Restricted

INSTRUCTIONS FOR INSTALLATION AND OPERATION OF MODEL

FSC FREQUENCY SHIFT CONVERTER

NAVSHIPS 900,078

PREPARED BY CHIEF OF NAVAL OPERATIONS AND
RADIO LABORATORY, NAVY YARD, WASHINGTON, D. C.

PUBLISHED BY ELECTRONICS DIVISION
BUREAU OF SHIPS • NAVY DEPARTMENT

Bureau of Ships,
Navy Department,
Washington 25, D.C.

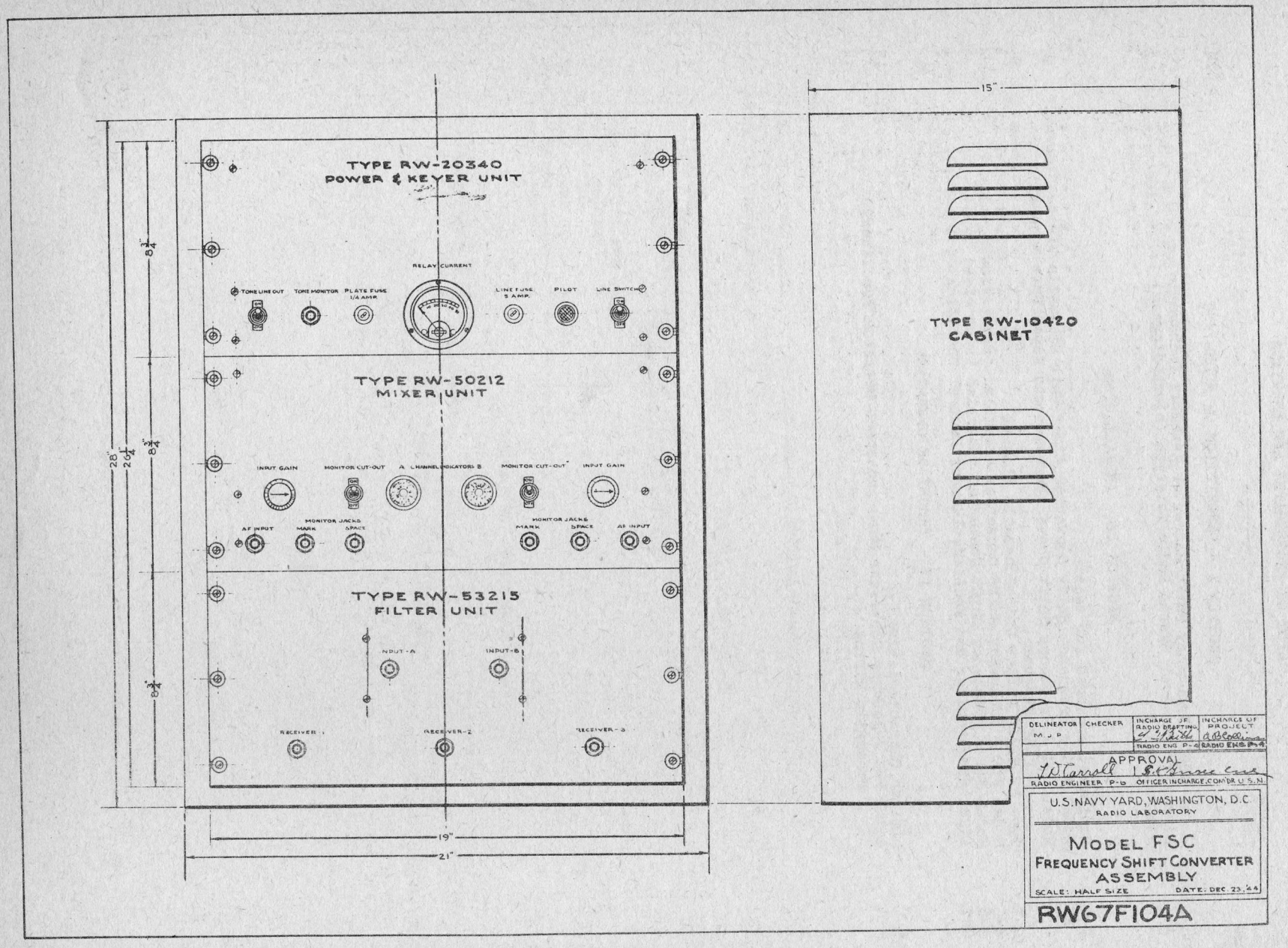
February 1, 1945

1. INSTRUCTIONS FOR INSTALLATION AND OPERATION OF MODEL FSC FREQUENCY SHIFT CONVERTER (Navships 900,078) is a RESTRICTED Publication.

