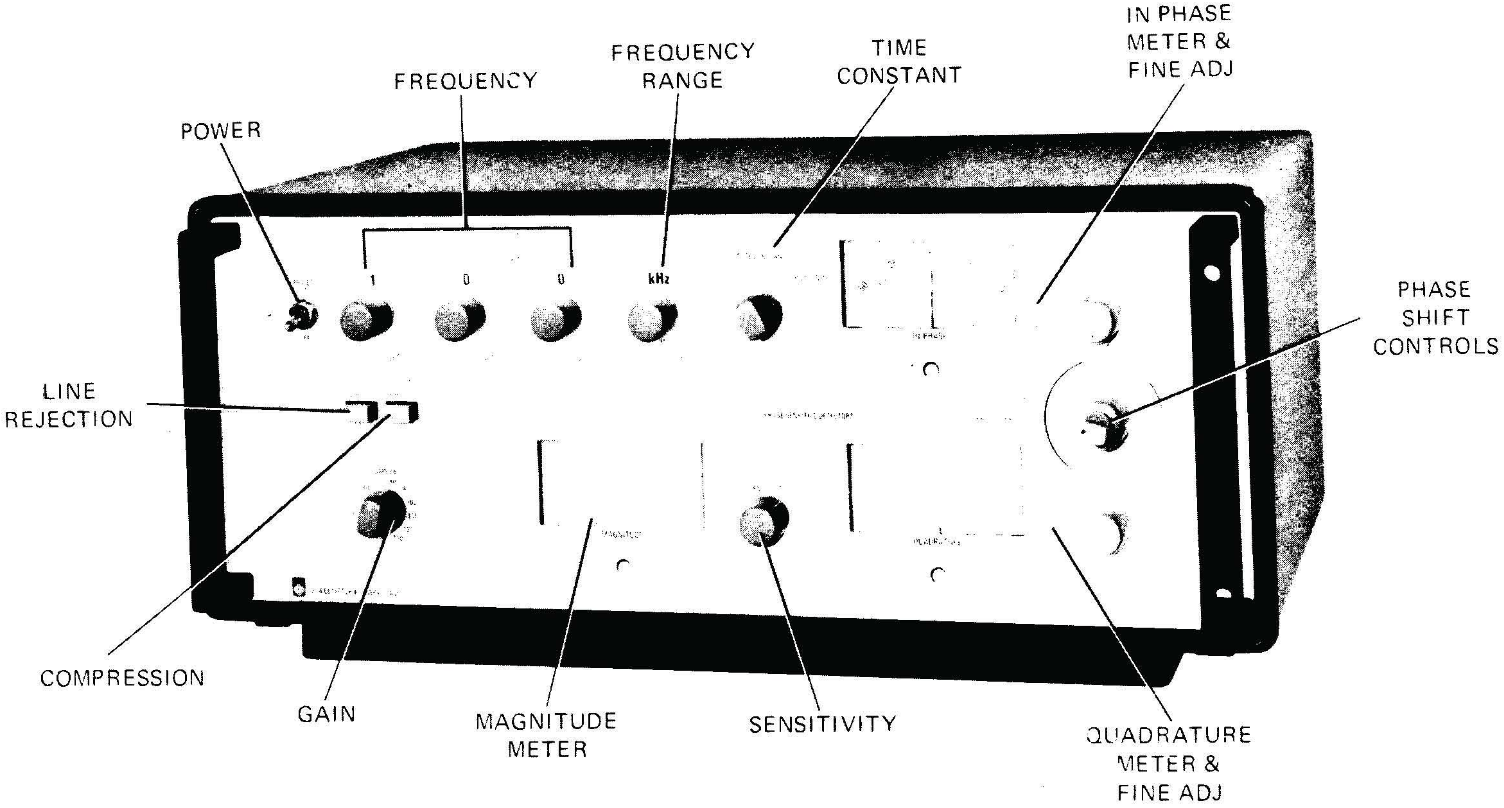
Contents

Type 1238 Detector

Concord, Massachusetts, U.S.A. 01742
November. 1983



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Condensed Operating Instructions

POWER.

a. Set the line-voltage switch (rear panel) to correspond with the available power (100-125 or 200-250 V).

b. If power-line frequency is 50 Hz, but the instrument was sold (or previously readjusted) for 60 Hz, ***or the converse***, make the jumper change and readjustment described in para. 5.5.

UNTUNED MAGNITUDE DETECTOR.

a. Provide the signal to be detected via shielded cable to rear-panel BNC connector INPUT SIGNAL. Normal levels: 2 μV to 1 V; limit: 200 V rms max.

b. Set controls as follows:

FREQUENCY – any
FREQUENCY range – FLAT
TIME CONSTANT – 1 s
FINE ADJUST – midrange
PHASE SHIFT – 0°
SENSITIVITY – minimum (ccw)
GAIN – 20 dB (ccw)
COMPRESSION – push button out
LINE REJECTION – push button out
POWER – ON.

c. Turn the GAIN control for MAGNITUDE meter reading between 20 and 100 – relative voltage level (not volts). For comparisons requiring GAIN-control change, note: 2 steps are a factor of 10 (1 step, factor of 3.16).

d. Take the amplified signal from rear-panel BNC connector AMPLIFIER OUTPUT to a scope, recorder, or other instrument if you wish to.

e. Set COMPRESSION push button in, if you want a quasi logarithmic function, making the 5-100 span of the meter response a factor of 100 in voltage (instead of 20).

f. Set LINE REJECTION push button in, if you want attenuation of the input-signal component at power-line frequency (by a factor of 100).

TUNED MAGNITUDE DETECTOR.

a. Set the controls as above, except:

FREQUENCY – frequency of desired signal
FREQUENCY range – decimal point and units.

b. Adjust source frequency or Detector FREQUENCY controls carefully for maximum response (best tuning).

c. Use the instrument as above, except that signal components and noise outside the 3% bandwidth are rejected. Tuned gain is 25 dB (factor of 18) greater than the FLAT gain. Normal input-signal levels: 1 μV to 400 mV.

DUAL-PHASE-SENSITIVE DETECTOR

a. Connect 2-phase reference signal from oscillator (GR 1316 recommended) to rear-panel BNC jacks REFERENCE INPUTS. Reference must be coherent with input signal; QUADRATURE leading, 90° ahead of IN PHASE.

b. Set the controls as above, except: *

- PHASE-SHIFT – set to make QUADRATURE meter zero and IN PHASE meter deflect to the right when input-signal phase is any initial angle ϕ.
- FINE ADJ (QUADRATURE) – fine control of above.
- FINE ADJ (IN PHASE) – set to make INPHASE meter zero when input signal is $\phi \pm 90^\circ$. If 90° phase shift is not available, leave control at midrange.

c. Use instrument as above except IN PHASE and QUADRATURE meters now indicate relative voltages and senses of input-signal components at ϕ and $\phi + 90^\circ$ respectively. Phase-sensitive detection provides very effective rejection of input-signal components not coherent with the reference.

d. Increase SENSITIVITY (cw) if necessary to measure small signals (approx 100 nV) even though MAGNITUDE meter deflection is very small. Range of this control: 16 dB (factor of 6).

e. Increase TIME CONSTANT if necessary to help in reducing noise (jumpy meters) with small input signals.

f. Avoid GAIN setting that makes MAGNITUDE meter deflect offscale, otherwise indications of IN PHASE and QUADRATURE meters may be invalid.

***The phase ϕ of the initial signal should be significant in your test system. For example, in a capacitance bridge, obtain this signal by unbalancing the bridge with *only* C or G, *not* an arbitrary combination.**

Specifications

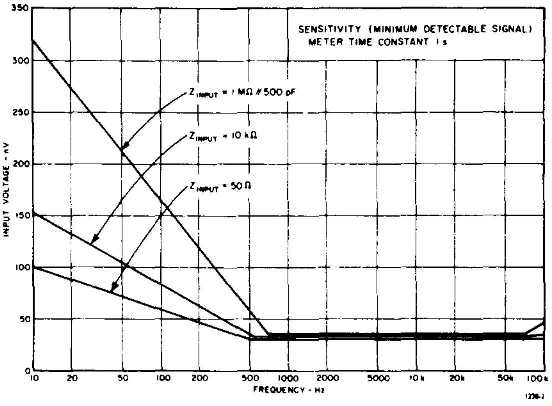
Frequency: 10 Hz to 100 kHz, flat or tuned. *Flat,* ±5 dB from 10 Hz to 100 kHz. *Tuned,* controlled by 4 in-line readout dials with ±5% of reading accuracy, 2 to 4% bandwidth, and second harmonic ≧30 dB down from peak. *Line-rejection filter,* reduces line level by ≧40 dB while signal is down 6 to 10 dB at 10 Hz from line frequency; filter can be switched out.
Signal Input from bridge or other source: Applied to rear BNC connector. *Sensitivity,* also see curve; 100 nV rms typical for full-scale deflection at most frequencies, compression can be switched in to reduce full-scale sensitivity by 20 dB. *Impedance,* 1 GΩ∥20 pF. *Maximum input,* 200 V rms. *Voltage gain,* ≈105 dB in flat mode, ≈ 130 dB in tuned mode, controlled by 12-position switch. *Spot noise voltage* <30 nV × $\sqrt{\text{bandwidth}_{\text{Hz}}}$ at 1 kHz with input impedance of 70 MΩ∥500 pf. *Monitored* by magnitude, in-phase, and quadrature meters; phase-sensitive detectors contain time-constant variable from 0.1 to 10 s in 5 steps.
Reference Inputs from oscillator: Applied to rear BNC connectors. Two ≧1-V rms reference signals required, with 90° phase difference between them. *Phase shifter* rotates both references continuously from 0 to 360° and two verniers rotate each reference individually ≈ 10°.

Outputs: ***Main amplifier***, 4 V rms (approx 2.3 V for full scale on Magnitude meter) available at rear BNC connector. ***Magnitude***, 6 V dc for full scale deflection; ***phase detectors***, up to 1 V dc each for full scale deflection (depending on Sensitivity setting); available at rear 5-pin connector.

Required: Oscillator with 0 and 90° outputs; the 1316 Oscillator is recommended.

Power: 105 to 125 and 210 to 250 V, 50 to 60 Hz, 15 W.

Mechanical: Bench or rackmount. Dimensions (w × h × d): Bench, 19.75 × 6.66 × 12.93 in. (502 × 169 × 329 mm); rack, 19 × 5.22 × 13.1 in. (483 × 133 × 332 mm). Weight: Bench 27 lb (12 kg) net, 40 lb (18 kg) shipping; rack, 21 lb (10 kg) net, 34 lb (16 kg) shipping.



Catalog Number	Description
	1238 Detector
1238-9700	60-Hz Bench Model
1238-9701	60-Hz Rack Model
1238-9703	50-Hz Bench Model
1238-9704	50-Hz Rack Model

Also included in each 1621 Precision Capacitance Measurement System.

Introduction—Section 1

1.1 PURPOSE.

The 1238 Detector is a sensitive, low-noise, analog instrument particularly suited for null detection in a highly precise bridge system such as the GR 1621. As you bring the bridge to balance, this detector continuously provides an indication of the remaining unbalance. You are also provided with the relative magnitudes and senses of its quadrature components. If, for example, the bridge measures C and G, separate zero-center phase-sensitive meters conveniently indicate the C and G components of unbalance. Also, these meters will resolve signals so small as to be "lost in the noise" of a magnitude-only detector.

To handle the great range of signal levels characteristic of bridges, this detector has manually selected gain, optional rejection of noise and harmonics by tuning, optional compression of the linear response characteristic, and a choice of 5 time constants for the phase-sensitive meters. Automatic protection circuitry saves the instrument from damage even if the input signal reaches 200 V while you have the gain set for 100 nV, full scale. The digital, in-line frequency controls match those of the companion 1316 Oscillator (used in the 1621 Precision Capacitance-Measurement System). Both instruments cover the frequency range of 10 Hz to 100 kHz with 3-digit resolution.

In addition to its prime purpose as a bridge detector, the 1238 is well suited as a low-noise amplifier with the very high input impedance of 1 GΩ in parallel with 20 pF. The filters may be switched out for a flat frequency characteristic. With the tuning filter in, the 1238 serves as an analyzer having about 3% bandwidth, better than 30 dB rejection of the 2nd harmonic, and a dynamic range (with the gain control) of at least 130 dB.

1.2 DESCRIPTION.

Figure 1-1.

The 1238 Detector is a high-gain, solid-state, tunable, metered amplifier with a pair of phase-sensitive detectors. They can be set to respond to any 2 quadrature (i.e., orthogonal) components of the input signal, if a pair of quadrature-related reference signals is provided, generally by the oscillator that drives the measurement system.

Figure 1-1 shows the 1238 circuitry by an elementary block diagram. The high-input-impedance preamplifier is well shielded and isolated; it has a separate power supply and all its control functions are handled by solid-state relays (insulated-gate field-effect transistors). Its first stage, a field-effect transistor, is diode protected against high-volt-

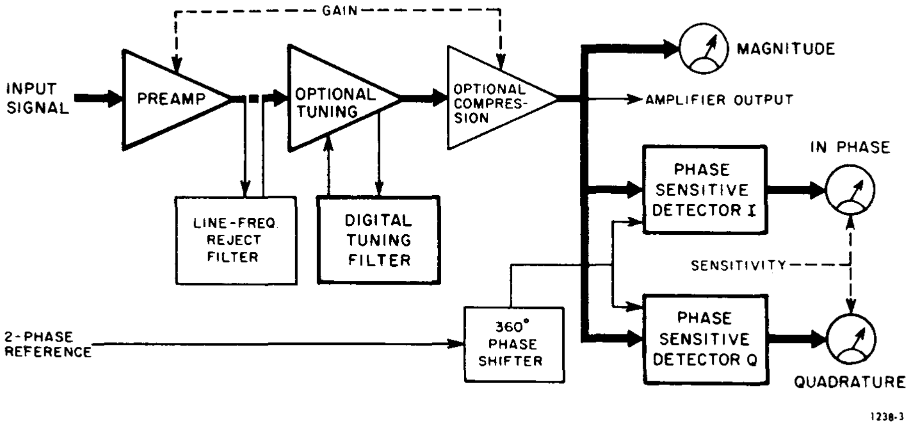


Figure 1-1. Elementary block diagram.

age input signals. The digital tuning filter, 360° phase shifter, meters, and sensitivity control are components of the front-panel assembly. Each phase-sensitive detector is a separate plug-in board. Amplifier and power supply circuits are on the mother board, which is easily accessible from above and below for adjustment and servicing.

1.3 CONTROLS, INDICATORS, AND CONNECTORS.

Tables 1-1 and 1-2 list and describe the front and rear panel controls, indicators, and connectors. Refer to the illustrations of Figures 1-2 and 1-3.

1.4 ACCESSORIES.

Table 1-3 lists the accessories supplied with the 1238 Detector. Table 1-4 lists connectors and patch cords suitable for connecting to the instrument and the recommended companion oscillator, which is shown in Figure 1-4.

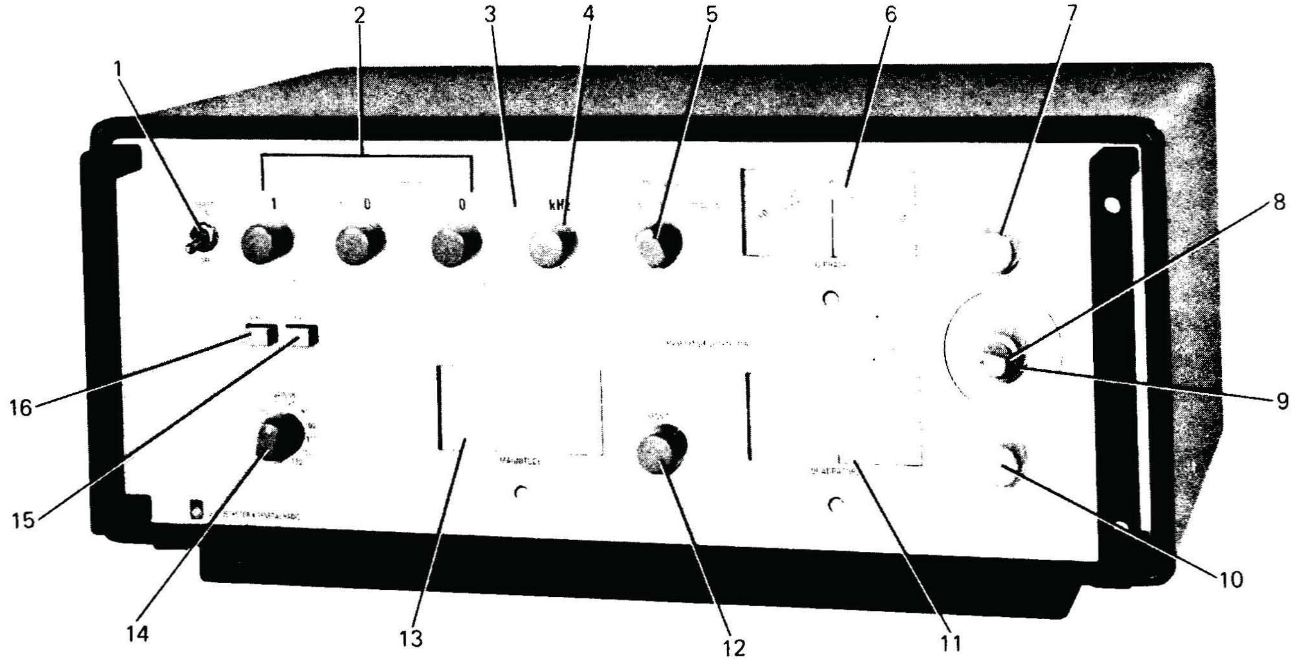


Figure 1-2. Front-panel controls and indicators.

Table 1-1

FRONT-PANEL CONTROLS AND INDICATORS

Fig. 1-2 Item	Name	Description	Function
1	POWER Switch	Toggle switch, up: ON; down: OFF.	Turns detector on and off.
2	FREQUENCY selector	Set of 3 rotary switches with decimal steps, 0 . . . 10.	Selects and indicates frequency to which detector is tuned (unless "FLAT"). With item 4, controls the digital tuning filter.
3	Decimal point	Set of 3 small, round, recessed lamps, one to the right of each digit in item 2.	Indicates proper location of decimal point in item-2 readout, as determined by item 4. Pilot-light indication: power is on.

Table 1-1 Cont.

FRONT-PANEL CONTROLS AND INDICATORS

Fig. 1-2 Item	Name	Description	Function
4	Frequency range	Rotary switch with 5 positions: FLAT, Hz, Hz, kHz, kHz.	Selects flat amplifier characteristic or frequency range of tuned response. Indicates frequency units for item 2. Controls its decimal point, item 3.
5	TIME CONSTANT	Rotary switch with 5 positions: 0.1, 0.3, 1, 3, 10 SECONDS.	Controls the smoothing (integration) of detected signals and hence, effectively, the damping of items 6 and 11, but not 13.
6	IN-PHASE meter	Zero-center meter graduated 50-0-50; has mechanical zero-adjustment screw.	Indication of one component of input signal (such as C unbalance in 1621 system).
7	FINE ADJUST (IN-PHASE)	Stepless rotary pot.	Trims the phase of item-6 reference so the quadrature component is rejected.
8	PHASE SHIFT (smaller knob)	Rotary switch with 4 positions: 0°, 90°, 180°, 270°.	Selects phase shift of 2-phase reference in 90° steps, supplemented by items 7, 9, and 10.
9	PHASE SHIFT (larger knob)	Stepless rotary control, calibrated -50° to +50°	Adjusts phase shift of 2-phase reference, over 100° centered on the indication of item 8. Set so items 6 and 11 respond to desired components of input signal.
10	FINE ADJUST (QUADRATURE)	Stepless rotary pot.	Trims the phase of item 11 reference so the in-phase component is rejected.
11	QUADRATURE meter	Zero-center meter graduated 50-0-50; has a mechanical zero-adjustment screw.	Indication of the input-signal component in quadrature with item 6 (Example: G unbalance in 1621 system).
12	SENSITIVITY control	Stepless rotary pot.	Fine control; used to keep IN-PHASE and QUADRATURE meters reading on scale (does not affect items 13 or 1R). Range 6:1.
13	MAGNITUDE meter	Meter, calibrated 0 to 100; has a mechanical zero-adjustment screw.	Indication of relative magnitude of input-signal (item 5R) components in pass band set by items 2, 16. Linearity depends on item 15.
14	GAIN, dB	Step attenuator, 12 positions: 20 . . . 130 dB.	Coarse gain control; used to keep MAGNITUDE meter reading on scale. (Turn cw if meter reads less than 30.)
15	COMPRESSION	Push-button switch (push to engage; push again to release).	Out: linear response, full gain. In: 20-dB-compressed response, 10 times-larger signal can be handled with MAGNITUDE meter on scale.
16	LINE REJECTION	Push-button switch (push to engage; push again to release).	Out: normal. In: 40 dB attenuation of line-frequency component of input signal. (Circuit can be adapted to either 50 or 60 Hz.)

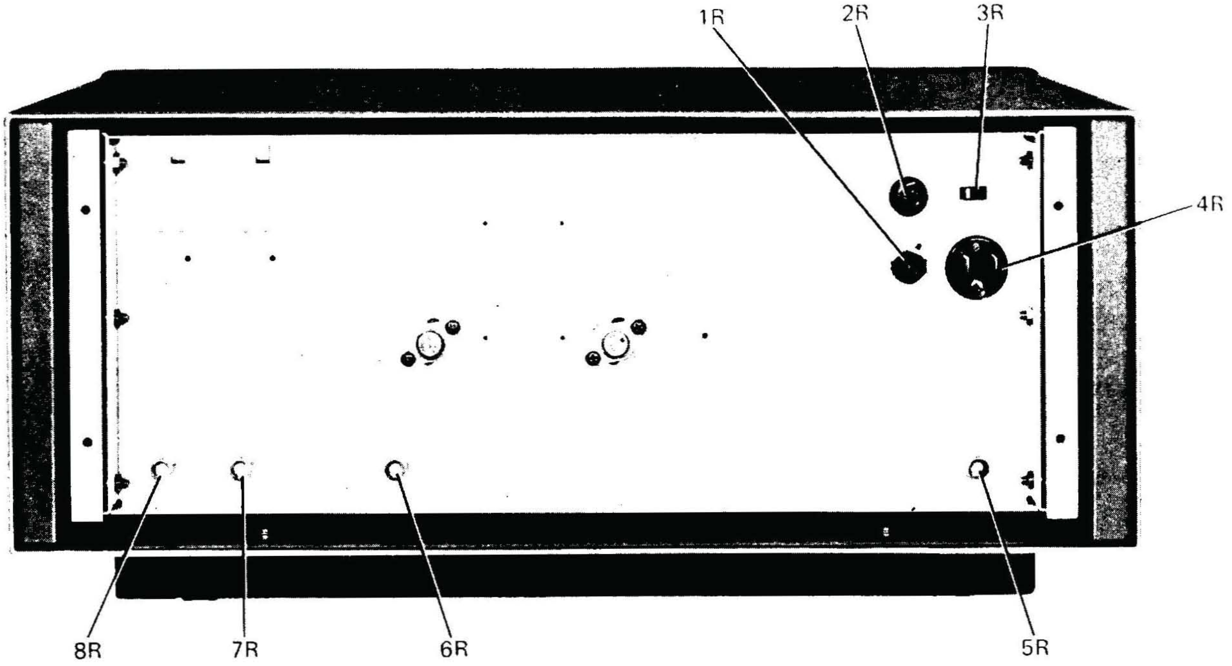


Figure 1-3. Rear-panel controls and connectors.

Table 1-2

REAR-PANEL CONTROLS AND CONNECTORS

Fig. 1-3 Item	Name	Description	Function
1R	DC METER OUTPUTS	5-pin socket (Figure 2-6).	Outputs for remote metering. Full-scale dc levels: MAGNITUDE, 6 V; IN-PHASE and QUADRATURE, 0.25-1.5 V, depending on item 12 (which does not affect ratio: dc out/signal in).
2R	1/2 AMP fuse	Fuse in extractor post holder	Protection against damage from short circuit
3R	Line-voltage switch	Slide switch (labeled 50-60 Hz) 2 positions: 100-125 V, 200-250 V.	Accomodates power supply to either range of line voltage.
4R	Power plug	3-pin power plug	Connection from power line and earth ground.
5R	INPUT SIGNAL	BNC Jack*	Main input. Impedance: 1 GΩ//20 pF for normal signal levels. Max level: 200 V rms.
6R	AMPLIFIER OUTPUT	BNC Jack*	Output for remote instrumentation. Level: 0-4 V rms (2.25 V at FS on item 13).
7R	IN-PHASE REFERENCE INPUT	BNC Jack*	One of two quadrature references required for phase-sensitive detection. See item 8R.
8R	QUADRATURE REFERENCE	BNC Jack*	The other – see item 7R. Required levels: 1 V rms min, each. Phase: Item 8R normally leads 7R by 90° ±5°

*BNC jack accepts Amphenol "BNC" plug or military connector No. UG-88/U.

Table 1-3
ACCESSORIES SUPPLIED

Name	Description or Function	GR Part No.
Power cord	Stackable hammerhead dual connector (one end) and socket (other end) each molded integrally to plastic jacket of 3-wire AWG number 18 type SVT cable, rated at 7A, 230 V. The connectors, designed for 125-V operation, conform to the Standard for Grounding Type Attachment Plug Caps and Receptacles, ANSI C73.11-1963. Length: 7 ft.	4200-9625 (4200-0220)
Plug	For DC METER OUTPUTS socket; 5-pins; Amphenol No. 126-217.	4220-5401

Table 1-4
COMPANION OSCILLATOR, CONNECTORS AND PATCH CORDS

Name	Description or Function	GR Part No.
Oscillator	Stable, synchronizable, transformer-coupled, metered, sine-wave source. **Frequency**: 10 Hz to 100 kHz; **Stability**: 0.001% in 10 min; **Calibration accuracy**: ±1%; **Distortion**: < 0.2%; **Power**: 0-1.6 W (up to 5A or 125 V rms); **Reference outputs** – **phase**: 0° and 90° leading main output; **level**: 1.25 V rms; **distortion**: < 0.4%; **min load**: 47 kΩ.	(Type 1316) 1316-9700 (Bench) 1316-9701 (Rack)
Patch Cords	Shielded cable with BNC plugs at each end; **Length**: 3 ft. (Type 776-C).	
	Shielded cable with BNC plug and GR874® connector at opposite ends; **Length**: 3 ft.	(Type 776-B)
Adaptor	BNC plug to 874 connector (Fits BNC jack).	(Type 874-QBPA)

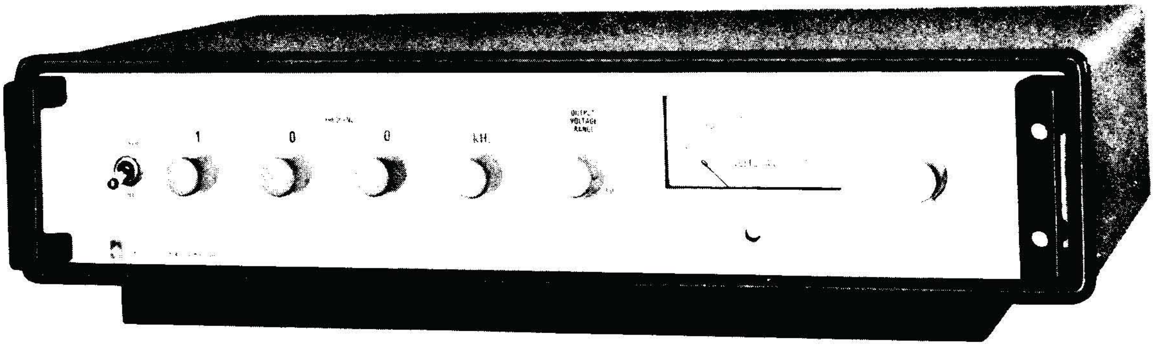


Figure 1-4. A recommended companion instrument, the 1316 Oscillator.

Installation–Section 2

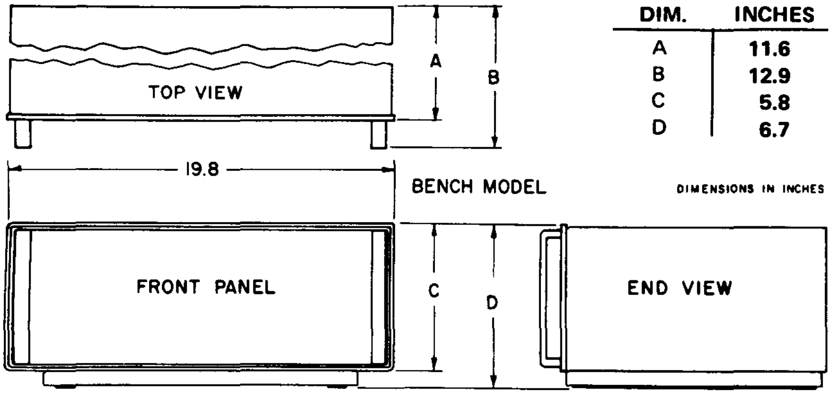
2.1 GENERAL.

