INSTRUCTION BOOK

for

COMMUNICATION RECEIVER MODEL FFR

THE TECHNICAL MATERIEL CORPORATION
Mamaroneck, New York

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I
GENERAL DESCRIPTION

1. PURPOSE AND BASIC PRINCIPLES

The Model FFR Communication Receiver has been designed to fulfill the long existing need for a sturdy, easily turnable, single frequency receiver, which will provide maximum flexibility and thoroughly dependable, unattended, continuous reception of AM radio telephone, CW telegraph or teletype, and MCW telegraph signals.

The design of this receiver is a departure from the conventional single channel receiver in that it provides for both crystal and VFO operation of the HFO and BFO. The front end is simply and accurately tuned by a single Frequency Tuning Dial with a vernier reduction ratio of 10 to 1, which permits maximum traverse speed and ease of operation. A specially designed input transformer provides an impedance matching circuit suitable for use with a straight wire antenna, a balanced doublet, and a 75 ohm unbalanced or 300 ohm balanced line.

The Model FFR covers a frequency range of 2 Mcs to 32 Mcs by means of four plug-in drawers, which contain the necessary coils to cover a 2 to 1 Frequency Range. These drawers are sturdily built and incorporate the 1st RF, 2nd RF, VFO, and Mixer circuits. This type of construction provides excellent shielding between stages and minimizes the difficulties usually encountered with this type of receiver.

When used in the TMC Model RCR Remote Control Receiver System, control of the HFO, BFO, and Sensitivity is accomplished on a tone basis; in addition, provision is made for ON/OFF control of the AVC and BFO. This feature is particularly useful when the receiver is to be used remotely for CW and phone operation. This remote control provides approximately plus or minus 2.5 kc and 5 kc adjustment of the HFO from a preset frequency of 5 Mcs and 10 Mcs, respectively, and a plus or minus 2 kc range of the BFO.

Output terminations are provided so that two receivers may be used in diversity for CW, FS and Phone services, and either receiver may be used in the MASTER or SLAVE position by front panel switches in the BFO and HFO circuits. The AVC bus, HFO, BFO, IF, and Diode Load are all brought out to the rear of the receiver chassis for diversity inter-connection. When used in diversity, crystal control of the HFO and BFO is also possible, providing a very compact dual diversity system requiring only 10-1/2 inches of space.

2. DESCRIPTION OF UNIT

The Communication Receiver, Model FFR, is shown in Figure 1-1. The panel is 3/16 inches thick by 19 inches long and 5-1/4 inches high, and is finished in TMC grey enamel. The chassis extends 15 inches behind the panel and is supported to the panel on each side by brackets. The controls most often used are located on the front panel, while the terminal connections are located at the rear of the receiver chassis.

Facilities for remote control applications have been provided at the rear of the receiver. For short distance operations (within a one mile radius) a ±3 volts D.C. applied separately to terminals 1 and 7 (on terminal strip E-102) and a -40 volts D.C. applied to terminal 3 of the same strip will provide remote control of the HFO, BFO and RF GAIN respectively. Also, a toggle switch must be connected to the BFO ON/OFF terminals and turned to its ON position. For remote control by a variation of amplitude tones, the TMC Tone Demodulator, Model AMD may also be mounted at the rear of the receiver. For remote control by frequency shifted tones, the TMC Remote Control Receiver System, Model RCR is used to provide the necessary control functions. In addition, any remote control system, which provides the necessary D.C. voltages as mentioned above, may be used in conjunction with the Model FFR.

Vacuum tubes are readily accessible from the top of the Model FFR and are mounted in a vertical position. All components are so mounted that trouble-shooting and maintenance may be easily accomplished.

3. TECHNICAL SPECIFICATIONS

Frequency Range:
2 to 32 megacycles in four bands.

Band Change:
By means of four plug-in tuning drawers, each covering the following frequencies:
FFRD-5 covers 2-4 Mcs.
FFRD-6 covers 4-8 Mcs.
FFRD-7 covers 8-16 Mcs.
FFRD-8 covers 16-32 Mcs.

Type of Reception:
AM, CW, and MCW signals. FS when used with appropriate Audio or IF type Frequency Shift Converter.

Tuning System:
Single dial control.

Antenna Input Circuit:
75 ohms unbalanced, 300 ohms balanced.

Oscillator Circuit:
Variable Frequency and Crystal Oscillator.

BFO Circuit:
Variable Frequency and Crystal BFO.

Sensitivity:
2.5 micro volts for a 10 db Signal to Noise Power ratio at 30 Mcs.

Image Ratio:
Better than 60 db for 2-16 Mcs., not less than 40 db. for 16-30 Mcs.

AVC Characteristics:
With an 80 db change in the input signal, the output remains constant within 12 db.

Selectivity:
5 kc at 6 db down.
25 kc at 60 db down.

Overall Selectivity:
Less than 5 kc at 6 db down.

Output Impedance:
8 ohms and 600 ohms.

Hum Level:
Better than 40 db.

Output Power:
2 watts maximum.

Input Power:
110/220 volts, 50/60 cycles, approximately 85 watts.

Noise Limiter:
A Noise Limiter circuit is provided, which provides maximum effectiveness in combating impulse noise.

Rear Panel Facilities:
Antenna Connections.
Fuse.
BFO Connections.
HFO Connections.
IF Connections.

Front Panel Controls:

Main Chassis	Tuning Drawers
Noise Limiter Switch.	Tuning Dial.
Pilot Light.	HFO Master-Slave Switch.
Audio Gain Control.	Crystal Trimmer.
Phone Jack.	Tuning Dial Lock.
BFO Master-Slave Switch.	
AVC/MANUAL Switch.	
BFO ON/OFF Switch.	
RF Gain Control and Power ON/OFF Switch.	
BFO Pitch.	

Remote Control Facilities:
(Rear Panel)
HFO EXTERNAL.
EXT RF Gain.
INT RF Gain.
BFO Relay.
BFO EXTERNAL.

Diversity Facilities:
(Rear Panel)
Loudspeaker Connections.
AVC Bus Connections.
Diode Load Connections.

Mounting:
Standard WE rack mounting.

Size and Weight:
19'' wide x 5 1/4'' high x 15'' deep, (w/coaxial), approximately 35 lbs.

Tube Complement:
3 each 6BA6, IF Amplifier.
1 each 6AL5, Detector and AVC.
1 each 6T8, Noise-Limiter, Audio.
1 each 6AQ5, Audio.
1 each 6J6, BFO Reactance Tube.
1 each 6AG5, BFO Oscillator.

Bands 5, 6 and 7:
4 each 6AG5, RF Amplifiers, HFO.
1 each 6AU6 Mixer.

Band 8:
3 each 6AK5 RF Amplifiers, HFO.
1 each 6AU6 Mixer.
1 each 6AG5 HFO Reactance Tube.

Power Supply:
1 each 5Y3GT, Rectifier.
1 each OA2, Voltage Regulator.

Construction and Components:
Equipment is manufactured in accordance with JAN specifications wherever practicable.

* * *

We reserve the right to make changes in the design of our equipment, consistent with good engineering practice, in order to make improvements in design and to effect economies in manufacture.

TABLE 1-1. PERFORMANCE DATA

(Approximate Values - Taken from Prototype Receiver)

Head	Frequency in Megacycles	Sensitivity in Microvolts for 1 volt across diode load (Approx. 2 watts output)	Antenna Input in Microvolts for 10db Signal - Noise Ratio	Image Ratio
FFRD-5	2.1	0.35 uv	0.36 uv	86000
	3.0	0.40 uv	0.40 uv	25000
	3.9	0.40 uv	0.35 uv	9500
FFRD-6	3.95	0.18 uv	0.32 uv	31000
	6.00	0.25 uv	0.35 uv	7200
	8.30	0.40 uv	0.42 uv	1400
FFRD-7	8.00	0.9 uv	0.44 uv	24500
	12.00	1.0 uv	0.53 uv	2800
	16.00	0.8 uv	0.60 uv	1000
FFRD-8	16.0	1.30 uv	1.2 uv	4000
	24.0	0.70 uv	0.9 uv	300
	32.0	0.50 uv	1.3 uv	200

SECTION II
THEORY OF OPERATION

1. GENERAL DESCRIPTION OF CIRCUITS

The design of the Model FFR featuring versatility and steady performance assures continous reception of phone and code signals over its entire frequency range of 2 Mcs. to 32 Mcs. Two R.F. and three I.F. stages provide a high degree of sensitivity, selectivity, and image rejection to insure uninterrupted reception. A noise-limiter, effective on both code and phone reception, reduces pulse interferences. Other circuit refinements feature a minimum of frequency drift in the oscillators, a high gain audio stage, and two manual volume controls.

The Model FFR utilizes 10 tubes, plus 5 more for each drawer, in a superheterodyne circuit, shown schematically in Figure 4-5. The circuitry employed consists of 2 stages of R.F. amplification, a mixer, HFO oscillator, HFO oscillator reactance control, 3 stages of I.F. amplification, detector and A.V.C., BFO oscillator, BFO oscillator reactance tube, noise limiter, A.F. amplifier, and an integral power supply system.

Contained in each of 4 drawers are 2 R.F. amplifiers, a mixer, an HFO oscillator, and an HFO oscillator reactance tube. At the rear of each drawer is a multiple connector plug by which the antenna circuit (A1), the I.F. input (A2), HFO output (A3), HFO input (A4), external oscillator injection, R.F. gain control, and the power supply voltages are connected to the receiver proper.

The main chassis deck consists of the I.F. strip, the audio amplifier, and the BFO assembly. The associated operating controls are mounted on the front panel of the receiver. The I.F. frequency is centered at 455 kcs.

