

TYPE 736-A

Change Notice for Form 508-F

The 6C6 tubes formerly used for V1, V2, and V3 have been replaced by 6J7's. Electrical characteristics are unchanged, but both the voltage table on page 11 and the schematic diagram (Figure 4) should be corrected to show the different pin connections of the 6J7. The difference in pin connections is shown below:

	6C6	6J7
	(old)	(new)
Plate	2	3
Grid 3	4	5
Grid 2	3	4
Grid 1	cap	cap
Cathode	5	8
Filament	1, 6	2, 7

GENERAL RADIO COMPANY
Cambridge 39,
Massachusetts

Form 508-FC

November, 1958

OPERATING INSTRUCTIONS

TYPE **736-A**

WAVE ANALYZER

Form 508-G
June, 1960

G E N E R A L R A D I O C O M P A N Y
WEST CONCORD, MASSACHUSETTS, USA

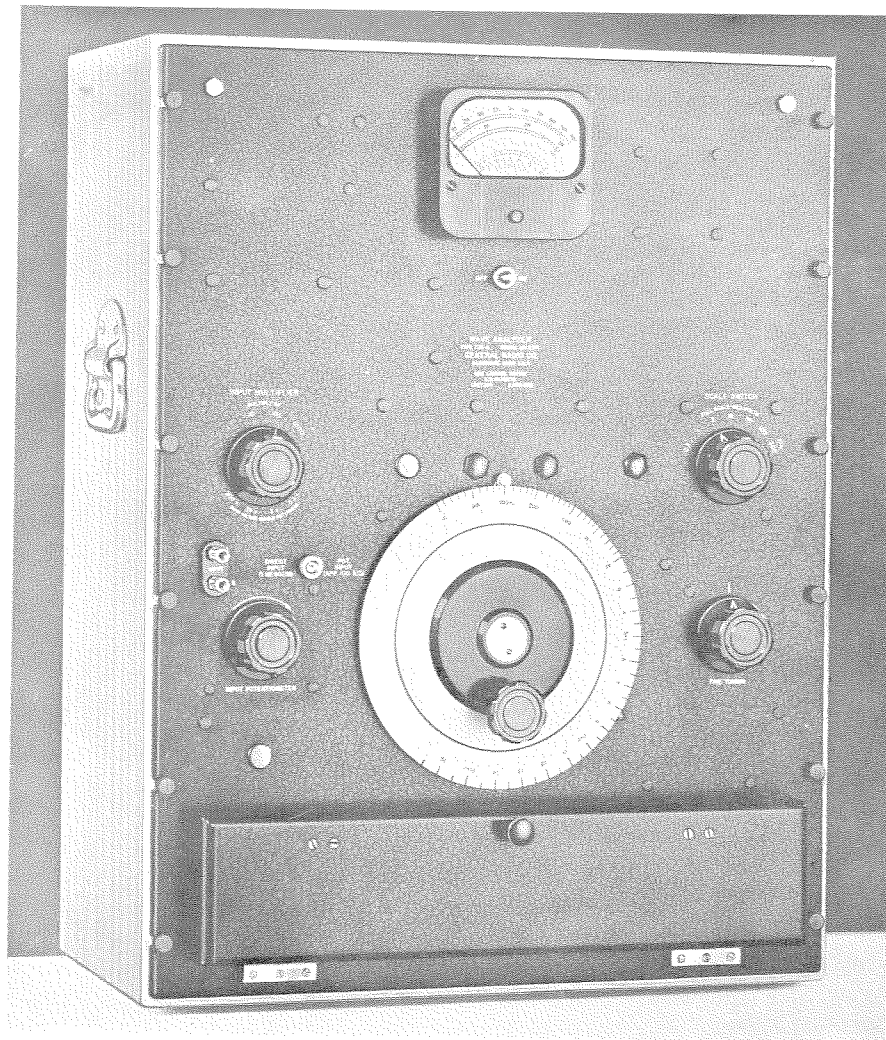


FIGURE 1. Panel view of Type 736-A Wave Analyzer

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 μ v. The over-all range is divided into four major ranges: 300 μ v to 300 mv, 3 mv to 3 v, 30 mv to 30 v, 0.3 to 300 v. Each of 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: $\pm (2\% + 1 \text{ cycle})$.

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) $19\frac{1}{2}$ $\times$ (height) $25\frac{1}{8}$ $\times$ (depth) $10\frac{7}{8}$ inches, over-all.

Net Weight: $86\frac{1}{4}$ pounds.

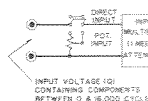
This apparatus uses inventions of United States Patents licensed by Radio Corporation of America. Patent numbers supplied upon request. Licensed only for use in measuring or testing electronic devices, electron tube circuits, parts of such devices and circuits, and elements for use in such devices and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

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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 fre-

quencies between 20 cycles and 16,500 cycles. It is, essentially, a sensitive vacuum-tube voltmeter with a 4-cycle bandwidth.

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

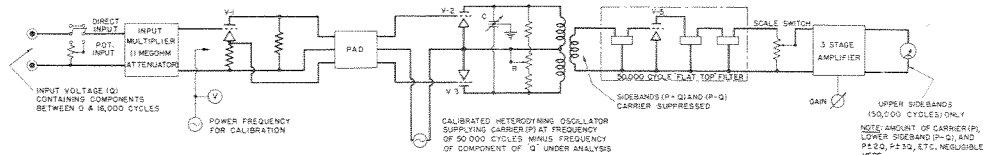


FIGURE 2. Functional schematic diagram of the Wave Analyzer showing the principles of operation

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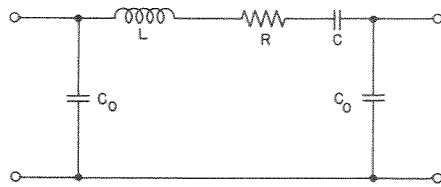


FIGURE 5. Equivalent circuit diagram of a three-electrode quartz crystal as used in the filter in Type 736-A Wave Analyzer

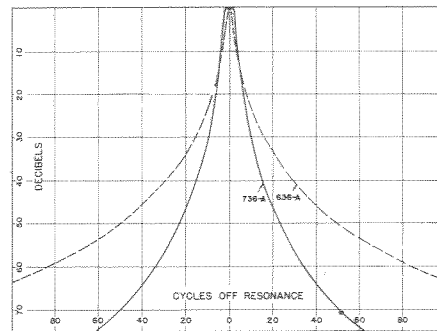


FIGURE 7. Filter characteristic showing the attenuation to unwarranted frequencies outside the pass band. The curve for Type 636-A is also shown.

