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INSTRUCTION AND OPERATING MANUAL
FOR

MODEL 460A
WIDE BAND AMPLIFIER
Serial 1996 and Above



HEWLETT-PACKARD COMPANY
275 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

#460A004

General Description

The Model 460A Wide Band Amplifier is designed to faithfully amplify extremely short pulses without objectionable ringing or overshoot. The high frequency response matches the Gaussian curve.



A gain of 20 db is obtained with this amplifier. Up to five amplifiers may be cascaded for additional amplification.

The Model 460A is useful as a general laboratory amplifier, to increase voltmeter and oscilloscope sensitivity, and in television work.

Parts Substitutions

Difficulties in procuring some of the parts used in this instrument may cause the electrical or physical values to deviate from those shown in this instruction manual. These substitutions have been made so as not to impair the performance of this instrument. Whenever replacement of any of these parts is necessary, either the substitute value or the original value may be used.

SPECIFICATIONS FOR  MODEL 460A
WIDE BAND AMPLIFIER

FREQUENCY RESPONSE:	High Frequency - closely matches Gaussian curve when operating into a 200-ohm resistive load. 3 db point is 140 mc. Low Frequency - when operating from a 200-ohm source and 0.1 μ f blocking condenser, frequency response off 3 db at 3 kc into an open circuit or succeeding amplifier. When operating into a 200-ohm load, off 3 db at 100 kc. With  410B VTVM - when used with  46A-95D Adapter, response ± 1 db, 200 KC to 200 MC.
GAIN:	Approximately 20 db into 200-ohm load. Gain control has range of 6 db. Five amplifiers may be cascaded.
OUTPUT:	Approx. 8 v peak open circuit. Output impedance, 300 ohms.
INPUT IMPEDANCE:	200 ohms.
NOISE FACTOR:	Less than 10 db.
DELAY CHARACTERISTICS:	Approx. .014 μ sec.
RISE TIME:	Approx. .0026 μ sec. (10% to 90% amplitude). No appreciable overshoot.
POWER SUPPLY:	115/230 v $\pm 10\%$, 50/1000 cps, 35 watts.
SIZE:	19" relay rack panel, 5-1/4" high; 6-3/4" deep.
WEIGHT:	11 pounds.

SECTION I
OPERATING INSTRUCTIONS

1-1 INSPECTION

This instrument has been thoroughly tested and inspected before being shipped and is ready for use when received.

After the instrument is unpacked, it should be carefully inspected for damage received in transit. If any shipping damage is found, follow the procedure outlined in the "Claim for Damage in Shipment" page at the back of this instruction book.

1-2 CONTROLS AND TERMINALS

ON

This toggle switch controls all the power supplied to the instrument from the power line.

GAIN

This variable resistor controls the gain of the amplifier.

FUSE

The fuseholder contains a 0.6 ampere cartridge fuse. The fuse may be replaced by unscrewing the fuseholder cap and inserting a new fuse. Replacement fuses for this instrument should be of the "slow blow" type as specified in the Replaceable Parts List.

1-3 INPUT, OUTPUT JACKS AND ACCESSORIES

The input and output jacks, located on the control panel, fit special connectors and cables which have been designed for use with Model 460A because it is not possible to obtain the best performance with this type of device if standard commercially available connectors are used.

The accessories listed below are not supplied with the instrument. These accessories are designed to solve special connection problems likely to be encountered in the use of the Model 460A. The accessories may be purchased from the Hewlett-Packard Company.

Ⓜ MODEL NO.

