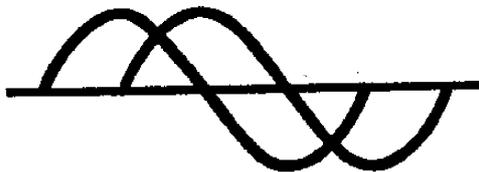


MULTIPHASE EXCITER
MODEL 20A

INSTRUCTION MANUAL



Central Electronics, Incorporated

A subsidiary of Zenith Radio Corporation

AMATEUR — COMMERCIAL — MILITARY — COMMUNICATION EQUIPMENT

MULTIPHASE EXCITER
MODEL 20A
INSTRUCTION MANUAL

108MXA

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No. 2,566,876
No. 2,611,036

CENTRAL ELECTRONICS, INC.
A SUBSIDIARY OF ZENITH RADIO CORPORATION
1247 W. BELMONT AVENUE
CHICAGO 13, ILLINOIS

M210
108MXA

Printed in U.S.A.

CONDENSED OPERATING INSTRUCTIONS FOR MULTIPHASE EXCITER MODEL 20A

Connect an antenna or a linear amplifier to the 52 ohm RF output. Set bandswitch to the band desired and the VFO-Xtal switch to the proper position. Turn CARRIER knob fully clockwise. Turn OPERATION selector to MANUAL and tune the MIXER and AMPLIFIER for maximum output as shown on the RF INDICATOR, an oscilloscope or an antenna meter.

TO OPERATE SINGLE SIDEBAND

Set the MODULATION selector to one of the sideband positions (SB1 or SB2). Turn the OPERATION selector to MANUAL. With the CARRIER knob set at "0" adjust the CARRIER NULL controls A and B for minimum RF indication with the INDICATOR switch in CARRIER NULL position. Now return the INDICATOR switch to SET MAX LEVEL. Adjust the SPEECH LEVEL control between 9 and 12 o'clock, depending upon microphone gain. Talk into the microphone and you're on SSB!

When the converted BC-458 is used as a VFO, the following sideband relationship occurs:

160 Meters	SB1 Upper	SB2 Lower	
80 Meters	*SB1 Lower	SB2 Upper	3990**
40 Meters	SB1 Upper	*SB2 Lower	7205**
20 Meters	SB1 Lower	*SB2 Upper	14290**
15 Meters	SB1 Lower	*SB2 Upper	21440**
10 Meters	*SB1 Upper	SB2 Lower	28650**

* Denotes sideband most commonly used

** Denotes frequency most commonly used

When 40 meter crystals or injection are used for 160 meter operation, SB2 will be the upper sideband and SB1 the lower.

TO OPERATE AM

Place the MODULATION selector in the AM position. Leave the CARRIER NULL knobs in the balanced-out condition. Advance the CARRIER knob until maximum output is obtained. Then reduce the CARRIER level to one half of the maximum value on the scope or to one half the maximum antenna current. Adjust the SPEECH LEVEL until the modulation peaks just reach the maximum output value on the scope. Too little or too much carrier will make the AM transmission sound distorted.

TO OPERATE PM (Narrow band phase modulation)

Turn the MODULATION selector to PM position. Leave the CARRIER NULL knobs on the balanced-out condition. Advance the CARRIER knob to nearly full output. Adjust the SPEECH LEVEL control so that the modulation peaks do not exceed the carrier.

TO OPERATE CW

Turn the MODULATION selector to CW. Place the OPERATION selector on MANUAL. Advance the CARRIER control to nearly full output. Plug key into jack on front panel.

TO USE THE VOICE CONTROL CIRCUIT (VOX)

Connect the receiver speaker to the Exciter, as shown in the circuit diagram. The resistor across 1 and 2 on the rear terminal strip should be about two to three times the speaker voice coil impedance and rated at twice the power output. The extra contacts on 8, 9 and 10 may be used to operate an antenna relay, additional receiver silencing circuits, etc. With the OPERATION selector in VOX position, talk into the microphone and adjust the VOX sensitivity control on the rear of the chassis for proper operation.

CALIBRATION LEVEL CONTROL

When the OPERATION selector is in the CALIBRATE position, the CAL LEVEL control will vary the output of the Exciter for frequency "spotting."

INDICATOR SWITCH

In the CARRIER NULL position, the speech circuit is disabled and the RF INDICATOR operates at maximum sensitivity. The CARRIER control should always be at "0" while balancing out the carrier with CARRIER NULL knobs A and B. In the SET MAX LEVEL position, the RF INDICATOR sensitivity can be adjusted by the IND LEVEL control.

RF INDICATOR

The 6E5 RF INDICATOR shows the peak RF voltage output of the Exciter. It can be used for peaking the Mixer and Amplifier tuning controls and also to determine the proper speech level while operating SSB. To determine the maximum undistorted SSB output of the Exciter or linear amplifier, advance the CARRIER control until no further increase in output is observed. Now set the IND LEVEL control to just close the eye. Return the CARRIER CONTROL to "0" and adjust the SPEECH LEVEL until the voice peaks reach about 80% of the full carrier value.

EXTERNAL BLOCKING BIAS

In the standby position, -100 volts DC appears at terminal 7 on the rear terminal strip. If a bias supply is used for a linear amplifier the positive should be returned to this terminal of the Exciter. All positive components in the bias supply must be "floating" from ground and connected only to the positive lead.

When zero bias tubes are used, the amplifier grid return lead should be by-passed and then connected to terminal 7. A secure ground connection should be made between the Exciter, linear amplifier, linear amplifier power supply and the bias supply.

EXTERNAL BLOCKING BIAS (Cont'd)

If an antenna relay with auxiliary contacts is used, these auxiliary "make" contacts can be used to key the blocking bias by connecting them to #6 and #7 on the rear terminal strip. Proper keying sequence is required so that the antenna circuit makes before the blocking bias is removed. Refer to Rear Connections Diagram, M200.

When the auxiliary contacts on an antenna relay are not used to key the transmitter, the jumper should remain between terminals 6 and 7 on the strip.

RESISTIVE LOADING OR "SWAMPING"

When driving a linear amplifier, some resistive loading should be used at the Exciter or at the amplifier grid circuit. Non-inductive resistors should be used and may be connected to the two screw terminal output strip on the rear chassis. The amount of resistive loading required will depend upon the type of tubes used in the amplifier. Pentodes, tetrodes and zero bias triodes require only a small amount, while medium and low μ tubes will require heavier swamping for low distortion.

If the Exciter is lightly loaded, there is a possibility of the system going into self-oscillation. Resistive loading is not necessary when the Exciter is coupled to a constant load, such as a 50 to 70 ohm antenna.

MATCHING THE GRID CIRCUIT OF A LINEAR AMPLIFIER STAGE

In order to obtain a maximum transfer of RF from the Exciter to grid circuit of a linear amplifier stage, it is often necessary to tune the reactance out of the link on the grid coil. This is especially true when Multi-band tuners are used. A suitable unit for this purpose is a two gang, or three gang, midget type of broadcast capacitor, about 400 mmfd. per section, with all the stators connected in parallel. This should be connected to series tune the PA grid link coil and can usually be inserted right at the PA coaxial cable connector. It is sometimes beneficial to experiment with the number of turns on the grid coil link to obtain maximum grid current.

Tuning the reactance out of the plate coil link in the Linear Amplifier in the same manner will assist in obtaining the heavy loading required for this type of service.

SUGGESTED LINEAR AMPLIFIERS

The 20A will drive tetrode and pentode tubes such as a pair of 813s, 4-125As, 4-250As, 4X250As and 4-400As to a kilowatt. Triodes such as 811As may be driven to about 400 watts up to 20 meters and 304TIs in class A1 to about a kilowatt on 80 and 40 meters.

GROUNDING GRID LINEAR AMPLIFIERS

Grounded grid amplifiers require about five times as much driving power as the same tubes operating in conventional grid-driven circuits. The 20A will

GROUNDED GRID LINEAR AMPLIFIERS (Cont'd)

drive grounded grid amplifiers, such as four high mu triode connected 837s, modified 1625s, or 6AG7s very well on the lower frequencies. For operation on the higher frequencies, or when high mu triode connected 813s, 803s or 703As are used, an additional driver stage is required.

PRELIMINARY ALIGNMENT INSTRUCTIONS

THE FOLLOWING IS RECOMMENDED FOR UNITS CONSTRUCTED FROM KITS

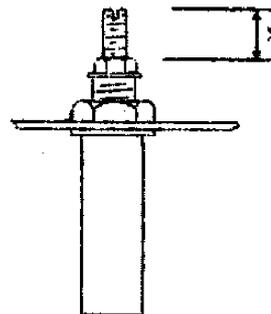
Check for "B" shorts with an ohmmeter before power is applied.

Before plate voltage is applied, the 6AG7 grid bias should be checked. This should be done by removing the 5U4G rectifier tube. With the relay in the normal position, the reading at Pin #4 of the 6AG7 should be minus 100V DC plus or minus 10% measured with a VTVM. When the relay is operated by hand, there should be approximately minus 11V DC at this point. After the 5U4G is inserted, the operating bias should be minus 10.5V DC obtained from the voltage divider R47 and R48.

Insert the 5U4G rectifier and apply power. Check "B" voltages in accordance with the chart on the circuit diagram, with the OPERATION switch on MANUAL.

Preliminary rough alignment of the slug tuned coils: If a grid dipper is available the coils should be aligned to the frequencies indicated on the Alignment Data Chart (Fig. B). If no dipper is available they should be set as follows BEFORE POWER IS APPLIED:

- No. 1 Red 1/2"
- No. 2 Green 1/8"
- No. 3 White 1/4" to 3/8"
- No. 4 Black 3/8"
- No. 5 Blue 3/8"
- No. 6 Orange 1/2"
- No. 7 Yellow 1/2"
- No. 8 Blue 1/4" (Not used on Model 10B)



The Audio Balance controls should be set in approximately mid-position.

During alignment, a slight amount of tension should be kept on the adjusting screws by proper adjustment of the locking nut to prevent erratic operation. After alignment, be sure to tighten the nuts, taking care not to upset the adjustment, especially on the Green coil, I2.

M211

Alignment of 10-20 108MK 109MK
3-17-54 Rev. 8-8-57 Rev. 11-14-58
Printed in USA

Page 3

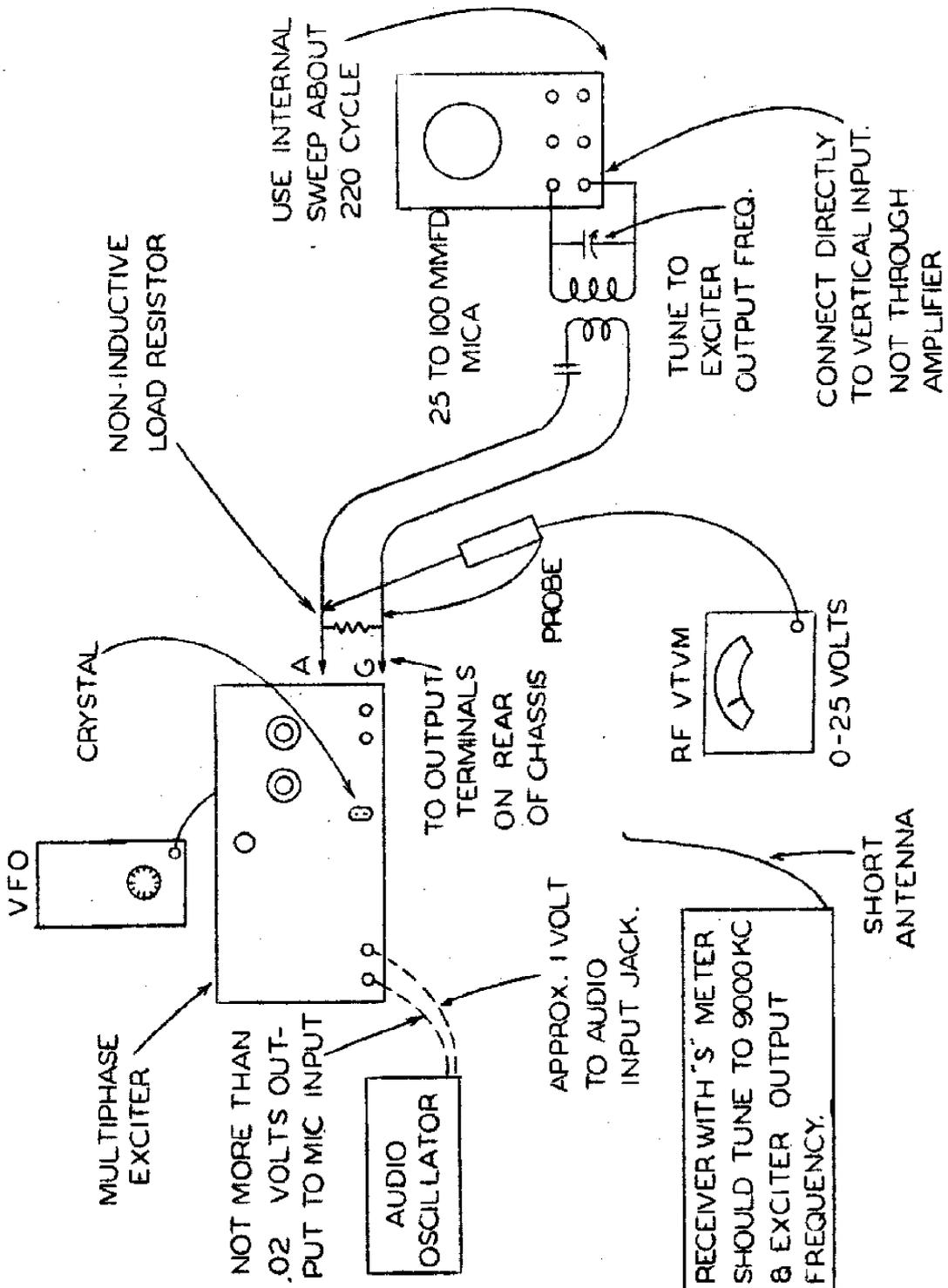


FIG. A

20A GENERAL ALIGNMENT PROCEDURE

SEE CHART FOR ALIGNMENT LOCATIONS

The front panel controls should be set as follows:

OPERATION SWITCH, in MANUAL
SPEECH LEVEL, completely counter-clockwise
MODULATION SWITCH, Sideband 1
CARRIER NULL A, middle position
CARRIER NULL B, middle position
CARRIER, completely counter-clockwise
VFO-KTAL SWITCH, in correct position
INDICATOR SWITCH, on SET MAX LEVEL
INDICATOR LEVEL, completely clockwise
BANDSWITCH, to proper band
TUNING CONTROLS, to output frequency

Refer to Fig. A. Connect a non-inductive load resistor of about 50 ohms, 20 watts to the Exciter output terminals. This resistive load may consist of one or two watt composition resistors in parallel or series-parallel to provide the proper resistance and dissipation.

Connect an oscilloscope, lightly coupled, to the RF output.

If available, an RF vacuum tube voltmeter with a 25 to 50 volt RMS range can be used to measure the RF output.

CAUTION! Never remove the 9000 kc. crystal from the socket while the 6U8 tube is operating. This may damage the tube.

Tune L1 and L2 for maximum RF voltage measured between the arm of Null Pot B and ground. An RF VTVM is required. Measure the RF voltage at the arms of Null Pots A and B. Adjust spacing between L1 and L2 to obtain equal voltage. As spacing is varied it will be necessary to repeak L1 and L2 for maximum. Normal voltage is between 5 and 6 volts peak. Multiply by .707 for RMS reading.

Advance the CARRIER control to about 7.

At this time it should be possible to hear a signal on the output frequency with the receiver operating near full sensitivity (AVC on) provided the VFO or frequency conversion crystal is operating. The receiver should be coupled lightly to the Exciter RF output terminal. Refer to Fig. B. Adjust L3, L4, L5 and the MDCR AND AMPLIFIER tuning capacitors for maximum output. As maximum output is reached, it will become necessary to reduce the carrier output by adjusting CARRIER pot and also reduce the sensitivity of the RF INDICATOR by turning the IND. LEVEL control counter-clockwise to prevent the eye from overlapping. Next, insert small amount of CARRIER and peak L3 through L5 again. Now turn CARRIER control off (counter-clockwise) and adjust both CARRIER NULL controls for minimum output. Minimum output will not necessarily occur at the center of the rotation due to stray capacities, etc. Loosen knobs and reset to reference marks with carrier nulled out.

ADJUSTMENT OF 15 MC TRAP L6 (ORANGE)

When operating on the 20 meter band, this trap circuit will reduce radiation of the third harmonic generated in the mixer by the heterodyning crystal or VFO operating in the vicinity of 5 MC. With the bandswitch set to 20 meters, the SPEECH LEVEL turned off, carrier balanced out or 9 MC master oscillator tube removed, and the OPERATION switch in the MANUAL position, RF output will be found when the Mixer and Amplifier tuning controls are resonated at approximately 15 MC. Adjust slug in trap L6 for minimum 15 MC. output.

ADJUSTMENT OF L7 (YELLOW) TRAP

This trap is tuned to 13 MC or 15 MC, depending upon the age of the unit and whether modification "C" has been made. Modification "C" adds a 180 ohm resistor, bypassed with a .005 capacitor, to the cathode of the 6BA7 Mixer. The Yellow trap coil is removed to the Mixer plate circuit and is tuned to 13 MC. For details refer to Change Notice #M170. If the change has been made, adjust L7 to 13 MC by any one of the three following methods:

1. Use a grid dipper.
2. If no dipper is available, a 6.5 MC crystal can be used in the socket on the front panel, with the VFO-XTAL switch in the XTAL position. With the bandswitch in the 20 meter position, OPERATION switch in MANUAL, carrier balanced out (or 9 MC master oscillator tube removed) and the TUNING controls peaked for maximum 13 MC output, L7 should be adjusted for minimum 13 MC signal.
3. The receiver S meter can also be used as an indicator. It should be tuned to the 13 MC signal, or to 26 MC for Collins receivers. With this method the 9 MC master oscillator tube must be operating with full carrier insertion and 5 MC injection from a crystal or VFO.

The VFO output should be advanced to the point where additional coupling will not increase the exciter output. Over-injection to the Mixer can cause unnecessary spurious radiation.

