OPERATING INSTRUCTIONS

TYPE 736-A

WAVE ANALYZER

GENERAL RADIO COMPANY

508-G

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WAVE ANALYZER

Form 508-G
June, 1960

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

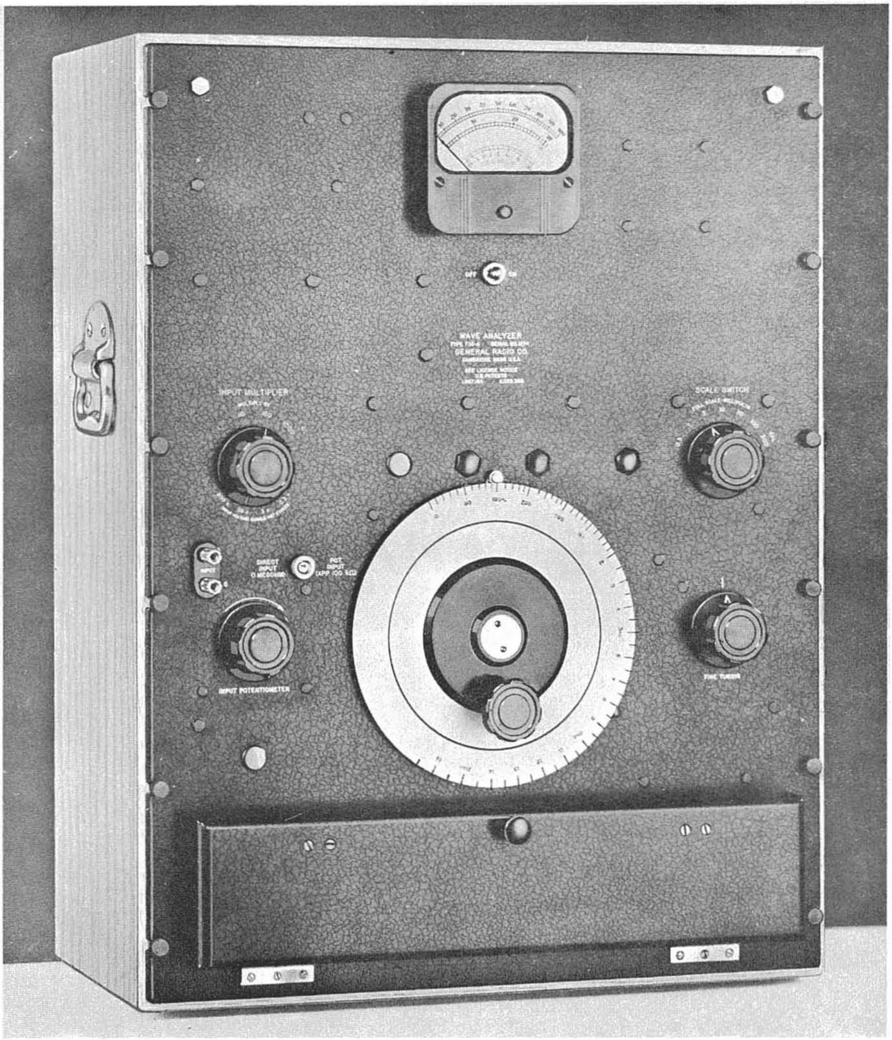


FIGURE 1. Panel view of Type 736-A Wave Analyzer

SPECIFICATIONS

Frequency Range: 20 to 16,000 cycles.

Selectivity: Approximately as shown in plot, page 4. The response is down 15 db at 5 cycles, 30 db at 10 cycles, 60 db at 30 cycles from the peak. The selectivity is constant over the frequency range.

Voltage Range: 300 microvolts to 300 volts full scale. The lowest division on the meter corresponds to 10 μv. The over-all range is divided into four major ranges: 300 μv to 300 mv, 3 mv to 3 v, 30 mv to 30 v, 0.3 to 300 v. Each o these ranges is divided into seven scale ranges; for example, the 0.3 v to 300 v range has the following full-scale ranges: 0.3 v, 1 v, 3 v; 10 v, 30 v, 100 v, 300 v.

A direct-reading decibel scale is also provided.

Voltage Accuracy: Within $\pm 5\%$ on all ranges. Spurious voltages from higher order modulation products introduced by the detector are suppressed by at least 70 db. Hum is suppressed by at least 75 db.

Input Impedance: One megohm when used for direct voltage measurements. When used with the input potentiometer it is approximately 100,000 ohms.

Accuracy of Frequency Calibration: $\pm$(2% + 1 cycle).

Tube Complement:

6—6J7	1—6C5
2—6K6-G	1—6X5-G
1—6B8	1—6F5-G
	3—NE-48 neon lamps

Power Supply: 105 to 125 volts (or 210 to 250), 40 to 60 cycles. A voltage stabilizing circuit is included. Power input is about 65 watts. Power input receptacle will accept either 2-wire (Type CAP-35) or 3-wire (Type CAP-15) power cord. Two-wire cord is supplied.

Accessories Supplied: Spare neon lamps, spare fuses, one Type 274-NL Shielded Connector, and a Type CAP-35 Power Cord.

Mounting: Shielded oak cabinet..

Dimensions: (Width) 19½ × (height) 25⅛ × (depth) 10⅞ inches, over-all.

Net Weight: 86¼ pounds.

This apparatus uses inventions of United States Patents licensed by Radio Corporation of America. Patent numbers supplied upon request. Licensed only for use in measuring or testing electronic devices, electron tube circuits, parts of such devices and circuits, and elements for use in such devices and circuits.

OPERATING INSTRUCTIONS

FOR

TYPE 736-A

WAVE ANALYZER

CAUTION

IT IS VERY IMPORTANT THAT NONE OF THE INTERNAL ADJUSTMENTS BE DISTURBED WITHOUT A CAREFUL READING OF THESE NOTES, PART VI IN PARTICULAR.

PART I

This wave analyzer is intended for the measurement of individual periodic components of a complex voltage wave, such components having amplitudes between 30 microvolts and 300 volts and having frequencies between 20 cycles and 16,500 cycles. It is, essentially, a sensitive vacuum-tube voltmeter with a 4-cycle band width.

PART II

2.1 The Type 736-A Wave Analyzer is of the heterodyne type. The incoming signal is mixed in a balanced detector with a carrier signal whose frequency is controlled by the large dial on the front panel. When the carrier is so adjusted that the sum of its frequency and that of one of the components of the signal equals 50,000 cycles the resultant signal is passed through a highly selective three-section quartz-crystal filter and its amplitude measured on a meter.

2.2 In order to obtain the balanced input voltage from the unbalanced input terminals a degenerative phase-inverter stage is provided.

2.3 The detector is so designed that the effective mutual conductance of the tube varies linearly with the grid voltage. It will be noticed from Figure 2 that the carrier signal is applied simultaneously to the two grids in the same phase. This means that (except for lack of balance between the tubes and between wiring capacities, both of which may be corrected for by the C and R balance adjustments) the carrier signal is completely balanced out of the amplifier. If a fixed d-c voltage is applied between the two grids this balance is destroyed and the carrier reappears.

If an alternating voltage is applied from grid to grid, a half-wave pulse of high frequency appears, from plate to plate of the detector, for every half cycle of the signal, resulting in a modulated wave having a scallop-shaped envelope.

2.4 As indicated in Figure 2, this is equivalent to saying that the output of the detector consists of upper and lower sidebands, the carrier being removed. Let P be the carrier oscillator frequency. This is set Q cycles lower than the 50,000-cycle crystal filter frequency, Q being the frequency of the audio-frequency component considered. The upper and lower sidebands will have frequencies of P + Q and P - Q, respectively. The frequency P + Q will be equal to 50,000 cycles so that this will be passed through the filter and amplifier, all others will be rejected. The net result is that the voltage output of the amplifier is proportional to the amplitude of Q. The frequency control of the carrier oscillator is graduated in values of Q so that the amplifier output is proportional to the amplitude of

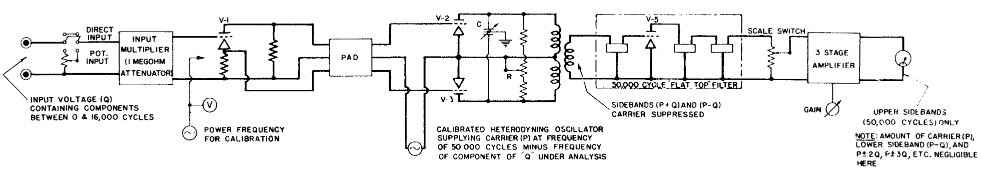


FIGURE 2. Functional schematic diagram of the Wave Analyzer showing the principles of operation

the frequency to which the main dial is set.

2.5 The instrument is calibrated by tuning to an internally provided power-frequency signal of known amplitude and adjusting the gain of the amplifier until a standard output is produced. Once this has been done the instrument is direct reading in voltage over its entire range.

PART III
DESCRIPTION OF PARTS
(For the location of the various parts, see Figure 3.)

INPUT CIRCUIT, PHASE INVERTER, DETECTOR, CALIBRATOR

3.1 The input circuit consists of a 100,000-ohm potentiometer, which can be switched in or out of the circuit at will, and a 1-megohm L-type pad for changing the voltage range of the instrument. The frequency characteristic of the 1-megohm multiplier is compensated by the condensers C_{64} and C_{65}. The potentiometer resistance is so chosen that the net input resistance is 100,000 ohms ± 10%, regardless of the setting. This potentiometer is provided to facilitate comparative measurements as outlined in Section 4.63.

3.2 The phase inverter tube, the detector tube and the oscillator tubes are lighted on d-c obtained from a rectifier and filter; a feature which makes the low hum level possible. It will be noticed that the coupling circuit between the phase inverter and detector includes a balancing potentiometer, R_{17}. This should not be disturbed except as mentioned in paragraph 6.13.

3.3 The detector circuit output is carefully tuned by the condenser C_{17}. It is particularly important that this setting should not be disturbed.

3.4 The calibrator consists of the meter M-1 which should be set at 4 volts, and a laboratory-set voltage divider R_{35}, R_{36}, R_{37}. There should never be any reason for changing the setting of R_{36}. It is entirely independent of tube characteristics.

