UNCLASSIFIED

LESSON PLAN

FOR

TONE INTELLIGENCE UNIT

MODEL TIS-3

WORLD WIDE SUPPLIERS OF ELECTRONIC COMMUNICATIONS EQUIPMENT

THE TECHNICAL MATERIEL CORPORATION

MAMARONECK, N.Y. OTTAWA, ONTARIO

Title: Model TIS-3 Tone Intelligence Unit

Military Nomenclature:

Terminal, Telegraph: **TH-39A/UGT and TH-39B/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

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.

Revised 4/66
P.E.G.

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 400 Bauds FSK
Up to 150 Bauds CW
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:

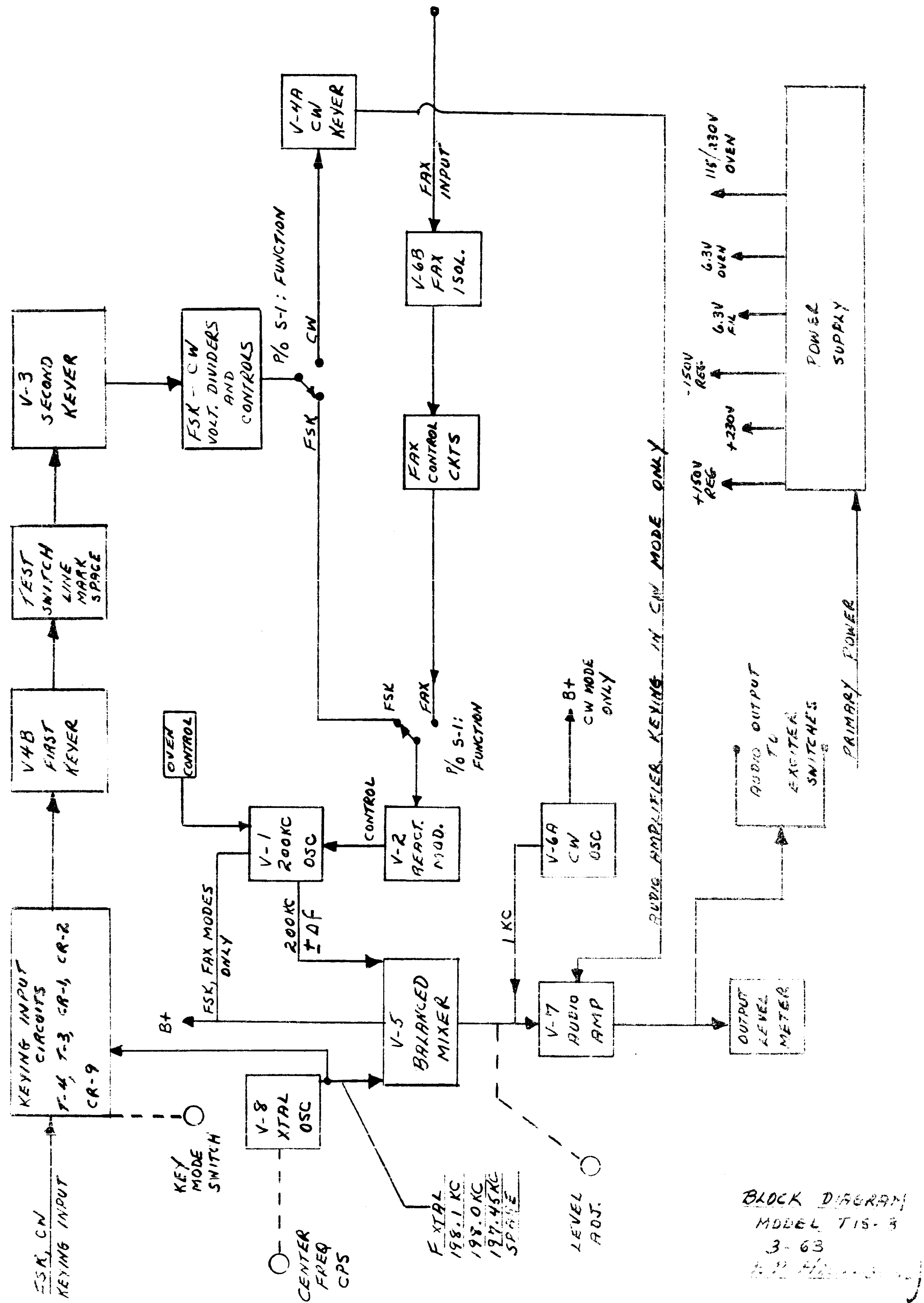
5 1/4 by 19 by 14 inches

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



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:

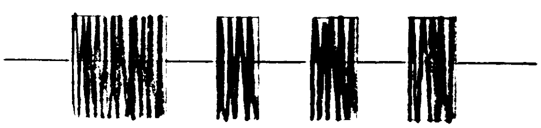
S-6 Position	Crystal Selected		S-6 Panel Marking
1	Y-1	198.1 KC	1900 CPS
2	Y-2	198.0 KC	2000 CPS
3	Y-3	197.45 KC	2550 CPS
4	Y-4		SPARE

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 KC $\pm \Delta f - f_{xtal}$. 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.

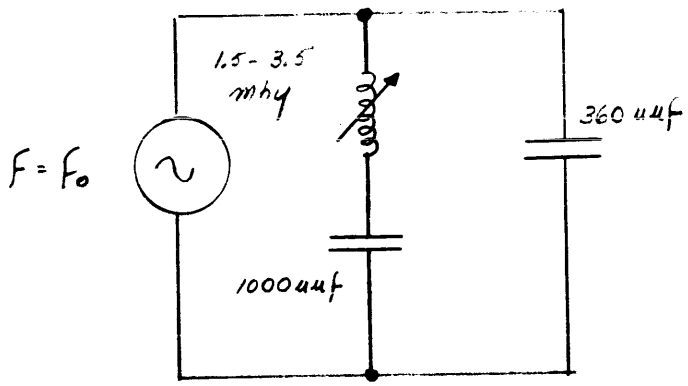
e) the cathode, control grid and screen grid are operated as a triode oscillator, with the screen grid acting as the plate electrode. The screen grid intercepts a sufficient number of electrons from the space current to sustain oscillations, but the majority of the of the electrons pass to the plate 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:

$Q \cong 50$



ASSUME 1000 uuf = C_1
360 uuf = C_2

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

(2) solving for the resonant frequency:

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

(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 $\frac{f_o}{Q}$

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.