DESCRIPTION

46A-16A

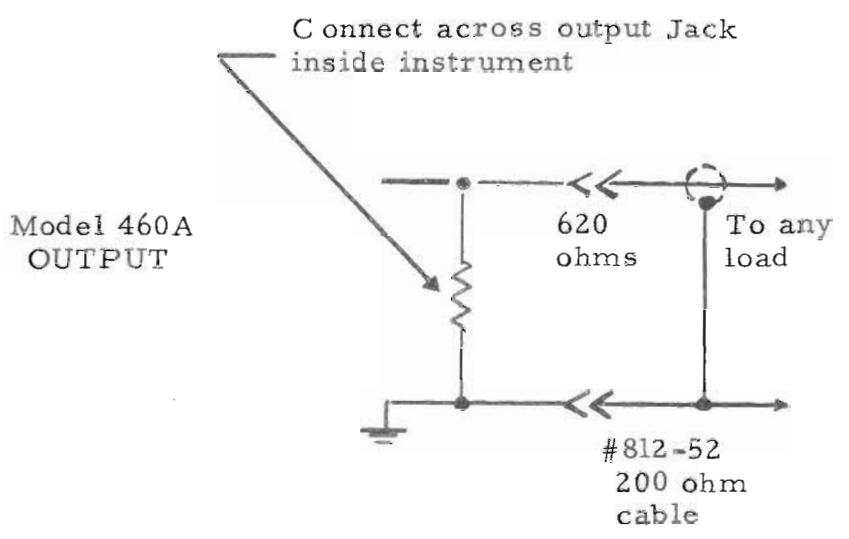
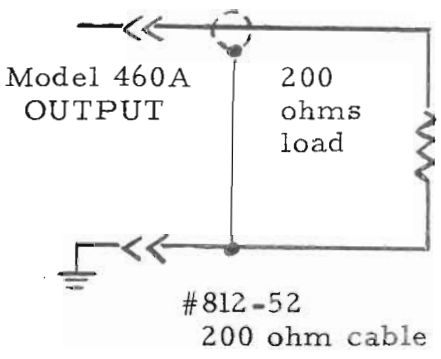
Patch Cord - Special 200 ohm cable two feet in length, complete with two No. 46A-95B Cable Plugs, for inter-connection of two amplifiers in cascade.

<u>hp</u> MODEL NO.	<u>DESCRIPTION</u>
46A-16B	<u>Patch Cord</u> - Same as No. 46A-16A except six feet in length.
46A-95A	<u>Panel Jack</u> - Special low capacitance panel jack designed for 200 ohm cable. Mates with Nos. 46A-16A and 46A-16B Patch Cords or No. 46A-95B Cable Plug. Requires 1-1/8 inch diameter mounting hole.
46A-95B	<u>Cable Plug</u> - Low capacitance plug designed for use with 200 ohm cable. Mates with No. 46A-95A Panel Jack and with No. 46A-95E Connector Sleeve.
812-52	<u>Cable</u> - Special 200 ohm cable available in lengths to meet customer requirements.
46A-95C	<u>50 Ohm Adaptor</u> - Provides a type N connection for coupling a 50 ohm transmission line to the input of a Model 460A amplifier. Includes a terminating resistor.
46A-95D	<u>Adaptor for Model 410A/B Voltmeter Probe</u> - Consists of a bayonet type sleeve with which a Model 410A/B Probe may be directly connected to the output of a Model 460A Amplifier. Includes the proper compensating LC components.
46A-95E	<u>Connector Sleeve</u> - Provides for joining two No. 46A-95B Cable Plugs in order to interconnect two lengths of 200 ohm cable.
46A-95F	<u>Adapter for connection to 5XP CRT.</u>

1-4 OPERATION


The input circuit of the Model 460A is a terminated transmission line with a characteristic impedance of 200 ohms.

The output circuit has an impedance of 280 ohms (resistive). The load impedance determines the gain of the amplifier. Therefore, it is not necessary to match the load to the output of the amplifier unless the gain is adversely affected. Shown below are two diagrams for connecting a matched or unmatched load to the Model 460A using a 200 ohm cable.



The GAIN control will vary the gain of the amplifier over a range of approximately 6 db. This control is provided so that the gain of the amplifier can be set to a known value if necessary. There is no feedback in the amplifier, so the gain is directly proportional to the Gm of the tubes. The gain is also determined by the output load and will vary with output load in accordance with the relation

$$\frac{280 \times Z_L}{280 + Z_L}$$

The Wide Band Amplifier can be used with the  Model 410B* Vacuum Tube Voltmeter to provide additional sensitivity in measuring high frequencies. A special adaptor is available to connect the probe of the Model 410B* to the output terminal of the amplifier. The overall frequency response of the Model 460A, in combination with the Model 410B, is within 1 db out to 190 mc. This combination will give a full scale meter reading on the Model 410B with 1/10 volt applied to the input of the Model 460A.