2. CIRCUIT ANALYSIS

A block diagram, Figure 2-1, shows the arrangement and functions of the various circuit sections. Constant reference to both the schematic and block diagrams will facilitate a more thorough understanding of the unit and will serve to illustrate the basic composition of the Model FFR.

INPUT COUPLING.- The antenna input terminals are provided at the rear of the receiver. An efficient coupling system between the antenna and the first RF tube provides sufficient gain to override the "shot effect" and thermal agitation originating in the first tube and its associated circuits. The antenna coupling is designed to provide optimum coupling from a 300 ohm balanced or a 75 ohms unbalanced line. A balanced doublet or straight wire antenna may also be used.

RF AMPLIFIERS AND MIXER.- Maximum sensitivity at high signal to noise ratio is assured by the design of the R.F. amplifiers. The coil assemblies of the amplifiers, together with those of the mixer and HFO oscillator, are placed directly adjacent to their respective sections of the four-gang tuning capacitor and their respective tubes. To insure stability and minimize oscillator radiation, the coils are enclosed in grounded shielded containers; input and output circuits are well isolated to prevent any possible regeneration. A 6AU6 triode-connected mixer is used for maximum conversion gain and low noise factor.

HIGH FREQUENCY OSCILLATOR.- The high frequency oscillator is aligned to track with the R.F. Amplifiers to produce a 455 kc intermediate frequency in the Mixer output. A front panel switch controls the H.F.O. for Master-Slave or crystal-controlled operation. For remote control purposes, a d.c. voltage(as obtained from the TMC Model AMD) of 0 to ±3 volts must be connected to the HFO external terminal at the rear of the receiver. This voltage controls the center frequency of the oscillator by varying the output impedance of the reactance modulator. The oscillator voltage is regulated by the OA2 regulator tube to provide maximum frequency stability under variable conditions of power supply voltage.

I.F. AMPLIFIERS.- Three separate I.F. stages of amplification are employed and provide adequate gain. Each I.F. transformer has its primary and secondary tuned by means of powdered iron cores. Eight tuned circuitsin the I.F. system provide the necessary I.F. selectivity. The bandwidth ratio at 60 to 6 db being less than 5 assures good I.F. selectivity performances.

DETECTOR AND AVC.- The detector and AVC functions are performed by the dual-diode 6AL5. Both the detector and AVC load connections are brought out to the rear terminal strip for diversity reception. One plate of the diode section of the tube is used for signal detection and the other for AVC rectification. The AVC voltage is connected to the 1st and 2nd R.F. amplifiers and to the grids of the 1st and 2nd I.F. amplifiers. Thus good AVC characteristic is obtained. The time constant is approximately .01 second.

BFO OSCILLATOR.- The beat frequency oscillator employs a magnetic-coupling Hartley circuit, which provides stability and a minimum of oscillator harmonics. A front panel switch, similar to the one used in the HFO, controls the BFO for Master-Slave or crystal-controlled operation. Likewise, a BFO External Control terminal on the rear of the unit permits remote control operation of the BFO tuning, when a d.c. voltage of ±3 volts is applied.

NOISE LIMITER.- A series-diode noise limiting circuit effects noise reduction on CW or modulated reception when inpulse noise is present. A front panel switch, S-100, permits the optional use of the noise limiter. The second part of the 6T8 is a resistance-coupled audio-amplifier triode, in whose grid is placed the conventional audio-volume control.

AUDIO-OUTPUT.- The 6AQ5 beam power amplifier, driven by the triode section of the 6T8 tube, delivers 2 watts into an 8 or 600 ohm load. A phone jack available on the front panel permits use of a headset of 600 ohms impedance or higher under normal conditions.

IF OUTPUT.- A connection is made through a 15 uuf condenser to the plate of the 2nd IF amplifier, which supplies the I.F. (455 kc) voltage to the IF output jack on the rear of the unit. This voltage is of sufficient amplitude for use with a variety of equipment, such as the TMC Diversity Combining Unit (Model DCU) and the TMC Diversity Visual Monitor (Model DVM).

RF GAIN CONTROL.- The RF gain control is provided for the manual control of the sensitivity to prevent overloading in the presence of strong signals and operates on either position of the MANUAL or AVC switch. When two receivers are used in diversity reception with antennas of different characteristics, it may be necessary to use the RF gain control when the AVC is in operation. For remote control operation, a shielded and well isolated control line with about -40 volts output must be connected across the EXTERNAL RF gain terminal on the rear chassis. When the RF gain is operated remotely, the RF gain control on the receiver should be set at its minimum position.

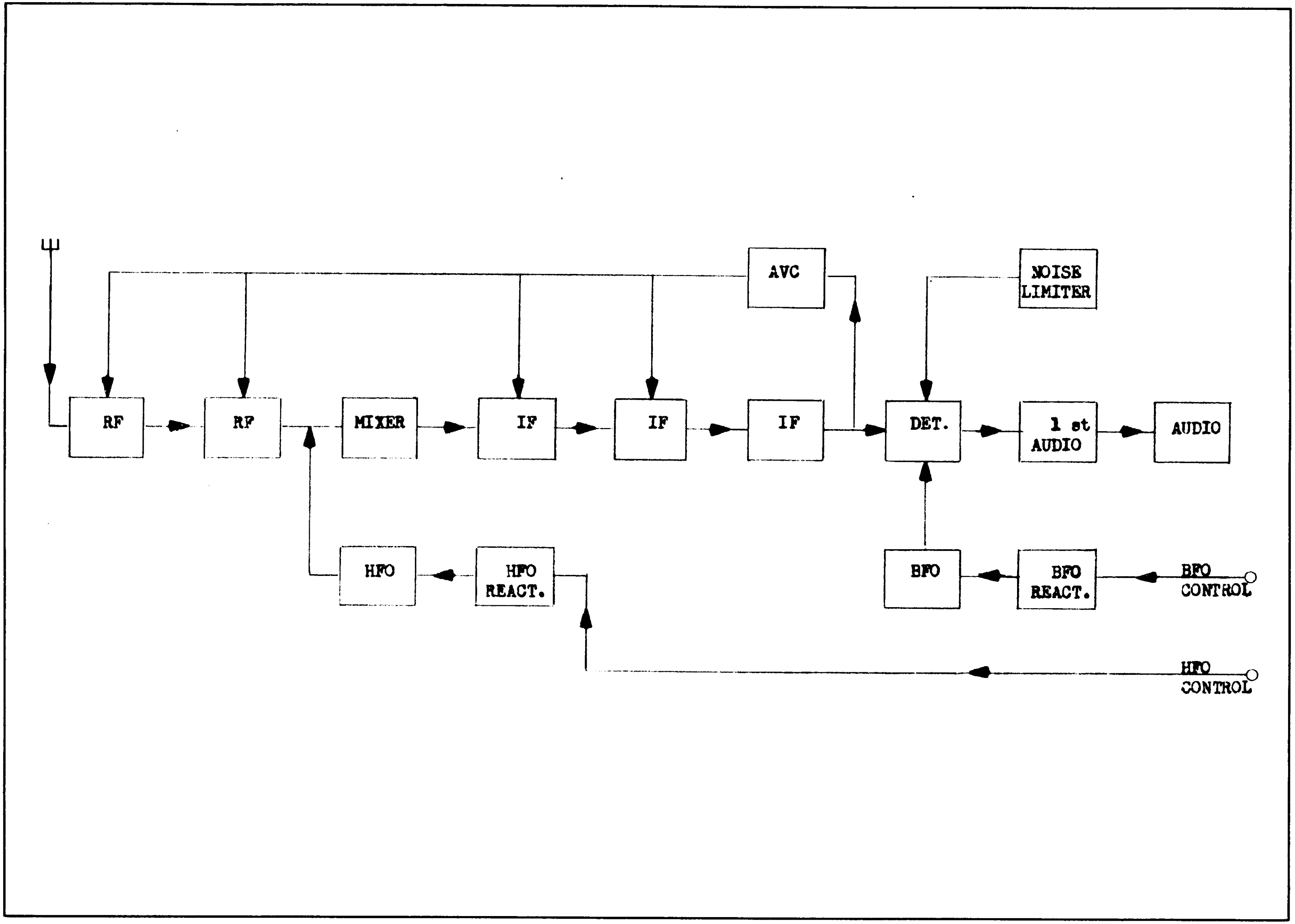


Figure 2-1. Block Diagram for the Model FFR.

POWER SUPPLY.- The power supply is self-contained and consists of a power transformer, rectifier, voltage regulator, and filter. It is designed for 110/220 volts, 50/60 cycles, single phase operation, with a power consumption of approximately 85 watts. The power supply includes a voltage regulator system which compensates for changes of load and line voltage, holding the voltage more constant. Adequate filtering is provided to prevent line noise and stray voltages from entering the receiver by way of the power line.

SECTION III
INSTALLATION AND OPERATION

1. INSTALLATION

A. UNPACKING

The Communication Receiver, Model FFR has been designed for ease of installation and minimum effort in operation. The unit comes in its individual shipping container and should be carefully unpacked. A close visual inspection should be made to ascertain any physical damage due to rough handling during shipment.

B. POWER SUPPLY

The unit is designed for operation from a 110 volts A.C. 50/60 cycles source, unless it is specifically ordered for 220 volts A.C., 50/60 cycles. The receiver is shipped from the factory with the power transformer wired for 110 volts A.C. operation only. However, a simple wiring change in the tapped primary circuit of the power transformer is necessary to change the Model FFR for 220 volts A.C. operation. This change is made directly on the power transformer terminal lugs and is as follows:

Connect the power line to terminals "1" and "3" on the primary power transformer winding, as indicated on the schematic diagram.

