ULTRA-LOW DISTORTION

POWER AMPLIFIER

INSTRUCTIONS

for

Model UF-101

KROHN-HITE INSTRUMENT COMPANY

CAMBRIDGE 39, MASSACHUSETTS, U.S.A.

PRODUCTION CHANGES UF-101 SERIAL NO. 124

R123 & R124 change from 150K to 270K
R203 & R215 change from 820K to 560K
R204 & R216 change from 150K to 100K

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Manufactured by

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CAMBRIDGE 39, MASSACHUSETTS, U. S. A.

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FIGURE

Figure 1 - Model UF-101 ULTRA-LOW DISTORTION POWER AMPLIFIER.

ULTRA-LOW DISTORTION POWER AMPLIFIER

Model UF-101

TECHNICAL SUMMARY

POWER OUTPUT: (Figs. 2 and 3)

Matched Load ..... 50 watts from 15 cps to 30 kc
Lowest Distortion Load* ..... 35 watts from 15 cps to 30 kc

INTERMODULATION DISTORTION (40 cps and 2 kc separated 12 db):
Less than 0.005% at 100 watts peak

HARMONIC DISTORTION: (Fig. 4)

Matched Load: 1,000 cps - Less than 0.005% at 50 watts, 15 cps - Less than 0.03% at 50 watts, 10 kc - Less than 0.02% at 50 watts

Lowest Distortion Load:
*Typical Distortion at 35 watts, 1,000 cps is 0.0015%

FEEDBACK: 80 db at 1,000 cps, 56 db at 15 cps, 60 db at 30 kc

FREQUENCY RESPONSE: (Fig. 5) ±0.5 db from 0.5 cps to 30 kc, ±3 db from 0.03 cps to 70 kc. Low frequency cut-off may be set at 0.03, 1, 1.6 or 25 cps.

TRANSIENT RESPONSE: (Fig. 6) excellent at all output impedances.

DEVIATION FROM LINEAR PHASE SHIFT: 2 degrees maximum 15 cps to 30 kc

NOISE REFERRED TO: Shorted Input - 8 microvolts, 100 K Input - 10 microvolts, 6.8 MEG Input - 20 microvolts.

OUTPUT IMPEDANCES:

Matched Load ..... 2, 4, 8 and 225 ohms
Lowest Distortion Loads* ..... 2, 4, 8, 16 and 450 ohms

MAXIMUM CAPACITANCE LOAD: 16 ohm output - 0.03 mfd; 450 ohm output - 0.001 mfd

INTERNAL IMPEDANCE: Less than 1/100 of output impedance.

INPUT IMPEDANCE: 100,000 ohm potentiometer or 6.8 megohms.

VOLTAGE GAIN: 14 db to 16 ohm output, 30 db with reduced feedback, 28 db or 44 db to 450 ohm output.

INPUT POWER: 105-125 volts, 50-60 cps, 365 watts no signal, 390 watts full signal.

TUBE COMPLEMENT: 1-12BZ7, 2-6U8, 4-6550, 2-5R4GY

FUSES: 4 ampere slo-blo and 0.3 ampere slo-blo.

*Load ohms adjusted to minimize distortion

SECTION I - DESCRIPTION

The KROHN-HITE Model UF-101 Ultra-Low Distortion Power Amplifier is designed for laboratory and high fidelity audio applications requiring extremely low distortion at power outputs up to 50 watts. It amplifies the frequency range from 0.03 cps to 70 KC and is capable of delivering high power within the range of 15 cps to 30 KC into loads from 1 to 800 ohms. Noise is unusually low and the transient response is excellent.

By incorporating 80 db of degenerative feedback around four stages and the output transformer, harmonic distortion at mid-audio frequencies has been reduced to less than 0.005% at 50 watts output. The output stage uses four type 6550 heavy duty beam pentodes in push-pull parallel in a special unity-coupled circuit.

The controls include an INPUT NETWORK selector providing a choice of low cut-off frequencies and input impedances, a GAIN DECIBELS potentiometer calibrated in decibels, an OUTPUT IMPEDANCE selector switch, and a high-low GAIN TO 16 OHM OUTPUT switch. Excellent transient response is achieved at each output impedance by switching the feedback to the particular output transformer winding in use. Normal sensitivity is 5.6 volts peak input for 100 watts peak output. The sensitivity is increased to 0.9 volts peak input at somewhat reduced performance by means of the high-low gain switch which lowers the feedback.

INPUT and OUTPUT connections are provided at both the front and rear and, in addition, three a-c outlets connected through the front panel switch provide power for associated equipment.

SECTION II - OPERATION

The Model UF-101 Ultra-Low Distortion Power Amplifier is checked carefully in final test to insure that it meets all our specifications. It is aged under full load and again tested prior to shipment to be sure that it is ready for use. The Model UF-101 is shipped complete and after unpacking is ready to be turned on and used. Before plugging in the Model UF-101 amplifier read the following:

1. CONTROLS

(a) POWER

In the Model UF-101, the power off-on switch is a three position rotary switch marked, POWER. The OFF position of the POWER switch inactivates the amplifier. In the WARM UP position the heaters of all the tubes and the three a-c outlets are energized. It is recommended that the POWER switch remain in the WARM UP position at least 15 seconds before the amplifier is activated in the third position, marked ON.

CAUTION! Do not plug UF-101 line cord into a power receptacle with the POWER switch in the ON position.

(b) INPUT NETWORK

This switch selects either a 6.8 megohm fixed input resistance or the 100K GAIN DECIBELS potentiometer. It also provides a choice of low cut-off frequencies. The 3 db down points are 25, 1.6, 1, and approximately 0.03 cycles (positions D). Response curves are shown in Figure 5. Positions D refer to direct input without any coupling capacitor. When using D it is important that the input voltage have no d-c component.

