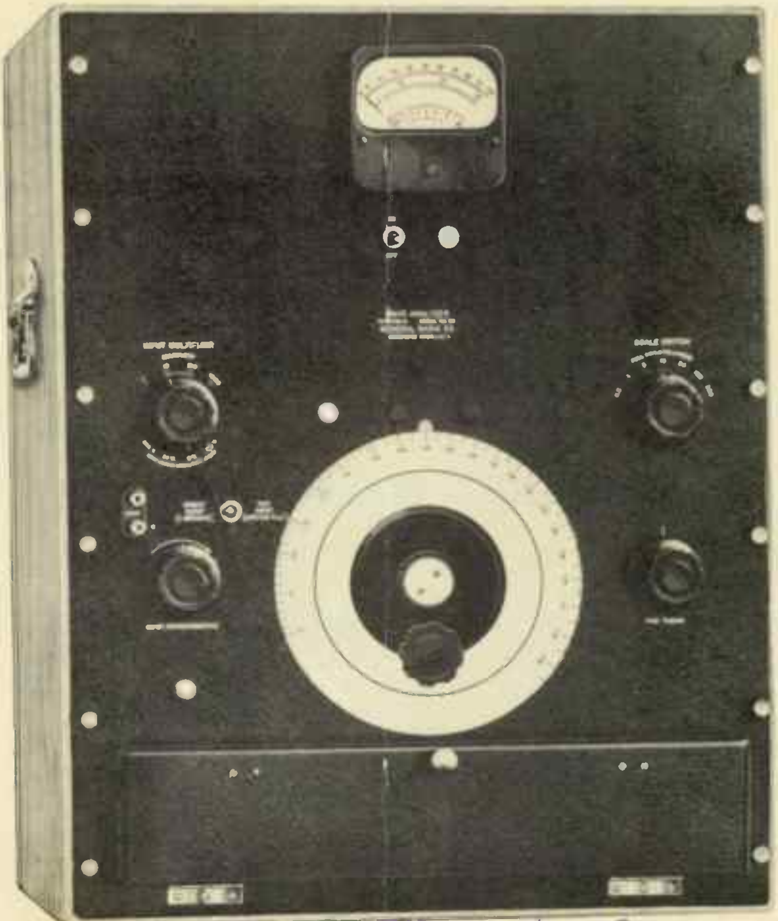
OPERATING INSTRUCTIONS

FOR

TYPE 736-A
WAVE ANALYZER

FORM 508-B

GENERAL RADIO COMPANY
CAMBRIDGE A, MASSACHUSETTS



Ser. #119

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

PATENT NOTICE

This instrument is manufactured under the following U. S. Patents and license agreements:

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Patent 1,542,995
Patent 1,967,185

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

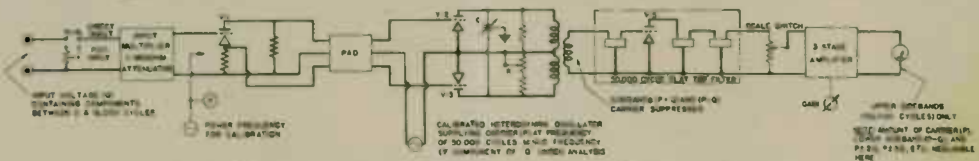


FIGURE 2. Functional schematic diagram of the Wave Analyzer showing the principles of operation

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

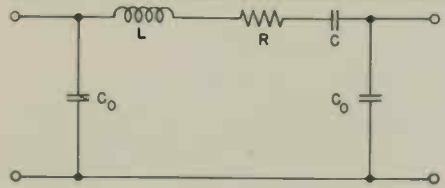


FIGURE 5. Equivalent circuit diagram of a three-electrode quartz crystal as used in the filter in Type 736-A Wave Analyzer

