WIDE-BAND • DC-1MC

10 WATT AMPLIFIER

MODEL DCA-10(R)

OPERATING AND MAINTENANCE MANUAL

SERIAL NO._____

KROHN-HITE CORPORATION

580 Massachusetts Ave., Cambridge, Mass., 02139, U.S.A.

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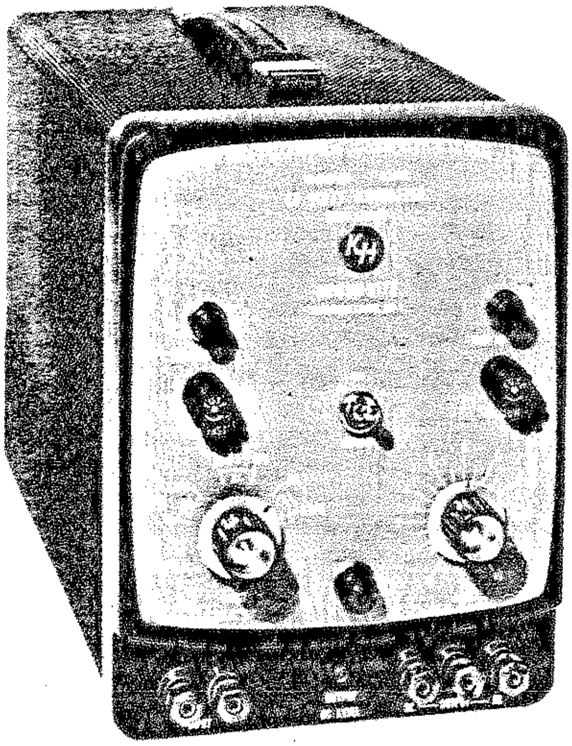


MODEL DCA-10

MODEL DCA-10R

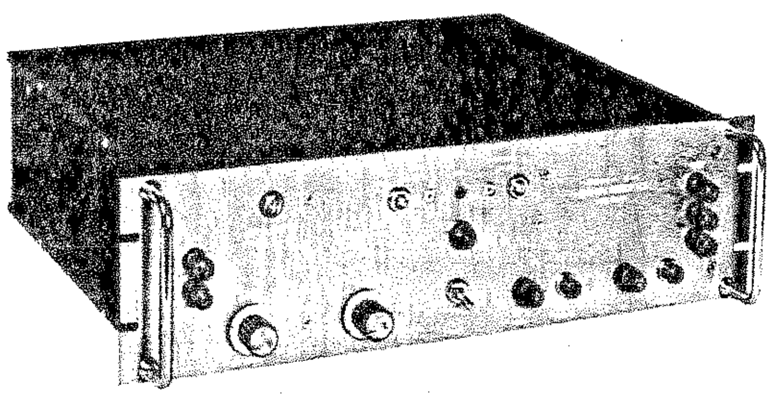


Figure 1 - MODEL DCA-10 and MODEL DCA-10R POWER AMPLIFIER

SECTION I - GENERAL DESCRIPTION

1. TECHNICAL SUMMARY

POWER OUTPUT: 10 volt-amperes (20 volt-ampere peaks), continuous, from dc to 500 kc into a 1,000 ohm resistive or reactive load; 10 watts (20 watt peaks), continuous, from 1 cps to 1 mc into a 600 ohm resistive load. See Note 2 on Page 7 and Figure 11.

OUTPUT VOLTAGE: Greater than 105 volts rms (300 volts peak to peak) open circuit from dc to 1 mc; 100 volts rms (280 volts peak to peak) across 1,000 ohms from dc to 500 kc; 78 volts rms (218 volts peak to peak) across 600 ohms from 1 cps to 1 mc.

OUTPUT CURRENT: Above 1 cps, greater than 210 ma rms (±300 ma peak) through 10 ohms; 130 ma rms (±180 ma peak) through 600 ohms; 100 ma rms (±140 ma peak) through 1,000 ohms. Below 1 cps, 42 ma rms (±60 ma peak) through 10 ohms; 52 ma rms (±75 ma peak) through 600 ohms; 100 ma rms (±140 ma peak) through 1,000 ohms.

OUTPUT REGULATION (from no load to full resistive load): Less than 2% from 10 cps to 100 kc, less than 5% over the entire frequency range.

INTERNAL IMPEDANCE: Less than 10 ohms from 10 cps to 50 kc, less than 50 ohms from dc to 100 kc and less than 100 ohms above 100 kc.

LOAD IMPEDANCE: Matching, nominal 600 ohms from 1 cps to 1 mc; below 1 cps, 1,000 ohms minimum load for full power output. See Figure 8. Minimum load, 10 ohms. See Figure 10.

LOAD POWER FACTOR: Unity to zero, lagging or leading.

OUTPUT DC LEVEL: Zero volts at capacitor-coupled AC OUTPUT terminals; nominal zero volts at the DC OUTPUT terminals.

OUTPUT DC LEVEL STABILITY (typical, after initial warm up, expressed in per cent of peak output voltage): ±0.02% in any one-hour period at fixed line voltage and ±0.2% for ±10% line voltage change in all positions of the INPUT SELECTOR switch except the X10 DC and POT DC positions where ±0.1% and ±1% apply.

VOLTAGE GAIN: Maximum of 10, variable continuously, fixed gain of 10 ± 10% (20 ±1 db), or fixed gain of 1 ± 10% (0 ± 1 db) as determined by the INPUT SELECTOR switch. Less than ±0.25 db change in gain for a 10% change in line voltage within the operating range.

FREQUENCY RESPONSE: Flat within ±1 db from dc to 1 mc under all specified operating conditions; approximately 3 db down at 2 mc. See Figure 10.

PHASE SHIFT: Zero ±1 degree from dc to 10 kc in the X10 and POT positions of the INPUT SELECTOR switch. See Figure 13. In the X1 position the phase shift is 180 ±1 degrees.

HARMONIC DISTORTION (rms): At full power output, less than 0.1% from 20 cps to 50 kc, less than 0.5% from near dc to 100 kc and less than 3% above 100 kc. In the X1 positions of the INPUT SELECTOR switch the distortion is less than 5% above 100 kc. See Figure 12. DC linearity is within $\pm 1\%$ with loads above 500 ohms.

HUM AND NOISE (referred to output): Less than 10 mv with the input shorted and less than 20 mv with an open circuit input.

DYNAMIC RANGE: Approximately 80 db.

SQUARE WAVE RESPONSE: See Figure 9.

INPUT IMPEDANCE: Greater than 1 megohm in parallel with approximately 50 uuf in the fixed gain positions; 5,000 ohms in parallel with approximately 50 uuf in the variable gain positions.

INPUT COUPLING: Either direct coupling or capacitor coupling with a low cut-off frequency of 1 cps.

INPUT SENSITIVITY: 7.8 volts rms with a 600 ohm load and 10 volts rms with a 1,000 ohm load for 10 watts output at maximum gain (X10).

INPUT VOLTAGE LIMITS: 400 volt maximum dc component in the ac coupled (1 CPS) fixed gain positions; combined input signal voltages (ac and dc) must not cause more than 2 watts dissipation in the 5,000 ohm GAIN potentiometer in either variable gain position.

AMBIENT TEMPERATURE AND DUTY CYCLE: Continuous duty at full 10 watt output up to 50°C (122°F) ambient.

FRONT PANEL CONTROLS:

- INPUT SELECTOR switch.
- GAIN control.
- OUTPUT DC LEVEL control (screwdriver adjust).
- POWER ON switch.

TERMINALS: Two multi-purpose binding posts for the INPUT (signal and ground)and three for the OUTPUT (DC signal, AC signal and ground).

POWER REQUIREMENTS: 105-125 or 210-250 volts; single phase; 50-60 cycles; 250 watts.

FUSE PROTECTION:

- Line: 2.5 ampere slow-blow.
- Plate supply: 3/16 ampere slow-blow.

TUBE COMPLEMENT (furnished with instrument): 2-6GT5, 2-6CL6, 1-6AQ5, 1-12AX7, 1-6AS7-GA, 1-6BK7-B, 1-5R4-GYB.

SECTION I - GENERAL DESCRIPTION

FORM: Furnished in an attractively styled perforated steel cabinet with a cast aluminum front panel and frame. Front panel finished in gray enamel; frame and cabinet in blue enamel. Other finishes available on special order. Over-all dimensions Model DCA-10: 7 1/2" wide, 10" high, 15" deep. Weight 35 lbs. net, 40 lbs. shipping. For rack mounting see Model DCA-10R described below.

NOTE 1: The specifications above apply only after adjustments in OPERATION, SECTION II-5 have been made. They apply to the direct-coupled (DC) positions of the INPUT SELECTOR switch and the direct-coupled (DC) output terminals unless otherwise stated.

NOTE 2: The permissible power output below 1 cps is limited with loads under 1,000 ohms because the plate temperature of the output tubes may become excessive during instantaneous plate dissipation peaks.

MODEL DCA-10R*

FRONT PANEL CONTROLS:

INPUT SELECTOR switch.
GAIN control.
OUTPUT DC LEVEL control (screwdriver adjust).
QUIESCENT CURRENT control (screwdriver adjust).
POWER OFF-ON switch.

TERMINALS: Two multi-purpose binding posts for the INPUT (signal and ground) and three for the OUTPUT (DC signal, AC signal and ground). In addition, three BNC type coaxial connectors are located on the rear of the chassis, one for the INPUT, one for the DC OUTPUT and one for the AC OUTPUT.

FORM: Furnished in a metal cabinet with standard relay rack panel only. Panel finished in gray enamel; dust cover in blue wrinkle. Other finishes available on special order. Over-all dimensions Model DCA-10R: 19" wide, 5 1/4" high, 15" deep. Weight 36 lbs. net, 41 lbs. shipping.

*This Instrument is the Model DCA-10 designed for rack mounting. The electrical specifications for this Model are identical with those for the Model DCA-10, except for an increase in Input Capacitance from 50 to 75 uuf.

To offer maximum versatility and convenience in this mounting method the shape of the instrument has been changed to conserve space, connectors have been added on the rear of the chassis, and all controls and test points have been located on the front panel so that access to the back of the instrument is not required during normal operation.

SECTION I - GENERAL DESCRIPTION

2. DESCRIPTION

The Model DCA-10* is a wide-band, low-distortion, direct-coupled power amplifier. It will deliver 10 volt-amperes (20 volt-ampere peaks) into a 1,000 ohm resistive or reactive load over the frequency range from dc to 500 kc and will deliver 20 watts continuously at dc. Over the frequency range from 1 cps to 1 mc the Amplifier will deliver 10 watts (20 watt peaks) into a 600 ohm resistive load.

The Amplifier provides a choice of three voltage gains as determined by the setting of the INPUT SELECTOR switch; fixed voltage gains of ten (20 db) with no phase reversal or one (0 db) with a phase reversal, or a continuously variable gain (between zero and ten) by means of the front panel GAIN control. For each gain setting the input may be either direct coupled or capacitor coupled with a low cut-off frequency of 1 cps.

Since the Model DCA-10 has a phase reversal in the fixed unity gain position, it can convert a single-ended signal to a balanced signal. Two Model DCA-10 Amplifiers can be cascaded to provide a balanced 20 watt output by operating the second Amplifier at unity gain.

The Amplifier output may be either direct coupled (DC) or capacitor coupled (AC) for applications requiring zero output dc level. When the AC output is used, the low cut-off frequency is approximately 25 cps with a 600 ohm resistive load. The output dc level of the direct-coupled (DC) output may be zeroed by the front panel OUTPUT DC LEVEL screwdriver control.

The Model DCA-10 is basically a three-stage, direct coupled amplifier. The first two stages are gain stages connected as balanced differential amplifiers for drift cancellation and operated in push-pull to minimize distortion and provide a balanced output. Two series-connected power tubes are used in the power output stage in a unique circuit which provides 10 watts conservatively over an extremely wide frequency range with low distortion which is characteristic of push-pull operation.

When the Amplifier is operated at the maximum gain of ten (20 db) the input is applied to one grid of the first balanced stage and the voltage feedback is applied to the opposite grid. This provides gain with no phase reversal which is typical of voltage feedback amplifiers. To obtain unity gain with a phase reversal, one grid of the first balanced stage is grounded and the junction of an input-output summing network is applied to the opposite grid as in operational feedback amplifiers.

The exceptional performance, frequency response, stability and low distortion of this highly-linear Amplifier is the result of quality components, good construction, careful engineering and the use of inverse feedback over an unusually wide frequency range. With this Amplifier and a suitable oscillator, high distortion-free power is now available over the entire frequency range from subsonic through the audio and ultrasonic range and extending into the radio-frequency range. The Model DCA-10 is ideally

*Patent Pending

suited for general purpose laboratory uses, computer systems, vibration analysis, seismological and geophysical studies and medical and biological research.

SECTION II - OPERATION

The Model DCA-10 Power Amplifier is adjusted and checked carefully in Final Test to insure that it meets all specifications. It is then aged and again tested prior to shipment to be sure that it is ready for use. The Amplifier is shipped complete and after unpacking is ready to be turned on and used. When rack mounting the Model DCA-10R, it may be necessary to remove the four rubber bumpers mounted on the bottom dust cover. The recommended operating procedure is described below.

1. CONTROLS

a. POWER - The power off-on toggle switch is marked POWER. In the ON position the Amplifier is completely energized and, after less than one minute warm up, may be used. However a longer time is required to stabilize the output dc level.

b. INPUT SELECTOR - The INPUT SELECTOR switch permits a choice of six different operating conditions in the switch positions marked DC X10, 1 CPS X10, DC X1, 1 CPS X1, DC POT and 1 CPS POT.

In the X10 positions, there is a fixed gain of ten with no phase reversal and the input impedance is approximately one megohm.

In the X1 positions, there is a fixed gain of unity with a phase reversal and the input impedance is also approximately one megohm. These X1 positions provide reduced distortion at frequencies below 500 cps, (see Figure 12) in addition to a more stable output dc level. The phase reversal enables the Amplifier to convert any single-ended signal into a push-pull balanced signal. Two Model DCA-10 Amplifiers with the OUTPUT of one connected to the INPUT of the other (operating in a X1 position) will provide a combined push-pull output of twenty watts.

In the POT positions there is no phase reversal, the gain is variable up to a maximum of ten as determined by the setting of the GAIN control and the input impedance is approximately 5,000 ohms.

CAUTION

The combined dc plus ac input signals should not dissipate over 2 watts in the 5,000 ohm GAIN control which is connected directly across the INPUT terminals in both POT positions.

In the 1 CPS X10 and 1 CPS X1 positions, the dc component of the input voltage may be as high as 400 volts.

In the three 1 CPS positions, the gain falls off below 1 cps (as shown in Figure 10) and the output dc level is more stable than in the three DC positions.

c. GAIN - To use the GAIN control, the INPUT SELECTOR switch should be in either of the two positions marked POT. The total gain of the Amplifier is adjustable up to a maximum of ten.

2. LOAD IMPEDANCE

Although the Amplifier may be used with any load of ten ohms or more, the rated 10 watt (or volt-ampere) output is obtained reliably from 1 cps to 500 kc with any resistive load from 600 to 1,000 ohms. Below 1 cps a 1,000 ohm resistive load should be used and above 500 kc a 600 ohm resistive load is recommended. When low-resistance loads are used on the DC OUTPUT, the output dc level should be maintained close to zero.

Output power in excess of rating, limited only by the clipping level, may be obtained without damaging the Amplifier, except at frequencies below 1 cps when the load is less than 1,000 ohms. These limitations are shown in Figure 11 for a typical Amplifier.

For reactive loads, the impedance level is 1,000 ohms for full 10 volt-ampere output.

Since 10 watts of average sine-wave power corresponds to 20 watt peaks, the Amplifier will provide 20 watts of dc power continuously into a 1,000 ohm load with a maximum output swing of $\pm 100\sqrt{2}$ volts. This is illustrated by the curves of Figure 11 which, at dc, show approximately twice the 1 cps power output.

3. LINE VOLTAGE

The Amplifier, as normally shipped, is connected for operation from an ac power source of 105 to 125 volts, 50 to 60 cycles, and uses a 2.5 ampere slow-blow line fuse. The Amplifier may be modified for operation from an ac power source of 210 to 250 volts, 50 to 60 cycles, by removing the two jumpers on the main power transformer, T301, between terminals 1 and 2 and between 3 and 4 and by adding a jumper between terminals 2 and 3 (leaving the lead from the 115 volt fan, B301, connected to terminal 3). A 1.25 ampere slow-blow line fuse should be used for 210-250 volt operation.

SECTION II - OPERATION

4. TERMINALS

a. INPUT - Two combination-type binding posts are provided on the front panel with the black post grounded. The Model DCA-10R also has a type BNC input connector on the rear of the chassis.

b. OUTPUT - Three combination-type binding posts are provided on the front panel, one for direct coupling (DC) and one for capacitor coupling (AC) with the middle terminal (GND) grounded. The DC OUTPUT may be used at any frequency. The AC OUTPUT is capacitor coupled to insure zero output dc level and when it is used, the low cut-off frequency varies with the resistance of the load: approximately 25 cps with a 600 ohm load, 15 cps with a 1,000 ohm load, 1/3 cps with a 100 K load and 1/6 cps with no load.

In the Model DCA-10R only, there are two additional output connectors, type BNC, on the rear of the chassis corresponding to the two front panel outputs.

If long leads are used between the OUTPUT and the load at high frequencies, the capacitive load of the leads must be considered. At 1 mc a shunt capacitance of 100 uuf will reduce the useful power output of the Amplifier approximately 10%.

Reasonable care should be exercised to prevent oscillation caused by stray capacitive coupling of the OUTPUT signal of the Amplifier to the INPUT leads or terminals.

5. TEST JACK VOLTAGE AND OUTPUT DC LEVEL

Adjustments have been made at the Factory for zero output dc level and the correct output-stage quiescent current. The screwdriver control for the output dc level is on the front panel of both Models. With shorted INPUT and the INPUT SELECTOR on DC X10, adjust this control until the output dc level (as measured at the DC OUTPUT terminal on the Model DCA-10 or on test jack TP101 on the Model DCA-10R) is zero. This is especially important when using low resistance loads on the DC OUTPUT.

The correct output-stage quiescent current is indicated by a dc reading of minus one volt on test jack J101. This test jack and the associated QUIESCENT CURRENT control is located at the rear of the Model DCA-10 and on the front panel of the Model DCA-10R.

After the Amplifier has had sufficient time to warm up and before extensive use it is recommended that these readings be checked and the controls readjusted if necessary.

6. FUSES AND INDICATORS

The 2.5 Ampere SLOW-blow fuse on the front panel is in series with the ac input power. When this fuse is open, the associated blown FUSE INDICATOR will light.

SECTION II - OPERATION

The 3/16 Ampere SLOW-blow fuse, also on the front panel, is in the ground circuit of the regulated power supplies. When this fuse is open, the associated blown FUSE INDICATOR will light, except under some unusual conditions of input signal and output load. See MAINTENANCE SECTION, SECTION IV-1.