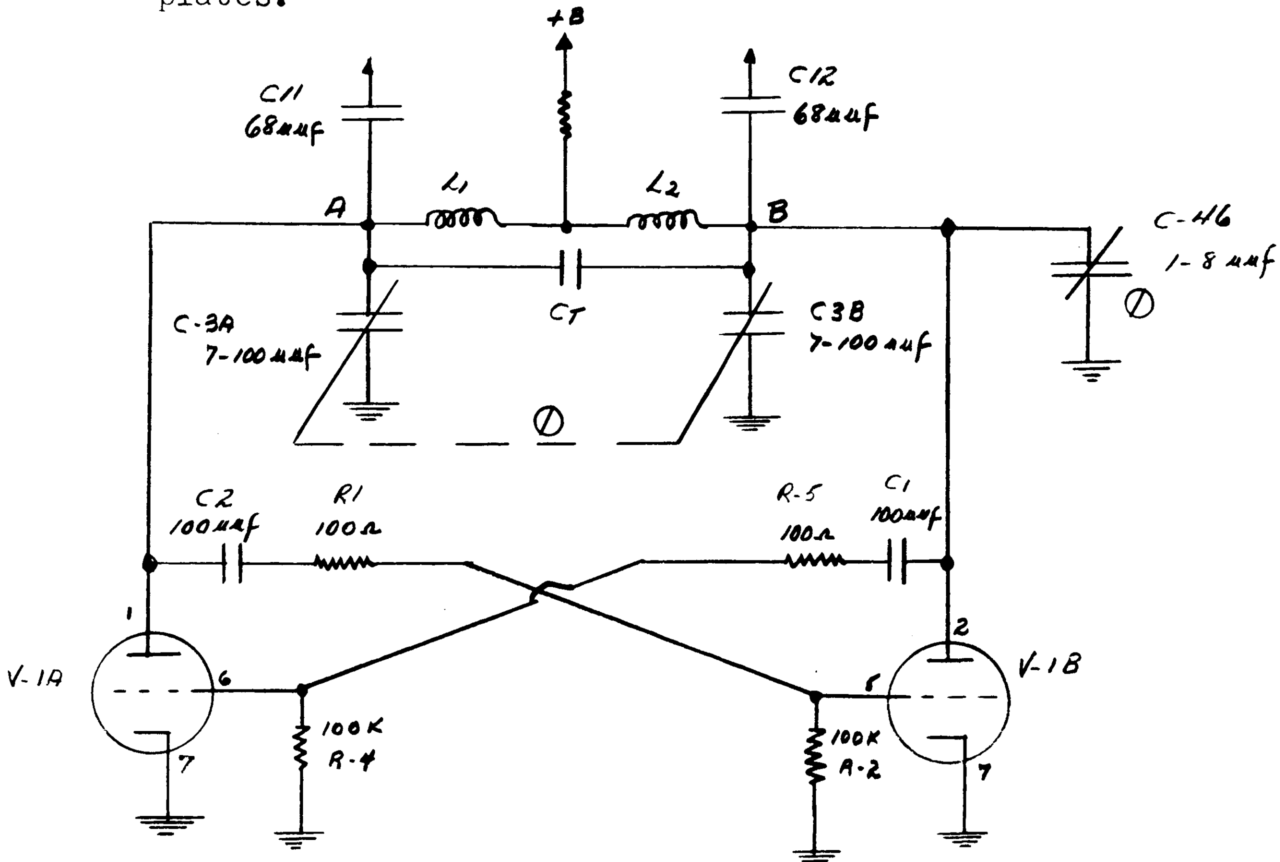
(2) terminal 1 of transformer T-4 in the keying input circuits.

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 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.

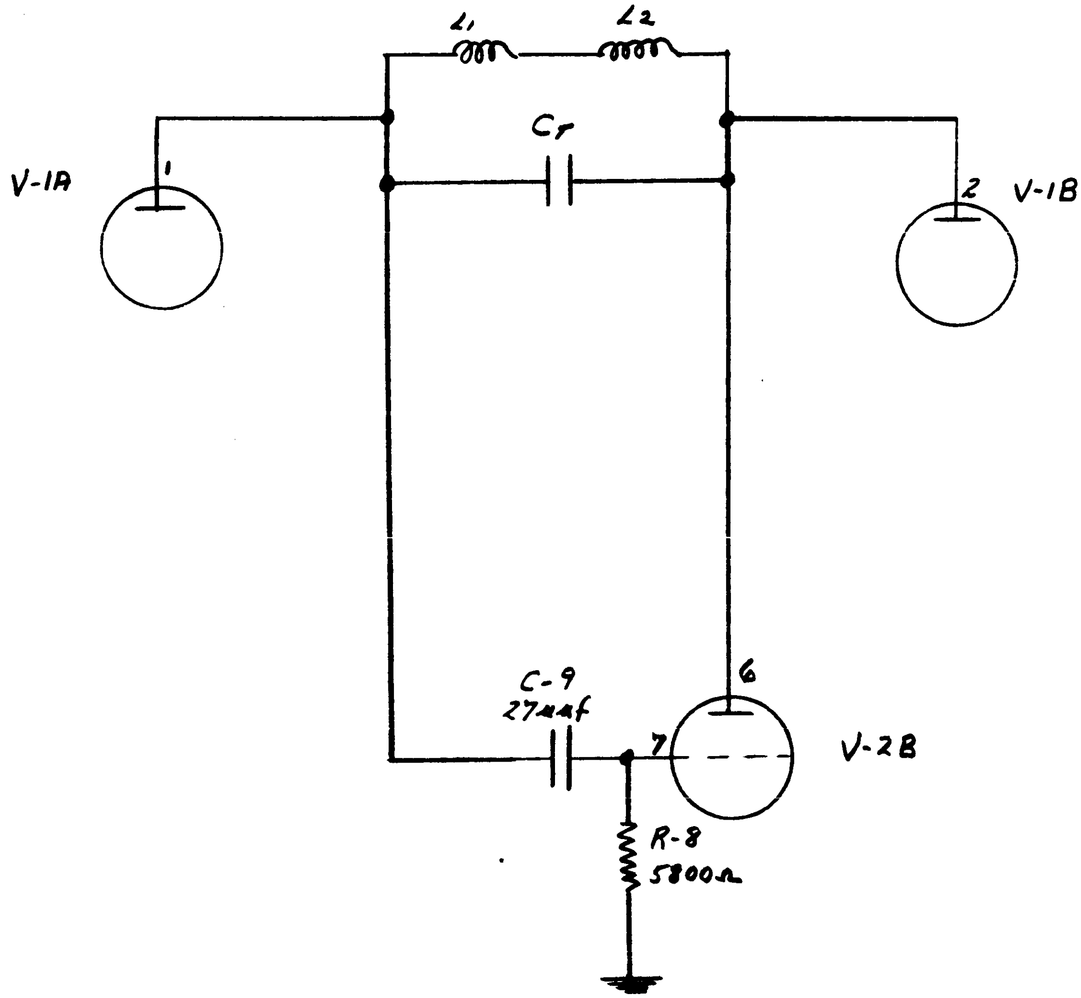
3. The Reactance Modulator Circuit:

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:



$$X_{c9} = \frac{159 \times 10^{-3}}{54 \times 10^{-7}} = 29.4K\Omega$$

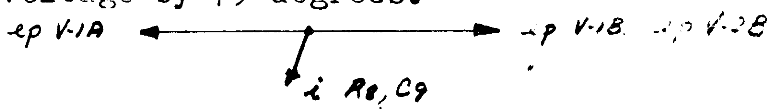
$$\tan\theta = \frac{X_c}{R} = \frac{29.4\ K\Omega}{5.8\ K\Omega} \quad \therefore \quad \theta \cong 79^\circ$$

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

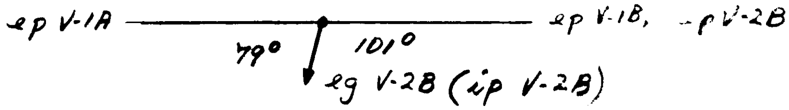
(1) the plate, pin 6, of V-2B connects to the plate, pin 2, of V-1B. This RF voltage will be taken as the reference vector.