CARRIER OSCILLATOR

3.5 The carrier oscillator coil is inside the aluminum shield on the oscillator shelf. It is wound on a slotted isolantite form and is adjusted for inductance by means of iron discs or brass discs, if necessary. The tuning condenser is made up of four units: the main frequency control, the FINE TUNING control, the FREQ. dial for adjusting the zero, and an air condenser mounted on the oscillator shelf. If in time the frequency zero setting drifts out of the FREQ. dial range, the condenser on the oscillator shelf may be readjusted as indicated in paragraph 6.6.

AMPLIFIER SHELF

3.611 The crystal filter consists of three crystals. Measurements have shown that a single crystal is approximately equivalent to the electrical circuit shown in Figure 5. The coupled pair of crystals, Q_2, Q_3 has a doubly peaked resonance curve. The heights of the two peaks are adjusted by the damping resistors R_{44}, R_{45}, R_{47}, R_{48} and R_{49}, in such a manner as to cause a dip of about 6% between the peaks.

3.612 The crystal Q_1 is adjusted in frequency to have its peak midway between the maxima of the other two. The inductance L_3 resonates the right-hand shunt condenser essentially eliminating it and placing the condenser C_{34} effectively in series with the equivalent resonant circuit shown in Figure 5. This makes it possible to shift the frequency of Q_1 without changing its damping. The combination R_{42}, C_{35} provides proper damping and a slight impedance transfer action. Actually, the crystal is ground 5 cycles below the frequency of the other two crystals to provide proper range for adjustment. The frequencies of the three as ground are nominally 50045, 50050 and 50050 cycles. The detector impedance at C_{17} has an appreciable influence on the damping of Q_1 which accounts for the note in paragraph 3.3.

3.62 The crystal adjustments C_{34}, R_{45} and R_{48} are purposely made inaccessible. The interaction between these controls is very considerable, and the greatest of care and considerable experience are required to adjust them for a proper resonance curve. Should an attempt be made to improve the resonance curve by readjusting these three, it may become necessary to send the instrument back to the factory.

3.63 The amplifier has four stages of gain. The first stage serves to separate the crystals and to provide a certain amount of gain before the loss of the

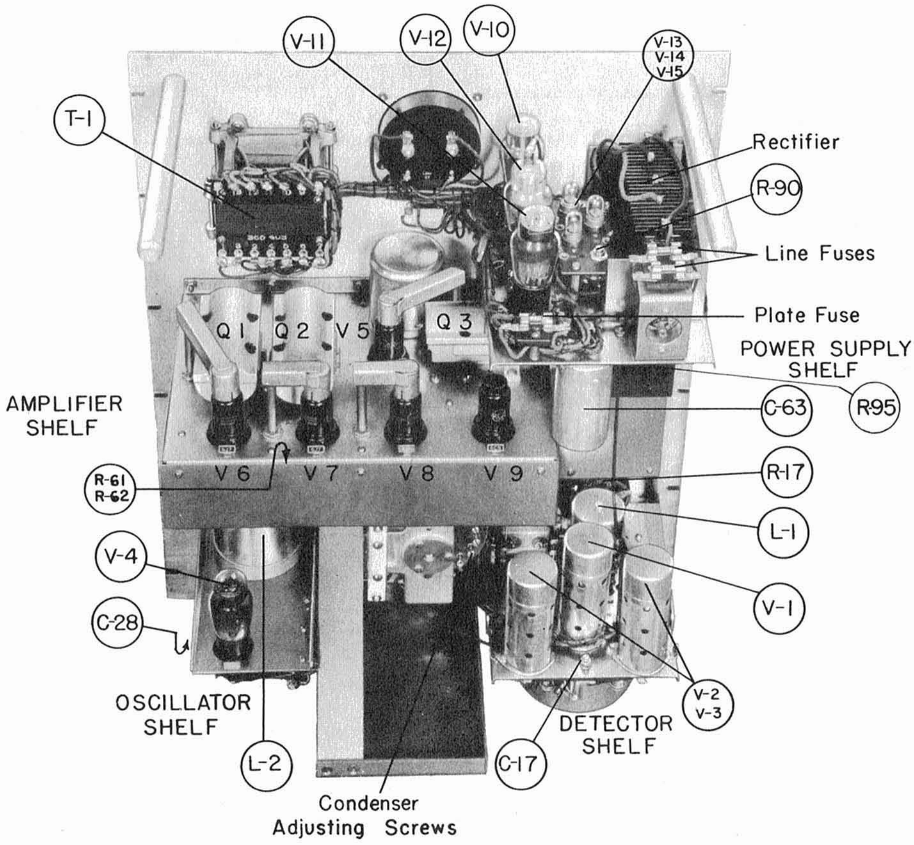


FIGURE 3. Inside rear view of the Wave Analyzer identifying the major parts

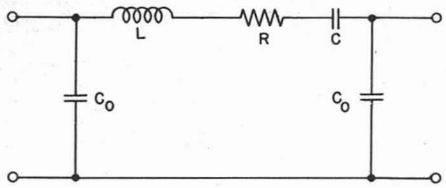


FIGURE 5. Equivalent circuit diagram of a three-electrode quartz crystal as used in the filter in Type 736-A Wave Analyzer

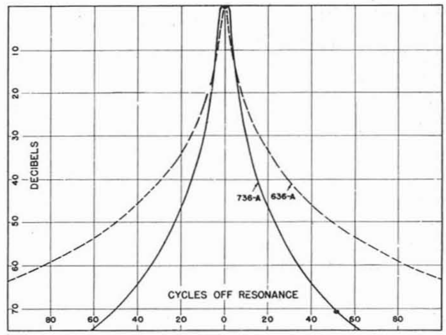
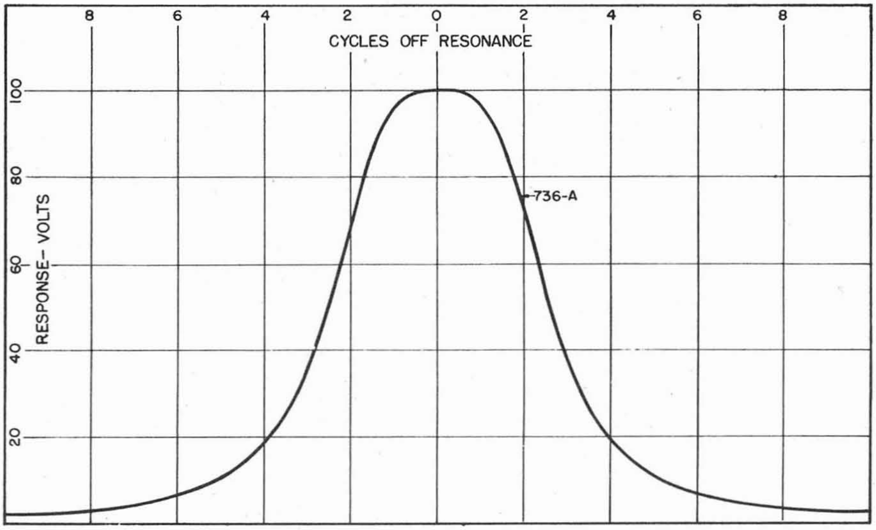


FIGURE 7. Filter characteristic showing the attenuation to unwarranted frequencies outside the pass band. The curve for Type 636-A is also shown.

FIGURE 6. (Below) Band pass characteristic of the quartz crystal filter used in Type 736-A Wave Analyzer.



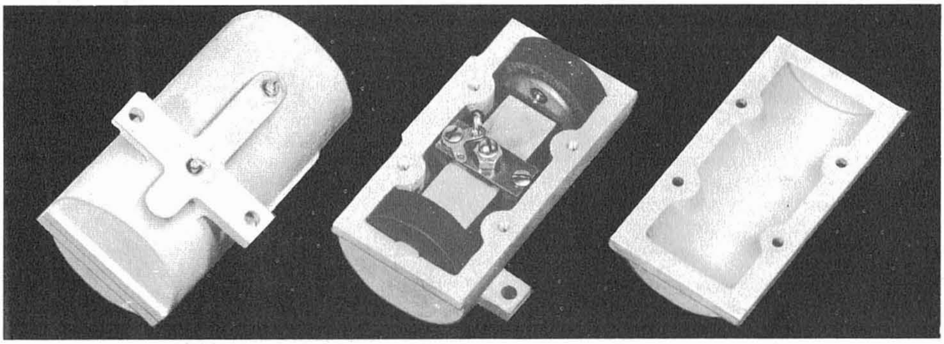


FIGURE 8. Photograph of quartz crystals used in the filter

coupled pair of crystals is encountered. The first and second stages are separated by the SCALE SWITCH which selects the required gain for the given input signal. R_{61} and R_{62} in the grid circuit of V-7 are provided for readjusting the sensitivity of the whole instrument should the GAIN control ever become insufficient. The tube used for the fourth stage of amplification is also used as a diode rectifier voltmeter tube which operates the degenerative d-c amplifier V-9.

3.64 A meter zero adjustment is provided by the mechanical setscrew on the meter. A rheostat, R_{81}, is provided to extend the range of this adjustment, if necessary. Its shaft is available by removing the flat metal cap above the left-hand side of the main frequency dial.

POWER SUPPLY 3.7 The power supply consists of a regulated high-voltage rectifier for plate supply and a low-voltage unit for supplying the heaters of V-1, V-2, V-3 and V-4. The filter coils of these are enclosed in a high permeability metal can (painted blue), which acts as a shield and prevents magnetic pickup in the INPUT POTENTIOMETER and the wire wound resistors of the INPUT MULTIPLIER. The plate voltage supply is controlled by the potentiometer R_{90}, which is available for screw-driver adjustment on the bakelite shelf with the neon tubes.

PART IV
OPERATION

TO PLACE IN OPERATION 4.1 Remove the metal screen on the back of the instrument and place the tubes in their sockets as indicated in Figure 9. It is particularly important that tubes V-2 and V-3 should be placed in their proper sockets and should not be interchanged. See 6.13 for replacement note. Each tube (or its carton) is marked. Four metal clamp caps are provided for the amplifier tube grid leads, and these should be firmly clamped in place over the metal shields of tubes V-5, V-6, V-7 and V-8. Place the ordinary shield cans over the tubes of the detector shelf V-1, V-2 and V-3.