(c) OUTPUT IMPEDANCE

Normally this selector switch is set at the number closest to the impedance of the load. Maximum power output is 35 watts and distortion is minimized. For more power, up to 50 watts, set the selector switch at 2 or 3 times the load impedance. See Figure 3 to determine the maximum undistorted power output versus load impedance. Distortion is somewhat increased because the feedback is reduced and output tube operation changes from Class A_1 to AB_1. Distortion measurements in Figure 4 were made across an 8 ohm load with the OUTPUT IMPEDANCE selector at 16.

(d) GAIN TO 16 OHM OUTPUT

This switch permits a selection of maximum input sensitivity of either 4 volts or 0.6 volts rms for 50 watts output, the latter at reduced feedback. The actual voltage gain may be determined from the table below.

Setting of OUTPUT IMPEDANCE	Switch at 14 DB		Switch at 30 DB	
	Voltage Gain	Decibels Voltage Gain	Voltage Gain	Decibels Voltage Gain
450	27	28	160	44
2	1.8	5	11	21
4	2.6	8	15	24
8	3.8	11	23	27
16	5.3	14	32	30

(e) GAIN DECIBELS

To obtain the total gain of the amplifier when the GAIN DECIBELS control is used, add this GAIN DECIBELS reading to the decibels gain obtained from the table in paragraph (d).

SECTION II - OPERATION

Sustained operation beyond points shown in fig. 2, page 15, "POW R OUTPUT VERSUS FREQUENCY" MUST BE AVOIDED.

4. OVERLOAD CAUTION

To avoid exceeding the dissipation ratings of the output or rectifier tubes, the amplifier should not be operated at sustained outputs over 50 watts, and never beyond the clipping level for more than 100 milliseconds at a time. Unshielded input wiring can pick up a signal from the output, causing oscillations and severe overheating. Any prolonged overload may cause the 0.3 ampere fuse to blow.

5. PIN JACKS

Adjustments have been made at the factory to set the voltage on each of the two pin jacks at the rear of the chassis. Before extensive use of the amplifier, it is recommended that these voltages be checked as described in Section V.

SECTION III - RELAY RACK MOUNTING DIRECTIONS

The Model UF-101R is exactly the same as the UF-101 except that the UF-101R is provided with additional hardware for converting to relay rack mounting. Any UF-101 can be converted to a rack mounted unit by procuring the necessary additional hardware. Since the relay rack mounting hardware is shipped separately even when ordering a Model UF-101R, the following procedure is provided to facilitate the assembly.

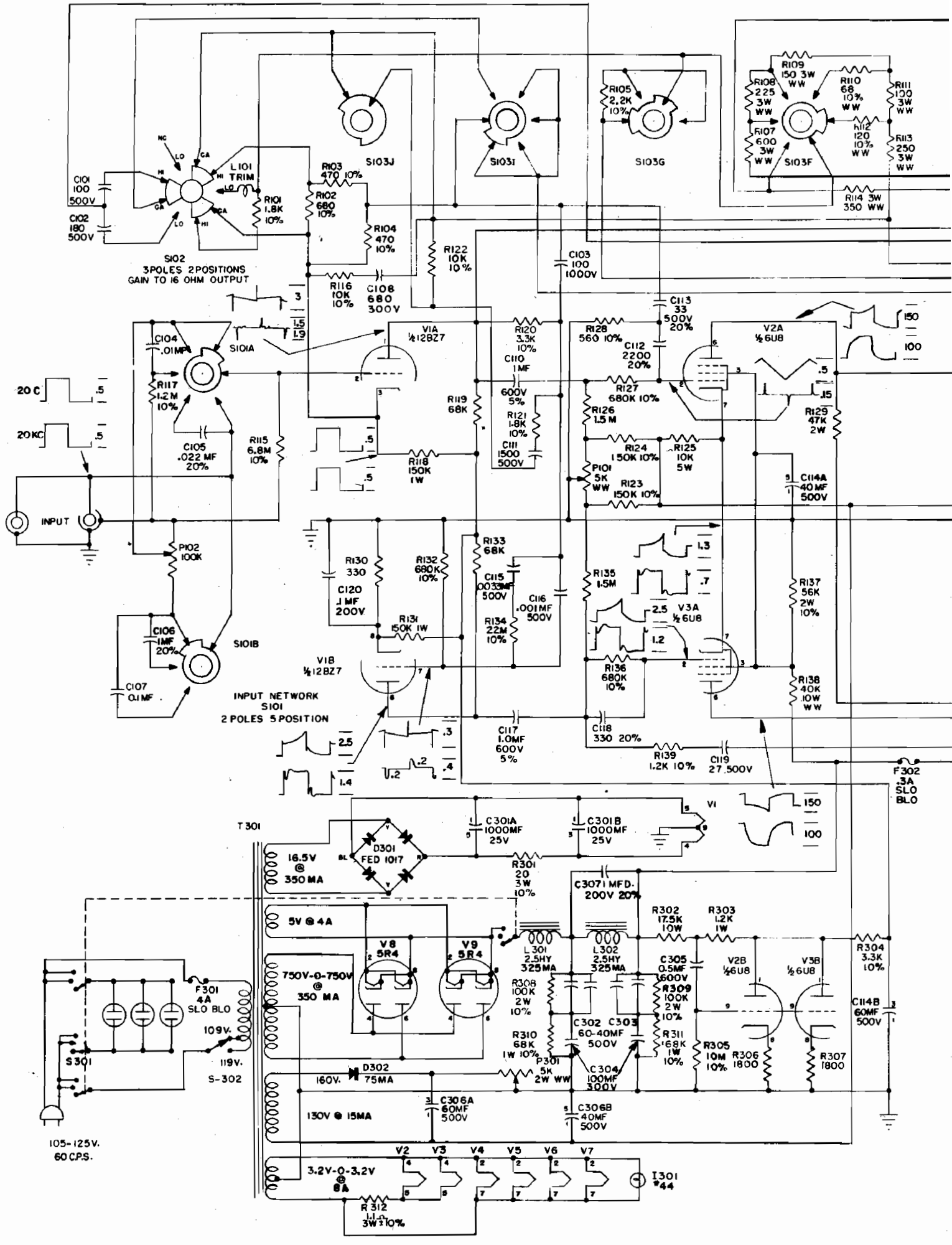
1. Remove 4 rubber bumpers on bottom of cabinet.