ADJUSTMENT OF 5 MC TRAP, L8

Blue coil near the right edge of the chassis. Set the bandswitch to 80 meters. With either a 5 MC crystal plugged into the socket on the front panel or 5 MC VFO insertion, adjust the Mixer and Amplifier tuning controls for maximum 5 MC output. This will occur slightly lower in frequency than the 7 MC dial calibration. Adjust L8 for minimum output.

ADJUSTMENT OF C81, C82, C83, C84

These four trimmers appear on a strip at the right of the bandswitching assembly, just below the 12BH7 tube. They tune the cathode coils on 10, 15, 20 and 40 meters, respectively. The 10 meter trimmer is the one closest to the chassis; the second one is 15 meters, etc. They should be peaked for maximum output in the center of their band with a small amount of CARRIER inserted.

20A

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SIDEBAND SUPPRESSION ADJUSTMENT

Before proceeding with the single sideband adjustments, it is recommended that the operator familiarize himself with the illustrations of the oscilloscope patterns shown in this manual. The ultimate objective in the single sideband alignment is to obtain a pattern containing a minimum amount of ripple when a pure sine wave is applied to the microphone input. These adjustments should preferably be made at less than full output, to prevent amplifier overloading, which might "wipe off" the small modulation ripple.

A low distortion audio oscillator (less than 1%) set to approx. 1,225 cycles, with an output level between .005 and .02 volts should be connected to the microphone jack. CAUTION: If a voltage in excess of .02 is applied to the mic input the speech amplifier will overload and it will be impossible to adjust the Exciter properly. It will be impossible to make the sideband adjustments if the audio oscillator has more than 1% distortion.

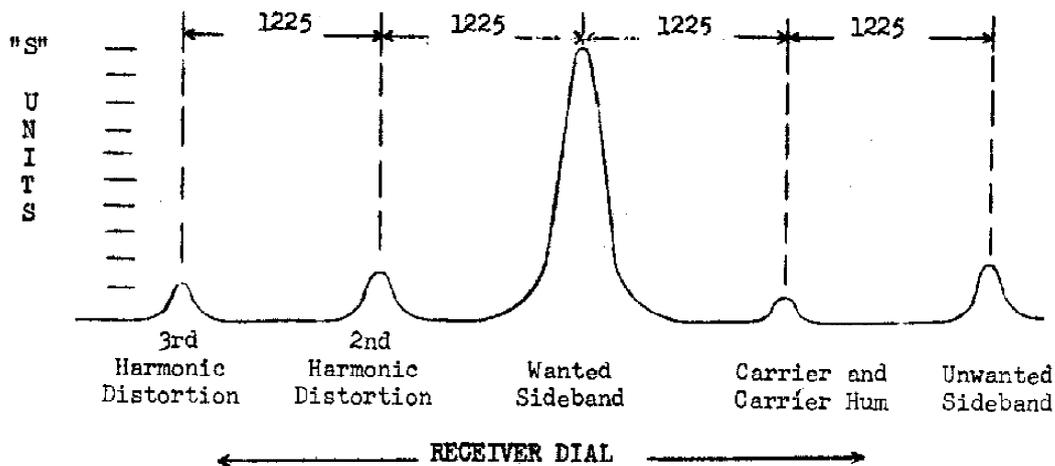
Adjust both CARRIER NULL pots for minimum carrier output. Advance the SPEECH LEVEL control until about half of maximum output is obtained on the oscilloscope. At this point a fair amount of ripple will be observed on the output wave. Adjust the Audio Balance controls for minimum ripple. Now switch from sideband 1 to sideband 2 and observe the ripple in each. If the amount of ripple is not equal, vary the adjustment slightly on L2 until the displays are identical in either sideband position. However, each time L2 is tuned it will be necessary to rebalance both carrier null controls for minimum. It will also be necessary to readjust the Audio Balance controls again. In most cases this procedure must be repeated until good suppression is obtained.

After the alignment has been completed, an analysis of the emitted wave may be made if the receiver has a sharp crystal filter and a calibrated "S" meter. The following illustration is an example of the "S" meter levels as the receiver dial is tuned through the signal with a 1225 cycle tone input to the Exciter.

In order to obtain proper sideband suppression, the RF voltages at the arms of the CARRIER NULL pots must be essentially equal when the carrier is balanced out. With tone input, the audio voltages at the by-passed ends of the Red and Green links must be approximately equal with the Modulation switch in one of the SB positions.

Poor sideband suppression may be caused by:

- Defective 12AT7 modulator tube.
- Defective phase shift network.
- Open or partially shorted 27A0-79 modulation transformer.
- Secondary of audio driver transformer 27AM-24 shorted to ground, master crystal oscillating on two adjacent frequencies simultaneously.
- L2 seriously misaligned, defective coil or capacitor. Check with a dipper for resonance.



It is possible to obtain an almost ripple-free pattern in one sideband at the expense of degradation of the other. Under this condition the suppression of the better sideband will be about 45 db., while the other is only 35 db. down. The object is to have them both equal, approximately 40 db. down.

If a deep modulation ripple is noticed on both sideband positions (with carrier balanced out), one side of the audio phase shift circuit is probably operating improperly. Check the Audio Balance controls adjustment, the 12AT7 (B) modulator tube, sideband switching circuit, or the phase shift network.

After the alignment has been completed, be sure to tighten the #6 lock-nuts on the iron core slugs.



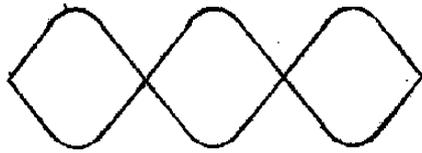
Good SSB Signal
Pure Tone Input



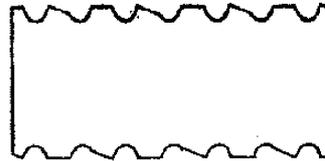
SSB Signal, Tone Input
Poor Sideband Suppression

1. Improper RF phasing (L2)
2. Improper AF balance (R18-15A)
3. Balanced Mod detuned (L3)

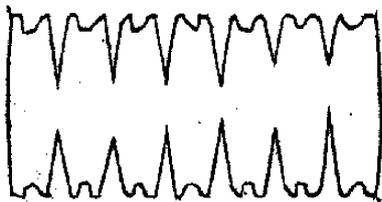
5-26-55 Rev. 12-1-58
Alignment 10-20A
Printed in USA



SSB SIGNAL, TONE INPUT
WITH PROPER CARRIER INSERTED
100% MODULATED



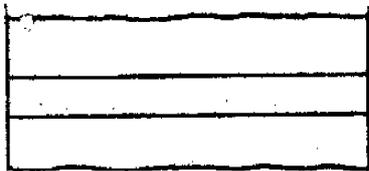
SSB SIGNAL, TONE INPUT
AUDIO DISTORTION
EXCESSIVE AUDIO INPUT
EXCESSIVE DISTORTION IN
AUDIO OSCILLATOR



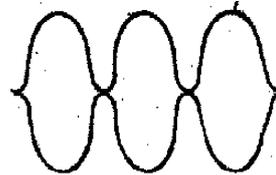
SSB SIGNAL, TONE INPUT
INSUFFICIENT 9000 kc. XTAL
OSCILLATOR OUTPUT



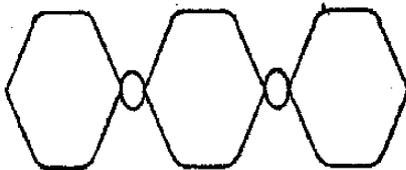
GOOD SSB SIGNAL, TONE
INPUT WITH SMALL PER-
CENT OF SPURIOUS RADIA-
TION (RF)



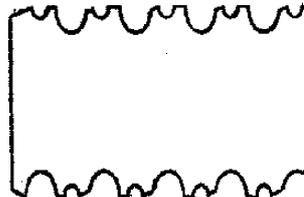
GOOD SSB SIGNAL, TONE INPUT
WITH LARGE PERCENT OF
SPURIOUS RF RADIATION



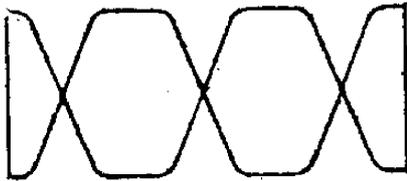
SSB WITH CARRIER, TONE
INPUT IMPROPER AMPLIFIER
BIAS



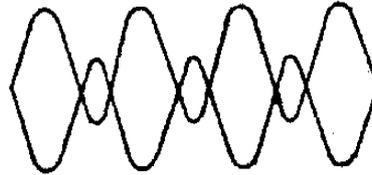
DOUBLE SIDEBAND WITH CARRIER
EXCESSIVE TONE MODULATION
WITH AUDIO PEAKS SQUARING OFF



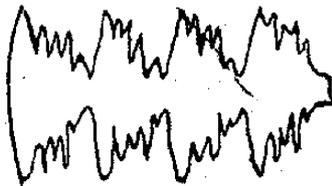
SSB SIGNAL, TONE INPUT
BALANCED MOD DETUNED (L3)



SSB WITH CARRIER, TONE INPUT.
 1. EXCESSIVE AUDIO
 2. INSUFFICIENT ANT. LOADING



DSRG DOUBLE SIDEBAND REDUCED CARRIER OBTAINED BY REDUCING CARRIER LEVEL AND INCREASING AUDIO INPUT LEVEL.



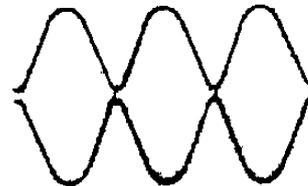
GOOD SSB SIGNAL VOICE INPUT



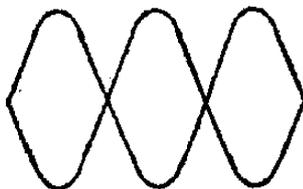
SSB SIGNAL, VOICE INPUT SQUARING AUDIO PEAKS EXCESSIVE SPEECH GAIN



SSB SIGNAL, TONE INPUT AMPLIFIER OVERLOADING DUE TO EXCESSIVE AF OR RF DRIVE. NOTE THE LACK OF SMALL RIPPLE ON ENVELOPE



DOUBLE SIDEBAND AM WITH CARRIER 100% MODULATED



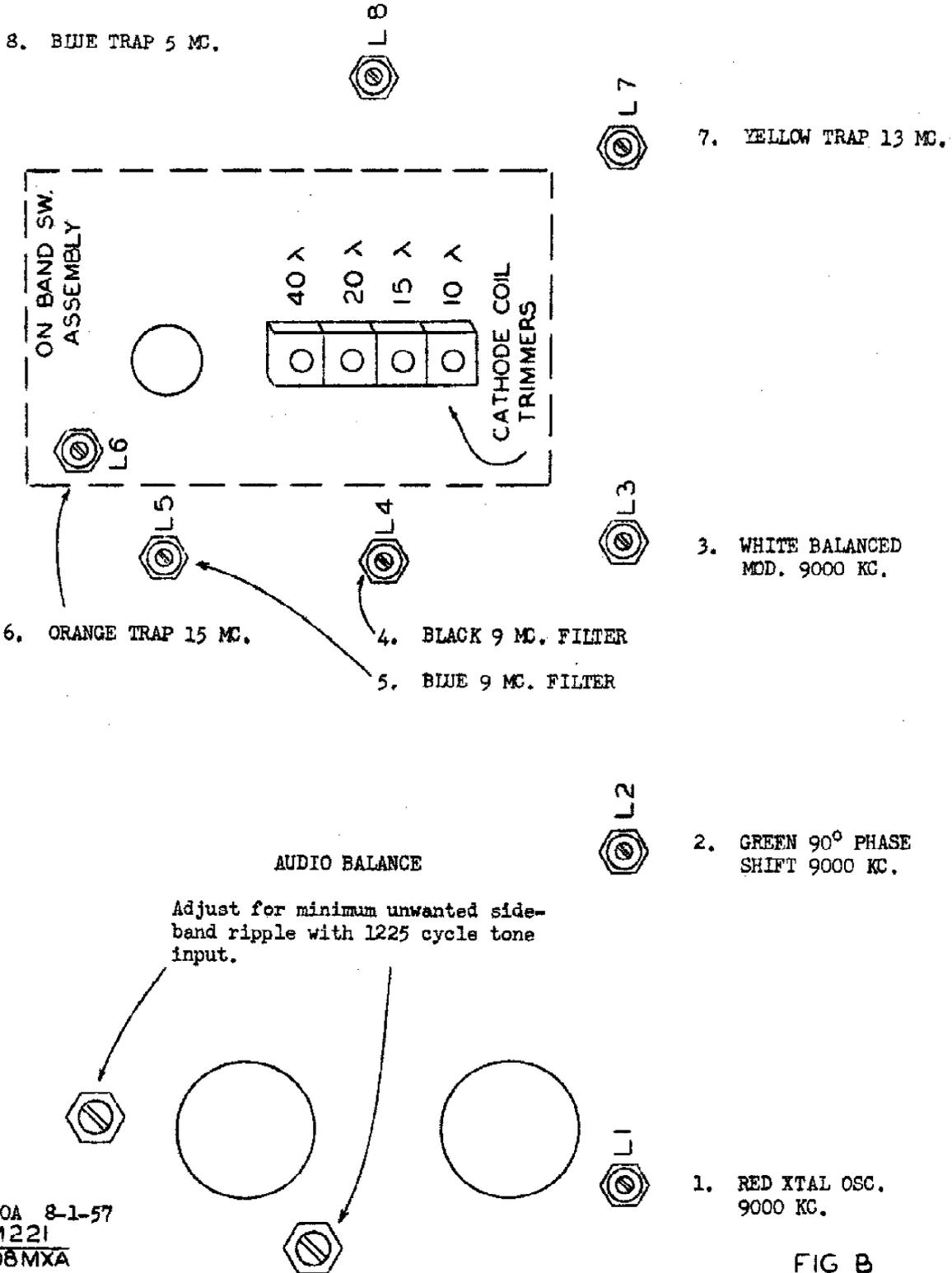
TWO TONE LINEARITY TEST OBTAINED WITH SINGLE TONE INPUT, WITH CARRIER BALANCED OUT ON AM

FOR ADDITIONAL REFERENCE THE FOLLOWING IS RECOMMENDED:

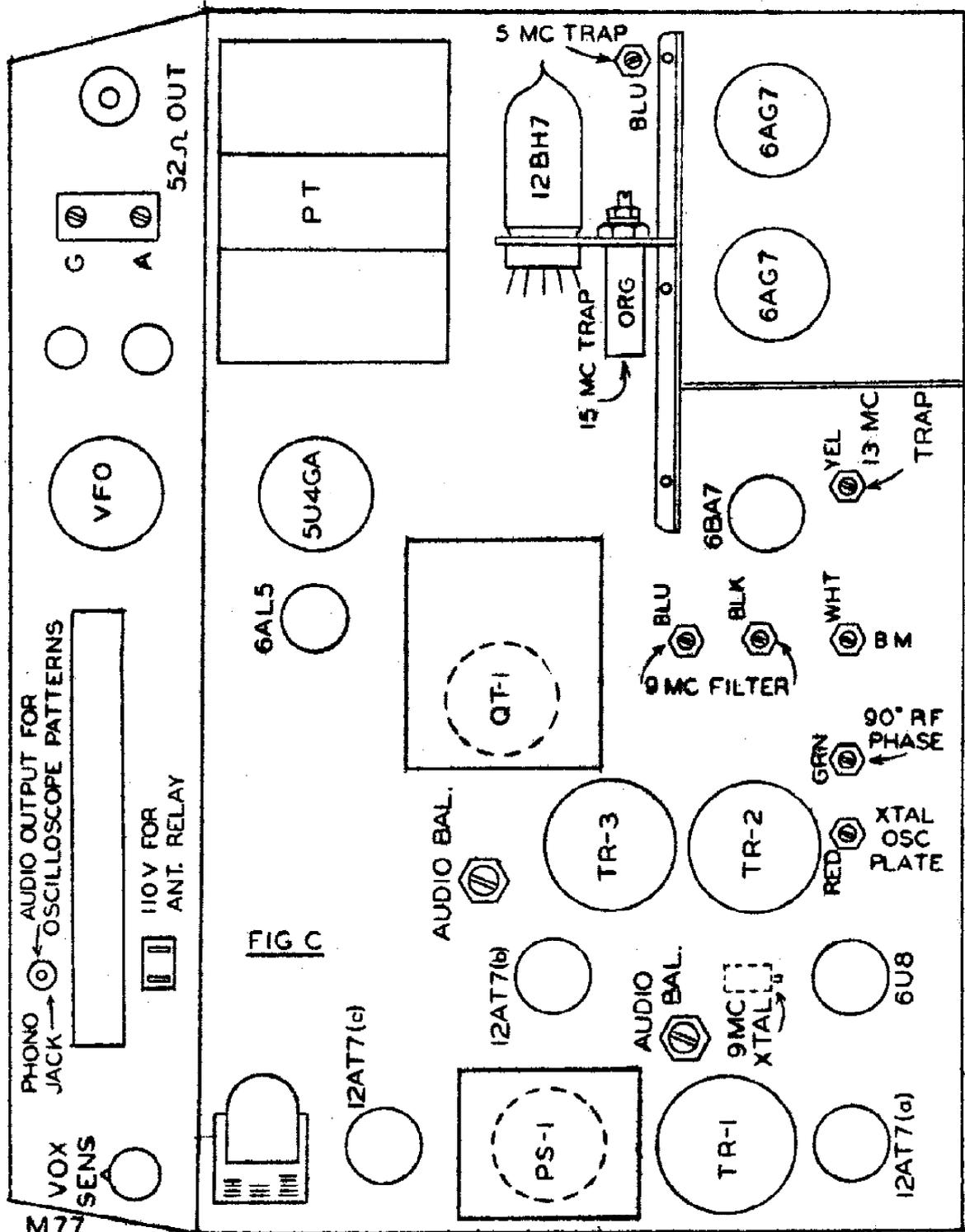
SUGAR COATED LINEAR AMPLIFIER THEORY - OCTOBER '51 QST

HOW TO TEST AND ALIGN A LINEAR AMPLIFIER - MAY '52 QST

FIGURE B LOCATION CHART
 ALIGNMENT FOR MULTIPHASE EXCITER MODEL 20A
 REFER TO PAGES 5 THRU 7 FOR PROCEDURE



20A 8-1-57
 M221
 108MXA



M77
 108MX
 20A - 5-6-56 Rev. 1-29-57

MULTIBAND OPERATION

The frequency conversion method used permits all band operation without affecting the single sideband adjustments. In the Multiphase Exciter a master 9000 KC crystal oscillator furnishes RF power to a pair of germanium diode balanced modulators, where the sidebands are produced. The modulator output is then applied to a low level mixer stage where it is heterodyned to the desired output frequency by a crystal or an external VFO. For example, a crystal, or a BC-457 (4 to 5.3 MC) or BC-458 (5.3 to 7 MC) command transmitter operating from a VR75, will provide output in the 20 to 75 meter phone bands.

