c. MAJOR AND MINOR UNITS DETAILS. — In more detail, the major and minor units of Radio Transmitting Set AN/FRT-5A consist of the following:

(1) RF UNIT T-225A/FRT-5. — RF Unit T-225-A/FRT-5 is the right-hand one of the two main bays. It contains, on a special mounting space, the units described under paragraphs (*a*), (*b*), (*c*), (*d*), (*e*), (*f*), and (*g*) below. This space is a pivoted, double-width, 25-inch high standard equipment rack. Pivoting this rack provides easy access to the rear of all the units mounted thereon. RF Unit T-225A/FRT-5 contains as permanent equipment the circuits and units described under paragraphs (*h*), (*i*), (*j*), (*k*), (*l*) and (*m*).

(*a*) RF OSCILLATOR O-91A/FRT-5. — (Refer to figure 1–3.) — RF Oscillator O-91A/FRT-5 is a stabilized variable-frequency oscillator which derives

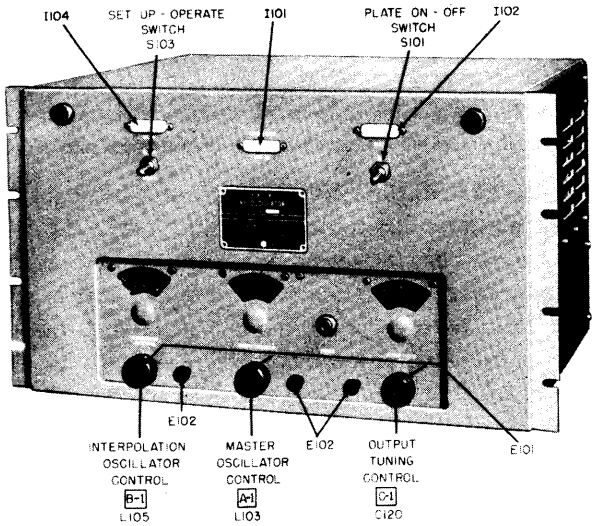


Figure 1–3. RF Oscillator O-91A/FRT-5, Front View

its stability from a 100-kc crystal standard. Utilizing a permeability tuned oscillator, it provides a frequency stabilized output in the range of 2-4.5 mc. It is mounted in the equipment rack which occupies the lower part of the r-f bay. Refer to table 1–1 for dimensions.

(*b*) RF OSCILLATOR O-92A/FRT-5. — (Refer to figure 1–4.) — RF Oscillator O-92A/FRT-5 is a crystal-controlled 10-channel oscillator. With proper crystals, the oscillator provides an output frequency of from 2-4.3 mc. Plate and filament voltages for this unit are derived from the main transmitter. It is mounted in the equipment rack of the r-f bay. Refer to table 1–1 for dimensions.

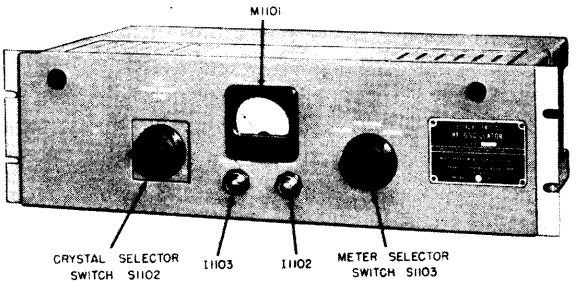


Figure 1–4. RF Oscillator O-92A/FRT-5, Front View

(*c*) FREQUENCY SHIFT KEYER KY-45A/-FRT-5. — (Refer to figure 1–5.) — Frequency Shift Keyer KY-45A/FRT-5 is used to provide a frequency shift which is linear with respect to the keying voltage. In a telegraph system, it causes the transmitter to emit one frequency for a "mark" signal and another for a "space" signal. Because of its linearity with respect to the keying voltage or current, it may also be used for "photo" and teleprinter transmission. This unit is mounted in the equipment rack of the r-f bay. Refer to table 1–1 for dimensions.

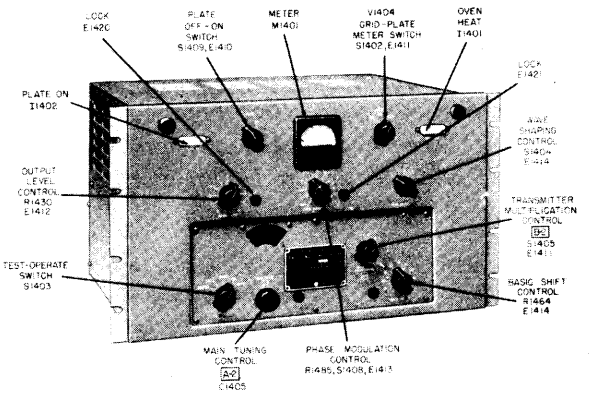


Figure 1–5. Frequency Shift Keyer KY-45A/FRT-5, Front View

(*d*) POWER SUPPLY PP-454A/FRT-5. — (Refer to figure 1–6.) — Power Supply PP-454A/-FRT-5 is a dual supply furnishing plate and filament voltages to RF Oscillator O-91A/FRT-5 and Frequency Shift Keyer KY-45A/FRT-5. It also supplies a regulated bias to the keyer. It is mounted in the equipment rack of the r-f bay. Refer to table 1–1 for dimensions.

(*e*) SERVO AMPLIFIERS. — There are six identical interchangeable, plug-in servo control amplifiers mounted in a common enclosure on the equipment rack in the r-f bay. One of these units is associated with each of the six tuned servo-positioned circuits in

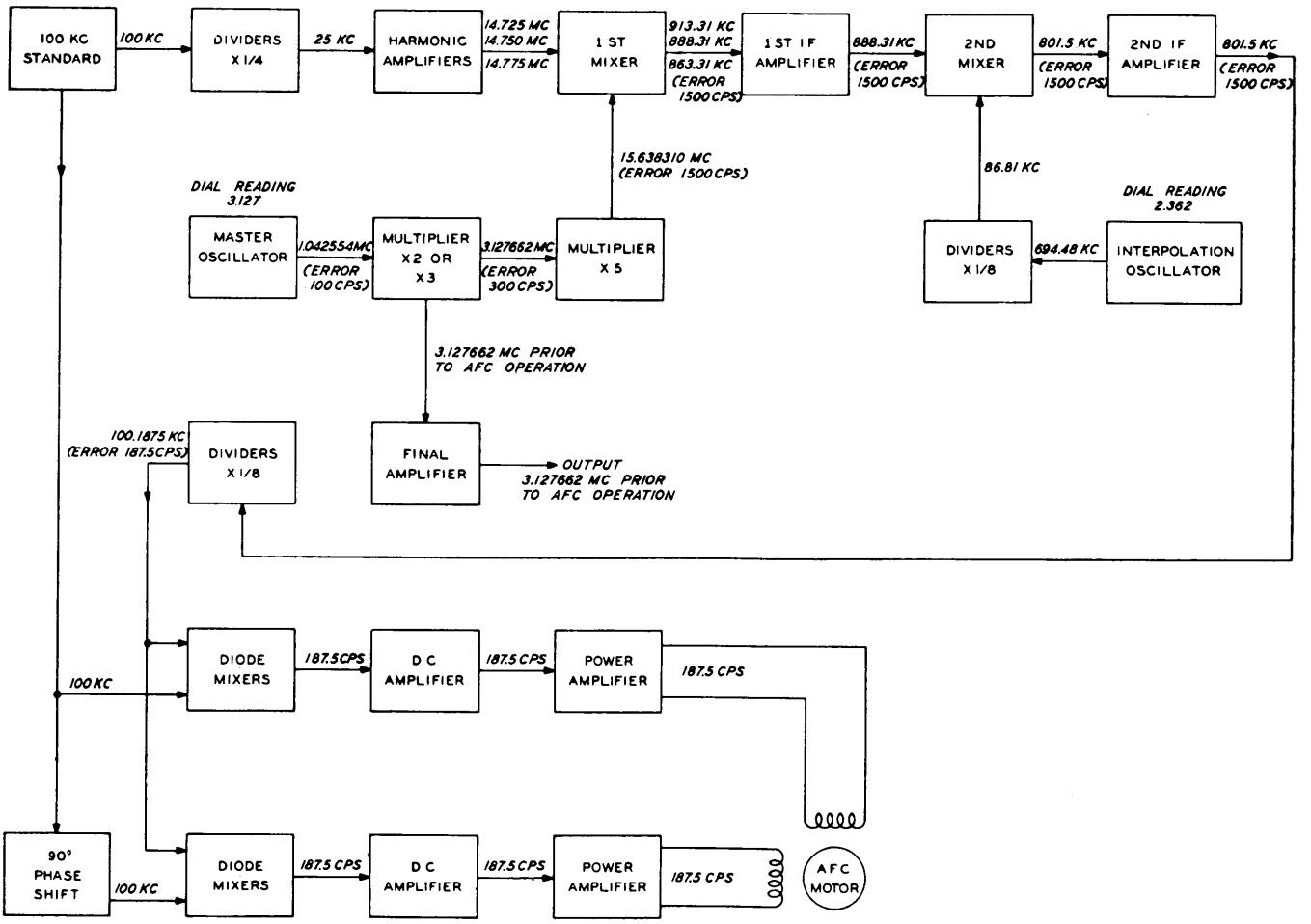
will be equal to the minimum frequency of the oscillator in kilocycles (600) plus 1/25th the reading on the dial (in units). In this example the dial reading is 2362, so the actual oscillator frequency in kilocycles would be 600 + (1/25 x 2362) or 694.48.

The remainder of the chart should be quite self-explanatory, with one exception. Take, for instance, a case where the output frequency is such that the 1st i-f amplifier would receive a frequency of 875 kc and also one of 900 kc. Since both of the frequencies lie in the pass band of the 1st i-f strip, both frequencies would be delivered to the second mixer with little or no attenuation. However, in any case of this sort, the output from the interpolation oscillator and interpolation dividers would be such that the output frequencies of the 2nd mixer would be 800 kc and 825 kc, and since the 2nd i-f amplifier will pass only a very narrow band of frequencies centered on 800 kc, the 825-kc signal would be attenuated in the 2nd i-f amplifier.

Figure 2–13 shows the frequencies which would result if the same output frequency (3,127,362 cps) were desired but with the master oscillator setting being in error by, e.g., 100 cps. It is evident that an output of a frequency other than zero will be obtained from the power amplifiers which will cause the AFC motor to rotate and correct the master oscillator frequency. As the master oscillator frequency error becomes smaller, the output from the power amplifiers also decreases in frequency until the master oscillator is set up on the exact desired frequency. Then the output frequency from the power amplifiers will again be zero cps and the AFC motor will cease to rotate.

(3) FREQUENCY SHIFT KEYER KY-45A/FRT-5.

(*a*) GENERAL. — The frequency-shift keyer is ordinarily used at the transmitting station of a frequency-shift radio-telegraph circuit. Telegraph signals are generated at a control point equipped with teleprinter keyboards and tape recorder. Both the transmitting and receiving radio stations may be remote from the communication centers and they are ordinari-



Figur 2–13. Block Diagram — RF Oscillat r O-91A/FRT-5, Typical Frequ nci s During Op ration, 100-cps Error in Mast r Oscillator Setting

ly connected to the station by means of land lines. Figure 2–14 is a block diagram of the frequency-shift keyer.

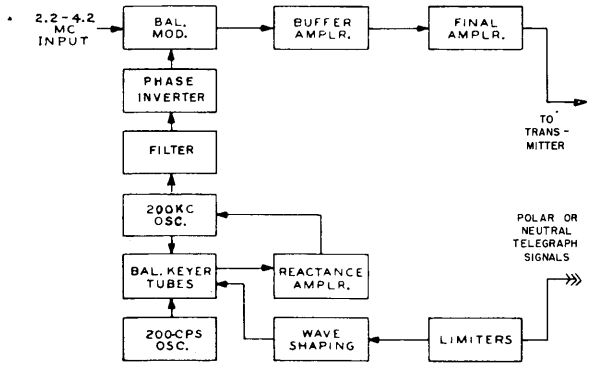
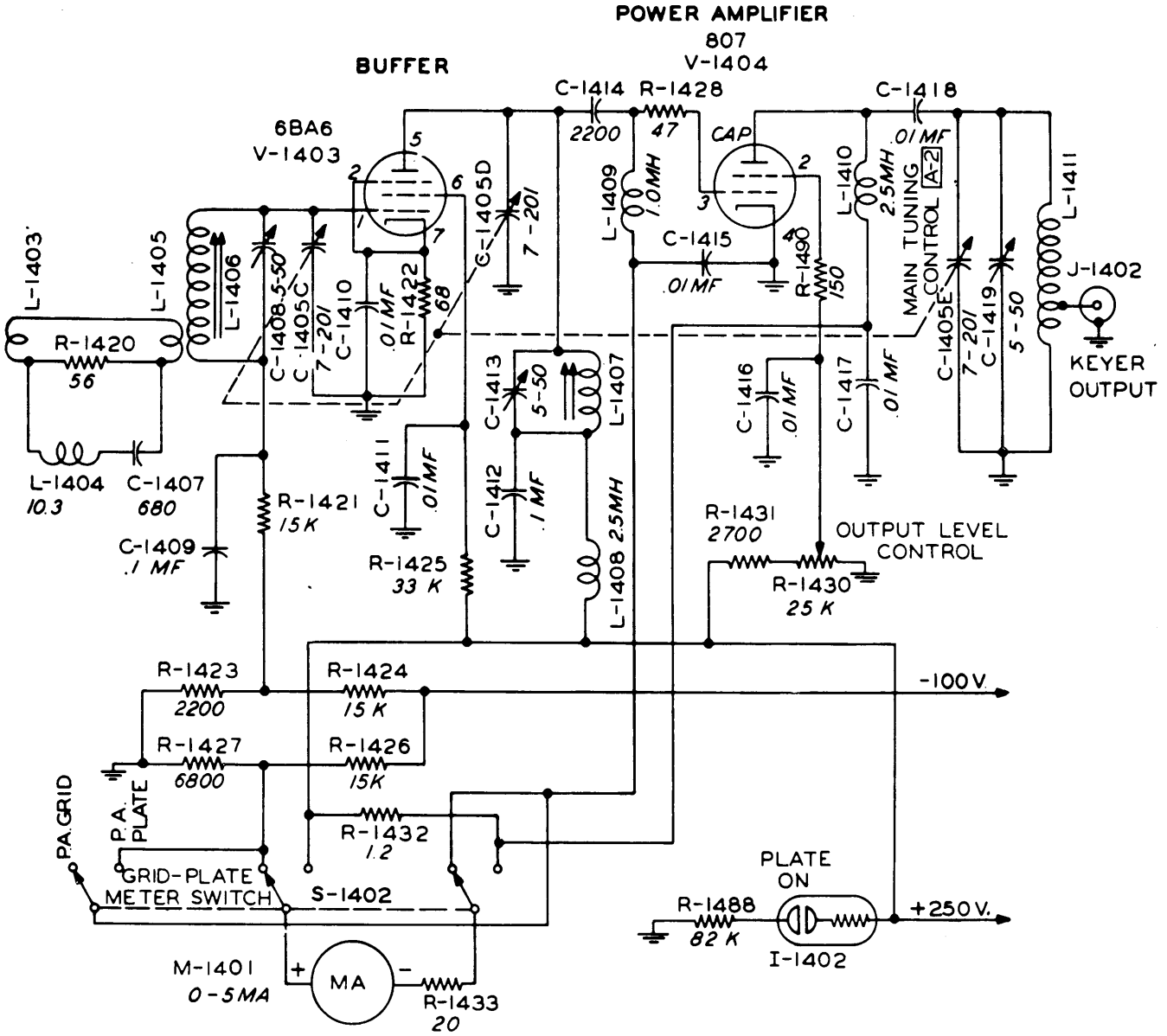


Figure 2–14. Functional Block Diagram — Frequency Shift Keyer KY-45A/FRT-5

(*b*) OPERATING FREQUENCY. — The keyer requires an injection voltage which is in the range of 2.2 mc to 4.2 mc, and 200 kc higher than the operating range. This injection voltage is mixed with a 200-kc frequency-shifted voltage from an internal source to produce an output voltage in the frequency range of 2 mc to 4 mc. The external injection voltage is ordinarily provided by RF Oscillator O-91A/FRT-5, but any stable injection voltage of good wave form in the range of 2.2 mc to 4.2 mc may be used.

(*c*) BALANCED MODULATOR, BUFFER AND FINAL AMPLIFIER. — A simplified schematic of the high frequency portions of the frequency-shift keyer is shown in figure 2–15. A radio-frequency source in the range of 2.2 mc to 4.2 mc is fed into J1401 and then to the #1 grids of V1401 and V1402 which con-



Figur 2–15. Simplified Sch matic — Frequ ncy Shift K y r KY-45A/FRT-5 High Frequency Section

stitute the balanced modulator (refer to figure 2–18). The #3 grids of V1401 and V1402 are excited in push-pull from a 200-kc voltage derived from the frequency-shifted oscillator. Since the high frequency input is supplied to the #1 grids of these tubes in identical phase, this voltage is cancelled in the output circuit because of its push-pull arrangement. Complete cancellation of this voltage occurs when the balance potentiometer R1416 is adjusted so that the transconductance of the two tubes is identical. With the high frequency input cancelled, only the mixer products remain, the most important of these being the sum and difference frequencies produced by the mixing of the high frequency signals with the 200-kc frequency-shift voltage. This keyer operates on the lower difference frequency (200 kc below the injected signal) which is selected by the four gang-tuned circuits associated with the OUTPUT TUNING control. These gang-tuned circuits include the modulator plate circuit (L1402), buffer grid (L1406), the power amplifier grid (L1407) and the power amplifier plate circuit (L1411). These four circuits are provided with inductive and capacitive trimming to make possible exact tracking throughout the 2-mc to 4-mc operating range. Because the tubes used in the buffer-amplifier and the final amplifier have effective screen grids, neutralization is unnecessary. A meter switch, S1402, provides a convenient means of measuring the grid and plate currents of the final amplifier.