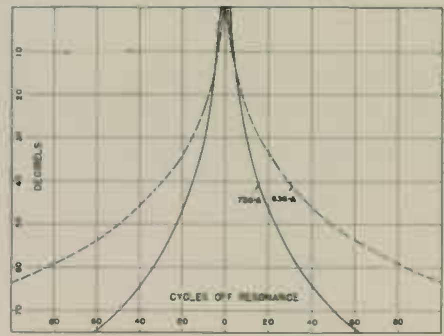
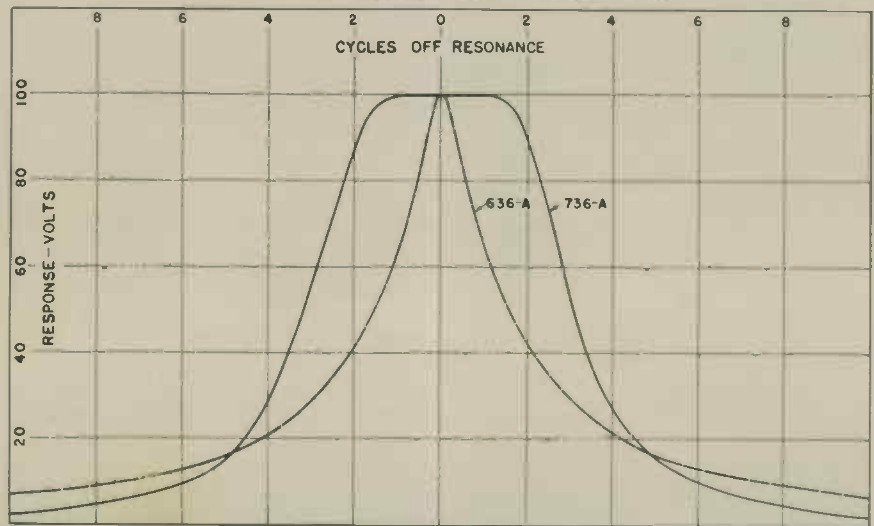


FIGURE 7. Filter characteristic showing the attenuation to unwarranted frequencies outside the pass band. The curve for Type 636-A is also shown

FIGURE 6. (Below) Band pass characteristic of the quartz crystal filter used in Type 736-A Wave Analyzer compared with that of the filter in the older Type 636-A