SECTION III - CIRCUIT DESCRIPTION

The Schematic Diagrams of the Model DCA-10(R) basic amplifier and integral power supply are shown in Figures 15 and 14 respectively. The darker lines on the amplifier schematic show the main signal paths when the INPUT SELECTOR switch is in the DC X10 position.

In order to provide 10 watts of power from dc to 1 mc with low output impedance and less than 0.1 per cent harmonic distortion over most of this frequency range (see Figure 12), a novel direct coupled amplifier circuit, incorporating broad-banded feedback, is employed.

The basic amplifier circuit consists of three direct coupled push-pull differential balanced stages. The first stage consists of the two halves of V1 connected as a differential amplifier. The second stage, consisting of V2, V3 and V4, is also a differential amplifier and it provides the oppositely-phased drive signals required by the upper and lower series-connected power output tubes, V5 and V6. Negative feedback from the Amplifier output is applied to one of the first stage grids.

Since the small resistors (100 ohms or less) in series with the control grids and screen grids of most of the tubes and with the plates of V5 and V6 are used merely for suppression of parasitic oscillations, they are omitted in the following discussion.

1. INPUT STAGE

The input stage, V1, is a push-pull common-cathode amplifier. This differential first stage provides drift cancellation as well as two separate isolated high-impedance inputs and two equal-amplitude oppositely-phased plate signals.

When the INPUT SELECTOR switch is in the X10 or POT positions, the input signal is applied to the grid of V1A. The grid of V1B receives approximately one tenth of the output signal (from the voltage divider composed of R207, R206, R204 and associated components) which is in phase with the input signal and slightly larger. These grid signals, which are almost equal, produce a cathode signal of approximately the same amplitude. The resulting current in the cathode resistors, R104 and R110, produces signals across the plate resistors, R107 and R112, which are in phase with each other. The differential driver stage, V3 and V4, does not amplify these in-phase signals appreciably but does amplify the difference in the plate signals caused by the unequal signals on the grids of V1.

SECTION III - CIRCUIT DESCRIPTION

With the INPUT SELECTOR switch on either of the X1 positions, the grid of V1A has no signal. The input signal and the Amplifier output signal, which is out of phase with the input, are applied to an input-output summing network. The resulting signal (in phase with the output) developed at the junction of this network is applied to the grid of V1B. This signal is amplified with a phase reversal by V1B and applied to the control grid of V4. It also follows the path from the cathode of V1B to the cathode of V1A and is amplified with no phase reversal by V1A and applied to the control grid of V3.

The parallel combination of L101, R109 and C104, connected between the cathodes of V1A and V1B, is used to alter the gain versus frequency response of V1 to prevent oscillation of the over-all feedback loop. This is discussed in SECTION III-6.

The plates of V1 are direct coupled through R150 and R151 to the driver control grids. Above 10 cps, C105 and C106 eliminate the loss due to loading by the dc level-pulling resistors, R115 and R117. These level-pulling resistors are connected to opposite ends of the OUTPUT DC LEVEL control, R116, which is adjusted to obtain zero dc at the output of the Amplifier (with no input) by compensating for unbalance in the two halves of V1.

2. DRIVER STAGE

The driver stage consists of V3 and V4 with a common cathode connection for differential amplification. V2 is used to modify the plate signal of V3.

The differential action, in conjunction with compensating circuits, helps to maintain the grid to cathode of the output tubes at equal amplitude and with opposite phase. This is important for low distortion with class AB operation because improper amplitude and excessive phase shift can result in one output tube being cut off before the other is turned on. A very large step signal is required from the drivers to bridge this open circuit condition, causing excessive output distortion. Although higher quiescent current might avoid this condition, the resulting increased dissipation in the output tubes is undesirable.

As mentioned in SECTION III-1, the differential driver stage does not amplify appreciably any in-phase signals applied to its grids. Since these in-phase signals do appear on the common cathodes, the screen grids are bypassed to the common cathodes by C111 to maintain pentode operation at the higher frequencies. R124 reduces the screen grid voltage to keep the screen grids within rating.

To maintain balanced push-pull operation of the output tubes under all conditions and to obtain good distortion cancellation, it is important that the upper tube, V6, be driven so that it will operate as an amplifier (as does V5) and not as a cathode follower. This operation is approximated by connecting the plate resistor, R127, of V3 to the cathode of V2 which has a signal nearly the same as that on the cathode of V6 (the gain of V2, as a cathode follower, should ideally be unity). Thus, most of the signal developed across R127 by V3 plate current is applied between grid and cathode of V6. R128 is used to prevent excessive V2 screen grid dissipation. C107 boosts the gain a small amount at high frequencies and becomes effective at the same frequency as C112 and C111 to provide a smooth transition.

At frequencies above 10 kc, the plate of V4 is coupled by capacitor C112 directly to the control grid of V5 and the effective value of R119 is reduced because C113 bypasses part of it. Below 1 kc, there is a loss through the level-pulling resistors, R120, R135, R141 and R142. The effective value of R119 is increased to obtain the same driver gain. To obtain a smooth transition from one of these conditions to the other, C113 becomes effective at the same frequency as C112 and C110.

The driver stage common-cathode resistor is the series string made up of R122; R134 and R136 in parallel with potentiometer R137, the quiescent current adjustment for the output tubes. Because a special circuit is used, adjustment of R137 does not appreciably unbalance the output tubes. The change in voltage occurring at the junction of R122 and R134 (due to an adjustment of R137) is coupled to the grid of V5 by R135 and provides the required correction voltage to maintain balanced operation.

Inductances L102 and L103 in the driver plates are peaking coils to improve high frequency performance. R126 limits the gain at very high frequencies. C114 and C115, with L104, are used to correct the phase and minimize distortion at 1 mc.

3. OUTPUT STAGE

The output tubes, V5 and V6, are series connected but function as a class AB push-pull amplifier. For low amplitudes the output is proportional to the difference between the grid signals as in a differential amplifier. For the peak swings of large signals, one of the tubes is cut off and the output is determined by the signal on the grid of the other tube. Push-pull operation of these series-connected output tubes gives even-harmonic distortion cancellation because the tubes are connected and driven so as to obtain identical operation. The output stage is capable of supplying the rated power output of 10 watts into any resistive load from 600 to 1,000 ohms over the frequency range from 1 cps to 500 kc.

The recommended resistive load above 500 kc, for an output of 10 watts, is 600 ohms. Because of stray capacity loading the limiting factor is the driver plate circuits. These circuits can supply the 240 volt peak-to-peak signal needed to produce 10 watts in a 600 ohm load but may not be able to supply the 300 volt peak-to-peak signal needed to produce 10 watts in a 1,000 ohm load.

At frequencies below 1 cps the recommended load for an output of 10 watts is 1,000 ohms. The permissible output power is limited with loads under 1,000 ohms as shown in Figure 8 because the plate temperature of the output tubes may become excessive during instantaneous plate dissipation peaks.

The 10-watt rating is an average rating for a sine-wave signal. Since this corresponds to 20 watts at the peak swings, the rated dc power output into a 1,000 ohm load is 20 watts.

The recommended 10 volt-ampere reactive load is also 1,000 ohms. With a lower impedance reactive load, the average plate dissipation is exceeded because the current is not minimum when the voltage across the tube is maximum, as is the case with resistive loads.

Loads of less than 10 ohms are not recommended because the internal loop gain is too low for satisfactory operation.

Both output tubes are operated as pentodes. The screen grid of V5 is supplied with approximately 200 volts from the voltage divider made up of R144 and R147. To maintain constant screen to cathode potential in V6, the screen supply is "floated" by connecting its negative terminal to the cathode of V6. This "floating" supply employs L302 and L303 to isolate the stray capacities of the transformer, T302, and associated circuitry from the cathode of V6 at high frequencies. Resistors R323 and R324 are used to suppress undesired resonances.

The plus 245 and minus 245 volt supplies for the output tubes are load regulated to reduce their source impedance and prevent degeneration of the gain of the output tubes. Since the driver plate potentials vary with line voltage, the 245 volt load regulated supplies are referenced to the varying minus 560 volt supply to minimize the variation of the quiescent current in the output tubes with changes in line voltage.

Since the gain of the cathode follower, V2, is less than unity and the plate resistance of V3 is not infinite, V6 does not function as a simple amplifier as does V5. To compensate for this inequality in the operating conditions of V5 and V6, a local degenerative feedback path through R142 and R141 from plate to grid of V5 is used. This degenerative path is interrupted by the diode CR101 during the positive swing of the output, permitting the driver to develop a large enough signal to bias off the grid of V5. Capacitor C117 removes the diode from the circuit at high frequencies, eliminating the distorted diode signal which could be coupled through stray capacities into other parts of the circuit. Some local feedback is then provided by C118 and R143.

Inductance L105 isolates the output stage from the OUTPUT terminals to assure stability with capacitive loads. The shunt resistor, R148, suppresses undesired resonances.

The AC output terminal is connected through C120 to insure that there is no dc in the output. R149 is used to charge C120, maintaining zero output dc level under no-load conditions.

On the Model DCA-10R only, a test point, TP101, is provided for convenience in checking the output dc level.

4. OVER-ALL FEEDBACK NETWORK

The Feedback Network components are shown inside the dash rectangle on the Schematic Diagram, Figure 15. A part of the signal at the cathode of V6 is fed back to the grid of V1B. Three different paths are provided: one at low frequencies, one at mid frequencies and one at high frequencies. Their cross-over frequencies correspond to gain changes in the open-loop amplifier response which rises in the region between 3 and 9 cps due to C105 and C106 and changes again in the vicinity of 2 kc due to C107, C113, C112 and C110. Small gain changes are introduced in the feedback network at these frequencies to compensate for the amplifier gain changes and thus obtain a flat closed-loop response. The low-frequency feedback path is made up of R206, adjusted by R207, with R204 from V1B grid to ground. C204 brings in the mid-frequency path through R208 with R205 to ground. At high frequencies the feedback gain is mainly determined by the ratio of C103 to C207 plus trimmer C206.

R202, R203 and C203 in parallel with trimmer C202 are used at the low, mid and high frequencies respectively as described in SECTION III-5. The main function of these components is to provide an input signal path in the X1 positions.

5. INPUT SELECTOR SWITCH

The INPUT SELECTOR switch, S101, in Figure 15, is effectively a four-pole six-position rotary switch. The front wafer consists of S101A and S101B and the rear wafer consists of S101C and S101D. The circuit arrangements for each of the positions, as shown in the Simplified Schematic Diagrams of Figures 2 and 3, are as follows:

In the DC X10 position, the amplifier INPUT is connected by S101A through R103 to the grid of V1A, as shown in Figure 2. Sections S101C and S101D ground two legs of the feedback network so that approximately one-tenth of the amplifier output signal is applied to the grid of V1B. The balanced differential output of V1 is applied to the balanced drivers, V3 and V4. Their output is fed to the output tubes, V5 and V6. Actually, some of the V1 plate signal, representing the difference between the input and part of the output, is the distortion of the output which is amplified and degenerates the distortion developed in the output tubes and drivers. The amplifier gain is ten and the OUTPUT is in phase with the INPUT, because the first stage is used as a differential amplifier.

In the 1 CPS X10 position, as shown in Figure 2, the amplifier circuitry is the same except for the introduction of capacitor coupling. The INPUT is coupled through C101. Capacitors C201 and C205 are connected in series with the feedback path to ground to increase the feedback gain below 1 cps. This improves the dc stability of the OUTPUT by a factor of approximately ten.

The DC and 1 CPS POT positions of S101 utilize the same circuitry as the respective X10 positions except that the INPUT is connected first

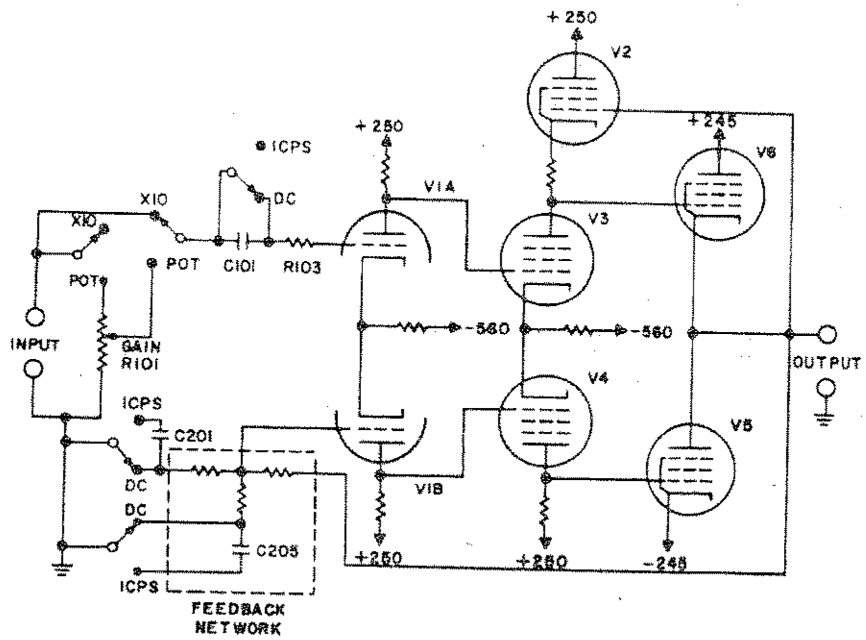


Figure 2 - Simplified Schematic for the DC X10, 1 CPS X10, DC-POT and 1 CPS-POT Positions.

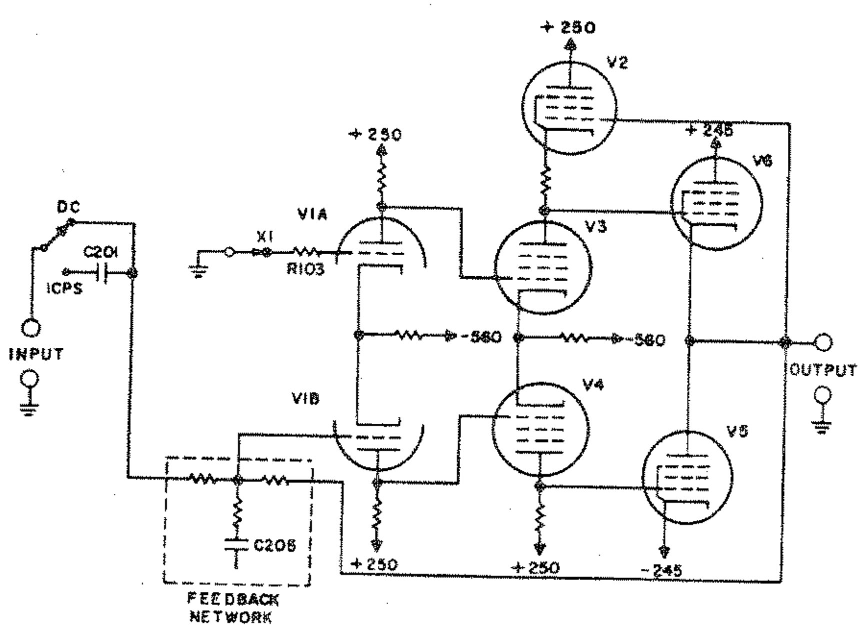


Figure 3 - Simplified Schematic for the DC X1 and 1 CPS X1 Positions.

through the GAIN potentiometer, R101. This potentiometer is not isolated from dc connected to the INPUT.

In the DC X1 position of S101, the circuit is changed considerably as shown in Figure 3. S101D grounds the grid of V1A through R103. The INPUT is connected to the previously grounded ends of R202, R203 and C202 in parallel with C203. The signal appearing on the grid of V1B is obtained by adding the INPUT and the OUTPUT signals through approximately equal feedback network resistors. The amplifier gain is unity and the OUTPUT is out of phase with the INPUT because the feedback voltage is added to the input voltage through a passive network.

The Amplifier closed-loop gain is actually determined by the ratio of R208 to R203 at mid frequencies, the ratio of R206 plus R207 to R202 at low frequencies and the ratio of C206 plus C207 to C203 plus C202 at high frequencies. C103 remains connected to ground to improve stabilization by maintaining the same high-frequency loop gain as was obtained in the X10 positions. However, at low and mid frequencies, by not grounding R204 and R205 the benefits of higher loop gain are obtained. In the 1 CPS X1 position of S101, the Amplifier circuits are the same as in the DC X1 position except that capacitor C201 is connected in series with the INPUT.

6. STABILIZATION

The open-loop frequency response of the amplifier and feedback network is compensated to obtain adequate stability of the feedback loop and optimum closed-loop square-wave response.

The main stabilizing circuit is the parallel combination of inductance L101, capacitor C104 and resistor R109 connected between the cathodes of V1. The impedance of this combination rises at higher frequencies with the increasing inductance of L101 and becomes large enough to begin degenerating the gain of V1. When C104 plus stray capacities resonate with L101, the impedance reaches a maximum, determined primarily by R109 and then decreases with the reactance of C104. The gain of V1 rises at frequencies above this resonance and the resulting phase lead provides the required stabilization.

Since the gain of V5 changes appreciably with output load, four additional networks are used to maintain the amplifier stability. In the plate circuit of V4 the resonance of L104 and C115 plus trimmer C114 contributes a phase lead in the V4-V5 path. C116 and R140 provide a small gain reduction followed by a leveling off. To reduce the gain variations around V5 at high frequencies, C118 and R143 are used for local plate to grid feedback. Since part of R119 is shunted by C113, its effective value for stray capacity lags is reduced.

Inductance L105 in series with the OUTPUT isolates the amplifier from capacitive loads at frequencies above 1 mc to avoid instability caused by an additional phase lag.

7. POWER SUPPLY

The power supply for the Model DCA-10 furnishes the amplifier circuit with three unregulated dc voltages, two load-regulated dc voltages and three unregulated ac heater voltages.

One of the unregulated dc voltages is a "floating" 200 volt screen grid supply for V6. Since its negative end is connected to the cathod of V6, it provides a fixed screen grid to cathode voltage for V6 while the cathode swings with the output signal. The supply uses half-wave semiconductor rectifiers, CR313 and CR314 in series, whose output is filtered by C313 and C314. The two chokes, L302 and L303, do not contribute appreciably to the ripple filtering. They are used to prevent loading of the cathode of V6 at high frequencies by the stray capacitance of the power transformer, T302, winding. Resistors R323 and R324 also minimize loading of the V6 cathode which would occur at the series resonant frequency of the chokes and the stray capacitance.

The other two unregulated dc supplies, plus 250 and minus 560 volts, are obtained from a single 810 volt dc supply with a grounded tap at the junction of R302 and R303 and of C301B and C302. The 810 volt dc supply uses a full-wave rectifier tube, V7, whose output is filtered by a capacitor-input filter consisting of C301A, L301 and C301B in series with C302. The +250 and -560 volt dc supplies, which are used for V1, V2, V3 and V4, have nearly all their load current drawn from +250 directly to -560. The current drawn through the grounded tap established by R302 and R303 is small and produces very little change in these voltages.