(*d*) 200-KC OSCILLATOR, BALANCED KEYER AND REACTANCE AMPLIFIERS. — (Refer to figure 2–16.) — The portion of the frequency-shift keyer which produces the frequency-shifted signal consists of a 200-kc oscillator (V1411), a balanced keyer tube (V1408) and two phase-shifting amplifiers (V1409 and V1410). The operation of the circuit can be most easily explained by means of vector diagrams. In figure 2–16 is shown the simplified circuit and in figure 2–17 are shown the various vector diagrams which will be used in the course of this explanation. If we let the vector E_0 represent the voltage across the oscillator grid coil L1415, then vector V1408G_1 represents the voltage at one terminal of pick-up loop L1416 while V1480G_2 represents the voltage at the opposite terminal of the same loop (V1416). The two voltages

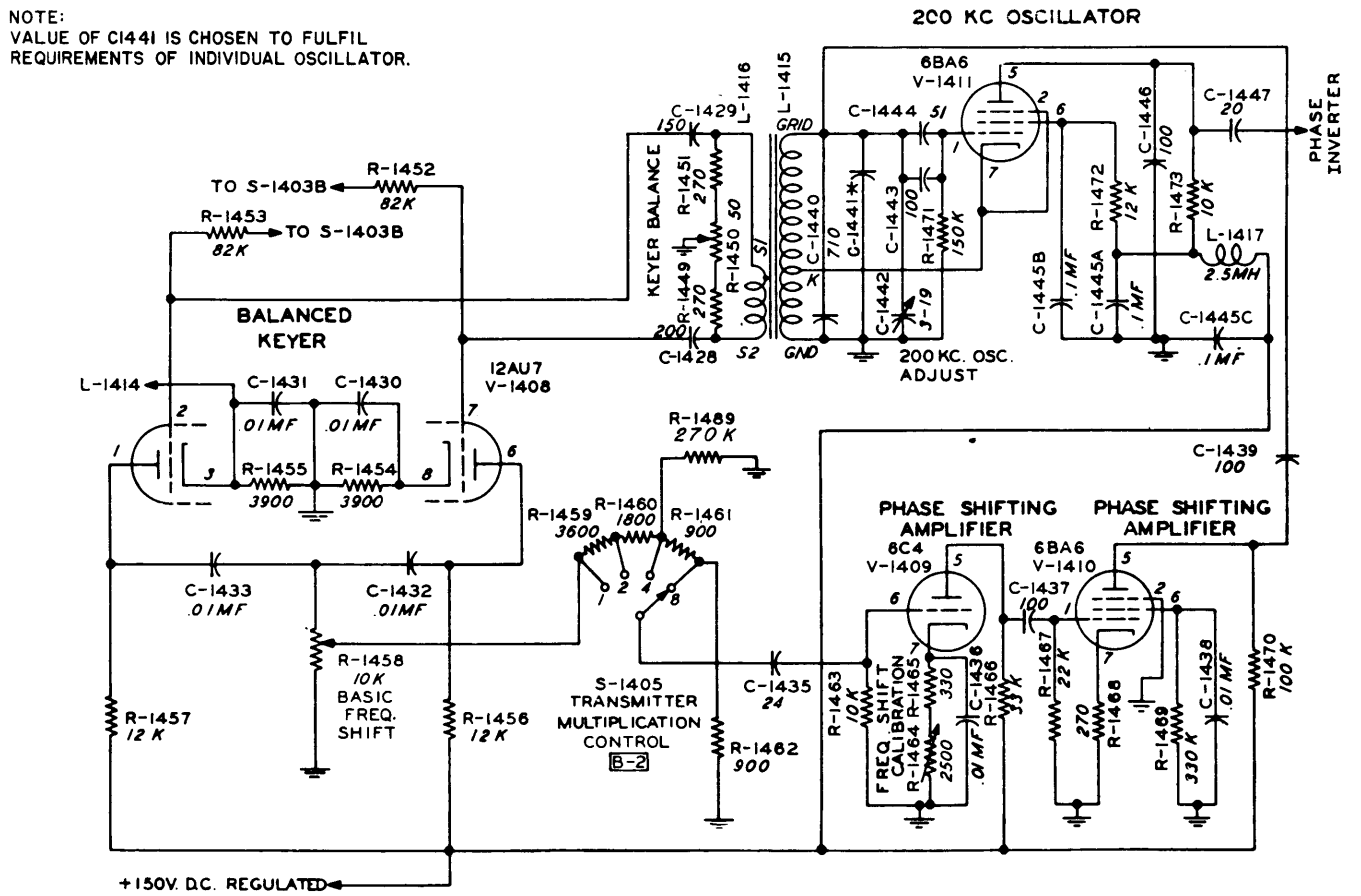


Figure 2–16. Simplified Schematic — Frequency Shift Keyer KY-45A/FRT-5, Reactance Tube Circuits

represented by vectors V1408G_1 and V1408G_2 are fed to the two grids of the keyer tube (V1408). Each section of V1408 is a voltage amplifier; one section (section 1) operates at a fixed amplification and the other section operates under the control of keying impulses with a gain determined by the bias applied to its grid. If the constant bias voltage is applied to one section, (section 1) of V1408, the output of this tube may be represented by the vector V1408P_1 in figure 2–17. At some particular instant during keying, the other section (section 2) will have its grid more positive and, at this instant, the plate signal may be represented by vector V1408P_2 which is 180° out of phase. The resultant vector at the plate of the tubes is shown at "C" in figure 2–17. Because C1435 has a high capacitive reactance at 200 kc, a leading current flows through the

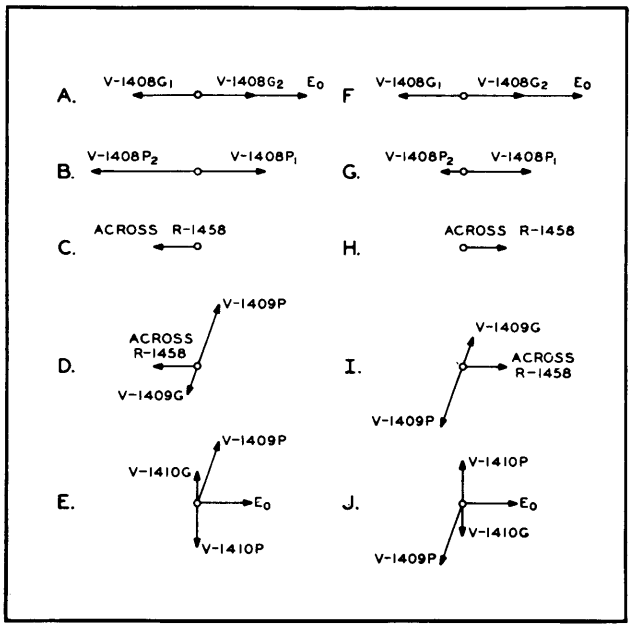


Figure 2–17. Vector Diagram — Frequency Shift Keyer KY-45A/FRT-5

series circuit consisting of C1435 and R1463. The values of C1435 and R1463 in this circuit are so selected that a phase shift of about 70° occurs and the leading vector shown at "D" results across R1463. The magnitude of this voltage may be adjusted by changing the position of the arm of potentiometer R1458 and/or the setting of tap switch S1405. This voltage is applied to the grid of V1409. The output of this tube may be represented by the vector V1409P which is 180° displaced from the voltage on the grid of V1409. Another capacitor-resistor series circuit, C1437 and R1467, brings about a 20° phase shift and the resulting voltage, represented by vector V1410G_1, is applied to V1410 whose plate voltage is then represented by V1410P. When this voltage is compared with the original oscillator vector, E_0, it may be seen that a lagging 90° relationship exists between these two voltages and a leading or capacitive current flows in the oscillator tank producing an effect much as if an additional capacitor had been placed across L1415, resulting in a lower frequency.

When the bias voltage applied to the grid of the section of V1408, which is allowed to vary in amplification, is made more negative than that of the constant amplification section, the vector relationships are as shown at "F". Vector V1408P_2 is smaller than V1408P_1 and the resultant vector appears at "H". This vector encounters a phase shift through C1435 and R1463 so that the vector relationships exist as shown at "I". After passing through V1409 the voltages appear as shown at "J". Here the voltage V1410P leads the oscillator voltage and a lagging current flows which adds to the inductive current in the oscillator tank, effectively reducing the circuit capacity and raising the frequency. The condition shown at "E" corresponds to a radio-telegraph "mark" because it is effective in lowering the frequency of the 200-kc oscillator (raising the final output frequency). The condition shown at "J" corresponds to a radio-telegraph "space" because it raises the frequency of the 200-kc oscillator. The circuit constants are so chosen that a linear change in keyer tube grid voltage produces linear frequency shift.

The magnitude of the reactive voltage (i.e., frequency shift) can be adjusted by potentiometer R1458. Further division of this voltage is possible through the use of TRANSMITTER MULTIPLICATION switch S1405, the function of which will be explained later.

Thus, under the control of the keyer tube, it is possible to produce either a leading or a lagging voltage at the plate of V1410 and this is equivalent to adding inductance or capacitance in its effect on the oscillator frequency. Control R1458 then provides a means by which the total amount of frequency shift can be adjusted. Because the amount of frequency shift which is present in the associated transmitter is dependent upon the degree of multiplication to which the output of this keyer is subjected, it is necessary to reduce the amount of frequency shift by means of control S1405. This switch provides for full shift, one-half shift, one-quarter shift, and one-eighth shift to provide for multiplication by one, two, four, and eight in the associated transmitter. To calibrate the frequency-shift control, R1458, an adjustment in the gain of the amplifier is provided by the cathode potentiometer R1464. Because of slight differences in the keyer tube gain characteristics and in circuit wiring, a balancing control, R1450, is provided to equalize the output of each section of the keyer tube when the d-c voltages

applied to the two grids are identical. A small amount of adjustment of the oscillator frequency is possible through adjustment of C1442. Because of the temperature-controlled oven and the high inherent stability of the circuit, adjustment of this control is unnecessary for extended periods of time.

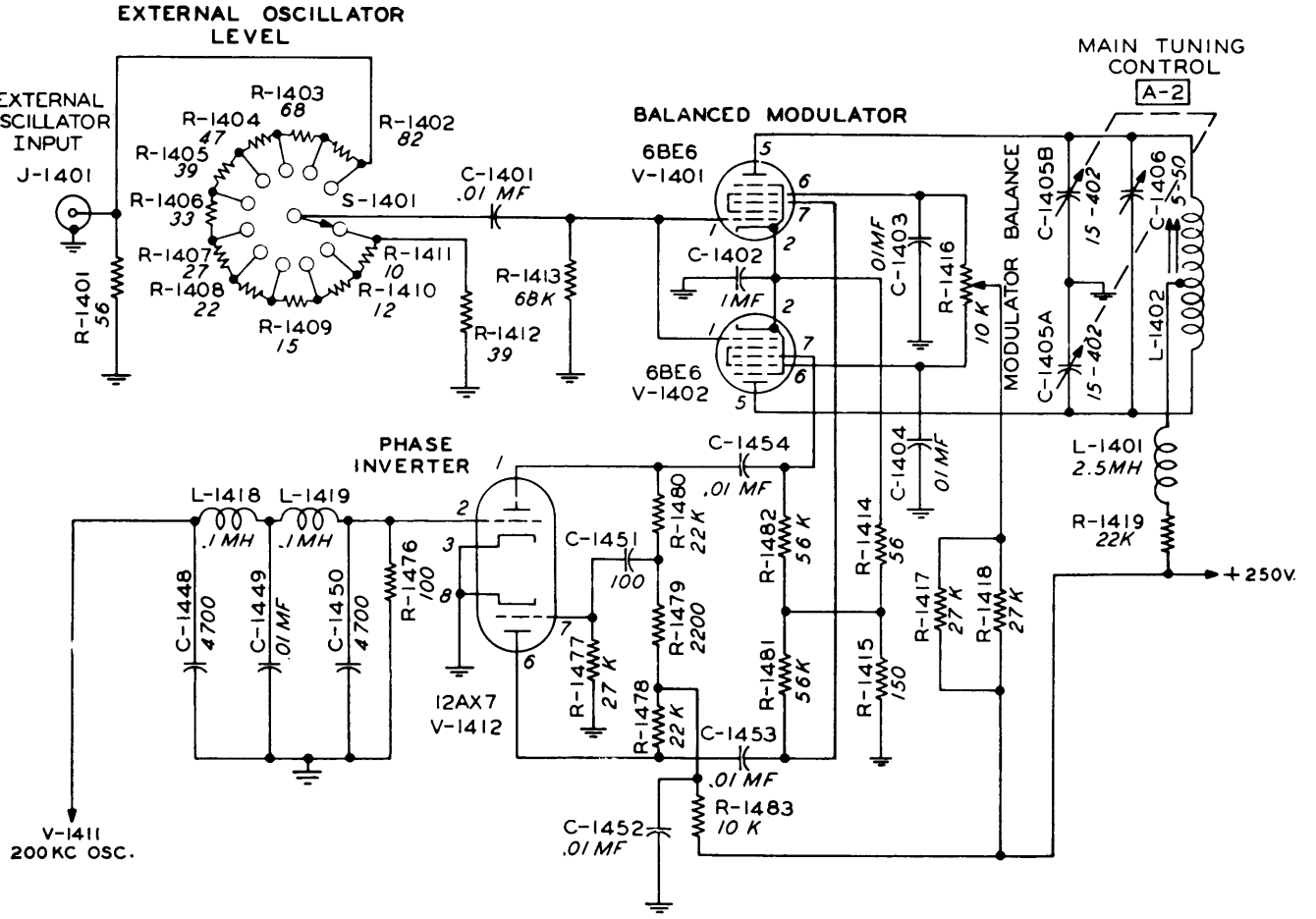


Figure 2–18. Simplified Schematic — Frequency Shift Keyer KY-45A/FRT-5, 200-Kc Filter and Phase Inverter Tube

(*e*) 200-KC FILTER AND PHASE INVERTER. — Figure 2–18 shows the 200-kc filters and the phase inverter in simplified form. Because harmonics of the 200-kc oscillator fall within the pass-band of the high frequency circuits of this keyer, these harmonics must be suppressed to eliminate spurious output. This is done with a low-pass filter consisting of C1448, C1449, C1450, L1418, and L1419. This filter passes the fundamental with very little attenuation but offers a high degree of rejection in the second and higher harmonics of the 200-kc oscillator. The phase inverter tube, V1412, serves to produce push-pull 200-kc voltage for application on the #3 grids of the balanced modulator tubes. This phase inverter employs a twin triode to secure the push-pull output voltages.

(*f*) LIMITERS AND WAVE-SHAPING FILTER. — (Refer to figure 2–19.) — Radio teleprinter or picture transmission signals are applied to the keyer line input connector J1407. Teleprinter signals pass through a negative peak limiter (V1405) so that only positive keying impulses reach switch S1403A. With S1403A in the FSK position a positive peak limiter presents an essentially fixed voltage having square-wave characteristics to the wave-shaping filter. The wave-shaping filter is a low-pass pi-section circuit. By selecting the proper position of S1404 it is possible to apply the desired amount of wave shaping to the square wave delivered by the limiter tubes. Wave shaping at this point materially reduces the side-band frequency components which are present with square-wave keying.

The TEST-OPERATE switch, S1403, provides a means by which carrier, space, mark, FSK, or photo transmission of the keyer can be provided. In the CARRIER position the input line is disconnected and

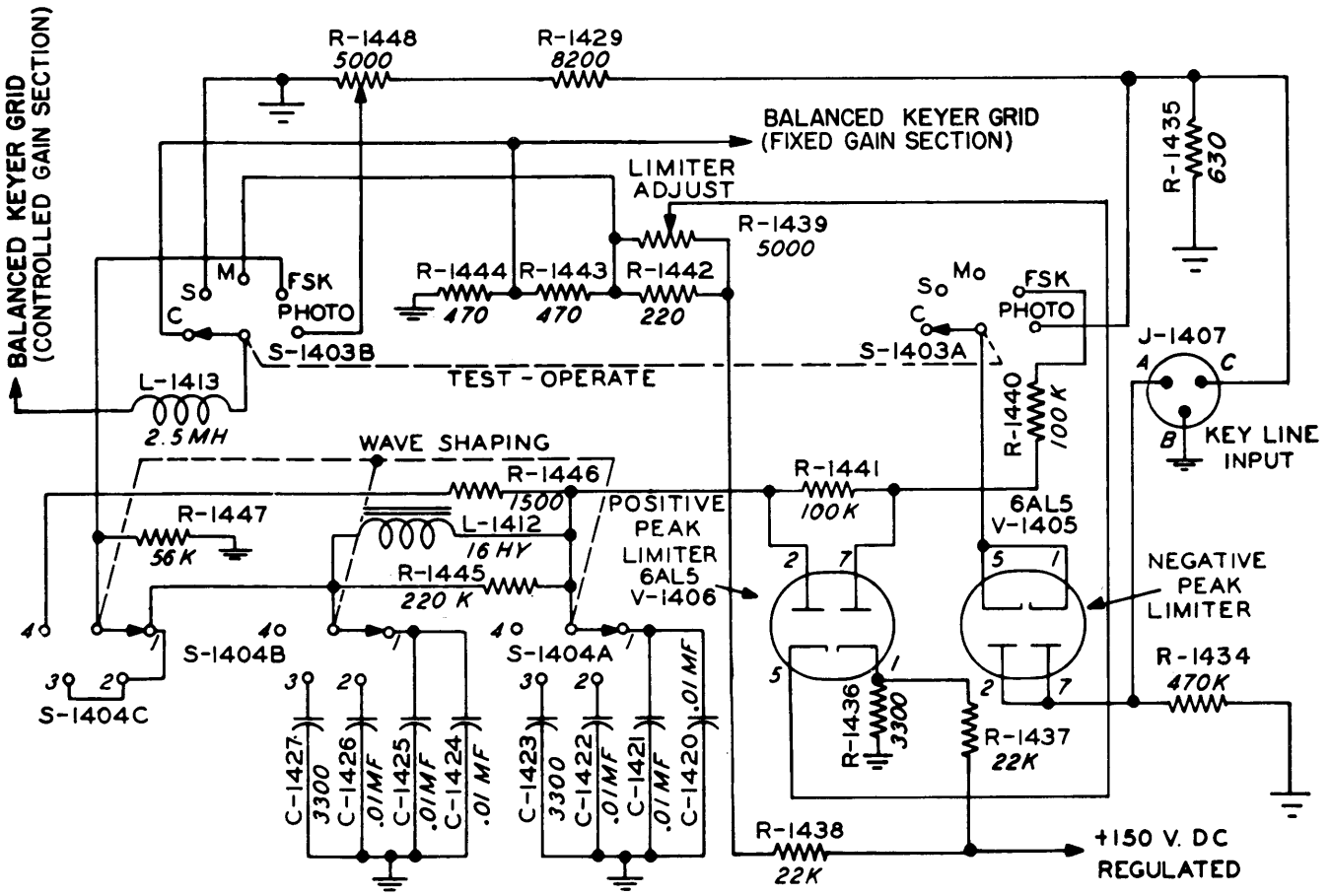


Figure 2–19. Schematic — Frequency Shift Keyer KY-45A/FRT-5, Input Circuit and Wave Shaping Filter

the same voltage is applied to both keyer tube grids. This results in voltages in phase opposition but of identical magnitude at the plates of the keyer tube so that essentially zero voltage appears across R1458, resulting in the natural frequency of oscillation for the 200-kc oscillator. In the MARK position a positive voltage is applied to the keyed grid of V1408 (pin #7) causing lower frequency of oscillation for the 200-kc oscillator, while in the SPACE position the input line is disconnected and zero voltage is applied to the keyed grid so that the 200-kc oscillator operates at a higher frequency. In the FSK position, the input line is connected through the positive peak limiter and into the keyed grid of V1408 through the wave-shaping filter. In the PHOTO position S1403 connects the input line without the wave shaping or positive peak limiting to the keyed grid of V1408. In photo transmission, the frequency of the 200-kc oscillator follows the keying voltage present on the line in a linear fashion. The key line input connector is arranged so that separate lines for photo and FSK may be left permanently connected. The proper line is then automatically selected by the TEST-OPERATE switch.

(*g*) PHASE MODULATION OSCILLATOR. — (Refer to figure 2–20.) — The phase modulation oscillator is a simple Hartley oscillator tuned to 200 cps. This 200-cps oscillator provides a voltage across R1455 such that up to one radian of phase modulation at 850-cps total shift is possible on the output signal. The use of phase modulation permits frequency diversity which is a decided advantage in the presence of severe multipath distortion in radio transmission.

(4) POWER SUPPLY PP-454A/FRT-5. — (Refer to figure 7–49.) — Power Supply PP-454A/FRT-5 provides the filament, bias, and plate potentials necessary for the operation of Frequency Shift Keyer KY-45A/FRT-5 and RF Oscillator O-91A/FRT-5. Figure 7–50 is a schematic diagram of Power Supply PP-454A/FRT-5. Two separate power supplies are incorporated.

One of the power supplies furnishes voltage for RF Oscillator O-91A/FRT-5. This power supply includes a full-wave rectifier using two type 5R4GY rectifiers. The filter system employs a choke input and utilizes two 10-mf capacitors on the output. A type OA2

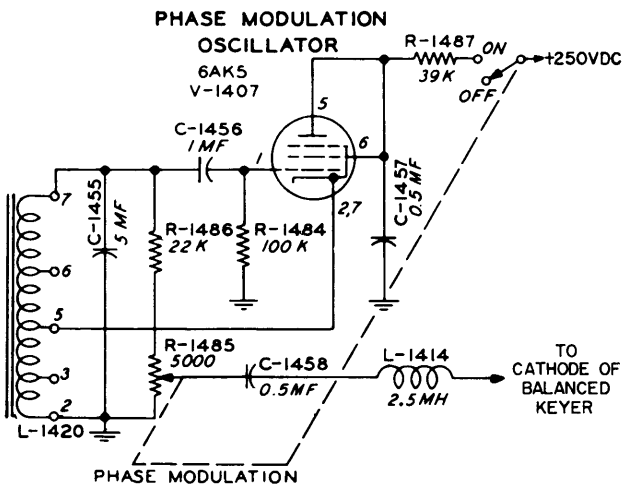


Figure 2–20. Schematic — Frequency Shift Keyer KY-45A/FRT-5, Phase Modulation Oscillator

voltage regulator tube is used for regulation. Potentials of 150 volts regulated and 250 volts unregulated are supplied to the RF Oscillator.

The other power supply furnishes the voltage for Frequency Shift Keyer KY-45A/FRT-5. This power supply is a full-wave type using a single type 5R4GY rectifier tube. The filter system for this supply has a choke input and uses two 4-mf capacitors. A type OA2 voltage regulator tube is used to improve the regulation. This unit has an additional voltage supply which uses a 6X4 rectifier tube and an RC filter network system. The voltage output from this winding is a negative 100 volts. Potentials of 150 volts regulated and 250 volts unregulated are supplied to the frequency-shift keyer.

Power Supply PP-454A/FRT-5 incorporates a voltmeter and switching arrangement for checking all voltages coming from within.

b. TRANSMITTER PROPER.

(1) GENERAL. — The RF Unit T-225A/FRT-5 consists of seven different sections which will be considered in more detail in the following order.

(*a*) MAIN COMPONENTS.