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

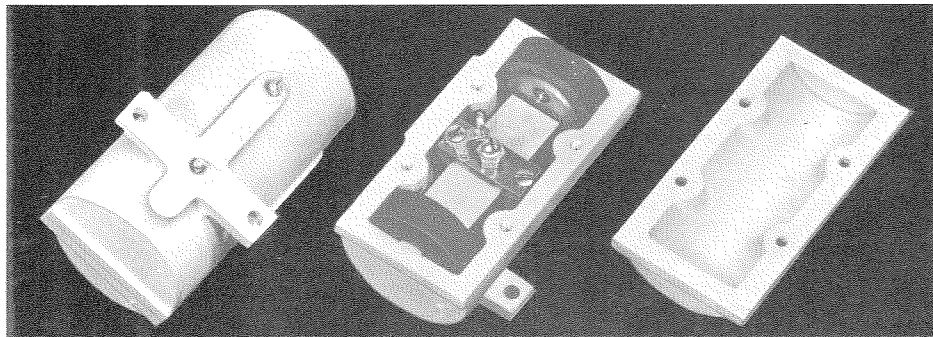
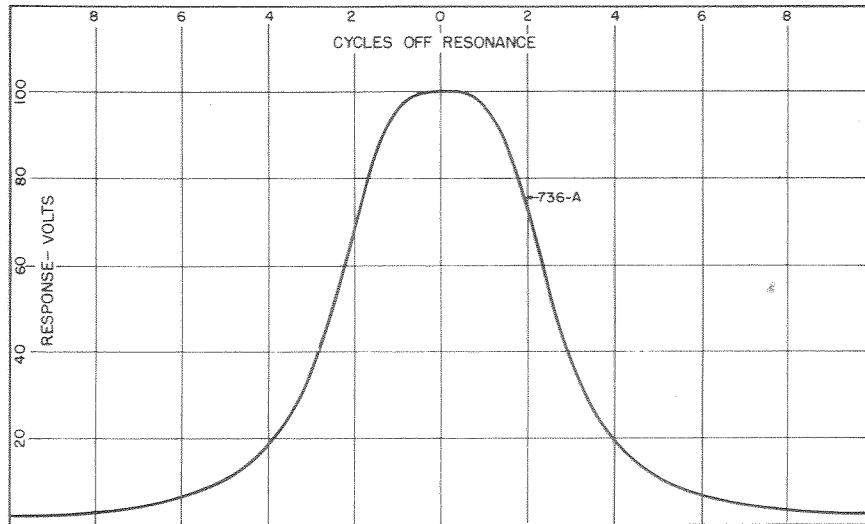


FIGURE 8. Photograph of quartz crystals used in the filter

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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_{91} , is provided to extend the range of this adjustment, if necessary. Its shaft is available by re-

moving 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_{91} 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 neces-

sary. 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

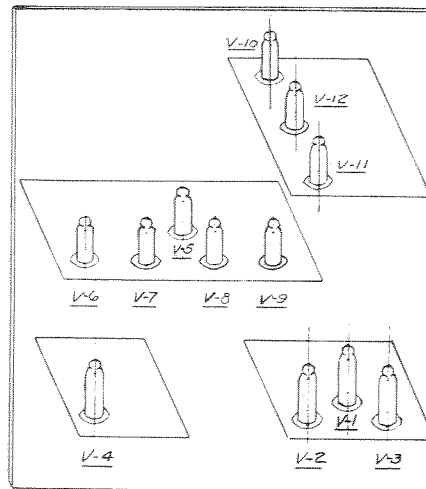


FIGURE 9. Location of tubes

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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

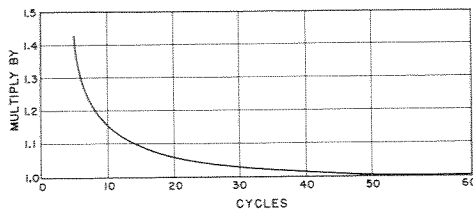


FIGURE 10. Frequency characteristic of the Wave Analyzer

precisely, the peak voltage should not exceed $1.41 \times$ 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 4.61 With DIRECT INPUT METER SCALE PUT 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.

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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 $\pm 0.5\%$) 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 R17, as indicated in paragraph 6.13, but for noise applications this is not ordinarily necessary.

*Type 1551-A Sound-Level Meter

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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 shieldcaps 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 $\frac{3}{4}$ 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.

TUBE (TYPE)
V1 (6J7)
V2 (6J7)
V3 (6J7)
V4 (6K6G)
V5 (6J7)
V6 (6J7)

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.