4.2 Nominal line voltages of 115 volts can be used. As the instruments are shipped from the factory the power transformers are arranged for either 115-volt or 230-volt operation as ordered. The line voltage should be between 105 volts and 125 volts (or 210 volts and 250 volts) and the frequency must be between 42 cycles and 60 cycles.

4.3 After the back has been replaced the instrument should be turned on and should preferably be permitted to warm up for a few minutes.

CALIBRATION METHOD 4.41 Set the meter zero with the power on but with the main frequency dial turned away from any signal which may be present. See also paragraph 3.64. It is a good plan to set R_{81} so that the mechanical meter adjustment is in the neutral position. This is done at the factory. It is not essential, but is a convenience.

4.42 To set the frequency dials to read correctly, adjustments will be necessary. To do this, set the FINE TUNING dial at the line, the main frequency scale at 0 and the USE-CAL switch at USE. Set the SCALE SWITCH to give a readable deflection. Tune the FREQ. adjustment knob which is under the cover at the bottom of the instrument for a maximum deflection, readjusting the SCALE SWITCH and perhaps the DET. ADJUST knobs to keep the meter on scale. (The voltmeter circuit is so arranged that the meter cannot be overloaded by any signal).

4.43 Adjust the DET. ADJUST knobs so that the meter does not give an indication

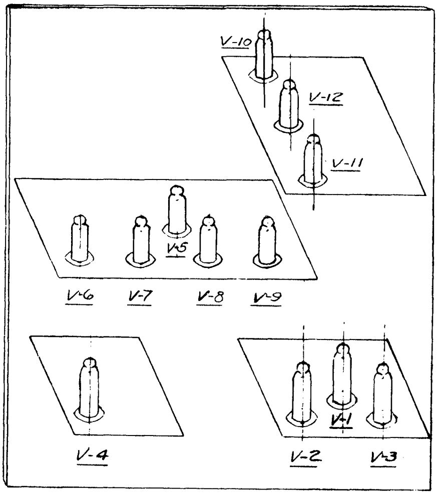


FIGURE 9. Location of tubes

of more than full scale with the SCALE SWITCH on 100. In case low-frequency signals of low amplitude are to be measured, this should be done more accurately as experience shows it to be necessary. When measuring harmonics of a low-frequency signal, interference from the fundamental will usually be more serious than that from the carrier, so that this is a special case.

4.44 Set the SCALE SWITCH to 300, the USE-CAL switch to CALIBRATE and tune to the power frequency with the main dial. With the USE-CAL switch on USE, adjust the meter to zero deflection by the mechanical adjustment. Set the small meter to 4 volts thus standardizing the calibrating voltage. With USE-CAL switch at CAL and SCALE SWITCH at 300, adjust the GAIN control until the meter gives a deflection of 300. (See paragraph 6.3 for extending the range of this control, if necessary.) Throw the USE-CAL switch to USE and the instrument is ready for making measurements.

4.45 This procedure must be repeated periodically during the measurements because the zero frequency adjustment and sensitivity will both drift somewhat as the instrument heats up. Some short cuts will be found possible with experience but all steps are included here even though it takes longer to describe the operation than to perform it.

4.46 A voltage-stabilized plate supply is used, but no voltage regulation is provided for the cathode heaters of the vacuum tubes. The resulting variation in gain with line voltage is seldom serious, and is compensated in part by other circuit characteristics. When the line voltage fluctuates widely, it may be necessary to check the gain frequently.

CHOICE OF RANGE

4.51 The input circuits should be so chosen that no component of the input signal gives more than a full-scale deflection when the SCALE SWITCH is set at 300. More precisely, the peak voltage should not exceed 1.41 x the value given on the INPUT MULTIPLIER. (If the INPUT POTENTIOMETER is used, the output of the potentiometer should not exceed this value.)

4.52 No damage will be done to the instrument by failure to follow these rules, but the results may be in error. This is because the phase inverter tube or the detector tubes may be overloaded, giving rise to products of the form P + 2Q or P + 3Q where P is the carrier oscillator frequency and Q is the signal frequency. Such products would give rise to second and third harmonic readings with a pure sinusoidal signal applied.

4.53 Products of this type are suppressed by at least 75 db with respect to the fundamental (0.02%). (See paragraph 6.13.)

4.54 The INPUT MULTIPLIER setting and the setting of the INPUT POTENTIOMETER should be left unchanged when measuring the various components of the input signal. The SCALE SWITCH, however, may be changed at will.

INTERPRETATION OF METER SCALE

4.61 With DIRECT INPUT and with the INPUT MULTIPLIER set at 1, the SCALE SWITCH gives the full-scale reading of the meter. For other values of the INPUT MULTIPLIER the values should be multiplied by the appropriate factor. When using the DIRECT INPUT, the nominal input impedance is 1 megohm, and all scales are direct reading in voltage.

4.62 The DECIBEL figure gives the voltage in decibels with respect to one microvolt. The three decibel readings (of the INPUT MULTIPLIER, of the SCALE SWITCH and of the meter) should be added.

4.63 The INPUT POTENTIOMETER is provided so that percentage measurements may be made with direct reading scales. To do this, set the SCALE SWITCH at 100 and tune in the fundamental (or other reference signal). Adjust the INPUT MULTIPLIER and INPUT POTENTIOMETER to give a full-scale meter reading. The multiplier should be left at the highest possible setting. The meter and SCALE SWITCH combination are now direct reading in percentage.

FREQUENCY CHARACTERISTICS

4.7 Figure 10 shows the frequency characteristic of the analyzer. When desired, correction may be made on the data by applying the factor indicated on the curve for the frequency considered.

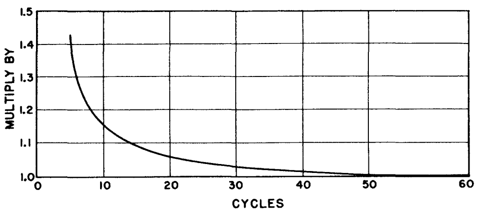


FIGURE 10. Frequency characteristic of the Wave Analyzer

SPURIOUS RESPONSES It is possible that a spurious response be obtained as a result of a signal with frequency components above 16.5 kc. For example, if a 20-kc component is present, a response may be found at the dial point corresponding to about 15 kc. Furthermore, a response that is independent of tuning will be found if a signal with a 50-kc component (corresponding to filter frequency) is applied.

If a noise signal having energy in a broad band above 16.5 kc is applied to the input, the analysis of the energies in the region below 16.5 kc may be seriously in error because of these spurious effects.

When the possibility of errors from such spurious responses exists, it is best to limit the band to the audio range by means of filters before the signal is applied to the analyzer.

PART V
SUGGESTIONS AS TO USE

MEASUREMENT OF DISTORTION 5.1 As indicated in paragraph 4.63, distortion percentages may be read directly if the INPUT POTENTIOMETER is used.

USE AS VOLTMETER 5.21 Perhaps it is desirable to call attention to the fact that the analyzer can be used to measure the magnitude of voltages as well as their relative values. This may prove convenient in some cases. The full-scale range is 300 microvolts to 300 volts, and the impedance is one megohm (in shunt with the binding post capacity).

5.22 Direct current which may be present along with the signal has no influence on the analyzer so that no precautions need be taken and the analyzer may be connected from grid or plate to ground in an amplifier circuit without causing error except insofar as a one-megohm resistor may upset the circuit to be measured.

CARRIER ENVELOPE ANALYSIS 5.3 The wave analyzer, in conjunction with a linear rectifier, can be used to measure the distortion in the envelope of a modulated radio-frequency wave. Those interested are referred to the General Radio Experimenter for February, 1936, Volume X, No. 9, which describes this type of measurement with a Type 636-A Wave Analyzer (now obsolete). Type 736-A is used in the same way.

FILTER MEASUREMENTS 5.4 On many types of electric-wave filters, accurate measurements are impossible unless a sharply-tuned voltmeter is used. This subject is discussed in the General Radio Experimenter for March, 1935, Volume IX, No. 10.

BRIDGE DETECTOR 5.5 Although rather elaborate for the purpose, an analyzer, if available, serves as an ideal bridge detector since it is uninfluenced by harmonics.

NOISE MEASUREMENTS 5.61 Used in conjunction with a microphone or vibration pickup, or, still better, with General Radio Noise Meter* the analyzer can be used to analyze noise. In this case it must be realized that the band width is 4 cycles wide so that fluctuation in vibration frequency covering a spread of more than this will make accurate readings difficult or impossible to obtain. In practice, gasoline engines under laboratory conditions can be made to hold constant within a spread of 1% (or ± 0.5%) which means that measurement of components up to about 400 cycles is possible.

5.62 The analyzer draws about 65 watts from the power line. Satisfactory operation in an airplane or in other field conditions can be obtained by the use of a motor generator.

5.63 If a phonograph record of the noise is available this serves as a very good method of measurement since it makes accurate reproduction and repeated study possible under laboratory conditions.

5.64 Tubes V-1, V-2 and V-3 at some time may be subject to microphonics under extreme field conditions of noise measurement. In such cases, Type 1603 Tubes may be substituted for the 6C6 tubes which are electrically identical to them. This should normally require readjustment of potentiometer R_{17}, as indicated in paragraph 6.13, but for noise applications this is not ordinarily necessary.

*Type 1551-A Sound-Level Meter

PART VI
SERVICING

TUBES 6.11 Tubes V-5, V-6, V-7, V-10 and V-11 may be replaced at will, providing they meet routine inspection requirements.

6.12 Tube V-1 which is Type 6J7 used as a phase inverter may influence the setting of R17 to a minor extent. (See paragraph 6.13.)

6.13 If the detector adjustments cannot be made to balance out the carrier meeting the conditions in paragraph 4.43, tubes V-2 and V-3 (6J7's) may have to be replaced. Then the procedure of paragraph 6.132 must be followed. Also check that the resistance of L-1 between terminals 5 and 6. The detector coil should be tested for open circuit or shorted turns, and checks made that there are no shorted capacitors or loose connections in the detector circuit.