The two load-regulated dc supplies, plus 245 and minus 245 volts, are nearly identical and only the +245 volt supply will be discussed in detail. The unregulated dc source used a full-wave semiconductor rectifier, CR301 to CR306, the output of which is filtered by a simple capacitive filter consisting of C303A and C303B. A conventional series-type degenerative regulator with a single-stage triode amplifier is used. V8A is used as the series tube and V9A is the amplifier stage. V9 is operated with less than rated heater voltage to reduce grid current. The regulator adjusts the nominal +245 volt output so that the voltage at the junction of R308, R309, and R327 is the required bias voltage for V9A. R309, R326, R327, and R328 are connected to the -560 volt source as a reference. If the +245 volt output is too high, the bias on the grid of V9A is reduced and the plate current increases. The plate of V9A becomes more negative and drives the grid of V8A toward cut-off. This decreases the regulated output to its correct value by increasing the voltage across V8A. C304 provides a high-frequency path from the +245 volt output directly to the grid of V9A. R307 is connected to the cathode of V8A providing zero bias when V9A is cut off. The single stage of gain is adequate for the required degree of load regulation.

Since the amplifier circuitry is sensitive to hum and noise coming from the -245 volt supply, C308 has been added at the grid of V9B for cancelling the hum and noise appearing at the regulated output.

Capacitors C305 and C309 are large enough to provide low impedance at the higher frequencies where the gain of V9 drops because of stray capacities loading the plates.

Resistor R306, in series with the ground lead to the negative end of C303, provides a voltage for test jack J101. The value of this resistor is chosen so that the recommended 40 milliampere quiescent current in V6 plus the 15 milliampere current in R310 develop minus one volt at J101 with respect to ground.

Resistors R310 and R317 load the regulated outputs to keep the current in V8A and V8B from becoming zero under conditions which cause V5 or V6 to draw no current. R317 is larger than R310 because some current is always drawn from the -245 volt supply by R144 in the screen grid circuit of V5.

Three different ac heater windings are required to accommodate the widely different cathode potentials in this type of amplifier circuit to assure low heater to cathode voltage on all tubes. The transformer, T301, has in addition, a 5.1 volt winding providing 5 volts ac for the heater of the rectifier tube, V7, and a 6.4 volt winding providing 6.3 volts ac for the heater of the series regulator tube, V8.

R304, R312 and R325 provide discharge paths for C303, C306 and C314 respectively to reduce shock hazards during servicing.

S301 is the main POWER switch. A neon FUSE INDICATOR, DS301, is connected across the ac line fuse, F301, through a current limiting resistor, R301, so that the neon glows when F301 is open. DS302, F302 and R311 in series with the common ground lead of the two load-regulated supplies function in a similar manner. When F302 is open, its blown FUSE INDICATOR, DS302, will light except under some unusual conditions of input signal and output load. See MAINTENANCE, SECTION IV-1.

Interlock switch S302, located on the rear of the Model DCA-10 (not used on Model DCA-10R) opens when the chassis is removed from the cabinet, disconnecting the fan, B301. This fan has a 115 volt ac motor and must always remain connected across one of the two 115 volt primaries of T101, normally terminals 1 and 3. Similarly, T302, which has a single 115 volt primary must always remain connected across the other 115 volt primary of T301, normally terminals 2 and 4.

Movable jumpers are arranged so that the primaries of transformer T301 can be used in parallel for 115 volt operation or in series for 230 volt operation. For 230 volt operation the jumpers from terminals 1 to 2 and from 3 to 4 are removed and terminal 2 is jumpered to terminal 3, shown as a dash line on the Schematic Diagram Figure 14. With this connection fan B301 is in series with the primary of transformer T302 across the 230 volt source. T301, acting as an autotransformer, maintains 115 volts across each of these components.

SECTION IV - MAINTENANCE

All the components in the Model DCA-10 are of the highest quality and should have a long trouble-free life since they are operated well below their manufacturer's rating. If the Amplifier is not functioning properly and requires maintenance, the following simplified procedure in the order described may facilitate locating the source of trouble. In the Model DCA-10 the chassis and attached front panel and frame can be pulled out through the front of the cabinet after the two screws in the rear of the cabinet are removed. In Serial No. 101 through 127 of the Model DCA-10 one additional screw is used on the bottom of the cabinet. Access to the Model DCA-10R is obtained by removing the six self-tapping screws on either the top or bottom mounting plates. All tubes except the 5R4-GYB can be replaced by removing the top plate only.

1. FUSE FAILURE

There are two fuses on the front panel of the Model DCA-10. The 2.5 Ampere SLOW-blow fuse (1.25 Ampere SLOW-blow for 210-250 volt operation) is used in the primary circuits of the transformers to protect the power supply components from short circuits. A 3/16 Ampere SLOW-blow fuse is used to protect the Amplifier components. The rating of these fuses was selected for the proper protection of the Amplifier and they should be replaced with the same type and rating.

The 3/16 Ampere SLOW-blow fuse is in the ground circuit of the plus 245 and minus 245 volt regulated power supplies. When this fuse is blown, the associated blown FUSE INDICATOR will light except under the following unusual conditions:

a. When the output load is less than 1,000 ohms and there is an overloading (clipping) output signal at frequencies above 20 kc.

b. For any output load there is a negative output dc level at which this FUSE INDICATOR will not light but this voltage range is small and at all other output levels the indicator works satisfactorily.

The Amplifier will still function under some conditions when the 3/16 Ampere SLOW-blow fuse is blown but its performance is impaired at frequencies below 1 kc. With a sine-wave input the Amplifier output signal from 100 cps to 1 kc will appear sinusoidal even with 10 watts out, but the distortion below 1 kc is higher and may increase to one per cent at 100 cps. The maximum power output is greatly reduced at frequencies below 100 cps. The Amplifier can furnish output power at frequencies above 100 cps with this fuse blown because the signal current is supplied by the output capacitors, C305 and C309, which are across the +245 and -245 volt regulated supplies.

If a 3/16 Ampere fuse failure is detected, the following precautions are recommended before turning the Amplifier on after replacing the fuse:

a. If the Amplifier output current exceeds the rated 210 ma rms at frequencies below 5 kc, the 3/16 Ampere fuse may blow.

b. When a low dc impedance load is used, a small dc output level unbalance may cause excessive output current and contribute to the fuse failure.

c. In the DC positions of the INPUT SELECTOR switch an excessive input dc level may cause a fuse failure.

d. Short circuits in the filter capacitors, C305 and C309, can best be detected by connecting an ohmmeter across the terminals directly.

e. A fuse failure may be caused by a defective tube.

If a 2.5 Ampere fuse failure is detected, the following procedure is recommended before turning the Amplifier on after replacing the fuse:

a. Check for a faulty rectifier tube, V7.

b. Short circuits in the filter capacitors, C303, C306, C313, C314, C301, C302, C305 and C309 used in the power supplies, can best be detected by connecting an ohmmeter across the terminals directly. Short circuits across C303, C306, C313 and C314 may be due to either a defective capacitor or a defective semiconductor rectifier. See SECTION IV-4.

c. Disconnect the ac line cord and measure the resistance across the contacts of the line cord plug with the POWER switch in the ON position and the 2.5 Ampere fuse inserted. For 105-125 volt operation the resistance should be approximately 1.1 ohms and approximately 3.6 ohms for the 210-250 volt connection. A lower resistance probably indicates a short in the primary of one of the transformers, T301 and T302, or a shorted motor, B301, (interlock switch S302 opens in the Model DCA-10 and should be shorted for this measurement) since all of them are connected in parallel.

2. TUBE REPLACEMENT

Before any detailed maintenance procedure, turn on the Amplifier and then check to make certain that the correct tubes are inserted properly in their respective sockets. The type number of each tube is marked on the chassis adjacent to the tube. At the same time note if the filaments of all the tubes are lit and replace any that fail to light.

If this procedure produces no results, the most likely source of failure is the electron tubes since they have an inherently shorter life. Obtain appropriate new tubes and then, one at a time, substitute the new tube in each position in the Amplifier where it is used.

SECTION IV - MAINTENANCE

When any of the tubes are replaced, it is recommended that the quiescent current and output dc level be checked and readjusted if necessary. See OPERATION, SECTION II-5.

If either or both power output tubes, V5 and V6, are replaced it is recommended that the trimmer capacitor C114 be readjusted as outlined in 500 HOUR CHECK, SECTION V.

In most cases, the above procedure will localize a malfunction in the Model DCA-10 when it ceases to function or fails to operate within its rated specifications.

If the above procedure has not isolated the malfunction, the following step-by-step procedure is presented to permit a thorough detailed evaluation of the Amplifier performance.

This maintenance procedure consists of two major parts. The first part, sub-headings 3 and 4, deals with the power supply which is shown in Figure 14 and the second part, sub-headings 5 and 6, encompasses the amplifier proper as shown in Figure 15. Although it is recommended that this procedure be used in the order presented, occasionally depending on the nature of the malfunction, a considerable saving of time may be realized by omitting sub-headings 3 and 4 if routine voltage measurements indicate that the five high-voltage supplies are functioning properly.

This Amplifier uses a large number of parasitic suppressor resistors. To insure that these resistors are checked, it is recommended that the tube voltages and resistances be measured directly at the pin of each socket.

This procedure applies for 105-125 volt operation. For 210-250 volt line voltage the appropriate line voltages and currents should be modified by a factor of two.

3. POWER SUPPLY DESCRIPTION

A brief circuit description of the power supply is presented to provide the information required for maintenance. For a more detailed description of the power supply refer to CIRCUIT DESCRIPTION, SECTION III.

The Model DCA-10 power supply, as shown in Figure 14, provides five high-voltage dc power supplies and three unregulated low-voltage ac filament supplies. Two of the high-voltage supplies are load regulated and three are unregulated.

The +250 volt and -560 volt unregulated supplies, both referred to chassis ground, are used to power the first and second stages of the amplifier. A full wave rectifier, V7, is used to generate approximately

820 volts across the input filter capacitor, C301. After additional filtering by L301, C301 and C302 the +250 volt and -560 volt supplies, referred to ground, are established by grounding the junction of C301 and C302 and the junction of R302 and R303.

Two load-regulated supplies of +245 volts and -245 volts, with respect to chassis ground, furnish the plate supply power for the two series connected output tubes, V5 and V6, and the screen supply for the lower power output tube, V5. The +245 and -245 volt load-regulated power supplies use full-wave semiconductor rectifiers, CR301-CR306 and CR307-CR312, with capacitor input filters, C303 and C306, respectively. Each supply uses one section of the dual power triode, V8, as a series regulator and one section of the dual triode amplifier, V9, as a regulating amplifier.

A floating power supply of 200 volts is used to supply the screen power of the upper power output tube, V6. The negative return of this supply is connected to the cathode of V6. This floating supply consists of a half-wave semiconductor rectifier, CR313 and CR314, and a capacitor-input filter, C314. A separate transformer, T302, is used.

4. POWER SUPPLY MAINTENANCE

For this maintenance procedure the following test equipment is required:

1. Vacuum-tube volt-ohmmeter with input resistance greater than 10 megohms.

2. General purpose oscilloscope.

3. Variable autotransformer of 3 ampere capacity.

4. Ammeter with full scale sensitivity of 3 amperes ac.

5. Five power resistors of ±5% tolerance, two 6 K and one 4 K each of 20 watt minimum rating, and a 2K and 11K resistor, each of 50 watt minimum rating.

Disconnect the power cord of the Model DCA-10 from the power receptacle and remove all electron tubes, V1 through V9, but do not disturb the semiconductor rectifiers, CR301 through CR314.

a. Measure the resistance across the two dual 40 uf electrolytic capacitors, C303 and C306. The resistance* across both C303 and C306 should be approximately 100 K. The most likely source of trouble, if these readings are incorrect, is the capacitors C303 and C306 or the semiconductor rectifiers CR301 through CR312.

b. Measure the resistance across the floating screen supply. This resistance, which can be measured most easily from pin 4 to pin 8 of V6, should be approximately 45 K. The most likely source of trouble, if this reading is incorrect, is the filter capacitors C313 and C314, or the semiconductor rectifiers CR313 and CR314.

c. Plug the power cord of the Amplifier into an autotransformer with an ac ammeter of 3 amperes full scale in series with the Amplifier power cord. Set the autotransformer for zero ac volts out and turn on the POWER-ON switch of the Amplifier. Increase the autotransformer slowly towards 115 volts while observing the ammeter. In the Model DCA-10, under normal conditions at a 115 volt line with all the electron tubes removed, the ammeter should read approximately 0.5 amperes. When the fan motor is activated by pressing the safety interlock push-button switch, S302, located in the rear of the chassis, the ammeter should read approximately 0.7 amperes. In the Model DCA-10R, the ammeter should read approximately 0.7 amperes since there is no fan motor safety switch.

If the ammeter reads appreciably above the correct value, turn the Amplifier off for there is an internal short circuit in either the transformer, T301 or T302, or there is a short circuit in the primary or secondary external wiring of both transformers. Figure 16 shows a VOLTAGE AND RESISTANCE CHART for both power transformers, T301 and T302. When a short circuit is indicated, it is advisable to measure the resistance across all the terminals of both transformers and the resistance from all terminals to chassis ground. Any discrepancy in the measured values should be investigated carefully because the short circuit could be either internal in a transformer or external in the associated wiring.

d. Turn the Amplifier off and measure the resistance from the +250 and -560 volt unregulated supplies to ground. The resistance should be approximately 14 K and 22 K respectively. If these readings are incorrect, or a short circuit is indicated, the most likely source of trouble is R302, R303, C301, C302, L301 or associated wiring. If these components are not defective, the most likely source of trouble is a component associated

*The resistance value obtained from this measurement will depend on the type of ohmmeter used because of the semiconductor rectifiers CR301 through CR312. With ohmmeters using an internal battery the correct reading is approximately 100 K if the positive end of this battery is connected to the positive terminal of C303 or C306. When the ohmmeter leads are reversed an incorrect and appreciably lower reading will be obtained. With most vacuum tube ohmmeters these measurements will vary only by a small amount when the leads are reversed.

with V1, V2, V3 or V4. The resistance readings of these tubes as shown in the VOLTAGE AND RESISTANCE CHART should be checked.

e. Insert only the rectifier tube, V7, and connect an external power resistor of 4 K with a 20 watt minimum rating from the +250 volt unregulated supply to chassis ground and an external power resistor of 11 K with a 50 watt minimum rating from the -560 volt unregulated supply to chassis ground. These two external power resistors approximate the amplifier load on the +250 and -560 volt unregulated supplies in its normal quiescent condition with no input signal.

At a line voltage of 115 volts the ac line current should now be approximately 1.25 amperes and the unregulated supply voltages should be approximately +250 and -560 volts. The hum and ripple of these supplies should not exceed 150 and 500 millivolts rms respectively and the ripple frequency of each supply should be predominantly twice the line frequency. If these voltages are incorrect, the most likely source of trouble is the value of C301, C302, L301, the rectifier tube V7 or the secondary voltages as measured across the terminals 7 to 8 and 8 to 9 of transformer T302. The correct terminal voltages at normal load are shown in Figure 16.

f. Turn the Amplifier off and measure the resistance from the +245 and -245 volt load-regulated supplies to chassis ground. The resistance of each should be approximately 17 K. If these readings are incorrect or a short circuit is indicated, the most likely source of trouble is R310, R317, C305, C309, R144, R147, C119 or associated wiring.

g. Insert the current regulator tube, V8, and the regulating amplifier tube, V9. Connect two external power resistors of 6 K with a 20 watt minimum rating from the +245 and the -245 volt load-regulated supplies to chassis ground. These two external power resistors approximate the amplifier load on the load-regulated +245 and -245 volt power supplies in normal quiescent condition with no input signal. Be sure that the external 4 K and 11 K power resistors are connected to the +250 and -560 volt unregulated supplies and that these voltages are approximately correct because the magnitudes of the +245 and -245 volt load-regulated supplies are determined by the magnitude of the -560 volt unregulated supply. This is accomplished in the circuit design by connecting the voltage determining precision resistors, R314 and R309, to the -560 volt supply. The +245 and -245 volt load-regulated supplies are therefore "slaved" to the -560 volt unregulated supply and will vary with line voltage.

At a line voltage of 115 volts the ac line current should now be approximately 1.8 amperes. If the -560 volt unregulated supply is approximately correct, the load-regulated supplies will be approximately +245 and -245 volts. The hum and ripple of these supplies should not exceed 50 millivolts rms and the ripple frequency of each supply should be predominantly twice the line frequency. If these voltages are incorrect, the most likely source of trouble is the electron tubes V8 or V9, the precision resistors R308, R313, R314, R309, R326, R327, and R328 or the capacitors C304 and C307.

h. Leave the four external power resistors connected to the four supplies as previously described and connect another external power resistor of 2 K with a minimum rating of 50 watts from the +245 volt load-regulated supply to chassis ground. Observe the voltage magnitude and ripple of this supply and the ac line current as this 2 K resistor is applied. The voltage should not decrease by more than 10 volts, the ripple should increase but remain below 100 millivolts rms and the ac line current should increase to approximately 2 amperes.

Remove the 2 K power resistor from the +245 volt load-regulated supply and connect it to the -245 volt load-regulated supply while observing the voltage magnitude, ripple and ac line current. The voltage should not decrease by more than 10 volts, the ripple should not increase to more than 100 millivolts rms and the ac line current should increase to approximately 2 amperes.

The 2 K power resistor is intended to determine whether the +245 and -245 volt supplies will regulate at full load. If these supplies fail to meet the above specification when they are fully loaded, the most likely source of trouble is the electron tubes V8 or V9, filter capacitors C303 or C306, semiconductor rectifiers CR301 to CR312 or incorrect secondary voltages across terminals 10-11-12 and 13-14-15 of transformer T301 as shown in Figure 16.

i. Remove the 2 K power resistor but leave the other four power resistors connected as previously. Measure the voltage and ripple of the floating screen supply directly across R325 or C314. At a 115 volt line this voltage should be approximately 200 volts and there should be less than 1 volt rms saw-tooth ripple at line frequency. If these voltages are incorrect, the most likely source of trouble is C313, C314, CR313 CR314, T302, L302 or L303. Each of the chokes, L302 and L303, has a dc resistance of 30 ohms.

This completes the evaluation of the five high-voltage power supplies. Before removing the four external power resistors, measure the five low-voltage unregulated ac heater supplies across the terminals 5-6, 16-17, 18-19, 20-21 and 22-23-24 of transformer T301. The correct voltages are shown in Figure 16.

Before continuing with the remainder of this maintenance procedure, disconnect all the external power resistors and insert all the tubes except the power output tubes, V5 and V6.

5. AMPLIFIER DESCRIPTION

A brief circuit description of the amplifier proper is presented to provide the information required for maintenance. For a more detailed analysis refer to CIRCUIT DESCRIPTION, SECTION III.