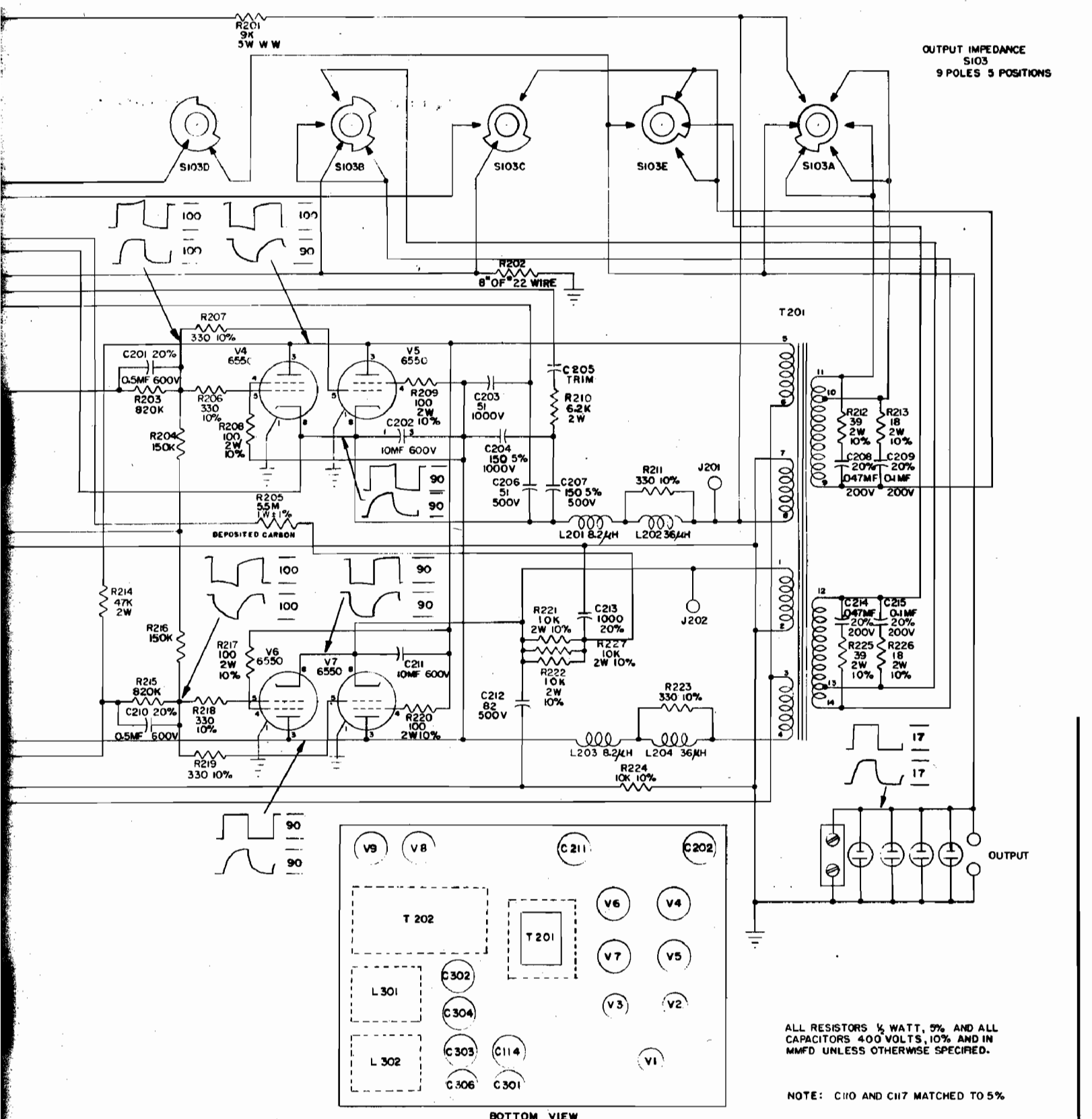
2. There are four locking screws in the back of the instrument. Remove either the two on the left or the two on the right.

3. Fasten one of the brackets to the bottom of the cabinet on the side that the two locking screws were removed with the enclosed 8-32 x 1/4" undercut flathead screws.

4. Replace the two locking screws in the rear of the cabinet and then remove the other two locking screws. Fasten the other bracket in a similar manner.

5. Additional hardware consisting of machine screws, cupped washers and protective fibre washers are enclosed for relay rack mounting.