Several amplifiers can be cascaded when more than 20 db gain is desired. The maximum gain which can be used will be limited by the effective noise generated in the input circuit of the amplifier. The noise factor is approximately 10 db.

The time of rise of a single unit is approximately 2.6 millimicroseconds. As units are cascaded, the time of rise goes up as the square root of the sum of the squares of times of rise of the individual stages. Therefore, for two stages in cascade, the time

* Also Model 410A

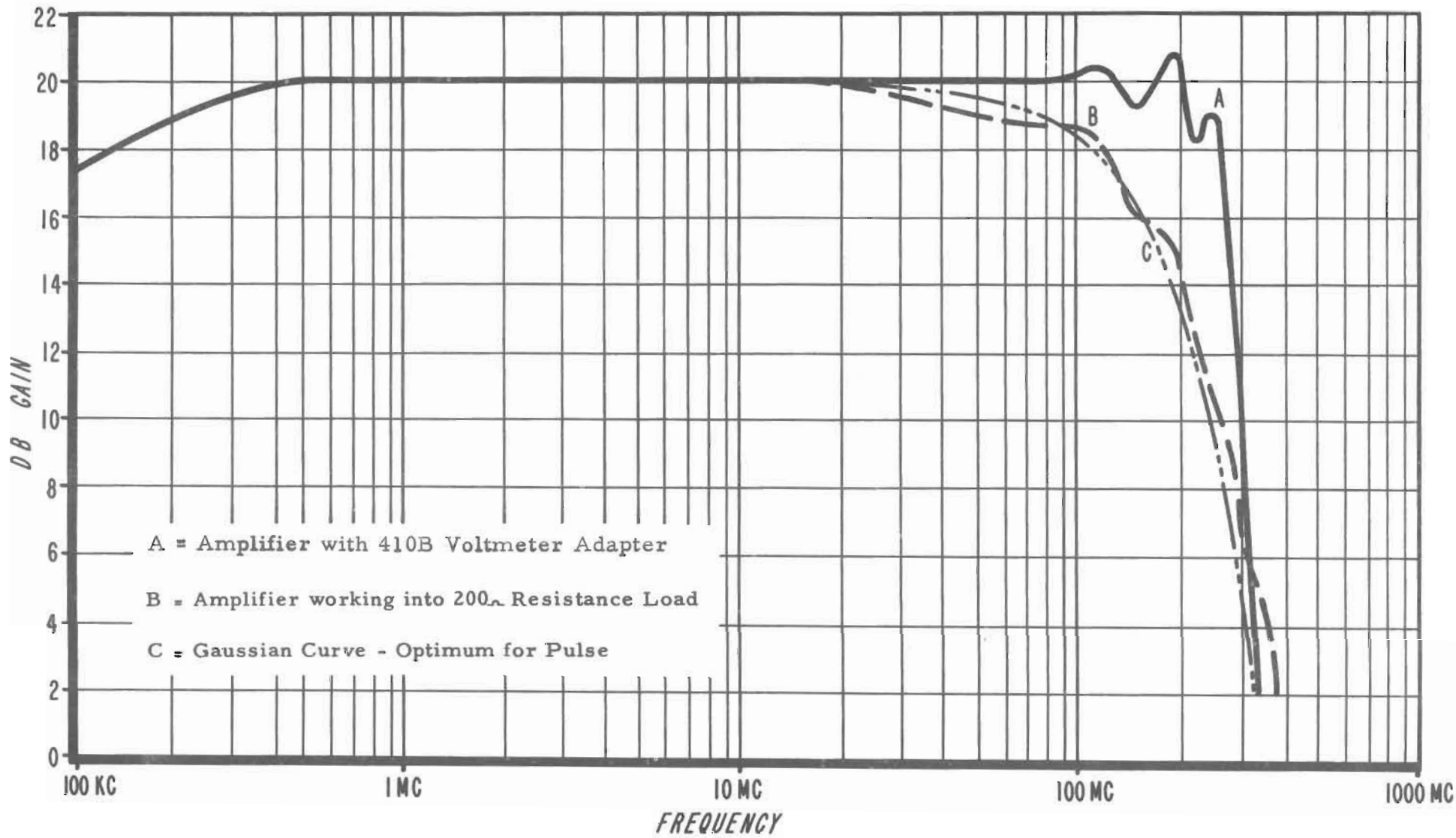
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of rise will be approximately 3.7 millimicroseconds and for three stages, the time of rise will be approximately 4.4 millimicroseconds.