(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:

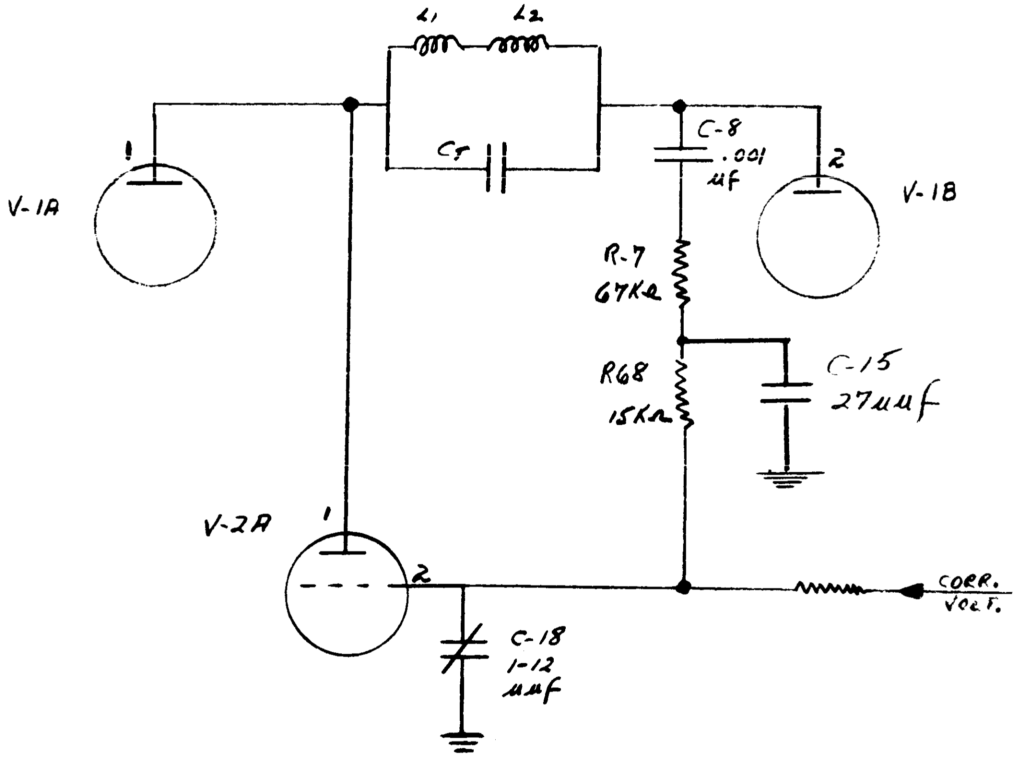


(5) the plate current of V-2B will be in phase with the grid voltage of V-2B. Since this plate current will lag the plate voltage, the tube is acting as an inductive reactance.

$$\frac{e_p\ V\text{-}2B\ \angle 0^\circ}{i_p\ V\text{-}2B\ \angle -101^\circ} = Z_{V2B}\ \angle +101^\circ = X_L$$

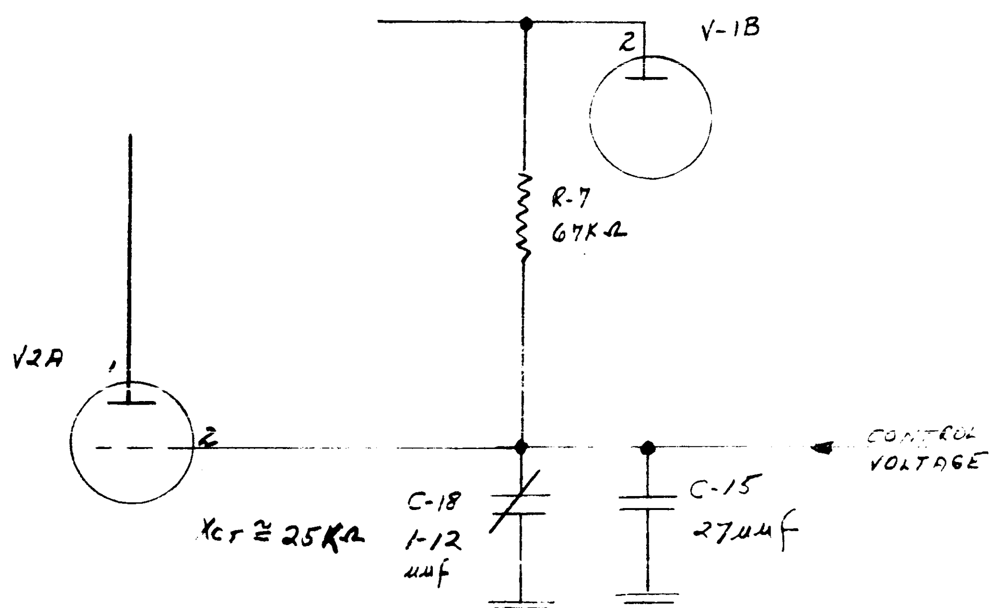
(6) the current in V-2B is an inductive current.

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 primarily a blocking capacitor; it couples the signal, but it also keeps 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:

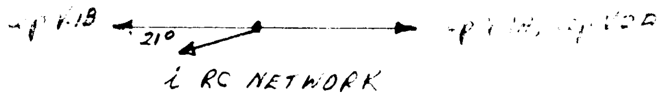
(1) the plate, pin 1, of V-2A connects to the plate, pin 1, of V-1A. This RF voltage will be taken as the reference vector.

(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.

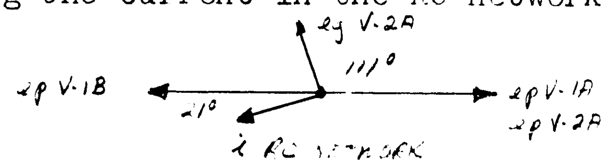
(3) the phase angle of the coupling circuit is found to be:

$$\tan\theta = \frac{X}{R} = \frac{25K}{67K} \qquad \theta \cong 21^\circ$$

(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.

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

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 raise 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 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:

$200KC \pm \Delta f - F_{Y1}$ = $1900\ CPS \pm \Delta f$

$200KC \pm \Delta f - F_{Y2}$ = $2000\ CPS \pm \Delta f$

$200KC \pm \Delta f - F_{Y3}$ = $2550\ CPS \pm \Delta f$

$200KC \pm \Delta f - F_{Y\ SPARE}$

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.