The 1238 Detector is available for either bench use or for installation in an EIA Standard RS-310 19-in. relay rack with universal hole spacing. Appropriate cabinet and hardware sets are available for conversion of a bench model for rack installation or vice versa.

Locate the instrument for convenience of operation and in a suitable environment. The provisions for remote metering add flexibility to the arrangement of your measurement system.

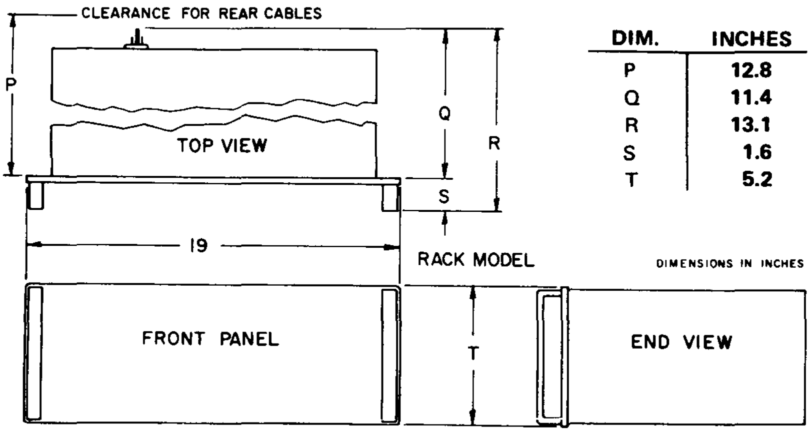
2.2 DIMENSIONS.

The dimensions of bench and relay-rack models of the detector are given in Figures 2-1 and 2-2.



DIM.	INCHES
A	11.6
B	12.9
C	5.8
D	6.7

Figure 2-1. Dimensions of the bench-model instrument.



DIM.	INCHES
P	12.8
Q	11.4
R	13.1
S	1.6
T	5.2

Figure 2-2. Dimensions of the rack-model instrument.

2.3 ENVIRONMENT.

The instrument is designed to operate in rooms where people work. Its specifications are valid over a temperature range of 0-55° C. Storage temperature range is −20 to +70° C.

It is important to keep vents unobstructed, for normal air convection. The environment of the instrument is directly affected by others nearby, particularly those below if they are hot.

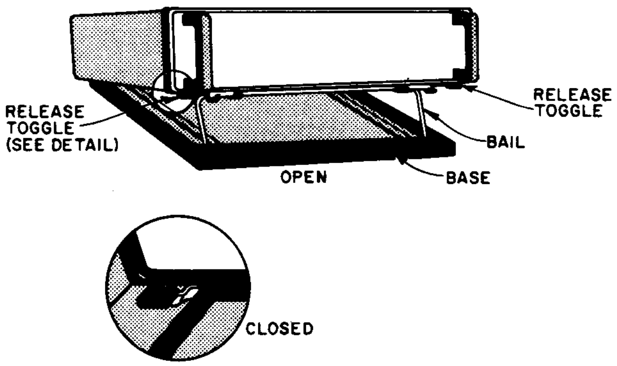


Figure 2-3. The instrument may be tilted for a higher viewpoint.

2.4 BENCH MODELS.

2.4.1 Position, Horizontal or Tilted. Figure 2-3.

Each bench model comes completely assembled in a metal cabinet intended for use on a table or laboratory bench. If the user's viewpoint is much above bench level, he may prefer to tilt the instrument for a better view of front-panel legends and indicators. The base remains horizontal. Use the following procedure for tilting:

a. Reach under the cabinet, near the front, at each side of the pedestal base, and push each release toggle back. (It moves about 3/4 in.)

b. Lift the front of the instrument a few inches from its base, keeping each hand where a fingertip can touch the bail as it swings down.

c. Swing the bail forward while raising the instrument, then lowering it gently to rest on the bail. This is the tilted, or open position.

d. To reverse the procedure, first be sure the release toggles are pushed back.

e. Lift the cabinet slightly, as before; swing the bail back; then lower the cabinet fully.

f. Lock the cabinet and base together by sliding the release toggles forward. This is the horizontal, or closed position.

2.4.2 Cabinet Removal. Figure 2-4.

To remove the bench-model cabinet, first stand the instrument in the normal position, free of all cables, and proceed as follows:

a. Remove the 4 dress-panel screws (A) accessible through holes in the handles.

b. Withdraw the instrument forward, out of the cabinet.

2.4.3 Conversion for Rack Mounting.

To convert a bench instrument for rack mounting, exchange the cabinet and install appropriate hardware, as follows:

a. Obtain the Rack-Mounting Cabinet described in Table 2-1 from General Radio Company.

b. Obtain, optionally, a Bracket Set (same table). Brackets are especially recommended for a heavy instrument, which needs support from the rear rail of the rack.

c. Remove the cabinet, as in para. 2.4.2.

d. Remove the rear cover from the bench cabinet with screws (B, Figure 2-5), for later installation on the rack cabinet.

e. Proceed with the rack installation: skip to para. 2.5.2, step b.

2.5 RACK MODELS.

2.5.1 General.

Each rack model comes completely assembled in a suitable metal cabinet, which is designed to stay semipermanently in a rack. The instrument can be drawn forward on extending tracks for access with support, or (with a lift) withdrawn completely. The cabinet and bracket set listed in Table 2-1 are included with a rack-model 1238 Detector. Table 2-2 lists the screw sizes for reference.

Table 2-1

RACK-MOUNTING CABINET AND BRACKET

Description	Part No.
Cabinet with tracks; screws A, B,	4174-3624
Rear-support bracket set; screws C, E.	4174-2007

Table 2-2

KEY TO SCREW SIZES

Ref Fig. 2-4 & 2-5	Description	No. – thds/in.	Length (inches)
A	Dress-panel screws with washers.	10-32	0.56
B	Thread-forming screws.	8-32	0.25
C	Thread-cutting screws.	10-32	0.50
E	Thread-forming screws.	8-32	0.19
F	Thread-cutting screws.	10-32	0.50

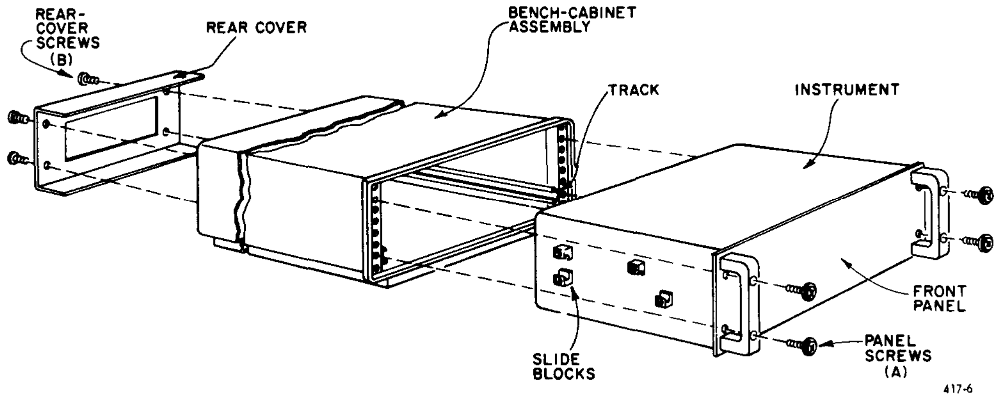


Figure 2-4. Bench-cabinet installation.

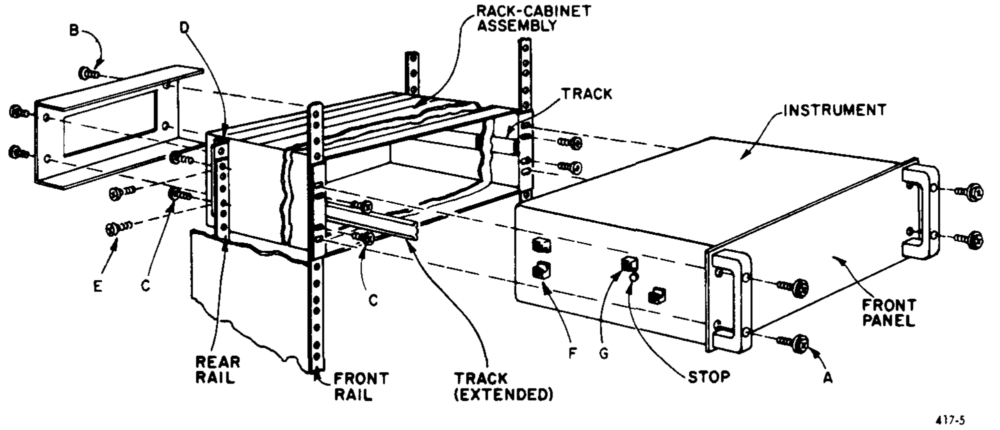


Figure 2-5. Rack-cabinet installation.

2.5.2 Installation.

Figure 2-5.

Directions follow for mounting the cabinet in a rack and installing the instrument on its tracks:

a. Remove 4 dress-panel screws (A) and slide the instrument out of the cabinet. When free motion along the tracks is stopped, tilt the front of the instrument up slightly. Continue withdrawal, past the stops, pulling the instrument horizontally until it is free.

b. Insert the rack cabinet wherever desired in the rack – be sure it's level – and fasten it with 4 screws (C) to the front rails.

c. If the cabinet can be supported at the rear, remove the rear cover (screws B) for better access. Otherwise skip to step e.

d. Use brackets (D) to support the cabinet with the rear rails. Generously elongated screw holes allow positioning as desired. With screws (E) fasten brackets to cabinet. Pass screws (C) through brackets and screw them into the rear rail. (Details may be varied to suit particular situations.)

e. To install the instrument, first set its rear edge into the cabinet front opening. Slide the instrument back, making sure that the rear slide blocks and the upper front ones engage the tracks. (Stops prevent complete insertion.)

f. Slide the instrument forward ***with*** the tracks, keeping a hand on each side (fingers underneath). Slide the instrument ***back*** about 1/2 in. along both tracks, past the stops, by pressing down on the tracks (with thumbs) while tilting the front of the instrument up slightly.

g. Push the instrument back into the rack, checking for smooth operation of the tracks and slide blocks.

NOTE

The instrument is now readily accessible for behind-the-panel adjustments. It slides in and out freely on extending tracks. Obtain this advantage whenever desired by removing the panel screws (A).

h. Fasten the instrument in place using 4 dress-panel screws (A). (Pass your screwdriver through holes in the handles.)

i. Replace the rear cover, with its screws (B).

2.5.3 Conversion to Bench Use.

To convert a rack-mounting instrument for bench use, exchange the cabinet, as follows:

a. Obtain a Bench Cabinet, Part no. 4172-4017, from General Radio Company.

b. Remove the instrument from the rack cabinet, after removing the panel screws (A, Figure 2-5). (When free motion along the tracks is stopped, tilt the front of the instrument up slightly to clear the stops.)

c. Slide the instrument into the bench cabinet.

d. Fasten instrument to cabinet using dress-panel screws (A, figure 2-4).

e. Transfer the rear cover, with screws (B), from rack cabinet to bench cabinet.

2.6 POWER-LINE CONNECTION.

Power requirement for the 1238 Detector is 15 W at 100-to-125 or 200-to-250 V, 50-to-60 Hz. Make connection as follows:

a. Set the line-voltage switch on the rear panel (Figure 1-3) to correspond with the available power-line voltage. Use a small screwdriver to slide the switch.

b. Connect the external power line to the power plug using the power cord supplied or an equivalent 3-conductor cord (para. 1-4).

The fuse should have the current rating shown on the rear panel regardless of which line-voltage range is chosen in step a.

2.7 LINE-VOLTAGE REGULATION.

The accuracy of measurements accomplished with precision electronic test equipment operated from ac line sources can often be seriously degraded by fluctuations in primary input power. Line-voltage variations of ±15% are commonly encountered, even in laboratory environments. Although most modern electronic instruments incorporate some degree of regulation, possible power-source problems should be considered for every instrumentation setup. The use of line-voltage regulators between power lines and the test equipment is recommended as the only sure way to rule out the effects on measurement data of variations in line voltage.

2.8 SYSTEM CONNECTIONS.

2.8.1 Inputs.

Connect the REFERENCE INPUTS jacks to the 2-phase reference ports of the oscillator supplying signal to the bridge or measurement system. If that oscillator is the GR 1316, its corresponding jacks are labeled REFERENCE OUTPUTS. The normal relationship between the phases is QUADRATURE leading IN PHASE by 90°. (If you provide a lagging-quadrature reference pair, the calibrations of the PHASE SHIFT controls are reversed in sense, but their primary function is still valid.) Use BNC patch cords such as those listed in para. 1-4, adapted if necessary to your oscillator.

Connect the signal to be detected via the INPUT SIGNAL jack, making sure that the 200-V-rms limit is not exceeded. Use a BNC patch cord, as mentioned above.

2.8.2 Outputs.

NOTE

The 1238 meters provide visual outputs; no output connections are necessary.

Connect the AMPLIFIER OUTPUT jack to a scope, a-c level recorder, or other instrument if you wish, using another BNC patch cord or adaptor. This signal is subject to the controls on the left half of the 1238 front panel only. The level is generally 0-4 V rms if the COMPRESSION button is "out"; however, 2.25 V corresponds to full scale on the MAGNITUDE meter. (In untuned, i.e. FLAT, operation, levels are limited to less than 4 V whenever GAIN is set to 20, 30, or 80 dB.) The available power is limited; keep the load impedance above 25 kΩ.

Connect remote indicators, such as voltmeters, if desired, via the DC METER OUTPUTS socket. Use a 5-pin plug, such as listed in para. 1-4, making connections as shown in Figure 2-6. The A-B circuit provides 0-6 V dc, corresponding to 0-100 on the MAGNITUDE meter. Do not ground that circuit. The D-H and E-H circuits provide 0-1 V dc corresponding to full scale deflection of the IN-PHASE and QUADRATURE meters respectively, when the SENSITIVITY control is set ccw. (That control affects only the 1238 phase-sensitive meters, not the remote circuit. Therefore, turning the knob cw causes full-scale deflection at lower DC METER OUTPUT voltages.) Pin H is grounded. Keep the load impedance in each of the 3 meter circuits above 25 kΩ.

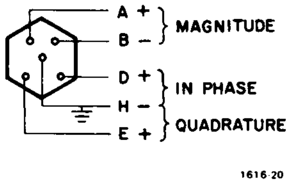


Figure 2-6. The DC METER OUTPUTS socket, exterior (rear) view.

Operation – Section 3

CAUTION

Do not connect a power cord until the line-voltage switch has been set properly.

3.1 PRELIMINARY CHECKS AND SETUP.

Refer to paragraph 1.3 for figures illustrating the controls, indicators, and connectors and for their functional descriptions. The recommended initial operating procedure follows:

a. Position the line-voltage switch on the rear panel according to the available power-line voltage (either 100-125 V or 200-250 V). To slide the switch, use the tip of a small screwdriver. Line frequency can be either 50 or 60 Hz for these preliminary and functional checks; a procedure will be described below for readjusting the line-frequency rejection filter (if necessary) to match your power source.

b. Check that the 3 meters read zero (2 of them at mid scale). If not, reset with the mechanical zero-adjustment screw just below each meter; use a small screwdriver.

c. Provide the 3 input signals, as described in para. 2.8 – a 2-phase reference and a coherent signal to be detected (10 μV – 100 mV).

d. Connect the power plug to a suitable power line, using the power cord supplied. Flip the POWER switch ON. Verify that a decimal point is illuminated in the FREQUENCY selector. In the FLAT position of the frequency range switch, the 1st decimal point serves only as a pilot light; in the other positions, the decimal points serve also as part of the FREQUENCY readout.

3.2 PHASE ADJUSTMENT.

Verify that the instrument is operational, as follows:

a. Set the front-panel controls as listed:

POWER – ON
FREQUENCY – FLAT
TIME CONSTANT – 0.3 s
PHASE SHIFT – 0°
LINE REJECTION – push button out
COMPRESSION – push button out
GAIN – 20 dB
SENSITIVITY – ccw (minimum)
FINE ADJUST – midrange (both controls)

b. Turn the GAIN up (cw) until the MAGNITUDE meter reads 20-80.

c. Switch the FREQUENCY and frequency range controls to the input-signal frequency. The meter pointer will go off scale.

d. Turn the GAIN down (ccw) until the MAGNITUDE meter reads 20-80. If the source frequency is not calibrated within ±5%, vary it and watch the meter for maximum response (correct tuning). Set to that frequency. Fine-tune either oscillator or detector for peak response. Reset the GAIN control as before.

e. Set the PHASE SHIFT controls so the IN PHASE meter indicates to the right (it may be off-scale) and the QUADRATURE meter reads zero. Use the lower FINE ADJUST control to refine that adjustment.

NOTE

The initial input signal has been used to establish which component of future input signals will be designated IN PHASE.

f. If the means are available to do so, shift the input signal exactly 90° and set the upper FINE ADJUST control for zero on the IN PHASE meter. Otherwise leave that control alone.

The 1238 Detector is now ready to use at the frequency of step d, above.

3.3 ROUTINE OPERATION.

3.3.1 Magnitude.

Observe or measure changes in magnitude of the input signal by watching the MAGNITUDE meter and turning the GAIN control. If the COMPRESSION push button is left "out," the meter responds linearly with voltage and the GAIN control varies 10 dB per step, 2 steps being a factor of 10 in voltage. The meter calibration is relative voltage; no units are specified.

If the frequency selector is set to FLAT, the magnitude you observe includes all components (10 Hz to 100 kHz). Otherwise, the components outside the 3% bandwidth of the tuning filter are excluded. This detector is primarily intended for single-frequency measurements, rejecting harmonics and noise. Gain is 25 dB (a factor of 18) higher when tuned than when FLAT. Refer also to para. 3.3.4.

3.3.2 Phase Sensitive Detection.

It is often convenient to have separate "phase sensitive" indications of 2 quadrature components of a single-frequency input signal. In fact if such a signal is vanishingly small, it may be necessary to employ phase-sensitive detection to obtain any reliable measure of the signal at all. The right-hand half of the 1238 Detector, panel is devoted to this function.

If the PHASE SHIFT has been set as described above, so long as the tuning remains unchanged, you can observe or measure (relatively) the input-signal components according to the following guidelines[1]:

1. IN PHASE + . . . like the initial signal
2. IN PHASE – . . . 180° out of phase
3. QUADRATURE + . . . 90° leading *
4. QUADRATURE – . . . 90° lagging.*

The responses are normally linear, both meters being affected together by the GAIN, SENSITIVITY, and TIME CONSTANT controls. If the MAGNITUDE meter is reading on scale, the zero reading of either phase sensitive meter is valid even if the other is deflected off scale. Also, under that condition, the phase information indicated by the off-scale IN PHASE or QUADRATURE meter (or both) is correct.

3.3.3 Compressi n. Figure 4-5.

Set the COMPRESSION push button *in*, if you want the quasi-logarithmic characteristic. With it, a 20-dB larger signal level is indicated by full scale on the MAGNITUDE meter, whereas there is a relatively minor change in gain at lower signal levels. In other words, compression is a voltage-dependent attenuation (or automatic gain control) which multiples signal voltage by a smoothly varying factor that is 45% for small signals, reaches 35% for a signal that would normally be full scale on the MAGNITUDE meter, and is only 10% for one that would normally be a factor-of-10 overload. Figure 4-5. shows this relationship.

Use compression to save time and annoyance in situations with large variations of input-signal level and consequently the need to change the GAIN setting frequently. Also, use compression to avoid overloading the amplifier and MAGNITUDE meter when the input signal is approximately 1 V rms, the instrument is tuned, and the GAIN control is set as low as it will go.

NOTE

COMPRESSION makes all meter responses and output signals quasi-logarithmic with respect to the input-signal level.

COMPRESSION introduces distortion, similar to limiting or clipping which can be seen in the AMPLIFIER OUTPUT waveform regardless of whether the instrument is tuned or FLAT. However, the tuning, if used, is just as effective in removing harmonics from the input signal (so they do not affect the indicators or the output signal) whether the COMPRESSION button is in or out.

COMPRESSION has a negligible effect on the phase of the signal being detected and therefore on the sense or null of the indication by IN PHASE or QUADRATURE meter.

3.3.4 Line-Frequency Rejection.

Set the LINE REJECTION push button *in* if you want the extra filtering thus provided.

NOTE

Leave this button ***out*** if the input-signal frequency is above 10 kHz.

The filter is fixed-tuned to either 50 or 60 Hz, and should preferably be set as you want it before you obtain the instrument. Directions for retuning are in para. 5.5.

One of the most common and pernicious kinds of noise or spurious components or "pickup" that can be superimposed on the desired input signal comes from the power lines. Of course, use care to avoid such noise: keep power currents from sharing ground circuits with the input signal, shield all low-signal-level components and interconnections; position sensitive equipment far away from electrical machinery; etc. But it often occurs that power-frequency noise is present despite all reasonable precautions, and that the desired signal has no important component at power-line frequency. Then it is expeditious to use a "notch" filter that will greatly attenuate any input-signal component at this frequency, but pass all other components unaltered.

Such a filter is built into the 1238 Detector for your convenience. To use it, simply set the LINE REJECTION button *in*. It provides you a 40-dB reduction in any line-frequency component that may be present, when the instrument is used FLAT; or it adds 40 dB to the substantial reduction provided by the digital tuning filter when that is set to a different frequency, such as 1 kHz.

There are 2 exceptions. Leave the LINE REJECTION button ***out*** if the input signal of interest is above 10 kHz because amplifier response up near 100 kHz will otherwise be attenuated. Leave the button out, also, if the signal of interest is within 10 Hz or so of line frequency.

***The opposite, i.e., 3 "lagging" and 4 "leading," is true if the QUADRATURE REFERENCE INPUT lags the IN PHASE. See para. 2.8.**

[1] + means deflection to the right; –, to the left.

Theory–Section 4

4.1 GENERAL. **Figure 1-1.**

The 1238 Detector is a high-gain amplifier with a low-noise, high-impedance input stage, optional filtering, optional compression, and a pair of phase-sensitive detectors. Intended for use as an unbalance detector and indicator for precision bridges, it has calibration of frequency and gain. Although not intended as a voltmeter, its meters indicate the magnitudes of the amplifier output and each phase-detector output. The phase detectors are responsive to an orthogonal pair of components of the amplified signal. Any desired pair can be chosen by manipulation of a phase shifter acting in the 2-phase reference-signal channel.

The circuitry includes field-effect and bipolar transistors, and linear integrated-circuits, as amplifiers and buffers. Insulated-gate-field-effect transistors are used as solid-state relays to supplement mechanical switches in some of the control functions.

4.2 BLOCK-DIAGRAM DESCRIPTION. **Figure 4-1.**

Main Signal Channel. The input signal is routed directly into the preamplifier, which contains an amplitude limiter that safeguards the circuit from damage by input signals up to 200 V. Three attenuators in the preamplifier are set electrically by the GAIN control, via the family of control signals CA, CB, CC.

The LINE REJECTION push button determines (via the pair of control signals CX) whether the line-frequency rejection filter is included in the signal channel. This is a narrow-band-stop filter.

Farther along the main amplifier chain, the frequency range switch determines which group of digitally-selected elements is used in the tuned-filter stage, or, if you select FLAT, connects an untuned network. That switch, together with the 3 digital FREQUENCY switches, tune the instrument to a selected frequency. In order to reject unwanted-frequency components without introducing difficulty in keeping source and detector in tune, the tuned filter has a bandwidth of about 3%.

The fourth attenuator is also set electrically by the GAIN control, via the pair of control signals CD. Similarly, the quasi-logarithmic circuitry is connected or disconnected by the COMPRESSION push button via control signal CZ.

The main signal being processed is designated SIG1 at the INPUT SIGNAL jack, SIG1A, SIG2, SIG3, and SIG3A at intermediate stages most of which are in the diagram, Figure 4-1, and SIG4 at the AMPLIFIER OUTPUT jack. SIG4 drives the MAGNITUDE meter (via the meter rectifier circuit) and both phase detectors.

Phase-Detector Circuitry. The REFERENCE INPUTS, internally designated REFI and REFQ, are each split into a pair of signals. NORTH is a replica of REFI, SOUTH is 180° out of phase. Similarly, EAST is like REFQ, WEST, 180° away.

The PHASE SHIFT switch and continuous control rotate the phase of the quadrature pair PHASI/PHASQ within

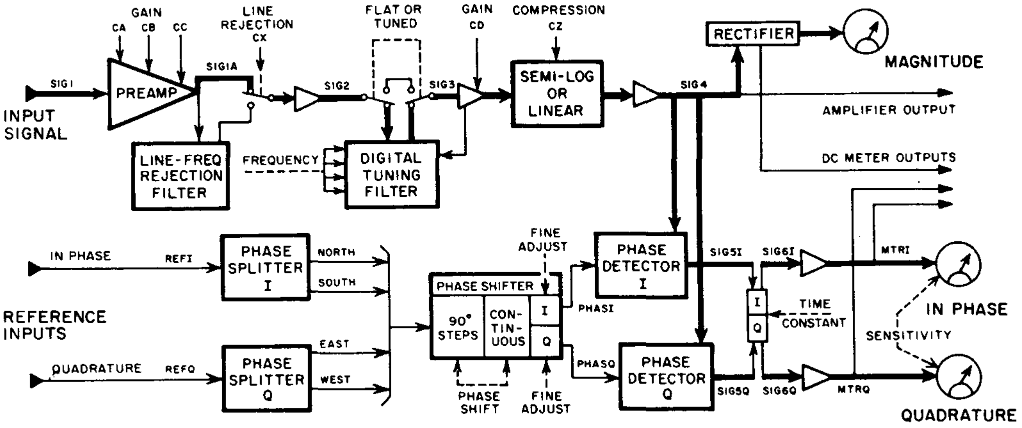


Figure 4-1. Overall block diagram.

the framework set up by NORTH, EAST, SOUTH, and WEST (which, as the nomenclature implies, is a full circle). The FINE ADJUST controls trim the phases of PHASI and PHASQ separately as may be required to make them exactly orthogonal.

Thus, the PHASE SHIFT controls determine what quadrature pair of components of SIG4 will be resolved by the phase sensitive detectors. For example, if PHASE SHIFT is set to ϕ°, the IN PHASE meter responds to the component ϕ° leading the IN PHASE REFERENCE INPUT and the QUADRATURE meter responds to the component $\phi + 90^\circ$ leading. (However, that sense obtains only if the QUADRATURE REFERENCE INPUT leads the IN PHASE by 90° If it lags, replace "leading" by "lagging" in the statement above.)

In each phase detector, PHASI (or PHASQ) drives a synchronous switch which detects the appropriate component of SIG4. The resulting dc signal is amplified by circuits with an adjustable time constant, for smoothing, to drive the IN PHASE (or QUADRATURE) meter. The SENSITIVITY control affects these meters simultaneously, with a range of 6:1 but does not affect the meter-drive signals MTRI and MTRQ.

Outputs. The AMPLIFIER OUTPUT is the ac signal SIG4. The 3 DC METER OUTPUTS consist of MTRI, MTRQ, and a rectified voltage proportional to the MAGNITUDE-meter current.

4.3 CIRCUIT DESCRIPTION.

4.3.1 Preamplifier (B Board). Figure 6-5.

Although its etched circuit is part of the B board, the preamplifier is well isolated, decoupled, and shielded from the higher-level circuitry. A separate power supply, also on the B board, serves the preamplifier. A separate ground GS1 is tied through 10 Ω to chassis ground at AT1. GS1 is also the electrical midpoint between the power-supply terminals BP1 (+15 V) and BN1 (−15 V).

SIG1 from the INPUT SIGNAL jack drives the high-impedance field-effect transistor Q1 through a safety network. The midpoint between C1 and C2 is limited to instantaneous levels between ±2 V (clipping starts at ±1.2 V).

As shown in Figure 4-2, the voltage of the desired signal Es appears across the preamplifier input as SIG1, except for a negligible drop in the leads Ri and Ro and in source resistance Rs, if that is reasonably small. En represents an unwanted signal or noise source, which might send large currents through the ground loop Ro and Rg if R1 were not present. (Though there are several physical causes for En, its frequency is usually that of the signal Es.) Because of the resistance values, most of En appears across R1, and a negligible fraction across Ro. Therefore, the noise is largely eliminated from the preamplfier input.

Typically, the preamplifier output signal SIG1AA (60 dB above the SIG1 level) is so much larger than En that the voltage across R1 can be neglected in determining SIG1AB. That is, SIG1AA = SIG1AB, and we simply designate the preamplifier output as SIG1A, without specifying which ground is the reference.

The input-stage field-effect transistor Q1 is biased for best low-noise performance. Its gate is set at −150 mV with respect to its source by the use of R9 and Q4 to set the dc voltage at Q3 emitter. The feedback loop through Q3, Q5, and Q1, by acting to hold Q3 base slightly below that dc level, maintains the desired bias on Q1.

Gain through Q1 and Q3 depends on the feedback from Q5 emitter to TP1. When CA is zero, Q2 is a high impedance and that gain is unity. When CA is +15 V, Q2 effectively grounds C3 and the gain is 20 dB. CA, like CB-, CC-, and CD-series signals is controlled by the GAIN switch, A-S8. Refer to Table 4-1, 1st 2 rows.