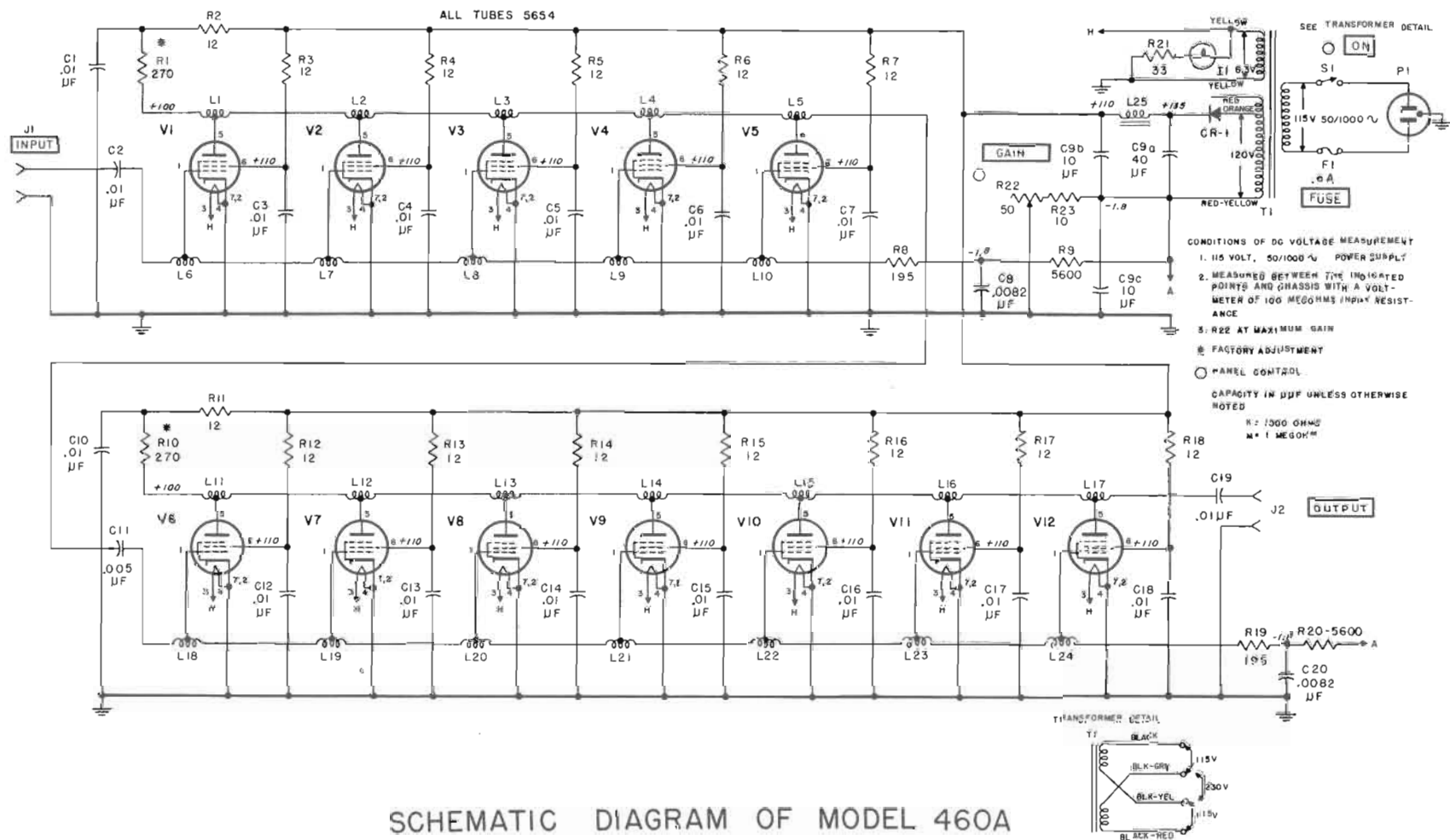
1-5 CIRCUIT DESCRIPTION

The Model 460A is a new type amplifier which has a very wide transmission band. It has two stages with five tubes in the first stage and seven tubes in the second stage. The grids of these tubes are connected along one transmission line for the input circuit and the plates of the tubes are connected along a second transmission line for the output circuit. A wave traveling down the input line excites the grids in succession and half of the corresponding wave generated in the plate circuit travels down the plate line toward the output and is reinforced at each successive plate. The part of the wave in the plate line which travels in the reverse direction is absorbed by a termination of the other end of that line. By the time the wave in the plate line reaches the output, it has been amplified by about 10 db. The second stage adds another 10 db to make a total of 20 db gain for the unit.