The Model DCA-10 is basically a three-stage direct-coupled amplifier. The first stage, V1A and V1B, and the second stage, V3 and V4, are gain stages connected as balanced differential amplifiers operated in push-pull to provide a balanced output. Two series-connected power output tubes, V5 and V6, are used in the power output stage. A cathode follower, V2, provides a plate supply voltage for V3 with a superimposed signal voltage derived from the cathode of V6.

When the Amplifier is operated at the maximum gain of plus ten (20 db) the input is applied to the grid of V1A. The voltage feedback is applied to the grid of V1B via the feedback network to produce positive gain. To obtain minus unity gain the grid of V1A is grounded and the junction of the input-output feedback network is applied to the grid of V1B.

6. AMPLIFIER MAINTENANCE

For the following maintenance procedure a vacuum-tube voltmeter with input resistance greater than ten megohms is required.

a. Turn the Amplifier off and check that all the tubes except V5 and V6 are inserted in their respective sockets. Connect the grid of V1B to ground, set the INPUT SELECTOR to the DC POT position and turn the GAIN control to the maximum ccw position. Connect the DC OUTPUT terminal to the GROUND terminal or chassis ground to permit the cathode follower, V2, to function properly with V5 and V6 removed.

b. Set the autotransformer to zero ac volts out and turn the Amplifier on. Increase the autotransformer output slowly towards 115 volts while observing the ammeter. Under normal conditions the ammeter should read approximately 1.5 amperes and the two unregulated supplies should be approximately +250 and -560 volts respectively. If these voltages are incorrect and these supplies have been checked out (as recommended in Power Supply Maintenance in SECTION IV-4) and found correct, a discrepancy in these voltages now indicates a short circuit or a defective component in the first two stages of the amplifier.

c. Measure the dc plate voltage of V1A and V1B. Each should be approximately 160 volts. The most likely source of trouble if these readings are incorrect is the +250 or -560 volt unregulated supplies, the electron tube V1A or the components associated with the first stage. Be sure that both grids of V1 are at ground potential and that L101 is not open. If necessary check the resistance readings as shown in the VOLTAGE AND RESISTANCE CHART in Figure 16.

d. Measure the dc voltages on the grids of V3 and V4. Each should be approximately -320 volts. Measure the grid to grid dc voltage of V3 and V4. When the dc feedback is interrupted, as it is with V5 and V6 removed, this voltage depends on the setting of the front panel OUTPUT DC LEVEL screwdriver control. If this control is adjusted from minimum to maximum the grid to grid dc voltage should vary from -5 to

+5 volts minimum. The most likely source of trouble if these voltages are incorrect is the -560 volt unregulated supply, the precision resistors R113, R108, R150, R151, R117, R115, capacitors C105, C106 or potentiometer R116.

e. Measure the dc plate voltage of V3. This voltage should vary from approximately -80 volts to +25 volts as the OUTPUT DC LEVEL control is adjusted from minimum to maximum. If these voltages are incorrect, the most likely source of trouble is the electron tubes, V2 or V3, the plate load components R127, R126 and L102, the common screen dropping resistor R124, the suppressor resistors R123 and R121, the common cathode resistors R122, R134, R136 and the QUIESCENT CURRENT screwdriver control R137, which is mounted on the rear of the chassis in the Model DCA-10 and on the front panel in the Model DCA-10R. If the dc plate voltage is greater than -100 volts, check that the DC OUTPUT terminal has been grounded.

f. Measure the common screen and cathode voltage of V3 and V4. The screens should be at approximately -95 volts and the cathodes at approximately -315 volts. If necessary, check the resistance readings of V3 as shown in the VOLTAGE AND RESISTANCE CHART, Figure 16.

g. Measure the dc plate voltage of V4. This voltage should vary from approximately +200 to -200 volts as the OUTPUT DC LEVEL control is adjusted from minimum to maximum. If this voltage is incorrect, the most likely source of trouble is the electron tubes V3 and V4 and the plate load components R119, C115, C114 and L103. If necessary, check the resistance readings of V4 as shown in the VOLTAGE AND RESISTANCE CHART, Figure 16.

h. Measure the dc grid voltage of V6. This voltage should vary from approximately -85 volts to +20 volts as the OUTPUT DC LEVEL control is varied from minimum to maximum. If these voltage are incorrect, the most likely source of trouble is one of the plate-to-grid coupling network components R133, R131, R125 or C110.

i. Measure the dc grid voltage of V5. This voltage should vary from approximately -225 to -325 volts as the OUTPUT DC LEVEL control is varied from minimum to maximum. If these voltages are incorrect, the most likely source of trouble is the plate-to-grid coupling network components R135, R120, R140, L103, R141, R142, R138, R139, C118, C116, C112, C117 and diode CR101. If necessary, check the resistance readings of V4 and V5 as shown in the VOLTAGE AND RESISTANCE CHART, Figure 16.

j. Turn the Amplifier off and set the autotransformer to zero. Remove the connection from the DC OUTPUT terminal to ground and the connection from the grid of V1B to ground. Insert the power output tubes, V5 and V6. Turn the Amplifier on and increase the autotransformer output slowly towards 115 volts while observing the ammeter. Under normal conditions, with the quiescent control adjusted as outlined in OPERATION, SECTION II-5, the ammeter should read approximately 2 amperes. If the ammeter reads appreciably above this value, turn the Amplifier off.

If the line current is excessive, the most likely source of trouble is one of the power output tubes, V5 and V6, a short circuit from the DC OUTPUT terminal to ground or a defective feedback network. If the power output tubes are checked and found satisfactory or new tubes are substituted and the trouble persists, remove the power output tubes, turn the Amplifier on and measure the screen grid voltages of V5 and V6. The dc screen grid voltage of V6, as measured between pins 1 and 3, or between pin 1 and the DC OUTPUT terminal, should be approximately +200. The dc screen voltage of V5, as measured between pin 1 and chassis ground, should be approximately -45 volts. If the dc screen voltage of V5 is incorrect, the most likely source of trouble is the power resistors R144 and R147 or the capacitor C119.

Disconnect any external load on the Amplifier OUTPUT terminals and measure the resistance from the DC OUTPUT terminal to chassis ground. Under normal conditions this resistance should be approximately 100 K to 600 K, depending on the polarity and voltage of the internal battery of the ohmmeter and the shunting effect of the diode CR101. If this resistance reading is incorrect, check the resistance readings of V5 and V6 as shown in the VOLTAGE AND RESISTANCE CHART, Figure 16.

k. Insert the power output tubes, V5 and V6, turn the Amplifier on and set the INPUT SELECTOR switch to the DC X10 position. After sufficient warm up time, adjust the OUTPUT DC LEVEL control to approximately zero volts (as measured at the DC OUTPUT terminal) and then adjust the QUIESCENT control for -1 volt at the test jack, J101, located on the rear of the Model DCA-10 and on the front panel of the Model DCA-10R. If these voltages cannot be obtained, turn the Amplifier off and measure the resistance from the DC OUTPUT terminal to the grid of V1B and also from the grid of V1B to chassis ground. These resistances will depend on the setting of the INPUT SELECTOR switch and should vary between approximately 0.5 and 3 megohms. If these readings are incorrect, check the wiring and components associated with the feedback network shown in Figure 15.

7. AMPLIFIER GAIN VS. FREQUENCY

The Amplifier maintenance procedure up to this point should uncover defects which disturb the quiescent (no input signal) operating potentials. If the Amplifier fails to meet its rated specification (see SECTION I) when all the quiescent potentials are correct and all the tubes have been tested or replaced, it is advisable to take an open-loop frequency response curve of the amplifier and a response curve of the feedback network.

SECTION IV - MAINTENANCE

The following test equipment will be required to make these measurements:

1. Sine-wave generator with 1 volt rms maximum output over the frequency range from 100 cps to 5 mc.

2. Vacuum-tube voltmeter (with a probe of 10 uuf maximum input capacitance and 10 megohms minimum input resistance) having 0.01 volt minimum full scale sensitivity over the frequency range from 10 cps to 5 mc.

3. Oscilloscope with a band width of 5 mc minimum and probe with 10 uuf maximum input capacitance and 10 megohm minimum input resistance.

4. Non-inductive 1,000 ohm resistor with a 30 watt minimum rating (a series and/or parallel combination of suitable 2 watt carbon resistors can fulfill this requirement).

5. Capacitor of 0.1 uf with 200 VDC minimum rating.

6. Capacitor of 100 uf with 100 VDC minimum rating.

To take an open-loop response of an amplifier, it is necessary to interrupt the feedback path. This can be accomplished most easily in this direct-coupled Amplifier by connecting a capacitor from the feedback grid of the first-stage balanced amplifier, V1B, to ground. The dc levels and quiescent tube voltages will not be disturbed because this capacitor interrupts only the ac feedback path, permitting the dc feedback to function.

Set the INPUT SELECTOR switch to the 1 CPS POT position with the GAIN control in the maximum CW position and short circuit the INPUT of the Amplifier. Connect a 100 uf oil or paper capacitor with a 100 VDC or higher rating from the grid of V1B to chassis ground and a 1,000 ohm non-inductive resistor with a 30 watt minimum rating from the AC or DC OUTPUT terminals to ground. To eliminate hum on open-loop measurements at frequencies above 10 kc, the 100 uf capacitor can be changed to a 0.1 uf capacitor.

Turn the Amplifier on and, after a sufficient warm up period, check the quiescent current and OUTPUT DC LEVEL as described in OPERATION, SECTION II-5. Remove the short circuit from the INPUT of the Amplifier and apply a 0.1 volt signal to the INPUT terminals of the Amplifier. Measure the output voltage of the Amplifier with the vacuum-tube voltmeter and monitor the output of the Amplifier with the oscilloscope to make sure that the output is similar to the input. Figure 4 shows a typical open-loop frequency response curve of a Model DCA-10 Amplifier when functioning normally. The open-loop gain should be approximately 700 (57 db) at low frequencies with a 0.7 (3 db) fall off at approximately 200-300 kc. At 1 mc, the gain should be approximately 30 db.

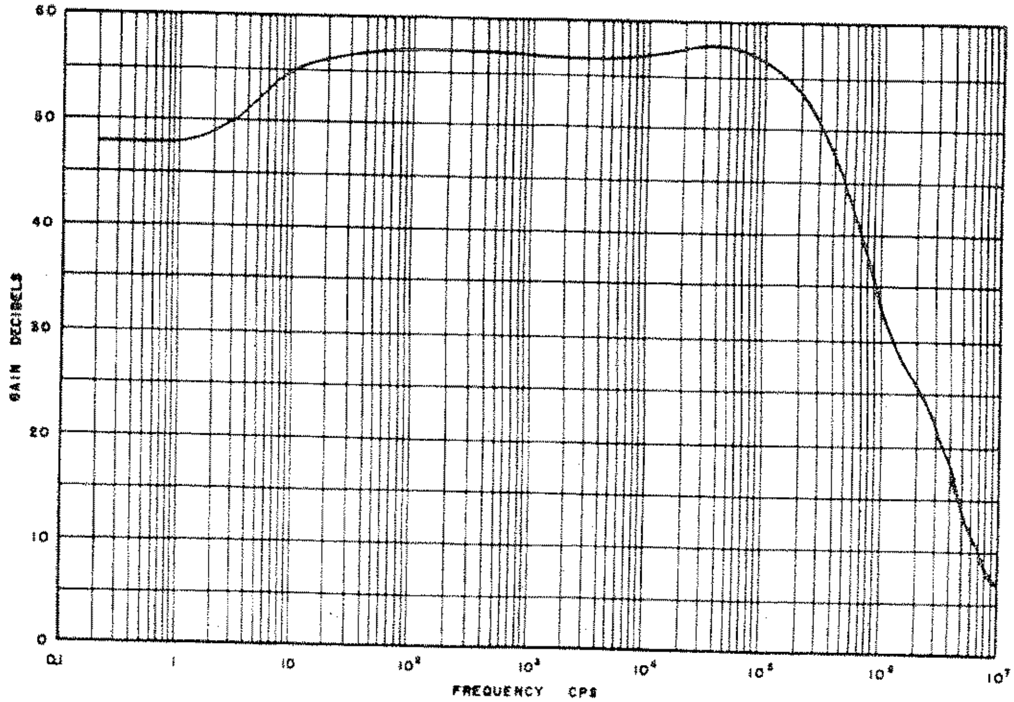


Figure 4 - Open-Loop Amplifier Frequency Response

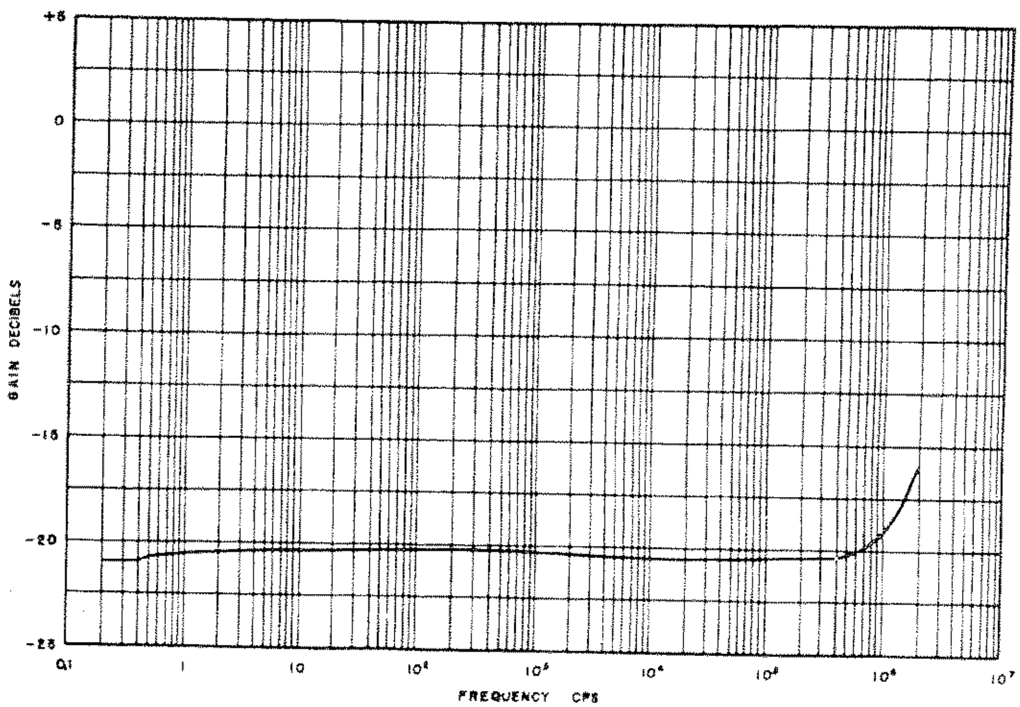


Figure 5 - Open-Loop Feedback Network Response

If the open-loop gain is appreciably different from the typical response as shown in Figure 4 or the output signal is badly distorted, the most likely source of trouble is the components associated with V1-V6. The following procedure is recommended to facilitate localizing the trouble:

a. Connect the 0.1 uf capacitor and 1,000 ohm load resistor as previously and apply a 0.1 volt rms 10 kc signal to the INPUT terminals. The ac voltage at the grid of V1A should also be 0.1 volts rms. Since the gain of the first stage is approximately 10 (20 db) the voltage at the plate of V1A and V1B should be approximately 1 volt rms and these signals should be 180° out of phase with each other. If these voltages are incorrect, check all the components associated with V1.

b. Measure the ac voltages at the grids of V3 and V4. They should be 180° out of phase and have a magnitude of approximately 1 volt rms. If these voltages are incorrect, check the plate coupling capacitors, C105 and C106.

c. Since the gain of V3 is approximately 70 (37 db), the ac plate voltage of V3 and ac grid voltage of V6 should be approximately 70 volts rms. The gain of V4 is approximately 25 (28 db) and therefore the ac plate voltage of V4 and ac grid voltage of V5 should be approximately 25 volts rms. The signal at the plate of V3 and grid of V6 should be 180° out of phase with the signal at the plate of V4 and grid of V5. If these voltages are incorrect, check capacitors C107, C110, C111, C112 and C113.

d. Measure the ac cathode voltage of V6 directly at the socket. It should be approximately 70 volts rms and in phase with the plate signal of V3. If this voltage is correct, the voltage at the AC OUTPUT terminal should also be approximately 70 volts rms. If incorrect, check the output capacitor, C120, and the high-frequency decoupling network consisting of R148 and L105. The dc resistance of L105 is approximately 0.5 ohm.

If the open-loop gain is normal at 10 KC but appreciably different from the typical curve shown in Figure 4, at higher frequencies, the most likely source of trouble is one of the peaking coils L102, L101, L103 and L104 which should have dc resistances of 12, 5, 16 and 16 ohms respectively. If the above components are not defective, the following procedure is recommended to facilitate localizing the trouble.

a. Leave the 0.1 uf capacitor and 1,000 ohm load resistor connected as previously and apply a 1 volt rms 1 mc signal to the INPUT terminals. Since the gain of V1A is approximately 1.1 (1 db) at 1 mc, the signal at the plate of V1A should be 1.1 volts. The signal at the plate of V1B will be approximately 1.6 volts. since the gain of V1B is 1.6 (4 db) at 1 mc. At 1 mc the plate signals will be almost in phase with each other and approximately 90° out of phase with the input signal. If these voltages are incorrect, check the components R109, L101 and C104.

b. The voltage gain of the upper driver, V3, should be approximately 30 db and its ac plate signal should be approximately in phase with the ac plate signals of V1 and out of phase by approximately 90° with the input signal of V1. If this voltage is incorrect, check the components R128, R127, R126, C107 and L102.

c. The voltage gain of the lower driver, V4, should be approximately 20 db and its ac plate signal should be approximately 180° out of phase with the upper driver ac plate signal. If this voltage is incorrect, check the components R119, C112, C113, C114, C115, L103 and L104.

d. Measure the ac cathode voltage of V6 directly at the socket. It should be approximately 30 volts rms and in phase with the plate signal of V3. If this voltage is incorrect, check the load resistance and the output capacitance, keeping in mind that 100 uuf will reduce the output voltage by approximately 10% at 1 mc.

If, after careful evaluation, it is believed that the basic amplifier is functioning properly and the open-loop response is typical, as shown in Figure 4, it is recommended that a response curve of the feedback network be taken.

Turn the Amplifier off, remove the 1,000 ohm resistor and the 100 uf or 0.1 uf capacitor used for open-loop measurements. Apply a 1 volt rms signal to either the AC or DC OUTPUT terminal. Measure the voltage at the output of the feedback network at the grid of V1B. A typical response curve of a feedback network is shown in Figure 5. The gain is approximately 0.1 (-20 db) and is constant within 1 db from dc to 1 mc, rising to 0.16 (-16 db) at approximately 2 mc. Slight variations of approximately 1/4 db at the crossover frequencies (as described in CIRCUIT DESCRIPTION, SECTION III) will occur, if carefully observed in this response curve.

