INSTRUCTION MANUAL

Type 1952 UNIVERSAL FILTER

GENERAL RADIO COMPANY

A

INSTRUCTION MANUAL

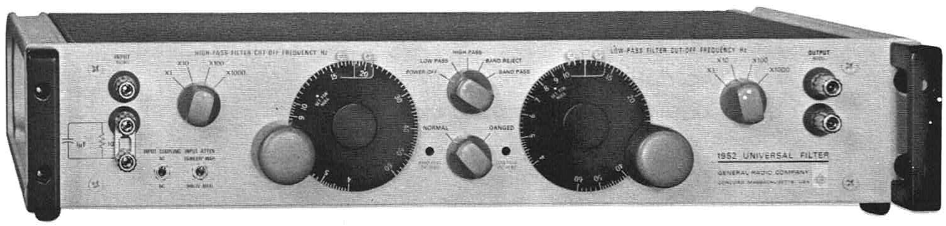
Type 1952 UNIVERSAL FILTER

Form 1952-0100-A
ID-0100
May, 1968

NOTE: This instrument is equipped with our new snap-on knob for added convenience and safety. Refer to the Service Section for details.

GENERAL RADIO COMPANY
WEST CONCORD, MASSACHUSETTS, USA

SPECIFICATIONS



FREQUENCY RANGE

Cut-off Frequencies: Adjustable 4 Hz to 60 kHz in four ranges.

Pass-Band Limits: Low-frequency response to dc (approx 0.7 Hz with ac input coupling) in LOW PASS and BAND REJECT modes. High-frequency response uniform ±0.2 dB to 300 kHz in HIGH PASS and BAND REJECT modes.

Controls: Log frequency-dial calibration; accuracy ±2% of cut-off frequency (at 3-dB points).

FILTERS

Filter Characteristics: Filters are fourth-order (four-pole) Chebyshev approximations to ideal magnitude response. The nominal pass-band ripple is ±0.1 dB (±0.2 dB max); nominal attenuation at the calibrated cut-off frequency is 3 dB; initial attenuation rate is 30 dB per octave. Attenuation at twice or at one-half the selected frequency, as applicable, is at least 30 dB.

Tuning Modes: Switch selected, LOW PASS, HIGH PASS, BAND PASS, and BAND REJECT.

Ganged Tuning: The two frequency controls can be ganged in BAND PASS and BAND REJECT modes so the ratio of upper to lower cut-off frequencies remains constant as controls are adjusted. Range overlap is sufficient to permit tuning through successive ranges without the need to reset frequency controls if ratio of upper to lower cut-off frequencies is 1.5 or less.

Minimum Bandwidth: 25% (approx ⅓ octave) in BAND PASS mode.

Null Tuning: In BAND REJECT mode, setting the frequency controls for a critical ratio of upper to lower cut-off frequency (indicated on dials) gives a null characteristic (point of infinite attenuation) that can be tuned from 5 Hz to 50 kHz.

INPUT

Gain: 0 or −20 dB, switch selected. Accuracy of gain is ±1 dB, of 20-dB attenuator is ±0.2 dB.

Impedance: 100 kΩ.

Coupling: Ac or dc, switch selected. Lower cut-off frequency (3 dB down) for ac coupling is about 0.7 Hz.

Max Voltage: Max sine-wave input is 3 V rms (8.4 V pk-pk) or 30 V rms with input attenuator at 20 dB. Max peak input voltage for dc coupling is ±4.2 V. For ac coupling max peak level of ac component must not exceed ±4.2 V and dc component must not exceed 100 V. Input can tolerate peak voltages of ±100 V without damage. An LC filter at input limits bandwidth to 300 kHz, thus reducing danger of overloading active circuits at frequencies above normal operating range.

GENERAL

Output: 600-Ω impedance. Any load can be connected without affecting linear operation of output circuit. Temperature coefficient of output offset voltage is between 0 and +4 mV/°C.

Noise: <100 μV in an effective bandwidth of 50 kHz.

Distortion: Max harmonic distortion, with all components in the pass band, for a linear load, is less than 0.25% for open-circuit voltages up to 3 V and frequencies up to 50 kHz.

Power Required: 100 to 125 or 200 to 250 V (switch selected), 50 to 60 Hz, 2.5 W. Or 19.2 V, approx 20 mA from rechargeable nickel-cadmium batteries (not supplied), about 10-h operation. Connections for external battery.

Accessories Supplied: Power cord, spare fuses, bench- or rack-mount hardware.

Accessories Available: Rechargeable batteries (two required) and 1560-P60 Battery Charger.

Dimensions (width x height x depth): Bench, 19 x 3⅞ x 15 in. (485 x 99 x 385 mm); rack, 19 x 3½ x 11¾ in. (485 x 89 x 300 mm); charger, 4¼ x 3¾ x 8 in. (110 x 96 x 205 mm).

Weight: Net. 20½ lb (9.5 kg); shipping, 25 lb (11.5 kg).

Catalog Number	Description
	1952 Universal Filter
1952-9801	Bench Model
1952-9811	Rack Model
8410-1040	**Rechargeable Battery** (2 req'd)
	1560-P60 Battery Charger
1560-9660	115 volts
1560-9661	230 volts

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Introduction—Section 1

1.1 PURPOSE

The Type 1952 Universal Filter is intended for general-purpose use in the laboratory. Nearly limitless applications are possible, due to its five modes of operation: LOW PASS, HIGH PASS, BAND REJECT, NULL, and BAND PASS. For example, it can be used to control bandwidth in a measuring system (to reduce noise), to eliminate a single frequency component when it interferes with a measurement, or to produce bands of noise in conjunction with a noise generator. It can also function as part of a spectrum analyzer or distortion meter. In the filter, the low-pass and high-pass frequency controls can be ganged to facilitate tuning a constant-percentage pass band or reject band, a feature that enhances its versatility.

1.2 DESCRIPTION

1.2.1 GENERAL

The Type 1952 consists, basically, of active low- and high-pass filters. By means of internal switching, the low- and high-pass sections can be cascaded to provide a band-pass characteristic, or they can be connected in parallel, with the outputs adding, to give a band-reject characteristic. The pass band of the low-pass filter extends to dc; that of the high-pass filter is cut off at 300 kHz and above. Each cut-off frequency is continuously tunable by means of potentiometers that can be ganged (by means of a control on the front panel) to provide convenient band-pass and band-reject tuning. The filters are synthesized as four-pole Chebyshev approximations to an ideal magnitude characteristic and have nominal pass-band ripple of $\pm$0.1 dB.

1.2.2 POWER SUPPLY

Power for the Type 1952 Universal Filter is normally supplied by connection to a 115- or 230-V, 50- to 60-Hz power line; however, provision has been made for battery operation (refer to paragraph 2.2.2).

1.2.3 MOUNTING

The instrument is supplied either for use in a standard 19-inch relay rack (catalog number 1952-9811) or as a bench model (catalog number 1952-9801).

1.3 CONTROLS, CONNECTORS, AND INDICATORS

The type and function of the controls, connectors, and indicators on the front and rear panels of the Type 1952 are given in Tables 1-1 and 1-2.

1.4 ACCESSORIES SUPPLIED

Supplied accessories are described below.

ACCESSORIES SUPPLIED

ITEM	*GR PART NO.*
3-wire power cord	4200-9622
Spare fuse (.031A)	5330-0200
Spare fuse (.062A)	5330-0300

The relay-rack model is shipped with a support set and hardware. (Part numbers are given in paragraph 2.4.)

1.5 ACCESSORIES AVAILABLE

A rechargeable nickel-cadmium battery, P/N 8410-1040 (Burgess, Type CD-25 or equivalent), is available for use with the filter (two batteries required). A battery charger is also available; order P/N 1560-9660 for 100-125-V operation or P/N 1560-9661 for 200-250-V operation.

Table 1-3 lists the wide variety of GR patch cords available for use with the Type 1952 Universal Filter.

TABLE 1-1

FRONT PANEL CONTROLS AND CONNECTORS

Fig. 1-1 Reference	*NAME*	*TYPE*	*FUNCTION*
1	INPUT 100 k Ω	Three in-line jacktop binding posts, 3/4-inch apart (GR938)	Input signal connects to upper pair, which have plastic insulators. The third post is connected to the chassis. A removable link between the two lower terminals can be used to connect the middle post directly to the chassis. When the middle terminal is connected to the chassis through 10 Ω in parallel with 1 μF. The binding posts are connected in parallel with the INPUT jack on the rear panel.
2	INPUT COUPLING AC–DC	Miniature 2-position toggle switch	Couples the input to the input-isolation amplifier, either directly (dc) or through a 2.2μF capacitor (ac).
3	INPUT ATTEN 20 dB (30 V MAX) 0 dB (3 V MAX)	Miniature 2-position toggle switch	Selects an over-all gain of 0 or -20 dB.
4	HIGH-PASS FILTER CUT-OFF FREQUENCY Hz	4-position rotary switch (multiplier) and continous rotary control with calibrated dial	Selects cut-off frequency for high-pass filter.
5	------------	5-position rotary function switch	Selects one of 4 modes of operation – LOW PASS, HIGH PASS, BAND REJECT, or BAND PASS. Also turns line power to the instrument on or OFF.
6	NORMAL–GANGED	2-position rotary control that engages a clutch	In GANGED position, clutch gangs HIGH PASS and LOW PASS controls together.
7	BAND-PASS DC ZERO	Potentiometer, adjusted by screwdriver through hole in panel	Sets output dc offset voltage when in BAND PASS mode.
8	LOW-PASS DC ZERO	Potentiometer, adjusted by screwdriver through hole in panel	Sets output dc offset voltage when in LOW PASS, HIGH PASS, or BAND REJECT modes.
9	LOW-PASS FILTER CUT-OFF FREQUENCY Hz	4-position rotary switch (multiplier) and continuous control with calibrated dial	Selects cut-off frequency for low-pass filter.
10	OUTPUT 600	Jack-top binding post pair; 3/4-inch spacing (GR 938)	Output signal available at these terminals. Impedance is 600 Ω ; any load impedance can be connected. In parallel with OUTPUT phone jack on rear panel.
11	-------------	GR Tab	"Power on" indicator (pilot light).

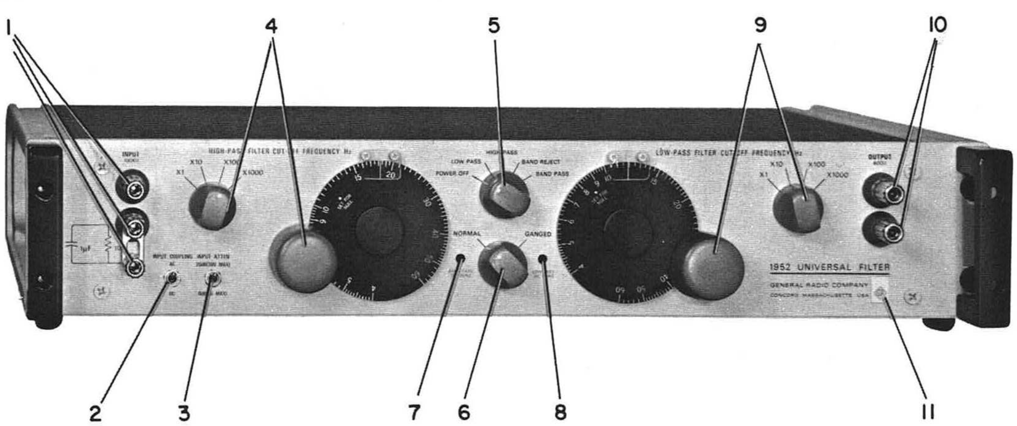


Figure 1-1. Front Panel Controls

TABLE 1-2

REAR PANEL CONTROLS AND CONNECTORS

Fig. 1-2 Reference	*NAME*	*TYPE*	*FUNCTION*
1	--------	3-pin, male, power connector	Accepts female end of P/N 4200-9622 Power Cord (supplied) for connection to power line.
2	--------	2-position slide switch	Selects proper input-power transformer connections for either 100 to 125-V or 200 to 250-V configuration.
3	.062 A	Extraction-post fuse holder	For 100-125-V line fuse (Slo-Blo).
4	.031 A	Extraction-post fuse holder	For 200-250-V line fuse (Slo-Blo).
5	BATTERY	Flat plate, mounted on two screw studs	Batteries are installed on back of plate.
6	OUTPUT 600 Ω	Telephone jack	Output signal available at this jack. Impedance is 600 Ω ; any load impedance can be connected. In parallel with OUTPUT binding posts on front panel. Jack accepts standard 2-contact telephone plug, such as Switchcraft No. 440 or equivalent.
7	BAT-LINE	2-position slide switch	Selects proper internal wiring for either battery or power-line operation.
8	--------	3 in-line pin jacks labelled +, G, and –	Voltmeter can be connected to these terminals to measure battery voltage (at least 8.8 V).
9	INPUT 100 k Ω	Telephone jack	Input signal can be connected to this jack. In parallel with INPUT binding posts on front panel. Jack accepts standard 2-contact telephone plug, such as Switchcraft No. 440 or equivalent.

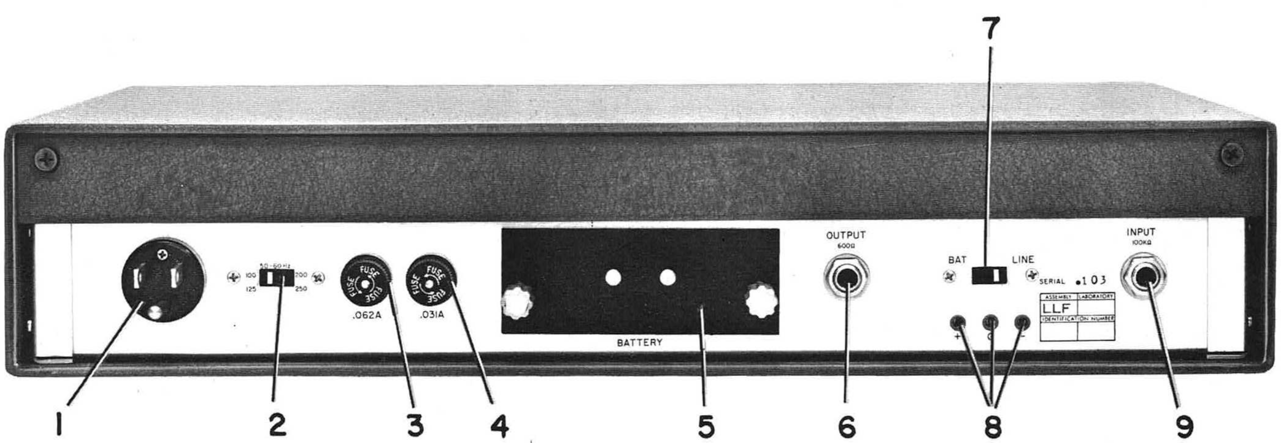
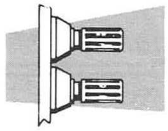
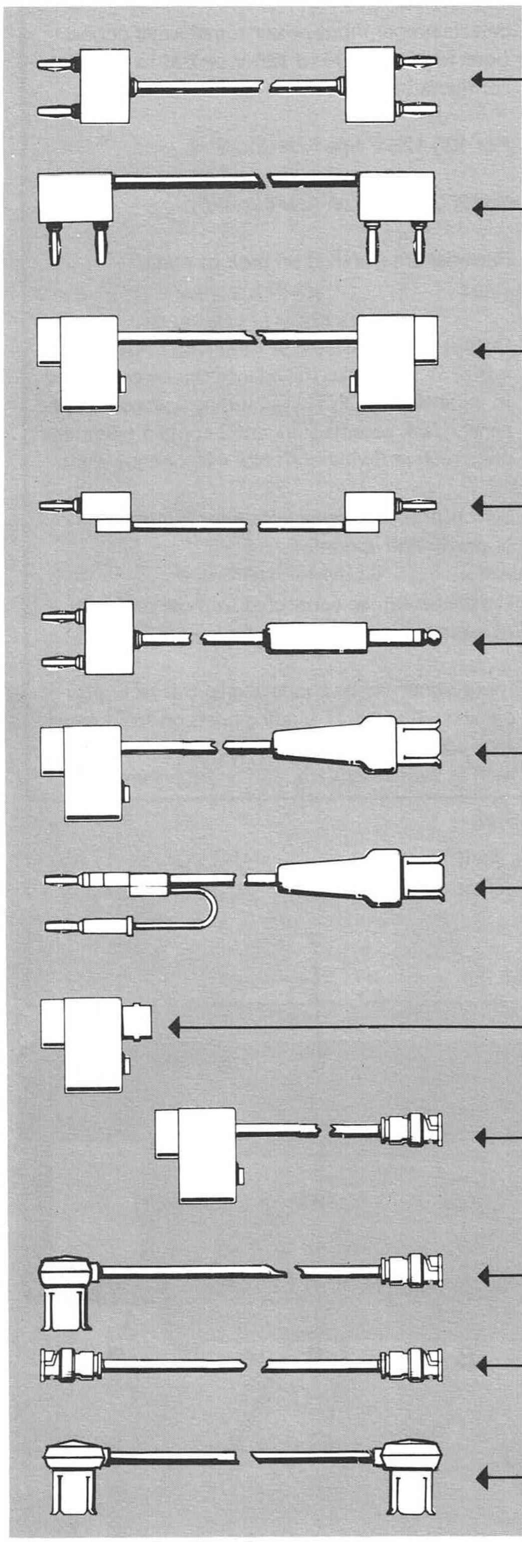


Figure 1-2. Rear Panel Controls.

TABLE 1-3
GR PATCH CORDS



NOTE: GR874 connectors are 50 Ω and are mechanically sexless; i.e., any two, although identical, can be plugged together.



TYPE NO.	DESCRIPTION	CATALOG NO.
274-NQ	Double-plug patch cord, in-line cord, 36'' long	0274-9860
274-NQM	Double-plug patch cord, in-line cord, 24'' long	0274-9896
274-NQS	Double-plug patch cord, in-line cord, 12'' long	0274-9861
274-NP	Double-plug patch cord, right-angle cord, 36'' long	0274-9880
274-NPM	Double-plug patch cord, right-angle cord, 24'' long	0274-9892
274-NPS	Double-plug patch cord, right-angle cord, 12'' long	0274-9852
274-NL	Shielded double-plug patch cord, 36'' long	0274-9883
274-NLM	Shielded double-plug patch cord, 24'' long	0274-9882
274-NLS	Shielded double-plug patch cord, 12'' long	0274-9862
274-LLB	Single-plug patch cord, black, 36'' long	0274-9468
274-LLR	Single-plug patch cord, red, 36'' long	0274-9492
274-LMB	Single-plug patch cord, black, 24'' long	0274-9847
274-LMR	Single-plug patch cord, red, 24'' long	0274-9848
274-LSB	Single-plug patch cord, black, 12'' long	0274-9849
274-LSR	Single-plug patch cord, red, 12'' long	0274-9850
1560-P95	Adaptor cable, double-plug to telephone plug, 36'' long	1560-9695
874-R34	Coaxial patch cord, double plug to GR874, 36'' long	0874-9692
874-R33	Coaxial patch cord, two plugs to GR874, 36'' long	0874-9690
274-QBJ	Adaptor, shielded double plug to BNC jack	0274-9884
776-A	Patch cord, shielded double plug to BNC plug, 36" long	0776-9701
776-B	Patch cord, GR874 (right-angle) to BNC plug, 36" long	0776-9702
776-C	Patch cord, BNC plug to BNC plug, 36" long	0776-9703
776-D	GR874 to GR874, both right-angle, 36" long	0776-9704

Installation—Section 2

2.1 DIMENSIONS

Dimensions of the Type 1952, both relay-rack and bench mounted, are given in Figure 2-1.

2.2 CONNECTION TO POWER SUPPLY

2.2.1 LINE OPERATION

For line operation, connect the Type 1952 to a 50- to 60-Hz line of 100-125 V or 200-250 V. Use the three-wire power cord (P/N 4200-9622, supplied) and connect it to the three pin, male, power connector (1, Figure 1-2) on the rear panel. The long pin (ground) on the connector attaches directly to the chassis of the instrument.

Set the slide switch (2, Figure 1-2) according to the line voltage; the white line should be nearer the appropriate marking (100-125 or 200-250). Fuse values of .062 A and .031 A (as noted on the rear panel) protect the instrument for the 100- to 125-V and 200- to 250-V sources, respectively.

Set the BAT-LINE slide switch (7, Figure 1-2) to LINE. The power consumption is approximately 2.5W.

2.2.2 BATTERY OPERATION

Although normally operated from a power line, the Type 1952 is also designed for battery operation using two 9.6-V, 225-mAh, rechargeable, nickel-cadmium batteries (P/N 8410-1040). These can be ordered from General Radio, or Burgess Type CD-25 batteries (or equivalent) can be used.

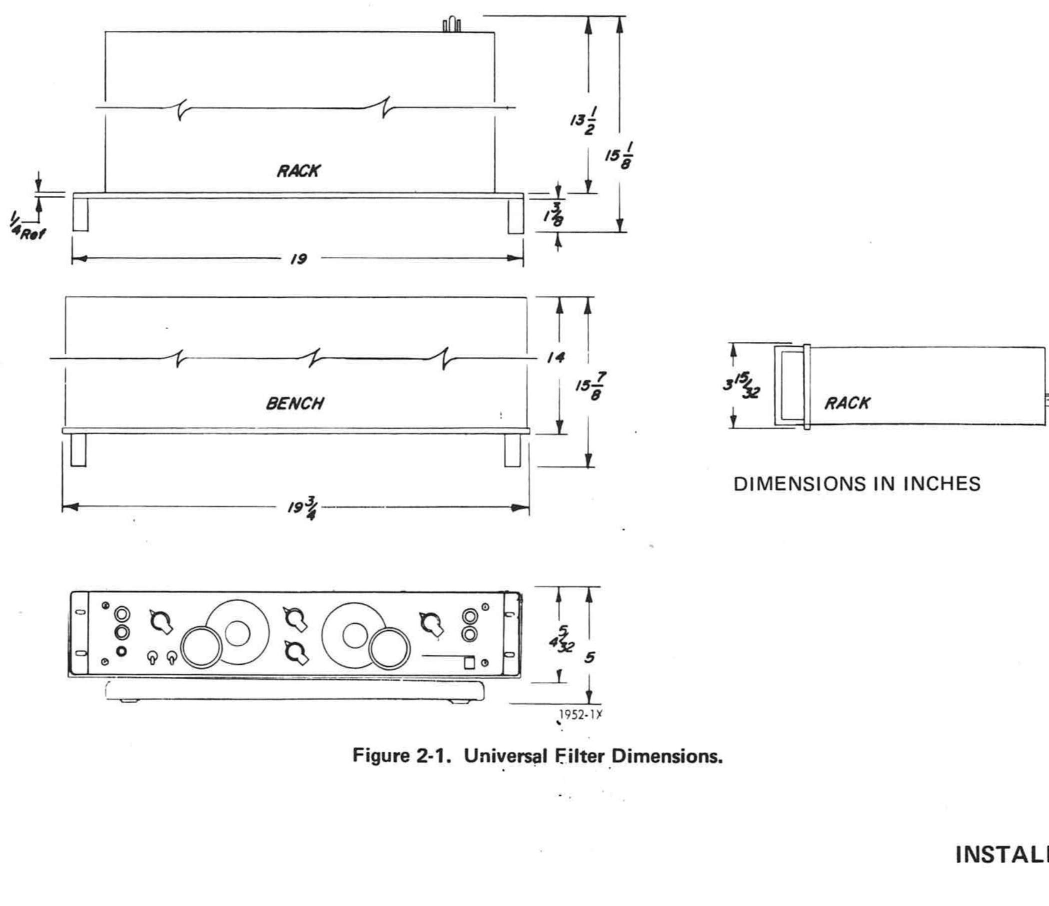


Figure 2-1. Universal Filter Dimensions.