Between Q5 and Q8, the signal goes either directly or through a voltage divider. If CB1 is −15 V and CB2 zero, the path is directly through Q6. If CB1 is zero and CB2 is −15 V, the path is through Q7 and a .01 divider, for 40 dB of attenuation. The gain through Q8, Q9, Q10 together is 100, or 40 dB. Refer to Table 4-1, next 3 rows.

Between Q10 and Q14 the signal goes through the 3rd part of the attenuator circuitry. When CC1 is −15 V, the path is direct. When CC2 is −15 V, attenuation is 20 dB, and similarly CC3 switches in 40 dB of attenuation. At any one time, one of the CC-series signals is −15 V; the other two are 0 V. Q14 contributes no gain.

In summary, the preamplifier gain, from SIG1 to SIG1A is −40, −20, 0, 20, 40, or 60 dB depending on the GAIN control setting.

4.3.2 Line Rejection Filter (B board). Figure 6-5.

The LINE REJECTION push button determines whether the signal passes through this filter or not. It does when the push button is in, making CX2 negative 15 V, CX1 zero and Q16 conducts. The straight-through connection is made when the push button is out. CX1 is negative 15 V; CX2, zero; and Q15 conducts. U1 contributes only unity gain except for signal components at frequencies in the rejection "notch".

The active-filter network, Figure 4-3, has 3 equal capacitors, making $\beta = 1$ in the expression for an ideal single-frequency rejection filter:

$$R_{34} = \frac{(1+\beta)\,(1+2\beta)}{\beta}\,R,$$

which has a transmission null at the frequency:[1, 2]

$$f_o = \frac{1}{2\,\pi\,RC\,\sqrt{3\,\alpha\,(1-\alpha)}}.$$

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[1] Hall, H. P., "RC Networks with Single-Component Frequency Control", IRE Transactions – Circuit Theory, Vol CT-2, No. 3, September 1955.

[2] Hall, H. P., "Single-Component-Controlled RC Null Circuits", *GR Experimenter*, July 1961.

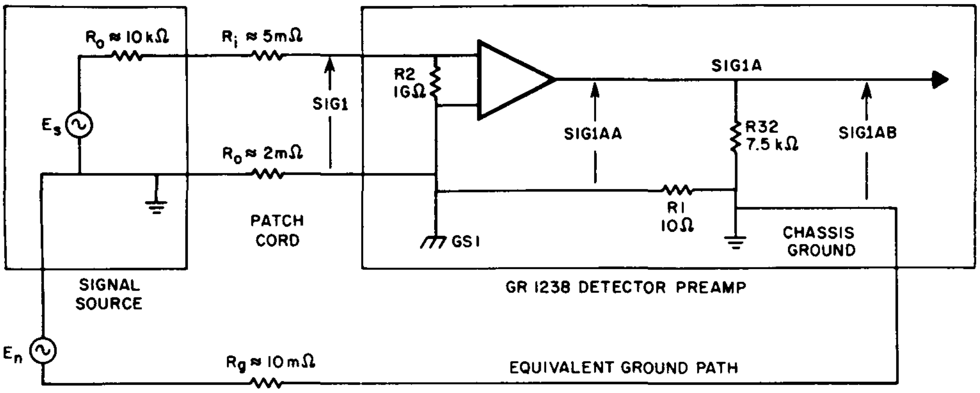

Figure 4-2. Preamplifier circuitry simplified to show the separation of ground GS1 from chassis ground, for the rejection of noise that may be present in a ground loop.

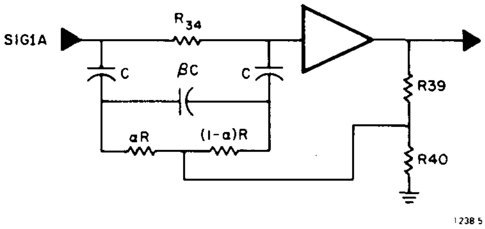

Figure 4-3. The filter used for LINE REJECTION — simplified diagram.

Table 4-1

GAIN-CONTROL LOGIC AND GAIN BY STAGES

Active components in the stage	GAIN control signal	Control-signal states* and dB gain per stage$^{\Delta}$											
(SIG1)	CA	0	0	0	+	+	+	+	+	+	+	+	+
Q1, 2, 3, 5 (Q5E)		0	0	0	20	20	20	20	20	20	20	20	20
	CB2	–	–	–	–	–	–	0	0	0	0	0	0
	CB1	0	0	0	0	0	0	–	–	–	–	–	–
Q6, 7, 8, 9, 10 (Q10C)		0	0	0	0	0	0	40	40	40	40	40	40
	CC3	–	–	0	–	0	0	–	–	0	0	0	0
	CC2	0	0	–	0	–	–	0	0	–	–	0	0
	CC1	0	0	0	0	0	0	0	0	0	0	–	–
Q11, 12, 13, 14 (SIG1A)		–40	–40	–20	–40	–20	–20	–40	–40	–20	–20	0	0
Q34, U4† (SIG3A)		30	30	30	30	30	30	30	30	30	30	30	30
	CD1	–	0	–	0	–	0	–	0	–	0	–	0
	CD2	0	–	0	–	0	–	0	–	0	–	0	–
Q17 . . . Q25 (SIG4)		30	40	30	40	30	40	30	40	30	40	30	40
GAIN-control setting		20	30	40	50	60	70	80	90	100	110	120	130

*States are designated +, –, 0 for +15 V, –15 V, or zero, respectively

$^{\Delta}$U1 and U5 are each unity-gain stages.

†Tuned gain 30 dB; FLAT gain about 5 dB.

There are 2 adjustments (Figure 5-2). R89 trims the effective value of R34. R139 and an associated jumper determine α, keeping R constant at 8.41 kΩ. For an ideal notch, then, R_{34} should be 50.5 kΩ. It is set slightly higher, however, to widen the notch (at the price of imperfect rejection at its center). That choice reduces the notch center frequency very slightly (less than 1%) below f_o in the formula above. The effective notch center frequency is set as desired with R139, which can change α by about ±10%.

The buffer stage, Q34 has unity gain. Its output is designated SIG2.

4.3.3 Digital Tuning Filter (Panel; B board). Figure 4-4.

An RC active filter* amplifies the component of SIG2 to which the filter is tuned. The resonant frequency is the reciprocal of 2πRC. The response characteristic (gain and effective Q) is maintained by keeping the two R's equal, the two ½ C's and the C in proportion to each other, and the effective gain of the amplifier constant. However, the R/C ratio is not critical, as their product is varied in such a way as to select frequency in digital steps to 3 significant figures.

Therefore, the 3 capacitances are tracked together. C changes as you turn the frequency-range switch, from 1.050 down to .001050 μF in 4 decade steps. Similarly, the 2 resistances are tracked together. R changes by parallel combinations (additive conductance) as you turn the 3 FREQUENCY controls, from 0.667 to above 667 μ℧ in digital steps of 0.667 μ℧.

The effective gain of the amplifier is stabilized at a value close to 6 by the inner feedback loop around U4, incorporating the voltage divider R54, R55, and R56. The nominal tuned gain between SIG2 and FDBK is 40 dB; between there and SIG3A, −10 dB; overall, 30 dB.

However, if you set the frequency selector to FLAT, the entire digital tuning network is removed, the outer feedback loop is opened, and 470-Ω resistor is inserted between the signal path at SIG3 and ground. The overall gain between SIG2 and SIG3A is about 5 dB (almost negligible) and untuned.

The following relationships are readily derived from the schematic diagram. They are useful to show how critical are the amplifier gain and the matching of resistor or capacitor sets in determining the gain and bandwidth of the active filter. The filter gain is G; at resonance, it is G_o; $2\pi f_o = \omega_o$; and Q is the ratio of resonant frequency to bandwidth.

$$G = \frac{\text{"FDBK"}}{\text{"SIG2"}} = \frac{K}{A + j\omega B + D/j\omega}$$

$$G_o = K/A,\quad \omega_o = \sqrt{D/B},\ \text{and}\ Q = \sqrt{BD}/A,$$

where A, B, and D depend on component values, but A also on K; and where K is the amplifier gain (with the inner feedback loop closed).

$$A = 1 + \frac{C_3}{C_1} + \frac{C_2}{C_1}\left(1 + \frac{R_1}{R_2} - K\right) + \frac{R_1}{R_2},$$

$$B = R_1 \frac{C_3}{C_1}(C_1 + C_2),\ \text{and}\ D = \frac{1}{R_2 C_1},$$

where the subscripts are assigned left-to-right in Figure 4-4; the nominal values are so related that: $C_1 = C_2 = ½\,C_3$ and $R_1 = R_2$. Ideally, to make $G_o = 100$, $K = 5.94$; and to make the bandwidth 3%, $Q = 33$.

The digital tuning network is mounted on its front-panel switch assembly and shown schematically in Figure 6-4. However, a set of 4 trimmer capacitors is located with U4 on the B board:

C26, between FDBK and TRIM1, trims the upper ½C;
C25, between TRIM2 and TRIM1, does the same on range 3;
C27, between SIG3 and ground, trims C;
C20, between TRIM3 and ground, trims C on range 3;
where range 3 spans 1.0 to 10 kHz.

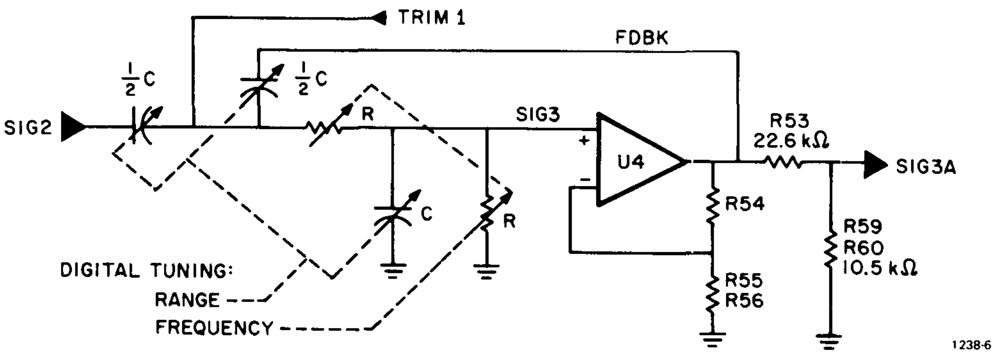

Figure 4-4. The filter used for tuning FREQUENCY – simplified diagram.

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*Sallen and Key, "A Practical Method of Designing RC Active Filters," *IRE Transactions* – Circuit Theory, Vol CT-2, No. 1, March 1955.

4.3.4 Compressed/Linear Amplifier (B board). Figure 6-7.

The signal SIG3 next passes through an attenuator, 0 or 10-dB loss, and 2 amplifiers that buffer the compression network and contribute 40 dB of gain. The attenuator is switched by the GAIN control, which acts by making the CD2 level −15 V to enable direct conduction through Q17 or the CD1 level −15 V to select the lossy path through Q18. CD1 is zero when CD2 is −15 V and vice versa.

Q19, Q20, and Q21 together contribute a gain of 6 (15.5 dB). Q23, Q24, and Q25 together have a gain of 17 (24.5 dB).

The COMPRESSION push button makes CZ negative 15 V (zero), for the in (out) position, closing (opening) the circuit through Q22 and the pair of diodes CR5/CR6.

Since full scale on the MAGNITUDE meter corresponds to 2.25 V rms (3.18 V pk) at WT57 and the same at the output of Q25, a gain of 17 means the corresponding level at Q23 base is 187 mV pk. That level is characteristic whether you select compression or not. However, without compression there is no attenuation between Q21 and Q23; with compression this attenuation is a factor of 10. R71 is adjusted for that purpose.

The factor-of-10 compression can be expressed by means of an auxiliary scale on the MAGNITUDE meter, with 1000 at the top instead of 100. Such a scale, drawn straight, is provided in Figure 4-5

4.3.5 Output Amplifier/Meter Rectifier (B board).

The output amplifier U5 has unity voltage gain. It drives the phase detectors, the AMPLIFIER OUTPUT circuit, and the MAGNITUDE meter rectifier with SIG4, isolating Q25 from these loads. VR21 and VR22 limit the voltage level ahead of U5 to 6.1 V pk, for protection of the circuits that follow. Therefore, SIG4 can be 0-4 V rms without clipping.

The full-wave rectifier CR7/CR8 is followed by large capacitors, in a voltage-doubler circuit which make the MAGNITUDE-meter peak-responsive. R85 and R86 limit its current to the full-scale value (200 μA) at full AMPLIFIER OUTPUT voltage of 2.25 V rms. Pins A and B of the DC METER OUTPUTS jack connect the rectifier to your optional, remote, ungrounded magnitude meter, which should have current-limiting resistance similar to that of R85/R86, or to a dc recorder with impedance of 25 kΩ or more.

4.3.6 Phase Splitter (C board). Figure 6-10.

There are 2 identical C boards, distinguished by the letters I (in phase) and Q (quadrature) in this discussion.

> NOTE
>
> C-board signals named in the following few paragraphs are in the "I" category except for names in parenthesis, which are the "Q" equivalents.

The phase splitter circuit Q201/Q202/Q203 passes the REFERENCE INPUT signal REFI (or REFQ) with negligible gain or phase shift, the corresponding output being NORTH (or EAST). This circuit also generates the inverse signal SOUTH (or WEST) so that the pair of outputs are 180° apart in phase.

Therefore, the outputs NORTH, EAST, SOUTH, and WEST are 90° apart as their names imply, with the sense of the sequence determined by the externally supplied signals. Normally, the QUADRATURE REFERENCE INPUT leads the IN PHASE; then EAST leads NORTH, but the converse is possible.

4.3.7 Phase Shifter (panel, D board). Figure 6-12.

The PHASE SHIFT switch A-S1 and continuous control A-R3/A-R4 enable you to rotate the phase-detector reference pair PHASI/PHASQ to any desired phase positions in the entire 360° circle of possibilities.

The PHASE SHIFT switch works as follows, if the continuous control is set at 0°: for switch positions 0°, 90°, 180° 270°, PHASI becomes NORTH, EAST, SOUTH, WEST, respectively; and PHASQ is always 90° ahead, i.e., EAST, SOUTH, WEST, NORTH, respectively. The PHASE SHIFT continuous control shifts both PHASI and PHASQ through an angle of ±50° about the positions just described, but keeps them always essentially 90° apart. The two FINE ADJUST controls are uncalibrated (in contrast with the PHASE SHIFT switch and continuous control); one shifts the phase of PHASI, the other of PHASQ, over ±10° ranges.

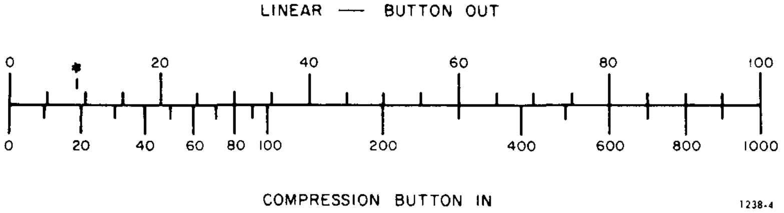


Figure 4-5. MAGNITUDE meter responses. Upper scale: linear with voltage, as marked on meter. Lower scale: compressed, units being percentage of full-scale linear response. Compressed scale is not on the meter. Asterisk (*) marks ideal (noise-free) level of full-scale IN PHASE meter response.

They have adequate range to enable you to set PHASI and PHASQ exactly 90° apart, for any combination of control settings, with REFQ as much as 5° away from its nominal quadrature phase relation to REFI.

If REFQ leads REFI by 90°, as is recommended in the 1621-system instructions, EAST leads NORTH, PHASQ leads PHASI, the PHASE SHIFT calibrations are degrees that PHASI leads REFI, upscale on the QUADRATURE meter indicates a component leading the upscale-IN-PHASE-meter component by 90°, and that component, in turn, leads the IN PHASE REFERENCE INPUT signal by the PHASE SHIFT angle. However, if REFQ lags REFI, replace "lead" with "lag" in the preceding statement.

The D board is mounted to the rear of the PHASE SHIFT switch A-S1 and serves as terminal board as well as mount for fixed resistors associated with the potentiometers mentioned above.

4.3.8 Squaring Amplifier and Synchronous Switch (C board).

The sinusoidal phase reference PHASI (or PHASQ) passes through buffer Q204 to the inverting (–) input of comparator U201 which is used as a zero-crossing detector. The moment PHASI goes "+", the output of U201 jumps to –0.5 V; when it goes "–", to +3.2 V. A small amount of hysteresis is provided by the feedback through R218 and C207 so that the comparator will make only one transition at every substantial zero-crossing of PHASI, and not respond to possible low-level noise. (U201 has a response time less than 0.1 µs.)

Q205 current is turned on and off "hard" for equal time intervals. The output of Q206 is a symmetrical square wave of nearly the full ±15 V amplitude permitted by the power supplies. Feedback through R224 improves the symmetry of the above-mentioned hysteresis and enhances the overall stability.

The heart of the phase-sensitive detector is the synchronous switch, Q207 driving Q208, both field-effect transistors.

The square wave from Q206 serves to open and close the synchronous switch, driving d-c buffer amplifier U202 with that "slice" of SIG4 which coincides with the "+" half of the square wave. During that half cycle, diodes CR204 and CR205 are nonconducting; Q208 is "on" because Q207 is "on"; but the latter blocks even leakage or the transient current through the capacitance of CR204 from reaching Q208 or the signal path to U202. During the "–" half cycle, both diodes conduct, both Q207/Q208 gates are biased strongly negative, and R230 pulls the signal at U202 down to zero.

4.3.9 Time-Constant Circuit and Meter Driver.

The unity-gain buffer U202 provides a low-impedance source for the time-constant circuit (C216 is series with A-R10 . . . A-R19). TIME CONSTANT switch A-S2 selects the resistors in pairs, so that the I and Q phase detectors always have the same time constant. It is simply the product of the values of the selected resistor and C216.

Meter driver U203 has a gain of 3, between its input SIG6 and its output MTRI (or MTRQ). For minimum SENSITIVITY, full scale on the IN PHASE meter (for example) corresponds to MTRI = 1.5 V; for maximum SENSITIVITY, 245 mV. The latter corresponds to SIG6 = 82 mV, SIG4 = 280 mV pk = 200 mV rms, and a MAGNITUDE meter reading of 9 or 10 (about –20 dB referred to full scale), assuming the signal is in phase.

Service and Maintenance–Section 5

5.1 GR FIELD SERVICE.

Our warranty (at the front of this manual) 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 the nearest GR service facility (see back page), giving full information of the trouble and of steps taken to remedy it. Describe the instrument by type, serial, and ID numbers. (Refer to front and rear panels.)

Instrument Return. Before returning an instrument to GenRad for service, please ask our nearest office for a "Returned Material" number. Use of this number in correspondence and on a tag tied to the instrument will ensure proper handling and identification. After the initial warranty period, please avoid unnecessary delay by indicating how payment will be made, i.e., send a purchase-order number or (for transportation charges) request "C.O.D."

For return shipment, please use packaging that is adequate to protect the instrument from damage, i.e., equivalent to the original packaging. Advice may be obtained from any GR office.

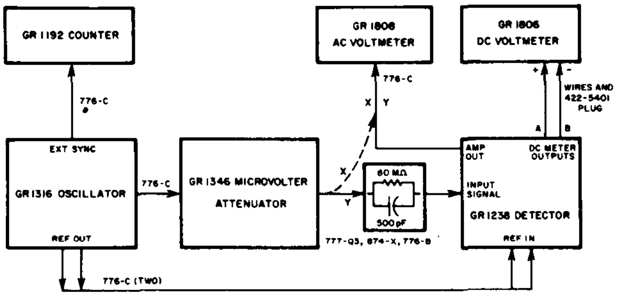


Figure 5-1. Test setup for performance evaluation. X-X and Y-Y represent alternative cable arrangements; do not use switches.

5.2 MINIMUM PERFORMANCE STANDARDS.

5.2.1 General. **Figure 5-1.**

The equipment, methods, and criteria for verifying the specified performance of the 1238 Detector are given below. Pertinent adjustments are described in para. 5.4 and 5.5 If performance is grossly inadequate, erratic, or cannot be corrected by the adjustments, refer to trouble analysis, para. 5.6.

Equipment needed for the measurements and procedures of this section is listed in Table 5-1. Set the front-panel controls to the standard positions of Table 5-2, except as specified otherwise, in all the procedures of Section 5.

CAUTION

Keep the oscillator level below 10 V to safeguard the attenuator.

5.2.2 Gain and Tuning.

Use the following procedure to check the gain and tuning, first with an indicated FREQUENCY of 515 Hz.

a. Make the test setup shown in Figure 5-1. Supply the attenuator with an external, series, high-impedance load in an 874-X Insertion Unit, through which the signal goes to the 1238 Detector INPUT SIGNAL jack (connection Y). The alternative connection, to measure the voltage at the attenuator output (connection X) is to be made by rearranging cables; switches are not recommended. Make initial settings as listed in Tables 5-2 and 5-3, except tune the 1238 Detector to an indicated FREQUENCY of 515 Hz.

NOTE

The high series impedance simulates the internal impedance of the 1616 Precision Capacitance Bridge.

Table 5-1

TEST EQUIPMENT

Item	Requirements	Recommended Type*
Oscillator	Frequency: 10 Hz – 100 kHz Voltage: 0-4 V rms into 600 Ω Distortion: <0.2% (100 Hz-10 kHz) Output impedance:< 5 Ω Reference outputs: 2-phase, phase separation: 90 ±10°, voltage: 1.25 ±0.25 V rms into 50 kΩ.	1316
Electronic Voltmeter	Voltage range: 1.5 – 150 V F.S. Ac accuracy: ±1% of reading ±0.1% of FS, (up to 3 times worse below 40 Hz). Frequency range: 10 Hz to 200 kHz Scales: Volts rms and dBm (ref 1 mW into 600 Ω).	1808
Electronic Voltmeter	Voltage range: 1.5 – 150 V F.S. Dc accuracy: ±2% of reading Input impedance: 10 MΩ.	1806
Attenuator (metered)	Audio-frequency "microvolter". Attenuation: 0-120 dB in 20-dB steps; Accuracy: ±.04 dB/step ± 154 dB below input level. Frequencies: 10 Hz – 100 kHz Accuracy of meter: ±4%.	1346
Counter	General-purpose	1192
Scope	General-purpose, with plug-in differential amplifier, time base, and probe.	Tektronix 5103N/D10, 5A20N, 5B10N and P6060.
Adaptors	Connectors: shielded banana, 874. Component mount with 874 connectors.	777-Q3 874-X
Patch cords (cables)	With connectors: BNC, BNC; length: 36" (5 required) With connectors: BNC, 874; length: 36".	776-C 776-B
Resistors	Type: composition Power: 1/8 W Values: 18 MΩ ±10% (2); 22 MΩ ±10% (2) (or any other combination to make 80 MΩ).	Ohmite "Little Devil"
Capacitors	Type: mica Value: 510 pF ±10%	Cornell-Dubilier CD19 . . .
Metered adjustable autotransformer	Output line voltage 0-117% of input line (nominal 120 V). Meters: 0-150 V, 0-1 and 0-5A, 0-150 and 0-750 W.	

***Equivalents may be substituted.**

Table 5-2

STANDARD SETTINGS FOR 1238 EVALUATION

Control	Setting
POWER	ON
FREQUENCY	FLAT
TIME CONSTANT	0.3 s
FINE ADJUST	Midrange (both controls)
PHASE SHIFT	180° (large dial at 0°)
SENSITIVITY	Minimum (ccw)
GAIN	40 dB
COMPRESSION	Disabled (button out)
LINE REJECTION	Disabled (button out)

Table 5-3

PRELIMINARY SETTINGS IN TEST SETUP

Instrument	Control	Setting
1316 Oscillator	FREQUENCY	500 Hz
	OUTPUT V RANGE	1.5 V
	OUTPUT ADJUST	MAX (cw)
1346 Microvolter	METER F S	ATTEN ONLY
	F S OUTPUT V	40 dB
	OUTPUT	ON
1192 Counter	GATE TIME	1 s
	FREQUENCY	button in
	All other buttons	out
	AC/DC	AC
	TRIGGER LEVEL	midrange
	DISPLAY	1 s
1806 Voltmeter	MEASUREMENT	DC+
	DC INPUT R	100 M
	DC ZERO	See 1806 manual
	Terminal configuration	Ungrounded
	VOLTS F S	15
1808 Voltmeter	Range	1.5 V (0 dBm)

Table 5-4

GAIN CHECKOUT

Attenuator dB	INPUT dBm†	INPUT rms	GAIN dB	OUTPUT* dBm†	OUTPUT* V
0	-15	138 mV	20	5	1.38
20	-35	13.8 mV	30	-5	0.44
			40	5	1.38
40	-55	1.38 mV	50	-5	0.44
			60	5	1.38
60	-75	138 µV	70	-5	0.44
			80	5	1.38
80	-95	13.8 µV	90	-5	0.44
			100	5	1.38
100	-115	1.38 µV	110	-5	0.44
			120	5	1.38
120	-117Δ	1.09Δ µV	120	3	1.09
			130	13	3.46

† Level in dB referred to zero at 774.6 mV (1 mW in 600 Ω).
* Nominal level.
ΔNominal; set as required to obtain 3 dBm when GAIN = 120.

b. Verify that the 1238 digital tuning filter is peaked within ±5% of the FREQUENCY setting, as follows. Tune the oscillator to a peak response on the ac voltmeter. The 3rd FREQUENCY dial of the oscillator has a continuous adjustment range slightly in excess of a decade, to facilitate such tuning. Reduce the oscillator level (OUTPUT ADJUST) if necessary to keep the voltmeter reading on scale. Read the frequency on the counter; for a nominal 515 Hz, the acceptable range is 489-541 Hz.

c. Verify that the tuned gain is 40 ± 3 dB for the GAIN setting of 40 dB, as follows. Use the ac voltmeter to measure the level at the attenuator (connection X in Figure 5-1). Drop the attenuator setting to 20 dB and set the oscillator output so that measurement is –35 dBm (13.8 mV) The oscillator level will be about 138 mV.

Now rearrange the cables so the ac voltmeter measures the AMPLIFIER OUTPUT of the 1238 Detector (connection Y); the voltmeter should read 5 dBm (acceptable: 2-8 dBm or 0.975-1.943 V rms). Record the measurement, preferably in dBm, for later reference.

d. Verify that the FLAT gain is below the tuned gain by no more than 31 dB (25 is nominal) as follows. Reset the oscillator level for a voltmeter reading of 5 dBm. Switch the 1238 frequency range to FLAT and the 1346 attenuator to 0 dB. The voltmeter should read –6 dBm or higher. Return the attenuator to 20 dB.

e. Verify that the 2nd-harmonic rejection is at least 30 dB, as follows. Tune the oscillator to double the frequency of step b (as indicated accurately by the counter). Reset the voltage at the attenuator output (connection X) to –35 dBm. Return the 1238 frequency-range switch to the proper test-frequency setting of step c, and the voltmeter to connection Y. The voltmeter should read less than –25 dBm, such as –30, assuming you read 5 dBm in step c.

f. Verify that the GAIN steps are 10.0 ± 1.1 dB each, and that the cumulative error never exceeds 5.5 dB, as follows. Retune oscillator and detector to approximately 515 Hz as in step b. Set the oscillator level as before, so the output from the attenuator at 0 dB is –15 dBm (connection X). Set the 1238 GAIN to 20 dB and reconnect the voltmeter to read OUTPUT (connection Y). Record the output level, preferably in dBm.

Refer to Table 5-4; you have set up the first row (step c was the 3rd row). Similarly, check each of the GAIN settings from 20 to 120 dB and record the measured output. The easiest way to handle the results is to add 10 dB to every other measurement (nominal value –5 dBm) so that all results are nominally 5 dBm. Any two adjacent measurements may differ by as much as 1.1 dB. The largest and smallest may differ by as much as 5.5 dB.

NOTE

> At small input signal levels, take an average reading on the voltmeter. To be sure the OUTPUT voltage measures signal, not noise, observe whether the indication drops by 20 dB for a 20-dB increase of attenuation.

If, for example, with GAIN = 100 dB, when you switch the attenuator from 80 to 100 dB, the OUTPUT measurement drops from 3.2 dBm (the nominal is 5 dBm) to –16.5 dBm, the noise accounts for about 0.3 dB. If it is necessary to obtain maximum accuracy, because you are in doubt about the instrument meeting the specifications, then, use a higher signal level. But never go high enough to make the OUTPUT 14.3 dBm (4 V rms). In this example, go back to the 80-dB setting and raise the oscillator level 10 dB (to a reading of 13.2 dBm). Then correct subsequent output measurements, by subtracting 10 dB, to complete your set of data.

When the attenuator reads 120 dB, increase the oscillator level as required to get a signal clearly above noise (3 dBm average OUTPUT reading is recommended) before switching to a GAIN of 130 dB. Verify that the OUTPUT increases by 10 dB ± 1.1 dB between the GAIN settings of 120 and 130 dB. Finally, verify that the signal you have is coming through the attenuator (not a stray path) by switching the microvolter OUTPUT control OFF and ON. The OFF indication should be less, by at least 6 dB.

This completes the 515-Hz checkout. Now make a similar checkout, except for the GAIN control steps, at 4 other frequencies, as follows.

g. Reset the 1238 Detector to 49.9 Hz. Repeat steps b, c, d, e. Repeat also for 1238 Detector FREQUENCY settings of 6.51 kHz, 33.3 kHz, and 97.7 kHz, except step e for the highest frequency.

