38789

INSTRUCTION MANUAL

MODEL 315

RESISTOR-NOISE TEST SET

For Serial No.______________

Quan-Tech®
DIVISION OF KMS INDUSTRIES, INC.

43 SOUTH JEFFERSON ROAD WHIPPANY, NEW JERSEY 07981

201-887-5508

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LIST OF ILLUSTRATIONS

ALL SCHEMATICS ARE LOCATED IMMEDIATELY FOLLOWING THE LAST PAGE OF TEXT.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Quan-Tech Laboratories, Inc. warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electronic tubes and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misadjustments, misuse, or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

Calibration checks of this instrument can easily be made in accordance with the instruction manual. Routine readjustments should never be attempted. If, however, the instrument has been damaged and requires recalibration or alignment, explicit calibration procedures as defined in the instruction manual must be followed.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

The instruments should be packed in their original containers, or in a strong exterior container and surrounded by two inches of shock absorbing material.

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MODEL 315
RESISTOR-NOISE TEST SET

GENERAL

The Model 315 is a compact, bench-size instrument for making precise quantitative measurements of excess resistor-noise. The index of measurement is microvolts-per-volt in a decade of frequency, expressed in decibels as recommended by the National Bureau of Standards.*

SPECIFICATIONS

RANGE .... Resistor Test Range — 100 ohms to 22 megohms.

Noise Voltage — 0.6 microvolts in a decade to 1000 microvolts in a decade.

Applied DC Voltage — 3 to 300 volts.

FILTER .... Geometric mean 1000 cycles, flat-topped bandpass.

DETECTOR .... Pure RMS.

OUTPUT .... Indicated for both noise voltage and applied DC voltage on separate panel meters as well as analog outputs for data processing. AC monitor jack included.

ACCURACY OF NOISE VOLTAGE MEASUREMENT .... ±5%.

DIMENSIONS .... 15″ W x 11″ H x 11″ D overall, weight 30 lbs., completely self-contained.

POWER INPUT .... 117/234 volts, 50-60 cycles, 60 watts.

*See: "A Recommended Standard Resistor Noise Test System," G. T. Conrad, Jr., N. Newman, & A. P. Stansbury; I.R.E. Transaction of the Professional Group on Components Parts; Vol. CP-7, No. 3, Sept. 1960. Reprint available from Quan-Tech Laboratories on request.

SECTION 1

OPERATING INSTRUCTIONS

RESISTOR MEASUREMENTS

1. For initial operation of the Resistor-Noise Test Set, plug the power cord into a suitable source of power. Refer to the plate on the rear of the instrument near the power cord for the voltage and frequency for which this instrument is wired. See Section 5 for instructions on how to change the input voltage. Turn the switch to the ON position. Since there are vacuum tubes contained in this instrument, a few minutes warm-up will be required.

2. Insert the resistor to be tested in the test jig, making sure that firm contact is made with the resistor lead. Before closing the top, make sure that the voltage to be applied to the resistor is not excessive.

3. Set RESISTOR RANGE control to the value indicated for the test resistor.

4. Set the FUNCTION switch to CALIBRATE. Close the test jig top and adjust the CALIBRATE ADJUST control until the NOISE meter reads at the CAL line (10 db). Switch the FUNCTION switch to SYSTEM NOISE and note noise reading on NOISE meter. If necessary, adjust METER MULTIPLIER to give an on scale reading.

5. Switch FUNCTION switch to TOTAL NOISE and adjust VOLTAGE ADJUST to appropriate voltage. Typical voltage values can be obtained from Table 1-1.

6. To obtain the Noise Index, microvolts per volt in a decade, merely subtract the dc voltage reading (D) in db from the total noise voltage reading (T) in db. For resistors having small amounts of noise, that is, a small difference between system noise (S) and total noise, a correction factor f(T — S), must be applied. This correction factor may be obtained from the graph in Figure 1-2. Thus the Index = T — [f(T — S)] — D in db.

7. Noise Index in db may be converted to noise voltage in microvolts/volt by referring to Figure 1-1.

DIODE MEASUREMENTS

ZENER DIODES:

1. Turn the instrument on and allow to warm up for a few minutes.

2. Place a short circuit in the test jig, set the FUNCTION switch to CALIBRATE and adjust the NOISE meter to the CAL line (10 db).

3. Set the FUNCTION switch to SYSTEM NOISE and note the NOISE meter reading. (This reading should be somewhat less than —8 db.) Remove the short circuit.

4. Select the appropriate position on the RESISTOR RANGE switch.

Resistor Range	$R_{IS} = R_M +$ R301 + R303	Zener Current
0.1K– < 2.5K	2,600	10- 30 ma
2.5K– < 25K	11,600	3- 10 ma
25K– <250K	100K	0.3- 3 ma
250K– 22M	1 Meg	30-300 μa

5. Calculate the required DC supply voltage, which equals the Zener voltage plus the Zener current times the isolating resistor. $V_{DC} = V_Z + (I_Z \times R_{IS})$ (For example, a 6 volt Zener with 5 ma through it. $6 + [(5 \times 10^{-3}) (11.6 \times 10^3)] = 64$ VDC). *WARNING:* Do not exceed the maximum Zener current for each range to limit dissipation in the isolating resistor.

6. Close the cover and set the FUNCTION switch to TOTAL NOISE. Set the VOLTAGE ADJUST control to the value calculated in Step 5.

7. Insert the Zener Diode in the jig and close the cover. The DC Voltmeter will read the Zener voltage, and the Noise meter the Zener noise. If there is less than 10 db difference from the value noted in Step 3, use the Correction Chart for Presence of System Noise, Figure 1-2, as with resistors.

BACK-BIASED DIODES:

1. Turn the instrument on and allow to warm up for a few minutes.

2. Place a short circuit in the test jig, set the FUNCTION switch to CALIBRATE, and adjust the NOISE meter to the CAL line (10 db). Remove the short circuit.

3. Set the RESISTOR RANGE switch to the 250K-22M position. Set the FUNCTION switch to SYSTEM NOISE, close the test jig cover, and note the NOISE reading (this reading should be somewhat less than 18 db).

4. Set the FUNCTION switch to TOTAL NOISE and set the VOLTAGE ADJUST control to the desired voltage. *NOTE:* The minimum supply voltage in the Model 315 is 20-30 volts.

5. Insert the diode in the test jig and close the cover.

Note the noise reading. If there is less than 10 db difference from the value noted in Step 3, use the Correction Chart for Presence of System Noise, Figure 1-2, as with resistors.

6. If the DC Voltage reading changes from Step 4, it indicates leakage in the diode, which may be calculated as the difference between the two voltage readings through the 1 megohm isolating resistor.

REMOTE OPERATING CABLE, TYPE 1107

This instrument is supplied with a Remote Cable, Type 1107. Extreme care should be exercised when using this cable to prevent errors in noise readings due to extraneous noise or hum pickup or capacitive loading of the signal lead. The cable termination should be properly shielded from both magnetic and electrostatic fields and the signal lead should be provided with a low capacitance interlock switch to prevent the operator coming in contact with the high voltage present when in TOTAL noise position.

When the instrument is used without this remote cable the instrument jack, J302, should be shielded with the shield cover provided.

See Schematics, T-1903 and T-1904, for Remote Cable connections.