1. Buffer and frequency multipliers
2. Electronic keyer
3. Driver
4. Power amplifier
5. Coupling network

(*b*) AUXILIARY FEATURES.

1. Tuning system
2. Metering and monitoring circuits

(2) RF UNIT T-225A/FRT-5 — MAIN COMPONENTS.

(*a*) BUFFER AND FREQUENCY MULTIPLIERS. — (Refer to figure 2–21.) — The first stage in the transmitter proper is a broad-band buffer stage, V501, employing a type 6AG7 tube. This stage provides the necessary voltage gain and isolation between the exciters and the first frequency multiplier. Exciting input voltage is coupled to the buffer grid through a 50-ohm coaxial input line and autotransformer T501. The coaxial line is loaded by a group of four carbon resistors, R501 through R504, to provide a fixed load for the exciters while the autotransformer raises the voltage applied to the grid approximately 2 to 1. It will be noted that a second coaxial line is coupled through C501 to the buffer grid. The line extends to external jacks and provides a means of frequency monitoring.

The output circuit of the buffer contains only an r-f choke (L501) as its load, and is capacity coupled, through C507, to the grid of the first multiplier stage (V502).

The first multiplier uses a type 807 tube and has a tuned plate circuit consisting of L503 and C511. Both the capacitor and inductor are variable. They are mechanically coupled together and varied simultaneously by a tuning motor. These two components and their gearing are assembled as a small unit and will cover the frequency range of 4000 kc to 13,000 kc. Since the oscillator-buffer output is in the range of 2000 kc to 4000 kc, the first frequency multiplier is intended for doubling, tripling, or quadrupling the input frequency.

The output of the first multiplier is capacity coupled, through C512, to the grid of the second multiplier V503, also a type 807 tube. The plate tank of the second multiplier is composed of C517 and L506, and is identical to that of the first multiplier except for its frequency range, which is 4000 kc to 26,000 kc. This multiplier is designed for use as a doubler or as a straight amplifier.

The full r-f output of the second multiplier is capacity coupled, through C518, to the grid of the type 4-400A driver tube, V504. The magnitude of this voltage and therefore the grid current of the driver may be controlled, from the front panel, by means of the r-f excitation control, R519. This potentiometer varies the screen voltage and hence the output of the first multiplier tube, V502. A second drive control is also incorporated in the unit. This control, potentiometer R522, is mechanically linked to L506 and C517, the second multiplier tank, and is automatically positioned when the tank is tuned. It controls the second multi-

tween 2,435,000 cps and 2,439,224 cps, or 4224 cps.

The desired oscillator output frequency will be most accurately obtained if the required settings of the interpolation oscillator control dial and the master oscillator control dial are approached while rotating these dials in their clockwise direction.

(*f*) Set the OUTPUT TUNING control as close as possible to the desired frequency. A steady tone should be heard in the headphones.

(*g*) Readjust the MASTER OSCILLATOR dial for a low pitched tone (50-100 cps), then readjust the OUTPUT TUNING control for loudness and clarity of tone.

(*h*) Now, to determine if the AFC motor and associated circuits are working properly, remove the headphone connector plug and place the SET UP-OPERATE switch in its OPERATE position. The AFC motor should be heard going into operation.

(8) FREQUENCY SHIFT KEYER KY-45A/FRT-5. — It is assumed that the total frequency shift is 850 cps (frequency raised by 425 cps for a mark signal and lowered 425 cps for a space signal). The procedures are, of course, identical for a different over-all shift of frequency (for example 800 cps) except for the slightly different numerical values which apply. With the 115-volt supply connected to the keyer, the OVEN HEAT pilot light should come on, indicating that the oven heater is working.

(*a*) R-F TUNING.

1. Set the EXT. OSC. ATTENUATOR (S1401) on the rear of the unit to 0 db. The setting of this control is tentative and will be selected more accurately during the following procedure.

2. Rotate the METER switch (S1402) to the GRID position, and provide a suitable carrier from one of the two r-f oscillators.

3. Starting at position "0", rotate the MAIN TUNING dial (C1405) slowly and note that two successive peak values of current are indicated on the meter (M1401). These two current peaks correspond to the two resonant peaks for the lower and upper side bands respectively. The current peak at the lower frequency indicated on the main tuning dial corresponds to the lower side band and is the one to be used.

4. Rotate the MAIN TUNING dial [A-2] (C1405) to a position which corresponds to the lower side-band resonant peak.

5. Set the OUTPUT LEVEL control (R-1430) in a position which provides the most favorable driving power to the first amplifying stage of the transmitter proper (1 to 2 milliamps buffer and 1st multiplier grid current).

6. Rotate the meter switch to the PLATE position.

(*b*) CHECK OF FREQUENCY. — The r-f output of the keyer must be checked to be sure that its frequency is accurate and stable. This output stability is derived from both the 200-kc oscillator and the external r-f injection stability.

1. Rotate the BASIC SHIFT control (R-1458) to position zero.

2. Make certain that the external oscillator is adjusted for a frequency exactly 200 kc above the desired keyer output frequency.

3. Adjust the station frequency-measuring equipment to the desired keyer output frequency.

4. Trim the 200-kc OSC. ADJUST control (C1442 — in front of oven) on the keyer for zero beat with the monitor.

(*c*) FREQUENCY SHIFT.

1. Determine the multiplication factor which is to be used. It must be either 2, 4, or 8 as required to multiply the 2-mc to 3-mc keyer output to the desired transmitter operating frequency.

2. Set the TRANSMITTER MULTIPLICATION switch [B-2] (S1405) at the position corresponding to the chosen multiplication factor.

3. Set the BASIC SHIFT dial for the desired basic frequency shift as indicated on the calibration chart, figure 4–13.

4. Set the TEST-OPERATE (S1403) switch to the SPACE position. The output frequency will be slightly lowered for this, the space frequency.

5. With the frequency monitor still connected and adjusted as it was for step 2 *d* above, compare the audio beat signal that is now obtained with an adjustable audio oscillator to determine its frequency. This beat should have a frequency equal to one-half the total required shift divided by the multiplication factor. For example, if the basic shift were to be a total of 850 cps, and the multiplication factor were four, the audio beat signal should have a frequency equal to (850/2) times (1/4), or 106.25 cps. A slight adjustment of the BASIC SHIFT control may be necessary to obtain the exact degree of shift required.

6. Operate the TEST-OPERATE switch to the MARK position. In this position the frequency

should be approximately as much higher than the zero shift frequency as it was lower in the SPACE position. The monitor beat note should be nearly the same as it was for space. In any event the frequency-shift calibration control should be adjusted until the desired total shift, e.g., 850 cps, is obtained. This may mean a shift of minus 400 cps for space and plus 450 cps for mark, etc.

(*d*) KEYING SIGNAL INPUT.

1. Operate the TEST-OPERATE switch to the FSK position.

2. With a mark keying signal applied, adjust the LIMITER ADJUST control, located on the rear of the unit, until the same beat frequency is obtained as was obtained in steps 3 *e* and 3 *f* above. This insures that the FSK mark and space correspond to those obtained from the TEST-OPERATE mark and space.

(*e*) WAVE SHAPING. — The setting of the WAVE SHAPING switch depends on the keying speed. The relation between the switch positions and the keying speed is as follows:

SWITCH POSITIONS	KEYING SPEED (DOT-CYCLES PER SECOND)
1	0 to 23
2	23 to 60
3	60 to 120
4	120 to 240

Position #4 provides minimum wave shaping.

5. NEUTRALIZATION AND PA GRID AND CATHODE CURRENT BALANCE PROCEDURE.

Refer to paragraphs 3*c*(12) through 3*c*(16) of Section 7 for the neutralization procedure, the PA grid current balance procedure and the PA cathode current balance procedure.

6. TUNING FOR INITIAL OPERATION.

The equipment is now ready for operation. Installation personnel should place the set into operation as a final check. Refer to Section 4 for tuning procedures applicable to the final check.

7. MODIFICATION OF PA INPUT TO EFFECT LINEAR AMPLIFICATION FOR SINGLE SIDE-BAND SUPPRESSED-CARRIER OPERATION.

a. GENERAL. — A kit of parts for converting the input circuit of the power amplifier stage to accept balanced drive voltage from an external driving source is supplied with each AN/FRT-5A equipment.

The circuit that is normally employed at the grids of this PA stage is designed to present a high impedance load to the type 4-400A driver tube (V504) and to deliver balanced push-pull voltage to the relatively

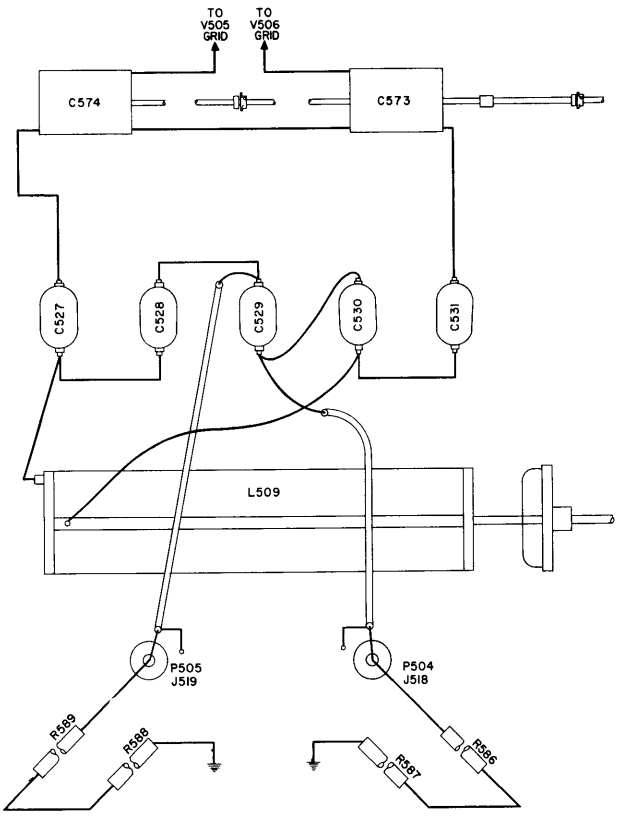


Figure 3–15. Wiring Diagram — RF Unit T-225A/-FRT-5, Conversion of PA Input Circuit for Single Side-band Excitation

low impedance grid circuits of the PA tubes (V505 and V506). However, such a circuit is not suitable for accepting drive from an external exciter such as the Western Electric type D156000 single side-band suppressed-carrier transmitter and therefore it must be modified slightly for such operation.

After modification, the transmitter input is approximately 200 ohms balanced to ground, and requires between 400 and 500 watts peak drive power. The two input terminals are coaxial connectors designed to be used with JAN type RG-8/U coaxial cables fitted with JAN type UG-59A/U male connectors. The connectors, but no cable, are supplied with the conversion kit. These input terminals are located on the rear side of the power amplifier grid circuit enclosure in RF Unit T-225A/FRT-5 and are accessible through the rear doors. The coaxial cables are to be inserted through the cable openings in the bottom of the cab-

These keys simulate off-on keying and are normally open (when the handle extends straight out from the panel). They are arranged to lock closed in the upper position, but to make only momentary contact in the down position. This makes it possible for the operator to manually key the transmitter for test purposes.

(4) PA BIAS ADJUST. — The PA bias adjusting control (R302) is located at the bottom of the relay panel behind the lower front door of the power unit. This control is normally adjusted to its extreme counterclockwise position and left there. It is used for careful adjustment of the bias when the amplifier is adjusted for linear operation, as is required for single side-band suppressed-carrier transmission.

(5) OFF-ON KEYER. — The off-on keyer has two controls which are to be adjusted for best keying waveform. One of these controls (R548) is the KEYING INPUT LEVEL control. This is located on the main control panel of the RF Unit T-225A/FRT-5 and is simply a variable voltage divider across the keying line. In order to retain any wave shaping that may have been applied to the original pulse and to prevent changing the relative spacing of the mark-to-space signals, this input level should be operated at as low a value (counterclockwise direction) as will produce constant keying. The other control, OUTPUT LEVEL control R560, is located on the front panel of the on-off keyer unit itself, which is to the right of the main control panel of the r-f unit. This control primarily adjusts the value of the biasing voltage when the key is open and the carrier is off. This bias voltage is increased or made more negative as the control is rotated counterclockwise. For normal general operation, the control is to be set in middle position. If means are available for observing the keying waveform, this control may be varied to obtain the best result.

On the front panel of the keyer is a selector switch (S502) marked KEYING INPUT FOR MARK. This is a set-up switch. It sets the vacuum tube keyer so that it will accept one of the four types of keying that are indicated. When the nature of the key line signal is known, this switch is set accordingly.

A control, marked KEYING SELECTOR (S501), is located in the middle of the control panel on RF Unit T-225A/FRT-5. Its middle position is marked LOCAL. In this position the test keys on the control panels are the only source of keying voltage, external circuits being disconnected. To the left is a REMOTE position. This connects the external incoming key line directly to the off-on keyer for normal keying. The right side is marked FSK. In this position the off-on keyer is by-passed and the carrier is locked on. The input keying line is also shunted from the off-on keyer to the key line input of the frequency shift keyer mounted on the rack.

(6) PATCH PANEL. — A patch panel, otherwise known as an input-switching or interconnecting panel, is provided in the upper left-hand corner of the equipment rack behind the lower front door of RF Unit T-225A/FRT-5. This is shown in figures 3–9 and 3–11. The r-f input to the transmitter appears at one of the coaxial jacks (J201) on this panel, while the outputs of the crystal oscillator, the master oscillator and the frequency-shift keyer appear on separate coaxial jacks (J1202, J1203 and J1205). Jumper or patch cables are provided for interconnecting the frequency-shift keyer and either of the two oscillators. Several external and spare circuits are also available.

h. CRYSTAL OSCILLATOR O-92A/FRT-5. — This is a 10-channel crystal oscillator which has no tuning controls. A 10-position CRYSTAL SELECTOR SWITCH [K] (S1102) on the front panel allows the selection of the particular crystal required to provide the desired output frequency. The only other adjustments are the frequency trimming capacitors across the individual crystal positions. These are internal adjustments and not to be touched except by qualified personnel.

A second switch on the control panel (S1103) inserts the small test meter into either the OSCILLATOR CATHODE or the BUFFER CATHODE for current checks. The third position of this selector, marked REMOTE, provides for remote metering if the remote equipment is available. This transmitter does not include such equipment.

i. MASTER OSCILLATOR O-91A/FRT-5. — This is a continuous coverage oscillator delivering output from 2000 kc to 4500 kc. Its front panel controls include a MASTER OSCILLATOR TUNING dial, an INTERPOLATION OSCILLATOR TUNING dial, an OUTPUT TUNING dial and a SET UP — OPERATE switch (S103). The master oscillator and output tuning are calibrated in kilocycles and are set up as close to the desired frequency as possible. The interpolation oscillator dial is calibrated directly in cycles-per-second and is used in conjunction with the automatic frequency correcting circuit within this unit to bring the master oscillator to the desired frequency. Refer to the detailed operating instructions further on in this section for the exact procedure to be followed in adjusting this and other controls.

j. FREQUENCY SHIFT KEYER KY-45A/FRT-5. — Frequency Shift Keyer KY-45A/FRT-5 contains a

TABLE 4–1. CONTROL LOCATION AND FUNCTION

FUNCTIONAL DESIGNATION	LOCATION	LETTER DESIGNATION	TYPE OF COMPONENT	SYMBOL	PURPOSE OF CONTROL
PLATE—ON-OFF	KY-45A/FRT-5 (Front Panel)	——	Switch	S1401	Controls connection of 250 volts and 150 volts from power supply to components of the F. S. Keyer. The PLATE ON pilot lamp comes on when the switch is in the ON position.
METER—GRID-PLATE	KY-45A/FRT-5 (Front Panel)	——	Switch	S1402	Permits switching of M1401 to either the GRID or PLATE circuit of the POWER AMPLIFIER, V1404.
OUTPUT LEVEL	KY-45A/FRT-5 (Front Panel)	——	Potentiometer	R1430	Controls the r-f output level of the keyer.
PHASE MODULATION	KY-45A/FRT-5 (Front Panel)	——	Potentiometer and Switch	R1485 S1408	Connects the 250-volt plate supply to phase-modulating oscillator V1407 with switch S1408 and with potentiometer R1485, modifies the magnitude of the phase modulation.
WAVESHAPING	KY-45A/FRT-5 (Front Panel)	——	Switch	S1404	Modifies the output wave shape of the keying tube by connecting different combinations of series inductance and bridged capacitance.
TEST-OPERATE	KY-45A/FRT-5 (Front Panel)	——	Switch	S1403	Permits selecting CARRIER - SPACE - MARK - FSK or PHOTO operation.
MAIN TUNING	KY-45A/FRT-5	A	Capacitor	C1405A through C1405E	Tunes the output circuits of the BALANCED MODULATORS, the BUFFER and the POWER AMPLIFIER.
TRANSMITTER MULTIPLICATION	KY-45A/FRT-5 (Front Panel)	B-2	Switch	S1405	Sets the magnitude of the frequency shifts in ratios corresponding to the frequency multiplication factor of the transmitter.
BASIC SHIFT	KY-45A/FRT-5 (Front Panel)	——	Potentiometer	R1458	Adjusts the magnitude of the frequency shift.
KEYER BALANCE	KY-45A/FRT-5 (Behind Front Panel)	——	Potentiometer	R1450	Equalizes the magnitude of the balanced keyer output voltage. This condition is reached only when the TEST-OPERATE switch is in the CARRIER position.
200-KC OSC. ADJUST.	KY-45A/FRT-5 (Behind Front Panel)	——	Capacitor	C1442	Adjusts frequency of frequency-shifted signal (200 kc oscillator).
FREQUENCY SHIFT CALIBRATION	KY-45A/FRT-5 (Behind Front Panel)	——	Potentiometer	R1464	Adjusts the gain of phase shifting amplifier V1409 which in turn calibrates the BASIC SHIFT control (R1458).
PHOTO ADJUST	KY-45A/FRT-5 (Rear of Unit)	——	Potentiometer	R1448	Limits the amount of photo signal to the balanced keyer tube.
LIMITER ADJUST	KY-45A/FRT-5 (Rear of Unit)	——	Potentiometer	R1439	Adjusts the bias on the balanced keyer and limiter tubes.
MODULATOR BALANCE	KY-45A/FRT-5 (Rear of Unit)	——	Potentiometer	R1416	Equalizes the output of the balanced modulator.
EXT. OSC. ATTENUATOR	KY-45A/FRT-5 (Rear of Unit)	——	Switch	S1401	Permits adjusting the level of the r-f input from the external oscillator.
PLATE ON-OFF	O-91A/FRT-5 (Front Panel)	——	Switch	S101	Controls connection of 250-volt and 150-volt outputs from power supply to components of the r-f oscillator. The PLATE ON pilot comes on when the switch is in the ON position.
TEST-OPERATE	O-91A/FRT-5 (Front Panel)	——	Switch	S103	Controls the AFC motor. When the switch is in the OPERATE position the AFC ON pilot comes on.
INTERPOLATION OSCILLATOR	O-91A/FRT-5 (Front Panel)	B-1	Inductance	L105	Interpolates within the 0-5000 cps range between adjacent points of M.O. dial.
MASTER OSCILLATOR	O-91A/FRT-5 (Front Panel)	A-1	Inductance	L103	Determines the output frequency as indicated on the dial.
OUTPUT TUNING	O-91A/FRT-5 (Front Panel)	C-1	Capacitor	C120	Tunes the output circuit of V112, the output circuit of V113 and the plate circuits of the two harmonic amplifiers V104 and V105.