5.2.3 Line Rejection.

The following procedure is to check the line-frequency rejection filter. Use the test setup as before, but set the 1238 frequency range to FLAT, the 1346 attenuator at 20 dB, and the 1238 GAIN at 40 dB.

a. Tune the oscillator to 40 Hz and set its OUTPUT ADJUST for an attenuated voltage (connection X) of –9 dBm. Retune to 50, 60, and 70 Hz, watching the voltage. If it stays within ±0.1 dB (±1% in voltage), the variation can be neglected; otherwise the level should be reset for each new frequency in steps b, c, below.

b. Determine the central frequency to which the filter is adjusted and verify the 40-dB rejection as follows. Depress LINE REJECTION. Measure the AMPLIFIER OUTPUT level (connection Y) for oscillator frequencies of 50 and 60 Hz. The lower reading is central. Check that it is at least 40 dB (2 steps of the voltmeter range switch) below the level measured with the LINE REJECTION button "out."

c. Verify that skirt rejection is within specifications, as follows. Tune the oscillator 10 Hz above the central frequency. Check that the difference between LINE REJECTION "in" and "out" is at least 6 dB but no more than 10 dB. Retune to a frequency 10 Hz below the central frequency and repeat this check. Finally, leave the push button "out."

5.2.4 Magnitude Calibrations.

This procedure verifies that the MAGNITUDE meter is calibrated properly with respect to the output level both without and with compression.

a. Set the oscillator OUTPUT VOLTAGE RANGE to 1:5, the 1346 attenuator to 40 dB, the 1238 GAIN to 50 dB, FREQUENCY to 515 Hz, and tune the oscillator for peak output, as before. The dc meter should already be connected, ungrounded, between pins A and B of DC METER OUTPUTS. (See Figures 2-6 and 5-1.)

b. Adjust the oscillator level so the 1238 MAGNITUDE meter is deflected precisely to full scale. Check that the dc voltmeter reads 6.0 V ±10% (5.4 – 6.6 V). (Normally, the corresponding ac voltmeter reading is about 2.3 V.)

c. Depress the COMPRESSION pushbutton and switch the attenuator to 20 dB. The dc voltmeter should read the same as in step b, within ±10%.

d. Release the pushbutton. Reset the attenuator to 40 dB.

5.2.5 Phase-Sensitive Circuitry.

Check as follows that the PHASE SHIFT controls are functional and that the phase-sensitive meters respond with the required sensitivity. The test frequency should be 515 Hz and the MAGNITUDE meter should already be reading at full scale. Reconnect the dc meter to pins D and H (ground) of DC METER OUTPUTS.

a. Reduce the signal level 20 dB by switching the attenuator to 60 dB. Set SENSITIVITY to maximum (cw). Set the PHASE SHIFT dial for maximum deflection (+ or –) of the IN PHASE meter. Concurrently, set the oscillator OUTPUT ADJUST to make that deflection exactly full scale. Check the zero condition by switching the 1346 Microvolter OUTPUT to OFF for a moment; the IN PHASE meter should then read 0 ± 1/2 division.

b. Check that the dc voltmeter reads 243 mV ±20% at full scale on the IN PHASE meter, + if this meter reads +, and conversely. (The limits are 190-295 mV.)

c. Check that the 2 phase-sensitive channels have similar gain, as follows. Switch the PHASE SHIFT 90° and peak the QUADRATURE meter using the PHASE SHIFT dial. The reading should be full scale, within ±1 division. Check the zero as in step a.

d. Check that the 2 phase-sensitive channels can be made orthogonal and that the FINE ADJUST control is functional as follows. While the QUADRATURE meter reads FULL SCALE, set the IN PHASE meter to zero, using the PHASE SHIFT dial. Verify that this zero occurs at different settings on that dial, depending on the IN PHASE FINE ADJUST knob. These settings should cover a range of at least 10° (nominal 20°) on the PHASE SHIFT dial. Leave the FINE ADJUST knob at midrange and the IN PHASE meter reading zero. Notice the PHASE SHIFT reading for a reference.

e. Check the continuity of the IN-PHASE-channel phase shift as follows. Rotate the PHASE SHIFT dial approximately 45° each side of that reference. The meter deflection should vary smoothly with this rotation, reaching about ±35 on the meter scale. Find another reference phase where this meter reads zero (approximately 180° from the first one) and repeat. Near one zero, the meter deflects in the same direction as you rotate the dial, near the other, in the opposite direction.

f. Similarly, check the QUADRATURE-channel phase shift. This meter should read zero about 90° from the phase reference found in step d. Deflection should be in both senses, as before.

g. Check the zero adjustment of the phase-sensitive meters, when the time constant is large, as follows. Set TIME CONSTANT to 10 s, GAIN to 20 dB, and the Microvolter OUTPUT OFF. Wait at least 2 minutes. Verify that these meters read 0 ± 1 division. Return TIME CONSTANT to 0.3 s and Microvolter OUTPUT to ON.

h. With GAIN at 50 dB, set PHASE SHIFT controls (nearer 180° than 0°) for peak on the IN PHASE meter.

i. Check noise level as follows. 1346 Microvolter:

METER FULL SCALE – 1 V, ac
FULL SCALE OUTPUT VOLTAGE – 1 μV
LEVEL – maximum (cw)

Disconnect the counter and both voltmeters from the test setup. Set the 1238 TIME CONSTANT to 10 s. Set the oscillator level for 1/10 full scale on the Microvolter meter; then turn the Microvolter OUTPUT OFF. Set the 1238 GAIN to 130 dB.

The noise level may be rather large on the MAGNITUDE meter (such as 35) but the average reading of the IN PHASE meter should be 0 ± 15 (0 ± 3 divisions). If not, check that the oscillator and detector are securely fastened in their cabinets, cables are reliably shielded, and the front-panel output terminals of the attenuator are also shielded.

j. Verify that the low-frequency sensitivity is 100 nV or better for full-scale deflection, as follows. Switch the 1346 Microvolter OUTPUT ON. The IN PHASE meter should deflect to 50 or offscale. Allow at least 30 s for the circuit to stabilize.

k. Check that the sensitivity at 100 kHz is better than 100 nV for 2/3-scale deflection, as follows. Set:

Detector FREQUENCY – 97.7 kHz
TIME CONSTANT – 0.3 s
GAIN – 120 dB
1346 Microvolter FULL SCALE – 10 μV.

Tune the oscillator for maximum MAGNITUDE response. With SENSITIVITY fully cw, set PHASE SHIFT so the QUADRATURE meter reads 0 ± 3 div while the IN PHASE meter points off scale to the right. (The oscillator level should be about 0.2 V.)

l. Check the noise level as in step i. The noise level on the MAGNITUDE meter will be larger than before (such as 90) but the average reading on the IN PHASE meter should be 0 ± 20 (0 ± 4 divisions).

m. Switch the Microvolter OUTPUT ON. Within 30 s, the IN PHASE meter should deflect at least to 35 (possibly off scale). Readjust PHASE SHIFT controls if necessary to bring the QUADRATURE reading (avg) to 0 ± 25. Switch the PHASE two steps (180°). The IN PHASE meter should slowly reverse polarity. This completes the performance checkout.

5.3 DISASSEMBLY. **Figure 2-4.**

5.3.1 Cabinet Removal.

Remove the 4 front-panel screws (A) accessible through holes in the handles. Disconnect all cables and the power cord at the rear. Slide the instrument forward out of the cabinet. For more detail, refer to Section 2.

5.3.2 Lamp Removal.

For replacement of a burned-out lamp, use the following guidelines:

a. With the cables disconnected, slide the instrument forward, out of its cabinet a few inches, as described above. The lamp holders will be apparent, one directly behind each decimal point in the FREQUENCY readout. The uppermost terminal of each (wired together and to ground) is part of the retaining clip.

b. Slip the clip off by lifting this terminal up and back; then unhook the lower part of the clip.

c. Pull the lamp out toward the rear, using a bit of adhesive tape, or tip the instrument so the lamp falls out.

d. To replace the retaining clip behind a new lamp, engage the lower part first. Then lift the upper part up and forward, snapping it into position.

5.3.3 Knobs and Dials – Removal.

CAUTION

Do not pull on the dial to remove a dial/knob assembly. Always remove the knob first. Do not use a screwdriver or other instrument to pry off the knob if it is tight, since this may damage the dial. Do not lose the spring clip in the knob when it is removed.

To remove the knob and dial (if any) from 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 dry fingers close to the panel and pull the knob straight away from the panel.

b. Observe the position of the setscrew in the bushing when the control is fully ccw.

c. Release the setscrew with an Allen wrench; pull the bushing off the shaft. The dial will come off with the bushing.

NOTE

To separate the bushing from the knob, if for any reason they should be combined off the shaft, drive a machine tap a turn or two into the bushing to provide sufficient grip for easy separation. If the retention spring in the knob falls out, reinstall it in the interior notch with the small slit in the inner diameter of the wall.

5.3.4 Knobs and Dials – Replacement.

To replace a knob (with or without a dial):

a. Slip the bushing on the shaft and rotate the former to the correct position as observed in disassembly.

b. Hold the bushing in position so it, or the attached dial, is spaced away from the panel by at least the thickness of a filing card. Hold the bushing even farther forward, if necessary, to prevent the shaft tip from protruding. However, hold the PHASE SHIFT dial back, so its front surface is flush with the panel.

c. Tighten the setscrew in the bushing.

d. Place knob on bushing with retention spring opposite the setscrew.

e. Push knob on until it bottoms and pull it lightly, to check that the retention spring is seated in groove in bushing.

5.3.5 – Shield Covers.

The bottom cover, extending under two thirds of the instrument, can be removed for access to the mother-board circuitry. Remove 6 screws along the front and rear edges of the cover, ***not*** the other 4 screws (which hold transverse shields). The cover is off in Figure 5-3.

Lift out the preamplifier shield (in the left rear corner, Figure 5-2), if necessary, after removing 5 screws. One screw shows clearly in the figure, 2 others are at the rear, and 2 at the side of the instrument.

For access to the rectifier circuitry atop the power transformer (A-T1), remove the 2 screws and cover. (Only the screw holes show in the figure; the cover is off.)

5.4 OUTLINE OF ADJUSTMENTS. Figures 5-2, 5-3.

This paragraph lists adjustments in alphanumeric order, giving their purposes. Instructions for setting most of these are given in para. 5-5. You can locate all adjustments but one, by reference to Figure 5-2; B-R108 is in Figure 5-3.

B-C20. Trims resonant frequency of digitally tuned active filter, on lower "kHz" range only (Set after C27.)

B-C25. Trims resonant gain of same filter (SIG3A/SIG2) on lower "kHz" range only. (Set after C26.)

B-C26. Trims resonant gain of that filter on upper "kHz" range (minor effect on lower ranges). Interacts noticeably with C27 (both affect gain, but in the opposite sense).

B-C27. Trims resonant frequency of that filter on upper "kHz" range (minor effect on lower ranges). Interacts noticeably with C26 (both affect frequency in the same sense).

B-R9. Sets bias level of preamp input stage (for minimum noise level).

B-R55. Sets low-frequency-resonant (and FLAT) gain of digitally tuned active filter (SIG3A/SIG2).

B-R71. Sets the COMPRESSION level.

B-R86. Sets the MAGNITUDE meter response with respect to the AMPLIFIER OUTPUT level (SIG4).

B-R89. Trims the shape of the LINE REJECTION notch, i.e., the effective Q of the filter. Also affects the resonant frequency, secondarily.

B-R108. Main power-supply regulator adjustment.

C-C214. Trims square-wave drive for synchronous switch, at high freq, for 0 phase-detector offset.

C-R231. Trims dc level of SIG5 for zero offset of phase detector (low frequency and small TIME CONSTANT). Interacts with R234.

C-R234. Trims level of current injected at SIG6 for zero offset of phase detector (low frequency and large TIME CONSTANT).

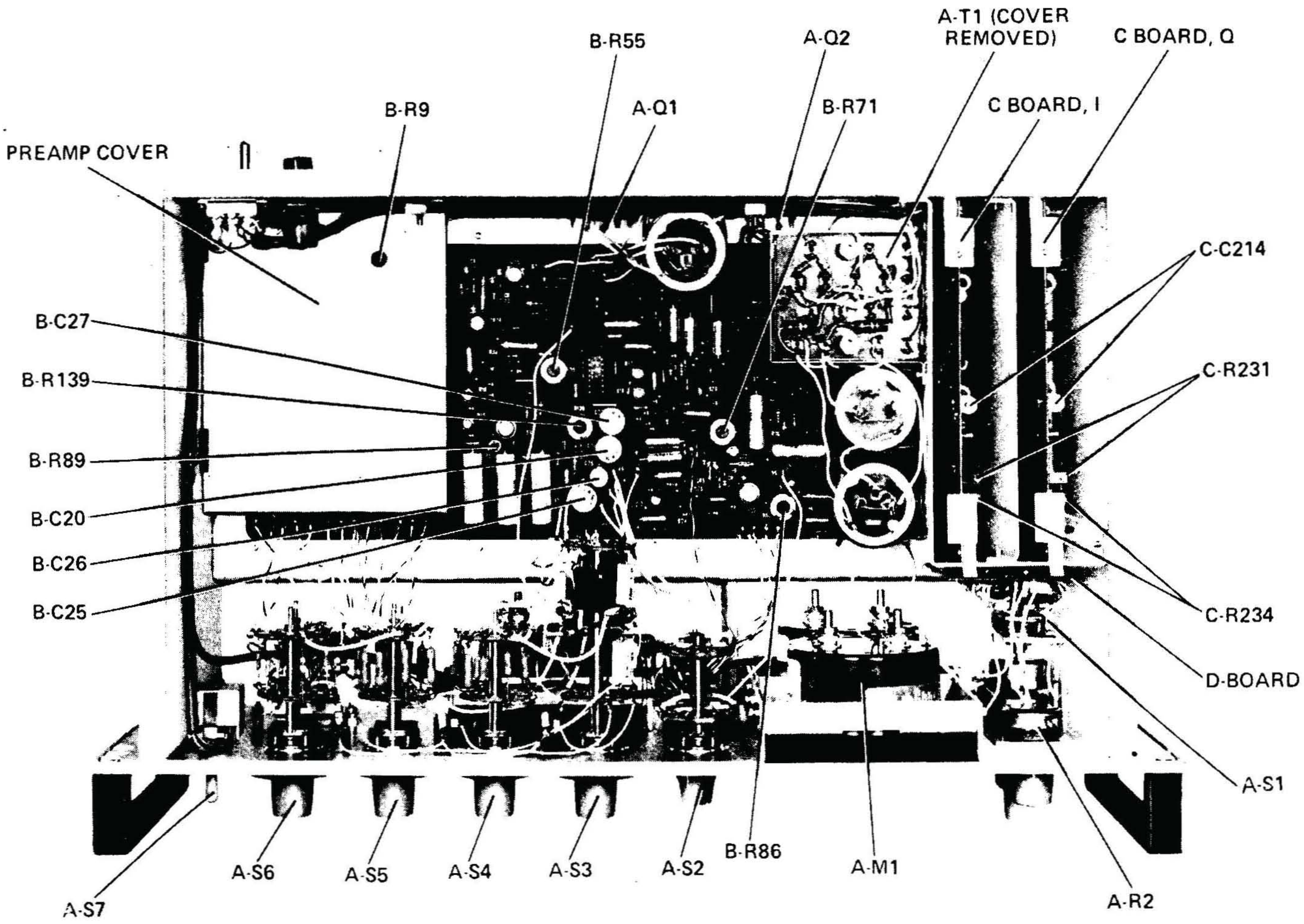


Figure 5-2. Interior, top view.

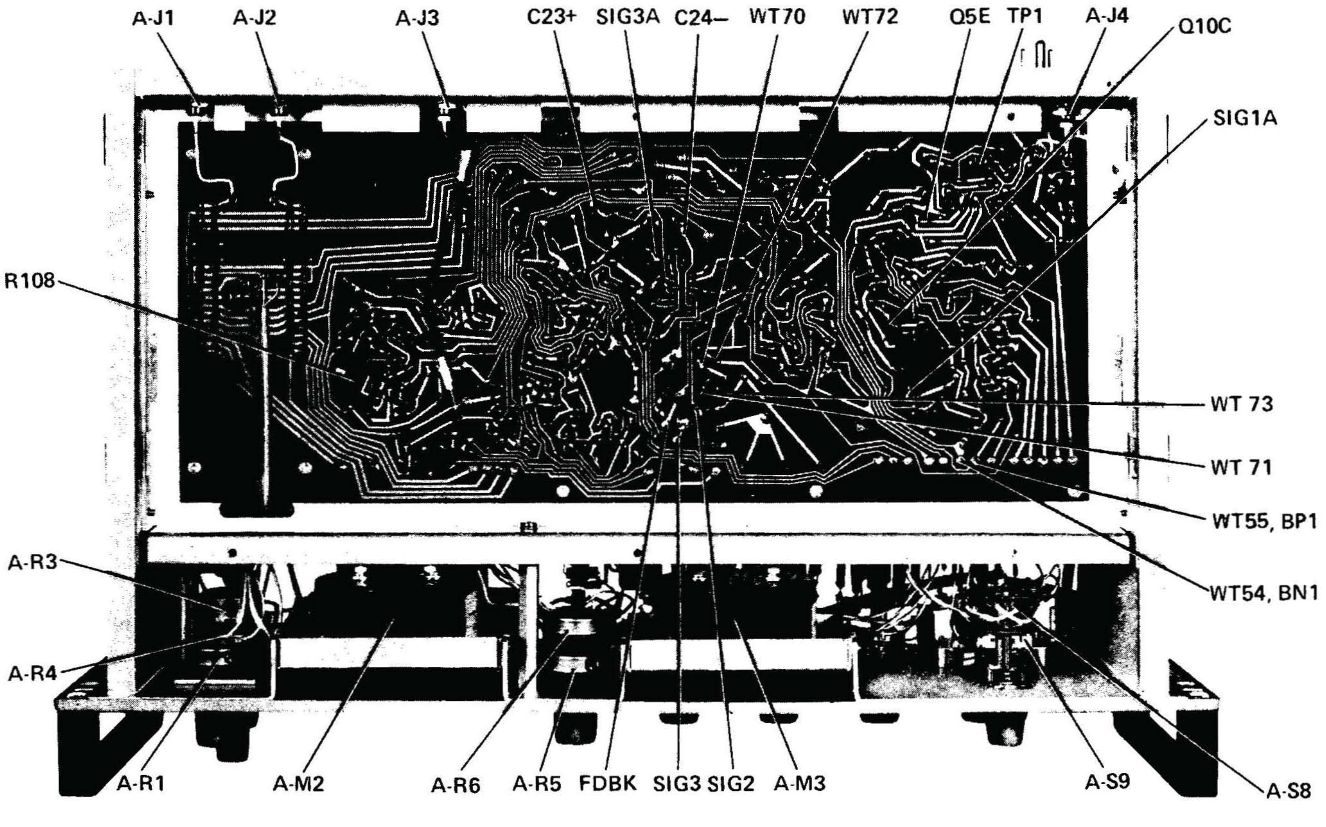


Figure 5-3. Interior, bottom view, shield cover removed. Designators not starting with A- have a B- prefix assumed.

5.5 ADJUSTMENT PROCEDURES.

The following discussion explains the purpose and conditions for each adjustment, without any detail about setup. The sequence is logical for a complete readjustment of the instrument, but nearly any one adjustment can be implemented separately. Refer to para. 5.2 for details of instrumentation and measurement.

NOTE

After making each adjustment (except in para. 5.5.1 and 5.5.2) lay a sheet of aluminum across the top of the instrument to simulate the cabinet and notice whether the parameter you have set is affected. If it is, readjust to obtain the desired results with the sheet in place.

5.5.1 Power Supply.

Set the main negative supply voltage to −15.0 V dc with B-R108. Do so with a voltmeter connected from chassis ground (GS3) to the case of A-Q2 (WT35) on the rear panel. A-Q2 is farther from the fuse than A-Q1 (Figure 5-2).

5.5.2 Preamplifier Input-Stage Bias.

Set the voltage at TP1 to 150 mV for FET's with 4 leads, 750 mV for FET's with 3 leads with B-R9. Use an ungrounded voltmeter connected from the shell of A-J4 (WT2) to TP1 (Figure 5-3).

5.5.3 Low-Frequency Gain.

Set the tuned gain (SIG4/SIG1) to 20 dB with B-R55. Be sure to tune the oscillator for maximum output with the detector FREQUENCY set to 500 Hz; the COMPRESSION button must be "out" and GAIN at 20 dB. Measure INPUT SIGNAL (SIG1) and AMPLIFIER OUTPUT (SIG4) as in para. 5.2.

5.5.4 Magnitude Meter Calibration.

Set the MAGNITUDE meter to full scale when the corresponding DC METER OUTPUT is 6.0 V dc, using B-R86. The points to monitor are pins A and B (+ and −, respectively); see Figure 2-6. The signal level should be large enough to calibrate with a GAIN setting of 100 dB or less, thus assuring a noise-free output.

5.5.5 COMPRESSION Adjustment.

Set the compression to 20 dB with B-R71, as follows. First establish the INPUT SIGNAL level required for full scale on the MAGNITUDE meter, as in the preceding paragraph, with the pushbuttons "out." Then, depress COMPRESSION, increase the INPUT SIGNAL level exactly 20 dB, and adjust for the same MAGNITUDE reading.

5.5.6 High-Frequency Tuning and Gain.

If the low-frequency gain is correct, trim the digitally tuned active filter as follows. Set FREQUENCY to 100.0 kHz and GAIN to 20 dB, and measure resonant frequency and gain as in para. 5.2. There is strong interaction between the adjustments, particularly in regard to gain. Set B-C27 to bring the resonant frequency to 100.0 kHz; set B-C26 to bring the corresponding gain to 20 dB; repeat as necessary. Finally, correct the gain and verify that the resonant frequency is well within ±4%. Both gain and resonant frequency must be determined at the oscillator frequency that produces a peak output from the detector. (Do not tune with the detector FREQUENCY controls.)

5.5.7 Medium-Frequency Tuning and Gain.

If the low- and high-frequency gain and tuning adjustments are correct, trim the filter as in para. 5.5.6, except as follows: set FREQUENCY to 5.00 kHz, use B-C20 for tuning, and use B-C25 for gain adjustment.

5.5.8 Line Rejection.

The following procedure is to set the line-frequency rejection filter to either 50 (or 60) Hz, whichever is correct for your electric power.

a. Cut the unwanted wire jumper and put another one in, as follows: 50 Hz, connect WT72 to WT73 (60 Hz, connect WT70 to WT71). See Figure 5-3. Heat the joints moderately, when soldering, to avoid damaging the etched-board foil.

b. Establish a reference level as in para. 5.2.3, with the frequency range set to FLAT, GAIN at 40 dB, and push buttons "out." Set the oscillator to exactly 50.0 (or 60.0) Hz and its level so the AMPLIFIER OUTPUT is 0 dBm.

c. Press LINE REJECTION "in" and adjust B-R139 for a minimum AMPLIFIER OUTPUT. If this minimum is larger than −40 dBm, the filter must be given a higher effective "Q". Do this by turning B-R89 cw. Readjust B-R139 for a new minimum.

d. Check the skirt rejection at frequencies of 40 and 60 (or 50 and 70) Hz. If the AMPLIFIER OUTPUT level at either skirt is less than −10 dBm, the "Q" must be raised further, as described above. If the level at either skirt is greater than −6 dBm, the "Q" is too high; turn B-R89 ccw; repeat steps c and d, if necessary, for the best combination of adjustments.

e. Attach a label on the rear panel, near the power plug, announcing that the filter is set for 50 (or 60) Hz.

5.5.9 Phase-Sensitive Detector Zeros.

There are 3 d-c offset adjustments to be set for zero when the signal level is zero. The REFERENCE INPUTS, however, must be normal. Proceed in the following sequence:

a. Set the GAIN to 20 dB, INPUT SIGNAL level to zero, and SENSITIVITY to maximum (cw). Tune the oscillator to 500 Hz.

b. With the TIME CONSTANT set to 0.3 s, adjust C-R231 on each C board for zero on the corresponding meter (the IN PHASE meter for C-board, I; the QUADRATURE meter for C board, Q).

c. With a TIME CONSTANT of 10 s, set each of the C-R234 adjustments similarly. The long time constant might cause this procedure to be rather tedious unless you use the following technique: let the circuit stabilize for 30 s; observe the reading "X"; reset C-R234, cw if "X" is negative; wait 7 s; realizing that the meter has moved just half-way to its final position, estimate a final reading "Y"; reset C-R234 again, on the basis of the "experience" just gained, unless, of course, "Y" is zero; after another 7 s, the meter points about halfway between "Y" and a final position "Z"; again reset C-R234 unless "Z" is zero; etc.

d. Because of interaction between these adjustments, repeat steps b and c as often as is necessary to be assured of a zero reading for either time constant.

e. Tune the oscillator to 100 kHz and set the TIME CONSTANT to 0.3 s. Adjust C-C214 on each C board for zero on the corresponding meter. If the range of C-C214 is inadequate for this purpose, it may be necessary to change the value of C-R230. Decrease this resistance if the meter points left (negative), and vice versa.

5.6 TROUBLE ANALYSIS.

The analysis of trouble is usually straightforward because there is essentially only one channel of amplification and the 2 detectors are identical. The phase shifters are readily monitored with a scope. If the trouble appears to be related to circuitry on one of the C boards (phase splitter, phase detector, or meter driver circuits) it may be helpful to interchange the 2 boards, observing the resultant effect on performance.

5.6.1 Power Supply.

The following normal values and tolerances are useful references for troubleshooting.

Total Power. 15 W nominal, 16 W max, from 115 (or 230 V) power line.

Main DC–. At case of A-Q2 (Figure 6-2), reference: chassis; –15 ±0.1 V, settable.

Main DC +. At case of A-Q1, (Figure 6-2), reference: chassis; +15 ±0.4 V.

Preamp DC– (BN1). At WT54 (Figure 5-3), reference: GS1 (shell of INPUT SIGNAL jack A-J4); –15 ±0.8 V.

Preamp DC + (BP1). At WT55 (Figure 5-3), reference: GS1; +15 ±0.8 V.

Negative 12. At B-C24 negative (Figure 5-3), reference: chassis; –12 ±0.6 V.

Positive 12. At B-C23 positive (Figure 5-3) reference: chassis; +12 ±0.6 V.

NOTE

The preceding 6 voltages should be within the given tolerances for line voltage in the range 112 ±13 V rms (or 225 ±25 V, depending on position of line-voltage switch, rear panel). Use the recommended variable autotransformer.

5.6.2 Operating Levels and Gains.

One of the first determinations in analysis of trouble is that the malfunction is within the normal operating range of the instrument. For example, inability to provide an undistorted output signal at high level (full scale on the MAGNITUDE meter) is a malfunction at most GAIN settings, but is perfectly normal at a setting of 20, 30, or 80 dB. A handy collection of such data is given in Table 5-5 as a supplement to the Specifications.

Table 5-5

CHARACTERISTIC GAINS & OPERATING LEVELS

Control Settings			Amplifier (SIG1 to SIG4)				Full-scale Input	
COMPRESSION	FREQUENCY	GAIN dB	Gain		Max undistorted		MAG meter*	IN PHASE meter**
			dB	V Ratio	Input	Output		
Linear	Tuned	130	130	3.2×10^{6}	1.3 μV	4 V	700 nV*	65 nV
		20	20	10	400 mV	4 V	220 mV	20 mV
Linear	FLAT	130	105	1.8×10^{5}	22 μV	4 V	13 μV	1.1 μV
		80	55	560	1.4 mV	0.8 V†	(4 mV)	360 μV
		30	5	1.8	400 mV	0.7 V†	(1.3 V)	110 mV
		20	-5	0.56	400 mV	0.2 V†	(4 V)	360 mV
Compressed	Tuned	130	110$^{\Delta}$	3×10^{5} $^{\Delta}$	—	—	7 μV	140 nV
		20	0$^{\Delta}$	1$^{\Delta}$	—	—	(2.2 V)	45 mV
Compressed	FLAT	130	85$^{\Delta}$	1.8×10^{4} $^{\Delta}$	—	—	1.3 μV	2.5 μV
		20	-25$^{\Delta}$	.056$^{\Delta}$	—	—	(40 V)	800 mV

*Includes hypothetical data: starred = hidden by noise; parenthesis = overload.

**Assuming SENSITIVITY control cw and frequency low or medium. For minimum SENS, multiply by 6.3; for 100 kHz, by roughly 2.

†Table includes all control settings that allow distortion not due to COMPRESSION to occur below F.S. on MAG meter, i.e., below 2.25 V output.

$^{\Delta}$ Assuming signal level is F.S. on MAG meter. Gain is greater at lower levels.

5.6.3 Gain by Stages.

Analysis of trouble in the main amplifier channel is usually facilitated by comparing the overall tuned gain (SIG4/SIG1) with the GAIN setting, at each of the 12 settings. Refer to Table 4-1. There, the channel is broken into 5 sections, only 1 of which is unchanged by GAIN changes. Each of the other 4 is switched in a unique way.