A BC-458 can be modified to provide band switched VFO injection for operation from 160 through 10 meters with excellent stability.

The VFO socket on the rear of the exciter furnishes plate voltage for this purpose.

Complete instructions are furnished for Command unit modifications.

Central Electronics has made available kits for the BC-458 which contain all the necessary conversion parts. The 458K covers 160 through 15 meters and the 458-10 is the ten meter conversion kit. Factory modified 458s are also available, 160 through 15 meters and 160 thru 10 meters.

The following chart indicates the injection frequencies required with the 9 mc. master oscillator

OUTPUT FREQUENCY	INJECTION FREQUENCY
1800 kc.	7200 kc.* or 10800 kc.
2000 kc.	7000 kc.* or 11000 kc.
3500 kc.	5500 kc.* or 12500 kc.
3800 kc.	5200 kc.* or 12800 kc.
4000 kc.	5000 kc.* or 13000 kc.
7000 kc.	16000 kc. or 5333.3 kc. x 3
7200 kc.	16200 kc. or 5400 kc. x 3
7300 kc.	16300 kc. or 5433.3 kc. x 3
14000 kc.	5000 kc.* or 23000 kc.
14200 kc.	5200 kc.* or 23200 kc.
14300 kc.	5300 kc.* or 23300 kc.
21000 kc.	12000 kc.* or 30000 kc.
21450 kc.	12450 kc.* or 30450 kc.
28000 kc.	37000 kc.
28500 kc.	37500 kc.
29700 kc.	38700 kc.

*Injection at these frequencies may be obtained from crystals plugged into the front panel socket.

160 meter crystals or injection should not be used for 40 meter operation. For example, when using 1800 kc. injection ($9000 - 1800 = 7200$) the fourth harmonic of the injection frequency will also be present in the mixer output. This fourth harmonic ($1800 \times 4 = 7200$) will be further amplified by the 6AG7 stage and result in a strong spurious signal.

The same holds true if 19 MC injection is used for 28 MC operation. In this case the second harmonic is 38 MC and $38 - 9 = 29$ MC. As a result there will be a spurious signal radiated which is about 30 db. below the desired one. Therefore only 37 MC should be used for 10 meter operation.

NOVICE OR C.W. OPERATION ONLY

Break-in CW may be used on the 160, 80, 40 and 20 meter bands with direct frequency crystals. Turn the Modulation selector to the CW position. Plug the crystals into the socket on the front panel and tune the Mixer and Amplifier to frequency.

THEORY OF OPERATION

Refer to the Block Diagram, Fig. A1.

SPEECH AMPLIFIER

Both sections of a 12AT7 tube are used as a speech preamplifier. A closed circuit jack is connected in series with the grid of the second stage for external AF input and may be used for a phone patch, audio oscillator input, etc. Maximum input to the jack should be less than 1.2 volts rms.

VOICE AMPLIFIER

An additional stage of amplification consisting of one section of a 12AT7 further amplifies the speech. The VOX SENSITIVITY control located on the rear of the chassis, controls the input to this stage and the sensitivity of the VOX system. A 470K resistor in series with the grid prevents any grid rectification from reflecting distortion back into the speech system.

VOICE RECTIFIER

One section of a 6AL5 rectifies the output of the voice amplifier. R40 and C40 determine the VOX time constant. The rectified voltage is positive at this point.

RELAY CONTROL

The other section of the 12AT7 Voice Amp tube is used to operate the VOX relay. The cathode resistor, R45, permits a residual current of about 3 ma. through the relay, which will attract at about 3-1/2 to 4 ma. Therefore any small positive voltage from the Voice rectifier will trip the relay. R40A, 1 megohm, prevents excessive positive grid current from damaging the tube.

RELAY CONTROL (Cont'd)

Section 2 of the Operation Selector switch connects the grid of the tube to the positive output of the Voice Rectifier for VOX operation, or to a voltage divider for MANUAL operation. The divider consists of R42 and R43, which is connected across the B plus 300 volts and ground. The divider furnishes about 30 volts positive (through a 1 meg. current limiting resistor) to the grid of the Relay Control Tube. When an open key is inserted in the KEY jack, 30 volts negative appears at the junction of R42 and R43. When the key is closed, the voltage at the junction returns to positive 30. The application of the negative voltage while the key is open provides faster relay release for high speed keying.

QT-1 CIRCUIT

The QT-1 is a plug in unit for use with Multiphase Exciters, to prevent operation of the voice control circuit by the loudspeaker. With this unit, the voltage appearing across the loudspeaker voice coil is amplified, rectified and applied in negative polarity to the grid of the relay control tube. The loudspeaker will develop two opposing voltages at the grid of the relay tube, a positive voltage from the microphone channel and a negative voltage from the speaker voice coil. When these two voltages are correctly proportioned, the loudspeaker will not trip the relay.

AF DRIVER

The triode section of a 6U8 and transformer TR-1 serves as a low impedance driver to the audio phase shift network. The input voltage divider to the PS-1 is about 400 ohms on one side and 1400 on the other. Therefore the voltage applied to one side is .285 of that applied to the other side. R15A, the Audio Balance potentiometer, permits exact balance of the input voltage.

AUDIO PHASE SHIFT NETWORK

The PS-1 is a precision 90 degree differential phase shift network consisting of two independent circuits. The output of each circuit is applied to the grid of a modulator tube. Phase shift between the two output terminals is 90 degrees plus or minus 1.3 degrees over the essential speech range. Although the input voltages to the PS-1 are .285 to 1, the output voltages are equal. The trimmer capacitors are laboratory adjusted and readjustment should never be attempted in the field.

MODULATOR

Each section of the 12AT7 serves as an independent modulator, furnishing equal 90 degree displaced audio voltages at low impedance to the Balanced Modulator, through transformers TR-2 and TR-3. The cathode of one section of the tube has an adjustable resistor, R18, to obtain equal modulator outputs.

MODULATION SWITCH

In SB1 position, both modulation transformers feed the balanced modulator. In SB2, the white and brown leads from the secondary of TR2 are reversed, which reverses the sideband. In AM, the secondary of TR-3 is opened to disable one

MODULATOR SWITCH (cont'd)

of the modulators and the "cold" end of the Green link is returned to ground through a 15 ohm resistor. This resistor is approximately the same resistance as the secondary of the transformer and is inserted to prevent unbalance of the modulator circuit. In PM, TR-3 is restored to the circuit, the secondary of TR-2 is opened and the "cold" end of the Red link is returned to ground through a 15 ohm resistor. In the CW position, the secondaries of both modulation transformers are opened and both links are returned to ground through 15 ohm resistors.

MASTER OSCILLATOR

The control grid and screen grid in the pentode section of the 6U8 are utilized as a crystal controlled Pierce oscillator, with the electron coupled plate circuit tuned to 9 mc. Inductive coupling between L1 and L2 provides the required 90 degrees RF phase shift.

BALANCED MODULATOR (Refer to Fig. A2)

Basically, the phasing method of single sideband generation consists of two independent audio frequency phase shift systems, two sources of RF shifted 90 degrees in phase and two balanced modulators. Each balanced modulator produces a double sideband signal, with the carrier cancelled out. When these modulator outputs are combined, single sideband will be produced, provided the phase shifts are proper and the voltages equal. In actual practice, only one RF source is required and one common tank circuit is used for the balanced modulators. Referring to the basic diagram, if the carrier is unbalanced the proper amount in Channel A and modulator B is disabled, normal AM will be produced. If the carrier in channel A is completely unbalanced and modulator A is disabled, modulator B will furnish RF sidebands displaced 90 degrees from the carrier, which combine with the carrier to produce phase modulation. Phase modulation generated by this method provides a modulation index of 1, which has the same bandwidth as amplitude modulation and is the maximum deviation permitted in the amateur bands below 29 mc.

9 MC. TUNED CIRCUITS

L4 and L5 are critically coupled 9 mc. tuned circuits which prevent strong harmonics present in the balanced modulator from reaching the grid of the mixer tube.

MIXER

The 9 mc. signal is applied to the control grid of the 6U8 mixer and the external VFO is fed to the injection grid. For front panel crystal control, the VFO-XTAL switch changes the injection grid and screen grid to a Pierce oscillator circuit. The plate circuit of the Mixer stage is series fed and the plate voltage appears on these coils. The output is capacitively coupled to the cathode follower.

13 and 15 MC. TRAP COILS

Mixers, being non-linear devices, also generate strong harmonics. When operating on 20 meters it is necessary to trap out two undesirable components. The 5 mc. injection frequency will give output at 15 mc., while the second harmonic (18 mc.) of the generating system combines with the 5 mc. VFO to produce 13 mc. L6 and L7 are used to reduce the level of these components.

CATHODE FOLLOWER

On 160 and 80 meters, an RF choke is used in the 12BH7 cathode output circuit. On the higher frequency bands individual tuned circuits are required to furnish adequate driving power for the amplifier and further discriminate against undesirable products.

LINEAR AMPLIFIER

The grid of the parallel 6AG7 linear amplifier is capacitively coupled to the cathode follower stage. Trap L8 is inserted in series with the grids to reduce the level of the 5 mc. injection frequency when operating at 4 mc. The plate circuit is shunt fed and the 50 ohm output taps are made directly to the coil on 160, 80 and 40 meters. A tapped inductively coupled link is used on the higher frequencies.

INDICATOR RECTIFIER

One section of the 12BH7 is coupled to the 50 ohm RF output to function as a rectifier to furnish the negative DC voltage to operate the 6E5 RF INDICATOR.

INDICATOR SWITCH

In the CARRIER NULL position, the full output of the Indicator Rectifier is applied to the 6E5 for maximum sensitivity and the speech circuit is disabled to prevent room noise from operating the eye. In the SET MAX LEVEL position the RF INDICATOR sensitivity is adjustable by means of the INDICATOR LEVEL potentiometer.

CALIBRATION LEVEL

With the OPERATION switch in the CALIBRATE position, the bias on the Mixer and Amplifier grids is varied from normal to negative 40 volts for frequency spotting with the CAL LEVEL potentiometer. In this switch position, negative 100 volts still remains on #7 on the rear terminal strip to keep the final amplifier biased to cut-off, to prevent excessive radiation.

KEYING CIRCUIT

In standby, negative 100 volts is applied to the grids of the Mixer and Amplifier stages. This voltage also appears at the rear strip, terminal #7, for block biasing any external linear amplifier. In transmit, this voltage is shorted to ground by the internal relay with the switch in the MANUAL or VOX position. There are two methods for "silent" CW operation, to avoid relay noise. With the

KEYING CIRCUIT (Cont'd)

OPERATION SWITCH in the STANDBY position, the key connected to 7 and 5 (ground), the blocking bias will be shorted out when the key is closed. The receiver will not be muted; a TR switch, separate receiving antenna or manually operated antenna switch must be used. If the key is placed in series with terminals 6 and 7, the relays will close in the MANUAL position and the key will short out the blocking bias. Normal VOX operation may be resumed by closing the switch on the key.

BIAS RECTIFIER

One section of a 6AL5 is used as a half wave rectifier to supply negative 100 volts for blocking bias, and operating bias for the 6AQ7s.

ACCESSORY POWER SOCKET

This is the octal socket located on the rear of the chassis and furnishes 6.3 volts AC and 300 volts DC for VFO operation.

PHONE JACK

When the speaker is connected as shown in the diagrams, inserting the phone plug will disconnect the loudspeaker. The phones will be controlled by the VOX circuit.

MAINTENANCE AND SERVICE

CAUTION!!

ON FACTORY BUILT EXCITERS, DO NOT ADJUST THE SLUG TUNED COILS UNLESS ABSOLUTELY NECESSARY. EXPERIENCE HAS PROVEN THAT IMPROPER OPERATION DUE TO MISALIGNMENT IS VERY RARE. WHEN THE POWER IS ON, DO NOT REMOVE THE 9 MC. CRYSTAL WHILE THE 6U8 TUBE IS IN ITS SOCKET. LOSS OF RF EXCITATION WILL RESULT IN EXCESSIVE PLATE DISSIPATION AND POSSIBLE DAMAGE TO THE TUBE.

TUBE REPLACEMENT

Use only RCA type 6AG7. Other versions of this tube are unusually subject to interelectrode shorts. Avoid old war surplus 6AG7s; many of these will oscillate vigorously.

A blue haze may be observed near the bottom of the envelope on most 6U8 tubes as operated in this equipment. This is normal and is due to electron bombardment of the glass. In gassy tubes the blue haze occurs between the tube elements.

Erratic operation of the voice control relay is usually due to a weak relay control tube 12AT7(C) or a tube with unusual characteristics.

Lack of sideband suppression may be due to a defective modulator tube 12AT7(B). Be sure that both filaments are lighted.

REPLACING SHORTED TUBES

Shorted tubes will often damage associated plate and cathode resistors even though the short has been of an intermittent nature. If abnormal or intermittent operation occurs after replacing a shorted tube, the resistors should be checked with an ohmmeter if possible, or observed visually for discoloration. In some instances it is possible to observe sparking in a severely damaged resistor under subdued light, or it may fall apart under slight pressure from an insulated tool.

Whenever a shorted 6U8 is replaced, R20 and R21A should be checked. Inadvertent shorts in the 6BA7 mixer plate or plate coil assembly will usually damage R67, located on a small terminal strip on the rear of the Mixer tuning capacitor.

INTERMITTENT OR NO RF OUTPUT ON ONE OR MORE BANDS

The two rotor end plates of the Mixer and Amplifier tuning capacitors should be checked for shorts. When necessary, bend the end plates away from the stator slightly to provide sufficient clearance.

MODULATION LOW OR ABSENT

This is often caused by a defective microphone or broken leads at the microphone connector. If another microphone is not available for test, press the

MODULATION LOW OR ABSENT (Cont'd)

male mike connector pin with your finger. On an exciter that is correctly tuned and otherwise operating properly, sufficient signal will be provided to make the eye overlap at full Speech and Indicator sensitivity.

VOICE CONTROL RELAY OPERATION

The relay is designed to attract at approximately 4 ma. and release at 2-1/2 to 3 ma. In cases where the relay lacks sensitivity, R45 should be decreased to 2500 ohms. If it does not release readily, R45 should be increased to 3000 ohms. Any departure from these values usually indicates shorted turns in the relay coil, or possibly high leakage or a short from the coil to the frame.

CALIBRATE SIGNAL WEAK

Under some circumstances, when a well shielded linear amplifier and a coaxial relay are used, the calibrate signal will be weak. It will be necessary to couple some of the exciter output into the receiver. Coaxial cable should be used and two insulated wires twisted together for about four inches will furnish sufficient coupling when connected at the exciter two lug terminal strip. A coaxial T connector should be used at the receiver.

CARRIER DOES NOT BALANCE OUT PROPERLY

When operating on the 3.9 mc. phone band, be sure that the pointers on the Mixer and Amplifier tuning controls are within about 1/8 inch of the panel marking. It is possible to "tune up" on the output of the 5 mc. crystal or VFO when the pointers are in the vicinity of 7.2 mc. The 5 mc. carrier cannot be cancelled with the carrier balance potentiometers and this effect is often mistaken for oscillation or lack of carrier balance. On 40 meters it is possible to tune to the 9 mc. generating system with the dial pointers at 14 mc. Reasonable care should be taken when tuning to make sure that the pointers are close to the desired operating frequency.

RFC-1 may be open. Remove the plug-in diode assembly. The resistance of the choke should be about 30 ohms. If the choke is not open, the diodes should be checked with an ohmmeter. Each diode should be within about 10% of the average value in the forward direction. The back resistance should be at least 100 times as great and this ratio is unimportant.

SIDEBAND SUPPRESSION

In order to obtain good sideband suppression, the RF voltages applied to the balanced modulator must be within 10% of each other, when L1 and L2 are peaked. If the difference is greater it will be necessary to adjust the position of L1 until they are more equal. This may be measured conveniently at the arm of each carrier null pot, with the carrier balanced out and should be between 3.2V and 4.2V rms, or 4-1/2 to 6V Peak.

The audio voltages must also be equal and these appear at the red and green wires at the bottom of the Modulation switch. The Modulation switch must be in one of the sideband positions for this measurement, with an audio signal

SIDEBAND SUPPRESSION (Con'd)

of 1225 cycles to the exciter input. A 1000 ohm per volt rectifier type AC meter is satisfactory for purposes of comparison. If the voltages cannot be balanced by means of the audio balance controls R15A and R18, one of the components on the side that has the lowest reading is usually at fault. This may be caused by a defective modulator tube, open or shorted turns on the modulation transformer, driver transformer secondary shorted to ground, open contact on Modulation switch, etc.

With the power turned off, the PS-1 can be checked while in its socket for trimmer shorts. NEVER attempt adjustment of the trimmer capacitors in the PS-1. The components used are extremely stable, are operated at very low voltage and will maintain their accuracy indefinitely.

Note that the input voltage divider to the PS-1 is about 400 ohms on one side and 1400 ohms on the other. Therefore the voltage applied to one side is .285 of that applied to the other side. The output voltages of the phase shift network are equal.

Common errors in units constructed from kits which cause poor sideband suppression are:

1. 400 and 1400 (or 1430) ohm resistors reversed.
2. PS-1 socket wired incorrectly. Remember this is a 9 pin socket.
3. Poorly soldered connection at the 2 lug terminal strip TQ, located under the chassis near the Modulation switch. This is at the junction of the two Green wires and the .001 capacitor.