TABLE 4–1. CONTROL LOCATION AND FUNCTION (Cont'd)

FUNCTIONAL DESIGNATION	LOCATION	LETTER DESIGNATION	TYPE OF COMPONENT	SYMBOL	PURPOSE OF CONTROL
100 KC EXT. INT.	O-91A/FRT-5 (Rear of Unit)	——	Switch	S105	To connect the internal 100-kc crystal in the circuit, or to connect an external 100-kc crystal in the circuit.
OUTPUT CONTROL	O-91A/FRT-5 (Rear of Unit)	——	Potentiometer	R165	Changes the r-f output level of the r-f oscillator.
CRYSTAL SELECTOR SWITCH	O-92A/FRT-5 (Front of Unit)	K	Switch	S1102 A&B	Selects one of the ten crystals for the oscillator circuit.
OSC. CATH., BUFF. CATH., EXTERNAL	O-92A/FRT-5 (Front of Unit)	——	Switch	S1103	Inserts front panel meter in oscillator cathode or buffer cathode, or connects meter shunts to external metering circuits.
ON-OFF	PP-454A/FRT-5 (Front Panel)	——	Switch	S1001	Controls connection of 230-volt a-c power to the primaries of power transformers T1001 and T1002.
METER SWITCH	PP-454A/FRT-5 (Front Panel)	——	Switch	S1003 A&B	Switches the output voltages to the meter circuit for reading.
METER SWITCH	PP-490A/FRT-5 (Control Panel)	——	Switch	S314	Simultaneously inserts A-C LINE VOLTAGE and P. A. FILAMENT VOLTAGE voltmeters into indicated positions for checking. Provides switching to each of the three phase lines, REG. BUS 1 & L PA FIL. and REG. BUS 2 & R PA FIL.
SERVO CONTROL	PP-490A/FRT-5 (Control Panel)	——	Switch	S306	Controls application of 230-volt a-c power to the servo power supply and provides a-c cover-load protection.
CONTROL CIRCUIT	PP-490A/FRT-5 (Control Panel)	——	Switch	S303	Controls application of 230-volt a-c power to the relays and timers which control the high voltage, low voltage and bias d-c power supplies and provide a-c overload protection.
L. V. AND BIAS	PP-490A/FRT-5 (Control Panel)	——	Switch	S302	Controls application of the 230-volt a-c power to the primary windings of the low voltage and bias supply plate transformers and provides a-c overload protection.
TUNE OPERATE SWITCH	PP-490A/FRT-5 (Control Panel)	——	Switch	S310	Permits the selecting of L. V. TUNE, H. V. TUNE or OPERATE circuits.
TEST KEY	PP-490A/FRT-5 (Control Panel)	——	Switch	S316	Applies a test keying voltage to the keyer tube and thus turns on the carrier.
AUTO SHUT-DOWN	PP-490A/FRT-5 (Control Panel)	——	Switch	S324	Completes the circuit to AUTO SHUT-DOWN TIMER when in AUTO SHUT-DOWN position. Disables automatic shut-down feature when in OFF position.
LEFT PA FILAMENT	PP-490A/FRT-5 (Control Panel)	——	Potentiometer	R327	Gives a vernier voltage adjustment between the taps selected by S512.
LOW LEVEL FILAMENT	PP-490A/FRT-5 (Control Panel)	——	Switch	S304	Controls application of 230-volt a-c power to the primaries of all the rectifier, buffer, multiplier and driver filament transformers and provides a-c overload protection.
FILAMENT — EMERGENCY SHUT-DOWN	PP-490A/FRT-5 (Control Panel)	——	Switch	S307	In series with switch S510. Applies 230-volt a-c primary power to low level filaments contactor K301.
PA FILAMENT	PP-490A/FRT-5 (Control Panel)	——	Switch	S305	Controls application of 230-volt a-c power to the primaries of the PA filament transformers, and provides a-c overload protection.
BLOWER	PP-490A/FRT-5 (Control Panel)	——	Switch	S301	Controls application of 230-volt a-c power to the blower motors, and provides overload protection.
RIGHT PA FILAMENT	PP-490A/FRT-5 (Control Panel)	——	Potentiometer	S326	Gives a vernier voltage adjustment between the taps selected by S513.

TABLE 4–1. CONTROL LOCATION AND FUNCTION (Cont'd)

FUNCTIONAL DESIGNATION	LOCATION	LETTER DESIGNATION	TYPE OF COMPONENT	SYMBOL	PURPOSE OF CONTROL
EXCITER TEST	T-225A/FRT-5 (Control Panel)	——	Switch	S503	Inserts EXCITER TEST meters No. 1 and No. 2 simultaneously into the following circuits, with the indicated meter range: #1 Buffer Cathode — 100 ma. #2 Buffer and 1st Mult. Grid — 10 ma. #1 1st Mult. Cathode — 100 ma. #2 2nd Mult. Grid — 10 ma. #1 2nd Mult. Cathode — 200 ma. #2 Driver Grid — 50 ma. #1 L PA Grid RF Peak — 1000 V. #2 L PA Plate RF Peak — 10 KV. #1 R PA Grid RF Peak — 1000 V. #2 R PA Plate RF Peak — 10 KV. Note: {#1 is read on meter M505 / #2 is read on meter M506
FILAMENT — EMERGENCY SHUT-DOWN	T-225A/FRT-5 (Control Panel)	——	Switch	S510	In series with switch S307. Applies 230-volt a-c primary power to low level filaments contactor K301.
KEYING INPUT LEVEL	T-225A/FRT-5 (Control Panel)	——	Potentiometer	R548	Controls the amount of input voltage from the incoming keying line being applied to the keyer tube.
RF EXCITATION	T-225A/FRT-5 (Control Panel)	G	Potentiometer	R519	Controls screen voltage of the multiplier tubes and is used to set PA grid current level.
P.A. TEST	T-225A/FRT-5 (Control Panel)	——	Switch	S504	Inserts PA TEST meter in the following circuits with the indicated meter range: L. PA GRID — 0.5 amp R. PA GRID — 0.5 amp TOTAL GRID — 1 amp L. PA CATHODE — 0.5 amp R. PA CATHODE — 0.5 amp
TEST KEY	T-225A/FRT-5 (Control Panel)	——	Switch	S521	Applies a test keying voltage to the keyer tube when KEYING SELECTOR Switch is in LOCAL position.
KEYING SELECTOR	T-225A/FRT-5 (Control Panel)	——	Switch	S501	Permits the selecting of REMOTE, LOCAL or FSK operation.
MONITOR PHONES	T-225A/FRT-5 (Control Panel)	——	Jack	J505	Provides for aural checking of the frequency monitor output from the front panel of the transmitter when the monitor output is connected to the transmitter terminals provided.
1st MULTIPLIER PLATE TUNING	T-225A/FRT-5 (Control Panel)	A	Potentiometer	R591	Varies the resonant frequency of the plate tank circuit for V502 through a servo positioning system.
2nd MULTIPLIER PLATE TUNING	T-225A/FRT-5 (Control Panel)	B	Potentiometer	R592	Varies the resonant frequency of the plate tank circuit for V503 through a servo positioning system.
DRIVER PLATE TUNING	T-225A/FRT-5 (Control Panel)	C	Potentiometer	R593	Varies the resonant frequency of the plate tank circuit for V504 through a servo positioning system.
POWER AMPLIFIER PLATE TUNING	T-225A/FRT-5 (Control Panel)	D	Potentiometer	R594	Varies the resonant frequency of the plate tank circuit for V505 and V506 through a servo positioning system.
POWER AMPLIFIER LOADING	T-225A/FRT-5 (Control Panel)	E	Potentiometer	R595	Varies the position of the output coupling network relative to the PA plate tank circuit through a servo positioning system.
ANTENNA TUNING	T-225A/FRT-5 (Control Panel)	F	Potentiometer	R596	Varies the resonant frequency of the output coupling network through a servo positioning system.

TABLE 4–1. CONTROL LOCATION AND FUNCTION (Cont'd)

FUNCTIONAL DESIGNATION	LOCATION	LETTER DESIGNATION	TYPE OF COMPONENT	SYMBOL	PURPOSE OF CONTROL
SHORTING BAR	T-225A/FRT-5 (Above IPA)	[L]	Strap	——	Shorts out C571.
LEFT P.A. FIL.	T-225A/FRT-5 (Inside Front Lower Door)	——	Switch	S512	Selects the primary taps on PA filament transformer T506.
RIGHT P.A. FIL.	T-225A/FRT-5 (Inside Front Lower Door)	——	Switch	S513	Selects the primary taps on PA filament transformer T505.
KEYING INPUT FOR MARK	T-225A/FRT-5 (Inside Front Lower Door)	——	Switch	S502	Sets up on-off keyer for operation from keying input pulses that are negative to ground for mark, positive for mark, polarized to ground negativ for mark, or polarized positive for mark.
OUTPUT LEVEL	T-225A/FRT-5 (Inside Front Lower Door)	——	Potentiometer	R530	Adjusts the amplitude of the keying pulse applied to the keyed stages in the transmitter.
TEST KEYING LEVEL	T-225A/FRT-5 (Inside Front Lower Door)	——	Potentiometer	R568	Adjusts the amplitude of the d-c voltage applied to the keyer input through the test key.
ADJ. A	T-225A/FRT-5 (Inside Front Lower Door)	——	Potentiometer	R554	Adjusts voltage gain of phase inverter portion of keyer.
ADJ. B	T-225A/FRT-5 (Inside Front Lower Door)	——	Potentiometer	R570	Adjusts ratio of positive and negative test voltages for polarized positive keyer set up.
ADJ. C	T-225A/FRT-5 (Inside Front Lower Door)	——	Potentiometer	R573	Adjusts ratio of positive and negative test voltages for polarized negative keyer set up.

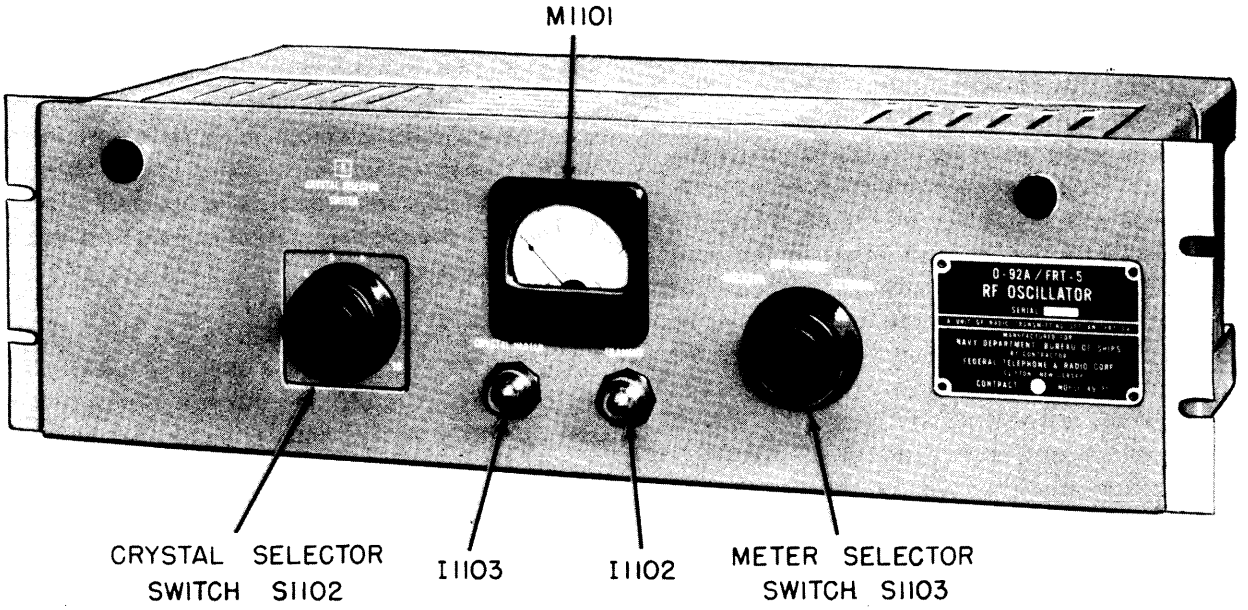


Figure 4–3. RF Oscillator O-92A/FRT-5, Front View

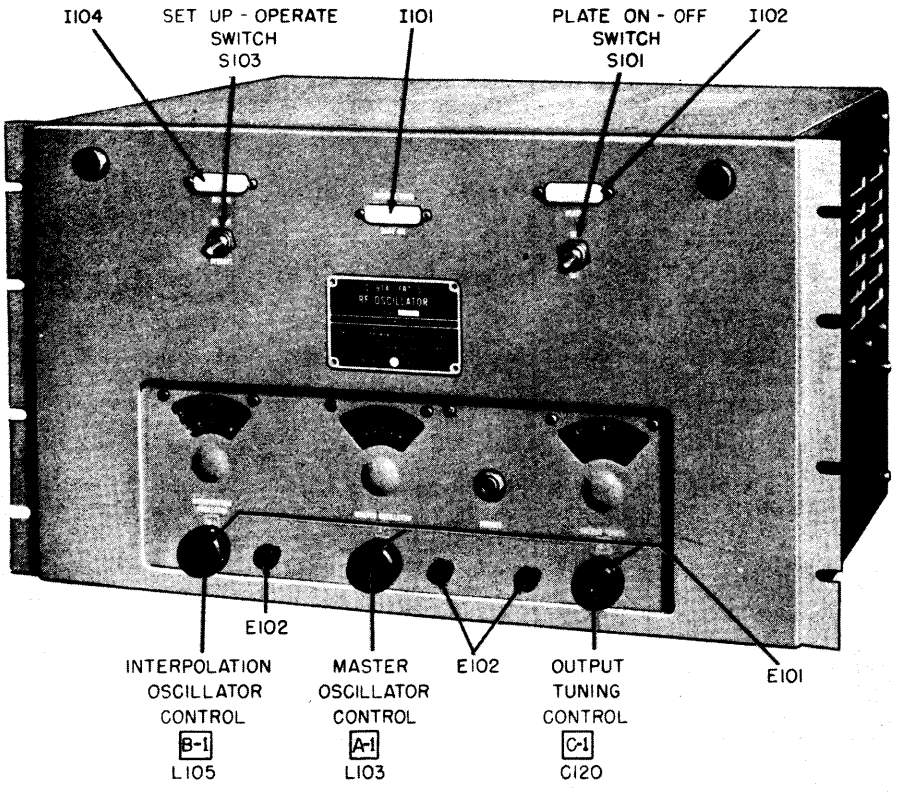


Figure 4–4. RF Oscillator O-91A/FRT-5, Front View

number of special front panel controls. These are listed in table 4–1, and illustrated in figures 4–5 and 7–46. Instructions for operation of the frequency-shift keyer are given in paragraph 3 *d* below. These should be thoroughly understood before any attempt is made to use the unit.

Briefly, its front panel controls are as follows. There is a MAIN TUNING control which is calibrated in kilocycles. It is to be set at an exact fraction of ½, ¼, or ⅛ of the desired transmitter output frequency along with a second switch marked TRANSMITTER MULTIPLICATION, which is to be set to the same factor. An OUTPUT LEVEL control is provided for adjusting the voltage applied to the transmitter input. This should be set to produce between 1 and 2 ma of buffer and first multiplier grid current. A TEST-OPERATE switch, a BASIC SHIFT control, a WAVE SHAPING switch, and a PHASE MODULATION control constitute the remainder of the front panel controls. Their use is carefully explained in the portion of this section dealing with the actual tune-up procedure.

3. OPERATION.

a. GENERAL. — Since the tuning of this equipment involves a rather complex procedure, it has been deemed advisable, for the purpose of explanation, to assume an arbitrary set of operating conditions. It will be assumed that conventional "on-off" keying is to be used and that the transmitter frequency is to be 26,000 kc.

It should be understood that the procedures set forth below will apply to actual operating conditions, as well as to the example chosen. Tuning charts are included in this section to aid the operator in the tuning and adjusting of this transmitter. The operator is referred to table 4–1 for the explanation of panel designations, location and functions.

b. PROCEDURE USING CRYSTAL OSCILLATOR O-92A/FRT-5. — Tables 4–2 and 4–3, and the tuning charts shown in figures 4–6 through 4–13, provide initial or typical setting data. It should not be assumed that the settings of the individual transmitter being tuned will coincide exactly with those shown in these charts.

(1) On Power Supply PP-490A/FRT-5 place the circuit breakers marked SERVO CONTROL (S306), CONTROL CIRCUIT (S303), LV & BIAS (S302), LOW LEVEL FILAMENT (S304), PA FILAMENTS (S305) and BLOWER (S301) in their ON positions.

(2) Connect the output of RF Oscillator O-92A/-FRT-5 to the transmitter input. This is accomplished by attaching one end of one of the patch cords (short lengths of RG-58/U coaxial cable) to the CRYSTAL OSC. OUTPUT jack (J1202) on the patch panel, and the other end of the cable to the TRANSMITTER INPUT jack (J1201) on the patch panel.

(3) Operate the FILAMENT EMERGENCY SHUT-DOWN switches on both cabinets (S510 and S307) to their FILAMENT ON positions.

(4) Operate the TUNE OPERATE switch to the LV TUNE position.

(5) Operate the CRYSTAL SELECTOR SWITCH [K] to the position which will give the desired transmitter output frequency. In this case, the desired output is 26 mc, hence the 3250-kc crystal should be used.

Note

Referring to figure 4–6, multiplication factors of 2, 4, 6, or 8 may be used, the only criteria being that the oscillator frequency be between 2.0 to 4.0 mc.

(6) Refer to the calibration curves, figures 4–8 through 4–18, and set up controls [A], [B], [C], [D], [E], [F], and [G], on the control panel of RF Unit T-225A/FRT-5 to the settings indicated by the curves. In this example, the frequency is being multiplied by four in the 1st multiplier and by two in the 2nd multiplier resulting in a total multiplication of eight.

(7) Check the position of shorting strap [L]. It should be open for frequencies above 15 mc, and closed for frequencies below 15 mc. Strap [L] is located above the power amplifiers and is accessible through the upper front door of RF Unit T-225A/FRT-5.

(8) Operate either one of the two TEST KEY controls to the upper or locking position.

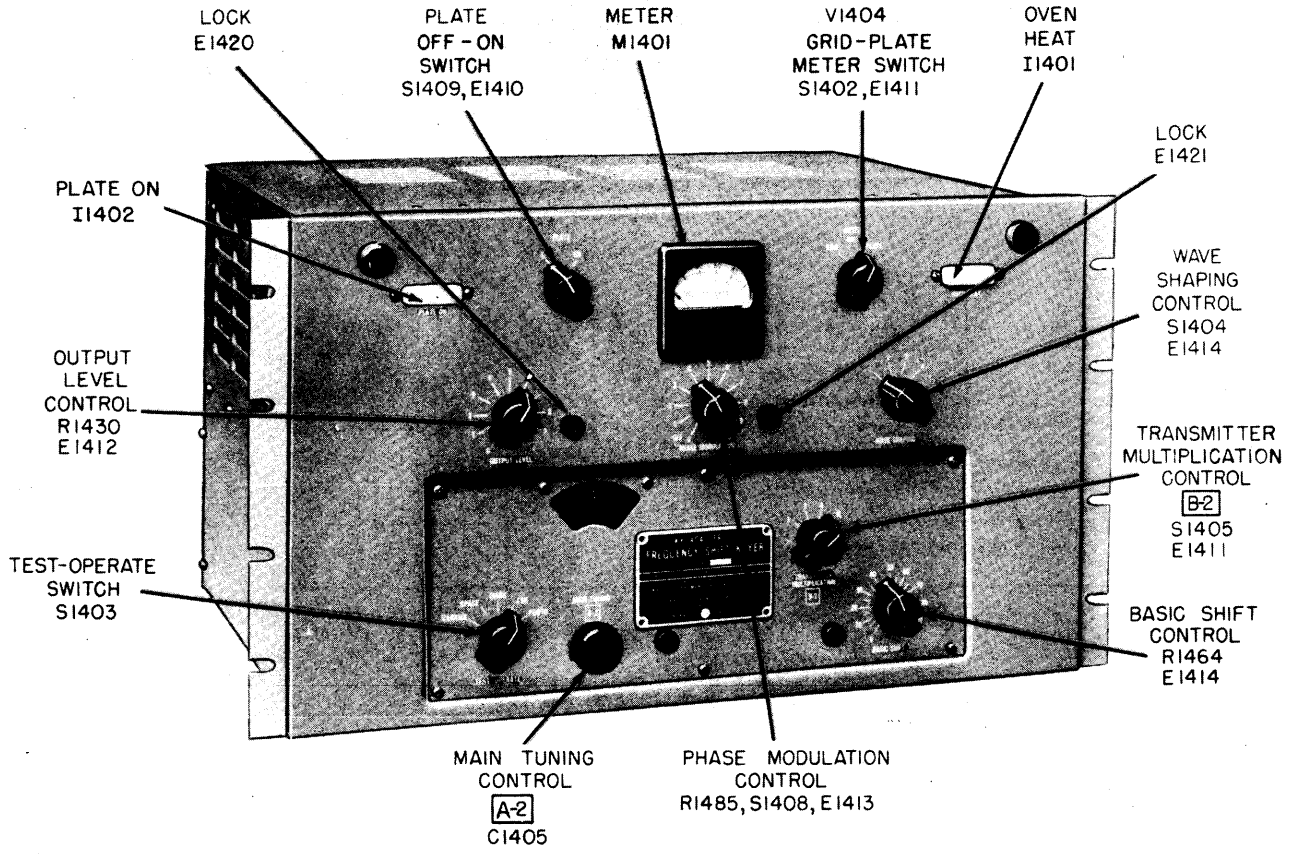
(9) Set the KEYING SELECTOR switch, S501, on RF Unit T-225A/FRT-5 to the LOCAL position.

(10) Rotate the EXCITER TEST switch, S503, on RF Unit T-225A/FRT-5 to the first position marked:

#1 — BUFFER CATHODE — 100 MA.