To install the batteries, remove the two thumb nuts that hold the BATTERY plate in place on the rear panel (see Figure 1-2) and slide the plate from the studs. Snap the two batteries in place on the back of the plate, and guide the batteries into the two plastic tubes and the plate onto the studs. Be sure the plate is turned so that the word "BATTERY" on the panel is exposed. Lock the plate in place by replacing the two thumb nuts.

The batteries can remain in place during operation from a power line.

For battery operation, set the BAT-LINE slide switch (7, Figure 1-2) to BAT.

2.2.3 CHARGING THE BATTERY

The life of the recommended batteries is about 10 hours. They can be recharged by using the Type 1560-P60 Charger (order P/N 1560-9660 for 100-125-V or P/N 1560-9661 for 200-250-V). This charger delivers a constant charging current of 22 mA to the batteries; about 14 hours are required for a full charge.

To monitor the battery voltage, connect a suitable dc voltmeter to the red pin jacks (8, Figure 1-2) on the rear panel. The voltages between + and G and between - and G should be at least 8.8 volts; lower voltage indicates a need for charging the batteries.

2.2.4 USE OF AN EXTERNAL BATTERY

The filter can be operated by means of an external battery connected to the two outer red pin jacks (+ and -) on the rear panel. The internal batteries must be removed before external power is applied. Set the BAT-LINE switch to the BAT position. The voltage of each external battery cell must be between 8.8 and 11.5 V. If an external on-off switch is not provided, the BAT-LINE switch can be used to turn the power to the filter on or off; power is on in the BAT position, off in the LINE position.

2.3 BENCH MODEL

2.3.1 POSITIONING

The bench model (P/N 1952-9801) is ready to use as received from an installation standpoint. The bench cabinet has one adjustment that allows the instrument panel to be tilted upward toward the operator. To tilt the instrument, proceed as follows:

a. Place the right thumb on the right-hand release toggle and the left thumb on the left-hand release toggle (Figure 2-2).

b. Push each toward the rear of the cabinet until they stop.

c. Lift the front of the instrument upward (the rear of the pedestal is the pivot).

d. As the legs reach the perpendicular point with the pedestal, hold the instrument with one hand and pull the legs forward to the front of the pedestal with the other. The instrument is now ready to operate in the tilted position.

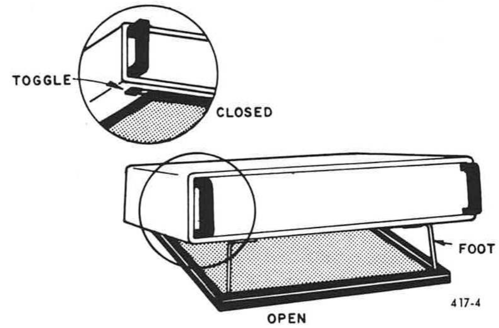


Figure 2-2. Type 1952 Bench Model Positioning.

2.3.2 REMOVING THE INSTRUMENT

To remove a bench-mounted instrument from its cabinet, proceed as follows:

a. Remove the four screws (P/N 7270-6310, No. 10-32, 9/16 in. with nylon washer) from the front panel (Figure 2-3).

b. Pull the instrument out the front of the cabinet.

2.4 RACK MODEL

To mount the rack-model (P/N 1952-9811) instrument in an EIA standard 19-inch relay rack, proceed as follows:

a. Remove the panel screws (P/N 7270-6310, No. 10-32, 9/16 inch with nylon washer) and slide the instrument out of its cabinet (Figure 2-4).

b. Insert the cabinet in the rack and secure it to the front of the rack with the four front-support screws provided (P/N 7080-1500, No. 10-32, 1/2 inch).

c. If the rack contains a rear support, remove the rear-cover screws and remove the rear cover. Attach the brackets (P/N 4171-8520, 1¼-inch sides, 2¾-inch long) to the cabinet with the four rear-bracket screws (P/N 7080-1500, No. 10-32, ½ inch), washers (P/N 8100-1517, No. 10, flat and P/N 8040-2400, No. 10, locking) and nuts (P/N 5810-3300, No. 10-32, hexagonal) provided; use the set of slots that most nearly aligns the bracket with the rear support. Secure the bracket to the rear support.

d. Place the rear of the instrument in the cabinet. Push the instrument all the way in and secure it to the rack with the panel screws.

2.5 GROUNDING THE INSTRUMENT

The ground (lower) binding post on the front panel is normally connected to the low INPUT binding post by means of the removable link (Figure 1-2). It is often desirable in a system with the chassis of the filter connected to the chassis of other instruments, to have the currents follow well-defined paths. When the link is disconnected, a circuit consisting of 10Ω in parallel with 1 uF is connected between signal ground (middle binding post) and chassis ground. This impedance is low enough to provide good cabinet shielding, with little change in the effect of internal stray capacitance, but high enough to eliminate signal ground currents in the chassis.

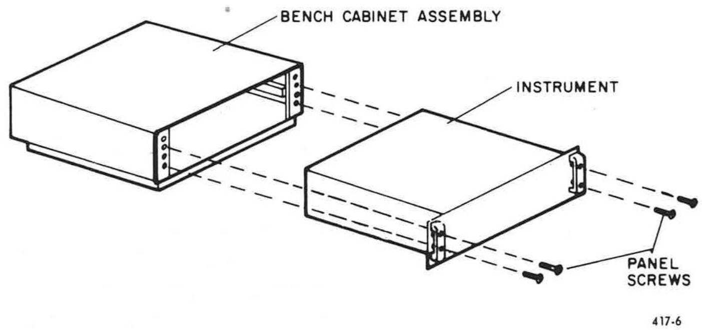


Figure 2-3. Removing the Bench Model from its Cabinet.

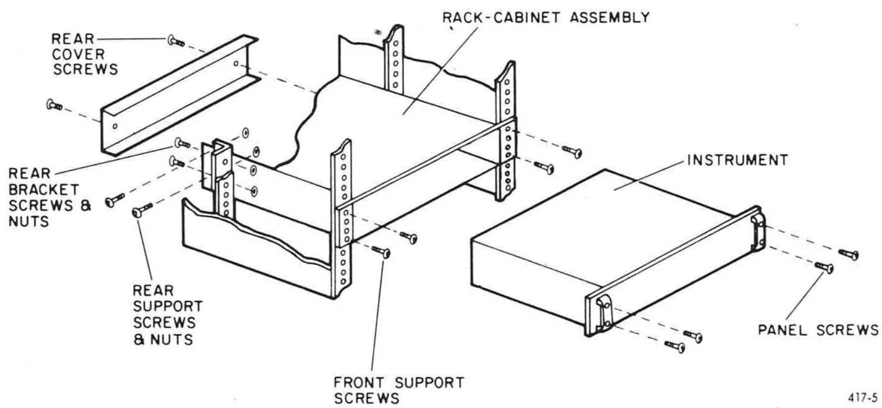


Figure 2-4. Removing the Rack Model from its Cabinet.

Operation—Section 3

3.1 GENERAL

After completing the installation procedure as given in Section 2, turn the function switch (5, Figure 1-1) on the front panel to the desired mode of operation. This switch turns the power to the instrument on and off for both line and internal-battery operation.

The INPUT and OUTPUT binding posts on the front panel will accept a variety of connectors. Also, similarly labeled phone jacks on the rear panel are wired in parallel with the front-panel binding posts.

3.2 EXTERNAL CONNECTIONS

3.2.1 INPUT

The input impedance is 100 k Ω

The over-all gain of the filter can be altered by changing the setting of the INPUT ATTEN switch (3, Figure 1-1). With this switch in the 0 dB position, the input signal level must not exceed 3 V, rms, for sinusoidal signals. This corresponds to a total swing at the input of about ±4.2 V when the INPUT COUPLING switch (2, Figure 1-1) is set to DC. With the COUPLING switch at AC, the ac component of the input signal (that remaining after the dc level has been subtracted) must not exceed ±4.2 V. Input voltages ten times higher are permissible if the INPUT ATTEN switch is set to 20 dB, but then the pass-band loss between the INPUT and OUTPUT terminals will be 20 dB. Under all conditions, the input can tolerate peak voltages of ±100 V without damage.

In the AC position, the INPUT COUPLING switch connects a capacitor in series with the input lead. The lower cut-off frequency (3 dB down) at the input is then about 0.7 Hz. Thus, any dc component in the input signal is eliminated before it reaches the input isolation amplifier (see Figure 5-1). The dc component of the input must not exceed 100 volts.

With the INPUT COUPLING switch in the DC position, the input isolation amplifier is coupled directly to the INPUT. The filter is then direct coupled from INPUT to OUTPUT when either the LOW PASS or the BAND REJECT mode is selected. An LC filter at the INPUT limits the bandwidth to 300 kHz and thus reduces the danger of overloading the active circuits of frequencies above the normal operating range of the instrument. (The ground link should usually be connected. Refer to paragraph 2.5.)

3.2.2 OUTPUT

The output amplifier is coupled directly to the OUTPUT. Although the dc offset drift has been minimized, two screwdriver adjustments, BAND-PASS DC ZERO and LOW-PASS DC ZERO, accessible through holes in the panel on either side of the NORMAL—GANGED switch, are included to further reduce the dc offset drift, if desirable. When the function switch is at BAND PASS, set the BAND-PASS DC ZERO adjustment for zero volts before connecting the load. Use the LOW-PASS DC ZERO adjustment whenever the function is set to LOW PASS, HIGH PASS, or BAND REJECT.

Adjustment of the FREQUENCY controls (refer to paragraph 3.3) will produce a change of a few millivolts in the offset voltage at the OUTPUT. If this voltage cannot be tolerated, use the proper offset adjustment (see above) to set it to zero after the FREQUENCY controls have been set. A capacitor can be inserted between the OUTPUT and the load, to eliminate the dc component.

The open-circuit output swing is limited to ±4.2 V, peak-to-peak, (for 0 dB ATTEN setting), as is the input swing. The OUTPUT impedance is 600 Ω , and any load impedance can be connected without affecting the linear operation of the output circuit.

3.3 FREQUENCY SELECTION

3.3.1 LOW-PASS OR HIGH-PASS OPERATION

For normal LOW-PASS or HIGH-PASS operation, select the desired mode by means of the function switch, then set the appropriate CUT-OFF FREQUENCY controls to the desired frequency. Multiply the dial reading, in each case, by the corresponding switch setting to obtain the actual cut-off frequency. Normalized curves of the magnitude and phase responses of the individual filters, as well as their step-response curves, are given in paragraph 3.5.

3.3.2 BAND-PASS OPERATION

With band-pass operation, when the desired ratio of upper to lower cut-off frequencies is 1.4 or greater, (35% bandwidth), set the chosen ***upper*** cut-off frequency on the LOW-PASS FILTER CUT-OFF FREQUENCY controls and set the chosen ***lower*** cut-off frequency on the HIGH-PASS FILTER CUT-OFF FREQUENCY controls. When these controls have been set, the NORMAL—GANGED switch can be set to GANGED; both filters can then be tuned by turning either the LOW-PASS or the HIGH-PASS dial. Because the FREQUENCY dials are logarithmic, once the selected band-pass characteristic has been set, the ratio of upper to lower cut-off frequencies remains constant. Thus the bandwidth is a constant fraction of the filter center frequency. The center (geometric-mean) frequency is given by:

$$f_C = \sqrt{f_H f_L}$$

f_C = center frequency

f_H = upper cut-off frequency, set on LOW-PASS FILTER CUTOFF FREQUENCY HZ controls

f_L = lower cut-off frequency, set on HIGH-PASS FILTER CUTOFF FREQUENCY HZ controls.

The percentage bandwidth is given by:

$$B = \frac{f_H - f_L}{\sqrt{f_H f_L}} \times 100$$

The overlap of the frequency ranges makes it unnecessary, in the BAND PASS and BAND REJECT modes, to reset a FREQUENCY dial each time the set-time of a multiplier switch is changed. In the BAND PASS mode, this feature is useful when the radio of upper to lower cut-off frequencies is 1.5 or less.

As the ratio of upper to lower cut-off frequencies is reduced, a point is reached beyond which a further reduction of the indicated bandwidth has little effect on the actual bandwidth. The minimum bandwidth is fixed, by the shape of the low- and high-pass filter characteristics, at 25.5% (see Figure 3-1). This corresponds to a ratio of upper to lower cut-off frequencies of 1.3. The indicated ratio should not be set to less than 1.3, as this results only in a reduction in the gain of the filter, while the actual cut-off frequency ratio remains at 1.3. The curves of Figure 3-1 show the effects of reducing the indicated bandwidth to low values. For indicated bandwidths less than 35%, the actual and indicated bandwidths do not agree, and the gain of the filter

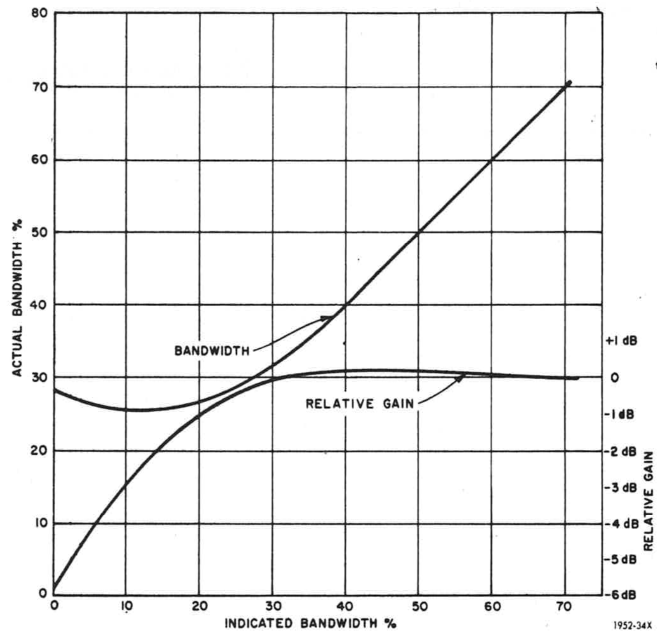


Figure 3-1. Filter Gain and Actual Bandwidth versus Indicated Bandwidth.

begins to decrease. Note that the minimum actual bandwidth of 25.5% occurs when the indicated bandwidth is 12%; also, the loss in gain for this condition is 2.4 dB. Use this curve to obtain actual bandwidth and loss for narrow bandwidths.

3.4 BAND-REJECT AND NULL OPERATION

With BAND-REJECT operation, if the desired ratio of upper to lower cut-off frequencies is 2.0 or greater, set the HIGH-PASS FILTER CUT-OFF FREQUENCY HZ controls (dial and switch) to the upper cut-off frequency and the LOW-PASS FILTER CUT-OFF FREQUENCY HZ controls to the lower cut-off frequency. The NORMAL—GANGED switch can then be set to GANGED and the filter tuned with either the low- or high-pass continuous controls. Because the FREQUENCY dials are logarithmic, once the selected band-reject characteristic has been set, the ratio of upper to lower cut-off frequencies remains constant. Thus the bandwidth is a constant fraction of the filter center frequency. A series of curves showing the normalized BAND-REJECT magnitude and phase characteristics is given in paragraph 3.5.4.

When the indicated ratio of upper to lower cut-off frequencies is set to less than 2.0, the actual cut-off frequency will not agree with that shown on the controls. Ratios below 2.0 have little application, except for the important case of one critical ratio that results in a narrow point of very high attenuation in the band-reject curve. This special null characteristic has many applications.

To obtain this null characteristic, set the NORMAL–GANGED switch to NORMAL, the function switch to BAND REJECT, the FREQUENCY dials to the dots marked SET FOR NULL, and the FREQUENCY multiplier switches to the desired ranges. (The multipliers must, of course, be set to the same range.) Change the NORMAL–GANGED switch to GANGED and adjust either dial to the desired null frequency. This frequency is the geometric mean of the indicated LOW-PASS and HIGH-PASS cut-off frequencies; that is,

$$f_{null} = \sqrt{f_{IH}\, f_{IL}}$$

where f_{IH} is the frequency indicated by the HIGH-PASS FILTER CUT-OFF FREQUENCY Hz controls, and f_{IL} is the frequency indicated by the LOW-PASS FILTER CUT-OFF FREQUENCY Hz controls.

If the null is used to reject a single spectral component and if a sensitive indicating meter is available, the null can be set precisely at the correct frequency and, if necessary, can be fine tuned for maximum attenuation. The procedure is as follows:

Tune to the component to be rejected and reduce its level to a minimum (on the indicating meter). Set the NORMAL–GANGED switch to NORMAL and, by using alternately the LOW-PASS and the HIGH-PASS FREQUENCY controls, proceed to reduce its level further. The ultimate attenuation is limited by the resolution of the potentiometers operated by the FREQUENCY controls. The rejection will vary in relatively large steps as this limit is approached. The procedure is similar to that of balancing a bridge.

3.5 FILTER CHARACTERISTICS

3.5.1 GENERAL

In the following paragraphs the magnitude, phase, and transient responses for the various modes of operation of the filter are shown. Use of the curves will permit one to predict readily the effects of the filter on the particular signal. The curves are normalized so that either the cut-off frequency or the center frequency (whichever applies) occurs at 1 Hz. The usual methods of frequency and time scaling should be used to apply the given data to other frequencies. Two types of signals are used where applicable, to demonstrate transient response: a step and a tone burst. The burst was derived from a Type 1396 Tone Burst Generator. It is symmetrical, containing an integral number of sine-wave cycles and beginning and ending on zero crossings.

3.5.2 LOW-PASS AND HIGH-PASS FILTER CHARACTERISTICS

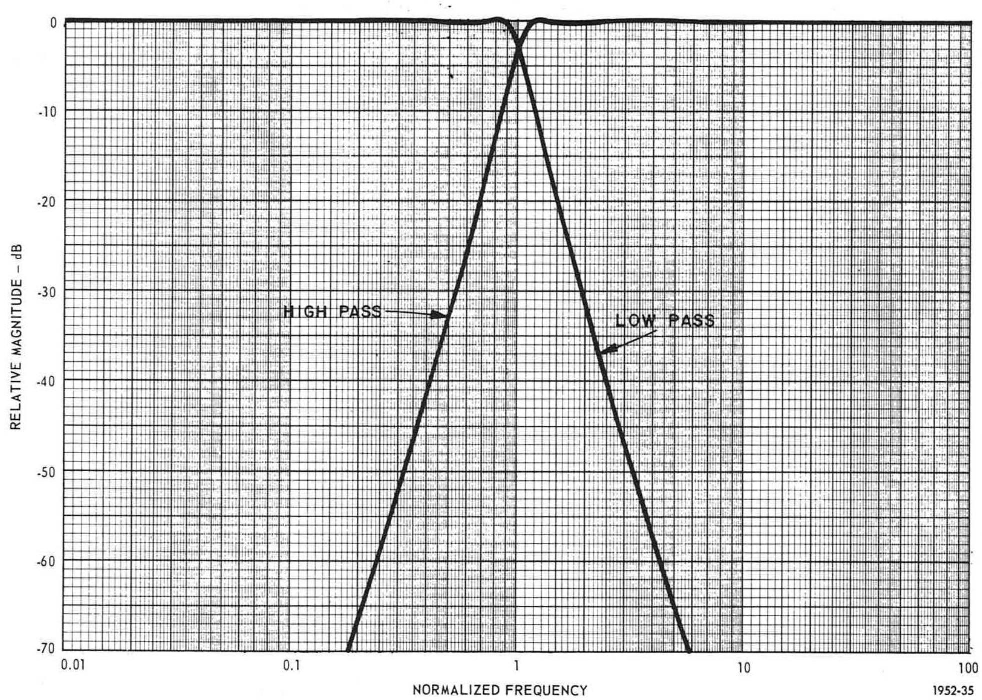


Figure 3-2. Normalized Magnitude vs. Frequency Characteristics for the Low-Pass and High-Pass Modes.