SIDEBAND SUPPRESSION ALIGNMENT WITHOUT THE USE OF A SCOPE

In an emergency, it is possible to adjust the sideband suppression using an audio oscillator and a receiver.

The receiving antenna should be removed, the BFO turned OFF and the AVC ON. Tune in the signal on the receiver.

Remember that with sine wave audio input, a pure SSB signal has NO modulation and resembles a CW carrier. With the Modulation switch in one of the SB positions, adjust audio balance pots R15A and R18, L2 and the Carrier Balance controls for MINIMUM modulation in the receiver. Minimum modulation corresponds with maximum sideband suppression. It will not be possible to eliminate the modulation entirely due to distortion in the audio oscillator, the speech amplifier and the limitations of sideband suppression. An audio oscillator with less than 1% distortion must be used and the audio input to the exciter should be sufficiently low to prevent overloading of the speech amplifier.

HUM AND CARRIER DRIFT

Lightly loaded RF amplifier stages have excessive voltage gain and tend to be highly regenerative. When two or more linear amplifiers follow the exciter, it often happens that there is an excess of driving power available

HUM AND CARRIER DRIFT (Cont'd)

for the final amplifier. When this occurs, the speech gain control must be turned down low and there will be excessive carrier, carrier drift and hum. The solution for this condition is to adequately swamp the output of the Exciter and first amplifier, to provide a relatively constant load. The hum and noise in the Exciter are normally at least 60 db, down from full output.

UNSTABLE CARRIER OR CARRIER NULL POTENTIOMETERS

These may be cleaned by applying carbon tetrachloride with an eye dropper into the gap directly under the terminals and rotating the knob vigorously.

SIDEBAND REVERSED

If the sideband relationships listed on Page 1 of the Operating Instructions is reversed in units constructed from kits, or when a transformer is replaced, the brown and white modulation transformer leads are improperly coded. To reverse the sidebands, the secondary leads (brown and white) of either modulation transformer should be reversed.

PARASITIC OSCILLATION

Never install antennas, open wire feeders or antenna tuners in close proximity to the VFO, Exciter, or external Exciter wiring. Keep radiated RF from entering the AC power lines. If a separate receiving antenna is used, it should be located as far away as possible from the transmitting antenna, and run at right angles to it.

If the De Luxe Case and Panel are used on a BC-458 VFO, be sure to scrape the paint underneath the nuts on the rear of the cabinet to insure good contact between the case and the chassis. When operating in strong RF fields it may be necessary to add a short heavy jumper from the front of the VFO panel to the front panel of the Exciter. The AC cord from the VFO should be plugged into the same AC outlet as the Exciter to reduce the possibility of large RF pickup loops. On VFOs that have had considerable handling, be sure that the ground connection is intact at the octal male plug that goes to the Exciter. If this connection is broken, severe oscillation will occur.

It is important that the two springs which are attached to the perforated metal cover on top of the 6AG7 coil compartment make good contact with the front panel.

REDUCING PARASITIC OSCILLATION IN LINEAR AMPLIFIERS

Amplifier stages that follow the Exciter must have adequate grid swamping resistance, especially if more than one stage is used.

The amplifier should use a two watt carbon resistor about 50 ohms, connected right at the grid terminal of the tube, in series with the grid lead. The use of series grid resistors raises the drive requirement, especially at the higher frequencies, so the resistance should be kept as low as possible consistent with reliable operation. A plate parasitic suppressor consisting of a few turns of wire on a similar resistor is often required for stability. High power amplifiers may require a series or parallel arrangement of grid resistors to obtain the required dissipation and the plate suppressor should be similar to the Ohmite type P-300. With push-pull or parallel operation, individual suppressors should be used for each tube.

The use of a small series grid resistor has eliminated oscillation even in grounded grid circuits.

Provisions for neutralization should be made when operating tetrodes or pentodes on the higher frequency bands.

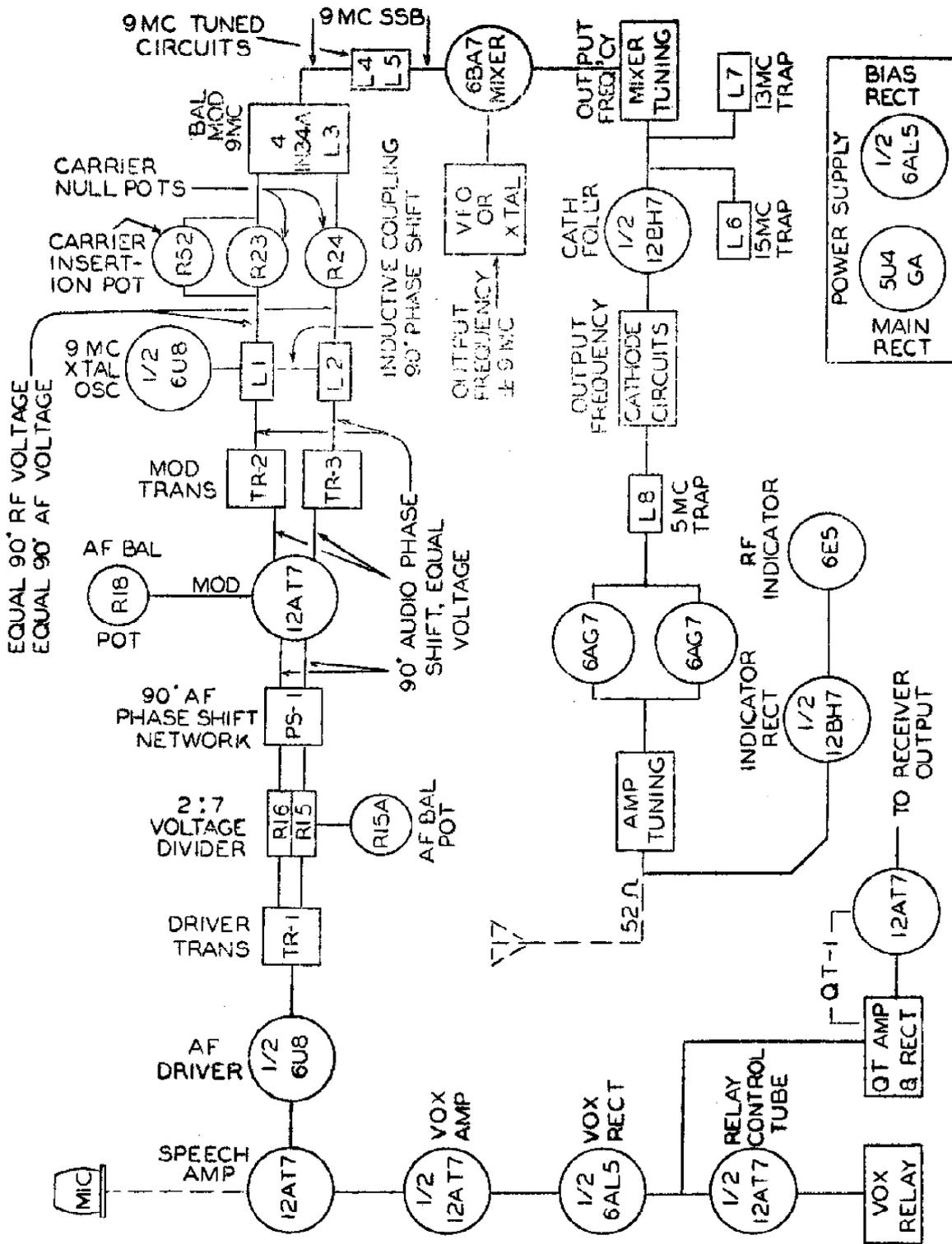
TELEVISION INTERFERENCE

Whenever the equipment is operated in TV fringe areas, it may be necessary to use a low pass filter.

It is very important that the Exciter and final amplifier are not driven to the "flattening" point, at which the harmonic output increases considerably, and is almost certain to create TVI. Keep the Speech Level control down to the point where only occasional voice peaks reach maximum amplitude, as observed on an oscilloscope.

Interference may be generated by an antenna relay in which the antenna contacts are arcing due to improper timing sequence of the auxiliary contacts.

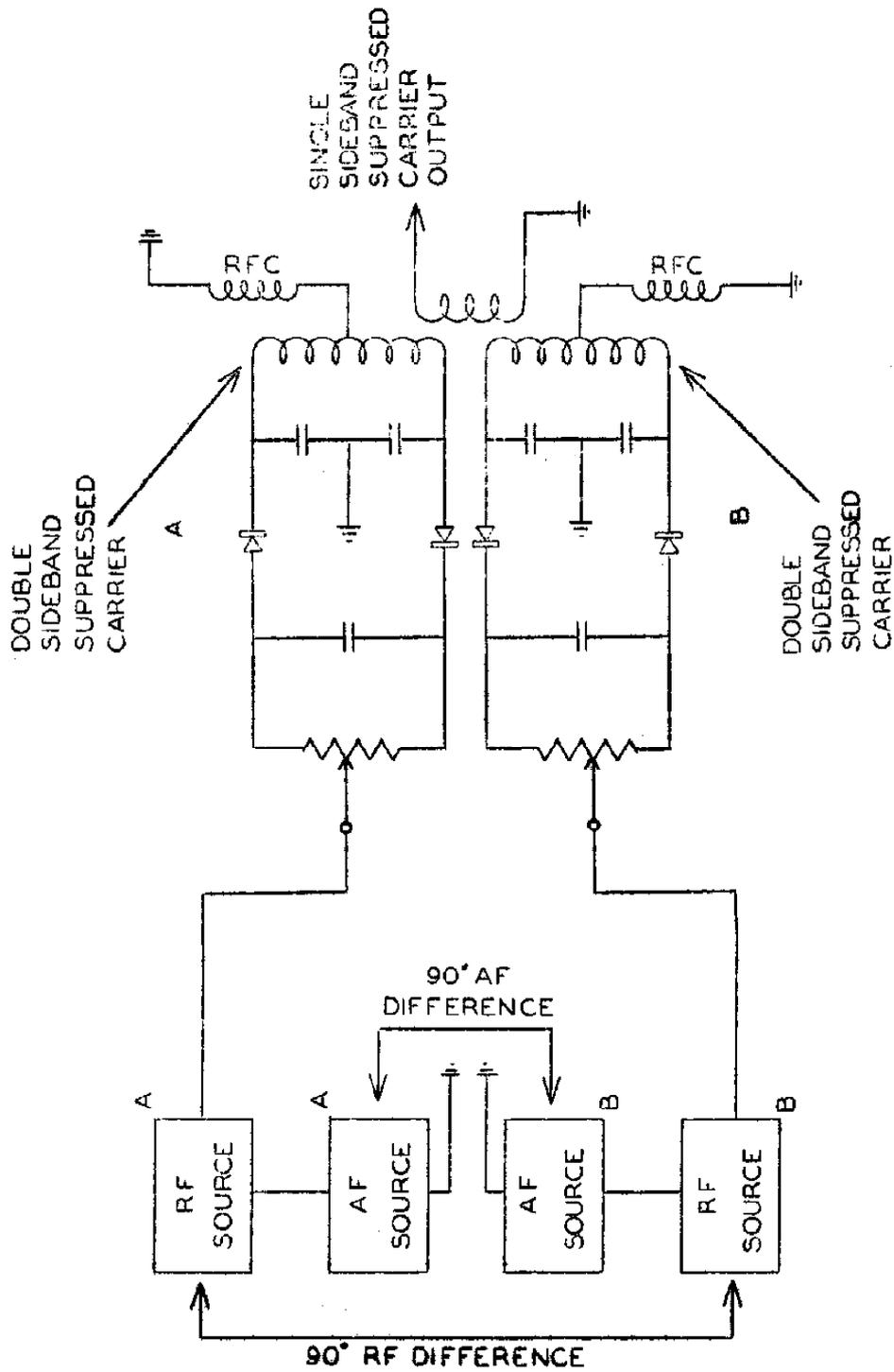
Many TR switches, antenna impedance matching or power indicating meters which rectify radio frequency energy intentionally or unintentionally will often increase the harmonic output, and should be followed by a low pass filter.