6.131 The balance point can be shifted by installing a 20-kilohm 1/2-watt resistor in place of R-23 or R-25, whichever is necessary.

6.132 If tubes V-2 and V-3 (Type 6J7) are replaced, the new ones must be balanced with reference to third order coefficients. To do this, apply to the analyzer input a low-distortion 1-kc signal from a balanced source such as the Type 1304 Beat-Frequency Oscillator. Set the GAIN control at minimum. Adjust the 1-kc input signal level with the analyzer turned to 1-kc to give full scale reading with the SCALE SWITCH at 300.

2. Reverse the leads from the oscillator and note the new reading. Adjust R-17 (under the small metal cap below the INPUT POTENTIOMETER on panel) to give a reading halfway between the two previous readings.

3. Repeat the reversing and adjusting until no change in reading occurs when the input polarity is reversed.

6.133 In an emergency, if a sinewave is not available, the power-line frequency may be used in some cases for matching the 6J7 tubes (V-2 and V-3) to the third order coefficient. This is a rather dangerous procedure because if a load on the power line happens to be a high-power rectifier, it will usually introduce an appreciable amount of second harmonic.

6.14 Some difficulty has been experienced with 6K6-G tubes (V-4) used as oscillators. At times sudden jumps in frequency are observable, causing an erratic deflection of the meter even though the applied signal is constant in amplitude and frequency. Occasionally a tube must be replaced for this reason. V-4 is otherwise interchangeable with V-11 so that V-11 may be used if V-4 becomes troublesome. See also paragraphs 6.15 and 6.16.

6.15 Occasionally trouble develops in the rectifier portion of V-8 (a 6B8). This is probably due to leakage paths within the tube. A satisfactory tube will fit the meter scale calibration as drawn, a defective one may not. If a signal causing more than full-scale deflection of the meter is removed, the pointer should return quite rapidly to zero. In the case of a seriously defective tube 5 to 10 seconds may be required for the pointer to return sensibly to zero.

6.151 A defective V-8 may be indicated by the meter reading up-scale or erratic one-third-scale deflection after a short period of operation. It may also be impossible to reset the electrical zero.

6.152 An unstable meter reading is sometimes caused by dirty or open FINE or COARSE potentiometers.

6.16 If V-9 must be replaced for any reason, the meter scale linearity should be checked, but non-linearity of the scale with applied voltage can usually be traced to the 6B8 tube, V-8.

6.17 Replacement of V-12 may require a readjustment of R_{90}, the potentiometer on the phenolic panel with the neon lamps, to give a voltage of 170 v as measured from terminal No. 1 of this block to ground with a high resistance voltmeter. It may also be necessary to change the neon tubes, see paragraph 6.18.

6.18 The neon tubes V-13, V-14 and V-15 should be of a type intended for voltage regulation, since the gas pressure is rather critical. Type NE-48 neon tubes are recommended. If two or more of the neon tubes do not light, also test for an open resistor R-86 or a burned out plate fuse F-3. If the plate voltage is not the proper value check the tubes and pins of sockets of neon tubes for good contact.

HEATER RECTIFIER 6.2 The heater rectifier is of a copper-sulphide-magnesium type. If left idle for an extended period (several months) it may become inoperative and cause a line fuse to burn out when the power is first turned on. In this case the fuses should be short-circuited for a second or so and the rectifier will re-establish an active rectifying film. The fuses may be safely replaced when this has been healed.

If the heater voltage deviates materially from 6.3 volts, with 115-volt line, rheostat R-95 should be adjusted to bring voltage to 6.3 volts.

SENSITIVITY 6.3 If it becomes impossible to adjust the sensitivity as outlined in paragraph 4.44, resistors R_{61} and R_{62} may be changed in value or one of them removed. These will be found on the socket of V-7 inside the shield of the amplifier shelf. Low sensitivity may be caused by poor contact of V-8 in its socket or to a defective tube. Reinsert tube and if condition still persists try a new tube. See also Section 6.8.

VOLTMETER ZERO ADJUSTMENT 6.4 In case it becomes impossible to bring the meter to zero by the mechanical knob on the meter, R_{81} may be readjusted. (This will be found under the small metal cap at the right of the INPUT MULTIPLIER switch.)

SELECTIVITY CURVE 6.5 If the crystal response curve departs by an objectionable amount from the data given in Figure 7, See Section 6.9 As indicated in paragraph 3.62, serious trouble may result from attempts to modify the curve. Difference in peaks when approaching resonance may be corrected by adjusting C-34.

FREQUENCY ADJUSTMENT 6.6 If the zero frequency adjustment drifts beyond the range of the FREQ. knob, this may be brought back by adjusting C-28 which will be found on the oscillator shelf.

HUM 6.7 Be sure USE-CAL switch points make good contact. If they do not, power frequency hum may be introduced in the input of the instrument. This may be checked by tuning to the power frequency and turning SET to 4 VOLT knob and noticing meter change. Also check that C-63 is properly grounded.

SIGNAL TRACING 6.8 If the instrument has low sensitivity or no output, or if there is no meter deflection when the main dial is set to zero and C-28 is tuned it may be desirable to check the gain in the different sections of the instrument by signal tracing. The procedure is given below.

6.81 Vacuum-Tube Voltmeter Circuit: Remove grid caps from tubes V-5, V-6 and V-7. Connect the output from a General Radio Type 1001-A or 805-C Standard-Signal Generator or its equivalent to the grid of V-8, through a 0.1 µf blocking capacitor, and the ground of the 736-A. Tune the generator to 50 kc and set the output attenuator to 130 millivolts. This should give approximately full-scale reading of the 736-A meter if the V-8 amplifier circuit and the V-9 voltmeter tube circuits are normal.

6.82 Amplifier Stages: Remove signal-generator connection from grid of V-8 and connect it to grid of V-7, restoring the normal grid connection to V-8. Reduce the attenuator on the generator to 2.25 millivolts; the 736-A meter should read about full scale. Similarly, a full-scale meter reading should result from the application of 570 microvolts to grid of V-6 or 205 microvolts to the grid of V-5. Note that the signal on V-5 passes through one stage of the crystal filter, and that the frequency of the signal generator will have to be varied slightly until a maximum reading of the 736-A meter indicates that the signal is at the filter frequency. The meter scale switch should be set at 0.3 for this last check. In case of trouble, a new tube should first be tried, and then the circuit should be checked.

6.83 Oscillator Circuit: The normal output of the oscillator is about one-half volt. This can be checked with a General Radio Type 1800 Vacuum-Tube Voltmeter or its equivalent from the cathode of either detector tube (V-2 or V-3) to ground. V-4 or L-2 may need replacement if output is not correct.

6.84 Input Circuit: Balance the detectors in the usual manner. Set the switch to DIRECT INPUT and the input multiplier to X 10. A signal of 3 volts at about 1000 cycles applied to the input terminals should result in a voltage of 0.25 volt across the output of coil L-1. This should be measured with a Type 1800-A Voltmeter between coil terminal 3 and ground. If the voltage is too low, the shield caps on V-2 and V-3 detector tubes should be checked to make sure that they are not touching and grounding the grid connections.

CRYSTAL ADJUSTMENT 6.9 The crystal adjustments are set at the factory and should not normally require further alteration. However, in the event that the initial adjustment has obviously been upset, a skilled technician can restore calibration by the following procedure.

a. Set potentiometer R45 fully clockwise, R48 at center, and C34 at center (slot vertical).

b. Connect a source of about 100 cycles to the analyzer INPUT terminals. (General Radio Types 1302-A and 1304-B Oscillators are satisfactory.) Set the oscillator frequency to a point near 100 cycles that will permit adjustment over several cycles above and below.

c. Slowly approach resonance at a constant rate from one and then the other direction by means of the FINE control. Note the peaks (meter readings) obtained.

d. Adjust C34 so that these peaks are of equal magnitude. Lock C34 in this position.

e. Adjust the input voltage for a convenient DB rating of the analyzer (about ¾ scale).

f. Adjust R45 and R48 equal amounts as necessary to obtain a 3.2-cps bandwidth at the -1 db points with symmetrical skirts. The final cycles-off-resonance curve for the crystal amplifier must be 1.5 cycles wide across the flat top, 3.2 cycles wide 1 db down, and less than 6 cycles wide 8 db down.

PART VII
ROUTINE MAINTENANCE

7.1 The fine degree of accuracy and long life of this instrument is dependent in part upon the smooth operation of controls, clean contacts, and the exclusion of dust and foreign matter.

7.2 The air capacitors in this instrument require occasional attention and the dust and lint between the plates should be removed with pipe cleaners. With the calibrated capacitors, care must be taken not to bend the plates. Foreign matter between terminals on a fixed capacitor should be periodically removed. Otherwise the combination of dirt and moisture will produce a low value of leakage resistance.

7.3 A very fine grade of sandpaper is recommended for cleaning the contacts although the residue must be removed with a fine brush. Fine sandpaper may also be used on the wire-wound controls as it is important that these be kept clean.

7.4 The slip ring on the main capacitor should be kept clean and a thin coating of a fine grade of lubricant such as Lubriko may be used.

7.5 The table below lists tube socket voltages measured between socket terminals indicated, using a 20,000-ohms-per-volt d-c meter and a 1000-ohms-per-volt a-c meter.