If the response curve deviates appreciably from typical, the most likely source of trouble is one of the components in the feedback network which is shown on the Amplifier Schematic Diagram, Figure 15. The likeliest component to fail in the feedback network is one of the precision deposited carbon resistors R202, R203, R204, R205, R206 and R208. With the INPUT SELECTOR switch in the 1 CPS X10 position, the resistance as measured across each of these resistors should be 2, 1.5, 0.62, 0.2, 1.5 and 2.2 megohms respectively. R201 and R105 are adjusted at the Factory and should be between 2.5 - 3 k and 200-300 ohms respectively.

If necessary, check the feedback network capacitors C202, C203, C204, C205, C206 and C207. If C202, C203, C206 and C207 are defective and replaced, or the trimmers C202 and C206 have been tampered with, it will be necessary to readjust these trimmers as described in the 500 HOUR CHECK, SECTION V.

SECTION IV - MAINTENANCE

Because of the complex signal paths required to obtain the proper open-loop response and the multiple feedback paths at high frequencies, it is not practical to provide a complete trouble-shooting procedure. When the maintenance procedure as provided is not adequate, it is necessary to know how the circuits normally operate. Refer to the CIRCUIT DESCRIPTION, SECTION III, and the Schematic Diagrams, Figures 14 and 15. The darker lines on Figure 15 show the main signal paths.

8. AIR FILTER

The Model DCA-10R obtains air for cooling through an air filter that is mounted in the rear of the Amplifier. By removing the top cover, this filter can be easily removed. This filter should be inspected periodically and cleaned or replaced when necessary. The air filter may be cleaned in warm water and detergent and, after drying, should be coated with a suitable oil adhesive.

SECTION V - 500 HOUR CHECK

Under normal laboratory conditions the Model DCA-10 should function without requiring any maintenance since high-quality components are used throughout and all are operated well within their manufacturers' ratings. Since the Amplifier uses electron tubes whose performance deteriorates with time, it is recommended that a routine check be made after approximately 500 hours' operation to ensure that the Amplifier is performing in accordance with its specifications. The Amplifier will not incur any permanent damage if this routine 500-hour maintenance is not performed.

Whenever any tubes in the Model DCA-10 are replaced, it is recommended that both the output dc level and quiescent current be adjusted. Short circuit the INPUT terminals and set the INPUT SELECTOR switch to the DC X10 position. After allowing sufficient warm up time, adjust the front panel OUTPUT DC LEVEL screwdriver control, R116, until the output dc level, measured between the DC OUTPUT terminal and chassis ground, is zero. Then adjust the QUIESCENT CURRENT screwdriver control, R137, until the voltage measured between the test jack, J101, and chassis ground is minus 1 volt. The quiescent current control, R137, and test jack, J101, are on the rear of the chassis of the Model DCA-10 and on the front panel of the Model DCA-10R. In the event that these voltages cannot be adjusted to their correct values, refer to MAINTENANCE, SECTION IV.

If the Amplifier appears to be functioning properly, it is recommended that the feedback network trimmers, R207, C202 and C206 be adjusted to ensure that the Amplifier frequency response is within specification. This can be accomplished easily by checking the square wave response of the Amplifier. All three trimmers are mounted on the large terminal board which is positioned behind the INPUT terminals of the Model DCA-10 and behind the GAIN control of the Model DCA-10R.

SECTION V - 500 HOUR CHECK

For this procedure the following test equipment is required:

a. General purpose ac-dc oscilloscope.

Make sure that the oscilloscope will pass a 2 cps square wave without any appreciable tilt or that the vertical amplifier is in the direct-coupled (dc) position.

b. Square wave generator covering the frequency range from 2 cps to 1 kc.

c. Load resistor of 1,000 ohms ±5% with one watt minimum rating.

Turn the Amplifier on and apply a 2 cps one volt peak-to-peak square wave to the INPUT terminals. Set the INPUT SELECTOR switch to the DC X10 position and connect the 1,000 ohm resistor from the DC OUTPUT terminal to chassis ground. Monitor the Amplifier output developed across the 1,000 ohm load resistor with the oscilloscope and adjust the potentiometer trimmer, R207, until the square wave has a flat top.

Set the INPUT SELECTOR switch to the 1 CPS X10 position and apply a 1 kc one volt peak-to-peak square wave to the INPUT terminals. Adjust the trimmer capacitor, C206, until the square wave has a flat top. C206 is adjacent to the trimmer capacitor C202 and directly above the potentiometer trimmer, R207.

Set the INPUT SELECTOR switch to the 1 CPS X1 position and apply a 1 kc one volt peak-to-peak square wave to the INPUT terminals. Leave the 1,000 ohm load connected as previously. Adjust the trimmer capacitor C202, which is adjacent to the trimmer capacitor C206, until the square wave output of the Amplifier has a flat top.

Occasionally these two trimmer capacitors may interact so that it is advisable to repeat these measurements and readjust the trimmer capacitors if necessary.

If all electron tubes are changed when the Amplifier undergoes routine maintenance, the distortion, after the OUTPUT DC LEVEL and QUIESCENT CURRENT controls have been adjusted, will remain within specification. At 1 mc, however, the distortion may not be minimum. To obtain minimum distortion at 1 mc, it may be necessary to adjust the trimmer capacitor C114. This trimmer is in the plate circuit of V4 and is positioned adjacent to the power resistor, R119, mounted vertically under the chassis next to the socket of V4.

Commercial 1 mc distortion measuring equipment is not commonly available. Distortion measurements, however, can be easily made at this frequency by constructing a simple rejection filter, shown in Figure 7, which will attenuate 1 mc and pass higher harmonics to permit distortion measurements.

SECTION V - 500 HOUR CHECK

Since the typical Model DCA-10 Amplifier distortion at 1 mc is approximately 2-3%, a signal generator with less than 1% distortion is required for this measurement. If a generator with this distortion specification is not available, a band-pass (purifying) filter, shown in Figure 6, can be constructed to obtain a suitable distortion-free 1 mc source.

For convenience in use and to provide shielding, each of these filters may be constructed in a small metal chassis similar to the BUD "Minibox" #CU-3004. Two standard binding posts, similar to the type used on the front panel of the Model DCA-10, can be mounted on one end of the metal enclosure on 3/4 inch centers and two jacks (banana type), with one suitably insulated, can be mounted on the other end. The components in these filters require a tolerance of ±5%.

In addition to these filters the following test equipment is required for the 1 mc distortion-measuring procedure:

a. Sine-wave generator of approximately 10 volts rms maximum output at 1 mc with less than 1% distortion. If a generator with less than 1% distortion is not available, the purifying filter, shown in Figure 6, must be used. Since the filter has a gain of approximately five, a generator with approximately 2 volts rms output at 1 mc is sufficient.

b. Average-reading vacuum-tube voltmeter with low-capacity probe (10 uuf maximum) and frequency range up to 5 mc.

c. Oscilloscope with a bandwidth of 5 mc minimum and probe of 10 uuf maximum capacity.

d. Non-inductive 600 ohm ±5% resistor with a 30 watt minimum rating (a series and/or parallel combination of suitable 2 watt carbon resistors can fulfill this requirement).

Before using the rejection filter it is necessary to tune it for a null at 1 mc by adjusting the trimmers R2 and C2, shown in Figure 7. If this filter is constructed in a closed metal chassis, it is convenient to have access to these controls through a hole in the chassis.

Set the signal generator to a frequency of 1 mc and apply a signal of approximately 5 volts rms to the input of the band-pass (purifying) filter. Connect the output of the purifying filter to the input of the rejection filter and, using the probe, monitor the output of the rejection filter with the oscilloscope. With the oscilloscope set for maximum gain, adjust R2 and C2 until the 1 mc output of the rejection filter is nulled (minimum).

Turn the Amplifier on and set the INPUT SELECTOR switch to the 1 CPS X10 position. Connect the 600 ohm non-inductive load between the AC OUTPUT terminal and chassis ground. Apply an 8 volt rms 1 mc signal to the INPUT terminals of the Amplifier directly if the distortion

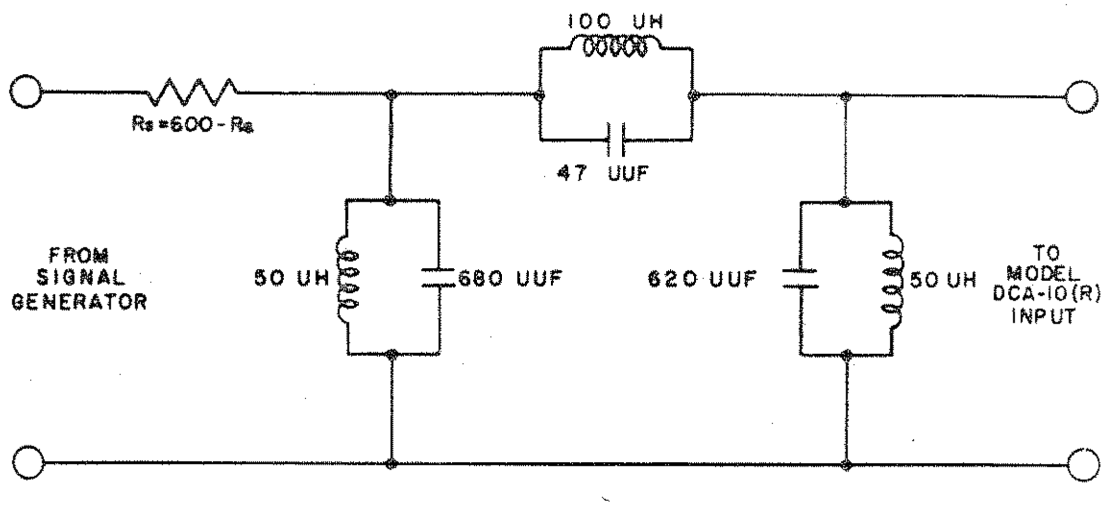


Figure 6 - Band-Pass (Purifying) Filter for Obtaining a Pure 1 mc Signal

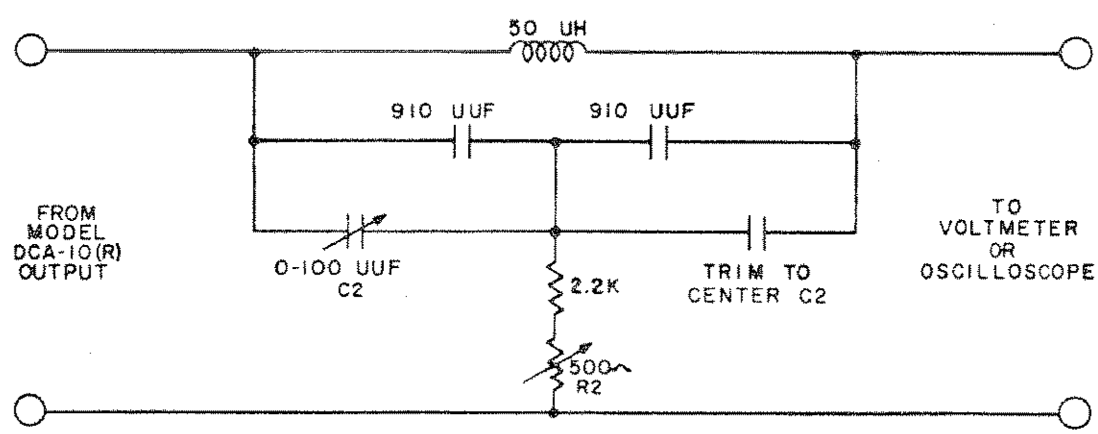


Figure 7 - Rejection Filter for 1 mc Distortion Measurements

of the sine-wave generator is less than 1%. If the distortion of the 1 mc source is greater than 1%, which is true for most commercial generators, insert the purifying filter, shown in Figure 6. This filter is designed to operate with a 600 ohm source. If the sine-wave generator has an internal impedance of 600 ohms, no additional series resistor, R_s, is required. If the generator source impedance is lower than 600 ohms, it is necessary to add a resistor so that the sum of R_s and the generator source impedance is equal to 600 ohms.

When using the purifying filter, adjust the signal generator amplitude so that the 1 mc output voltage developed across the 600 ohm load of the Amplifier is 80 volts rms. Connect the 80 volt rms output of the Amplifier to the input of the rejection filter and monitor the output of the rejection filter with the vacuum-tube voltmeter probe and oscilloscope probe. If necessary, adjust the sine-wave generator frequency so that the 1 mc component of the distorted signal is nulled (minimum). Adjust the trimmer capacitor C114 until the harmonic distortion, measured by the voltmeter or oscilloscope, is minimized.

The residual harmonic voltage at the output of the rejection filter can be measured by the average-reading vacuum-tube voltmeter of 5 mc bandwidth to obtain the rms average value of the distortion. The per cent distortion is given by V/80 x 100 where V is the vacuum-tube voltmeter reading in volts and 80 is the Amplifier output voltage.

For example, if the vacuum-tube voltmeter reads 1.6 volts, the total harmonic distortion is 2 per cent.

After completion of this 500 hour check, which is recommended after replacement of the electron tubes, the Amplifier should perform in accordance with its rated specifications. If it is necessary to check other specifications, refer to ACCEPTANCE AND PERFORMANCE TESTS, SECTION VI.

SECTION VI - ACCEPTANCE AND PERFORMANCE TESTS

This Test Procedure is included in the Model DCA-10 Operating and Maintenance Manual to assist Instrument Maintenance Personnel in making routine performance checks and to assist Incoming Inspection Personnel in making initial acceptance tests.

The Procedure outlined is based on the use of standard laboratory test equipment which should be available to all personnel who may perform these tests. It should be understood that the procedure outlined here does not necessarily represent the Factory Test Procedure in method, scope or detail.

SECTION VI - ACCEPTANCE AND PERFORMANCE TESTS

The majority of this Amplifier's specifications require care in checking, but the method of measurement is neither unusual nor extremely difficult. These specifications will be mentioned briefly and any applicable precautions will be noted.

The specifications given under Technical Summary apply to the direct-coupled (DC) positions of the INPUT SELECTOR switch and the direct-coupled (DC) OUTPUT terminals unless otherwise specified.

Primary consideration is given to measurement of harmonic distortion, which may be difficult at the low levels of distortion and wide frequency range encountered in this Amplifier.

The Procedure is prefaced by a series of precautions which should be studied carefully before any checking is attempted.

<u>EQUIPMENT REQUIRED</u> to perform the checks outlined in this Procedure:

1. Audio Oscillator (Krohn-Hite Model 440-A or equivalent) with sine-wave and square-wave output (square-wave rise time 0.5 microsecond or better) covering the frequency range from 0.1 cps to 100 kc. In the frequency range from 5 cps to 10 kc the harmonic distortion should be less than 0.1 per cent.

2. Signal Generator with 10 volt rms output from 100 kc to 1 mc with less than 1 per cent harmonic distortion.

3. AC Voltmeter capable of indicating 1 millivolt to 200 volts with a bandwidth of 2 mc.

4. Passive non-inductive loads (30 watt resistors having values of 600 and 1,000 ohms ±5%). These can be a series and/or parallel combination of 2 watt composition resistors.

5. Wide Band Oscilloscope with direct-coupled vertical amplifier having response to 5 mc. Some oscilloscopes may be used for measuring phase shift*.

6. Frequency Counter or Phase-Angle-Meter may be needed for phase measurements if suitable oscilloscope is not available.

7. Wave Analyzer or Distortion Meter.

8. DC Voltmeter or other suitable indicator in the 10 millivolt to 10 volt range.

9. AC Voltmeter for checking line voltage.

10. Variable Autotransformer to set line voltage.

*See "A New Angle on Phase Measurements" by G. E. Bauder - a Tektronix, Inc. publication.

SECTION VI - ACCEPTANCE AND PERFORMANCE TESTS

PRECAUTIONS to be observed when making measurements on this Amplifier:

1. Use shielded cables for all test signal connections.

2. Use short low-capacity cable on the Amplifier OUTPUT to avoid excessive capacitive loading at frequencies above 100 kc. See OPERATION, SECTION II-4.

3. Check that the Amplifier is functioning and is being operated within its ratings as outlined in OPERATION, SECTION II.

4. Make certain that all auxiliary test equipment is calibrated and working properly in accordance with the manufacturers' specifications.

1. POWER OUTPUT

The power output of the Amplifier can be measured by an output-power meter or by a standard wattmeter with a separate load, provided that the wattmeter is calibrated for the measuring frequency. The simplest method consists of measuring the voltage developed across a load resistor of known value. In most cases the value of this resistor will be 600 or 1,000 ohms with a 30 watt minimum rating. It should be non inductive for high-frequency measurements and can be a series and/or parallel combination of 2 watt composition resistors.

Power in watts is determined from the relation $E(rms)^2/R$ for sinusoidal voltages and $E(p \text{ to } p)^2/4R$ for square wave voltages. Other waveforms require very careful handling if a power computation is to be made.

For reactive-load tests, a different load is needed at each different frequency (16 uf or 16 henries at 10 cps; 1,600 uuf or 1.6 millihenries at 100 kc; etc.).

Rated output cannot be obtained if the line voltage is below 105 volts.

If the direct-coupled (DC) positions of the INPUT SELECTOR switch are used with uni-directional square wave input signals, without an external coupling capacitor to remove the dc component, the maximum output power will be limited by clipping at the peak of the uni-directional swing.

Above 1 mc, the available output power drops as shown in Figure 11.

The Amplifier is not restricted to the matched load impedances. With other load impedance values the maximum power output will be reduced as shown in Figure 8. Characteristics of the Amplifier, other than maximum power output, will not be affected by the use of moderately mismatched loads. Maximum power output from this Amplifier is obtained just below the signal level at which clipping (squaring) of a sinusoidal output signal occurs. The maximum signal level for square-wave operation is more difficult to detect and is usually indicated by the onset of "ringing" and spurious high-frequency transient signals which modify the output square wave. If the Amplifier is left in an overloaded condition for any appreciable time, the fuse may blow.

2. OUTPUT REGULATION

Output regulation is determined by measuring the change (e) in output voltage from no load to full load when a 1,000 ohm (30 watt rating) load resistor is applied to the OUTPUT terminals. The Amplifier input voltage must be held constant during these measurements because the output voltage change (e) usually will be less than 2%. The output voltage will normally decrease when the load is applied. A decrease indicates positive regulation while negative regulation corresponds to an increase in the output voltage with load.

The output regulation in per cent is defined as $-100e/E_o$, where E_o is the open-circuit output voltage. As an example, at 20 kc, assume that E_o decreases by 1 volt when a 1,000 ohm resistive load is applied to the OUTPUT terminals. If 100 volts rms is the open circuit voltage, the per cent output regulation is -100 x -1/100 or +1%.

3. INTERNAL IMPEDANCE

In an amplifier that incorporates only degenerative voltage feedback, the internal impedance will always be positive and consist of series resistance and reactance. If the resistive component of the internal impedance is positive, the amplifier output regulation will always be positive.