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TEST VOLTAGES

TUBE (TYPE)	PIN	VOLTS	RES TO GND	TUBE (TYPE)	PIN	VOLTS	RES TO GND
V1 (6J7)	3, 4	76	155 k	V7 (6J7)	3	87	220 k
	5, 8	25	30 k		4	34	1.2 M
	cap	22.5	2.6 M		5, 8	0.85	1.1 k
V2 (6J7)	3	113	150 k		cap	0	5 k
	4	80	660 k	V8 (6B8)	3	58	220 k
	5, 8	0	0.5		4, 5	22	18 M
V3 (6J7)	3	113	150 k		6	45	1 M
	4	80	660 k		8	24	20 k
	5, 8	0	0.5	V9 (6C5)	3	82	23 k
V4 (6K6G)	cap	-4.15	9 M		5	220	18 M
	3	80	124 k		8	25	9.5 k
	4	80	124 k	V10 (6X5G)	3-5	585 ac	950
	5	0	15		8	355	∞
V5 (6J7)	8	19	18 k	V11 (6K6G)	3, 4	350	∞
	3	85	33 k		5	200	∞
	4	148	13.5 k		7, 8	210	0
	5, 8	3.8	1 k	V12 (6F5G)	4	200	∞
V6 (6J7)	cap	0	240 k		8	82	470 k
	3	12	220 k		cap	80	5 M
	4	150	11 k	XFMR T1	5-6	18 ac	
	5, 8	6	5 k		11-13	585 ac	
	cap	0	64				

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

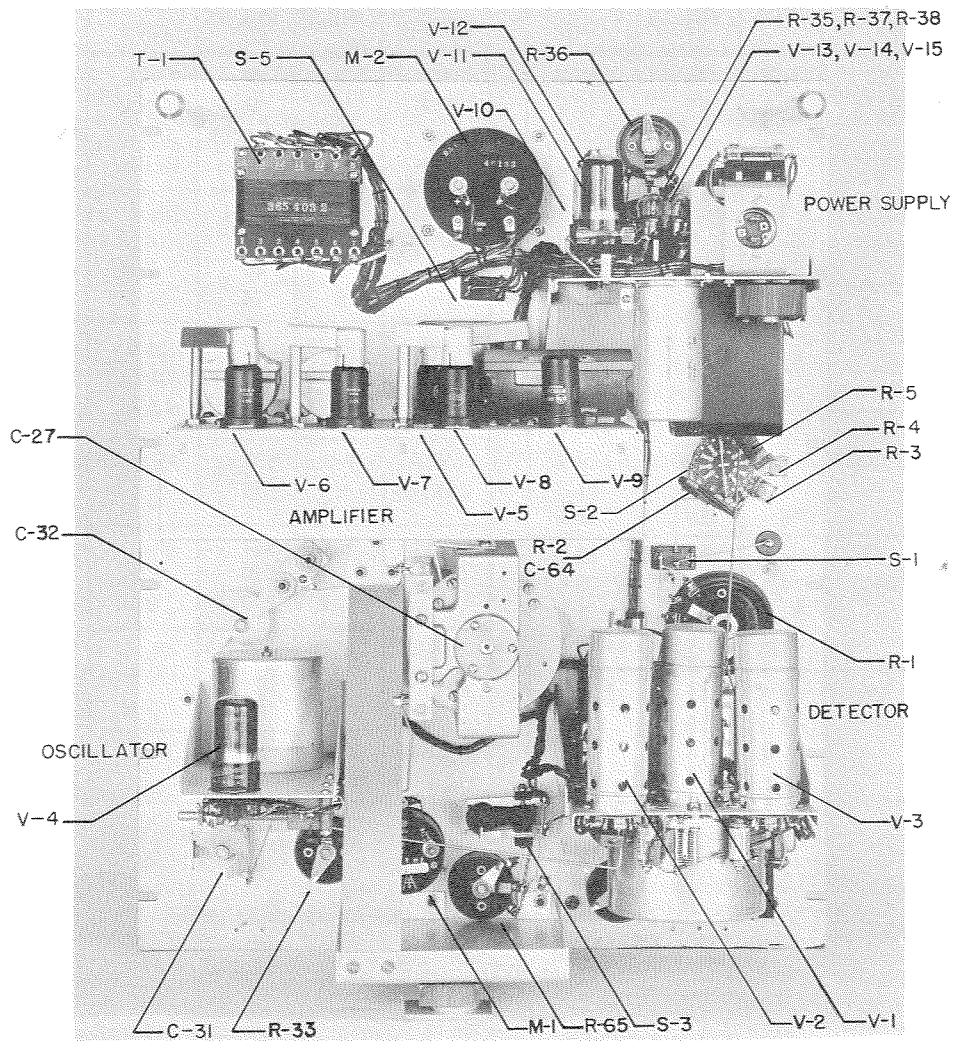
DIRECT input

USE-CAL switch at USE

Set to 4 v ac

Gain on full

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Rear View of Type 736-A Wave Analyzer

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R-35, R-37, R-38
V-13, V-14, V-15