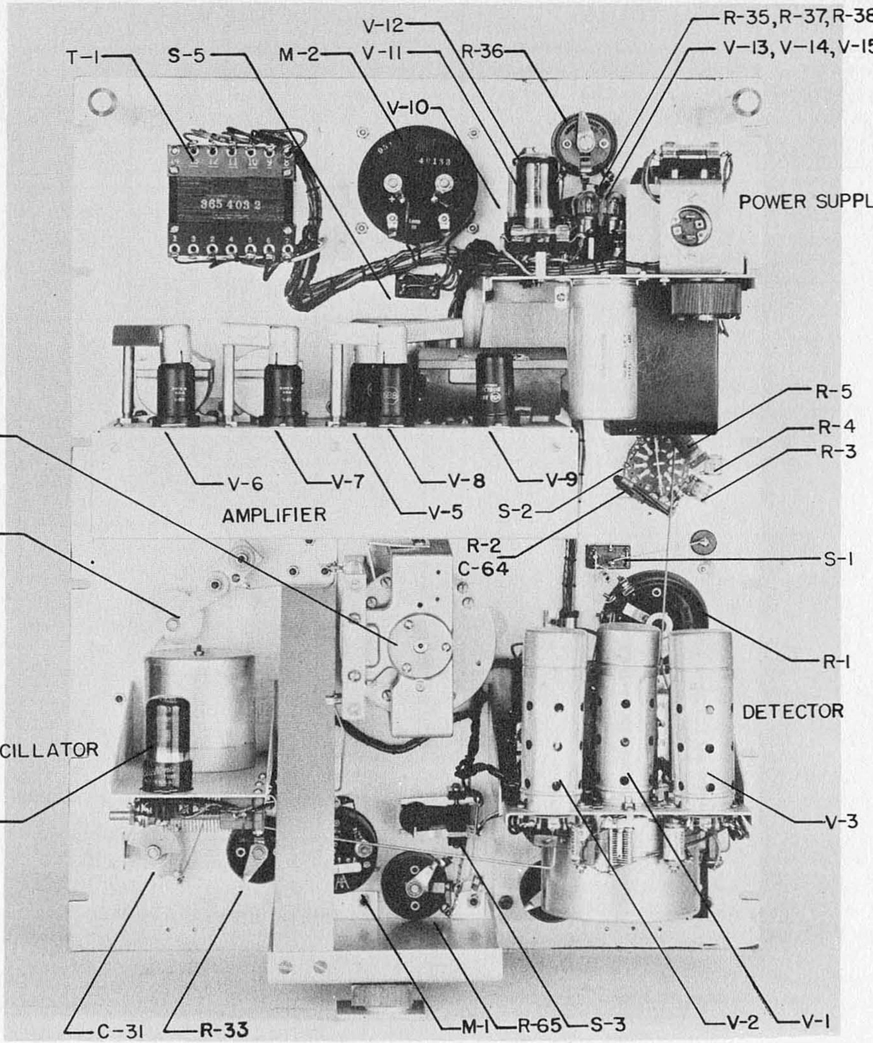
TEST VOLTAGES

TUBE (TYPE)	PIN	VOLTS	RES TO GND
V1 (6J7)	3, 4	76	155 k
	5, 8	25	30 k
	cap	22.5	2.6 M
V2 (6J7)	3	113	150 k
	4	80	660 k
	5, 8	0	0.5
	cap	-4.15	9 M
V3 (6J7)	3	113	150 k
	4	80	660 k
	5, 8	0	0.5
	cap	-4.15	9 M
V4 (6K6G)	3	80	124 k
	4	80	124 k
	5	0	15
	8	19	18 k
V5 (6J7)	3	85	33 k
	4	148	13.5 k
	5, 8	3.8	1 k
	cap	0	240 k
V6 (6J7)	3	12	220 k
	4	150	11 k
	5, 8	6	5 k
	cap	0	64

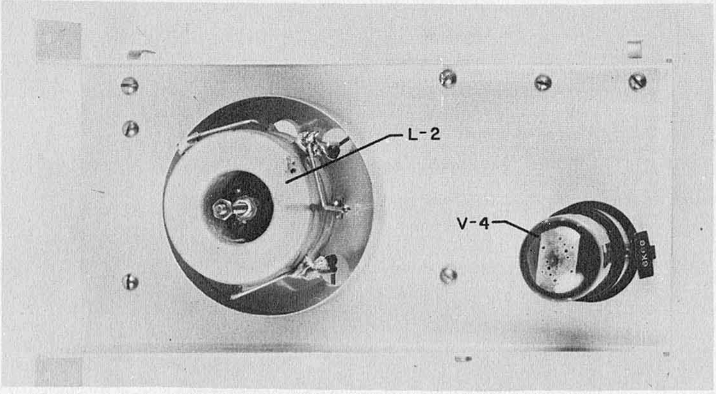
TUBE (TYPE)	PIN	VOLTS	RES TO GND
V7 (6J7)	3	87	220 k
	4	34	1.2 M
	5, 8	0.85	1.1 k
	cap	0	5 k
V8 (6B8)	3	58	220 k
	4, 5	22	18 M
	6	45	1 M
	8	24	20 k
V9 (6C5)	3	82	23 k
	5	220	18 M
	8	25	9.5 k
V10 (6X5G)	3-5	585 ac	950
	8	355	∞
V11 (6K6G)	3, 4	350	∞
	5	200	∞
	7, 8	210	0
V12 (6F5G)	4	200	∞
	8	82	470 k
	cap	80	5 M
XFMR T1	5-6	18 ac	
	11-13	585 ac	

NOTES:

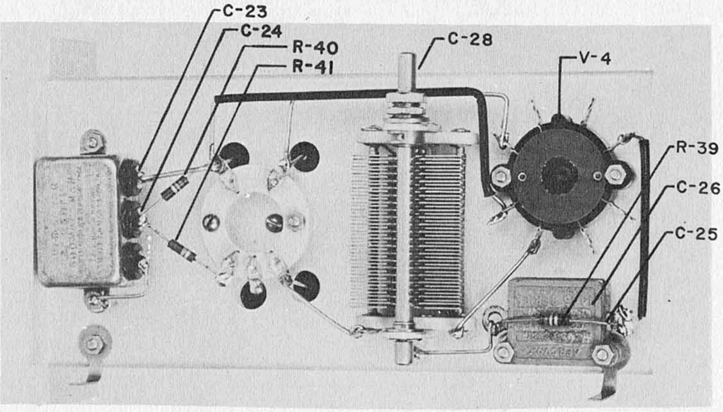
All voltages dc, from pin to ground, unless otherwise noted.
Input 115 v, 60 cps
INPUT MULTIPLIER at 1000
SCALE SWITCH at 300
Main dial at 1000 cps
DIRECT input
USE-CAL switch at USE
Set to 4 v ac
Gain on full



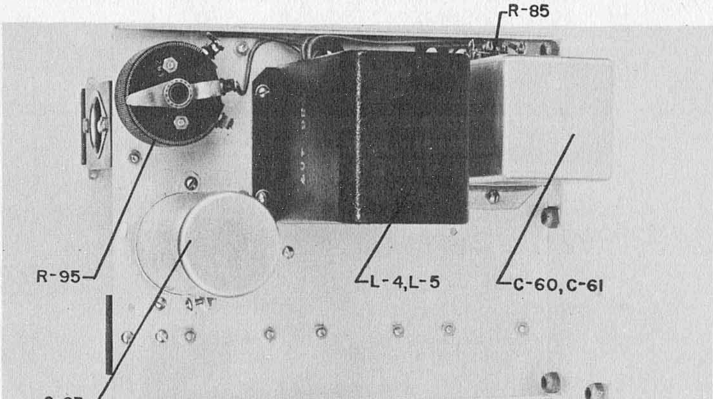
Rear View of Type 736-A Wave Analyzer



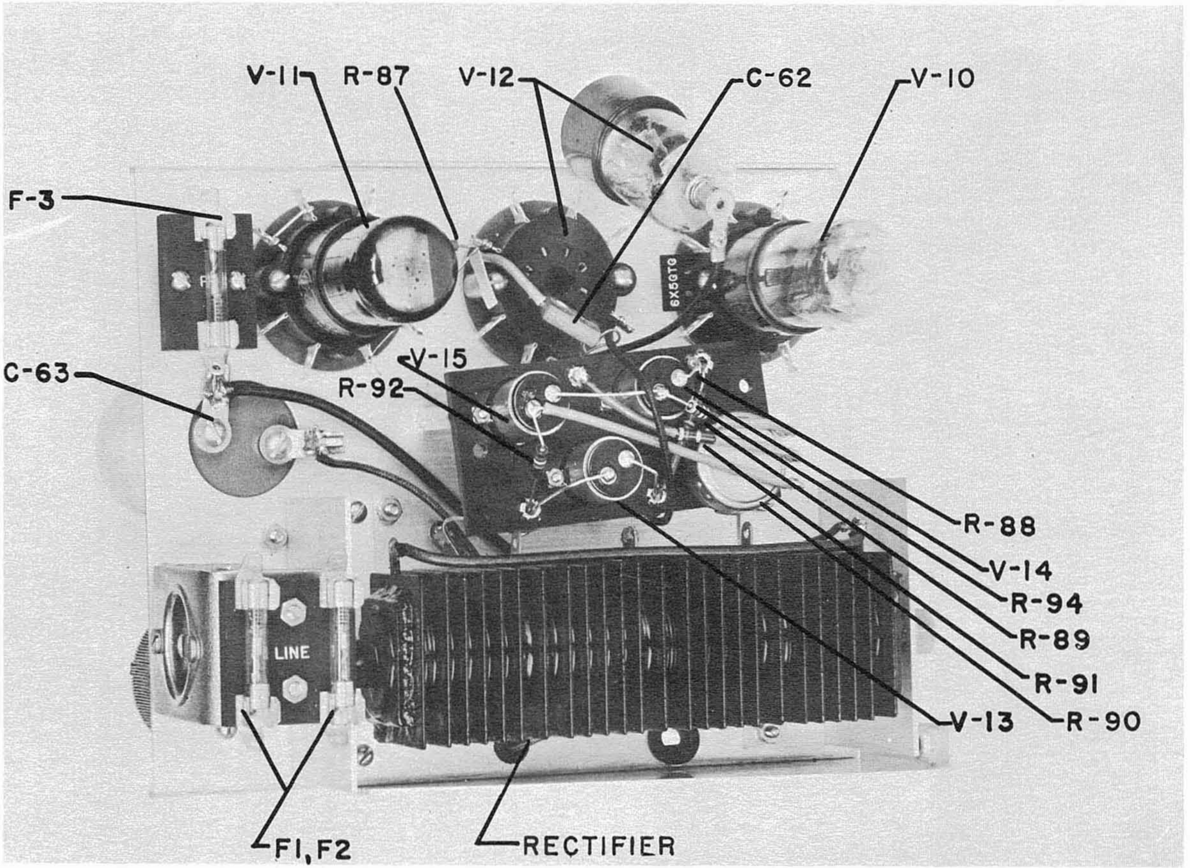
Type 736-A Oscillator Shelf (Top)