C. ELECTRICAL CONNECTIONS

The antenna connections should be made at the proper terminals at the rear of the unit. The input impedance has been designed to match a balanced 300 ohm or an unbalanced 75 ohm transmission line. When using a balanced 300 ohm line, one side is to be connected to point "1" and the otherside to point "2"; when using a 75 ohm unbalanced line, connect the shield to the ground terminal, point "3", and the center conductor to point "1" (Refer to terminal E-100 on the schematic diagram.). A jack is provided on the front panel for plugging in a pair of headphones. Both high and low impedance headphones may be used in the phone jack. Audio output terminals for connection of a loudspeaker are provided at the rear of the receiver (terminal E-101). The output transformer is designed to match a speaker having either 8 ohms or 600 ohms impedance.

After unpacking, install receiver as follows:

1. Seat the tubes firmly in their sockets.
2. Connect a loudspeaker to the 8 ohm or 600 ohm terminals on E-101(on the rear chassis) or a headset to the phone jack(J-106) on the front panel.
3. Connect the antenna according to the instructions set forth in the above paragraph.
4. Connect the power cord to a 110 volts, 50/60 cycles source of supply.
5. Set the controls for operation as set forth in Section III-2B.

The unit may be placed on a table or mounted in a rack. The panel is equipped with standard slots for rack mounting. Before mounting the receiver in the rack, inspect the tubes to see that they are firmly seated in their respective sockets. Once the desired converter drawer has selected, the operator must be certain to tighten the lock nuts on the front panel in order to secure the drawer to the main chassis.

2. OPERATION

A. DESCRIPTION OF CONTROLS.

All controls are identified by the front panel markings for ease of identification and are arranged for ease of operation. Figure 3-1 illustrates the dial and control knobs.

The MAIN TUNING DIAL is in the lower right corner of each converter drawer. The knob operates the four gang-tuned capacitors and turns the dial scale through a vernier gear-train reduction of 10 to 1. The dial is calibrated directly in megacycles. A lock on the shaft of the main tuning dial effects positive locking action without disturbing the frequency setting.

The TRIMMER control in the upper left corner of the converter drawers operates a tuning capacitor, which is connected across the crystal in the HFO oscillator circuit. This TRIMMER is used to adjust the crystal on frequency when crystal-control of the HFO is desired.

The HFO MASTER-SLAVE switch, on the lower left corner of each drawer, is a two pole, three position switch, and, starting from fully counterclockwise, permits optional External, Xtal, or HFO operation in the HFO circuit. The crystals for each frequency range are not supplied for the separate drawers.

The R. F. GAIN CONTROL is a continously variable sensitivity control used with the AUDIO GAIN control for all manual operation. Clockwise rotation increases the gain of the I.F. and R.F. stages. The A. C. POWER switch (S102) is associated with the R.F. GAIN control, and the A.C. power is tuned "On" as the R.F. GAIN control is as turned clockwise from its extreme counter-clockwise position.

The A.F. GAIN control adjusts the amount of audio voltage applied to the first audio tube. Clockwise rotation of this control increases the audio output power of the receiver.

The AVC-MANUAL toggle switch adjusts the receiver for either AUTOMATIC VOLUME CONTROL or MANUAL VOLUME CONTROL. The AVC can be used for both phone and code reception.

The NOISE-LIMITER toggle switch sets the unit for operation of noise limitation. Any noise peak voltages in excess of the set threshold are prevented from reaching the audio amplifiers. The limiter circuit is a series diode type and is equally effective for both phone or code reception.

The BFO CONTROL (S-104) turns on the BFO oscillator and is used for CW code reception. The CW code characters are made audible by the heterodyning action of the BFO with the IF signal frequency.

The BFO PITCH control operates a tuning capacitor (C137) across the tank circuit of the BFO oscillator. Turning of the knob in either direction of zero set changes the resonant frequency to give the desired pitch.

The BFO MASTER-SLAVE switch is similar to the HFO MASTER-SLAVE control and permits optional EXTERNAL, XTAL, or BFO operation in the BFO circuit.

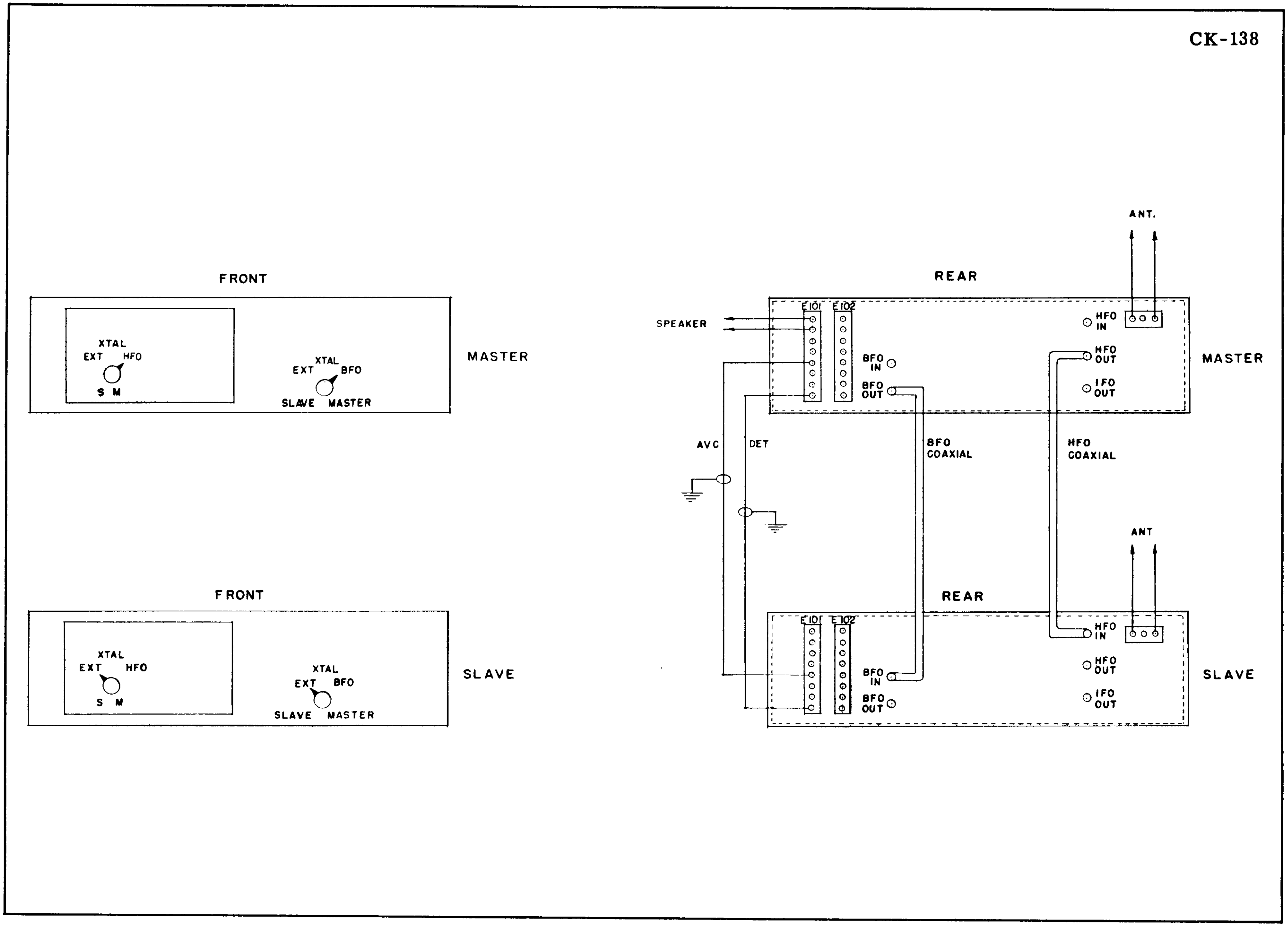
B. TUNING PROCEDURE

Initially, the operator must select the converter drawer covering the desired frequency range and plug the draw into the receiverproper. After the unit is mounted, he must adjust the receiver controls in the following manner:

1. Turn the R.F. GAIN control to the "On" position. The front panel light should be lighted.
2. Set the HFO MASTER-SLAVE switch on the front panel to the HFO position. If crystal-controlled operation of the HFO is desired, set the switch to the XTAL position.
3. Set the RF GAIN control fully on and the A.F. GAIN volume control to the desired audio level.
4. Set the NOISE-LIMITER and AVC-MANUAL controls to the desired mode of operation.
5. Tune in to the desired station via the main tuning dial.
6. Once the desired frequency is attained, adjust the RF GAIN control, AVC-MANUAL control, and the A.F. GAIN volume control to the desired value.

The receiver is now adjusted for phone reception and will tune to the frequency shown on tuning dial. When the AVC is being used, the R.F. GAIN control should be advanced as far as receiving conditions permit. However, the R.F. GAIN control may be retarded to reduce any objectionable disturbances or noise backgroud. The operation of the A.V.C. will be restricted unless the R.F. GAIN control is fully advanced. The operator should adjust the audio output volume entirely by use of the A.F. GAIN control.

For C.W. reception the receiver is tuned in the same manner as described above, except that the BFO CONTROL switch is turned to its "On" position and the BFO MASTER-SLAVE switch is set to its HFO position. If crystal-controlled operation of the BFO is desired, set the latter switch to its XTAL position. Then set the BFO pitch control to any desired value. When the BFO MASTER-SLAVE switch is on the XTAL position, the BFO PITCH control is inoperative. In the presence of a strong CW signal, the BFO injection may not be sufficient to give good heterodyne action, in which case the RF GAIN should be reduced to a desirable level. The BFO injection has been optimized around weak and medium strength signals. A large BFO injection causes a higher AVC voltage to be developed and thereby decreasing the basic receiver sensitivity.



Connections for Diversity Operations

C. DIVERSITY OPERATION

When properly spaced individual antennas are available, two Model FFR receivers may be used for diversity reception. Figure 3-3 illustrates the proper connections for diversity operation. The AVC terminals of the two receivers must be connected together with a patch cable; likewise, the DETECTOR terminals (Refer to E-101 on the schematic.)