POWER SUPPLY

R-5
R-4
R-3

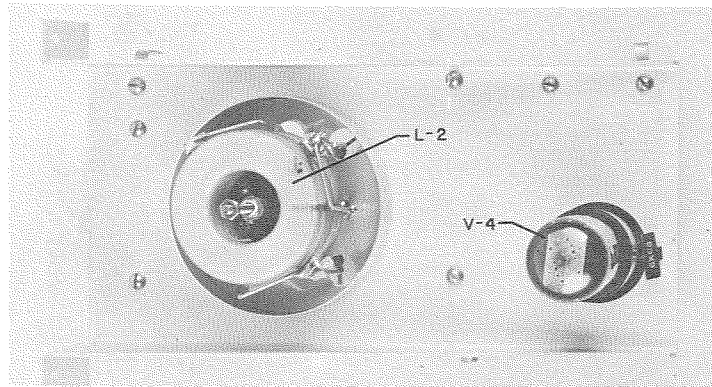
S-1

R-1

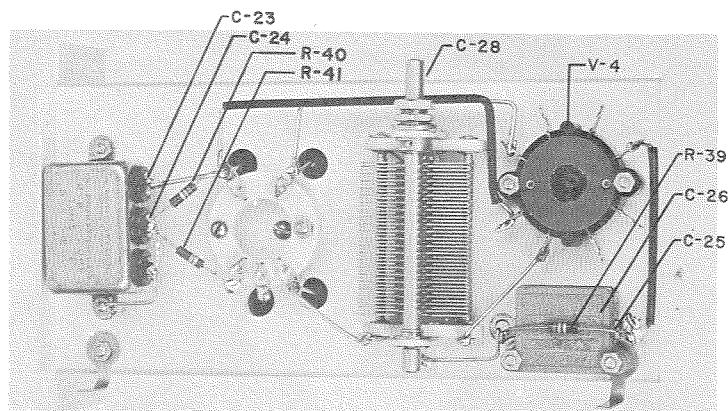
DETECTOR

V-3

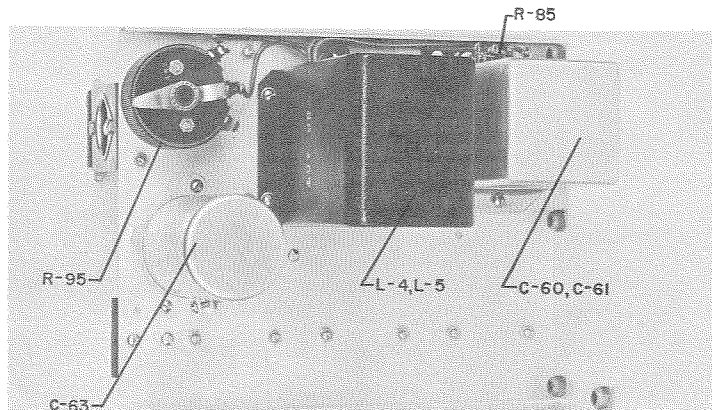
V-2 V-1



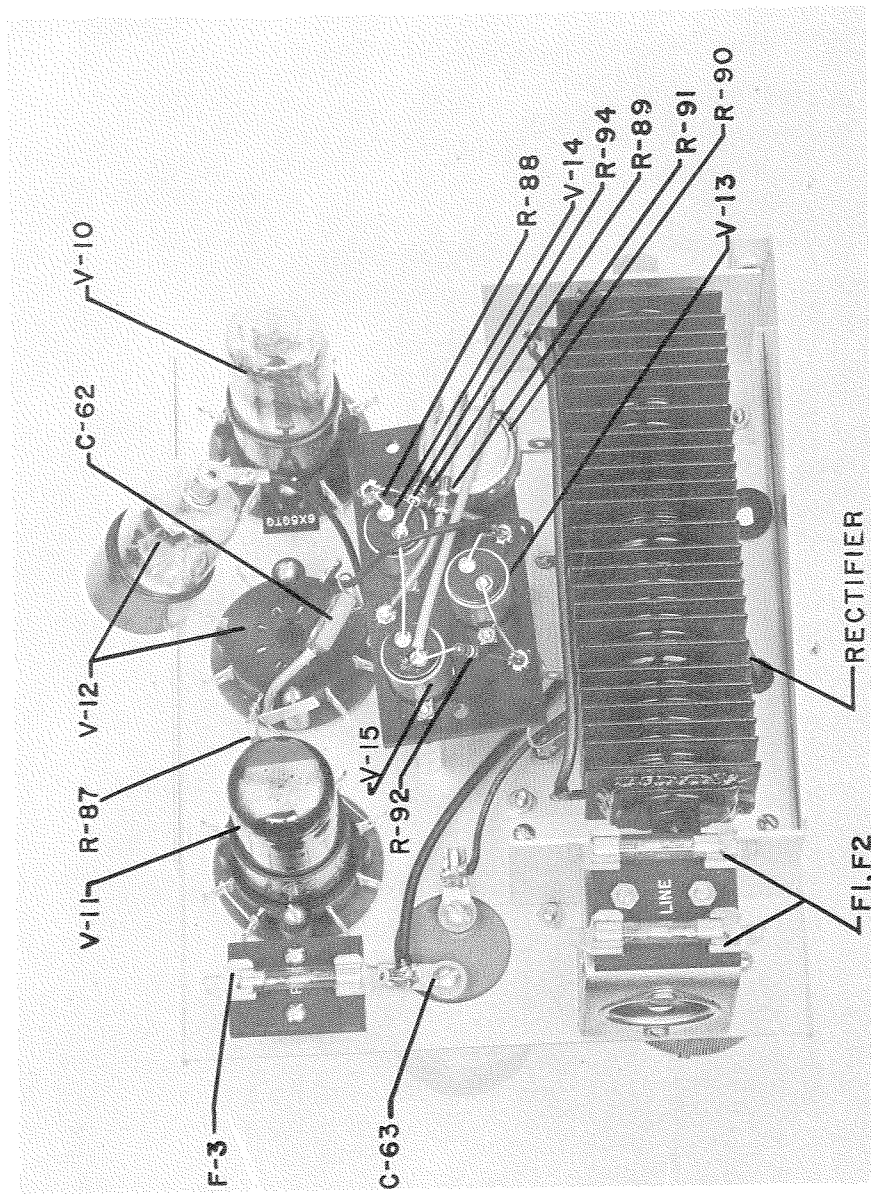
Type 736-A Oscillator Shelf (Top)



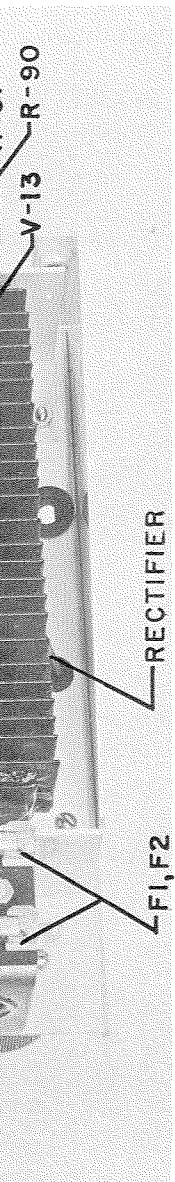
Type 736-A Oscillator Shelf (Bottom)