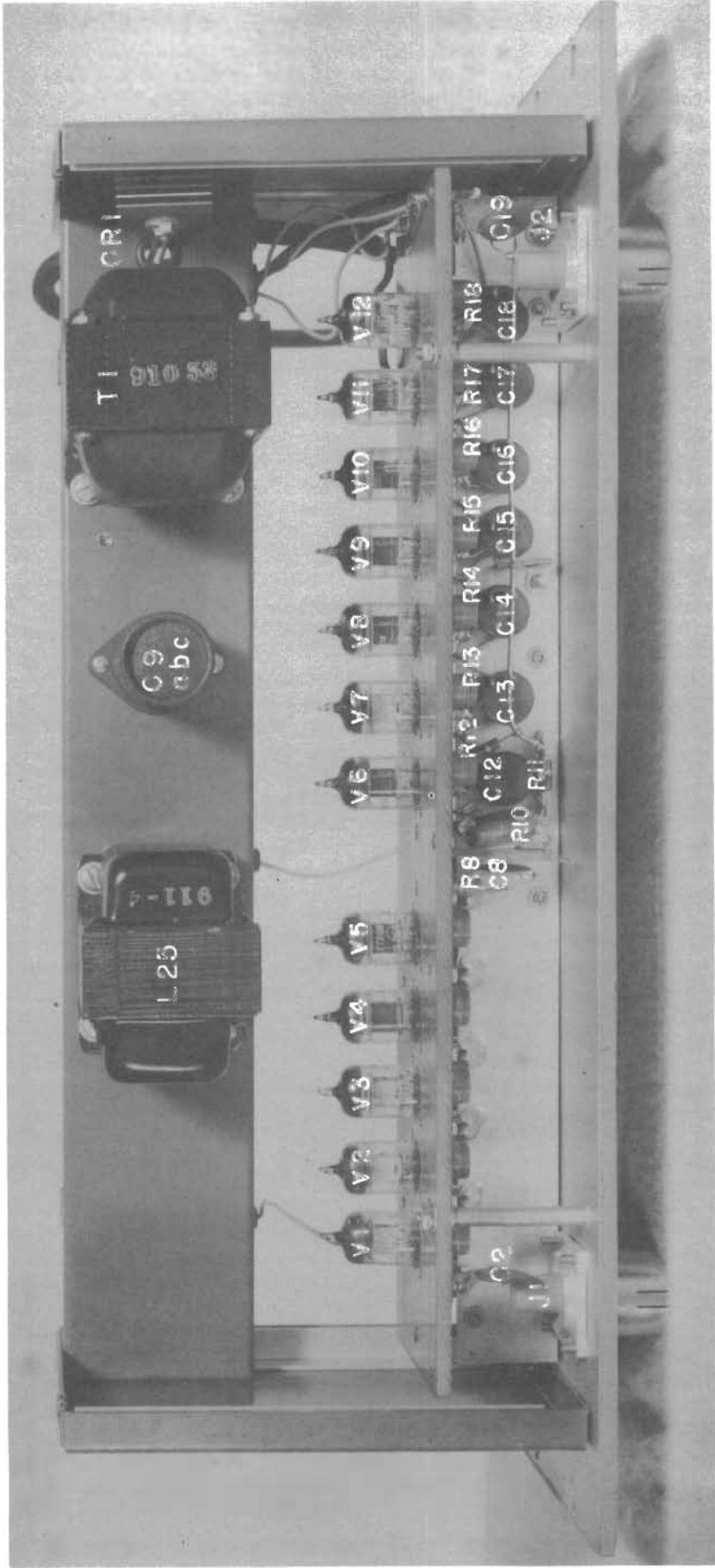
The Model 460A will amplify pulses with an extremely short rise time and with virtually no overshoot. The time of rise of the amplifier itself is approximately 2.6 millimicroseconds. The amplifier has an amplitude response closely matching the Gaussian Curve, which is the ideal transmission for pulse amplifications when ringing or overshoot cannot be tolerated.