Since the audio output of only one receiver is required, the operator should turn down the audio gain on one receiver and use only the gain of the other. Single oscillator control is obtained by connecting a shielded, low capacitance cable from the HFO OUTPUT connector (J-102) of one receiver to the HFO INPUT connector (J-101) of the other receiver, and setting the HFO MASTER-SLAVE switches of both receivers to the HFO and EXTERNAL-SLAVE positions, respectively. Or, if an external, precision oscillator is used, such as the TMC Variable Frequency Oscillator (Model VOX), both receivers should be set to the EXTERNAL-SLAVE position. The BFO may be set in exactly the same manner, in this instance, by using connectors J-104 and J-103. For crystal controlled operation of either both the HFO and BFO, insert a crystal in the master receiver and set the MASTER-SLAVE switch to the "XTAL" position; do not insert a crystal in the slave receiver, but merely set the MASTER-SLAVE switch to the EXT position.

D. REMOTE CONTROL.

Terminal strip E-102 at the rear of the receiver is provided for all connections for remote control operation. The operator must connect the outputs of two seperate ±3 volts D.C. to the BFO EXTERNAL and the HFO EXTERNAL terminals of the above mentioned strip. A -40 volts must be connected across the EXTERNAL RF GAIN terminal on the same strip, and the jumper between terminals "3" and "4" must be removed (see schematic diagram). In addition, the BFO switch must be turned ON. (When the Model AMD is being used, the RELAY terminals of the AMD and the BFO RELAY terminals on E-102 must be connected.

In all operations of the Model FFR, once the correct frequency is set on the receiver, the operator should tighten the dial lock on the panel drawer. The final adjustments and tightening of the dial lock should be done only after the receiver has had adequate time to reach operating stability, i.e. two or three hours.

SECTION IV
MAINTENANCE

1. SERVICE MAINTENANCE

A. GENERAL

The Model FFR has been designed for rugged, long term, trouble free duty. Familiarity with the receiver will permit quick frequency change, and once the receiver is properly adjusted, little attention beyond normal maintenance is required. It is recommended that any maintenance to the equipment be performed by a competent maintenance technician. The power supply system has been protected by a fuse easily accessible at the rear of the receiver. Power fuse failure in the receiver would normally be indicated by failure of the red pilot light to be on when the unit is turned on. If a fuse burns out immediately after replacement, do not replace it a second time until the cause has been corrected.

The location of all tubes and components in the Model FFR are shown in Figures 4-1 and 4-2. Normally, the tubes used in this unit have a long useful life, although occasionally a defective tube may be encountered and must be replaced. The tubes may be checked visually to see if they are lighted, or for warmth. When necessary, the tubes should be carefully removed and tested, and when replaced, care should be taken to install tube shields.

B. PREVENTATIVE

All tubes and components in the Model FFR have been carefully selected to assure maximum efficiency in operation. If the receiver sensitivity is reduced and tube failure is suspected, test each tube one at a time in a reliable tube tester. Replace the tube in the same socket from which it was removed, if its measured characteristics are within the manufacturers tolerances (usually +20% from tube manual values). No special selection is necessary in the event of tube replacement, but the operator should remember that tubes of the same type will vary slightly in their individual characteristics.

Failure may occur due to the breakdown of a capacitor or resistor. Test all DC and AC voltages as indicated on the tube voltage and resistance data sheets, Figure 4-2, and investigate any serious discrepancies. A faulty bypass capacitor may cause overload of associated resistors, which should be checked for any change in resistor value. A shorted resistor may be sighted by scorching or discoloration marks on the surface of the resistor. An open capacitor may cause unwanted oscillations and may be checked by connecting a good capacitor across it.

In order to prevent actual failure of the equipment due to corrosion, dust, and other destructive ambient conditions, it is recommended that the inside of the chassis be thoroughly inspected for signs of dirt, dampness, molding, charring, and corrosion, and to correct any defect found with a charring agent of proven quality. When placing the Model FFR in the rack, the operator should make certain that all terminal screw connections at the rear of the receiver are tight.

2. CIRCUIT ALIGNMENT

The circuits in the Model FFR have been carefully aligned with precision instruments at the factory, and realignment should be undertaken only when sub-par performance of the receiver against its normal operation is determined. A fiber screw-driver is recommended to make all the screw-type adjustments necessary for alignment. The TMC Tone Demodulator, Model AMD should be disconnected during alignment.

A. THE I.F.

It is recommended that the I.F. strip be aligned first. The receiver should be set up in the same manner as described in Section III-1C with no antenna lead-in and loudspeaker connected. The test instruments to be used are an accurate signal generator and a high-impedance A.C. voltmeter. The signal generator should be modulated 30 percent at 400 or 1000 cycles. Connect a 600 ohm load to the rear of the receiver and the A.C. voltmeter across the load; the signal-generator should be so adjusted as to give a 20-25 volt reading on the voltmeter. The I.F. is 455 kcs. In order to accurately calibrate a 455 kc test signal from the signal generator, a precision 455 kc crystal is placed in the BFO circuit (Y-100 on the schematic), and the BFO MASTER-SLAVE switch is set to the XTAL position. Then with the controls set as follows:

1. The BFO switch to ON position.
2. The AVC-MANUAL switch to the MANUAL position.
3. The A.F. GAIN turned on maximum.
4. The R.F. GAIN turned on maximum.
5. The NOISE-LIMITER switch to the OFF position.

Proceed as follows:

a. Set the HFO MASTER-SLAVE switch to the EXTERNAL position. The HFO is now acting as an amplifier.

b. Inject a 455 kc unmodulated signal from the signal generator to the HFO INPUT jack (J-101)

c. Vary the tuning dial of the signal generator until a "Zero Beat" is obtained. This beat will be evidenced by a sharp peaked response on the output meter; a headset or loudspeaker may also be used to hear the "Zero Beat".

This frequency is then that of the crystal and the I.F. alignment is made to this frequency, which is not to be disturbed for the remaining alignment. It may be necessary to adjust the signal generator output to prevent overload of the I.F. amplifiers.

Without changing the frequency setting of the signal generator, turn on the modulation of the signal generator and turn the BFO switch to the OFF position. The I.F. tuned, powdered-core transformers, T-101, T-102. T-103. and T-503 (T-603, T-703, and T-803 for the 6th, 7th, and 8th bands, respectively) should be carefully adjusted to give a maximum output on the voltmeter.

At this point, turn off the modulation; switch the BFO switch to the ON position; and set the BFO MASTER-SLAVE switch to BFO. Set the BFO PITCH control on the front panel to its "Zero" position. At this setting the BFO oscillator should produce a "Zero Beat" with the 455 kcs test signal. In the event that there is no "Zero Beat" at the "Zero" setting, tune the adjustable inductor (L-103) on the bottom of the receiver until a "Zero Beat" occurs at the "Zero" setting.

B. THE BFO REACTANCE TUBE.

Adjustment of the BFO Reactance Tube (V-106) requires a ±3 D.C. voltage to be applied between point 7 and ground on terminal board E-102 at the rear of the receiver. A high impedance vacuum tube voltmeter whose scale is thrown off zero to obtain center scale reading, such as the RCA Volt-Ohmyst model, is connected across points 7 and 8 on E-102. The BFO switch is set to its ON position, and the BFO PITCH control is set to its Zero position. Then proceed as follows:

1. Connect an oscilloscope across a 600 ohm load on terminal board E-101, and plug a set of headphones into the phone jack, if desired.

2. Set an audio-oscillator at 2000 cycles and connect its output to the horizontal input of the oscilloscope, the vertical input of the oscilloscope being connected across the 600 ohm load.

3. Following the same procedure as described in Section IV-2A, feed a calibrated test signal into the HFO INPUT jack (J-101).

4. Vary the D.C. output from a +3 to a -3 voltage and notice the lissajous pattern on the screen of the oscilloscope. A circle or ellipse should appear on the screen when the voltage limits of ±3 volts are reached. This would indicate that the BFO oscillator has shifted a ±2 kc. If the frequency shift is greater or less the ±2 kc and is asymmetrical about the zero-center point of the voltmeter, the reactance tube is then unbalanced.

5. Balancing of the reactance tube is accomplished by adjusting the variable resistor R-136, located on the main deck behind L-103. This screw-driver adjustment effects balance when a symmetrical frequency shift about the zero-center point of the voltmeter is seen on the oscilloscope.

C. THE R.F. HEAD

The following suggested procedure for alignment of the HFO oscillator, R.F. amplifiers, the first detector, and HFO Reactance tube requires an accurate signal generator, a vacuum tube voltmeter, and an LM18 meter. A typical alignment of Band 8 will serve as an example, which can be followed for all the bands included in the Model FFR.

1. After allowing the receiver to warm-up for at least two hours, connect the signal generator with a proper matching resistor to the antenna terminals. The proper matching is done as follows: If the impedance of the signal generator is less than 75 ohms, then the matching Resistor 75-Zgenerator. The generator should be modulated 30% at 1000 cycles.

2. Place a high impedance vacuum tube voltmeter across a 600 ohm load at the proper load terminals.

3. Plug a set of headphones into the PHONE jack, if desired.

4. Set the BFO to "Off", the LIMITER to "Off", the R.F. GAIN full, the HFO MASTER-SLAVE switch to HFO, and adjust the A.F. GAIN to an output of 20 volts on the meter.

