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LESSON PLAN

FOR

TONE INTELLIGENCE UNIT

MODEL TIS-3



THE TECHNICAL MATERIEL CORPORATION
MAMARONECK, N.Y.

OTTAWA, ONTARIO

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Title: Model TIS-3 Tone Intelligence Unit

Military Nomenclature:

Terminal, Telegraph: TT-39A/UGT

Objectives:

- a) to discuss the characteristics, capabilities and special features of the Model TIS-3 Tone Intelligence Unit.
- b) to discuss the principles of operation and circuitry of the Model TIS-3, pointing up significant circuit parameters.
- c) to discuss the operation of the unit in all modes.
- d) to demonstrate, with appropriate test equipment, the alignment of the unit.

References:

- a) TMC Technical Manual for Model TIS-3 (TT-39A/UGT)
- b) TMC Production Specification S-516C.
- c) TMC Production Schematic CK-464M.
- d) TMC Sales-Service Bulletin 245B.

Training Aids:

- a) Model TIS-3 Unit.
- b) Square Wave Generator: Measurements Corp. Model 71, or equivalent.
- c) Frequency Counter: Any model capable of measurements at 200 KC.
- d) Oscilloscope: Tektronics Model 545A, or equivalent.
- e) VTVM: H.P. Model 410B, or equivalent.
- f) Panoramic Analyzer.
- g) Relay: C.P. Clare Model HG-1002, or equivalent.
- h) Battery Supply: 0 to plus 20 volts.
- i) Regulated Power Supply: 105 to 125 volts.

Presentation:

A. General Orientation:

(to be accomplished with actual TIS-3 unit)

1. General Description:

- a) the TMC Model TIS-3 Tone Intelligence Unit is a multipurpose audio tone keyer which will provide CW, FAX or FSK modes of operation when used with a SSB transmitter, telephone lines or microwave links.
- b) a front panel switch (CENTER FREQ CPS) allows the selection of any one of four discrete frequencies to provide compatibility under various types of operation, as follows:
 - (1) 1900 CPS: this is the international standard for facsimile operation.
 - (2) 2000 CPS: for use with transmitting and receiving equipment limited to tuning in 1 KC steps.
 - (3) 2550 CPS: the standard audio center frequency used for 850 cycle frequency shift teletype.
 - (4) SPARE: any practicable frequency may be selected by the customer by simply installing the crystal and adjusting one chassis trimmer capacitor. The frequency of the crystal to be installed is found by:

$$F_{XTAL} = 200KC - f_{CENTER AUDIO DESIRED}$$

Example:

Audio center frequency desired: 2400 CPS.

$$F_{XTAL} = 200KC - 2.4KC = 197.6 KC$$

- c) in the FSK mode of operation, a total shift of 12 to 1000 cycles is possible. The total shift is selected by the front panel SHIFT CPS control, geared to a counter which conveniently indicates the total shift.
- d) in the FAX mode of operation, a linear shift of 1200 cycles is possible plus or minus 600 cycles about the center frequency selected. (usually 1900 cycles).
- e) voltage or current keying in the FSK and CW modes is accommodated by the KEY MODE switch, which selects voltage keying at 50 and 100 volts, or current keying at 20 or 60 milliamperes.

- f) the audio output level is monitored by a front panel OUTPUT LEVEL meter. A LEVEL ADJUST control regulates the audio output, as required.
- g) a front panel TEST switch permits the keying circuits to simulate a MARK or SPACE condition, for monitoring and test purposes.
- h) a front panel switch selects STANDBY - B PLUS ON operation. In STANDBY operation filament and oscillator oven circuits remain energized to insure stability and to minimize warmup time.
- i) all connections are made at the rear of the unit, to a clearly labelled terminal strip.

2. Technical Specifications:

a) Keying Speeds:

Up to 75 bauds (100 WPM), FSK.
Up to 140 bauds, CW. (250 WPM)
UP to 400 bauds, FAX.

b) Keying Inputs:

50V, 100V, 20ma., 60ma.; all neutral, floating, or either side grounded. (CW and FSK)

0 - 20 volts positive for a linear shift of 1200 cycles (FAX)

c) FSK Shift:

12 to 1000 cycles, total, continuously adjustable.

d) CW Tone Frequency:

1000 cycles.

e) Frequency Stability:

better than 0.5% for:
0 - 50 degree Centigrade ambient temperature change.
plus or minus 10% line voltage variation.
0 - 95% relative humidity.

f) Output Level:

continuously adjustable from 0 to 1 milliwatt (0 dbm)

g) Power Input:

105, 115, 125, 210, 230 volts; 50 - 60 CPS; single phase, 100 watts continuous; 170 watts intermittent: (oven cycling)

h) Output Impedance:

600 ohms, balanced.

i) Oven Temperature:

200 KC Oven: 70 degrees Centigrade.

Crystal Ovens: 75 degrees Centigrade, plus or minus 2 degrees.

j) Crystal Type:

Use CR-47/U

k) Dimensions and Weight:

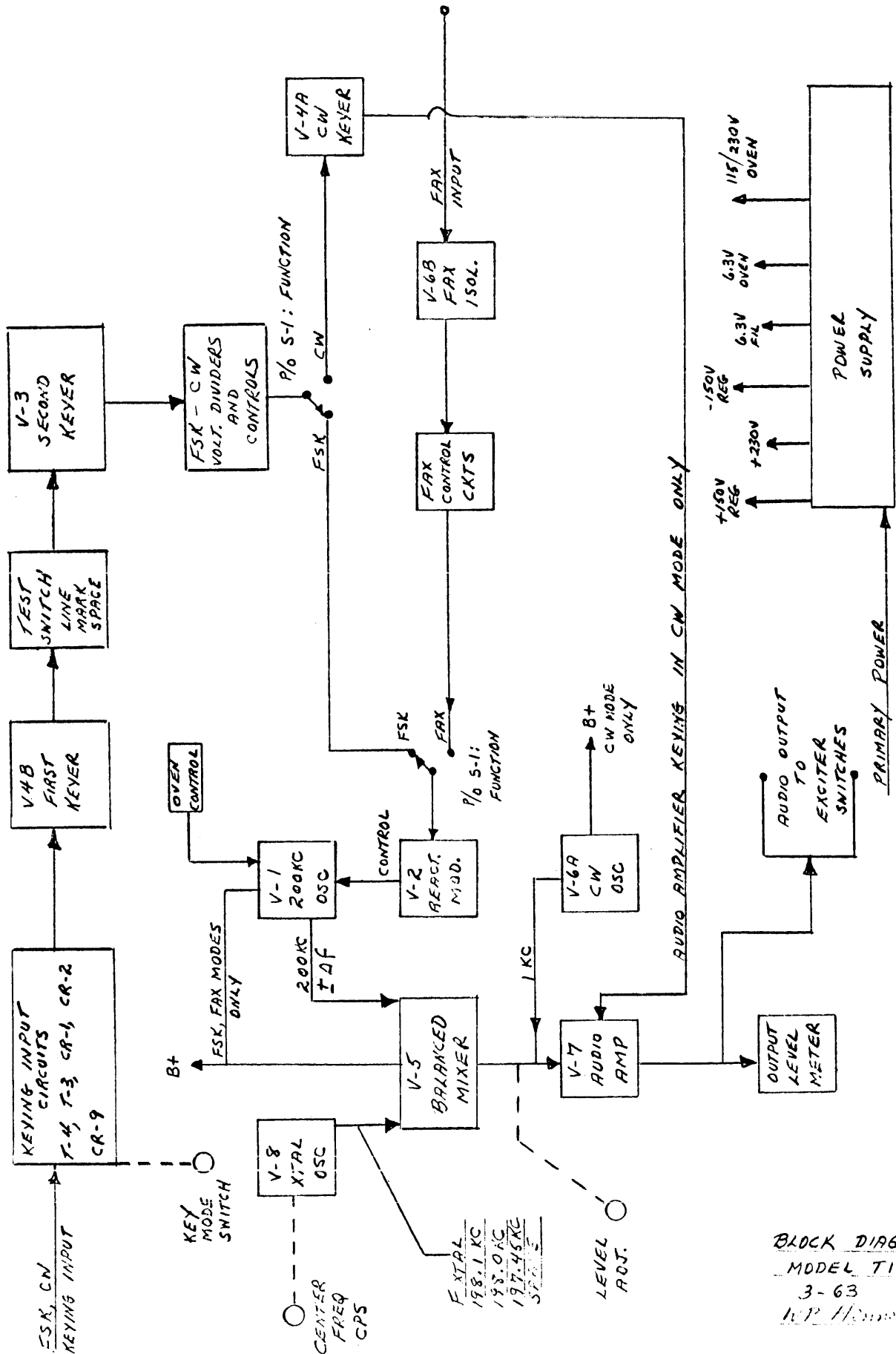
5 1/4 by 19 by 14 inches

38 pounds

l) Tube Complement:

2 ea. OA2
1 ea. 6AB4
1 ea. 6AG5
1 ea. 6J6
4 ea. 12AU7
1 ea. 5963

Block Diagram Model TIS-3 Tone Intelligence Unit



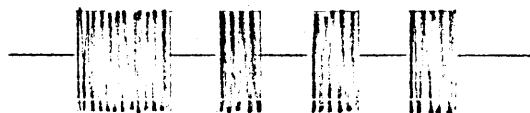
BLOCK DIAGRAM
MODEL TIS-3
3-63
W.P. / [Signature]

3. Discussion of the Model TIS-3 Block Diagram:

- a) V-8 is a crystal oscillator, operating at any one of four discrete frequencies. The frequency selection is made by S-6, the CENTER FREQ CPS switch. The table below shows the switch positions, oscillator frequencies, and corresponding front panel markings:

<u>S-6 Position</u>	<u>Crystal Selected</u>	<u>S-6 Panel Marking</u>
1	Y-1 198.1 KC	1900 CPS
2	Y-2 198.0 KC	2000 CPS
3	Y-3 197.45 KC	2550 CPS
4	Y-4	SPARE

- b) V-1 is a 200 KC oscillator, operating in conjunction with V-2, a reactance modulator stage. The reactance modulator receives a DC control voltage from FSK or FAX circuits, and shifts the frequency of the 200 KC oscillator by an amount Δf in response to certain characteristics of the input FAX or FSK signals. This circuit receives plate supply in the FSK and FAX positions of the function switch only.
- c) V-5 is a balanced mixer circuit; it receives the output of the crystal oscillator, V-8, and the output of the 200 KC oscillator and passes the audio difference, which is $200 \text{ KC} \pm \Delta f - f_{\text{CRYSTAL}}$. This circuit receives plate supply in the FSK and FAX positions of the FUNCTION switch.
- d) V-7 is a push pull audio amplifier stage, which amplifies the output of the mixer stage, and delivers it to the Channel 1 and Channel 2 EXCITER switches. An audio OUTPUT LEVEL meter is incorporated at this point.
- e) V-6A is an audio oscillator circuit, adjusted for output at 1 KC. This stage receives plate supply only in the CW position of the FUNCTION switch. The 1 KC audio tone is applied to the interstage transformer coupling the mixer and audio amplifier. In the CW mode of operation, the audio amplifier is keyed on and off in response to input CW signals; the audio output consists of pulses at 1 KC, as shown below.



- f) the keying input circuits receive FSK or CW signals in various standard modes. Four modes: 50V, 100V, 20 ma, or 60 ma, are accommodated by the KEY MODE switch. The output of the crystal oscillator, V-8, is also applied here, for the purpose of regenerating the keying impulses. The keying input circuits, together with the first and second keyers and the FSK-CW voltage divider and control circuits, produce DC voltages suitable for controlling:
- (1) V-2 , the reactance modulator, in FSK mode.
 - (2) V-4A, the CW keyer, in CW mode.
- g) a TEST switch is inserted between the first and second keyers. This switch has three positions: LINE, MARK and SPACE.
- (1) in LINE position, FSK or CW signal impulses are transferred from the first to the second keyer.
 - (2) in MARK position, the switch simulates a MARK or "key down" condition for test purposes.
 - (3) in SPACE position, the switch simulates a SPACE or "key up" condition for test purposes.
- h) in the CW mode, the CW keying impulses cause CW keyer V-4A to "start" and "stop" audio amplifier V-7, in accordance with the keying characteristics. In this mode, audio amplifier V-7 receives as its only signal input a 1 KC tone from CW oscillator V-6A.
- i) in the FAX mode, the reactance modulator, V-2, receives a DC control voltage from the facsimile isolation stage, V-6B and the FAX control circuits; this control voltage shifts, linearly, the 200 KC oscillator frequency in accordance with the amplitude of the facsimile input.
- j) the power supply receives single phase 60 cycle AC at various amplitudes and delivers the various voltages indicated.