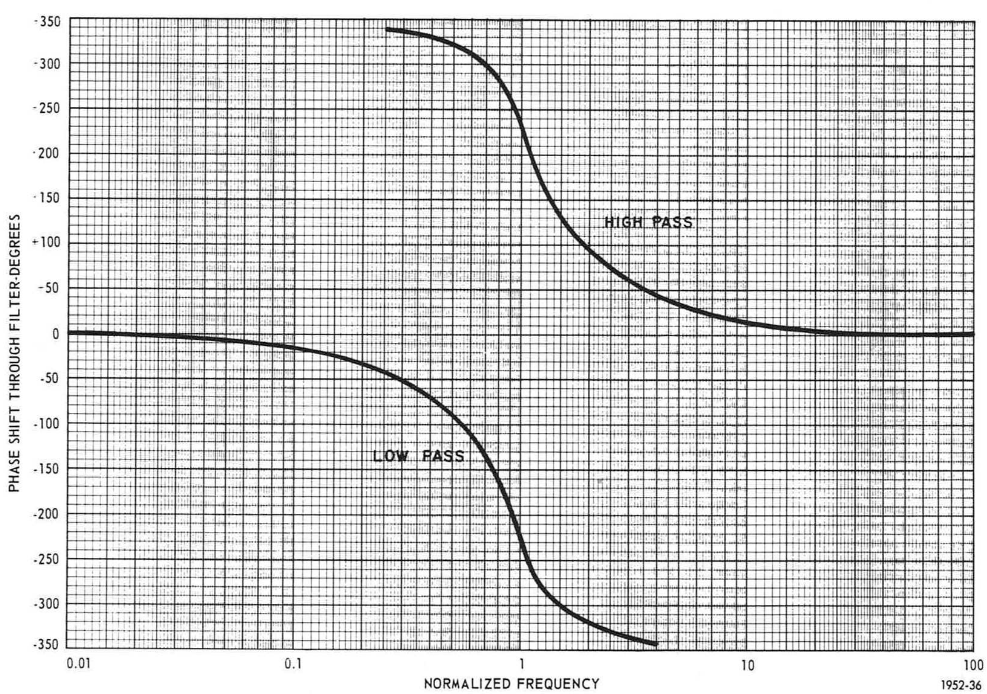
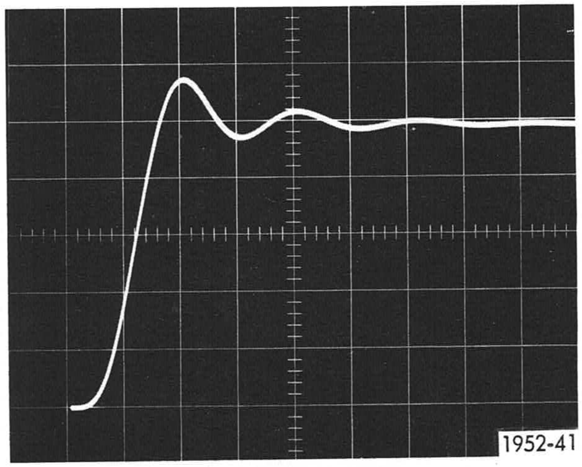
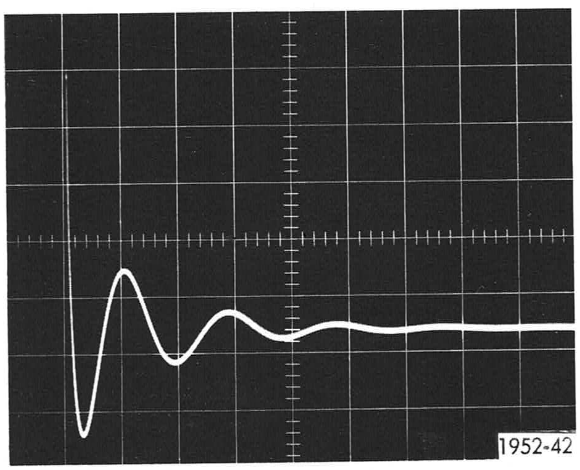


Figure 3-3. Normalized Phase vs. Frequency Characteristics for the Low-Pass and High-Pass Modes.



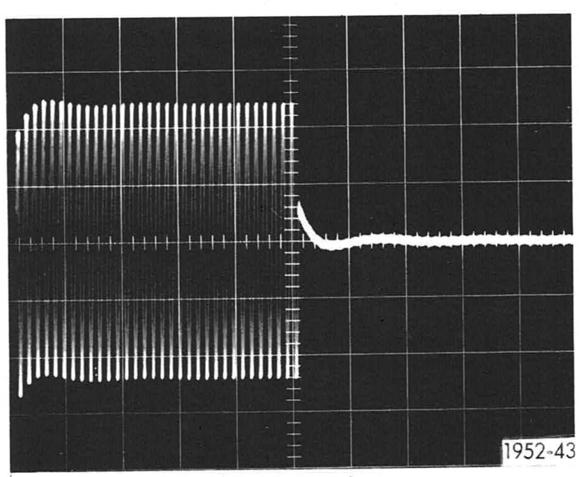
Normalized cut-off frequency 1Hz. Step amplitude 5V. Horizontal scale 0.5 S/cm. Vertical scale 1 V/cm.

Figure 3-4. Step Response of Low-Pass Filter.



Normalized cut-off frequency 1 Hz. Step amplitude 5V. Horizontal scale 0.5 S/cm. Vertical scale 1 V/cm.

Figure 3-5. Step Response of High-Pass Filter.



Normalized cut-off frequency 1 Hz. Burst amplitude 5V pk-pk. Horizontal scale 0.5 S/cm. Vertical scale 1 V/cm.

Figure 3-6. Response of the High-Pass Filter to a Tone Burst.

3.5.3 BAND-PASS FILTER CHARACTERISTICS

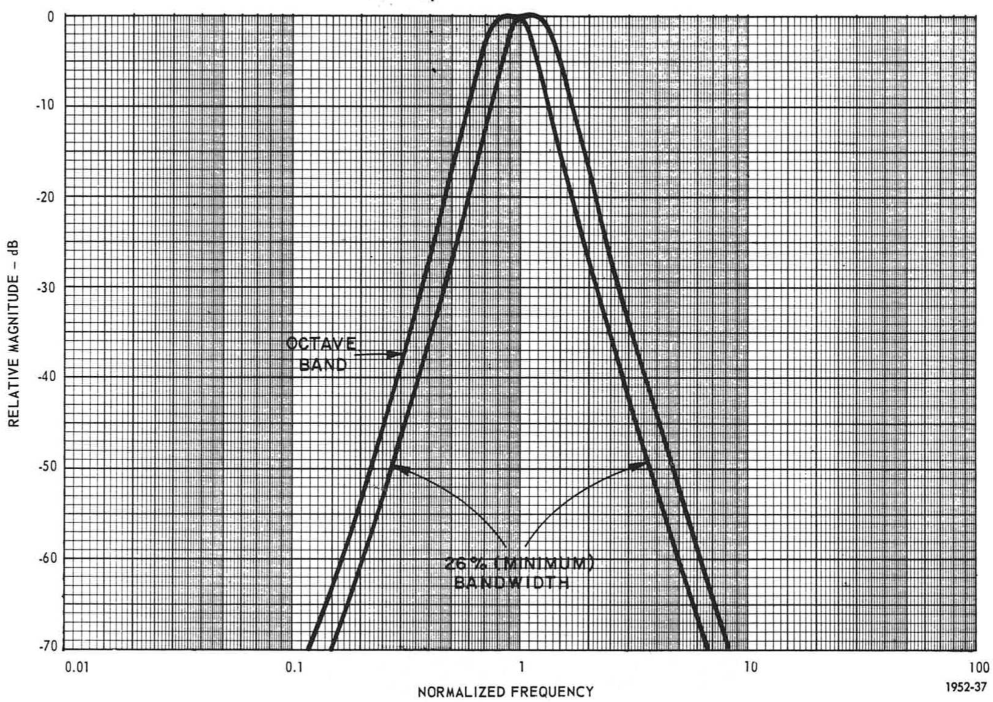


Figure 3-7. Normalized Magnitude vs. Frequency Characteristic for the Band-Pass Mode.

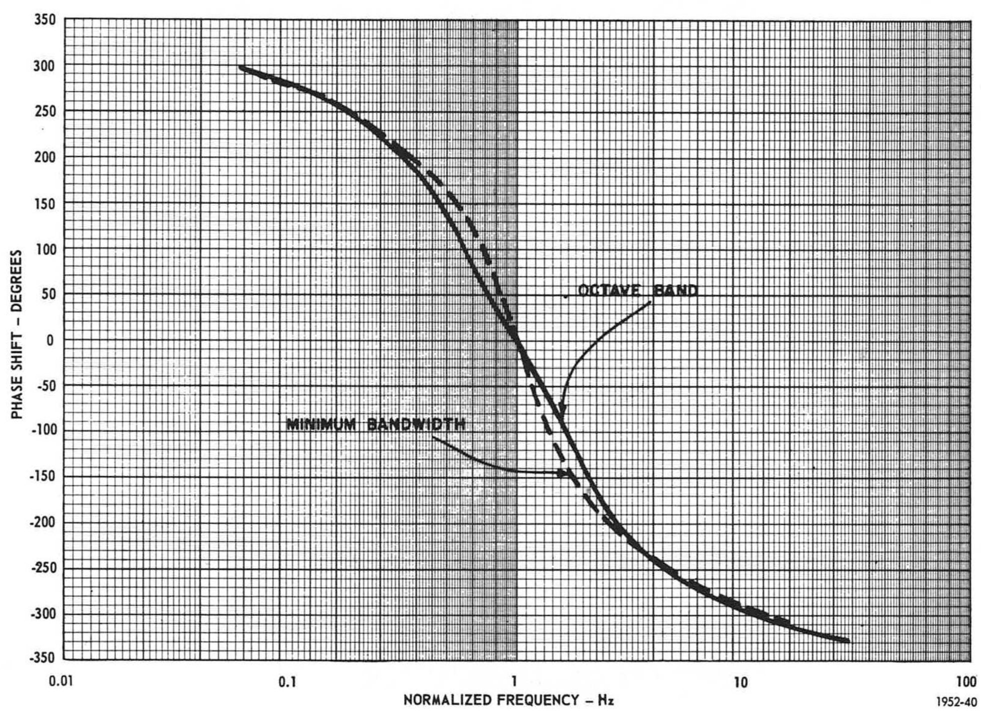
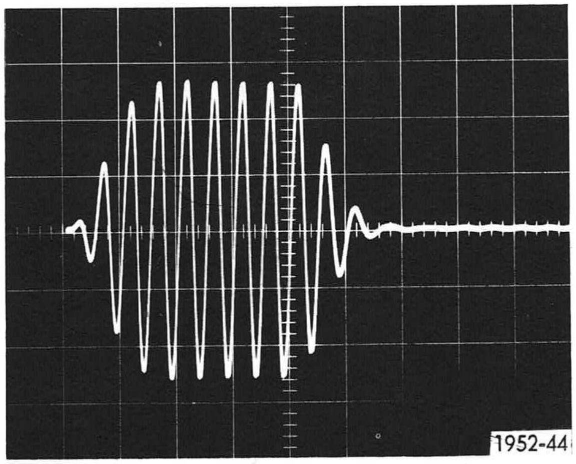
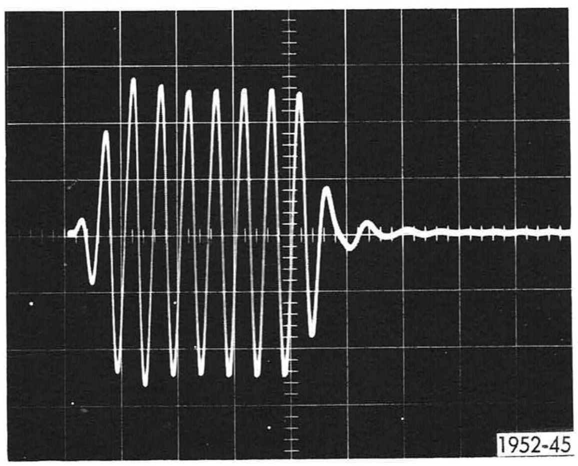


Figure 3-8. Normalized Phase vs. Frequency Characteristics for the Band-Pass Mode.



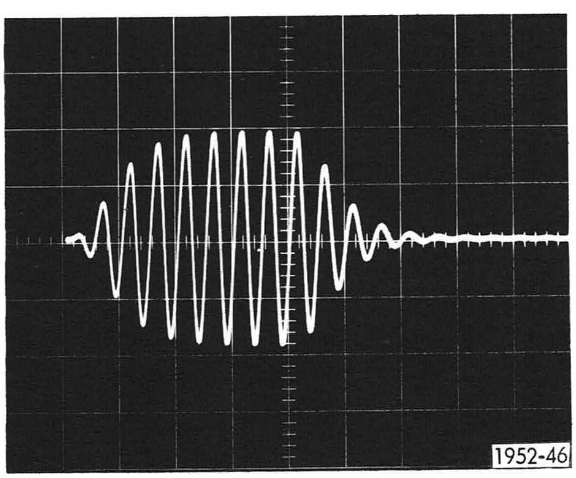
Normalized center. Frequency 1 Hz. Burst amplitude 5V pk-pk. Horizontal scale 2 S/cm. Vertical scale 1 V/cm.

Figure 3-9. Response of One Octave Band-Pass Filter to a Tone Burst.



Normalized center frequency 1 Hz. Burst amplitude 5V pk-pk. Horizontal scale 2 S/cm. Vertical scale 1 V/cm.

Figure 3-10. Response of One-Half Octave Band-Pass Filter to a Tone Burst.



Normalized center frequency 1 Hz. Burst amplitude 5V pk-pk. Horizontal scale 2 S/cm. Vertical scale 1 V/cm.

Figure 3-11. Response of Minimum Bandwidth (25.5%) Band-Pass Filter to a Tone Burst.

3.5.4 BAND-REJECT AND NULL FILTER CHARACTERISTICS

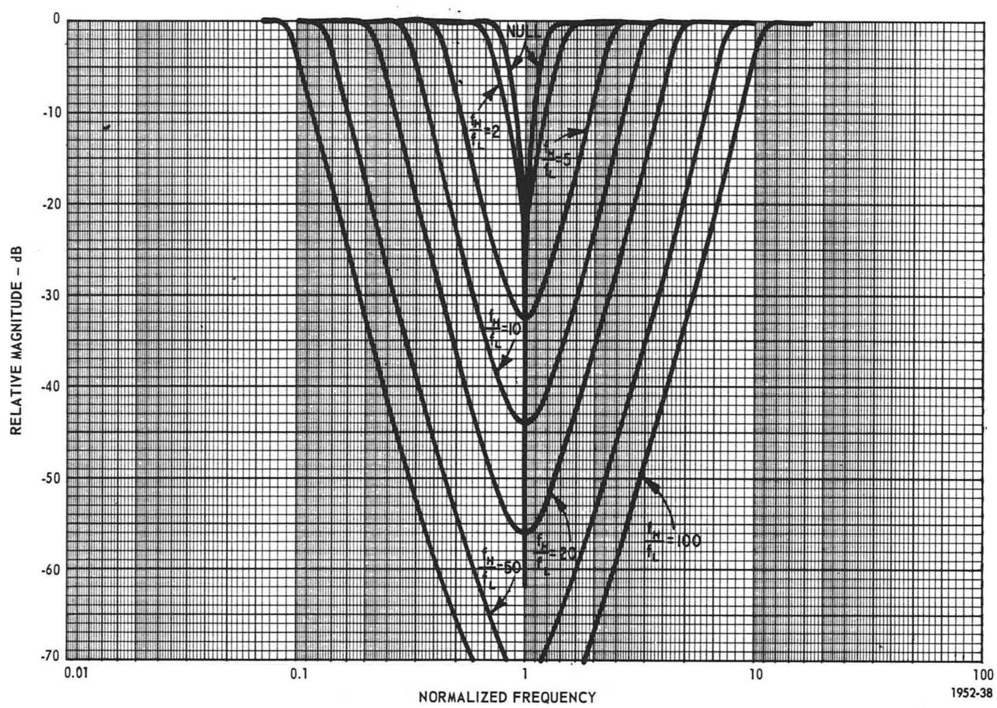


Figure 3-12. Normalized Magnitude vs. Frequency Responses for the Band-Reject and Null Modes with Indicated Ratios of Upper-To-Lower Cut-Off Frequencies.

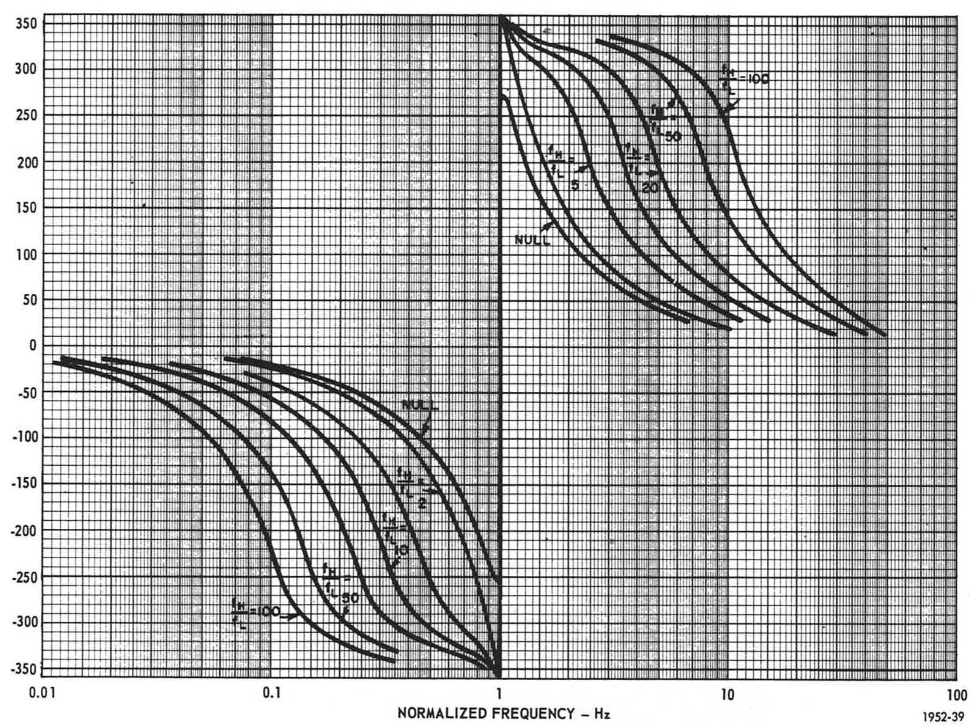
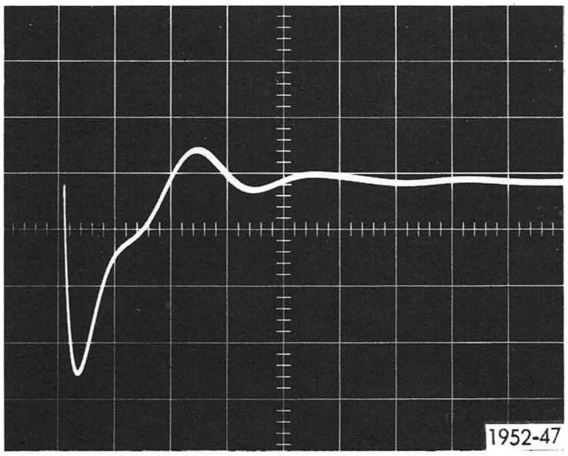
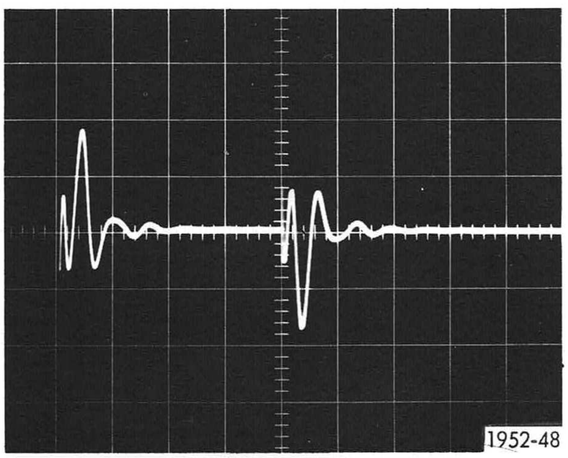


Figure 3-13. Normalized Phase vs. Frequency Responses for the Band-Reject and Null Modes with Indicated Ratios of Upper-To-Lower Cut-Off Frequencies.



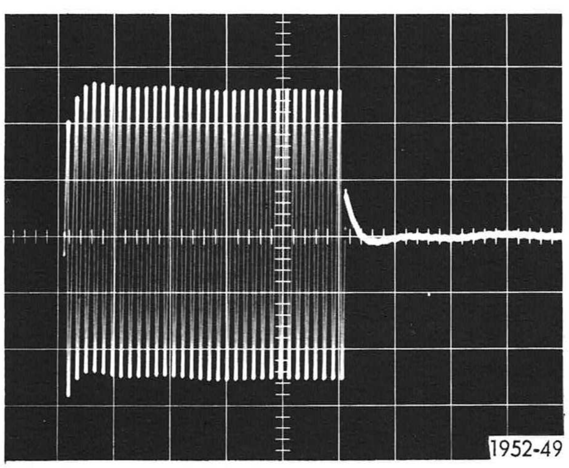
Normalized center frequency 1 Hz. Step amplitude 5V. Horizontal scale 0.5 S/cm. Vertical scale 2 V/cm.

Figure 3-14. Step Response of the Null Filter.



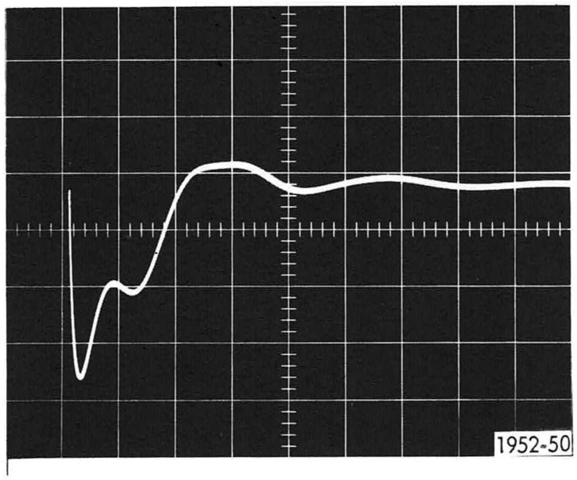
Normalized center frequency 1 Hz. Burst amplitude 5V pk-pk. Horizontal scale 2 S/cm. Vertical scale 1 V/cm.

Figure 3-15. Response of the Null Filter to a Tone Burst Centered in the Stop Band.



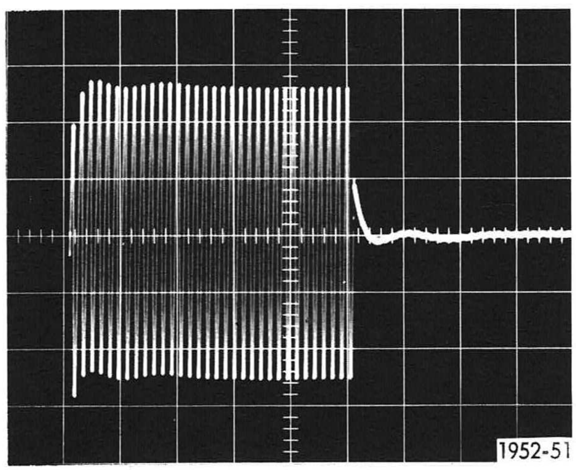
Normalized center frequency 1 Hz. Burst amplitude 5V pk-pk. Horizontal scale 0.5 S/cm. Vertical scale 1 V/cm.