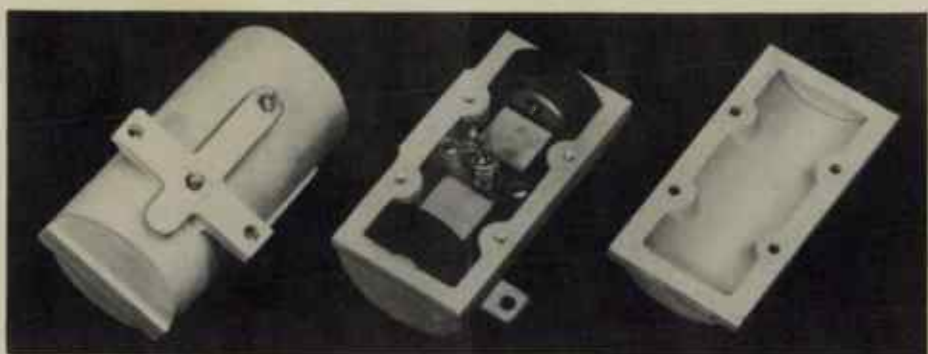


FIGURE 8. Photograph of quartz crystals used in the filter

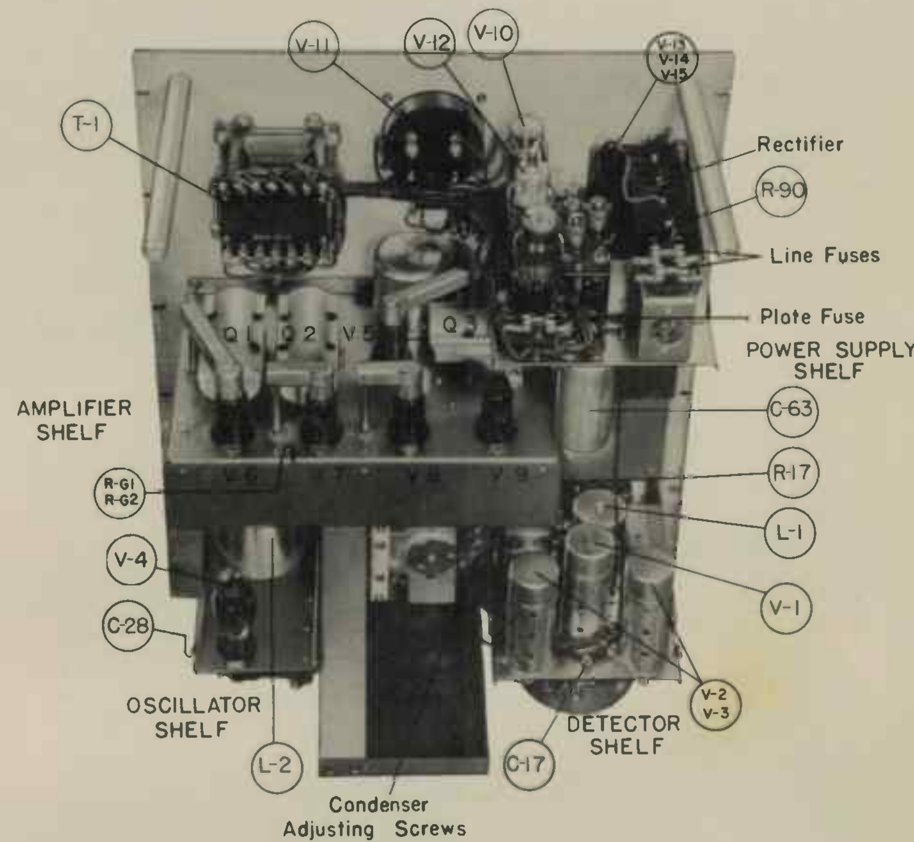


FIGURE 3. Inside rear view of the Wave Analyzer identifying the major parts

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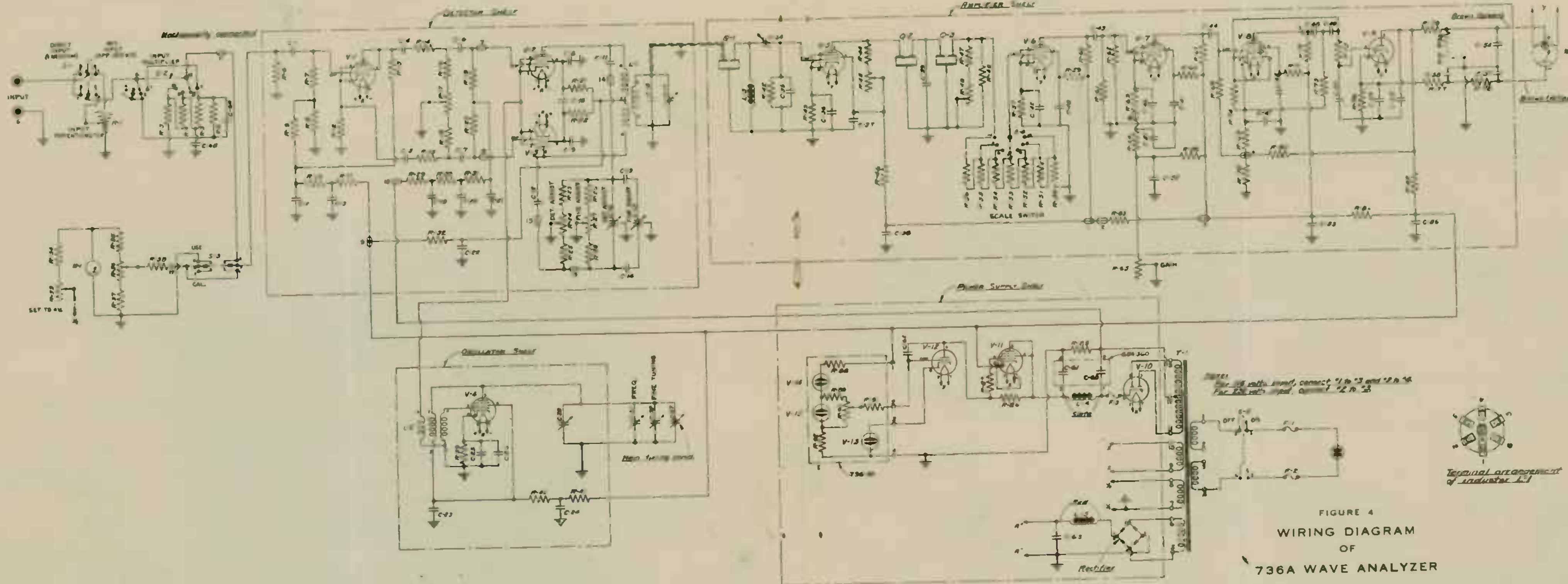

