TM 11-6625-355-45

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

GS AND DEPOT MAINTENANCE MANUAL

AUDIO OSCILLATORS
TS-421/U AND
TSU-421A/U

HEADQUARTERS, DEPARTMENT OF THE ARMY

JUNE 1966

WARNING

Be careful when working on the 500-volt power supply and 300-volt plate circuits or on the 115-volt ac line connections. Remove power when making inspections inside the equipment. Always set the OUTPUT ATTENUATOR (DB) (0–100) control to 20 DB or more before handling connections to the OUTPUT terminals; with O output attenuation, over 150 volts a.c may be present at the OUTPUT terminals.

DON'T TAKE CHANCES!

TECHNICAL MANUAL
No. 11–6625–355–45

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C.,22June1966

GS and Depot Maintenance Manual

AUDIO OSCILLATORS TS-421/U AND TS-421A/U

***This manual supersedes TM 11–6625-355–12, 7 November 1960, and together with TM 11–6625-355–2, 11 May 1966, supersedes TM 11–2649, 1 October 1945.**

CHAPTER 1

THEORY

Section 1. GENERAL

1-1. Scope

a. This manual covers general support and depot maintenance for Audio Oscillators TS-421/U, and TS-421/U. It includes instructions appropriate to genera] support, and depot maintenance for troubleshooting, testing, calibrating, repair of equipment, and replacing maintenance parts. It also lists test equipment for general support and depot maintenance. Detailed circuit operation of the equipment is described in the theory section. Audio Oscillators TS–421/U and TS–421A/U are similar and will be referred to as Audio Oscillator TS–421 (*)/U. Information in this manual applies to both models unless otherwise specified.

b. The complete technical manual for this equipment includes TM 11–6625–355–12.

c. The direct reporting by the individual user of errors, omissions, and recommendations for improving this manual is authorized anti encouraged. DA Form 2028 (Recommended Changes to DA Publications) will be used for reporting these improvement recommendations. This form will be completed using pencil, pen, or typewriter, and forwarded direct to Commanding General, U.S. Army Electronics Command, ATTN: AMSEL-MR-(NMP)–MA, Fort Monmouth, N. J., 07703.

1 –2. Index of Equipment Publications

Refer to the latest issue of DA Pam 310–4 to determine whether there are new editions, changes or additional publications pertaining to the equipment. Department of the Army Pamphlet No. 310–4 is a current index of technical manuals, technical bulletins, supply manuals (type 4, 6, 7, and 8), lubrication orders, and modification work orders that are available through publications supply channels. The index lists that individual part (–10, –20,–35P, etc.) and the latest changes and revisions of each equipment publication.

1 –3. Differences in Models

Internal differences in models TS-421/U and TS–421A/U are listed below. Components which have the same function, but are nomenclature differently are listed in the separate columns. Where their is a difference in component value, the value is listed beside its nomenclature'. For external differences, and other internal differences, refer to TM 11–6625-355-12.

Item	TS-421/U	TS-421A/U
Resistors ----------	R2, 848K	R2, 850K
	R3, 84.6K	R3, 85K
	R4, 8.23 Meg	R4, 85K
	R5, 823K	R5, 850K
	R6, 82.1K	R6, 8.61 Meg
	R7, 500K variable	Not used
	R8, 50K variable	Not used
	R9, 5K variable	Not used
	R19	R20

Item	TS-421/U	TS-421A/U
Resistor	R20	R21
	R22	R31
	R23	R32
	R25, 100K	R24, 1.2 Meg
	R27, 3.3K	R25, 22K
	R28, 100K	R55, 22K
	R30	R28
	R31, 27,5K	R29, 5K variable and R30, 27.5K
	R32, 500	R35, 600
	R33, 56K	R26, 560K
	R34, 56K	R27, 560K
	R35, 3.3K	R23, 8.2K
	R37, 800	R19, 1K
	R38	R45
	R39, 1.5K	Not used
	R40, 6.2K	R46, 1K
	R41, 5K	R47, 500
	R42	R48
	R43	R49
	R44	R51
	R45	R52
	R46	R50
	R47, R48	R53, R54
	R24	R33
Capacitors	C1	C2
	C2	C1, C21
	C4, 8 µfd	C4, 10 µfd
	C5	Not used
	C6	C8
	C 7	Clot
	C8	C10a
	C9	C10b
	C10	C17
	C11,8µfd	C15, C16 each are 4 µfd
	C12	C18
	C13, 400 µµf	C7, 22 µµf
	C14, .001 µfd	C19, 20 µfd
	C15	Not used
	C17	C12
	C18	C13
	C19	C14
Controls	MAIN tuning dial	FREQUENCY dial
	VOLUMN control	AMPLITUDE control
Switches	S2	S5
	S4	S2

1-4. Signal Paths
(fig. I-l)

a. When the audio oscillator is used for gain, distortion or frequency response measurements, the audiofrequency (af) output from resistance-capacitance (rc) oscillator stage is amplified, measured by the OUTPUT LEVEL meter, attenuated, and fed to the external equipment being tested. The response signal of the equipment under test is fed through the input attenuator and input amplifier into the INPUT LEVEL meter for measurement.

h. When the audio oscillator is used as a source of af voltage, the output from the rc oscillator stage is amplified, measured by the OUTPUT LEVEL meter, attenuated, and fed to the external equipment being tested.

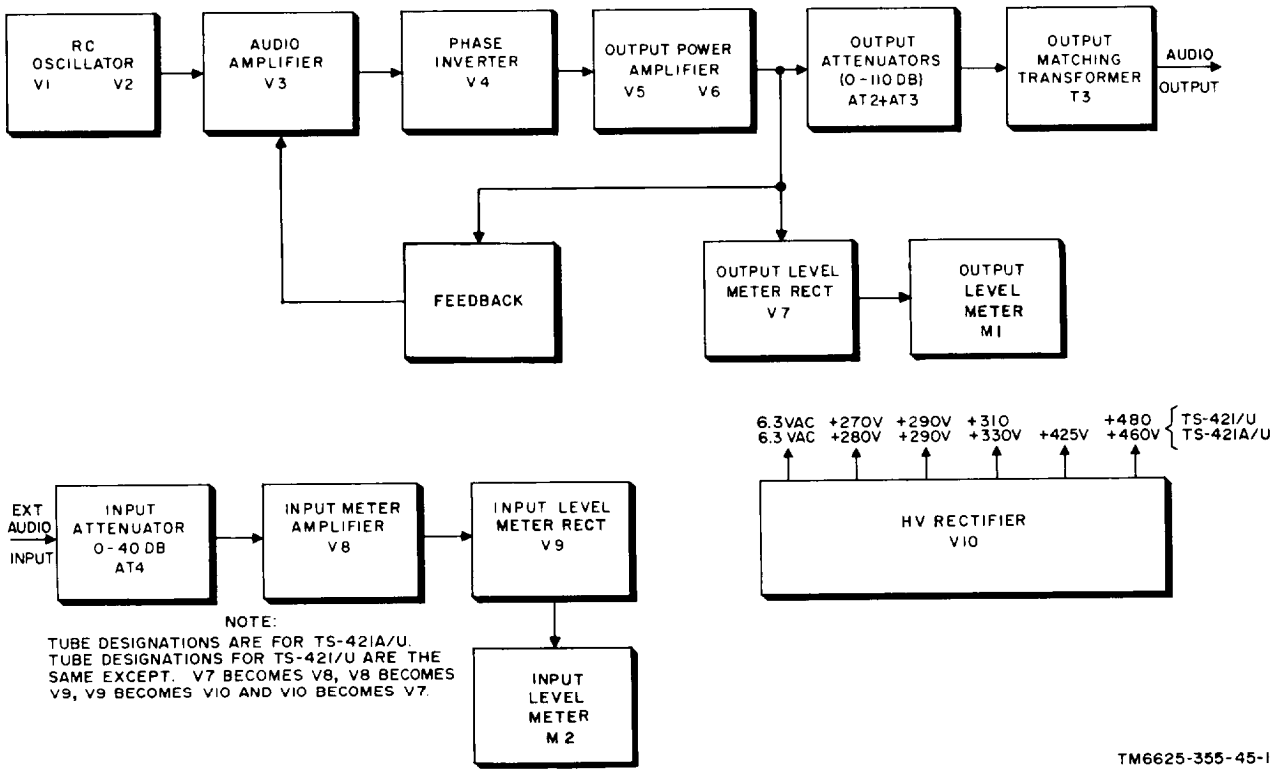


Figure 1–1. Audio Oscillator TS–421(*)/U, block diagram.

Section II. UNIT THEORY

1-5. Block Diagram

The audio oscillator is a signal response measuring device used to check the response characteristics of equipments within the af range. Signal paths shown in the block diagram (fig. l–l) are discussed in a through *g* below.

a. Rc *Oscillator Section (V1 and* V2). The oscillator section is a two-stage recoupled oscillator which provides accurate af voltage within the range of 20–20,000 cycles per second (cps). The af output is fed to audio amplifier V3.

b. *Audio Amplifier V3.* Audio amplifier V3 selects a portion of the rc oscillator output voltage for subsequent amplification. The amplifier. is a triode type with a voltage gain of about 5.

c. *Phase Inverter V4 and Output Power amplifiers V5 and V6.* The phase inverter **provides a balanced, phase-inverted output to the grids of V5 and V6. The push-pull output power amplifier provides maximum amplification of the output signal.**

d. Output Level Meter Rectifier V7 (V8 for TS–421/U) and OUTPUT LEVEL Meter M1. **The output level meter rectifier rectifies a portion of the output from the power output amplifier and applies it to the OUTPUT LEVEL meter for measurement.**

e. *Output Attenuators AT2 and AT3 and Output Matching Transformer T3.* 'The' output attenuators provide from O to 110 decibels (db) attenuation in 1–db steps. The output matching transformer allows an exact output impedance match for an output load of 50, 200, 600, or 5,000 ohms (12.5. 50, 125, 200, 500, 12.50 or 5000 for TS–421/U).

f. Input Attenuator AT4. **Input attenuator AT4 provides from 0 to 40–db attenuation of**

input signal in 5–db steps, to reduce high input voltage levels to within the range of the INPUT LEVEL meter circuit

g. *Input Meter Amplifier* V8 *(V9 for TS-421/U). The input meter* amplifier is a two-stage circuit with an overall gain of about 15. This amplifier provides a high input impedance to avoid loading the signal source and provides sufficient output signal for proper indication on the INPUT LEVEL meter.

h. *INPUT LEVEL Meter M2.* The INPUT LEVEL meter measures the input signal from the circuit under test.

i. Power Supply. The power supply consists of a full-wave rectifier and capacitor-input filter. Two sections of inductance capacitance (lc) filtering and several sections of rc filtering are employed. The power supply can be connected to operate with either 115-volt or 230-volt alternating-current (at) input.

1-6. Rc (Wien-Bridge) Oscillator

a. *General* Instead of using a resonant lc circuit, the Wien-Bridge oscillator uses rc coupling combined with a two-stage amplifier to provide positive feedback to the grid of the first stage which results in oscillation, Tuning is accomplished by varying the rc combination in the feedback circuit, which controls the amount of positive feedback to the first stage. A current-sensitive resistor provides degeneration which limits the oscillator output voltage to the desired range and minimizes distortion.

b. *Frequency General.*

(1) A simplified schematic diagram of the rc oscillator circuit (fig. 1–2) shows that the necessary *360 phase* shift for positive feedback is obtained through use of a two-stage amplifier. The feedback to the first stage is obtained from the output of the second stage through rc coupling network R3, C2A, R4, and C2B for TS–421A/U and R1, C1, R2 and C2 for TS–421/U. The input voltage to V1 from A to ground has exactly the same phase as the voltage from B to ground, which is the condition of pure positive feedback. This condition can occur only when the phase angles of the two resistance-capacitance branches (R3, C2A and R4, C2B) (R1, C1, R2, and C2 for TS-421/U are equal and opposite, thereby canceling out any phase difference between the voltage applied at A and B, with respect to ground.

(2) For any combination of resistance and capacitance in the two rc branches, zero phase shift will occur at only one frequency, which determines the frequency of oscillation. The formula for the output frequency is

$$f_0 = \frac{1}{2\pi\ rc}$$

1–7. Audio Amplifier V3 (fig. 1-3 or 5-4)

(a. The audio amplifier is a triode stage that amplifies the input from the rc oscillator. Resistor R58 (TS–42IA/U only) and capacitor C23 (TS-421A/U only) form a frequency-compensating network which adjusts the input amplitude of the signal received from the oscillator to achieve a flat frequency response in the output from the amplifier. The values of R58 and C23 are selected to provide an output voltage within 21 to 25 volts at 1000–cycles, on TS–421A/U only. Variable resistor R21 (R20 for TS-421/U) is the AMPLITUDE (VOLUME for TS–421/U) control which allows a portion of the oscillator output voltage to be applied to the input of audio amplifier V3. Capacitor C5 is the coupling capacitor between R21 and the grid of V3 on TS–421A/U only. On TS–421/U, capacitor C7 and resistor R23 form a decoupling network for. the plate circuit of tube V3. Resistor R22 is the grid-return resistor for V3 which is used on TS–421A/U only. Resistor R23 (R35 for TS–421/U) is the cathode-brasing resistor and C19 (C14 and C15 for TS-421/U) is the cathode bypass capacitor. Resistor R24 (R25 for TS–421/U) is the plate load for V3.

b. Cathode-biasing resistor R23 (R35 for TS–421/U) and cathode bypass capacitor C19 (C14 and C15 for TS-421/U) are returned to ground through winding E-F on output transformer T2 (fig. 1–4). The transformer feedback winding and its connections are arranged to provide negative feedback to V3.

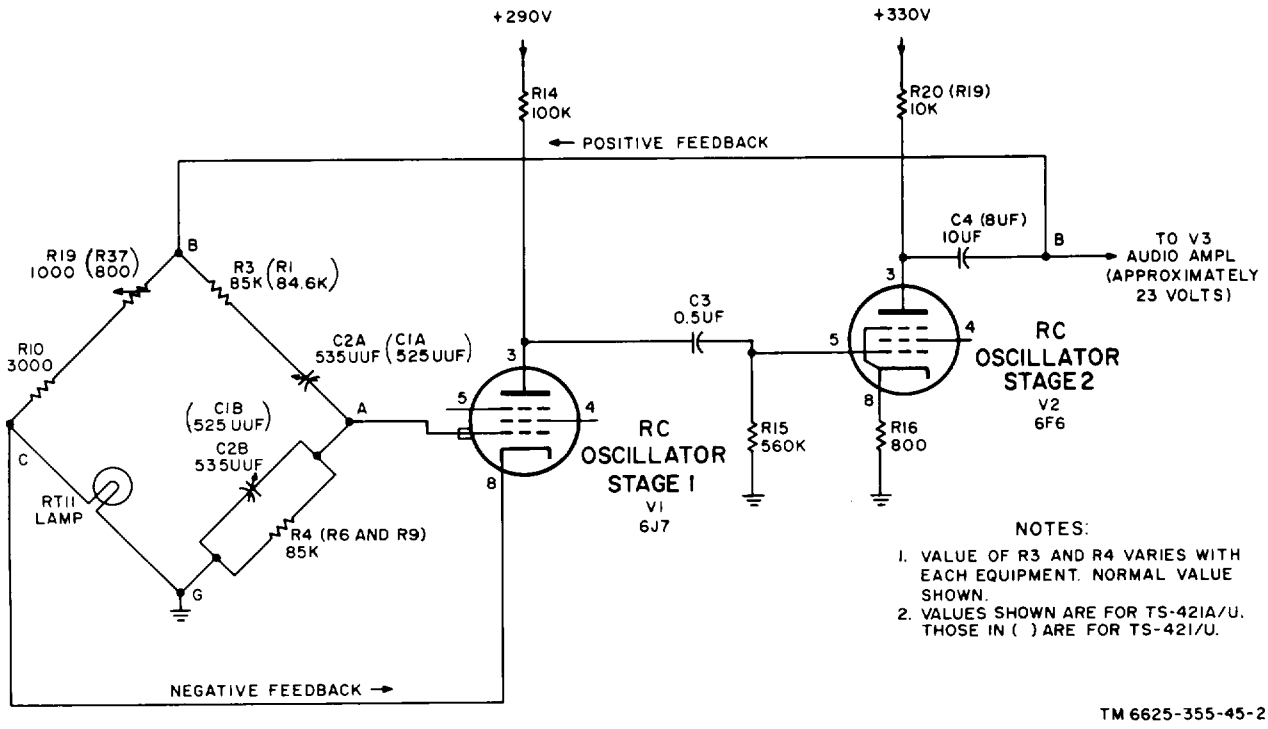


Figure 1–2. RC (Wien Bridge) oscillator, simplified schematic diagram.

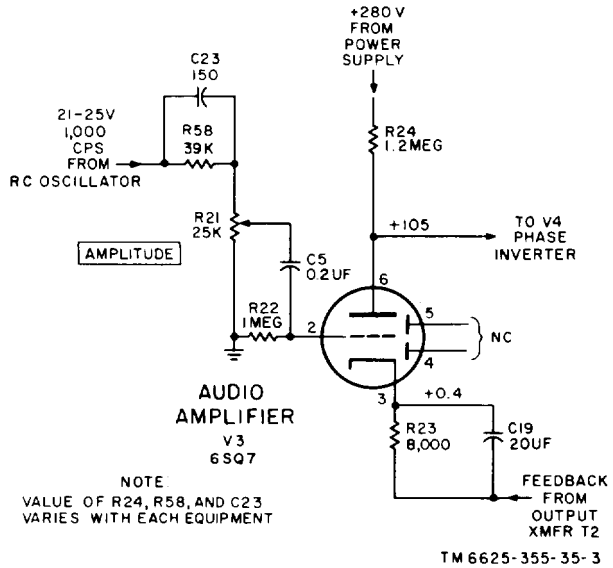


Figure 1–4. Audio amplifier, schematic diagram.

1-8. Phase Inverter V4 and Output Power Amplifier V5 and V6

The output power amplifier is a conventional push-pull power amplifier which uses a phase inverter to supply proper drive to the grids of V5 and V6.

a. *Phase Inverter T8–421A/U.* **Resistor R55 is the plate load resistor for V4 (fig. 1–4). Resistor R25 is the cathode-biasing resistor for V4 and acts as a cathode-follower load resistor for V4. The output signal developed across R55 in the plate circuit is coupled to the grid of V5 through C9. The output signal developed across R25 in the cathode' circuit is equal in magnitude and opposite in phase to the one developed in the plate circuit and is coupled to the grid of V6 through C8. This 180° phase difference results because the voltage on the cathode of a tube is in phase with the signal voltage applied to the grid, while the output voltage on the plate circuit of a tube is 180° out of phase with the signal voltage applied to the grid, A positive-going signal to the grid of V4 increases the**

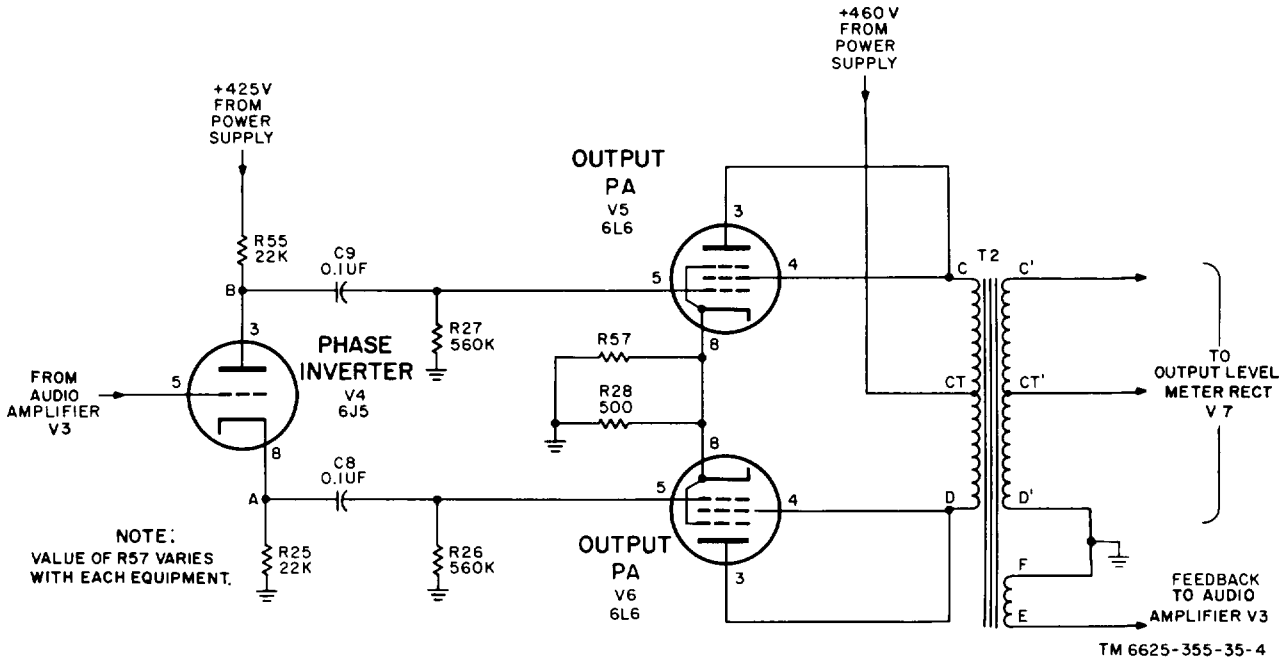


Figure 1-4. Phase inverter and output power amplifier,schematic diagram.

flow of current through the tube. This increase's current flow through R25 and R55. The increased current flow through R25 will increase the voltage drop across it and thereby raise the voltage at point A, which is coupled to the grid of V6. The increased flow of current through R55 will increase the voltage drop across it and thereby decrease the output voltage at point B, which is coupled to the grid of V5. Application of a negative-going signal to the grid of V4 will produce the opposite effect, and tile two outputs will still be 180" out of phase with eachother. The voltage magnitudes of each output will be identical, because they are developed by an equal change of current through equal resistances.

b. Phase *Inverter, TS–421/U.* Resistor R28 is the plate load resistor for V4 (fig. 5–4). Resistor R27 is the cathode'-biasing resistor for V4. The output signal of amplifier tube V3 is passed through capacitor C5 and is impressed on resistors R26 and R21; both have the same value as resistor R29. The signal voltage which appears across resistor R21 is applied to the grid of tube V4 through coupling capacitor. C16. The output of tube V4 is passed through capacitor C6 and applied across resistors R29 and R21. Thus, half of the output of both tubes V3 and V4 appears across resistor R21. Since these two voltages are always of opposite polarity (tube V4 produces phase inversion because of normal R-C amplifier operation), the resultant voltage across resistor R21 is the difference between the two voltages applied. The output of tube V3 is slightly greater than the output of tube V4 since the effective voltage at the grid of tube V4 is the difference between the outputs of tubes V3 and V4. The use of tube V1 makes possible the application of signal voltages at the grids of tubes V5 and V6 which are equal in magnitude but opposite in polarity.

c. *Push-Pull Output Power Amplifier TS–421(*)/U.The exciting* voltages of equal magnitude but opposite phase are developed by phase inverter V4 and applied to grids of v5 and V6, as described in a above. The outtputs from V'5 and V6 are therefore 180° out of phase with each other and equal in magnitude. These outputs are applied to the end taps of output transformer T2. The plate and screen supply voltage for tubes V5 and V6 is supplied through center tap CT of transformer T2. Thus, the C-CT portion of the transformer

winding acts as a plate load and output coupling impedance for tube V5 (fig. 1–5), the D–CT portion of the T2 winding acts as a plate load and output coupling impedance for tube V6. Center tap CT is held at a constant voltage by the power supply; therefore, the output signal from V5 produces an increase 01. decrease in the voltage between C and CT, and the output signal voltage from V6 (180° out of phase with that from V5) produce's a decrease or increase, at the same time, in the voltage between D and CT. In the no signal condition, plate current for each tube will be equal and will flow through T2 in opposite directions so that the net magnetizing current applied to the primary winding of the transformer is zero. Thus, no output signal is developed. When a sinusoidal signal is applied to the respective control grids of V5 and V6, sinusoidal plate currents flow in the primary winding of transformer T2. The plate current of V5 is 180° out of phase with the plate current of V6 since the two grid signals are 18° out of phase with each other. During tile positive swing of the plate current in V5, point C on the primary becomes more negative with relation to point CT. At the same time, the fall in plate current in V6 causes point D to become less negative with respect to point CT by an equal amount. Therefore, the voltage across the entire primary (CD) is twice the value across either end and the center tap. Thus, the output of each tube is effectively added by this push-pull operation. A half-cycle later, all the polarities reverse, which effectively produces a sinusoidal output to the secondary winding of T2. Resistors R26 and R27 are grid-return resistors for V5 ancl V6 on TS–421A/U, respectively. Resistors R33 and R34 on TS–421,/U are used to limit the value of peak plate current flow when too large an af grid voltage is applied to the output tubes. Resistor R28 (paralleled by R57 when necessary for accurate factory calibration) is the cathode-biasing resistor for V5 and V6 (TS-421A/U only). Resistor R30 on TS–421/U is the cathode-biasing resistor for tubes V5 and V6.

d. *Feedback Stabilization Loop.* Feedback output winding E–F output transformer 2 is connected in series with the cathode-biasing network (R23, C19 for TS-421A/U) (R35, C14, C15 for TS–421,/U) of tube V3 (fig. 1–3 or 5–4). This winding connects the' cathode-biasing network to ground. The winding between taps E and F is arranged to provide negative feedback to V3. This negative feedback assure's a good frequency response and minimum distortion in the audio oscillator output.