M199
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20 A BLOCK DIAGRAM

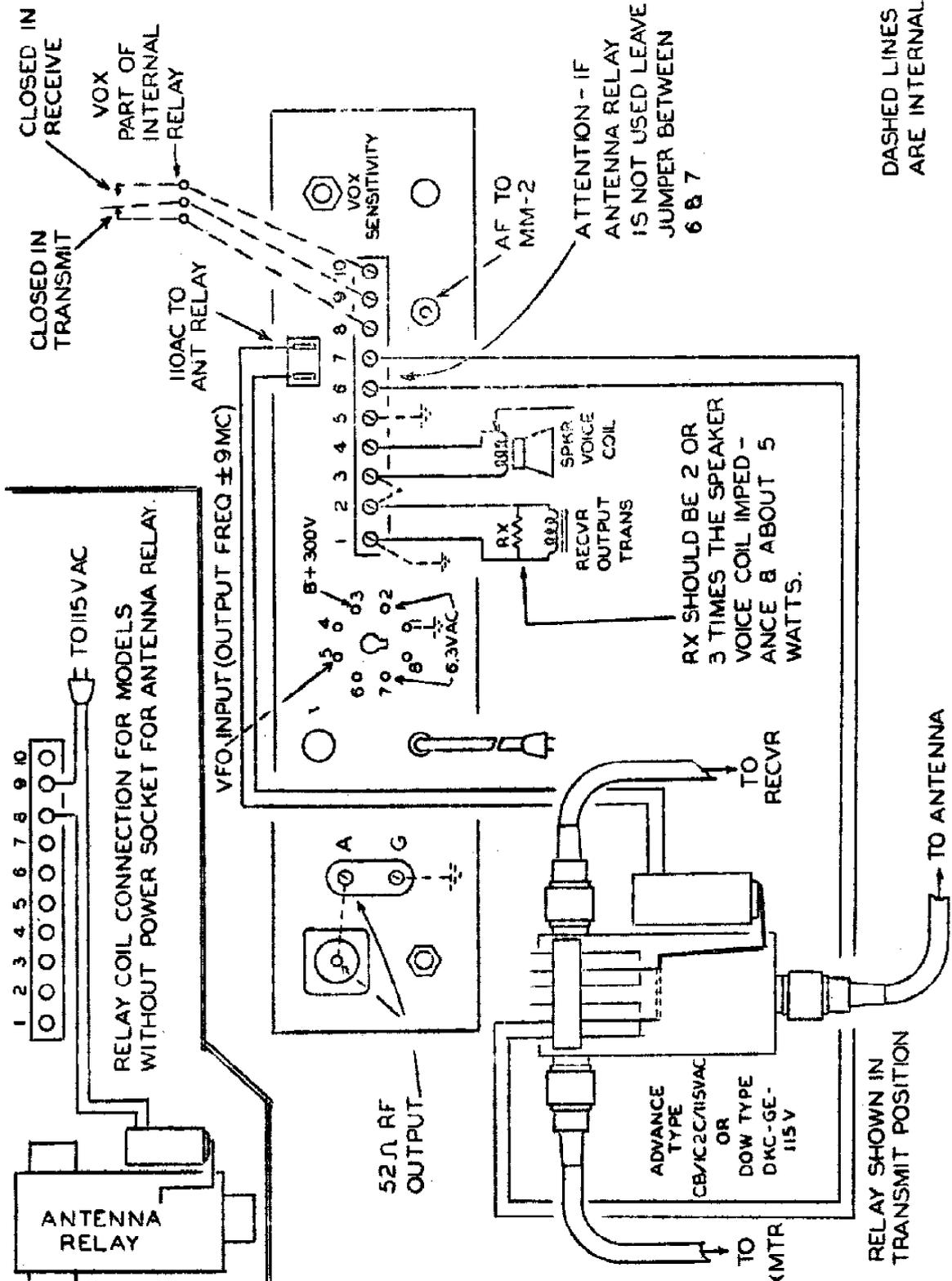
FIG. A1



BASIC PHASING SINGLE SIDEBAND GENERATION SYSTEM

FIG A 2

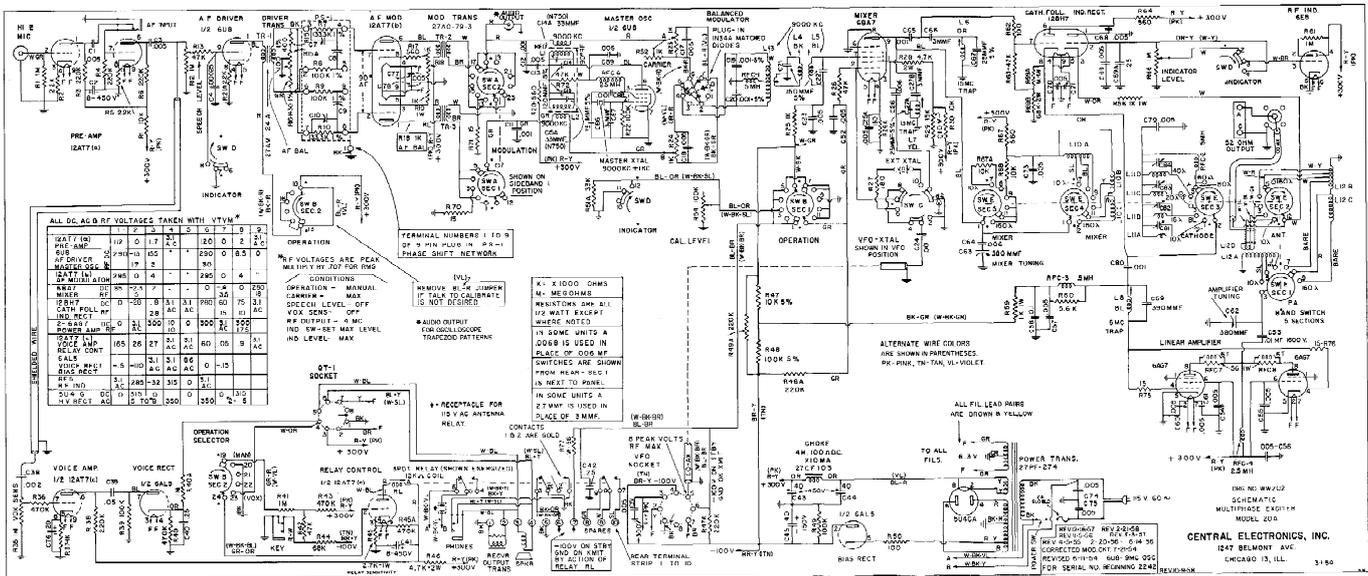
10A-10B-20A REAR CONNECTIONS



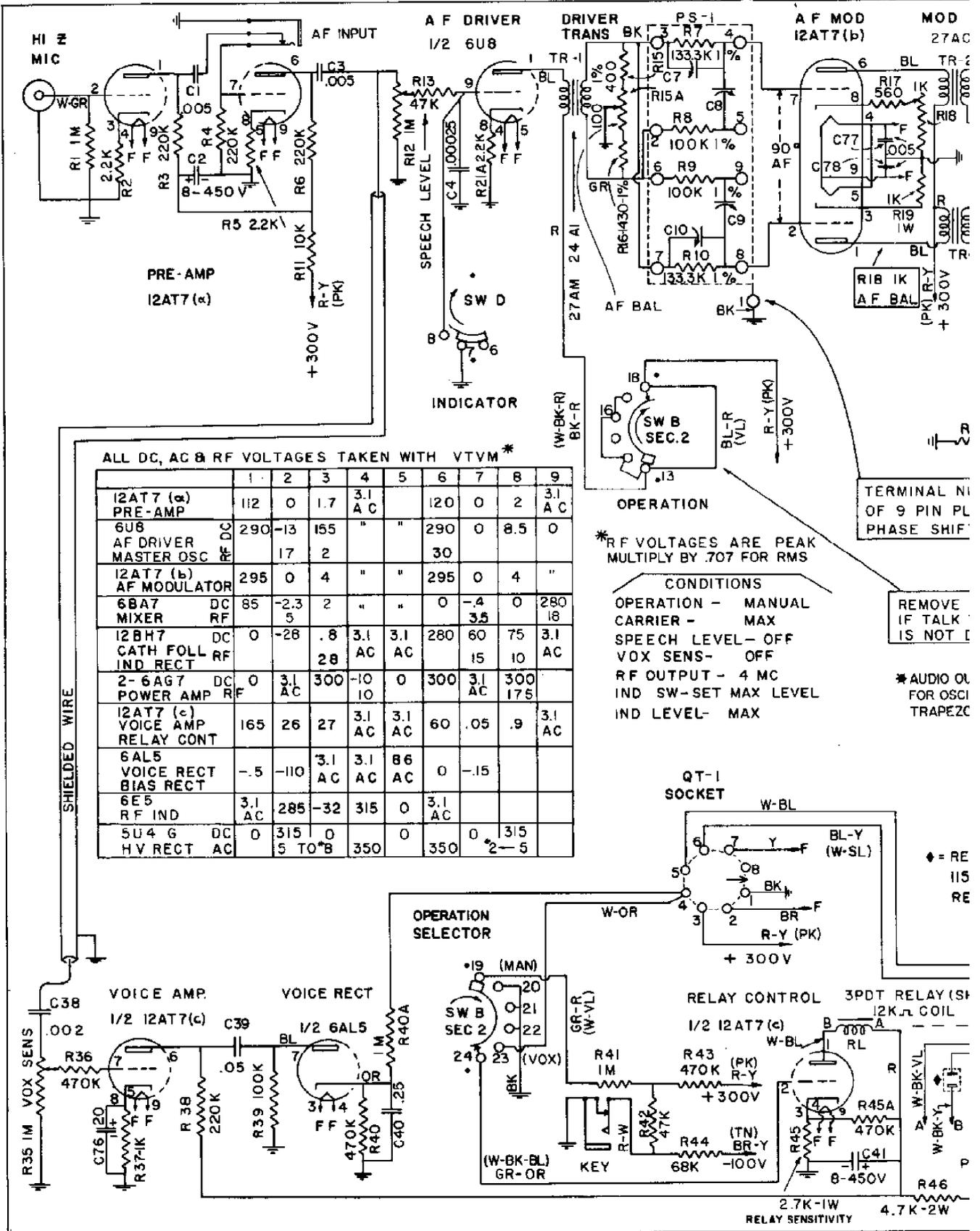
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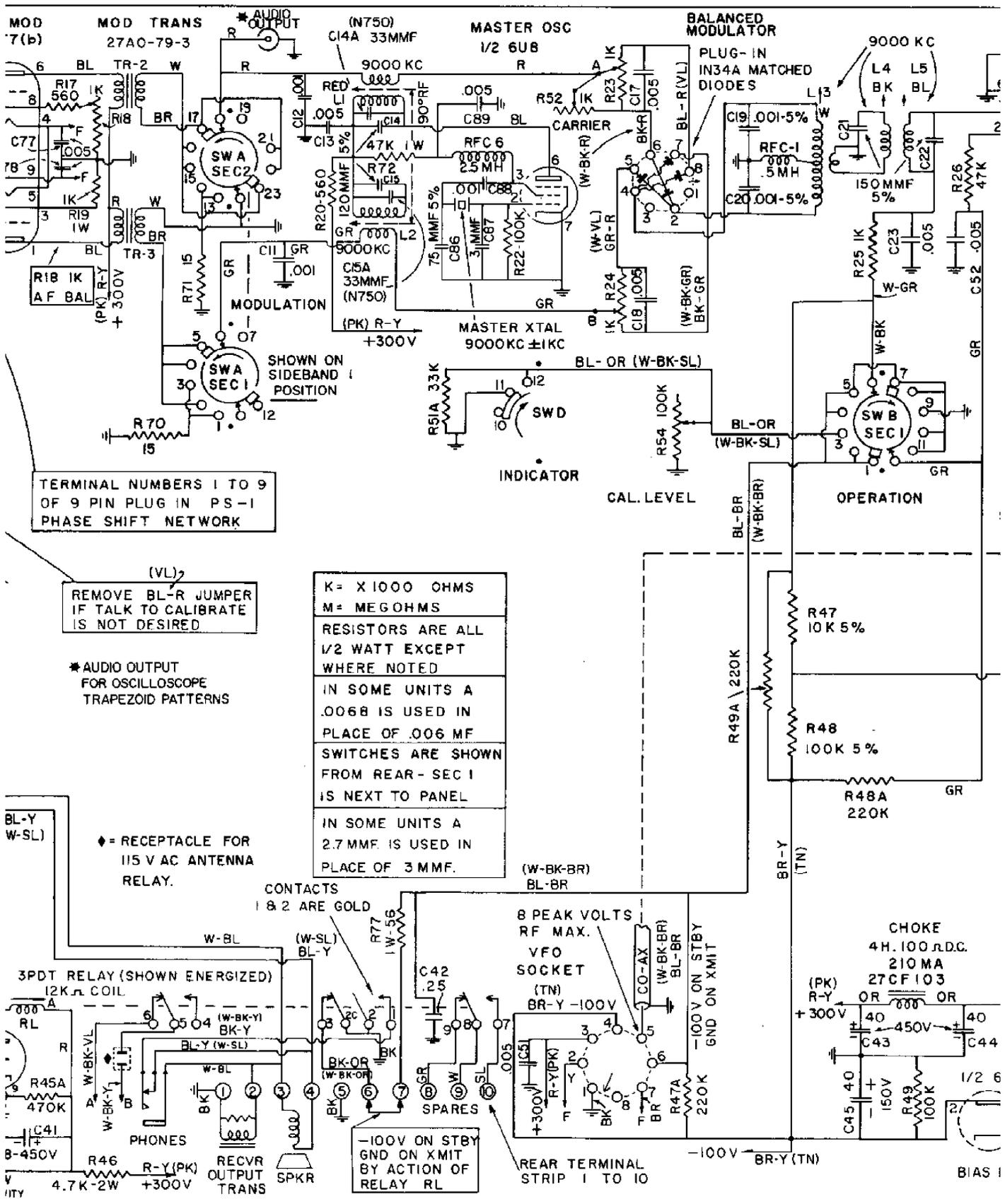
M200

20A Page 25



CENTRAL ELECTRONICS, INC.
 1247 BELMONT AVE.
 CHICAGO 13, ILL.
 3150





TERMINAL NUMBERS 1 TO 9 OF 9 PIN PLUG IN PS-1 PHASE SHIFT NETWORK

(VL)
REMOVE BL-R JUMPER IF TALK TO CALIBRATE IS NOT DESIRED

*AUDIO OUTPUT FOR OSCILLOSCOPE TRAPEZOID PATTERNS

K = X 1000 OHMS
M = MEGOHMS
RESISTORS ARE ALL 1/2 WATT EXCEPT WHERE NOTED
IN SOME UNITS A .0068 IS USED IN PLACE OF .006 MF
SWITCHES ARE SHOWN FROM REAR - SEC 1 IS NEXT TO PANEL
IN SOME UNITS A 2.7 MMF IS USED IN PLACE OF 3 MMF.

◆ = RECEPTACLE FOR 115 V AC ANTENNA RELAY.

CONTACTS 1 & 2 ARE GOLD

8 PEAK VOLTS RF MAX. VFO SOCKET (TN)

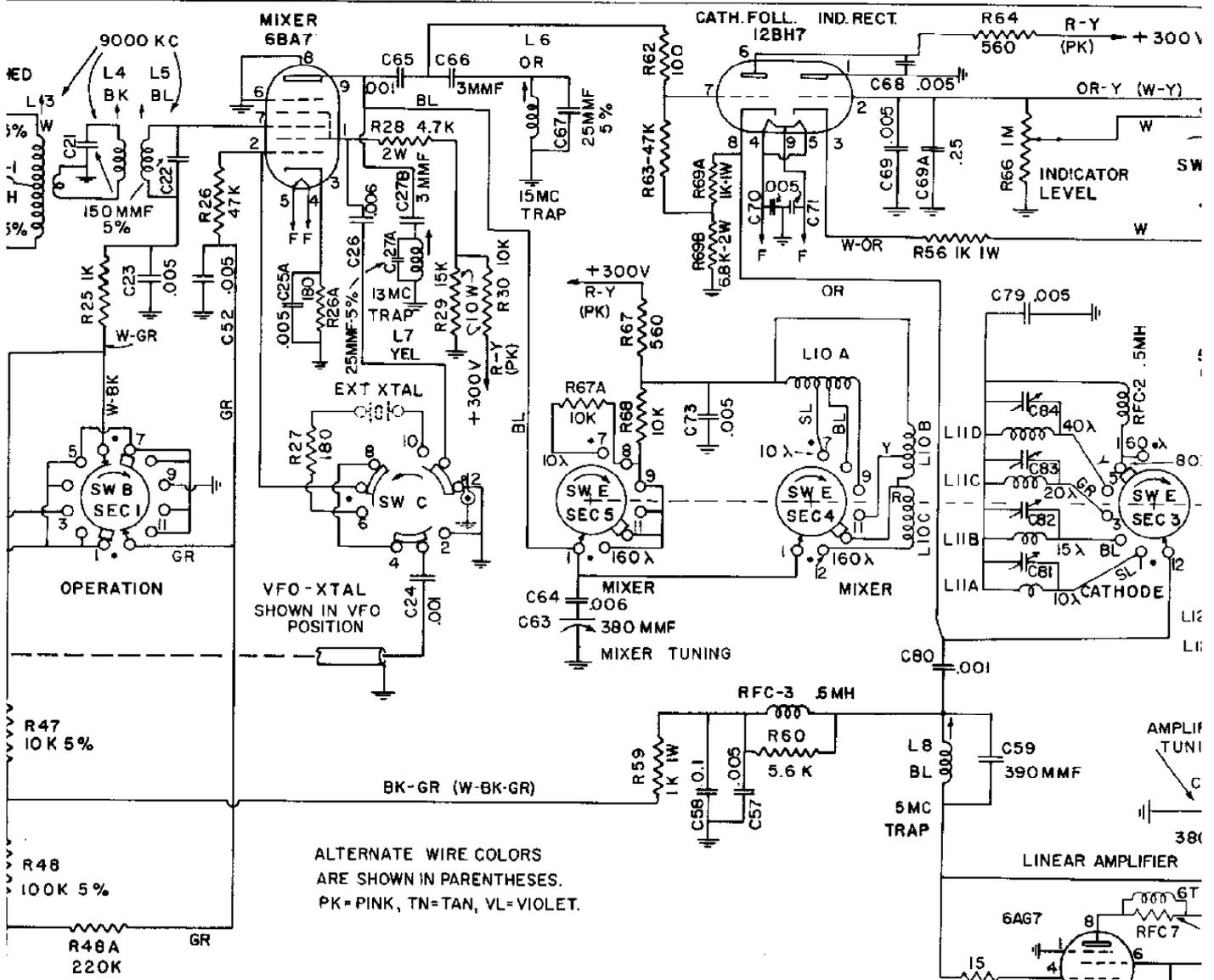
CO-AX (W-BK-BR) BL-BR

REAR TERMINAL STRIP 1 TO 10

-100V ON STBY GND ON XMIT BY ACTION OF RELAY RL

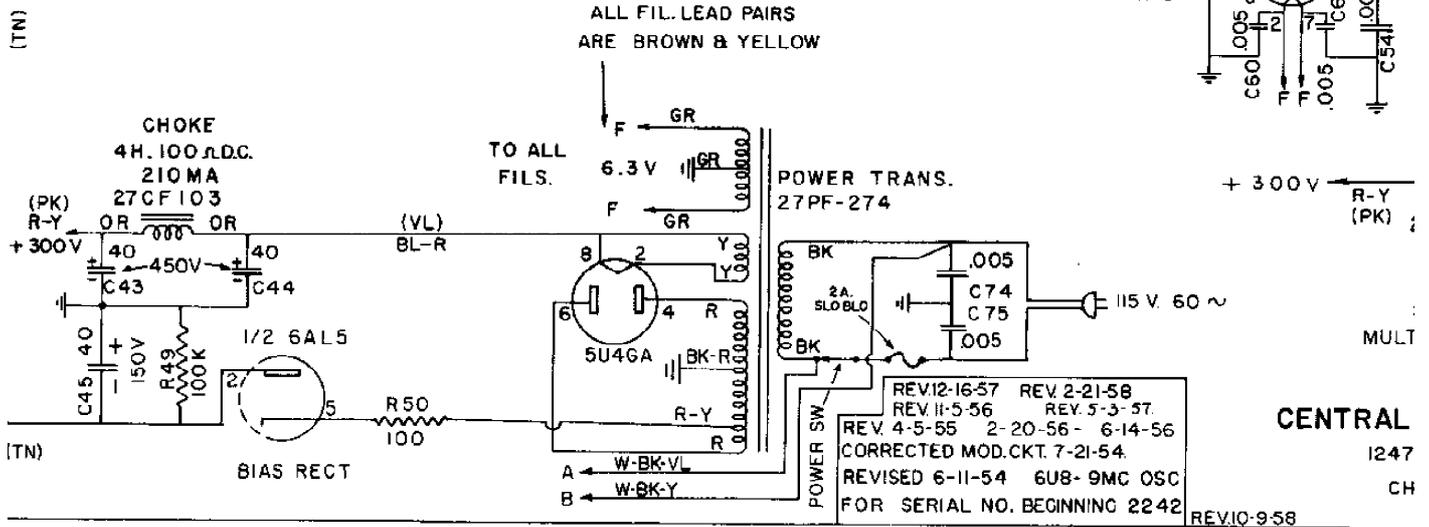
CHOKE
4H. 100 D.C.
210 MA
27CF 103

(PK) R-Y OR 40 OR 40
+300V C43 450V C44 40
C45 40
+150V R49 100K 1/2 6
BIAS 1



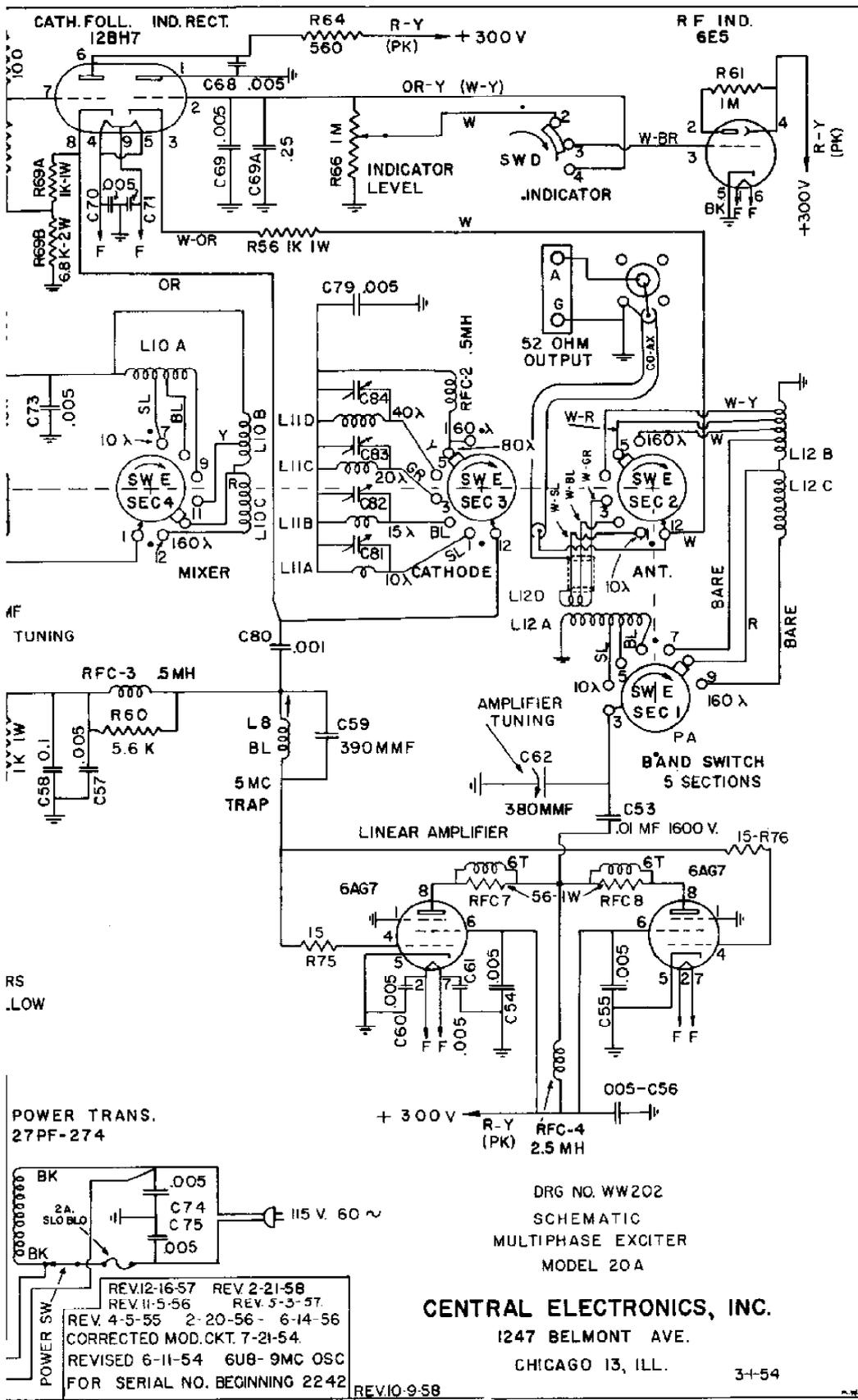
ALTERNATE WIRE COLORS ARE SHOWN IN PARENTHESES. PK=PINK, TN=TAN, VL=VIOLET.