2. This publication is intended for the use of Naval personnel (officer, enlisted and civilian) who are engaged in the installation, maintenance and operation of this equipment.

3. Additional copies of this publication may be obtained from the Bureau of Ships, Navy Department, Washington 25, D.C.

J. B. Dow
Captain, USN



Model FSC - Frequency Shift Converter Assembly (schematic)

SECTION I - DESCRIPTION OF MODEL FSC - FREQUENCY SHIFT CONVERTER

1. General - This instruction book contains directions for the installation, operation and maintenance of the Model FSC Frequency Shift Converters, Serial Nos. 1 to 70 inclusive, the purpose of which is to demodulate frequency-shift-keyed radio teletype signals. The apparatus functions at audio frequencies and hence may be used with any stable communication receiver equipped with a beat frequency oscillator. This equipment was developed to meet an urgent need for which commercial equipment was not currently available. Extensive tests on actual operating circuits have demonstrated that results, favorably comparable with similar commercial apparatus, can be readily obtained.

2. Physical Description of Converter - The Converter is mounted in a steel cabinet (RW10420), 28" high by 21" wide by 15" deep (see drawing on page opposite) and weighs approximately 150 lbs. It consists of three basic units designated as the Mixer Unit (RW50212), Power and Keyer Unit (RW20340) and Filter Panel (RW53215). The Mixer Unit chassis contains two identical demodulators which separate the mark and space tones and combine the receiver outputs at DC. The Power Unit contains a regulated power supply giving plate, screen and bias potentials, a DC Amplifier for operating the output relay, and a Tone Keyer. The Filter Panel contains the input, mark and space filters for each demodulator channel.

3. Frequency Shift Keying - Briefly, frequency shift keyed signals are those in which marks are transmitted as a given frequency and spaces are transmitted as a slightly different frequency, usually about 850 cycles lower. Hence, signals are transmitted by both opening and closing the sending contacts of the teletypewriter, this being known as "polar keying", and results in a substantial improvement in the keying action. The transmitted carrier is therefore effectively continuous (since at any instant either marks or spaces are being transmitted), making it possible to employ receiving methods not normally practicable for an interrupted signal; that is, current limiting and automatic volume control. These improvements when coupled with frequency and spaced diversity provide a total improvement of approximately 40 db over an on/off keyed radio telegraph channel.