1-9. Output Level Meter Rectifier. OUTPUT LEVEL Meter and Output Attenuators AT2 and AT3
(fig. 1-5)

a. General. The OUTPUT LEVEL meter is a conventional average-reading voltmeter which indicates the output signal voltage from the output taps of T2 after it has been rectified by V7 (W for TS–421/U). The output attenuators provide attenuation of the high-level output signal in 1–db steps from O to 110 db.

b. Output Level Meter Rectifier and OUTPUT LEVEL Meter. The arrangement of output taps C' and D' and center tap CT' of T2 is such that with a signal present, the center tap will always be negative with respect to either C' or D'. Therefore, current will flow through OUTPUT LEVEL meter Ml, R29, (R31 for TS–421/U) R30, and through one side of output level meter rectifier V7 (V8 for TS–421/U). The current will flow through pins 4 and 3 or pins 8 and 5 of V7 (V8 for TS–421/U) depending upon which plate is temporarily positive with respect to CT'. Half a cycle later, the signal will pass through 180" of phase and change the signal polarity between C' and D'. The current will continue to flow through Ml, R29, and R30, (R31 for TS–421/U), but now will pass through the other side of V7 (V8 for TS–421/U), because a different plate is now positive with respect to CT'. This action furnishes

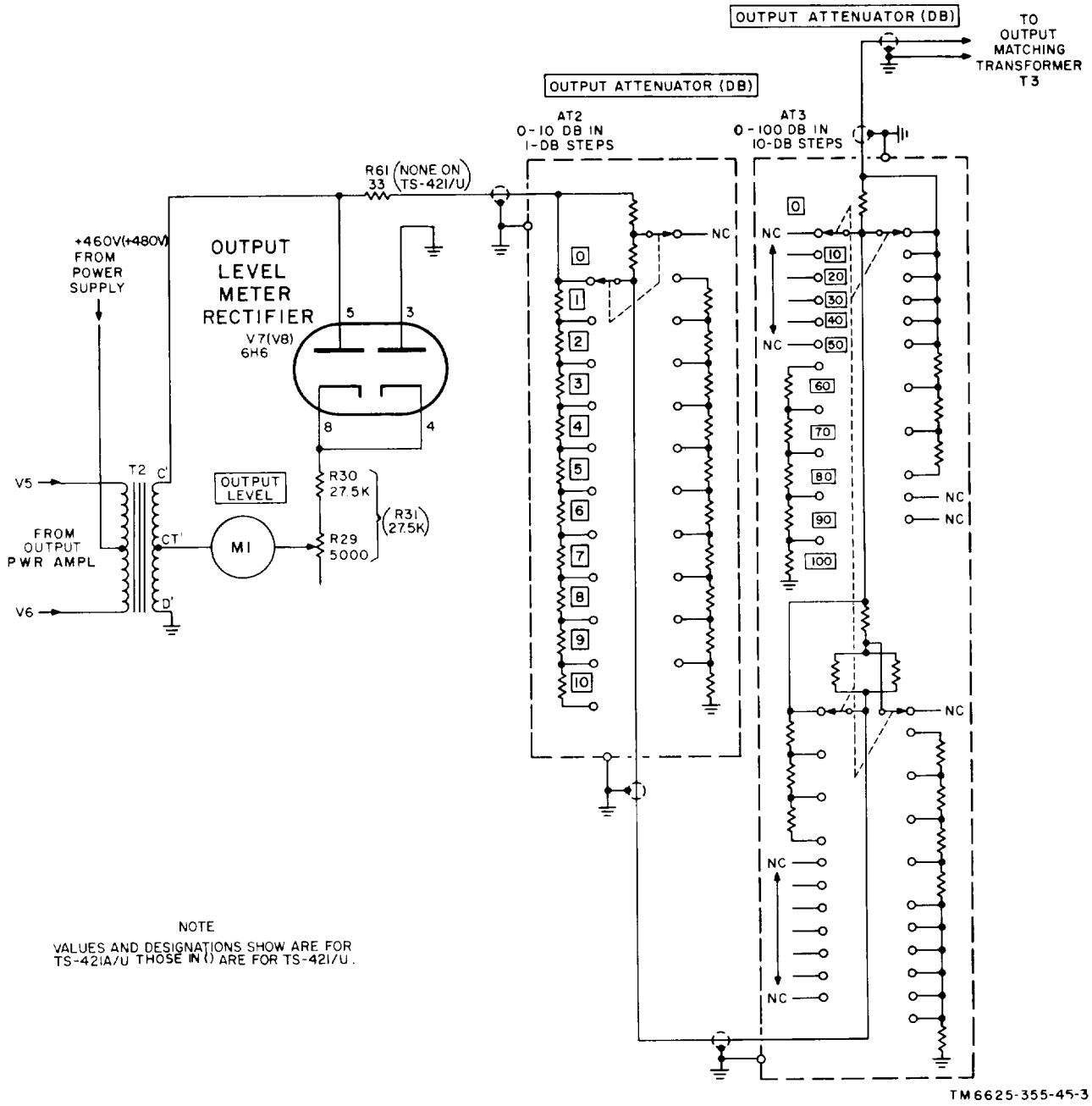


Figure 1-5. Output level meter rectifier, OUTPUT LEVEL meter and output *attenuators schematic diagram.*

a full-wave rectified direct-current (de) signal through M1. Meter 311 responds to the average value of this output level signal, The signal current passing through the meter is limited by R30 and R29 (R31 for TS–421/U) and R29. The face of M1 is calibrated to indi - cate the corresponding ac root mean square (rms) voltage of the balanced output from T2 Resistor R2- (R31 for TS–421/U) allows calibration adjustment of M1 to give an accurate output voltage reading, The meter circuit

is connected in parallel with output attenuators AT2 and AT3. Thus, the voltage indicated by M1, combined with the settings of AT2 and AT3, is an accurate indication of output voltage. Meter M1 is also calibrated to give a direct reading of decibels (referred to 1 milliwatt in 600 ohms) (dbm) power level into any matched output load. The values of R61 (for TS–421A/U ONLY) and R30 are factory-selected to permit precise calibration with an initial mid-range setting of adjustable resistor R29 (R31 for TS421A/U).

c. Output Attenuator AT2. Output attenuator AT2 is a conventional bridged-T variable attenuator using tapped precision wire-wound resistors. The unit is sealed and is replaceable only as a unit. Therefore, a detailed description of the circuitry and resistance values are not given. This attenuator provides from 0 to 10 db of attenuation in 1–db steps. The attenuation adjustment is provided by adjustment of the resistance in the bridge leg across the top of the T and. simultaneously, in the vertical leg of the T. This is accomplished by a rotary switch which connects the proper resistance taps into the circuit. With AT2 in the 0-db position, the bridge leg across the top of the T is shorted and the vertical leg of the T is open-circuited, thereby providing a no-loss path for the signal through the attenuator. As the attenuator setting is increased, the fixed resistors that form the top of the T are placed in the circuit. The bridge leg is continually increased in resistance, and the vertical (or shunt) leg is continually decreased. This action further attenuates the signal passing through AT2.

d. Output Attenuator AT3 Output attenuator AT3 is also a bridge-T variable attenuator which uses tapped precision wire-wound resistors. The resistors in AT3 have different values than those in AT2 and are arranged in a different configuration to provide from O to 100-db attenuation in 10-db steps. Both AT2 and AT3 are arranged to present a constant impedance level in the output line of approximately 500 ohms.

1–10. Output Matching Transformer (fig. 1-6)

Output matching transformer T3 provides a balanced, center-tapped output, The signal from the output attenuators is fed into the primary of output matching transformer T3. Resistor R60 provides proper impedance matching for the transformer input, for TS–421A/U ONLY. The output winding is equipped with taps which provide proper turns ratios for output impedance loads of 50, 200, 600 (500 for TS–421/U), or 5,000 ohms, The desired pair of taps is selected by IMPEDANCE switch S2 (S4 for TS–421/‘U) and connected to the vertically spaced OUTPUT terminals for balanced output. A center-tap connection on T3 is brought out to the CT terminal for applications where center-tapped balanced output may be needed. The black OUTPUT terminal is grounded and is provided with a captive ground strap (on TS–421A/U ONLY) which may be connected to the lower vertically spaced OUTPUT terminal if unbalanced output is desired. LOAD switch S3 connects 600-ohm resistor R35 across the 60(ohm output taps of T3 (500-ohm resistor R32 across 500-ohm output taps of T3 for TS–421/U), to permit calibration of the audio oscillator without connection to an external load.

1–11. Input Attenuator Circuit (fig. 1-7)

The response signal of the equipment under test is fed to the input attenuator which reduces it to a level suitable for the subsequent input meter amplifier and INPut LEVEL meter circuits. Input attenuator AT4 contains a series string of voltage- divider resistors. The input signal from the INPUT terminals is always applied across the entire voltage-divider network, which presents a 5,000-ohm input impedance. This input impedance level is appropriate minimum loading of equipments under test, which usually have output impedance levels of 600 ohms or less. The individual voltage-divider resistor values are chosen to provide O to 40-db attenuation in .5–db steps. The INPUT ATTENUATOR

(DB) switch selects the' output from the desired attenuator tap to be applied to the grid of input meter amplifier V8 (V9 for TS–421/U).

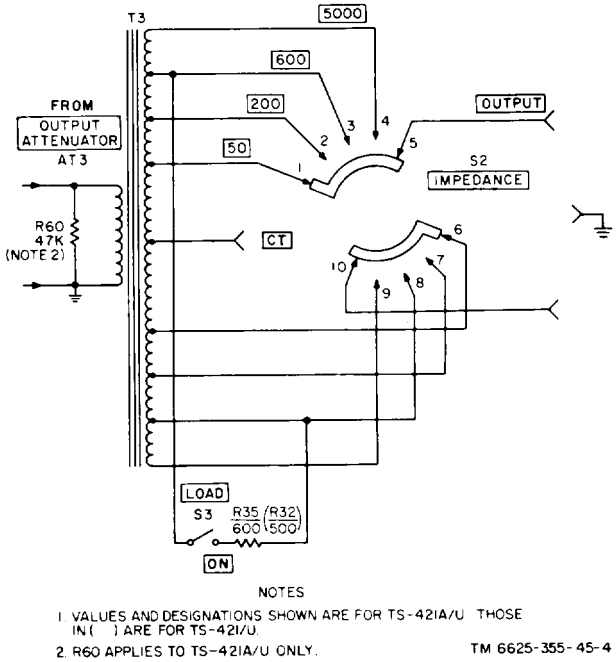


Figure 1–6. Output matching transformer, schematic diagram.

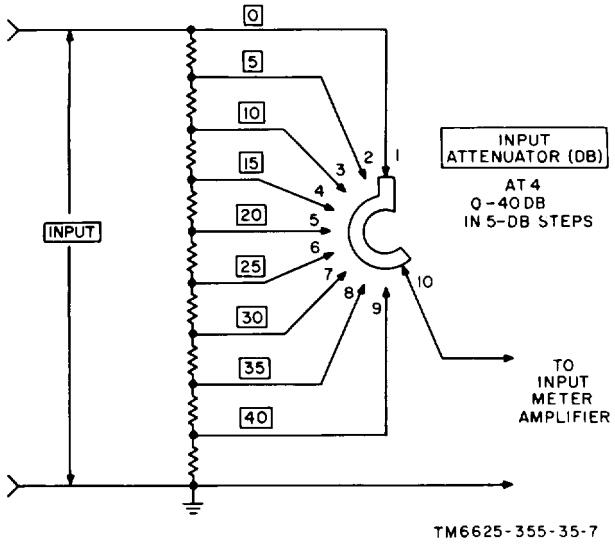


Figure 1–7. Input attenuator circuit schematic diagram.

1-12. Input Meter Amplifier, Input Level Meter Rectifier, and INPUT LEVEL Meter, TS421A/U (fig. 1-8)

a. Input Meter Amplifier. The input meter amplifier is a conventional two-stage recoupled amplifier employing negative feedback for good frequency response and minimum distortion, and with output connected to drive the input level meter rectifier circuit which includes the INPUT LEVEL meter.

(1) The signal from input attenautor AT4 is coupled to the grid of V8A through C12. Resistor R45 is the grid-return resistor for V8A. The output signal of V8A is developed across plate load resistor R51. This signal is coupled to the grid of l~8B through C13. Resistor R49 is the grid-return resistor for V8B. Resistors R46 and R47 are the cathode-biasing resistors for V8A, and R48 is the cathode-biasing resistor for V8B. Resistor R52 is the plate load resistor for V8B, The output signal developed across R52 is coupled to a network consisting of R50, C14, R53, R54, R46, and R47. Within this network, the signal which drives the input level meter circuit is developed between points D and E, across R53 and R54. The value of R50 in combination with R52, R46, and R47 is chosen for proper dc cathode bias of V8A in the no-signal condition. When an output signal appears from V8B—C14, R53, and R54 present a considerably lower impedance path between points C and E than through R50, Hence, R53, R54, R46, and R47 also constitute a voltage divider for the output signal.

(2) The small amount of output signal voltage which appears across R46 and R47 is combined with the cathode bias of V8A and provides negative feedback to the input meter amplifier as follows: A positive-going signal applied to the grid of V8A will produce a negative-going signal at

the grid of V8B, because the increased current through V8A will cause the voltage at point F to drop. As a result, a positive-going signal will be produced at the output of V8B (point C) because of the decrease in current through V8B and through R52. With point C being raised in voltage, more current will flow through R50, R53, R54, R46, and R47 to ground. Hence a positive-going signal voltage will be developed across R46 and R47 because of the ground reference point of R47 and the increased current flow. The feedback signal, by raising the cathode bias on V8A, will reduce the gain of V8A. Resistance values in the feedback-divider network are selected so that the feedback signal will have less amplitude than the signal applied to the grid of V8A. Just enough negative feedback is used to achieve the desired overall amplification, with a flat frequency response and minimum distortion in the output. Resistor R47 adjusts the amount of negative feedback and selects the correct overall amplification for the amplifier.

b. Input Level Meter Rectifier and INPUT LEVEL Meter. Coupling capacitor C14 prevents B + voltage from existing across R53 and R54 is such that with a signal present, meter circuit. When a sine-wave signal voltage is applied to point D, the ac voltage at D with respect to E will be alternately positive and negative. The effect of the signal through R46 and R47, which separates point E from ground, will not be significant compared to the effect of signal current fluctuations in the much larger resistors, R53 and R54, which cause points D and E to be alternately positive and negative with respect to each other. The arrangement of point T at the junction of R53 and R54 is such that with a signal present, point T will always be negative with respect to either. D or E which are tied to the two plates of diode V9. Therefore, de will flow through INPUT LEVEL meter Mz and through one plate of diode V9. The de current will flow through pins 4 and 3 when E is positive or pins 8 and 5 of V9, when D is positive' with respect to T. This provides full-wave rectifier action, which produces a full-wave rectified dc through M2. INPUT LEVEL meter M2 responds to the average value of this signal and is calibrated to read the corresponding ac rms voltage existing at the INPUT terminals. Resistor R47 controls the overall amplification of the input meter amplifier to produce the exact voltage between D and E, which brings about the correct meter reading for calibration purposes. The meter reading must be combined with the setting of input attenuator AT4 to obtain a total indication of the input voltage, Meter M2 is also calibrated to give a direct reading of dbm power level from a 600–ohm input impedance source.

1–1 3. Input Meter Amplifier, Input Level Meter Rectifier, and INPUT LEVEL Meter, TS-421/U (fig. 1-8)

a. Input Meter Amplifier. The input meter amplifier is a conventional two-stage recoupled amplifier employing negative feedback for good frequency response and minimum distortion, and with output connected to drive the input level meter rectifier circuit which includes the INPUT LEVEL meter-.

(2) The signal from input attenuator AT4 is coupled to the grid of V9A through C17. Resistor R38 is the grid-return resistor for V9A. The output signal of V9A is developed across plate load resistor R44. This signal is coupled to the grid of V9B through C18. Resistor R43 is the grid-return resistor for V9B. Resistors R40 and R41 in parallel with R39 are the cathode-biasing resistors for V9A, and R42 is the cathode-biasing resistor for V9B. Resistor R45 is the plate load resistor for V9B. The' output signal developed across R45 is coupled to a network consisting of R46, C19, R47, R48 and R39 in parallel with R40 and R41. Within this

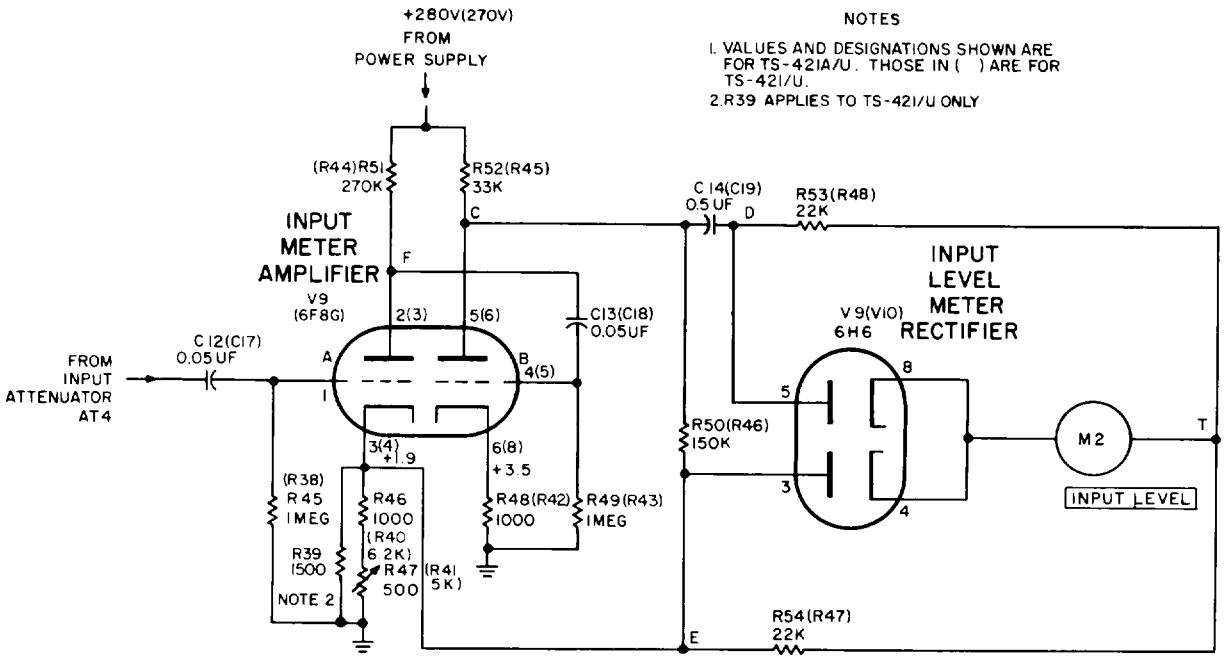


Figure 1-8. Input meter amplifier,input level meter rectifier, and INPUT LEVEL meter; schematic diagram.

network, the signal which drives the input level meter circuit is developed between points D and E, across R47 and R48. The value of R46 in combination with R45, R39, R40 and R41 is chosen for proper dc cathode bias of V9A in the no-signal condition. When an output signal appears from V9B–C19, R47 and R48 present a considerably lower-impedance path between points C and E than through R16. Hence, R47, R48 and R39 in parallel with R40 and R41 also constitute a voltage divider for the output signal.

The small amount of output signal voltage which appears across R39 is combined with the cathode bias of V9A and provides negative feedback to the input meter amplifier as follows: A positive-going signal applied to the grid of V9A will produce a negative-going signal at the grid of V9B, because the increased current through V9A will cause the voltage at point F to drop. As a result, a positive-going signal will be produced at the output of V9B (point C) because of the decrease in current through V9B and through R45. With point C being raised in voltage, more current will flow through R46, R47, R48, R39, R40 and R41 to ground. Hence a positive-going signal voltage will be developed across R40 and R41 because of the ground reference point of R41 and the increased current flow. The feedback signal, by raising the cathode bias on V9A, will reduce the gain of V9A. Resistance values in the feedback-divider network are selected so that the feedback signal will have less amplitude than the signal applied to the grid of V9A. Just enough negative

feedback is used to achieve the desired overall amplification, with a flat frequency response and minimum distortion in the output. Resistor R41 adjusts the amount of negative feedback and selects the correct overall amplification for the amplifier.

b. Input *Level Meter Rectifier and INPUT LEVEL Meter.* Coupling capacitor C19 prevents B + voltage from existing across R47 and R48 and couples the input signal to the meter circuit. When a sine-wave signal voltage is applied to point D. the ac voltage at D with respect to E will be alternately positive and negative. The effect of the signal through R39 in parallel with R40 and R41, which separates point E from ground, will not be significant compared to the effect of Signs] current fluctuations in the much larger. resistors, R47 and R48, which cause points D and E to be alternately positive and negative with respect to each other. The arrangement of point T at the junction of R47 and R48 is such that with a signal present, point T will always be negative witll respect to either D or E which are tied to the two plates of diode V10. Therefore, dc will flow through INPUT LEVEL meter M2 and through one plate of diode V10. The dc Current will flow through pins 4 and 3 when E is positive or pins 5 and 8 of V10, when D is positive with respect to T. This provides full-wave rectifier action which produces a full-wave rectified dc through M2. INPUT LEVEL meter M2 responds to the average value of this signal and is calibrated to read the corresponding ac rms voltage existing at the INPUT terminals. Resistor R-41 controls the overall amplification of the input meter amplifier to produce the exact voltage between D and E, which brings about the correct meter reading for calibration purposes. The meter reading must be combined with the setting of input attenuator AT4 to obtain a total indication of the voltage. Meter M2 is also calibrated to give a direct reading of dbm power level from a 500-ohm input impedance source.

1–14. Power Supply (fig. 1-9)

The power supply contains a high-voltage (hv), full-wave rectifier with lc and rc output filtering.

a. *Power Supply,* TS–421A/U. When the POWER switch is set to ON, power transformer T1 receives ac power through P1, fuse F1, and POWER switch S5. The transformer input has two primary windings which can be wired to accept either. 115 volts ac or 230 volts ac power (TM 11-6625-355-12). The two primary windings receive 115 volts when connected in parallel, For 230-volt use, the two primary windings are connected in series. The 6.3–volt secondary winding of T3 provides filament voltage for tubes V1 through V9. A 7–ohm resistor, R59, is connected in series with the filament of V9 to reduce the voltage applied to it, (fig. 5–5) This decreased voltage produces a lower filament temperature which minimizes gas current effects in the tube. POWER indicator lamp 11 is connected across the 6.3—volt filament winding to indicate that the power is on or off.

b. *Power Supply,* TS-421/U. When the POWER switch is set to ON, power transformer T1 receives ac power through P1, fuse F1 and POWER switch S2. The transformer input has a single primary winding which accepts 115 volts single phase ac power. The 6.3-volt secondary winding of T3 provides filament voltage for tubes V1 through V6 and V8 through V10. POWER indicator lamp 11 is connected across the 6.3–volt filament winding to indicate that the power is on or off.

c. *Rectifier Circuit Analysis,* Filament voltage for V10 (V7 for TS–421/U) is obtained from the 5-volt secondary winding of T1. The hv secondary winding develops about 900 volts ac rms between end taps A and B, and about 450 volts between either end tap and center tap CT, which is grounded. Each end tap is connected to a plate of V10 V7 for TS–421/U). A full-wave rectified dc output of about + 500 volts is developed between the filament-cathode of V10 (V7 for TS–421/U) (point D) and ground.

d. Filter Circuit Analysis. Filter chokes L1 and L2 and filter capacitors C12, C10 and C11 are used in the filter circuit of TS-421/U. Filter chokes L1 and L2 and filter capacitors C15, C16, C17, and C18 are used in the filter circuit of TS–421A/U.

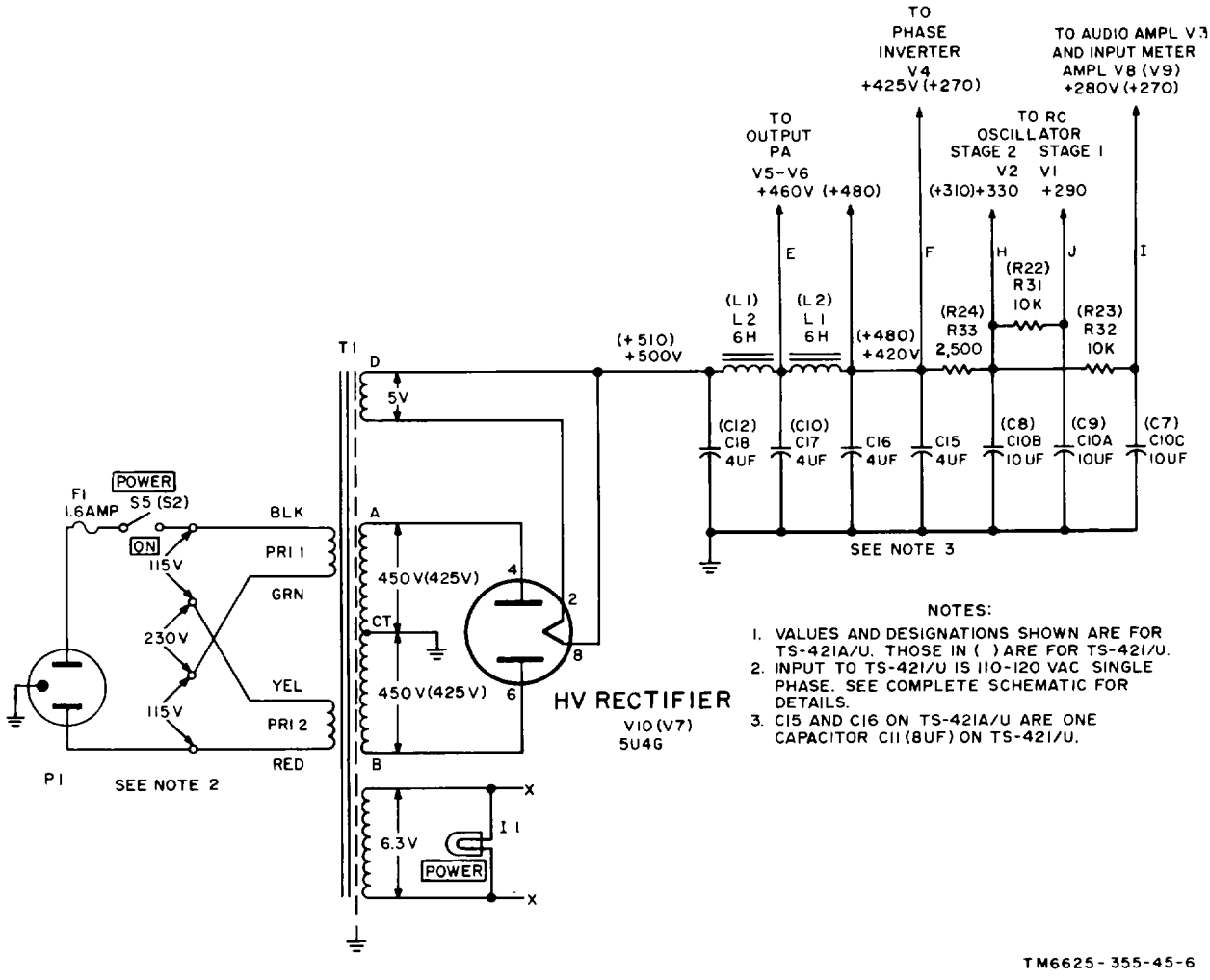


Figure 1–9. Power supply, schematic diagram.

CHAPTER 2

TROUBLESHOOTING

Section 1. GENERAL TROUBLESHOOTING INFORMATION

Warning: When servicing the audio oscillator, be extremely careful of the high voltages present in the power supply. Voltages as high as 900 volts ac are present at the output of power transformer T1. Voltages between 300 and 500 volts dc are present in several filter sections in the plate supply circuits. The audio oscillator output that is applied to the OUTPUT terminals when no output attenuation is used may exceed 150 volts; 115 volts ac exist across the power cord connections within the chassis. Death or serious injury can result from contact with any of these voltages. Always disconnect the power cord when performing servicing which does not require power. Be extremely careful when handling or testing any part of the audio oscillator with the power turned on.