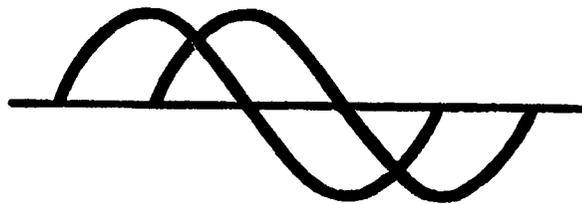
ALL FIL. LEAD PAIRS ARE BROWN & YELLOW



CENTRAL
1247
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REV. 10-9-58





Central Electronics, Inc.

RESEARCH - DEVELOPMENT - MANUFACTURING
AUDIO - COMMUNICATIONS - MEDICAL ELECTRONICS

MULTIPHASE EXCITER
MODEL 20 A
INSTRUCTION MANUAL

This unit is licensed under one or
both of the following U.S. Patents

No. 2,566,876
No. 2,611,036

CENTRAL ELECTRONICS, INC.

1247 W. Belmont Avenue

Chicago 13, Illinois

CONDENSED OPERATING INSTRUCTIONS FOR MULTIPHASE EXCITER MODEL 20A

Connect an antenna or a linear amplifier to the 52 ohm RF output. Set bandswitch to the band desired and the VFO-Xtal switch to the proper position. Turn CARRIER knob fully clockwise. Turn OPERATION selector to MANUAL and tune the MIXER AND AMPLIFIER for maximum output as shown on the RF INDICATOR, an oscilloscope or an antenna meter.

TO OPERATE SINGLE SIDEBAND

Set the MODULATION selector to one of the sideband positions (SB1 or SB2). Turn the OPERATION selector to MANUAL. With the CARRIER knob set at "0" adjust the CARRIER NULL controls A and B for minimum RF indication with the INDICATOR switch in CARRIER NULL position. Now return the INDICATOR switch to SET MAX LEVEL. Adjust the SPEECH LEVEL control between 9 and 12 o'clock, depending upon microphone gain. Talk into the microphone and you're on SSB!

TO OPERATE AM

Place the MODULATION selector in the AM position. Leave the CARRIER NULL knobs in the balanced-out condition. Advance the CARRIER knob until maximum output is obtained. Then reduce the CARRIER level to one half of the maximum value on the scope or to one half the maximum antenna current. Adjust the SPEECH LEVEL until the modulation peaks just reach the maximum output value on the scope. Too little or too much carrier will make the AM transmission sound distorted.

TO OPERATE PM (Narrow band phase modulation)

Turn the MODULATION selector to PM position. Leave the CARRIER NULL knobs on the balanced-out condition. Advance the CARRIER knob to nearly full output. Adjust the SPEECH LEVEL control so that the modulation peaks do not exceed the carrier.

TO OPERATE CW

Turn the MODULATION selector to CW. Place the OPERATION selector on MANUAL. Advance the CARRIER control to nearly full output. Plug key into jack on front panel.

TO USE THE VOICE CONTROL CIRCUIT (VOX)

Connect the receiver speaker to the Exciter as shown in the circuit diagram. The resistor across 1 and 2 on the rear terminal strip should be about two to three times the speaker voice coil impedance and rated at twice the power output. The extra contacts on 8, 9 and 10 may be used to operate an antenna relay, additional receiver silencing circuits, etc. With the OPERATION selector in VOX position talk into the microphone and adjust the VOX sensitivity control on the rear of the chassis for proper operation.

CALIBRATION LEVEL CONTROL

When the OPERATION selector is in the CALIBRATE position the CAL LEVEL control will vary the output of the Exciter for frequency "spotting".

INDICATOR SWITCH

In the CARRIER NULL position the speech circuit is disabled and the RF INDICATOR operates at maximum sensitivity. The CARRIER control should always be at "0" while balancing out the carrier with CARRIER NULL knobs A and B. In the SET MAX LEVEL position, the RF INDICATOR sensitivity can be adjusted by the IND LEVEL control.

RF INDICATOR

The 6E5 RF INDICATOR shows the peak RF voltage output of the Exciter. It can be used for peaking the Mixer and Amplifier tuning controls and also to determine the proper speech level while operating SSB. To determine the maximum undistorted SSB output of the Exciter or linear amplifier, advance the CARRIER control until no further increase in output is observed. Now set the IND LEVEL control to just close the eye. Return the CARRIER CONTROL to "0" and adjust the SPEECH LEVEL until the voice peaks reach about 80% of the full carrier value.

EXTERNAL BLOCKING BIAS

In the standby position, -100 volts DC appears at terminal 7 on the rear terminal strip. If a bias supply is used for a linear amplifier the positive should be returned to this terminal of the Exciter. All positive components in the bias supply must be "floating" from ground, and connected only to the positive lead.

When zero bias tubes are used, the amplifier grid return lead should be by-passed and then connected to terminal 7. A secure ground connection should be made between the Exciter, linear amplifier, linear amplifier power supply and the bias supply.

If an antenna relay with auxiliary contacts is used, these auxiliary "make" contacts can be used to key the blocking bias by connecting them to #6 and #7 on the rear terminal strip. Proper keying sequence is required so that the antenna circuit makes before the blocking bias is removed.

When the auxiliary contacts on an antenna relay are not used to key the transmitter, the jumper should remain between terminals 6 and 7 on the strip.

RESISTIVE LOADING OR "SWAMPING"

When driving a linear amplifier, some resistive loading should be used at the Exciter or at the amplifier grid circuit. Non-inductive resistors should be used and may be connected to the two screw terminal output strip on the rear chassis. The amount of resistive loading required will depend upon the type of tubes used in the amplifier. Pentodes, tetrodes and zero bias triodes require only a small amount, while medium and low mu tubes will require heavier swamping for low distortion.

If the exciter is lightly loaded, there is a possibility of the system going into self-oscillation. Resistive loading is not necessary when the Exciter is coupled to a constant load, such as a 50 to 70 ohm antenna.

20A PRELIMINARY ALIGNMENT INSTRUCTIONS

THE FOLLOWING IS RECOMMENDED FOR UNITS CONSTRUCTED FROM KITS

Check for "B" shorts with an ohmmeter before power is applied.

Before plate voltage is applied, the 6AG7 grid bias should be checked. This should be done by removing the 5U4G rectifier tube. With the relay in the normal position, the reading at Pin #4 of the 6AG7 should be -100V DC plus or minus 10% measured with a VTVM. When the relay is operated by hand, there should be approximately -11V DC at this point. After the 5U4G is inserted, the operating bias should be -10.5V DC obtained from the voltage divider R47 and R48.

Insert the 5U4G rectifier and apply power. Check "B" voltages in accordance with the chart on the circuit diagram, with the OPERATION switch on MANUAL.

Preliminary rough alignment of the slug-tuned coils: If a grid dipper is available the coils should be aligned to the frequencies indicated on the Alignment Data Chart (Fig. B). If no dipper is available they should be set as follows BEFORE POWER IS APPLIED:

No. 1	Red	1/2"
No. 2	Green	3/16"
No. 3	White	1/2"
No. 4	Black	1/2"
No. 5	Blue	1/2"
No. 6	Orange	5/16"
No. 7	Yellow	5/16"
No. 8	Blue	3/8"



The Audio Balance controls should be set in approximately mid-position.

During alignment, a slight amount of tension should be kept on the adjusting screws by proper adjustment of the locking nut to prevent erratic operation.

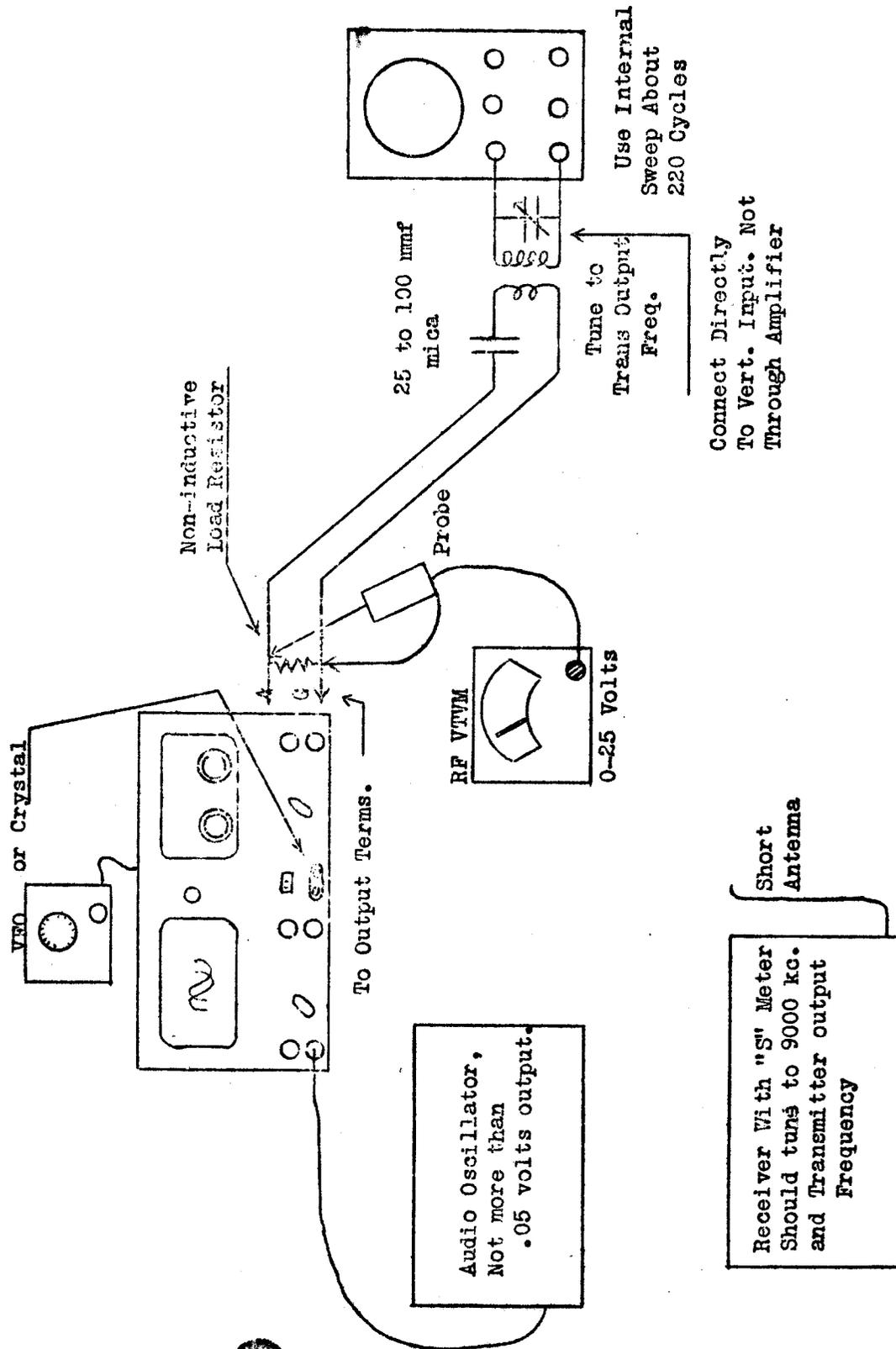


FIG. A

20A GENERAL ALIGNMENT PROCEDURE

The front panel controls should be set as follows:

- OPERATION SWITCH, in MANUAL
- SPEECH LEVEL, completely counter-clockwise
- MODULATION SWITCH, Sideband 1
- CARRIER NULL A, middle position
- CARRIER NULL B, 80% clockwise
- CARRIER, completely counter-clockwise
- VFO-XTAL SWITCH, in correct position
- INDICATOR SWITCH, on SET MAX LEVEL
- INDICATOR LEVEL, completely clockwise
- BANDSWITCH, to proper band
- TUNING CONTROLS, to output frequency

Refer to Fig. A. Connect a non-inductive load resistor of about 50 ohms, 20 watts to the Exciter output terminals. This resistive load may consist of several one or two watt composition resistors in parallel or series-parallel to provide the proper resistance and dissipation.

Connect an oscilloscope, lightly coupled, to the RF output.

If available, a RF vacuum tube voltmeter with a 25 to 50 volt RMS range should be connected to the RF output.

In Exciters that are constructed from kits and are being aligned for the first time, it is recommended that the initial 9 MC alignment of L1 through L5 be made with the red lead removed from the center arm of CARRIER NULL pot A (R23). This will prevent interlocking of the adjustments. After peaking these circuits twice, connect the red wire back to the pot. This procedure will not be required on units previously aligned.

Tune the crystal oscillator plate circuit (L1) until the signal is heard in a receiver tuned to 9 MC. Oscillation should occur with nearly the entire length of the thread outside the form. If a receiver at this frequency is not available a lightly coupled grid dipper should be used. L1 should be tuned for about 90% of maximum output, for reliable oscillation.

At this time it should be possible to hear a signal on the output frequency with the receiver operating near full sensitivity (AVC on) provided the VFO or frequency conversion crystal is operating. The receiver should be coupled lightly to the Exciter RF output terminal. Refer to Fig. B. Adjust L2, L3, L4, L5 and the MIXER AND AMPLIFIER tuning capacitors for maximum output. As maximum output is reached, it will become necessary to reduce the carrier output by adjusting CARRIER NULL pot B and also reduce the sensitivity of the RF INDICATOR by turning the CAL LEVEL control counter-clockwise to prevent the eye from overlapping. Now adjust CARRIER NULL knobs for minimum carrier output. If you have removed the red lead from R23, it must be connected at this time. Next, unbalance CARRIER NULL pot B a slight amount and peak L2

through L5 again. Now adjust both CARRIER NULL controls for minimum output. Minimum output will not necessarily occur at the center of the rotation due to stray capacities, etc. Turn CARRIER NULL knob B completely clockwise to see if the crystal remains in oscillation. This places an additional load on the oscillator and may pull it out of oscillation. If this occurs, it will be necessary to turn the screw of L1 counter-clockwise until reliable operation is assured.

When L2 (green) is mounted approximately 3/4" (center to center) away from L1 (red), the RF voltage from the arm of each CARRIER NULL pot to ground will be equal when the carrier is balanced out. If desired, this may be checked with an RF vacuum tube voltmeter.

ADJUSTMENT OF L6 and L7

When operating on the 20 meter band, these trap circuits reduce the radiation of the third harmonic generated in the mixer by the heterodyning crystal or VFO operating in the range of 5 to 5.3 MC. With the bandswitch set to 20 meters, the SPEECH LEVEL turned off, carrier balanced out, and OPERATION switch in the MANUAL position, RF output will be found when the Mixer and Amplifier tuning controls are set at about 15.5 MC. Adjust both these traps for minimum 15,450 kc. output while using a crystal at approximately 5,150 kc. If no crystal in this range is available, one at approximately 3,850 kc. will supply sufficient 4th harmonic output for this purpose. If you do not intend to operate 14 MC crystal controlled, it will not be necessary to adjust L7 (yellow). When only VFO operation is contemplated in this band, L6 (the orange coil on top of the bandswitching assembly) should be tuned for minimum 15,450 kc. output with the VFO set at 5,150 kc.

Although the 3rd harmonic output may be only a few percent of the total, it can be amplified by the Mixer and Amplifier stages and result in considerable output. With the trap circuits properly aligned, the power output at 15,450 kc. will be less than 10% of that normally obtained at 14 MC., even though the Mixer and Amplifier are peaked at 15,450 kc. When the Mixer and Amplifier are peaked at 14 MC. the other signal will be down in excess of 50 db. in the Exciter. The addition of a properly tuned linear amplifier stage will increase the rejection of the 15 MC. signal to at least 70 to 80 db. down.

The VFO output should be advanced to the point where additional coupling will not increase the Exciter output. Over-injection to the Mixer can cause unnecessary spurious radiation.

ADJUSTMENT OF 5 MC. TRAP L8

Blue coil near the right edge of the chassis. Set the bandswitch to 80 meters. With either a 5 MC. crystal plugged into the socket on the front panel or 5 MC. VFO insertion, adjust the Mixer and Amplifier tuning controls for maximum 5 MC. output. This will occur slightly lower in frequency than the 7 MC. dial calibration. Adjust L8 for minimum output.

ADJUSTMENT OF C81, C82, C83, C84: These four trimmers appear on a strip at the right of the bandswitching assembly, just below the 12BH7 tube. They tune the cathode coils on 10, 15, 20 and 40 meters, respectively. The 10 meter trimmer is the one closest to the chassis; the second one is 15 meters, etc. They should be peaked for maximum output in the center of their band with a small amount of CARRIER inserted.