For further analysis, check signal levels and waveforms at intermediate points corresponding to the junctions of the 5 sections. These points are identified in Figure 5-3 as follows: Q5E, Q10C, SIG1A, and SIG3A.

NOTE

There is a jumper wire, carrying SIG1A between Q14 and R34, which can be cut (inside of preamp cover) if necessary for isolation of circuitry.

5.6.4 Digitally Tuned Active Filter.

If the section containing integrated circuit B-U4 is faulty, check whether gain is normal as follows: SIG2 to SIG3A, 30 dB (tuned); SIG2 to FDBK, 40 dB (tuned). Measurement points are shown in Figure 5-3. If necessary disconnect the wire carrying SIG3 to B-WT16 from the frequency range switch A-S3. Then the gain (K) from SIG3 to FDBK should be 15.5 dB.

If the abnormality appears only at certain settings of the FREQUENCY controls, investigate the associated switches and the parts mounted on them. Both the gain and effective "Q" of the active filter depend critically on the ratios of C and R switched in at any one time. (So it is that some parts, such as capacitors B-C5A, B-C5B, B-C5C, B-C5D, are matched sets, and must be replaced only as sets.)

In the theory para. 4.3 are equations for the digital tuning filter. Using them, one can find the significance of small inaccuracies in filter parameters. For example, an error of 0.1% in any single R or C value has the consequences tabulated in Table 5-6. (In Figure 4-4 the capacitors C_1 and C_2 are each labeled "1/2 C": SIG2 goes to C_1, FDBK to C_2. C_3 and R_2 are the grounded components.) Notice that C_1, C_2, and C_3 are associated with the frequency-range switch; R_1 and R_2 with the 3 decade FREQUENCY switches.

The importance of keeping the gain K stable is brought out by noticing that a 0.1% decrease in K reduces the gain through the tuned, active filter by 10% (nearly 1 dB).

The filter parameters, in the left column of Table 5-6, have 4000 different sets of normal values. However, to make a systematic check of the filter performance only 34 settings are required. Use the setup and procedure of para. 5.2 to measure resonant frequency and gain (and, if you wish, bandwidth) at the following settings of FREQUENCY:

1. 50.0 Hz, 5.00 kHz, 50.0 kHz, 500. Hz.
2. 501, 502, ... 509, 50X Hz.
3. 510, 520, ... 590, 5X0 Hz.
4. 100, 200, ... 900, 1000 Hz.

You have thereby checked every set of components and every switch contact used in this filter.

Table 5-6

SENSITIVITY OF FILTER TO
PARAMETER INACCURACIES

If this is 0.1% below nominal	There will be this change in performance		
	ω_o	Q or G_o	G_o
C_1	+ .025%	+ 3.3%	+ .28 dB
C_2	+ .025	- 6.6	- .56
C_3	+ .050	+ 3.3	+ .28
R_1	+ .050	+ 1.7	+ .15
R_2	+ .050	- 1.7	- .15

5.6.5 Phase Shifters.

To analyze the performance of the PHASE SHIFT and FINE ADJUST controls, use a scope to monitor PHASQ and PHASI. Refer to the Signal Index in Section 6. They should be 90° apart and fairly constant in amplitude (within a 2:1 range, max to min) for all settings of these controls. PHASI should be related to the IN-PHASE REFERENCE INPUT (REFI) through the angle indicated by the PHASE SHIFT controls. Analyze first at a frequency of 500 Hz, then at other frequencies if necessary.

If normal phase relationships are not found, check that the REFERENCE INPUTS are being supplied, as specified. Then check for the phase-splitting function, i.e., that the 4 signals NORTH, EAST, SOUTH, and WEST make a full set, 90° apart. Reference to the schematic diagrams and a trial interchange of the two C boards will help you decide whether to replace a C board or repair the circuit on the switch and its associated D board.

Refer to Figure 6-6 for points below the C board, Q, where you can measure PHASQ, WEST, and EAST. The corresponding points at the C board, I, location are PHASI, SOUTH, and NORTH.

5.6.6 Phase-Sensitive Detectors.

Analyze by swapping C boards. Because there is no gain through U202, SIG5 should be a d-c signal equal to the average of a half cycle of SIG4. Of course, the dc signal will be +, –, or even zero, depending on the phase relationship between PHASI (or PHASQ) and SIG4.

There should be no d-c gain between SIG5 and SIG6, but the gain between SIG6 and MTRI (or MTRQ) is normally 3. A typical value of MTRI is 240 mV for 9 (just under 2 divisions) on the MAGNITUDE meter, if you set an optimum PHASE SHIFT. This level also corresponds to full scale on the IN PHASE meter.

Parts Lists and Diagrams – Section 6

HANDLING PRECAUTIONS
FOR ELECTRONIC DEVICES
SUBJECT TO DAMAGE BY STATIC ELECTRICITY

Place instrument or system component to be serviced, spare parts in conductive (anti-static) envelopes or carriers, hand tools, etc. on a work surface defined as follows. The work surface, typically a bench top, must be conductive and reliably connected to earth ground through a safety resistance of approximately 250 kilohms to 500 kilohms. Also, for personnel safety, the surface must NOT be metal. (A resistivity of 30 to 300 kilohms per square is suggested.) Avoid placing tools or electrical parts on insulators, such as books, paper, rubber pads, plastic bags, or trays.

Ground the frame of any line-powered equipment, test instruments, lamps, drills, soldering irons, etc., directly to earth ground. Accordingly, (to avoid shorting out the safety resistance) be sure that grounded equipment has rubber feet or other means of insulation from the work surface. The instrument or system component being serviced should be similarly insulated while grounded through the power-cord ground wire, but must be connected to the work surface before, during, and after any disassembly or other procedure in which the line cord is disconnected.

Exclude any hand tools and other items that can generate a static charge. (examples of forbidden items are non-conductive plunger-type solder suckers and rolls of tape.)

Ground yourself reliably, through a resistance, to the work surface; use, for example, a conductive strap or cable with a wrist cuff. The cuff must make electrical contact directly with your skin; do NOT wear it over clothing. (Resistance between skin contact and work surface through a commercially available personnel grounding device is typically in the range of 250 kilohms to 1 megohm.)

If any circuit boards or IC packages are to be stored or transported, enclose them in conductive envelopes and/or carriers. Remove the items from such envelopes only with the above precautions; handle IC packages without touching the contact pins.

Avoid circumstances that are likely to produce static charges, such as wearing clothes of synthetic material, sitting on a plastic-covered or rubber-footed stool (particularly while wearing wool), combing your hair, or making extensive erasures. These circumstances are most significant when the air is dry.

When testing static-sensitive devices, be sure dc power is on before, during, and after application of test signals. Be sure all pertinent voltages have been switched off while boards or components are removed or inserted, whether hard-wired or plug-in.

MECHANICAL PARTS LIST

FRONT

Fig Ref	Qnt	Description	GR Part No.	Fed Mfg Code	Mfg Part No.
1	1	Toggle switch, A-S7, POWER ON/OFF	7910-1300	04009	83053-SA
2	2	Handle	5360-2017	24655	5360-2017
3	1	Dial asm., FREQUENCY, A-S6	1864-1210	24655	1864-1210
4	4	Knob asm., FREQUENCY; includes retainer 5220-5402	5520-5220	24655	5520-5220
5	2	Dial asm., FREQUENCY, A-S5, -S4	5120-2440	24655	5120-2440
6	1	Dial asm., frequency range, A-S3	1238-2010	24655	1238-2010
7	2	Knob asm., TIME CONSTANT, A-S2, GAIN, A-S8 includes retainer 5220-5402	5500-5221	24655	5500-5221
8	1	Bench cabinet asm., complete	4172-4017	24655	4172-4017
	1	included: Cabinet asm.	4172-2042	24655	4172-2042
	1	Base	4171-7021	24655	4171-7021
	2	Foot	4171-7010	24655	4171-7010
9	3	Knob asm., FINE ADJUST, A-R2, -R1, SENSITIVITY, A-R5, -R6; includes retainer 5220-5402	5520-5221	24655	5520-5221
10	1	Cabinet gasket	5331-2156	24655	5331-2156
11	1	Forward knob asm., PHASE SHIFT switch, A-S1; inc retainer 5220-5403	5500-5132	24655	5500-5132
12	1	Rearward knob asm., PHASE SHIFT; includes retainer 5220-5402	5520-5330	24655	5520-5330
13	1	Dial asm., PHASE SHIFT, A-R3, -R4	1238-1220	24655	1238-1220
14	2	Push button, LINE REJECTION, COMPRESSION, A-S9 (A, B)	0861-5987	71590	J52304

REAR

Fig Ref	Qnt	Description	GR Part No.	Fed Mfg Code	Mfg Part No.
1	1	Transistor, A-Q2	8210-1095	40250	
2	1	Transistor, A-Q1	8210-1121	93916	2N3740
3	3	Fuse-mounting device, A-XF1	5650-0100	24655	5650-0100
4	1	Slide switch, A-S10, line voltage	7910-0832	82389	11A-1118
5	1	Connector, power plug, A-J5	4240-0210	24655	4240-0210
6	1	Connector, 5-pin socket, A-J6, DC METER OUTPUTS	4230-5405	02660	126-197
7	1	Connector, BNC, floating, A-J4, INPUT SIGNAL, installed with:	4230-2301	09408	UG -1094A/U
	1	Insulating bushing	4120-2710	07047	10221-N
	1	Insulating washer	8030-1619	31615	Nat. nylon, .385 ID
8	3	Connector, BNC; A-J1, 2, and 3; QUADRATURE, IN PHASE, AMP OUTPUT	4230-2300	81349	UG-1094/U

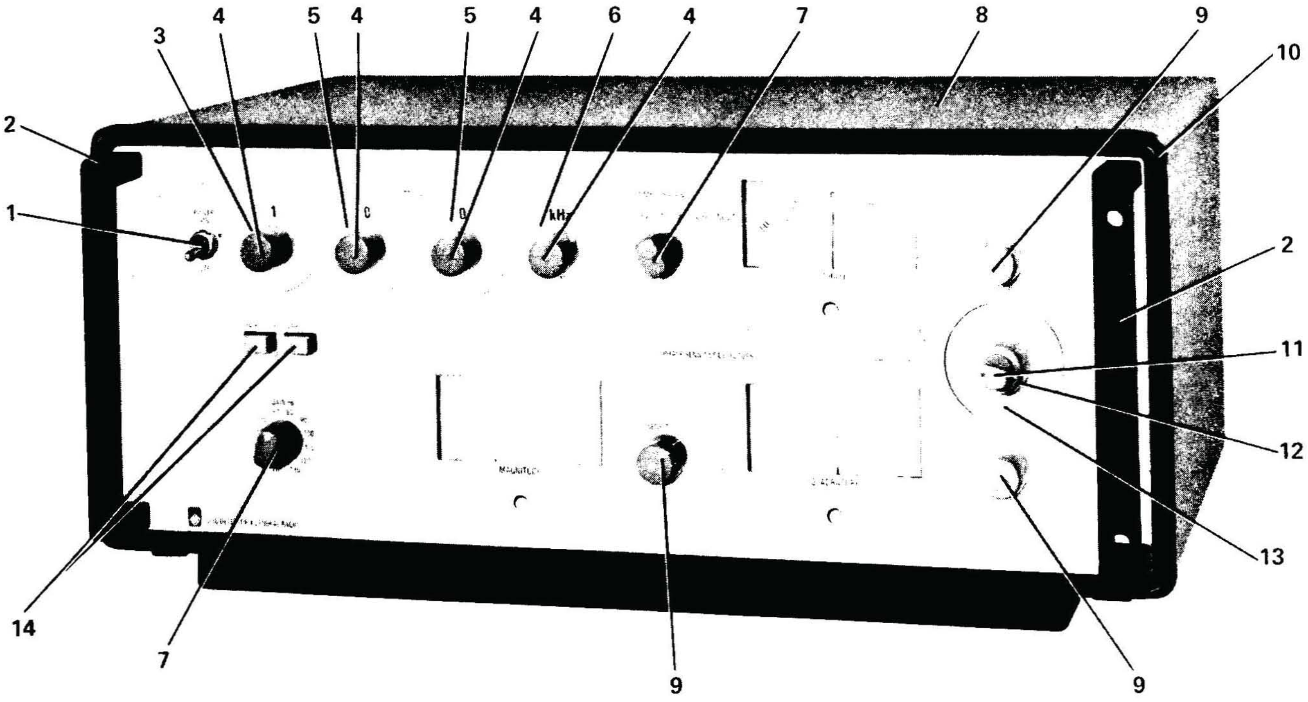


Figure 6-1. Front view; mechanical replaceable parts are identified.

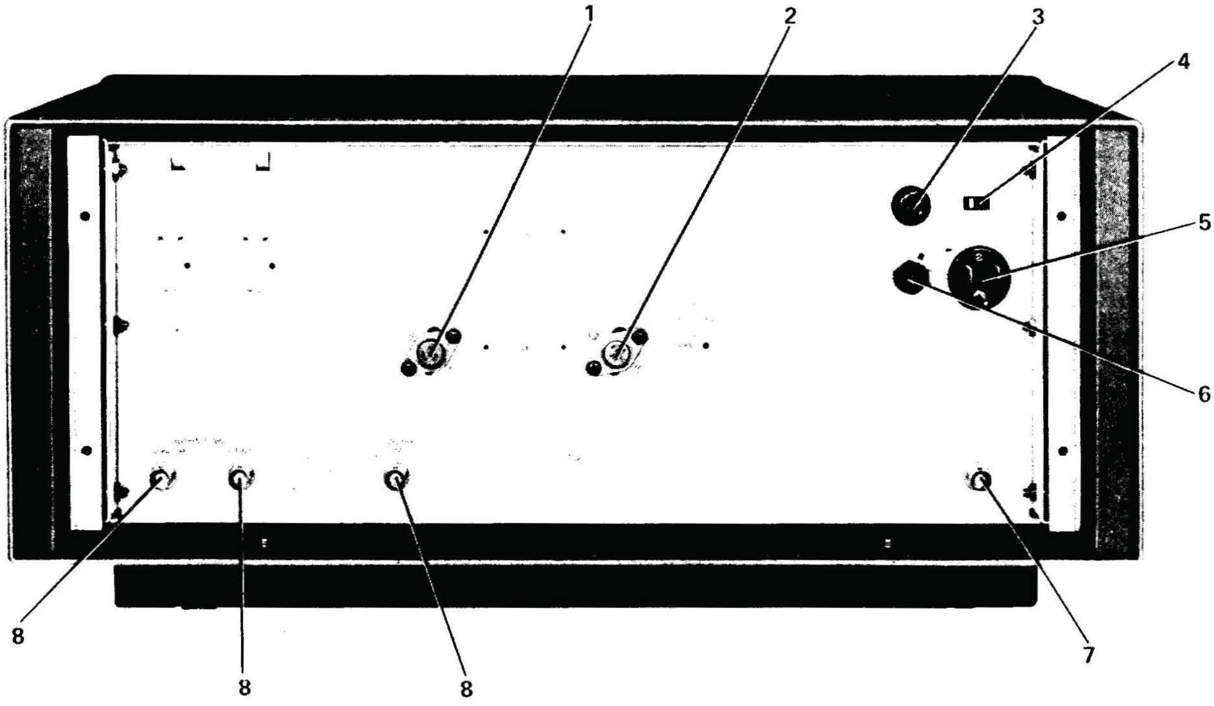
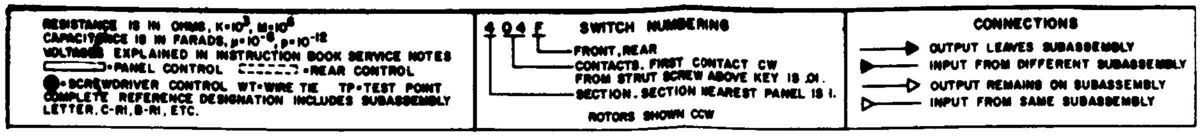


Figure 6-2. Rear view; mechanical replaceable parts identified.



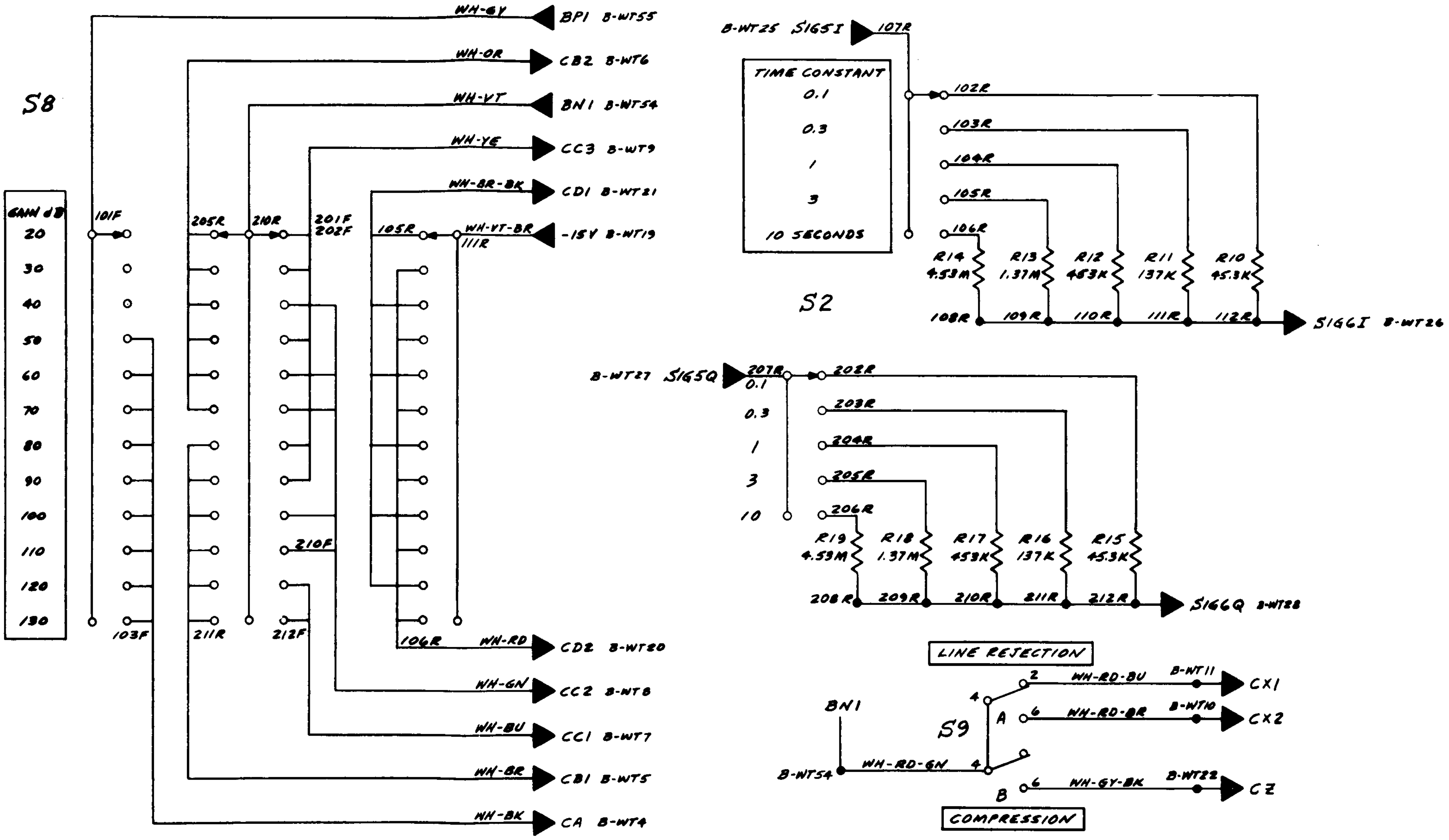


Figure 6-3. Switching diagram for GAIN, TIME C, LINE REJ, and COMPRESSION controls. A_1

ELECTRICAL PARTS LIST

CHASSIS MOUNTED PARTS P/N 1238-3000

REFDES	DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
C 1	CAP ALUM 1200-600-600 UF 35V	4450-5610	24655	4450-5610
C 2	CAP ALUM 1200-600-600 UF 35V	4450-5610	24655	4450-5610
C 3	CAP MICA 525PF 1PCT 300V	4710-0581	81349	CM05FC525FN
C 4	CAP MICA 5250 PF 1PCT 500V	4560-0165	24655	4560-0165
*C 5	CAPACITOR SET .0525UF MATCH QUAD	1238-0460	24655	1238-0460
**C 6	CAPACITOR SET .525UF MATCH QUAD	1238-0450	24655	1238-0450
C 7	CAP MICA 525PF 1PCT 300V	4710-0581	81349	CM05FC525FN
C 8	CAP MICA 5250 PF 1PCT 500V	4560-0165	24655	4560-0165
C 15	CAP MICA 10500PF 1PCT 500V	4565-2105	81349	CM07FD10500PF 1PCT
C 16	CAP MICA 1000PF 1PCT 500V	4710-0100	81349	CM06FD102FN
C 17	CAP ALUM 450-225-225 UF 100V	4450-4000	56289	60D 100V
CR 1	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR 2	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR 3	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR 4	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR 5	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR 6	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR 7	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR 8	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR 9	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154
CR 10	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154
CR 11	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154
CR 12	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154
DS 1	LAMP FLANGE BASE 14V .08A 750H	5600-0309	71744	CM-330
DS 2	LAMP FLANGE BASE 14V .08A 750H	5600-0309	71744	CM-330
DS 3	LAMP FLANGE BASE 14V .08A 750H	5600-0309	71744	CM-330
F 1	FUSE SLO-BLOW 1/2A 250V	5330-1000	75915	313 .500
J 1	RECPT BNC	4230-2300	24655	4230-2300
J 2	RECPT BNC	4230-2300	24655	4230-2300
J 3	RECPT BNC	4230-2300	24655	4230-2300
J 4	RECPT BNC	4230-2301	24655	4230-2301
J 5	RECEPTACLE POWER IEC STD 6A 250V	4240-0210	24655	4240-0210
J 6	RECPT MIN HEX 5 CONT FEMALE	4230-5405	02660	126-218
M 1	METER	5730-1434	24655	5730-1434
M 2	METER	5730-1434	24655	5730-1434
M 3	METER	5730-1433	24655	5730-1433
Q 1	TRANSISTOR 2N3740	8210-1121	04713	2N3740
Q 2	TRANSISTOR 40250	8210-1095	02735	40250
R 1	POT COMP KNOB 5K OHM 10 PCT LIN	6000-0500	01121	JAIN056S502UZ
R 2	POT COMP KNOB 5K OHM 10 PCT LIN	6000-0500	01121	JAIN056S502UZ
R 3	POT COMP 5K/5K OHM 20PCT SPECIAL	6045-0300	24655	6045-0300
R 4	POT COMP 5K/5K OHM 20PCT SPECIAL	6045-0300	24655	6045-0300
R 5	POT COMP KNOB 25K/25K 10PCT 1SFT	6045-2010	24655	6045-2010
R 6	POT COMP KNOB 25K/25K 10PCT 1SFT	6045-2010	24655	6045-2010
R 7	RES WW MOLDED .62 OHM 5 PCT 2W	6760-8625	75042	BWH 0.62 OHM 5PCT
R 8	RES WW MOLDED .62 OHM 5 PCT 2W	6760-8625	75042	BWH 0.62 OHM 5PCT
R 10	RES FLM 45.3K 1 PCT 1/4W	6350-2453	81349	RN60D4532F
R 11	RES FLM 137K 1 PCT 1/4W	6350-3137	81349	RN60D1373F
R 12	RES FLM 453K 1 PCT 1/4W	6350-3453	81349	RN60D4533F
R 13	RES FLM 1.37M 1 PCT 1/4W	6350-4137	81349	RN60D1374F
R 14	RES FLM 4.53M 1 PCT 1/4W	6350-4453	81349	RN60D4534F
R 15	RES FLM 45.3K 1 PCT 1/4W	6350-2453	81349	RN60D4532F
R 16	RES FLM 137K 1 PCT 1/4W	6350-3137	81349	RN60D1373F
R 17	RES FLM 453K 1 PCT 1/4W	6350-3453	81349	RN60D4533F
R 18	RES FLM 1.37M 1 PCT 1/4W	6350-4137	81349	RN60D1374F
R 19	RES FLM 4.53M 1 PCT 1/4W	6350-4453	81349	RN60D4534F
☐ R 21	RESISTOR SET 15K MATCHED PAIR	1238-0420	24655	1238-0420
☐☐ R 22	RESISTOR SET 7.5K MATCHED PAIR	1238-0410	24655	1238-0410
△ R 23	RESISTOR SET 7.5K MATCHED PAIR	1238-0410	24655	1238-0410
△△ R 24	RESISTOR SET 3K MATCHED PAIR	1238-0400	24655	1238-0400
R 29	RES FLM 150K 1/2 PCT 1/2W	6451-3150	81349	RN65D1503D
R 30	RES FLM 75K 1/2 PCT 1/2W	6451-2750	81349	RN65D7502D
R 31	RES FLM 75K 1/2 PCT 1/2W	6451-2750	81349	RN65D7502D
R 32	RES FLM 30K 1/2PCT 1/2W	6193-2230	81349	RN70C3002D
R 33	RES FLM 150K 1/2 PCT 1/2W	6451-3150	81349	RN65D1503D

***Matched Quad C5A, C5B, C5C, C5D**
****Matched Quad C6A, C6B, C6C, C6D**
☐ Matched Pair R21A, R21B
☐☐ Matched Pair R22A, R22B
△ Matched Pair R23A, R23B
△△ Matched Pair R24A, R24B

ELECTRICAL PARTS LIST (cont)

CHASSIS MOUNTED PARTS P/N 1238-3000

REFDES		DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
R	34	RES FLM 75K 1/2 PCT 1/2W	6451-2750	81349	RN65D7502D
R	35	RES FLM 75K 1/2 PCT 1/2W	6451-2750	81349	RN65D7502D
R	36	RES FLM 30K 1/2PCT 1/2W	6193-2230	81349	RN70C3002D
R	37	RES FLM 1.5M 1 PCT 1/2W	6450-4150	81349	RN65D1504F
R	38	RES FLM 750K 1 PCT 1/2W	6450-3750	81349	RN65D7503F
R	39	RES FLM 750K 1 PCT 1/2W	6450-3750	81349	RN65D7503F
R	40	RES FLM 300K 1PCT 100PPM 1/2W	6619-3400	24655	6619-3400
R	41	RES FLM 1.5M 1 PCT 1/2W	6450-4150	81349	RN65D1504F
R	42	RES FLM 750K 1 PCT 1/2W	6450-3750	81349	RN65D7503F
R	43	RES FLM 750K 1 PCT 1/2W	6450-3750	81349	RN65D7503F
R	44	RES FLM 300K 1PCT 100PPM 1/2W	6619-3400	24655	6619-3400
R	46	RES COMP 470 OHM 5PCT 1/4W	6099-1475	81349	RCR07G471J
R	47	RES COMP 27 K 5PCT 1/4W	6099-3275	81349	RCR07G273J
R	48	RES COMP 27 K 5PCT 1/4W	6099-3275	81349	RCR07G273J
R	49	RES COMP 2.2 K 5PCT 1/4W	6099-2225	81349	RCR07G222J
R	50	RES COMP 2.2 K 5PCT 1/4W	6099-2225	81349	RCR07G222J
S	1	SWITCH ROTARY ASM	7890-8370	24655	7890-8370
S	2	SWITCH ROTARY ASM	7890-8360	24655	7890-8360
S	3	SWITCH ROTARY ASM	7890-8330	24655	7890-8330
S	4	SWITCH ROTARY ASM	7890-4840	24655	7890-4840
S	5	SWITCH ROTARY ASM	7890-4840	24655	7890-4840
S	6	SWITCH ROTARY ASM	7890-8340	24655	7890-8340
S	7	SWITCH TOGGLE 2POS DPST STEADY	7910-1300	04009	83053
S	8	SWITCH ROTARY ASM	7890-8350	24655	7890-8350
S	9	SWITCH PUSHBUTTON MULT 2 SECT	7880-2400	24655	7880-2400
S	10	SWITCH SLIDE 2 POS DPDT STEADY	7910-0832	82389	11A-1266
T	1	TRANSFORMER POWER	0345-4970	24655	0345-4970