FIGURE 4
WIRING DIAGRAM
OF
736A WAVE ANALYZER

RESISTORS

R-1 = 100 KΩ
R-2 = 890 KΩ ± 1%
R-3 = 99.67 KΩ ± 1/2%
R-4 = 9.1 KΩ
R-5 = 1001 Ω
R-6 = 2 MΩ
R-7 = 1.5 MΩ
R-8 = 750 KΩ
R-9 = 2 MΩ
R-10 = 50 KΩ
R-11 = 100 KΩ
R-12 = 30 KΩ
R-13 = 30 KΩ
R-14 = 100 KΩ
R-15 = 100 KΩ
R-16 = 13 KΩ
R-17 = 5 KΩ
R-18 = 13 KΩ
R-19 = 5 MΩ
R-20 = 5 MΩ
R-21 = 500 KΩ
R-22 = 500 KΩ
R-23 = 30 KΩ
R-24 = 20 KΩ
R-25 = 30 KΩ
R-26 = 250 KΩ
R-27 = 20 KΩ
R-28 = 250 KΩ
R-29 = 1 MΩ
R-30 = 1 MΩ
R-31 = 1 MΩ
R-32 = 150 KΩ
R-33 = 25 Ω
R-34 = 20 Ω
R-35 = 5 KΩ
R-36 = 200 Ω
R-37 = 300 Ω
R-38 = 1 KΩ
R-39 = 20 KΩ
R-40 = 75 KΩ
R-41 = 50 KΩ
R-42 = 250 KΩ
R-43 = 1 KΩ
R-44 = To be selected in laboratory
R-45 = 20 KΩ
R-46 = 2 KΩ
R-47 = 10 KΩ
R-48 = 20 KΩ
R-49 = 250 KΩ
R-50 = 64 Ω
R-51 = 138.4 Ω
R-52 = 437.66 Ω
R-53 = 1384 Ω
R-54 = 4376.6 Ω
R-55 = 13840 Ω
R-56 = 43766 Ω
R-57 = 5 KΩ
R-58 = 750 KΩ
R-59 = 250 KΩ
R-60 = 200 KΩ
R-61 = } To be selected
R-62 = } in laboratory
R-63 = 500 Ω
R-64 = 500 Ω
R-65 = 20 KΩ
R-66 = 1 MΩ
R-67 = 200 KΩ
R-68 = 1 MΩ
R-69 = 1 KΩ
R-70 = 20 KΩ
R-71 = 1 MΩ
R-72 = 200 KΩ
R-73 = 2 MΩ
R-74 = 20 MΩ
R-75 = 3 MΩ
R-76 = 20 KΩ
R-77 = 500 Ω
R-78 = 500 Ω
R-79 = 50 KΩ
R-80 = 250 KΩ
R-81 = 20 KΩ
R-82 = 50 KΩ
R-83 = 10 KΩ
R-84 = 500 Ω
R-85 = 300 Ω
R-86 = 1 MΩ
R-87 = 2 MΩ
R-88 = 100 KΩ
R-89 = 500 KΩ
R-90 = 1 MΩ
R-91 = 5 MΩ
R-92 = 250 KΩ
R-93 = 7.5 KΩ