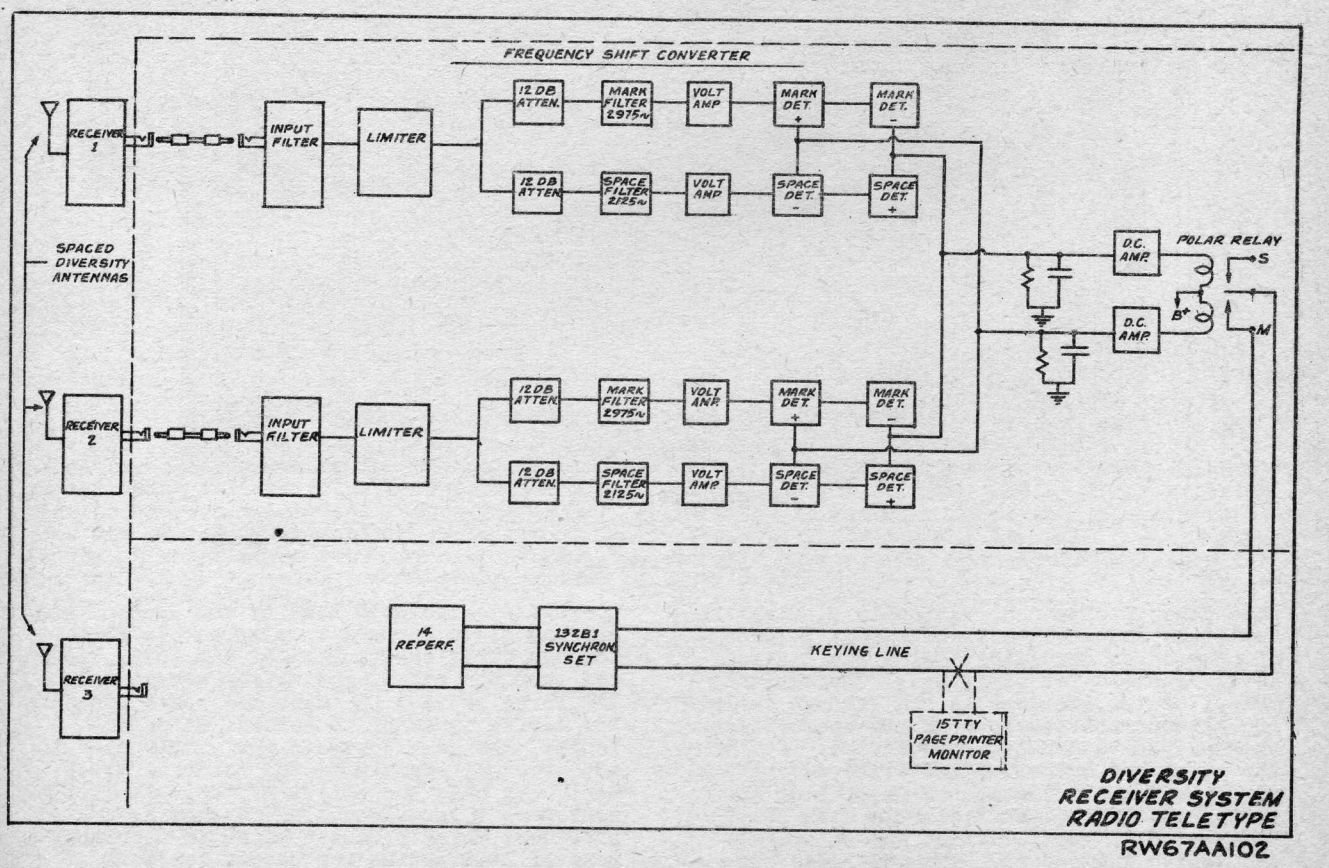


Figure 1-1 - Diversity Receiver System Radio Teletype.

creases to zero and begins to swing negative as 2550 cycles is passed. Move the positive lead from the voltmeter to terminal 1 of TB No. 3, adjust the oscillator frequency slightly to obtain maximum positive voltage, and reduce the space gain control until 10 volts is obtained. Shift the oscillator back to 2975 cycles, again observing the meter reading to decrease to zero as 2550 cycles is passed and swing negative as 2975 is approached. Return the positive lead to terminal 2 of TB No. 3 and check that 10 volts is still obtained. If not, make the necessary readjustments by decreasing both gain control settings until a point is reached where the adjustment of either does not affect the voltage controlled by the other. The final adjustment should preferably be between 8 to 10 volts although the unit will function on diode output voltages down to a minimum of 4.0.[1]

(2) Having completed the adjustment of Channel (A), repeat the process on Channel (B) by turning off (A) MONITOR CUT-OUT and turning (B) on. Channel (B) should be adjusted to provide exactly the same diode output voltage as did Channel (A).

(3) When the adjustment of Channel (B) is completed, set the oscillator at 2975 cycles and turn both MONITOR CUT-OUT switches ON. The relay current should remain at the same value (15 ma.) as obtained with only one channel running. If the current falls to zero ma. when both switches are ON, it indicates that the filters of one channel are reversed.

If any of the foregoing conditions cannot be met in preliminary testing of the equipment, refer to Section V - Maintenance. When tests are completed, assemble the unit in the cabinet, as shown in figures 2-5 and 2-6.

2. Installation

a. Receiver Requirements - The Converter will operate on the output of any type communication receiver equipped with a beat frequency oscillator. Obviously, stability and drift are the important criteria in the selection of a receiver that will provide reliable service and the minimum of operator adjustments. Three types of Navy receivers are particularly good in this regard and have been used successfully on operating circuits; preference is in the order listed: RBP, RBC and RDM.

b. Location of Converter - The Converter is normally mounted adjacent to the receivers with which it is used and there is no need for a special arrangement other than that the operator be able to see the tuning indicators and tune the receivers while his phones are plugged into the monitor jacks. There are no critical requirements as to the length of signal input or output keying lines. In existing shore installations the Converters have been used exclusively with RBP receivers (rack and panel type) and have been mounted at the end of the RBP bay in the same manner as is done with the FMA bay of the AN/FGC-1A. For such installations it is desirable to have the ship's carpenter construct a wooden cabinet about 30" high and of the same contour, width and depth as the Converter which will raise the unit to a height convenient for operation and give the appearance of a standard size rack.

c. Patch Panel - Five single circuit jacks are located on the filter panel and are used for selecting any two of the three receiving channels available in type RBP and RDM diversity receivers. This facilitates selecting the two receivers giving the best diversity action and also permits quick changeover in event of receiver failure or routine servicing.