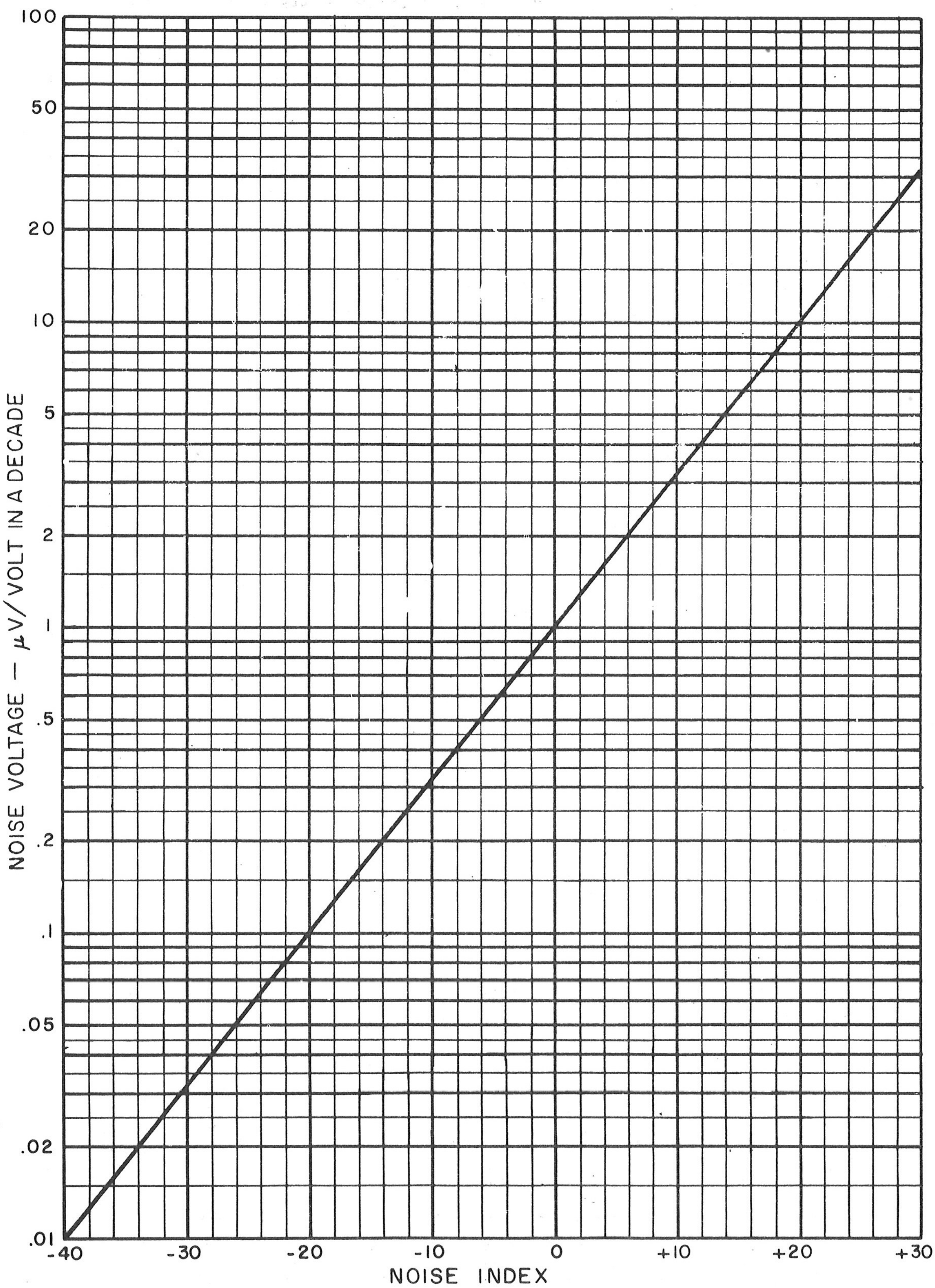


FIGURE 1-1. NOISE CONVERSION GRAPH

TABLE 1-1. RECOMMENDED OPERATING CONDITIONS

		½ watt and High Wattage Ratings			⅛, ¼ and 1/10 Watt Ratings		
R Ω	R_m Ω	(D)* db	V Volts	P_{dc} MW	(D)* db	V Volts	P_{dc} MW
100	1 K	10.1	3.2	100	10.1	3.2	100
120	1 K	11.6	3.8	120	10.9	3.5	100
150	1 K	13.5	4.7	150	11.8	3.9	100
180	1 K	15.1	5.7	180	12.5	4.2	100
220	1 K	16.9	7.0	220	13.4	4.7	100
270	1 K	18.3	8.2	250	14.3	5.2	100
330	1 K	19.2	9.1	250	15.1	5.7	100
390	1 K	19.9	9.9	250	15.8	6.2	100
470	1 K	20.7	10.8	250	16.7	6.9	100
560	1 K	21.4	11.8	250	17.5	7.5	100
680	1 K	22.3	13.0	250	18.3	8.2	100
820	1 K	23.1	14.3	250	19.2	9.1	100
1.0 K	1 K	24.0	15.8	250	20.0	10.0	100
1.2 K	1 K	24.8	17.3	250	20.8	11.0	100
1.5 K	1 K	25.8	19.4	250	21.7	12.2	100
1.8 K	1 K	26.6	21.2	250	22.5	13.4	100
2.2 K	1 K	27.4	23.4	250	23.4	14.8	100
2.7 K	10 K	28.3	26.0	250	24.3	16.4	100
3.3 K	10 K	29.2	28.7	250	25.2	18.2	100
3.9 K	10 K	29.9	31.2	250	25.9	19.7	100
4.7 K	10 K	30.8	34.3	250	26.7	21.7	100
5.6 K	10 K	31.5	37.4	250	27.5	23.7	100
6.8 K	10 K	32.3	41.2	250	28.3	26.1	100
8.2 K	10 K	33.2	45.3	250	29.1	28.6	100
10 K	10 K	34.0	50.0	250	30.1	32.0	100
12 K	10 K	34.8	54.8	250	30.9	35.0	100
15 K	10 K	35.8	61.2	250	31.8	39.0	100
18 K	10 K	36.6	67.1	250	32.5	42.0	100
22 K	10 K	37.4	74.2	250	33.4	47.0	100
27 K	100 K	38.3	82.2	250	34.3	52.0	100
33 K	100 K	39.2	90.8	250	35.1	57.0	100
39 K	100 K	40.0	98.7	250	35.8	62.0	100
47 K	100 K	40.7	108	250	36.7	69.0	100
56 K	100 K	41.5	118	250	37.5	75.0	100
68 K	100 K	42.3	130	250	38.3	82.0	100
82 K	100 K	43.1	143	250	39.2	91.0	100
100 K	100 K	44.0	158	250	40.0	100	100
120 K	100 K	44.8	173	250	40.8	110	100
150 K	100 K	45.8	194	250	41.7	122	100
180 K	100 K	46.5	212	250	42.5	134	100
220 K	100 K	47.5	234	250	43.4	148	100
270 K	1 M	38.6	85.0	26.8	38.6	85.0	26.8
330 K	1 M	40.0	99.0	29.7	40.0	99.0	29.7
390 K	1 M	41.0	112	32.2	41.0	112	32.2
470 K	1 M	42.1	127	34.3	42.1	127	34.3
560 K	1 M	43.1	143	36.5	43.1	143	36.5
680 K	1 M	44.2	161	38.1	44.2	161	38.1
820 K	1 M	45.1	180	39.5	45.1	180	39.5
1.0 M	1 M	46.0	200	40.0	46.0	200	40.0
1.2 M	1 M	46.8	218	39.6	46.8	218	39.6
1.5 M	1 M	47.6	240	38.4	47.6	240	38.4
1.8 M	1 M	48.0	250	34.7	48.0	250	34.7
2.2 M	1 M	48.0	250	28.4	48.0	250	28.4
2.7 M	1 M	48.0	250	23.2	48.0	250	23.2
3.3 M	1 M	48.0	250	18.9	48.0	250	18.9
3.9 M	1 M	48.0	250	16.0	48.0	250	16.0
4.7 M	1 M	48.0	250	13.3	48.0	250	13.3
5.6 M	1 M	48.0	250	11.2	48.0	250	11.2
6.8 M	1 M	48.0	250	9.2	48.0	250	9.2
8.2 M	1 M	48.0	250	7.6	48.0	250	7.6
10 M	1 M	48.0	250	6.2	48.0	250	6.2
12 M	1 M	48.0	250	5.2	48.0	250	5.2
15 M	1 M	48.0	250	4.2	48.0	250	4.2
18 M	1 M	48.0	250	3.5	48.0	250	3.5
22 M	1 M	48.0	250	2.8	48.0	250	2.8

* $D = 20 \log_{10} V$

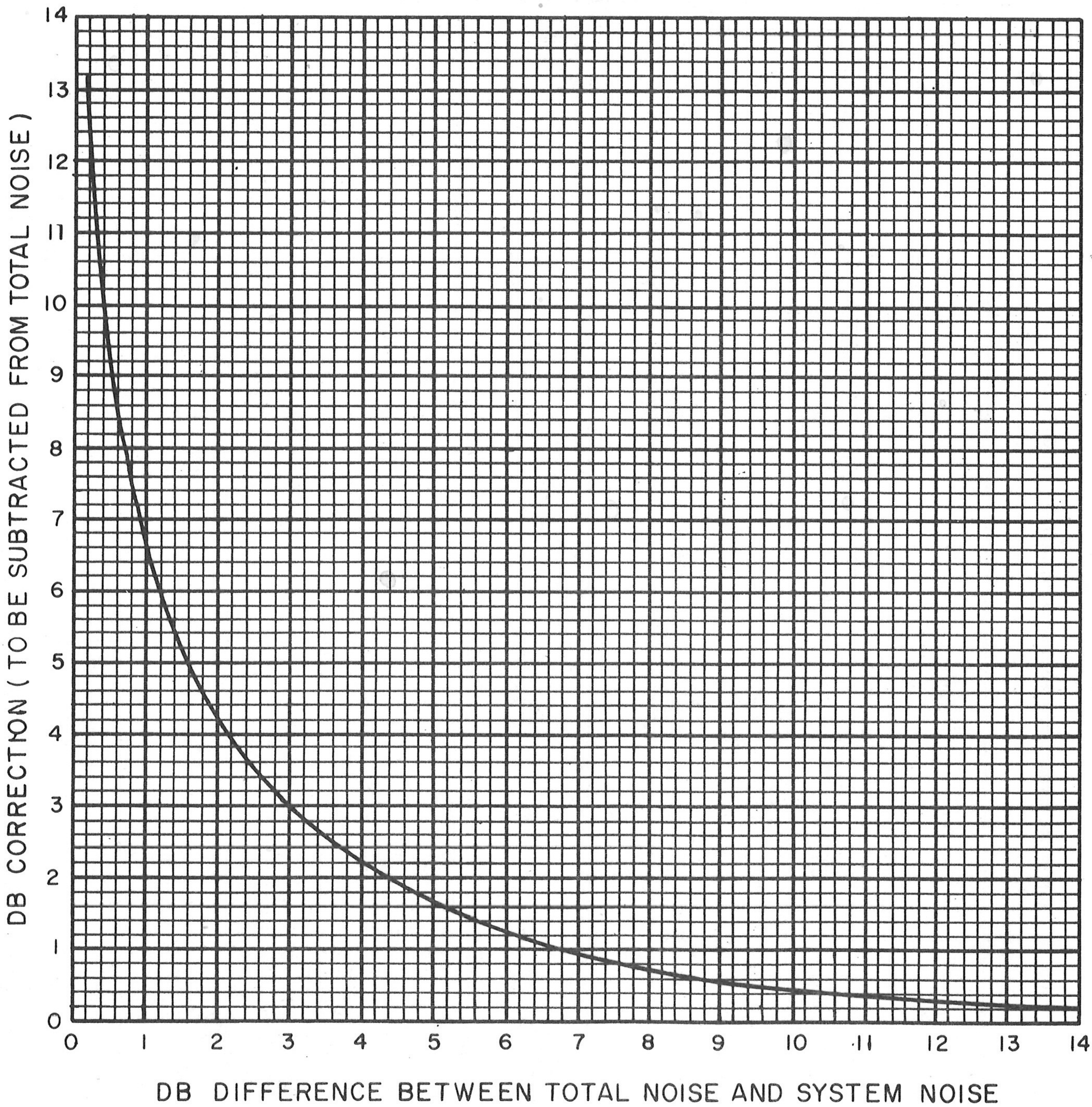


FIGURE 1-2. CORRECTION CHART FOR PRESENCE OF SYSTEM NOISE

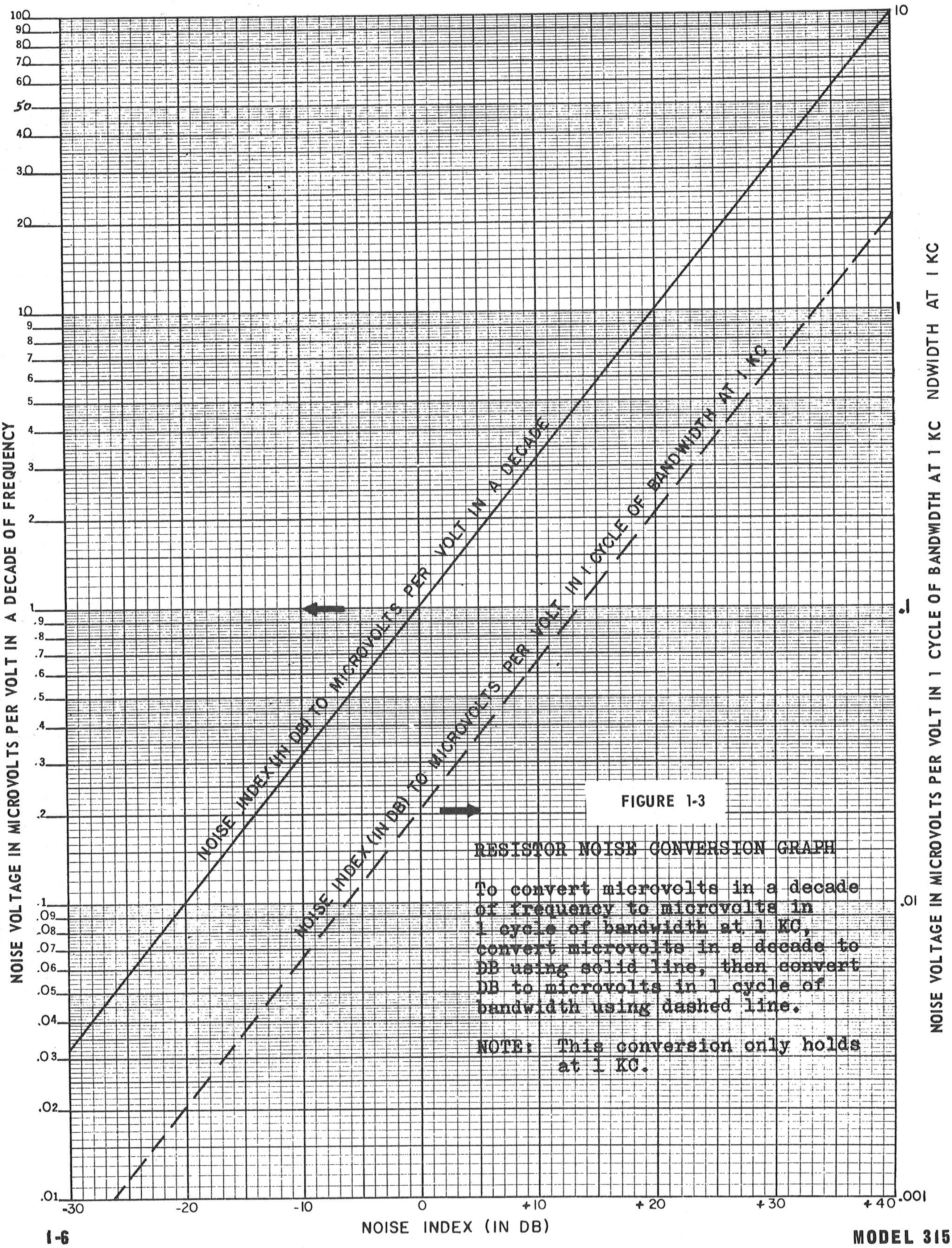


FIGURE 1-3

RESISTOR NOISE CONVERSION GRAPH

To convert microvolts in a decade of frequency to microvolts in 1 cycle of bandwidth at 1 KC, convert microvolts in a decade to DB using solid line, then convert DB to microvolts in 1 cycle of bandwidth using dashed line.