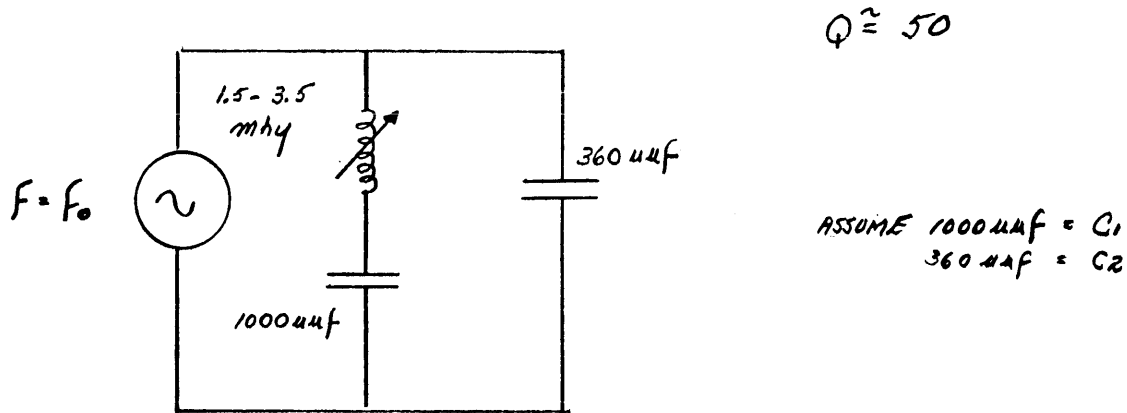
B. Detailed Discussion of Model TIS-3 Circuitry:

(refer to CK-464M and simplified circuits)

1. The Crystal Oscillator Circuit:

- a) V-8 and its associated components form an electron coupled crystal oscillator circuit. Any one of four discrete frequencies may be generated, depending on the position of S-6, the CENTER FREQ CPS switch.
- b) in position 1, S-6 indicates that the center frequency selected is 1900 cycles. Actually, the switch is selecting crystal Y-1, which causes the circuit to operate at 198.1 KCS. This frequency is subsequently mixed with a 200 KC frequency, to produce the 1900 cycle difference.
- c) similarly, in position 2, S-6 indicates that a center frequency of 2000 cycles is being selected. The crystal oscillator circuit, with Y-2, is operating at 198.0 KC. In position 3, S-6 indicates a center frequency of 2550 cycles; the crystal oscillator circuit, with Y-3, is actually operating at 197.45 KC. In each case, the crystal frequency, mixing with the output of a 200 KC oscillator, produces the final "center frequency".
- d) the front panel marking corresponding to position 4 of S-6 is SPARE. This position is provided for any special center frequency required. Unless a certain frequency is specified by the customer, this position is unused.
- e) the cathode, control grid and screen grid are operated as a triode oscillator, with the screen grid acting as the plate electrode. The screen grid intercepts a sufficient number of electrons from the space current to sustain oscillations, but the majority of the of the electrons pass to the plate electrode and develop output power by flowing through the tuned load impedance.
- f) in the electron coupled oscillator circuit, adjustments in the plate circuit produce negligible effects on the oscillator portion; thus, loading of the oscillator is not a problem.
- g) the output from the crystal oscillator is taken from plate tank L-6, configured as a split capacitor tank. This type of tank circuit produces a high C/L ratio, which promotes a better flywheel effect.

h) as far as a signal is concerned, the plate circuit is arranged as follows:



(1) at resonance: $\omega L - \frac{1}{\omega C_1} = \frac{1}{\omega C_2}$

(2) solving for the resonant frequency:

$$f_0 = 159 \times 10^{-3} \sqrt{\frac{C_1 + C_2}{L C_1 C_2}}$$

(3) using the maximum and minimum values of "L", the tuning range is found to be approximately 159 KC to 254 KC.

(4) the circuit is factory adjusted for maximum output at 197.45 KC. Since the bandwidth equals $\frac{f_0}{Q}$

and the total bandwidth is 3.55 KC, the output is constant for all positions of S-6, the CENTER FREQ CPS selector switch. This bandwidth also limits the practicable limits of the SPARE crystal.

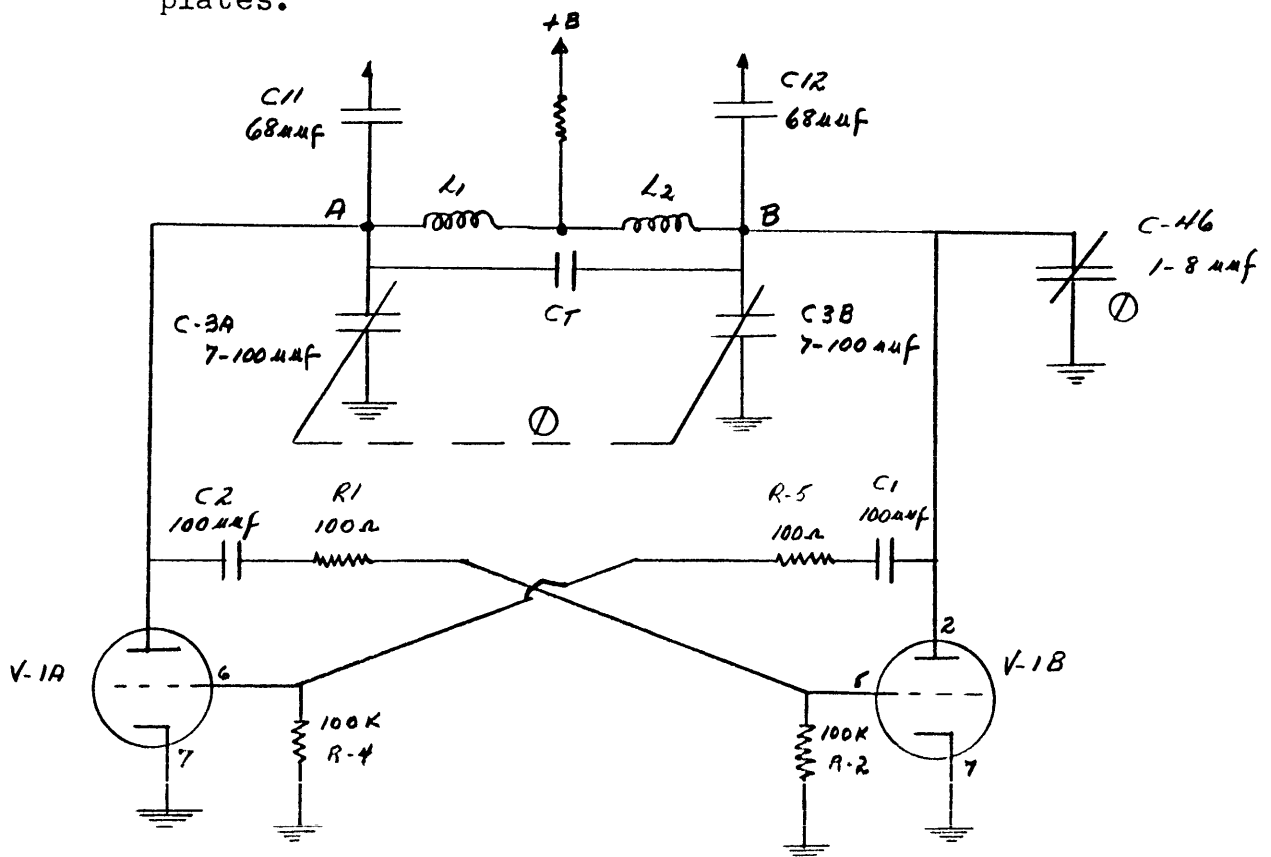
- i) C-35, C-36, C-37 and C-38 are adjusted to produce exact crystal oscillator output frequencies of 198.1 KC, 198 KC, 197.45 KC and the frequency of the SPARE crystal, respectively.
- j) Z-1 and Z-2 are octal socket plug-in units. Z-1 contains Y-1 and Y-2; Z-2 contains Y-3 and Y-4, if installed. A 6.3 volt AC supplies the 7.5 watt heaters in both these ovens. A thermostat in each unit maintains the temperature at 75 degrees Centigrade plus or minus 2 degrees.

k) the output of the crystal oscillator circuit is applied, via the YELLOW lead of L-6, to:

- (1) the control grid circuits of mixer V-5, via C-29 and C-30.
- (2) terminal 1 of transformer T-4 in the keying input circuits.

2. The 200 KC Oscillator Circuit:

- a) V-1, together with its associated circuitry, forms a push pull oscillator circuit with a nominal output frequency of 200 KCS. The term "nominal" is used, because the 200 KC frequency will be shifted higher or lower in response to changes in teletype and facsimile signals.
- b) the circuit is a modified "Kallitron" oscillator; this type of negative resistance oscillator is used to provide a constant amplitude, high stability sine wave output.
- c) the simplified schematic is shown below. Note that the circuit is essentially a symmetrical plate coupled multivibrator with a tuned tank connected between the plates.



- d) Ct represents the total capacity shunting L1 and L2 less the other capacitors represented.
- e) C-3 provides coarse control of the frequency; C-46 provides fine tuning. Both capacitors are screwdriver adjustments.
- f) plate voltage is applied, via the front panel FUNCTION switch, in FSK and FAX positions only. Thus, the 200 KC oscillator does not function in the CW position of the function switch.
- g) the operation of the circuit is as follows:
 - (1) assume that plate current in V-1A is increasing; then eb V-1A is decreasing and the sine wave at point A is decreasing.
 - (2) if eb V-1A is decreasing, C-2, R-1 and R-2 will couple a negative going voltage to the grid, pin 5, of V-1B.
 - (3) if eg V-1B is decreasing, then ib V-1B is decreasing and eb V-1B is increasing. This corresponds to an increasing sine wave at point B.
 - (4) if eb V-1B is increasing, C-1, R-5 and R-4 will couple a positive going voltage to the grid of V-1A, causing a further increase of current in V-1A.
 - (5) at the peak of the negative excursion at A, corresponding to the peak of the positive excursion at B, the action switches; current in V-1A decreases, causing an increase in eb V-1A. C-2 attempts to charge, via R-1 and R-2, causing a positive going signal at the grid, pin 5, of V-1B.
 - (6) ib V-1B increases, causing eb V-1B to decrease; this causes C-1 to discharge, via R-5 and R-4, to produce a negative going voltage at the grid, pin 6, of V-1A. This further decreases ib V-1A, and the action continues.
- h) the Kallitron oscillator produces a sine wave of good stability with low harmonic content.
- i) the output of this circuit is applied, via C-11, R-53, and C-12, R-54, to the control grids, pins 2,7, of the mixer circuit, V-5. It should be noted that the 200 KC oscillator output is applied to the mixer grids in push-pull. The output of the crystal oscillator, previously discussed, is applied to the mixer grids in parallel.

j) the 200 KC oscillator is associated with a reactance modulator circuit, V-2, which shifts the 200 KC frequency higher and lower in accordance with a control voltage corresponding to FSK or FAX information. This circuit will be discussed in detail subsequently.

k) the 200 KC oscillator circuit is adjusted as follows:

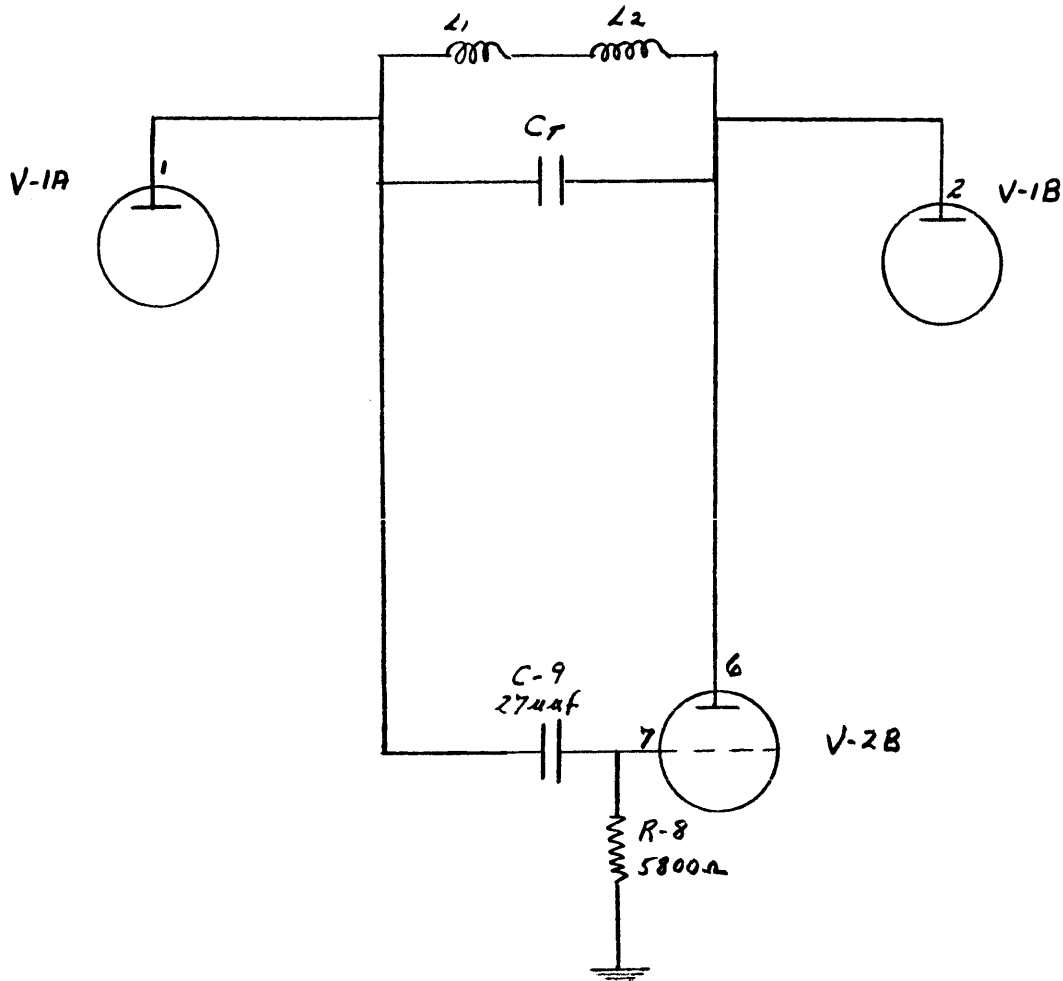
- (1) TIS-3 controls are set to produce "zero control" voltage from the reactance modulator. Ostensibly, then, the 200 KC oscillator is operating at 200 KC exactly.
- (2) a frequency counter is connected to either pin 2 or pin 7 of V-5, the mixer tube. The crystal oscillator circuit is disabled.
- (3) C-3, a screwdriver adjustment on the rear chassis apron, is adjusted for a counter reading of 200 KC plus or minus 10 cycles.
- (4) C-46 is then adjusted for exactly 200 KC.
- (5) the 200 KC voltage at pin 2 or 7 of V-5 is approximately 6 volts peak to peak, or 2.1 volts RMS.

l) the output frequency of the 200 KC oscillator will henceforth be indicated as $200 \text{ KC} \pm \Delta f$ where Δf is the frequency shift established by R-31, the front panel SHIFT CPS control in FSK operation, or by the characteristics of an input facsimile signal in FAX operation.

3. The Reactance Modulator Circuit:

- a) the reactance modulator circuit, V-2, together with its associated components, receives a control voltage at pin 2 and acts to change the frequency of the 200 KC oscillator by a definite and predetermined amount.
- b) the control voltage is applied via one section of S-1, the front panel FUNCTION switch. With S-1 in FSK position, the control voltage originates in the keyer circuits and arrives at S-1 from R-31, the SHIFT CPS control a precision potentiometer geared to a counter. The correction voltage shifts the frequency of the 200 KC oscillator up or down by an amount determined by the SHIFT CPS control, and at a rate determined by the keying signals. The total shift is continuously variable from 12 to 1000 cycles.

- c) with the FUNCTION switch in the FAX position, the control voltage originates in the cathode circuit of V-6B, the facsimile isolation stage. The FAX control voltage applied to the reactance modulator stage via S-1, shifts the frequency of the 200 KC oscillator by an amount and at a rate determined by the input facsimile signal.
- d) a simplified circuit of the 200 KC oscillator and V-2B is sketched below:



$$X_{C9} = \frac{159 \times 10^{-3}}{54 \times 10^{-7}} = 29.4 \text{ K}\Omega$$

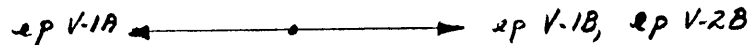
$$\tan \theta = \frac{X_C}{R} = \frac{29.4 \text{ K}\Omega}{5.8 \text{ K}\Omega} \therefore \theta \approx 79^\circ$$

e) an analysis of the action of V-2B on the 200 KC circuit is given below:

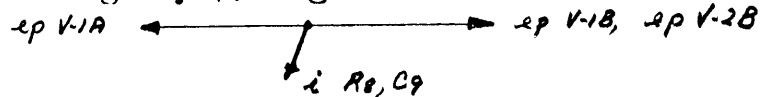
- (1) the plate, pin 6, of V-2B connects to the plate, pin 2, of V-1B. This RF voltage will be taken as the reference vector.



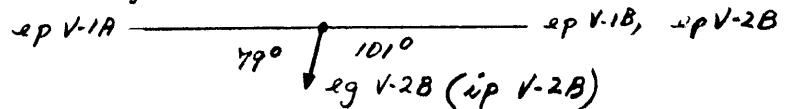
- (2) the signal applied to the grid, pin 7, of V-2B is applied from the opposite end of the 200 KC tank. This is ep V-1A; this voltage is 180 degrees out of phase with the reference vector.



- (3) the phase angle, θ , of C-9, R-8, is 79 degrees; that is, the current in this network will lead the applied voltage by 79 degrees.



- (4) since the voltage across R-8 is in phase with the current through it, and, since this voltage is also eg V-2B, the relationship between ep V-2B and eg V-2B may be drawn as follows:

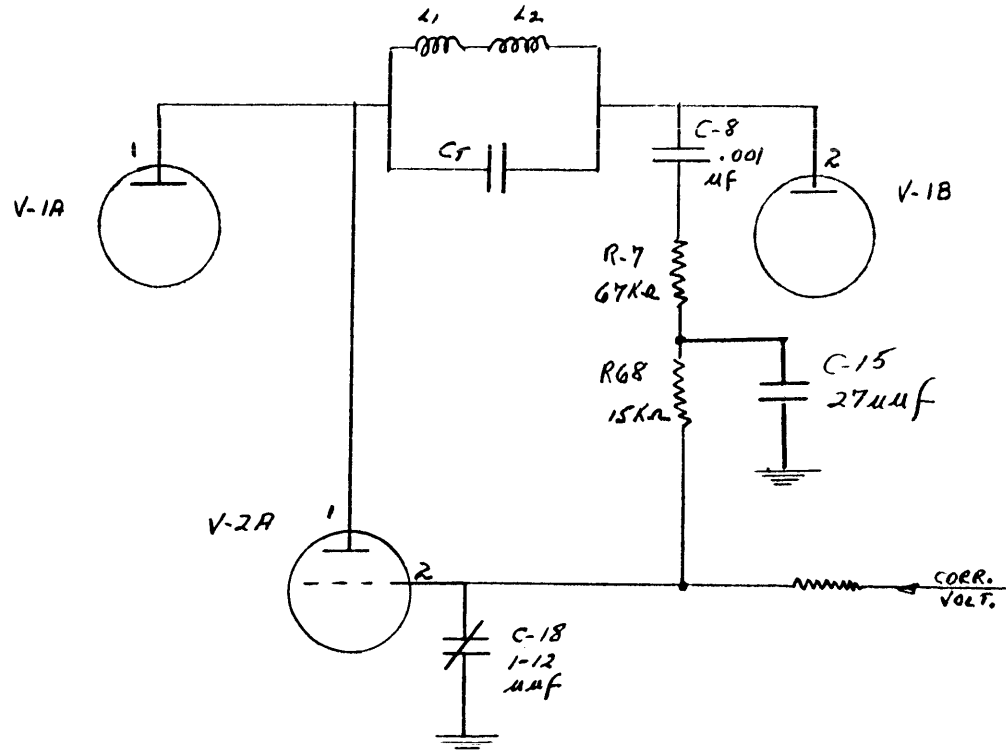


- (5) the plate current of V-2B will be in phase with the grid voltage of V-2B. Since this plate current will lag the plate voltage, the tube is acting as an inductive reactance.

$$\frac{ep V-2B \angle 0^\circ}{ip V-2B \angle -101^\circ} = Z_{V2B} \angle +101^\circ = X_L$$

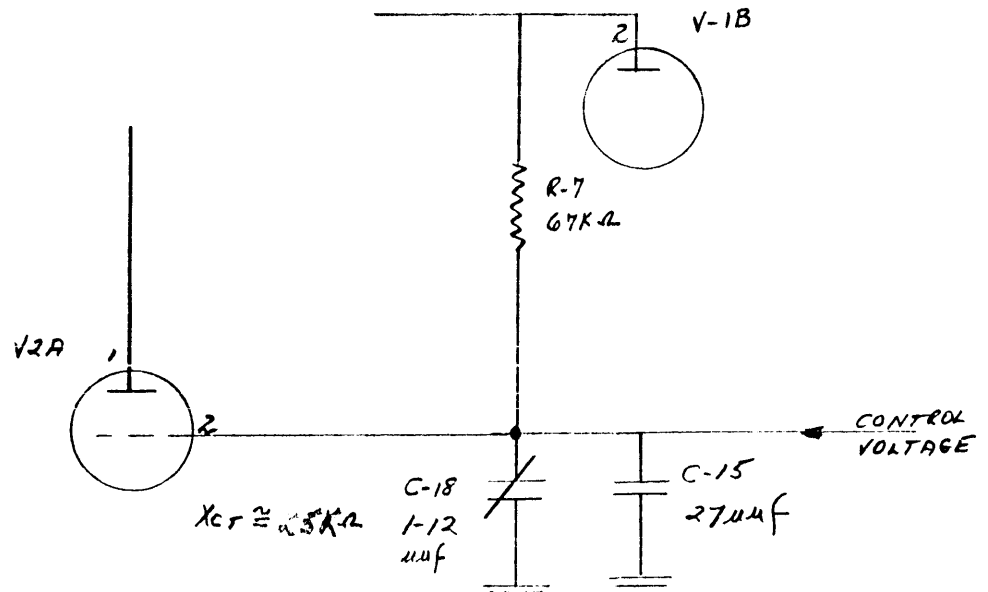
- (6) the current in V-2B is an inductive current.

f) a simplified sketch of the circuit of the 200 KC oscillator and V-2A is given below:



the reactance of C-8, on the order of 800 ohms, may be disregarded. C-8 is primary a DC blocking capacitor, to couple the signal but to keep plate voltage from the grid of V-2A.

The reactance of C-15 is about 30 K ohms at 200 KCS. The reactance of C-18 (mid range) is about 100 K ohms. R-68 is a small value in comparison with the reactance of C-18, so that the circuit may be reduced to the following, for all practical purposes:

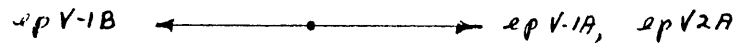


g) an analysis of the action of V-2A on the 200 KC circuit is given below:

- (1) the plate, pin 1, of V-2A connects to the plate, pin 1, of V-1A. This RF voltage will be taken as the reference vector.



- (2) the signal applied to the grid circuit of V-2A is applied from the opposite end of the tank. This is ep V-1B; this voltage is 180 degrees out of phase with the reference vector.