2–1. General Instructions

Troubleshooting at genera] support and depot maintenance level includes al! the techniques outlined for orgainizational maintenance and any special or additional techniques required to isolate a defective part, The general support and depot maintenance procedures are not complete in themselves but supplement the procedures described in TM 11–6625–355–12. The systematic troubleshooting procedure for general support and depot maintenance begins with the operational and sectionalization checks that can be performed at the organizational level, and is completed by means of sectionalizing, localizing, and isolating techniques.

2–2. Organization of Troubleshooting Procedures

a. General. The first step in servicing a defective Audio Oscillator TS–421(*)/U is to sectionalize the fault to one of four main circuits within the unit. The next step is to localize the fault. Localization means tracing the fault to the defective part responsible for the abnormal condition. Some faults, such as burned-out resistors and arcing and shorted transformers can often be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking voltages and resistance.

b. *Sectionalization.* Audio Oscillator TS–421(*)/U consists of one physical unit that contains several stages, The first step when tracing trouble is to locate the stage or stages at fault by the following mehods:

(1) *Visual inspection.* Visual inspection will locate faults without testing or measuring circuits. Meter readings or other visual signs should be observed and an attempt made to sectionalize the fault to a particular stage.

(2) *Operation tests.* Operational tests frequently indicate the general location of trouble. In many instances, the tests will help in determining the exact nature of the fault, The preventive maintenance' checks and services chart (TM 11–6625–355–12) is a good operational test.

c. *Localizatiion.* The tests listed below will aid in isolating the trouble. First, isolate the trouble to a single stage or circuit, and then isolate the trouble within that circuit by voltage, resistance, and continuity measurements.

(1) *Voltage and resistance measurements.* These measurements will help locate the individual part at fault. Use resistor and capacitor color codes (fig. 5–2 and 5–3) to find the vaule of the components. Use the voltage and resistance diagram figure 2–5 (TS-421/U) *or* figure '2-6 (TS–421A/U) to find normal readings, and compare them with the readings taken.

(2) *Troubleshooting chart.* The trouble symptoms listed in the chart (para 2–6e) will aid in localizing trouble to a component part.

(3) *Signal tracing.* Signal tracing (para 2–7) will help in isolating a trouble to a specific circuit at fault.

(4) *S t a g e - g a i n .* The stage-gain chart (para 2–10) will help to locate hard-to-find troubles in the individual stage or circuit.

(5) *Intermittent troubles.* In all these tests, the possibility of intermittent troubles should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the equipment. It is possible that some external connections may cause the trouble. Check the wiring for loose connections; move wires and components gently with an insulated tool. This check may show where a faulty connection or component is located.

2–3. Test Equipment Required

The following chart lists test equipment required for troubleshooting Audio Oscillators TS–421/(*)U. The chart also lists the associated technical manuals and the assigned common names.

Test equipment	Technical manual	Common name
Spectrum Analyzer TS–723A/U	TM 11–5097	Spectrum analyzer
Voltmeter, Meter ME–30A/U.	TM 11-6625-320–12	Ac voltmeter
Test Set, Electron Tube TV-2/U	TM 11-6625-316-12	Tube tester
Test Set, Electron Tube TV-7/U	TM 11-6625-274-12	Tube tester
Tool Equipment TK-100/G	------	Tool set

Section II. TROUBLESHOOTING AUDIO OSCILLATOR TS–421(*)/U)

2–4. Checking Filament and B-l- Circuits for Shorts

a. When *to Check.* When any of the following conditions exist, check for short circuits and eliminate the troubles before applying power.

(1) When the preventive maintenance checks and services made at the organizational level has indicated that neither the POWER indicator. lamp nor any of the tube filaments is energized when power is applied (para 3-1, TM 11–6625–355-12), Check for a short in the filament circuit.

(2) When the preventive maintenance checks and services made at the organizational level has indicated that no output is obtained under. any conditions (para 3–4, TM 11–6625–355–12), check for a short in the B + output and filter circuits of the power Supply.

(3) Fuse repeatedly blows out after replacing.

b. Preparation *for Tests.*

(1) Remove the equipment from its case (TM 11-6625-355-12) .

(2) Remove all tubes.

Caution: Do not rock or rotate a tube when removing it from a socket; pull it straight out with a tube puller.

(3) Remove the POWER indicator lamp (TM 11-6625-355-12).

(4) Replace the tubes and indicator lamp when these short-circuit tests have been completed.

c. Measurements. Make the measurement indicated below. If abnormal results are obtained, make the additional isolating checks outlined. When the faulty part is found, repair the trouble before applying power to the unit.

TS-421A/U		SHORT-CIRCUIT TESTS
Point of measurement	Normal indication	Isolating procedure
From pin 2 of V1O to ground.	About 29K -------	A much lower resistance indicates a short circuit to ground in the power supply filter sections. Check C18, C17, C16, and C15, and the three sections of C10 for shorts. If this does not isolate the trouble, measure the resistance to ground from the following tube socket terminals: V5 and V6 — Pin 3 V4 — Pin 3 V3 — Pins 3, 6 V2 — Pin 3 V1 — Pin 3 V8 — Pins 2, 5 The correct resistance value for each of these measurements is shown on the voltage and resistance diagram, (fig. 2–6).

TS421A/U		SHORT-CIRCUIT TESTS
Point of measurement	Normal indication	Isolating procedure
From pin 2 of V7 to ground	About 30K ----------	A much lower resistance indicates a short circuit to ground in the power supply filter sections, Check C7 through C12 for shorts. If this does not isolate the trouble, measure the resistance to ground from the following tube socket terminals: V5 and V6 — Pin 3 V4 — Pin 5 V3 — Pins 2, 5 V2 — Pin 3 V1 — Pin 3 V9 — Pins 3,6 The correct resistance value for each of these measurements is shown on the voltage and resistance diagram, (fig. 2-5).

2–5. Test Setup

Bench tests of the audio oscillator require connection to a 115- or 230-volt ac power source, depending on the model and the connections of tile primairy windings of power transformer T1, and to varouis test equipment. The test equipment connections vary from test to test. For all tests, make a test set-Up as outlined below.

a. Remove the audio oscillator chassis from its case (TM 11–6625–3-55-12) and stand it on one side, so that tests can be made, where necessary, on the Underside of the chassis.

b. Connect the power cord to a 115-volt ac power source.

c. Turn the LOAD switch to the ON position.

d. Connect the test equipment as specified for tile particular test (para 2-6-2–10).

2-6. Localizing Troubles

a. *General.* The methods used to localize troubles within the equipment are described below. Refer. to Figures 2–3 and 2–4 (2–1, 2–2 for. TS–421/U) to locate individual parts. voltage and resistance measurements are shown in figure 2–6, c below (fig. 2–5 for TS–421/U). Subparagraph e below contains a troubleshooting chart which gives the procedure to be used to sectionalize and localize various types of trouble.

b. Visual Inspection. Use visual inspection to locate any parts that are obviously defective, Some faults, such as burned-out resistors or capacitors, and arcing and shorted transformers, can often be located by sight, smell, or hearing. The majority of faults, however. must be localized by performing voltage and

Resistance measurements, Turn the chassis on its side and inspect for broken wires and loose solder joints. Check all fixed capacitors for leaks and bulging. Check all resistors for cracks and discoloration. Inspect the transformers and chokes for evidence of overheating. Make a visual inspection of the equipment before proceeding with voltage and resistance measurements or other troubleshooting techniques.

c. *Voltage and Resistance* Measurements. These measurements are used to compare the resistance and voltages measured between each tube socket terminal and chassis ground with the normal indications shown in figure 2–5 (fig. 2–6 for TS–42lA/U), make a voltage and resistance check, first measure the resistance with the power off and then take the voltage measurement. Turn the chassis on its side for access to the tube socket connections. If the resistance measurement localizes the fault, do not perform the voltage measurement. If the resistance measurement does not localize the fault, perform the dc voltage measurement and then the ac voltage measurement.

d. Use of Chart. The troubleshooting chart is designed to supplement the operational check in TM 11–6625–355–12. If no operational symptoms are known, begin with item 1 of the preventive maintenance checks and services chart (TM 11–6625–355–12). Proceed until a symptom of trouble appears. If no trouble can be located or sectionalized by use of the equipment performance checklist, proceed to the troubleshooting chart below.

Caution: **If operational symptoms are not known, or if they indicate the possibility of short circuits within the indicator, make the short-circuit checks described in paragraph 2-4 before applying power to the unit.**

e. Troubleshooting Chart TS-421A/U.

Note. Perform the operations in the preventive maintenance checks and services chart (para 3–4, TM 11–6625-3.55–12) before using this chart, unless trouble has already been localized.

Step	Symptom	Probable trouble	Correct ion
1	Line power indicator lamp 11 does not light, none of the filaments of the electron tubes light.	No ac power is applied to power supply. Open fuse F1 in power supply.	Check power cord connection. Check for ac input voltage at chassis terminal board where ac power cord is connected to transformer leads. Replace fuse F1. If replaced fuse blows, check for shorted power transformer T1. Disconnect small yellow wire between pin 2 of V10 and L2. Replace fuse again. If fuse does not blow, check for a shorted capacitor C15, C16, C17, or C18, or open power transformer T1. Replace part and reconnect yellow wire.
2	Line power indicator lamp 11 lights, some tube filaments light, while others do not.	Defective tube(s) ---------- Open circuit in 6.3 vac filament supply.	Replace defective part. Check continuity of 6.3 vac filament supply wiring; repair defeet.
3	Line power indicator lamp 11 lights. .411 tubes light but no indication of audio output is obtained on OUTPUT LEVEL meter M1.	Defective tube ---------- Short circuit in dc power supply.	Replace defective tube. Check voltages of V10 first; check V7 next; then check all other tubes. Perform steps 4 through 9 below.
4	Voltage at pin 3 of V5 or V6 substantially less than +410 vdc.	Defective V10, C18, C17, L2, C16, C15, or L1.	Replace defective part.

Step	Symptom	Probable trouble	Correction
5	voltage at pin 3 of V4 substantially less than +305 vdc.	Same as step 4; also defective R33, C10B, R55, or C9.	Replace defective part.
6	Voltage at pin 3 0f V2 substantially less than +150 vdc.	Same as steps 4 and 5; also defective C10C, R32, R31, C10A, R20, R18, or R17.	Replace defective part.
7	Voltage at pin 3 of VI substantially less than +150 vdc.	Same as steps 4, 5, and 6; also defective R14, R13, or R12.	Replace defective part.
8	Voltage at pin 6 of V3 substantially less than -105 vdc.	Same as steps 4 through 7; also defective R24.	Replace defective part.
9	Voltage at pin 2 of V8 substantially less than -48 vdc; voltage at pin 5 of V8 substantially less than +120 vdc.	Same as steps 4 through 8; also defective R51, R52, C14, R53, R54, R150, R46, or R47.	Replace defective part.
10	Same as step 3; steps 4 through 8 have not located cause of trouble	Short circuit in FREQUENCY tuning capacitor C2A or C213 (rear sections), on in C22 or C24.	Use a gentle airstream to blow any foreign matter out of the plates of C2A or C2B. Replace C22 or C24 if necessary.
1 1	Measure ac (1,000 cps) voltage between test point 1 and chassis ground. This voltage should be between 21 and 25 vac.	If no voltage or low voltage exists, C4, R19, C23, R10, C7, R58, or R21 is defective.	Check and replace defective parts.
	Note. If normal voltage exists, usc the signal	If high voltage exists R58, C23, R21, C5, or R22 is defective.	Check and replace defective parts.
	tracing test (para 18) to locate trouble.	If above steps do not locate trouble, check voltage and resistance measurements at pins of tubes V1, V2, V3, to localize the defect.	Check and replace defective parts.
12	Intermittent output, usually accompanied by flashing of barretter lamp RT1 1.	Capacitor C3, C4, C5, C8, or C9 intermittently open.	Check and replace defective capacitors.
		Short circuit in FREQUENCY tuning capacitor C2A or C2B (front sections), or in Cl or C21.	Clear short circuit in C2A or C2B as outlined in step 10. Replace Cl or C21 if necessary.
13	Excessive distortion in output signal.	Defective tube V1, V2, V3, V4, or V5.	Check tubes with tube tester and replace any found to be defective.
		Open circuits in capacitor C10A, C10R, C10C, C15, C16, C17, or C18.	Check capacitors and replace any found to be defective.
		Defective output transformer T2 or output matching transformer T3.	Check transformers and replace if necessary.
		Defective C19 or R23. ---------	Check parts and replace if necessary.
14	INPUT LEVEL meter does not respond to an input signal.	Defective tube V8 or V9	Check tubes with tube tester and replace any found to be defective.
		Open resistor in input attenuator AT4.	Check resistance between the INPUT terminals; should be 5,000 ohms. Infinite resistance indicates open input attenuator \vhich must be replaced.

Step	Symptom	Probable trouble	Correction
15	Nonlinear response from INPUT LEVEL meter.	Defective coupling capacitor C12, C13, or C14. Defective tube V9 ----------	Check capacitors and replace any -- found to be defective. Check tube and replace if neces- sary.

f. Troubleshooting *Chart TS-421/U.*

Note. Perform the operations in the preventive maintenance checks and services chart (TM 11–6625-355–12) using this chart, unless trouble has already been localized.

Step	Symptom	Probable trouble	Correction
1	Line power indicator lamp 11 does not light, none of the filaments of the electron tubes light.	No ac power is applied to power Supply. Open fuse F1 in power supply.	Check power cord connection. Check for ac input voltage at chassis terminal board where ac power cord is connected to transformer leads. Replace fuse ' F1. If replaced fuse blows, check for shorted power transformer T1. Disconnect small yellow wire between pin 2 of V7 and L1. Replace fuse again. If fuse does not blow, check for a shorted capacitor C10, C11, or C12, or open power transformer T1. Replace part and reconnect yellow wire.
2	Line power indicator lamp 11 lights, some tube filaments light, while others do not.	Defective tube(s) ---------- Open circuit in 6.3 vac filament supply.	Replace defective part. Check continuity of 6.3 vac fila- ment supply wiring; repair defect.
3	Line power indicator lamp 11 lights. All tubes light but no indication of audio output is obtained on OUTPUT LEVEL meter Ml.	Defective tube ---------- Short circuit in dc power supply.	Replace defective tube. Check voltages of V7 first; check V8 next; then check all other tubes. Perform steps 4 through 9 below.
4	Voltage at pin 3 of V5 or V6 substantially less than +350 vdc.	Defective V7, C10, C11, 1,2, C12, or L1.	Replace defective part,
5	Voltage at pin 5 of V4 substantially less than + 200 vdc.	Same as step 4; also defective R24, C11, R28, or C5.	Replace defective part.
6	Voltage at pin 3 of V2 substantially less than +150 vdc.	Same as steps 4 and 5; also defective C11, R23, R19, R18, or R17.	Replace defective part.
7	Voltage at pin 3 of VI substantially less than + 150 vdc.	.Same as steps 4, 5, and 6; also defective R14, R13, or R12.	Replace defective part.
8	Voltage at pin 5 of V3 substantially less than + 200 vdc.	Same as steps 4 through 'i; also defective R25.	Replace defective part.
9	Voltage at pin 3 of V9 substantially less than + 130 vdc; voltage at pin 6 of V9 substantially less than + 100 vdc.	Same as steps 4 through 8; also defective R39, R40, C19, R41, R44, R45, R46, or R47,	Replace defective part.

Step	Symptom	Probable trouble	Correction
10	Same as step 3; steps 4 through 8 have not located cause of trouble.	Short circuit in FREQUENCY tuning capacitor C1A or C1B (rear sections), on in C13.	Use a gentle airstream to blow any foreign matter out of the plates of CIA or C1B. Replace C13 if necessary.
11	Measure ac (1,000 cps) voltage between test point 1 and chassis ground. This voltage should be between 21 and 25 vac.	If no voltage or low voltage exists, C4, RIO, C13, R20, or R37 is defective.	Check and replace defective parts.
	Note. If normal voltage exists, use the signal tracing test (para 2–7) to locate trouble.	If high voltage exists, C7, or R20 is defective.	Check and replace defective parts.
		If above steps do not locate trouble, check voltage and resistance measurements at pins of tubes VI, V2, V3, to localize the defect.	Check and replace defective parts.
12	Intermittent output, usually accompanied by flashing of barretter lamp RT11.	Capacitor C3, C4, C5, or C6 intermittently open.	Check and replace defective capacitors.
		Short circuit in FREQUENCY tuning capacitor C1A or C1B (front sections) or in C2.	Clear short circuit in CIA or C1B as outlined in step 10. Replace C2 if necessary.
13	Excessive distortion in output signal.	Defective tube V1, V2, V3, V4, or V5.	Check tubes with tube tester and replace any found to be defective.
		Open circuit in capacitor C10, C11, C12, C7, C8 or C9.	Check capacitors and replace any found to be defective.
		Defective output transformer T2 or output matching transformer T3.	Check transformers and replace if necessary,
		Defective C14, or R35 or C15.	Check parts and replace if necessary.
14	INPUT LEVEL, meter does not respond to an input signal.	Defective tube V9 or V10 _____	Check tubes with tube tester and replace any found to be defective.
		Open resistor in input attenuator AT4.	Check resistance between the INPUT terminals; should be 5,000 ohms. Infinite resistance indicates open input attenuator which must be replaced.
		Defective coupling capacitor C17, C18, or C19.	Check capacitors and replace any found to be defective.
15	Nonlinear response from INPUT LEVEL meter.	Defective tube V10 _____	Check tube and replace if necessary.

2–7. Signal Tracing

Signal tracing procedures help to sectionalize trouble to a stage of the audio oscillator circuitry. Signal tracing is particularly helpful in locating the stage responsible for distortion and can also be used to locate the stage which is not passing the signal whenever the audio oscillator is producing no output. Paragraphs 2–8 through 2–9 contain procedures for tracing the presence of a proper amplitude signal through the various circuit groups. No external signal generator is required as a signal source because Audio Oscillator TS–421(*)/U contains an oscillator which can be used as a signal source for signal tracing.

2–8. Signal Tracing of Rc Oscillator and Amplifier Circuit Group

a. Turn the audio oscillator chassis on its side and connect the ground lead of the ac

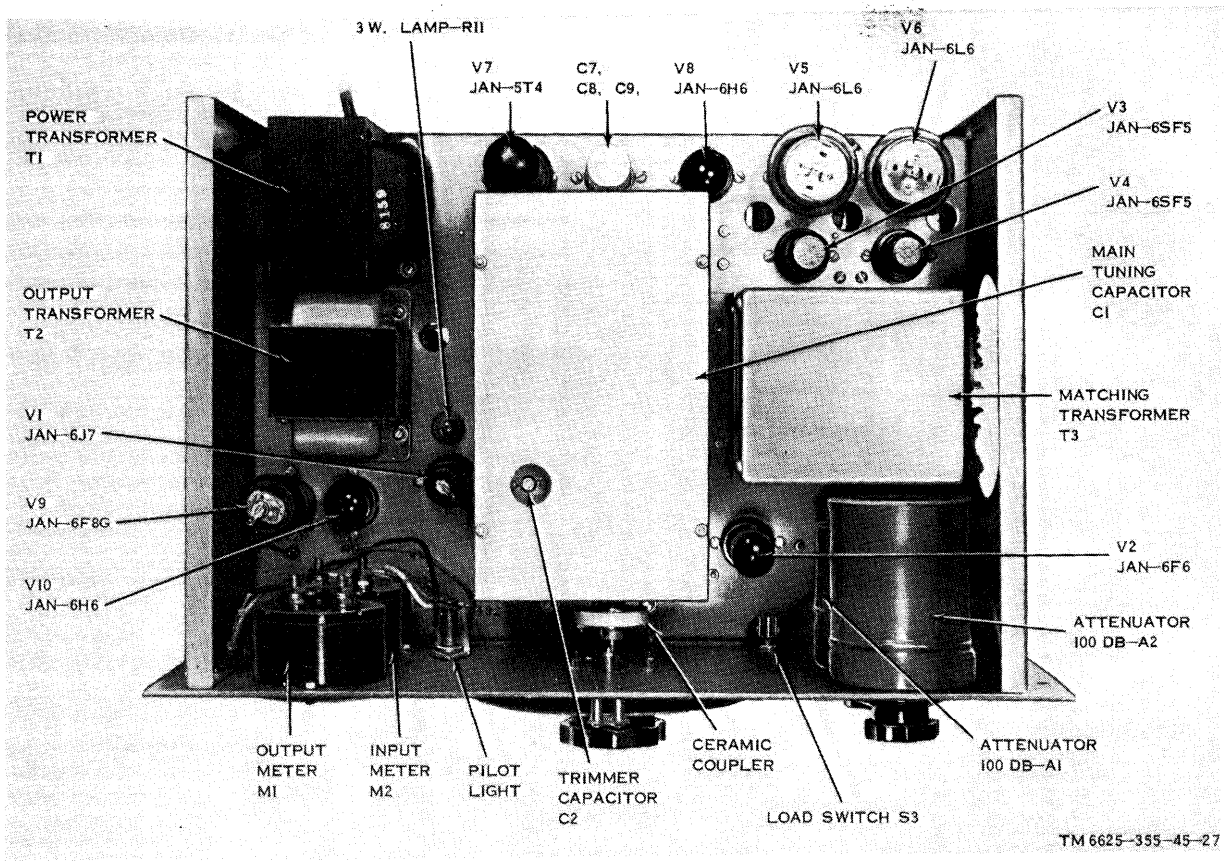


Figure 2-1. *Top view of chassis, TS–42l/U.*

voltmeter to the audio oscillator chassis. Connect the power cord to a suitable power source.

Note. In the following steps, test voltage readings are given in relation to AMPLITUDE (VOLUME for TS–421/U) control settings rather than OUTPUT LEVEL meter readings. This makes the test independent of the OUTPUT LEVEL meter. Since the AMPLITUDE (VOLUME for TS-421/U) control is not precisely calibrated, test voltages within ±1101 percent of those indicated should be satisfactory for signal tracing purposes.

b. Set the switch and control settings on the audio oscillator under test as follows:

For TS–421A/U	
Control	Setting
FREQUENCY RANGE switch ____	X10
FREQUENCY dial ----------	100
AMPLITUDE control _____	*50*
LOAD switch _____	*ON*
IMPEDANCE switch _____	*600*
POWER switch ----------	*ON*

For TS-421/U	
Control	setting
FREQUENCY RANGE switch _____	x l
MAIN dial _____	*60*
VOLUME control _____	*80*
LOAD switch _____	*ON*
IMPEDANCE switch _____	*500*
POWER switch ----------	*ON*

e. Touch the ac voitmeter test probe to test point 1(fig. *5–4 or 9–5),* and observe the indicated voltage. The voltage should be between 21 and 25 volts. Vary the position of the FREQUENCY RANGE switch and FREQUENCY dial (MAIN dial for TS-421/U). The voltage may vary while the controls are being changed, but should return to nearly the same voltage regardless of the positions of the FREQUENCY RANGE switch and FREQUENCY (Main dial for TS–421/U) dial.

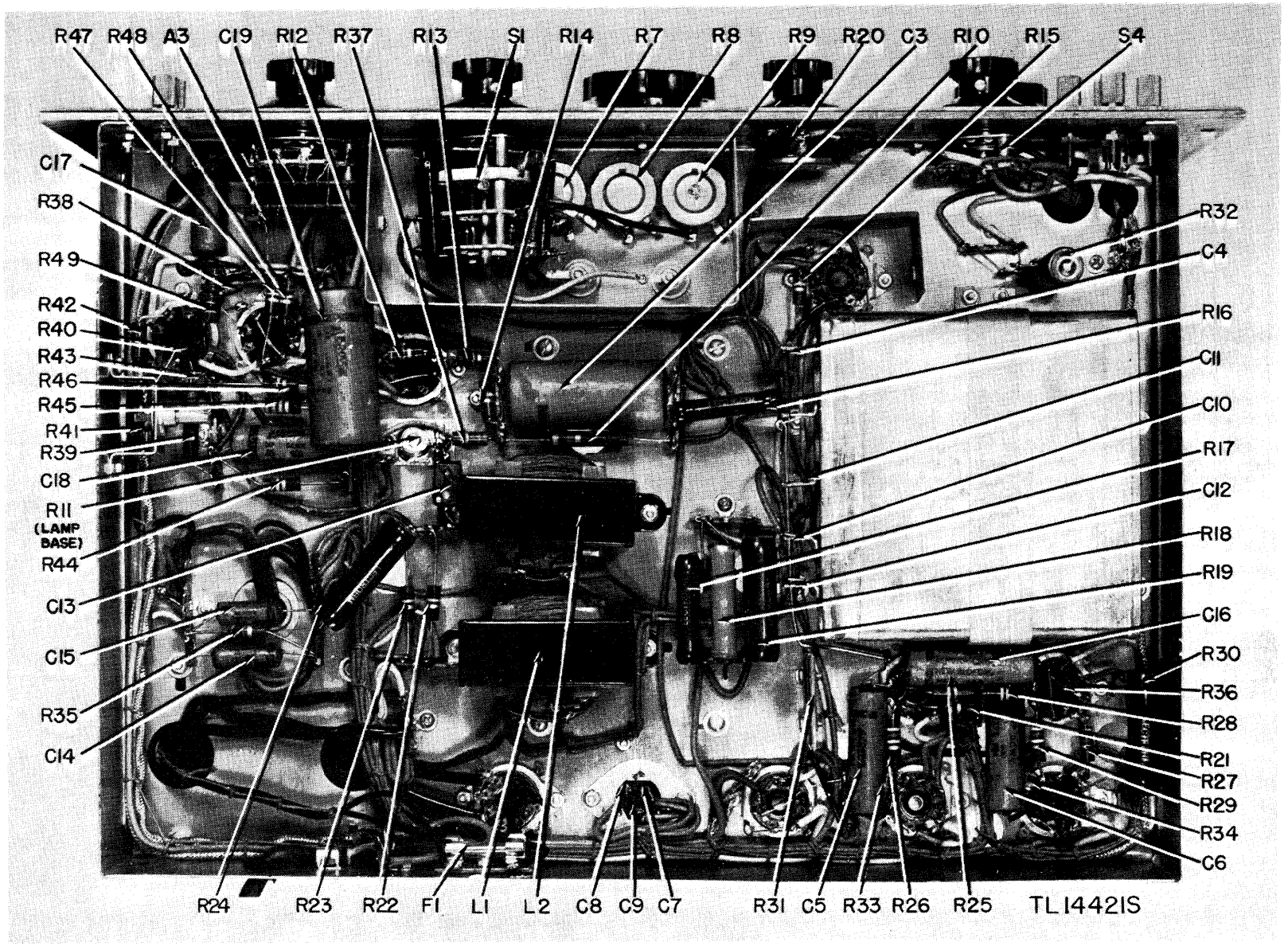


Figure 2–2. Botton view of chassis, TS–421/U.