NOTE: This conversion only holds at 1 KC.

SECTION 2

THEORY OF OPERATION

The Model 315 is completely self-contained and requires no accessories for operation. Basically, this instrument serves to measure the increase in noise due to current passing through a resistor.

The simplified block diagram of the system shown in Figure 2-1 illustrates the principles of operation. The dc supply supplies a variable dc voltage from 30 to 450 volts to the test resistor and is isolated by the isolation resistors shown. The dc voltage across the resistor is measured with a vacuum tube voltmeter and the ac noise is amplified, filtered and metered with a thermal type meter. Since the test resistors are of different impedances, calibration of each different value may be made by adjustment of the system gain. Thus, the noise measured is equivalent to that which would come from a 1 ohm generator in series with a test resistor in the same manner as the calibration source.

Figure 2-2 of the detailed block diagram is an elaboration of the simplified diagram and is given in order to simplify servicing and location of parts in the equipment should it be required.

Figure 2-3, Typical Filter, is a plot of the four section Butterworth Bandpass Filter employed in the instrument. Slight deviations (in the order of a few percent) may be found from unit to unit. The filter has been designed with a center frequency of 1000 cycles and having a 1000 cycle bandpass.

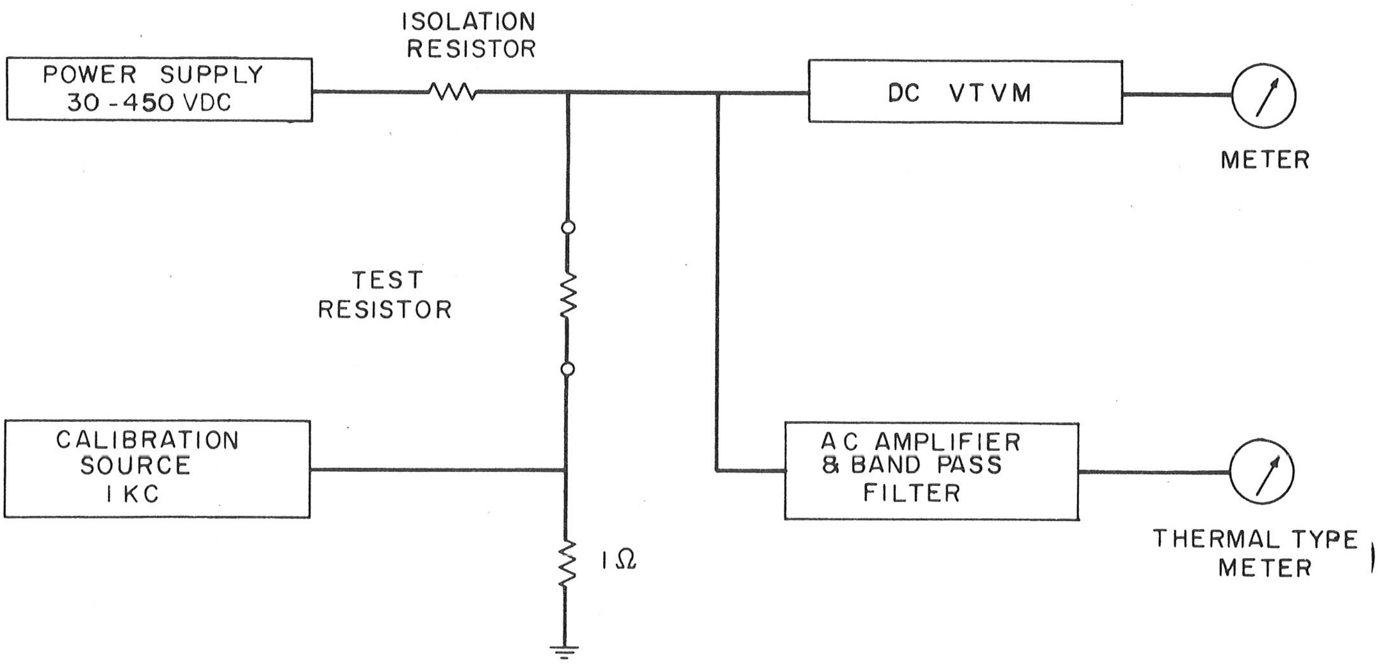


FIGURE 2-1. BLOCK DIAGRAM OF SYSTEM

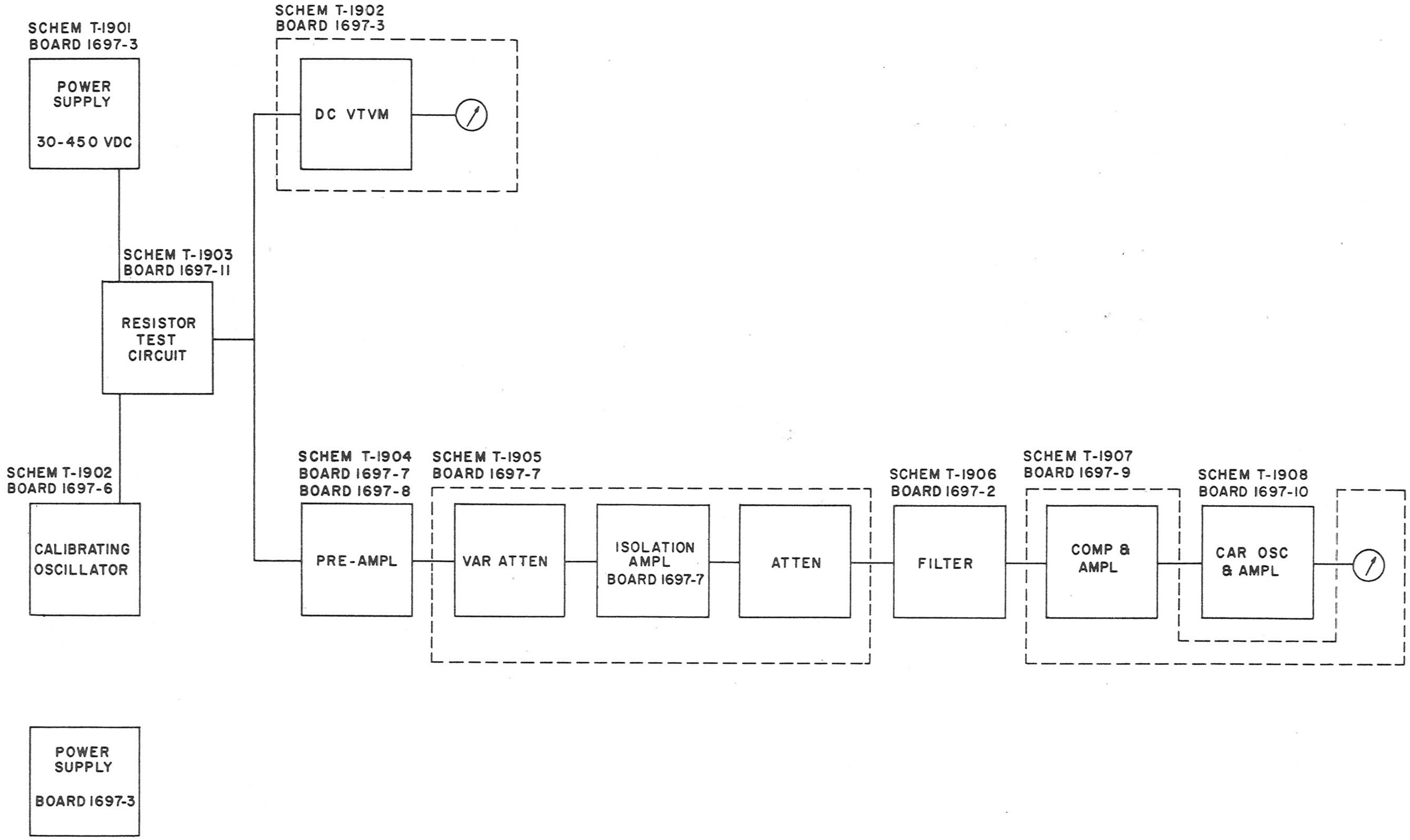


FIGURE 2-2. DETAILED BLOCK DIAGRAM — MODEL 315

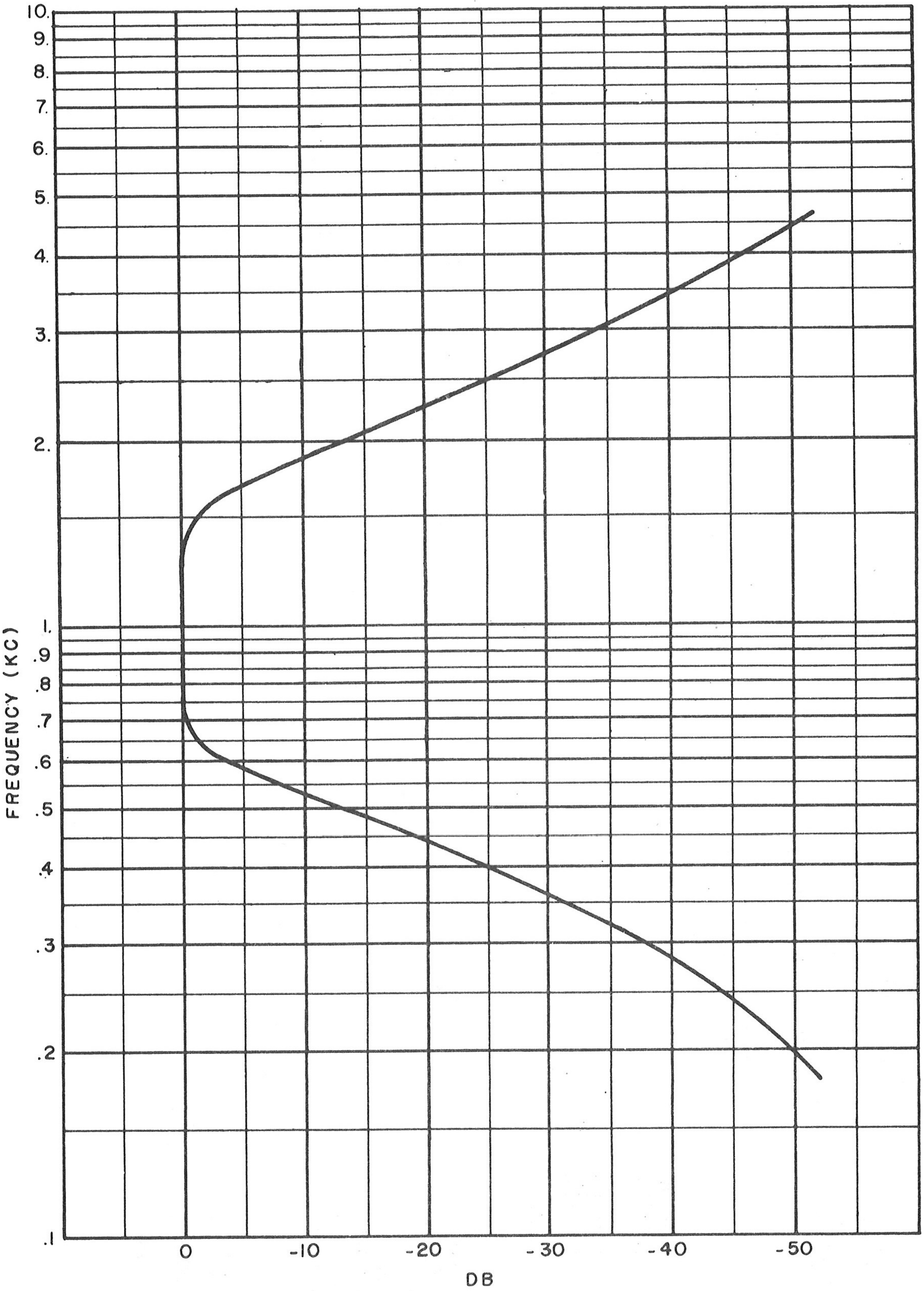


FIGURE 2-3. TYPICAL FILTER

SECTION 3

GENERAL CURRENT NOISE DISCUSSION

The limitation in sensitivity of electronic systems due to noise has been known for over 30 years. Even ideal amplifiers have a threshold determined by the resistance of the signal source. Nyquist's formula, based on the statistical theory of thermodynamics, gives the noise voltage at the terminals of an impedance.

$$\overline{E_{th}^2}^{\,1/2} = (4k\ T\ B\ R)^{1/2} \qquad \text{eq. 1}$$

where $\overline{E_{th}^2}^{\,1/2}$ = rms value of the thermal noise voltage, in volts.
k = Boltzman's constant, 1.38×10^{-23} Joules/degree.
T = Temperature in degrees Kelvin.
B = Bandwidth of measuring system in cycles.
R = Real part of the impedance Z, in ohms.