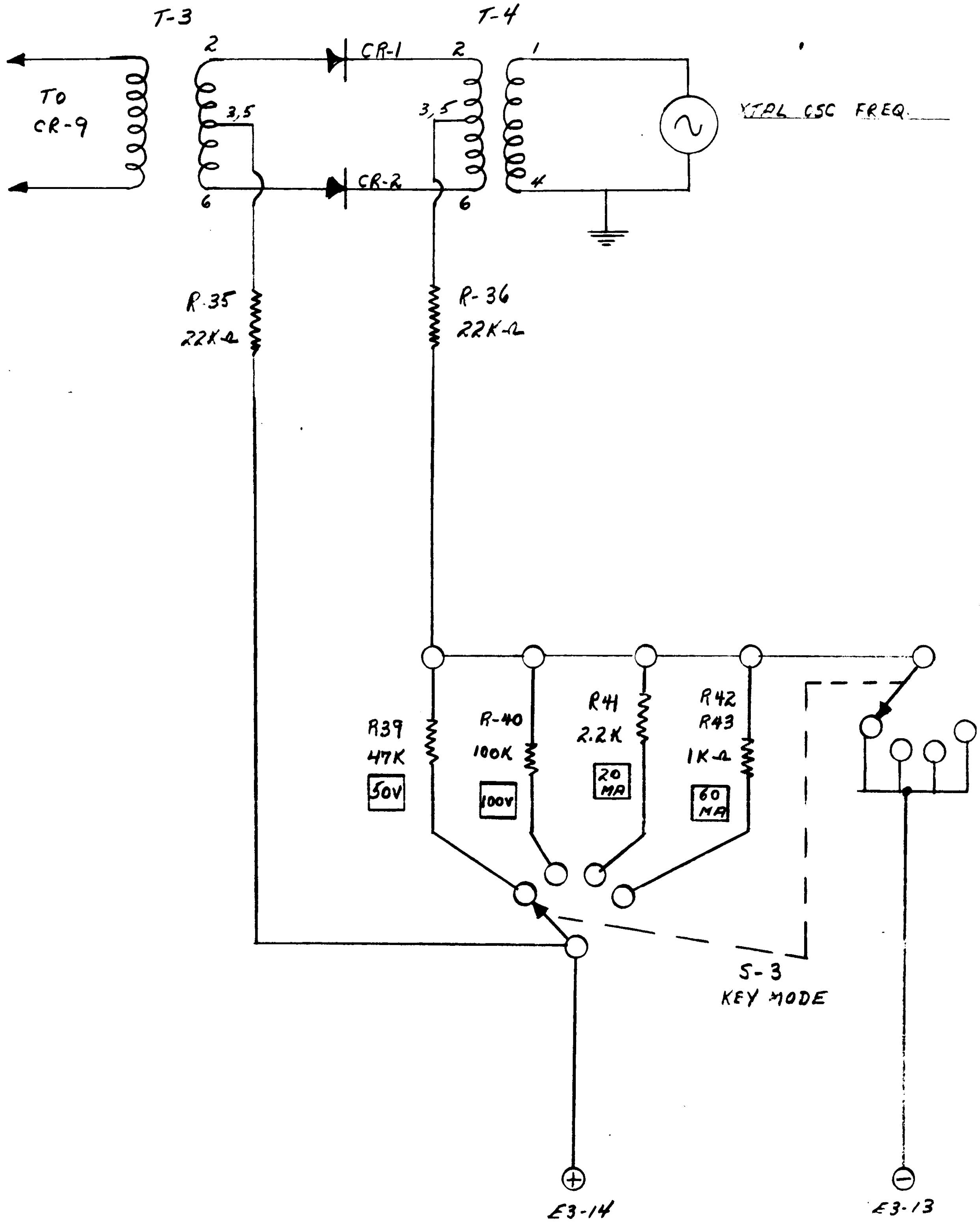
5. The Keying Input Circuit and First Keyer:

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:

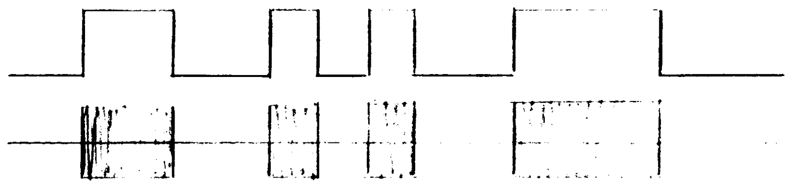
Simplified Circuit of Keying Input Arrangement:



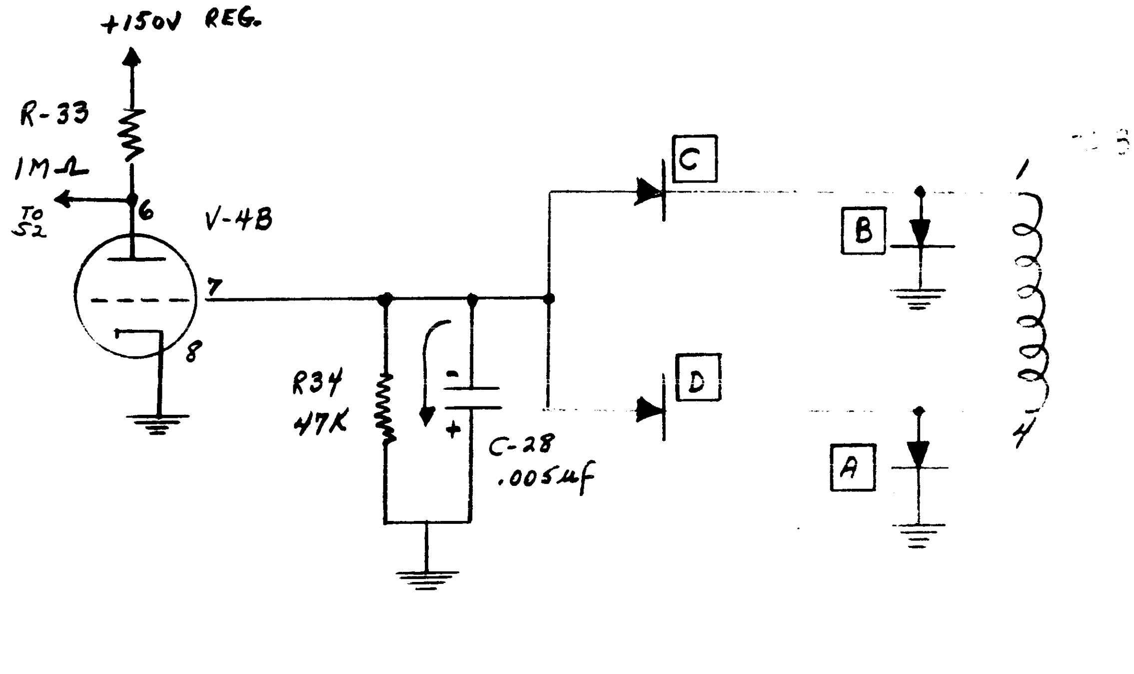
(1) when the polarity at terminal 14 is positive corresponding to a MARK, diodes CR-1 and CR-2 conduct, allowing the crystal oscillator frequency to appear at the secondary of T-3. When the polarity reverses, corresponding to a SPACE, the diodes do not conduct and the crystal oscillator frequency does 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 receifier 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 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 millisecond

(5) the period of a teletype "bit" is 22 milliseconds.