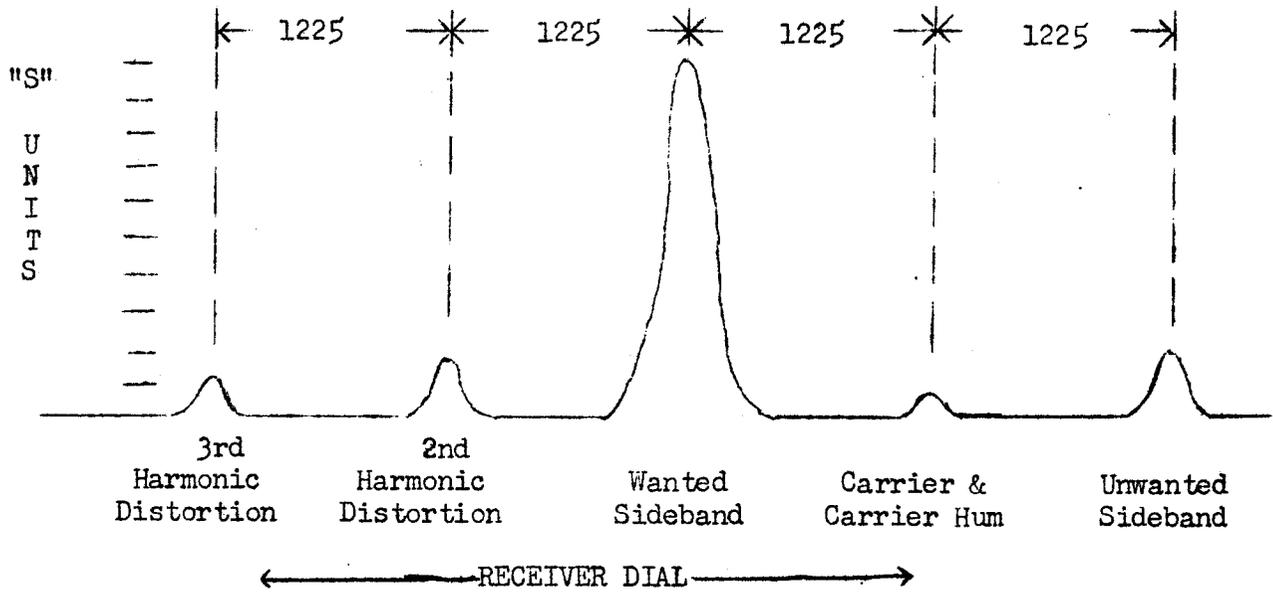
SIDEBAND SUPPRESSION ADJUSTMENT: Before proceeding with the Single Sideband adjustments, it is recommended that the operator familiarize himself with the illustrations of the oscilloscope patterns shown in this manual. The ultimate objective in the single sideband alignment is to obtain a pattern containing a minimum amount of ripple when a pure sine wave is applied to the microphone input. These adjustments should preferably be made at less than full output, to prevent amplifier overloading, which might "wipe off" the small modulation ripple.

A low distortion audio oscillator (less than 1%) set to approx. 1,225 cycles, with an output level between .005 and .05 volts should be connected to the microphone jack. CAUTION: If a voltage in excess of .075 is applied to the Mic. input the speech amplifier will overload and it will be impossible to adjust the exciter properly.

Adjust both CARRIER NULL pots for minimum carrier output. Advance the SPEECH LEVEL control until about half of maximum output is obtained on the oscilloscope. At this point a fair amount of ripple will be observed on the output wave. Adjust the Audio Balance controls for minimum ripple. Now switch from Sideband 1 to Sideband 2 and observe the ripple in each. If the amount of ripple is not equal, vary the adjustment slightly on L2 until the displays are identical in either sideband position. However, each time L2 is tuned, it will be necessary to rebalance both carrier null controls for minimum. It will also be necessary to readjust the Audio Balance controls again.

It is possible to make these sideband suppression adjustments using a receiver in place of an oscilloscope. Turn the AVC on, the BFO off, and remove the antenna to prevent receiver overload. Now tune in the signal. Minimum modulation heard in the loudspeaker corresponds to minimum modulation of the R.F. envelope. Adjust as described in the previous paragraph.

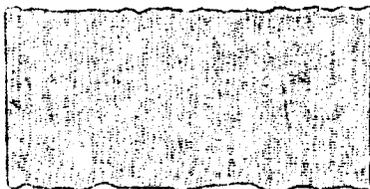
After the alignment has been completed, an analysis of the emitted wave may be made if the receiver has a sharp crystal filter and a calibrated "S" meter. The following illustration is an example of the "S" meter levels as the receiver dial is tuned through the signal with a 1225 cycle tone input to the exciter.



It is possible to obtain an almost ripple-free pattern in one sideband at the expense of degradation of the other. Under this condition the suppression of the better sideband will be about 45 db., while the other is only 35 db. down. The object is to have them both equal, approximately 40 db. down.

If a deep modulation ripple is noticed on both sideband positions (with carrier balanced out), one side of the audio phase shift circuit is probably operating improperly. Check the Audio Balance controls adjustment, the 12AT7(B) modulator tube, sideband switching circuit, or the phase shift network.

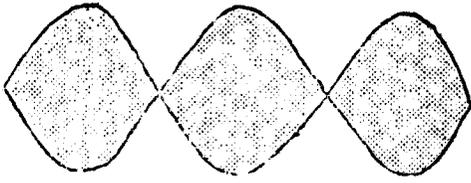
After the alignment has been completed, be sure to tighten the #6 lock-nuts on the iron core slugs.



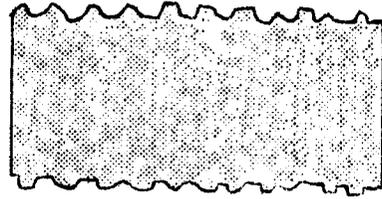
Good SSB Signal
Pure Tone Input



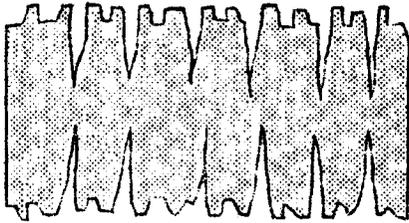
- SSB signal, Tone Input
1. Carrier leakage
 2. Improper RF phasing (L2)
 3. Improper AF balance (R18-15A)
 4. Balanced Mod detuned (L3)
 5. Poor sideband rejection



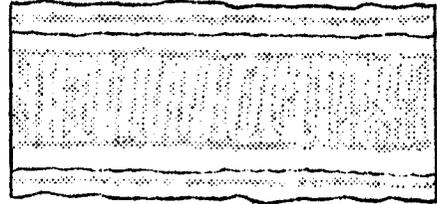
SSB SIGNAL, TONE INPUT
WITH PROPER CARRIER INSERTED
100% MODULATED



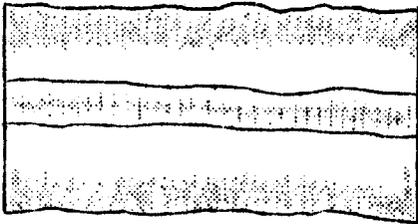
SSB SIGNAL, TONE INPUT
AUDIO DISTORTION
EXCESSIVE AUDIO INPUT



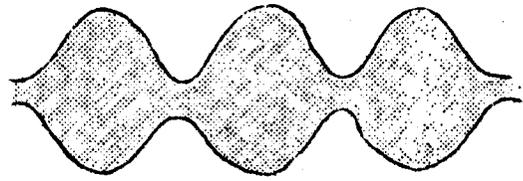
SSB SIGNAL, TONE INPUT
INSUFFICIENT 9000 kc. XTAL
OSCILLATOR OUTPUT



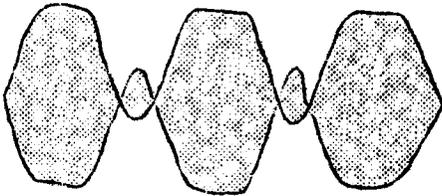
GOOD SSB SIGNAL,
TONE INPUT WITH SMALL PERCENT
OF SPURIOUS RADIATION (RF)



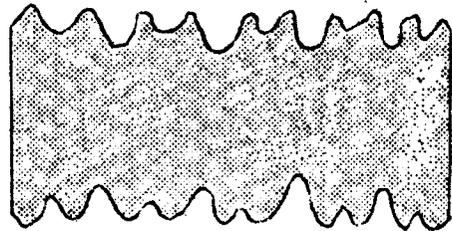
GOOD SSB SIGNAL, TONE INPUT
WITH LARGE PERCENT OF
SPURIOUS RF RADIATION



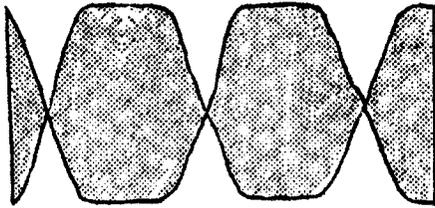
SSB WITH CARRIER, TONE INPUT
IMPROPER AMPLIFIER BIAS



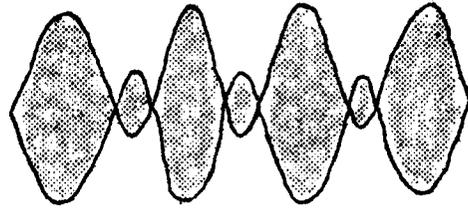
DOUBLE SIDEBAND WITH CARRIER
EXCESSIVE TONE MODULATION
WITH AUDIO PEAKS SQUARING OFF



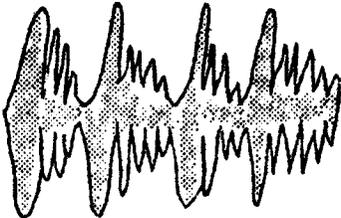
SSB SIGNAL, TONE INPUT
BALANCED MOD DETUNED (L3)



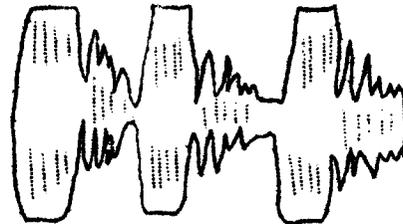
SSB WITH CARRIER, TONE INPUT
 1. EXCESSIVE AUDIO
 2. INSUFFICIENT ANT LOADING



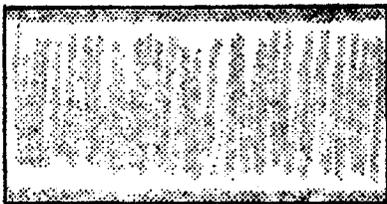
DSRC DOUBLE SIDEBAND REDUCED
 CARRIER OBTAINED BY REDUCING
 CARRIER LEVEL AND INCREASING
 AUDIO INPUT LEVEL



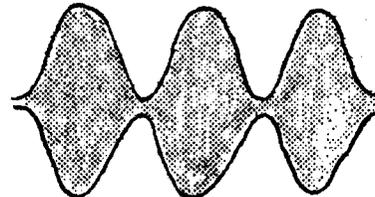
GOOD SSB SIGNAL
 VOICE INPUT



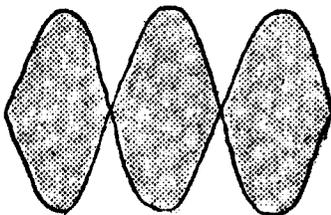
SSB SIGNAL, VOICE INPUT
 SQUARING AUDIO PEAKS
 EXCESSIVE SPEECH GAIN



SSB SIGNAL, TONE INPUT
 AMPLIFIER OVERLOADING DUE TO
 EXCESSIVE AF OR RF DRIVE
 NOTE THE LACK OF SMALL
 RIPPLE ON ENVELOPE



DOUBLE SIDEBAND AM WITH
 CARRIER 100% MODULATED



TWO TONE LINEARITY TEST
 OBTAINED WITH SINGLE TONE
 INPUT, WITH CARRIER BALANCED
 OUT ON AM

FOR ADDITIONAL REFERENCE
 THE FOLLOWING IS RECOMMENDED:

SUGAR COATED LINEAR AMPLIFIER
 THEORY OCT. '51 QST

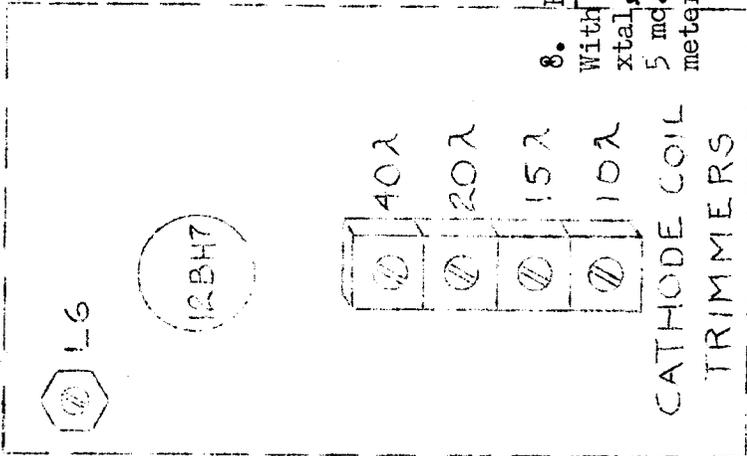
HOW TO TEST AND ALIGN A LINEAR
 AMPLIFIER MAY '52 QST

FIGURE B

ALIGNMENT DATA FOR MULTIPHASE EXCITER MODEL 20A

Use VFO at 5150, or else

ON BAND SW.
ASSEMBLY



8. BLUE TRAP 5 MC
With 5 mc VFO or xtal, tune for min 5 mc. output on 80 meter band.

6. ORANGE TRAP 15.5 MC.
an xtal at 5150 or 3800.
Adjust for min. 15.5 mc. output on 20 m. band with mixer and amp tuned for max. 15.5 mc. output

Adjust for minimum unwanted sideband ripple with 1225 cycle tone input

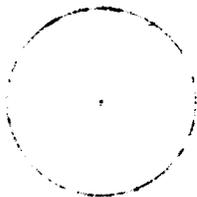
5. BLUE 9 MC FILTER

Same as 4

4. BLACK 9 MC FILTER

Adjust for max output with CARRIER NULL B Knob unbalanced slightly

AUDIO BALANCE



AUDIO BALANCE

adjust same as above



1. RED XTAL OSC. 9000 KC
Peak for about 90% of maximum output for reliable xtal operation with CARRIER NULL knob B unbalanced



2. GREEN 90% PHASE SHIFT 9000 KC.

Peak for max. output with CARRIER NULL knob B unbalanced slightly. Afterward, adjust for equal sideband suppression with 1225 cycle tone input



3. WHITE BALANCED MOD. 9000 KC

Adjust for max output with CARRIER NULL knob unbalanced slightly



7. YELLOW TRAP 15.5 MC

Adjust in same manner as orange trap. Will tune only with 20 meter xtal in use



L-7



L-3



L-2



L-1



L-4



L-5



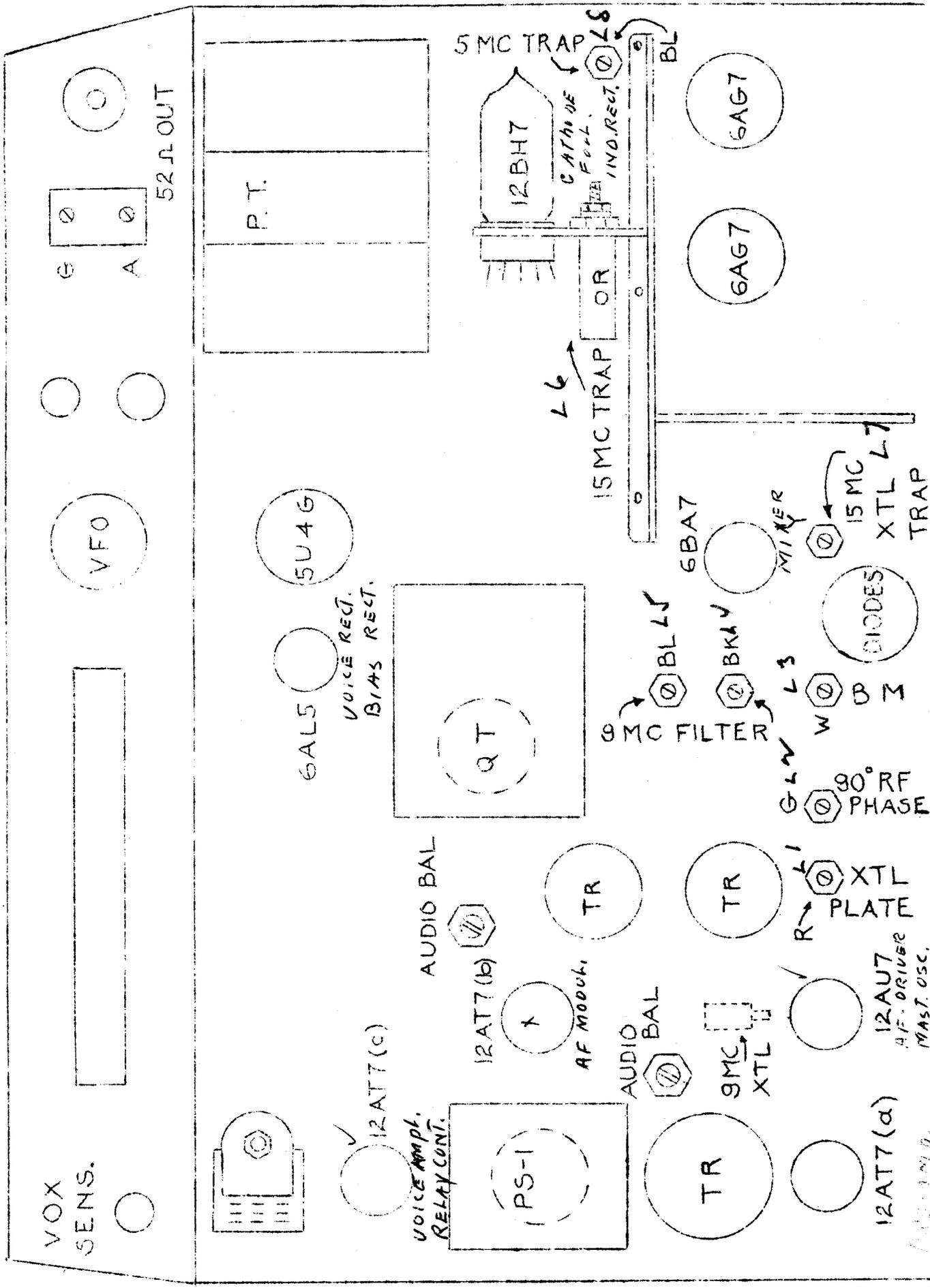
L-6



L-7



L-8



MULTI-BAND OPERATION OF THE MULTIPHASE EXCITER MODELS 10 AND 20

The following chart indicates the injection frequencies required with the 9 mc. master oscillator:

<u>OUTPUT FREQUENCY</u>	<u>INJECTION FREQUENCY</u>
1800 kc.	7200 kc.* or 10800 kc.
2000 kc.	7000 kc.* or 11000 kc.
3500 kc.	5500 kc.* or 12500 kc.
3800 kc.	5200 kc.* or 12800 kc.
4000 kc.	5000 kc.* or 13000 kc.
7000 kc.	16000 kc. or 5333.3 x 3 Kc.
7200 kc.	16200 kc. or 5400 x 3 kc.
7300 kc.	16300 kc. or 5433.3 x 3 kc.
14000 kc.	5000 kc.* or 23000 kc.
14200 kc.	5200 kc.* or 23200 kc.
14300 kc.	5300 kc.* or 23300 kc.
21000 kc.	30000 kc.
21250 kc.	12250 kc. or 30250 kc.
21450 kc.	12450 kc. or 30450 kc.
28000 kc.	37000 kc.
28500 kc.	37500 kc.
29700 kc.	38700 kc.