S102
3 POLES 2 POSITIONS
GAIN TO 16 OHM OUTPUT
S103J
S103I
S103G
S103F
L101 TRIM
C101 100 500V
C102 180 500V
R101 1.8K 10%
R102 680 10%
R103 470 10%
R104 470 10%
R105 2.2K 10%
R106 225 3W WW
R107 600 3W WW
R108 225 3W WW
R109 150 3W WW
R110 68 10% WW
R111 100 3W WW
R112 120 10% WW
R113 250 3W WW
R114 3W 350 WW
R116 10K 10%
C108 680 300V
R122 10K 10%
C103 100 1000V
C113 33 500V 20%
R128 560 10%
C112 2200 20%
V2A ½6U8
C104 .01MF
S101A
V1A ½12BZ7
R120 3.3K 10%
C110 1MF 600V 5%
R119 68K
R121 1.8K 10%
C111 1500 500V
R117 1.2M 10%
C105 .022 MF 20%
R115 6.8M 10%
R118 150K 1W
R127 680K 10%
R126 1.5 M
R124 150K 10%
R125 10K 5W
P101 5K WW
R123 150K 10%
R129 47K 2W
C114A 40 MF 500V
20 C
20 KC
INPUT
P102 100K
C106 1MF 20%
S101B
C107 0.1 MF
V1B ½12BZ7
R130 330
C120 1 MF 200V
R132 680K 10%
R131 150K 1W
R133 68K
C115 .0033MF 500V
R134 22M 10%
C116 .001MF 500V
R135 1.5M
V3A ½6U8
R136 680K 10%
R137 56K 2W 10%
R138 40K 10W WW
INPUT NETWORK
S101
2 POLES 5 POSITION
C117 1.0MF 600V 5%
C118 330 20%
R139 1.2K 10%
C119 27,500V
F302 .3A SLO BLO
V1
C301A 1000MF 25V
C301B 1000MF 25V
T301
D301 FED 1017
16.5V @ 350 MA
R301 20 3W 10%
C307 1 MFD. 200V 20%
5V @ 4A
V8 5R4
V9 5R4
750V-0-750V @ 350 MA
L301 2.5HY 325MA
L302 2.5HY 325MA
R302 17.5K 10W
R303 1.2K 1W
R304 3.3K 10%
C305 0.5MF 600V
R309 100K 2W 10%
V2B ½6U8
V3B ½6U8
C114B 60MF 500V
R308 100K 2W 10%
R310 68K 1W 10%
C302 C303 60-40MF 500V
R311 68K 1W 10%
R305 10M 10%
R306 1800
R307 1800
P301 5K 2W WW
C304 100MF 300V
F301 4A SLO BLO
S301
109V.
119V.
S-302
105-125V. 60 C.P.S.
D302 75MA
160V.
C306A 60MF 500V
C306B 40MF 500V
130V @ 15MA
V2 V3 V4 V5 V6 V7
3.2V-0-3.2V @ 8A
I301 #44
R312 1.1Ω 3W 10%



BOTTOM VIEW

ALL RESISTORS ½ WATT, 5% AND ALL CAPACITORS 400 VOLTS, 10% AND IN MMFD UNLESS OTHERWISE SPECIFIED.

NOTE: C110 AND C117 MATCHED TO 5%

UPPER WAVEFORM 20 CYCLES
LOWER WAVEFORM 20 KILOCYCLES

WAVEFORM TAKEN WITH SWITCHES IN MAXIMUM CLOCK WISE POSITION. FOR FURTHER IMFORMATION SEE SECTION VI.

VOLTAGE MEASUREMENTS MADE BETWEEN PINS OF EACH SOCKET AND GROUND WITH V.T.V.M. ALL KNOBS IN MAXIMUM CLOCK WISE POSITION, LINE VOLTAGE SWITCH AT REAR OF CHASSIS IN. HIGH POSITION WITH 119V. (LOW POSITION FOR 109V LINE). NO CONNECTIONS TO THE INPUT OR OUTPUT TERMINALS.

RESISTANCE MEASUREMENTS TAKEN IN SAME MANNER EXCEPT WITH LINE CORD DISCONNECTED.

VARIATION OF 20% TO BE EXPECTED.

TUBE		PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8	PIN 9
V1	R	500K	95K	350	4	4	150K	680K	330	0
	V	149	0	1.1	6.5	6.5	149	0	1.1	—
V2	R	50K	2.3M	40K	.6	.1	95K	60K	1.8K	9.3M
	V	280	−1.9	235	2.1 VAC	2.95 VAC	285	4.2	8	.2
V3	R	500K	2.3M	40K	.6	.1	95K	60K	1.8K	9.3M
	V	280	−1.9	235	2.1 VAC	2.95 VAC	285	4.2	8	.2
V4	R	0	.1	33K	33K	180K	—	.1	50	—
	V	0	3.2 VAC	540	540	−57	—	3.2 VAC	6.3	—
V5	R	0	.1	33K	33K	180K	—	.1	50	—
	V	0	3.2 VAC	540	540	−57	—	3.2 VAC	6.3	—
V6	R	0	.1	33K	33K	180K	—	.1	50	—
	V	0	3.2 VAC	540	540	−57	—	3.2 VAC	6.3	—
V7	R	0	.1	33K	33K	180K	—	.1	50	—
	V	0	3.2 VAC	540	540	−57	—	3.2 VAC	6.3	—
V8	R	—	30K	—	40K	—	38	—	30K	—
	V	—	600	—	740 VAC	—	740 VAC	—	600	—
V9	R	—	30K	—	40K	—	38	—	30K	—
	V	—	600	—	740 VAC	—	740 VAC	—	600	—

FIGURE 7 MODEL UF-101

DRAWN BY C.W.H. 8-24-53 J.R.J.
SCALE:
DATE: 4/22/54
APPROVED BY E.K.
REVISED 6-10-55 J.R.J.

POWER AMPLIFIER

KROHN-HITE INSTRUMENT COMPANY
CAMBRIDGE 39, MASS.

DRAWING NUMBER
UF-101-2

SECTION IV - CIRCUIT DESCRIPTION

A schematic diagram of the Model UF-101 is on Pages 8 and 9.