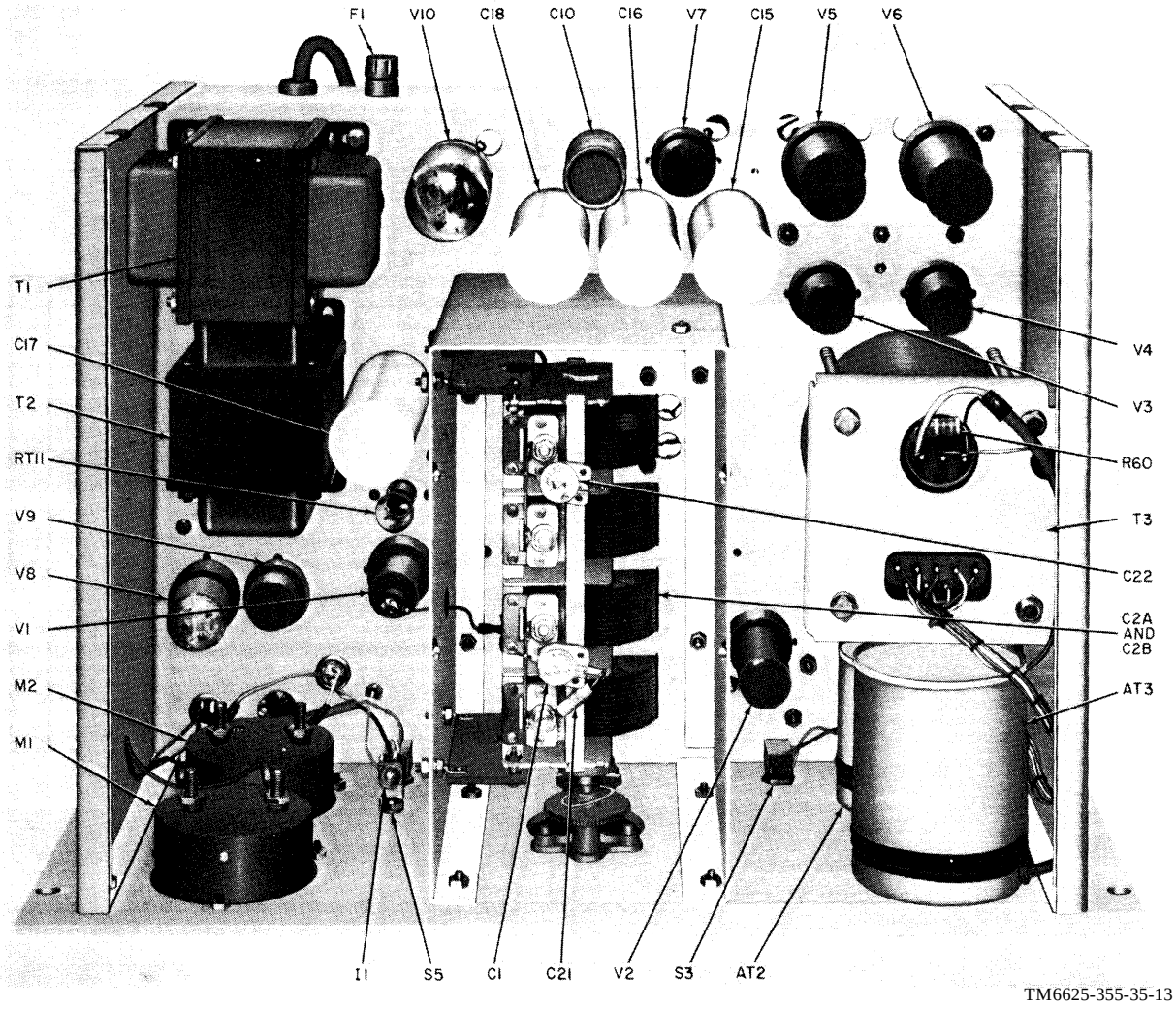


Figure 2-3. Top view of chassis, TS-421A/U.

If the voltage changes greatly when the FREQUENCY RANGE switch and FREQUENCY (MAIN dial for TS-421/U) dial are rotated, check for defective resistor RI through R6 (R1 through R9 for TS-421/U), S1, C2A, or C2B (Cl for TS–421/U). If zero voltage is indicated, check the voltage at terminals 2, 3, 4, 7, and 8 of sockets of V1 and V2. Compare the voltages with those given in figure 2–6 (fig. 2–5 for TS–421/U). If the voltages are correct and no oscillator output is obtained, check tubes V1 and V2 and the associated circuit components. If the oscillator output voltage is correct, proceed to *d* below.

d. Touch the ac voltmeter test probe to terminal 2 (3 for TS–421/U) (control grid of the V3 tube socket. With the AMPLITUDE (VOLUME for TS-421/U) control set at 50, the audio oscillator signal voltage should be about 4.4 volts (10 v rms for TS-421/U). With the AMPLITUDE (Volume for TS-421/U) control set at 100, the voltage should be about 8.9 volts (20v rms for TS-421/U). This voltage should not change for any setting of the FREQUENCY RANGE switch and FREQUENCY dial (MAIN dial for TS–421/U) setting. If zero voltage or low voltage is measured at this point, the trouble is in

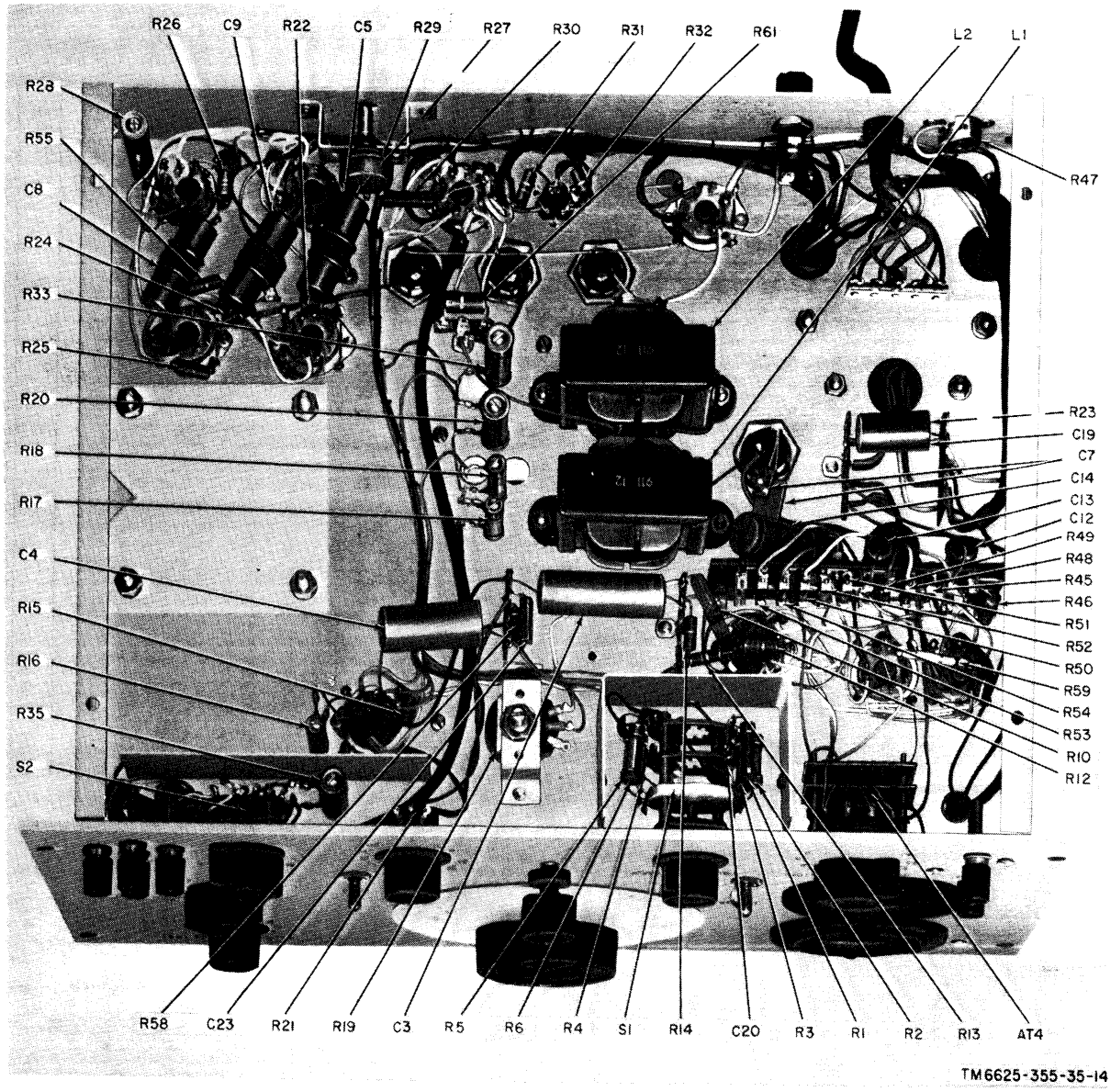
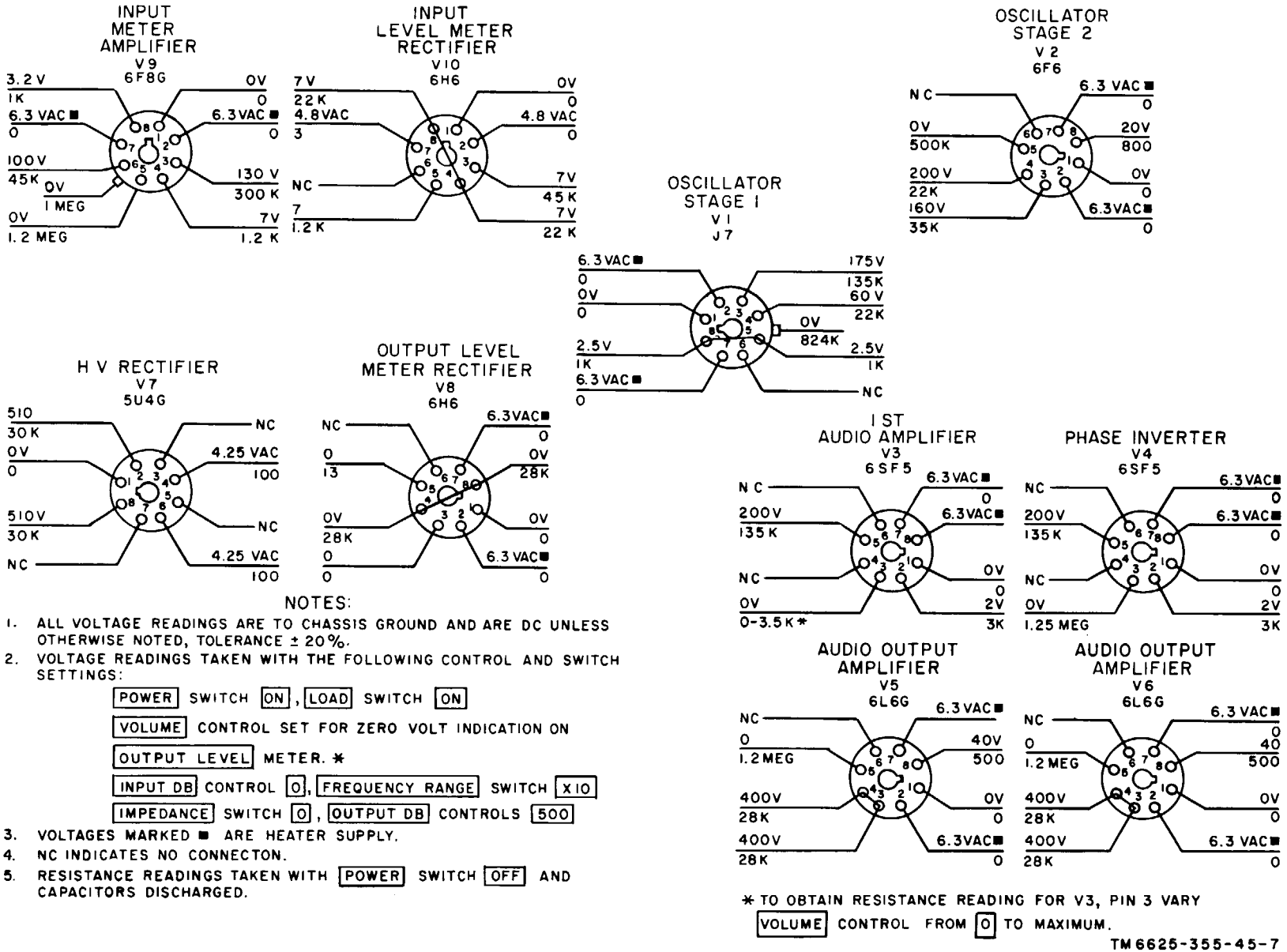


Figure 2-4. Bottom view of chassis, ***TS-421A/U.***

the coupling circuit between V2 and V3. Check for defective R58, C23, R21, C5, or R22 (R20 for TS-421/U) .

c. Touch the ac voltmeter test probe to terminal 5 (control grid) (3 for **TS–421/U)** of *V4* tube socket. With the AMPLITUDE (VOLUME for TS-421/U) control set at 50, the audio oscillator signal voltage should be about 22 volts. With the AMPLITUDE (VOLUME for TS–421/U) control setting increased to 10, the voltage should be about 44 volts. If zero voltage or low voltage is present, cheek the voltages applied to the terminals of the V3 tube socket. If the correct voltages are not present, the trouble is in the V3 audio amplifier stage. Check tube V3 and the associated circuit components.

f. Touch the ac voltmeter test probe' to terminals 5 of V5 and V6 tube sockets. With the AMPLITUDE (VOLUME for TS–421/U)



NOTES:

1. ALL VOLTAGE READINGS ARE TO CHASSIS GROUND AND ARE DC UNLESS OTHERWISE NOTED, TOLERANCE ± 20%.
2. VOLTAGE READINGS TAKEN WITH THE FOLLOWING CONTROL AND SWITCH SETTINGS:
   - [POWER] SWITCH [ON], [LOAD] SWITCH [ON]
   - [VOLUME] CONTROL SET FOR ZERO VOLT INDICATION ON
   - [OUTPUT LEVEL] METER. *
   - [INPUT DB] CONTROL [0], [FREQUENCY RANGE] SWITCH [X10]
   - [IMPEDANCE] SWITCH [0], [OUTPUT DB] CONTROLS [500]
3. VOLTAGES MARKED ■ ARE HEATER SUPPLY.
4. NC INDICATES NO CONNECTON.
5. RESISTANCE READINGS TAKEN WITH [POWER] SWITCH [OFF] AND CAPACITORS DISCHARGED.

* TO OBTAIN RESISTANCE READING FOR V3, PIN 3 VARY [VOLUME] CONTROL FROM [0] TO MAXIMUM.

TM6625-355-45-7

Figure 2-5. Tube socket voltage and resistance diagram, TS-421/U.

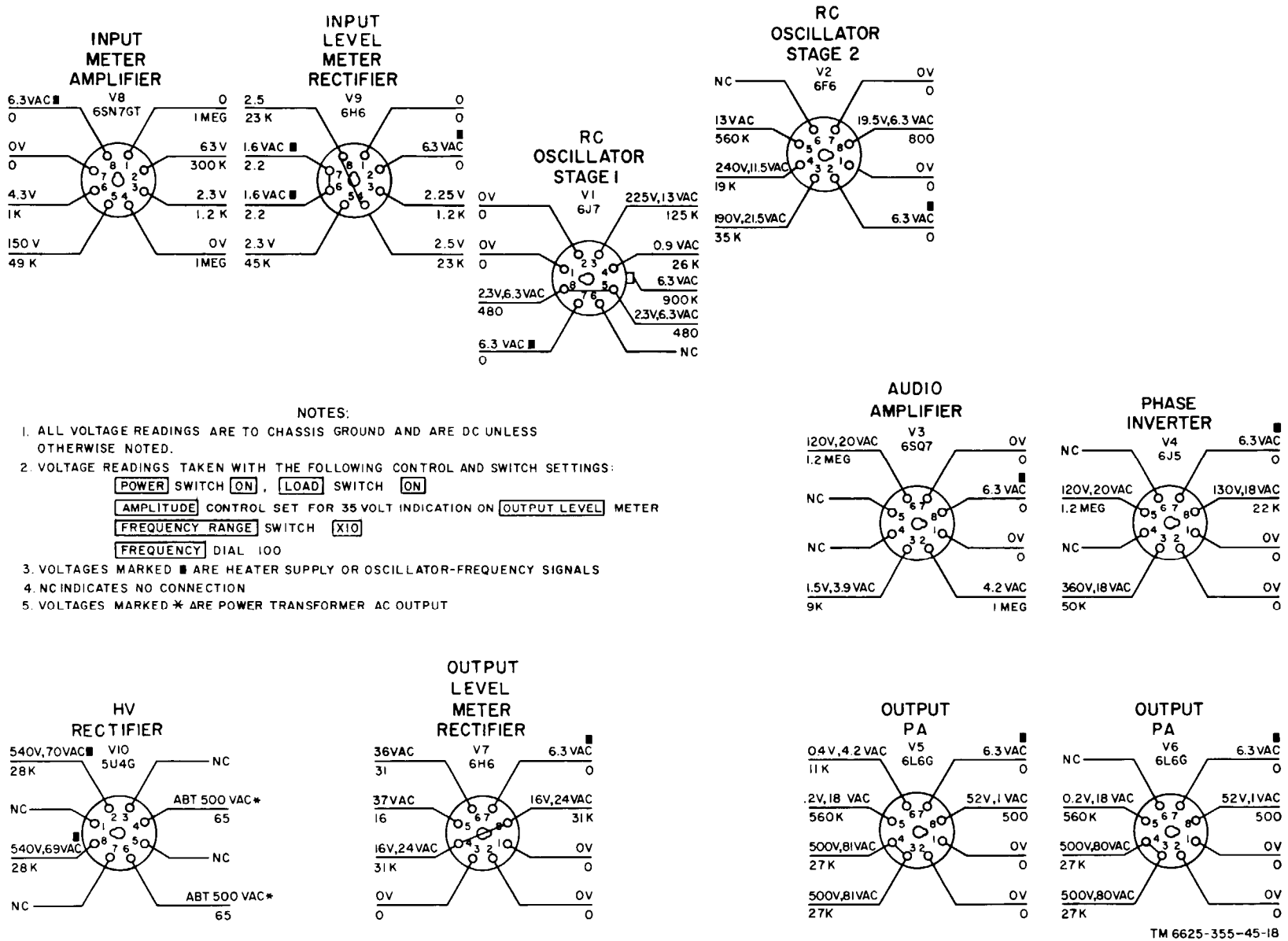


Figure 2–6. Tube socket voltage and resistance diagram, TS–421A/U.

control set at 50, the voltage should be 22 volts. With the AMPLITUDE (VOLUME for TS–421/U) control setting increased to 100, the voltage should be 44 volts, If zero voltage or low voltage is measured, check the voltages applied to the terminals of the V4 tube socket. If the correct voltages are not present, the trouble is in the V4 phase inverter stage. Check tube V4 and the associated circuit components.

g. Touch the ac voltmeter test probe to terminal 3 of the V5 and V6 tube sockets. The voltage should be about 85 volts with the AMPLITUDE (VOLUME for TS–421/U) control set 50 and about 170 volts with the AMPLITUDE (VOLUME for TS-421/U) control set at 100. If zero voltage or low voltage is measured, check the voltages applied to the other terminals of the V5 and V6 tube sockets. If the correct voltages are not present, the trouble is in the V5 and V6 output power amplifier stages. Check tubes V5 and V6 and the associated circuit components. Check for winding resistance of 430 ohms between each input end tap and the center tap of output transformer T2.

2–9. Signal Tracing INPUT LEVEL Meter Circuits

c. Make the following switch and control settings on the audio oscillator under test:

TS-421A/U	
Control	Setting
FREQUENCE RANGE switch	X10
FREQUENCY dial _____	100
AMPLITUDE control -----	To produce a reading of +37 dbm on the OUTPUT LEVEL meter.
IMPEDANCE switch-----	5000
OUTPUT ATTENUATOR (DB) (0-100) switch __	30
OUTPUT ATTENUATOR (DB) (0-10) switch----------	O
INPUT ATTENUATOR (DB) switch _____	10
LOAD switch----------	f

TS-421/U	
Control	Setting
FREQUENCY RANGE switch	x l
MAIN dial ----------	60
VOLUMN control _____	To produce a reading of +37 dbm on the OUTPUT LEVEL meter.
IMPEDANCE switch -----	5000
OUTPUT ATTENUATOR (DB) (0-100 switch -----	40
OUTPUT ATTENUATOR (DB) (0-10) switch -----	0
INPUT ATTENUATOR (DB) switch ----------	40
LOAD switch ----------	off

Note. b through g apply to TS-421A/U and IL through n apply to TS-421/U.

b. Connect the captive ground link between the ground terminal and the lower vertically spaced OUTPUT terminal. Connect an insulated test lead between the upper vertically spaced OUTPUT terminal and the upper INPUT terminal. Connect the ground (common) lead of the ac voltmeter to the audio oscillator chassis.

c. Measure the ac voltage at terminal 1 of the V8 tube socket. This voltage should be about 1.5 volts ac rms. If this voltage is not correct, the trouble is in input attenuator AT4, C12, or R45. If the voltage' is considerably higher (near 50), the trouble is an open resistor in AT4. If the voltage is low, there may be a shorted resistor in AT4, or C12 or R45 may be defective. In this case, make a resistance check of AT4 as outlined in d below. If the voltage messured above is correct, proceed to e below.

d. Remove all power from the audio oscillator. Disconnect the lead between the upper INPUT terminal and the upper vertically spaced OUTPUT terminal. Measure the resistance between test point 4 (fig. 5–5) and chassis ground for all settings of the INPUT ATTENUATOR (DB) switch.

(1) The proper values are indicated in the following chart:

INPUT ATTENUATOR (DB) switch setting	Resistance (ohms)
0	5K
5	2.8K
10	1.6K
15	890
20	500
25	280
30	156
35	87
40	50

(2) If the resistance values measured differ from the above values by more than ± 10 percent, input attenuator AT4 is defective. If the correct values are measured, check C12 and R45. Set the INPUT ATTENUATOR (DB) switch to 10 db, and reconnect the lead between the upper INPUT terminal and the upper vertically spaced OUTPUT terminal. Reapply power to the audio oscillator.

e. Measure the ac voltage at terminals 2 and 4 of the V8 tube socket. The reading should be approximately 3.7 volts in each case. If the voltage is correct, proceed to f below. If the voltage is not correct at one or both points, check V8 and the associated circuitry components.

f. Measure the ac voltage at pin 5 of V8. This voltage should be about 23,5 volts. If the voltage is not correct, check V8 and the associated circuitry.

g. Measure the ac voltage at test point 5 and at test point 6 (fig. 5–5). The voltage should be 23.5 volts at test point 5 and 16.2 volts at test point 6, If these voltages are not correct, check R53, RF54, R50, C14, M2, and V9. If the voltages measured are correct and M2 is not operating, check M2 and V9. If M2 is operating properly, it should indicate about 1.58 volts.

h. Connect the *OUTPUT* terminals to the *INPUT* terminals.

i. Readjust the *VOL.* control, if necessary, to make the *OUTPUT LEVEL* meter read 30 volts on the scale.

j. Readjust the *INPUT DB* attenuator to make the INPUT LEVEL meter read approximately 1 volt. If this reading is not obtained at any setting of the control, set the attenuator at O.

k. Measure the ac voltage at pin 5 (grid or tube cap) of V9. This measurement should be O volts. If the voltage is not correct, check V9 and the associated circuitry,

1. Measure the voltage at pin 3 of V9; this measurement should be about 130 volts.

m, Measure the voltage at pin 6 of V9; this measurement should be about 100 volts.

n. Measure the voltage at pin 4 of V9; this measurement should be about 7 volts.

2-10. Stage-Gain Measurements

Use the techniques outlined below when the output of the receiver is abnormally low or distorted (items 6 through 9 of the trouble-shooting chart (para 2–6e)). The stage-gain measurements supplement the signal-tracing procedures, and the stage-gain chart provides a quick check to localize trouble to a particular stage.

a. *General Instructions.* Connect the audio oscillator to a power source and set the front panel controls as indicated in the following chart. Connect the captive ground strap to the lower vertically spaced OUTPUT terminal. Connect the ground (common) lead of the ac voltmeter to the audio oscillator chassis.

TS-421A/U	
Control	Setting
POWER switch	ON
AMPLITUDE control	100
FREQUENCY RANGE switch	X10
FREQUENCY dial	100
IMPEDANCE switch	600
LOAD switch	ON
OUTPUT ATTENUATOR (DB) (0-10) switch	0
OUTPUT ATTENUATOR (DB) (0-100) switch	0

TS-421/U	
Control	Setting
POWER switch	ON
VOLUME control	100
FREQUENCY RANGE switch	X1O
MAIN control	100
IMPEDANCE switch	500
LOAD switch	ON

TS-421/U

Control	Setting
OUTPUT ATTENUATOR (DB) (0-10) switch	0
OUTPUT ATTENUATOR (DB) (0-100) switch	0

b. Stage Gain of Audio Amplifier and Output Stages. Use the ac voltmeter test probe to cheek for proper. voltage at the points listed in the chart below. The chart indicates approximate input and output voltage and stage gain. Test points are the same for both models, but the pin numbers may be different for model TS–421/U. Check main schematic figure 5–4.

TS-421A/U

Test connections	Input voltage (ac rms)	output voltage (ac rms)	Stage gain
Pin 2 (grid) and pin 6 (plate) of V3	8.9	44	4.95
Pin 5 (grid) and pin 3 (plate) of V4	44	44	1
Pin 5 (grid) and pin 3 (plate) of V5 or V6	44	170	3.86
Pin 3 of V5 or V6 (input to T2) and, pin 5 of V7 (output from T2)	170	76	0.447
Pin 6 (tie-point) of V7 (input to AT2 and AT3) and test point 3 (output of AT2 and AT3)	74	74	1
Test point 3 (input of T3) and upper vertically spaced OUTPUT terminal	74	73	0.99

TS-421/U

Test connections	Input voltage (ac rm.)	output voltage (ac rms)	Stage gain
Pin 3 (grid) and pin 5 (plate) of V3	8.9	44	4.95
Pin 3 (g-rid) and pin 5 (plate) of V4	44	44	1
Pin 5 (grid) and pin 3 (plate) of V5 or V6	44	170	3.86
Pin 3 of V5 or V6 (input to T2) and, pin 5 of V8 (output from T2)	170	76	0.447

TS–421/U

Test connections	Input voltage (ac rms)	Output voltage (ac rms)	Stage gain
Pin 6 (tie-point) of V8 (input to AT2 and AT3) and test point 3 (output of AT2 and AT3)	74	74	1
Test point 3 (input of T3) and upper vertically spaced OUTPUT terminal	74	73	0.99

c. Stage Gain in of INPUT LEVEL Meter Circuits.