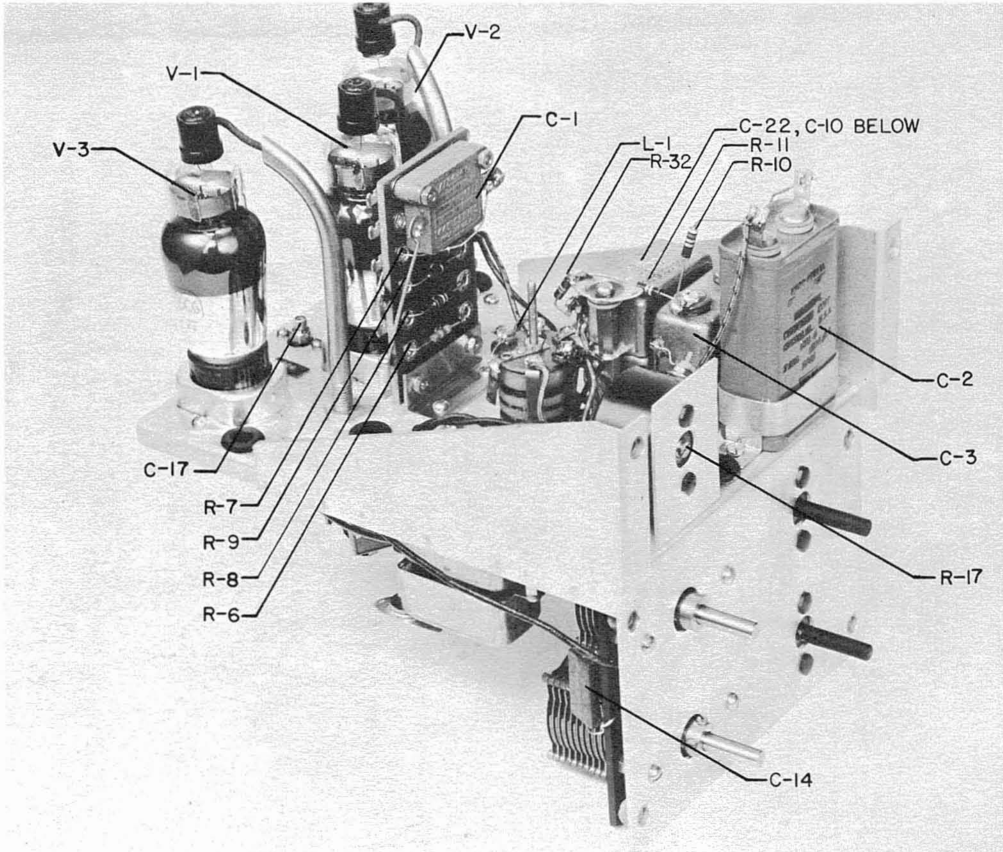
Type 736-A Oscillator Shelf (Bottom)



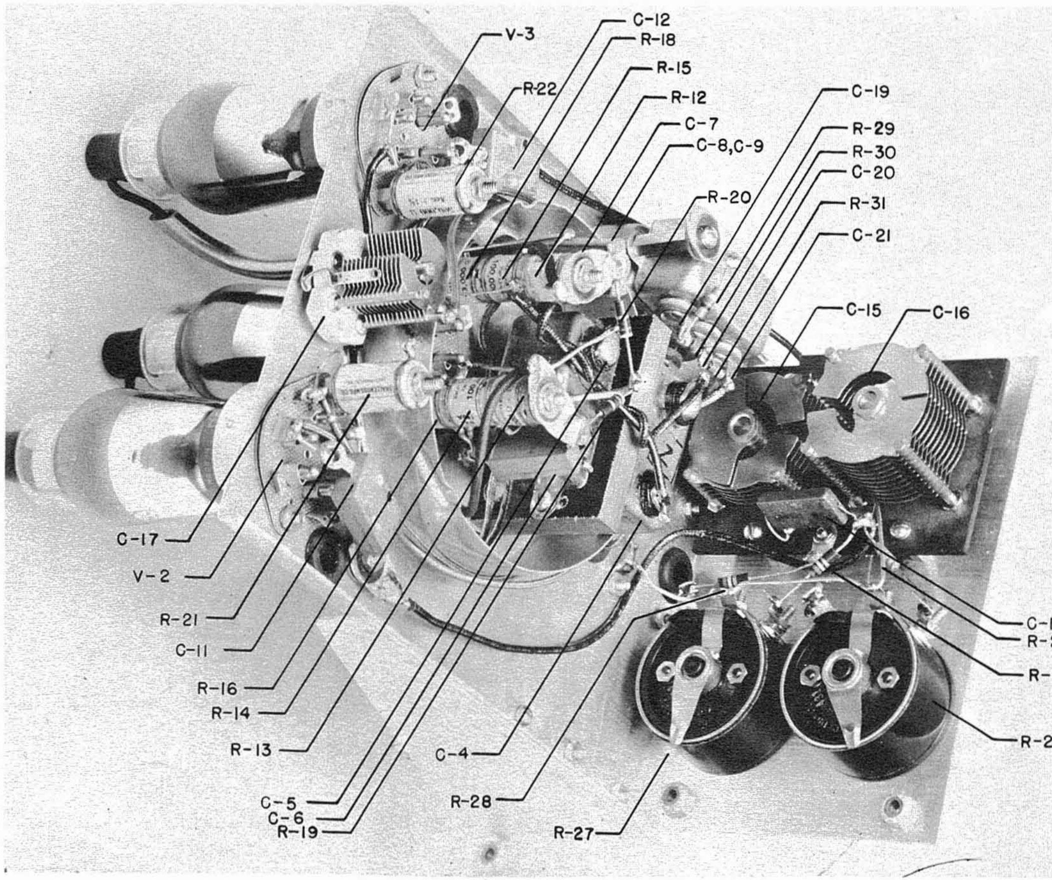
Type 736-A Power Supply Shelf (Bottom)



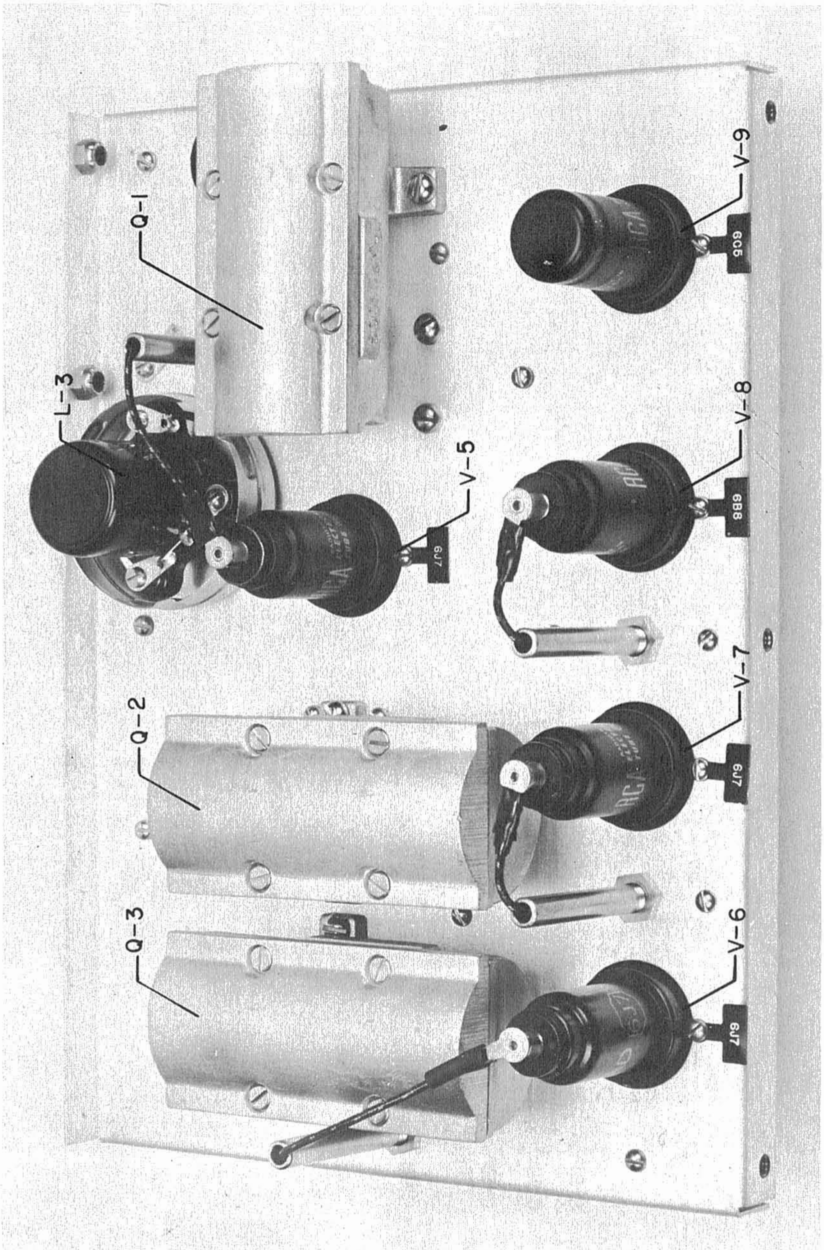
Type 736-A Power Supply Shelf (Top)