1. BASIC AMPLIFIER

Four stages, consisting of two high-μ triode amplifiers, two push-pull pentodes in a cathode-coupled phase inverter, and four beam pentode output tubes in push-pull parallel, provide a voltage gain of at least 94 db to the 16 ohm output before feedback is applied. 80 db of feedback is taken from the output terminals through a voltage divider, selected by the OUTPUT IMPEDANCE switch S103, to the cathode of the first triode V1A.

2. DRIVER-OUTPUT STAGE

To minimize high frequency distortion an unusual unity-coupled circuit has been used which results in more-nearly perfect push-pull action of the output tubes. Four equal primary windings on the output transformer are driven by both the plates and cathodes. Since the plate of one side delivers a signal of the same magnitude and phase as the cathode of the other side, these points can be connected together through a 10 microfarad capacitor. Coupling between the output tubes at high frequencies, then, is through a pair of capacitors, C-202 and C-211, instead of through the output transformer with its leakage inductance.

Pentode operation is achieved by connecting the screen of one side to the plate of the opposite which swings in such a way as to maintain the screen-cathode voltage constant. To supply the very high grid driving voltage necessary to overcome the large cathode swing, the B supplies for each side of the push-pull cathode-coupled driver stage are also taken from the plates of opposite output tubes. In this manner a large swing required at each driver plate is aided by having its B supply swing in the same direction by nearly the same amount.

3. STABILIZATION

Freedom from oscillations and ringing has been achieved by carefully shaping the open-loop frequency response at both ends of the range to a 9 db per octave downward slope so as to keep the phase shift below 135 degrees. At extreme low frequencies phase shift between the third and fourth stages has been eliminated by means of partial direct-coupling. Phase shift between the second and third has also been eliminated at these frequencies by feeding directly from the first stage to the third which

SECTION II - OPERATION

Sustained operation beyond points shown in fig. 2, page 15, "POW R OUTPUT VERSUS FREQUENCY" MUST BE AVOIDED.

4. OVERLOAD CAUTION

To avoid exceeding the dissipation ratings of the output or rectifier tubes, the amplifier should not be operated at sustained outputs over 50 watts, and never beyond the clipping level for more than 100 milliseconds at a time. Unshielded input wiring can pick up a signal from the output, causing oscillations and severe overheating. Any prolonged overload may cause the 0.3 ampere fuse to blow.

5. PIN JACKS

Adjustments have been made at the factory to set the voltage on each of the two pin jacks at the rear of the chassis. Before extensive use of the amplifier, it is recommended that these voltages be checked as described in Section V.

SECTION III - RELAY RACK MOUNTING DIRECTIONS

The Model UF-101R is exactly the same as the UF-101 except that the UF-101R is provided with additional hardware for converting to relay rack mounting. Any UF-101 can be converted to a rack mounted unit by procuring the necessary additional hardware. Since the relay rack mounting hardware is shipped separately even when ordering a Model UF-101R, the following procedure is provided to facilitate the assembly.

1. Remove 4 rubber bumpers on bottom of cabinet.

2. There are four locking screws in the back of the instrument. Remove either the two on the left or the two on the right.

3. Fasten one of the brackets to the bottom of the cabinet on the side that the two locking screws were removed with the enclosed 8-32 x 1/4" undercut flathead screws.

4. Replace the two locking screws in the rear of the cabinet and then remove the other two locking screws. Fasten the other bracket in a similar manner.

5. Additional hardware consisting of machine screws, cupped washers and protective fibre washers are enclosed for relay rack mounting.

has two out-of-phase inputs. As a result, ringing in the vicinity of 0.1 cps is almost critically damped.

At extreme high frequencies a similar by-passing technique is used. Multiple feedback paths from the primary of the output transformer through small capacitors to various points, successively eliminate phase shift in the output transformer, the first stage and the second stage. The overall feedback around the push-pull output stage falls so slowly from 3000 cycles that it passes through unity at 10 megacycles.

4. STABILITY DURING OVERLOAD

Under overload conditions a push-pull amplifier is subject to widely varying gain and phase shift as some tubes cut off while others conduct heavily. Many modes of oscillation are possible and the permissible feedback is much less than under small signal conditions.

To avoid reducing the high-frequency feedback to the point where distortion became appreciable, the circuit of the Model UF-101 was designed for a compromise in stability. During momentary overloads, such as occur when reproducing music, the amplifier clips cleanly and is stable. If a sustained overload of 10 db lasts for 1 second or more, the 0.5 mfd coupling capacitors C-110 and C-117 have time to charge due to grid current, and high frequency oscillations occur. The presence of these oscillations is a warning that the amplifier is being abused and they will cease when the signal is reduced.

5. POWER SUPPLY

The power supply delivers +550 volts at the plates of the 6550 output tubes, -135 volts adjustable bias, and 12.6 volts d-c for the heater of the first tube. It has a regulator for decoupling the first two amplifier stages. The regulator is a shunt type using the triode sections of two 6U8's in parallel. Use of capacitive coupling through C-305 increases the gain in comparison with a direct coupled shunt regulator and results in more effective decoupling.

SECTION V - PREVENTIVE MAINTENANCE

The Model UF-101 Ultra-Low Distortion Power Amplifier is designed in accordance with sound engineering practices and manufactured with highest quality components. In normal laboratory use it

should give long trouble-free service. Due to the feedback circuit design, gradual deterioration of tubes or components will ordinarily not be detected until complete failure occurs. For this reason it is recommended that a periodic check and readjustment of the output tube plate currents be made after every 500 hours of use in order to maintain lowest distortion operation. Unbalance of these plate currents produces d-c flux in the output transformer and lowers its inductance, resulting in impaired low frequency response (see Fig. 5).