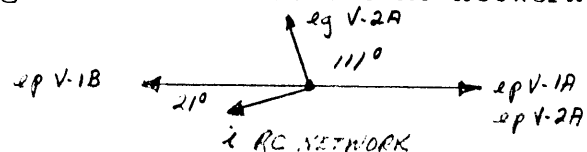
- (3) the phase angle of the coupling circuit is found to be:

$$\text{TAN } \theta = \frac{X}{R} = \frac{25K}{67K} \quad \theta \approx 21^\circ$$

- (4) the current in the RC network will lead the applied voltage, ep V-1B, by 21 degrees.



- (5) eg V-2A is the voltage across capacitors C-18, C-15. This voltage will lag the current in the RC network by 90 degrees.



- (6) eg V-2A leads ep V-2A by 111 degrees. Since the plate current of V-2A will be in phase with the grid voltage of this stage, V-2A is acting as a capacitive reactance.

- (7) ip V-2A is a capacitive current.

$$\frac{ep V-2A \angle 0^\circ}{ip V-2A \angle +111^\circ} = \therefore Z_{V2A} \angle -111^\circ = X_C$$

- h) when a positive voltage is applied at pin 2 of V-2A, the capacitive current in V-2A increases, as would be the case if capacitance were increased. This lowers the frequency of the 200 KC oscillator. In addition, the increase of current in V-2A causes increased bias on V-2B, due to the common cathode bias arrangement. This reduces the inductive current in V-2B, which would be the case if inductive reactance had been increased. This also tends to lower the frequency of the 200 KC oscillator.
- i) when a negative voltage is applied to pin 2 of V-2A, the capacitive current in V-2A decreases; this is tantamount to an increase in capacitive reactance, which would result if capacitance were decreased. This tends to raise the frequency of the 200 KC oscillator. In addition, the reduced bias on V-2B causes an increase in inductive current in that stage. This is tantamount to a decrease in inductive reactance, which would result if inductive action were decreased. This also tends to lower the frequency of the 200 KC oscillator.
- j) C-18 is made adjustable to vary slightly the phase shift in the grid circuit of V-2A. During the alignment procedure, equal positive and negative voltages are alternately applied to the grid circuit of V-2A, and the linearity of the frequency shift of the oscillator noted. C-18 is adjusted for best linearity.

4. The Mixer (V-5) Audio Amplifier (V-7) and Output Level Meter Circuits:

- a) V-5 is a type 12AU7 dual triode operated as a balanced mixer. The output of the crystal oscillator stage is applied to the control grids, pins 2,7, in parallel via C-29 and C-30. The frequency depends on the crystal selected by the CENTER FREQ CPS switch, S-6.
- b) the output of the 200 KC oscillator circuit is applied to the mixer control grids in push pull, via R-53 and R-54. This frequency is $200\text{ KC} \pm \Delta F$ where ΔF is the frequency shift developed by FSK or FAX signals.
- c) the plates of the mixer tube connect to T-2, an audio transformer with a frequency response of 200 cps - 10 KC, plus or minus 2 db.
- d) the original input frequencies, their sum, their difference and other products are present, to some degree, in the plate circuit. It should again be noted that care was taken in the design of the 200 KC and crystal oscillators to maintain their outputs as "harmonic free" as possible.
The audio transformer will respond only to the difference frequencies. RF bypass capacitors C-21 and C-22 offer negligible reactance to all but the difference frequencies, which are:

$$\begin{array}{rcl}
 \underline{200\text{KC} \pm \Delta F - F_{Y1}} & = & \underline{1900\text{CPS} \pm \Delta F} \\
 \underline{200\text{KC} \pm \Delta F - F_{Y2}} & = & \underline{2000\text{CPS} \pm \Delta F} \\
 \underline{200\text{KC} \pm \Delta F - F_{Y3}} & = & \underline{2550\text{CPS} \pm \Delta F} \\
 200\text{KC} \pm \Delta F - F_{Y\text{SPARE}} & &
 \end{array}$$

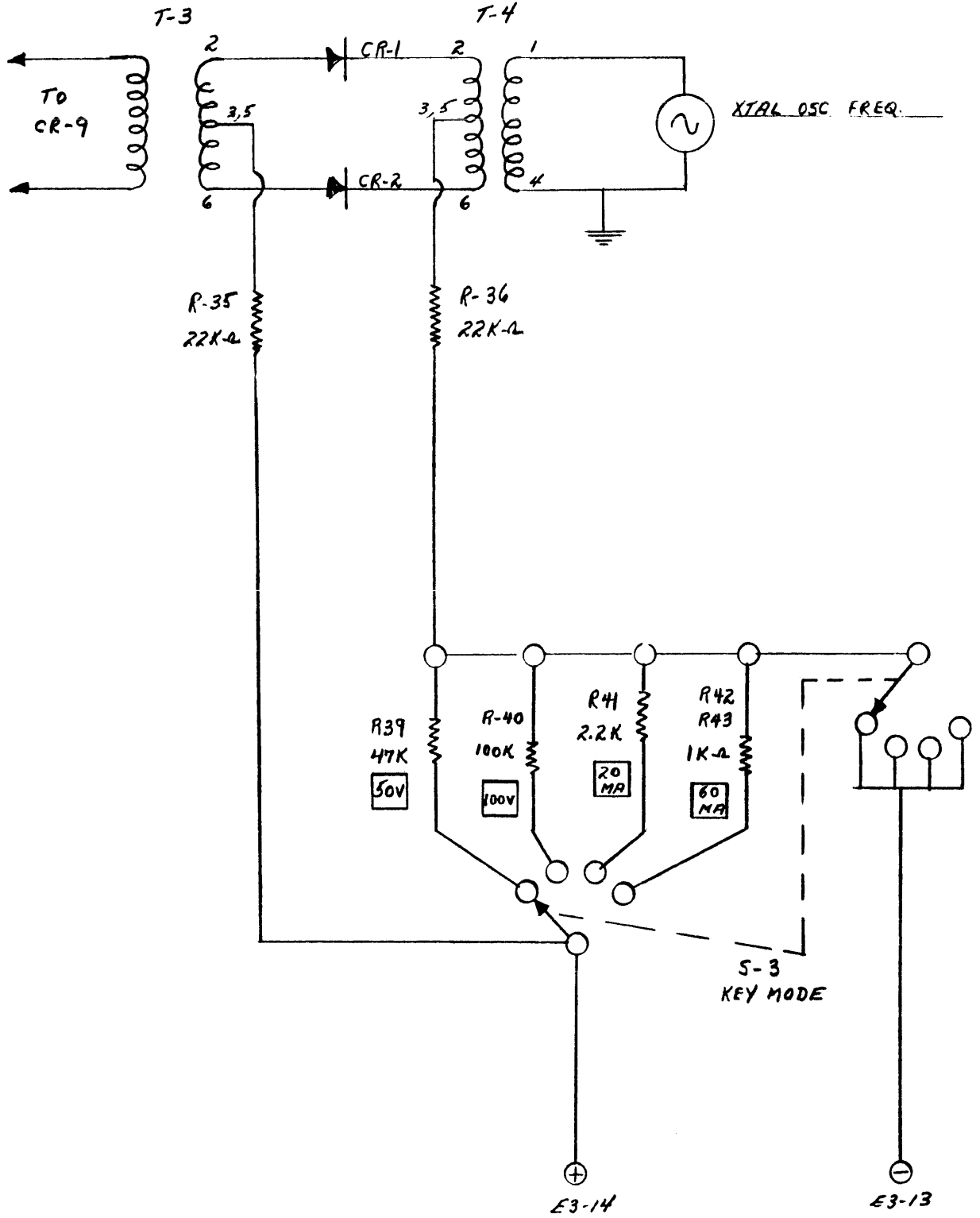
- e) R-67, the mixer balance adjust potentiometer, is adjusted for minimum distortion and hum with a panoramic analyzer connected to the audio output.
- f) plate voltage is applied to the mixer stage at terminals 5, 6 of T-2, via S-1, the FUNCTION switch. Note that in the FSK and FAX positions of this switch, B Plus is applied to the 200 KC oscillator and mixer circuits, but that, in the CW position, the plate supply is removed.

- g) the push pull audio output at the secondary of T-2, controlled by tandem LEVEL ADJUST potentiometers R-49A and R-49B, is applied to the control grids, pins 2 and 7, of conventional push pull audio amplifier V-7. The load for this stage is T-5, an audio transformer identical to T-2. Audio balance potentiometer R-64 is adjusted for equal conduction of both halves of V-7.
- h) the secondary of T-5 is centertapped to ground, to provide a balanced output. The audio at this point is applied:
 - (1) to Channel 1 and Channel 2 LINE - CW, FSK FAX switches, S-4 and S-5.
 - (2) to the output level meter circuit. This circuit is designed so that, with a 600 ohm load connected across the audio output, the meter indicates zero DB when 1 milliwatt of power is expended in the load. This corresponds to a load voltage of approximately .78 volts RMS or 2.1 volts peak to peak. A simple, conventional full wave rectifier and filter circuit is employed.
- i) the arrangement of the cathode circuit of V-7 should be examined at this time. R-45 and C-26 provide a normal cathode bias circuit. The "high" side of this circuit connects to the cathode, pin 3, of V-4A. This circuit is used to key the audio amplifier on and off in response to CW signals. This circuit will be discussed in detail subsequently.

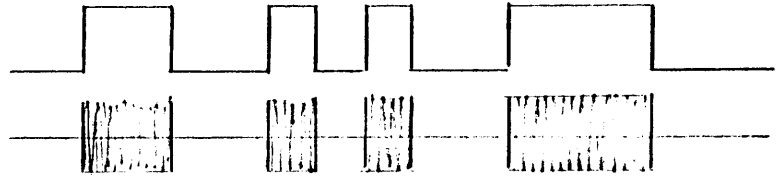
5. The Keying Input Circuit and First Keyer:

- a) the keying input circuit will accept FSK or CW keying signals at terminals 13, 14, of E-3. A KEY MODE switch, S-3, matches the type of keying signal to the input circuits.
- b) the circuit receives FSK or CW signals at 50V, 100V, 20 ma., or 60 ma. The signals may be neutral, floating, or have either side grounded. Polarity should be observed, however. The positive terminal is E-3-14 and the negative terminal is E-3-13.
- c) a simplified sketch of the input keying arrangement is presented on the following page:

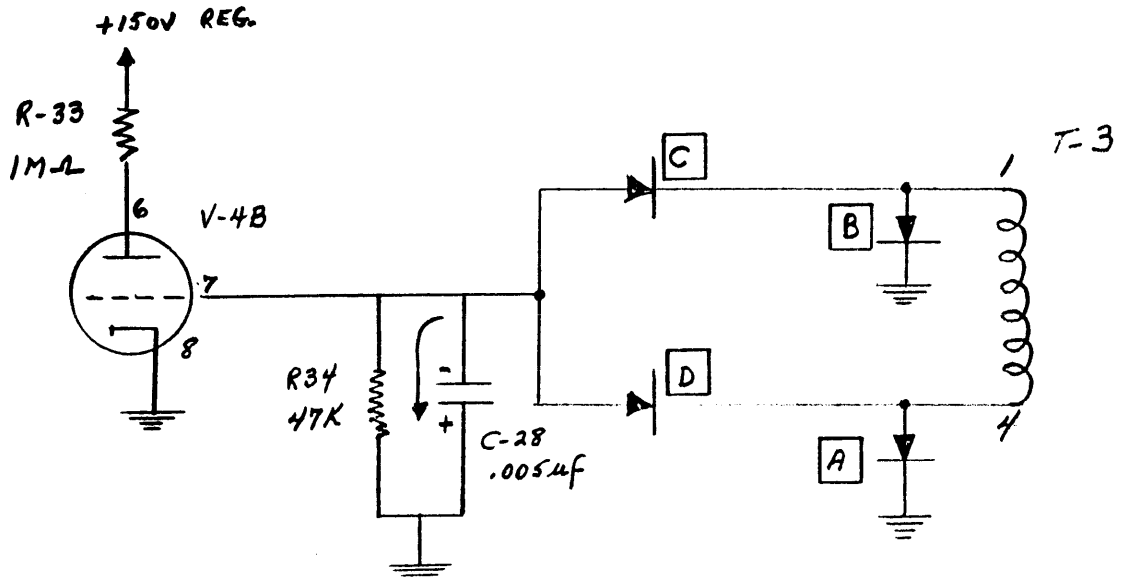
Simplified Circuit of Keying Input Arrangement:



- (1) when the polarity at terminal 14 is positive corresponding to a MARK, diodes CR-1 and CR-2 conduct, allowing the crystal oscillator frequency to appear at the secondary of T-3. When the polarity reverses, corresponding to a SPACE, the diodes do not conduct and the crystal oscillator frequency does not appear at the secondary of T-3.
- (2) the keying mode switch and its selected resistance act in much the same manner as an ammeter shunt, to provide a load for the keying voltage or current, and to limit the current through the receiver circuit. In MARK condition, the rectifier circuit presents an impedance of 44 K ohms (R-35 plus R-36) to the shunt. In SPACE condition, an infinite impedance is presented.
- (3) the secondary of T-3 sees RF pulses, the durations of which correspond to the durations of the keying MARKS.