#2 — BUFFER AND 1ST MULT. GRID — 10 MA.

The EXCITER TEST #1 meter indicates the buffer



Figur 4–5. Fr qu ncy Shift K y r KY-45A/FRT-5, Fr nt Vi w

N t

The desired oscillator output frequency will be most accurately obtained if the required settings of the INTERPOLATION OSCILLATOR control B-1 and the MASTER OSCILLATOR control dial A-1 are approached while rotating these dials in their clockwise direction.

(*g*) At this point, a steady tone should be audible in the headphones.

(*h*) Readjust the MASTER OSCILLATOR, control A-1, until a low pitched tone (50 to 100 cps) is heard in the headphones.

(*i*) This tone should be made as loud and as clear as possible by slight readjustment of the OUTPUT TUNING, control C-1.

(*j*) Remove the headphones cord plug and set the SET UP-OPERATE switch in the OPERATE position.

(*k*) Record the dial readings of each control for this frequency for future reference.

(*l*) Refer to the foregoing procedure and follow steps 3 *b* (5) through 3 *b* (22) to complete tuning of the transmitter.

(2) SETTING UP ON A FREQUENCY PREVIOUSLY RECORDED ON TUNING CHARTS.

(*a*) Throw SET UP-OPERATE switch on RF OSCILLATOR O-91A/FRT-5 to SET-UP position.

(*b*) Set the MASTER OSCILLATOR, control A-1, to the setting previously recorded for that control.

(*c*) Set the INTERPOLATION OSCILLATOR, control B-1, to the setting previously recorded for that control.

(*d*) Set the OUTPUT TUNING, control C-1, to the setting previously recorded for that control.

(*e*) Insert headphone cord plug in jack and recheck final settings of INTERPOLATION OSCILLATOR and OUTPUT TUNING dials as described in paragraphs 3 *c* (1 (*e*) through 3 *c* (1) (*j*) above.

(*f*) Refer to the procedure given in paragraph 3 *b* above and follow steps (5) through (22) to complete tuning of the equipment.

d. PROCEDURE USING FREQUENCY SHIFT KEYER KY-45A/FRT-5. — Whether this keyer is in use or not, keep a-c power connected to the oven (J1406) so as to maintain correct operating temperatures. In order to use the keyer it will be necessary to provide it with an r-f carrier from some external source and to connect its output to the transmitting input. This is done on the patch panel shown in figure 3–16 by means of two jumper cables. Connect one end of one of the cables to the patch panel jack marked EXTERNAL (J1206), CRYSTAL OSCILLATOR OUTPUT (J1202), or MASTER OSCILLATOR OUTPUT (J1203), depending upon which one is to be used to provide the r-f carrier for the keyer, and connect the other end of the same cable to the jack marked FS KEYER INPUT (J1205). Connect another jumper cable from the FS KEYER output jack (J1204) to the TRANSMITTER INPUT jack (J1201).

Note

The r-f carrier which is provided to the keyer must be 200 kc higher than the desired keyer output (input to the transmitter). Since the transmitter has provision for multiplication by factors of 2, 4, 6, and 8, these will have to be considered when determining the transmitter input frequency corresponding to a desired transmitter output frequency.

(1) SETTING OF CONTROLS.

(*a*) Set operating control MAIN TUNING A-2 to the output frequency of the keyer as determined above. This is equal to the transmitter output frequency divided by the particular multiplying factor at which the transmitter is operating. Set the TRANSMITTER MULTIPLICATION control B-2 on the keyer to the same multiplying factor. (See table 4–2 for typical settings.) No provision is made for operation of the keyer with a transmitter multiplying factor of 6, but if it is necessary to do so, the required shift may be obtained by using the BASIC SHIFT control. Merely adjust the BASIC SHIFT to a point where the shift at the keyer is equal to the desired final shift divided by the transmitter multiplication factor.

(*b*) Turn the METER SWITCH to the GRID position.

(*c*) Turn the OUTPUT LEVEL control to full output (position 10).

(*d*) Readjust the MAIN TUNING control A-2 slightly until maximum grid current indication is obtained, as indicated on meter M1401.

(*e*) Turn the METER SWITCH to the PLATE position (average reading between 35 ma and 75 ma.)

(*f*) Adjust the output control to supply between 1 ma and 2 ma buffer and 1st multiplier grid current.

(2) CHECK OF FREQUENCY.

(*a*) Set TEST-OPERATE switch to CARRIER position.

(*b*) Tune a receiver to the transmitter frequency.

(*c*) Adjust the radio-frequency measuring equipment to the transmitter output frequency.

(*d*) Adjust the 200-kc OSCILLATOR ADJUST control until a zero-beat condition is obtained between the r-f measuring equipment and the transmitter output.

(3) ADJUSTMENT OF FREQUENCY SHIFT.

(*a*) Set the TEST-OPERATE switch to the CARRIER position.

(*b*) Using a receiver as a mixer, beat an accurate external frequency standard, set at the transmitter output frequency, against the keyer output. Assuming the keyer is exactly on the carrier frequency (step 2), a zero-beat condition will be obtained in the receiver.

(*c*) Set the TRANSMITTER MULTIPLICATION switch B-2 to the position indicating the desired transmitter multiplication factor.

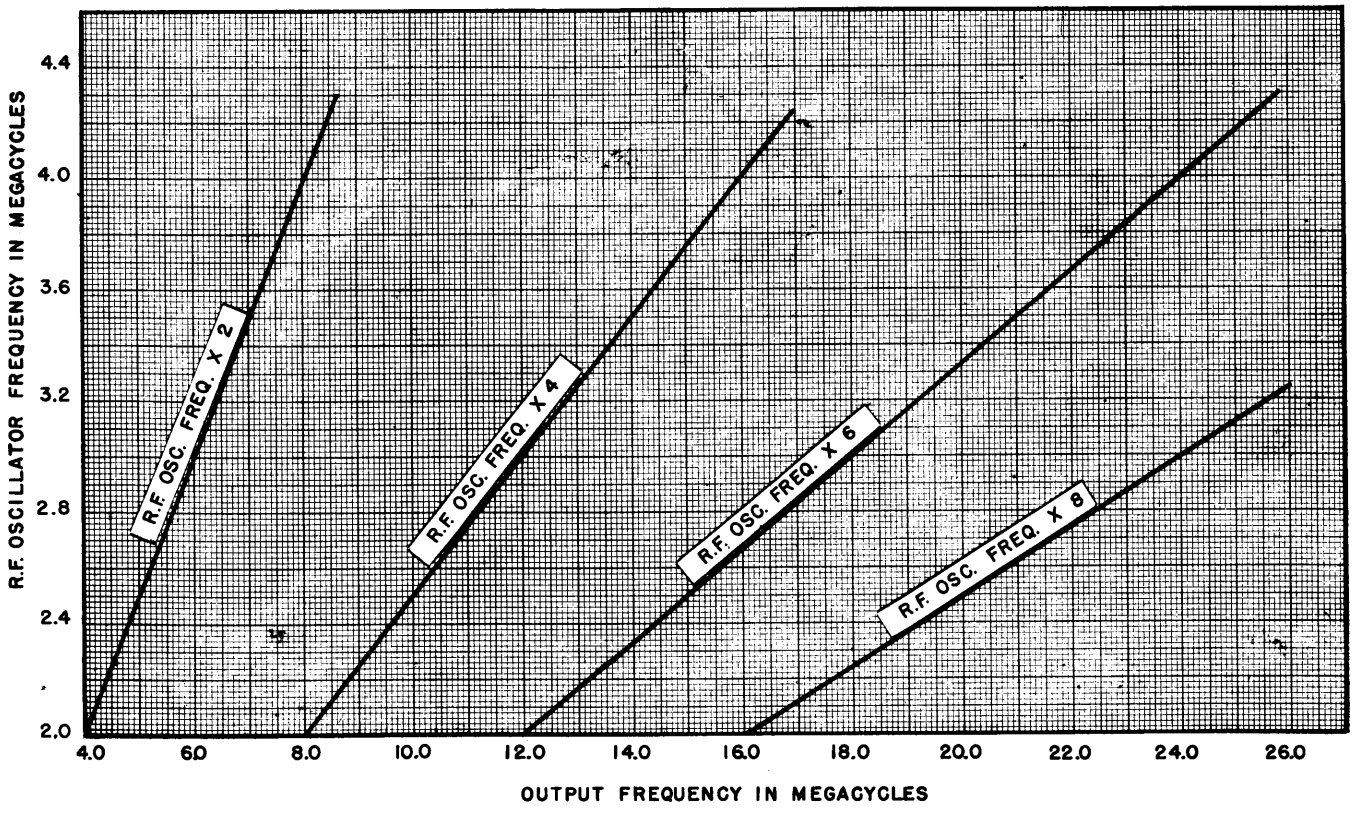
(*d*) Connect the output of an audio oscillator to the receiver audio system and adjust the audio oscillator for a frequency corresponding to one-half the final shift required (for example, one-half of 850 cps or 425 cps).

(*e*) Set TEST-OPERATE switch to the SPACE position.

(*f*) Compare the audio output of the receiver with the audio oscillator and adjust the BASIC SHIFT until the two audio frequencies produce a zero beat.

(*g*) Set the TEST-OPERATE switch to the MARK position, and make sure that a near zero beat is also produced in this position.

e. TUNING PROCEDURE FOR SINGLE SIDEBAND OPERATION. — With the single side-band modification complete, as described in paragraph 7 of



Figur 4–6. Tuning Chart — Oscillator Output Frequency vs Transmitt r Output Frequ ncy

TABLE 7–2. RESISTANCE MEASUREMENTS (C nt'd)

CIRCUIT SYMBOL	PIN NUMBERS								
	1	2	3	4	5	6	7	8	9
Power Supply PP-454A/FRT-5									
V1001	NC	90K	NC	18	NC	19	NC	90K	
V1002	NC	90K	NC	18	NC	19	NC	90K	
V1003	30K	NC	4	4	NC	30K	40		
V1004	NC	110K	NC	40	NC	42	NC	110K	
V1005	NC	0	NC	NC	85K	NC	NC		
V1006	NC	0	NC	NC	100K	NC	NC		
RF Oscillator O-92A/FRT-5									
V1101	50K	200	Gnd	Gnd	12.8K	42K	INF.		
V1102	Gnd	Gnd	INF.	50K	150	6.5K	Gnd	6.5K	
V1103	INF.	Gnd	13 meg		INF.		6.5K	INF.	
V1104	INF.	INF.	13 meg		INF.		6.5K	INF.	
RF Unit T-225A/FRT-5 (Voltmeters)									
V1301	350,000	INF.	0	0	INF.	350,000	0		
V1302	350,000	INF.	0	0	INF.	350,000	0		
V1303	300,000	INF.	0	0	INF.	300,000	0		
V1304	300,000	INF.	0	0	INF.	300,000	0		
Frequency Shift Keyer KY-45A/FRT-5									
V1401	68K	206	H	0	35K	26K-37K[4]	56K		
V1402	68K	206	H	0	35K	26K-37K[4]	56K		
V1403	17.2K	68	0	H	13K	46K[5]	68		
V1404	H	150-12.5K[5]	5.6K	0	0				
V1405	00[6] 256K[7]	470K	0	H	00[6] 256K[7]		470K		
V1406	3K	56K	0	H	1K		156K		
V1407	100K	25	0	H	00[8] 51K[9]	00[8] 51K[9]			
V1408	25K	82K	3.9K	0	0	25K	82K	3.9K	H
V1409	46K		H	0		10K	330-2.8K[10]		
V1410	22K	0	0	H	113K	343K	270		
V1411	150K	0	0	H	23K	25K	1.2		
V1412	47K	100	0	0	0	45K	27K	0	H

CIRCUIT SYMBOL	TERMINAL NUMBERS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
J1001	0	0	H	H	85K	85K	NC	NC	NC	NC					
J1002	0	0	H	H	100K	100K	100K	NC	NC	NC					

[1]Value depends on position of switch S105.
[2]Value depends on position of variable resistor R165.
[3]These tubes do not have contact pins. In each, the resistances from the filament, grid and plate contacts to ground are 0.6, 1300 and 60,000 ohms, respectively.
[4]Depends on setting of R1416.
[5]Depends on setting of R1430.
[6]S1403 in CARRIER position.
[7]S1403 in FSK position.
[8]S1407 open.
[9]S1407 closed.
[10]Depends on setting of R1464.

TABLE 7–3. TUBE OPERATING VOLTAGES AND CURRENTS (KEY CLOSED) (Cont'd)

JAN TUBE TYPE	FUNCTION AND CIRCUIT SYMBOL	PLATE (VOLTS)	PLATE (MA)	SCREEN (VOLTS)	SCREEN (MA)	SUPPRESSOR (VOLTS)	CATHODE (VOLTS)	GRID (VOLTS)	HEATER (AC VOLTS)
2C51	Interpolation circuit V117	+120(4) +135(6)					+92(2) +92(8)	+86(3) +84(7)	6.3
6AK5	Buffer V118	+42		+42			+.3	−4	6.3
5686*	Power amplifier V119	+255		+260		+63	+63	+79	6.3
5686*	Power amplifier V120	+255		+260		+60	+60	+38	6.3
5686*	Power amplifier V121	+255		+260		+80	+80	+50	6.3
5686*	Power amplifier V122	+255		+260		+72	+72	+50	6.3
2C51	DC amplifier V123	+48(4) +43(6)					+0.75(2) +0.75(8)	0(3) 0(7)	6.3
2C51	DC amplifier V124	+48(4) +48(6)					+0.75(2) +0.75(8)	0(3) 0(7)	6.3
6AL5	Diode mixers V125	−0.6(2) −0.6(7)					0(1) 0(5)		6.3
6AL5	Diode mixers V126	−0.75(2) −0.75(7)					0(1) 0(5)		6.3
6BE6	Dividers V127	+260		+105			+2.2	0(1) 0(7)	6.3
6BA6	Dividers V128	+255		+135		+5.4	+5.4	—	6.3
6AK5	100 KC amplr V129	+130		+140			+3.4		
6SJ7	Master oscillator V131	+250		+155		0	0	−7	6.3
6SJ7	Interpolation oscillator V130	+250		+140		0	0	−3	6.3
	Frequency Shift Keyer KY-45A/FRT-5								
6BE6	Balanced modulator V1401								
6BE6	Balanced modulator V1402								
6BA6	Buffer V1403	+290		+190		+.75	+0.75	−7.6	6.3
807	Power amplifier V1404			+260			0	−65	6.3
6AL5	Limiter V1405	−0.5(2) −0.5(7)					0(1) 0(5)		6.3
6AL5	Limiter V1406	0(2) 0(7)					+20(1) +7(5)		6.3
6AK5	Phase modulation oscillator V1407	+100		+100			+0.4	−7.8	6.3
12AU7	Balanced keyer V1408	+125(1) +130(6)					+8.7(3) +8.7(8)	+3.2(2) +3.2(7)	6.3
6C4	Phase shifting amplifier V1409	+65					+1.5	0	6.3
6BA6	Phase shifting amplifier V1410	+50		+20		0	+0.4	0	6.3
6BA6	200 KC oscillator V1411	+100		+125		0	0	−8.7	6.3
12AX7	Phase inverter V1412	+150(1) +163(6)					0(3) 0(8)	0(2) −0.45(7)	6.3

(14) POWER OUTPUT CHECK AND CALIBRATION ADJUSTMENT.

(*a*) SET-UP.

1. Set the EXT-INT switch S105 in the INT position.

2. Turn AFC control on; AFC ON indicator I404 should light.

3. Rotate POWER OUTPUT control R185 to its maximum clockwise position.

4. Connect one VTVM across the 50-ohm load resistor installed across J108 in step 3 *a* (2) (*c*), above.

5. Connect the second VTVM to terminal #4 of T109.

6. Make sure all tubes are in their respective sockets.

(*b*) PROCEDURE.

1. Turn PLATE ON-OFF switch ON.

2. Measure the output voltage and frequency for each of the following combinations of settings of MASTER OSCILLATOR dial A-1 and OUTPUT TUNING dial C-1. Limits: minimum voltage, 2 volts; maximum frequency error, 30 cps.

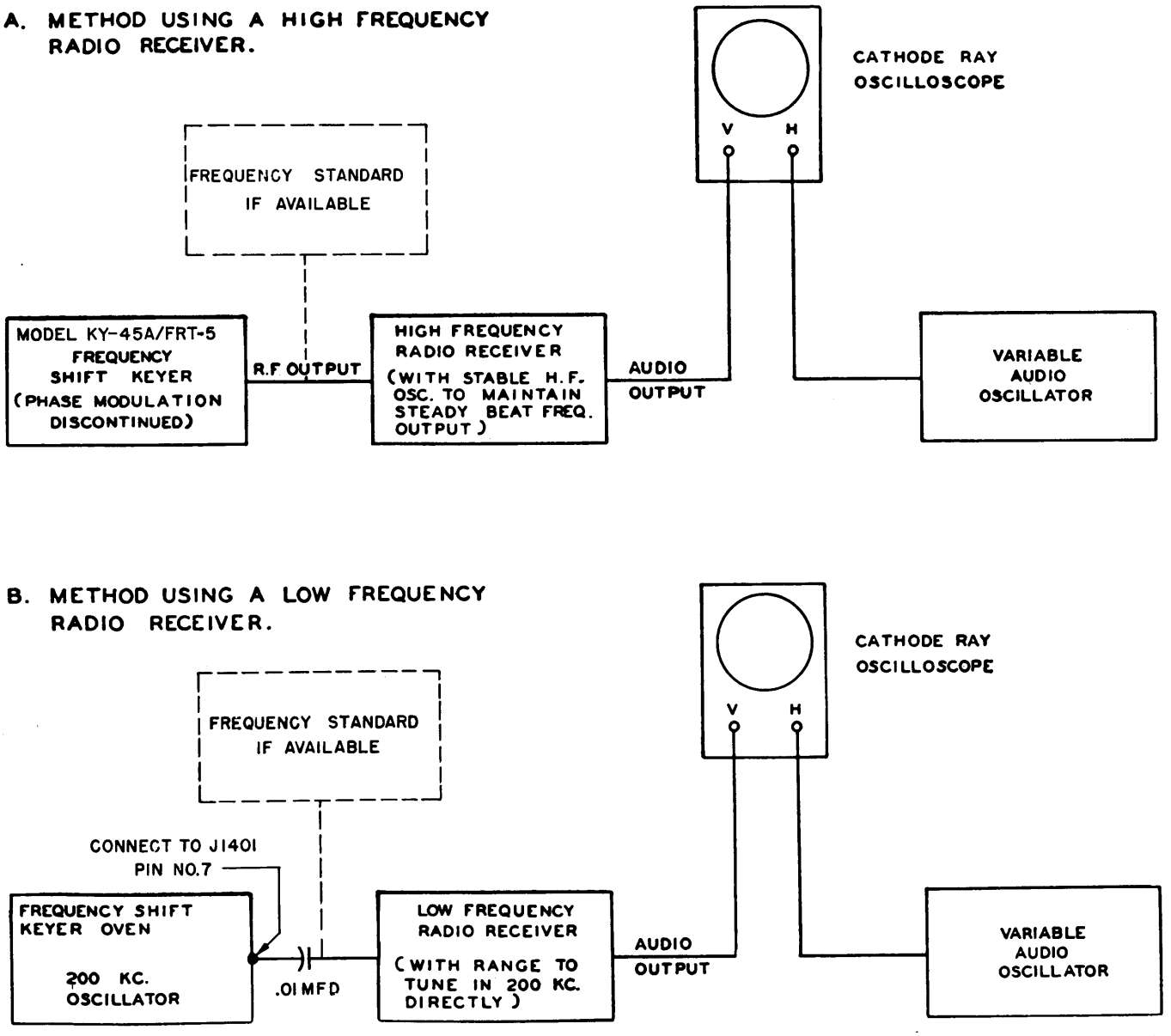


Figure 7–4. Test Set-Up Diagram — Frequency Shift Keyer KY-45A/FRT-5, Method of Connecting Oscilloscope to Display Patterns of Different Frequency Shifts

MASTER OSCILLATOR dial A-1	OUTPUT TUNING dial C-1
2.0	2.0
2.5	2.5
3.0 (doubling)	3.0
3.0 (tripling)	3.0
3.5	3.5
4.0	4.0
4.5	4.5

3. Minimum voltage over the band should be 4.0 v dc, as read on VTVM (output from term. #4 on T109).

4. Turn PLATE ON-OFF switch OFF.

b. ALIGNMENT OF FREQUENCY SHIFT KEYER KY-45A/FRT-5.

(1) TEST EQUIPMENT NEEDED FOR ALIGNMENT.