The plate current check is made simply by measuring the voltage from the chassis to each of the pin jacks at the rear. This voltage should be between 6.0 and 6.5 volts d-c at each jack, and the voltage between jacks should be less than 0.5 volts. Allow the amplifier to warm up for a half-hour first; set the OUTPUT IMPEDANCE selector at 2, the INPUT NETWORK selector at 1.6, and the GAIN DECIBELS control at minimum.

Readjustment of these voltages to compensate for tube drift may be made at the rear of the chassis by first resetting the screw driver adjustable BALANCE potentiometer for zero difference between the jacks and then resetting the BIAS potentiometer for 6.0 to 6.5 volts at each one. After 5 minutes recheck the adjustments.

A drift to less than half the normal voltage at either jack during any 500-hour period may be reason to suspect weakening of the tubes. All tubes should be tested and weak ones replaced.

NOTE: Whenever any of the type 6U8 or 6550 tubes are replaced by new ones or interchanged in their sockets, the tip jack voltages must be readjusted. If the range of the BALANCE potentiometer is not sufficient, interchange the 6U8 tubes. An unbalance in the opposite direction, after the interchange, indicates that these tubes are highly unbalanced and one or both should be replaced.

SECTION VI - CORRECTIVE MAINTENANCE

Whenever any trouble is encountered in the Model UF-101 amplifier, the preceding tip jack voltage check should be made first. In the event that both voltages are zero and the tube heaters do not light, the a-c line fuse may have blown. Replacement should be with a 4-ampere slo-blo fuse only. The 0.3-ampere slo-blo fuse protects the type 6550 tubes from a prolonged overload and, if blown, will also make both tip jack voltages zero.

The likeliest source of failure is the vacuum tubes since they have an inherently shorter life. Failure of the tip jack voltage to remain fairly constant after a ten-minute warm-up may indicate a slightly gassy 6U8 or 6550.

In most cases replacement of the defective tubes and readjustment of the BIAS and BALANCE potentiometers (as under PREVENTIVE MAINTENANCE) will effect a cure. More obscure troubles may be

detected by measurement of the resistances and then the voltages in accordance with the charts accompanying the schematic diagram. Troubles in the switching circuits may be found by measuring the gain with an input of 0.1 volt at 1000 cycles and comparing the results with the chart under Controls, part d, page 6. Square wave testing may also help in finding troubles in the switching circuits and feedback networks.

The waveforms and peak to peak amplitudes at various points in the circuit are shown on the schematic for a 0.5 volt peak to peak square wave input. The upper waveforms are for a 20 cps square wave input and the lower waveforms are for a 20 kc square wave input. The amplifier controls were set as follows:

INPUT NETWORK ..... D-100K POT
GAIN DECIBELS ..... FULL CLOCKWISE
OUTPUT IMPEDANCE 16
GAIN TO 16 OHM OUTPUT ..... 30 DB
POWER ..... ON

The output terminals were loaded with a 16 ohm 5 watt resistive load.

WARRANTY AND SERVICE

KROHN-HITE Instruments are conservatively designed to provide continuous reliable service under normal laboratory conditions. The material and workmanship in every instrument is guaranteed for one year from the date of purchase. Any instrument developing defects during this period will be repaired or defective parts will be replaced without charge when the failure is result of defective material or workmanship. Our warranty does not apply to vacuum tubes.

If trouble develops which cannot be corrected by following the procedures outlined under CORRECTIVE MAINTENANCE, it is recommended that the instrument be returned to the factory for servicing. Before returning the instrument, please write to our Service Department giving detailed information concerning the failures and we shall send shipping instructions.