d. Connection of RBP to Converter

(1) Input to the converter is obtained from the 500-ohm output transformer on the Monitor Detector of each receiver which feeds the monitor jacks in the Signal Control Panel. The center-tap of this transformer (T301) is grounded and must be opened since one side of the Converter input is grounded. T301 is physically located in the lower right hand corner (viewed from the rear of the receiver) of the I. F. Amplifier compartment at the base of each receiver bay. A long soldering lug connects the transformer center-tap directly to the chassis and it is simply lifted off with the aid of an iron. The output line from this transformer appears on the first three pairs of terminals (numbered 1, 2 and 3) on the left hand side of terminal strip TB No. 2 on the rear of the Signal Control Panel. Shielded two conductor lines are run from these terminals to the input terminal strip on the rear of the Converter filter panel, which is similarly numbered in pairs: 1, 2 and 3. The right hand terminal of each pair is the ground side and all are made common with the ground terminal at the far left side of the strip.

(2) Adjustment of BFO - To prevent detuning of the high frequency oscillator in order to obtain the beat frequencies required it is necessary to tune the existing BFO's in each receiver to the maximum possible difference frequency with the 50 kcs I.F. This is accomplished by loosely coupling the output of an LM or LP signal generator into the grid of V301, the first 450 kcs I.F. stage, placing the AF BEAT-ZERO BEAT switch on ZERO BEAT, then tuning the signal generator to obtain zero beat while listening at the monitor jack. The BFO switch is then thrown to AF BEAT and the padder condensers on the BFO 50 kcs Oscillator adjusted to obtain the maximum possible beat note. This results in the BFO being tuned to a frequency approximately 2300 cycles lower than the 50 kcs I.F., so that when the high frequency oscillator vernier is adjusted to provide the correct operating frequencies for the Converter, the signal is passed effectively through the center of the IF pass band. The switch is permanently left in the AF BEAT position for use with the Converter. The top of the BFO Oscillator is actually the mounting plate for the AF BEAT-ZERO BEAT switch and the padders are made accessible by simply slipping off the cover. In the event it would be desired to return the receiver to telegraph service and the

---

[1] After placing the unit in operation on a circuit, the diode output voltage should be checked about once a month and any necessary readjustments made to compensate for inequalities of gain in the two channels that would arise due to aging of tubes.

zero beating feature required, it is simply necessary to feed a 450 kcs signal into the first 450 kcs I.F. stage, and with the switch in ZERO BEAT position retune the padders to obtain zero beat.

(3) Use of Signal Control Panel - The receivers, insofar as the functioning of the Converter is concerned, are operated as distinctly separate units. However, the Signal Control Panel may be used to combine the receivers in the normal manner to obtain the control voltage for Automatic Gain Control and to use the diode current meters as being representative of the diversity action obtained in the Converter. However, it should be borne in mind that the combination[1] of receivers in the Signal Panel in no way either aids or impedes the operation of the Converter and except for the additional diversity effect obtained by the proper use of AGC, the output of the Monitor Detectors is uneffected by the keyer panel combination.

e. Connection of RDM to Converter

(1) The receivers are operated as separate units and the input for the Converter is obtained from the 600 ohm winding on the output transformer (T2) of each receiver. This voltage appears on TB4 and no modification of the output circuit is required. Receivers are used in the manner described in the RDM instruction book in part 3, "Single Receiver Operation" of Section IX - Operation. Connection of the line from the receiver to the Converter is the same as described in Section II, 2d(1).

(2) The tone keyer and diversity mixer of the receiver are not used.

(3) Frequency adjustment is made by using the BFO vernier. To obtain the proper order of mark and space frequencies, tune to the signal from the low side of zero beat and adjust the BFO vernier in a counter-clockwise direction.

f. Connection of RBC to Converter

(1) Two receivers are required, the output being obtained from the three prong amphenol connector (J 303) on the rear of the cabinet. The grounded center-tap (Terminal 5) on the output transformer (T 301) is opened. Connection of the line from the receiver to the Converter is the same as described in Section II, 2d(1).