The Amplifier internal impedance can be calculated from the Output Regulation and the no-load to full-load change (θ) in the output voltage phase angle. See SECTION VI-6. It is desirable to measure the phase angles with an accuracy of one (1) degree or better. By applying the cosine theorem to the vector triangle made up of the loaded and the unloaded output voltages with phase difference θ and the voltage drop across the internal impedance, the following formula is obtained:

$$Z_I = Z_L \sqrt{A^2 + 4(1+A)\,(\sin\theta)/2)^2}$$

where Z_I is the magnitude of the internal impedance to be determined, Z_L is the magnitude of the impedance of the load and

$$A = \frac{\%\ \text{Output Regulation}}{100 - \%\ \text{Output Regulation}}$$

For small values of Output Regulation (in the order of 2%) A is approximately equal to the % Output Regulation/100 with negligible error.

At frequencies below 50 kc, θ is normally negligible and $Z_I = AZ_L$

4. OUTPUT DC LEVEL STABILITY

For these tests, make certain that the measuring equipment does not drift more than 1 millivolt per hour. The specifications are expressed in per cent of the maximum obtainable peak output voltage. For 150 volts, the ±0.02% limit corresponds to 0.02/100 x 150, which is 0.03 volts or 30 millivolts.

5. FREQUENCY RESPONSE

Frequency response is defined as the frequency range over which the voltage gain of the Amplifier remains within the specified limits. In order to obtain the maximum frequency response, the INPUT SELECTOR switch must be in one of the direct-coupled (DC) positions.

This specification can be checked with or without a load on the Amplifier. The performance with various loads is shown in Figure 10. If the measurement is made with a load connected, the maximum power limitation versus frequency shown in Figure 11 must be carefully observed. At frequencies above 1 mc, the input voltage must be reduced to stay within the power limitation. Even if the measurement is made under no-load conditions, the input voltage must be reduced above 1 mc because the output voltage swing is restricted by limitations in the driver stage.

6. PHASE SHIFT

This instrument will faithfully amplify complex waveforms because it has an approximately linear phase shift versus frequency characteristic. The deviation from linear phase shift, or phase distortion, can be readily determined by plotting the phase shift characteristic from measurements made using a phase angle meter, frequency counter, oscilloscope or other suitable phase measuring device. A straight line should be carefully drawn through an average of the plotted points with a slope such that an extension of the line would pass through the origin.

7. HARMONIC DISTORTION

The absolute measurement of low values of distortion is difficult and requires instruments which are not known to be commercially available.

The best method of measuring distortion is to apply a distortion-free signal to the Amplifier INPUT and measure the distortion products appearing in the OUTPUT.

Two different methods of measuring harmonic distortion down to 0.001% have been used. The first, used for rapid production testing of Amplifiers, requires complex filter networks and measures total harmonic distortion at a single frequency. It consists of generating an ultra-low distortion sine wave and feeding it through the Amplifier under test. The fundamental frequency is then filtered out, leaving the harmonics produced by the Amplifier. The amplitude of this harmonic signal is read on an average-reading vacuum-tube voltmeter and compared with the Amplifier output voltage.

The equipment employed to generate an ultra-low distortion sine wave consists of a Krohn-Hite Model 440-A Push-Button Oscillator feeding two cascaded sharply-peaked 120 db feedback amplifiers which together attenuate harmonics 1,000 times.

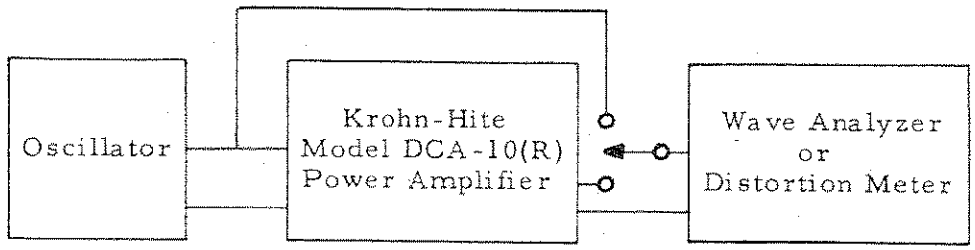
For eliminating the fundamental frequency the equipment consists of three cascaded null filter and 90 db feedback amplifier combinations, plus a special band-pass filter with corner peaking. The over-all response is flat from the second harmonic of the fundamental to the fifth harmonic with a sharp cut-off on each side and rejection in the order of 150 db at the fundamental frequency.

Since the specialized equipment for making this type of measurement is not normally available, an alternate method is presented which utilizes far less equipment but requires highly stable components and unusual precision in the setting of phase and amplitude controls. This method consists of measuring the difference signal between the oscillator terminals and the Amplifier OUTPUT with suitable attenuation and phase-shift networks inserted between the oscillator and the Amplifier INPUT to reduce the over-all gain to unity and phase shift to zero. This difference signal is the distortion and noise produced by the Amplifier. A Krohn-Hite Model 310-AB Band-Pass Filter is used on this difference signal to remove the noise and the last trace of fundamental frequency, leaving only the harmonics which are read on an average-reading vacuum-tube voltmeter. Since oscillator distortion tends to be cancelled, the Krohn-Hite Model 440-A can be used without additional filtering.

Because of the severe difficulties of these two methods of measuring harmonic distortion, a third method is suggested. This method is probably the best substitute for an absolute measurement and when carefully done will yield satisfactory results with commercially available instruments.

While this method is not new or unique in any way, there are definite precautions which must be observed in using the test equipment and there are fundamental limitations to the accuracy obtainable.

The suggested technique is one in which the distortion introduced by the Amplifier is considered to be the difference in the distortion values measured at the INPUT and OUTPUT terminals of the Amplifier. This method is shown schematically as follows:



Using this method of distortion measurement, it is theoretically possible, although extremely unlikely, that readings may be obtained indicating low distortion (same measured distortion at the INPUT and OUTPUT) from relatively high-distortion amplifiers. If an amplifier is distorting in a special way, with the phase and magnitude of each of the harmonics exactly right, vector addition of the distortion introduced by the amplifier and the input distortion can give a result which has the same magnitude as the original input distortion. For example, if there is 0.04% of third-harmonic distortion in the input signal, and if an amplifier introduces 0.08% of third-harmonic distortion of exactly opposite phase, the magnitude of the resulting third-harmonic distortion in the amplifier output signal will be 0.04% minus 0.08% or minus 0.04%. "Minus" indicates that the output distortion is 180 degrees out-of-phase with the input distortion, but if the phase is not checked, there will be no indication that the OUTPUT third-harmonic distortion is not the same distortion as that measured at the INPUT.

The probability of obtaining low-distortion readings from a relatively high-distortion amplifier is extremely small because in addition to the third harmonic, cited in the previous example, being exactly the right phase and magnitude, the other harmonics must either be absent completely or also have exactly the right phase and magnitude. If a case should be noted where the OUTPUT distortion appears to be less that that measured at the INPUT, the readings should be very carefully checked and a careful measurement of the phase relationship of the harmonics is indicated.

It is essential that certain precautions be observed when a wave analyzer or distortion meter is used to measure low values of distortion. Experience at Krohn-Hite does not cover all makes of distortion measuring equipment, but the same general considerations should apply to all wave analyzers and distortion meters.

When using a distortion meter to measure low values of distortion, the following information and precautions apply:

A. Great care should be taken to ensure that the instrument is properly calibrated in accordance with the manufacturer's instructions. In particular, since the panel meter indicates internally generated power supply ripple voltage, it is important that any hum-balance adjustments be made with great care. Before making a measurement, check that no meter indication is observed on any range when the INPUT terminals are shorted.

B. This type of instrument usually has an internal amplifier which has some inherent distortion. Consequently there will be an indication of distortion, even when a pure sine-wave voltage is applied. The amount of internal distortion is usually small, and only becomes important when the low end of the most sensitive scale is being read. A typical residual distortion specification is 0.1%, and it is assumed that an actual value of 0.05% might reasonably be expected in a reputable manufacturer's instrument. This amount of residual distortion leads to a reading error of only 1% when the total reading is 5%, but when a total distortion value of 0.1% is being measured, the reading error can be as high as 50%.

C. At very low distortion levels the phase relationship between input harmonic voltages and those generated within the distortion meter becomes important because the panel meter indicates the magnitude of the vector sum of these voltages. Depending on relative phase and amplitude, an input harmonic voltage could produce a distortion reading anywhere from zero to many times its actual value.

When using a wave analyzer to measure very low values of distortion, the following information and precautions apply:

A. Great care should be taken to ensure that the instrument is properly calibrated in accordance with the manufacturer's instructions. This is most important.

B. When this instrument is used as a distortion meter, the sensitivity controls are adjusted to give a full scale (100%) meter reading when the tuning control is carefully set to the fundamental frequency of the input signal. Once the analyzer sensitivity and input signal amplitude adjustments have been made, they must not be disturbed while the harmonics are being measured.

C. When this instrument is used as a frequency selective voltmeter to measure relative fundamental and harmonic voltage amplitudes, an input sensitivity setting must be selected which gives an "on scale" meter reading when the tuning control is carefully set to the fundamental frequency of the input signal. If the analyzer does not have a variable sensitivity control, the input signal amplitude can be adjusted to give a full scale meter reading, if desired, to facilitate the measurement. Once the analyzer sensitivity and input signal amplitude adjustments have been made, they must not be disturbed while the harmonics are being measured.

D. When using the analyzer to measure low levels of distortion by either of the above methods, do not increase the analyzer sensitivity or increase the input signal amplitude independently in an attempt to obtain a better harmonic voltage amplitude or percentage reading. The input circuits of the analyzer will be overloaded by the fundamental frequency voltage and the resulting distortion will lead to erroneous readings, even though the meter appears to be functioning properly.

E. With regard to residual instrument distortion and the phase relationship between these harmonics and input signal distortion harmonics, the same considerations apply as in the distortion meter.

Another difficulty in checking the distortion of the Model DCA-10 Amplifier is lack of equipment for use at the high frequency end of its range. In this case it is possible to obtain satisfactory results with LC circuits of the type described in 500 HOUR CHECK, SECTION V.

The DC linearity of the Amplifier can be checked by plotting output vs. input voltage and measuring the deviation from a straight line drawn through the origin (make certain that the Amplifier output dc level is set to zero before the data is taken).

8. HUM AND NOISE

When checking this specification make certain that the INPUT terminals are very carefully shielded against electrostatic pick-up. It is suggested that for the open circuit cases, a shielded plug such as the GR type 274-ND or 274-NK Shielded Double Plug, with no leads connected, be used for this purpose.

Measurement of the noise should be made with an ac average-reading vacuum-tube voltmeter having a band width of not more than 2 mc to avoid the possibility of including unwanted radio-frequency voltages picked up from the power line or by incomplete shielding of the meter leads.

9. DYNAMIC RANGE

This is a measure of signal to noise ratio. With a maximum rms output of 105 volts and noise of 5 millivolts the dynamic range is approximately 86 db.

10. SQUARE-WAVE RESPONSE

It is recommended that a signal amplitude of 155 volts p to p be used. See SECTION VI-1 for high level precaution.

SECTION VII - SERVICE AND WARRANTY

KROHN-HITE Instruments are designed and manufactured in accordance with sound engineering practices and should give long trouble-free service under normal operating conditions. If this Amplifier fails to provide satisfactory service and the source of trouble cannot be located, write to the Factory Service Department giving all the information available concerning the failure.

Do not return the Instrument without written authorization for, in most cases the information necessary to repair the Instrument can be provided, thus avoiding the transportation problems and costs. When it becomes necessary to return the Instrument to the Factory, kindly pack it carefully and ship via Express, prepaid.

KROHN-HITE Instruments are conservatively designed to provide continuous reliable service under normal laboratory conditions. The material and workmanship in every new instrument manufactured by KROHN-HITE is guaranteed for one year from the date of shipment to the original purchaser. Any instrument developing defects during this period will be repaired or replaced without charge when the failure is the result of defective material or workmanship. This warranty does not apply to electron tubes, fuses, batteries, transistors and other semiconductor devices.

KROHN-HITE reserves the right to make design changes at any time without incurring any obligation to incorporate these changes in instruments previously purchased.

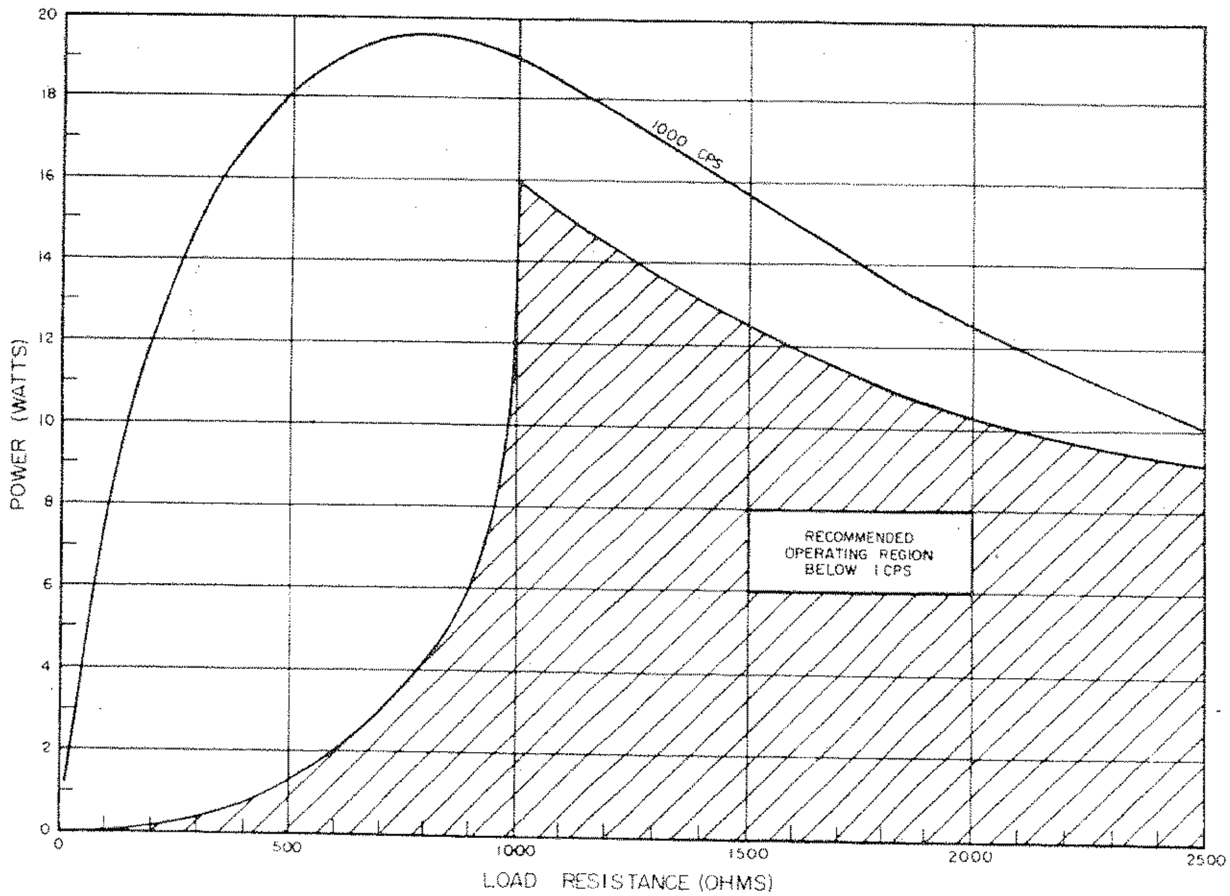


Figure 8 - MAXIMUM POWER OUTPUT vs. LOAD RESISTANCE

For values above 2,500 ohms, power at 1 kc is approximately 25,000 divided by load ohms. Under 1,000 ohms, permissible power output below 1 cps is reduced because of tube dissipation ratings.

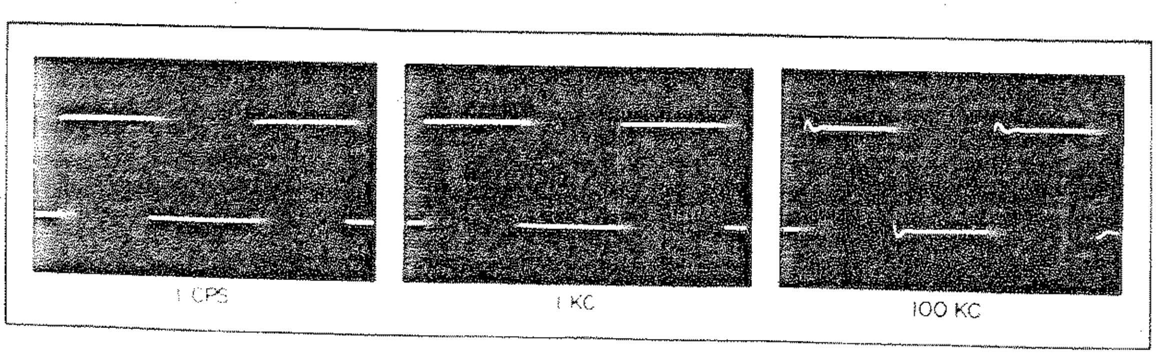


Figure 9 - SQUARE WAVE RESPONSE

These waveforms show a 155 volt peak to peak signal across a 600 ohm resistive load.

ohms is reduced because of tube dissipation r ngs.