Figure 3-16. Response of the Null Filter to a Tone Burst in the Pass Band.



Normalized center frequency 1 Hz. Step amplitude 5V. Horizontal scale 0.5 S/cm. Vertical scale 2 V/cm.

Figure 3-17. Step Response of the Octave-Wide Band-Reject Filter ($\frac{f_H}{f_L} = 2$).



Normalized center frequency 1 Hz. Burst amplitude 5V pk-pk. Horizontal scale 0.5 S/cm. Vertical scale 1 V/cm.

Figure 3-18 Response of the Octave-Wide ($\frac{f_H}{f_L} = 2$) Band-Reject Filter to a Tone Burst in the Pass Band.

Applications—Section 4

4.1 REDUCTION OF INTERFERING SIGNALS

It is often necessary, in a measuring system, to filter out an interfering signal. The mode of the Type 1952 Universal Filter to be used will depend on the particular application. For example, if the interfering signal is broadband and if its frequency is higher than the frequencies of interest, use the LOW PASS mode on the Type 1952. If the interfering signal is lower in frequency, use the HIGH PASS mode. In either case, if the bandwidth of the unwanted signal is narrow (e.g., a single descrete component), better results will be obtained in the BAND REJECT - null mode. Reference to the magnitude and phase characteristics of paragraph 3.5 will help to determine the best trade-off between attenuation of the unwanted signal and the distortion of the magnitude and phase of the signal of interest. When the interfering signal lies both above and below the frequency range of interest, use the BAND PASS mode; when it lies within the band of interest, use the BAND REJECT mode.

Disconnecting the link between the low INPUT terminal and the chassis may reduce signals generated through multiple ground paths when the filter is used as part of a system. Also, battery operation will eliminate interference transmitted through the power line.

4.2 PRODUCING CONTROLLED BANDS OF NOISE

The filter can be used with the Type 1381, 1382, or 1390 Random Noise Generator to produce controlled bands of noise. Because random noise contains occasional peaks that are much higher than the rms value, the possible consequences of clipping these peaks must be considered.

Below 50 kHz, which is the maximum upper cutoff frequency (3-dB point) of the Types 1381 and 1382 Noise Generators, the Type 1952 clips at about ±5 V. Thus a noise signal with an rms value approaching 5 V would be severely distorted. It is normally considered good practice to pass noise peaks up to four times the rms level of the noise. It follows that the rms voltage applied to the INPUT should not exceed 1.25 V.

The Type 1381 Random Noise Generator includes a built-in clipping circuit that can be set to limit noise peaks to 2, 3, 4, or 5 times the rms level of the noise. Higher rms levels of this clipped noise can then be transmitted through the Type 1952. Table 4-1 shows the rms levels of clipped noise that can be applied to the filter without further clipping.

When the Type 1390 Random Noise Generator is used with the filter, do not use the 5-MHz range. The filter cannot pass signals above 300 kHz, and use of the 5-MHz range on the generator only increases the possibility of overloading. For good peak-handling capacity, do not exceed 1.25 V rms, when using the Type 1390 on its 20-kHz range, or 1.0 V, rms, when on its 500-kHz range.

The output voltage from the Type 1390 is indicated on a built-in meter; that from the Type 1381 or 1382 Generator should be measured with a meter having an rms- or average-responding detector. It should be noted that, if the average-responding meter is calibrated to indicate rms level for sine-wave signals, it will read about 11% low for noise signals.

4.3 USE WITH TYPE 1142 FREQUENCY METER

The Type 1952 is ideally suited for filtering out the carrier-related frequencies from the Type 1142 Frequency Meter and Discriminator. Use the LOW PASS or BAND PASS mode; set the upper cut-off frequency low enough to suppress carrier components, but higher than the highest frequency in the modulating signal.

Connect the INPUT of the Type 1952 to the FM terminals of the Type 1142 and set the INPUT ATTEN switch to 20 dB. (Note that, in the Type 1142 Instruction Manual, paragraph 2.5.2, the value to use for Vdc in the formula for fm deviation will now be 1.5 V.) This makes it possible for the filter to pass the 45-V negative pulse from the Type 1142.

In some models of the Type 1142, a .0033-μF capacitor (C7) is connected internally across the FM terminals. The capacitor partially filters the pulses in the output signal. However, this capacitor limits the upper frequency of the modulating signal to 10 kHz (i.e., has its 3-dB point at 10 kHz). The capacitor should be removed from the circuit if higher frequencies are involved.

The low-level circuits in the Type 1952 are susceptible to interference from the stray magnetic fields produced by the Type 1142. For best performance, leave at least 3½ inches between rack mounted instruments, and allow several inches between chassis for bench installations.

4.4 SPECTRUM AND DISTORTION ANALYSIS

In its BAND PASS mode, the Type 1952 can be used as the filter in a spectrum analyzer. In the BAND REJECT–null mode it can function as part of a distortion meter. In either case, connect a sensitive ac voltmeter to the output, to serve as a detector and meter. In addition, an attenuator may be required at the INPUT. The Type 1561-R Precision Sound-Level Meter is well suited for this application, especially when the signal source is acoustical; it can serve as both the input attenuator and the output voltmeter. Connect the Type 1952 to the FILTER jacks and calibrate the system. A Type 1562 Sound-Level Calibrator is recommended for calibrating when a microphone is used.

TABLE 4-1

MAXIMUM RMS LEVEL WITHOUT INCREASED CLIPPING

CLIPPING CONTROL SETTING ON TYPE 1381 RANDOM-NOISE GENERATOR	*MAXIMUM RMS LEVEL INPUT ATTENUATOR AT 0 DB*
2σ	2.5 V
3σ	1.6
4σ	1.25
5σ	1.0
∞	at 1.0 V peaks will be clipped at 5σ by the Type 1952

Theory – Section 5

5.1 GENERAL

In this section, the various circuits in the Universal Filter will be described.

The Type 1952 consists of five basic sections: input amplifier, output amplifier, low-pass filter, high-pass filter, and power supply. Connections to the amplifiers and to the filters are changed by manipulating the function switch, to give the basic modes of operation: low-pass, high-pass, band-pass, and band-reject. A block diagram of the circuit is given in Figure 5-1.

5.2 INPUT-AMPLIFIER CIRCUIT

This circuit includes an isolation amplifier, an input attenuator, a coupling capacitor, and fixed low-pass filter. The input amplifier isolates the filter circuitry from the source and limits the bandwidth of the signal presented to the active circuitry. Figure 6-16 includes the schematic diagram of this voltage amplifier. It includes transistors Q401 and Q402. Its low output impedance is suited to driving the filter stage that follows. The RLC filter reduces the input signal when its level is above the normal operating range of the instrument, to prevent overloading of the input isolation amplifier and the other active stages that follow.

The input attenuator is operated by a miniature 2-position toggle switch (INPUT ATTEN) on the front panel. In one position (20 dB) it reduces the input signal level by 20 dB. Thus, large signals can be applied to the INPUT without the use of an external attenuator. The coupling capacitor can be bypassed by means of the COUPLING SWITCH when it is not needed to remove components below 1 Hz from the input signal.

5.3 LOW-PASS AND HIGH-PASS FILTERS

Figure 6-14 shows a schematic of the low-pass filter. The filter consists of four voltage amplifiers (each of unity or near-unity gain) and the precision resistors and capacitors that determine the cut-off frequency. A different set of capacitors is switched into the circuit for each of the four positions of switch S101 (multiplier). The continuous fre-

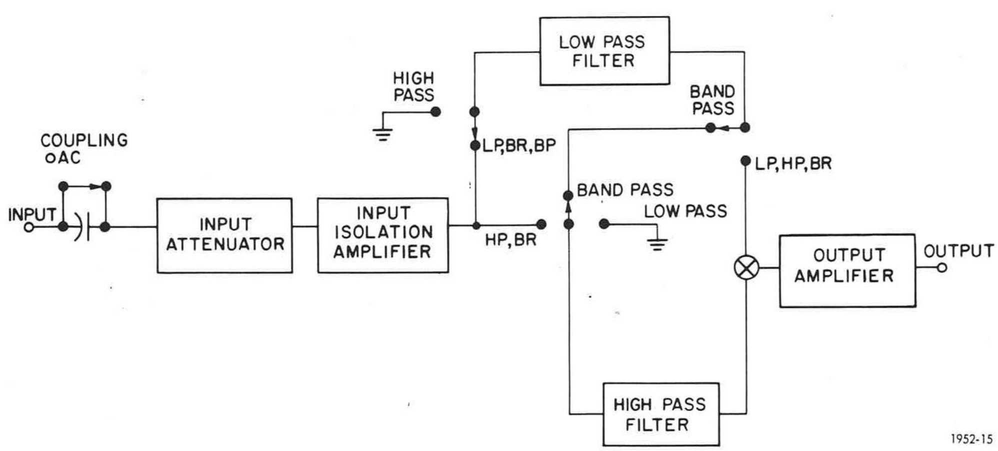


Figure 5-1. Type 1952 Universal Filter Block Diagram.

quency control (dial) adjusts the four-gang potentiometer, R101, to span the selected range. Each stage produces one of the two-pole responses needed to form the over-all Chebyshev frequency characteristic.

Note that the first transistors in the amplifiers are alternately PNP and NPN types. Thus, the effect of a temperature drift in one base-emitter junction is cancelled by that of another. This method of drift cancellation is employed throughout the circuitry of the instrument to minimize the drift of the offset voltage at the output.

A schematic diagram for the high-pass filter is shown in Figure 6-14. The configuration is similar to that of the low-pass filter, but the placement of resistors and capacitors has been reversed and a buffer amplifier has been added to permit cascading of the low-pass and high-pass filters in the band-pass mode.

The FREQUENCY controls for the low-pass and high-pass filters are mechanically connected by means of a clutch operated by the NORMAL-GANGED switch. Toothed belts are used to couple the clutch plates to the frequency controls.

5.4 OUTPUT AMPLIFIER

The output amplifier (Figure 6-16) includes a conventional complementary-symmetry stage with a voltage gain of approximately X6. This gain makes up for the loss in the input circuit and the loss involved in summing the outputs of the filters, thus giving an over-all gain of X1 (0 dB) for the instrument. The output offset controls operate potentiometers in this section.

5.5 POWER SUPPLY

Figure 6-15 shows the power supply, which furnishes the stable, low-hum, positive and negative 7.5-volt power required by the amplifier and filter circuits.

The transformer and rectifier drive a simple pre-regulator that greatly reduces the hum and any variations in the line voltage. The main regulator is driven by either the pre-regulator or the optional batteries, as determined by the position of the BAT-LINE switch.

Service and Maintenance—Section 6

6.1 WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

6.2 SERVICE

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest District Office, requesting a "Returned Material Tag". Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

6.3 MINIMUM PERFORMANCE SPECIFICATIONS

The following procedures are recommended for incoming inspection or periodic checks. Their intent is to establish that the instrument meets catalog specifications. Out-of-tolerance specifications may be corrected by internal adjustments as described in the Trouble-Shooting Procedure, paragraph 6.4.

6.3.1 EQUIPMENT REQUIRED

The instruments listed in Table 6-1 (or their equivalent) are recommended for testing the Universal Filter. All interfaces (cables as well as connections) should be shielded.

6.3.2 PRELIMINARY CHECKS

a. Connect the Type 1806 Electronic Voltmeter (set as a dc voltmeter) to the filter OUTPUT terminals and short circuit the INPUT. With the function switch at LOW PASS and the LOW-PASS FILTER CUT-OFF FREQUENCY at 7x100, set the output to 0 V dc by adjusting the LOW PASS DC ZERO potentiometer (8, Figure 1-2).

b. Vary the LOW-PASS FILTER CUT-OFF FREQUENCY dial from 4 to 60; the dc voltmeter indication should not vary more than 50 mV across the range. Change the function switch to HIGH PASS and vary the HIGH-PASS FILTER CUT-OFF FREQUENCY dial from 4 to 60; the dc voltmeter indication should not vary more than 50 mV across the range.

c. Change the function switch to BAND PASS and set the LOW- and HIGH-PASS FILTER CUT-OFF FREQUENCIES at 7x100; adjust the BAND PASS DC ZERO potentiometer (7, Figure 1-2) for a 0 V dc output.

d. Disconnect the dc voltmeter and the input short circuit. Connect the Type 1310 Oscillator to the INPUT and set the equipment as shown in Table 6-2.

e. Connect the Type 1806 to the filter OUTPUT. With the function switch at BAND PASS, the output should be 0.9 to 1.1 V.

f. Set the Type 1310 to 200 Hz (maintaining its 1-V output) and set both filter multiplier switches to X10. The output should not vary from the previous reading by more than ±5%.

g. Repeat steps e and f with the multipliers at X100 and X1000 and the Type 1310 at 2 kHz and 20 kHz, respectively.

TABLE 6-1

TEST EQUIPMENT

INSTRUMENT	*RECOMMENDED TYPE*	*REQUIREMENT*
Metered Autotransformer	GR Type W5MT3AW Variac	Low range wattmeter (0 to 20 W)
Oscillator	GR Type 1310	20-V output into an open circuit; 160 mW into 600 Ω; 2 Hz to 2 MHz
Oscillator	GR Type 1309	5-V output into an open circuit; 10 mW into 600 Ω; 10 Hz to 100 kHz
Millivoltmeter	Hewlett Packard 400EL with X1 Probe	±1% accuracy
Distortion Analyzer	Hewlett Packard 331A or 334A	Distortion level down to 0.1%
Sound-Level Meter	GR Type 1551	150-dB range
Infrasonic Voltmeter	Ballantine 316	Frequency range down to 2 Hz
Counter	GR Type 1191	10-mV rms sensitivity; frequency range to 1 MHz
Oscilloscope	Tektronix 503	Frequency range to 1 MHz
Electronic Voltmeter	GR Type 1806	±2% accuracy
Decade Attenuator	GR Type 1450-TB	600 Ω input and output impedance; 0.1 dB steps
Resistors: 10 Ω 100 Ω 270 Ω 330 Ω 560 Ω	----------	5% Carbon Resistors
Jacks, Plugs, Cables	GR 274 Series	As required, see table at the end of this manual
500 Ω Pad	GR Type 500-G	±0.025% accuracy

TABLE 6-2

PRELIMINARY TEST CONDITIONS

TYPE	*PARAMETER*	*SETTING*
1952	INPUT ATTEN	0 dB
	LOW-PASS FILTER CUT-OFF FREQUENCY	50 X 1
	HIGH-PASS FILTER CUT-OFF FREQUENCY	5 X 1
	INPUT COUPLING	AC
1310	FREQUENCY	20 Hz
	OUTPUT LEVEL	1 V*

* Measured on the Type 1806 (set for ac volts) at the Type 1310 output.

The output should not vary more than ±5% from the original reading with the X1 multiplier setting.

h. Repeat the procedure of paragraphs e, f, and g for the remaining function-switch settings (LOW PASS, HIGH PASS, and BAND REJECT). In each case the voltmeter indications should be 0.9 to 1.1 V at an oscillator frequency of 20 Hz, and should not vary more than ±5% from the original reading as the oscillator frequency and multiplier settings are varied.

6.3.3 INPUT ATTENUATOR

a. Use the test set-up of Figure 6-1 and the conditions of Table 6-3.

b. Change the filter INPUT ATTEN to 20 dB and the Type 1450-TB to 0 dB. The 400EL must read a filter output of 0.92 to 1.08 V.

c. Repeat this test at 300 kHz, measuring a ±8% maximum deviation when the attenuators are changed.

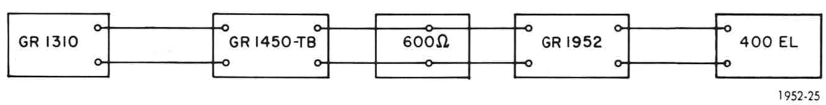


Figure 6-1. Test Set-Up for Input Attenuation Test.

TABLE 6-3

TEST CONDITIONS, INPUT ATTENUATION

TYPE	*PARAMETER*	*SETTING*
1450-TB	Attenuation	20 dB
1952	HIGH-PASS FILTER CUT-OFF FREQUENCY	4 X 100
	Function Switch	HIGH PASS
	INPUT COUPLING	DC
	INPUT ATTEN	0 dB
1310	FREQUENCY	4 kHz
	LEVEL	1 V*

* On 400EL, measured at the Type 1952 OUTPUT.

6.3.4 NOISE AND DISTORTION

a. Use the set-up of Figure 6-2 (the filter must be in its cabinet for all remaining tests) and the conditions of Table 6-4.

b. Adjust the Type 1551 CAL control for a full-scale reading (+10). Short the Type 1952 INPUT and change the Type 1551 dB range to 50. The Type 1551 meter must then read less than +10 dB; this is equal to a 100-μV noise level.

c. Remove the filter input short, substitute a 331A (or 334A) Distortion Analyzer for the Type 1551 in the circuit, connect a 600 Ω load across the filter OUTPUT, and reset the equipment according to Table 6-5.

d. Measure the distortion (or the 331A or 334A) at 50 kHz to be less than 0.25%.

e. Change the Type 1952 function switch to LOW PASS and set the LOW-PASS FILTER CUT-OFF FREQUENCY to 50 X 1000. Change the Type 1309 to 45.3 kHz at 3 V (measured on Type 1806). The distortion at 45.3 kHz should be less than 0.25%.

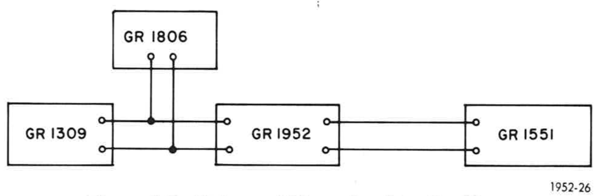


Figure 6-2. Noise and Distortion Test Set-Up.

TABLE 6-4
INITIAL CONDITIONS NOISE TEST

TYPE	*PARAMETER*	*SETTING*
1952	HIGH-PASS FILTER CUT-OFF FREQUENCY	4 X 1000
	LOW-PASS FILTER CUT-OFF FREQUENCY	7 X 1000
	Function Switch	BAND PASS
	INPUT ATTEN	0 dB
1551	METER	FAST
	WEIGHTING	20 kHz
	dB range	130
1309	FREQUENCY	5.2 kHz
	LEVEL	1 V*

* Measured on the Type 1806 at the Type 1309 output.

TABLE 6-5
INITIAL CONDITIONS, DISTORTION TEST

TYPE	*PARAMETER*	*SETTING*
1952	HIGH-PASS FILTER CUT-OFF FREQUENCY	4 X 1
	Function switch	HIGH PASS
	INPUT ATTEN	0 dB
1309	FREQUENCY	50 kHz
	LEVEL	3 V*

* Measured on the Type 1806

6.3.5 SIGNAL-HANDLING CAPACITY

a. Use the set-up of Figure 6-3 and the conditions of Table 6-6.

b. Increase the Type 1310 LEVEL until the Type 1952 output waveform starts to clip. At this point the indication on the Type 1806 should be greater than 3.0 V.

c. Repeat the test with the Type 1952 function switch in the HIGH PASS and BAND PASS positions. In both cases the voltage must exceed 3.0 V when the waveform starts to clip.

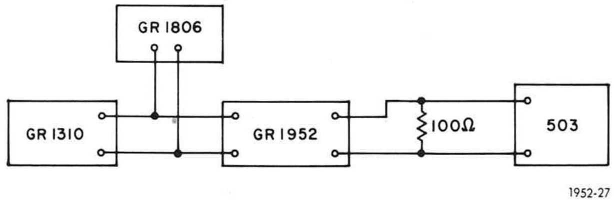


Figure 6-3. Test Set-Up for Signal Handling Capacity.

TABLE 6-6

INITIAL CONDITIONS, SIGNAL HANDLING CAPACITY TEST

TYPE	*PARAMETER*	*SETTING*
1952	HIGH-PASS FILTER CUT-OFF FREQUENCY	60 X 1
	LOW-PASS FILTER CUT-OFF FREQUENCY	60 X 1000
	Function Switch	LOW PASS
	INPUT ATTEN	0 dB
1310	FREQUENCY	1 kHz

6.3.6 FILTER CHARACTERISTICS

High Pass Band

a. Use the set-up of Figure 6-4 and the conditions of Table 6-7.

b. Adjust the Type 1310 for a 0 dB reading (reference amplitude) on the 400EL. Decrease the Type 1310 FREQUENCY until a -3 dB point is reached on the 400EL.

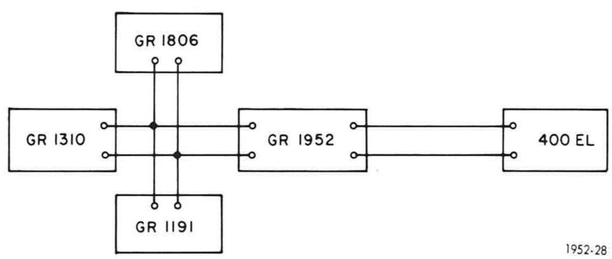


Figure 6-4. Test Set-Up for High-Pass Band Test.

TABLE 6-7

INITIAL CONDITIONS, HIGH PASS BAND

TYPE	*PARAMETER*	*SETTING*
1952	HIGH-PASS FILTER CUT-OFF FREQUENCY	5 X 100
	Function Switch	HIGH PASS
1310	FREQUENCY	5 kHz
400EL	Full scale range	3 V

The 3 dB point should occur at 500 Hz ± 2% (490 to 510 Hz).

c. Decrease the Type 1310 FREQUENCY to 250 Hz. The level on the 400EL must be at least 30 dB below the 5 kHz level.

d. Set the oscillator FREQUENCY to 590 Hz (1.695 msec period; 1.18 times cutoff) and note the reading on the 400EL. Continue increasing frequency to 300 kHz. The deviation on the 400EL (between 590 Hz and 300 kHz) must not exceed 0.4 dB. (Constant input to the Type 1952 must be maintained for this test.)

e. Repeat the entire procedure for each cutoff frequency listed in Table 6-8 (refer to Figure 6-5). In each case set the reference amplitude at a frequency 10 times cutoff. The frequency at each point of interest should be as given in the table.