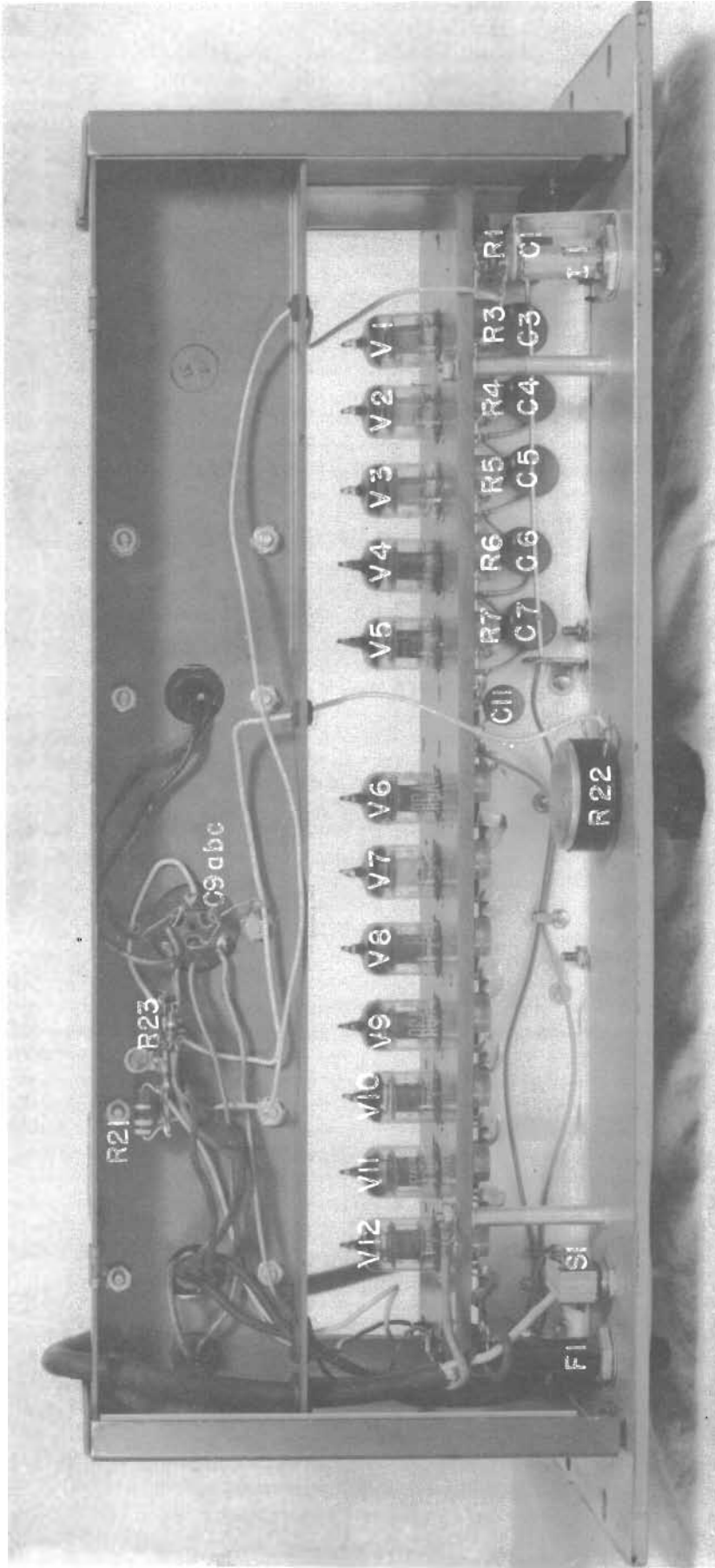
TYPICAL RESPONSE CURVES
 MODEL 460A
 WIDE BAND AMPLIFIER



SCHEMATIC DIAGRAM OF MODEL 460A
WIDE BAND AMPLIFIER
SERIAL 1996 & ABOVE



Model 460A Top View



Model 460A Bottom View

TABLE OF REPLACEABLE PARTS

NOTE

Any changes in the Table of Replaceable Parts will be listed on a Production Change sheet at the front of this manual.