5. Set the signal generator and the Model FFR dials to 32 Mcs.

The HFO is set to operate at a frequency above the first detector and R.F. amplifiers and not below. The fundamental-image relationship of this receiver is such that the signal image frequency always appears 910 kcs. higher on the dial of the signal generator (or 910 kcs. lower on the receiver dial). Referring to the oscillator trimmer C-827, starting from the maximum capacity setting in clockwise rotation, two distinct peaks will be obtained. After one of the peaks has been tuned in and assumed to be correct, the signal generator dial is tuned from 32 Mc. to 32.910 Mc. If a signal appears on this new setting, then the peak setting of the trimmer is correct. If the wrong peak was chosen, the operator should tune the trimmer to its adjacent peak and recheck the 32.91 Mc point on the signal generator. In all cases when checking the image frequency, the signal generator output should be increased because of pre-selector discrimination against image frequencies.

The next step is to set the signal generator and the FFR dial to 31 Mcs and peak the MIXER, RF, and ANTENNA trimmers C-813, C-809, C-802 in that order. When adjusting the MIXER trimmer, the signal generator should be reset slightly because of the pulling effect of the MIXER on the HFO oscillator. At the lower frequency heads, the MIXER trimmer may have two peak settings. One of these is due to the MIXER being tuned to the frequency of the HFO oscillator, resulting in great oscillator injection voltage, thus giving an apparent indication of correct alignment. However, this is the wrong setting. The correct setting is the one with maximum trimmer capacity.

Then, tune the signal generator and the FFR dial to 16 Mcs. Turn the trimmer "slug" of the HFO oscillator until an indication is noticed in the voltmeter. Check for its image at the 16.91 Mcs. setting on the signal generator, at the same time increasing the attenuating control on the signal generator. Once the correct peak setting of the slug is chosen, set the signal generator and the FFR dial to 17.5 Mcs. and peak the MIXER, RF, and ANTENNA "Slugs" in that order. Again, the operator must remember to retune slightly the dial of the signal generator because of the pulling effect of the MIXER on the HFO oscillator. Then, return the dial settings of the signal generator and the FFR to 32 Mcs. and repeat the procedure.

Table 4-1 gives a list of the frequency settings to be followed for the alignment of all the bands in the Model FFR. Using the frequencies shown in this table, align the bands in the same procedure as described above.

D. THE HFO REACTANCE TUBE

It is recommended that the HFO Reactance

Tube be adjusted in the center band. Set a standard crystal in the BFO circuit, and "Zero-beat" an unmodulated 24 Mcs. signal from an LM18 or a BC-221 frequency meter connected into the antenna with a ±3 v.D.C. signal connected to the HFO EXTERNAL terminal on E-102. Note the amount of shift on the frequency meter when the "zero-beat" has been established. Then trim C-823 to give a maximum shift when the ±3 D.C. voltage has been applied to the reactance tube input. A suggested circuit for the varying and controlling of a ±3 v.D.C. source in the BFO and HFO Reactance Tube alignment is shown in Figure 4-3. Then repeat the procedure for aligning the R.F. Head.

TABLE 4-1. RF AND HFO ALIGNMENT CHART

Freq. Band Mcs	FFRD-5 Low End	FFRD-5 High End	FFRD-6 Low	FFRD-6 High	FFRD-7 Low	FFRD-7 High	FFRD-8 Low	FFRD-8 High
Osc set to	1.95 Mc	4.1 Mc	3.9	8.3	7.9	16.4	16	32
Mixer peaked at	2.1 Mc	3.90 Mc	4.25	7.9			17.5	31
RF peaked at	2.1 Mc	3.9 Mc	4.25	7.9			17.5	31
Ant peaked at	2.1 Mc	3.9 Mc	4.25	7.9			17.5	31