Although most engineers are experienced with the noise generated in vacuum tubes, few have an understanding of the types or magnitudes of noise generated in other electronic devices such as, transistors and other semi-conductors, electrolytic capacitors, and current carrying resistors. Perhaps one of the least realized, but important source of noise, is that of current carrying resistors.

If current is passed through a resistor, an increase in noise above the thermal noise occurs. In wire wound, and some metal film resistors, this effect is of second order and may not be detectable unless the resistors are faulty. However, in resistors, such as composition, deposited carbon resistors, and certain metal film resistors, the effect is by no means negligible and may exceed the theoretical value by an order of magnitude or more. The use of such noisy resistors in critical points of low level circuits may increase the noise at the input by the same factor.

Unlike thermal noise, which is "flat" or independent of frequency (well into the gigacycle region), resistor current noise has a decreasing power vs. frequency spectrum. The relationship of frequency, dc current, and noise in a resistor is given in the equation,

$$\overline{e\,(f)^2} = C\,I^{\alpha} f^{-\gamma} \qquad \text{eq. 2}$$

where $\overline{e\,(f)^2}$ = Mean square noise voltage per cycle of bandwidth at a frequency f.
C = Constant dependent upon the noise quality of the resistor.
I = dc current in amps.
f = Frequency in cycles.
α = 1.4 to 2.2 dependent upon the resistor, and has a mean value of 1.9.
$\gamma \cong 1.0$.

Thus, for most purposes equation 2 may be written,

$$\overline{e\,(f)^2} = C\,I^2 f^{-1} \qquad \text{eq. 3}$$

showing the $1/f$ characteristics of noise power spectral density.

The resistor current noise for a given bandwidth may be obtained by integration of $\overline{e\,(f)^2}$

$$\overline{E_c^2} = \int \overline{e\,(f)^2}\, df \qquad \text{eq. 4a}$$

Since $\overline{e\,(f)^2} = CI^2 f^{-1}$, then

$$\overline{E_c^2} = \int CI^2 f^{-1}\, df \qquad \text{eq. 4b}$$

$$\overline{E_c^2} = CI^2 \ln f \Big|_{f_1}^{f_2} \qquad \text{eq. 4c}$$

$$\overline{E_c^2}^{\,1/2} = \left[CI^2 (\ln f_2 - \ln f_1) \right]^{1/2} \qquad \text{eq. 4d}$$

or

$$\overline{E_c^2}^{\,1/2} = \left[CI^2 \ln \left(\frac{f_2}{f_1} \right) \right]^{1/2} \qquad \text{eq. 4e}$$

It can be seen from Equation 4e that bandwidths having equal ratios of upper to lower cut-off frequencies, such as octaves or decades of bandwidth, the current noise magnitudes are equal.

SECTION 3 - GENERAL CURRENT NOISE DISCUSSION

The National Bureau of Standards has recommended the unit microvolts per volt in a decade in db as a standard for current noise in a resistor. There are two advantages of this unit; one, the ease of measurement; and two, the familiarity of the terms for the engineer.

The above unit or INDEX is defined as:

$$\text{INDEX} = 20 \log \frac{\overline{E_c^2}^{\,1/2}}{V} \text{ db (in a decade of frequency)} \qquad \text{eq. 5}$$

Therefore equation 4e may be changed to

$$\overline{E_c^2}^{\,1/2} = V\,10^{\text{INDEX}/20}\left(\log \frac{f_2}{f_1}\right)^{1/2} \qquad \text{eq. 6}$$

where $\overline{E_c^2}^{\,1/2}$ = total rms current voltage.
V = dc voltage.
f_1 & f_2 = lower and upper effective bandpass limits.

Since current noise is of a $1/f$ nature, its effect will be masked by thermal noise at higher frequencies. In practice, this is usually true above 100 kc. Both thermal noise and current noise have a Gaussian or normal voltage amplitude distribution. Since their sources are independent they may be added as shown,

$$\overline{E_{Total}^2}^{\,1/2} = \left[\overline{E_c^2} + \overline{E_{th}^2}\right]^{1/2} \qquad \text{eq. 7}$$

Figure 3-1 shows the noise spectral density as a function of frequency of a typical 10 K ½ watt resistor with 20 volts dc applied.

This resistor has a current noise INDEX of approximately −10 db (0.3 μv/v in a decade). It has been found from the evaluation of a large quantity of composition resistors that nearly all fall in the range of 0.1 to 10 μv/v in a decade of current noise.

We may add the noise in decades in an r m s fashion. That is, for 2 decades of $1/f$ noise we have $\sqrt{2}$ times as much noise voltage, and for 3 decades $\sqrt{3}$ times as much. It should be pointed out that we have not added equal bandwidths but equal percentage bandwidths. Thus, for bandwidths other than one decade equation 6 must be used.

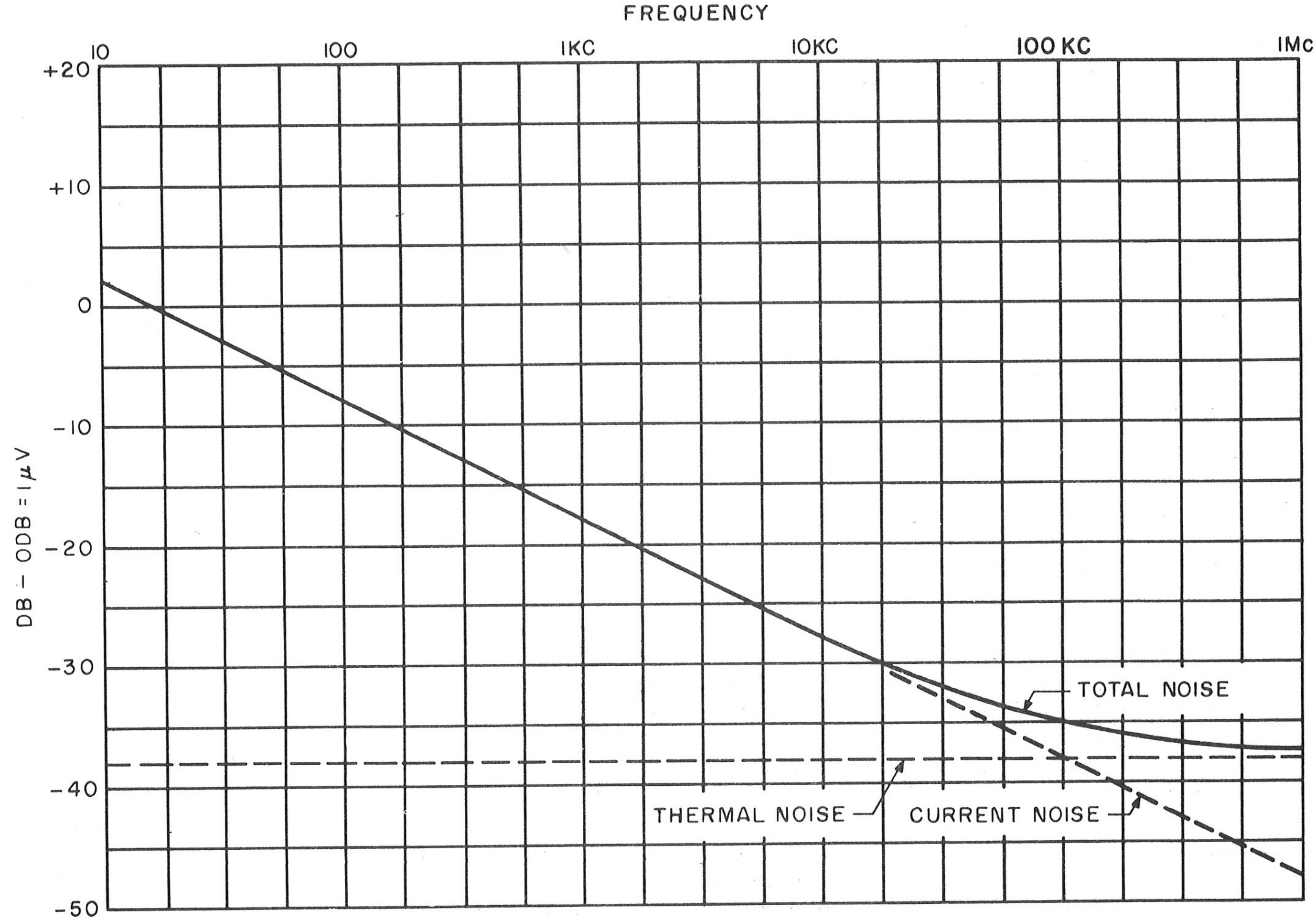


FIGURE 3-1. NOISE VOLTAGE SPECTRAL DENSITY 10K OHM COMPOSITION RESISTOR, 20 VDC

SECTION 3 - GENERAL CURRENT NOISE DISCUSSION

APPLICATIONS:

In order to apply the Index of current noise of a resistor in circuit design one must know the Index, the voltage and the position in the circuit. Let us look at a few practical applications of this noise. Since composition resistors of reasonable quality have an Index reasonably close to 0 db in a decade, we can see that the current noise voltage is more a function of the applied dc voltage than of the value of the resistor.

Assume a 10 K resistor has an Index of 0 db. This resistor will appear as a noise generator of 10 K impedance and for every volt of dc applied to its terminals the generator will develop 1 µv of current noise in one decade of bandwidth, or, in a bandwidth from 10 cycles to 10 kc (three decades) 1.73 µv/v of noise. For ten volts dc it would generate 17.3 µv of noise. By comparison, the thermal noise over the same bandwidth would be 1.25 µv. If this resistor were the bias resistor of a transistor input stage as shown in Fig. 3-2(a) the noise would be 14 times the theoretical minimum.

The effects of current noise are quite noticeable even in the plate circuits of vacuum tube amplifiers, and to a lesser extent in transistor collector circuits. The 100K resistor in Fig. 3-2(b) having a noise Index of 0 db and 100 volts applied voltage would result in approximately 5.5 µv of noise equated to the input, or an equivalent input resistance of 0.16 megohms. In this application negative feedback would reduce the noise in proportion to the feedback.

Similar results will be found in operational amplifier feedback, resistors, power supply references, servo loops, etc.