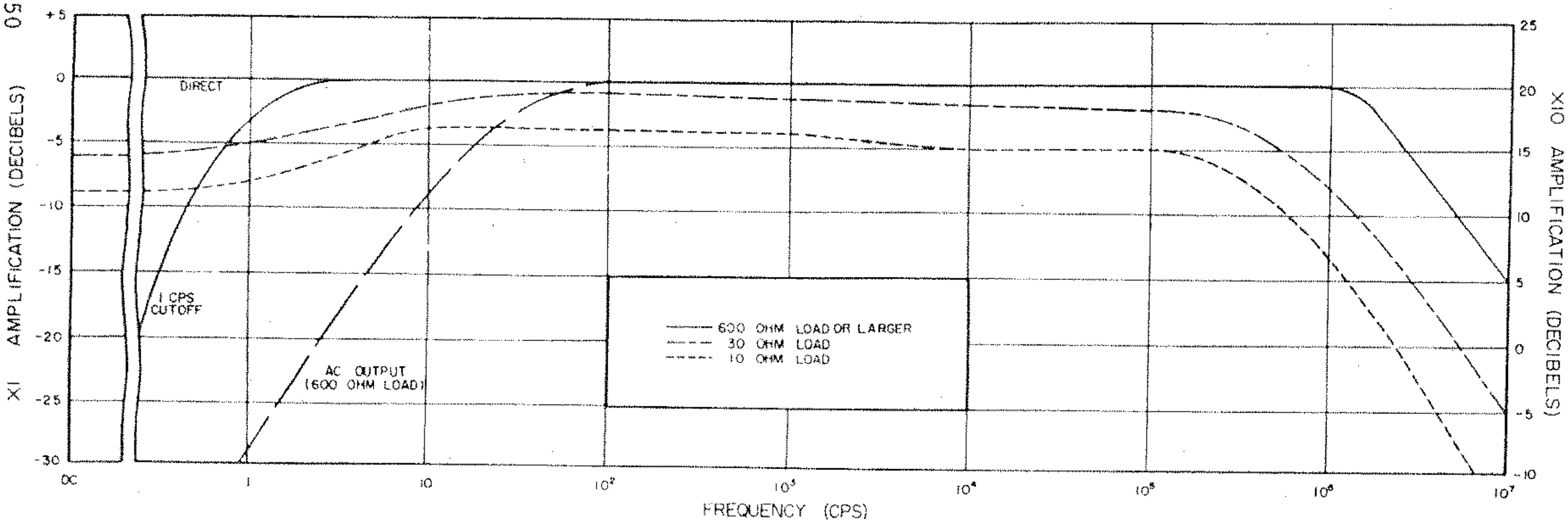


Figure 10 - VOLTAGE AMPLIFICATION vs. FREQUENCY

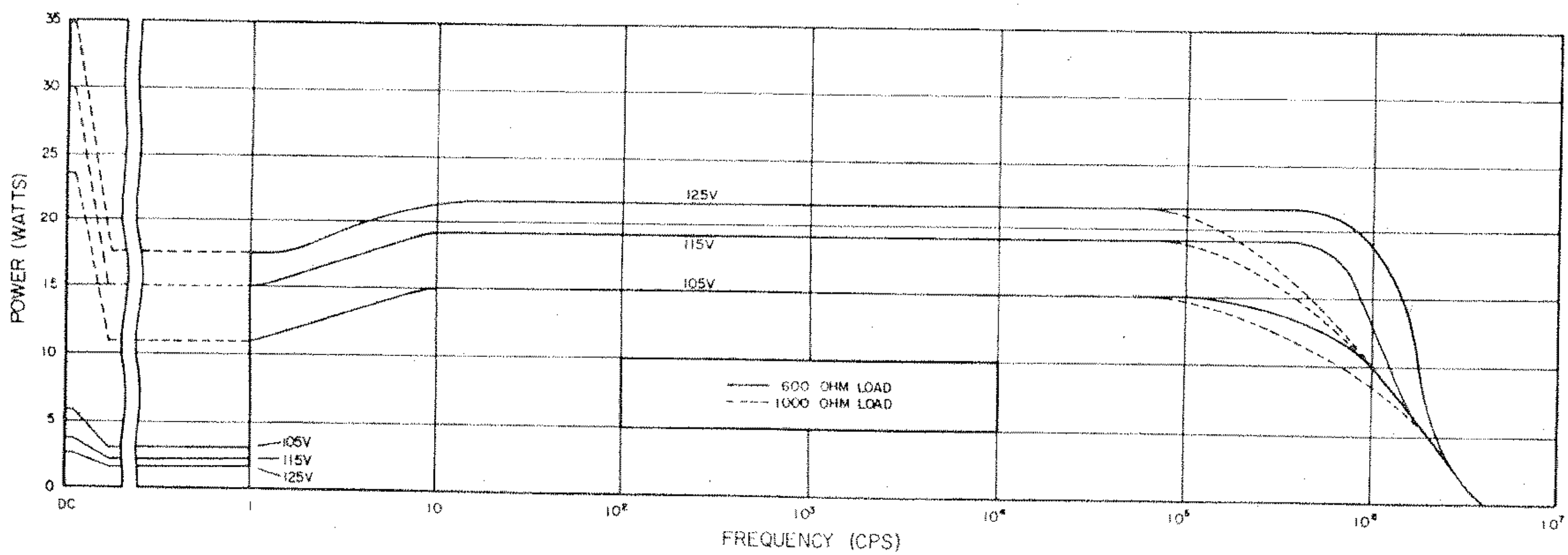


Figure 11 - MAXIMUM POWER OUTPUT vs. FREQUENCY

Curves are for designated line voltages and resistive loads. Below 1 cps, the maximum power output into 600 ohms is reduced because of tube dissipation ratings.

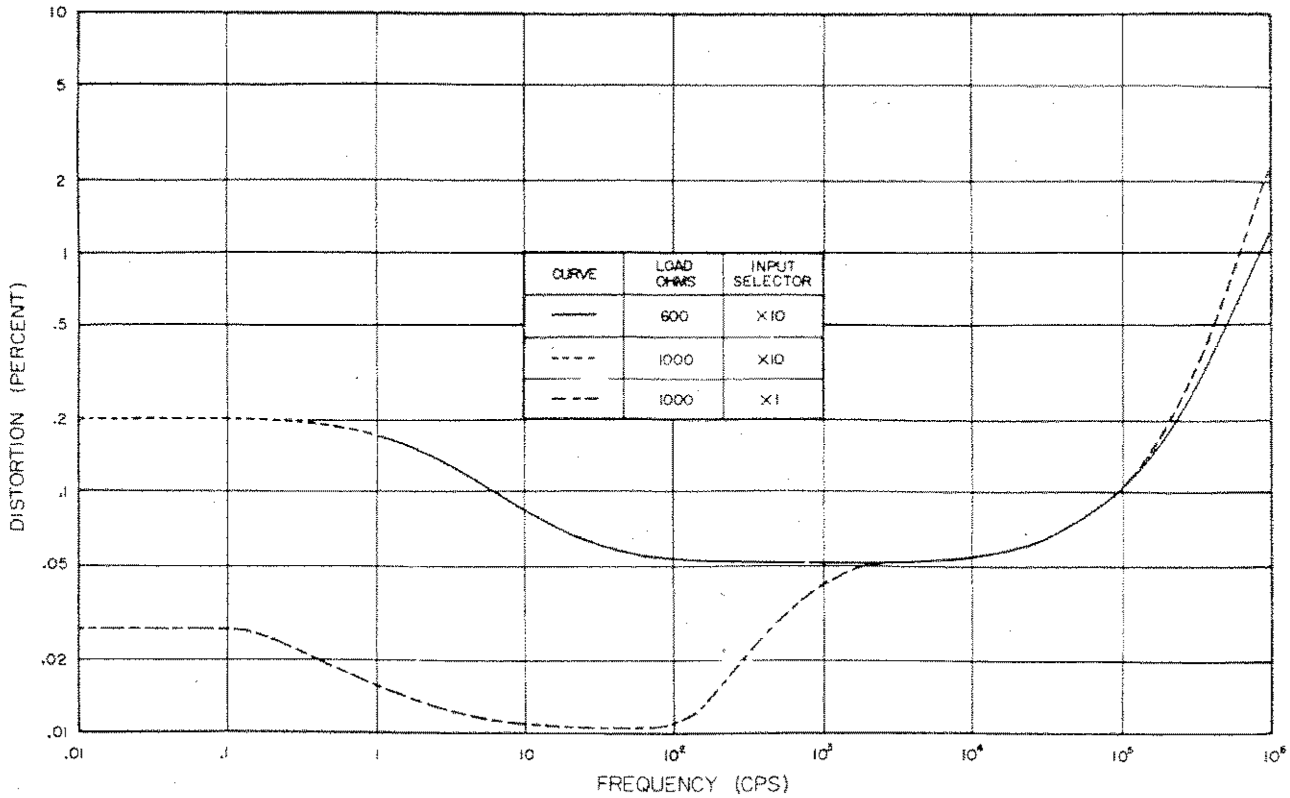


Figure 12 - DISTORTION vs. FREQUENCY
Curves are for 10 watt output power level

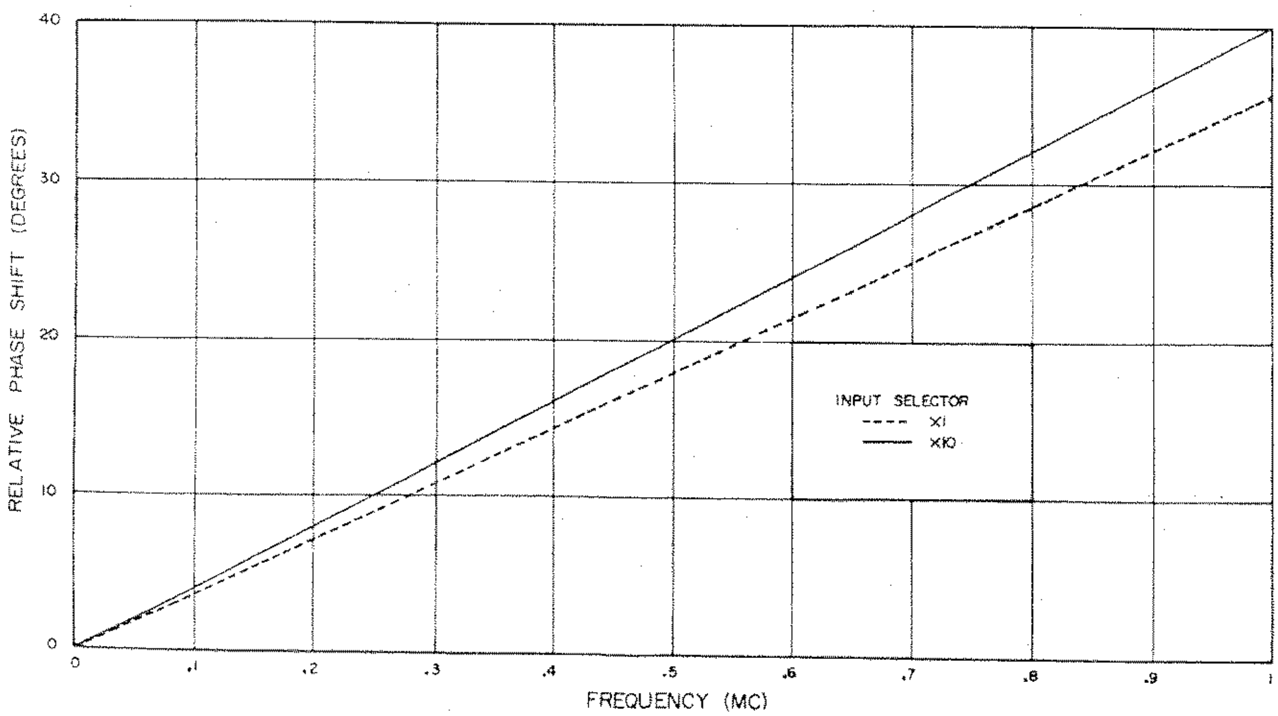


Figure 13 - PHASE SHIFT vs. FREQUENCY

SECTION IX - PARTS LIST

Schematic Symbol	Description	Qty	Mfg	Mfg Part No.
B301	Fan Motor	1	ALL	JS0690
C100	1 uuf mica		EL	
C101	.22 uf, 400 v, 10%, Tubular	1	SP	160P22494
C102	390 uuf, 500 v, 20%, Mica	1	EL	CM19C391M
C103	330 uuf, 500 v, 10%, Mica	1	EL	CM19C331K
C104	39 uuf, 500 v, 10%, Duro-mica	1	EL	DM-15-390K
C105	.1 uf, 1000 v, 10%, Tubular	3	SP	160P104910
C106	Same as C105			
C107	.0015 uf, 400 v, 10%, Tubular	1	SP	160P15294
C110	.0047 uf, 500 v, 20%, Ceramic	1	SP	20C194A2
C111	.002 uf, 1000 v, 10%, Ceramic	1	SP	20C12A2
C112	220 uuf, 500 v, 5%, Mica	1	EL	CM19C221J
C113	.012 uf, 400 v, 5%, Tubular	1	SP	109P12354
C114	1.5-20 uuf, trimmer, 400 v, 10%	3	AR	402
C116	5.1 uuf, 500 v, 10%, Mica	1	EL	CM19C051K
C117	51 uuf, 500 v, 10%, Mica	1	EL	CM19C510K
C118	15 uuf	1	EL	
C119	20 uf, 150 v, +100%-10%	1	SP	TVA-1410
C120	10 ufd, 200 v, 10%	1	C-D	MTW112
C121	.01 uf, 500 v, 20%, Ceramic	1	SP	29C214A
C201	.15 uf, 400 v, 10%, Tubular	1	SP	109P15494
C202	Same as C114			
C203	24 uuf, 500 v, 10%, Duro-mica	2	EL	DM-15-240K
C204	.068 uf, 400 v, 10%, Tubular	1	SP	109P68394
C205	2 uf, 100 v, 20%, Can	1	C-D	WC1200-1

SECTION IX - PARTS LIST

Schematic Symbol	Description	Qty	Mfg	Mfg Part No.
C206	Same as C114			
C207	Same as C203			
C301	2 x 7 uf, 1000 v, 10%, Can	1	C-D	TRH 102
C302	20 uf, 450 v, +50%-10%, Electrolytic	1	SP	D31574-6013
C303	2 x 40 uf, 450 v, +50%-10%, Electrolytic	2	SP	17D15-D26400
C304	.1 uf, 400 v, 20%, Tubular	4	SP	160P10404
C305	4 uf, 450 v, +50%-10%, Electrolytic	2	SP	TVA-1702
C306	Same as C303			
C307	Same as C304			
C308	.001 uf, 400 v, 10%, Tubular	1	SP	109P10294
C309	Same as C305			
C310	.02 uf, 500 v, 20%, Ceramic	1	SP	41C205A
C311	Same as C304			
C312	.1 ufd, 600 v, 20%, Tubular	1	SP	160P10406
C313	Same as C304			
C314	60 ufd, 250 v, +100%-10%, Electrolytic	1	SP	D33894
CR101	Rectifier-Silicon, 750 ma, 200 piv	1	RCA	1N3253
CR301	Rectifier-Silicon, 750 ma, 400 piv	14	RCA	1N3254
CR302	Same as CR301			
CR303	Same as CR301			
CR304	Same as CR301			
CR305	Same as CR301			
CR306	Same as CR301			
CR307	Same as CR301			

Schematic Symbol	Description	Qty	Mfg	Mfg Part No.
CR308	Same as CR301			
CR309	Same as CR301			
CR310	Same as CR301			
CR311	Same as CR301			
CR312	Same as CR301			
*CR313	Same as CR301			
*CR314	Same as CR301			
**CR313	Rectifier-Silicon, 750 ma, 600 piv	1	RCA	1N3255
DS301	Fuse Indicator	2	I-D	Omni-Glow 1040H51
DS302	Same as DS301			
DS303	Pilot Light	1	GE	#47
F301	Fuse, Slow-Blow, 2-1/2 A	1	BU	MDL-2-1/2
F302	Fuse, Slow-Blow, 3/16 A	1	BU	MDL-3/16
L101	220 uh	1	Del	3500-16
L102	680 uh	1	Del	BS-807
L103	1 mh	2	Del	BS-805
L104	Same as L103			
L105	8.2 uh	1	Del	1537-34
L301	11 H, 500 Ω, 20%	1	K-H	C-100-13B
L302	22 mh	2	Del	2281-2
L303	Same as L302			
R100	15 k, 1/2 w, 5%	1	A-B	EB-1535
R101	5 k, 2 w, 20%	1	A-B	JA1N060P502UA
R102	1.2 Meg, 1/2 w, 10%	1	A-B	EB-1251
R103	180 k, 1/2 w, 5%	1	A-B	EB-1845
R104	18 k, 2 w, 10%	1	A-B	HB-1831
R105	390 ohms			

SECTION IX - PARTS LIST

Schematic Symbol	Description	Qty	Mfg	Mfg Part No.
R106	100 ohms, 1/2 w, 20%	14	A-B	EB-1012
R107	13 k, 2 w, 5%	2	A-B	HB-1335
R108	250 k, 1/2 w, 1%	6	IRC	Type CEC-TO
R109	2.7 k, 1/2 w, 5%	1	A-B	EB-2725
*R110	50 k, 25 w, 5%, WW	1	K-H	10-500-R110
**R110	50 k, 25 w, 5%, WW	1	K-H	10R-500-R110
R111	Same as R106			
R112	Same as R107			
R113	Same as R108			
R114	Same as R106			
R115	Same as R108			
R116	10 k, 2 w, 20%, Potentiometer	1	A-B	JA1H040S103UA
R117	Same as R108			
R118	Same as R106			
R119	11.88 k, tapped at 3.17 k, 25 w, 5%, WW	1	K-H	10-118-R119
R120	390 k, 2 w, 5%	1	A-B	HB-3945
R121	Same as R106			
**R122	3.5 k, 25 w, 5%, WW	1	K-H	10R-350-R122
*R122	3.5 k, 25 w, 5%, WW	1	K-H	10-350-R122
R123	Same as R106			
**R124	35 k, 10 w, 5%, WW	1	K-H	10R-350-R124
*R124	35 k, 10 w, 5%, WW	1	K-H	10-350-R124
R125	15 k, 1/2 w, 5%	1	A-B	EB-1535
R126	18 k, 1/2 w, 10%	1	A-B	EB-1831
R127	2.5 k, 10 w, 5%, WW	1	K-H	10-250-R127
R128	68 k, 1 w, 10%	1	A-B	GB-6831
R129	Same as R106			

Schematic Symbol	Description	Qty	Mfg	Mfg Part No.
R130	4.7 ohms, 1 w, 10%	2	A-B	GB-47G1
R131	Same as R106			
R132	Same as R106			
R133	620 k, 1 w, 5%	2	A-B	GB-6245
*R134	840 ohms, 20 w, 5%, WW	1	K-H	10-840-R134
**R134	840 ohms, 20 w, 5%, WW	1	K-H	10R-840-R134
R135	200 k, 1 w, 5%	1	A-B	GB-2045
*R136	4 k, 10 w, 5%, WW	1	K-H	10-400-R136
**R136	4 k, 10 w, 5%, WW	1	K-H	10R-400-R136
**R137	2 k, 5 w, 20%, Potentiometer	1	Cent.	BA401-236
*R137	2 k, 5 w, 20%, Potentiometer	1	Cent.	BA401-130
R138	Same as R106			
R139	Same as R106			
R140	3 k, 1/2 w, 5%	1	A-B	EB-3025
R141	Same as R133			
R142	91 k, 1/2 w, 5%	1	A-B	EB-9135
R143	12 k, 1/2 w, 5%	1	A-B	EB-1235
R144	30 k, 10 w, 5%	2	W-L	10X30000
R145	Same as R106			
R146	Same as R130			
R147	6.3 k, 10 w, 5%		W-L	10X6300
R148	100 ohms, 10 w, N.I.	1	W-L	10BR100
R149	100 k, 1/2 w, 5%	1	A-B	EB-1045
R150	Same as R108			
R151	Same as R108			
R201	2.4 k			
R202	6 m, 1/2 w, 1%	1	IRC	Type DCC
R203	1.8 m, 1/2 w, 1%	1	IRC	Type DCC