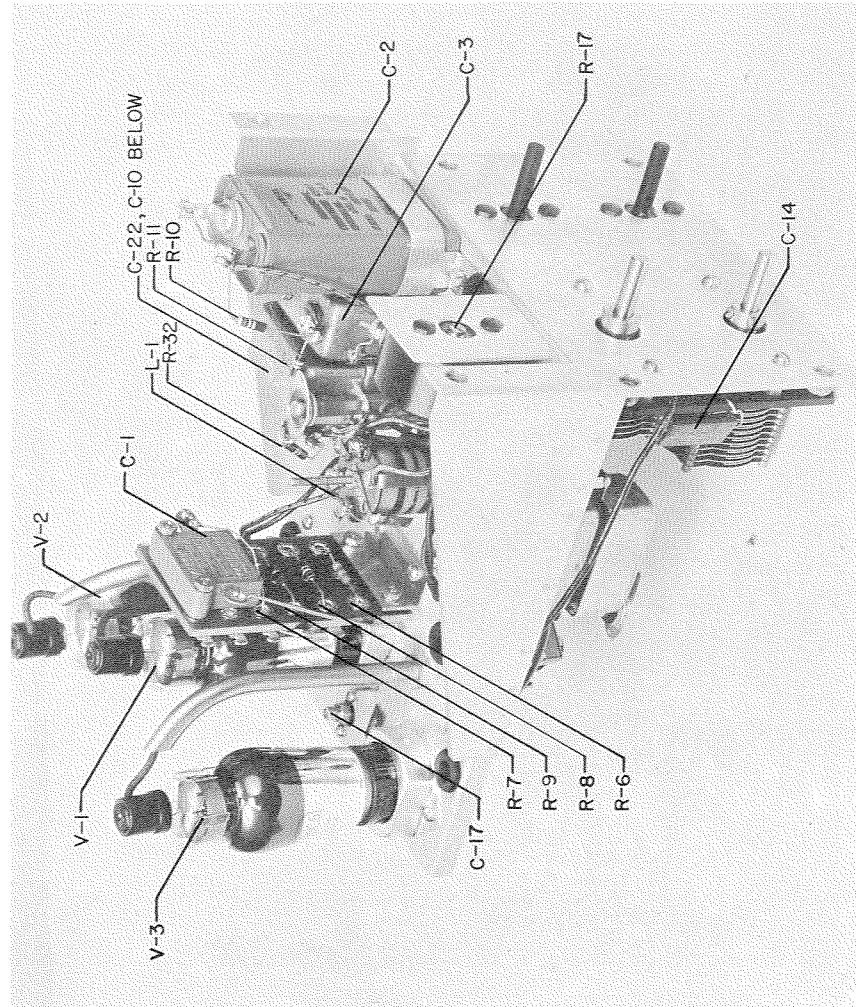
Type 736-A Power Supply Shelf (Bottom)



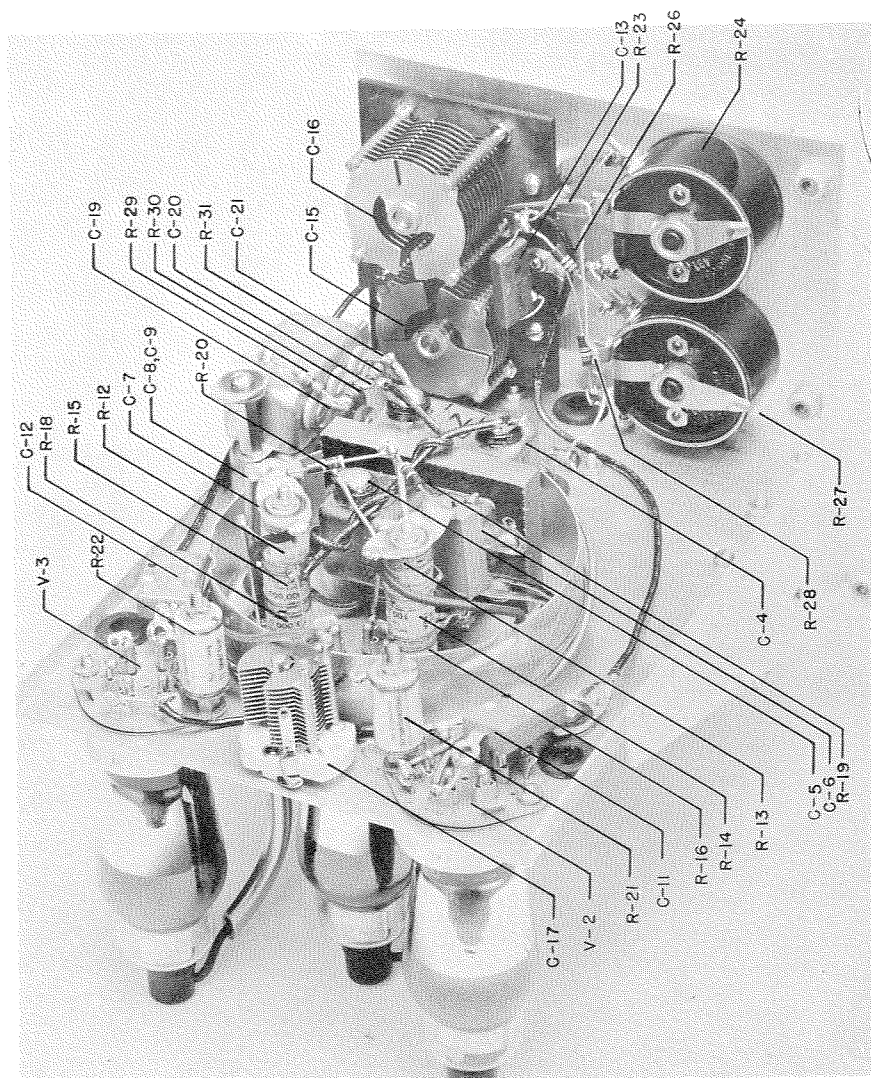
Type 736-A Power Supply Shelf (Top)



Type 736-A Power Supply Shelf (Top)