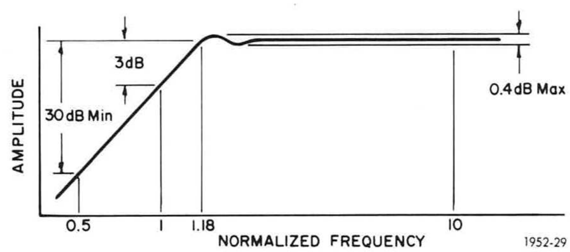


Figure 6-5. Typical High-Pass Filter Characteristic.

Low Pass Band

a. Continue to use the set-up of Figure 6-4, but with the conditions of Table 6-9.

b. Adjust the oscillator for a 0 dB reading (reference amplitude) on the 400EL. Increase the oscillator FREQUENCY from 50 Hz (0.1 times cutoff) to 425 Hz (0.85 times cutoff). The indication of the 400EL should not vary more than 0.4 dB between these frequencies.

c. Continue to increase the oscillator FREQUENCY until the 400EL indicates a -3 dB point. At this point the frequency should be 500 Hz ± 2% (490 to 510 Hz).

d. Set the oscillator to 1 kHz; the level on the 400EL must be at least 30 dB below the 50 Hz level.

e. Repeat the above procedure for each cutoff frequency listed in Table 6-10 (refer to Figure 6-6). In each case set the reference amplitude at a frequency 0.1 times cutoff. The frequency at each point of interest should correspond to that shown in the table.

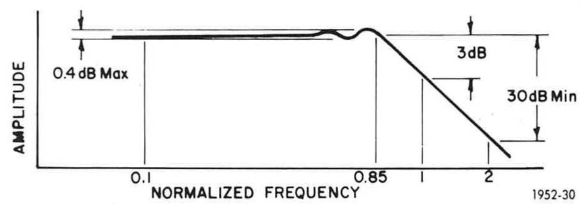


Figure 6-6. Typical Low-Pass Filter Characteristic.

TABLE 6-8

HIGH PASS BAND TEST FREQUENCIES

HIGH-PASS FILTER CUT-OFF	*CUT-OFF X 10*	*CUT-OFF X 1.18*	*FREQUENCY (±2%) at 3-dB – DOWN POINT*
10 X 100	10 kHz	1180 Hz	980 to 1020 Hz
50 X 100	50 kHz	5900 Hz	4900 to 5100 Hz
20 X 1000	200 kHz	23.6 kHz	19.6 to 20.4 kHz
20 X 10	2 kHz	2.36 kHz	19.6 to 20.4 Hz
20 X 1	200 Hz	23.6 Hz	19.6 to 20.4 Hz

TABLE 6-9

INITIAL CONDITIONS, LOW PASS BAND

TYPE	*PARAMETER*	*SETTING*
1952	Function Switch	LOW PASS
	LOW-PASS FILTER CUT-OFF FREQUENCY	5 X 100
1310	FREQUENCY	50 Hz
400EL	Full scale range	3 V

TABLE 6-10

LOW PASS BAND TEST FREQUENCIES

LOW PASS FILTER CUT-OFF	*0.1 X CUT-OFF*	*0.85 X CUT-OFF*	*FREQUENCY (±2%) at 3-dB – DOWN POINT*
10 X 100	100 Hz	850 Hz	980 to 1020 Hz
50 X 100	500 Hz	4250 Hz	4900 to 5100 Hz
20 X 1000	2 kHz	17.0 kHz	19.6 to 20.4 kHz
20 X 10*	20 Hz	170 Hz	196 to 204 Hz
20 X 1*	2 Hz	17.0 Hz	19.6 to 20.4 Hz

* Use the Ballantine 316 Infrasonic Voltmeter in place of the 400EL.

6.3.7 ULTIMATE ATTENUATION

a. Use the set-up of Figure 6-4, except use a direct connection between the filter and the 400EL (no probe). Set conditions as listed in Table 6-11.

b. Adjust the oscillator LEVEL for a 0-dB indication on the 400EL (approximately 3V output will be required of the oscillator).

c. Change the oscillator FREQUENCY to 70 kHz and the 400EL to 1 mV full scale. Correct the oscillator FREQUENCY for a peak indication on the 400EL. The peak should be less than -2 dB, corresponding to an ultimate attenuation of 72 dB.

6.3.8 BAND PASS

a. Continue with the set-up of the previous test, and the conditions of Table 6-12.

TABLE 6-11

INITIAL CONDITIONS, ULTIMATE ATTENUATION

TYPE	*PARAMETER*	*SETTING*
1952	HIGH-PASS FILTER CUT-OFF FREQUENCY	60 X 1000
	LOW-PASS FILTER CUT-OFF FREQUENCY	50 X 10
	Function switch	LOW PASS
1310	FREQUENCY	70 Hz
400EL	Full scale range	3 V

TABLE 6-12

INITIAL CONDITIONS, BAND PASS TEST

TYPE	*PARAMETER*	*SETTING*
1952	HIGH-PASS FILTER CUT-OFF FREQUENCY	10 X 100
	LOW-PASS FILTER CUT-OFF FREQUENCY	20 X 100
	Function switch	BAND PASS
1310	FREQUENCY	1.4 kHz
400EL	Full scale range	3 V

b. Adjust the oscillator LEVEL for a 0-dB reading on the 400EL. Sweep the oscillator down to 1 kHz and up to 2 kHz and note that the amplitude rolls off by 3 dB at these frequencies (±2%, 980 to 1020 Hz and 1960 to 2040 Hz).

6.3.9 BAND REJECT

a. Continue with the previous set-up, and the conditions of Table 6-13.

b. Adjust the oscillator LEVEL for a 0-dB reading on the 400EL. Change the 400EL to 100 mV full scale and the oscillator FREQUENCY for a null indication on the 400EL. The null point should occur at approximately 1 kHz and should be at least 30 dB below the initial reading.

6.3.10 GANGING

Set the filter NORMAL-GANGED switch to GANGED and sweep the frequency dials several times, being careful not to hit the stops. Return to the SET FOR NULL dots and note that there has been no slippage in the clutch.

6.3.11 INPUT COUPLING

a. Connect the oscillator to the filter INPUT and the 316 to the OUTPUT. Set the conditions of Table 6-14.

b. Adjust the oscillator LEVEL for a convenient reading on the 316 (do not exceed 3 V input) and note the reading.

c. Change the filter INPUT COUPLING switch to DC. The 316 reading should increase approximately 0.5 dB.

6.4 TROUBLE-SHOOTING PROCEDURE

6.4.1 GENERAL

The Type 1952 Universal Filter needs no routine maintenance. If difficulties arise, the following information is provided to aid in localizing the trouble. Internal adjustments and repairs should be performed by qualified personnel only.

6.4.2 VISUAL CHECK

If the filter does not function properly when operated according to the instructions of Section 3, perform the following checks to locate any immediately obvious failures:

a. Look for any sign of damaged components, such as broken resistors, burned capacitors, and the like.

b. Look for any loose conductors, e.g., screws, bits of solder, that may have fallen into the instrument.

c. Look for broken cables. Sometimes a broken wire is held in place by its insulation, so that it is necessary to apply a slight pulling pressure to the wire to find a break. Perform this test on the cables leading to anchor terminals and switches.

TABLE 6-13

INITIAL CONDITIONS, BAND REJECT TEST

TYPE	*PARAMETER*	*SETTING*
1952	HIGH- AND LOW-PASS FILTER dials	Null dot
	Multipliers	X 100
	Function switch	BAND REJECT
400EL	Full scale range	3 V
1310	FREQUENCY	100 Hz

TABLE 6-14

INITIAL CONDITIONS, INPUT COUPLING TEST

TYPE	*PARAMETER*	*SETTING*
1952	LOW-PASS FILTER CUT-OFF FREQUENCY	5 X 100
	Function switch	LOW PASS
	INPUT COUPLING	AC
1310	FREQUENCY	2 Hz
316	Volts full scale	20

6.4.3 INTERNAL ADJUSTMENTS

Power Supply

a. Connect the Type 1806 Electronic Voltmeter between AT9 (on the power-supply board, see Figures 6-13 and 6-15) and ground, and set the full-scale range to +15 V dc. Set the filter function switch to LOW PASS. Adjust R511 for a +7.5 V dc reading on the voltmeter.

b. Reconnect the voltmeter between AT8 and ground and change its full-scale range to −15 V dc. Adjust R512 for a −7.5 V dc reading.

Low Pass Filter, Low-Q Section

a. Connect the Type 1310 Oscillator to the filter INPUT and the 400EL Millivoltmeter to AT102 (ground 400EL at AT109 – refer to Figures 6-9 and 6-14). Keep the connection between the 400EL probe and AT102 as short as possible. Set the equipment as listed in Table 6-15.

b. Change the oscillator to 606 Hz and adjust the filter LOW-PASS FREQUENCY dial for a reading of 0.232 V on the 400EL.

c. Loosen the LOW-PASS FREQUENCY dial from the potentiometer shaft (via two Allen-head set screws immediately behind the front panel) and set the dial to 5. Tighten the dial on the shaft, being careful to maintain the 0.232-V reading on the 400EL and the 5 dial setting on the filter.

Low Pass Filter, High-Q Section

a. Disconnect the lead from the end of R101C going to AT102 and establish the set-up of Figure 6-7.

b. Set the filter controls as listed in Table 6-15; set the oscillator FREQUENCY to 45.3 Hz and the LEVEL for 1.0 V on the 400EL. Change the oscillator FREQUENCY to 453 Hz and adjust R117 in the filter for a 2.48 V reading on the 400EL.

c. Change the filter LOW-PASS FILTER CUT-OFF FREQUENCY to 50 x 100 and tune the oscillator for a peak (near 4530 Hz). Adjust R109 and R113 so that the peak occurs at exactly 4530 Hz at an amplitude of 2.48 V (on the 400EL).

> Note: R109 changes frequency and amplitude in the same direction; R113 in opposite directions.

d. Remove the connection to R101C and resolder the lead from AT102 to RT101C.

High Pass Filter, High-Q Section

a. Connect the Type 1310 Oscillator to the filter INPUT and the 400EL to AT205 (ground 400EL at AT216; refer to Figures 6-10 and 6-14). Set the equipment as listed in

TABLE 6-15

INITIAL CONDITIONS, LOW PASS TEST

TYPE	*PARAMETER*	*SETTING*
1952	Function switch	LOW PASS
	LOW-PASS FILTER CUT-OFF FREQUENCY	5 X 100
	INPUT COUPLING	DC
	INPUT ATTEN	0 dB
	GANGED-NORMAL	NORMAL
1310	FREQUENCY	60.6 Hz
	LEVEL	1.0 V (on 400EL)

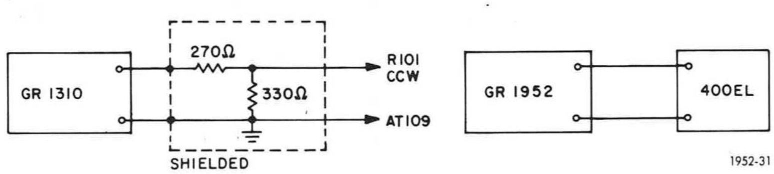


Figure 6-7. Low-Pass, High-Q Section Test Set-Up.

Table 6-15, except set the filter function switch to HIGH PASS and the HIGH-PASS FILTER CUT-OFF FREQUENCY to 5 x 100, and set the oscillator for 4120 Hz at 500 mV (on the 400EL; requires approximately 1.5 V output from the oscillator).

b. Change the oscillator FREQUENCY to 412 Hz. Adjust the filter HIGH-PASS FREQUENCY dial for a 116-mV reading on the 400EL. Loosen the HIGH-PASS FREQUENCY dial from the potentiometer shaft and set the dial to 5. Tighten the dial on the shaft, maintaining the 116 mV reading on the 400EL.

High Pass Filter, High-Q Section

a. Remove the lead between AT205 and AT206 on the high pass filter board (see Figures 6-10 and 6-14), and make the set-up of Figure 6-8.

b. Set equipment controls as in the high pass, low-Q test, except set the oscillator for 5520 Hz and a 100 mV reading on the 400EL (requires approximately 1.7 V output from the oscillator).

c. Change the oscillator to 552 Hz and adjust R227 in the filter for a 248-mV reading on the 400EL.

d. Change the HIGH-PASS FILTER CUT-OFF FREQUENCY to 50 x 100 and set the oscillator FREQUENCY for a peak indication on the 400EL (near 5520 Hz). Adjust R224 and R225 so that the peak occurs at exactly 5520 Hz with an amplitude of 248-mV (on the 400EL).

> Note: R224 changes frequency and amplitude in opposite directions; R225 in the same direction.

e. Remove the connection to AT206 and resolder the lead between AT205 and AT206. Check that both of the filter tuning dials cover their full range between 4 and 60 before hitting the stops. If either dial will not go past 4 or 60, loosen the set screws on the hubs of the large gears behind the front panel and adjust until the span is correct.

DC Stability and Control

a. Remove all connections to the filter INPUT and short the INPUT. Connect the Type 1806 Electronic Voltmeter to the filter OUTPUT and set controls as listed in Table 6-16.

b. Adjust R204 (on the low pass filter board) for a 0-V dc reading on the voltmeter. Change the filter function switch to BAND PASS, and vary the HIGH PASS FILTER dial over its entire range (4 to 60). The dc output voltage should not vary more than ±0.05 V.

c. Change the filter function switch to HIGH PASS and vary the HIGH PASS FILTER dial over its entire range again. The dc output voltage should not vary more than ±0.05 V. Return the dial to 7.

d. Vary the LOW PASS FILTER dial over its entire range. The dc output should again vary no more than ±0.05 V.

6.4.4 BIAS CONDITIONS

Table 6-17 lists the dc voltages to be expected at the emitter and collector of each transistor in the Type 1952. Individual instruments should agree within ±10% of the values given when measured under the following conditions.

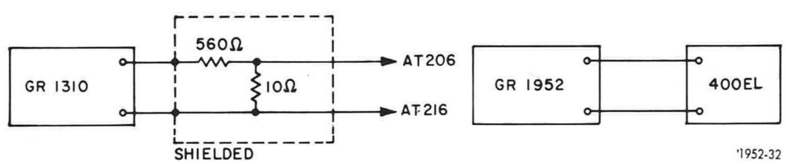


Figure 6-8. High-Pass, High-Q Section Test Set-Up.

TABLE 6-16

INITIAL CONDITIONS, DC STABILITY AND CONTROL

TYPE	*PARAMETER*	*SETTING*
1952	Function Switch	LOW PASS
	HIGH-PASS FILTER CUT-OFF FREQUENCY	7 X 100
	LOW-PASS FILTER CUT-OFF FREQUENCY	7 X 100
1806	VOLTS FULL SCALE	1.5 V
	MEASUREMENT	DC

TABLE 6-17

DC VOLTAGES

TRANSISTOR	*MEASUREMENT TO GROUND FROM:*	*DC VOLTS*
	LOW PASS FILTER	
Q101	E	+0.06
	C	-6.8
Q102	E	-7.5
	C	+0.06
Q103	E	-0.50
	C	+6.8
Q104	E	+7.5
	C	-0.50
Q105	E	+0.15
	C	-6.8
Q106	E	-7.5
	C	0
Q107	E	-0.50
	C	+6.8
Q108	E	+7.5
	C	-0.50
	HIGH PASS FILTER	
Q203	E	-0.75
	C	+6.8
Q204	E	+7.5
	C	-0.75
Q205	E	-1.0
	C	+6.8
Q206	E	+7.5
	C	-0.70
Q207	E	-0.50
	C	+6.8
Q208	E	+7.5
	C	-0.50
Q209	E	-1.0
	C	+6.8
Q210	E	+7.5
	C	-0.55
Q211	E	-0.50
	C	+6.8
Q212	E	+7.5
	C	-0.50

TRANSISTOR	*MEASUREMENT TO GROUND FROM:*	*DC VOLTS*
	OUTPUT AMPLIFIER*	
Q301	E	0
	C	-6.8
Q302	E	-7.5
	C	-0.70
Q303	E	+0.05
	C	+7.5
Q304	E	-0.05
	C	-7.5
	INPUT AMPLIFIER	
Q401	E	-0.50
	C	+6.8
Q402	E	+7.5
	C	-0.50
	POWER SUPPLY	
Q501	E	+11.3
	C	+15.8
Q502	E	-11.3
	C	-15.8
Q503	E	+7.6
	C	+11.3
Q504	E	-7.6
	C	-11.3
Q505	E	+4.7
	C	+8.3
Q506	E	-4.7
	C	-8.3

* Output amplifier voltages will vary with settings of the DC ZERO controls.

(E = Emitter, C = Collector)

Line Voltage	115 V ac
INPUT COUPLING	DC
INPUT ATTEN	0 dB
HIGH- and LOW- PASS FILTER CUT-OFF FREQUENCY	10 X 100
Function Switch	BAND PASS
LOW and BAND PASS DC ZERO	Adjusted for 0 V dc output (as in paragraph 6.3.2)
NORMAL-GANGED Switch	NORMAL

Refer to Figures 6-9 through 6-17 for location of test points.

Note: On the etched boards, a dot near a transistor indicates the collector of that transistor.

6.5 BATTERY OPERATION

For battery-operated Universal Filters, the following check should be performed.

Remove the line connection and install two 9.6 V nickel-cadmium batteries (General Radio part number 8410-1040 or Burgess type CD-25) in the rear compartment. Set the BAT-LINE switch to BAT. Measure the voltages at AT9 and AT8 to be +7.5 and −7.5 V dc, respectively.

Measure the voltages at the + and − jacks (rear panel, beneath the BAT-LINE switch) at +10 and −10 V, respectively (for fully charged batteries).

Remove the batteries and reconnect the filter for line operation, if desired.

6.6 KNOB REMOVAL

If it should be necessary to remove the knob on a front-panel control, either to replace one that has been damaged or to replace the associated control, proceed as follows:

a. Grasp the knob firmly with the fingers, close to the panel (or the indicator dial, if applicable), and pull the knob straight away from the panel.

CAUTION

Do not pull on the dial to remove a dial/knob assembly. Always remove the knob first.

b. Observe the position of the set screw in the bushing with respect to any panel markings (or at the full CCW position of a continuous control).

c. Release the set screw and pull the bushing off the shaft, using an Allen wrench.

Note: To separate the bushing from the knob, if for any reason they should be combined off the instrument, drive a machine tap a turn or two into the bushing for sufficient grip for easy separation.

6.7 KNOB INSTALLATION

To install a snap-on knob assembly on the control shaft:

a. Mount the bushing on the shaft, using a small slotted piece of wrapping paper as a shim for adequate panel clearance.

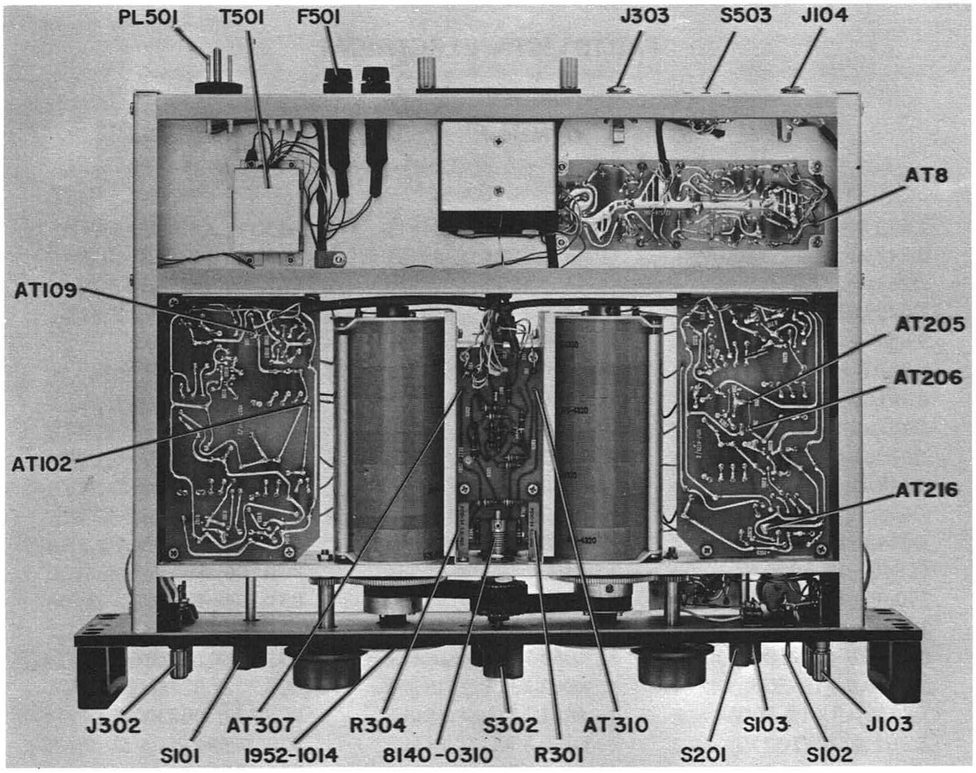
b. Orient the set screw on the bushing with respect to the panel-marking index and lock the set screw with an Allen wrench.

Note: Make sure that the end of the shaft does not protrude through the bushing or the knob won't set properly.