(6) the time constant of R-34, C-28 is <u>long</u> with respect to the period of the crystal oscillator frequency and <u>short</u> 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.

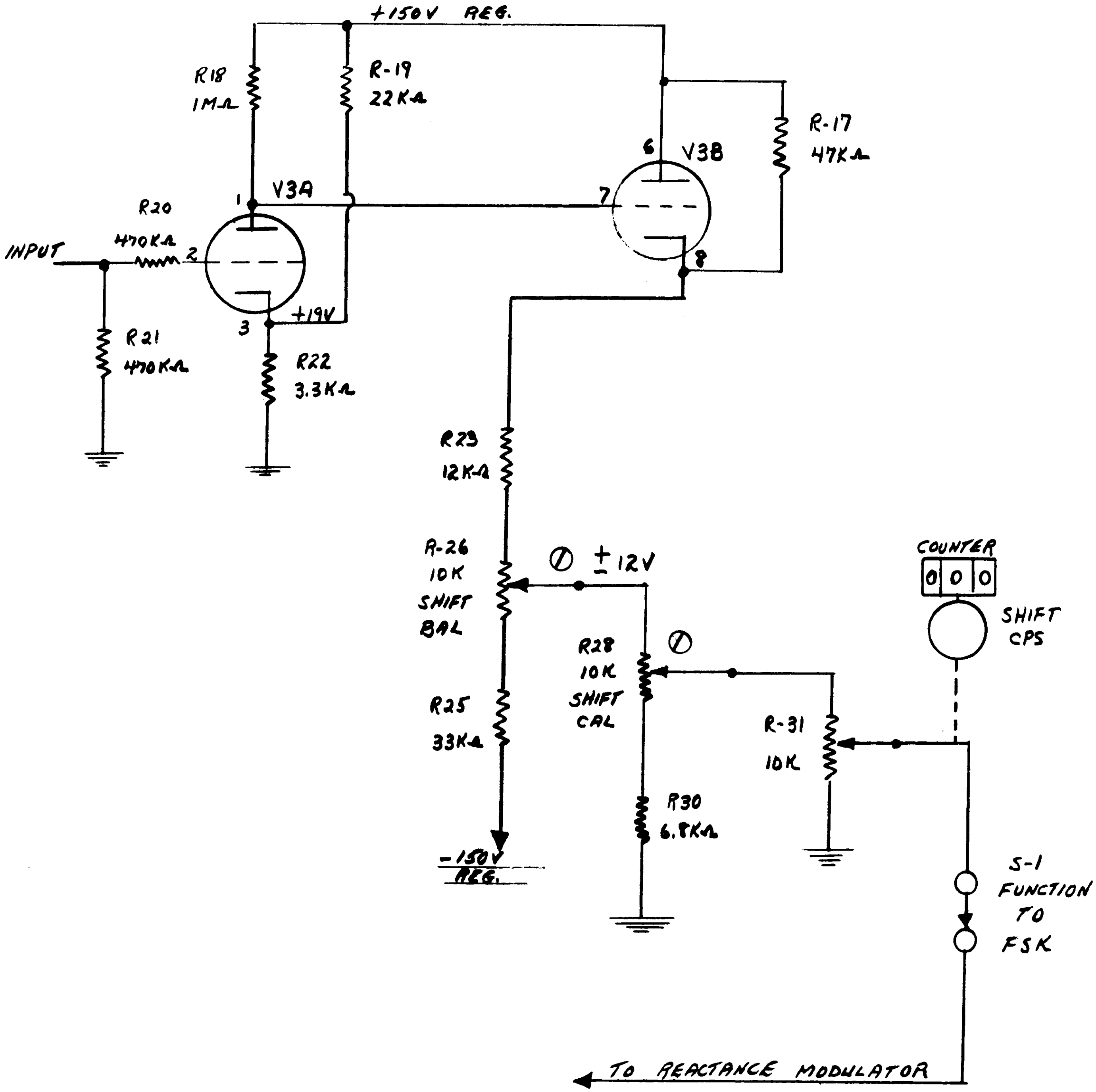
c) with V-3A conducting, the fall of plate voltage cuts off V-3B. This <u>reduces</u> the current in the voltage divider network consisting of R-17, R-23, R-26 and R-25, connected between the two 150 volt regulated supplies. A <u>negative</u> voltage appears at the wiper of R-26, the SHIFT BAL control.

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, <u>increasing</u> the current. A <u>positive</u> 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 CPS 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 <u>negative</u> voltage input will <u>raise</u> the frequency of the 200 KC oscillator, and that a positive input voltage will <u>lower</u> 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.

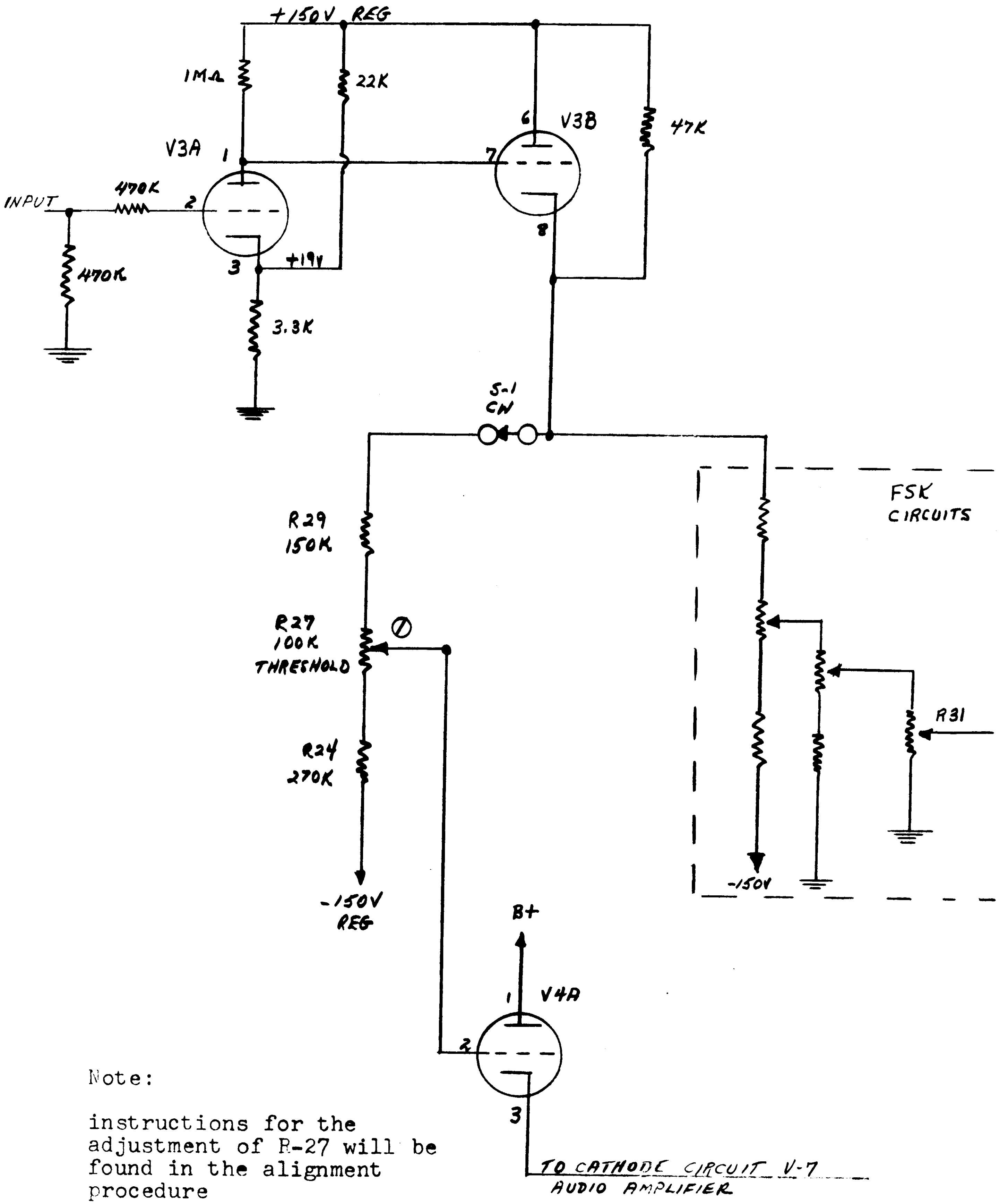
9. The CW Oscillator, V-6A:

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:

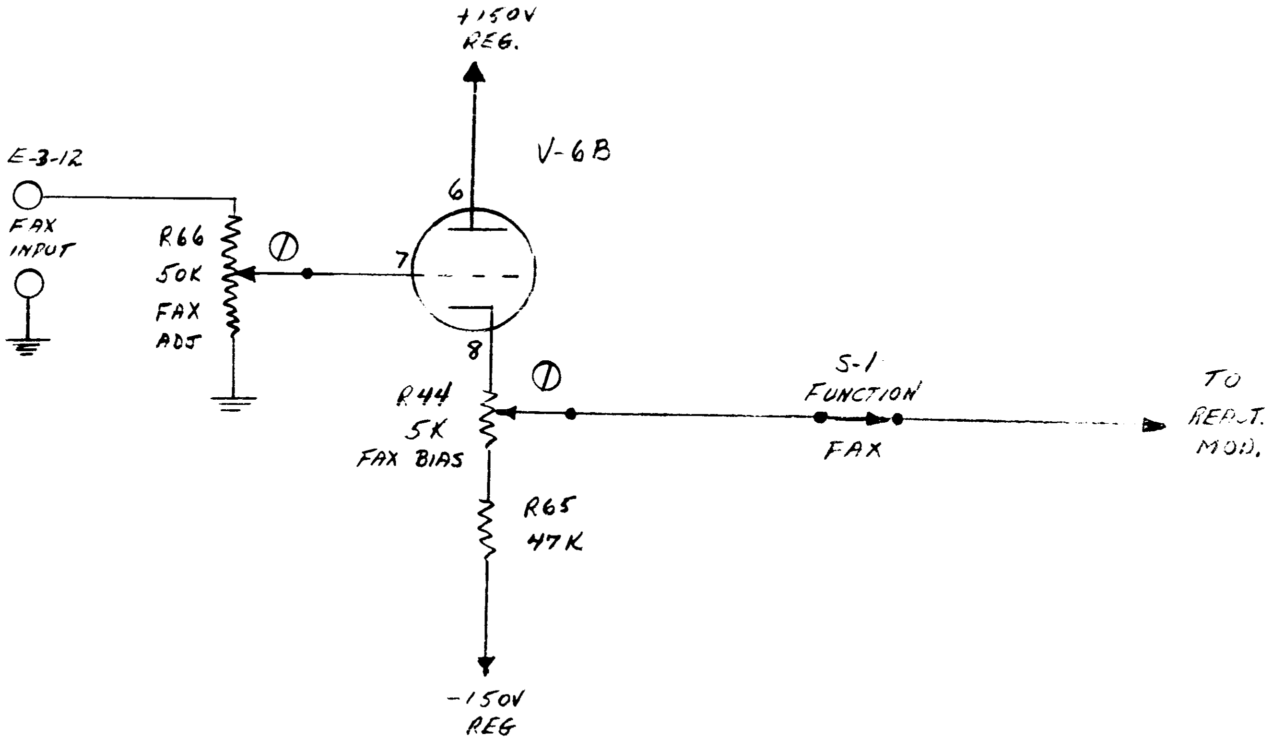


Note:

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, 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 2500 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.

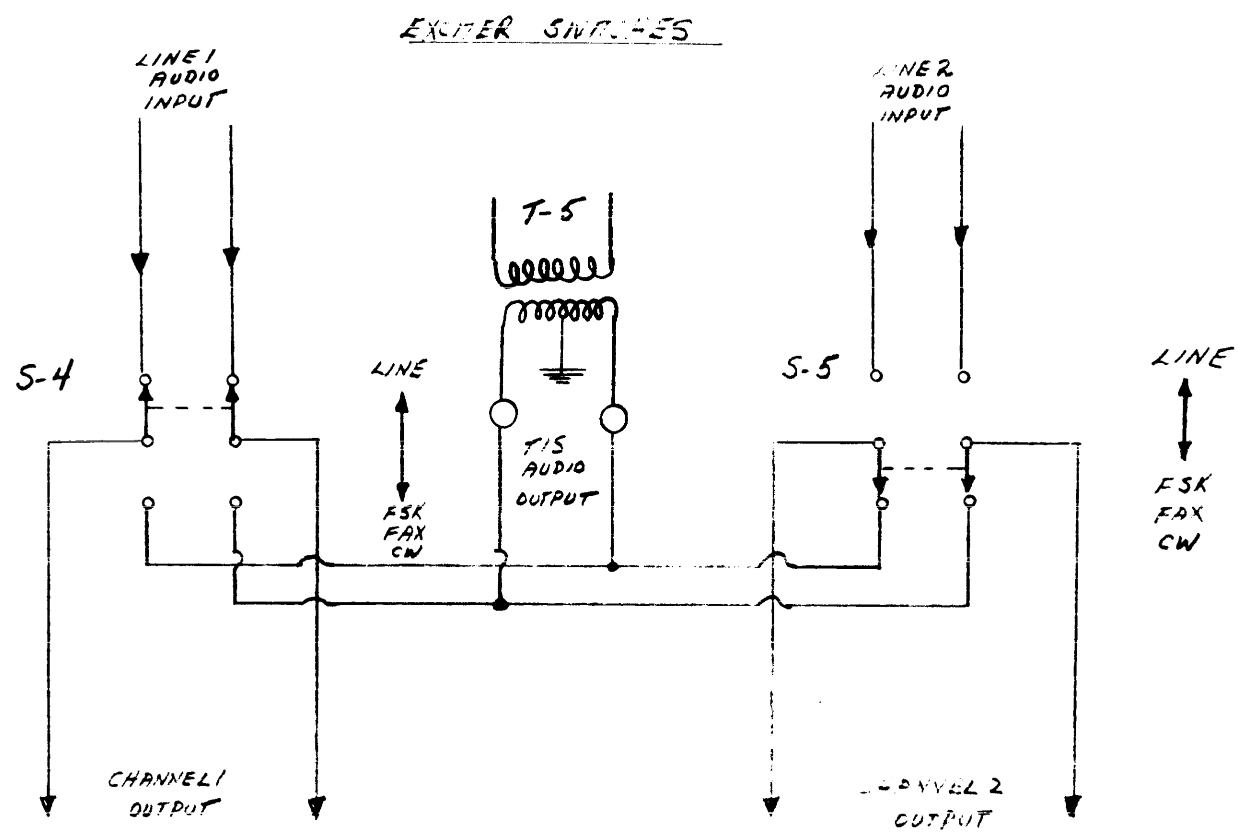
(7) The FAX input voltage is adjusted as indicated in the table below to produce the listed output frequencies.