- d) a simplified sketch of CR-9 and the first keyer, V-4B, is drawn below:



- (1) when, during an RF pulse, terminal 1 of T-3 is positive and terminal 4 is negative, diodes A and C cannot conduct. Current flows from T-3-4, through diode D, charging C-28 negatively, and from ground through diode B, to T-3-1, completing the circuit.
- (2) when T-3-1 is negative and T-3-4 is positive, diodes D and B cannot conduct. Current flows from T-3-1 through diode C, charging C-28 negatively, and from ground through diode A to T-3-4, completing the circuit.
- (3) the time constant, T, of R-34, C-28, is RC, or:
 $47 \times 10^3 \times 5 \times 10^{-9} = 235 \times 10^{-6} = .235 \text{ milliseconds}$
- (4) the period of the crystal oscillator frequency, assuming that S-6 is in position 2, is:
 $t = \frac{1}{f} = \frac{1}{1.98 \times 10^5} = .505 \times 10^{-5} \approx .005 \text{ millisecond}$
- (5) the period of a teletype "bit" is 22 milliseconds.
- (6) the time constant of R-34, C-28 is long with respect to the period of the crystal oscillator frequency and short with respect to the period of a teletype "bit". The RC network cannot respond to the fluctuations of the crystal oscillator frequency, hence develops a constant negative voltage for the duration of the pulse. However, when the RF pulse ends, the circuit rapidly discharges to zero because its time constant is short with respect to the period of the teletype "bit". The result is a rectangular wave, clamped at zero volts, which follows faithfully the "envelope" of the MARKS and SPACES.
- e) V-4B, the first keyer, has a large plate load resistor returned to a regulated plus 150 volt supply. Under these conditions, when eg is 0 volts, the plate current of V-4B is about 141 ua; this drops the plate voltage to about 3 volts. In addition, it does not require a large negative voltage at the grid to cut off V-4B.
- f) thus, for a wide range of keying signal conditions, V-4B conducts on spaces and is cut off on marks. Due to the manner in which the tube is operated, the conditions remain the same for a wide range of keying input amplitudes.

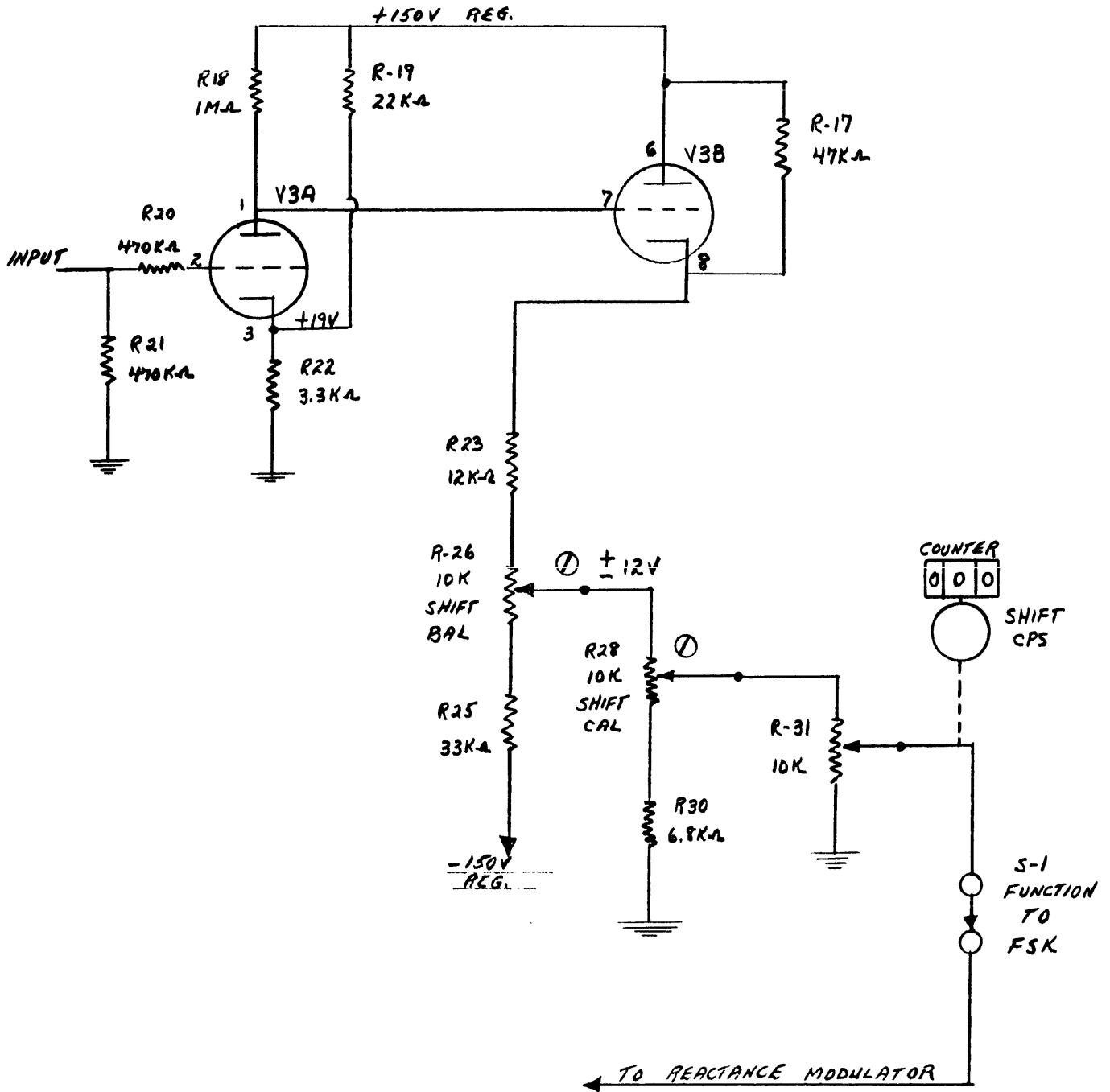
6. The TEST switch, S-2:

- a) the TEST switch, S-2, is connected between the plate circuit of V-4B and the control grid circuit of V-3A.
- b) in position 1, LINE, FSK or CW keying signals from the first keyer are transferred from V-4B to V-3A.
- c) in position 2, MARK, the switch simulates a MARK condition by connecting the control grid circuit of V-3A to a plus 150 volt supply via R-32, a 1 Megohm resistor.
- d) in position 3, SPACE, the switch simulates a SPACE condition by grounding the control grid circuit of V-3A.

7. The Second Keyer Circuit, V-3, in the FSK mode:

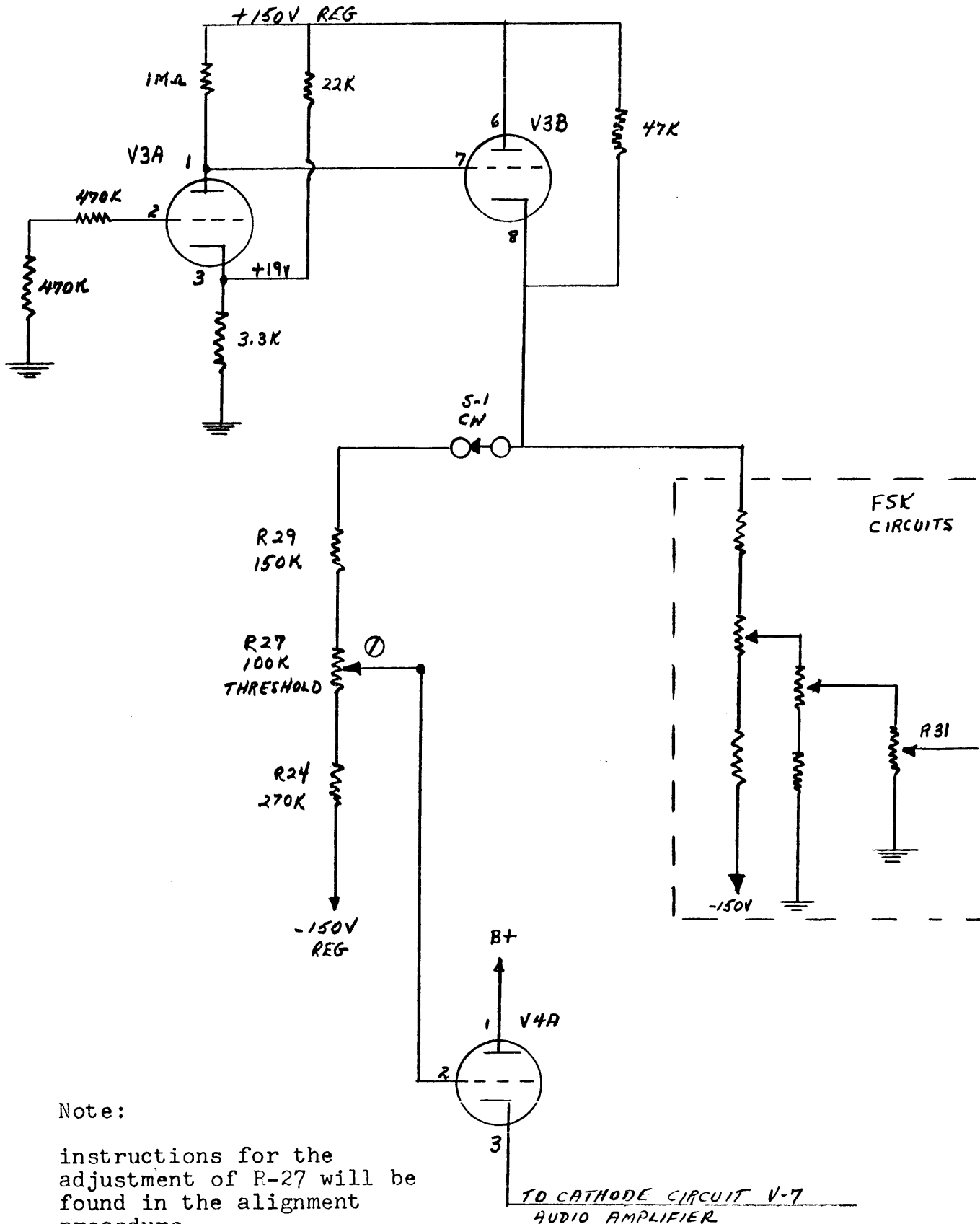
- a) the second keyer circuit is sketched in simplified form on the following page. The sketch shows the system in the FSK mode of operation. The circuit will subsequently be discussed with the FUNCTION switch in the CW position.
- b) the cathode of V-3A is held at plus 19 volts by voltage divider action. With a MARK input at S-2, V-3A conducts; grid limiting takes place and the control grid, pin 2, is limited to 19 volts, the cathode voltage.
- c) with V-3A conducting, the fall of plate voltage cuts off V-3B. This reduces the current in the voltage divider network consisting of R-17, R-23, R-26 and R-25, connected between the two 150 volt regulated supplies. A negative voltage appears at the wiper of R-26, the SHIFT BAL control.
- d) with a SPACE input at S-2, cathode bias cuts off V-3A. The rise of plate voltage causes V-3B to conduct. This conducting tube now shunts R-17 in the voltage divider network, increasing the current. A positive voltage now appears at the wiper of R-26, the SHIFT BAL control.
- e) The SHIFT BAL control, R-26, is adjusted so that, in MARK condition, -12 volts is taken off the wiper and, in SPACE condition, plus 12 volts appears at this point. This DC control voltage is further divided by R-28, the SHIFT CAL control, and, finally, by R-31, the front panel SHIFT OPS control. This voltage is applied to pin 2 of V-2, in the reactance modulator network, via S-1, the FUNCTION switch.
- f) a review of the discussion on the reactance modulator circuit discloses that a negative voltage input will raise the frequency of the 200 KC oscillator, and that a positive input voltage will lower the 200 KC oscillator frequency.