INDUCTORS

L-1 = 636-316
L-2 = 736-321
L-3 = 500 mil.h. 119B
L-4 = 345-305 } 736-407
L-5 = 345-307 }

CONDENSERS

C-1 = 0.01 μf
C-2 = 2 μf
C-3 = 1 μf
C-4 = 0.5 μf
C-5 = 0.5 μf
C-6 = 0.01 μf
C-7 = 0.01 μf
C-8 = 0.1 μf
C-9 = 0.1 μf
C-10 = 0.5 μf
C-11 = 0.01 μf
C-12 = 0.01 μf
C-13 = 10 μμf
C-14 = 10 μμf
C-15 =
C-16 =
C-17 = 0-100 μμf
C-18 = To be selected in laboratory
C-19 = 0.1 μf
C-20 = 0.1 μf
C-21 = 0.1 μf
C-22 = 0.5 μf
C-23 = 0.25 μf
C-24 = 0.25 μf
C-25 = 0.02 μf
C-26 = 0.02 μf
C-27 = 0.440 μμf
C-28 = 0-325 μμf
C-29 =
C-30 =
C-31 = 0-15 μμf
C-32 =
C-33 =
C-34 = 0-140 μμf
C-35 = 50 μμf
C-36 = 0.1 μf
C-37 = 0.1 μf
C-38 = 0.1 μf
C-39 = 100 μμf
C-40 = 0.1 μf
C-41 = 0.1 μf
C-42 = 0.1 μf
C-43 = 100 μμf
C-44 = 100 μμf
C-45 = 0.1 μf
C-46 = 0.1 μf
C-47 = 0.1 μf
C-48 = 100 μμf
C-49 = 0.01 μf
C-50 = 0.003 μf
C-51 = 0.1 μf
C-52 = 0.1 μf
C-53 = 0.1 μf
C-54 = 0.1 μf
C-55 = 0.1 μf
C-56 = 0.1 μf
C-57 = 0.1 μf
C-58 = 0.1 μf
C-59 = 0.1 μf
C-60 = 2 μf
C-61 = 1 μf
C-62 = 100 μμf
C-63 = 2000 μf
C-64 = 736-324
C-65 = 350 μμf

TUBES

V-1 = RCA Type 6C6
V-2 = RCA Type 6C6
V-3 = RCA Type 6C6
V-4 = RCA Type 6K6G
V-5 = RCA Type 6J7
V-6 = RCA Type 6J7
V-7 = RCA Type 6J7
V-8 = RCA Type 6B8
V-9 = RCA Type 6C5
V-10 = RCA Type 6X5G
V-11 = RCA Type 6K6G
V-12 = RCA Type 6F5G
V-13 = } Westinghouse
V-14 = } Type T-4-1/2
V-15 = } Neon Lamp

FUSES

F-1 = 3 amp. }
F-2 = 3 amp. } For 115-volt operation
F-3 = 0.1 amp. }
F-1 = 1.5 amp. }
F-2 = 1.5 amp. } For 230-volt operation
F-3 = 0.1 amp. }