FEDERAL SUPPLY CODE
FOR MANUFACTURERS

From Defense Logistics Agency Microfiche

H4-2 SB 708-42 GSA-FSS H4-2

Ref FMC Column
in Parts Lists

Code	Manufacturer
00136	McCoy Elctrns.,Mt.Holly Springs,PA 17065
00192	Jones Mfg.,Chicago,IL 60181
00194	Walsco Elctrns.,Los Angeles,CA 90018
00327	Welwyn Intntl.,Westlake,OH 44145
00434	Schweber Elctrns.,Westburg,NY 11590
00656	Aerovox.,New Bedford,MA 02745
00779	AMP Inc.,Harrisburg,PA 17105
01009	Alden Products.,Brockton,MA 02413
01121	Allen Bradley.,Milwaukee,WI 53204
01255	Litton Inds.,Beverly Hills,CA 90213
01281	TRW.,Lawndale,CA 90260
01295	TI.,Dallas,TX 75222
01526	GE.,Waynesboro,VA 22980
01930	Amerock.,Rockford,IL 61101
01963	Cherry Elctrc.,Waukegan,IL 60085
02111	Spectrol Elctrns.,City of Industry,CA 91745
02114	Ferroxcube.,Saugerties,NY 12477
02606	Fenwall Lab.,Morton Grove,IL 60053
02639	GE.,Schenectady,NY 12307
02660	Amphenol.,Broadview,IL 60153
02735	RCA.,Somerville,NJ 08876
02768	Fastex.,Desplains,IL 60016
03042	Carter Ink.,Cambridge,MA 02142
03508	GE.,Syracuse,NY 13201
03550	Vanguard Elctrns.,Inglewood,CA 90302
03636	Grayburne.,Yonkers,NY 10701
03877	Transitron Elctrns.,Wakefield,MA 01880
03888	KDI Pyrofilm.,Whippany,NJ 07981
03911	Clairex.,New York,NY 10001
04009	Arrow Hart.,Hartford,CT 06106
04643	Digitronics.,Albertson,NY 11507
04713	Motorola.,Phoenix,AZ 85008
04919	Component Mfg.,W.Bridgewater,MA 02379
05079	Tansistor Elctrns.,Bennington,VT 05201
05245	Corcom.,Chicago,IL 60639
05276	ITT Elctrns.,Pomona,CA 91766
05402	Controls Co.of Amer.,Melrose Pk,IL 60160
05574	Viking Inds.,Chatsworth,CA 91311
05624	Barber Colman.,Rockford,IL 61101
05748	Barnes Mfg.,Mansfield,OH 44901
05820	Wakefield Eng.,Wakefield,MA 01880
06383	Panduit.,Tinley Pk,IL 60477
06406	Truelove & Maclean.,Waterbury,CT 06708
06665	Precision Monolith.,Santa Clara,CA 95050
06743	Clevite.,Cleveland,OH 44110
06795	WLS Stamp.,Cleveland,OH 44104
06915	Richco Plstc.,Chicago,IL 60646
06928	Teledyne Kntcs.,Soland Bch,CA 92075
06978	Aladdin Elctrns.,Nashville,TN 37210
07047	Ross Milton.,Southampton,PA 18966
07126	Digitran.,Pasadena,CA 91105
07127	Eagle Signal.,Baraboo,WI 53913
07233	Cinch Graphik.,City of Industry,CA 91744
07261	Avnet.,Culver City,CA 90230
07263	Fairchild.,Mountain View,CA 94040
07387	Birtcher.,N.Los Angeles,CA 90032
07595	Amer.Semicond.,Arlington Hts,IL 60004
07699	Magnetic Core.,Newburgh,NY 12550
07707	USM Fastener.,Shelton,CT 06484
07828	Bodine.,Bridgeport,CT 06605
07829	Bodine Elctrc.,Chicago,IL 60618
07910	Cont Device.,Hawthorne,CA 90250
07983	State Labs.,New York,NY 10003
07999	Borg Inst.,Delavan,WI 53115
08524	Deutsch Fastener.,Los Angeles,CA 90045
08556	Bell Elctrc.,Chicago,IL 60632
08730	Vemaline Prod.,Franklin Lakes,NJ 07417
09213	GE.,Buffalo,NY 14220
09353	C&K Components.,Watertown,MA 02172
09408	Star-Tronics.,Georgetown,MA 01830
09823	Burgess Battery.,Freeport,IL 61032
09856	Fenwal Elctrns.,Framingham,MA 01701
09922	Burndy.,Norwalk,CT 06852
10025	Glasseal Prod.,Linden,NJ 07036
10389	Chicago Switch.,Chicago,IL 60647
11236	CTS of Berne.,Berne,IN 46711
11599	Chandler Evans.,W.Hartford,CT 06101
11983	Nortronics.,Minneapolis,MN 55427
12040	National.,Santa Clara,CA 95051
12045	Elctrc Transistors.,Flushing,NY 11354
12498	Teledyne.,Mountain View,CA 94043
12617	Hamlin.,Lake Millis,WI 53551
12672	RCA.,Woodbridge,NJ 07095
12697	Clarostat.,Dover,NH 03820
12856	Micrometals.,City of Industry,CA 91744
12954	Dickson Elctrns.,Scottsdale,AZ 85252
12969	Unitrode.,Watertown,MA 02172
13094	Electrocraft.,Hopkins,MN 55343
13103	Thermalloy.,Dallas,TX 75234
13148	Vogue Inst.,Richmond Hill,NY 11418
13150	Vernitron.,Laconia,NH 03246
13327	Solitron Devices.,Tappan,NY 10983
13715	Fairchild.,San Rafael,CA 94903
13919	Burr Brown.,Tucson,AZ 85706
14010	Anadex Inst.,Van Nuys,CA 91406
14195	Elctrc Controls.,Wilton,CT 06897
14196	American Labs.,Fullerton,CA 92634
14332	Relton.,Arcadia,CA 91006
14433	ITT.,W.Palm Beach,FL 33402
14482	Watkins & Johnson.,Palo Alto,CA 94304
14608	Corbin.,Berlin,CT 06037
14655	Cornell Dubilier.,Newak,NJ 07101
14674	Corning Glass.,Corning,NY 14830
14749	Acopian.,Easton,PA 18042
14752	Electrocube.,San Gabriel,CA 91776
14889	R&G Sloan.,Sun Valley,CA 91352
14908	Elctrc Inst & Spclty.,Stoneham,MA 02180
14936	General Inst.,Hicksville,NY 11802
15238	ITT.,Lawrence,MA 08142
15476	Digital Equip.,Maynard,MA 01754
15605	Cutler Hammer.,Milwaukee,WI 53202
15782	Houston Inst.,Bellaire,TX 77401
15801	Fenwal Elctrns.,Framingham,MA 01701
15819	Sinclair & Rush.,St.Louis,MO 63111
16037	Spruce Pine Mica.,Spruce Pine,NC 28777
16068	Intntl Diode.,Jersey City,NJ 07304
16179	Ommi Spectra.,Farmington,MI 48024
16301	Astrolab.,Linden,NJ 07036
16352	Codi.,Fairlawn,NJ 07410
16485	Sterling Inst.,New Hyde Park,NY 11040
16636	Indiana General.,Oglesby,IL 61348
16758	Delco.,Kokomo,IN 46901
16950	Precision Dynamics.,Burbank,CA 91504
16952	Amer Micro Devices.,Summerville,SC 29483
17117	Elctrc Molding.,Woonsocket,RI 02895
17540	Mohawk Spring.,Schiller Park,IL 60176
17745	Angstrohm Precsn.,Hagerstown,MD 21740
17771	Singer.,Somerville,NJ 08876
17850	Zeltex.,Concord,CA 94520
17856	Siliconix.,Santa Clara,CA 95054
18324	Signetics.,Sunnyvale,CA 94086
18542	New Prod Eng.,Wabash,IN 46992
18677	Scanbe.,El Monte,CA 91731
18736	Computer Diode.,S.Fairlawn,NJ 07936
18795	Cycon.,Sunnyvale,CA 94086
18911	Durant.,Watertown,WI 53094
19178	Zero.,Monson,MA 01057
19209	GE.,Gainesville,FL 32601
19373	Eastron.,Haverhill,MA 01830
19396	Paktron.,Vienna,VA 22180
19617	Cabtron.,Chicago,IL 60622
19644	LRC Elctrns.,Horseheads,NY 14845
19701	Electra.,Independence,KS 67301
20093	Elect Inds.,Murray Hill,NJ 07974
20754	KMC.,Long Valley,NJ 07853
21335	Fafnir Bearing.,New Britian,CT 06050
21688	Raytheon.,Norwood,MA 02062
21759	Lenox Fugle.,Watchung,NJ 07060
22526	Berg Elctrcs.,New Cumberland,PA 17070
22589	Electro Space Fabrctrs.,Topton,PA 19562
22753	UID Elctrcs.,Hollywood,FL 33022
23338	Wavetek.,San Diego,CA 92112
23342	Avnet Elctrcs.,Franklin Park,IL 60131
23936	Pamotor.,Bulingham,CA 94010
24351	Indiana Gnrl Elctrc.,Keasby,NJ 08832
24355	Analog Devices.,Cambridge,MA 02142
24444	General Semicond.,Tempe,AZ 85281
24446	GE.,Schenectady,NY 12305
24454	GE.,Syracuse,NY 13201
24455	GE.,Cleveland,OH 44112
24602	EMC Technlgy.,Cherry Hill,NJ 08034
24655	Gen Rad.,Concord,MA 01742
24759	Lenox Fugle.,S.Plainfield,NJ 07080
25008	Vactite.,Berkeley,CA 94710
25289	EG&G.,Bedford,MA 01730
26601	Tri-County Tube.,Nunda,NY 14517
26805	Omni Spectra.,Waltham,MA 02154
26806	American Zettler.,Costa Mesa,CA 92626
27014	National.,Santa Clara,CA 95051
27545	Hartford Universal Ball.,Rocky Hill,CT 06067
28480	HP.,Palo Alto,CA 94304
28520	Heyman Mfg.,Kenilworth,NJ 07033
28875	IMC Magnetics.,Rochester,NH 03867
28959	Hoffman Elctrcs.,El Monte,CA 91734
30043	Solid State Devices.,LaMirada,CA 90638
30646	Beckman Inst.,Cedar Grove,NJ 07009
30874	IBM.,Armonk,NY 10504
30985	Permag Magnetics.,Toledo,OH 43609
31019	Solid State Scntfc.,Montgomerville,PA 18936
31514	Standford Appld Engs.,Costa Mesa,CA 92626
31814	Analogic.,Wakefield,MA 01880
31951	Triridge.,Pittsburgh,PA 15231
32001	Jensen.,Chicago,IL 60638
33095	Spectrum Control.,Fairview,PA 16415
33173	GE.,Owensboro,KY 42301
34141	Koehler.,Marlboro,MA 01752
34156	Semicoa.,Costa Mesa,CA 92626
34333	Silicon Genrl.,Westminster,CA 92683
34335	Advanced Micro Devices.,Sunnyvale,CA 94086
34649	Intel.,Santa Clara,CA 95051
34677	Solitron Devices.,Jupiter,FL 33458
35929	Constanta.,Montreal,QUE,CAN
36462	National Ltd.,Montreal,QUE,CAN
37942	Mallory.,Indianapolis,IN 46206
38443	Marlin Rockwell.,Jamestown,NY 14701
39317	McGill Mfg.,Valpariso,IN 46383
40931	Honeywell.,Minneapolis,MN 55408
42190	Muter.,Chicago,IL 60638
42498	National.,Melrose,MA 02176
43334	New Departure-Hyatt.,Sandusky,OH 44870
43991	Norma Hoffman.,Stanford,CT 06904
49671	RCA.,New York,NY 10020
49956	Raytheon.,Waltham,MA 02154
50088	Mostek.,Carrollton,TX 75006
50101	GHZ Devices.,S.Chelmsford,MA 01824
50507	Micro Networks.,Worcester,MA 01606
50522	Monsanto.,Palo Alto,CA 94304
50721	Datel Systems.,Canton,MA 02021
51167	Aries Elctrcs.,Frenchtown,NJ 08825
51553	Diablo Systems.,Hayward,CA 94545
51642	Centre Eng.,State College,PA 16801
52648	Plessey.,Santa Ana,CA 92705
52676	SKF Inds.,Philadelphia,PA 19132
52763	Stettner Trush., Cazenovia, NY 13035
53021	Sangamo Elctrc.,Springfield,IL 62705
53184	Xciton.,Latham,NY 12110
53421	Tyton.,Milwaukee,WI 53209
54294	Shallcross.,Selma,NC 27576
54297	Assoc Prec Prod.,Huntsville,AL 35805
54715	Shure Bros.,Evanston,IL 60202
56289	Sprague.,North Adams,MA 01247
57771	Stimpson.,Bayport,NY 11705
58553	Superior Valve.,Washington,PA 15301
59730	Thomas & Betts.,Elizabeth,NJ 07207
59875	TRW.,Cleveland,OH 44117
60399	Torrington.,Torrington,CT 06790
61007	Townsend.,Braintree,MA 02184
61637	Union Carbide.,New York,NY 10017
61864	United Carr Fast.,Boston,MA
63060	Victoreen.,Cleveland,OH 44104
63743	Ward Leonard.,Mt.Vernon,NY 10550
65083	Westinghouse.,Bloomfield,NJ 07003
65092	Weston.,Newark,NJ 07114
70106	Acushnet Cap.,New Bedford,MA 02742
70109	Adams & Westlake.,Elkhart,IN 46514
70417	Chrysler.,Detroit,MI 48231
70485	Atlantic India Rubber.,Chicago,IL 60607
70563	Amperite.,Union City,NJ 07087
70611	Ark-Les Switch.,Watertown,MA 02172
70892	Bead Chain.,Bridgeport,CT 06605
70903	Belden.,Chicago,IL 60644
71126	Bronson.,Beacon Falls,CT 06403
71279	Cambridge Thermionic.,Cambridge,MA 02138
71294	Canfield.,Clifton Forge,VA 24422
71400	Bussmann.,St.Louis,MO 63107
71450	CTS.,Elkhart,IN 46514
71468	Cannon.,Los Angeles,CA 90031
71482	Clare.,Chicago,IL 60645
71590	Centralab.,Milwaukee,WI 53212
71666	Continental Carbon.,New York,NY
71707	Coto Coil.,Providence,RI 02905
71729	Crescent Box.,Philadelphia,PA 19134
71744	Chicago Min Lamp.,Chicago,IL 60640
71785	Cinch.,Chicago,IL 60624
71823	Darnell.,Downey,CA 90241
72136	Electromotive.,Willimantic,CT 06226
72228	Continental Screw.,New Bedford,MA 02742
72259	Nytronics.,Berkeley Hts,NJ 07922
72619	Dialight.,Brooklyn,NY 11237
72699	General Inst.,Newark,NJ 07104
72765	Drake.,Chicago,IL 60631
72794	Dzus Fastener.,W.Islip,NY 11795
72825	Eby.,Philadelphia,PA 19144
72962	Elastic Stop Nut.,Union,NJ 07083
72982	Erie.,Erie,PA 16512
73445	Amperex Elctrcs.,Hicksville,NY 11801
73559	Carling Elctrc.,Hartford,CT 06110
73690	Elco Resistor.,New York,NY
73803	TI.,Attleboro,MA 02703
73899	JFD Elctrcs.,Brooklyn,NY 11219
73957	Groov-Pin.,Ridgefield,NJ 07657
74193	Heinemann.,Trenton,NJ 08602
74199	Quam Nichols.,Chicago,IL 60637
74445	Holo-Krome.,Hartford,CT 06110
74545	Hubbell.,Stratford,CT 06497
74861	Industrial Cndnsr.,Chicago,IL 60618
74868	Amphenol.,Danbury,CT 06810
74970	Johnson.,Waseca,MN 56093
75042	IRC(TRW).,Burlington,IA 52601
75376	Kurz-Kasch.,Dayton,OH 45401
75382	Kuka.,Mt Vernon,NY 10551
75491	Lafayette.,Syosset,NY 11791
75608	Linden.,Providence,RI 02905
75915	Littelfuse.,Des Plains,IL 60016
76005	Lord Mfg.,Erie,PA 16512
76149	Mallory Elctrc.,Detroit,MI 48204
76241	Maurey.,Chicago,IL 60616
76381	3 M Co.,St.Paul,MN 55101
76385	Minor Rubber.,Bloomfield,NJ 07003
76487	Millen.,Malden,MA 02148
76545	Mueller Elctr.,Cleveland,OH 44114
76684	National Tube.,Pittsburg,PA
76854	Oak Inds.,Crystal Lake,IL 60014
77132	Dot Fastener.,Waterbury,CT 06720
77147	Patton MacGuyer.,Providence,RI 02905
77166	Pass Seymour.,Syracuse,NY 13209
77263	Pierce Roberts Rubber.,Trenton,NJ 08638
77315	Platt Bros.,Waterbury,CT 06720
77339	Positive Lockwasher.,Newark,NJ
77342	AMF.,Princeton,IN 47570
77542	Ray-o-Vac.,Madison,WI 53703
77630	TRW.,Camden,NJ 08103
77638	General Inst.,Brooklyn,NY 11211
78189	Shakeproof.,Elgin,IL 60120
78277	Sigma Inst.,Braintree,MA 02184
78429	Airco Speer.,St Marys,PA 15867
78488	Stackpole.,St Marys,PA 15867
78553	Tinnerman.,Cleveland,OH
78711	Telephonics.,Huntington,NY 11743
79089	RCA.,Harrison,NJ 07029
79136	Waldes Kohinoor.,New York,NY 11101
79497	Western Rubber.,Goshen,IN 46526
79725	Wiremold.,Hartford,CT 06110
79727	Continental Wirt.,Philadelphia,PA 19101
79840	Mallory Controls.,Frankfort,IN 46041
79963	Zierick.,Mt Kisco,NY 10549
80009	Tektronix.,Beaverton,OR 97005
80030	Prestole Fastener.,Toledo,OH 43605
80048	Vickers.,St Louis,MO 63166
80103	Lambda.,Melville,NY 11746
80183	Sprague.,N.Adams,MA 01247
80211	Motorola.,Franklin Pk,IL 60131
80251	Formica.,Cincinnati,OH 45232
80258	Standard Oil.,Lafeyette,IN 47902
80294	Bourns Labs.,Riverside,CA 92506
80368	Sylvania.,New York,NY 10017
80431	Air Filter.,Milwaukee,WI 53218
80583	Hammarlund.,New York,NY 10010
80740	Beckman Inst.,Fullerton,CA 92634
80756	TRW Ramsey.,St Louis,MO 63166
80894	Pure Carbon.,St Marys,PA 15857
81030	Int'l Inst.,Orange,CT 06477
81073	Grayhill.,LaGrange,IL 60525
81143	Isolantite.,Stirling,NJ 07980
81312	Winchester.,Oakville,CT 06779
81349	Military Specifications
81350	Joint Army-Navy Specifications
81483	Int'l Rectifier.,El Segundo,CA 90245
81741	Chicago Lock.,Chicago,IL 60641
81831	Filtron.,Flushing,NY 11354
81840	Ledex.,Dayton,OH 45402
81860	Barry Wright.,Watertown,MA 02172
82219	Sylvania.,Emporium,PA 15834
82227	No.Amer.Philips.,Cheshire,CT 06410
82273	IN Pattern & Model.,LaPort,IN 46350
82389	Switchcraft.,Chicago,IL 60630
82567	Reeves Hoffman.,Carlisle,PA 17013
82647	Metals & Controls.,Attleboro,MA 02703
82807	Milwaukee Resistor.,Milwaukee,WI 53204
82877	Rotron.,Woodstock,NY 12498
82901	IN General Magnet.,Valparaiso,IN 46383
83003	Varo.,Garland,TX 75040
83014	Hartwell.,Placentia,CA 92670
83033	Meissner.,Mt Carmel,IL 62863
83058	Carr Fastener.,Cambridge,MA 02142
83186	Victory Eng.,Springfield,NJ 07081
83259	Parker Seal.,Culver City,CA 90231
83330	H.H.Smith.,Brooklyn,NY 11207
83361	Bearing Spclty.,San Francisco,CA
83587	Solar Elctrc.,Warren,PA 16365
83594	Burroughs.,Plainfield,NJ 07061
83740	Union Carbide.,New York,NY 10017
83766	Mass Engrg.,Quincy,MA 02171
83781	National Elctrcs.,Geneva,IL 60134
84411	TRW.,Ogallala,NB 69153
84835	Lehigh Metals.,Cambridge,MA 02140
84970	Sarkes Tarzian.,Bloomington,IN 47401
84971	TA Mfg.,Los Angeles,CA 90039
85604	Kepco.,Flushing,NY 11352
86420	Payson Casters.,Gurnee,IL 60031
86577	Prec Metal Prod.,Stoneham,MA 02180
86684	RCA.,Harrison,NJ 07029
86687	REC.,New Rochelle,NY 10801
86800	Cont Elctrcs.,Brooklyn,NY 11222
88140	Cutler Hammer.,Lincoln,IL 62656
88204	GTE Sylvania.,Ipswitch,MA 01938
88219	Gould Nat Battery.,Trenton,NJ 08607
88419	Cornell Dubilier.,Fuquay Varina,NC 27526
88627	K&G Mfr.,New York,NY
89265	Potter & Brumfield.,Princeton,IN 47671
89482	Holtzer Cabot.,Boston,MA 02119
89665	United Transformer.,Chicago,IL
89870	Berkshire Transformer.,Kent,CT 06757
90201	Mallory Cap.,Indianapolis,IN 46206
90303	Mallory Bat.,Tarrytown,NY 10591
90634	Gulton Inds.,Metuchen,NJ 08840
90750	Westinghouse.,Boston,MA 02118
90952	Hardware Prod.,Reading,PA 19602
91032	Continental Wire.,York,PA 17405
91146	Cannon.,Salem,MA 01970
91210	Gerber.,Mishawaka,IN 46544
91293	Johanson.,Boonton,NJ 07005
91417	Harris.,Melbourne,FL 32901
91506	Augat Bros.,Attleboro,MA 02703
91598	Chandler.,Wethersfield,CT 06109
91637	Dale Elctrcs.,Columbus,NE 68601
91662	Elco.,Willow Grove,PA 19090
91719	General Inst.,Dallas,TX 75220
91836	Kings Elctrcs.,Tuckahoe,NY 11223
91916	Mephisto Tool.,Hudson,NY 12534
91929	Honeywell.,Freeport,IL 61032
92519	Electra Insul.,Woodside,NY 11377
92678	Edgerton Germeshuasen.,Boston,MA 02115
92702	IMC Magnetics.,Westbury,NY 11591.
92739	Ampex.,Redwood City,CA 94063
92966	Hudson Lamp.,Kearny,NJ 07032
93332	Sylvania.,Woburn,MA 01801
93346	Amer Elctrcs Labs.,Lansdale,PA 19446
93618	R&C Mfg.,Ramsey,PA 16671
93916	Cramer.,New York,NY 10013
94144	Raytheon.,Quincy,MA 02169
94154	Wagner Elctrc.,Livingston,NJ 07039
94271	Weston.,Archibald,PA 18403
94322	Tel Labs.,Manchester,NH 03102
94589	Dickson.,Chicago,IL 60619
94696	Magnecraft.,Chicago,IL 60630
94800	Atlas Ind.,Brookline,NH 03033
95076	Garde.,Cumberland,RI 02864
95121	Quality Comp.,St Marys,PA 15857
95146	Alco Elctrcs.,Lawrence,MA 01843
95238	Continental Conn.,Woodside,NY 11377
95275	Vitramon.,Bridgeport,CT 06601
95348	Gordos.,Bloomfield,NJ 07003
95354	Methode.;Rolling Meadow,IL 60008
95794	Amer Brass.,Torrington,CT 06790
95987	Weckesser.,Chicago,IL 60646
96095	Aerovox Hi Q.,Olean,NY 14760
96341	Microwave Assoc.,Burlington,MA 01801
96906	Military Standards
97918	Linemaster Switch.,Woodstock,CT 06281
98291	Sealectro.,Mamaroneck,NY 10544
98474	Compar.,Burlingame,CA 94010
98821	North Hills.,Glen Cove,NY 11542
99017	Protective Closures.,Buffalo,NY 14207
99117	Metavac.,Flushing,NY 11358
99313	Varian.,Palo Alto,CA 94303
99378	Atlee.,Winchester,MA 01890
99800	Delevan;E.Aurora,NY 14052
99934	Renbrandt.,Boston,MA 02118
99942	Centralab.,Milwaukee,WI 53201