Simplified Schematic of the Second Keyer, V-3, in FSK Mode:



- g) R-31 is a precision potentiometer, geared to the front panel SHIFT CPS knob and counter.
 - h) R-28, the SHIFT CAL control, calibrates R-31, the precision potentiometer. This factory adjustment is made with the counter at 1000 cycles. R-28 is adjusted for exactly plus 500 cycle shift in MARK condition and exactly minus 500 cycle shift in SPACE condition.
8. The Second Keyer, V-3, in the CW Mode:
- a) the second keyer circuit is again sketched, on the following page, with S-1, the FUNCTION switch, in the CW position.
 - b) note that the FSK voltage dividers remain in the circuit; however, the DC control voltage output from R-31 is not terminated.
 - c) S-1, the FUNCTION switch, inserts another voltage divider network, which operates similar to the one discussed for FSK operation. Positive and negative voltages, corresponding to SPACES and MARKS, respectively, are picked off the wiper of R-27, the THRESHOLD control. These are applied to the control grid of V-4A, the CW keyer tube. The cathode of V-4A connects to the "high" side of C-26, R-45, in the cathode circuit of audio amplifier V-7.
 - d) a "key down" input, corresponding to a "MARK", causes a negative voltage at the wiper of R-27. This cuts off V-4A, allowing V-7 to conduct under normal bias conditions.
 - e) a "key up" input, corresponding to a "SPACE", causes a positive voltage at the wiper of R-27. V-4A conducts, raising the bias on V-7 sufficiently to cut off that stage.
 - f) the remainder of the CW circuitry will be discussed subsequently.
9. The CW Oscillator, V-6A:
- a) V-6A is a simple CW oscillator, the frequency of which is adjusted to 1 KC by L-3.
 - b) the plate supply is connected via R-48 and S-1, the FUNCTION switch. B Plus is connected only in the CW position of S-1.
 - c) the output of the CW oscillator is taken from the plate circuit and is coupled, via C-23, to the primary of audio transformer T-2. In the CW position of the FUNCTION switch the mixer stage, V-5, does not operate. In the FSK and FAX positions of S-1, the CW oscillator does not operate; hence, the CW oscillator output may be conveniently be connected at T-2-7.

Simplified Schematic of the Second Keyer, V-3, in the CW Mode:

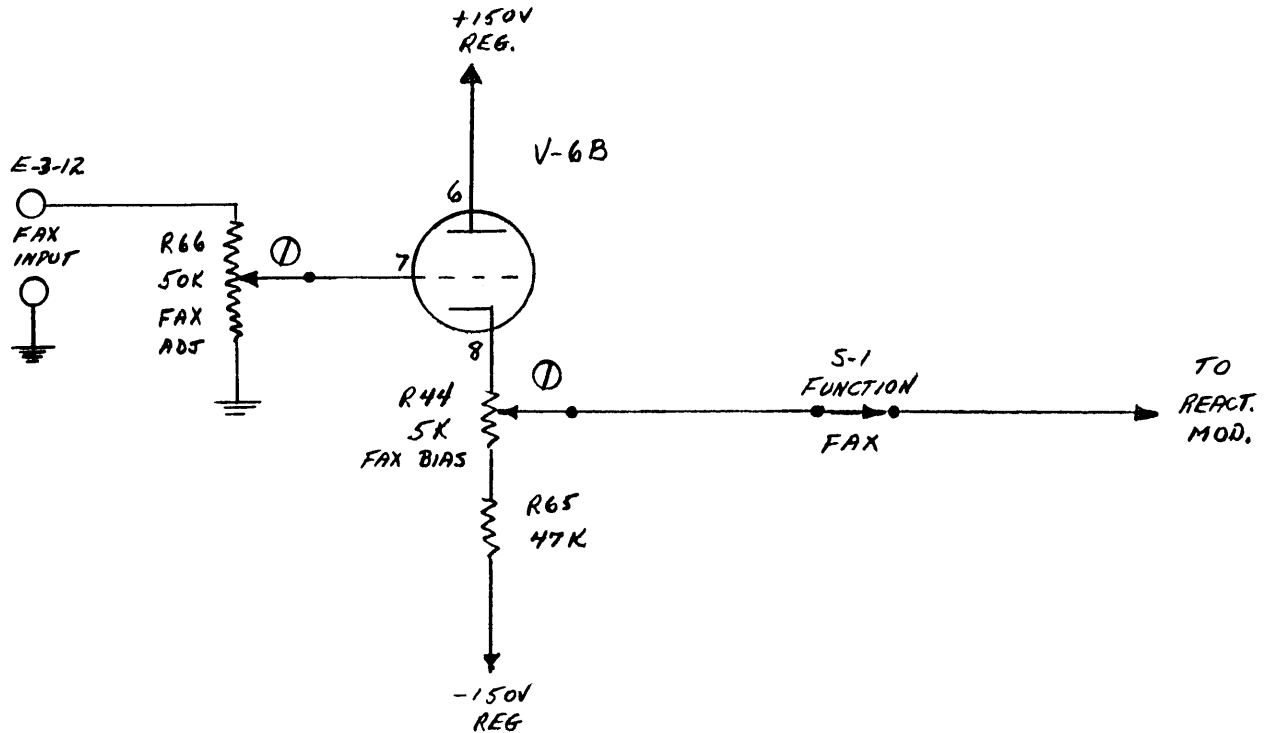


Note:

instructions for the adjustment of R-27 will be found in the alignment procedure

10. The Facsimile Circuits:

- a) a simplified schematic of the facsimile circuits is drawn below:



- b) the circuit is designed for a linear shift of 1200 cycles for a 0 - 20 volt positive input from associated facsimile equipment.
- c) the control voltage shift circuit is similar to that employed in the FSK and CW modes. The control voltage is taken off the wiper of R-44, the FAX BIAS control, and is applied to the reactance modulator stage via S-1, the FUNCTION switch.
- d) a discussion of the adjustment of the circuit will serve to explain the principles of operation:
- (1) the FUNCTION switch, S-1, is placed in the FAX position.
 - (2) the CENTER FREQ CPS switch, S-6, is placed in the 1900 CPS position. This is the international standard for facsimile transmission.
 - (3) a variable DC supply, 0 to plus 20 volts, is connected at the facsimile input terminals. A voltmeter is connected to read the voltage at the input terminals. The input voltage from the battery is made zero. The setting of R-66, the FAX ADJUST, is unimportant at this time.

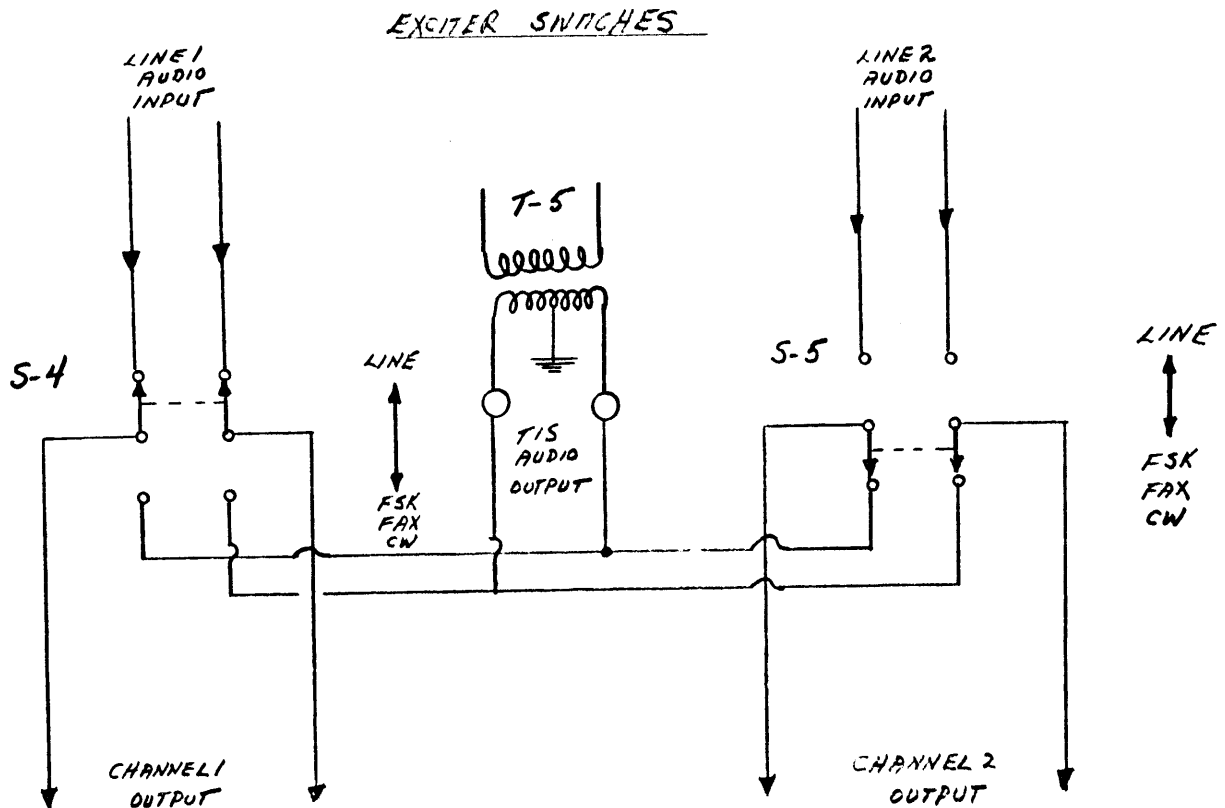
- (4) a frequency counter is connected across a 600 ohm load resistor at terminals 7,8 of E-3, the Channel 1 audio output. S-4, the Channel 1 EXCITER switch, is placed in the FAX FSK CW position.
- (5) R-44, the FAX BIAS control, is adjusted for an output frequency of 2300 cps. At this time, a negative control voltage is raising the frequency of the 200 KC oscillator.
- (6) the FAX ADJUST control, R-66, is moved to the position of maximum resistance.
- (7) the FAX input voltage is adjusted as indicated in the table below, to produce the listed output frequencies, plus or minus 5%. Note that this represents a frequency change of 80 cycles per volt.

<u>Positive DC Input</u>	<u>Output Frequency</u>
0	2300 cps
.5	2260
1	2220
2	2140
5	1900
6	1820
8	1660
10	1500

- (8) consult the alignment instructions if results differ sharply from the table above.

11. The EXCITER switches: S-4, S-5:

The EXCITER switches permit flexibility when the TIS-3 is interconnected in a sideband transmission system. LINE 1 and LINE 2 inputs may contain any type of audio intelligence; the frequency extremes of this intelligence are limited only by the frequency response characteristics of the associated sideband transmission equipment. With the EXCITER switches in the LINE position, the LINE 1 and LINE 2 audio inputs are connected to the CHANNEL 1 and CHANNEL 2 audio outputs of the TIS-3; from this point the audio is delivered to the Channel 1 and Channel 2 audio inputs of the associated sideband transmission equipment. Under these conditions, the TIS-3 is bypassed. When the EXCITER switches are thrown to the FSK-FAX-CW positions, the audio output of the TIS-3 is connected to the Channel 1 and Channel 2 audio outputs of the unit. The sketch below shows Channel 1 EXCITER switch in the LINE position, and Channel 2 EXCITER switch in the FSK FAX CW position. Thus: the Channel 1 audio line input is shunted to the Channel 1 audio output, and the audio output of the TIS-3 is connected to the Channel 2 audio output terminals.