(*a*) Signal generator, General Radio type 805C.
(*b*) Secondary frequency standard.
(*c*) Oscilloscope.
(*d*) Square wave generator.
(*e*) Audio oscillator.
(*f*) Dummy load, 50 ohms.
(*g*) VTVM, Ballantine type 300A.
(*h*) Keying relay, Western Electric type 215A.
(*i*) Discriminator (refer to figure 7–7).

(2) EQUIPMENT SET-UP.

(*a*) Interconnect Frequency Shift Keyer KY-45A/FRT-5 and Power Supply PP-454A/FRT-5 with the power cable.

(*b*) Connect the line cord to a 115-volt 60-cps power source.

(3) RF ALIGNMENT.

(*a*) EQUIPMENT SET-UP.

1. Connect the power cable between J1002 on Power Supply PP-454A/FRT-5 and J1404 on Frequency Shift Keyer KY-45A/FRT-5.

2. Connect the 115-volt a-c line at J1406. Allow oven temperature to stabilize for 60 minutes.

3. Remove the 200-kc oscillator tube, V1411.

4. Set RF TUNING dial at 4.0 mc.

5. The METER SWITCH (S1402) should be in PA GRID position.

6. Connect the signal generator, tuned to 4.0 mc with an output of approximately two volts, to EXT. OSC. INPUT, J1401. THE EXT. OSC. ATTENUATOR should be at zero db.

7. Adjust all variable ceramic capacitors so that their plates are approximately five degrees engaged and all tuning cores half way in.

8. Place MODULATOR BALANCE control R1416 in either maximum or minimum position.

(*b*) ALIGNMENT PROCEDURE.

1. Place POWER switch in ON position.

2. Adjust capacitors C1406, C1408 and C1413 so that maximum grid current is indicated on M1401.

3. Change signal generator frequency and RF TUNING to 2.2 mc and adjust cores of inductors L1402, L1406 and L1407 for a maximum grid current indication.

4. Repeat steps #2 and #3, alternating between 4.0 and 2.2 mc until no further increase is noted.

5. Place METER SWITCH in PA PLATE position. Turn OUTPUT CONTROL R1430 to maximum.

6. Tune signal generator to 4.0 mc and adjust C1419 for a minimum plate current indication.

7. Return signal generator to 2.2 mc and adjust core in L1411 for minimum plate current. Repeat steps #6 and #7 until no retuning is required to bring plate current to minimum. Connect 50-ohm load at J1402.

8. Replace the 200-kc oscillator tube, V1411.

(4) MODULATOR BALANCE ADJUSTMENT.

(*a*) Connect the signal generator, tuned to 3.0 mc, to the EXT. OSC. INPUT jack (J1401). The EXT. OSC. ATTENUATOR should be set at zero db.

(*b*) Turn RF TUNING dial to approximately 2.8 mc. Grid current and output should be indicated.

(*c*) Turn RF TUNING dial to approximately 3.0 mc. Grid current and output should be indicated. Adjust MODULATOR BALANCE control R1416 to obtain minimum plate current.

(*d*) Turn RF TUNING dial back to 2.8 mc and check output and grid current. Output should be five watts with 2.0 volts input to J1401, and with EXT. OSC. ATTENUATOR at zero db.

(5) TEST OPERATE FUNCTION SWITCH SET-UP.

(*a*) Adjust BASIC SHIFT control to "0", TEST OPERATE SWITCH to carrier position, TRANSMITTER MULTIPLICATION FACTOR switch to "1" and PHASE MODULATION DEGREES control to "0" (off).

(*b*) Using the three-beat method, adjust the 200-kc oscillator until an exact zero beat is obtained. Use signals taken from the keyer, the frequency standard and the BFO.

Measure the 200-kc frequency by coupling the output from the terminal #7 of tube V1401 through a 0.01-mf capacitor to a radio receiver capable of tuning to this frequency.

The measuring technique for steps #6, #7 and #8 is the same as that used in step #5 except that the receiver BFO is not used and the audio output from the receiver is compared, instead, with the audio frequency of a calibrated audio oscillator.

If a radio receiver capable of being tuned to 200 kc is not available, a high frequency receiver may be used, provided it covers the frequency range from 2 mc to 4 mc. In this case a sample of r-f voltage taken from the KEYER OUTPUT jack (J1402) must be coupled to the receiver input along with the output of the frequency standard, and it will be necessary to apply an injection voltage at the EXT. OSC. INPUT jack (J1401) of the keyer. With this method, if the frequency of the signal generator used to supply the injection voltage is known, the setting of the 200-kc oscillator and the adjustments to be made in steps #6, #7 and #8 may be made at the keyer output frequency which, after completion of step #5, will be 200 kc lower than that of the injection voltage.

(6) FREQUENCY SHIFT CALIBRATION.

(*a*) Begin with the equipment adjusted as in paragraph 3 *b* (5) (*b*) above. Turn the FREQUENCY SHIFT control to the maximum position.

(*b*) Adjust KEYER BALANCE control R1450 to return signal to zero beat. Place the TEST OPERATE switch in the SPACE position, and adjust the FREQ. SHIFT CALIBRATION control for a 1000-cps shift. Then place the switch on MARK. The frequency should increase to approximately 1000 cps.

(*c*) If a 1000-cps shift is not obtained, adjust FREQ. SHIFT CALIBRATION control and recheck. Correct adjustment is obtained when the total shift is 2000 cps, e.g., 1000 cps for mark and 1000 cps for space.

(*d*) Put the TEST OPERATE switch in the FSK position and apply a mark signal on key line J1407A. Adjust LIMITER ADJUST R1439 until a note is heard which is the same frequency as that obtained with the TEST-OPERATE switch in the MARK position. The frequency should increase as in step (*b*). Next apply a space signal. The frequency should now decrease producing a total shift of 2000 cps.

(7) "TRANSMITTER MULTIPLICATION FACTOR" CONTROL ACCURACY. — Place the TRANSMITTER MULTIPLICATION FACTOR control in position #1, and the TEST OPERATE switch in the CARRIER position, and adjust the FREQ. SHIFT CALIBRATION control for maximum shift. Keyer balance must be correct as in paragraph 3 *b* (6) above. Rotate TEST OPERATE switch to either MARK or SPACE; either will produce a 1000-cps beat note. Adjust the audio oscillator to produce a 1:1 oscilloscope pattern. Successively greater ratios of oscilloscope pattern should be obtained as the TRANSMITTER MULTIPLICATION FACTOR control is rotated clockwise.

"Transmitter Multiplication Factor" Control Position	*Oscilloscope Pattern*
1	1:1
2	2:1
4	4:1
8	8:1

The foregoing ratios shall be obtained by varying the audio oscillator not more than ±20 cps at each position.

(8) CARRIER SHIFT LINEARITY FOR PHOTO INPUT. — Place TEST-OPERATE switch in PHOTO position. Adjust PHOTO-ADJUST R1448 so that an input of 15 ma into the photo key line (pin "C" of connector J1407) yields zero cps shift from carrier. Vary the line current from 30 ma to 0 ma five ma steps. The amount of resultant shift should be within the following limits:

Line Current	*Required Shift*	*Tolerance*
30.0	+1000 cps	+5%
25.0	+ 667 cps	±50 cps
20.0	+ 333 cps	±33-1/3 cps
15.0	+ 0 cps	±16-2/3 cps
10.0	— 333 cps	0 cps
5.0	— 667 cps	±16-2/3 cps
0	—1000 cps	±33-2/3 cps

(9) PHASE MODULATION OSCILLATOR. — Turn the BASIC SHIFT control to give 850 cps shift (425 cps above and below) carrier.

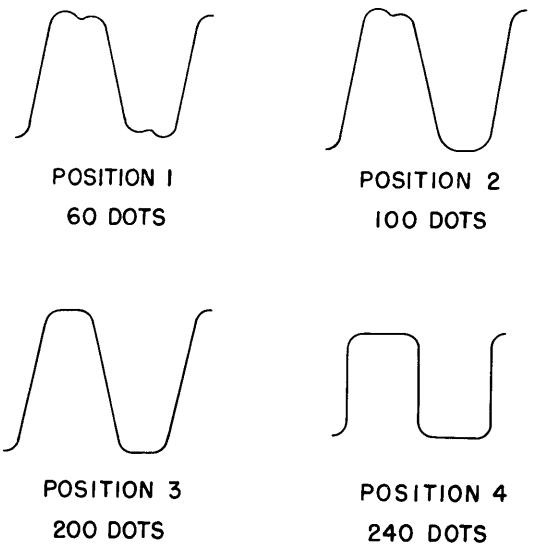
(*a*) Turn PHASE MODULATION control to ON position.

(*b*) Compare the output of the 200-cps oscillator at terminal #2 of J1403 with an audio oscillator, using an oscilloscope to check its frequency.

(*c*) Set WAVE SHAPING switch on position #3.

(*d*) Connect a 20-dot-cycle signal to key line input.

(*e*) Connect a discriminator (figure 7–7) and oscilloscope to keyer output jack J1402. This should be terminated with a 50-ohm load.



WAVE FORMS OF DISCRIMINATOR OUTPUT FOR DIFFERENT POSITIONS OF WAVE-SHAPING SWITCH S1404, AND FOR DIFFERENT DOT SPEEDS.

Figure 7–5. Oscillograms — Frequency Shift Keyer KY-45A/FRT-5, Wave Forms of Discriminator Output for Different Positions of Switch S1404, and for Different Dot Speeds

(*f*) Adjust the PHASE MODULATION dial to obtain one radian of phase modulation as indicated by the oscilloscope pattern. (Refer to figures 7–6 and 7–8.)

(10) WAVE SHAPING.

(*a*) Adjust keyer for 3.5 mc output.

(*b*) Connect square wave generator to the keying line at J1407A.

(*c*) View waveform on the oscilloscope.

(*d*) Check waveforms of r-f output for different positions of wave shaping switch, S1404, and for different dot speeds as shown in figure 7–5.

c. RADIO TRANSMITTING SET AN/FRT-5A ALIGNMENT.

(1) TEST EQUIPMENT NEEDED FOR ALIGNMENT.

(*a*) Dummy load.

(*b*) Secondary frequency standard.

(*c*) Vacuum tube voltmeter.

(*d*) Q-meter, Boonton Radio type 200A.

(*e*) Audio oscillator, Hewlett-Packard #200 BR or equivalent.

(*f*) A-C voltmeter, 0-10 volt, ½% accuracy.

(2) EQUIPMENT SET-UP.

(*a*) Interconnecting cables are to be installed between the cabinets for RF Unit T-225A/FRT-5 and Power Supply PP-490A/FRT-5 and the external units, namely, Power Control C-587A/FRT-5 and Power Transformer TF-122/U.

(*b*) The 230-volt 3-phase line is to be connected to Power Control C-587A/FRT-5.

(3) ADJUSTMENT OF FIRST MULTIPLIER PLATE TUNING COIL AND CAPACITOR.

(*a*) Plug in servo amplifier Z801 and allow it to warm up.

(*b*) The multiplier chassis should be tipped forward so that the type 807 tubes (V502 and V503) and their associated tank circuits are readily accessible. Refer to figure 3–10. The first multiplier is the one to the left. Turning the FIRST MULTIPLIER PLATE TUNING control [A] on the front panel should cause the associated plate tuning circuit, C511, and L503, to follow. If the circuit is wired properly the rolling coil contact will move toward the top of the exciter chassis as the control is rotated clockwise. The servo drive motor should operate only when the control is turned and should stop a short time after rotating the control.

(*c*) Adjust the "anti-hunting" control, R804, so that the servo motor starts and stops smoothly. This control is screw driver adjustment located on the front of each amplifier.

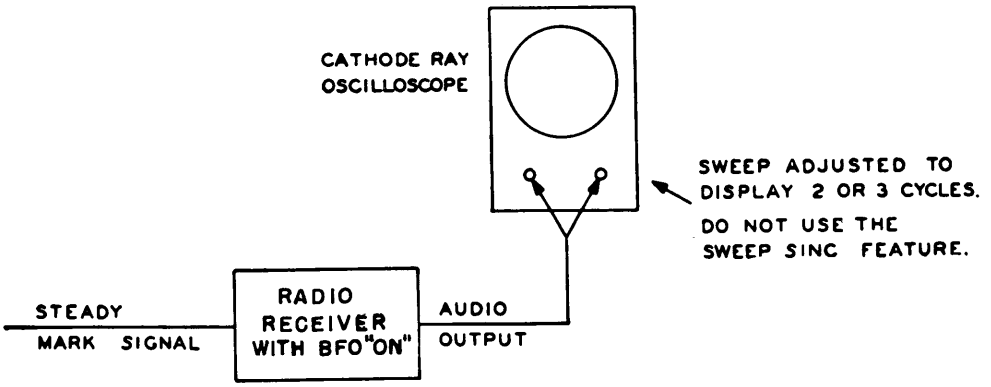
(*d*) If it is impossible to make the motor follow the control [A] in accordance with the above outlined procedure it may be an indication that the motor field is reversed. This can be checked by reversing the leads on terminals #11 and #12 on the backside of the connector, J806, mounted in the common servo amplifier enclosure. Refer to figure 7–69.

(*e*) After the servo control has been checked and found to operate properly, carefully adjust variable air capacitor C511 for maximum capacity. At this capacity setting, place the rolling contact of coil L503 on the last turn at the bottom (nearest the drive unit) end of the coil. Remove the servo drive unit by loosening the two hold-down screws, then turn the front panel control [A] counterclockwise to zero on its scale. This sets the servo drive motor at its low frequency limit.

(*f*) Replace the drive unit and check the operation to see that the circuit operates properly throughout its range.

WARNING

THE FUSE MOUNTS LOCATED ON EITHER SIDE OF THIS MULTIPLIER UNIT ARE ENERGIZED DURING THESE TESTS AND ACCIDENTAL CONTACT



CONNECTION OF OSCILLOSCOPE TO DISPLAY WAVEFORM WITH PHASE MODULATION.

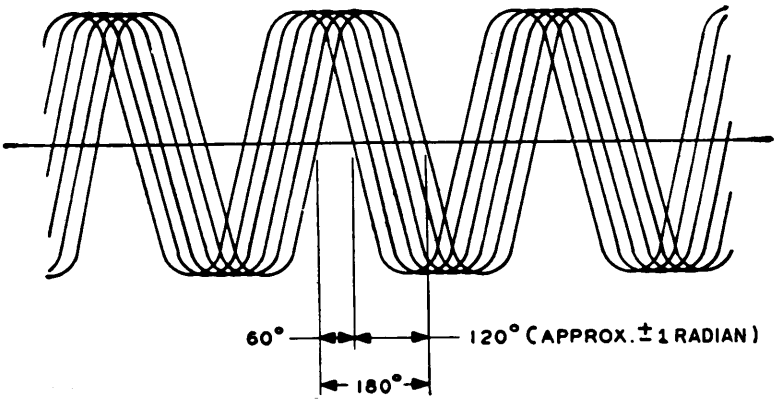


Figure 7—6. Test Set-Up Diagram — Frequency Shift Keyer KY-45A/FRT-5, Method for Checking One Radian of Phase Modulation, Using a Radio Receiver; and Oscillogram of Wave Shape

WITH THEIR TERMINALS WILL CAUSE AN UNPLEASANT, AND POSSIBLY DANGEROUS, SHOCK.

(4) ADJUSTMENT OF SECOND MULTIPLIER PLATE TUNING COIL AND CAPACITOR.

(*a*) Plug in servo amplifier Z802 and wait for it to warm up.

(*b*) This circuit is on the right side of the frequency multiplier chassis. Follow the same procedure as that outlined in paragraph 3 *c* (3) above, except for subparagraphs (*e*) and (*f*).

(*c*) After the servo control has been checked and found to operate satisfactorily, carefully set the variable air capacitor C517 to near minimum capacity so that the tips of the rotor blades and the stator blades are just ready to start meshing. At this capacitor setting set the roller contact of coil L506 on the top (end away from the drive unit) turn.

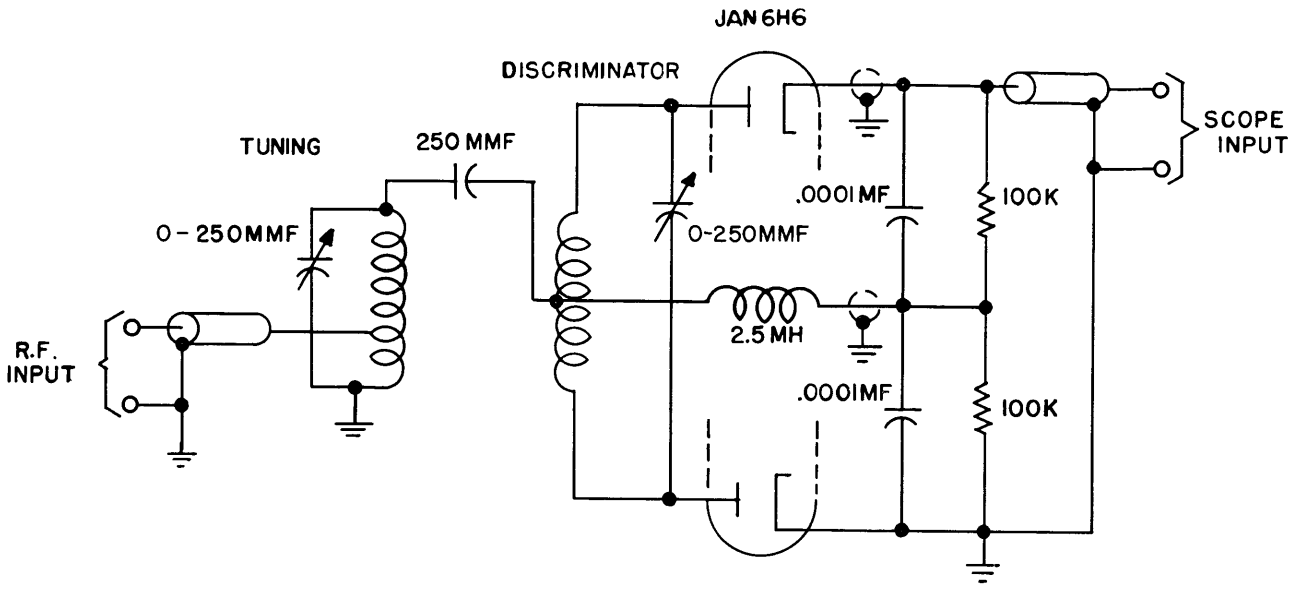
(*d*) Remove the servo drive unit by loosening the two hold-down screws, then turn the front panel control [B] completely clockwise to the "1000" mark on its scale. This sets the servo drive motor to its high frequency limit.

(*e*) Replace the servo drive unit and check the operation to see that the circuit operates properly throughout its range.

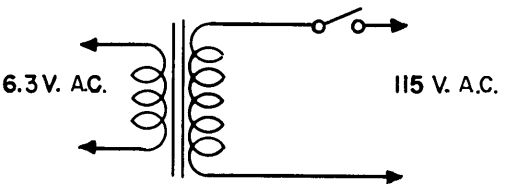
(5) ADJUSTMENT OF DRIVER PLATE TUNING COIL AND CAPACITOR.

(*a*) Plug in servo amplifier Z803 and allow it to warm up.

(*b*) Check operation of the servo drive unit in accordance with the procedure outlined in sub-



COILS ARE WOUND ON A 1 1/2 INCH DIAMETER FORM, SIDE BY SIDE, AND SINGLE LAYER CLOSE WOUND. DISCRIMINATOR COIL IS CENTER TAPPED.



FREQ. MC	TURNS TUNING	TAP TUNING	TURNS DISCRIMINATOR	SPACING BETWEEN COILS	SIZE WIRE
1.78 - 4.95	28	2	28	5/16 IN.	26 D.C.C.

Figure 7–7. Schematic — Frequency Shift Keyer KY-45A/FRT-5, Discriminator Circuit for Checking Wave Shapes

paragraphs (*b*), (*c*), and (*d*) of paragraph 3 *c* (3) above.

(*c*) Remove the variable vacuum capacitor C526 from the assembly.

(*d*) Rotate the tuning control counterclockwise until the slider on the variable inductor, L509, is at the extreme right end. The dial reading should be "0".

(*e*) Loosen the set screws on the shaft at the right end of the dual-coupled variable air capacitor assembly (C533 and C534) and adjust this capacitor carefully for maximum capacity. Retighten the set screws.

(*f*) Run the servo drive unit to its extreme high frequency position by rotating the DRIVER PLATE TUNING control [C] clockwise to the "1000" mark.

(*g*) Operate the circuit from the front panel control [C] to see that it is functioning properly. The vacuum capacitor C526 is still out.

(*h*) Set the SERVO CONTROL [C] so that there is exactly one turn of the variable inductor L509 between its left end and the slider.