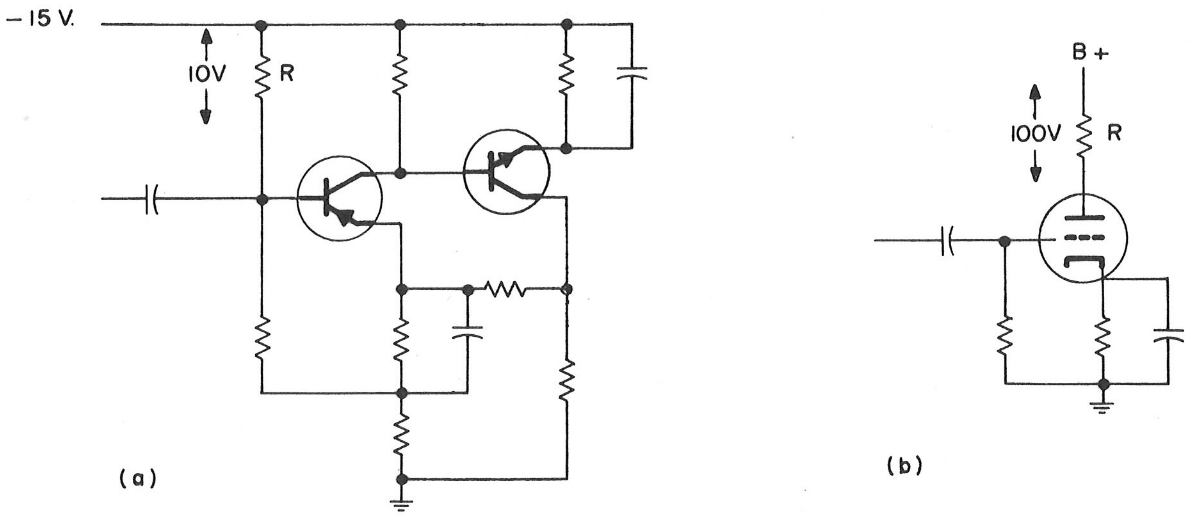


FIGURE 3-2. TYPICAL RESISTOR CURRENT NOISE SOURCES

SECTION 4
CIRCUIT ANALYSIS

POWER SUPPLY
(Board No. 1697-3) (Schematic T-1901)

The power supply shown on Schematic T-1901 supplies all regulated dc for the instrument. The reference for these supplies is the Zener Diode CR112. Transistors Q104, Q105, Q106 and Q107 form a double differential amplifier. Q106 drives the base of Q103 which is the pass transistor and supplies —26 volts for the transistor amplifiers, filters, measuring circuit and the filaments of all vacuum tubes except V101. Q101 and Q102 function as a sub-supply for +26 volts used in the vacuum tube voltmeter. The reference for this sub-supply is formed by the voltage divider network R103 and R117. The variable output voltage (+30 to +450 volts) is obtained from V101 and is varied by R107 which in conjunction with R106 and R127 form a voltage divider and obtains its reference from the CR112. Q109 and Q108 form an emitter coupled amplifier to drive V104, and in turn V101. The +300 volt and +150 volt output obtained from V102 and V103 supply voltage for the vacuum tube voltmeter and preamplifier tubes respectively.

VACUUM TUBE VOLTMETER
(Board No. 1697-3) (Schematic T-1902)

The vacuum tube voltmeter design consists of a balanced pair of tubes V202 and V203. The meter multiplier attenuator merely acts as a shunt at the grid and is in series with the 8 megohm resistor found in the resistor test circuit schematic. V201 is a protective diode to clamp severe overloads and keep them from reaching the transistorized portion of the circuit. Q201 and Q203 act as grounded collector impedance converters. Q202 operates as a differential detector and drives the output meter and dc analog output. The meter is adjusted to read full scale for 10 volts at the analog output.

CALIBRATING OSCILLATOR
(Board No. 1697-6) (Schematic T-1902)

The calibrating oscillator consists of a single transistorized transformer coupled oscillator with a resonant tank in the collector circuit. The magnitude of oscillation is controlled from the base tie point and may be adjusted over narrow limits by R221. The magnitude of the 1000 cycle signal at the output to the test circuit should be 650 microvolts. The calibrating oscillator circuit is separately regulated by CR204.

RESISTOR TEST CIRCUIT
(Schematic T-1903)

The sensitive portion of the resistor test circuit is enclosed in an iron shield below the chassis, and the position of leads in this area is critical.

PRE-AMPLIFIER
(Board No. 1697-7) (Schematic T-1904)

The entire Pre-Amplifier is doubly shielded, and well filtered supplies are included. The amplifier consists of Q404 operating as a source follower which is used on all ranges except the 0.1 K – 2.5 K range. Here the FET is by-passed to obtain lower system noise using the transistor input directly.

ISOLATION AMPLIFIER AND ATTENUATOR
(Board No. 1697-7) (Schematic T-1905)

The purpose of the isolation amplifier is to provide isolation and gain between the variable gain adjust (CALIBRATE ADJUST) and the meter multiplier attenuator. It consists of a PNP-NPN-PNP feedback triple and has a gain of approximately 150.

FILTER AMPLIFIER
(Board No. 1697-2) (Schematic T-1906)

The filter consists of a 4 section Butterworth filter, and each filter section operates essentially in the same manner. The output impedance of each transistorized amplifier in the filter is quite low, and the input impedance is determined by the base biasing resistors of each section. The Q of each of the filter resonant sections is determined by the respective base biasing resistors. Thus, each section of the filter is isolated from the other, and gain is obtained without overload due to interference.

MEASURING CIRCUIT

Compressor and Amplifier (Board No. 1697-9) (Schematic T-1907)

Carrier Oscillator and Amplifier (Board No. 1697-10) (Schematic T-1908)

The entire meter amplifier consists of an input voltage amplifier Q701 and Q702, volume compressor CR701, CR702, CR703, CR704 and Q703, a power amplifier Q704, Q705, Q706 and Q707, a hot wire element R729 and a level detector. The principle of operation of this part of the circuitry is to provide the hot wire element R729 with a constant average amplitude signal. This signal results in heating of the resistive element. The resistance due to heating of the element is then detected by measuring the magnitude of a 100 KC carrier signal which is supplied to the hot wire element by Q803. Q802, Q801 amplify the carrier signal across the hot wire element. This signal is rectified by CR801 and CR802. A threshold detector and amplifier consisting of Q709 and Q708 amplify the error signal between the reference threshold (adjustable by R735) and in turn control the volume compressor to maintain a constant amplitude signal again at R729, the hot wire element. This signal should be in the order of 2 volts.

SECTION 5

MAINTENANCE AND CALIBRATION

The components and transistors in the Model 315 are conservatively rated and should provide long and trouble free service. If, however, the instrument has been damaged and recalibration or alignment is required, the following instructions should be followed explicitly, or the instrument returned to the factory. Instructions are given on the Warranty page for the procedure to be followed should it be desired to return the instrument for any reason.

Although the Model 315 is a complex instrument, trouble shooting can readily be done in sections as indicated in the Block Diagram, Fig. 2-2.

Do not change any adjustments without a thorough knowledge of the circuit and the functions of the adjustment.

Standard transistor servicing care should be used throughout. Transistors can be easily damaged with large transient voltages. Therefore, take great care not to short any terminals when making measurements on the printed-circuit boards.

In soldering to the printed-circuit boards, have the iron only hot enough to make a rapid clean solder joint. DO NOT use a solder gun. DO NOT apply any force that would tend to push the copper away from the board.

REMOVAL FROM CASE

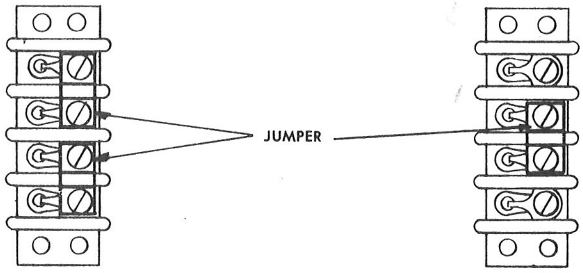
1. Remove the four (4) feet and the two (2) binder head screws from the bottom of the case.
2. Slide the instrument gently out of the front of the case.

CHANGING INPUT VOLTAGE

This instrument has been designed to operate from a 117 V.A.C. or a 234 V.A.C. power source. The plate on the rear of the instrument near the power cord indicates the voltage and frequency at which the instrument should be operated.

Should it be desired to change the input voltage,

1. Remove the instrument from the case.
2. Change the transformer primary connections by moving the jumpers on the 4 terminal barrier strip located near the power cord (See Figure 5-1).
3. Change the fuse. For 117 V.A.C. operation, the fuse should be $\frac{3}{4}$ Amp. Slow Blow; for 234 V.A.C. operation the fuse should be $\frac{3}{8}$ Amp. Slow Blow.
4. Reverse the plate located near the power cord to read the correct voltage.



For 117 V.A.C. operation   For 234 V.A.C. operation

FIGURE 5-1. INPUT VOLTAGE BARRIER STRIP

CALIBRATION

Before alignment is attempted the operator should become familiar with the Theory of Operation of this instrument, see Theory of Operation, Section 2, then proceed as follows:

POWER SUPPLY

CAUTION: The power supply contains high voltages.

1. —26 Volt Supply

a. Remove the 807 tube (V101).

b. Apply power and adjust R114 to obtain —26 Volts relative to ground on Pin #4, V104 (Board No. 1697-3).

c. Adjust R110 for minimum ripple and best regulation to line voltage variations.

d. Re-adjust R114 to again obtain —26 Volts.

2. +26 Volt Supply

a. Measure the +26 Volt supply at Pin #7, V104. The voltage will normally be between +25 to +27.5 volts.

b. No adjustment is provided, but the voltage may be changed by modification of R117A if necessary.

3. +150 and +300 Volt Supplies

a. Measure the VR regulated supplies. These voltages should be approximately +300V on Pin #5 of V102 and +150V on Pin #5 of V103.

CAUTION: *DO NOT* operate the power supply with any but the 807 tube (V101) removed.

4. Heater Voltages

a. Measure the heater voltage on Pins #4 and #5 of the 5879 tubes, V104, V201, V202 and V203. Heater voltage should be between 6VDC and 7VDC. These tubes are connected in series, and a faulty heater on one will effect all others in the string.

5. V101 Supply

a. Measure the screen and plate voltage of the 807 tube socket and cap with the tube *removed* from the socket. Plate voltage should be +550V to +700V with respect to ground. Screen voltage Pin #2 should be approximately +170V with respect to the cathode (Pin #4).

6. Variable +30 to +450 Volt Supply

a. *Remove power* and insert the 807 tube (V101).

b. Set the VOLTAGE ADJUST control (R107) approximately ⅔ clockwise.

c. Apply power and check the control of the variable regulated voltage as measured at the 807 tube cathode (Pin #4) and ground.

d. With the VOLTAGE ADJUST control full clockwise, the voltage should normally be between 470V to 480V. R127 may be selected to adjust this maximum voltage.

D.C. VACUUM TUBE VOLTMETER

CAUTION: *DO NOT* operate the power supply with any of the 5879 tubes removed.

1. V202 - V203 Balance

a. Ground the input to V202, (Pin #1), and connect a DC voltmeter, 3V range, to the DC ANALOG OUT PUT jack (J201).

b. Select a pair of 5879 tubes for V202-V203 to indicate zero voltage with R216 (Front panel screw driver adjust pot) near the center of its range.

c. A DC voltmeter connected between the cathodes of V202 and V203 (Pins #3) should also indicate zero voltage.