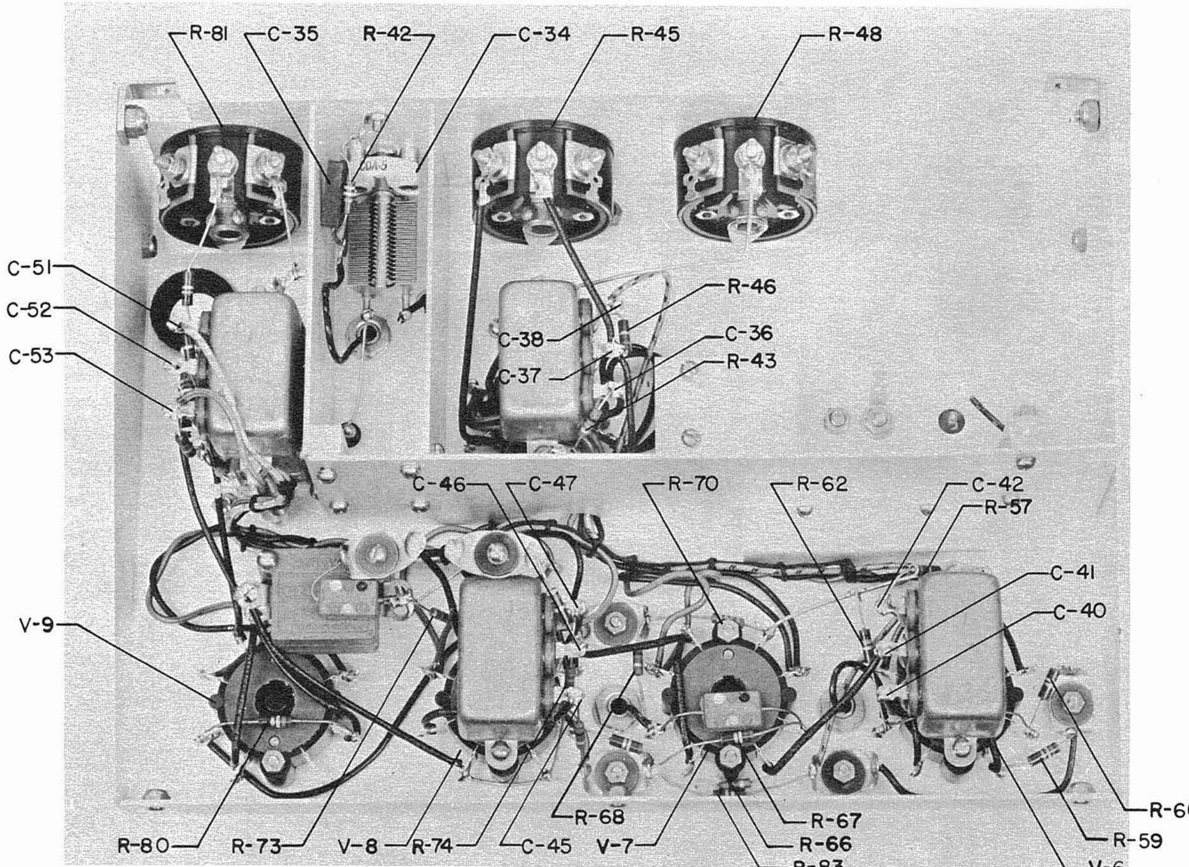
Type 736-A Detector Shelf (Top)



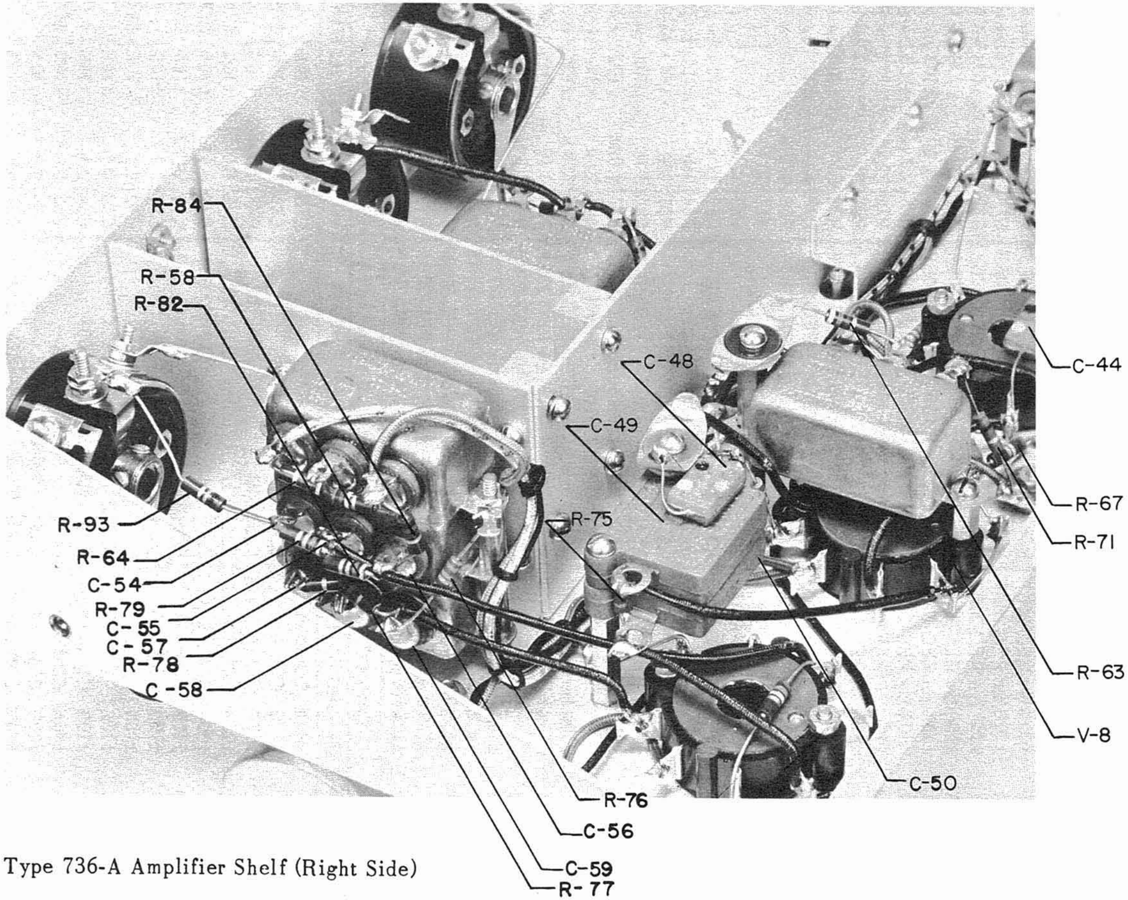
Type 736-A Detector Shelf (Bottom)



Type 736-A Amplifier Shelf (Top)



Type 736-A Amplifier Shelf (Bottom)



Type 736-A Amplifier Shelf (Right Side)

GENERAL RADIO COMPANY

RESISTORS. Resistances are in ohms except k = kilohm, M = megohms.

			PART NO. (SEE NOTE)
R1	100 k		314-401
R2	890 k	±1% 2w	REF-1-3
R3	99.67 k	±½%	REPR-16
R4	9.1 k	±1%	REPR-16
R5	1001	±½%	602-304
R6	1.8 M	±10% ½w	REC-20BF
R7	1.5 M	±10% ½w	REC-20BF
R8	680 k	±5% ½w	REC-20BF
R9	2.4 M	±5% ½w	REC-20BF
R10	47 k	±10% ½w	REC-20BF
R11	100 k	±10% ½w	REC-20BF
R12	30 k	±1%	REPR-16
R13	30 k	±1%	REPR-16
R14	100 k	±1%	REPR-16
R15	100 k	±1%	REPR-16
R16	13 k	±1%	REPR-16
R17	5 k		301-415
R18	13 k		REPR-16
R19	4.7 M	±10% ½w	REC-20BF
R20	4.7 M	±10% ½w	REC-20BF
R21	500 k	±1%	REPR-17
R22	500 k	±1%	REPR-17
R23	33 k	±10% ½w	REC-20BF
R24	20 k		301-431
R25	33 k	±10% ½w	REC-20BF
R26	270 k	±10% ½w	REC-20BF
R27	20 k		301-431
R28	270 k	±10% ½w	REC-20BF
R29	1 M	±10% ½w	REC-20BF
R30	1 M	±10% ½w	REC-20BF
R31	1 M	±10% ½w	REC-20BF
R32	150 k	±10% ½w	REC-20BF

			PART NO. (SEE NOTE)
R33	25		301A
R34	5.1	±10% ½w	REW-3C
R35	5 k	±1%	REPR-16
R36	200		301-404
R37	330	±10% ½w	REW-3C
R38	1 k	±10% ½w	REC-20BF
R39	18 k	±10% ½w	REC-20BF
R40	68 k	±10% ½w	REC-20BF
R41	56 k	±10% ½w	REC-20BF
R42	240 k	±5% ½w	REC-20BF
R43	1 k	±10% ½w	REC-20BF
R44	Value determined at lab.		
R45	20 k		301-430
R46	1.8 k	±10% ½w	REC-20BF
R47	10 k	±10% ½w	REC-20BF
R48	20 k		301-430
R50	64	±¼%	}
R51	138.4	±¼%	} 736-308
R52	437.66	±¼%	}
R53	1384	±¼%	736-309
R54	4376.6	±¼%	736-310
R55	13840	±¼%	REPR-16
R56	43766	±¼%	REPR-16
R57	4.7 k	±10% ½w	REC-20BF
R58	820 k	±10% ½w	REC-20BF
R59	270 k	±10% ½w	REC-20BF
R60	220 k	±10% ½w	REC-20BF
R61	10 k	±10% ½w	REC-20BF
R62	10 k	±10% ½w	REC-20BF
R63	470	±10% ½w	REC-20BF
R64	470	±10% ½w	REC-20BF

			PART NO. (SEE NOTE)
R65	20 k		301A
R66	1 M	±10% ½w	REC-20BF
R67	220 k	±10% ½w	REC-20BF
R68	1 M	±10% ½w	REC-20BF
R69	1 k	±10% ½w	REC-20BF
R70	22 k	±10% ½w	REC-20BF
R71	1 M	±10% ½w	REC-20BF
R72	220 k	±10% ½w	REC-20BF
R73	1.8 M	±10% ½w	REC-20BF
R74	18 M	±10% ½w	REC-20BF
R75	2.7 M	±10% ½w	REC-20BF
R76	22 k	±10% ½w	REC-20BF
R77	560	±10% ½w	REC-20BF
R78	560	±10% ½w	REC-20BF
R79	47 k	±10% ½w	REC-20BF
R80	270 k	±10% ½w	REC-20BF
R81	20 k		301-430
R82	47 k	±10% ½w	REC-20BF
R83	10 k	±10% ½w	REC-20BF
R84	560	±10% ½w	REC-20BF
R85	300	±5% ½w	REC-20BF
R86	1 M	±10% ½w	REC-20BF
R87	1.8 M	±10% ½w	REC-20BF
R88	22 k	±5% ½w	REC-20BF
R89	470 k	±10% ½w	REC-20BF
R90	1 M	±20%	POSC-11
R91	4.7 M	±10% ½w	REC-20BF
R92	47 k	±5% ½w	REC-20BF
R93	10 k	±10% ½w	REC-20BF
R94	470 k	±10% ½w	REC-20BF
R95	1.5		301-482

CAPACITORS. Capacitances are in μf except as otherwise indicated.

