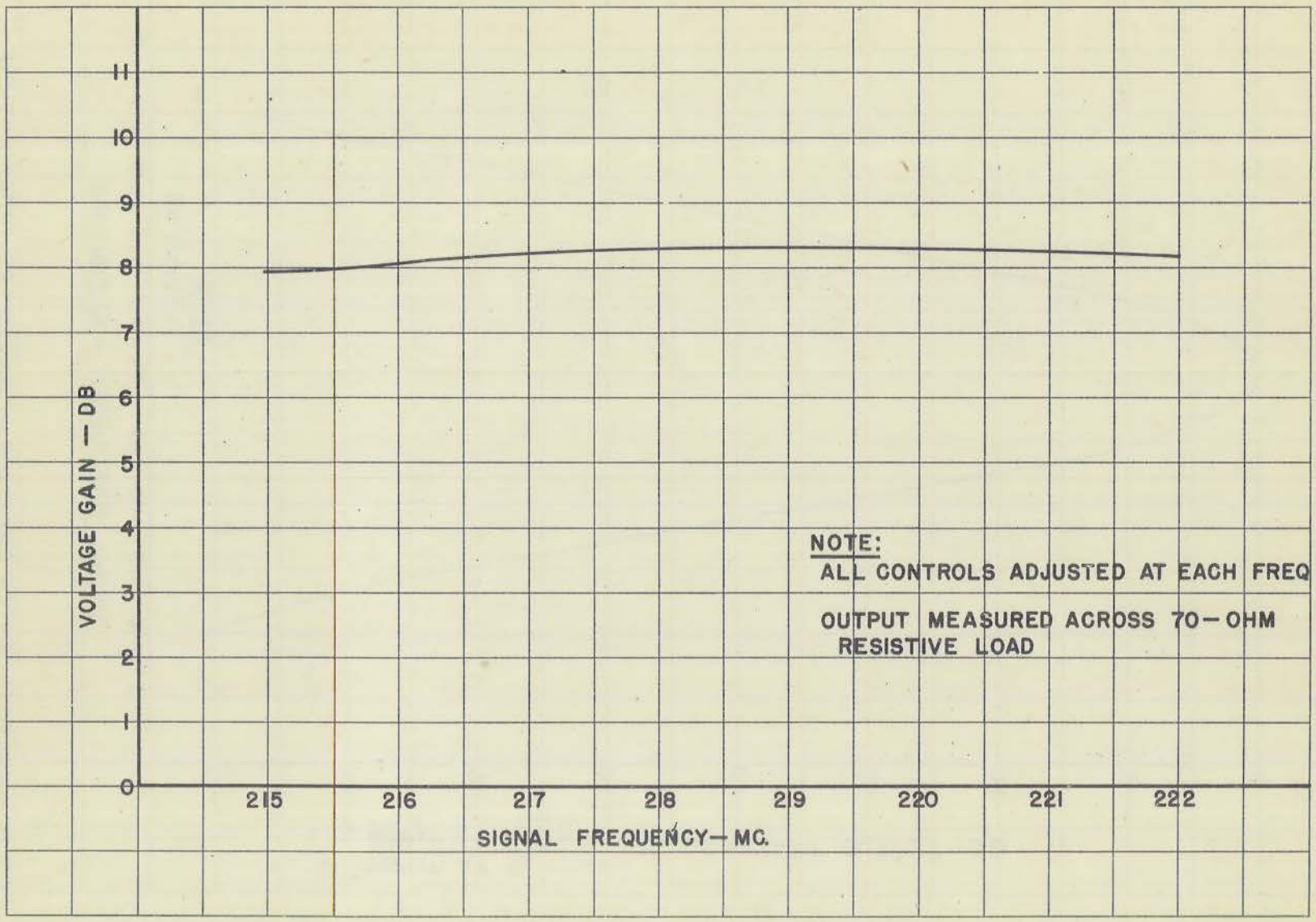

FIG. 17—CONVERTER GAIN CHARACTERISTICS

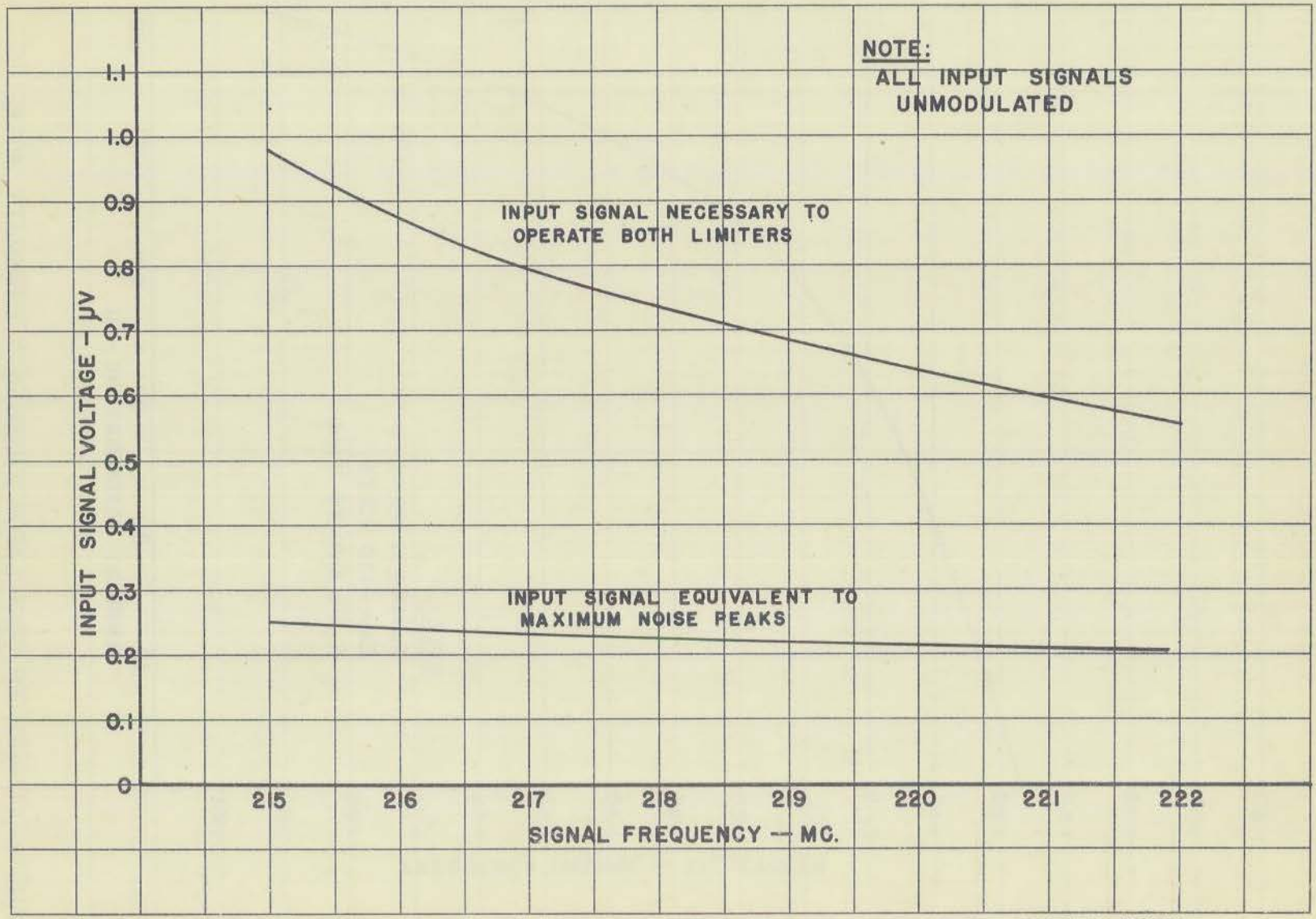