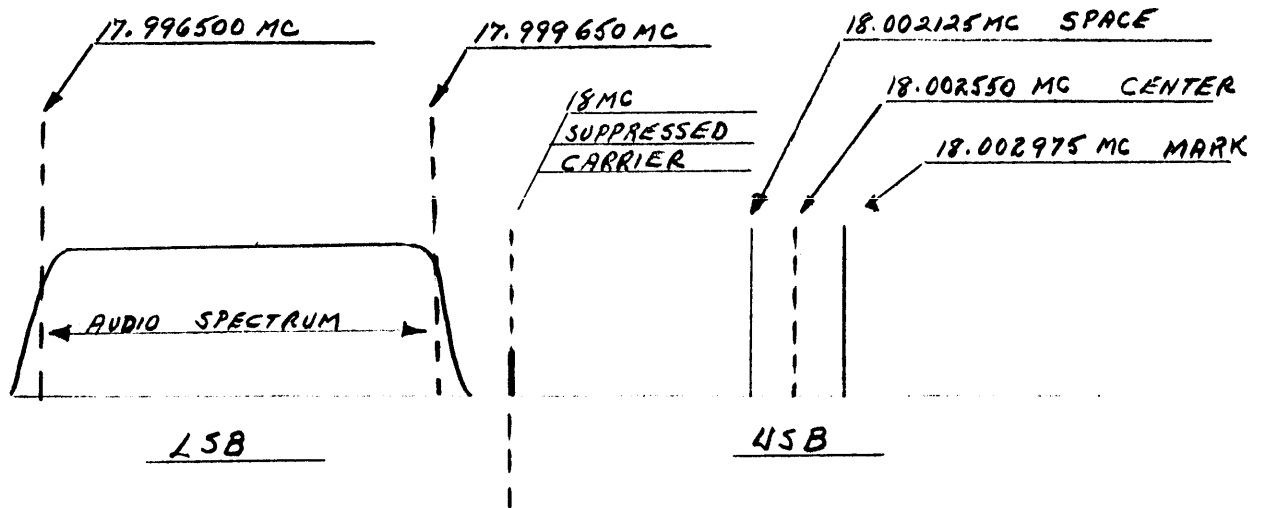


Assume that the LINE 1 audio input contains voice intelligence in the spectrum from 350 cycles to 3500 cycles per second, and that the TIS-3 is being operated in the FSK mode, with an 850 cycle total shift at a center audio frequency of 2550 cycles per second.

Assume that the Channel 1 Audio output, which connects to the Channel 1 audio input of the associated sideband transmission equipment, represents the lower sideband information.

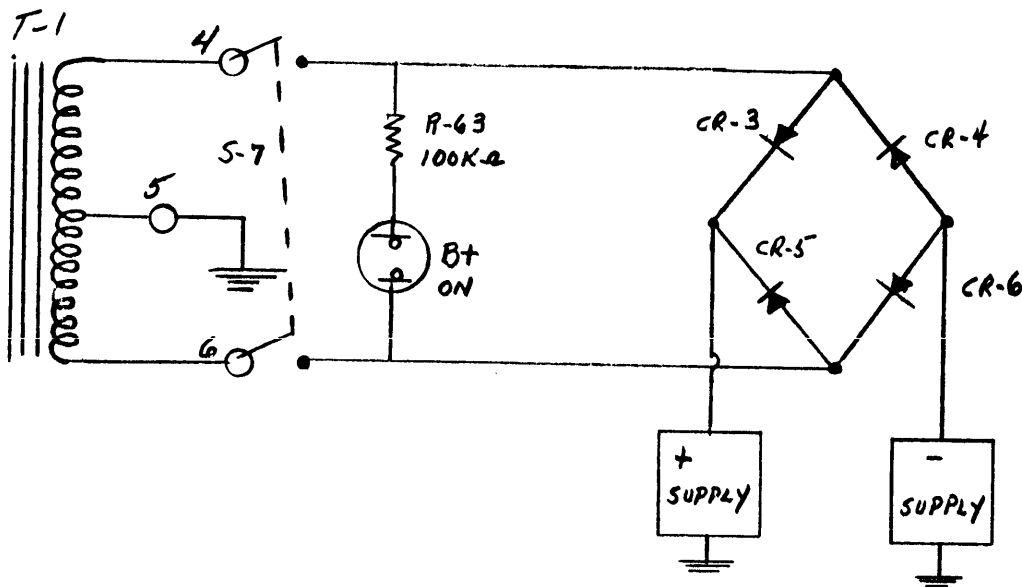
Assume that the Channel 2 Audio output, which connects to the Channel 2 audio input of the associated sideband transmission equipment, represents the upper sideband information.

Assume that the inputs to the sideband transmission equipment are to be translated to a frequency of 18 mcs. The RF output spectrum is sketched below:



12. The Power Supply:

- a) the power supply consists of a conventional full wave bridge rectifier circuit, two voltage regulators, and filter components.
- b) when the STANDBY - B PLUS ON switch, S-7, is placed in the B PLUS ON position, the high voltage secondary of T-1 connects to the bridge rectifier circuit, as shown in the sketch below. The B Plus indicator is connected across the high voltage windings of T-1.



- c) both the positive and negative supplies contain low pass filters and a type OA2 (150 volt) regulator tube.
- d) full B plus (approximately 230 volts) is taken off at R-60. This voltage is not regulated.

- h) adjust the associated teletype equipment to provide teletype input signals at the TIS-3 KEY INPUT terminals.
- i) manipulate the LEVEL ADJUST control for the amount of audio output desired on the OUTPUT LEVEL meter.
- j) to secure the equipment, place the STANDBY - B PLUS ON switch to the STANDBY position; disconnect the output of the associated teletype equipment.

3. CW Operation:

- a) place the FUNCTION switch to the CW position.
- b) place the TEST switch in the LINE position.
- c) the setting of the CENTER FREQ CPS switch is of no consequence.
- d) the setting of the SHIFT CPS control is of no consequence.
- e) set the KEY MODE switch to the position matching the mode of the CW signals connected at the KEY INPUT terminals.
- f) place the Channel 1 and Channel 2 EXCITER switches to the positions appropriate to the output connections decided upon.
- g) place the STANDBY - B PLUS ON switch to B PLUS ON.
- h) adjust the associated machine or hand key equipment to provide CW signals at the KEY INPUT terminals of the TIS-3.
- i) adjust the LEVEL ADJUST control for the amount of audio output desired on the OUTPUT LEVEL meter.
- j) to secure the equipment, place the STANDBY - B PLUS ON switch to the STANDBY position. Disconnect the output of the associated CW keying equipment.

4. FAX Operation:

- a) place the FUNCTION switch to the FAX position.
- b) the setting of the TEST switch is of no consequence.
- c) place the CENTER FREQ CPS switch to the 1900 position.
- d) the setting of the SHIFT CPS control is of no consequence.

- e) the setting of the KEY MODE switch is of no consequence.
- f) place the Channel 1 and Channel 2 EXCITER switches to the positions appropriate to the output connections decided upon.
- g) place the STANDBY - B PLUS ON switch to B PLUS ON.
- h) adjust the associated facsimile equipment to provide FAX signals at the TIS-3 FAX INPUT terminals.
- i) adjust the LEVEL ADJUST control for the desired amount of audio output on the OUTPUT LEVEL meter.
- j) to secure the equipment, place the STANDBY - B PLUS ON switch to the STANDBY position. Disconnect the output of the associated facsimile equipment.

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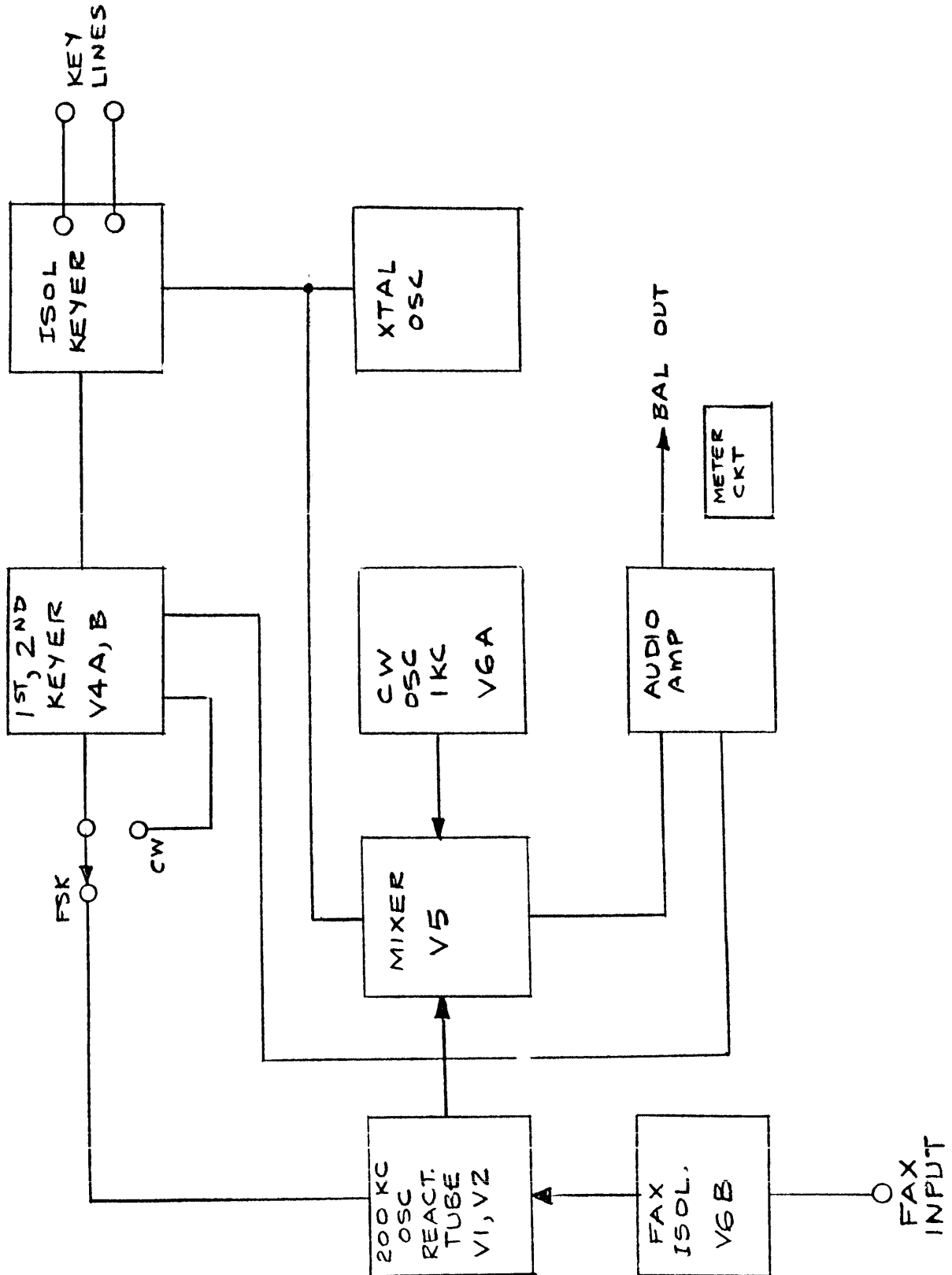
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BLOCK DIAGRAM



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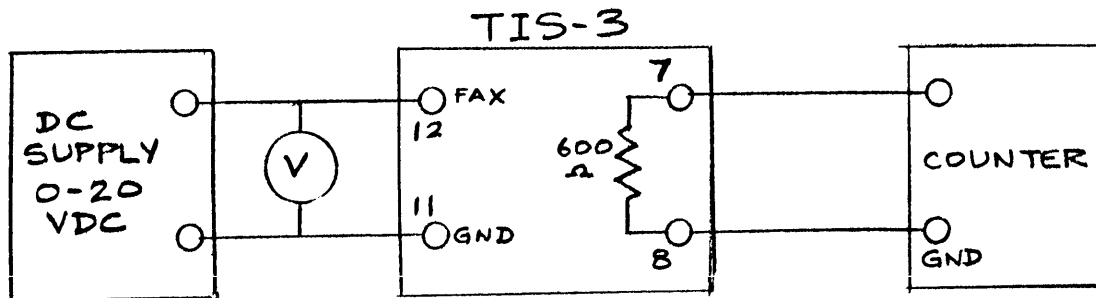
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FIGURE 1
FAX, REACTANCE TUBE TEST