(*i*) Using a Q-meter or other equally accurate means set the vacuum variable capacitor C526 to 40.7 mmf, and replace it in the circuit.

(*j*) Again check the operation of the circuit, readjusting the anti-hunt control, R804, if necessary, to obtain smooth starting and stopping.

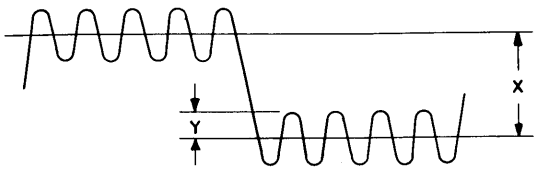
(6) ADJUSTMENT OF PA PLATE TUNING COILS AND CAPACITORS.

(*a*) Plug in amplifier Z804 and allow it to warm up.

(*b*) Check operation of the servo drive unit in accordance with the procedure outlined in subparagraphs (*b*), (*c*) and (*d*) of paragraph 3 *c* (3) above.

(*c*) Remove the variable vacuum capacitors

(1) WAVE FORM (APPROX. ± 1 RADIAN OF PHASE MODULATION.



(2) APPROXIMATE DETERMINATION OF PHASE MODULATION.

$$\text{PHASE MODULATION (RADIANS)} = \frac{\frac{Y}{X} \times \text{FREQUENCY SHIFT}}{\text{FREQUENCY OF PHASE MODULATING OSCILLATOR}}$$

MULTIPLY BY $\frac{360}{2\pi}$ TO CONVERT RADIANS INTO DEGREES.

EXAMPLE:

FREQUENCY SHIFT = 850 CYCLES
FREQUENCY OF PHASE MOD. O.S.C = 200 CYCLES
FROM ABOVE WAVE FORM Y/X = 1/4 APPROX.

$$\text{PHASE MODULATION} = \frac{\frac{1}{4} \times 850}{200}$$

$$= 1.06 \text{ RADIANS OR } 60.7 \text{ DEGREES}$$

Figure 7—8. Diagram — Frequency Shift Keyer KY-45A/FRT-5, Method of Checking Phase Modulation, Using Discriminator; and Oscillogram of One Radian of Wave Shape

C569 and C570 by opening the top and bottom clamp bands and sliding them up and outward.

(*d*) Disengage the drive coupling to the slider contacts of plate tank coil L516 and L517 by removing the two screws on each coupler. Block up the top section of the couplers to prevent them from making contact.

(*e*) Rotate the POWER AMPLIFIER PLATE TUNING control [D] clockwise to the "1000" position. Note that the plate tank drive mechanism follows properly, and that its limit switch stops its operation at or just before the dial reaches the "1000" mark. Turn the control to zero and note that the mechanism follows and that the limit switch operates at or near zero on this end also. Reset the system to the "1000" mark.

(*f*) Manually set sliding contacts one-quarter of a turn from the top of the tank coils L516 and L517. In this position the slider bars will be parallel and the top contact will be at the extreme rear of the coil.

1. With the sliders in this position and the servo drive dial set at the "1000" mark, the tank coil drive couplings should be lined up so that the top section could be lowered into place without rotating either top or bottom section. If this is not the case the chain sprocket wheels of the drive unit must be rotated to produce alignment. This is accomplished as follows:

a. Note the number of sprocket teeth and direction that each of the two large sprockets must be moved — write this down.

b. Turn the front panel control [D] to some position near the middle of the scale and when the drive has positioned itself shut off the SERVO POWER breaker.

c. Loosen the chain tightener on the drive unit and carefully move the sprockets with respect to the driving chain, the number of teeth and direction previously noted.

d. Retighten the chain and turn on the SERVO POWER breaker.

e. Again set the front panel control [D] at the "1000" mark; if you have been careful the coupler will be lined up ready to slip together.

2. Reassemble the drive couplers and operate the tank drive through its range two or three times to see that everything is operating smoothly. Reset control [D] at the "1000" mark and proceed to the next step.

(*g*) Using a Q-meter and a 15-mc frequency set the capacitance of the two variable vacuum capacitors C569 and C570 at approximately 100 mmf, being careful to set them alike.

(*h*) Manually rotate the splined nut clockwise (toward minimum capacity), carefully keeping track of the starting point and number of turns until the stop is reached. Select the unit which required the least number of turns from its 100-mmf setting to the top and set the other capacitor to the same number of turns, or part turns, from its 100-mmf position.

(*i*) Rotate both capacitor nuts one-quarter turn counterclockwise to make certain that they never hit the stops in operation and replace them in the transmitter, being careful not to turn the shaft in the process.

(*j*) Rotate the POWER AMPLIFIER PLATE TUNING control [D] counterclockwise to the zero position, noting that everything operates smoothly and properly.

(7) ADJUSTMENT OF COUPLING RACK IN RF UNIT T-225A/FRT-5.

(*a*) Plug in amplifier Z805 and allow it to warm up.

(*b*) The carriage should move to the rear of the cabinet as the POWER AMPLIFIER (PA) LOADING control [E] on the front panel is rotated clockwise toward the "1000" position.

(*c*) Check operation of the servo drive in ac-

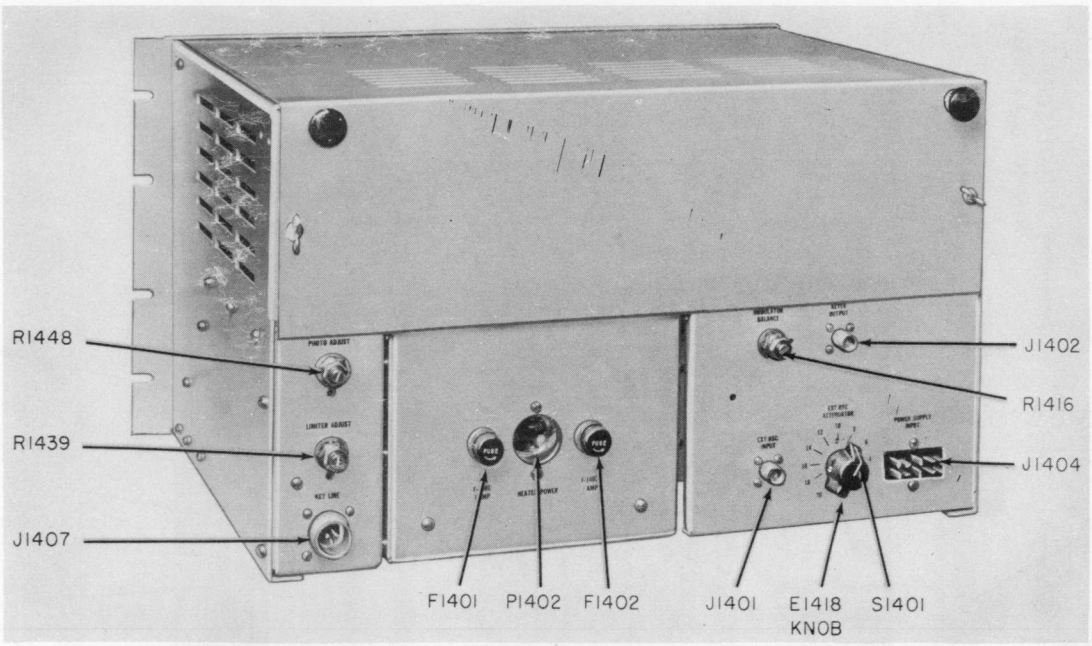


Figure 7—42. Frequency Shift Keyer KY-45A/FRT-5, Rear View

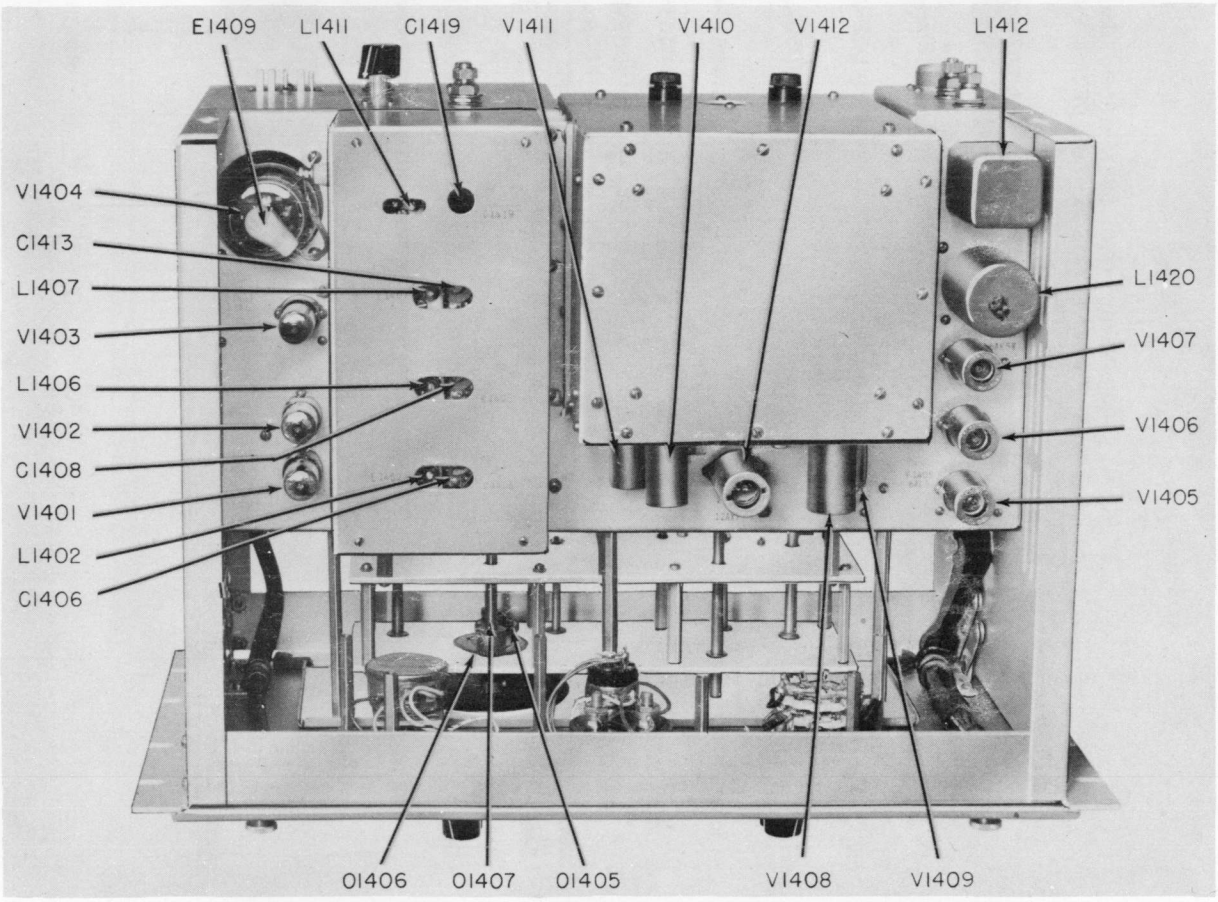


Figure 7—43. Frequency Shift Keyer KY-45A/FRT-5, Top View, Dust Cover Removed

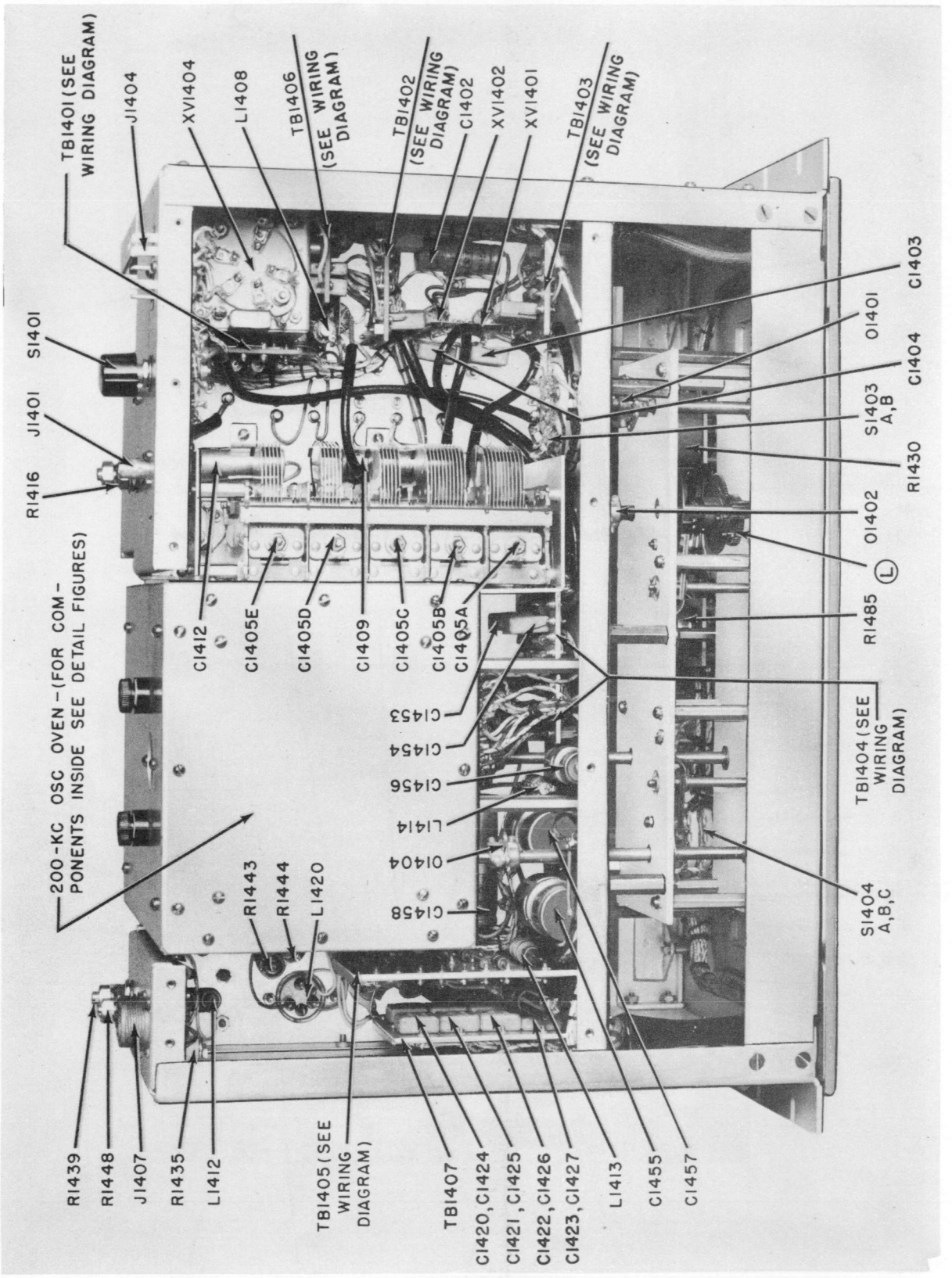


Figure 7—44. Frequency Shift Keyer KY-45A/FRT-5, Bottom View, Dust Cover Removed

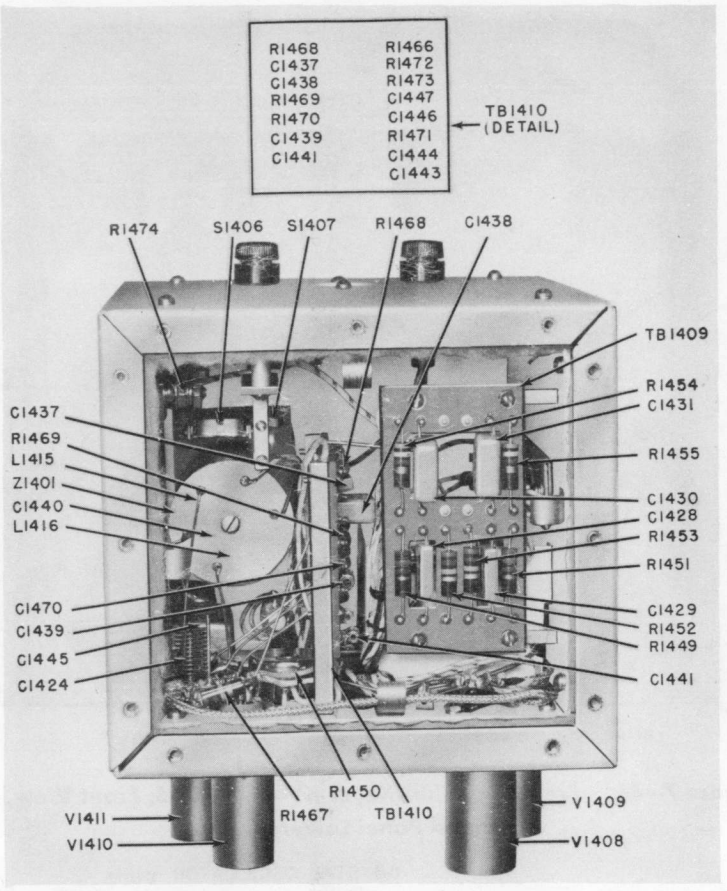


Figure 7—45A. Frequency Shift Keyer KY-45A/FRT-5, Top View of Oven, Cover Plate Removed

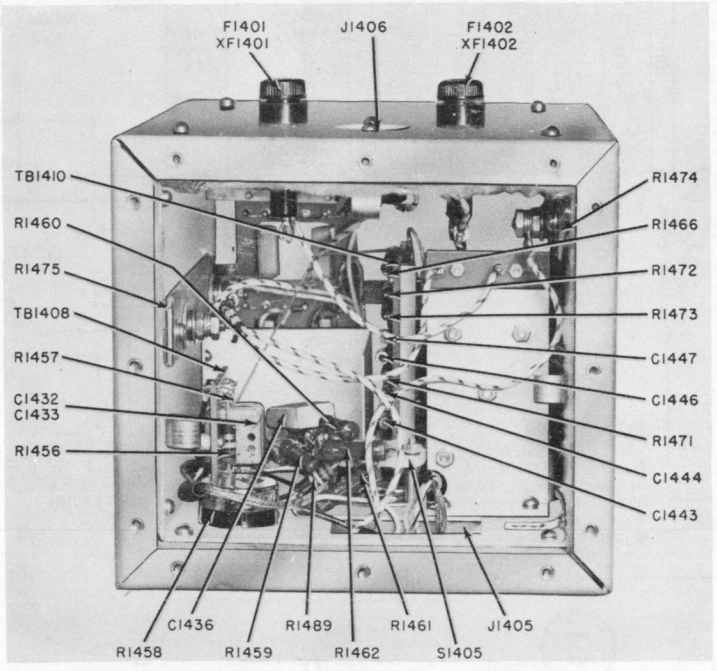


Figure 7—45B. Frequency Shift Keyer KY-45A/FRT-5, Bottom View of Oven, Cover Plate Removed

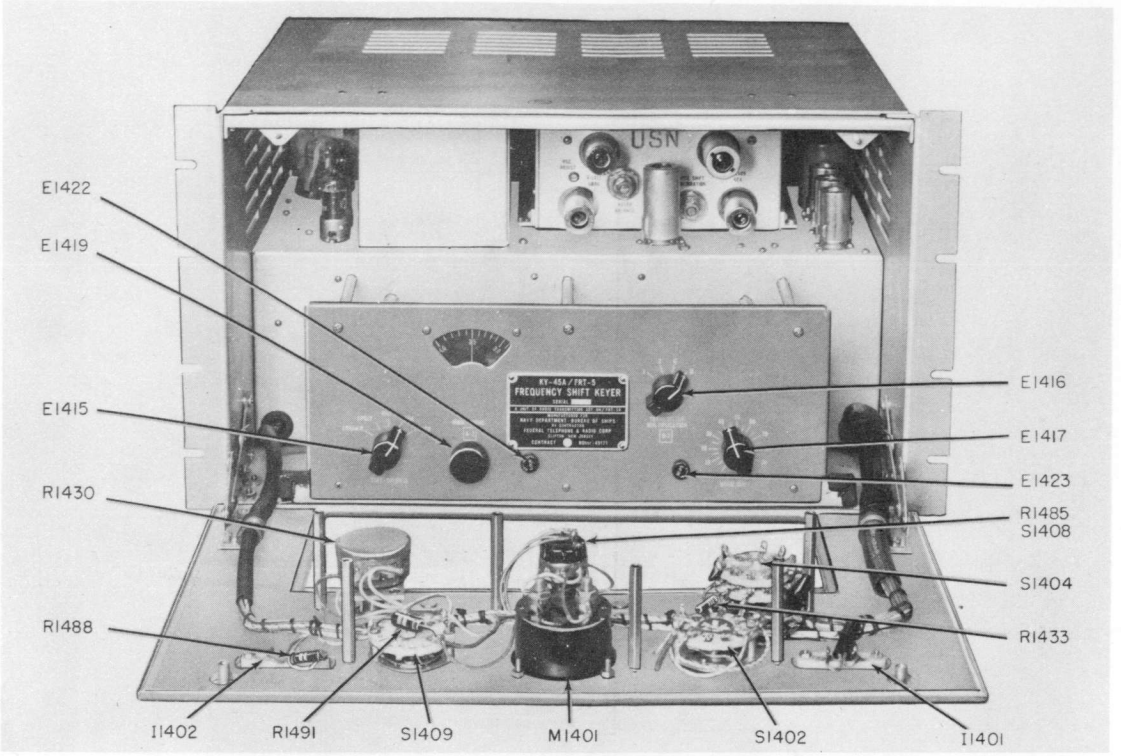


Figure 7—46. Frequency Shift Keyer KY-45A/FRT-5, Front View, Hinged Panel Lowered