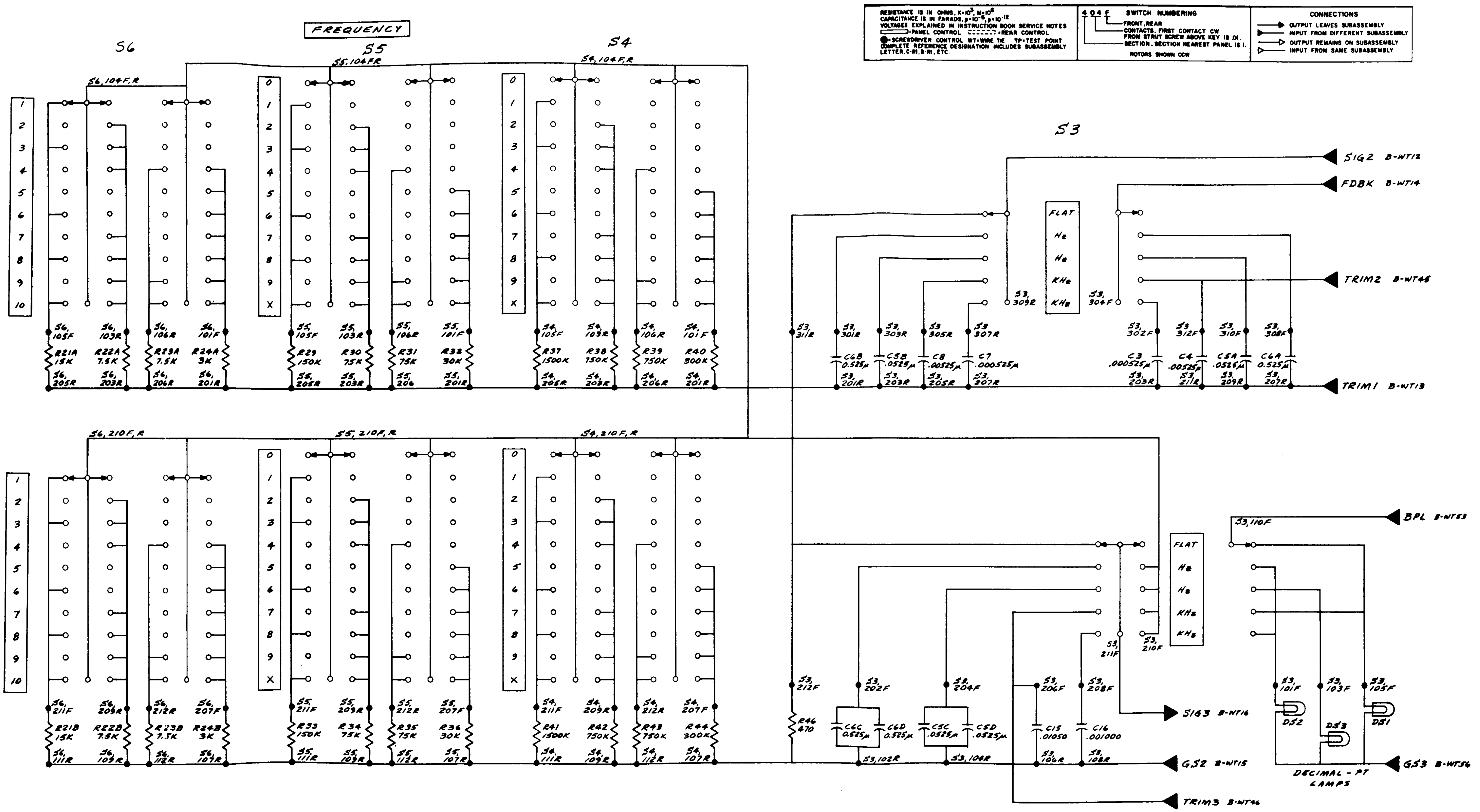


Figure 6-4. Switching diagram for FREQUENCY and frequency range controls. A_2

Figure (re 6-4→

ELECTRICAL PARTS LIST

AMPLIFIER & MAGNITUDE DETECTOR BOARD (B) P/N 1238-4720

REFDES		DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
C	1	CAP MYLAR .01UF 10 PCT 100V	4860-7750	56289	410P .01 UF 10PCT
C	2	CAP MYLAR .01UF 10 PCT 100V	4860-7750	56289	410P .01 UF 10PCT
C	3	CAP ALUM 1200 UF 6V	4450-6006	56289	30D 1200UF 6V
C	4	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	5	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	6	CAP TANT 330 UF 20PCT 6V DIP	4450-6250	90201	TDC 330UF 20PCT 6V
C	7	CAP TANT 22 UF 20PCT 15V	4450-5300	56289	150D226X0015B2
C	8	CAP TANT 2.2 UF 20PCT 20V	4450-4500	56289	150D225X0020A2
C	9	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	10	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	11	CAP CER TUB 5.1PF 5PCT 500V	4400-0511	95121	QC 5.1PF 5PCT 500V
C	12	CAP TANT 330 UF 20PCT 6V DIP	4450-6250	90201	TDC 330UF 20PCT 6V
C	13	CAP TANT 22 UF 20PCT 15V	4450-5300	56289	150D226X0015B2
C	14	CAP TANT 2.2 UF 20PCT 20V	4450-4500	56289	150D225X0020A2
C	15	CAP MYLAR .464UF 2 PCT 100V	4860-7990	56289	410P 0.464 UF 2PCT
C	16	CAP MYLAR .464UF 2 PCT 100V	4860-7990	56289	410P 0.464 UF 2PCT
C	17	CAP MYLAR .464UF 2 PCT 100V	4860-7990	56289	410P 0.464 UF 2PCT
C	18	CAP CER DISC 2200PF 5PCT 500V	4406-2225	72982	0871082Z5D00222J
C	19	CAP TANT 15 UF 20PCT 20V	4450-5200	56289	150D156X0020B2
C	20	CAP CER TRIM 8-50 PF	4910-1170	72982	557-051 E 8-50PF
C	21	CAP CER DISC .02UF 80/20PCT 100V	4402-3200	56289	55C21 .02UF
C	22	CAP CER DISC .02UF 80/20PCT 100V	4402-3200	56289	55C21 .02UF
C	23	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	24	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	25	CAP CER TRIM 8-50 PF	4910-1170	72982	557-051 E 8-50PF
C	26	CAP CER TRIM 8-50 PF	4910-1170	72982	557-051 E 8-50PF
C	27	CAP CER TRIM 8-50 PF	4910-1170	72982	557-051 E 8-50PF
C	28	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	29	CAP TANT 220 UF 20PCT 10V DIP	4450-6251	90201	TDC 220UF 20PCT 10V
C	30	CAP CER DISC 39PF 5PCT 500V	4404-0395	72982	0831082Z5D00390J
C	31	CAP TANT 22 UF 20PCT 15V	4450-5300	56289	150D226X0015B2
C	32	CAP TANT 2.2 UF 20PCT 20V	4450-4500	56289	150D225X0020A2
C	33	CAP TANT 33 UF 20PCT 10V	4450-5400	56289	150D336X0010B2
C	34	CAP TANT 47 UF 20PCT 20V	4450-5614	56289	150D476X0020R2
C	35	CAP TANT 47 UF 20PCT 20V	4450-5614	56289	150D476X0020R2
C	36	CAP TANT 330 UF 20PCT 6V DIP	4450-6250	90201	TDC 330UF 20PCT 6V
C	37	CAP TANT 6.8 UF 20PCT 35V	4450-5000	56289	150D685X0035B2
C	38	CAP TANT 47 UF 20PCT 20V	4450-5614	56289	150D476X0020R2
C	39	CAP TANT 33 UF 20PCT 10V	4450-5400	56289	150D336X0010B2
C	40	CAP TANT 47 UF 20PCT 20V	4450-5614	56289	150D476X0020R2
C	41	CAP TANT 2.2 UF 20PCT 20V	4450-4500	56289	150D225X0020A2
C	42	CAP TANT 22 UF 20PCT 15V	4450-5300	56289	150D226X0015B2
C	43	CAP TANT 22 UF 20PCT 15V	4450-5300	56289	150D226X0015B2
C	44	CAP CER DISC 39PF 5PCT 500V	4404-0395	72982	0831082Z5D00390J
C	46	CAP CER DISC.01UF 80/20PCT 500VU	4406-3109	72982	0811082Z5U00103Z
C	47	CAP ALUM 60 UF 25V	4450-2900	56289	30D606G025
C	49	CAP CER DISC.01UF 80/20PCT 500VU	4406-3109	72982	0811082Z5U00103Z
C	50	CAP TANT 3.3 UF 20PCT 15V	4450-4600	56289	150D335X0015A2
C	51	CAP ALUM 60 UF 25V	4450-2900	56289	30D606G025
C	52	CAP CER DISC 100PF 5PCT 500V	4404-1105	72982	0831082Z5D00101J
C	53	CAP TANT 220 UF 20PCT 10V DIP	4450-6251	90201	TDC 220UF 20PCT 10V
C	54	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	55	CAP CER DISC 470PF 5PCT 500V	4404-1475	72982	0831082Z5D00471J
C	56	CAP CER DISC 470PF 5PCT 500V	4404-1475	72982	0831082Z5D00471J
C	57	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	58	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	59	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	60	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	61	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C	62	CAP TANT 33 UF 20PCT 35V DIP	4450-6255	90201	TDC 33UF 20PCT 35V
C	63	CAP CER DISC 100PF 5PCT 500V	4404-1105	72982	0831082Z5D00101J
C	64	CAP CER DISC 22PF 5PCT 500V	4404-0225	72982	0831082Z5D00220J
C	65	CAP CER DISC 47PF 5PCT 500V	4404-0475	72982	0831082Z5D00470J
CR	1	DIODE DHD-707 30PIV IR.001UA SI	6082-1009	C7910	CD81172
CR	2	DIODE DHD-707 30PIV IR.001UA SI	6082-1009	C7910	CD81172
CR	3	DIODE DHD-707 30PIV IR.001UA SI	6082-1009	C7910	CD81172
CR	4	DIODE DHD-707 30PIV IR.001UA SI	6082-1009	C7910	CD81172
CR	5	DIODE 1N455 30PIV IR 30UA GE	6082-1010	14433	1N455
CR	6	DIODE 1N455 30PIV IR 30UA GE	6082-1010	14433	1N455
CR	7	DIODE 1N455 30PIV IR 30UA GE	6082-1010	14433	1N455
CR	8	DIODE 1N455 30PIV IR 30UA GE	6082-1010	14433	1N455
CR	15	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154
CR	16	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154
CR	17	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154
CR	18	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154
CR	20	DIODE 1N4154 25PIV IR.1UA SI	6082-1012	14433	IN4154

ELECTRICAL PARTS LIST (cont)

AMPLIFIER & MAGNITUDE DETECTOR BOARD (B) P/N 1238-4720

REFCES	DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
Q 1	TRANSISTOR(STATIC PROTECT REQ)	8210-1260	17856	DN1330
Q 2	TRANSISTOR 2N3414	8210-1290	56289	2N3414
Q 3	TRANSISTOR 2N4250	8210-1294	07263	2N4250
Q 4	TRANSISTOR PN3391A	8210-1292	56289	PN3391A
Q 5	TRANSISTOR 2N3414	8210-1290	56289	2N3414
Q 6	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 7	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 8	TRANSISTOR 2N4250	8210-1294	07263	2N4250
Q 9	TRANSISTOR 2N4250	8210-1294	07263	2N4250
Q 10	TRANSISTOR 2N3903	8210-1132	04713	2N3903
Q 11	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 12	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 13	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 14	TRANSISTOR PN3391A	8210-1292	56289	PN3391A
Q 15	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 16	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 17	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 18	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 19	TRANSISTOR 2N3903	8210-1132	04713	2N3903
Q 20	TRANSISTOR 2N3903	8210-1132	04713	2N3903
Q 21	TRANSISTOR 2N3905	8210-1114	04713	2N3905
Q 22	TRANSISTOR(STATIC PROTECT REQ)	8210-1180	17856	3N164
Q 23	TRANSISTOR 2N3903	8210-1132	04713	2N3903
Q 24	TRANSISTOR 2N3903	8210-1132	04713	2N3903
Q 25	TRANSISTOR 2N3905	8210-1114	04713	2N3905
Q 26	TRANSISTOR 2N3906	8210-1112	04713	2N3906
Q 27	TRANSISTOR 2N3414	8210-1290	56289	2N3414
Q 28	TRANSISTOR 2N3414	8210-1290	56289	2N3414
Q 30	TRANSISTOR 2N3900	8210-1118	03508	2N3900
Q 31	TRANSISTOR 2N3638	8210-1278	07263	PN3638
Q 32	TRANSISTOR 2N3905	8210-1114	04713	2N3905
Q 34	TRANSISTOR PN3391A	8210-1292	56289	PN3391A
Q 35	TRANSISTOR 2N697	8210-1040	04713	2N697
R 1	RES COMP 10 OHM 5PCT 1/4W	6099-0105	81349	RCR07G100J
R 2	RES COMP 1.0 G 10PCT 1/8W	6098-8109	81349	RCR05G108K
R 3	RES FLM 25.5K 1 PCT 1/8W	6250-2255	81349	RN55D2552F
R 4	RES FLM 1K 1 PCT 1/8W	6250-1100	81349	RN55D1001F
R 5	RES FLM 9.09K 1 PCT 1/8W	6250-1909	81349	RN55D9091F
R 6	RES COMP 1.0 M 5PCT 1/4W	6099-5105	81349	RCR07G105J
R 7	RES COMP 120 K 5PCT 1/4W	6099-4125	81349	RCR07G124J
R 8	RES COMP 8.2 K 5PCT 1/4W	6099-2825	81349	RCR07G822J
R 9	POT COMP TRM 5K OHM 20PCT 1T	6040-0600	01121	YR502M
R 10	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R 11	RES COMP 300 OHM 5PCT 1/4W	6099-1305	81349	RCR07G301J
R 12	RES COMP 300 OHM 5PCT 1/4W	6099-1305	81349	RCR07G301J
R 13	RES FLM 20K 1 PCT 1/8W	6250-2200	81349	RN55D2002F
R 14	RES FLM 200 OHM 1 PCT 1/8W	6250-0200	81349	RN55D2000F
R 15	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 16	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 17	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 18	RES COMP 7.5 K OHM 5PCT 1/4W	6099-2755	81349	RCR07G752J
R 19	RES COMP 75 K OHM 5PCT 1/4W	6099-3755	81349	RCR07G753J
R 20	RES FLM 1K 1 PCT 1/8W	6250-1100	81349	RN55D1001F
R 21	RES FLM 100K 1 PCT 1/8W	6250-3100	81349	RN55D1003F
R 22	RES COMP 7.5 K OHM 5PCT 1/4W	6099-2755	81349	RCR07G752J
R 23	RES FLM 18.2K 1 PCT 1/8W	6250-2182	81349	RN55D1822F
R 24	RES FLM 1.82K 1 PCT 1/8W	6250-1182	81349	RN55D1821F
R 25	RES FLM 200 OHM 1 PCT 1/8W	6250-0200	81349	RN55D2000F
R 26	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 27	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 28	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 29	RES COMP 200 OHM 5PCT 1/4W	6099-1205	81349	RCR07G201J
R 30	RES COMP 200 OHM 5PCT 1/4W	6099-1205	81349	RCR07G201J
R 31	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 32	RES COMP 7.5 K OHM 5PCT 1/4W	6099-2755	81349	RCR07G752J
R 33	RES FLM 2.55K 1 PCT 1/8W	6250-1255	81349	RN55D2551F
R 34	RES FLM 51.1K 1 PCT 1/8W	6250-2511	81349	RN55D5112F
R 35	RES FLM 6.57K 1/2PCT 1/8W	6251-1657	81349	RN55D6571D
R 36	RES COMP 3.3 K 5PCT 1/4W	6099-2335	81349	RCR07G332J
R 37	RES COMP 470 OHM 5PCT 1/4W	6099-1475	81349	RCR07G471J
R 38	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R 39	RES COMP 10 OHM 5PCT 1/4W	6099-0105	81349	RCR07G100J
R 40	RES COMP 91 OHM 5PCT 1/4W	6099-0915	81349	RCR07G910J
R 41	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 42	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 43	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 44	RES COMP 3.9 K 5PCT 1/4W	6099-2395	81349	RCR07G392J

ELECTRICAL PARTS LIST (cont)

AMPLIFIER & MAGNITUDE DETECTOR BOARD (B) P/N 1238-4720

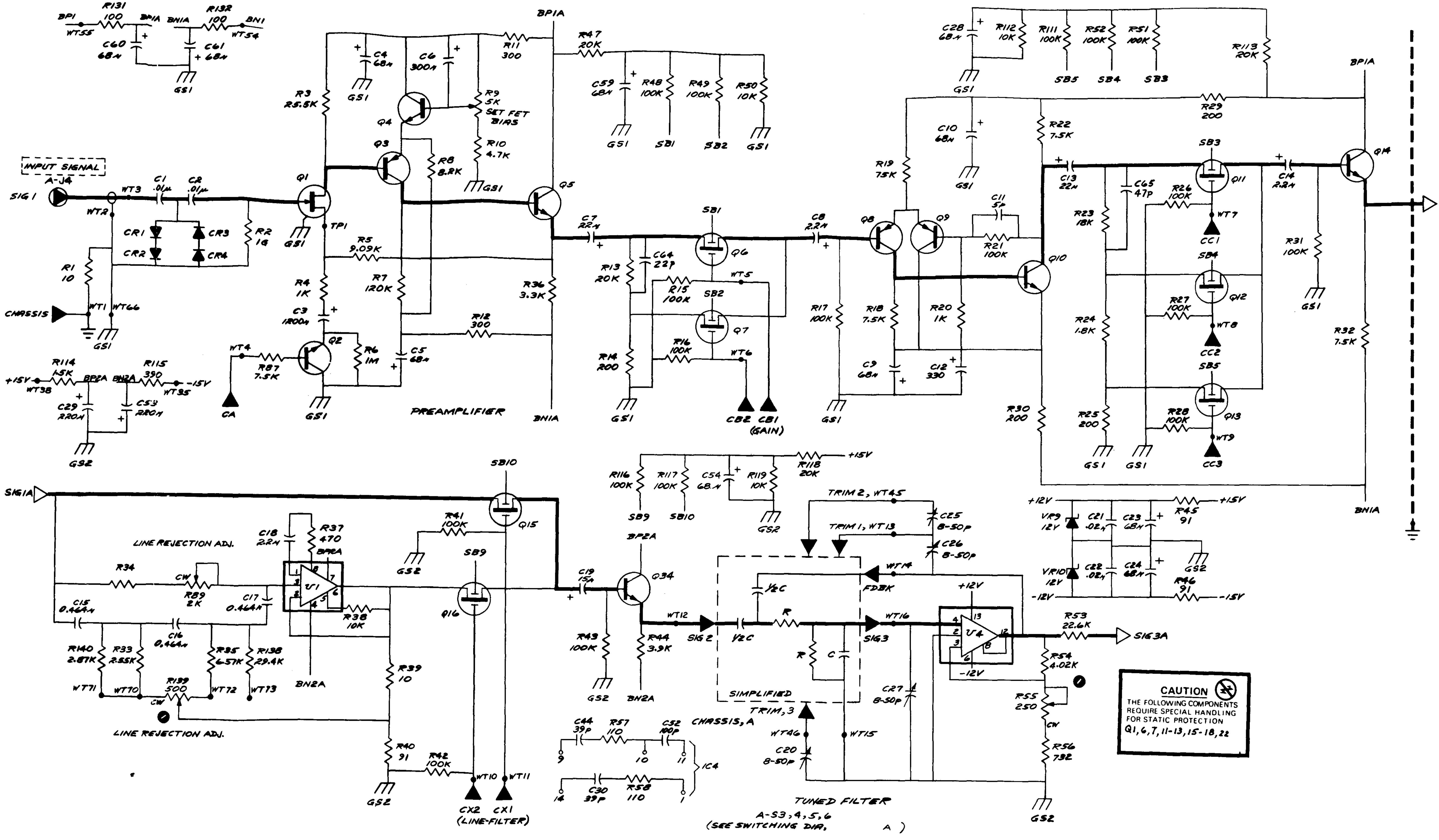
REFDES		DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
R	45	RES COMP 91 OHM 5PCT 1/4W	6099-0915	81349	RCR07G910J
R	46	RES COMP 91 OHM 5PCT 1/4W	6099-0915	81349	RCR07G910J
R	47	RES COMP 20 K OHM 5PCT 1/4W	6099-3205	81349	RCR07G203J
R	48	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	49	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	50	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R	51	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	52	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	53	RES FLM 22.6K 1 PCT 1/8W	6250-2226	81349	RN55D2262F
R	54	RES FLM 4.02K 1 PCT 1/8W	6250-1402	81349	RN5504021F
R	55	POT COMP TRM 250 OHM 20PCT 1T	6040-0200	01121	YR251M
R	56	RES FLM 732 OHM 1 PCT 1/8W	6250-0732	81349	RN55D7320F
R	57	RES COMP 110 OHM 5PCT 1/4W	6099-1115	81349	RCR07G111J
R	58	RES COMP 110 OHM 5PCT 1/4W	6099-1115	81349	RCR07G111J
R	59	RES FLM 7.15K 1 PCT 1/8W	6250-1715	81349	RN55D7151F
R	60	RES FLM 3.32K 1 PCT 1/8W	6250-1332	81349	RN55D3321F
R	61	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	62	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	63	RES COMP 2.2 K 5PCT 1/4W	6099-2225	81349	RCR07G222J
R	64	RES COMP 20 K OHM 5PCT 1/4W	6099-3205	81349	RCR07G203J
R	65	RES COMP 20 K OHM 5PCT 1/4W	6099-3205	81349	RCR07G203J
R	66	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R	67	RES COMP 36 K OHM 5PCT 1/4W	6099-3365	81349	RCR07G363J
R	68	RES COMP 1.0 K 5PCT 1/4W	6099-2105	81349	RCR07G102J
R	69	RES COMP 5.1 K OHM 5PCT 1/4W	6099-2515	81349	RCR07G512J
R	70	RES COMP 3.0 K OHM 5PCT 1/4W	6099-2305	81349	RCR07G302J
R	71	POT COMP TRM 25K OHM 20PCT 1T	6040-0800	01121	YR253M
R	72	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R	73	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R	74	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	75	RES COMP 20 K OHM 5PCT 1/4W	6099-3205	81349	RCR07G203J
R	76	RES COMP 20 K OHM 5PCT 1/4W	6099-3205	81349	RCR07G203J
R	77	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R	78	RES COMP 36 K OHM 5PCT 1/4W	6099-3365	81349	RCR07G363J
R	79	RES COMP 16 K OHM 5PCT 1/4W	6099-3165	81349	RCR07G163J
R	80	RES COMP 3.0 K OHM 5PCT 1/4W	6099-2305	81349	RCR07G302J
R	81	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R	82	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R	83	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	84	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R	85	RES COMP 27 K 5PCT 1/4W	6099-3275	81349	RCR07G273J
R	86	POT COMP TRM 5K OHM 20PCT 1T	6040-0600	01121	YR502M
R	87	RES COMP 7.5 K OHM 5PCT 1/4W	6099-2755	81349	RCR07G752J
R	88	RES COMP 1.0 K 5PCT 1/4W	6099-2105	81349	RCR07G102J
R	89	POT CERM TRM 2K OHM 20 PCT 1T	6049-0107	80294	3329H-1-202
R	90	RES COMP 10 OHM 5PCT 1/4W	6099-0105	81349	RCR07G100J
R	91	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R	92	RES COMP 47 OHM 5PCT 1/4W	6099-0475	81349	RCR07G470J
R	93	RES COMP 2.7 K 5PCT 1/4W	6099-2275	81349	RCR07G272J
R	94	RES WW MOLDED 2.7 OHM 10 PCT 2W	6760-9279	75042	BWH 2.7 OHM 10PCT
R	95	RES COMP 43 K OHM 5PCT 1/4W	6099-3435	81349	RCR07G433J
R	96	RES FLM 5.11K 1 PCT 1/8W	6250-1511	81349	RN55D5111F
R	97	RES FLM 5.11K 1 PCT 1/8W	6250-1511	81349	RN55D5111F
R	98	RES COMP 51 OHM 5PCT 1/4W	6099-0515	81349	RCR07G510J
R	99	RES COMP 10 OHM 5PCT 1/4W	6099-0105	81349	RCR07G100J
R	100	RES COMP 1.2 K 5PCT 1/4W	6099-2125	81349	RCR07G122J
R	101	RES COMP 47 OHM 5PCT 1/4W	6099-0475	81349	RCR07G470J
R	102	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R	103	RES COMP 82 K 5PCT 1/4W	6099-3825	81349	RCR07G823J
R	104	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R	105	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R	106	RES WW MOLDED 2.7 OHM 10 PCT 2W	6760-9279	75042	BWH 2.7 OHM 10PCT
R	107	RES COMP 3.0 K OHM 5PCT 1/4W	6099-2305	81349	RCR07G302J
R	108	POT WW TRM 1K OHM 10 PCT 1T	6056-0138	24655	6056-0138
R	109	RES COMP 3.3 K 5PCT 1/4W	6099-2335	81349	RCR07G332J
R	110	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R	111	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	112	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R	113	RES COMP 20 K OHM 5PCT 1/4W	6099-3205	81349	RCR07G203J
R	114	RES COMP 1.5 K 5PCT 1/4W	6099-2155	81349	RCR07G152J
R	115	RES COMP 390 OHM 5PCT 1/4W	6099-1395	81349	RCR07G391J
R	116	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	117	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	118	RES COMP 20 K OHM 5PCT 1/4W	6099-3205	81349	RCR07G203J
R	119	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R	120	RES COMP 200 K OHM 5PCT 1/4W	6099-4205	81349	RCR07G204J
R	121	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	122	RES COMP 200 K OHM 5PCT 1/4W	6099-4205	81349	RCR07G204J
R	123	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J

Note: This list continued on page 6-10.

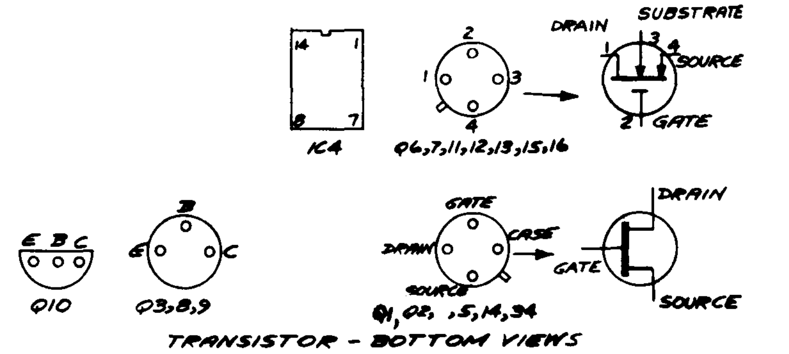
RESISTANCE IS IN OHMS, K=10^3, M=10^6
CAPACITANCE IS IN FARADS, μ=10^{-6}, p=10^{-12}
VOLTAGES EXPLAINED IN INSTRUCTION BOOK SERVICE NOTES
▭=PANEL CONTROL ⬚=REAR CONTROL
●=SCREWDRIVER CONTROL WT=WIRE TIE TP=TEST POINT
COMPLETE REFERENCE DESIGNATION INCLUDES SUBASSEMBLY LETTER, C-R1, B-R1, ETC.

4 0 4 F SWITCH NUMBERING
F — FRONT, REAR
04 — CONTACTS, FIRST CONTACT CW FROM STRUT SCREW ABOVE KEY IS .01.
4 — SECTION, SECTION NEAREST PANEL IS 1.
ROTORS SHOWN CCW

CONNECTIONS
→ OUTPUT LEAVES SUBASSEMBLY
▶— INPUT FROM DIFFERENT SUBASSEMBLY
—▷ OUTPUT REMAINS ON SUBASSEMBLY
▷— INPUT FROM SAME SUBASSEMBLY



CAUTION
THE FOLLOWING COMPONENTS REQUIRE SPECIAL HANDLING FOR STATIC PROTECTION
Q1, 6, 7, 11-13, 15-18, 22



TRANSISTOR - BOTTOM VIEWS

Figure 6-5→

Figure 6-5. Preamplifier and active filters, diagram. B_1

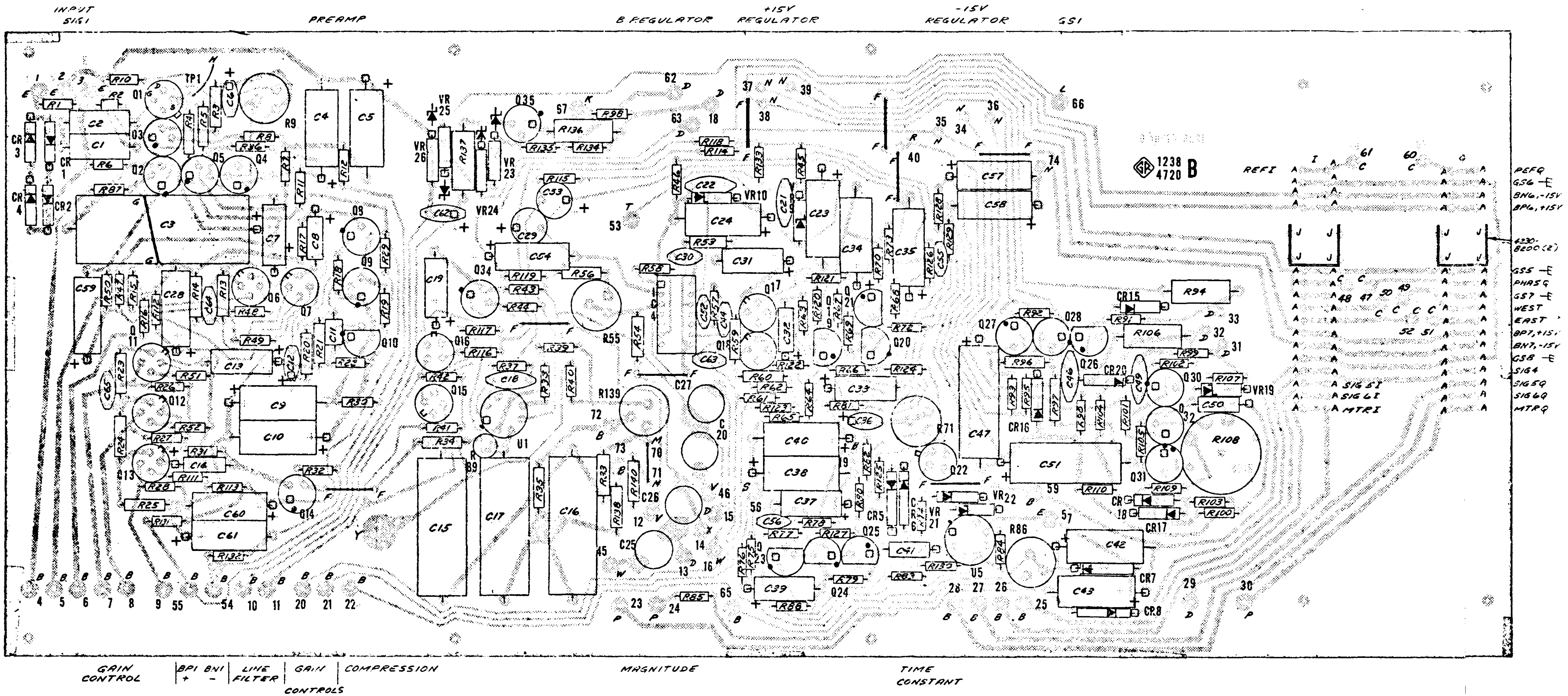
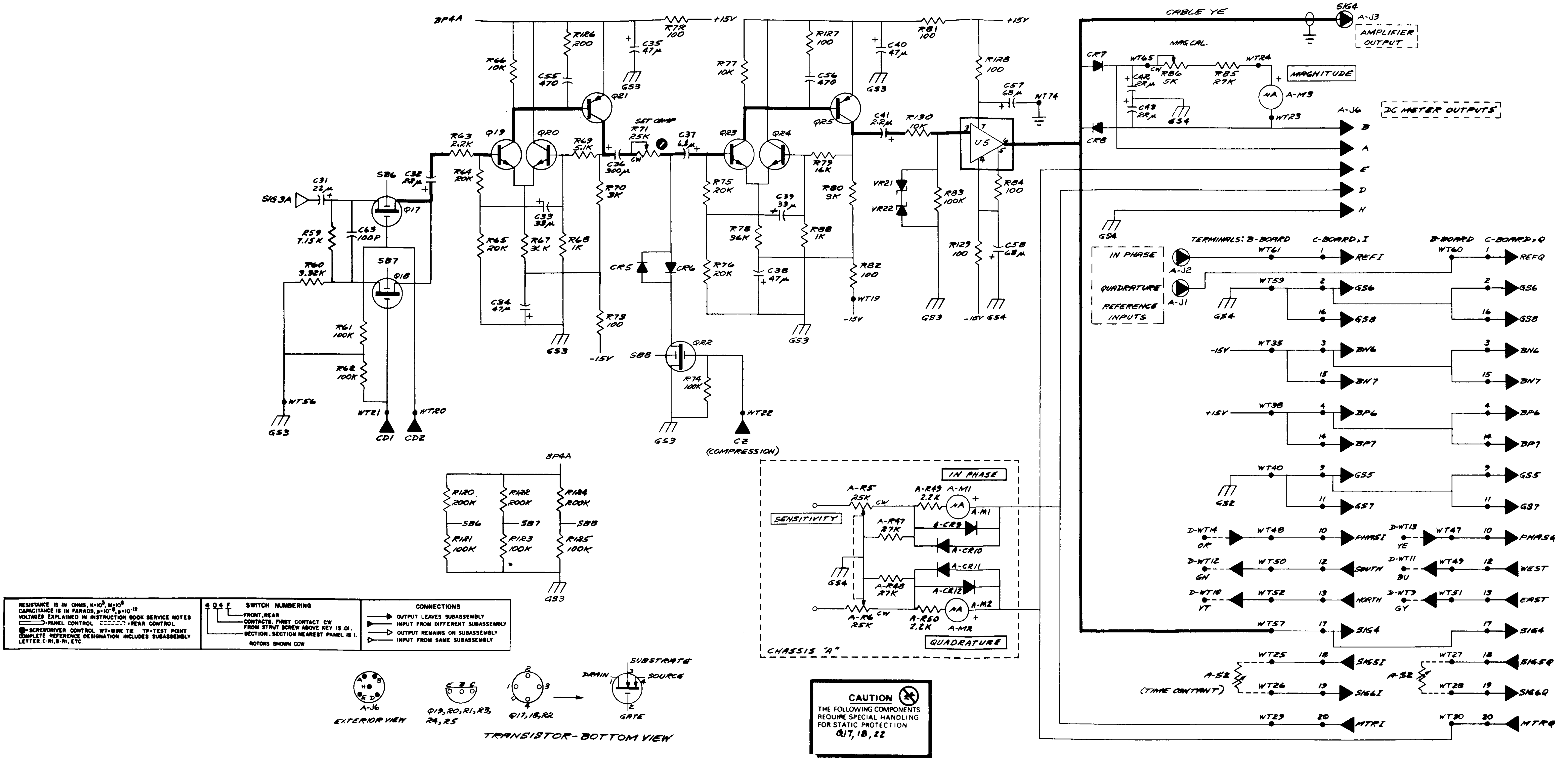


Figure 6-6. B-Board assembly, showing etched circuit.
Note: this board, part number 1238-4720, is not replaceable.