Positive DC Input	Output Frequency
0	2500
1	2440 ± 6
2	2380 ± 12
5	2200 ± 30
10	1900 ± 60
15	1600 ± 30
20	1300

(8) If the results differ sharply from the above table: with +20 volts DC input adjust R-66 until the output frequency is 1300 cps and check shift range again.

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.

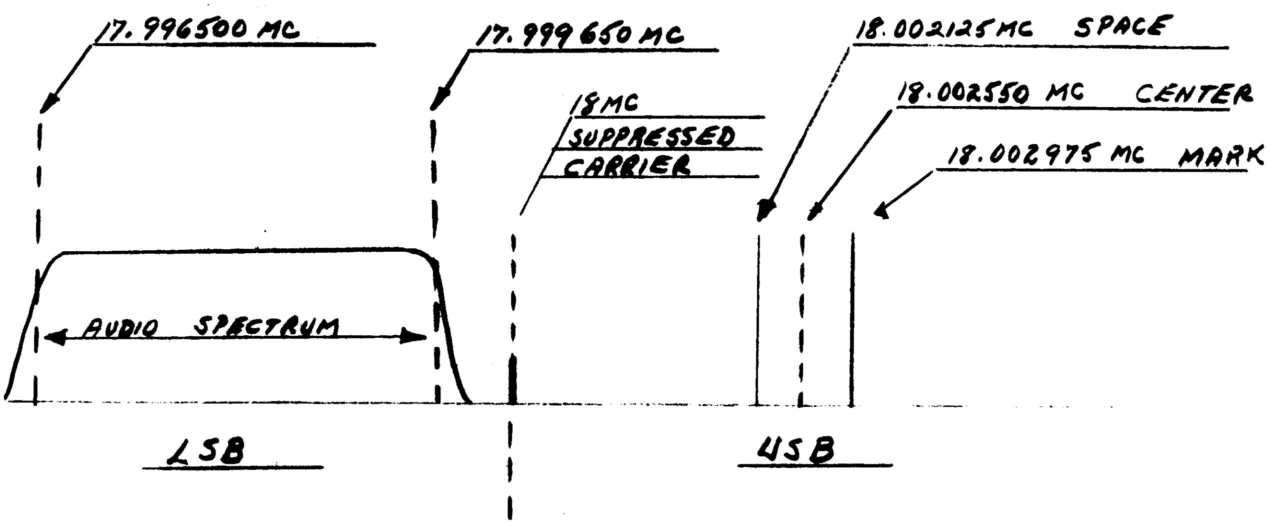


Assume that the LINE 1 audio input contains voice intelligence in the spectrum from 350 cycles to 3500 cycles per second, and that the TIS-3 is being operated in the FSK mode, with an 850 cycle total shift at a center audio frequency of 2550 cycles per second.

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.

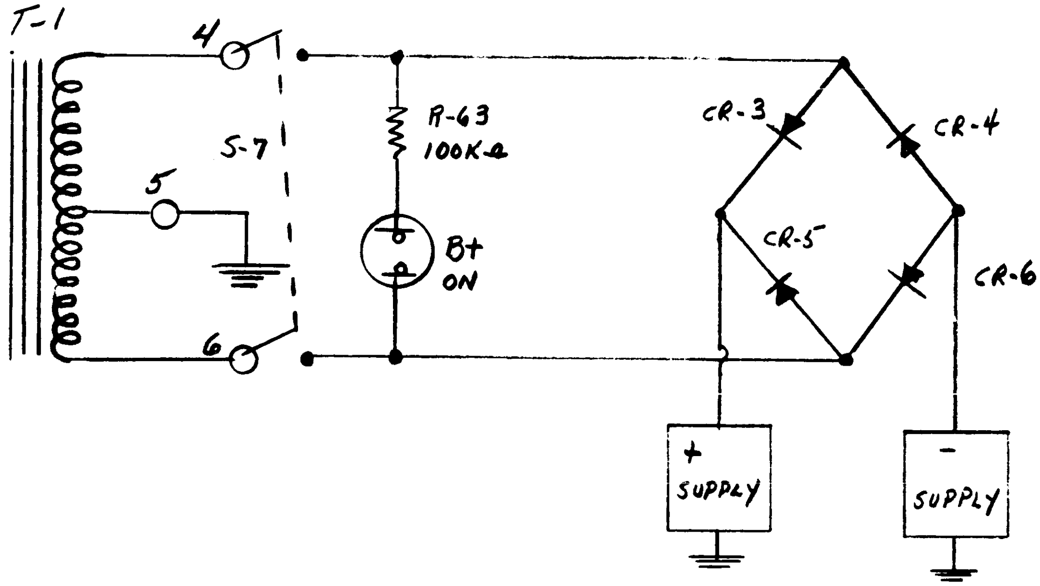
Assume that the inputs to the sideband transmission equipment are to be translated to a frequency of 18 mcs. The RF output spectrum is sketched below:



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.

C. Operation of the Model TIS-3 Tone Intelligence Unit

1. Preliminary:

a) the front panel STANDBY B PLUS ON switch is placed in the STANDBY position when the TIS-3 is not in use. In the STANDBY position:

(1) line voltage is applied to the oven heater circuits of the 200 KC oscillator. The front panel OVEN indicator monitors the cycling of the control thermostat. An overload in this circuit will result in the "blowing" of front panel "indicator" fuse F-2, labelled, "OVEN".

(2) 6.3 volts AC is applied to all filament circuits.

(3) 6.3 volts AC is applied to the heater circuits of Z-1 and Z-2, the plug in crystal oscillator ovens.

b) thus: in STANDBY position, oven and filament circuits are energized to maintain stability and to decrease warmup time. The line voltage plug, P-2, should be connected to a constantly energized voltage source. Should input power be removed for a considerable period, the unit will require a 24 hour warmup.

c) in STANDBY position, F-1, the front panel "indicator" fuse labelled "MAIN", protects the 6.3 volt circuits. In B PLUS ON operation, F-1 protects all circuits served by main power transformer T-1.