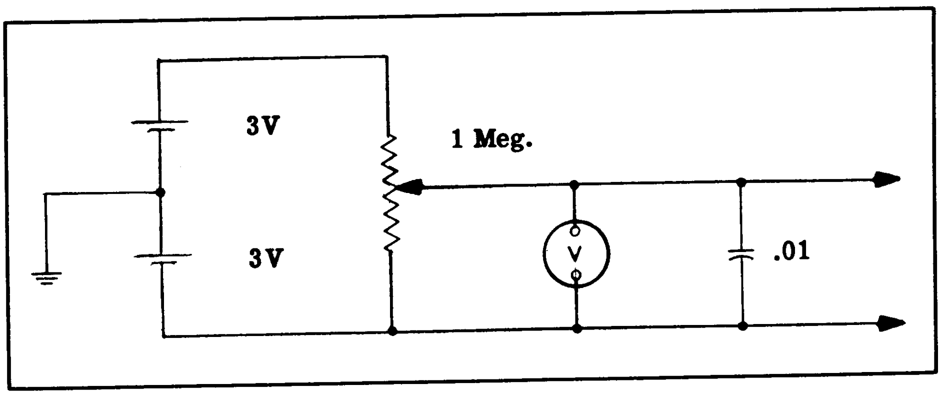


Figure 4-4. D.C. Control Circuit

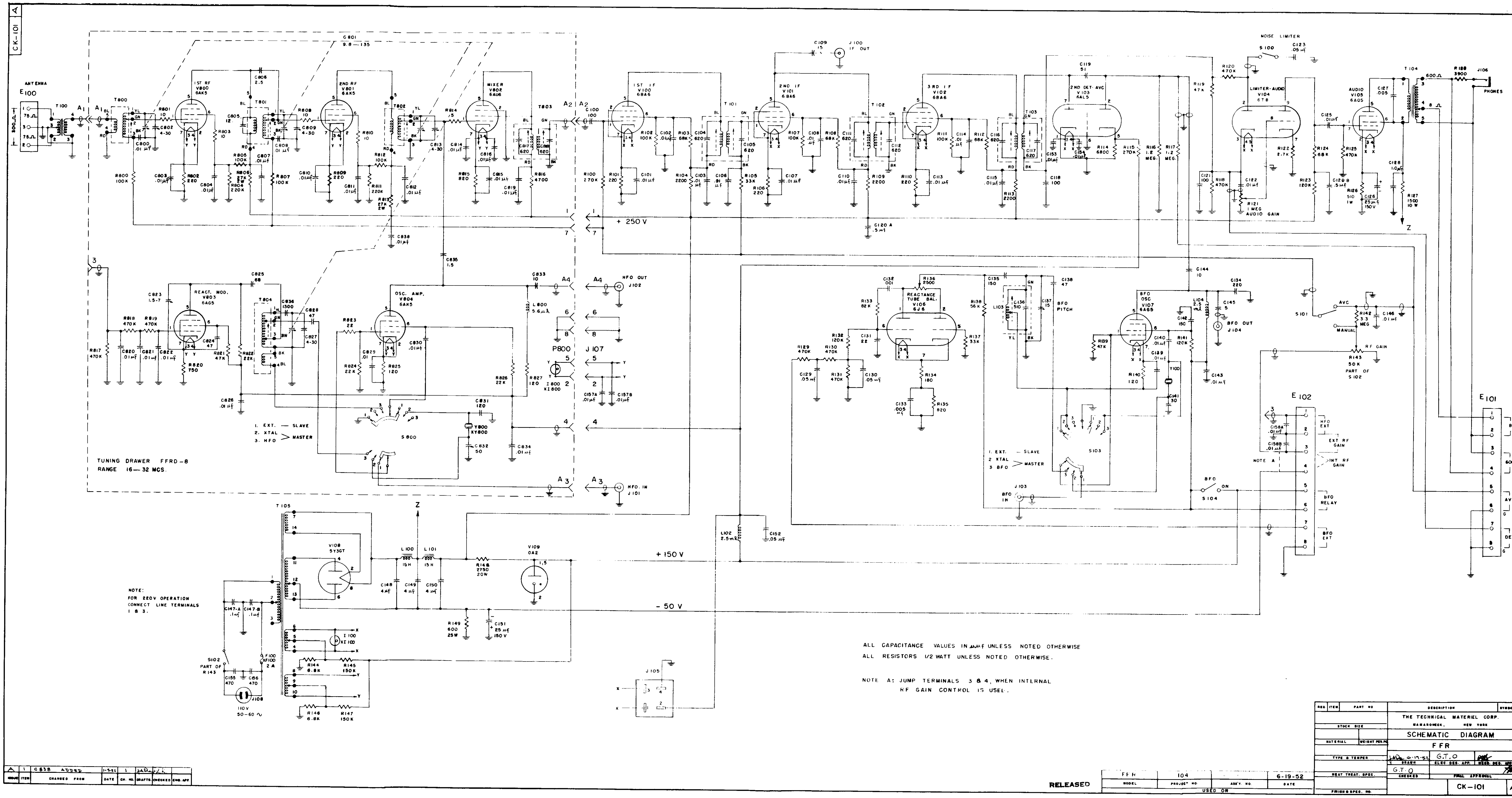
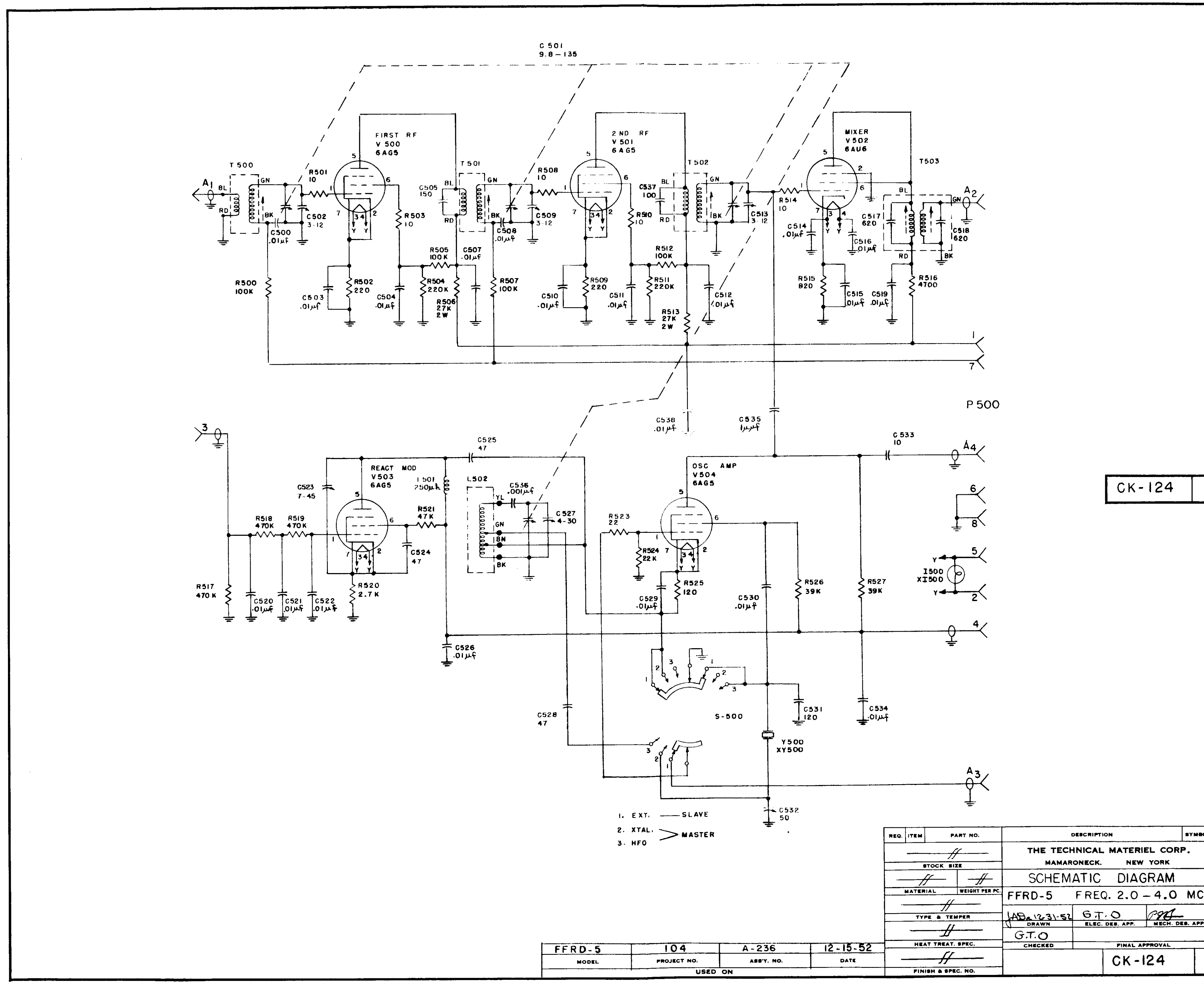
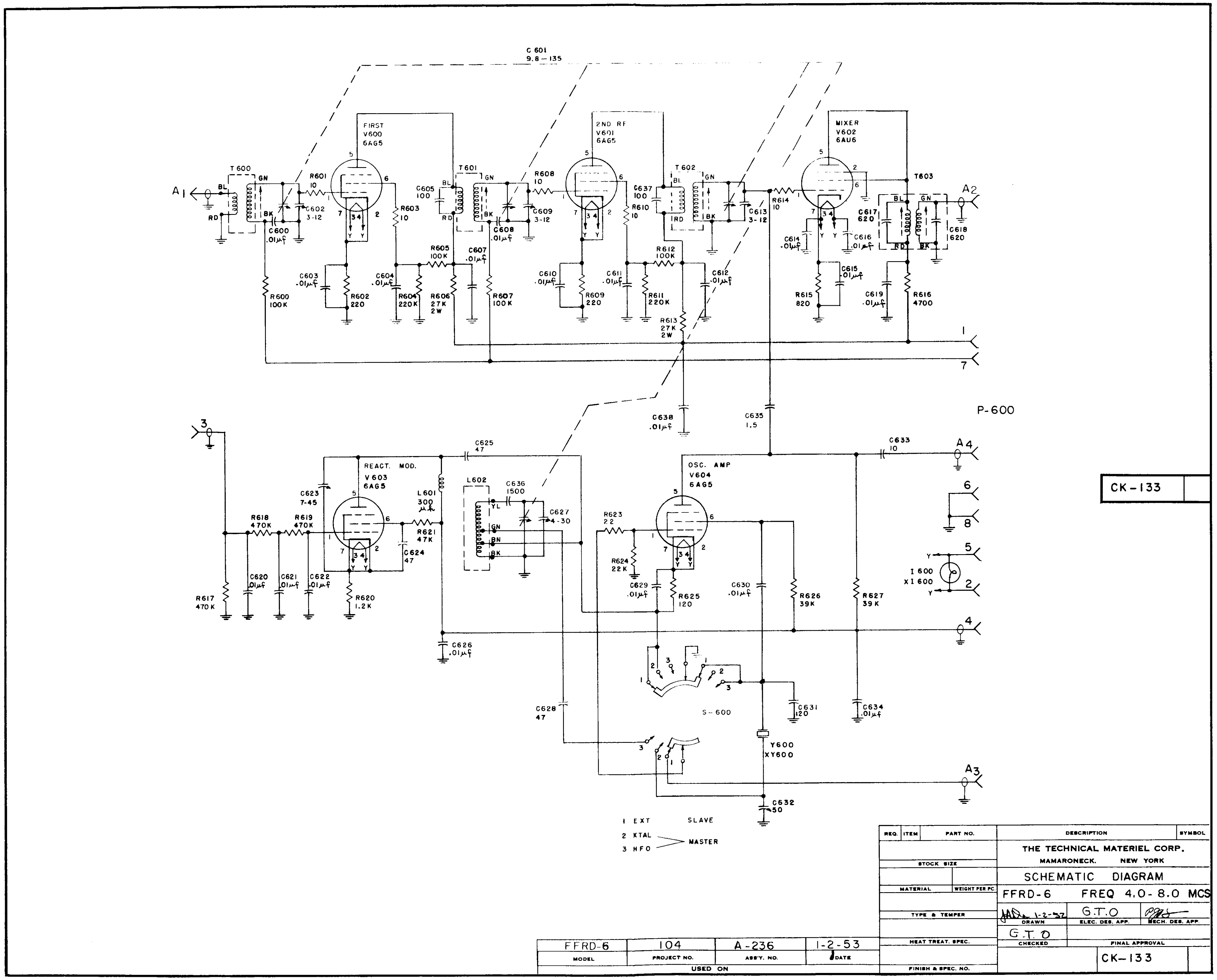


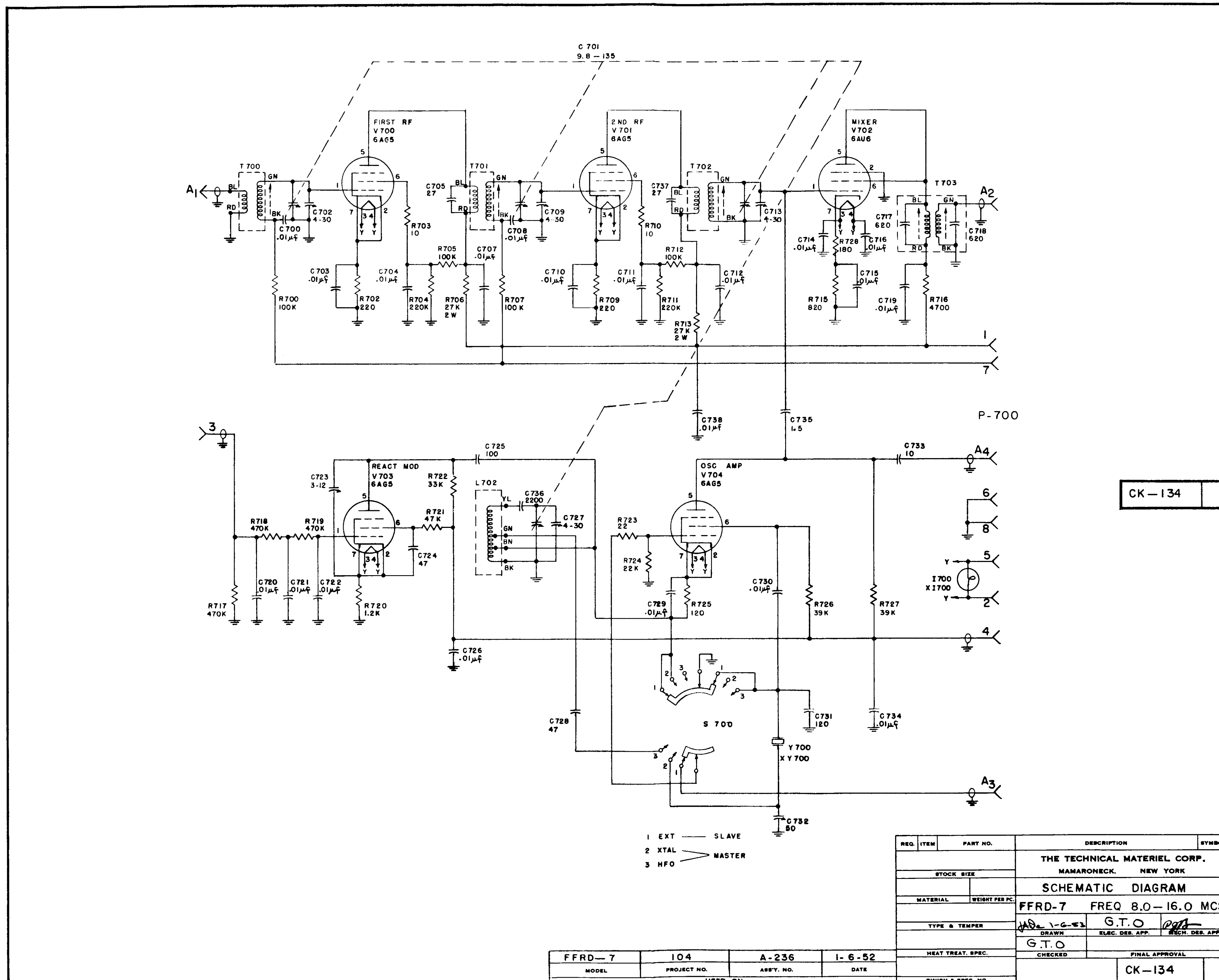
Figure 4-5. Schematic Diagram FFRD-8 and Main Deck