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

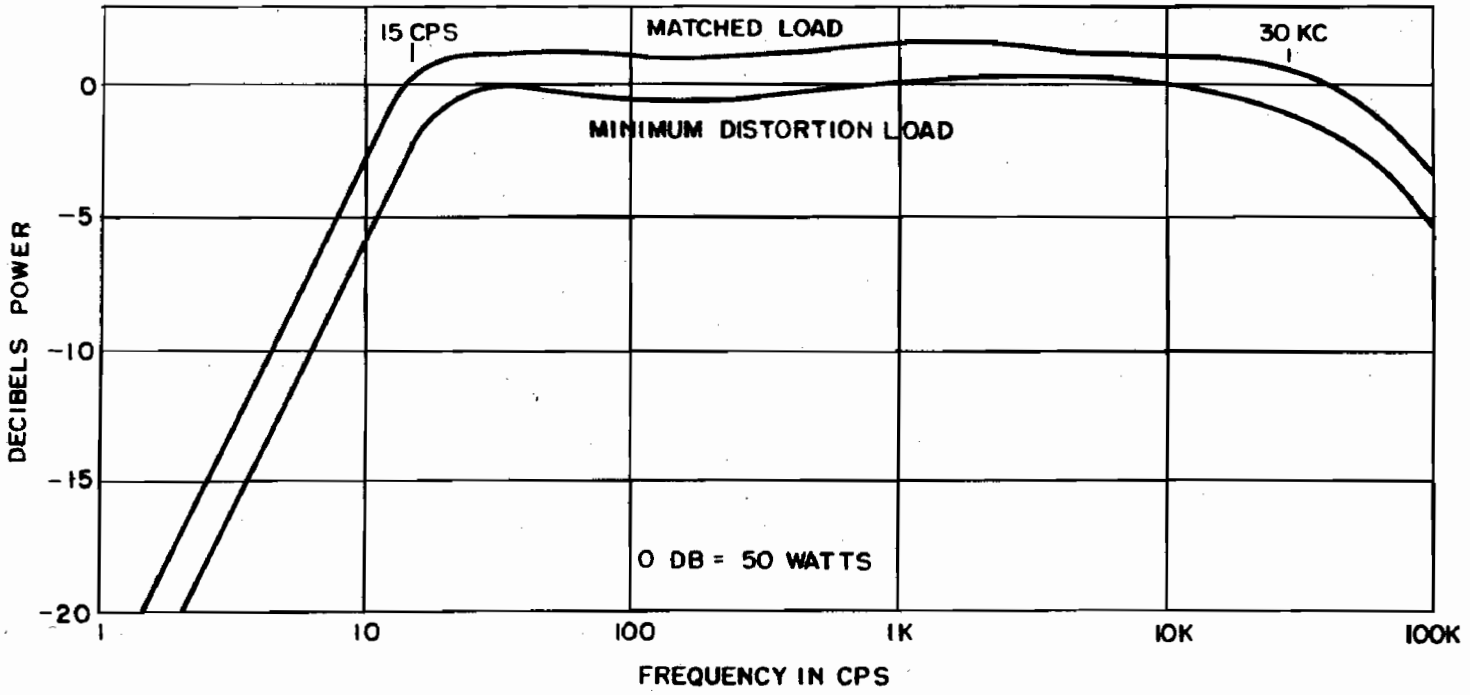


Figure 2. Maximum Undistorted Power Output vs. Frequency.

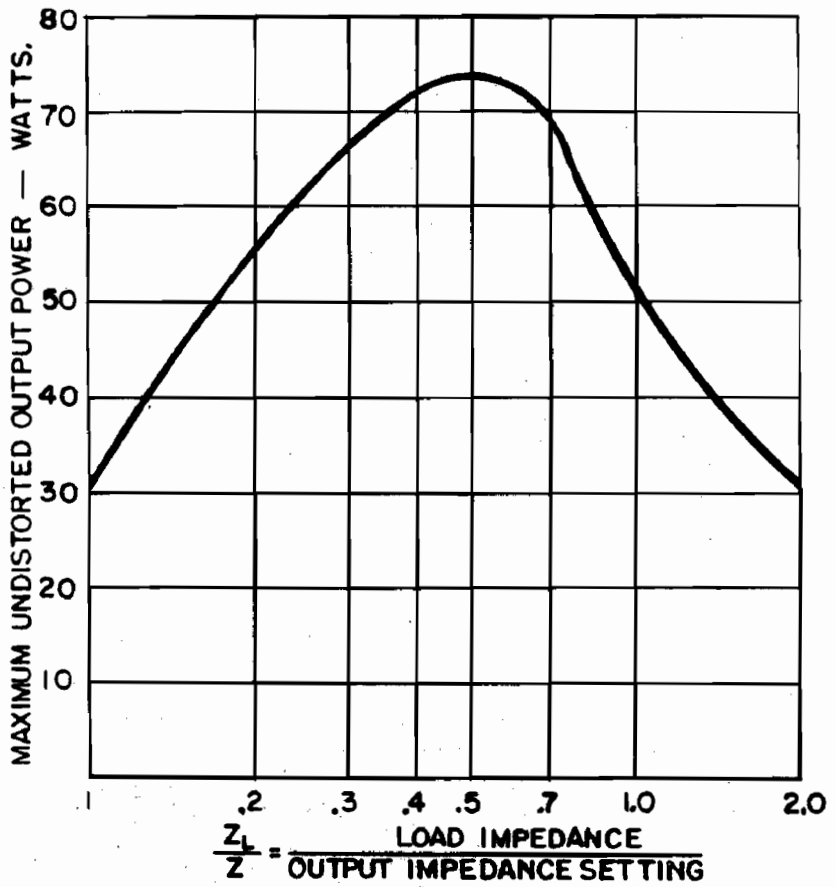


Figure 3. Maximum Undistorted Power Output vs. Load Impedance.