2. DC Voltmeter Calibration

a. Insert a resistor (approx. 470 ohms 2 watt) in the resistor test jig, set the VOLTAGE ADJUST control to minimum setting, and set the METER MULTIPLIER Switch to 0 DB position.

b. Connect a DC voltmeter across the resistor and with the door interlock switch energized set the voltage to 10V. The FUNCTION switch must be in the TOTAL NOISE position in order to obtain a voltage at the resistor terminals.

c. Adjust R207 to obtain 10V dc at the DC ANALOG OUTPUT jack (J201).

d. Switch the voltage METER MULTIPLIER Switch to the +20 DB position and re-adjust the front panel screwdriver adjust control (R216) for an indication of 1V at the DC ANALOG OUTPUT jack (J201).

e. Repeat Para. c & d above until 10V and 1V at J201 is obtained for 0 DB and +20 DB METER MULTIPLIER positions.

f. With 10V present at J201 as above, adjust R210 for 10V indication on DB-VOLTS meter (M201).

g. As some interaction is present in the above adjustments of R210, R207 and R216, the above calibrating sequence must be repeated until 10V at J201 and 10V meter indications are obtained for the 0 DB position of the METER MULTIPLIER Switch (S201) and 1V at J201 and 1V meter indication for the +20 DB position of the METER MULTIPLIER Switch (S201).

h. Remove the 470 ohm resistor from the test jig and check the meter calibration at 100V for the +20 DB position of the METER MULTIPLIER switch and 400V for the +40 DB position of the METER MULTIPLIER switch increasing the VOLTAGE ADJUST control as necessary to obtain the above voltages.

i. Insert a 1.2 megohm resistor in the test jig and with the VOLTAGE ADJUST control at the maximum voltage setting and the RESISTOR RANGE switch (S304) in the 250K - 22M position, the voltmeter should indicate at least 218V (46.8 DB).

CALIBRATING OSCILLATOR

1. Calibration

a. Using a shielded cable and sensitive vacuum tube voltmeter, measure the level of the 1000 cycle calibrating oscillator at the CAL. jack (J301).

b. Adjust this level to 650 microvolts by means of R221 (access to this adjustment may be made through the hole in the side of the chassis).

1 KC FILTER

1. Bandwidth

a. Connect an audio oscillator, approximately 1V at 1000 cycles to the CAL. jack (J301), with the METER MULTIPLIER in the +40 DB position, and the FUNCTION switch in the SYSTEM NOISE position.

b. With a short circuit in the test resistor jig, set the CALIBRATE ADJUST control to obtain a 500 microvolt signal at the input to Q601 as measured with a VTVM. Connect the VTVM to the output of the filter at C614 and measure the flatness of the filter and —3 DB bandwidth.

c. The —3 DB points should normally occur at 618 cycles and 1618 cycles. The band top will normally be flat ±2% over approximately 500 cycles.

d. The bandwidth and bandpass shape are determined by the "Q" adjustments R611, R623, R635 and terminating resistor R645.

METER AMPLIFIER

1. Calibration

a. With a short circuit in the resistor test jig, the FUNCTION switch in the CALIBRATE position, the CALIBRATE ADJUST control full counterclockwise to the minimum gain position, adjust R706 to obtain approximately 260 millivolts RMS at the NOISE jack (J701).

b. Increase the CALIBRATE ADJUST control to obtain 1.00V RMS at the NOISE jack (J701).

c. With the calibrating signal level as in paragraph b, adjust R735 to obtain 10V DC at the NOISE ANALOG jack (J702).

d. With the calibrating signal level as in paragraph b, adjust R716 until the NOISE meter indicates 20 DB.

INTERNAL NOISE

1. System Noise

a. With a short circuit in the resistor test jig, the FUNCTION switch in the CALIBRATE position, set the CALIBRATE ADJUST control for a NOISE meter indication of 10 DB (CAL mark).

b. Switch to SYSTEM NOISE. Residual noise will normally be below −15 DB. (A meter indication of ~~12~~ 5 DB with the METER MULTIPLIER switch in the —20 DB position.)

c. Remove the short circuit from the resistor test jig. With the RESISTOR RANGE switch in the 0.1-2.5 K position, the system noise will normally increase 5 to 7 DB.

d. Switch to the 2.5-25K position. The system noise will normally be between —3 and —1 DB.

e. Switch to the 25K-250K position. The system noise will normally be between 5.5 DB and 7.5 DB.

f. Switch to the .250K-22M position. The system noise will normally be between 14 DB and 18 DB.

2. Current Noise

a. Measure resistor current noise for the following values of *good* wire wound resistors (See operating instructions).

1K at 16V DC
10K at 50V DC
100K at 160V DC
1 Meg. at Maximum voltage

b. No increase over system noise will normally be observed.

SCHEMATIC LEGEND

K = 1000

⊘ = Screw Driver Adjustment

☐ = Front Panel Control

* = Factory Select

Unless Otherwise Specified:

All Resistances in Ohms

All Resistors ½ Watt

All Capacitances in Microfarads

SEMICONDUCTOR LEGEND

Changes and improvements in the semiconductor products available for commercial use necessitate type changes from time to time. To eliminate confusion and costly paperwork, many of these changes will be covered in the following legend. The purpose of this legend is to acknowledge the fact that the type number on a semiconductor found in a piece of equipment will not necessarily correspond with the type number given on the schematic diagram.

The legend is not intended to be an interchangeability list although in many cases good quality components* within a given category may be substituted with acceptable results. Normally, replacements should be made using components having the same type number as the component being replaced.

Those components bearing an asterisk on the schematic diagram are factory selected components and should be obtained from Quan-Tech Laboratories.

*It should be noted that the incoming inspection procedure followed at Quan-Tech Laboratories includes noise screening on most semiconductors.

TYPE # ON SCHEMATIC	TYPE # IN EQUIPMENT
T1480	2N1613
T1494	2N1613
1N703	1N748
1N709	1N753
1N2859	1N3253, 1N3254
1N2862	1N3254
1N482A	1N3604
1N3253	75A4
1N3254	75A4
2N396A	4JX1G759, 4JX1D653, 2N3644
2N414	2N396A, 4JX1G759, 4JX1D653, 2N3644
2N929	2N0N2, A642, 2N3566, A322, A324
2N1515	2N3644
2N1613	2N3566, 2N3643
2N2219	220N2, A642, 2N3566, A322, A324
2N2603	2N3250
2N3250	2N3644
2N270	2N3644
2N1306	2N3566
2N1304	2N3566
2N3250	2N3251
UC240	2N4869, 2N3819
2N3644	2N3250, 2N3251
2N3566	2N3643

SCHEMATIC LEGEND

k = 1000

⊘ = Screw Driver Adjustment

▭ = Front Panel Control

* = Factory Select

Unless Otherwise Specified:

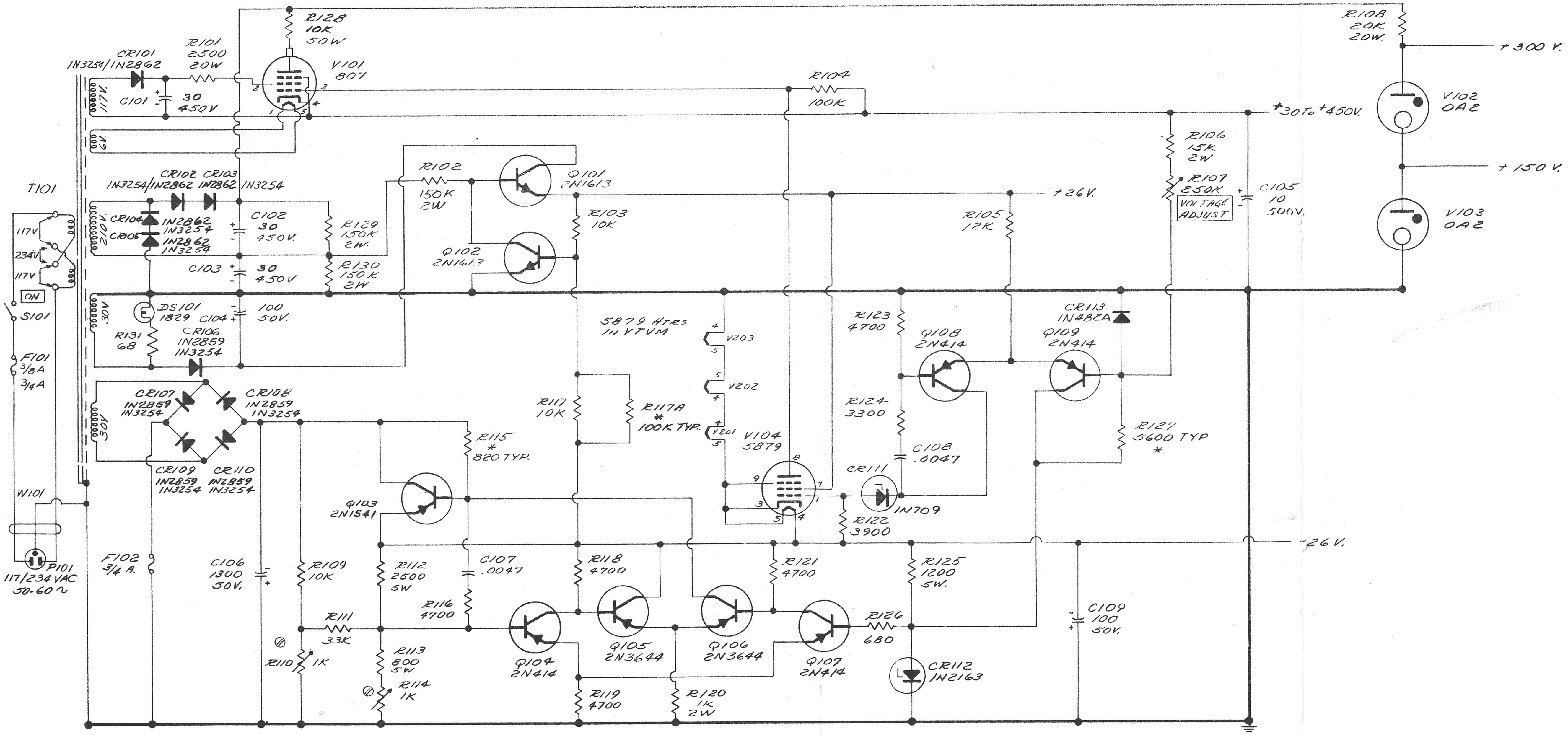
All Resistances in Ohms

All Resistors 1/2 Watt

All Capacitances in Microfarads

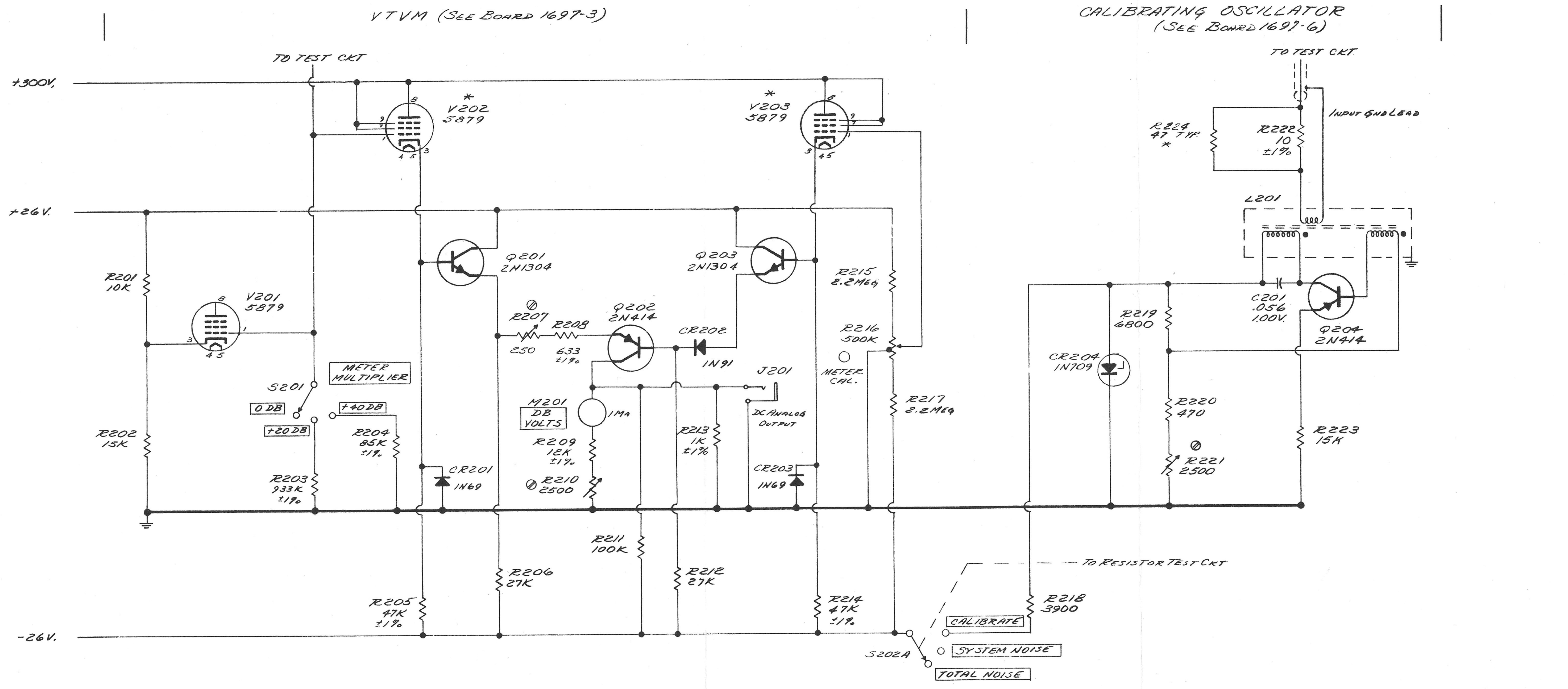
8/20/69

POWER SUPPLY (SEE BOARD 1697-3)



MODEL 315
SCHEMATIC
POWER SUPPLY

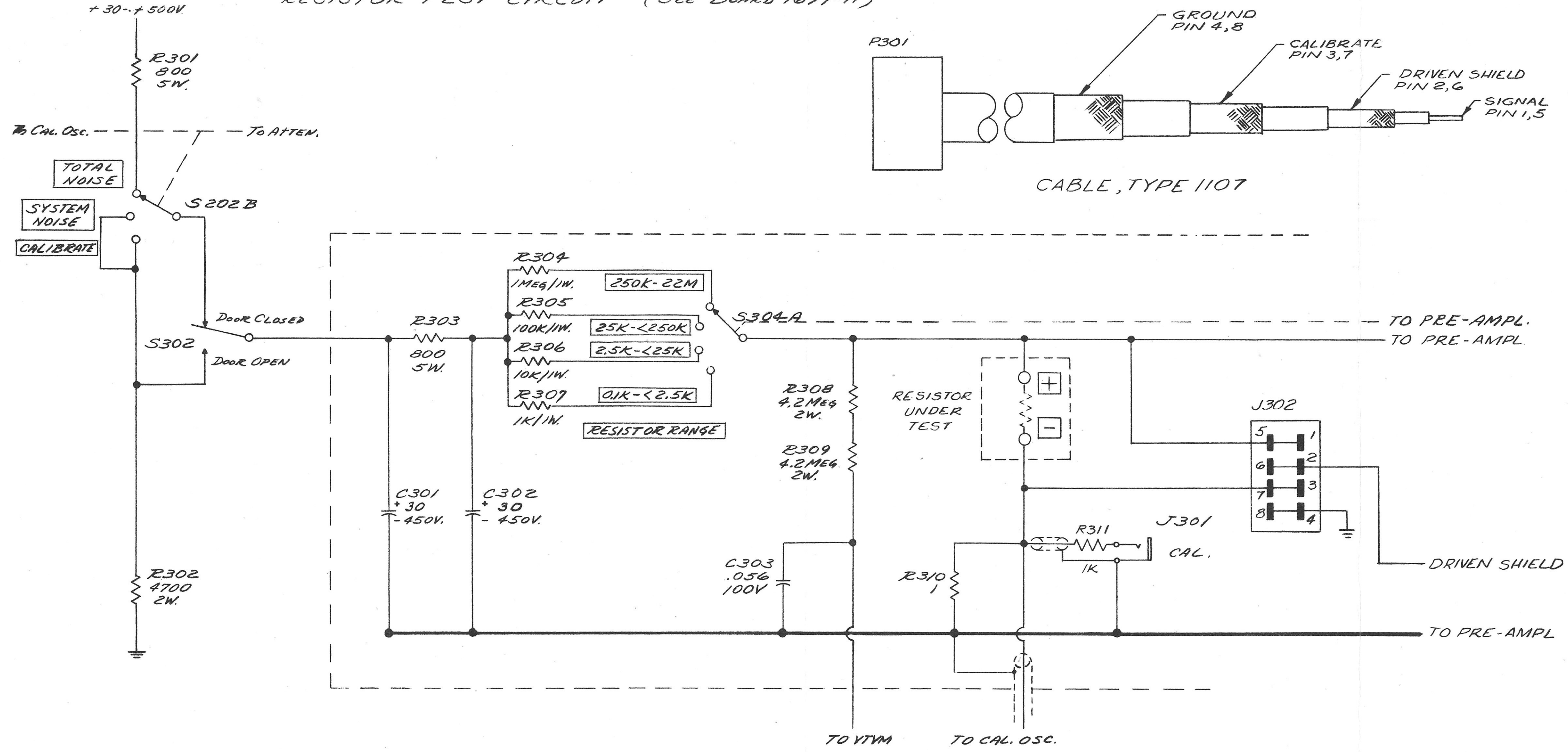
T-1901-S



MODEL 315
SCHEMATIC
VTVM
CALIBRATING OSCILLATOR

T-1902-F

RESISTOR TEST CIRCUIT (SEE BOARD 1697-11)

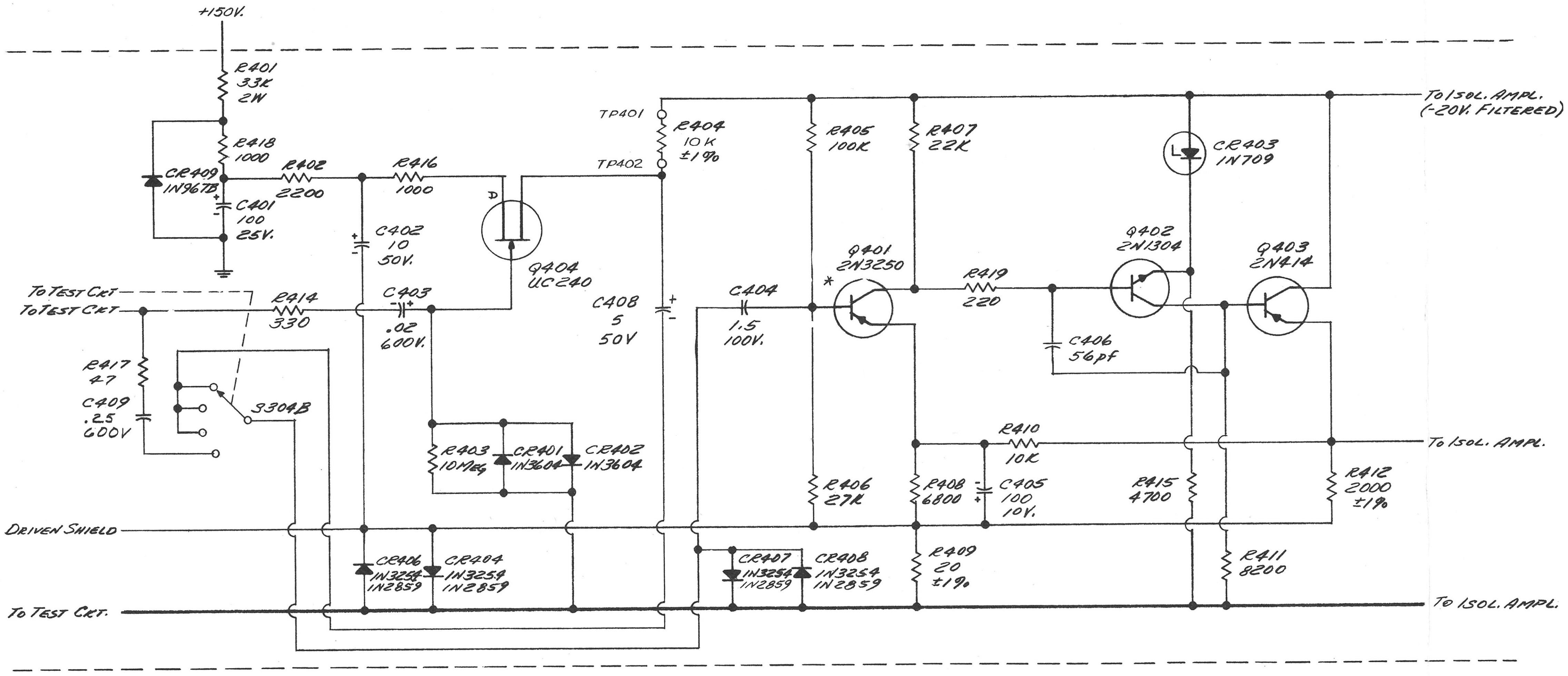


-10.5
10.
24
44.5

MODEL 315
SCHEMATIC
RESISTOR TEST
CIRCUIT

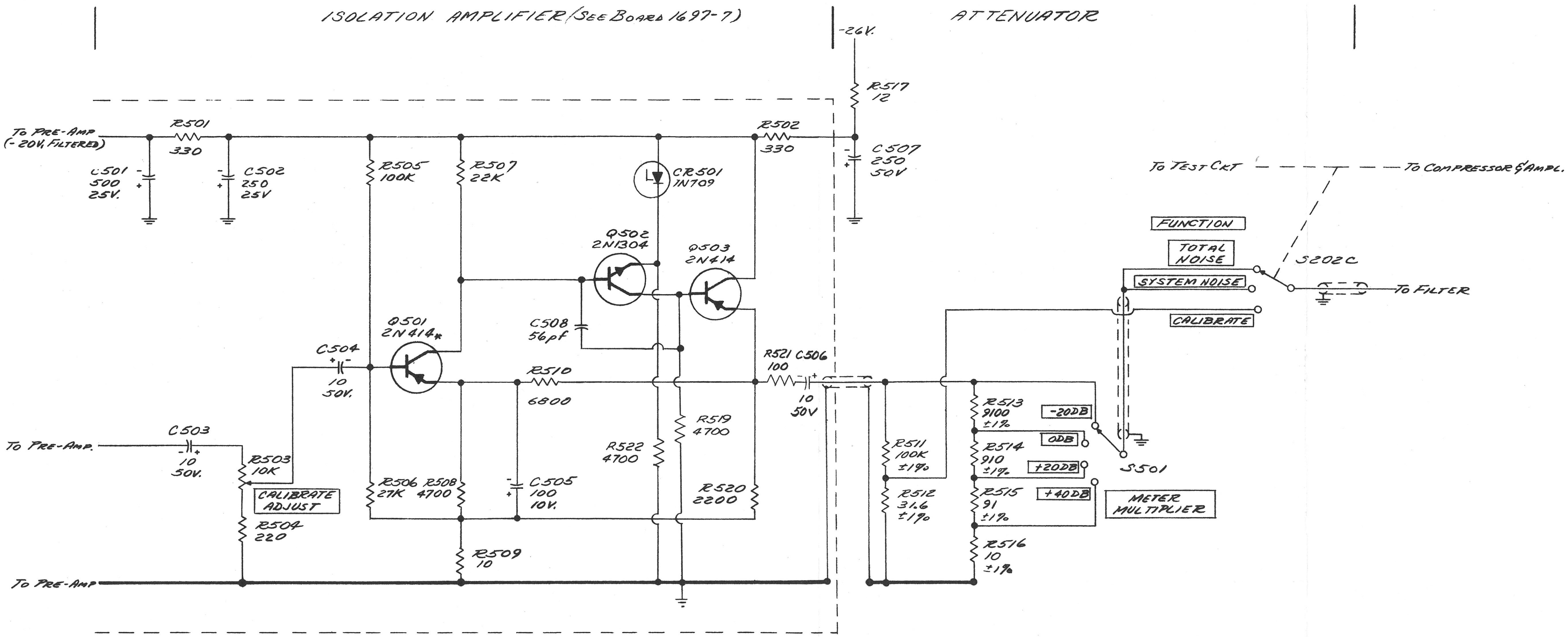
T-1903-G

PRE - AMPLIFIER (SEE BOARD 1697-7)