FIG. 18 — SENSITIVITY CHARACTERISTICS OF THE RECEIVER — CONVERTER COMBINATION

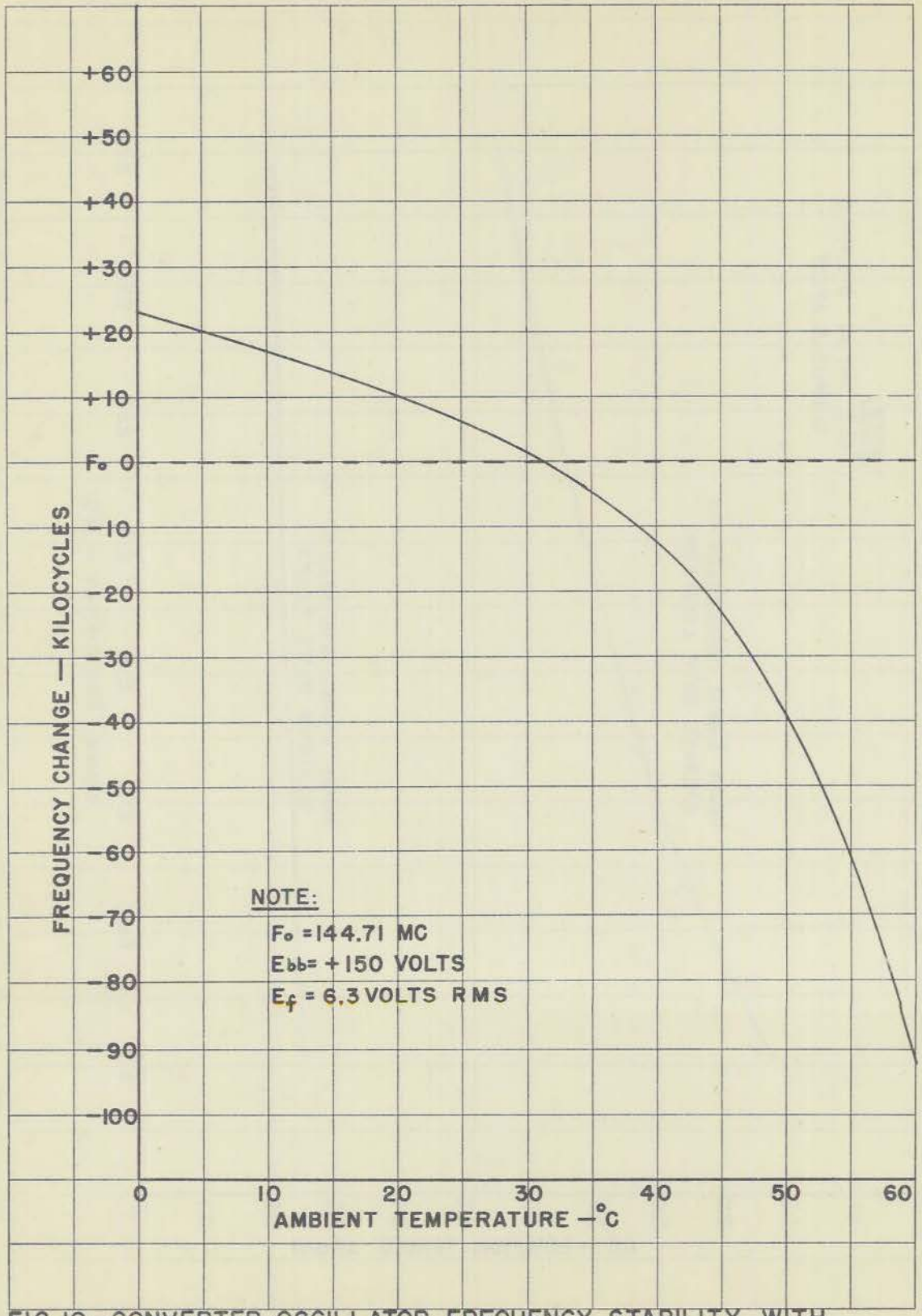

FIG. 19 — CONVERTER OSCILLATOR FREQUENCY STABILITY WITH TEMPERATURE CHANGE