(1) Set the audio oscillator controls as follows :

Control	Setting
AMPLITUDE control (VOLUME for TS-421/U)	To produce a reading of +37 dbm on the OUTPUT LEVEL meter.
IMPEDANCE switch	5000
OUTPUT ATTENUATOR (DB) (0-100) switch	30
OUTPUT ATTENUATOR (DB) (0-10) switch	0
INPUT ATTENUATOR (DB) switch	10
LOAD switch	off

(2) Connect a test lead between the UPper vertically spaced OUTPUT terminal and the upper INPUT terminal. Connect the captive ground link to the lower OUTPUT terminal. Use the ac voltmeter test probe to check for proper voltage at the points listed as follows:

TS-421A/U

Test connections	Input voltage (ac rms)	Output voltage (ac rms)	Stage gain
Pin 1 (grid) and pin 2 (plate) of V8 (first stage)	1.5	3.7	2.5
Pin 4 (grid) and pin 5 (plate) of V8 (second stage)	3.7	23.5	6.35

TS-421/U			
Test connections	Input voltage (ac rms)	Output voltage (ac rms)	Stage gain
Pin 5 (grid) and pin 6 (plate) of V9 (first stage) ------	1.5	3.7	2.5
Pin 1 (grid) and pin 3 (plate) of V9 (second stage) -----	3.7	23.5	6.35

CHAPTER 3

REPAIRS AND ALIGNMENT

Section 1. REPAIRS

3-1. General Parts Replacement Techniques

Most of the parts of Audio Oscillator TS–421 (*) /U can be reached and replaced easily without special procedures. Observe the following precautions:

a. Do not disturb the adjustment of screwdriver-adjustable capacitors C1 and C22 (C2 and C13 for TS–421/U) which are mounted on frequency tuning capacitor C2A and C2B (Cl for TS-421/U). The adjustment screws of Cl and C22 on TS-421A/U ONLY are solder-locked at the factory in the proper position.

b. If the FREQUENCY dial (MAIN dial for TS–421/U) and dial hub (fig. 3--1 and 3–2) are removed, be careful not to turn the rotor of capacitor C2A and C2B (Cl for TS–421\U) to either end of its range of movement since its protective stop is removed with the dial hub. (The protective stop is the long setscrew on the dial hub that makes contact with the stop boss.) Refer to paragraph 3–2 before attempting any disassembly of the capacitor drive assembly.

c. Do not disturb the adjustment of the screwdriver-adjustable variable resistors while working on the chassis.

d. When replacing parts which have factory-selected values (identified on the main schematic diagrams, (fig. 5–4 and 5–5)), replace with parts that have the same value.

e. Whenever 3-watt barretter lamp RT11 is replaced, readjust the rc oscillator voltage (para 3-11).

3–2. Removal of Capacitor Drive Assembly (fig. 3-1 and 3-2)

The frequency tuning capacitor drive assembly includes the FREQUENCY (MAIN for TS–421/U) dial and vernier knob and the mechanism which links these to frequency tuning capacitor C2A and C2B (Cl for TS-421/U). Only in extremely rare cases will the capacitor drive assembly have to be removed. Any necessary maintenance will usually consist in adjustment of the FREQUENCY (MAIN for TS–421/U) dial or replacement of the FREQUENCY (MAIN for TS421/U) dial or vernier knob due to damage. Disassembly is not necessary for lubrication purposes.

a. To remove the FREQUENCY (MAIN for TS–421/U), dial or vernier knob for replacement, remove the two setscrews from either knob, by using an Allen wrench.

b. To remove tuning capacitor C2A and C2B (Cl for TS–421/U), disconnect the external wiring and remove the nuts from the four mounting studs. Move the tuning capacitor unit slightly to the rear so that the rear yoke will disengage from the coupling.

Caution: Be careful not to bend or damage the tuning capacitor plates.

c. To remove the complete capacitor drive assembly, proceed as follows:

(1) Remove the vernier knob by removing the two setscrews with which it is retained; then remove the vernier drive spring and the *floating* vernier drive disk.

(2) Remove the FREQUENCY (MAIN for TS–421/U) dial knob by removing the two setscrews that retain it.

(3) Remove the FREQUENCY (MAIN for TS–421/U) dial clamp plate by removing its four attaching screws.

(4) Remove the FREQUENCY (MAIN for TS-421/U) dial by lifting it away from the dial hub,

(5) Remove the drive disk and shaft assembly from the front, since it is no longer retained by the edge of the FREQUENCY (MAIN for TS-421/U) dial.

(6) Remove the dial hub by removing the two setscrews (one, long and one short) that retain it. Remove the three flat washers from the shaft.

Caution: The long setscrew, which is the stop limit for the capacitor drive assembly, sets against the stop boss on the front of the capacitor drive housing at the desired limits of travel. Once this setscrew has been removed, be extremely careful not to turn the tuning capacitor shaft beyound the limits of its travel because the plates of CM and C2B (C1 for TS-421/U) may become bent. This would require recalibration of the audio oscillator.

(7) Loosen the two setscrews in the front coupling yoke and in the hub of the rear spur gear. Slip the front coupling yoke and/or the spur gear shaft forward enough to allow the flexible coupling insert to be removed from between the front and rear coupling yokes,

(8) Slip the front coupling yoke and the two spur gears off the spur gear shaft, The gear spring will cause the spur gears to twist apart slightly When they cease to mesh with the drive gear. Hold the spur gears tightly during removal to control the action of the gear spring.

(9) Slip the drive gear and shaft assembly out of the housing. Remove the washer from the shaft between the capacitor drive housing and the drive gear and shaft assembly.

(10) Remove the capacitor drive housing from the front panel by removing the attaching screws.

3–3. Reassembly of Capacitor Drive Assembly

To reassemble the capacitor drive assembly, proceed as follows:

a. Replace the capacitor drive housing on the chassis of the audio oscillator and attach it to the front panel with the attaching screws.

b. Replace the washer located between the capacitor drive housing and the drive gear and shaft assembly and slip the drive gear and shaft assembly back into the housing.

r. Replace the washer and the spur gears back on the spur gear shaft. Hold the spur gears tightly to control the action of the gear spring.

d. Slip the front coupling yoke on the spur gear shaft and tighten the two setscrews on the hub of the rear spur gear.

c. Replace the flexible coupling insert between the front and rear coupling yokes and tighten the two setscrews on the front coupling yoke.

f. Replace the three washers and dial hub on the drive gear and shaft assembly and tighten the two setscrews.

Caution: The long setscrew, which is the stop limit for the capacitor drive assembly, is set against the stop boss so that the tuning capacitor cannot be turned beyond its limits of travel.

g. Replace the drive disk and shaft assembly on the capacitor drive housing.

h. Replace the FREQUENCY (MAIN for TS–421/U) dial on the dial hub.

i. Replace the FREQUENCY (MAIN for TS–421/U) dial clamp plate and attach it to the dial hub with the four attaching screws.

j. Replace the FREQUENCY (MAIN for TS–421/U) dial knob and tighten the two setscrews that attach it to the drive gear and shaft assembly.

h-. Replace the vernier drive disk and vernier drive spring on the drive disk and shaft assembly.

1. Replace the vernier knob on the drive disk and shaft assembly and tighten its two setscrews.

m. Solder all external wiring that was previously removed.

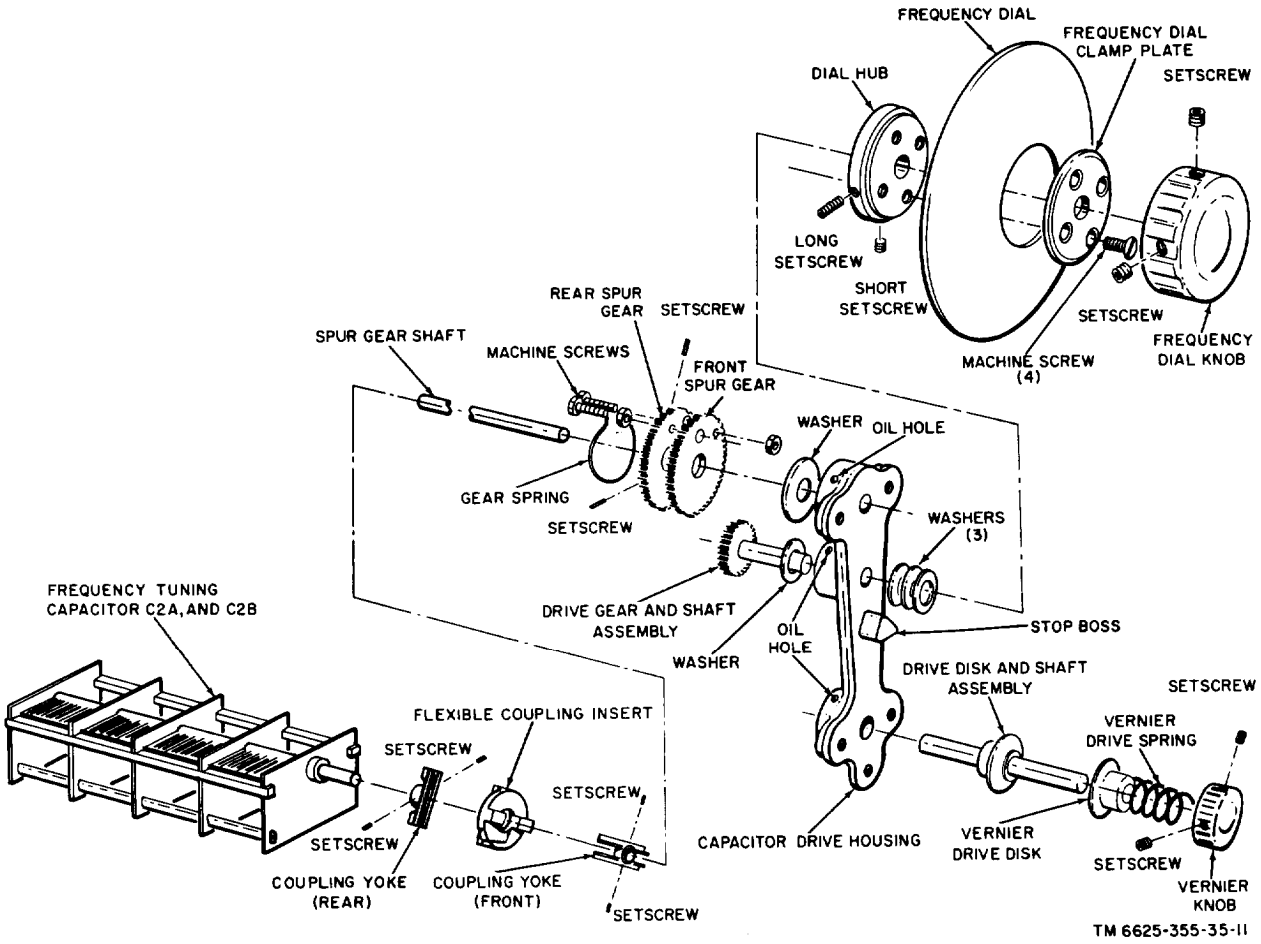


Figure 3-1. Capacitor drive assembly, exploded view, TS-421A/U.

3–4. Lubrication of Capacitor Drive Mechanism

a. Three oilholes are located in the front of the capacitor drive housing (fig. 3-1 and 3-2). These are the only points in the audio oscillator which need to be lubricated. The capacitor drive assembly does not have to be disassembled for lubrication.

b. Apply 1 drop of oil to these oilholes every 6 months.

c. To apply oil, dip a piece of wire into the oil, and transfer the oil to the shaft within the hole by touching the end of the wire. within the hole. Apply only 1 drop of oil to each hole. Rotate the FREQUENCY (MAIN for TS–421/U) dial after application of oil to all three holes to distribute the oil on the bearing surfaces.

Caution: **Be careful not to spill oil on the surfaces of the tuning capacitor plates. Calibration of the audio oscillator may be affected.**

3-5. Adjustment of FREQUENCY Dial (MAIN Dial for TS-421/U) Clamp Plate and Dial Hub

a. Incorrect setting of the FREQUENCY (MAIN for TS–421/U) dial clamp plate and dial hub may cause tuning capacitor C2A and C2B (C1 for TS-421/U) to turn beyond its stop limit and become damaged. The stop boss should halt the rotation of the drive assembly

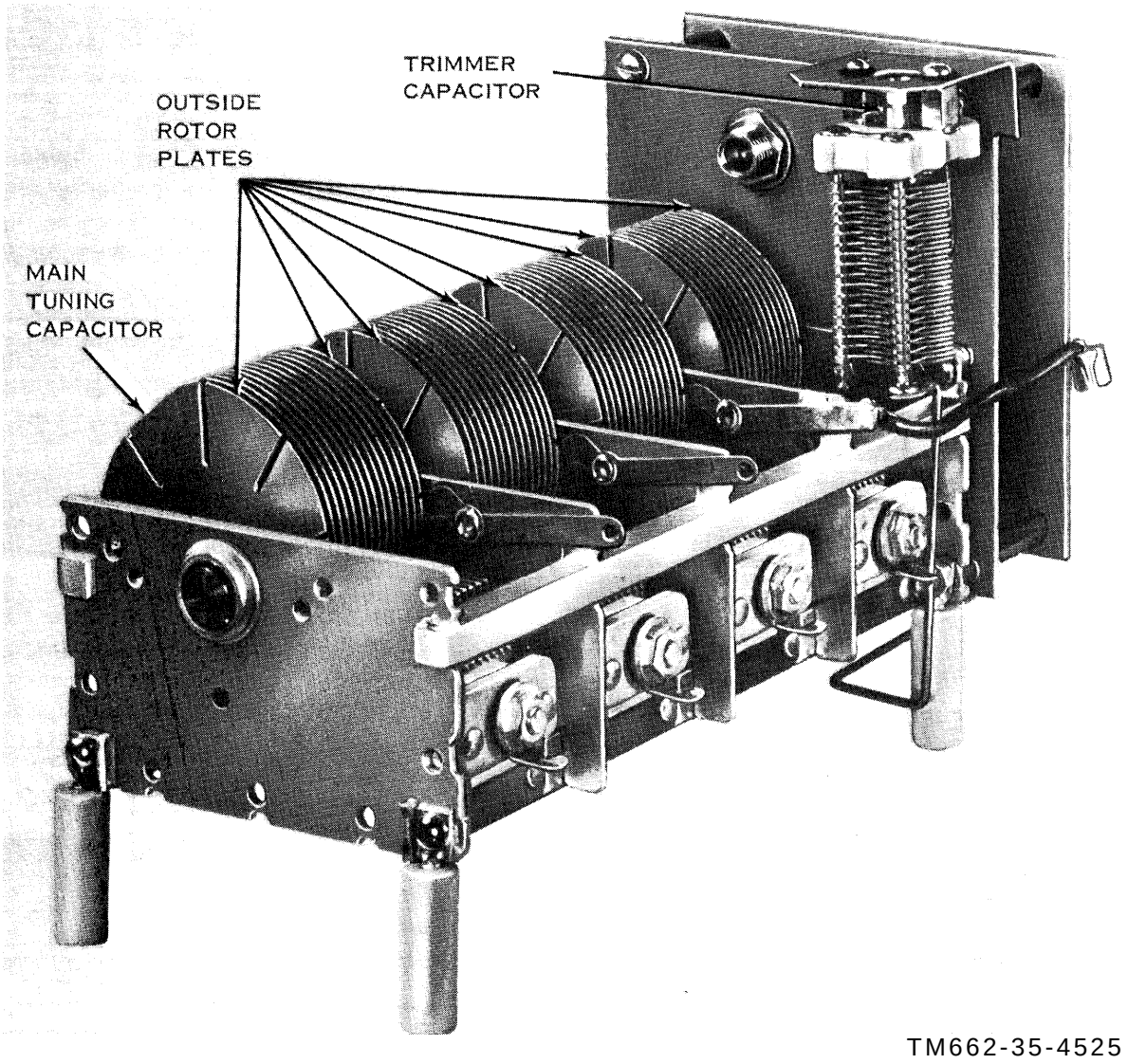


Figure 3-2. Main tuning capacitor, TS-421/U.

before the tuning capacitor reaches this limit. Whenever tuning capacitor C2A and C2B (C1 for TS–421/U) is removed or replaced, or whenever the capacitor drive assembly is disassembled, the FREQUENCY (MAIN for TS–421/U) dial clamp plate and dial hub. must be readjusted as part of the reassembly procedure.

b. The stops for the FREQUENCY (MAIN for TS–421/U) dial are located on the dial hub to which the FREQUENCY (MAIN for TS–421/U) dial is attached. The stops do not require readjustment when the FREQUENCY (MAIN for TS-421/U) dial has been repositioned. The FREQUENCY (MAIN for TS–421/U) dial must be removed for access to the dial hub to adjust the stops. The stop mechanism consists of a long setscrew which is one of two setscrews that attaches the dial hub to the drive gear shaft.

This long setscrew strikes one side of the triangular stop boss which is an integral part on the front of the capacitor drive housing. The stop boss limits the rotation of the dial hub and the FREQUENCY (MAIN for TS–421/U) dial to an arc of about 340°.

c. To adjust the FREQUENCY (MAIN for TS-421/U) dial clamp plate and dial hub properly, proceed as follows:

(1) Remove the two setscrews on the FREQUENCY (MAIN for TS-421/U) dial knob and remove the knob.
(2) Remove the four machine screws on the FREQUENCY (MAIN for TS–421/U) dial clamp plate and remove the clamp plate.
(3) Remove the FREQUENCY (MAIN for TS–421/U) dial.
(4) Turn the dial hub so that the capacitor plates are partially open.
(5) Loosen the two setscrews that attach the dial hub to the drive gear shaft.
(6) Grasp the flexible coupling insert and turn the drive mechanism very gently in the proper direction so that the capacitor plates begin to close.
(7) Stop closing the plates when the inside edge of the brass spacer on the movable set of plates is just even with the outside edge of the fixed set of plates, (The movable plate is within the width of its spacer of being fully closed.)
(8) Hold the spur gears to retain the capacitor position obtained in (7) above.
(9) Rotate the loose dial hub so that the long setscrew contacts the right-hand side (output attenuator side) of the stop boss; then retighten both setscrews in the dial hub.
(10) Check to see that all setscrews that hold the spur gears and coupling yokes of the capacitor drive assembly are securely tightened.
(11) Turn the capacitor drive mechanism fully counterclockwise, and replace the FREQUENCY (MAIN for TS-421/U) dial so that the calibration dot is exactly under the indicator line above the dial.
(12) Replace the FREQUENCY (MAIN for TS-421/U) dial clamp plate on the FREQUENCY (MAIN for TS–421/U) dial and attach it to the dial hub with the four machine screws.
(13) Replace the FREQUENCY (MAIN for TS–421/U) dial knob with the two setscrews that were previously removed.

Section II.ALIGNMENT

3-6. Test Equipment and Special Tools Required for Alignment

The following chart lists test equipment required for aligning Audio Oscillator TS–421(*)/U, the associated technical manuals, and the assigned common names.

Test equipment	Technical manual	Common name
Spectrum Analyzer TS-733A/U ----------	TM 11–5097	Spectrum analyzer
Voltmeter, Meter ME–30A/U ----------	TM 11–6625–320–12	Ac voltmeter

3–7. Rc Oscillator Alignment Procedure

a. General. The rc oscillator is designed to operate properly with a frequency accuracy of ± 2 percent. Spectrum Analyzer TS–723AW is a standard to check the frequency alignment and has an overall stability and accuracy tolerance of ± 2 percent. Hence, a total error of ± 4 percent may be indicated by the spectrum analyzer when the audio oscillator is actually operating properly. Therefore, do not attempt to readjust the alignment of the audio oscillator when the spectrum analyzer indicates an error of ± 4 percent or less.

b. *Alignment Principles.*

(1) Resistors R1 through R6 (fig. 5-5) (R1 through R9 and fig. 5-4 for

TS–421/U) mounted on FREQUENCY RANGE switch S1, and, in conjunction with the FREQUENCY (MAIN for TS–421/U) tuning capacitor assembly, determine the rc oscillator frequency and amplitude. The chart below lists the values of R1 through R6 and the values of the padder resistors normally used on TS–421A/U. The value of the padder resistors will vary somewhat in each equipment.

Resistor	Total resistance desired (ohms)	Value of precision ±1% resistor used (ohms)	Normal value of padder resistor a (ohms)
R1	8.5 meg	8.3 meg	0.2 meg
R2	850K	830K	20K
R3	85 K	83K	2K
R4	85 K	83K	2K
R5	850K	830K	20K
R 6	8.61 meg	8.3 meg	0.31 meg

a In some equipments, two padder resistors are connected in parallel to obtain the desired total resistance value.

(2) Variable capacitors C1 and CM (C2 and C13 for TS–421/U) are permanently installed padder capacitors which permit adjustment of the capacitance value of C2A and C2B (C1 for. TS–421U) to produce proper frequency tracking throughout the range of the FREQUENCY dial (MAIN for TS–421/U). On some equipments, C22 may be supplemented by the addition of C24 in parallel with it (C13 for TS–421/U). The value of capacitor C7 (C13 for TS–421/U) is selected to provide proper feedback for accurate oscillation near the 20,000-cps end of the frequency range. The value of C7 (C13 for TS-421/U) varies with each equipment. When the instrument is properly calibrated, the FREQUENCY (MAIN for TS-421/U) dial must be correctly coupled to C2A and C2B (C1 for TS-421/U) through the drive mechanism, or the frequency indicated by the FREQUENCY (MAIN for. TS–421/U) dial will be incorrect.

c. Alignment Adjustment. The audio oscillator is designed to stay in alignment without need of adjustment for long periods of time. When adjustment is necessary, it will be due to one of the errors described below. Appropriate adjustments are shown for each type of alignment error. Alignment is first performed with the FREQUENCY RANGE switch in the X1O position, and then in the X1 and X1OO positions. Detailed procedures for checking and adjusting alignment are given in paragraph 3–8.

Type of error	Adjustment
Constant frequency error (nearly linear) in all ranges (X1O, Xl, and Xl00) .	Adjust capacitor drive coupling so that FREQUENCY (MAIN for TS421/U) dial gives correct indication of the oscillator frequency after first checking for proper positioning of dial with calibration dot at extreme ccwposition.
Constant frequency error (nearly linear) in one range only.	Adjust the appropriate alignment resistors (para 3–7b) for that range only, by changing the carbon padder resistor which supplements the precision resistor. Depending on the amount of frequency error to be corrected, only one alignment resistor may need to be changed.
Varies with position of FREQUENCY (MAIN for TS-421/U) dial in all ranges.	Readjust the FREQUENCY (MAIN for TS-421/U) dial to correct the error at the low-frequency end of the band. Then, adjust Cl and/or C22 (C2, and C13 for TS–421/U) as necessary to correct for error at the high end of the band. If significant response (output level) changes are introduced by these adjustments, further special adjustments are needed to achieve the optimum balance of minimum frequency and voltage error. If correction of error at the low and high ends of the band leaves a significant error in the center of the band, the above corrections must be used for the center and high ends of the band,

Type of error	Adjustment
	and careful bending of capacitor plates must be used to eliminate the error at the low end of the band. *Caution:* Do not attempt to bend capacitor plates without following the detailed procedure given in paragraph 3-8d (8) and do not try to bend plates to correct for an apparent frequency error within the ± 4% tolerance of the indicated frequency.
Frequency response error (output voltage not maintained constant over the band).	Adjustment of response and oscillator frequency is related; adjustment to compensate for one will affect the other. Special adjustment techniques must be used to achieve the optimum balance of minimum frequency and voltage error.

d. Preliminary Measures. Blow out any dust that may be present on frequency tuning capacitor C2A and C2B (C1 for TS–421/U) before checking calibration. Use only a gentle airstream. Do not attempt to clean the capacitor plates with mechanical tools. The frequency alignment will be correct only when the shields around and above the tuning capacitor assembly are firmly in place. After blowing out dust, be sure to replace any shields that were removed before attempting alignment.

3-8. Alignment Test and Adjustment

a. Turn the FREQUENCY (MAIN for TS–421/U) dial fully counterclockwise. The calibration dot on the FREQUENCY (MAIN for TS–421/U) dial should be exactly under the hairline on the plastic indicator located above the dial. If not, remove the FREQUENCY (MAIN for TS–421/U) dial knob and loosen the four screws on the FREQUENCY (MAIN for TS–421/U) dial clamp plate. Rotate the FREQUENCY (MAIN for TS–421/U) dial to the proper position, and retighten the four screws on the FREQUENCY (MAIN for TS–421/U) dial clamp plate. Replace the FREQUENCY (MAIN for TS-421/U) dial knob.

b. Connect the spectrum analyzer to the audio oscillator as shown in figure 3–3. Connect the captive ground strap to the lower OUTPUT terminal of the audio oscillator on TS–421A/U only. Connect the lower OUTPUT terminal of the audio oscillator to the lover AF INPUT binding post of the spectrum analyzer. Connect the upper OUTPUT terminal of the audio oscillator to the upper AF INPUT binding post of the spectrum analyzer.

c. Apply power to the audio oscillator and the spectrum analyzer. Let each instrument warm up for 30 minutes. Make the following switch and control settings:

TS421A/U	
Control	Setting
Audio oscillator:	
FREQUENCY RANGE switch.	X10.
FREQUENCY dial	20.
LOAD switch	ON.
AMPLITUDE control	To give indication of 50 volts on OUTPUT LEVEL meter.
IMPEDANCE switch	600.
Spectrum analyzer:	
AF–RF selector switch.	AF.
Meter range switch	100%.
Function switch	SET LEVEL.
Frequency RANGE switch.	X10.
FREQUENCY tuning dial.	100,
INPUT control	Rotate from MIN position until spectrum analyzer meter pointer registers full-scale deflection (1.0) on the RMS volts scale.

TS–421/U	
Control	Setting
Audio oscillator:	
FREQUENCY RANGE switch.	X10.
MAIN dial	20.
LOAD switch	ON.
VOLUME control	To give indication of 50 volts on OUTPUT LEVEL meter.
IMPEDANCE switch	500.