Schematic Diagram for FFRD-5



Schematic Diagram for FFRD-6



Schematic Diagram for FFRD-7

TONE DEMODULATOR MODEL AMD

The TMC Tone Demodulator, Model AMD is an auxiliary unit used in conjunction with the Model FFR to provide D.C. control of the HFO and BFO oscillators for remote control operation. This remote control allows approximately ±2.5 kc and ±5 kc adjustment of the HFO from the preset frequency at 5 Mc and 10Mc, respectively, and a ±2 kc range of the BFO. Standard tone frequencies of 170 cycles separation are used to provide the control functions. One tone is required to vary the HFO and another tone for the BFO. In each case, the control is provided by varying the signal strength of the tone at the control station. Each tone is then amplified, rectified, and mixed in a D.C. network, whose output is a D.C. voltage which is proportional to the strength of the incoming tone signal. This D.C. voltage is then used to control the reactance tubes, which in turn control the HFO and BFO of the Model FFR receiver.

The Model AMD input-output requirements are as follows for an output of ±3 volts D.C:

1. -40 db to 0 db across a 600 ohm input in any 20 db range
   (a) -40 db to -20 db
   (b) -20 db to 0 db

The BFO RELAY is activated at a minimum signal of -40 db.

The Model AMD is mounted at the rear of the receiver. All that is necessary for proper connection is to put the power plug (P-101) into J-105 of the FFR; connect the input tones to terminals 1 and 10 of E-101 (refer to AMD Schematic); and connect the BFO DC OUT, HFO DC OUT, and BFO RELAY leads of E-101 to E-102 of the Model FFR.

ELECTRICAL PARTS LIST

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
C-101 ABC	CAPACITOR, fixed: paper; .5 uf, ±10%, 600 wvdc.	BFO filter	CP53B5FF504V
C-102	CAPACITOR, fixed: paper; .05 mfd, +40%, -20%, 400 wvdc, one section, plastic tubular case, 1-1/4" lg x 7/16" dia, 2 axial wire leads, terminal mounted.	Amplifier-Rectifier Coupling	CN-100-3
C-103	CAPACITOR, fixed: paper; .05 mfd, +40%, -20%, 400 wvdc, one section, plastic tubular case, 1-1/4" lg x 7/16" dia, 2 axial wire leads, terminal mounted.	Amplifier Plate Coupling	CN-100-3
C-104 ABC	CAPACITOR, fixed: paper; .5 uf, ±10%, 600 wvdc.	HFO filter	CP53B5FF504V
E-101	BOARD, terminal: barrier type; ten 6-32 x 1/4" binding head machine screws.	AMD Connections	TM-100-10
K-101	RELAY, sensitive: DPDT; 20,000 ohms, 55 wvdc.	BFO relay	A-227
L-101	REACTOR, filter choke: 300 henries; 6000 ohms; cylindrical, hermetically sealed metal can 1-1/8" lg x 7/8" dia, solder lug terminals.	BFO filter	TF-5002
L-102	REACTOR, filter choke: 300 henries; 6000 ohms; cylindrical, hermetically sealed metal can 1-1/8" lg x 7/8" dia, solder lug terminals.	BFO filter	TF-5002
P-101	CONNECTOR, plug: 4 contacts, male; polarized, 10 amps, 730 v. RMS, bakelite insulation.	AMD connector	PL-106-1
R-101	RESISTOR, variable: composition; 1,000,000 ohms, ±20%, 2 watts.	BFO Adjustment	RV4ATSA105B
R-102	RESISTOR, fixed: composition; 1500 ohms, ±10%, 1/2 watt.	BFO Amp. Cath. bias	RC20GF152K
R-103	RESISTOR, fixed: composition; 100,000 ohms, ±10%, 1/2 watt.	BFO Amp. plate load	RC20GF104K
R-104	RESISTOR, fixed: composition; 150,000 ohms, ±5%, 1/2 watt.	BFO filter	RC20GF154J
R-105	RESISTOR, fixed: composition; 82,000 ohms, ±5%, 1/2 watt.	BFO DC bridge network	RC20GF823J
R-106	RESISTOR, fixed: composition; 56,000 ohms, ±5%, 1/2 watt.	BFO DC bridge network	RC20GF563J
R-107	RESISTOR, fixed: composition; 56,000 ohms, ±5%, 1/2 watt.	BFO DC bridge network	RC20GF563J
R-108	RESISTOR, fixed: composition; 1,200,000 ohms, ±5%, 1/2 watt.	Voltage dropping	RC20GF125J

SYM	DESCRIPTION	FUNCTION	TMC PART NO.
R-109	RESISTOR, fixed: composition; 68,000 ohms, ±5%, 1/2 watt.	BFO DC bridge network	RC20GF683J
R-110	RESISTOR, fixed: composition; 1,000,000 ohms, ±10%, 1/2 watt.	BFO Amplifier Grid Leak	RC20GF105K
R-111	RESISTOR, variable: composition; 1,000,000 ohms, ±20%, 2 watts.	BFO Adjustment	RV4ATSA105B
R-112	RESISTOR, fixed: composition; 82,000 ohms, ±5%, 1/2 watt.	HFO Amp. plate load	RC20GF823J
R-113	RESISTOR, fixed: composition; 1500 ohms, ±10%, 1/2 watt.	HFO Amp. Cathode bias	RC20GF152K
R-114	RESISTOR, fixed: composition; 150,000 ohms, ±5%, 1/2 watt.	HFO filter	RC20GF154J
R-115	RESISTOR, fixed: composition; 150,000 ohms, ±5%, 1/2 watt.	HFO DC bridge network	RC20GF154J
R-116	RESISTOR, fixed: composition; 56,000 ohms, ±5%, 1/2 watt.	HFO DC bridge network	RC20GF563J
R-117	RESISTOR, fixed: composition; 56,000 ohms, ±5%, 1/2 watt.	HFO DC bridge network	RC20GF563J
R-118	RESISTOR, fixed: composition; 1,200,000 ohms, ±5%, 1/2 watt.	Voltage dropping	RC20GF125J
R-119	RESISTOR, fixed: composition; 68,000 ohms, ±5%, 1/2 watt.	HFO DC bridge	RC20GF683J
R-120	RESISTOR, variable: composition; 500,000 ohms, ±20%, 2 watts.	D.C. adjustment	RV4ATSA504B
T-101	TRANSFORMER, input: pri. imp. 200 ohms, 0 DC, sec. imp 250,000 ohms, 7/16" x 3/4" x 5/8" overall dim.	BFO Input	TF-107
T-102	TRANSFORMER, input: pri imp. 200 ohms, 0 DC, sec. imp 250,000 ohms, 7/16" x 3/4" x 5/8" overall dim.	HFO Input	TF-107
V-101	TUBE, electron: 12AT7.	BFO Amplifier	12AT7
V-102	TUBE, electron: 6T8.	BFO Rectifier & HFO Amplifier	6T8
XV-101	SOCKET, tube: miniature 9 pin; moulded plastic insulation.	Socket for V-101	TS-103-A
XV-102	SOCKET, tube: miniature 9 pin, moulded plastic insulation.	Socket for V-102	TS-103-A

OPERATING PROCEDURE FOR

TONE DEMODULATOR
MODEL AMD

The AMD-1 is mounted physically on the rear of the FFR chassis by means of screws in the provided inserts. Upon completion of mounting, the inter-connecting cable between the AMD-1 and FFR is installed as shown in Figure A-1. The BFO and HFO tone control cables are terminated at the proper terminals indicated on E-101 of the AMD-1.

Bearing in mind that the ultimate purpose of the AMD-1 is to transpose an audio tone varying in amplitude into DC variations for reactance tube shift in frequency, a procedure will be indicated for accomplishing the Remote Control of the FFR. The operation may be classified in two sections:-

1. BFO Operation
2. HFO Operation

1. BFO Operation:

The BFO section accomplishes two functions:-

(a) to turn on BFO of the receiver, and
(b) to provide a DC voltage variation for frequency shift of the BFO.

It will be assumed that the BFO audio tone control line has been terminated at the AMD-1 and an audio tone from a remote point present on the line. Turn the BFO ADJ "pot" (R-101) to its maximum position. Let it further be assumed that the signal level is reduced to 0 volts. If a VTVM is connected to the BFO DC OUT of the AMD-1, it will be noted that there is present a positive voltage of approximately 3.8 volts. As the input signal level is increased from 0, two things will happen:

(a) At approximately 6 mv signal input the BFO relay will be activated, turning on the FFR BFO.

(b) As the signal level is increased over a 20 db range, the positive voltage will be decreased to 0 then to -3 volts DC, thus providing a variation of ±3 v. DC presented to the BFO reactance tube of the FFR, (with a 20 db change in signal level). Therefore, the BFO will shift approximately ±2.5 KC. The above procedure pertains to a minimum signal level required on the control line. Under ordinary conditions, when the signal level present at any time may be as high as 0 db, it will be necessary to modify the procedure slightly.

Let there be impressed on the control line a signal level representing the greatest amplitude that will be present; ie, a level set by the remote control point representing the highest level it will present to the line in remote control operation.