2. FSK Operation:

a) place the FUNCTION switch to the FSK position.

b) place the TEST switch in the LINE position.

c) place the CENTER FREQ CPS switch to the 2000 or 2550 position, as appropriate.

d) set the SHIFT CPS control until the counter indicates the total frequency shift desired.

e) set the KEY MODE switch to the position matching the mode of the TTY signals furnished by associated TTY equipment.

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 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.

TH-39B (TIS-3A) Field Alignment Procedure

Test Equipment Required

1. Square Wave Generator, Measurements Model 71.
2. Frequency Counter, H.P. 524c or equivalent.
3. Oscilloscope, Tektronix 545A or equivalent.
4. DC Power Supply, 0 to +20 volts.
5. Mulit-meter, Simpson Model 260.
6. TMC Model ISK or equivalent.
7. TMC Model PSP-1 Power Supply or equivalent.

Preliminary

1. With Unit plugged into AC Power, check the following voltages with the B+ switch ON.

E-1 term. board	Voltage Indication ± 10%.
1 to Gnd	6.3 VAC
2 to Gnd	6.3 VAC
3 to 4	110 or 220 VAC
5 to Gnd	+200 VDC
6 to GND	+150 VDC
7.to Gnd	-150 VDC

2. At the end of approx. 15 minutes the oven should start to cycle.

Crystal Oscillator Alignment

1. Check Crystal Ovens for proper crystals:
   Y-1 198.1 Kc
   Y-2 198.0 Kc
   Y-3 197.45 Kc
   Y-4 Spare or Customers choice.
2. Connect scope yellow lead (center tap) of L-6; Voltage should be approx. 60 volts peak to peak;
3. Connect Counter to L-6 yellow lead;turn S-6 to 2,000 and tune L-6 for Max. output and adjust C-36 for 198.0 Kc.
4. Turn S-6 to 1900 and adjust C-35 for 198.1 Kc. Turn S-6 to 2550 and adjust C-37 for 197.45 Kc. Turn S-6 to SPARE and adjust C-38 for correct frequency of the Crystal if there is one.

200 Kc Oscillator and Reactance tube Alignment

1. Set the Controls as follows:
   a. R-31 (shift cps) to 000.
   b. S-2 (test) to SPACE.
   c. S-1 (function) to FSK.
   d. S-6 (center Freq.) to SPARE.

200 Kc Oscillator (cont.)

2. Connect scope and counter to pin 2 of V-5(mixer).
3. Adjust C-3 to 200 Kc ± 10 cycles.
4. Adjust C-46 to 200.000 Kc, scope should indicate 5 to 6 volts peak to peak.
5. Set R-31 (shift CPS) to 1,000; frequency should decrease to 199.500 Kc ± 5 cps; Switch S-2 to Mark position and the frequency should increase to 200.500 Kc± 5 cps. If the above is not obtained make the following adjustments.
   a. connect a center scale indicating VTVM to the arm of R-26.
   b. Adjust R-26 so that the indication on the VTVM is equally + and - when switching S-2 from MARK to SPACE. (approx. +12 and a -12 VDC). Disconnect test equipment.
   c. With R-31 set to 1,000 cps shift, adjust R-28 for an indication of 200.500 Kc when S-2 is in the MARK position, Switch S-2 to SPACE and frequency should be 199.500, if it is not it may be necessary to adjust C-18 for equal shift above and below 200.000 Kc.

Mixer and Audio Balance and Level Adjust

1. Set controls for test as follows:
   a. Connect 600 ohm load, scope and counter across terminals 7 and 8 of E-3 (ch.1).
   b. Throw S-4(Channel 1) down to CW,FAX,FSK position.
   c. Turn S-6 (center freq) to 1900.
   d. Set R-49 (level adj.) for 0 DM on output Meter.
   e. Turn S-2 (test) to MARK position.
   f. Turn S-1 (function) to FSK position.
   g. Set R-31 (shift CPS) to 000.

2. Using a DC volt meter measure the DC voltages on pin 3 and 8 of V-5 the Mixer, adjust R-67 so that they are equal.
3. Using a DC volt meter measure the DC voltages on pin 3 and 8 of V-7 Audio Amp., adjust R-64 so that they are equal.
4. By adjusting R-49 (level adj.) the output meter should indicate full scale and minimun.
5. With S-6 (center freq.) in the following positions the counter should indicate frequencies as below:

Position	Frequency
1. 1900	1900
2. 2000	2000
3. 2550	2550
4. SPARE	0

6. With R-49 (level adj) set for 0 DBM on the output meter the scope should indicate MORE than 1.5 V peak to peak.

FAX Alignment

1. Set controls as follows:
   a. S-1 (function) to FAX.
   b. R-31 (shift CPS) to 000.
   c. R-66 (FAX adj.) max. CW.
   d. Set S-6 (center freq.) to 1900.
   e. Connect scope and counter to 600 ohm load at pin 7 and 8 of E-3.
   f. Connect DC power supply 0 to +20 volts to FAX input pin 12 of E-3.
2. With +20 VDC to the FAX input adjust R-66 for an output frequency of 1300 cps,0 VDC adjust R-44(2500)
3. The following input voltages an d output frequencies are typical of a unit worning properly.

+ DCV	Output Freq.
20	1300
15	1600 ± 30
10	1900 ± 60
5	2200 ± 30
2	2380 ± 12
1	2440 ± 6
0	2500

CW Test and Alignment

1. Set Controls as follows:
   a. S-1 (function) to CW.
   b. R-27 (threshold adj.) to center of its range.
   c. Connect Square Wave Generator to FSK, CW Keying input, set mode SW to 50v position. set Gen. for 45 cps.
   d. S-2 (test) to LINE.

2. Connect scope(to pin 1 of V-6) and counter and adjust L-3 with an allen wrench for 1,000 cps and scope should indicate 60 volts peak to peak.

3. Adjust R-49 (level adj.) for 0 DBM.
4. Adjust R-46 for best square wave output.
5. Adjust R-27 (threshold adj.) for 0 volts out in a space condition. In a MARK condition the output should be 1,000 cps at 1.5 V peak to peak.

FSK Test

1. Connect Units as per Figure 1.
2. Set Controls as follows:
   a. Throw S-4 (chan. 1) down to CW,FAX,FSK.
   b. Turn S-6 (center freq.) to 2,000.
   c. Set S-3 (Key Mode) to proper input method.
   d. Adjust R-49 (level adj.) for 0 DBM.
   e. Turn S-2 (test) to LINE.

FSK Test(Cont.)

2. f. Turn S-1 (function) to FSK.
   g. Set R-31 (shift CPS) to 1,000.

3. Check for correct frequency shift by switching S-2 from Mark to SPACE using Below chart:

Set SHIFT to	Frequency Shift
1,000	1,000
800	800 ± 2
600	600 5
500	500 7
400	400 7
300	300 5
200	200 2
100	100 2
50	50 1
0	0 0

4. Turn S-2 (test) to LINE; R-31 to 800 shift.
5. Vary output freq. of Square Wave generator from 5 to 200 cps (400 Baud) and observe scope for distortion. If a Distortion Anyalizer is availible use it and adjust R-67 for Minimum distortion. It may be necessary to readjust R-64 (audio Bal.).

Figure 1
FSK, CW keying Test