			PART NO. (SEE NOTE)
C1	0.03	±10%	COM-50B
C2	2	±10%	COL-6
C3	1	±10%	COL-5
C4	0.5	±10%	COL-13
C5	0.5	±10%	COL-13
C6	0.01	±10%	COM-41B
C7	0.01	±10%	COM-41B
C8	0.1	±10%	} COLB-1
C9	0.1	±10%	}
C10	0.5	±10%	COL-13
C11	0.01	±10%	COM-41B
C12	0.01	±10%	COM-41B
C13	10 $\mu\mu$f	±10%	COM-20B
C14	10 $\mu\mu$f	±10%	COM-20B
C15	} Part of 736-35		
C16	}		
C17	6 - 100 $\mu\mu$f		COA-4
C18	510 $\mu\mu$f	±10%	COM-20B
C19	0.1	±10%	}
C20	0.1	±10%	} COLB-1
C21	0.1	±10%	}
C22	0.5	±10%	COL-13

			PART NO. (SEE NOTE)
C23	0.25	±10%	} COLB-3
C24	0.25	±10%	}
C25	0.02	±10%	COM-50B
C26	0.02	±10%	COM-50B
C27	0 - 440 $\mu\mu$f		539-412-3
C28	15.5 - 325 $\mu\mu$f		COA-6
C31	0 - 15 $\mu\mu$f		368A
C32	736-314 and 736-801		
C34	7 - 140 $\mu\mu$f		COA-5
C35	50 $\mu\mu$f	±10%	COM-20B
C36	0.1	±10%	}
C37	0.1	±10%	} COLB-1
C38	0.1	±10%	}
C39	95 $\mu\mu$f	±5%	COM-20B
C40	0.1	±10%	}
C41	0.1	±10%	} COLB-1
C42	0.1	±10%	}
C43	100 $\mu\mu$f	±10%	COM-20B
C44	100 $\mu\mu$f	±10%	COM-20B

			PART NO. (SEE NOTE)
C45	0.1	±10%	}
C46	0.1	±10%	} COLB-1
C47	0.1	±10%	}
C48	100 $\mu\mu$f	±10%	COM-20B
C49	0.01	±10%	COM-45B
C50	0.003	±10%	COM-45B
C51	0.1	±10%	}
C52	0.1	±10%	} COLB-1
C53	0.1	±10%	}
C54	0.1	±10%	}
C55	0.1	±10%	} COLB-1
C56	0.1	±10%	}
C57	0.1	±10%	}
C58	0.1	±10%	} COLB-1
C59	0.1	±10%	}
C60	2	±10%	} 684-360
C61	1	±10%	}
C62	100 $\mu\mu$f	±10%	COM-20B
C63	2000	6 dcwv	COE-1
C64	3.3 $\mu\mu$f	±10%	COC-21N750
C65	350 $\mu\mu$f	±10%	COM-20B
C66	10	250 dcwv	COE-33

FUSES			
F1	(for 115 v)	1.25-amp slo-blo	FUF-1
F1	(for 230 v)	0.6-amp slo-blo	FUF-1
F2	(for 115 v)	1.25-amp slo-blo	FUF-1
F2	(for 230 v)	0.6-amp slo-blo	FUF-1
F3	1/32-amp slo-blo		FUF-1

INDUCTORS		
L1	636-316	
L2	736-321	
L3	500 mh	119B
L4	345-205	736-407
L5	345-207	736-407

METERS		
M1	0-5 v ac	MEA-2
M2	0-500 μa	588-304

PLUG	
PL1	ZCDPP-10

CRYSTALS	
Q1	50045 cps
Q2	50050 cps
Q3	50050 cps

RECTIFIER	
RX1	2RE-943-2

SWITCHES		
S1	dpdt	SWT-335
S2	rotary	736-312
S3	dpdt	339-401
S4	rotary	736-36
S5	dpst	SWT-333

TRANSFORMER	
T1	365-403-2

TUBES					
V1	6J7	V6	6J7	V11	6K6G
V2	6J7	V7	6J7	V12	6F5G
V3	6J7	V8	6B8	V13	NE-48
V4	6K6G	V9	6C5	V14	NE-48
V5	6J7	V10	6X5G	V15	NE-48

NOTE: Type designations for resistors and capacitors are as follows:

COA - Capacitor, air
COC - Capacitor, ceramic
COE - Capacitor, electrolytic
COL - Capacitor, oil-impregnated
COLB - Capacitor, oil-impregnated, block
COM - Capacitor, mica

POSC - Potentiometer, composition
REC - Resistor, composition
REF - Resistor, film
REPR - Resistor, precision
REW - Resistor, wire-wound

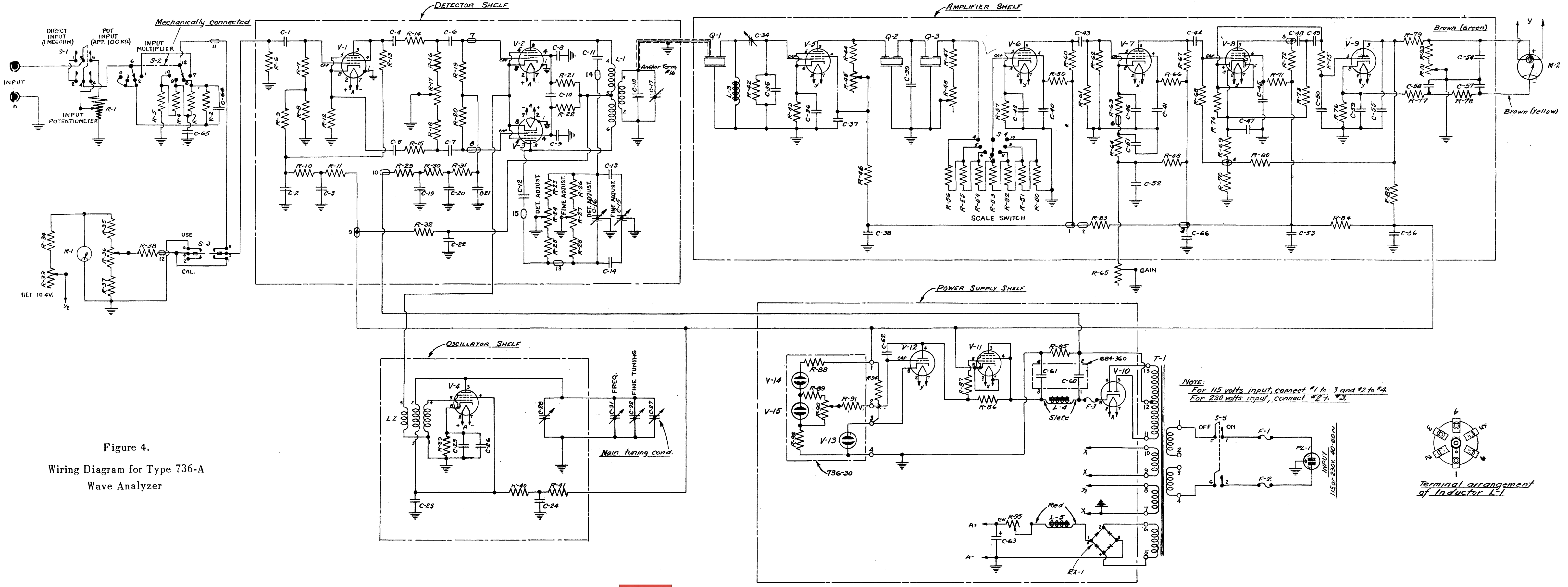


Figure 4.

Wiring Diagram for Type 736-A Wave Analyzer

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

EMerson 9-4400 | CLearwater 9-8900

DISTRICT OFFICES

NEW YORK

Broad Ave. at Linden, Ridgefield, N. J.
Telephone N.Y. WOrth 4-2722
N.J. WHitney 3-3140

PHILADELPHIA

1150 York Rd., Abington, Penna.
Telephone HAncock 4-7419

WASHINGTON

8055 13th St., Silver Spring, Md.
Telephone JUniper 5-1088

CHICAGO

6605 West North Ave., Oak Park, Ill.
Telephone VIllage 8-9400

LOS ANGELES

1000 N. Seward St., Los Angeles 38, Calif.
Telephone HOllywood 9-6201

SAN FRANCISCO

1186 Los Altos Ave., Los Altos, Calif.
Telephone WHitecliff 8-8233

CANADA

99 Floral Pkwy., Toronto 15, Ont.
Telephone CHerry 6-2171

REPAIR SERVICES

EAST COAST

General Radio Company
Service Department
22 Baker Ave., W. Concord, Mass.
Telephone EMerson 9-4400

NEW YORK

General Radio Company
Service Department
Broad Ave. at Linden, Ridgefield, N. J.
Telephone N.Y. WOrth 4-2722
N.J. WHitney 3-3140

MIDWEST

General Radio Company
Service Department
6605 West North Ave., Oak Park, Ill.
Telephone VIllage 8-9400

WEST COAST

General Radio Company
Service Department
1000 N. Seward St., Los Angeles 38, Calif.
Telephone HOllywood 9-6201

CANADA

Bayly Engineering, Ltd.
First Street, Ajax, Ontario
Telephone Toronto EMpire 2-3741

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