With the VTVM at the BFO DC OUT point on E-101 of the AMD-1, adjust the BFO ADJ potentiometer so that the VTVM reads -3 volts. Then as the signal level is reduced 20 db, the DC output will rise to +3 volts, and a greater reduction in level will turn off the internal BFO of the receiver. It may be noted that with the above procedure the BFO circuit is maintained at its highest sensitivity, thus reducing the effects of signal leakages or inter-modulation. If it is desired to employ a BFO crystal frequency, the FFR may be set to crystal BFO and the remote signal employed to turn the crystal BFO ON and OFF.

2. HFO Operation

The HFO operation is similar to that of the BFO operation, and the same procedure as employed in setting the BFO ADJ "pot" may be employed in setting the HFO ADJ "pot".

Before operation set the HFO ADJ "pot" and the DC ADJ "pot" to its maximum position. Connect the VTVM across the HFO DC OUT.

Upon completion of the adjustment of the HFO ADJ "pot", the maximum frequency deviation, depending upon the operating frequency, may be selected by adjusting the DC ADJ "pot". This "pot" selects only a certain proportion of the total DC excursion presented to the HFO reactance tube.

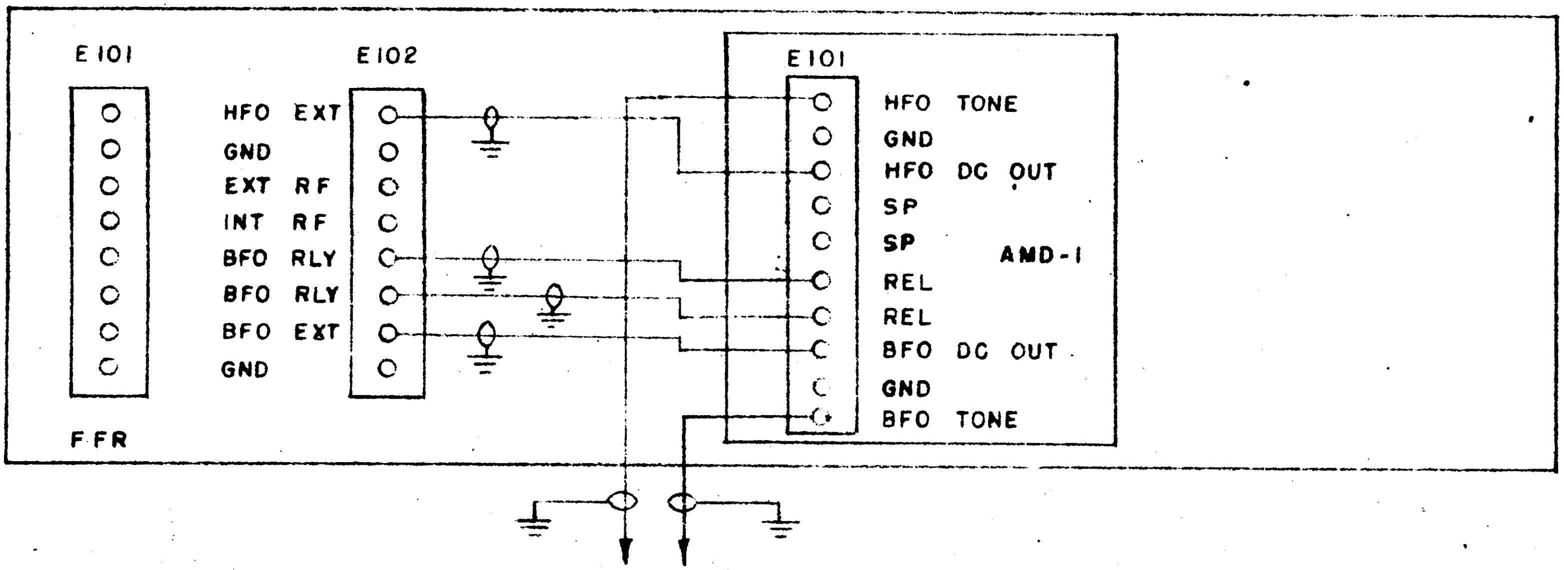
NOTE:-

With signal level present on the HFO and BFO control line, a positive voltage will be impressed on the respective HFO and BFO reactance tubes, thus causing a frequency shift.

If it is desired to operate the receiver independent of the remote control lines, it is advisable to pull out the P-101 cable which connects the AMD to the FFR and to remove the Relay connection on E-101 of the AMD. In this way the initial frequency calibration of the receiver will be in effect, and the BFO will be independent of the control lines.

IF IT IS FOUND DESIRABLE TO CHANGE ANY TOLERANCE OR OTHER DETAIL SPECIFIED ON THIS DRAWING NOTIFY THE PURCHASER PROMPTLY.	CK-146
MAXIMUM ALLOWABLE TOLERANCES HAVE BEEN DETERMINED AND DEVIATIONS WILL BE CAUSE FOR REJECTION. REMOVE ALL BURRS AND SHARP EDGES	

USED ON			
MODEL	PROJECT NO.	ASS'Y. NO.	DATE



REQ.	ITEM	PART NO.	DESCRIPTION	SYMBOL

THE TECHNICAL MATERIEL CORP.
MAMARONECK, NEW YORK

FIGURE A-1 CONNECTIONS FOR REMOTE CONTROL OPERATION

STOCK SIZE	
MATERIAL	WEIGHT PER PC.
TYPE & TEMPER	
HEAT TREAT. SPEC.	
FINISH & SPEC. NO.	

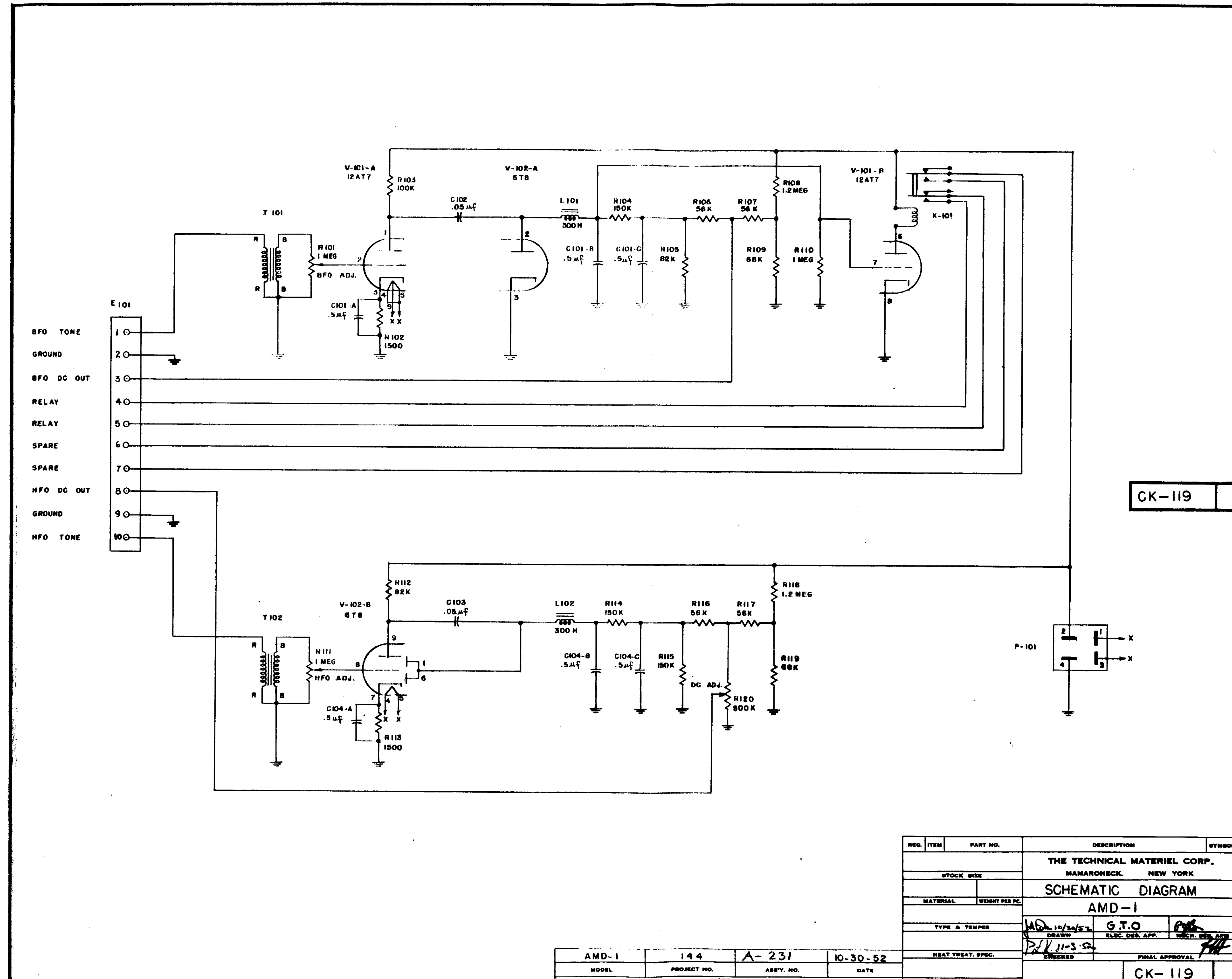
DRAWN	ELEC. DES. APP.	MECH. DES. APP.
JAWe 2-6-53	QRB	
CHECKED	FINAL APPROVAL	
	QRB	

CK-146

ISSUE	ITEM	CHANGED FROM	DATE	CN. NO.	DRAFTS	CHECKER	ENG. APP.

TOLERANCES		SCALE
ALL OTHERS	DEC. DIM. ± FRAC. DIM. ± ANGULAR DIM. ±	DRILL, PUNCH, COMMERCIAL STOCK SIZES AND MANUFACTURERS TOLERANCES ARE NOT INCLUDED.

FORM — 108



Schematic Diagram for Tone D modulator, AMD-1