(2) Adjustment of frequency is made with BFO vernier set to the right of the zero index.

g. Connection of Converter to Keying Line - A two conductor shielded cable for keying the teletype equipment is connected to the Converter output relay by means of terminals 3 and 4 on Jones plug P3. The polarity of the line is initially arranged so that for signals received of the correct order, the output reversing switch is on NORMAL MARK. Line current (60 ma.) for keying purposes is supplied by the rectifier in the teletype equipment.

h. Location of Teletype Equipment - Teletype equipment is inevitably a source of radio interference, especially if governor type motors are used, and therefore should be located as far as practicable (for the station arrangement) from the radio receivers. In some cases the teletype apparatus has been in a separate building, up to several miles distant from the receivers. However, if it is necessary to have it adjacent to the receivers much can be done to minimize the noise by bonding all equipment, running keying lines in shielded cable, and using a separate shielded power line for the teletype equipment. Experience has demonstrated that a major portion of the noise is radiated from the power line.

i. Teletype Monitoring Facilities - It would seem contradictory to recommend a monitor TTY[2] for use by the operator in view of the previous statement with regard to noise. While successful operation can be maintained without the operator having access to means for making page copy, it is undeniable that monitoring facilities are a great aid to efficient circuit operation. This is especially true if the installation involves several receiving radio-teletype circuits. It is also apparent that the noise problem is distinctly different for the monitor TTY which is operated only intermittently for circuit checking as compared with that equipment used continuously for traffic copy. The Monitor TTY (Model 15 RO) should be located so as to be readily available to the operator and connected in series with the keying line from the Converter to the traffic equipment.

j. Teletype Requirements - It is not within the scope of this manual to give a detailed description of printer station arrangements as these are covered in the Teletype instruction books and can be as simple or complicated as the particular job to be done requires. Often a Model 15 page printer is used and the receive line on it would be connected to the Converter output line. The polar-neutral key on the keyboard of the printer would be thrown to neutral position. The line current would be adjusted to 60 ma. This is only the procedure in general because the type of table used with the printer will determine actual wiring. If a reperforater is to be operated, a 132B1 Synchronizer Set (or 132A2) is usually required. The 132B1 Synchronizer as supplied is wired for a polar receiving line and a simple modification is required for neutral operation with line current being furnished by the rectifier.

k. Modification of Synchronizer Set for Neutral Operation

(1) To receive neutral signals on R relay of the 132B1 (or 132A2) set it is necessary to place 30 ma. of bias on the 2-7 winding of relay R and obtain line current for the 3-6 winding from the internal power wiring circuit. Figure 2-5a and 2-5b shows the strapping of B terminal blocks and the TEST-REG key necessary to do this. Rerer to the synchronizer instruction book, Printer Station

---

[1] Combination in this usage applies specifically to the tying of receiver outputs together to obtain diversity operation.

[2] Abbreviation for Teletypewriter.

the tuning indicator and for greatest clarity of tone in the headphones, watching the amplitude change on the side of the eye that corresponds to the tone to which you are listening (marks left, spaces right).

Having tuned Channel (A) properly, turn the MONITOR CUT-OUT switch of Channel (B) ON, and (A) OFF. Tune Channel (B) by the same procedure as given above. When Channel (B) is properly tuned turn on Channel (A) MONITOR CUT-OUT switch ((B) also on), and observe that the output meter does not change. To check that the two channels are mixing properly, turn (B) off momentarily and observe the output to remain constant, turn (B) back on and turn (A) off momentarily. The output meter should remain constant and the relay operate properly providing there are no deep fade outs during the period that only one channel is connected to the operating load; with both channels on, the unit should be insensitive to fading except for complete drop-outs on both receivers simultaneously.

Once having made the initial tuning adjustment it should only be necessary to make a slight readjustment to each channel about once an hour. This is done by first observing the channel indicators and selecting the one showing the greater asymmetry of swing. Turn OFF the MONITOR CUT-OUT switch for that channel and carefully readjust the frequency of the receiver feeding that channel for a symmetrical swing at maximum amplitude, checking the adjustment while listening with phones in the mark or space monitor jacks. Having adjusted the poorer channel, turn the MONITOR CUT-OUT switch for it back on and proceed to adjust the other channel by the same method. If the adjustment is performed in this manner it is possible to tune the equipment without disturbing the Teletype copy.

The operator is cautioned against "overtuning" the equipment; i.e., he should not acquire the habit of spending an unnecessarily long time studying his adjustment when running with only one channel on. The actual time required to properly make a tuning adjustment should only be a matter of seconds after reasonable familiarity with the operation of the equipment. The ideal situation, of course, is to be able to make all tuning adjustments when the transmitting station is in a steady marking condition between messages, since it is then impossible for the operator to garble traffic by any mistakes he might inadvertently make. This should be the policy whenever possible.

One notable difference between this Converter and the commercially constructed FMA bay of the AN/FGC-1A is the lack of Automatic Frequency Control. It has been conclusively demonstrated on operating circuits that this is not a serious drawback because the required tuning adjustments are neither excessive in number nor difficult to perform. However, it is necessary that operators, especially those having used the AN/FGC-1A, realize that this equipment does require periodic adjustment and that its successful usage depends upon conscientious operator attention.