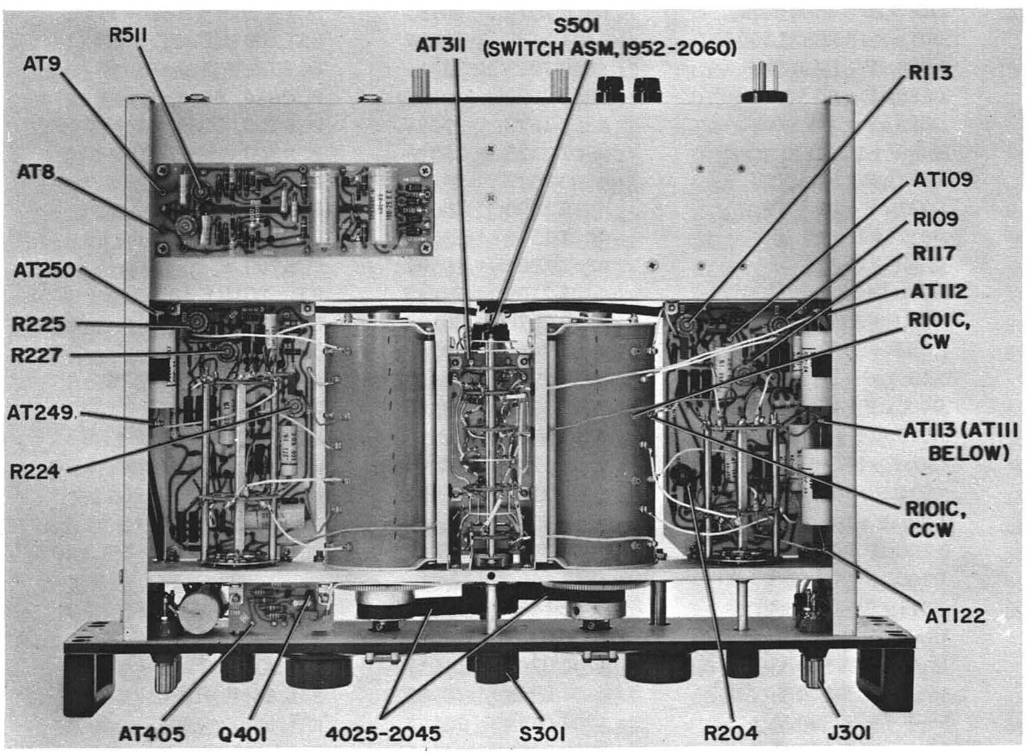
c. Place the knob on the bushing with the retention spring opposite the set screw.

d. Push the knob in until it bottoms and pull it slightly to check the retention spring is seated in the groove in the bushing.

Note: If the retention spring in the knob comes loose, reinstall it in the interior notch with the small slit in the wall.



Universal Filter; top interior view.



Type 1952; bottom interior view.

PARTS LIST — ELECTRICAL

Ref. No.	*Description*	*Part Number*	*Fed. Mfg. Code*	*Mfg. Part No.*	*Fed. Stock No.*
CAPACITORS					
C101	2.42μF ±1% 100 V	4860-8350	84411	663UW, 2.42μF ±1%	
C102	0.242μF±1% 1% 100 V	4860-7983	84411	663UW, 0.242μF ±1%	
C103	.0242μF ±1% 50 V	4862-1830	19396	PCR700, .0242μF ±1%	
C104	.00239μF ±1% 50 V	4862-1478	19396	PCR700, .00239μF ±1%	
C105	390pF ±10% 500 V	4404-1398	72982	831, 390pF ±10%	5910-978-4403
C106	1.01μF ±1% 100 V	4860-8277	84411	663UW, 1.01μF ±1%	
C107	0.101μF ±1% 100 V	4860-7932	84411	663UW, 0.101μF ±1%	
C108	.0101μF ±1% 50 V	4862-1710	19396	PCR700, .0101μF ±1%	
C109	.00100μF ±1% 50 V	4862-1350	19396	PCR700, .00100μF ±1%	
C110	0.448μF ±1% 100 V	4860-7931	84411	663UW, 0.448μF	
C111	.0448μF ±1% 50 V	4862-1925	19396	PCR700, .0448μF ±1%	
C112	.00448μF ±1% 50 V	4862-1575	19396	PCR700, .00448μF ±1%	
C113	413pF ±1% 50 V	4862-1216	19396	PCR700, 413pF ±1%	
C114	390pF ±10% 500 V	4404-1398	72982	831, 390pF ±10%	5910-978-4403
C115	2.24μF ±1% 100 V	4860-8306	84411	663UW, 2.24μF ±1%	
C116	0.224μF ±1% 100 V	4860-7930	84411	663UW, 0.224μF ±1%	
C117	.0224μF ±1% 50 V	4862-1812	19396	PCR700, .0224μF ±1%	
C118	.00230μF ±1% 50 V	4862-1473	19396	PCR700, .00230μF ±1%	
C119	2.2μF ±10% 100 V	4860-8300	84400	620S22591	
C120	27pF ±10% 500 V	4700-0238	14655	22A5Q27KD	
C121	27pF ±10% 500 V	4700-0238	14655	22A5Q27KD	
C122	1μF ±20% 25 V	4400-2070	80183	5C13, 1μF ±20%	
C123	1μF ±20% 25 V	4400-2070	80183	5C13, 1μF ±20%	
C124	1μF ±20% 25 V	4400-2070	80183	5C13, 1μF ±20%	
C201	.001μF +80 -20% 500 V	4404-2109	72982	831, .001μF +80 -20%	
C202	0.888μF ±1% 100 V	4860-7929	84411	663UW, 0.888μF ±1%	
C203	.0888μF ±1% 50 V	4862-2030	19396	PCD650, .0888μF ±1%	
C204	.0088μF ± 1% 50V	4862-1678	19396	PCR700, .00888μF ±1%	
C205	860pF ±1% 50 V	4862-1325	19396	PCR700, 860pF ±1%	
C206	0.371μF ±1% 100 V	4860-7927	84411	663UW, 0.371μF ±1%	
C207	.0371μF ±1% 50 V	4862-1890	19396	PCR700, .0371μF ±1%	
C208	.00371μF ±1% 50 V	4862-1546	19396	PCR700, .00371μF ±1%	
C209	350pF ±1% 50 V	4862-1202	19396	PCR700, 350pF ±1%	
C210	.001μF+80 -20% 500 V	4404-2109	72982	831, .001μF +80 -20%	
C211	1.0μF ±20% 25 V	4400-2070	80183	5C13, 1μF ±20%	
C212	1.0μF ±20% 25 V	4400-2070	80183	5C13, 1μF ±20%	
C213	0.400μF ±1% 100 V	4860-7928	84411	663UW, 0.400μF ±1%	
C214	.0400μF ±1% 50 V	4862-1908	19396	PCR700, .0400μF ±1%	
C215	.00400μF ±1% 50 V	4862-1559	19396	PCR700, .00400μF ±1%	
C216	430pF ±1% 50 V	4862-1225	19396	PCR700, 430pF ±1%	
C217	.001μF +80 -20% 500 V	4404-2109	72982	831, .001μF +80 -20%	
C218	2.00μF ±1% 100 V	4860-8297	84411	663UW, 2.00μF ±1%	
C219	0.200μF ± 1% 100 V	4860-7926	84411	663UW, 0.200μF ±1%	
C220	.0200μF ±1% 50 V	4862-1800			
C221	.0017μF ±1% 50 V	4862-1430	19396	PCR700, .00175μF ±1%	
C222	15pF ±10% 500 V	4700-0209	14655	22A5Q15KC	
C223	15pF ±10% 500 V	4700-0209	14655	22A5Q15KC	
C224	56pF ±10% 500 V	4404-0568	72982	831, 56pF ±10%	
C301	56pF ±10% 500 V	4404-0568	72982	831, 56pF ±10%	
C401	15pF ±10% 500 V	4700-0209	14655	22A5Q15KC	
C501	100μF +100 -10% 25V	4450-2300	76149	20-40595	5910-799-9284
C502	100μF +100 -10% 25 V	4450-2300	76149	20-40595	5910-799-9284
C503	.01μF +80 -20% 500 V	4401-3100	80131	CC61, .01μF +80 -20%	5910-974-5697

Ref. No.	Description	Part Number	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
CAPACITORS CONT:					
C504	.01μF +80 -20% 500 V	4401-3100	80131	CC61, .01μF +80 -20%	5910-974-5697
C505	33μF ±20% 10 V	4450-5400	56289	150D336X0010B1	5910-823-1623
C506	33μF ±20% 10 V	4450-5400	56289	150D336X0010B1	5910-823-1623
C507	68μF ±20% 15 V	4450-5615	80183	150D686X0015R2	
C508	68μF ±20% 15 V	4450-5615	80183	150D686X0015R2	
RESISTORS:					
R101A,B,C,D	39.7KΩ ±1%	0975-4320	24655	0975-4320	
R102	2.67KΩ± 1% 1/8 W	6250-1267	75042	CEA, 2.67KΩ ±1%	5905-683-5564
R103	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R104	33K Ω ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R105	2.67K Ω ±1% 1/8 W	6250-1267	75042	CEA, 2.67K Ω ±1%	5905-683-5564
R106	33K Ω ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R107	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R108	22 Ω ±5% 1/2 W	6100-0225	01121	RC20GF220J	5905-279-3519
R109	500 Ω ±20%	6040-0300	24655	6040-0300	
R110	2.21K Ω ±1% 1/8 W	6250-1221	75042	CEA, 2.21K Ω ±1%	5905-702-1147
R111	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R112	33K Ω ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R113	500 Ω ±20%	6040-0300	24655	6040-0300	
R114	2.43K Ω ±1% 1/8 W	6250-1243	75042	CEA, 2.43K Ω ±1%	5905-577-1685
R115	33K Ω ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R116	22 Ω ±5% 1/2 W	6100-0225	01121	RC20GF220J	5905-279 3519
R117	250 Ω ±20%	6040-0200	24655	6040-0200	
R118	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R119	10 Ω ±5% 1/2 W	6100-0105	01121	RC20GF100J	5905-190-8883
R120	11.0K Ω ±1% 1/8 W	6250-2110	75042	CEA, 11.0K Ω ±1%	
R121	88.7K Ω ±1% 1/8 W	6250-2887	75042	CEA, 88.7K Ω ±1%	
R201A,B,C,D	39.7K Ω ±1%	0975-4320	24655	0975-4320	
R204	50K ±20%	6040-0900	01121	FWC, 50K Ω ±20%	
R205	240 Ω ±5% 1/2 W	6100-1245	01121	RC20GF241J	5905-279-2593
R207	19.6K Ω ±1% 1/8 W	6250-2196	75042	CEA, 19.6K Ω ±1%	
R208	12K Ω ±5% 1/2 W	6100-3125	01121	RC20GF123J	5905-279-3502
R209	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R210	22 Ω ±5% 1/2 W	6100-0225	01121	RC20GF220J	5905-279-3519
R211	12K Ω ±5% 1/2 W	6100-3125	01121	RC20GF123J	5905-279-3502
R212	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R213	22 Ω ±5% 1/2 W	6100-0225	01121	RC20GF220J	5905-279-3519
R214	2.67K Ω ±1% 1/8 W	6250-1267	75042	CEA, 2.67K Ω ±1%	5905-683-5564
R215	12K Ω ±5% 1/2 W	6100-3125	01121	RC20GF123J	5905-279-3502
R216	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R217	2.67K Ω ±1% 1/8 W	6250-1267	75042	CEA, 2.67K Ω ±1%	5905-683-5564
R218	360 Ω ±5% 1/2 W	6100-1365	01121	RC20GF361J	5905-279-1889
R219	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R220	22 Ω ±5% 1/2 W	6100-0225	01121	RC20GF220J	5905-279-3519
R221	33K Ω ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R222	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R223	2.43K Ω ±1% 1/8 W	6250-1243	75042	CEA, 2.43K Ω ±1%	5905-577-1685
R224	500 Ω ±20%	6040-0300	24655	6040-0300	
R225	500 Ω ±20%	6040-0300	24655	6040-0300	
R226	2.43K Ω ±1% 1/8 W	6250-1243	75042	CEA, 2.43K Ω ±1%	5905-577-1685
R227	250 Ω ±20%	6040-0200	24655	6040-0200	
R228	12K Ω ±5% 1/2 W	6100-3125	01121	RC20GF123J	5905-279-3502
R229	360 Ω ±5% 1/2 W	6100-1365	01121	RC20GF361J	5905-279-1889
R230	22K ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004

Ref. No.	Description	Part Number	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
RESISTORS CONT:					
R231	22K ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R301	100K Ω ±10%	6046-4108	01121	RP, 100K Ω ±10%	
R302	240K Ω ±5% 1/2 W	6100-4245	01121	RC20GF244J	5905-279-2521
R303	39K Ω ±5% 1/2 W	6100-3395	01121	RC20GF393J	5905-279-3497
R304	500K Ω ±10%	6046-4508	01121	RP, 500K Ω ±10%	
R305	1M Ω ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R306	300K Ω ±5% 1/2 W	6100-4305	01121	RC20GF304J	5905-185-6859
R307	100K Ω ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R308	4.3K Ω ±5% 1/2 W	6100-2435	01121	RC20GF432J	5905-257-0935
R309	510 Ω ±5% 1/2 W	6100-1515	01121	RC20GF511J	5905-279-3511
R310	7.5K Ω ±5% 1/2 W	6100-2755	01121	RC20GF752J	5905-249-4195
R311	430 Ω ±5% 1/2 W	6100-1435	01121	RC20GF431J	5905-279-3512
R312	47 Ω ±5% 1/2 W	6100-0475	01121	RC20GF470J	5905-252-4018
R313	560Ω±5% 1/2 W	6100-1565	01121	RC20GF561J	5905-195-6800
R314	47 Ω ±5% 1/2 W	6100-0475	01121	RC20GF470J	5905-252-4018
R315	2.7K Ω ±5% 1/2 W	6100-2275	01121	RC20GF272J	5905-279-1880
R316	1.3K Ω ±5% 1/2 W	6100-2135	01121	RC20GF132J	5905-279-1870
R317	20.0K Ω ±1% 1/8 W	6250-2200	75042	CEA, 20.0K Ω ±1%	5905-702-5971
R318	20.0K Ω ±1% 1/8 W	6250-2200	75042	CEA, 20.0K Ω ±1%	5905-702-5971
R401	68K Ω ±5% 1/2 W	6100-3685	01121	RC20GF683J	5905-249-3661
R402	33K Ω ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R403	33K Ω ±5% 1/2 W	6100-3335	01121	RC20GF333J	5905-171-1998
R405	6.8K Ω ±5% 1/2 W	6100-2685	01121	RC20GF682J	5905-279-3503
R501	3K Ω ±5% 1/2 W	6100-2305	01121	RC20GF302J	5905-279-1751
R502	3K Ω ±5% 1/2 W	6100-2305	01121	RC20GF302J	5905-279-1751
R503	3.9K Ω ±5% 1/2 W	6100-2395	01121	RC20GF392J	5905-279-3505
R504	3.9K Ω ±5% 1/2 W	6100-2395	01121	RC20GF392J	5905-279-3505
R505	1.5K Ω ±5% 1/2 W	6100-2155	01121	RC20GF152J	5905-841-7461
R506	1.5K Ω ±5% 1/2 W	6100-2155	01121	RC20GF152J	5905-841-7461
R507	5.1K Ω ±5% 1/2 W	6100-2515	01121	RC20GF512J	5905-279-2019
R508	5.1K Ω ±5% 1/2 W	6100-2515	01121	RC20GF512J	5905-279-2019
R509	8.2K Ω ±5% 1/2 W	6100-2825	01121	RC20GF822J	5905-299-1971
R510	8.2K Ω ±5% 1/2 W	6100-2825	01121	RC20GF822J	5905-299-1971
R511	5K Ω ±20%	6040-0600	01121	FWC, 5K Ω ±20%	5905-967-4859
R512	5K Ω ±20%	6040-0600	01121	FWC, 5K Ω ±20%	5905-967-4859
R513	10 Ω ±5% 1/2 W	6100-0105	01121	RC20GF100J	5905-190-8883
R514	10 Ω ±5% 1/2 W	6100-0105	01121	RC20GF100J	5905-190-8883
TRANSISTORS:					
Q101	2N3906	8210-1112	93916	2N3906	
Q102	2N3414	8210-1047	24446	2N3414	5961-989-2749
Q103	2N3900	8210-1118	93916	2N3900	
Q104	2N3905	8210-1114	04713	2N3905	
Q105	2N3906	8210-1112	93916	2N3906	
Q106	2N3414	8210-1047	24446	2N3414	5961-989-2749
Q107	2N3900	8210-1118	93916	2N3900	
Q108	2N3905	8210-1114	04713	2N3905	
Q203	2N3900	8210-1118	93916	2N3900	
Q204	2N3905	8210-1114	04713	2N3905	
Q205	2N3900	8210-1118	93916	2N3900	
Q206	2N3905	8210-1114	04713	2N3905	
Q207	2N3900	8210-1118	93916	2N3900	
Q208	2N3905	8210-1114	04713	2N3905	
Q209	2N3900	8210-1118	93916	2N3900	
Q210	2N3905	8210-1114	04713	2N3905	

Ref. No.	Description	Part Number	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
TRANSISTORS CONT:					
Q211	2N3900	8210-1118	93916	2N3900	
Q212	2N3905	8210-1114	04713	2N3905	
Q301	2N3906	8210-1112	93916	2N3906	
Q302	2N3900	8210-1118	93916	2N3900	
Q303	2N3414	8210-1047	24446	2N3414	5961-989-2749
Q304	2N3905	8210-1114	04713	2N3905	
Q401	2N3900	8210-1118	93916	2N3906	
Q402	2N3905	8210-1114	04713	2N3905	
Q501	2N3414	8210-1047	24446	2N3414	5961-989-2749
Q502	2N3905	8210-1114	04713	2N3905	
Q503	2N3414	8210-1047	24446	2N3414	5961-989-2749
Q504	2N3905	8210-1114	04713	2N3905	
Q505	2N3414	8210-1047	24446	2N3414	5961-989-2749
Q506	2N3905	8210-1114	04713	2N3905	
DIODES:					
CR301	1N3604	6082-1001	24446	1N3604	5960-995-2199
CR501	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR502	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR503	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR504	1N3253	6081-1001	79089	1N3253	5961-814-4251
CR505	1N759A	6083-1014	81349	1N759A	5961-846-9157
CR506	1N759A	6083-1014	81349	1N759A	5961-846-9157
CR507	1N750A	6083-1028	07910	1N750A	5960-754-5897
CR508	1N750A	6083-1028	07910	1N750A	5960-754-5897
CR509	1N4009	6082-1012	24446	1N4009	
CR510	1N4009	6082-1012	24446	1N4009	
CR511	1N4009	6082-1012	24446	1N4009	
CR512	1N4009	6082-1012			
INDUCTORS:					
L201	5.6μH$\pm$10%	4300-1800	99800	1537-30, 5.6μH$\pm$10%	
L202	5.6μH$\pm$10%	4300-1800	99800	1537-30, 5.6 μH$\pm$10%	
L401	8200μH$\pm$10%	4300-6391	72259	WEE-DUCTOR, 8200μH	
FUSES:					
F501	115 V .062 AMP	5330-0300	71400	MDL, .062 AMP.	
F502	230 V.031 AMP	5330-0200	71400	MDL, .031 AMP.	5920-972-9496
SWITCHES:					
S101		7890-4450	76854	TYPE H	
S102		7910-0790	95146	MST-105D	
S103		7910-0791	95146	MST-205N	
S201		7890-4470	76854	TYPE H	
S301		7890-4440	76854	TYPE F	
S501		Part of 7890-4440			
S502		7910-0831	42190	4603	
S503		7910-0831	42190	4603	
TRANSFORMER:					
T501		0746-4480	24655	0746-4480	
PLUG:					
PL501		5600-0300	24454	#328	6240-155-7857

Ref.	Description	Part Number	Fed. Mfg. Code	Mfg. Part No.	Fed. Stock No.
JACKS:					
J101		0938-3000	24655	0938-3000	
J102		0938-3000	24655	0938-3000	
J103		0938-3000	24655	0938-3000	
J104		4260-1500	82389	2J-1503	5935-636-5923
J301		0938-3000	24655	0938-3000	
J302		0938-3000	24655	0938-3000	
J303		4260-1500	82389	2J-1503	5935-636-5923
J501		4260-1010	93916	SKT-8	
J502		4260-1010	93916	SKT-8	
J503		4260-1010	93916	SKT-8	
PILOT LIGHT					
P501		5600-1001	24655	5600-1001	6240-933-5816
MECHANICAL PARTS					
	L.P. DIAL ASM	1952-1011	24655	1952-1011	
	H.P. DIAL ASM	1952-1014	24655	1952-1014	
	BATTERY TUBE	1952-7030	24655	1952-7030	
	POWER CORD	4200-9622	24655	4200-9622	
	HANDLE LOOP	5360-2007	24655	5360-2007	
	INDICATOR	5470-0650	24655	5470-0650	6625-738-6353
	KNOB ASM, STOP ACTION	5500-5321	24655	5500-5321	
	KNOB ASM, CONTINUOUS	5520-5420	24655	5520-5420	
	LAMP HOLDER	5600-1023	24655	5600-1023	
	DRIVE BELT	4025-2045	24655	4025-2045	
ETCHED BOARD ASSEMBLIES					
	LOW-PASS FILTER	1952-2710	24655	1952-2710	
	HIGH-PASS FILTER	1952-2720	24655	1952-2720	
	OUTPUT AMPLIFIER	1952-2730	24655	1952-2730	
	INPUT AMPLIFIER	1952-2740	24655	1952-2740	
	POWER SUPPLY	1952-2750	24655	1952-2750	

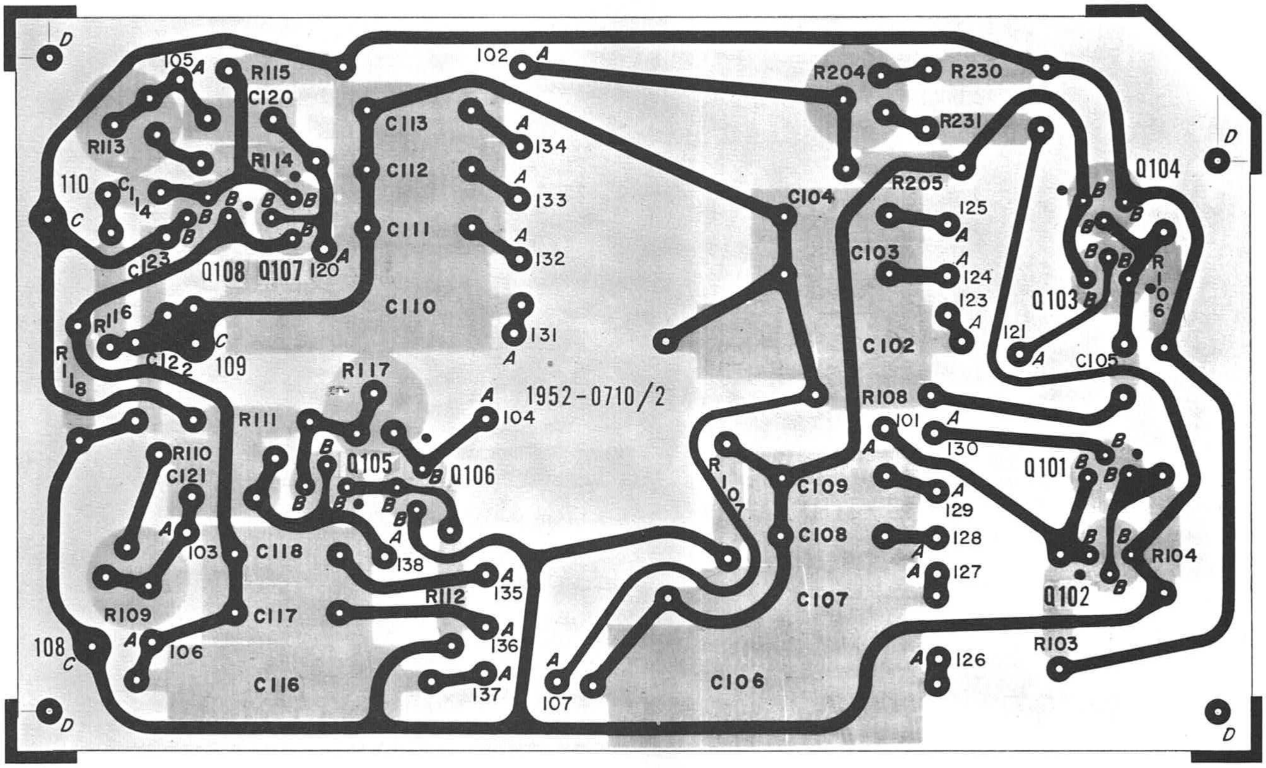


Figure 6-9. Etched Circuit Board Assembly, Low-Pass Filter (P/N 1952-2710).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