MODEL 315
SCHEMATIC
PRE-AMPLIFIER

T-1904-Q



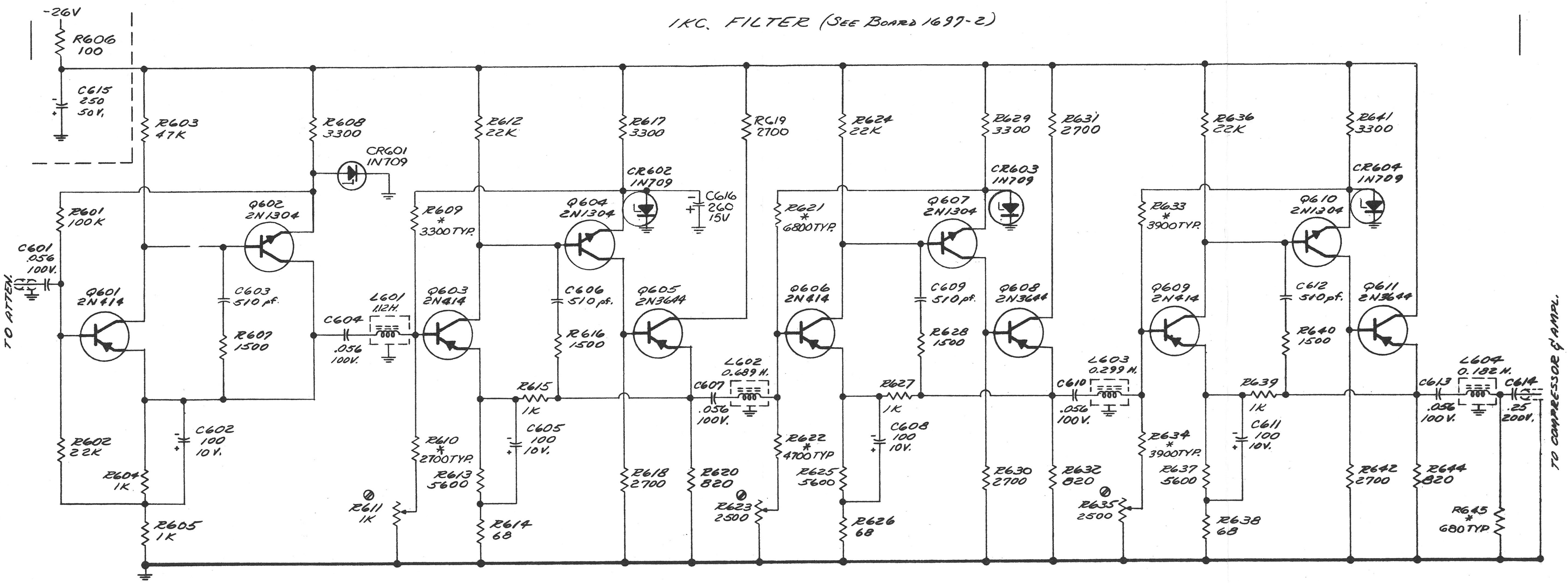
MODEL 315

SCHEMATIC

ISOLATION AMPLIFIER

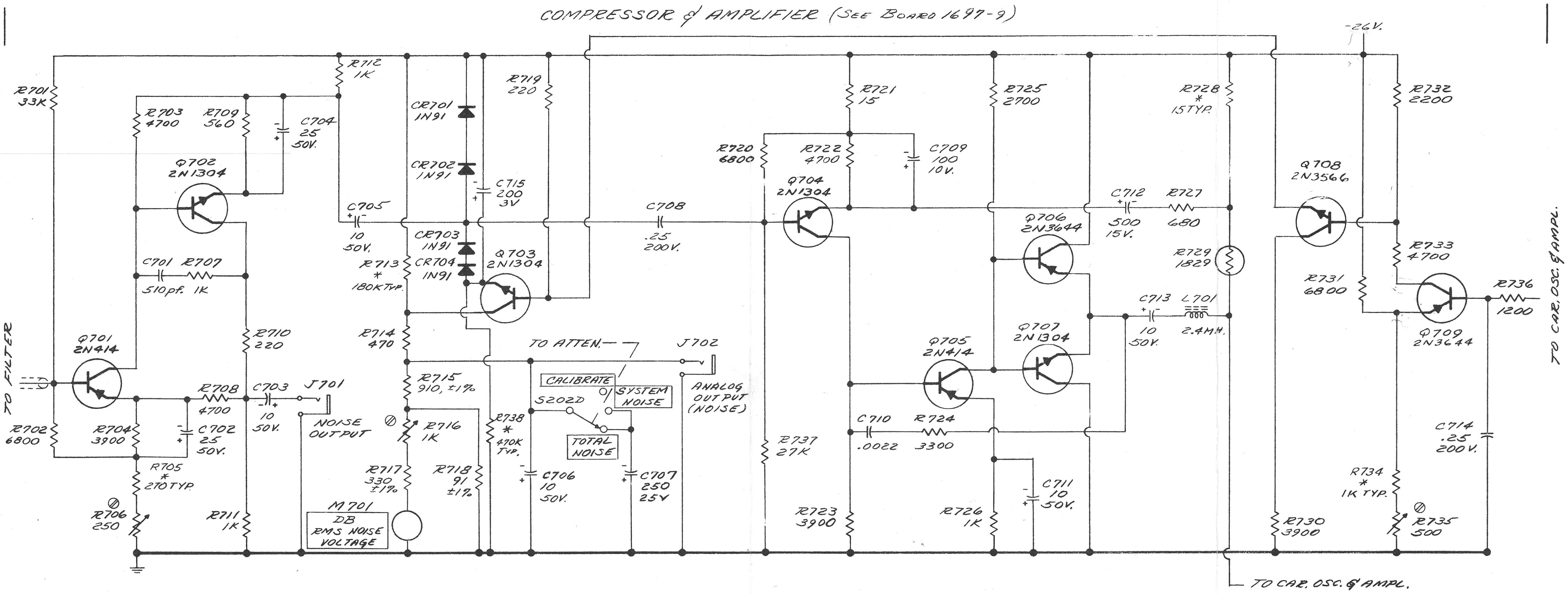
ATTENUATOR

T-1905-M



MODEL 315
SCHEMATIC
FILTER

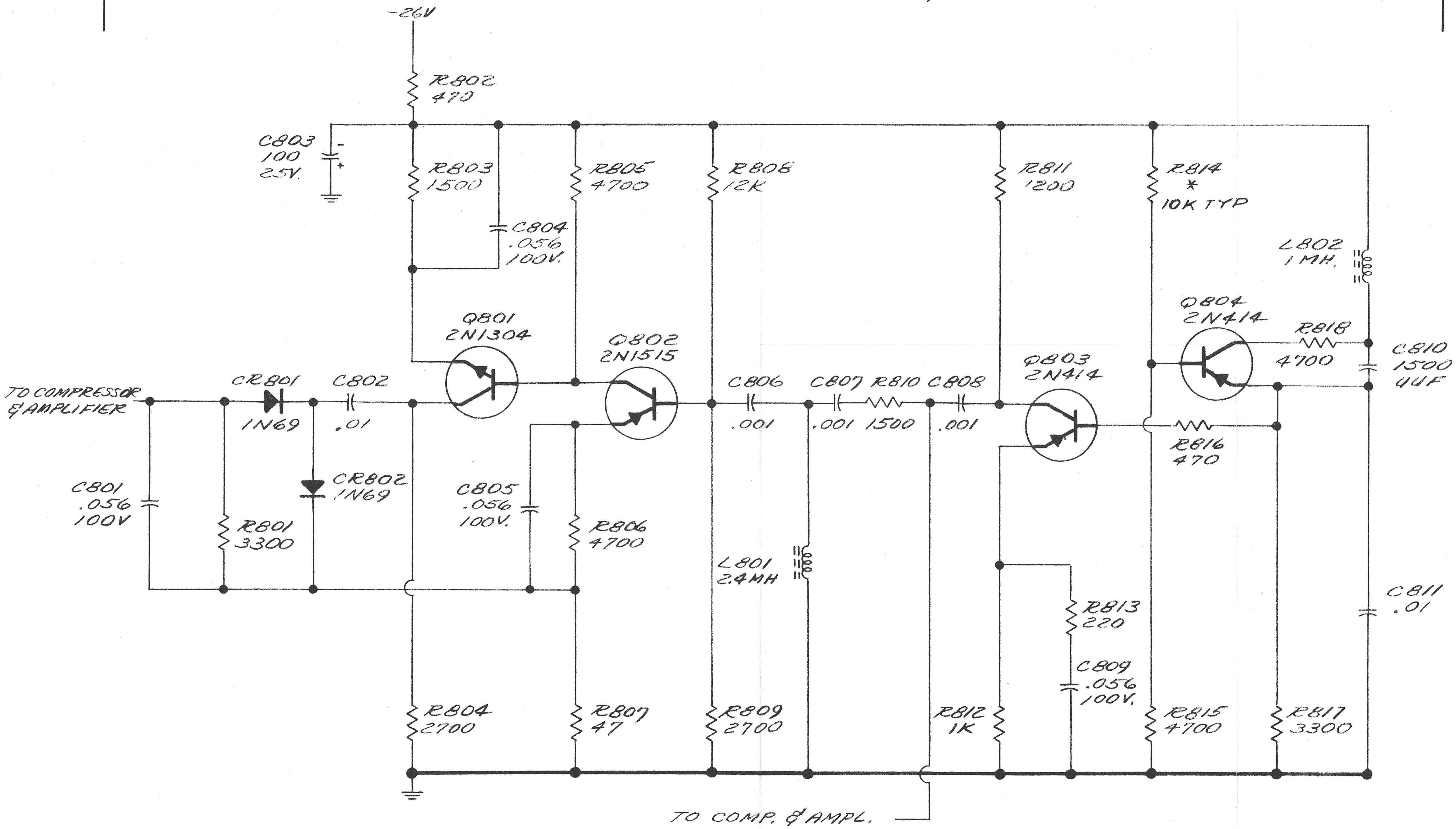
T-1906-N



MODEL 315
SCHEMATIC
COMPRESSOR &
AMPLIFIER

T-1907-M

CARRIER OSCILLATOR & AMPLIFIER (SEE BOARD 1697-10)



MODEL 315
SCHEMATIC
CARRIER OSCILLATOR
& AMPLIFIER

T-1908-C