Schematic Symbol	Description	Qty	Mfg	Mfg Part No.
R204	725 k, 1/2 w, 1%	1	IRC	Type DCC
R205	220 k, 1/2 w, 1%	1	IRC	Type DCC
R206	5.7 m, 1/2 w, 1%	1	IRC	Type DCC
R207	Potentiometer, 1 m, 2/10 w, 20%	1	CTS	FM5878
R208	1.72 m, 1/2 w, 1%	1	IRC	Type DCC
R301	100 k, 1/2 w, 10%	1	A-B	EB-1041
R302	15 k, 10 w, 5%	1	W-L	10X15000
R303	40 k, 25 w, 5%	1	K-H	10-400-R303
R304	100 k, 2 w, 10%	2	A-B	HB-1041
R305	Same as R106			
R306	18 ohms, 10 w, 5%	1	W-L	10X18
R307	470 k, 1/2 w, 5%	2	A-B	EB-4745
R308	218 k, 1/2 w, 1%	1	IRC	Type CEC-TO
R309	500 k, 1/2 w, 1%	4	IRC	Type CEC-TO
R310	17.5 k, 10 w, 5%	1	W-L	10X17500
R311	390 k, 1/2 w, 10%	1	A-B	EB-3941
R312	Same as R304			
R313	260 k, 1/2 w, 1%	1	IRC	Type CEC-TO
R314	166.7 k, 1/2 w, 1%	2	IRC	Type CEC-TO
R315	Same as R106			
R316	Same as R307			
R317	Same as R144			
R318	220 k, 1/2 w, 10%	1	A-B	EB-2241
R319	470 k, 1/2 w, 10%	1	A-B	EB-4741
R320	180 k, 1/2 w, 10%	1	A-B	EB-1841
R321	200 k, 1/2 w, 5%	1	A-B	EB-2045
R322	430 k, 1/2 w, 5%	1	A-B	EB-4345
R323	22 k, 2 w, 10%	2	A-B	HB-2231

SECTION IX - PARTS LIST

Schematic Symbol	Description	Qty	Mfg	Mfg Part No.
R324	Same as R323			
R325	47 k, 2 w, 10%	1	A-B	HB-4731
R326	Same as R309			
R327	Same as R309			
R328	Same as R309			
R329	Same as R314			
S101	Input Selector Switch	1	K-H	DCA-10-15
S301	Power Switch DPDT	1	C-H	8373K7
*S302	Push Button Switch SPST	1	C-H	8411K4
T301	Power Transformer	1	K-H	P-100-21D
T302	Screen Transformer	1	K-H	P-100-30
V1	Medium-Mu Twin Triode	1	RCA	6BK7B
V2	Beam Power Tube	1	RCA	6AQ5A
V3	Power Pentode	2	RCA	6CL6
V4	Same as V3			
V5	Beam Power Tube	1	RCA	6GT5
V6	Same as V5			
V7	Full Wave Vacuum Rectifier	1	RCA	5R46B
V8	Twin Triode	1	GE	6AS76A
V9	High-Mu Twin Triode	1	RCA	12AX7A

SECTION IX - PARTS LIST

MANUFACTURER LISTING

Abbreviation	Name	Address
A-B	Allen-Bradley Company	Milwaukee 4, Wisconsin
ALL	Alliance Manufacturing Company	Alliance, Ohio
AR	Arco	
BU	Bussman Manufacturing Company	St. Louis, Missouri
C-D	Cornell-Dubilier Electric Company	South Plainfield, N. J.
Cent.	Centralab	Milwaukee, Wisconsin
C-H	Cutler-Hammer, Incorporated	Milwaukee, Wisconsin
CTS	Chicago Telephone Supply Corporation	Elkhart, Indiana
Del	Delevan Electronics Corporation	E. Aurora, N. Y.
EL	Elmenco	Willimantic, Connecticut
GE	General Electric Company	Schenectady, N. Y.
I-D	Industrial Devices, Incorporated	Edge Water, N. J.
IRC	International Resistance Company	Philadelphia, Pennsylvania
K-H	Krohn-Hite Corporation	Cambridge, Massachusetts
RCA	Radio Corporation of America	Harrison, N. J.
SP	Sprague Electric Company	North Adams, Massachusetts
W-L	Ward Leonard Electric Company	Chicago, Illinois

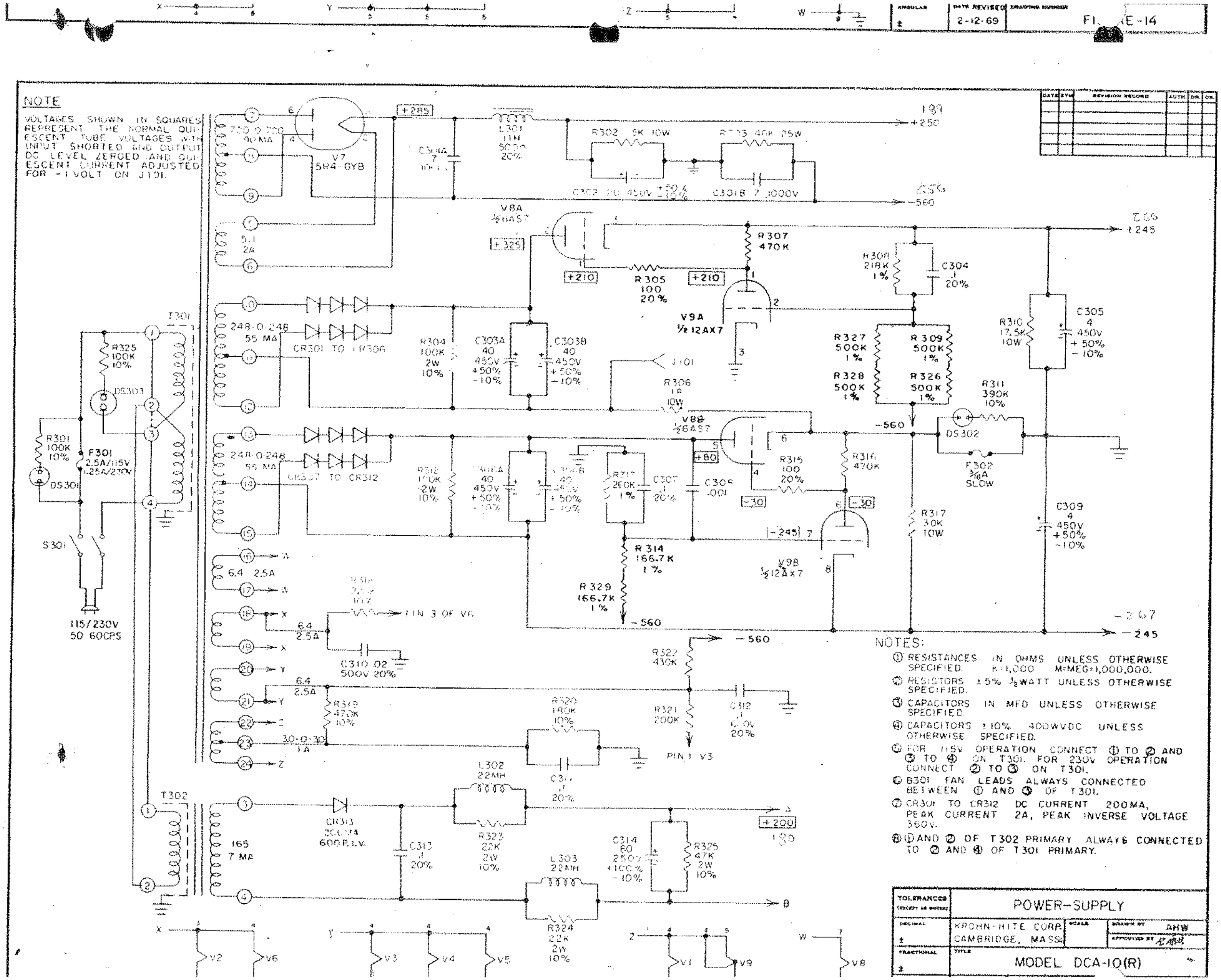
* Components used only on standard units.

** Components used only on rack units.

Manufacturer's Part No. listed may not agree with Part No. found in instrument, but are direct replacements.

When ordering parts from Factory, the following information should be supplied:

Instrument Model Number
Serial Number
Description
Manufacturer
Part No.


DATE REVISED 2-12-69
FI E-14
NOTE
VOLTAGES SHOWN IN SQUARES REPRESENT THE NORMAL QUIESCENT TUBE VOLTAGES WITH INPUT SHORTED AND OUTPUT DC LEVEL ZEROED AND QUIESCENT CURRENT ADJUSTED FOR -1 VOLT ON J101.
V7 5R4-GYB
720-0-720 90 MA
5.1 2A
248-0-248 55 MA
CR301 TO CR306
CR307 TO CR312
6.4 2.5A
30-0-30 1A
165 7 MA
CR313 200 MA 600 P.I.V.
L301 1H 500MA 20%
R302 5K 10W
R303 40K 25W
C302 20 450V +50% -10%
C301B 7 1000V
V8A 1/2 6AS7
V8B 1/2 6AS7
V9A 1/2 12AX7
V9B 1/2 12AX7
R307 470K
R305 100 20%
R308 218K 1%
C304 .1 20%
R309 500K 1%
R326 500K 1%
R327 500K 1%
R328 500K 1%
R310 17.5K 10W
C305 4 450V +50% -10%
R311 390K 10%
DS302
F302 3/16A SLOW
R317 30K 10W
C309 4 450V +50% -10%
R316 470K
R315 100 20%
R314 166.7K 1%
R329 166.7K 1%
C306 .001
R306 1A 10W
J101
C303A 40 450V +50% -10%
C303B 40 450V +50% -10%
R304 100K 2W 10%
R312 100K 2W 10%
C310 .02 500V 20%
R319 470K 10%
R320 180K 10%
R322 430K
R321 200K
PIN 3 OF V6
PIN 1 V3
L302 22MH
L303 22MH
R323 22K 2W 10%
R324 22K 2W 10%
C313 .1 20%
C314 60 250V +100% -10%
R325 47K 2W 10%
T301
T302
R325 100K 10%
DS303
R301 100K 10%
DS301
F301 2.5A/115V 1.25A/230V
S301
115/230V 50 60CPS
+285
+325
+210
+80
-30
-245
+200
+250
-560
+245
-245
NOTES:
① RESISTANCES IN OHMS UNLESS OTHERWISE SPECIFIED. K=1,000 M=MEG=1,000,000.
② RESISTORS ±5% 1/2WATT UNLESS OTHERWISE SPECIFIED.
③ CAPACITORS IN MFD UNLESS OTHERWISE SPECIFIED.
④ CAPACITORS ±10% 400WVDC UNLESS OTHERWISE SPECIFIED.
⑤ FOR 115V OPERATION CONNECT ① TO ② AND ③ TO ④ ON T301. FOR 230V OPERATION CONNECT ② TO ③ ON T301.
⑥ B301 FAN LEADS ALWAYS CONNECTED BETWEEN ① AND ③ OF T301.
⑦ CR301 TO CR312 DC CURRENT 200MA, PEAK CURRENT 2A, PEAK INVERSE VOLTAGE 360V.
⑧ ① AND ② OF T302 PRIMARY ALWAYS CONNECTED TO ② AND ④ OF T301 PRIMARY.
POWER-SUPPLY
KROHN-HITE CORP. CAMBRIDGE, MASS.
DRAWN BY AHW
MODEL DCA-10(R)

TUBE NO.	TUBE TYPE		PIN NUMBER 1	2	3	4	5	6	7	8	9
V1	6BK7B	V	160	0	3.0	-85	-85	160	0	3.0	0
		R	27K	180K	15K	140K	140K	27K	600K	15K	0
V2	6AQ5	V	0	11	0	0	250	175	-		
		R	>100K	700K	>300K	>300K	15K	85K	-		
V3	6CL6	V	-315	-	-	-320	-320	-30	-315	-95	-320
		R	26K	-	-	130K	130K	700K	26K	50K	200K
V4	6CL6	V	-315	-320	-	-320	-320	-30	-315	-95	-
		R	26K	200K	-	130K	130K	25K	26K	50K	-
V5	6GT5	V	-50	-285	-245	-320	-320	-285	-50	-	0
		R	6K	140K	17K	130K	130K	140K	6K	-	>100K
V6	6GT5	V	200	-35	0	0	0	-35	200	-	245
		R	>140K	650K	>100K	>300K	>300K	650K	>140K	-	17K
V7	5R4-GYB	V	-	290	-	-560	-	-560	-	290	
		R	-	14.5K	-	22K	-	22K	-	14.5K	
V8	6AS7	V	210	325	245	-30	80	0	0	0	
		R	490K	100K	17K	470K	100K	0	0	0	
V9	12AX7	V	210	-3	0	-85	-85	-30	-248	-245	-85
		R	490K	160K	0	135K	135K	470K	160K	17K	135K

All voltage and resistance values measured from the pins of each socket to ground (chassis), with all knobs in the maximum ccw position and input shorted.

Voltages measured with instrument operating from a 115 volt 60 cps source, quiescent set at -1 volt and dc level set to 0 volts.

All values measured with a Vacuum Tube Volt Meter

Transformer	Terminals	Volts (rms)	Ohms
T301	1,2-3,4	115	.84
	5-6	5.1	.077
	7-8	720	141
	8-9	720	144
	10-11	248	26
	11-12	248	26
	13-14	248	26
	14-15	248	26
	16-17	6.4	.07
	18-19	6.4	.07
	20-21	6.4	.07
	22-23	3.0	.1
	23-24	3.0	.1
T302	1-2	115	.84
	3-4	165	315

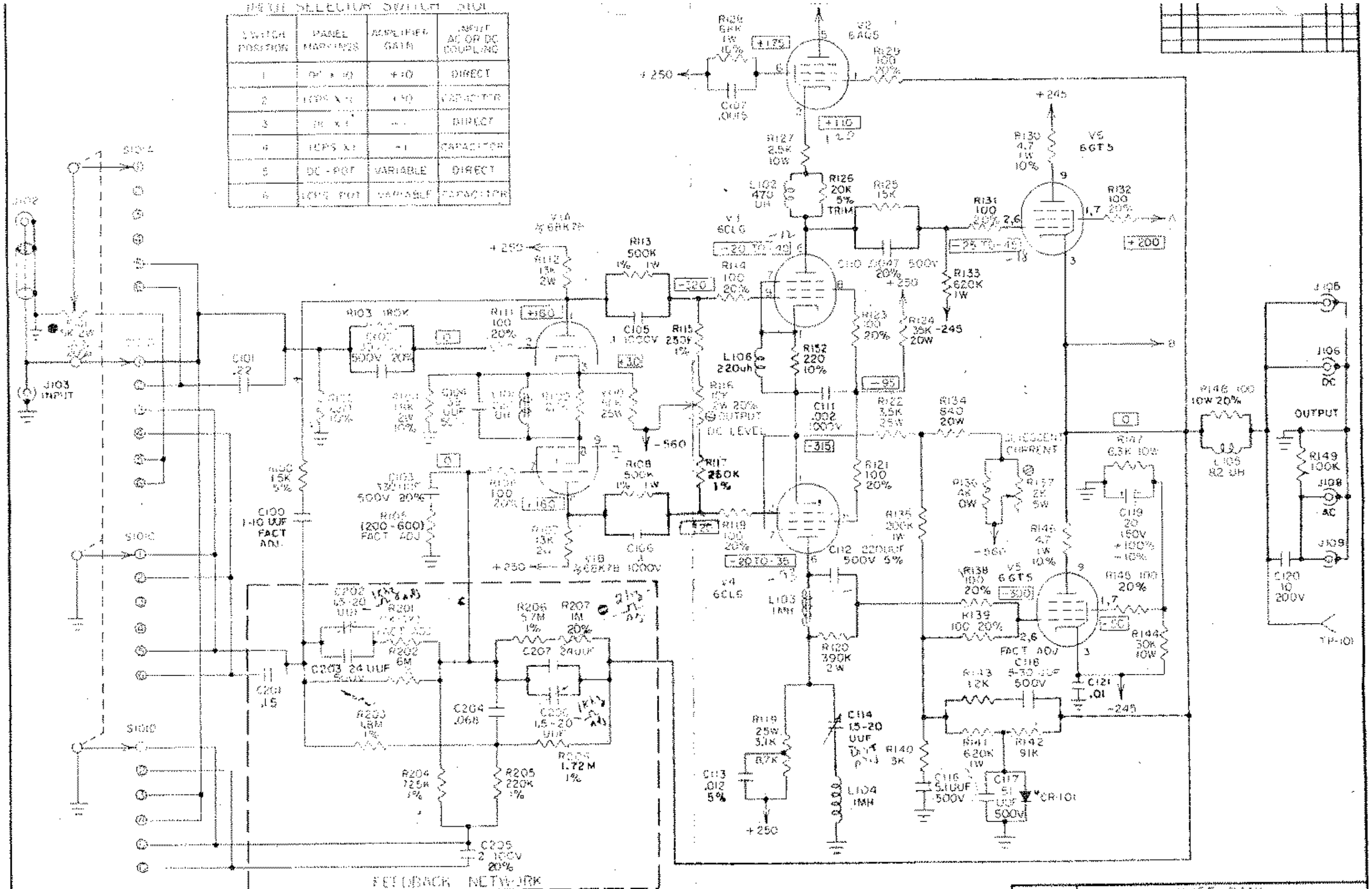
Voltage and resistance values for power transformers T301 and T302 measured between terminals indicated.

AC voltages measured with instrument operating from a 115 volt 60 cps source and amplifier input shorted.

Figure 16 - MODEL DCA-10(R) V TAGE AND RESISTANCE CHART

INPUT SELECTOR SWITCH S101

SWITCH POSITION	PANEL MARKINGS	AMPLIFIER GAIN	INPUT AC OR DC COUPLING
1	DC X 10	+10	DIRECT
2	1CPS X 10	+10	CAPACITOR
3	DC X 1	[illegible]	DIRECT
4	1CPS X1	+1	CAPACITOR
5	DC - POT	VARIABLE	DIRECT
6	1CPS POT	VARIABLE	CAPACITOR



① RESISTANCES IN OHMS UNLESS OTHERWISE SPECIFIED K=1000 M=1,000,000
② RESISTORS ±5% ½WATT UNLESS OTHERWISE SPECIFIED
③ CAPACITORS IN UFD UNLESS OTHERWISE SPECIFIED
④ CAPACITORS 100% 400WVDC UNLESS OTHERWISE SPECIFIED
* CR101 SPECIFICATIONS
PIV > 200V
RB > 2 MEG
RF < 200

⑥ VOLTAGES SHOWN IN SQUARES REPRESENT THE NORMAL QUIESCENT TUBE VOLTAGES WITH INPUT SHORTED AND OUTPUT DC LEVEL ZEROED AND QUIESCENT CURRENT ADJUSTED FOR +1 VOLT ON J101
⑦ ALL VOLTAGES ±20%

● KNOB CONTROL
⊘ EXTERNAL SCREWDRIVER ADJUST.
⊘ INTERNAL SCREWDRIVER ADJUST
——— FEEDBACK SIGNAL PATH
——— FORWARD SIGNAL PATH

TOLERANCES (UNLESS NOTED)	WIDE BAND 10 WATT AMPLIFIER
DECIMAL ±	KROHN-HITE CORP CAMBRIDGE, MASS
FRACTIONAL ±	MODEL DCA 10(R)
ANGULAR ±	DATE REVISED 2-12-69
	FIGURE-15