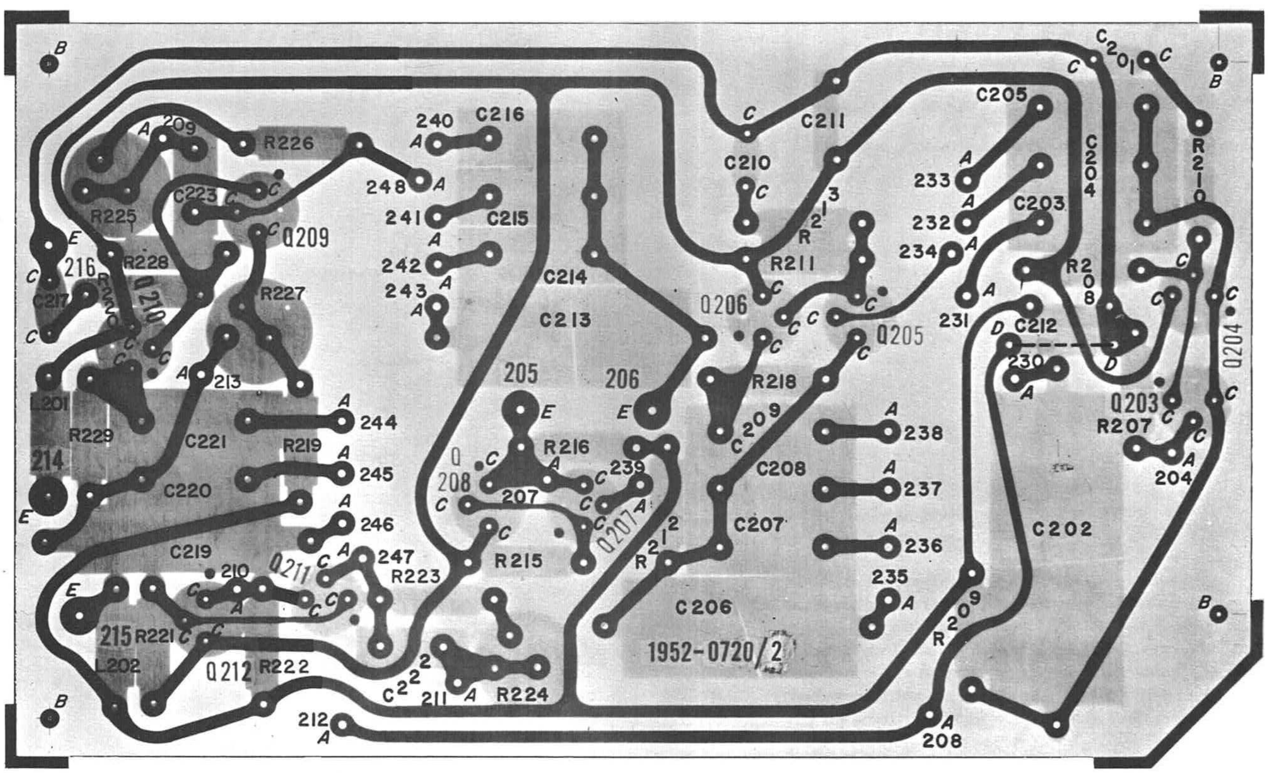


Figure 6-10. Etched Circuit Board Assembly, High-Pass Filter (P/N 1952-2720).

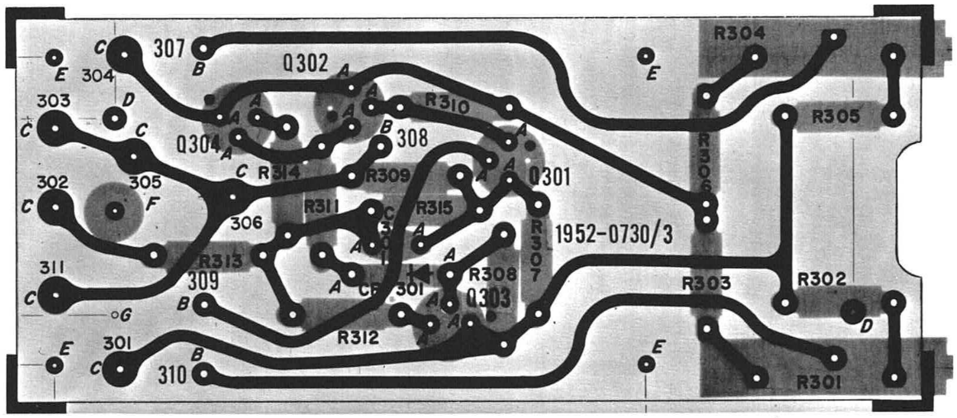


Figure 6-11. Etched Circuit Board Assembly, Output Amplifier (P/N 1952-2730).

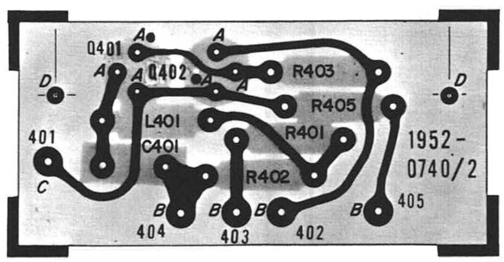


Figure 6-12. Etched Circuit Board Assembly, Input Amplifier (P/N 1952-2740).

NOTE

The number shown on the foil side of the board is not the part number for the complete assembly. This assembly number is given in the caption.

The dot on the foil at the transistor socket indicates the collector lead.

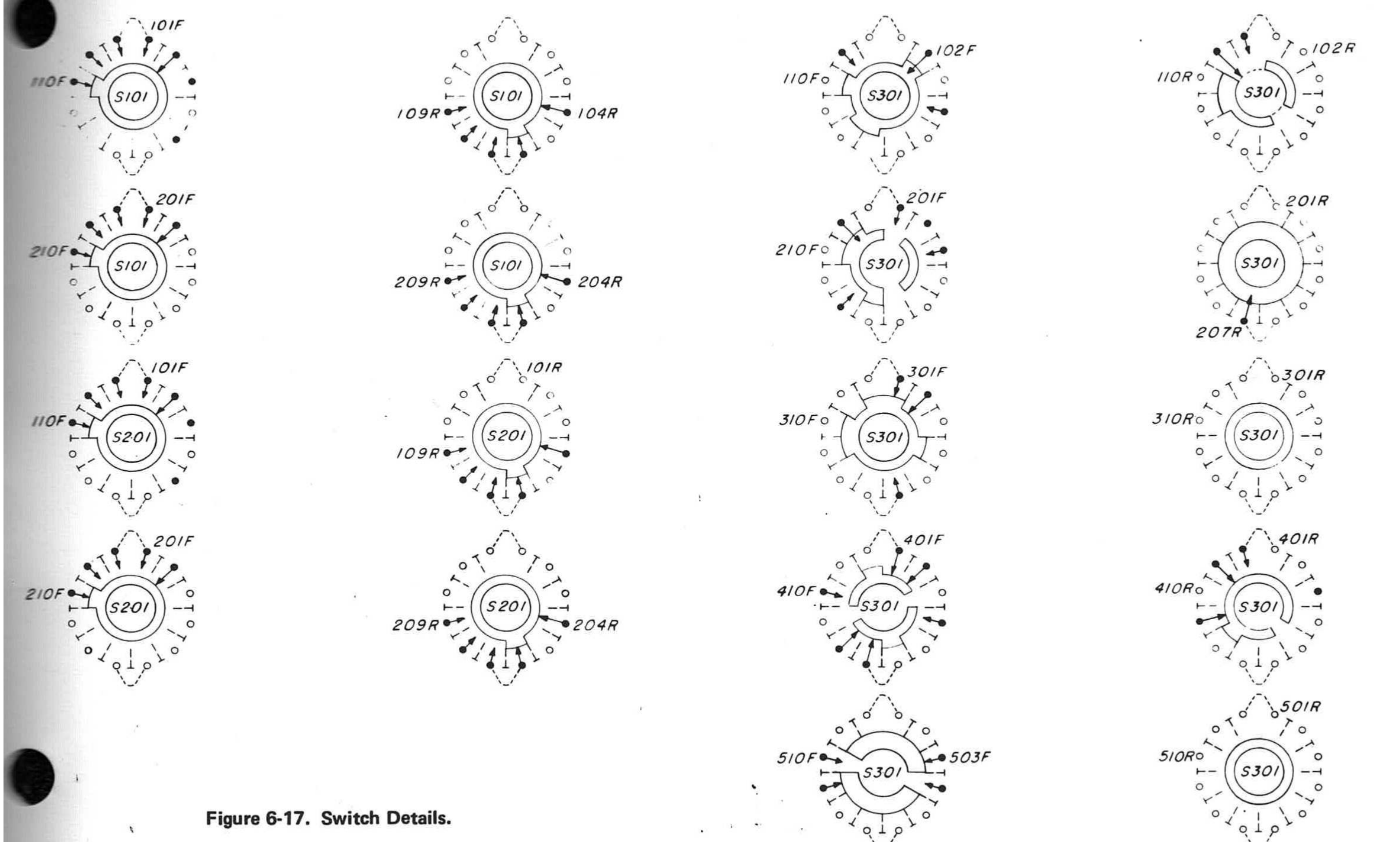


Figure 6-17. Switch Details.

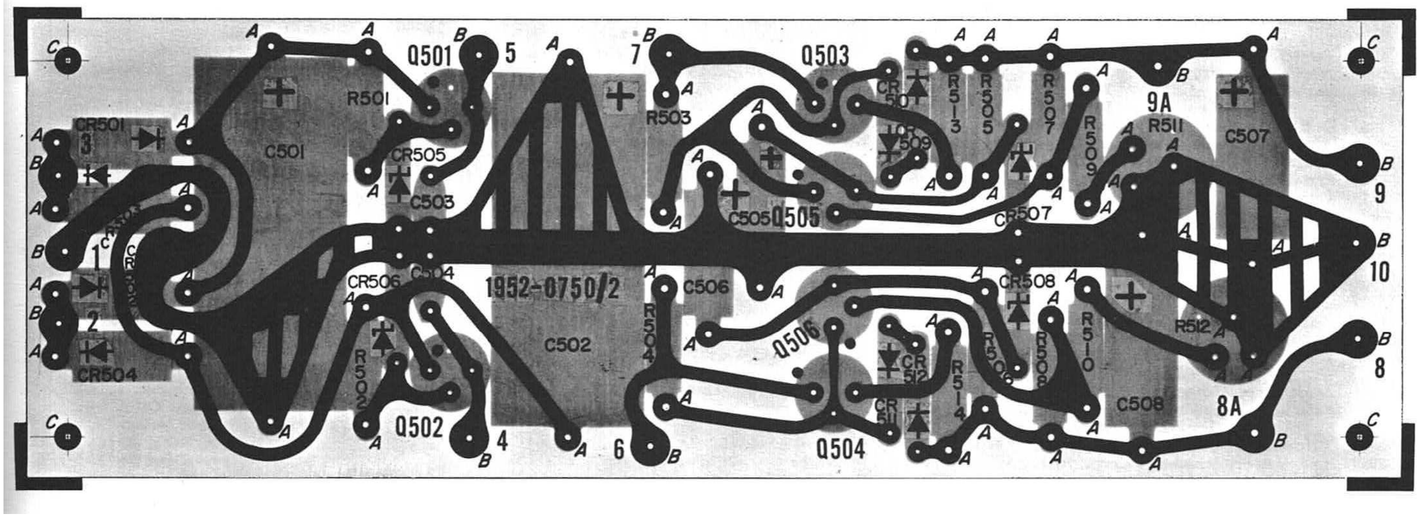


Figure 6-13. Etched Circuit Board Assembly, Power Supply (P/N 1952-2750).

NOTE: The number appearing on the foil side is not the part number. The dot on the foil at the transistor socket indicates the collector lead.

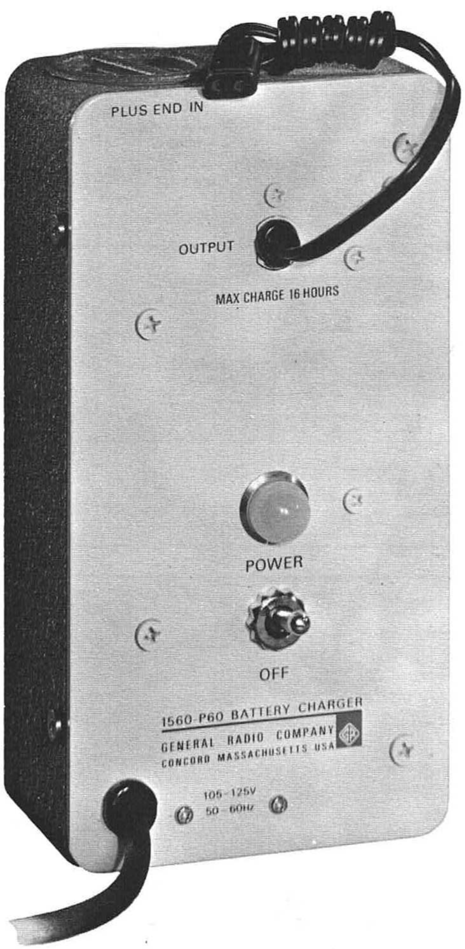
FEDERAL MANUFACTURERS CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) as supplemented through June, 1967.

Code	Manufacturers Name and Address
00192	Jones Mfg. Co., Chicago, Illinois
00194	Walsco Electronics Corp., Los Angeles, Calif.
00656	Aerovox Corp., New Bedford, Mass.
01009	Alden Products Co., Brockton, Mass.
01121	Allen-Bradley, Co., Milwaukee, Wisc.
01295	Texas Instruments, Inc., Dallas, Texas
02114	Ferroxcube Corp. of America, Saugerties, N. Y. 12477
02606	Fenwal Lab. Inc., Morton Grove, Ill.
02660	Amphenol Electronics Corp., Broadview, Ill.
02768	Fastex Division of Ill. Tool Works, Des Plaines, Ill. 60016
03508	G. E. Semiconductor Products Dept., Syracuse, N. Y. 13201
03636	Grayburne, Yonkers, N. Y. 10701
03888	Pyrofilm Resistor Co., Cedar Knolls, N. J.
03911	Clairex Corp., New York, N. Y. 10001
04009	Arrow, Hart and Hegeman Electric Co., Hartford, Conn. 06106
04713	Motorola Semi-Conduct Product, Phoenix, Ariz. 85008
05170	Engineered Electronics Co., Inc., Santa Ana, Calif. 92702
05624	Barber-Colman Co., Rockford, Ill. 61101
05820	Wakefield Eng., Inc., Wakefield, Mass. 01880
07127	Eagle Signal Div. of E. W. Bliss Co., Baraboo, Wisc.
07261	Avnet Corp., Culver City, Calif. 90230
07263	Fairchild Camera and Instrument Corp., Mountain View, Calif.
07387	Birtcher Corp., No. Los Angeles, Calif.
07595	American Semiconductor Corp., Arlington Heights, Ill. 60004
07828	Bodine Corp., Bridgeport, Conn. 06605
07829	Bodine Electric Co., Chicago, Ill. 60618
07910	Continental Device Corp., Hawthorne, Calif.
07983	State Labs Inc., N. Y., N. Y. 10003
07999	Amphenol Corp., Borg Inst. Div., Delavan, Wisc. 53115
08730	Vemaline Prod. Co., Franklin Lakes, N. J.
09213	General Electric Semiconductor, Buffalo, N. Y.
09408	Star-Tronics Inc., Georgetown, Mass. 01830
09823	Burgess Battery Co., Freeport, Ill.
09922	Burndy Corp., Norwalk, Conn. 06852
11236	C.P.S. of Berne, Inc., Berne, Ind. 46711
11599	Chandler Evans Corp., W. Hartford, Conn.
12498	Teledyn Inc., Crystalonics Div., Cambridge, Mass. 02140
12672	RCA Commercial Receiving Tube and Semiconductor Div., Woodridge, N.J.
12697	Clarostat Mfg. Co. Inc., Dover, N. H. 03820
12954	Dickson Electronics Corp., Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N. Y. 10983
14433	ITT Semiconductors, W. Palm Beach, Florida
14655	Cornell Dubilier Electric Co., Newark N. J.
14674	Corning Glass Works, Corning, N. Y.
14936	General Instrument Corp., Hicksville, N. Y.
15238	ITT, Semiconductor Div. of Int. T. and T, Lawrence, Mass.
15605	Cutler-Hammer Inc., Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co., Spruce Pine, N. C.
19644	LRC Electronics, Horseheads, New York
19701	Electra Mfg. Co., Independence, Kansas 67301
21335	Fafnir Bearing Co., New Briton, Conn.
24446	G. E. Schenectady, N. Y. 12305
24454	G. E., Electronic Comp., Syracuse, N. Y.
24455	G. E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co., W. Concord, Mass 01781
26806	American Zettler Inc., Costa Mesa, Calif.
28520	Hayman Mfg. Co., Kenilworth, N. J.
28959	Hoffman Electronics Corp., El Monte, Calif.
30874	International Business Machines, Armonk, N.Y.
32001	Jensen Mfg. Co., Chicago, Ill. 60638
35929	Constanta Co. of Canada Limited, Montreal 19, Quebec
37942	P. R. Mallory and Co. Inc., Indianapolis, Ind.
38443	Marlin-Rockwell Corp., Jamestown, N. Y.
40931	Honeywell Inc., Minneapolis, Minn. 55408
42190	Muter Co., Chicago, Ill. 60638
42498	National Co. Inc., Melrose, Mass. 02176
43991	Norma-Hoffman Bearings Corp., Stanford, Conn. 06904
49671	RCA, New York, N. Y.
49956	Raytheon Mfg. Co., Waltham, Mass. 02154
53021	Sangamo Electric Co., Springfield, Ill. 62705
54294	Shallcross Mfg. Co., Selma, N. C.
54715	Shure Brothers, Inc., Evanston, Ill.
56289	Sprague Electric Co., N. Adams, Mass.
59730	Thomas and Betts Co., Elizabeth, N. J. 07207
59875	TRW Inc. (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg. Co., Torrington, Conn.
61637	Union Carbide Corp., New York, N. Y. 10017
61864	United-Carr Fastener Corp., Boston, Mass.
63060	Victoreen Instrument Co., Inc., Cleveland, Ohio
63743	Ward Leonard Electric Co., Mt. Vernon, N. Y.
65083	Westinghouse (Lamp Div), Bloomfield, N. J.
65092	Weston Instruments, Weston-Newark, Newark, N. J.
70485	Atlantic-India Rubber Works, Inc., Chicago, Ill. 60607
70563	Amperite Co., Union City, N. J. 07087
70903	Belden Mfg. Co., Chicago, Ill. 60644
71126	Bronson, Homer D., Co., Beacon Falls, Conn.
71294	Canfield, H. O. Co., Clifton Forge, Va. 24422
71400	Bussman Mfg. Div. of McGraw Edison Co., St. Louis, Mo.
71590	Centralab, Inc., Milwaukee, Wisc. 53212
71666	Continental Carbon Co., Inc., New York, N. Y.
71707	Coto Coil Co. Inc., Providence, R. I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg. Co. and Howard B. Jones Div., Chicago, Ill. 60624
71823	Darnell Corp., Ltd., Downey, Calif. 90241
72136	Electro Motive Mfg. Co., Willmington, Conn.
72259	Nytronics Inc., Berkeley Heights, N. J. 07922
72619	Dialight Co., Brooklyn, N. Y. 11237
72699	General Instrument Corp., Capacitor Div., Newark, N. J. 07104
72765	Drake Mfg. Co., Chicago, Ill. 60656
72825	Hugh H. Eby, Inc., Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp., Union, N. J. 07083
72982	Erie Technological Products Inc., Erie, Penn.
73138	Beckman, Inc., Fullerton, Calif. 92634
73445	Amperex Electronics Co., Hicksville, N. Y.
73559	Carling Electric Co., W. Hartford, Conn.
73690	Elco Resistor Co., New York, N. Y.
73899	J. F. D. Electronics Corp., Brooklyn, N. Y.
74193	Heinemann Electric Co., Trenton, N. J.
74861	Industrial Condenser Corp., Chicago, Ill.
74970	E. F. Johnson Co., Waseca, Minn. 56093
75042	IRC Inc., Philadelphia, Penn. 19108
75382	Kulka Electric Corp., Mt. Vernon, N. Y.
75491	Lafayette Industrial Electronics, Jamaica, N.Y.
75608	Linden and Co., Providence, R. I.
75915	Littelfuse, Inc., Des Plaines, Ill. 60016
76005	Lord Mfg. Co., Erie, Penn. 16512
76149	Malloy Electric Corp., Detroit, Mich. 48204
76487	James Millen Mfg. Co., Malden, Mass. 02148
76545	Mueller Electric Co., Cleveland, Ohio 44114
76684	National Tube Co., Pittsburg, Penn.
76854	Oak Mfg. Co., Crystal Lake, Ill.
77147	Patton MacGuyer Co., Providence, R. I.
77166	Pass-Seymour, Syracuse, N. Y.
77263	Pierce Roberts Rubber Co., Trenton, N. J.
77339	Positive Lockwasher Co., Newark, N. J.
77542	Ray-O-Vac Co., Madison, Wisc.
77630	TRW, Electronic Component Div., Camden, N. J. 08103
77638	General Instruments Corp., Brooklyn, N. Y.
78189	Shakeproof Div. of Ill. Tool Works, Elgin, Ill. 60120
78277	Sigma Instruments Inc., S. Braintree, Mass.
78488	Stackpole Carbon Co., St. Marys, Penn.
78553	Tinnerman Products, Inc., Cleveland, Ohio
79089	RCA, Commercial Receiving Tube and Semiconductor Div., Harrison, N. J.
79725	Wiremold Co., Hartford, Conn. 06110
79963	Zierick Mfg. Co., New Rochelle, N. Y.
80030	Prestole Fastener Div. Bishop and Babcock Corp., Toledo, Ohio
80048	Vickers Inc. Electric Prod. Div., St. Louis, Mo.
80131	Electronic Industries Assoc., Washington, D.C.
80183	Sprague Products Co., N. Adams, Mass.
80211	Motorola Inc., Franklin Park, Ill. 60131
80258	Standard Oil Co., Lafeyette, Ind.
80294	Bourns Inc., Riverside, Calif. 92506
83033	Meissner Mfg., Div. of Maguire Industries, Inc. Mount Carmel, Illinois
80431	Air Filter Corp., Milwaukee, Wisc. 53218
80583	Hammarlund Co. Inc., New York, N. Y.
80740	Beckman Instruments, Inc., Fullerton, Calif.
81073	Grayhill Inc., LaGrange, Ill. 60525
81143	Isolantite Mfg. Corp., Stirling, N. J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp., Yonkers, N. Y.
81831	Filton Co., Flushing, L. I., N. Y
81860	Barry Controls Div. of Barry Wright Corp., Watertown, Mass.
82219	Sylvania Electric Products, Inc., (Electronic Tube Div.), Emporium, Penn.
82273	Indiana Pattern and Model Works, LaPort, Ind.
82389	Switchcraft Inc., Chicago, Ill. 60630
82647	Metals and Controls Inc., Attleboro, Mass.
82807	Milwaukee Resistor Co., Milwaukee, Wisc.
83058	Carr Fastener Co., Cambridge, Mass.
83186	Victory Engineering Corp (IVECO), Springfield, N. J. 07081
83361	Bearing Specialty Co., San Francisco, Calif.
83587	Solar Electric Corp., Warren, Penn.
83740	Union Carbide Corp., New York, N. Y. 10017
84411	TRW Capacitor Div., Ogallala, Nebr.
84835	Lehigh Metal Products Corp., Cambridge, Mass. 02140
84971	TA Mfg. Corp., Los Angeles, Calif.
86577	Precision Metal Products of Malden Inc., Stoneham, Mass. 02180
86684	RCA (Electrical Component and Devices) Harrison. N. J.
86800	Continental Electronics Corp. Brooklyn, N.Y. 11222
88140	Cutler-Hammer Inc., Lincoln, Ill.
88219	Gould Nat. Batteries Inc., Trenton, N. J.
88419	Cornell Dubilier Electric Corp., Fuquay-Varina, N. C.
88627	K and G Mfg. Co., New York, N. Y.
89482	Holtzer Cabot Corp., Boston, Mass.
89665	United Transformer Co., Chicago, Ill.
90201	Mallory Capacitor Co., Indianapolis, Ind.
90750	Westinghouse Electric Corp., Boston, Mass.
90952	Hardware Products Co., Reading, Penn. 19602
91032	Continental Wire Corp., York, Penn. 17405
91146	ITT Cannon Electric Inc., Salem, Mass.
91293	Johanson Mfg. Co., Boonton, N. J. 07005
91598	Chandler Co., Wethersfield, Conn. 06109
91637	Dale Electronics Inc., Columbus, Nebr.
91662	Elco Corp., Willow Grove, Penn.
91719	General Instruments, Inc., Dallas, Texas
91929	Honeywell Inc., Freeport, Ill.
92519	Electra Insulation Corp., Woodside, Long Island, N. Y.
92678	Edgerton, Germeshausen and Grier, Boston, Mass.
93332	Sylvania Electric Products, Inc., Woburn, Mass.
93916	Cramer Products Co., New York, N. Y. 10013
94144	Raytheon Co. Components Div., Quincy, Mass.
94154	Tung Sol Electric Inc., Newark, N. J.
95076	Garde Mfg. Co., Cumberland, R. I.
95146	Alco Electronics Mfg. Co., Lawrence, Mass.
95238	Continental Connector Corp., Woodside, N. Y.
95275	Vitramon, Inc., Bridgeport, Conn.
95354	Methode Mfg. Co., Chicago, Ill.
95412	General Electric Co., Schenectady, N. Y.
95794	Ansconda American Brass Co., Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp., Orlean, N. Y.
96214	Texas Instruments Inc., Dallas, Texas 75209
96256	Thordarson-Meissner Div. of McGuire, Mt. Carmel, Ill.
96341	Microwave Associates Inc., Burlington, Mass.
96791	Amphenoe Corp. Jonesville, Wisc. 53545
96906	Military Standards
97966	CBS Electronics Div. of Columbia Broadcasting Systems, Danvers, Mass.
98291	Sealectro Corp., Mamaroneck. N. Y. 10544
98821	North Hills Electronics Inc., Glen Cove, N. Y.
99180	Transitron Electronics Corp., Melrose, Mass.
99378	Atlee Corp., Winchester, Mass. 01890
99800	Delevan Electronics Corp., E. Aurora, N. Y.