* Injection at these frequencies may be obtained from crystals plugged into the front panel socket.

NOVICE OR C.W. OPERATION ONLY

Break-in CW may be used on the 160, 80 and 40 meter bands with direct frequency crystals. Turn the MODULATION selector to C.W. Then plug the 160, 80 or 40 meter crystal into the socket on the front panel and tune the controls to frequency.

Frequency multiplication may be used only when the Exciter feeds a high "Q" antenna tuner or power amplifier stage due to probable radiation of sub-multiple frequencies. It is possible to obtain 80 meter output from 160 meter crystals; 40 meter output from 80 meter crystals; and 20 meter output from 7 mc. or 4.7 mc. crystals.

BASIC MODIFICATION OF THE BC-457, BC-458 or BC-459
 AS A VFO FOR MODEL 10 or 20 MULTIPHASE EXCITER FOR 12 VOLT OPERATION

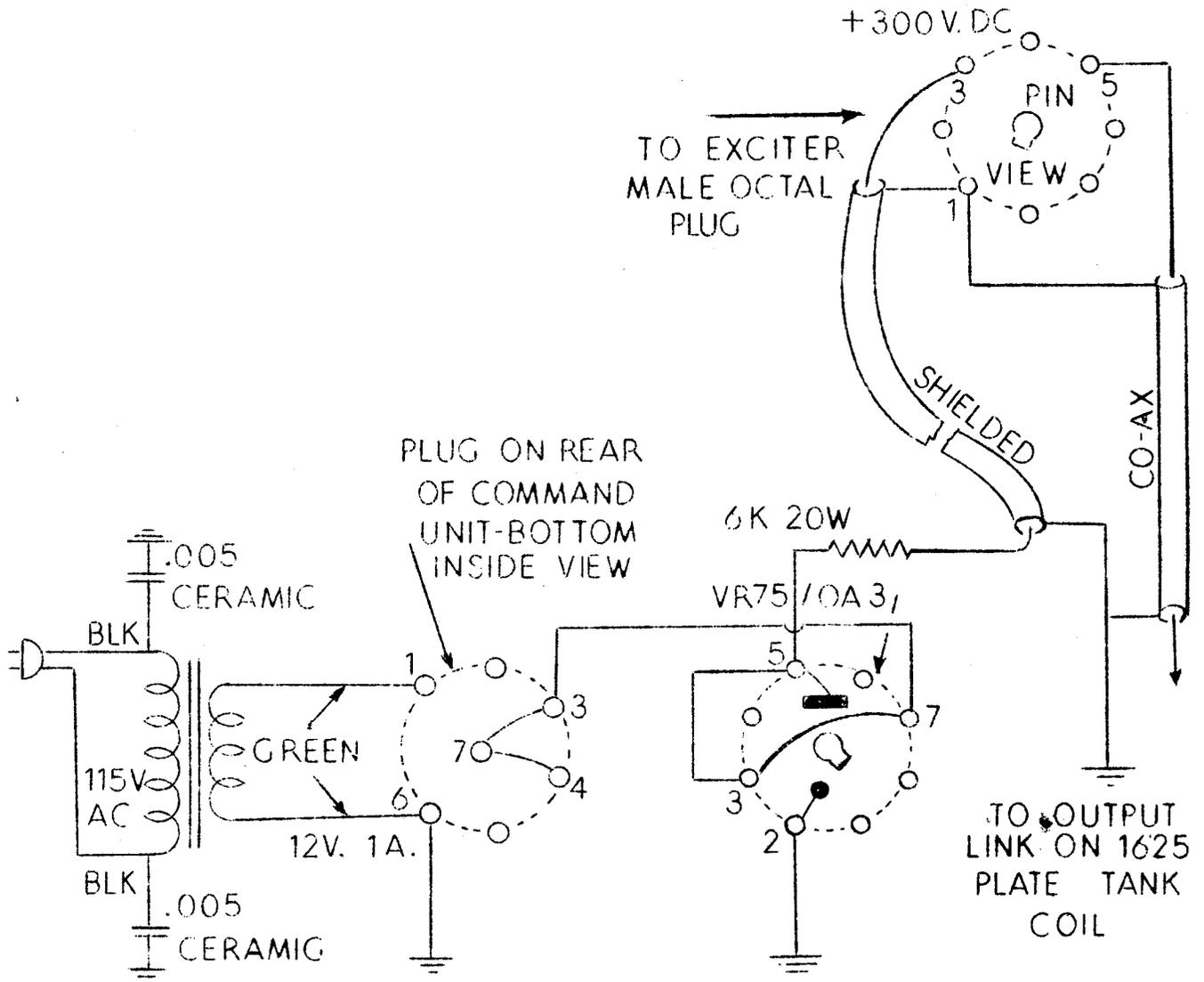
The contacts on the keying relay (beneath the chassis) should be closed by using jumpers or soldering the contacts together. This applies B plus to the oscillator and also grounds the cathode circuit on the 1625 stage. Remove the 1629 eye tube and also the 1625 located near the tuning shaft. Jumpers should be installed across the filament terminals of these unused sockets. Only one 1625 is necessary for proper operation.

The antenna loading coil and antenna relay are not necessary and can be removed. The co-ax cable to the Exciter can be attached directly to the output link of the 1625 final tank coil.

Plate voltage for the VFO is supplied from the Exciter through an octal socket on the rear.

The electrical connections for the external wiring are shown below.

Advance the antenna coupling adjustment on the VFO to the point where additional coupling will not increase the Exciter output. Over injection to the mixer will generate harmonics of the VFO frequency that can appear in the output as spurious radiation.



DETAILED CONVERSION INSTRUCTIONS
FOR
BC-457, BC-458, BC-459 WITH 12 VOLT OPERATION

This modification procedure allows the installation of a VR75 into the socket originally intended for the crystal calibrator and mounts the filament transformer and dropping resistor on the rear of the chassis.

NOTE: Socket connections read clockwise from underneath chassis.
Pin 7 on power socket (rear) is the center pin.

1. **CRYSTAL SOCKET:** (center octal socket rear of chassis)
 - a. Remove resistor between pin 3 and 8 - discard.
 - b. Remove black lead from pin 3 and take out of circuit (tape end of lead or cut back clear of circuit).
 - c. Disconnect end of resistor from pin 5.
 - d. Disconnect two black leads from pin 5.
 - e. Disconnect black wire from pin 5 on rear socket and remove from circuit.
 - f. Reconnect remaining black wire (from pin 5) and end of resistor (c above) to pin 6.
 - g. Add a jumper between pins 1 and 2.

2. **REAR SOCKET:**
 - a. Remove two black leads from pin 2 and take out of circuit (tape ends or cut back).
 - b. Remove leads from pins 3, 4 and 7 and connect to pin 5 of crystal socket.
 - c. Add a red jumper from 3 of the rear socket to pin 5 of the crystal socket.

3. **EYE TUBE SOCKET:** (VT 138)
 - a. Remove the two resistors from pin 8 and discard. Add a jumper from pin 2 to pin 7.

4. **RELAY:** (Underneath chassis - centered on right side viewing from front)
 - a. Solder each set of relay contacts to permanently close the two circuits. CAUTION - do not short the two separate circuits together!
 - b. Clip black lead on relay coil and tape end or cut back to preclude grounding.

5. **1625:**
 - a. Add a jumper from pin 1 to pin 7 on the 1625 socket farthest from the relay.

6. FILAMENT TRANSFORMER:

- a. Mount on 1/2" spacers slightly above (horizontally) rear socket with secondary (green) leads down.
- b. Trim secondary leads to proper length and solder into rear socket pins 1 and 6 (from outside).
- c. Drill hole for 3/8" grommet slightly below and to left of rear socket (viewed from rear).
- d. Pass filament transformer primary leads through grommet to underneath of chassis and solder leads to rear socket pins 2 and 5.
- e. Solder a .005 ceramic by-pass condenser from pin 2 on rear socket to ground (pin 2 of crystal socket).
- f. Solder a .005 ceramic by-pass condenser from pin 5 on rear socket to ground (pin 2 of crystal socket).
- g. Insert proper length of primary A.C. cord through grommet hole and solder leads to pins 2 and 5 of rear socket.

7. VR TUBE DROPPING RESISTOR:

- a. From outside chassis insert leads from a 20 watt, 6000 ohm resistor into rear socket pins 3 and 4 and solder securely. (Mounted outside chassis for heat radiation).

8. POWER WIRING:

See diagram

ADAPTING THE BC458 FOR 20 AND 80 METER OPERATION

The BC-458 (5.3 to 7 mc.) is recommended as a VFO rather than the BC-457 (4 to 5.3 mc.) for greater stability.

ADJUSTING THE FREQUENCY RANGE

After completing the proper modifications, plug the VFO into the socket on the rear of the Exciter. Remove the oscillator section shield can. Set the single plate adjustment trimmer to mid-capacity. Now loosen the two bristol set screws on the oscillator padding capacitor. It will be necessary to increase the capacity until the oscillator is at 5 mc. with the dial set at 5.3 mc. after the shield can is replaced. The iron core slug will change the frequency several hundred kilocycles and the capacity should be increased in small steps until 5 megacycles is reached. By drilling a 3/8" hole approximately 3/4" below the present one, the adjustment can be made with the shield can in place. If your receiver does not tune to 5 mc., use the Exciter tuned to 4 mc. with some carrier inserted. After the correct setting has been determined, be sure to tighten the set screws.

The amplifier air padder located beneath the chassis must be tuned to the new oscillator frequency. Adjust for maximum VR tube brilliance, or for maximum Exciter output with the VFO coupling set to about 4.

BANDSPREAD MULTIBAND OPERATION OF THE BC-458

By the addition of a bandswitch, three Miniductors and a 50 uufd. variable capacitor, operation in the 160, 80, 40, 20 and 15 meter bands is possible. CW operation from 21,000 to 21,200 is not recommended with this conversion, but satisfactory performance is obtained in the rest of the 21 mc. band.

It is suggested that whenever the 1625 stage is used as a frequency multiplier, the filament of the oscillator tube be operated on direct current to minimize hum. One method of obtaining this DC is to use a 12 volt filament transformer for the unit, with a full wave bridge rectifier and a filter capacitor of at least 1000 mfd.

Bandspread is accomplished by carefully removing rotor plates from both the oscillator and amplifier variable tuning capacitors. Those plates farthest from the worm gear drive should be removed so that only 8 remain in use. With the tuning capacitors open, gently rock the plates, one at a time, with a long nose pliers until they become loose. If too much force is used the rotor shaft may become dislodged and you will then very likely spend the rest of the day and evening recovering the small ball bearings and trying to figure out a method of reassembling everything. Care should also be taken not to exert any pressure on the stator sections as this can cause the glass insulating beads to fall out.

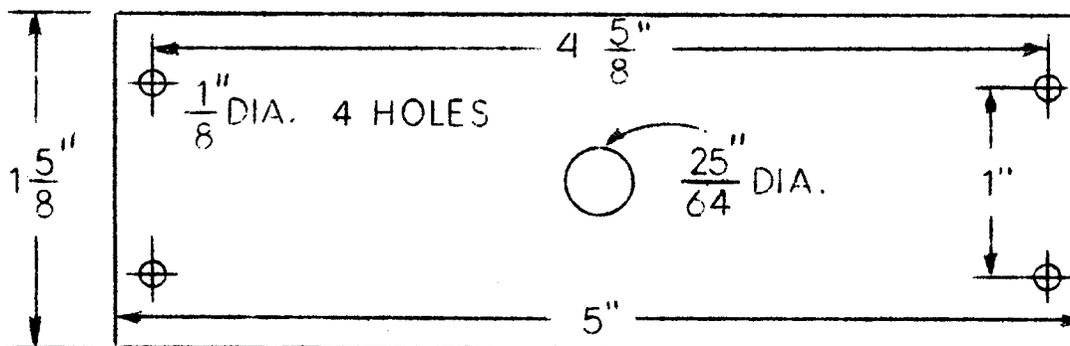
The 50 mmfd. zero temp coefficient variable capacitor should be mounted in the hole occupied by the Antenna binding post. File two notches in the edges of the hole to accept the mounting screws.

For 40 meter operation a coil consisting of 3-1/4 turns of #3014 B & W Miniductor (8 turns per inch) is shunted across the amplifier plate inductor so that it will triple into the range of 16 to 16.3 mc.

For 160 meters a coil consisting of 6-1/2 turns of #3015 B & W Miniductor (16 runs per inch) is used to double to 10,800 to 11,000 kc. Five turns are used for 15 meters, which requires 12,250 to 12,450 kc.

The antenna loading coil assembly should be removed and a metal plate installed in the window.

Suggested plate dimensions:



The entire unit should rest on a sponge rubber pad or soft rubber feet.

ALIGNMENT PROCEDURE

Set receiver and Exciter to 21,450 kc. Advance the CARRIER knob. With the VFO switch in the 21 mc. position and the dial at 7.0 mc., adjust the oscillator air padder (inside the can) for zero beat. This will occur with a little more than half capacity and the slot in the shaft will be slightly beyond the horizontal position.

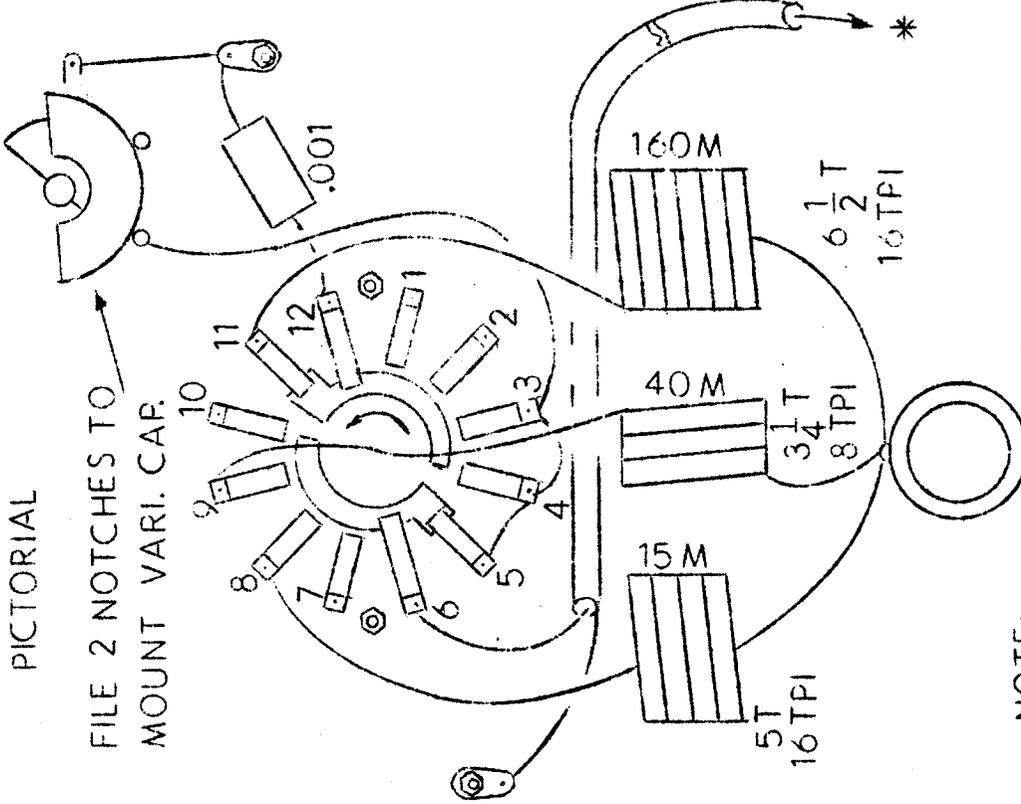
With the receiver and Exciter tuned to 4.0 mc., set the VFO bandswitch to 80 meters and the dial to 5.3 mc. Tune the 50 mmfd. APC capacitor for zero beat. Peak the amplifier air padding capacitor (under the chassis) for maximum VR tube brilliance or maximum Exciter output with the VFO loading set at 4.

Now return to the 21 mc. band. Slowly replace the large shield cover on the BC-458 and observe the effect upon the output of the Exciter. Replacing this cover reduces the inductance of the coils and increases the

resonant frequency. When the cover is off, the coil should have slightly more inductance than necessary. The inductance may be adjusted by breaking the polystyrene strip so that the last half turn can be varied to trim the inductor to the required value.

CALIBRATION CHART FOR BANDSPREAD VFO

1800 6485	7000 6248
1825 6531	7100 6363
	7200 6481
1875 6627	7300 6605
1900 6674	
1925 6724	14000 5300
	14100 5562
3500 6585	14200 5844
3700 6153	14300 6153
3800 5844	
3900 5562	21250 6715
4000 5300	21350 6855
	21450 7000



NOTE:
 BREAK THE POLYSTYRENE STRIP
 SO THAT THE LAST HALF TURN
 MAY BE VARIED TO ADJUST
 THE INDUCTANCE