TS-421/U	
Control	Setting
Spectrum analyzer:	
AF-RF selector switch.	AF.
Meter range switch ___	100%.
Function switch -------	SET LEVEL.
Frequency RANGE switch.	X10.
FREQUENCY tuning dial.	100.
INPUT control _____	Rotate from MIN position until spectrum analyzer meter pointer registers full-scale deflection (10) on the RMS volts scale.

d. Align the X10 frequency band as follows:

(1) With the audio oscillator FREQUENCY (MAIN for TS-421/U) dial set at 20, measure the output frequency by tuning the spectrum analyzer to the center of the null indication on the meter. Turn the meter range switch of the spectrum analyzer to the 10 percent and then to the 3 percent positions in order to read the decreasing null signal accurately as the spectrum analyzer is tuned to the exact frequency of the audio oscillator. The frequency indicated by the spectrum analyzer at the extreme minimum of the null is an accurate indication of the audio oscillator output frequency. The frequency should be 200 cps & 8 cycles (192 to 208 CPS) .

(2) Change the FREQUENCY (MAIN for TS-421/U) dial setting to 200. Do not change the AMPLITUDE (VOLUME for TS-421/U) control setting. The OUTPUT LEVEL meter should indicate between 48 and 52 volts. Measure the output frequency, which should now be 2,000 cps ± 80 cycles (1,920–2,080 cps).

(3) If either or both the frequency and output level are in error, adjust frequency tuning capacitor C2A and C2B (Cl for TS421/U) for the best compromise between accurate frequency and output level at each end of the frequency band. Make this adjustment with the power off at the coupling yoke (fig. 3-1 and 3–2) between the frequency tuning capacitor shaft and the capacitor drive mechanism. Loosen the two setscrews on the coupling yoke of the capacitor drive coupling and turn the capacitor shaft *slightly* to compensate for the error, then retighten. Adjustment at this point aligns the indication of the FREQUENCY (MAIN for TS-421/U) dial, and still retains the correct positioning of the calibration dot with respect to the counterclockwise (ccw) stop of the tuning capacitor drive assembly. The following chart lists some possible calibration errors and suitable adjustments to correct them:

Frequency error	(output lever a) Amplitude error	Adjustment
Small error between 200 and 2,000 cps.	None	If frequency is too high, adjust C2A and C2B (Cl for TS-421/U) shaft coupling to close plates slightly; if frequency is too low, adjust C2A and C2B (Cl for TS-421/U) shaft coupling to open plates slightly. Output level should read between 48 and 52 volts.
Error at one end of band only.	None	Adjust C2A and C2B (Cl for TS–421/U) shaft coupling so that a smaller frequency error is present at each end of the band. Open plates if error frequency is low; close plates if it is high. Repeat the test to check for amplitude error. If there is a significant amplitude error, readjust C2A and C2B (Cl for TS-421/U) to minimize error between amplitude and frequency.
Small error between 200 and 2,000 cps.	Small error ----	If frequency is too high, adjust C2A and C2B (Cl for TS-421/U) shaft coupling to close plates; if frequency is too low, adjust

Frequency error	(output lever a) Amplitude error	Adjustment
Error at one end of band only.	Small error ____	C2A and C2B (C1 for TS–421/U) shaft coupling to open plates. Repeat the test and check amplitude error. If the amplitude error has been increased, readjust C2A and C2B (Cl for TS-421/U) shaft coupling to minimize error between amplitude and frequency, Adjust C2A and C2B (C1 for TS-421/U) shaft coupling so that a smaller frequency error is present at each end of the band. Open plates if error frequency is low; close plates if it is high. Repeat the test and check amplitude error, If the amplitude error has been increased, readjust C2A and C2B (C1 for TS–421/U) to minimize error between amplitude and f requency.

2. Output level is set for 50 volts.

(4) If the adjustment of the shaft coupling for C2A and C2B (C1 for TS–421/U) cannot bring the frequency output within the ± 4 percent limit allowed at each end of the band and the output voltage level cannot be brought between 48 and 52 volts, proceed as follows:

(a) Make the C2A and C2B (C1 for TS–421/U) shaft coupling adjustment described in (3) above for accurate frequency output at the *low* end of the X10 band (200 cps).

(b) Turn the FREQUENCY (MAIN for TS-421/U) dial to 200' (2,000 cps) and adjust trimmer capacitor C22 (fig. 2–2) (C13 and fig. 2–1 for TS–421/U) in small increments until the correct frequency output (2,000 cps ± 4 percent) is produced. If the correct frequency cannot be obtained by adjustment of C22 (C13 for TS–421/U) alone, adjust Cl (C2 for TS421/U) also.

Caution: Trimmer capacitors (722 and C1 (C13 and C2 for TS-421/U) are delicate. The factory adjustment has been locked in place by a solder bond to the ceramic housing. Open this bond with gentle heat from a soldering iron before making an alignment adjustment. Once the proper adjustment has been made and checked as described below, relock the position of the trimmer capacitor by making another solder bond.

(c) After correcting the frequency error by adjusting C22 (and Cl if necessary) (C13 and C2 for TS–421/U), repeat the test at 200 and 2,0()() cps, and check to see that the output voltage level change between each end of the band is between 48 and 52 volts. If not, readjust the trimmers to minimize this voltage error and/or to achieve the optimum balance between frequency error and voltage error.

(d) Readjust C22 (C13 for TS–421/U) back toward its original position and make another adjustment on Cl (C2 for TS421/U) to further reduce the error. Several balancing adjustments back and forth between C22 and C1 (C13 and C2 for TS-421/U) may have to be made to achieve the correct frequency and output level values.

Note. In extreme cases, C22 may not have sufficient adjustment range to achieve optimum operation; then, fixed capacitor C24 (approximately 5 micromicrofarads (μμf)) may be added in parallel with C22 if it is not already present on the equipment for TS-421A/U ONLY.

(5) After the frequency error and amplitude error at the ends of the X10 band (200–2,000 cps) have been corrected, check for frequency tracking and output voltage level change throughout the range of the FREQUENCY (MAIN for TS421/U)

dial (with the FREQUENCY RANGE switch in the X10 position). At any position of the FREQUENCY (MAIN for TS–421/U) dial, the output frequency as measured by the spectrum analyzer should be within 34 percent of the frequency indicated by the FREQUENCY (MAIN for TS-421/U) dial. Also, the output voltage should be constant within 48 and 52 volts over the complete range of the FREQUENCY (MAIN for TS–421 U) dial. If these checks are correct, the X10 range is properly calibrated. If the checks still indicate an error, additional alignment must be performed as described in (6) below.

(6) To correct for a small error in the center of the X10 range band, trun the FREQUENCY (MAIN for TS–421/U) dial to 70. Correct the error by adjusting the tuning capacitor drive coupling yoke as outlined in (3) above. Readjust the tuning capacitor drive coupling yoke to correct any error. at the high end of the band, and adjust trimmer capacitors C22 and Cl (C13 and C2 for TS-421/U) to correct the error at the center of the band (FREQUENCY or Main dial at 70); use the method in (4) above. Check the alignment at the lower end of the band. If there is a frequency error greater than $\pm$4 percent, the plates of capacitor C2 (C1 for TS–421/U) must be adjusted by bending as described in (7) below. If a voltage error is present before and or after adjustment of the C2 (C1 for TS–421/U) plates, a balancing adjustment between C22 and C1 (C13 and C2 for TS–421/U) must again be performed to minimize both) frequency and voltage errors.

(7) Alignment by means of bending the frequency tuning capacitor plates should rarely be necessary. Perform this adjustment carefully. Bend only tile outer movable plate of each section. These plates are segmented for identification. Bend only the portion of the movable plate which has NOT closed within the fixed plates at the point where adjustment is required. The plates should be bent near their point of attachment to the rotating shaft (in from the end of the slotted segment). Adjacent segments should be bent so that the plates remain parallel with each other.

e. Align the X100 range band as follow's:

(1) Turn the FREQUENCY RANGE switch on the audio oscillator to the X100 position. Check for alignment at all positions of the FREQENCY (MAIN for TS-421/U) dial; use the spectrum analyzer to measure the output frequency, and the audio oscillator OUTPUT LEVEL meter to check the output level. If there is no significant error, the X100 range is properly calibrated, Proceed to the instructions in *f* below. If there is an error in the output frequency of the output level, continue to (2) below.

(2) To correct for an error in the X100 range when the complete X10 range has been properly aligned, change the value of one or both alignment resistors R3 and R4, (R9 for TS-421/U). Do this by changing the nonprecision padder resistor which supplements precision resistors R3 and R4 (R9 for TS–421/U). A 1-percent change in frequency (to correct error) can be made by changing only one of the padder resistors. If a greater frequency change is needed, change both padder resistors. Determine the resistance required to provide proper frequency alignment with the FREQUENCY (MAIN for TS-421/U) dial set at 20 or 30 (100 for TS–421/U). Increase the resistance about 1,000 ohms to produce a 1-percent decrease in frequency. Other amounts of frequency change can be produced with proportional changes in resistance. When changing a padder resistor, measure the resistance of the padder resistor that is removed to determine its value, and replace with another resistor of

the proper value to correct the frequency error, Two padder resistors in series or parallel can be selected to give the required overall resistance. After aligning the low end of the FREQUENCY dial, adjust C7 (C13 for TS–421/U) by adding or removing padder capacitors as necessary to calibrate the high end of the X100 range band (20,000 cps). Then repeat (1) above for checking the alignment in the X100 range band.

f. Align the X1 range band as follows:

(1) Turn the FREQUENCY RANGE switch on the audio oscillator to the X1 position. Check for frequency alignment and proper output level for all positions of the FREQUENCY (MAIN for TS–421/U) dial; use the spectrum analyzer to measure the output frequency, and the audio oscillator OUTPUT LEVEL meter to check the output level. If there is no error, the Xl range is properly aligned. If there is an error, change the value of one or both calibration resistors R1 and R6 (R7 for TS–421/U, fig. 3–4). Do this by changing the nonprecision padder resistor which supplements precision resistors R1 and R6 (R7 for TS–421/U, fig. 3–4).

(2) A 1-percent change in frequency (to correct error) can be made by changing only one of the padder resistors. If a greater frequency change is needed, change both padder resistors. Determine the resistance required to provide proper frequency alignment with the FREQUENCY (MAIN dial 011 TS–421/U set at 100) 7(3. Increase the resistance by 100,000 ohms to produce a l-percent decrease in frequency. When changing padder resisters, measure the resistance of the padder resistor removed to determine its value and replace with another padder of the proper value to correct the frequency error.

3–9. Alignment of OUTPUT LEVEL Meter

a. Set the POWER switch to ON and the AMPLITUDE (VOLUME for TS-421/U) control to 0. Set the OUTPUT LEVEL meter pointer to 0 by turning the zero adjustment screw on the front of the meter (TS–421/U only). Set the POWER switch to off.

Note. For proper operation, the meter pointer should move in the opposite direction to the direction of rotation of the zero adjustment screw. If not, rotate the zero adjustment screw through a maximum of meter pointer displacement until the pointer does move in the opposite direction to that of the screw; then, complete the zero-set adjustment.

b. Connect the ground lead of the ac voltmeter to the OUTPUT ground terminal. Connect the ac probe lead to the upper vertically spaced OUTPUT terminal.

c. Set the LOAD switch to the ON position. Turn the IMPEDANCE switch to the 600 (500 for TS–421/U) position. Turn the FREQUENCY RANGE switch to the Xl position and the FREQENCY (MAIN for TS–421/U) dial to the 100 setting, to obtain a 100–CPS output. Set the POWER switch to ON.

d. Turn the AMPLITUDE control (VOLUME control for TS–421/U) clockwise until the external ac voltmeter reads exactly 55 volts (50 volts for TS-421/U).

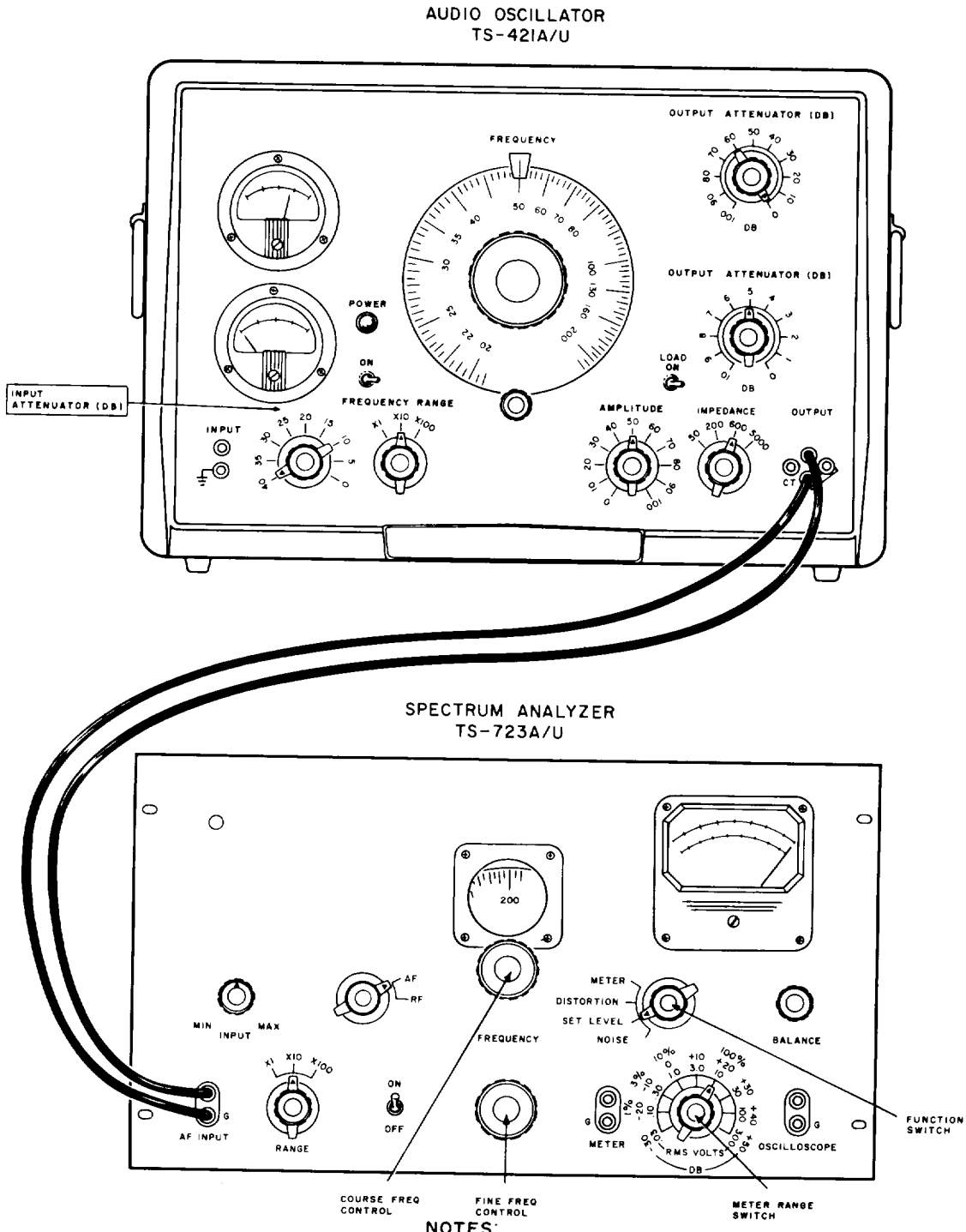
Note. *e* and *f* apply to TS–421A/U g and h apply to TS–421/U.

e. Locate variable resistor R29 at the rear of the chassis (TM 11–6625–3,55–12). This screwdriver-adjusted resistor, accessible through a hole in the rear of the chassis, is used to zero adjust the OUTPUT LEVEL meter.

f. Use a screwdriver to adjust this variable resistor until the OUTPUT LEVEL meter indicates exactly 55 volts.

g. If the OUTPUT LEVEL meter reads less than 50 volts, select a resistor which, when placed in parallel with R31, will raise the reading of the OUTPUT LEVEL meter to 50 volts. As an approximation, 1 megohrn placed in parallel with resistor R31 will raise the meter reading about 1 volt.

h. If the OUTPUT LEVEL meter reads more than 50 volts, place a resistor in series with R31. A resistor of 500 ohms will lower the meter reading by approximately 1 volt.



NOTES:

1. AMPLITUDE CONTROL IS VOLUME CONTROL ON TS-421/U.
2. SET IMPEDANCE SWITCH ON TS-421/U TO 500.
3. INPUT ATTENUATOR (DB) IS INPUT DB ON TS-421/U.

TM6625-355-45-15

Figure 3-3. Test connections for alignment.

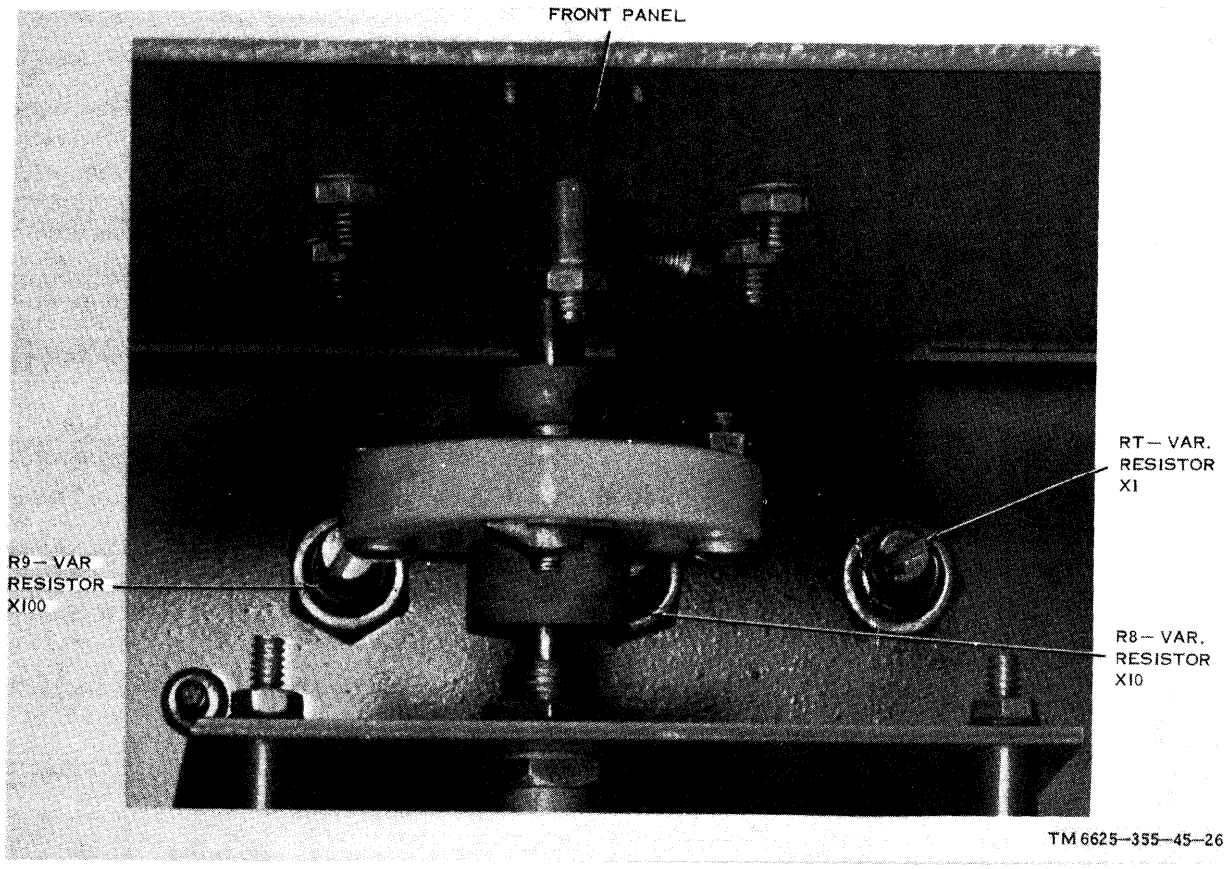


Figure 3–4. Locating of variable resistors R7, R8, and R9, TS–421/U.

3-10. Alignment of INPUT LEVEL Meter

a. Short-circuit the INPUT terminals on the audio oscillator by connecting a jumper between them. Set the POWER swich to ON and adjust the INPUT LEVEL meter pointer to 0 by turning the zero adjustment screw on the front of the meter (note, para 3–9a).

b, Remove the short circuit between the INPUT terminals.

c. Set the controls on the audio oscillator as follows:

TS-421A/U	
Control	Setting
INPUT ATTENUATOR (DB) switch,	0
FREQUENCY RANGE switch,	X10
FREQUENCY dial --------	40'
LOAD switch ----------	OFF
IMPEDANCE switch ------	5000

TS-421A/U	
Control	Setting
OUTPUT ATTENUATOR (DB) switches.	40 +6 (46 db total).
AMPLITUDE control _____	Turn to produce a reading of 53 volts on the OUTPUT LEVEL meter.

TS-421/U	
Control	Setting
INPUT ATTENUATOR (DB) switch.	0
FREQUENCY RANGE switch,	X10
MAIN dial__ -___---____,_,	100
LOAD switch _____	OFF
IMPEDANCE switch _____	5000
OUTPUT ATTENUATOR (DB) switches.	40 +7 (47 db total)
VOLUME control _____	Turn to produce reading of 50 volts on the OUTPUT LEVEL meter.

d. Connect the captive link from the ground OUTPUT terminal to the lower vertically spaced OUTPUT terminal on TS–421A/U only. Connect a jumper between the upper INPUT terminal and the upper vertically spaced OUTPUT terminal.

e. With the controls set as in c above, the INPUT LEVEL meter should indicate O db.

f. If the INPUT LEVEL meter does not indicate 0 db, locate variable resistor R47 (R41 for TS–421/U) at the rear of the chassis (TM 11–6625–355–12). This screwdriver-adjusted resistor, accessible through a hole in the rear of the chassis, is used to zero adjust the INPUT LEVEL meter.

g. Use a screwdriver to adjust this variable resistor until the INPUT LEVEL meter indicates exactly 0 db.

h, After the 0-db indication has been properly adjusted, change the OUTPUT ATTENUATOR (DB) controls to total 41 and then 51 db. This should produce an indication of + 5 db and –5 db, respectively, on the INPUT LEVEL meter.

3-11. Alignment of Rc Oscillator Voltage, When Replacing Lamp RT11

The 3–watt lamp RT11 (used as a barretter resistor) is operated at a low level and should have an almost infinite life; therefore, the lamp should not be changed indiscriminately. However, should the lamp require replacement, use the following procedure:

a. Remove the old lamp (fig. 2–1 or 2–3) and install the new one.

b. Set the POWER switch to the ON position, turn the FREQUENCY RANGE switch to the X10 position, and turn the OUTPUT ATTENUATOR (DB) to 30. Set the FREQUENCY (MAIN for TS421/U) dial at 100, to produce an oscillator frequency of 1,000 Cps.

c. Connect the ground lead of the ac voltmeter to the audio oscillator ground.

Note. Subparagraph d applies to TS–421 A/U, subparagraph e aplies to TS-421/U.

d. Measure the rc oscillator ac voltage at test point 1 (fig. 5–5) with the ac voltmeter. Adjust variable resistor R19 (fig. 2–2) to obtain a voltage indication between 21 and 25 volts on the ac voltmeter. If the voltage cannot be brought within the 21– to 25-volt range by adjustment of R19, install a new lamp and repeat the procedure until the desired range of voltage adjustment is found. (It should rarely be necessary to try more than one lamp.)

c. If RT11 has to be replaced, composition resistor R37 (fig. 2–2), connected to the lamp socket, may need changing. If, when using the ac voltmeter the ac voltage between the junction of capacitor C4 to resistor R10 and ground is not within the range of 19 to 22 volts, substitute a resistor for R37 so that these limits are obtained. If a resistor of more than 800 ohms is required, reject the lamp and try another.

CHAPTER 4

GENERAL SUPPORT TESTING PROCEDURES

4-1. General

a. Testing procedures are prepared for use by Army Field Maintenance Shops and Army Service Organizations responsible for general support maintenance of Army equipment to determine the acceptability of repaired equipment. 'These procedures set forth specific requirements that repaired equipment *must* meet before it is returned to the using organization. These procedures may also be used as a guide for testing equipment that has been repaired at direct support maintenance if the proper tools and tests equipments are available.

b. Comply with the instructions preceding each chart before proceeding to the chart. Perform each step in sequence. For each step, perform all the actions required in the *control setting* column; then perform each specific test procedure and verify it against its performance standard.

4-2. Test Equipment and Additional Equipment Required

All test equipment and additional equipment required to perform the testing procedures given in this section are listed in the charts below and are authorized under TA 11–17, Army Field Maintenance shops, and TA 11–100 (11–17), Allowances of Army Corps Expendable Supplies for Army Field Maintenance Shop, Continental United States.

a. *Test Equipment.*

Nomenclature	Federal stock No.	Technicalmanual
Frequency Meter AN/TSM-16	6625–542-1666	TM 11-6625-218-12
Spectrum Analyzer TS-723/U	6625–66&-9418	TM 11–5097
Voltmeter, Meter ME–30A/U	6625–669-0742	TIM 11–6625–320–12

b. *Additional Equipment.*

Quantity	Equipment	Federal stock No.
1 ea	Resistor, fixed, ww, 500 ohms, 5 w	5905–156-5921
1 ea	Resistor, fixed, ww, 600 ohms, 5 w	5905-539-4226
12 ft	Cable coaxial, RG-58/U	6145-161-0906
6ea	Plug banana	5935–405–0338
1 ea	Connector plug UG-88C/U	5935–539-0194

4-3. Special Requirements

a. General *Test Conditions.* All tests should be made under the following conditions.

(1) Tests should be made at normal room temperature.

(2) Warm up period should be at least 15 minutes.

(3) Input power should be 115 volts, 60 cycles, single phase, ac.

(4) All voltage measurements across the OUTPUT terminals should be made with an external standard load. The IMPEDANCE control should be set to match the external load with the load switch at OFF.

(a) TS-421/U standard load of 500 ohms.
(b) TS-421A/U standard load of 600 ohms.

b. Fabrication of Test Leads. The test procedures require that two special test leads be constructed. The test equipment required is listed in paragraph 4–2, Construct the leads as shown in figures 4–1 and 4–2.

4-4. Modification Work Orders

The performance standards listed in the following tests are based on the assumption that the modification work orders, applicable to Audio Oscillator TS-421(*)/U, have been performed. A listing of current modification work orders will be found in DA Pamphlet 310-4.