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

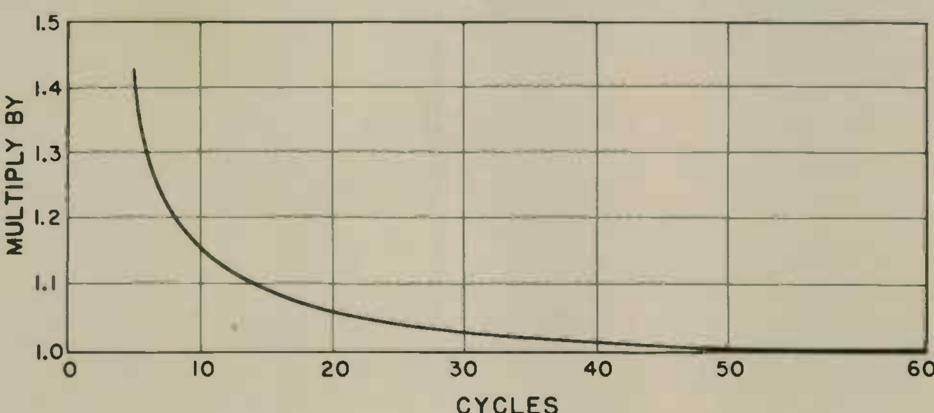

FIGURE 10. Frequency characteristic of the Wave Analyzer

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_{61}, 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_{61} 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

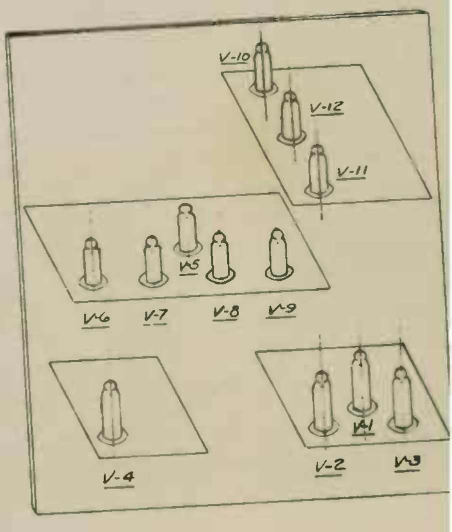

FIGURE 9. Location of tubes

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.

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 a Type 759-A 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.

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 a Type 6C6 used as a phase inverter may influence the setting of R_{17} to a minor extent. (See paragraph 6.13).

6.13 If tubes V-2 and V-3 (Type 6C6) are replaced, the new ones must be balanced with reference to third order coefficients. In order to do this a signal of very pure waveform should be applied to the input. In filtering the output of an audio oscillator to obtain a suitable test signal, an air-core filter should be used. Iron cores may introduce too much distortion. The signal should have a sufficient amplitude to give a full-scale deflection on the meter with the SCALE SWITCH set at 300, and with the analyzer tuned to the fundamental. The analyzer should then be tuned to the second harmonic and R_{17} adjusted for a minimum deflection. It should be less than 0.02% of the previous one. The adjusting screw of R_{17} will be found by removing the small metal cap below the INPUT POTENTIOMETER on the panel.

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. (Perhaps 3% of the tubes tried at the General Radio Company are defective in this respect).

6.15 Occasionally trouble develops in the rectifier portion of V-9 (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. In replacing this tube both of these features should be considered.

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

6.17 Replacement of V-12 may require a readjustment of R_{20}, the potentiometer on the bakelite 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.

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. Westinghouse Type T-4-1/2 are recommended.

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.

SENSITIVITY 6.3 If it becomes impossible to adjust the sensitivity as outlined in paragraph 4.44, resistors R[illegible] and R[illegible] may be changed or one of them removed. These will be found on the socket of V-7 inside the shield of the amplifier shelf. It is not expected that such a change will become necessary.

VOLTMETER ZERO ADJUSTMENT 6.4 In case it becomes impossible to bring the meter to zero by the mechanical knob on the meter, R[illegible] 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, it is recommended that the user communicate with the Service Department, General Radio Company, for instructions. As indicated in paragraph 3.62, serious trouble may result from attempts to modify the curve.

FREQUENCY ADJUSTMENT 6.6 In case by any chance the zero frequency adjustment drifts beyond the range of the FREQ. knob, this may be brought back by adjusting C-23 which will be found on the oscillator shelf.