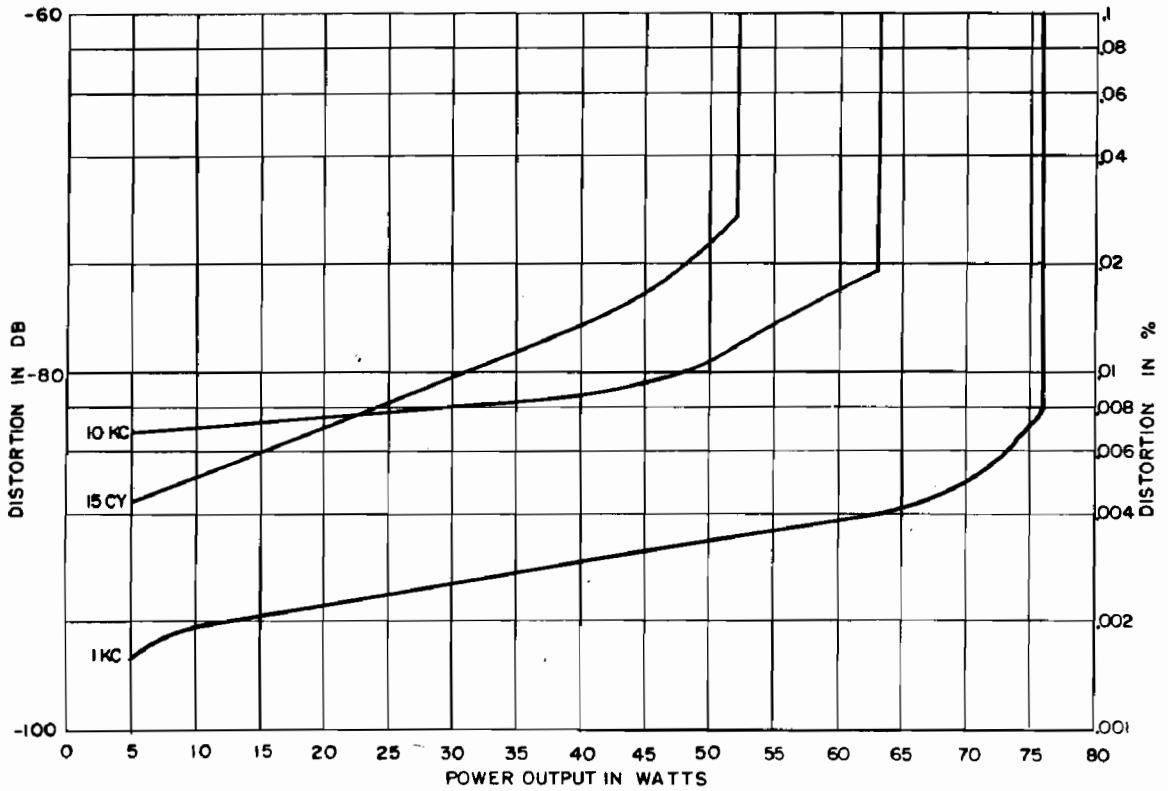


Figure 4. Distortion vs. Power with Matched Load.

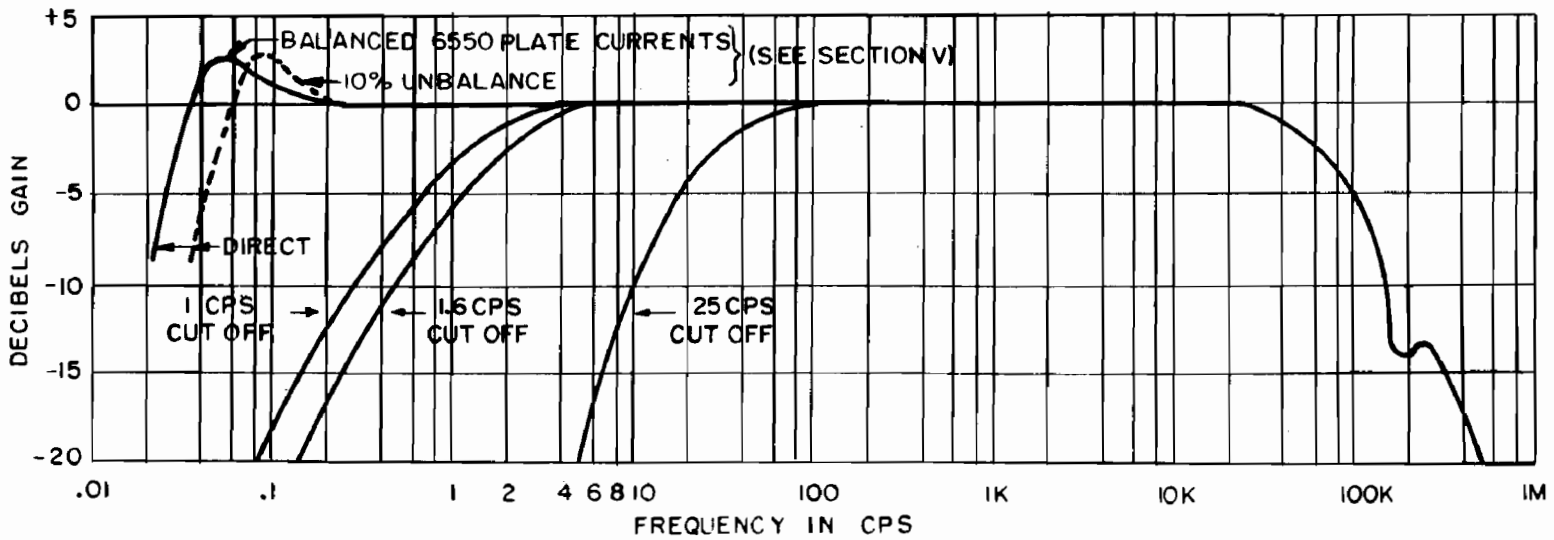


Figure 5. Frequency Response.

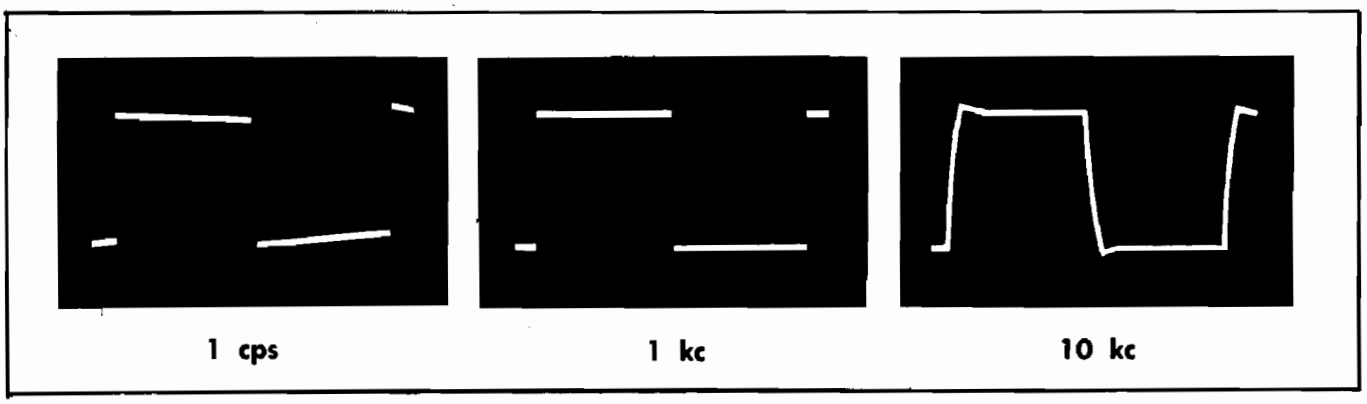


Figure 6. Square Wave Response.

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