Appendix

Type 1560-P60 BATTERY CHARGER

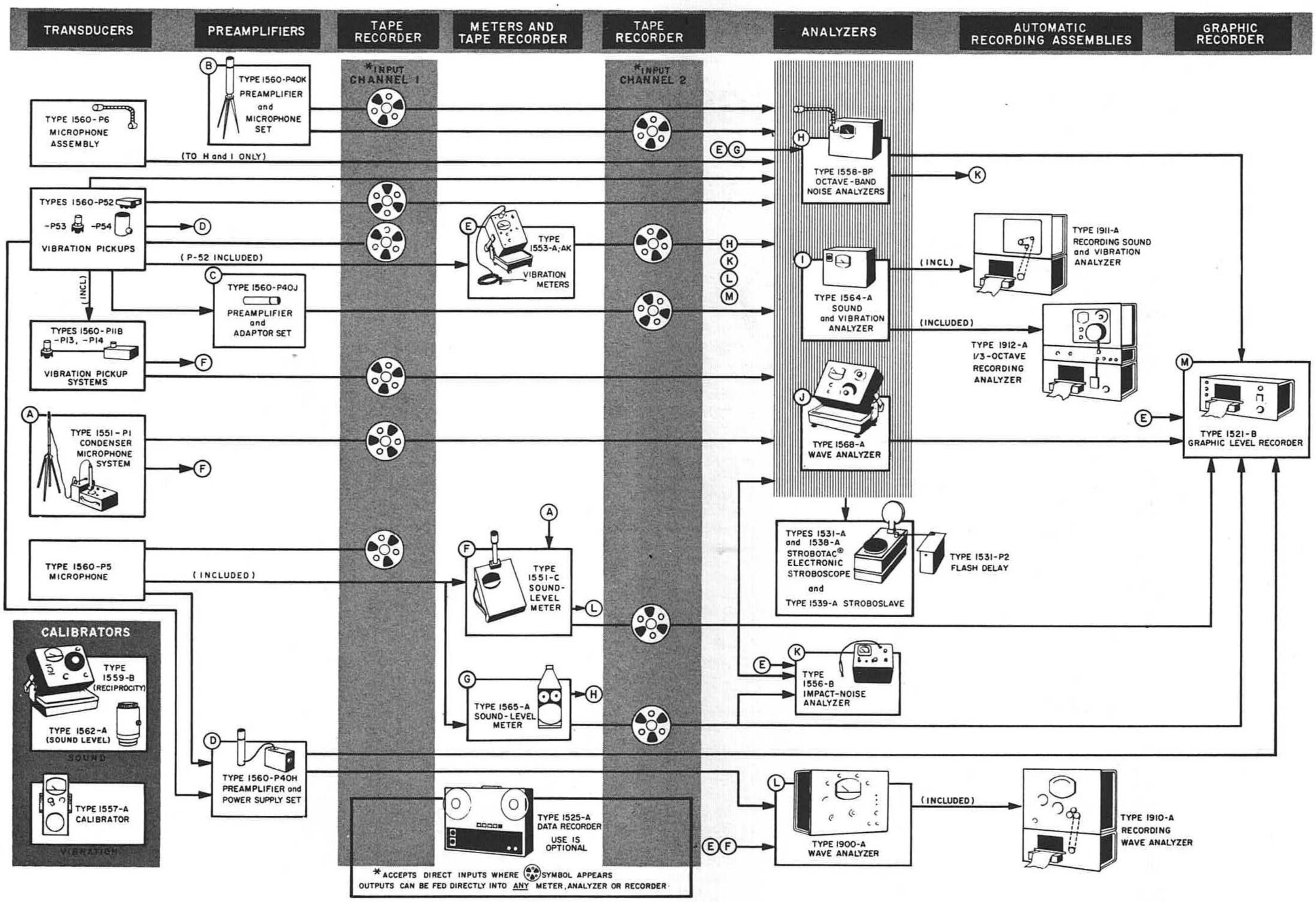


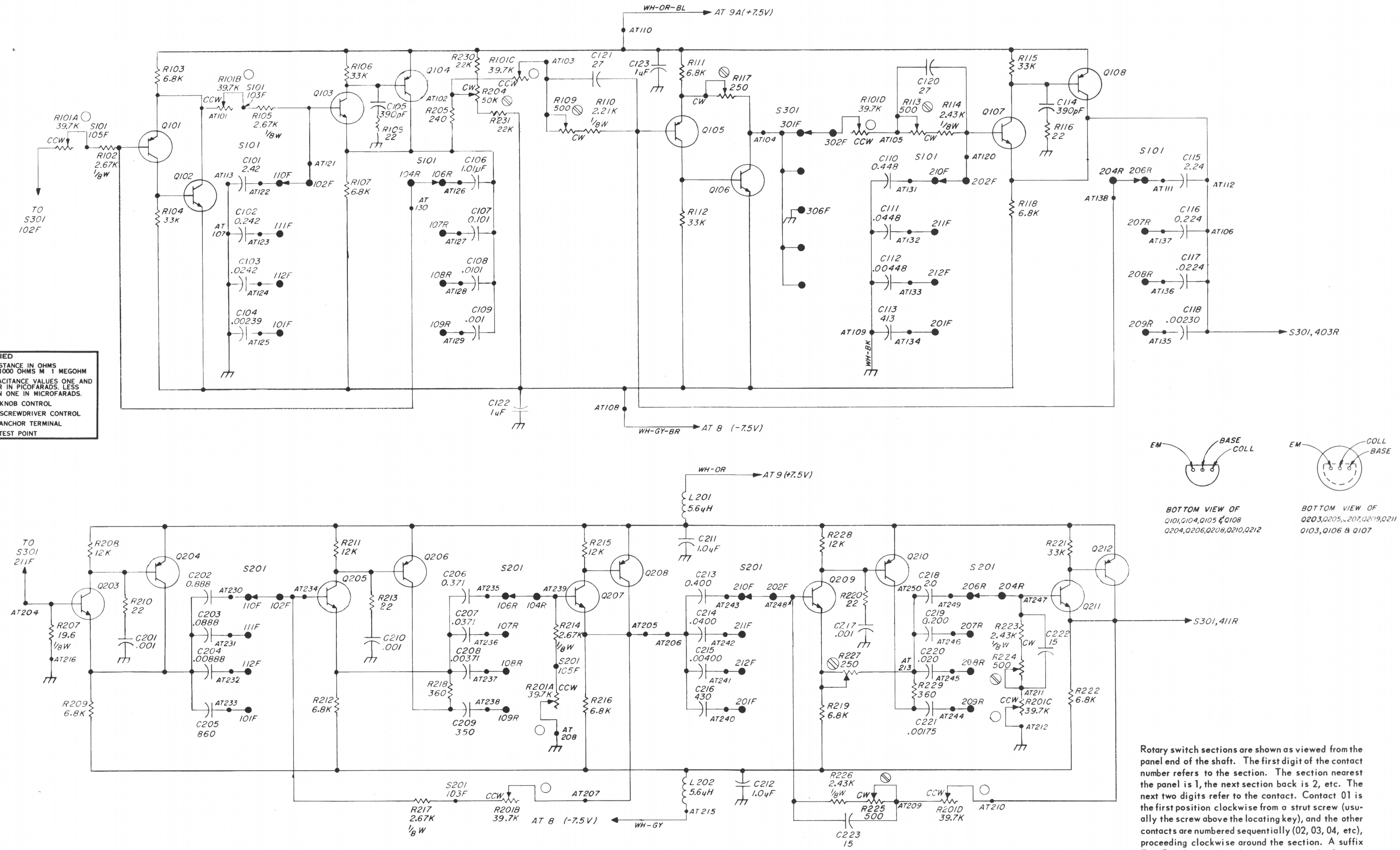
SPECIFICATIONS

Batteries Charged: One or two sets, each set consisting of two series-connected nickel-cadimum batteries. Each battery is designated as the GR 8410-1040; two constitute a set.
Battery Rating: 19.2 V nominal, total with two batteries in series; capacity 225 milliampere-hours.
Charging Time: 14 to 26 h to recharge batteries that have been discharged to 17.6 V (series voltage) under load.
Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 5 W max.
Dimensions (width x height x depth): 4 3/16 x 8 x 3 11/16 in. (110 x 205 x 94 mm).
Weight: Net, 3 lb (1.4 kg); shipping, 9 lb (4.2 kg).

Catalog Number	*Description*
	1560-P60 Battery Charger
1560-9660	115 volts
1560-9661	230 volts
8410-1040	Rechargeable Battery (2 per set)

THE GENERAL RADIO SOUND- AND VIBRATION-MEASURING LINE.





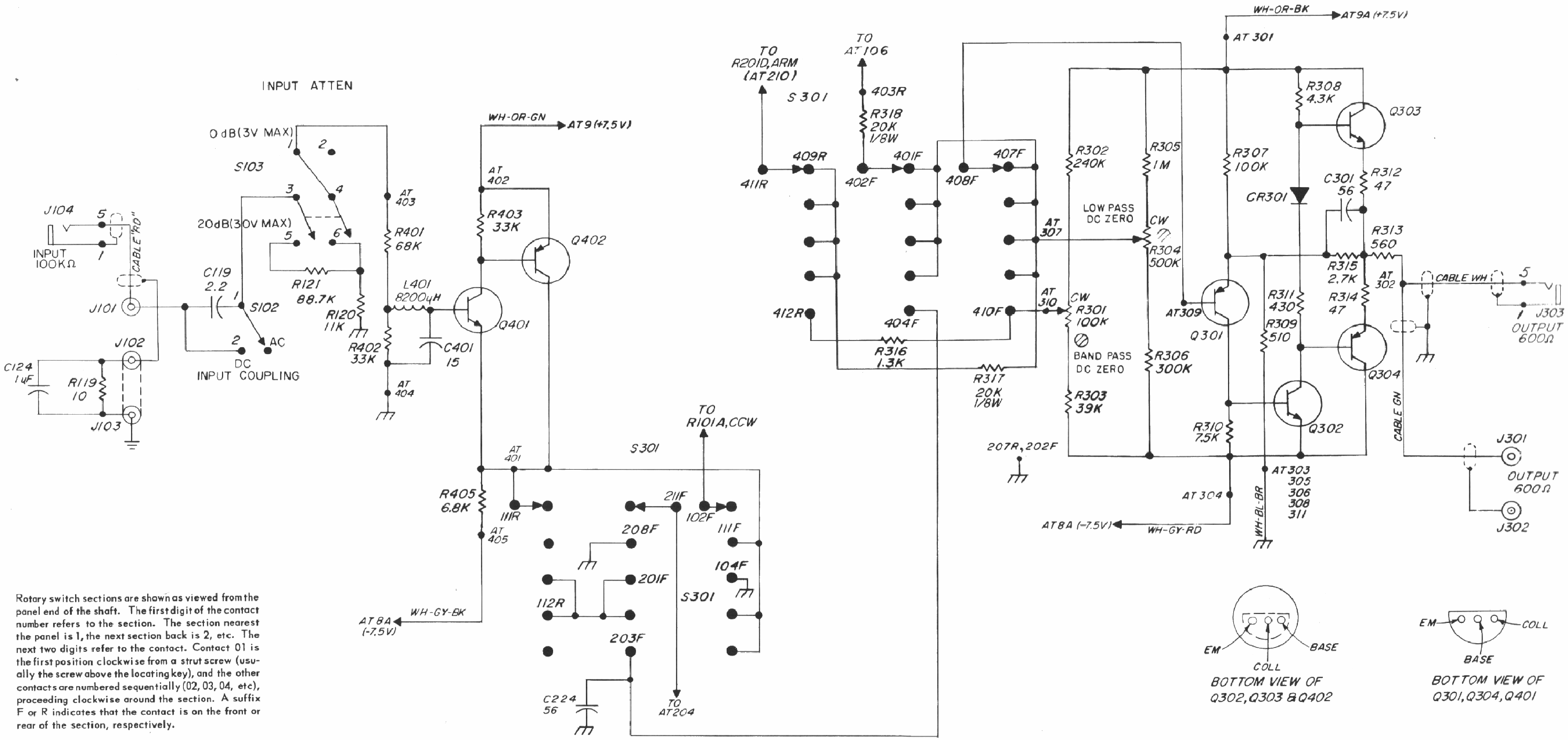
NOTE UNLESS SPECIFIED

...RY SWITCHES ...LOCKWISE.
...NG OF SWITCHES ...PARATE SHEET ...RUCTION BOOK.
... NOTES IN INSTRUC- ... VOLTAGES ...AGRAM.
...TT.

5. RESISTANCE IN OHMS K = 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ○ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT = ANCHOR TERMINAL
10. TP = TEST POINT

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

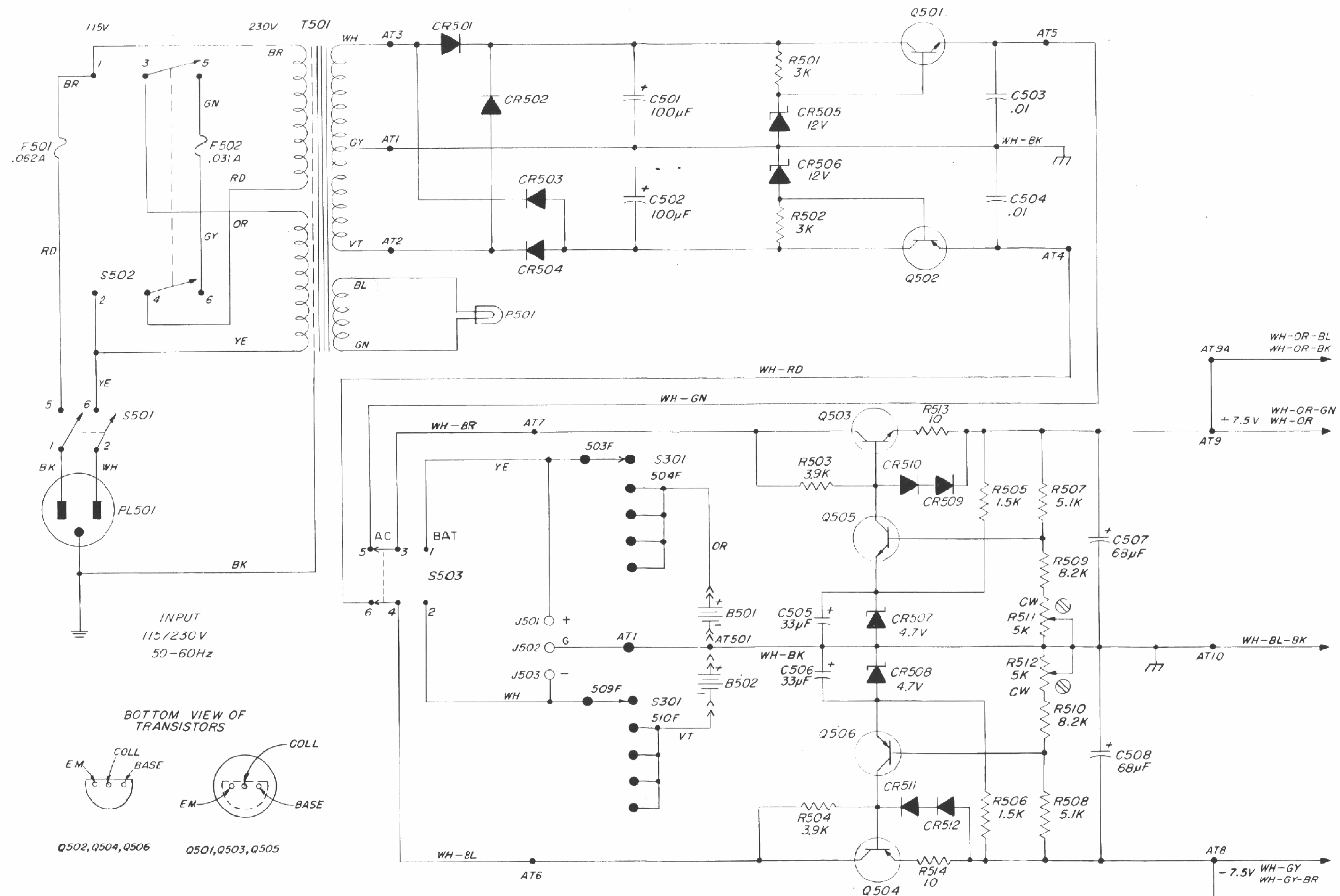
Figure 6-14. Schematic Diagrams, Low- and High-Pass Filter.



Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED	
1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE	5 RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
2 CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK	6 CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
3 REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM	7 ○ KNOB CONTROL
	8 ⊘ SCREWDRIVER CONTROL
	9 AT ANCHOR TERMINAL
4 RESISTORS 1/2 WATT	10 TP TEST POINT

Figure 6-16. Schematic Diagrams, Input and Output Amplifiers.



NOTE: BATTERIES ARE OPTIONAL

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ◯ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

Figure 6-15. Schematic Diagrams, Power Supply.