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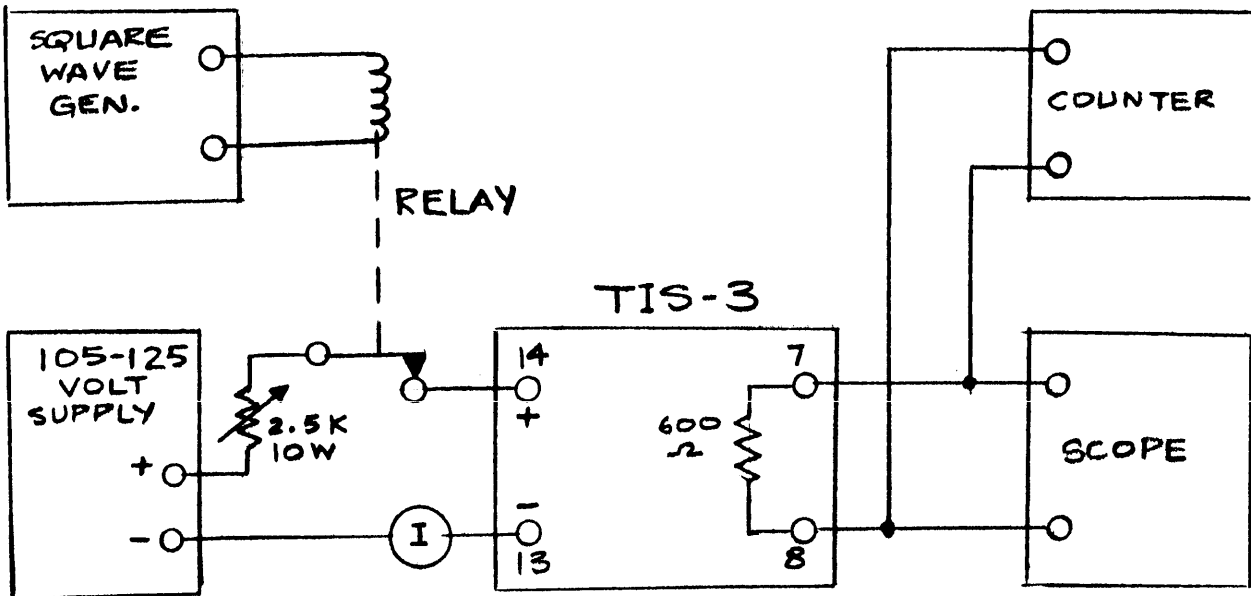
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FIGURE 2 FSK CW KEYING TEST



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IPRELIMINARY TEST

- A. Check unit for obvious wiring mistakes and poor solder connections.
- B. Check with ohmmeter at terminal strip E1 for shorts.

<u>E1</u>	<u>Approx. Resistance</u>
1	0
2	0
3	INF.
4	INF.
5	20K
6	18K
7	30K
8	N.C.

- C. Plug the unit into 110 volt AC and check the following voltages. Turn the STANDBY switch to B+.

<u>E1</u>	<u>Volts Approx.</u>
1 to GND	6.3 VAC
2 to GND	6.3 VAC
3 to 4	110 VAC
5	200 VDC*
6	+150 VDC*
7	-150 VDC*

*These voltages are removed by turning B+ switch to STANDBY.

- D. Measure the following AC volts on E2.

<u>E2</u>	<u>Volts Approx.</u>
1 to 2	110 VAC
5 to 6	110 VAC

- E. Oven light I2 should be on. The oven should reach operating temperature in approx. 15 minutes and the oven light should go out for start of oven cycle.

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- F. B+ - STANDBY switch should operate B+ light.
- G. Make the following check with an ohmmeter on terminal strip E3.
1. With S4, S5 in the LINE position, the following lines should be shorted.

1 to 7	4 to 10
3 to 8	6 to 9
 2. With S4, S5 in the CW, FAX, and FSK position there should be 70 ohms between 7,8 and 70 ohms between 9,10. The terminals 2,5,11 should read ground. Terminal 12 should read 50K ohms, terminal 13 INF, and terminal 14 INF.

II

XTAL OSCILLATOR TEST V8

- A. Check xtal oven Z1 for proper xtals. Y1, 198.100 kc; Y2, 198.000 kc and Z2 for Y3, 197.450 kc. The spare xtal position should also be checked out during this test by putting Y3 into spare holder.
- B. Connect a scope and counter to the center top of L6 thru a 50 mmfd capacitor and tune for maximum voltage with S6 in position 3 (2550). This should be approximately 12.5 volts Peak to Peak (using scope). Check waveform for HUM.
- C. Turn S6 to position 1 (1900) and adjust C35 if necessary to 198.100 kc.
- D. Turn S6 to position 2 (2000) and adjust C36 if necessary to 198.000 kc.
- E. Turn S6 to position 3 (2550) and adjust C37 if necessary to 197.450 kc.

III

200 KC OSCILLATOR AND REACTANCE TUBE

- A. Set the following controls:
 1. C3 to approx. one-third max. capacitance.
 2. C46 to approx. mid capacitance.
 3. R31 (shift cps) to a reading of 000.
 4. R28 (shift cal.) to mid resistance.
 5. R26 (shift bal.) to mid resistance.
 6. S2 (test) to SPACE.

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- 7. S6 (center frequency) to SPARE (position 4).
 - 8. C18 to approx. 3/4 capacitance.
 - 9. S1 (function) to FSK.
- B. Connect the scope and counter to pin 2 of V5 (mixer tube).
- C. Adjust C3 to within ± 10 cycles of 200 kc and lock shaft. Now set to 200 kc by adjusting C46. Make sure shift ampl. R31 is set to 000. With a scope check the output which should be approx. 6 volts peak to peak. Also check the waveform for distortion and HUM.
- D. Put VTVM on the center arm of R26 (shift bal.). Set meter on the 50 volt scale and adjust the meter to center scale with the zero adjust to read \pm volts. By switching the Test switch to SPACE, set the pot to read approx. -12 volts. Now switch Test Switch to MARK and meter should read approx. +12 volts. Set R31 (shift cps) to 1000 and turn the Test Switch from MARK to SPACE. Shift should be ± 500 cycles. If shift is not equal on both sides readjust R26 slightly so shift is equal.
- E. With shift set to 1000 cps adjust R28 (shift cal.) for ± 500 cycle shift. Adjust C18 for best linearity. Reset 200 kc Osc. to 200 kc after each adjustment.

<u>SHIFT CPS ($\pm 5\%$)</u>	<u>COUNTER READING(EXAMPLE)</u>	
	+	-
0	000	000
50	-25	+26
100	-50	+52
200	-98	+102
300	-152	+153
400	-205	+202
500	-254	+253
600	-303	+302
800	-401	+401
1000	-500	+500

- F. At 1000 cycle shift, turn the test switch from SPACE to LINE. Shift must be the same. Make sure all controls are locked. This completes the test.

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IVMIXER AND AUDIO TEST

A. Set controls up for test in the following way:

1. Connect the counter, scope and 600 ohm load across pins 7 and 8 of E3 (channel 1).
2. Turn S4 (exciter channel 1) to the CW, FAX and FSK position.
3. Turn S6 (center frequency) to 1900 (position 1).
4. Set R49 (level adj.) to mid resistance.
5. Turn S2 (test) to MARK position.
6. Turn S1 (function) to FSK position.
7. Set R45 (audio bal.) to mid resistance.
8. Set R31 (shift cps) to a reading of 000.

B. The output level meter should be reading approx. 0 db. R49 (level adj.) should vary the output level meter reading from 0 to full scale. This indicates the mixer, audio and metering circuits are working properly.

C. With S6 (center frequency) in the following positions, the counter readings should be:

<u>POSITION</u>	<u>COUNTER READING</u>
1 (1900)	1900
2 (2000)	2000
3 (2550)	2550
4 (spare)	0

D. With R49 (level adj.) set to 0 db, the voltage on channel 1 should be approx. 1.8 volts peak to peak.

E. Set R31 (shift cps) to the following settings with S6 (center frequency) set to position 3(2550):

<u>SHIFT CPS ±5%</u>	<u>OUTPUT FREQUENCY</u>	
	space	mark
100	2500	2600
300	2400	2700
500	2300	2800
800	2150	2950
1000	2050	3050

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V

FAX TEST

A. Set controls up for test in the following way:

1. Switch S1 (function) to FAX (position 2).
2. Refer to Figure 1 for test set-up.
3. Set FAX input volts to 0 vdc.
4. Turn S6 (center frequency cps) to position 1 (1900) and adjust R44 (FAX BIAS) for output frequency of 2300 cps.
5. Set R66 (FAX ADJ.) to maximum resistance.
6. The following readings are typical for a unit operating properly:

<u>+VDC</u>	<u>CPS ±5% (Center Frequency 1900 cps)</u>
0	2300
.5	2260
1	2220
2	2140
5	1900
6	1820
8	1660
10	1500

If frequency is below 1500 cps at 10 vdc, adjust R66 (FAX ADJ.) for 1500 cps and repeat FAX test.

VI

CW KEYING TEST

A. Refer to Figure 2 for Test Set-up.

1. Set S1 (Function) to CW (Position 3).
2. Set R27 (Threshold Adj.) to mid resistance.
3. Set S3 (Key Mode) to 60 mA (Position 4).
4. Short-Out Contacts of Relay and adjust keying current to 60 ma.
5. Set square wave generator to 50 cycles.
6. Turn S6 (Center Frequency) to 2000 (Position 2).
7. Set S2 (Test) to Line (Position 1).
8. Adjust R49 (Level Adj.) for a reading of 0 db on output level meter.

B. Put counter on Pin 1 of V6A, CW Oscillator. Adjust L3 with Allen wrench for 1000 cps. This should be approximately 25 volts RMS.

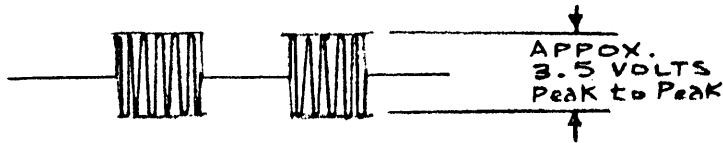
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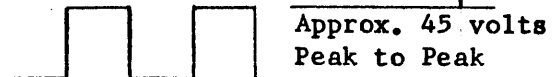
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- C. Adjust R27 (Threshold) and R64 (Audio balance) for best square wave of output waveform. R27 (Threshold) is adjusted to the point where unkeyed portion is at zero volts.

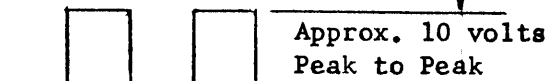


- D. Short relay and measure output frequency. Output frequency should be 1000 cps.
- E. Vary square wave generator from 5 cps to 200 cps, checking wave shape of output.
- F. Disconnect key line and measure level in unkeyed state. Tone should be down at least 60 db.
- G. Typical wave shapes and voltages with controls set as in CW Keying Test, Part A.

Pin 2 of V4 (1st Keyer)



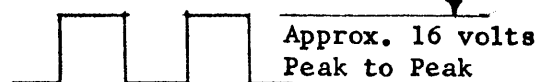
Pin 3 of V4 (1st Keyer)



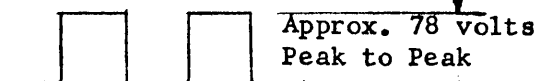
Pin 7 of V4 (1st Keyer)



Pin 2 of V3 (2nd Keyer)



Pin 8 of V3 (2nd Keyer)



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- H. Check output waveforms and voltages with S3 (Key Mode) in the 50 volt, 100 volt and 20 ma positions. Use the series potentiometer in test set-up to obtain these levels. These waveforms and voltages should be the same as shown in CW Keying Test, Part C.

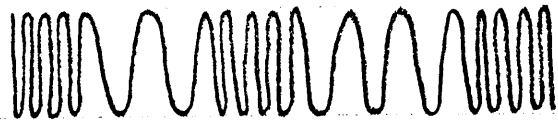
VII

FSK TEST

- A. Set controls to following positions:

1. Turn S1, (FUNCTION) to FSK.
2. Set shift to 1000 cps.

Check shifted tone for envelope distortion from 0 to 1000 cps shift. The response should be flat within ± 1 db.



VIII

AUDIO DISTORTION TEST

- A. Put analyzer on 600 ohm output (channel 1).
- B. Set switches to FSK, 0 SHIFT, 2 kc TONE and test switch to LINE.
- C. Set audio level meter to 0 db.
- D. Adjust R67 (mixer balance) for minimum distortion and hum. This should be down at least 40 db.