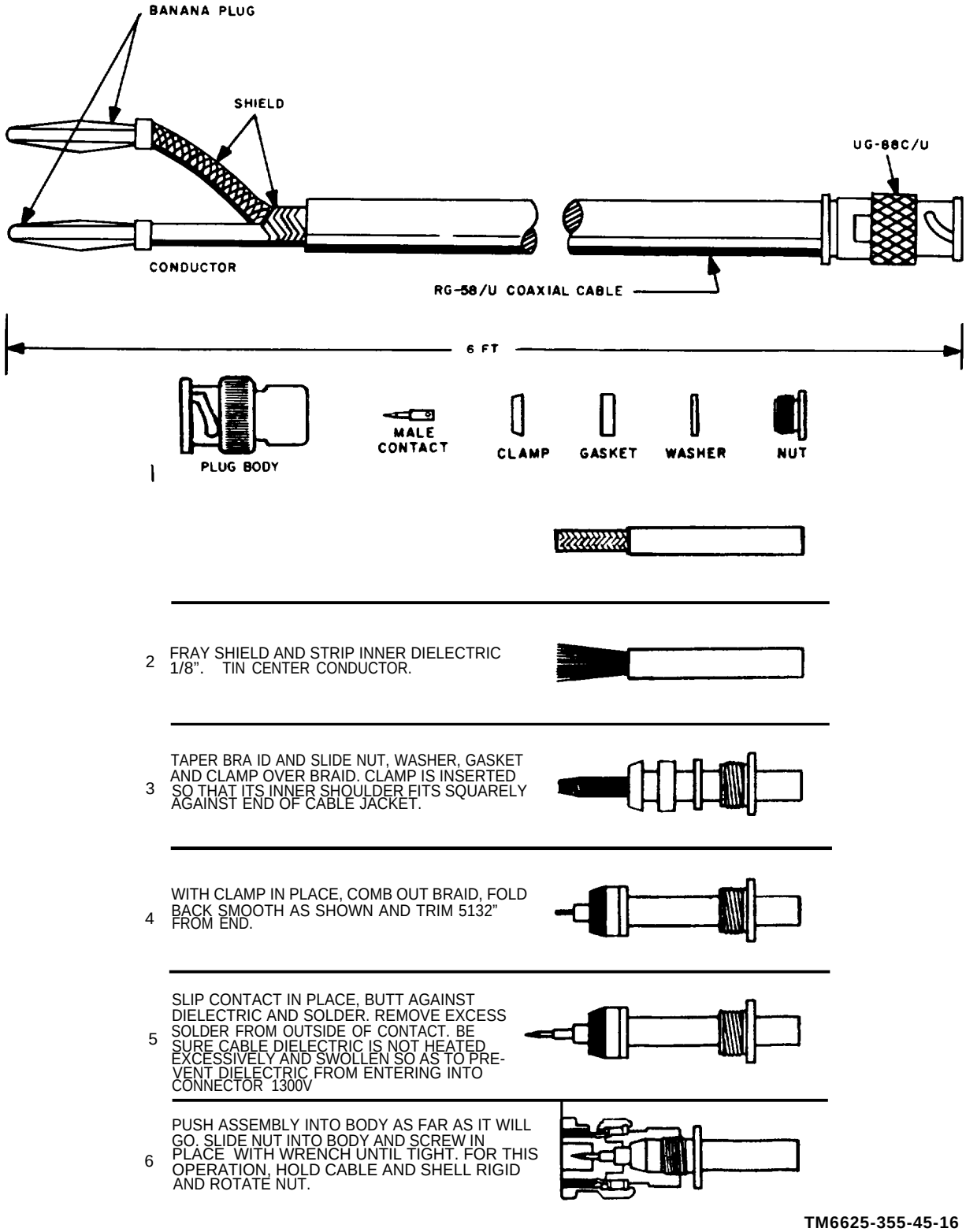


Figure 4-1. *Test lead for frequency calibration test, construction details.*

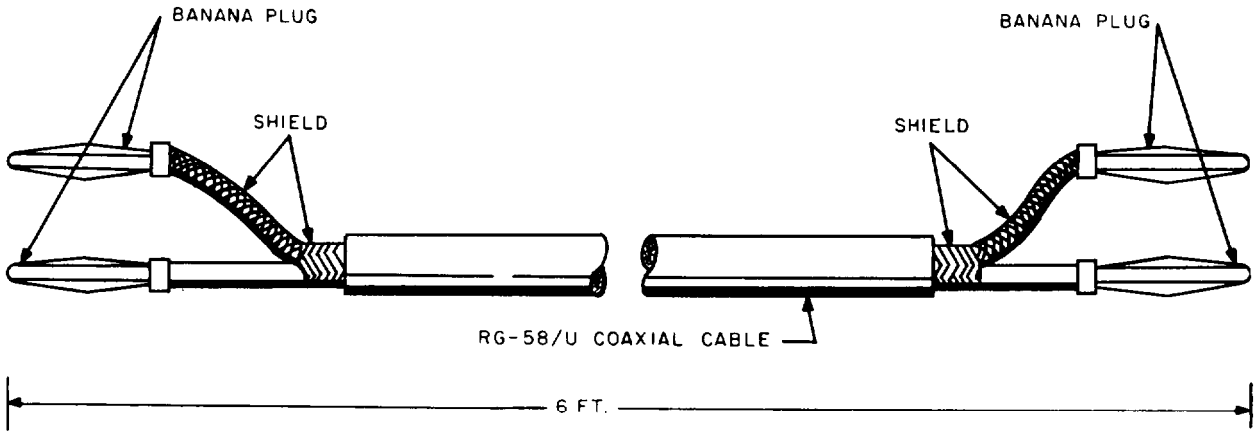


Figure 4–2. Test lead for general support testing, construction details.

4-5 Physical Tests and Inspections

a. Test Equipment and Materials. Electronic Light Assembly MX-12 92/PAQ.

b. Test Connections and Conditions.

(1) No connections necessary.

(2) Remove the test set chassis from its case.

c. Procedure.

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
1	None.	Controls may be in any position.	*a.* Inspect case and chassis for damage, missing parts, and condition of paint. *Note.* Touchup painting is recommended in lieu of refinishing whenever practical; screw heads, binding post, receptacles, and other plated parts will not be painted or polished with abrasives. *b.* Inspect all controls and mechanical assemblies for loose or missing screws, bolts, and nuts. *c.* Inspect all connectors, sockets, receptacles, fuseholders, and meter for looseness, damage, or missing parts.	*a.* No damage evident or parts missing. External surfaces intended to be painted will not show bare metal. Panel lettering will be legible. *b.* Screws, bolts, and nuts will be tight; none missing. *c.* No loose parts or damage. No missing parts.
2	None.	Controls may be in any position.	*a.* Rotate all panel controls throughout their limits of travel. *b.* Inspect dial stops for damage or bending and for proper operation. *c.* Operate all switches.	*a.* Controls will rotate freely without bending or excessive looseness. *b.* Stops will operate properly without evidence of damage. *c.* Switches will operate properly.
3	*MX-1292/PAQ* Connect mercury-vapor lamp.	Controls may be in any position.	Turn on mercury-vapor lamp and expose the portion of the equipmen that has been repaired or disturbed to the direct rays of the lamp.	All repaired or disturbed electrical components and chassis surfaces will be covered. There must be *no* varnish on switch contacts or moving parts of mechanical assemblies. *Note.* Moisture-fungiproofing varnish glows gray-green under the rays of a mercury-vapor lamp.

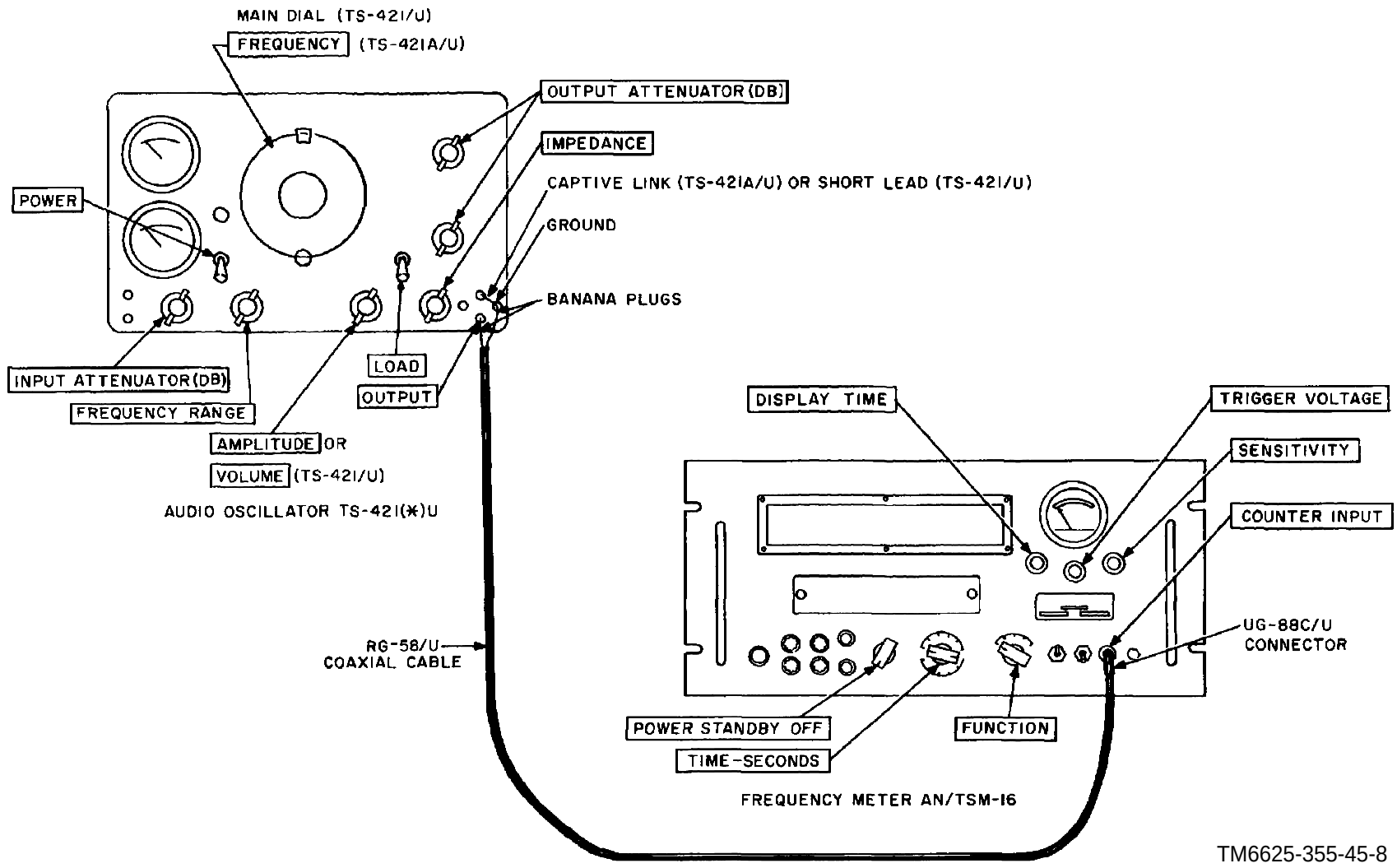


Figure 4-3. Frequency calibration test, connection diagram.

4-6. Frequency Calibration Test

a. Test Equipment and Materials. Frequency Meter AN/TSM–16.

b. Test Connections and Conditions.

(1) Connect the equipment as shown in figure 4–3.

(2) Allow equipment to warm up for 15 minutes.

c. Procedure.

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
1	*AN/TSM–16* POWER-STANDBY-OFF switch: STANDBY. FUNCTION switch: TEST. DISPLAY TIME control: Near fully counterclockwise. TRIGGER VOLTAGE control: Fully counterclockwise. SENSITIVITY control: Fully counterclockwise. AUTO-MANUAL switch: AUTO. TIME/SECONDS switch: 1. INT.-EXT. switch (rear): INT.	POWER switch: OFF. LOAD switch: ON. AMPLITUDE or VOLUME control: 50. OUTPUT ATTENUATOR (0–100 db) switch: 100 db. INPUT ATTENUATOR switch: 40 db. IMPEDANCE switch: 5000.	None.	None.
2	POWER-STANDBY-OFF switch: POWER.	Same as step 1.	*a.* Wait until XTAL OVEN ON indicator lamp cycles on and off, indicating proper operating temperature. Slowly turn the TRIGGER VOLTAGE control clockwise until the numerical indicator begins to count. Observe the position of the control.	None.
			b. Continue to turn TRIGGER VOLTAGE control slowly until counting stops. The correct setting for the TRIGGER VOLTAGE control is halfway between this position and position observed in *a* above.	None.
			c. Rotate TIME/SECONDS switch to all positions and observe the numerical indicators for each position. Frequency Meter AN/TSM–16 TIME/SECONDS switch positions and indicators are listed below. *Switch* — *Indication* .0001 — 000010 .001 — 000100 or 000099 .01 — 001000 or 000999 .1 — 010000 or 009999 1 — 100000 or 099999 10 — 000000 or 999999	None.
3	Same as step 1, except: FUNCTION switch: SCAN COUNT.	Same as step 1, except: LOAD switch: OFF.	*a.* Couple the output of the TS–421(*)/U to the COUNTER INPUT receptacle; use the original cord or, if necessary, the UG–541/U adapter.	*a.* None.
			b. Adjust the SENSITIVITY control for a meter pointer defection at the lower end of the green area on the INPUT LEVEL meter scale.	*b.* None.
			c. Set the TS–421(*)/U FREQUENCY (MAIN) dial and FREQUENCY RANGE switch as follows: *FREQUENCY (MAIN) dial* — *FREQUENCY RANGE switch* 200 — X1 20 — X10 50 — X10 100 — X10 200 — X10 200 — X100	*c.* The frequency reading should be within the following accuracy in cps. 196 to 204 196 to 204 490 to 510 980 to 1020 1960 to 2040 19600 to 20400

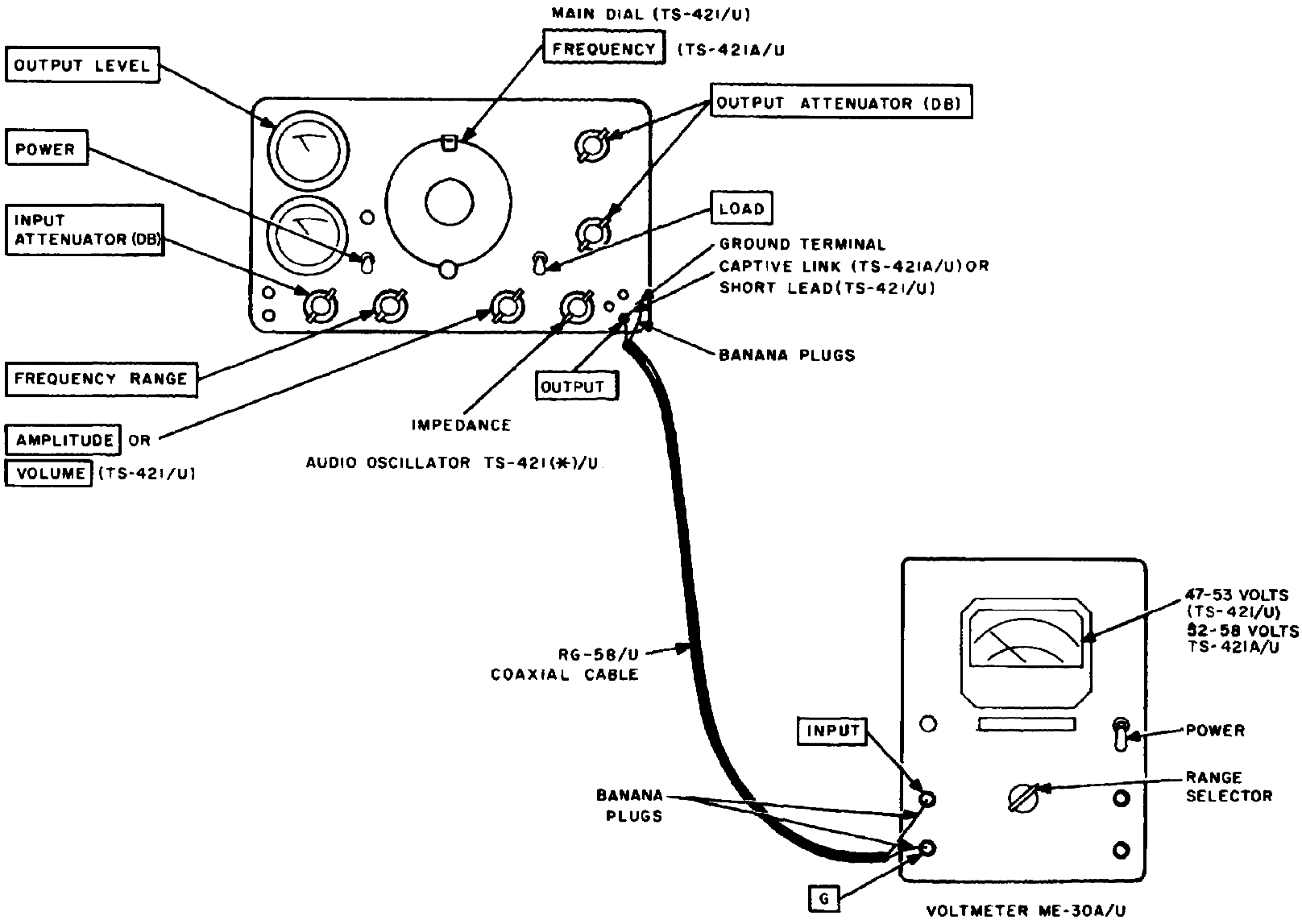


Figure 4-4. Power output, output level meter calibration, and frequency response test connections.

4-7. Power Output, Output Level Meter Calibration, and Frequency Response Test

a. Test Equipment and Materials. Voltmeter, Meter ME–30A/U.

b. Test Connections and Conditions.

(1) Connect the equipment as shown in figure 4–4.

(2) Meter pointer should indicate exactly 0 on the voltage scales of the ME–30A/U.

(3) Turn on the equipment and allow it to warm up for 15 minutes.

c. Procedure.

Step No.	Control settings		Test procedure	Performance standard
	Test equipment	Equipment under test		
1	*ME–30A/U* Range selector switch: 100	LOAD switch: ON AMPLITUDE or VOLUME control: 50 OUTPUT ATTENUATOR (0–100) switch: 100 DB INPUT ATTENUATOR switch: 40 DB	With the TS–421(*)/U controls set as indicated, check for a midscale indication on the OUTPUT LEVEL meter.	None.
2	Same as step 1.	Same as step 1, except: IMPEDANCE switch: 500 (for TS–241/U) 600 (for TS–421A/U) MAIN or FREQUENCY dial: 20 FREQUENCY RANGE switch: 100 OUTPUT ATTENUATOR: 0 db	Adjust the VOLUME or AMPLITUDE control for an OUTPUT LEVEL meter reading of 50 volts (5 watts) on the TS–421/U, and 55 volts (5 watts) on the TS–421A/U.	The voltage reading on the ME–30A/U should be between 49 and 51 volts for the TS–421/U and 54 to 56 volts for the TS–421A/U.
3	Same as step 1.	Same as step 2, except: LOAD switch: OFF MAIN OR FREQUENCY dial: 100 FREQUENCY RANGE switch: X1	Set the OUTPUT ATTENUATOR controls and the VOLUME or AMPLITUDE control to obtain a reading of +37 DB on the OUTPUT LEVEL meter.	The output voltage should be between 47 and 53 volts on the ME–30A/U when measured from the TS–421/U, and between 52 and 58 volts when measured from the TS–421A/U.
4	Range selector switch: 10 DB.	Same as step 1, except: IMPEDANCE switch: 500 (for the TS–421/U) 600 (for the TS–421A/U) MAIN or FREQUENCY dial: 40 FREQUENCY RANGE switch: X10	*a.* Adjust the VOLUME or AMPLITUDE control for a reading of 0 db on the ME–30A/U meter. *b.* Adjust the MAIN or FREQUENCY control to 20 and the FREQUENCY RANGE switch to X1. Leave all other controls in their original positions. *c.* Adjust the MAIN or FREQUENCY control to 200 and the FREQUENCY RANGE switch to X100. Leave all other controls in their original positions.	*a.* None. *b.* The ME–30A/U reading should be between –2DB and +2DB. *c.* The ME–30A/U reading should be between –1DB and +1DB.

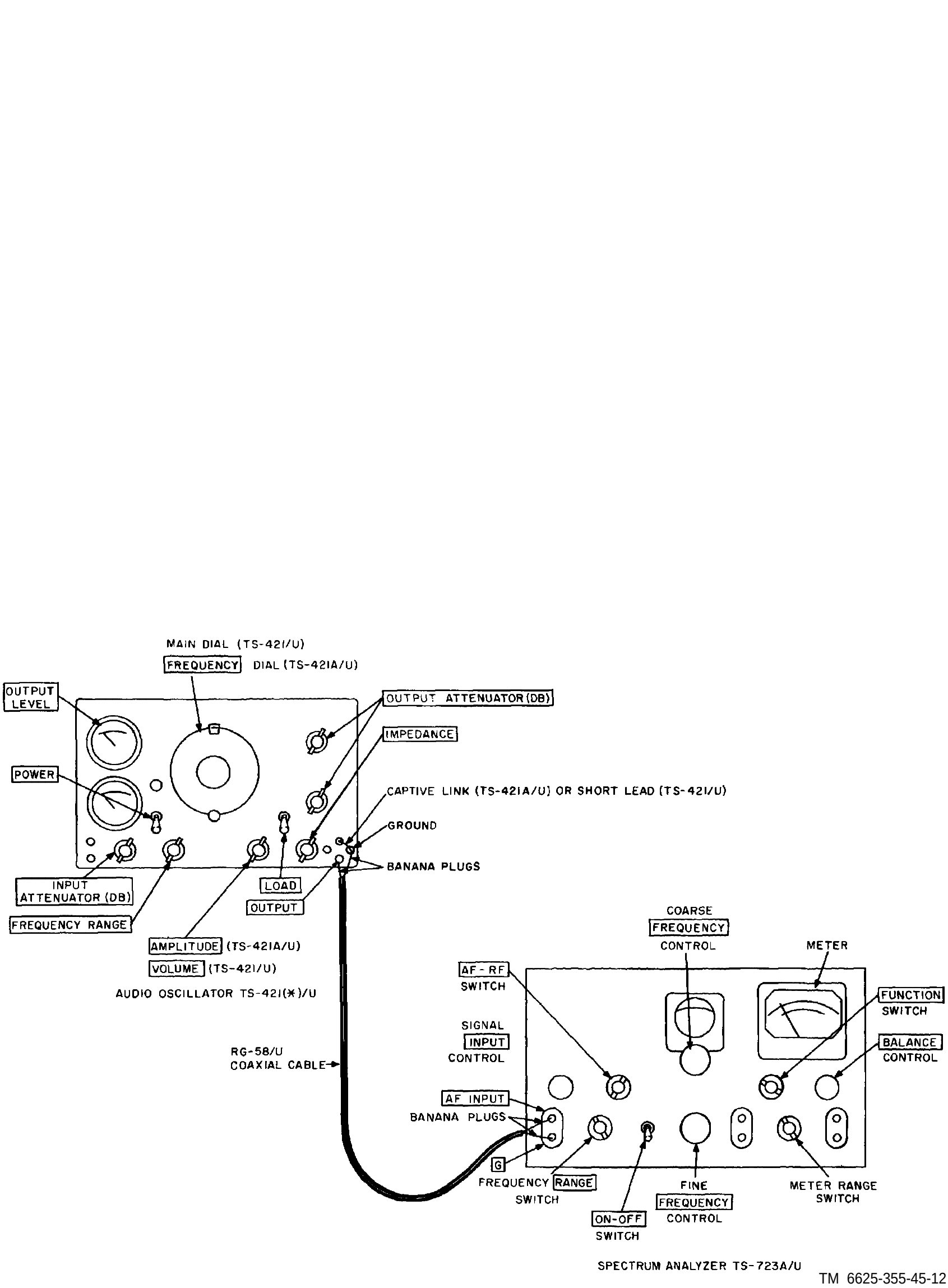


Figure 4-5. Distortion test setup.

4-8. Distortion Test

a. Test Equipment and Materials. Spectrum Analyzer TS–723A/U.

b. Test Connections and Conditions.

(1) Connect the equipment as shown in figure 4–5. Ground the TS–723A/U to a convenient ground point; use No. 12 AWG wire.

(2) Turn on the equipment and allow it to warm up for 15 minutes before proceeding with the test.

c. Procedure.

Step No.	Control settings: Test equipment	Control settings: Equipment under test	Test procedure	Performance standard
1	*TS–723A/U* Signal INPUT control: MIN Meter range switch: 100 AF-RF switch: AF Function switch: SET LEVEL	LOAD switch: ON VOLUME or AMPLITUDE control: 50 OUTPUT ATTENUATORS: 0 IMPEDANCE switch: 500 (TS–421/U) 600 (TS–421A/U)	Check the TS–421(*)/U for midscale deflection of the OUTPUT LEVEL meter.	None.
2	Same as step 1.	Same as step 1.	Adjust the VOLUME or AMPLITUDE control of the TS–421(*)/U for a reading of 50 volts on the OUTPUT LEVEL meter of the TS–421/U or 55 volts on the TS–421A/U. Adjust the signal INPUT control of the TS–723A/U for a reading of exactly 1.0.	None.
3	Same as step 1, except: FREQUENCY RANGE switch: X10 Function switch: DISTORTION	Same as step 1, except: MAIN or FREQUENCY dial: 100 FREQUENCY RANGE switch: X10	Adjust the TS–723A/U coarse FREQUENCY control knob until the meter pointer drops sharply. Adjust the fine FREQUENCY control knob for maximum dip of the meter pointer. Adjust the BALANCE control for minimum meter reading. Continue to adjust the fine TUNING and BALANCE controls for minimum reading while adjusting the meter range switch to maintain a midscale reading. Continue this process until the lowest possible reading is obtained on the meter.	Distortion should be less than 1 percent.