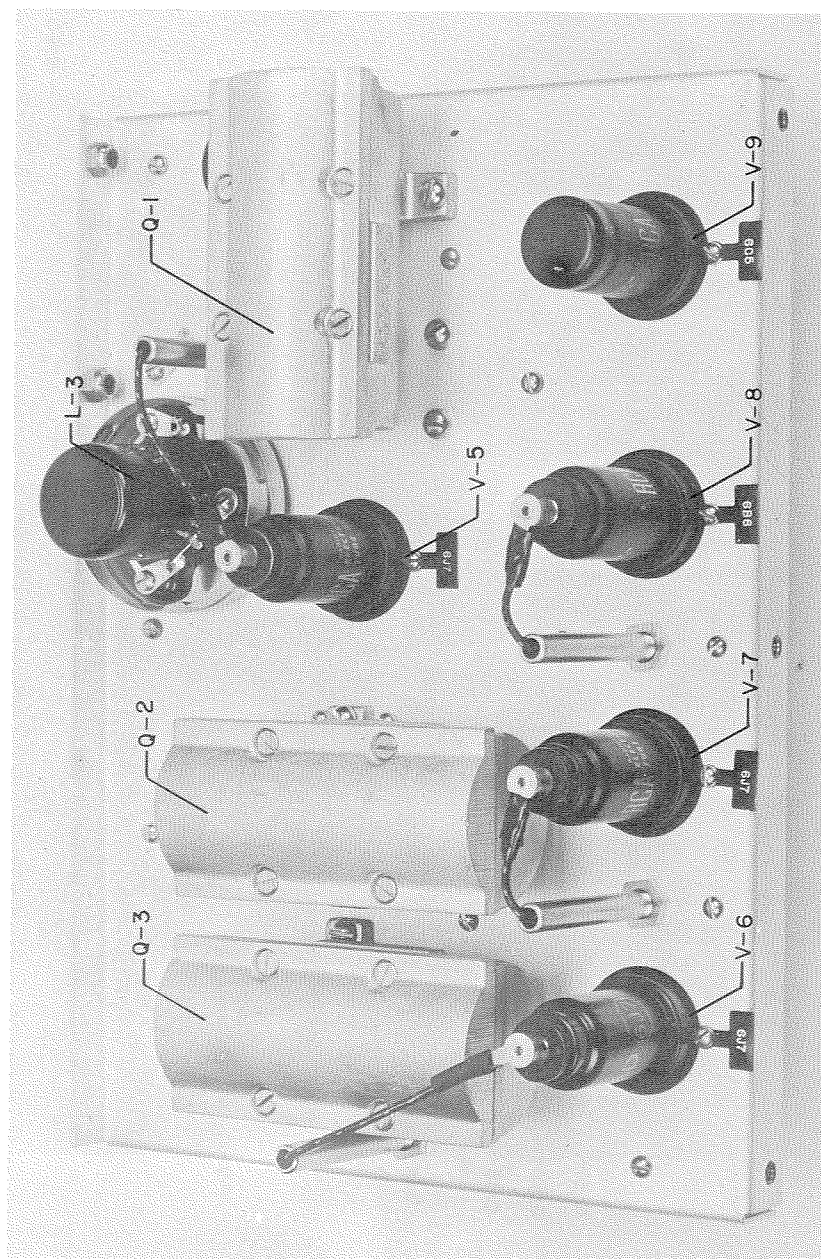
Type 736-A Detector Shelf (Top)



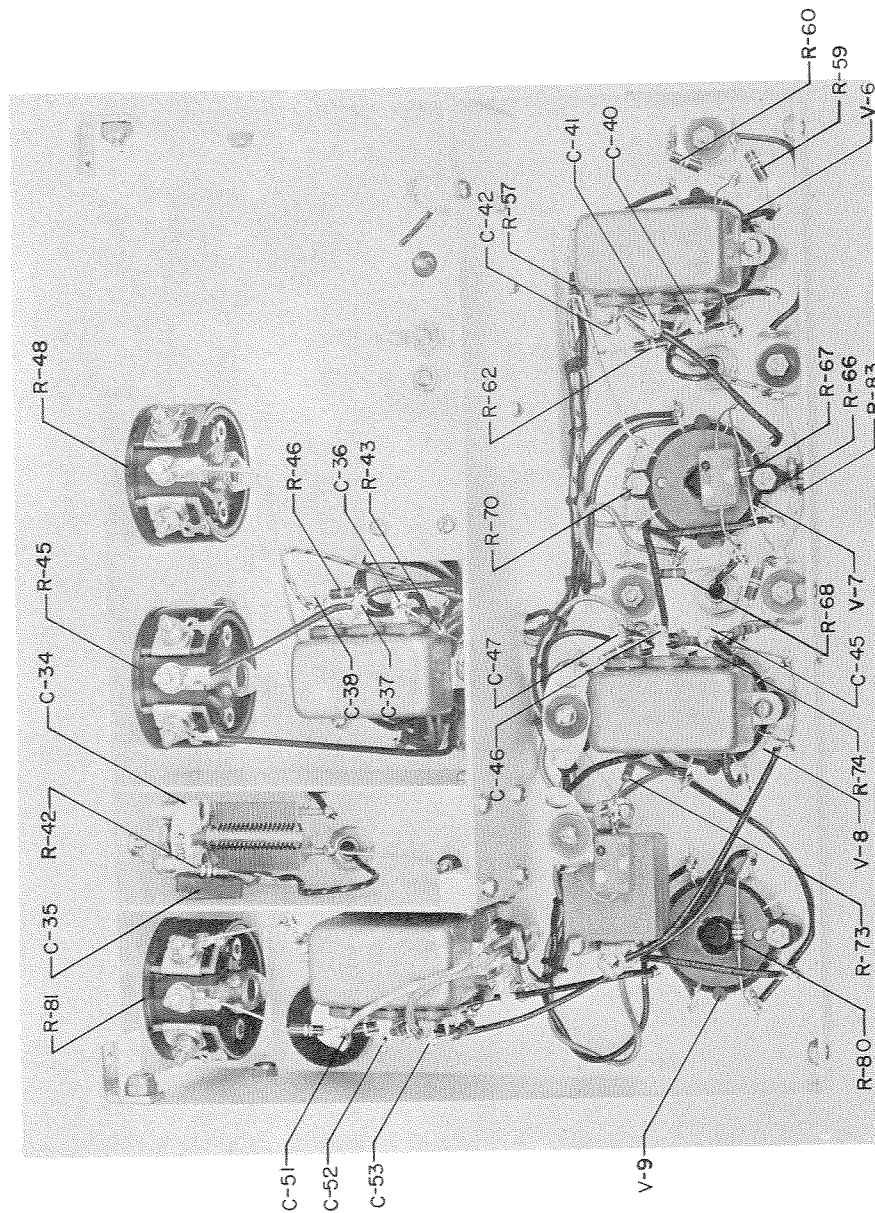
Type 736-A Detector Shelf (Bottom)