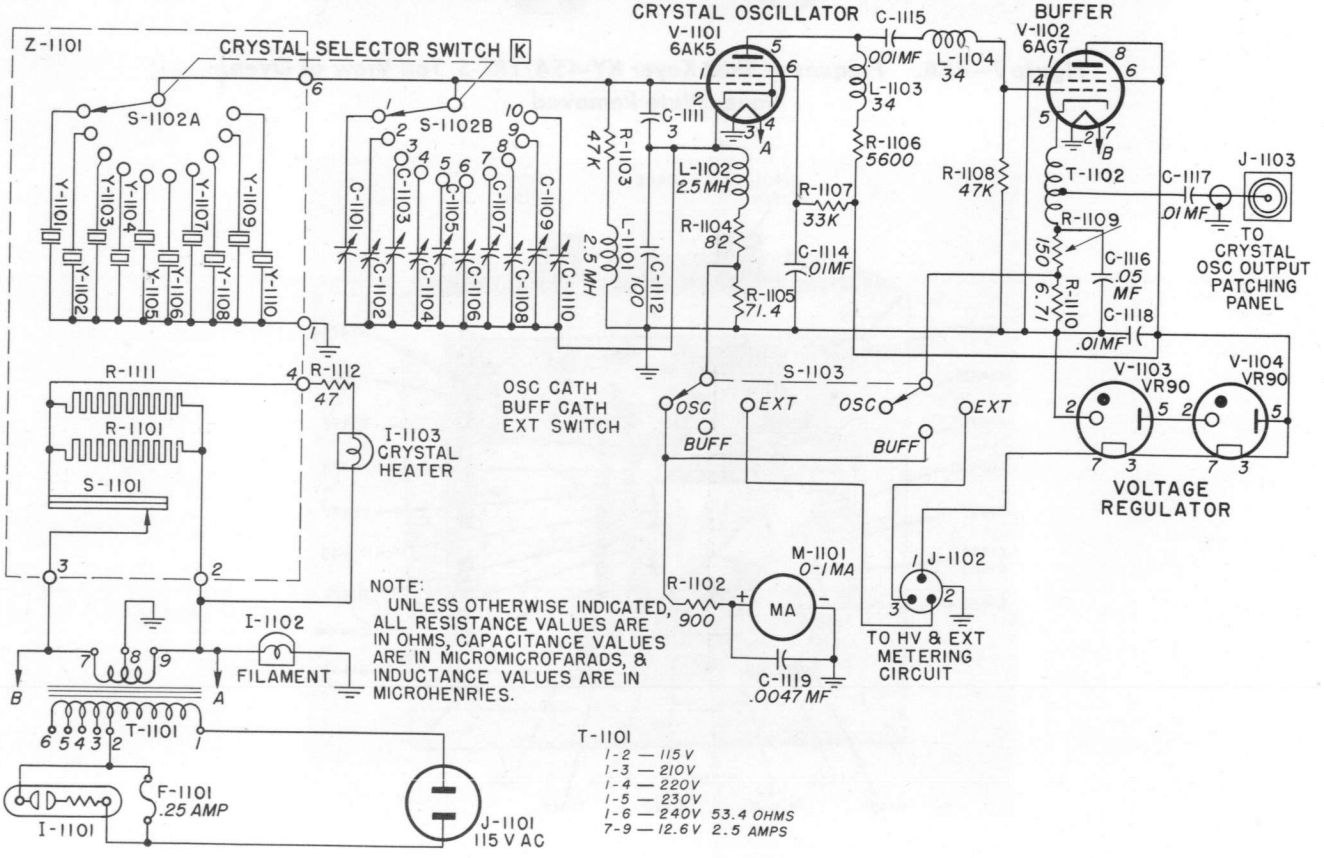


Figure 7—47. Schematic — RF Oscillator O-92A/FRT-5

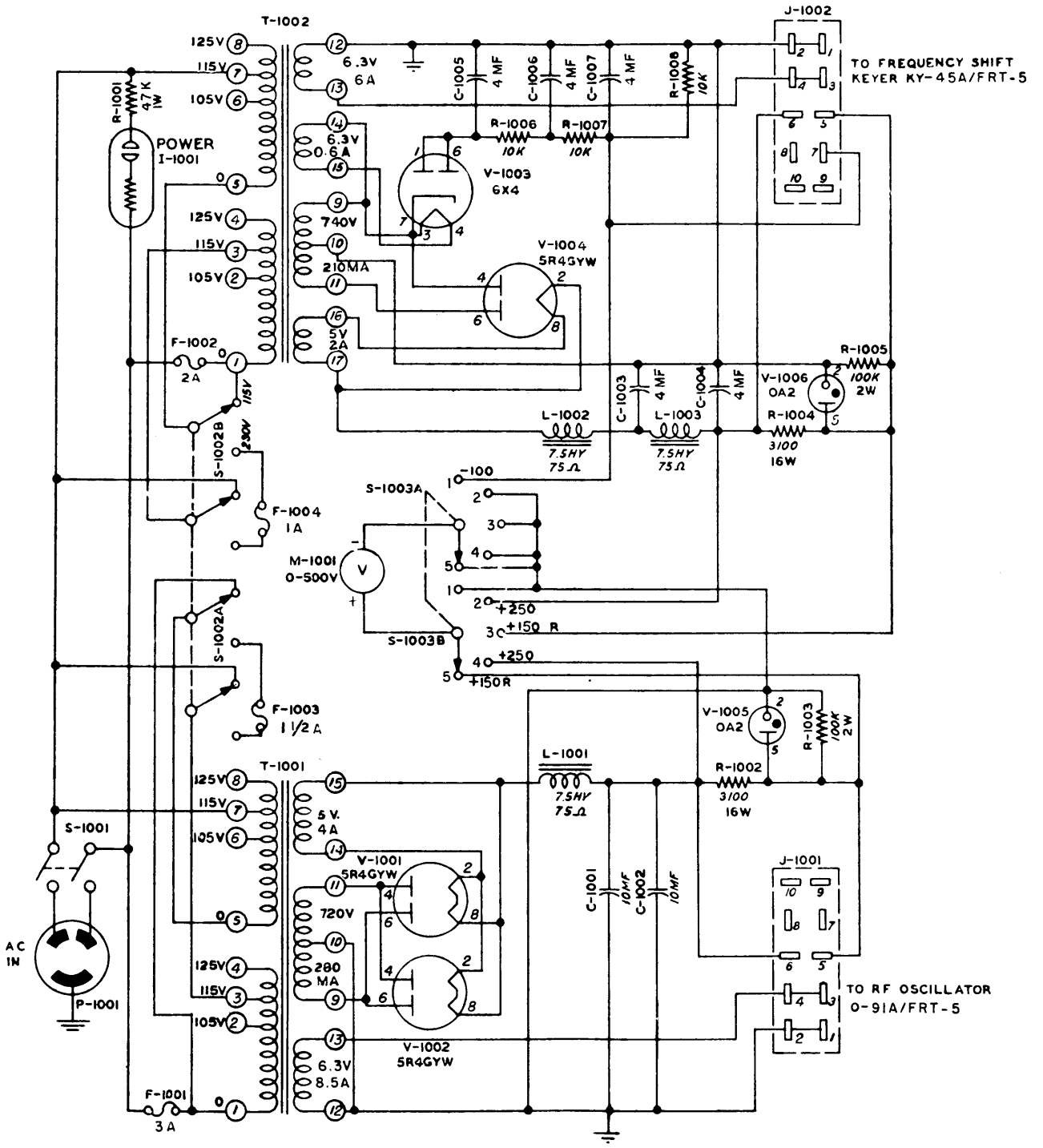


Figure 7–49. Schematic — Power Supply PP-454A/FRT-5

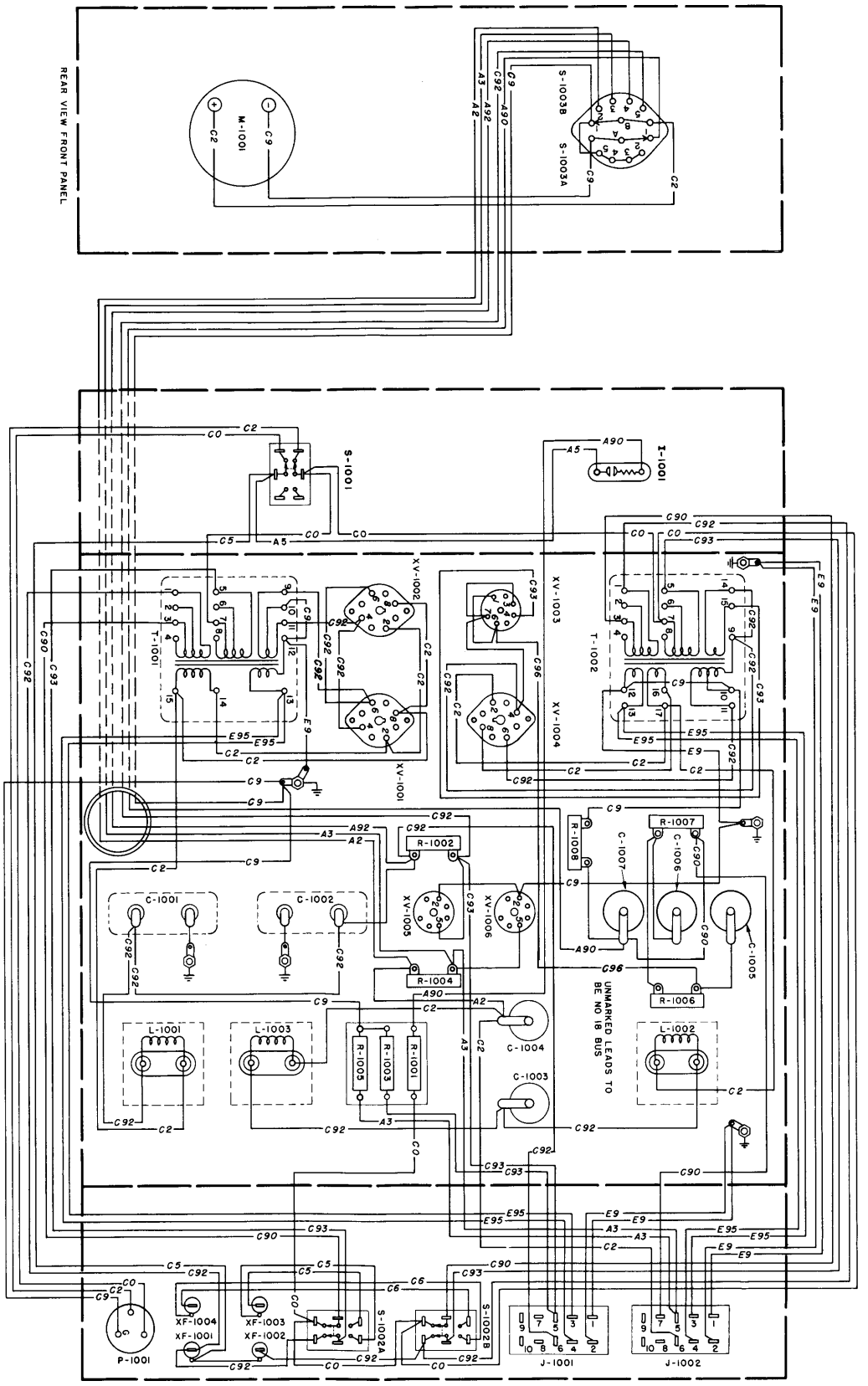
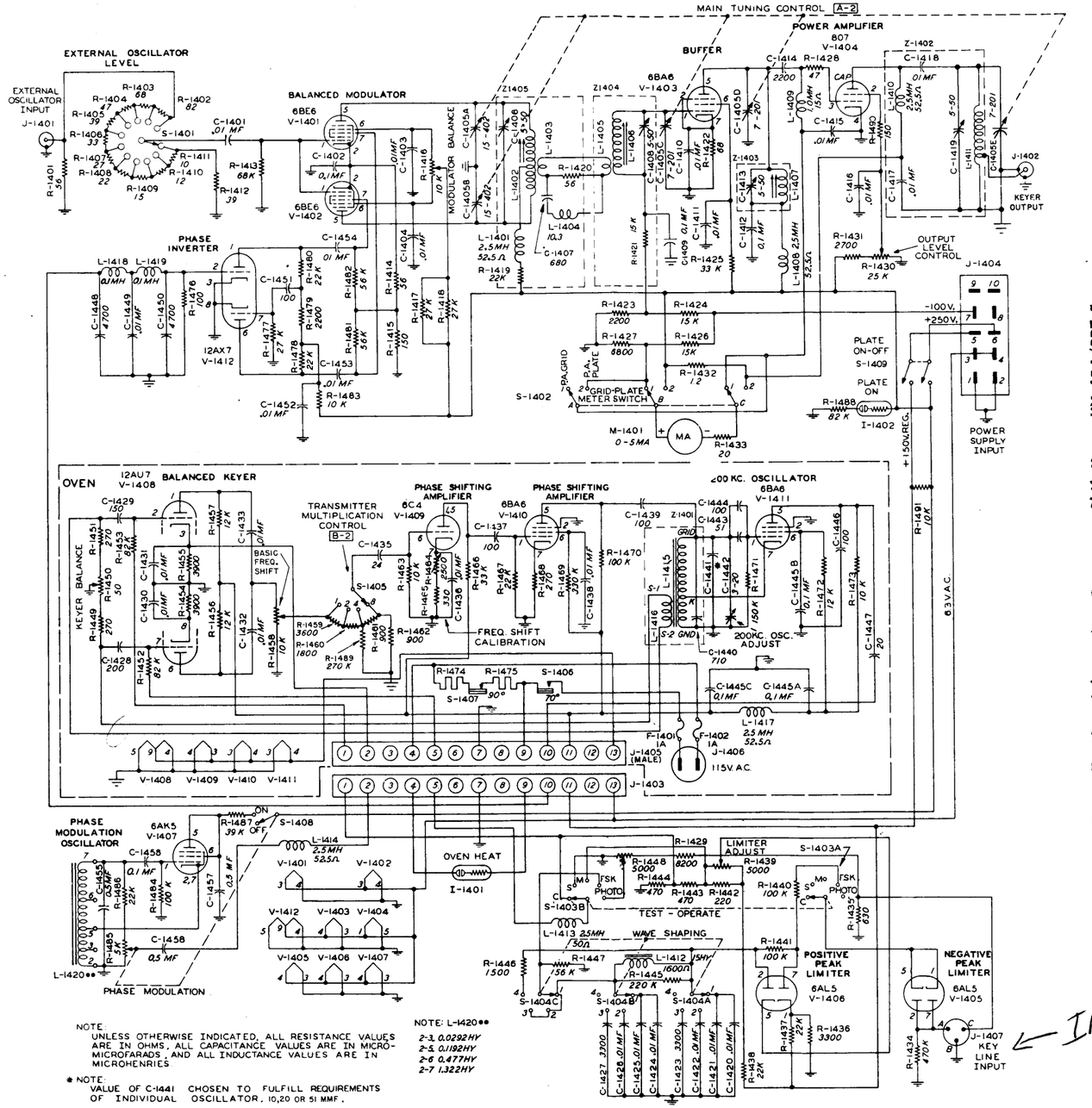


Figure 7–50. Wiring Diagram — Power Supply PP-454A/FRT-5



NOTE:
UNLESS OTHERWISE INDICATED, ALL RESISTANCE VALUES ARE IN OHMS, ALL CAPACITANCE VALUES ARE IN MICROFARADS, AND ALL INDUCTANCE VALUES ARE IN MICROHENRIES

* NOTE:
VALUE OF C-1441 CHOSEN TO FULFILL REQUIREMENTS OF INDIVIDUAL OSCILLATOR. 10,20 OR 51 MMF.

NOTE: L-1420••
2-3 0.0292HY
2-5 0.1192HY
2-6 0.477HY
2-7 1.322HY

Figure 7–53. Schematic — Frequency Shift Key for KY-45A/FRT-5

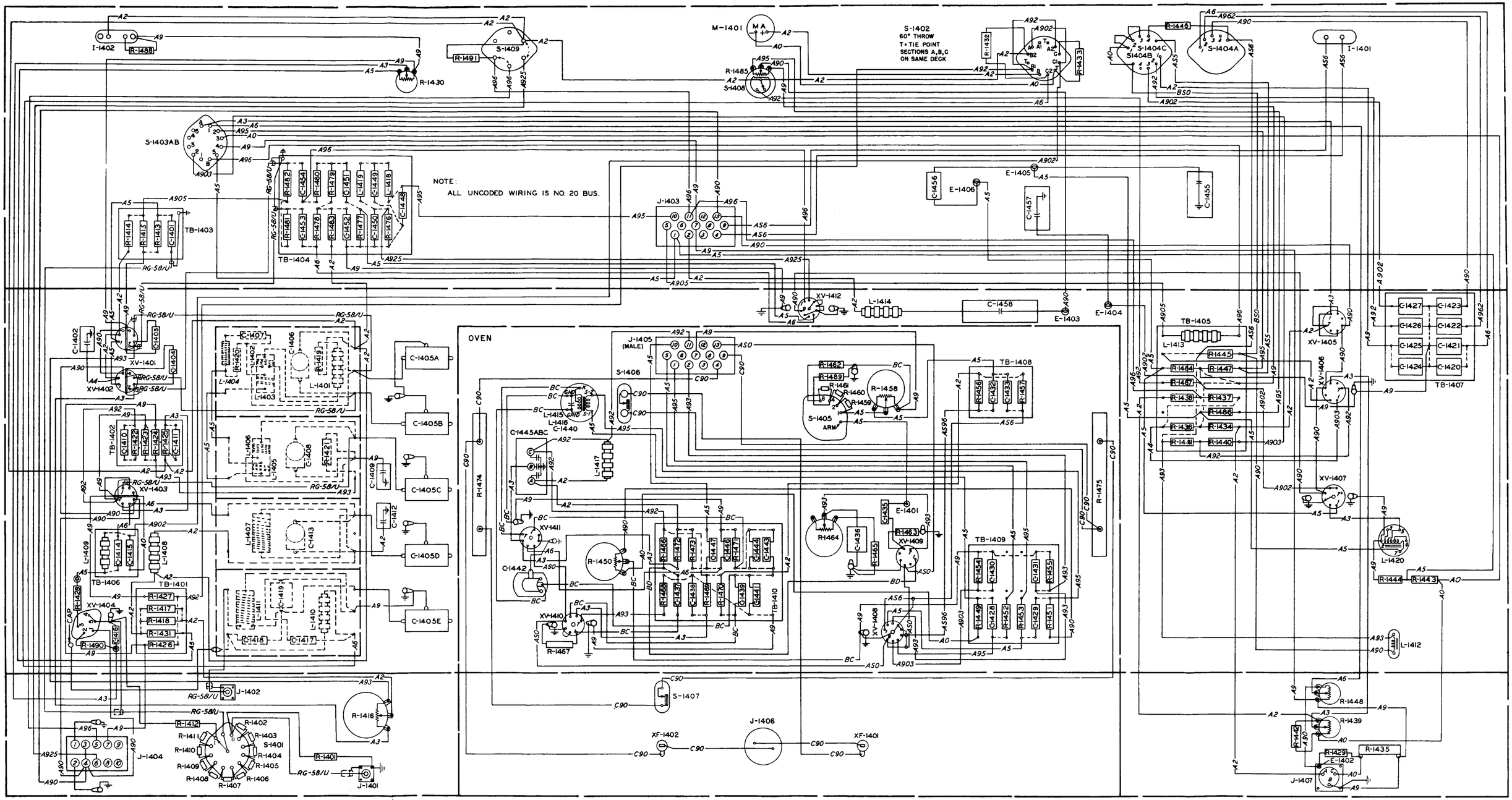


Figure 7–54. Wiring Diagram — Frequency Shift Keyer KY-45A/FRT-5, Chassis