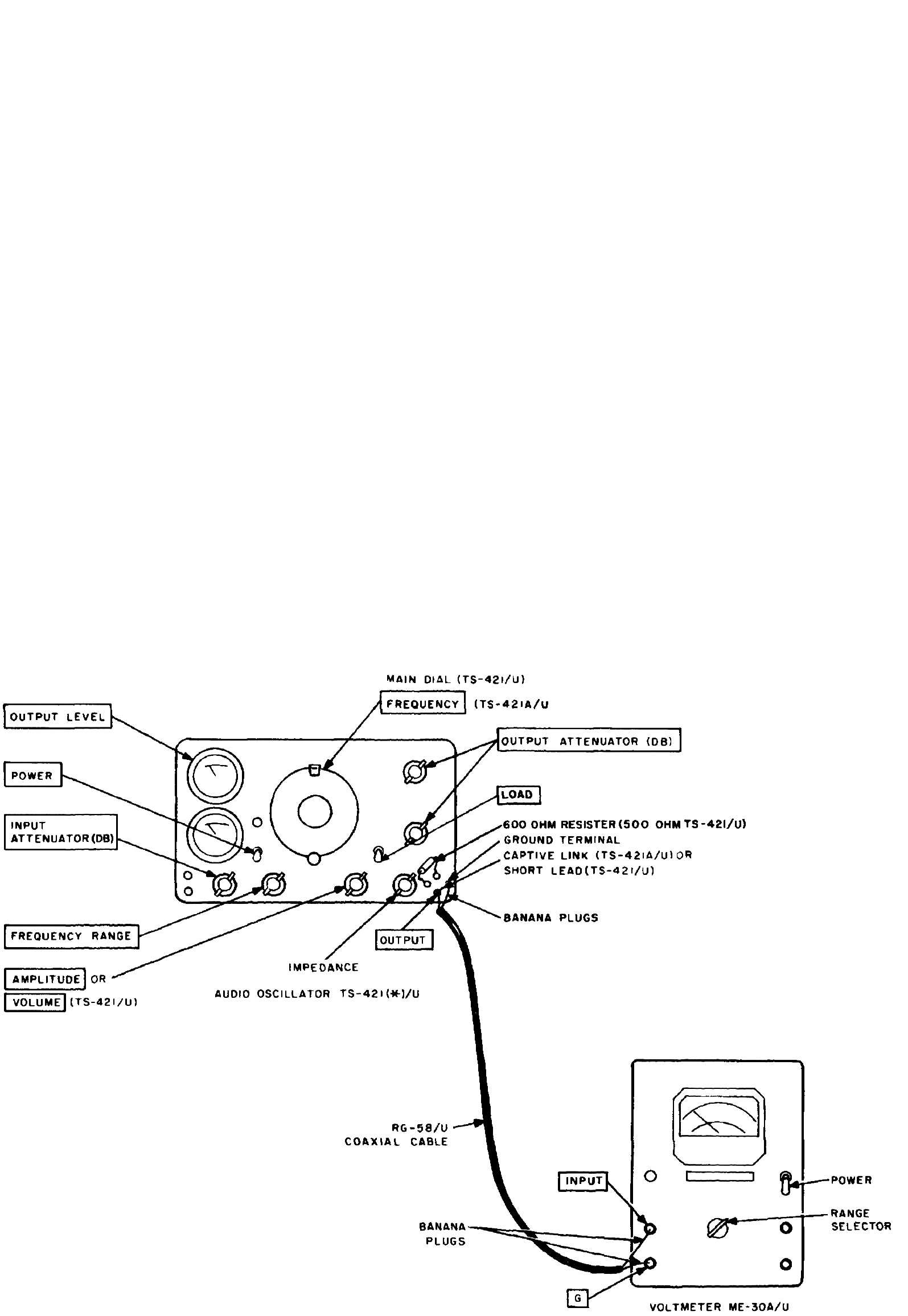


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Figure 4-6. Output attenuator test, connection diagram.

4-9. Output Attenuator Test

a. Test Equipment and Materials. Voltmeter, Meter ME–30A/U.

b. Test Connections and Conditions.

(1) Connect the equipment as shown in figure 4–6.

(2) Check to see that the meter pointer indicates exactly 0 on the ME–30A/U.

(3) Place a 500-ohm resistor across OUTPUT terminals for the TS–421/U, and a 600-ohm resistor across the OUTPUT terminals for the TS–421A/U.

c. Procedure.

Step No.	Control settings		Test procedure	Performance standard
	Test equipment	Equipment under test		
1	Range switch: 100.	AMPLITUDE or VOLUME control: 50. OUTPUT ATTENUATOR (0–100) switch: 100. IMPEDANCE switch: 500 (TS–421/U) 600 (TS–421A/U) LOAD switch: OFF. MAIN or FREQUENCY dial: 100. FREQUENCY RANGE switch: X10.	Check for midscale indication on the OUTPUT LEVEL meter of the TS–421(*)/U.	None.
2	Same as step 1.	Same as step 1, except: OUTPUT ATTENUATOR: 0	Adjust the AMPLITUDE or VOLUME control of the TS–421(*)/U for a reading of 50 volts on the ME–30A/U. Place the 0 to 10 OUTPUT ATTENUATOR switch in 1.	ME–30A/U reads between 41.9 to 47.3 volts.
3	Same as step 1.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 2	Observe the ME–30A/U meter reading.	ME–30A/U reads between 37.3 and 42.1 volts.
4	Same as step 1.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 3	Same as step 3.	ME–30A/U reads between 33.3 and 37.5 volts.
5	Same as step 1.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 4	Same as step 3.	ME–30A/U reads between 29.7 to 33.5 volts.
6	Range switch: 30.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 5	Same as step 3.	ME–30A/U reads between 26.4 and 29.8 volts.
7	Same as step 6.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 6	Same as step 3.	ME–30A/U reads between 23.6 and 26.6 volts.
8	Same as step 6.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 7	Same as step 3.	ME–30A/U reads between 21.0 and 23.6 volts.
9	Same as step 6.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 8	Same as step 3.	ME–30A/U reads between 18.7 and 21.1 volts.
10	Same as step 6.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 9	Same as step 3.	ME–30A/U reads between 16.6 and 18.8 volts.
11	Same as step 6.	Same as step 2, except: OUTPUT ATTENUATOR (0–10) : 10	Same as step 3.	ME–30 reads between 14.9 and 16.7 volts.
12	Range switch: 10.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 10	Same as step 3.	ME–30 reads between 4.7 and 5.3 volts.
13	Range switch: 3.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 20	Same as step 3.	ME–30 reads between 1.49 and 1.67 volts.
14	Range switch: 1.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 30	Same as step 3.	ME–30A/U reads between 0.47 and 0.53 volts.
15	Range switch: 1.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 40	Same as step 3.	ME–30A/U reads between 0.15 and 0.17 volt.
16	Range switch: .1.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 50	Same as step 3.	ME–30A/U reads between 0.047 and 0.053 volt.
17	Range switch: .03.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 60	Same as step 3.	ME–30A/U reads between 0.015 and 0.017 volt.
18	Range switch: .01.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 70	Same as step 3.	ME–30A/U reads between 0.0047 and 0.0053 volt.
19	Range switch: .003.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 80	Same as step 3.	ME–30A/U reads between 0.0015 and 0.0017 volt.
20	Range switch: .001.	Same as step 11, except: OUTPUT ATTENUATOR: (0–100) : 90	Same as step 3.	ME–30A/U reads between 0.00047 and 0.00053 volt.
21	Range switch: .001.	Same as step 11, except: OUTPUT ATTENUATOR (0–100) : 100	Same as step 3.	ME–30A/U reads between 0.00015 and 0.00017 volt.

CHAPTER 5

DEPOT OVERHAUL STANDARDS

5–1. Applicability of Depot Overhaul Standards

The tests outlined in this chapter are designed to measure the performance capability of a repaired equipment. Equipment that is to be returned to stock should meet the standards given in these tests.

5–2. Applicable References

a. Repair Standard. Applicable procedures of the Army depots performing this test and its general standards for repaired electronic equipment given in TB Sig 355–1, TB Sig 355–2, and TB Sig 355—3 form a part of the requirements for testing this equipment.

b. Technical Publication. The technical publication applicable to the equipment to be tested is TM 11–6625–355–12.

c. Modification Work Orders. Perform all modification work orders applicable to this equipment before making the tests specified, DA Pam 310–4 lists all available' MWO's.

5–3. Test Facilities Required

a. The items below are required for depot testing:

Item	Technical manual	Common name
Frequencv Meter AN/TSM-16	TM 11–6625–218–12----------	Frequency meter
Spectrum Analyzer TS-723/U	TM 11–5097----------	Spectrum analyzer
Voltmeter, Meter ME-30A/U	TM 11-6625-320-12----------	Voltmeter
Variable Transformer CN-16/U	----------	Variable transformer

b. In addition to the test facilities required, tile items below are required for depot testing

Quantity		
1	Resistor,fixed ww,500 ohms, 5 w.	5905-156-5921
1	Resistor,fixed, ww 600 ohms, 5 w.	5905-539-4226
12 ft	Cable, coaxial, RG-58/U.	6145–161-0906
6 ea	Bannana, plug _____	5935–405-0338
1 ea	Connector, plug, UG88c/u.	5945-539-0194

5-4. Frequency Calibration Test

Perform the test given in paragraph 4-6.

5–5. Power Output, Output Level Meter Calibration, and Frequency Response Tests

Perform the tests given in paragraph 4–7.

5-6. Distortion Test

Perform the test given in paragraph 4–8.

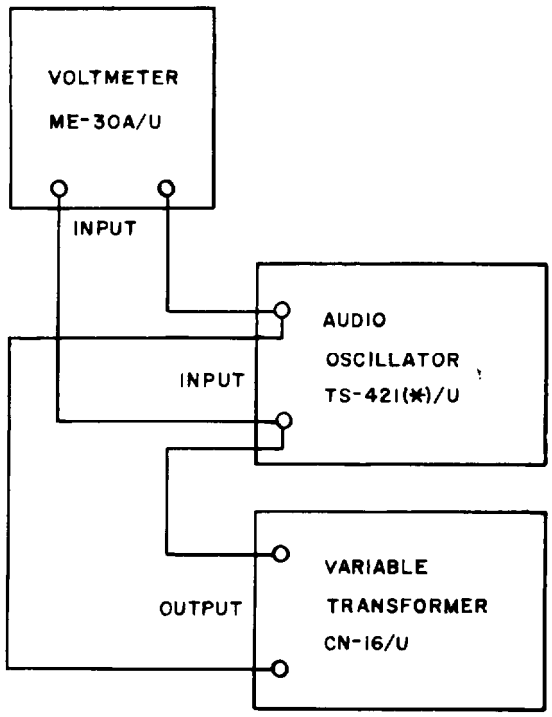
5–7. Output Attenuator Test

Perform the test given in paragraph 4-9.

5–8. Input Attenuator Test (fig. 5-1)

If the results of this test (10 not meet the standards below, replace the input attenuator. The output voltage from the variable transformer required for an INPUT LEVEL meter reading of 2 volts should be within the limits indicated for the INPUT DB attenuator setting in the chart below,

INPUT DB attenuator setting	Volt limits
0	1.96 to 2.04
5	3.48 to 3.63
10	6.20 to 6.44
15	11.0 to 11.5
20	19.6 to 20.4
25	34.8 to 36.3
30	62.0 to 64.4
35	110 to 115
40	196 to 204

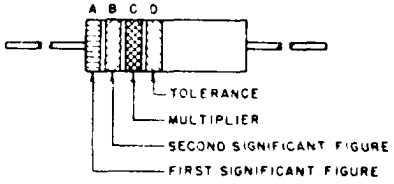


TM 6625355 45 19

Figure 5–1. Input attenuator test, connection diagram.

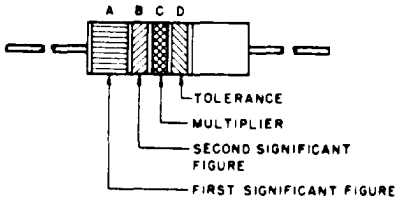
COLOR CODE MARKING FOR MILITARY STANDARD RESISTORS

COMPOSITION-TYPE RESISTORS



BAND A— Equal Width Band Signifies Composition-Type

WIREWOUND-TYPE RESISTORS

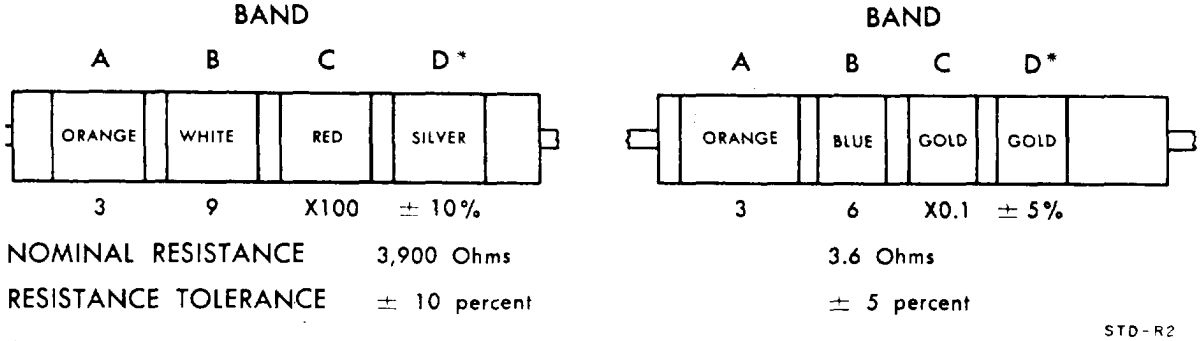


BAND A— Double Width Signifies Wire-wound Resistor

COLOR CODE TABLE

BAND A		BAND B		BAND C		BAND D*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1		
BROWN	1	BROWN	1	BROWN	10		
RED	2	RED	2	RED	100		
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000	SILVER	± 10
GREEN	5	GREEN	5	GREEN	100,000	GOLD	± 5
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	SILVER	0.01		
WHITE	9	WHITE	9	GOLD	0.1		

EXAMPLES OF COLOR CODING

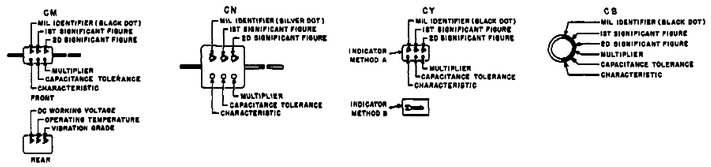


*If Band D is omitted, the resistor tolerance is ±20%, and the resistor is not Mil-Std.

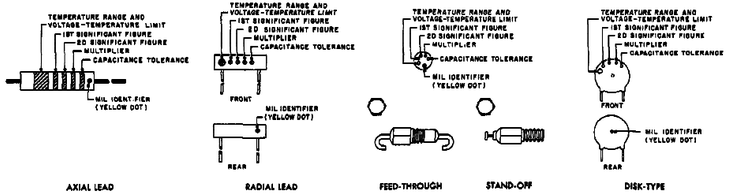
Figure 5-2. MIL-STD resistor color-code markings.

COLOR CODE MARKING FOR MILITARY STANDARD CAPACITORS

GROUP I Capacitors, Fixed, Various-Dielectrics, Styles CM, CN, CY, and CB



GROUP II Capacitors, Fixed Ceramic-Dielectric (General Purpose) Style CK



GROUP III Capacitors, Fixed, Ceramic-Dielectric (Temperature Compensating) Style CC

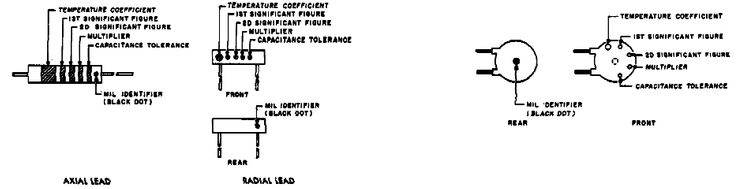


Figure 5-3. MIL-STD capacitor color-code markings.

COLOR CODE TABLES

TABLE I – For use with Group I, Styles CM, CN, CY and CB

COLOR	MIL ID	1st SIG FIG	2nd SIG FIG	MULTIPLIER[1]	CAPACITANCE TOLERANCE CM	CN	CY	CB	CHARACTERISTIC[2] CM	CN	CY	CB	DC WORKING VOLTAGE CM	OPERATING TEMP. RANGE CM	VIBRATION GRADE CM
BLACK	CM, CY CB	0	0	1			± 20%	± 20%		A				−55° to +70°C	10–55 cps
BROWN		1	1	10					B	E		B			
RED		2	2	100	± 2%		± 2%	± 2%	C		C			−55° to +85°C	
ORANGE		3	3	1,000		± 20%			D			D	300		
YELLOW		4	4	10,000					E					−55° to +125°C	10–2,000 cps
GREEN		5	5		± 5%				F				500		
BLUE		6	6											−55° to +150°C	
PURPLE (VIOLET)		7	7												
GREY		8	8												
WHITE		9	9												
GOLD				0.1			± 5%	± 5%							
SILVER	CN				± 10%	± 10%	± 10%	± 10%							

TABLE II – For use with Group II, General Purpose, Style CK

COLOR	TEMP. RANGE AND VOLTAGE – TEMP. LIMITS[3]	1st SIG FIG	2nd SIG FIG	MULTIPLIER[1]	CAPACITANCE TOLERANCE	MIL ID
BLACK		0	0	1	± 20%	
BROWN	AW	1	1	10	± 10%	
RED	AX	2	2	100		
ORANGE	BX	3	3	1,000		
YELLOW	AV	4	4	10,000		CK
GREEN	CZ	5	5			
BLUE	BV	6	6			
PURPLE (VIOLET)		7	7			
GREY		8	8			
WHITE		9	9			
GOLD						
SILVER						

TABLE III – For use with Group III, Temperature Compensating, Style CC

COLOR	TEMPERATURE COEFFICIENT[4]	1st SIG FIG	2nd SIG FIG	MULTIPLIER[1]	CAPACITANCE TOLERANCE Capacitances over 10uuf	Capacitances 10uuf or less	MIL ID
BLACK	0	0	0	1		± 2.0uuf	CC
BROWN	−30	1	1	10	± 1%		
RED	−80	2	2	100	± 2%	± 0.25uuf	
ORANGE	−150	3	3	1,000			
YELLOW	−220	4	4				
GREEN	−330	5	5		± 5%	± 0.5uuf	
BLUE	−470	6	6				
PURPLE (VIOLET)	−750	7	7				
GREY		8	8	0.01			
WHITE		9	9	0.1	± 10%		
GOLD	−100					± 1.0uuf	
SILVER							

1. The multiplier is the number by which the two significant (SIG) figures are multiplied to obtain the capacitance in uuf.
2. Letters indicate the Characteristics designated in applicable specifications: MIL–C–5, MIL–C–91, MIL–C–11272, and MIL–C–10950 respectively.
3. Letters indicate the temperature range and voltage-temperature limits designated in MIL–C–11015.
4. Temperature coefficient in parts per million per degree centigrade.

STD–CB

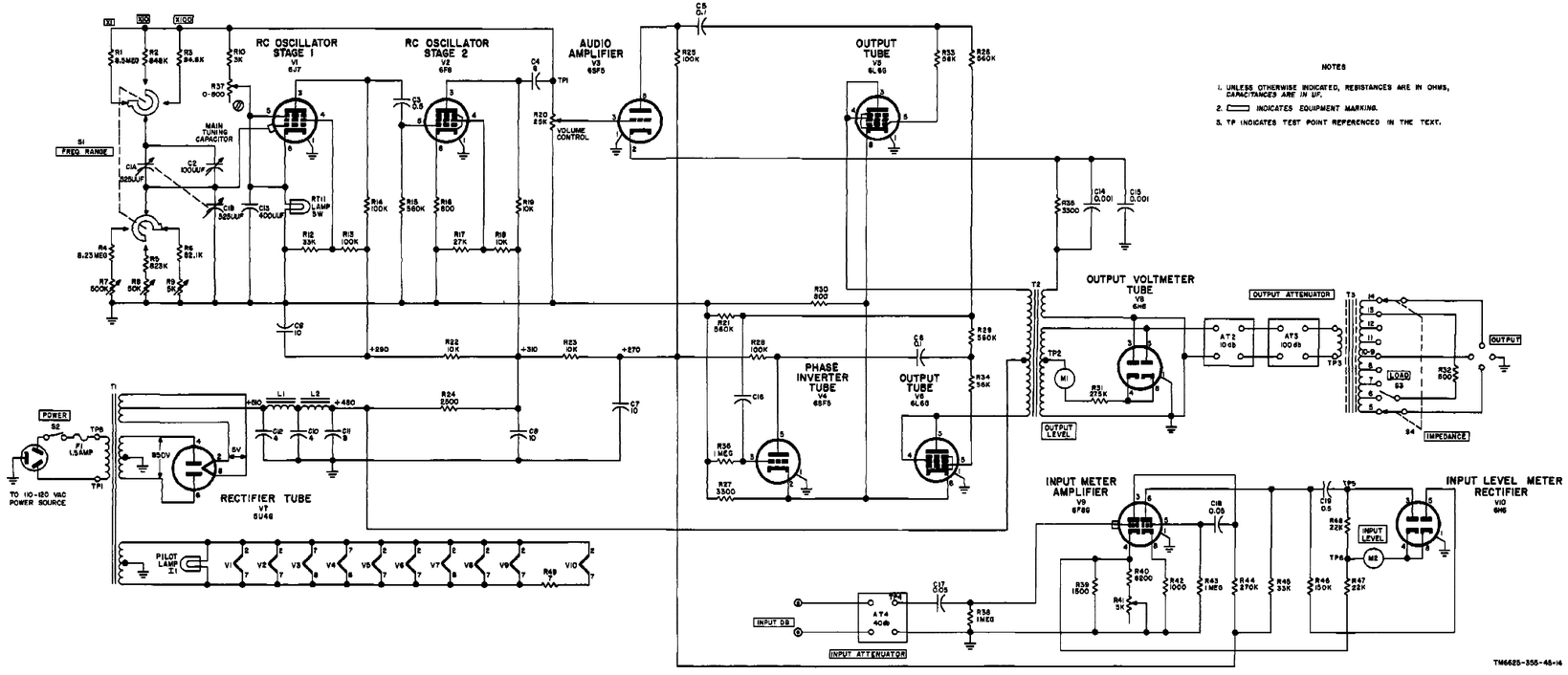
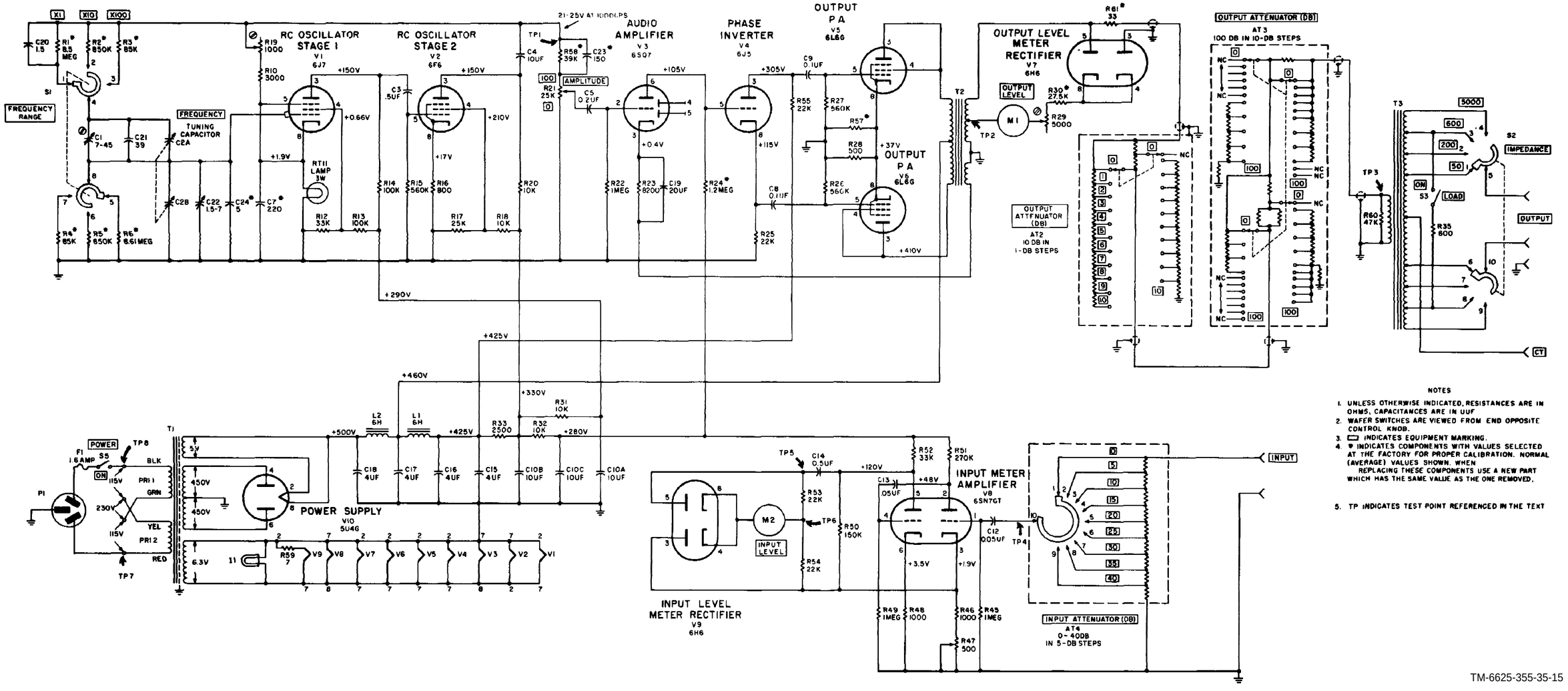


Figure 5-4. Audio Oscillator TS-421/U, schematic diagram.



TM-6625-355-35-15

Figure 5-5. Audio Oscillator TS-421a/U, schematic diagram.

APPENDIX

REFERENCES

Following is a list of references available to the general support and depot repairman of Audio oscillators TS-421/U and TS-421A/U.

DA Pam 310–4	Index of Technical Manuals, Technical Bulletins Supply Manuals (types 7, 8, and 9) Supply Bulletins, Lubrication Orders, and Modification Work Orders.
TM 11–5097	Spectrum Analyzers TS–723A/U, TS–723B/U, TS–723C/U, and TS–723D/U
TM 11–6625-274–12	Operator's and Organizational Maintenance Manual Test Sets, Electron Tube TV–7/U, TV-7A/U, TV-7B/U, and TV–7D/U.
TM 11–6625–316–12	Operator and Organizational Maintenance Manual Test Sets. Electron Tube TV–2/U, TV–2A/U, TV-2 B/U and TV-2C/U.
TM 11–6625–320-12	operator's and Organizational Maintenance Manual Voltmeter, Meter ME-30A/U and Voltmeters, Electronic ME–30B/U and ME–30C/U.

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Inst.] (2) except
Ft Monmouth (70)
Ft Hancock (4)
Ft Gordon (10)
Ft Huachuca (10
WSMR (5)
Ft Carson (21)
Ft Knox (12)
APG (5)
USAEPG (5)
Redstone Arsenal (5)
Army Dep (2) except
LBAD (14)
SAAD (30)
TOAD (14)
FTWOAD (10)
LEAD (7)
SHAD (3)
NAAD (5)
SVAD (5)
CHAD (3)
ATAD (10)
GCAD (5)
ERAD (5)
PUAD (5)
GENDEP (0S) (2)
Sig See, GENDEP (OS) (5)
Sig Dep (OS) (12)
Sig Fld Maint Ships (2)
AMS (1)
USAERDAA (2)
USAERDAW (13)
USACRREL (2)
Units org under fol TOE:
11–5'7 (2)
11-97 (2)
11-98 (2)
11-117 (2)
11-127 (2)
11-155 (2)
11-157 (2)
11-158 (2)
11-500 AA-AC (2)
11-587 (2)
11-592 (2)
11-597 (2)
55–405 (2)
55-406 (2)

NG : State AG (3) ; units same as Active Army except allowance is one copy to each unit.

USAR : None.

For explanation of abbreviations used, see AR 320-50.

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