Type 736-A Detector Shelf (Bottom)



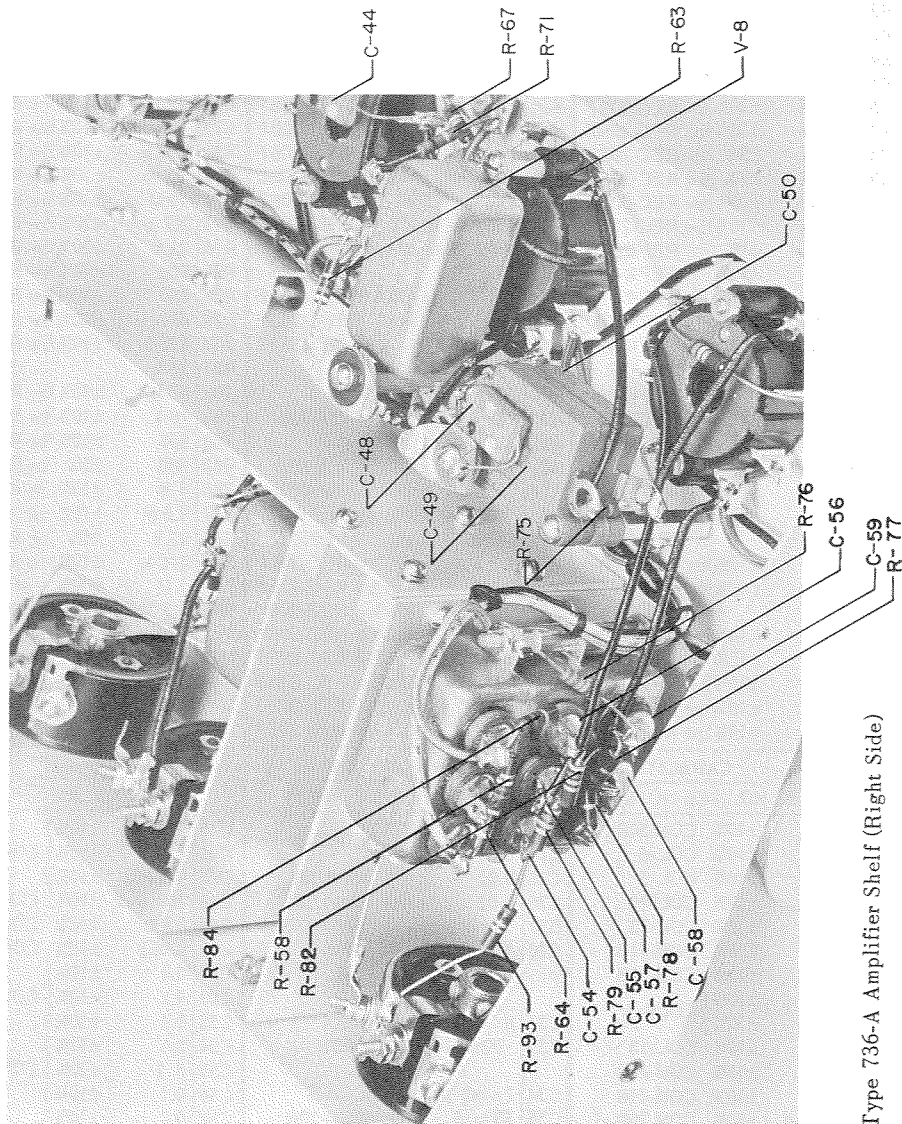
Type 736-A Amplifier Shelf (Top)



Type 736-A Amplifier Shelf (Bottom)