When ordering parts from the factory always include the following information:

- Instrument model number
- Serial number
- hp- stock number of part
- Description of part

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R1, R10	Resistor: fixed, composition, 270 ohms ±10%, 1/2 W Electrical value adjusted at factory	23-270	B EB 2711
R2, R3, R4, R5, R6, R7 R11-R18	Resistor: fixed, composition, 12 ohms, ±10%, 1/2 W	23-12	B EB 1201
R8	Resistor: fixed, composition, 195 ohms, ±1%, 1/2 W	30-195	Electra Mfg. Co. Type DC-1/8
R9, R20	Resistor: fixed, composition, 5600 ohms, ±10%, 1/2 W	23-5600	B EB 5621
R19	Resistor: fixed, composition, 195 ohms, ±1%, 1/2 W	30-195	Electra Mfg. Co. Type DC-1/8
R21	Resistor: fixed, composition, 33 ohms, ±10%, 1 W	24-23	B GB 3301
R22	Resistor: variable, wirewound, 50 ohms, ±10%, 3 W, linear taper	210-2	G 21-010-067
R23	Resistor: fixed, composition, 10 ohms, ±10%, 1 W	24-10	B GB 1001
C1-C7, C10 C12-C19	Capacitor: fixed, ceramic, .01 μf, 500 vdcw	15-43	K Type BPD-10
C9abc	Capacitor: fixed, electrolytic, 40 μf, 10 μf, 10 μf, 150 vdcw	18-8	X
C8, C20	Capacitor: fixed, ceramic, .0082 μf, 500 vdcw	15-46	K Type BPD
C11	Capacitor: fixed, ceramic, .005 μf, min., 500 vdcw	15-47	K Type BPD-5
S1	Switch, toggle: SPST	310-11	D, #81715
T1	Transformer: power	910-133	HP
L25	Reactor: 6H	911-47	HP
F1	Fuse: 0.6 Amp, Slo-Blo type	211-49	T, #313.600
I1	Lamp: 6-8 volt #47	211-47	O, #47
V1-V12	Tube: electron, 5654	212-5654	ZZ
J1, J2	Jack: panel	46A-76	HP

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
CR-1	Rectifier: selenium	212-50	M, 403Dx78A
	Knob:	37-11	HP
	Power Cord:	812-56	HP
	Fuseholder:	140-16	T, #342003

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

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LIST OF MANUFACTURERS CODE LETTERS
FOR REPLACEABLE PARTS TABLE

<u>Code Letter</u>	<u>Manufacturer</u>
A	Aerovox Corp.
B	Allen-Bradley Co.
C	Amperite Co.
D	Arrow, Hart and Hegeman
E	Bussman Manufacturing Co.
F	Carborundum Co.
G	Centralab
H	Cinch Manufacturing Co.
HP	Hewlett-Packard
I	Clarostat Manufacturing Co.
J	Cornell Dubilier Electric Co.
K	Hi-Q Division of Aerovox Corp.
L	Erie Resistor Corp.
M	Federal Telephone and Radio Corp.
N	General Electric Co.
O	General Electric Supply Corp.
P	Girard-Hopkins
R	International Resistance Co.
S	Lectrohm, Inc.
T	Littelfuse, Inc.
V	Micamold Radio Corp.
X	P. R. Mallory Co., Inc.
Z	Sangamo Electric Co.
AA	Sarkes Tarzian
CC	Sprague Electric Co.
DD	Stackpole Carbon Co.
EE	Sylvania Electric Products, Inc.
FF	Western Electric Co.
HH	Amphenol
II	Dial Light Co. of America
KK	Switchcraft, Inc.
LL	Greomar Mfg. Co.
MM	Carad Corp.
ZZ	Any tube having RETMA standard characteristics

CLAIM FOR DAMAGE IN SHIPMENT

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

WARRANTY

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

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

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.
2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

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Laboratory Instruments for Speed and Accuracy
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CABLE "HEWPACK"