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)				PART NO. (SEE NOTE)				PART NO. (SEE NOTE)			
R1	100 k		314-401	R33	25		301A	R65	20 k		301A
R2	890 k	±1%	2w REF-1-3	R34	5.1	±10% ½w	REW-3C	R66	1 M	±10% ½w	REC-20BF
R3	99.67 k	±½%	REPR-16	R35	5 k	±1%	REPR-16	R67	220 k	±10% ½w	REC-20BF
R4	9.1 k	±1%	REPR-16	R36	200		301-404	R68	1 M	±10% ½w	REC-20BF
R5	1001	±½%	602-304	R37	330	±10% ½w	REW-3C	R69	1 k	±10% ½w	REC-20BF
R6	1.8 M	±10% ½w	REC-20BF	R38	1 k	±10% ½w	REC-20BF	R70	22 k	±10% ½w	REC-20BF
R7	1.5 M	±10% ½w	REC-20BF	R39	18 k	±10% ½w	REC-20BF	R71	1 M	±10% ½w	REC-20BF
R8	680 k	±5% ½w	REC-20BF	R40	68 k	±10% ½w	REC-20BF	R72	220 k	±10% ½w	REC-20BF
R9	2.4 M	±5% ½w	REC-20BF	R41	56 k	±10% ½w	REC-20BF	R73	1.8 M	±10% ½w	REC-20BF
R10	47 k	±10% ½w	REC-20BF	R42	240 k	±5% ½w	REC-20BF	R74	18 M	±10% ½w	REC-20BF
R11	100 k	±10% ½w	REC-20BF	R43	1 k	±10% ½w	REC-20BF	R75	2.7 M	±10% ½w	REC-20BF
R12	30 k	±1%	REPR-16	R44	Value determined at lab.			R76	22 k	±10% ½w	REC-20BF
R13	30 k	±1%	REPR-16	R45	20 k		301-430	R77	560	±10% ½w	REC-20BF
R14	100 k	±1%	REPR-16	R46	1.8 k	±10% ½w	REC-20BF	R78	560	±10% ½w	REC-20BF
R15	100 k	±1%	REPR-16	R47	10 k	±10% ½w	REC-20BF	R79	47 k	±10% ½w	REC-20BF
R16	13 k	±1%	REPR-16	R48	20 k		301-430	R80	270 k	±10% ½w	REC-20BF
R17	5 k		301-415					R81	20 k		301-430
R18	13 k		REPR-16	R50	64	±¼%	736-308	R82	47 k	±10% ½w	REC-20BF
R19	4.7 M	±10% ½w	REC-20BF	R51	138.4	±¼%		R83	10 k	±10% ½w	REC-20BF
R20	4.7 M	±10% ½w	REC-20BF	R52	437.66	±¼%		R84	560	±10% ½w	REC-20BF
R21	500 k	±1%	REPR-17	R53	1384	±¼%	736-309	R85	300	±5% ½w	REC-20BF
R22	500 k	±1%	REPR-17	R54	4376.6	±¼%	736-310	R86	1 M	±10% ½w	REC-20BF
R23	33 k	±10% ½w	REC-20BF	R55	13840	±¼%	REPR-16	R87	1.8 M	±10% ½w	REC-20BF
R24	20 k		301-431	R56	43766	±¼%	REPR-16	R88	22 k	±5% ½w	REC-20BF
R25	33 k	±10% ½w	REC-20BF	R57	4.7 k	±10% ½w	REC-20BF	R89	470 k	±10% ½w	REC-20BF
R26	270 k	±10% ½w	REC-20BF	R58	820 k	±10% ½w	REC-20BF	R90	1 M	±20%	POSC-11
R27	20 k		301-431	R59	270 k	±10% ½w	REC-20BF	R91	4.7 M	±10% ½w	REC-20BF
R28	270 k	±10% ½w	REC-20BF	R60	220 k	±10% ½w	REC-20BF	R92	47 k	±5% ½w	REC-20BF
R29	1 M	±10% ½w	REC-20BF	R61	10 k	±10% ½w	REC-20BF	R93	10 k	±10% ½w	REC-20BF
R30	1 M	±10% ½w	REC-20BF	R62	10 k	±10% ½w	REC-20BF	R94	470 k	±10% ½w	REC-20BF
R31	1 M	±10% ½w	REC-20BF	R63	470	±10% ½w	REC-20BF	R95	1.5		301-482
R32	150 k	±10% ½w	REC-20BF	R64	470	±10% ½w	REC-20BF				

CAPACITORS. Capacitances are in $\mu\mu\text{f}$ except as otherwise indicated.

PART NO. (SEE NOTE)				PART NO. (SEE NOTE)				PART NO. (SEE NOTE)			
C1	0.03	±10%	COM-50B	C23	0.25	±10%	COLB-3	C45	0.1	±10%	COLB-1
C2	2	±10%	COL-6	C24	0.25	±10%		C46	0.1	±10%	
C3	1	±10%	COL-5	C25	0.02	±10%		C47	0.1	±10%	
C4	0.5	±10%	COL-13	C26	0.02	±10%	COM-50B	C48	100 $\mu\mu\text{f}$	±10%	COM-20B
C5	0.5	±10%	COL-13	C27	0-440 $\mu\mu\text{f}$		539-412-3	C49	0.01	±10%	COM-45B
C6	0.01	±10%	COM-41B	C28	15.5-325 $\mu\mu\text{f}$		COA-6	C50	0.003	±10%	COM-45B
C7	0.01	±10%	COM-41B					C51	0.1	±10%	COLB-1
C8	0.1	±10%	COLB-1	C31	0-15 $\mu\mu\text{f}$		368A	C52	0.1	±10%	
C9	0.1	±10%		C32	736-314 and 736-801			C53	0.1	±10%	
C10	0.5	±10%	COL-13					C54	0.1	±10%	COLB-1
C11	0.01	±10%	COM-41B	C34	7-140 $\mu\mu\text{f}$		COA-5	C55	0.1	±10%	
C12	0.01	±10%	COM-41B	C35	50 $\mu\mu\text{f}$	±10%	COM-20B	C56	0.1	±10%	
C13	10 $\mu\mu\text{f}$	±10%	COM-20B	C36	0.1	±10%	COLB-1	C57	0.1	±10%	COLB-1
C14	10 $\mu\mu\text{f}$	±10%	COM-20B	C37	0.1	±10%		C58	0.1	±10%	
C15	Part of 736-35			C38	0.1	±10%		C59	0.1	±10%	684-360
C16				C39	95 $\mu\mu\text{f}$	±5%	COM-20B	C60	2	±10%	
C17	6-100 $\mu\mu\text{f}$		COA-4	C40	0.1	±10%	COLB-1	C61	1	±10%	
C18	510 $\mu\mu\text{f}$	±10%	COM-20B	C41	0.1	±10%		C62	100 $\mu\mu\text{f}$	±10%	COM-20B
C19	0.1	±10%	COLB-1	C42	0.1	±10%		C63	2000 6 dcwv		COE-1
C20	0.1	±10%		C43	100 $\mu\mu\text{f}$	±10%	COM-20B	C64	3.3 $\mu\mu\text{f}$	±10%	COC-21N750
C21	0.1	±10%		C44	100 $\mu\mu\text{f}$	±10%	COM-20B	C65	350 $\mu\mu\text{f}$	±10%	COM-20B
C22	0.5	±10%	COL-13					C66	10 250 dcwv		COE-33

(SEE NOTE)	
301A	
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
301-430	
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
5% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
5% 1/2w	REC-20BF
10% 1/2w	REC-20BF
20%	POSC-11
10% 1/2w	REC-20BF
5% 1/2w	REC-20BF
10% 1/2w	REC-20BF
10% 1/2w	REC-20BF
301-482	

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	
METERS		
M1	0-5 v ac	MEA-2
M2	0-500 μ a	588-304
PLUG		
PL1	ZCDPP-10	

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

6x6 0.400 amp
6x7 0.300 "