CAUTION
THE FOLLOWING COMPONENTS REQUIRE SPECIAL HANDLING FOR STATIC PROTECTION
Q1,6,7,11-13,15-18,22

NOTE: *Orientation:* Viewed from parts side. *Part number:* Refer to caption. *Symbolism:* Outlined area = part; black ckt pattern (if any) = parts side, gray = other side. *Pins:* Separate dot (●) = collector, half dot (◖) or 1 = I-C pin 1.



RESISTANCE IS IN OHMS, $K=10^3$, $M=10^6$
CAPACITANCE IS IN FARADS, $\mu=10^{-6}$, $p=10^{-12}$
VOLTAGES EXPLAINED IN INSTRUCTION BOOK SERVICE NOTES
▭ = PANEL CONTROL ⬚ = REAR CONTROL
● = SCREWDRIVER CONTROL WT = WIRE TIE TP = TEST POINT
COMPLETE REFERENCE DESIGNATION INCLUDES SUBASSEMBLY LETTER, C-R1, B-R1, ETC.

4 0 4 F SWITCH NUMBERING
F — FRONT, REAR
04 — CONTACTS. FIRST CONTACT CW FROM STRUT SCREW ABOVE KEY IS 01.
4 — SECTION. SECTION NEAREST PANEL IS 1.
ROTORS SHOWN CCW

CONNECTIONS
——► OUTPUT LEAVES SUBASSEMBLY
►—— INPUT FROM DIFFERENT SUBASSEMBLY
——▷ OUTPUT REMAINS ON SUBASSEMBLY
▷—— INPUT FROM SAME SUBASSEMBLY

CAUTION
THE FOLLOWING COMPONENTS REQUIRE SPECIAL HANDLING FOR STATIC PROTECTION
Q17, 18, 22

Figure 6-7→

Figure 6-7. Final amplifier, metering, and motherboard diagram. B_2

Table 6-1

SIGNAL INDEX (1238)

Name	Description	Diagram	Address	Figure
BN1	Power-supply bus, −15 V, for preamplifier only.	6-8 6-5	B-WT54	5-3 6-6
BP1	Same as BN1, except +15 V.		B-WT55	
CA	Control of gain of Q1. . .Q5; 20 dB when CA is +15 V, 0 dB when 0 V.	6-5 6-3	B-WT4	6-6
CB1	Control of 0-dB path after Q5; *.	6-5 6-3	B-WT5	6-6
CB2	Control of −40-dB path after Q5; *.	6-5 6-3	B-WT6	6-6
CC1	Control of 0-dB path after Q10; *.	6-5 6-3	B-WT7	6-6
CC2	Control of −20-dB path after Q10; *.	6-5 6-3	B-WT8	6-6
CC3	Control of −40-dB path after Q10; *.	6-5 6-3	B-WT9	6-6
CD1	Control of −10-dB path after SIG3A; *.	6-7 6-3	B-WT21	6-6
CD2	Control of direct path after SIG3A; *.	6-7 6-3	B-WT20	6-6
CX1	Control of direct path around line filter; *.	6-5 6-3	B-WT11	6-6
CX2	Control of path through line rejection filter; *.	6-5 6-3	B-WT10	6-6
CZ	Control of compression between Q21 and Q23; compr when CZ is −15 V, linear when 0 V.	6-7 6-3	B-WT22	6-6
EAST	Reference signal in phase with REFQ.	6-7 6-10 6-12	B-WT51 C pin 13 D-WT9	6-6 6-9 6-11
FDBK	Feedback signal in tuned filter; main output from U4.	6-5 6-4	B-WT14	6-6
GS1	Ground, preamplifier only; 0-V reference for BN1 and BP1.	6-8 6-5	B-WT66 A-T1, 16	6-6
GS2 GS3 GS4	Ground points, nominally identical; 0-V reference for main power supply.	6-8 6-5	B-WT40 B-WT56 B-WT59	6-6
GS5 GS6 GS7 GS8	Ground points, nominally identical with GS2 and GS4.	6-7 6-10	C pin 9 C pin 2 C pin 11 C pin 16	6-9
MTRI	Output of meter driver C-U203; C-board, I, "in phase"; one of the DC METER OUTPUTS.	6-7 6-10	B-WT29 C pin 20 A-J6,D	6-6 6-9 6-2
MTRQ	Same as MTRI, except C-board, Q, "quadrature"		B-WT30 A-J6, E	
NORTH	Reference signal in phase with REFI.	6-7 6-10 6-12	B-WT52 C pin 13 D-WT10	6-6 6-9 6-11
PHASI	Shifted reference signal for "I" phase detector.	6-7 6-10 6-12	B-WT48 C pin 10 D-WT14	6-6 6-9
PHASQ	Same as PHASI, except for "Q" detector.		B-WT47 D-WT13	
REFI	In-phase reference input signal.	6-7 6-10	A-J2 B-WT61 C pin 1	6-2 6-6 6-9
REFQ	Same as REFI, except quadrature.		A-J1 B-WT60	
SIG1	INPUT SIGNAL	6-5	A-J4 B-WT3	6-2 6-6
SIG1A	Signal out of preamplifier into line rejection filter or Q34.	6-5	Jct of B-C15 & B-Q15	5-3 6-6
SIG2	Signal ahead of tuned filter.	6-5 6-4	B-WT12	6-6 5-3

Table 6-1 (Cont)

SIGNAL INDEX (1238)

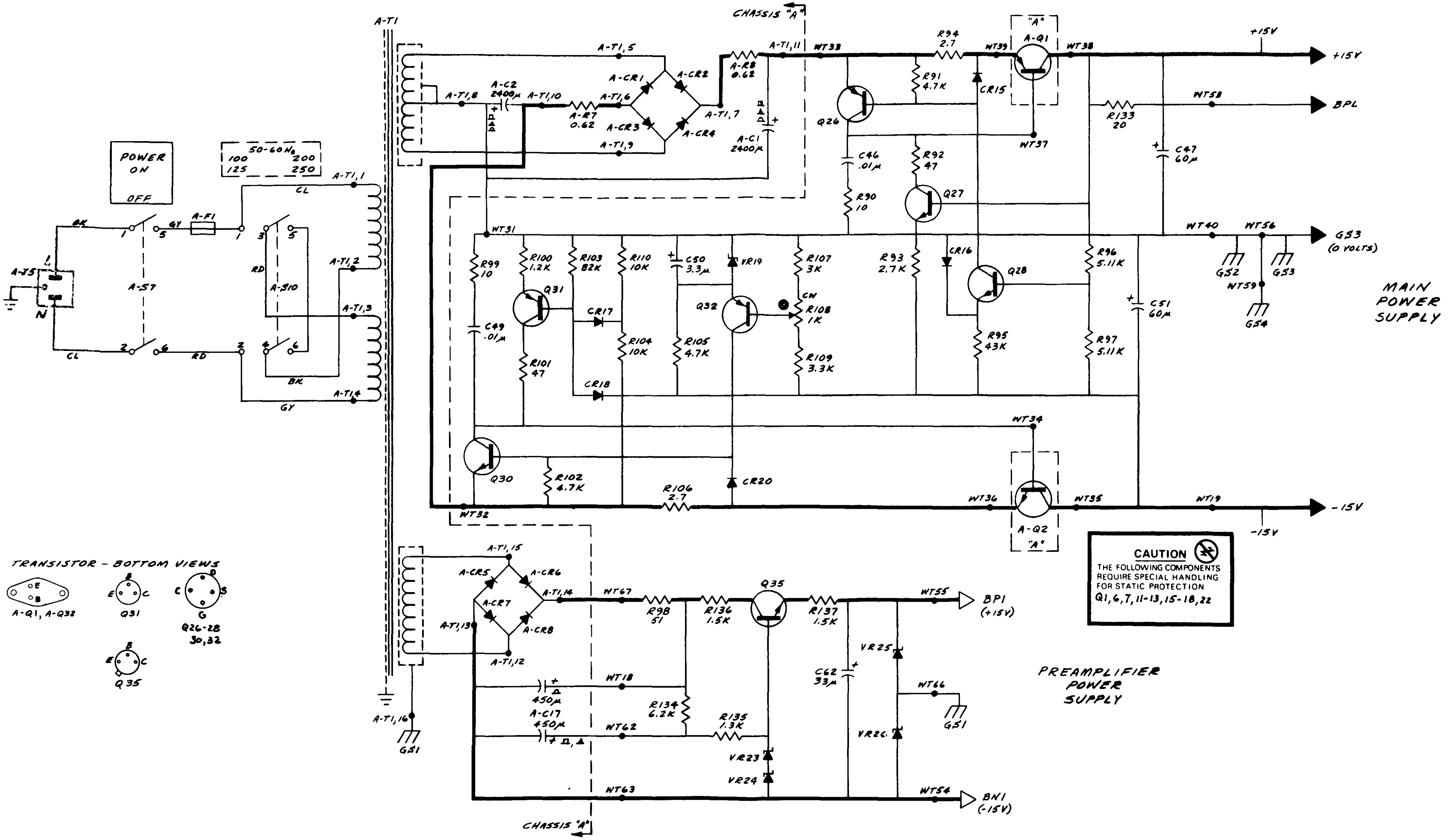
Name	Description	Diagram	Address	Figure
SIG3	Signal in tuned filter, at + input to U4.	6-5	B-WT16	6-6
		6-4		5-3
SIG3A	Attenuated output from U4 (after tuned filter).	6-5	Jct of	6-6
		6-7	B-R53 &	5-3
			B-C31	
SIG4	AMPLIFIER OUTPUT (from U5).	6-7	A-J3	6-2
		6-10	B-WT57	
			C pin 17	
SIG5I	Detected signal, "dc", out of C-U202; C-board, I; into A-S2.	6-10	C pin 18	6-9
		6-7	B-WT25	5-2
SIG5Q	Same as SIG5I, except C-board, Q		B-WT27	
SIG6I	Detected and smoothed signal, "dc". into final meter driver, C-U203; C-board, I.	6-10	C pin 19	6-9
		6-7	B-WT26	6-6
SIG6Q	Same as SIG6I, except C-board, Q.		B-WT28	
SOUTH	Reference signal 180° from REFI.	6-7	B-WT50	6-6
		6-10	C pin 12	6-9
		6-12	D-WT12	6-11
TRIM1	Signal at interior of tuned-filter network, at summing point.	6-5	B-WT13	6-6
TRIM2	Signal in tuned filter, identical to FDBK on lower kHz range only.	6-5	B-WT45	6-6
		6-4		
		6-4		
TRIM3	Signal in tuned filter, identical to SIG3 on upper kHz range only.	6-5	B-WT46	6-6
		6-4		
WEST	Reference signal 180° from REFQ.	6-7	B-WT49	6-6
		6-10	C pin 12	6-9
		6-12	D-WT11	6-11

* The path is connected when the signal is −15 V; the path is blocked when the signal is 0 V.

ELECTRICAL PARTS LIST (cont)

AMPLIFIER & MAGNITUDE DETECTOR BOARD (B) P/N 1238-4720

REFDES	DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
R 124	RES COMP 200 K OHM 5PCT 1/4W	6099-4205	81349	RCR07G204J
R 125	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R 126	RES COMP 200 OHM 5PCT 1/4W	6099-1205	81349	RCR07G201J
R 127	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R 128	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R 129	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R 130	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R 131	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R 132	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R 133	RES COMP 20 OHM 5PCT 1/4W	6099-0205	81349	RCR07G200J
R 134	RES COMP 6.2 K OHM 5PCT 1/4W	6099-2625	81349	RCR07G622J
R 135	RES COMP 1.3 K OHM 5PCT 1/4W	6099-2135	81349	RCR07G132J
R 136	RES COMP 1.5 K 5PCT 1W	6110-2155	81349	RCR32G152J
R 137	RES COMP 1.5 K 5PCT 1W	6110-2155	81349	RCR32G152J
R 138	RES FLM 29.4K 1 PCT 1/8W	6250-2294	81349	RN55D2942F
R 139	POT COMP TRM 500 OHM 20PCT 1T	6040-0300	01121	YR501M
R 140	RES FLM 2.87K 1 PCT 1/8W	6250-1287	81349	RN55D2871F
U 1	IC LINEAR MC1439G	5432-1439	04713	MC1439G
U 4	IC LINEAR CA3030A	5432-1014	86684	CA3030A
U 5	IC LINEAR LM302	5432-1008	12040	LM302H
VR 9	ZENER 1N759A 12V 5PCT .4W	6083-1014	14433	IN759A
VR 10	ZENER 1N759A 12V 5PCT .4W	6083-1014	14433	IN759A
VR 19	ZENER 1N957B 6.8V 5PCT .4W	6083-1009	07910	IN957B
VR 21	ZENER 1N752A 5.6V 5PCT .4W	6083-1004	14433	IN752A
VR 22	ZENER 1N752A 5.6V 5PCT .4W	6083-1004	14433	IN752A
VR 23	ZENER 1N972B 30V 5PCT .4W	6083-1040	14433	IN972B
VR 24	ZENER 1N972B 30V 5PCT .4W	6083-1040	14433	IN972B
VR 25	ZENER 1N965B 15V 5PCT .4W	6083-1015	14433	IN965B
VR 26	ZENER 1N965B 15V 5PCT .4W	6083-1015	14433	IN965B



CAUTION

THE FOLLOWING COMPONENTS REQUIRE SPECIAL HANDLING FOR STATIC PROTECTION

Q1,6,7,11-13,15-18,22

RESISTANCE IS IN OHMS, $K=10^3$, $M=10^6$
CAPACITANCE IS IN FARADS, $\mu=10^{-6}$, $p=10^{-12}$
VOLTAGES EXPLAINED IN INSTRUCTION BOOK SERVICE NOTES
▭=PANEL CONTROL ⬚=REAR CONTROL
●=SCREWDRIVER CONTROL WT=WIRE TIE TP=TEST POINT
COMPLETE REFERENCE DESIGNATION INCLUDES SUBASSEMBLY LETTER, C-R1, B-R1, ETC.

404F SWITCH NUMBERING
F — FRONT, REAR
04 — CONTACTS. FIRST CONTACT CW FROM STRUT SCREW ABOVE KEY IS .01.
4 — SECTION. SECTION NEAREST PANEL IS 1.
ROTORS SHOWN CCW

CONNECTIONS
→ OUTPUT LEAVES SUBASSEMBLY
▶— INPUT FROM DIFFERENT SUBASSEMBLY
—▷ OUTPUT REMAINS ON SUBASSEMBLY
▷— INPUT FROM SAME SUBASSEMBLY

Figure 6-8. Power supply diagram. B3

ELECTRICAL PARTS LIST

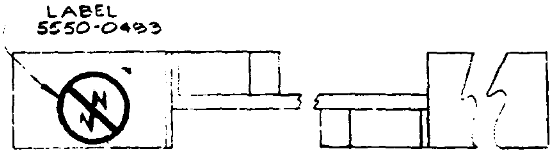
PHASE DETECTOR BOARD (C) P/N 1238-4700

REFDES	DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
C 201	CAP TANT 120 UF 20PCT 10V	4450-5616	56289	150D127X0010R2
C 202	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 203	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 204	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 205	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 206	CAP TANT 120 UF 20PCT 10V	4450-5616	56289	150D127X0010R2
C 207	CAP CER TUB 6.8 PF 10PCT 500V	4400-0800	95121	QC 6.8PF 10PCT 500V
C 208	CAP TANT 120 UF 20PCT 10V	4450-5616	56289	150D127X0010R2
C 209	CAP CER DISC 100PF 5PCT 500V	4404-1105	72982	0831082Z5D00101J
C 210	CAP CER DISC.047/.05UF80/20 100V	4403-3500	56289	0845024Z5U05032
C 211	CAP CER DISC.047/.05UF80/20 100V	4403-3500	56289	0845024Z5U05032
C 212	CAP CER DISC .02UF 80/20PCT 100V	4402-3200	56289	55C21 .02UF
C 213	CAP CER DISC .02UF 80/20PCT 100V	4402-3200	56289	55C21 .02UF
C 214	CAP GLASS TRIM 1.0-8.5 PF PC	4910-1100	72982	563-013
C 215	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C 216	CAP MYLAR MTLZD 2.2UF 5PCT 50V	4860-9852	56289	431P2255R5
C 219	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 220	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 221	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 222	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 223	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 224	CAP TANT 68 UF 20PCT 15V	4450-5615	56289	150D686X0015R2
C 225	CAP CER DISC 30PF 5PCT 500V	4404-0305	72982	0831082Z5D00300J
CR 201	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR 204	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR 205	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
Q 201	TRANSISTOR PN3391A	8210-1292	56289	PN3391A
Q 202	TRANSISTOR PN3391A	8210-1292	56289	PN3391A
Q 203	TRANSISTOR PN3391A	8210-1292	56289	PN3391A
Q 204	TRANSISTOR PN3391A	8210-1292	56289	PN3391A
Q 205	TRANSISTOR	8210-1295	24655	8210-1295
Q 206	TRANSISTOR	8210-1295	24655	8210-1295
Q 207	TRANSISTOR(STATIC PROTECT REQ)	8210-1143	04713	2N4220
Q 208	TRANSISTOR(STATIC PROTECT REQ)	8210-1143	04713	2N4220
R 201	RES COMP 300 K OHM 5PCT 1/4W	6099-4305	81349	RCR07G304J
R 202	RES COMP 33 K 5PCT 1/4W	6099-3335	81349	RCR07G333J
R 203	RES COMP 62 K OHM 5PCT 1/4W	6099-3625	81349	RCR07G623J
R 204	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R 205	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R 206	RES COMP 200 OHM 5PCT 1/4W	6099-1205	81349	RCR07G201J
R 207	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R 208	RES COMP 3.9 K 5PCT 1/4W	6099-2395	81349	RCR07G392J
R 209	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R 210	RES COMP 3.9 K 5PCT 1/4W	6099-2395	81349	RCR07G392J
R 211	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R 212	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R 215	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R 216	RES COMP 1.0 K 5PCT 1/4W	6099-2105	81349	RCR07G102J
R 217	RES COMP 1.0 K 5PCT 1/4W	6099-2105	81349	RCR07G102J
R 218	RES COMP 1.0 M 5PCT 1/4W	6099-5105	81349	RCR07G105J
R 219	RES COMP 1.0 K 5PCT 1/4W	6099-2105	81349	RCR07G102J
R 220	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R 221	RES COMP 1.0 K 5PCT 1W	6110-2105	81349	RCR32G102J
R 222	RES COMP 22 OHM 5PCT 1/4W	6099-0225	81349	RCR07G220J
R 223	RES COMP 22 OHM 5PCT 1/4W	6099-0225	81349	RCR07G220J
R 224	RES COMP 1.0 M 5PCT 1/4W	6099-5105	81349	RCR07G105J
R 225	RES COMP 300 OHM 5PCT 1/4W	6099-1305	81349	RCR07G301J
R 226	RES COMP 910 OHM 5PCT 1/4W	6099-1915	81349	RCR07G911J
R 227	RES COMP 7.5 K OHM 5PCT 1/4W	6099-2755	81349	RCR07G752J
R 228	RES COMP 3.3 K 5PCT 1/4W	6099-2335	81349	RCR07G332J
R 229	RES COMP 3.0 K OHM 5PCT 1/4W	6099-2305	81349	RCR07G302J
R 230	RES COMP 24 K OHM 5PCT 1/4W	6099-3245	81349	RCR07G243J
R 231	POT CERM TRM 1K OHM 10 PCT 15T	6049-0186	80294	3006P-1-102
R 232	RES COMP 200 OHM 5PCT 1/4W	6099-1205	81349	RCR07G201J
R 234	POT CERM TRM 50K OHM 10 PCT 15T	6049-0191	80294	3006P-1-503
R 235	RES COMP 100 M 5PCT 1/2W	6100-7105	81349	RCR20G107J
R 236	RES COMP 20 K OHM 5PCT 1/4W	6099-3205	81349	RCR07G203J
R 237	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R 238	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R 239	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R 240	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R 241	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J

ELECTRICAL PARTS LIST (cont)

PHASE DETECTOR BOARD (C) P/N 1238-4700

REFDES	DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
U 201	IC LINEAR VA710C	5432-7101	04713	MC1710CG
U 202	IC LINEAR LM302	5432-1008	12040	LM302H
U 203	IC LINEAR LM301A	5432-1004	12040	LM301AH
VR 202	ZENER 1N759A 12V 5PCT .4W	6083-1014	14433	IN759A
VR 203	ZENER 1N753A 6.2V 5PCT .4W	6083-1006	14433	IN753A



CAUTION
THE FOLLOWING COMPONENTS
REQUIRE SPECIAL HANDLING
FOR STATIC PROTECTION
U201, Q207 & 208

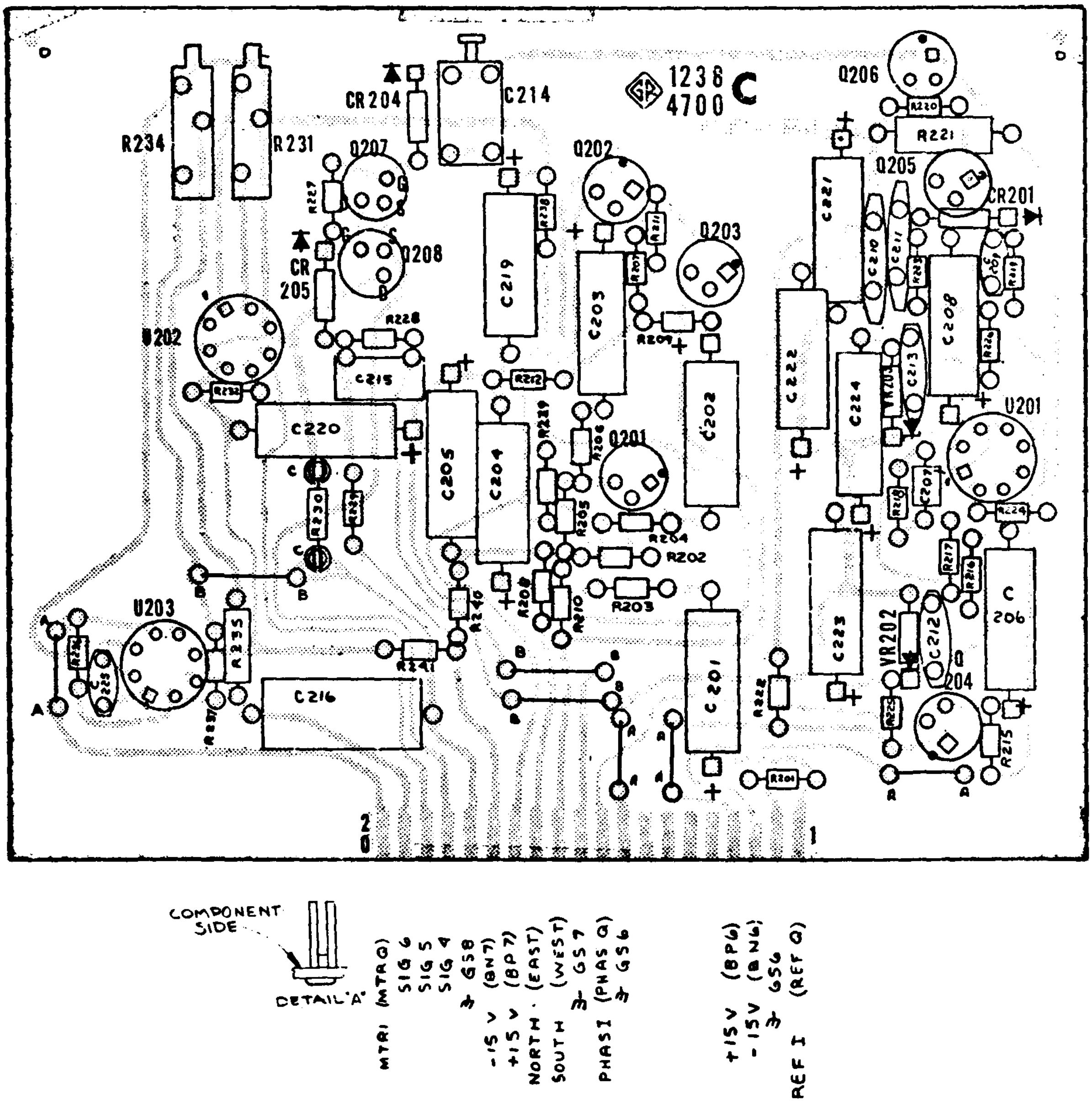
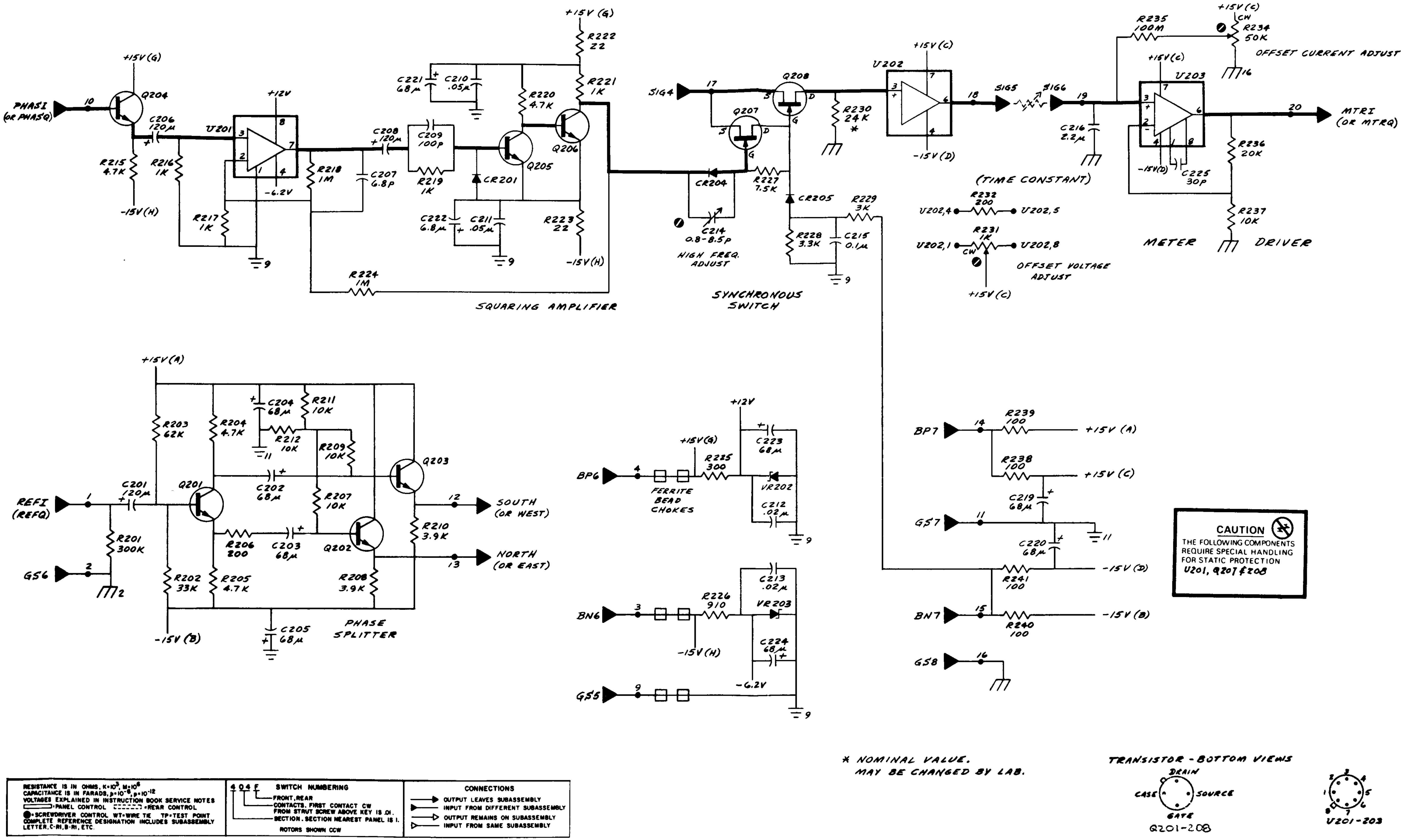


Figure 6-9. C-board assembly, showing etched circuit, (P/N 1238-4700).



CAUTION
THE FOLLOWING COMPONENTS REQUIRE SPECIAL HANDLING FOR STATIC PROTECTION
U201, Q207 & 208

* NOMINAL VALUE.
MAY BE CHANGED BY LAB.

RESISTANCE IS IN OHMS, K=10³, M=10⁶
CAPACITANCE IS IN FARADS, μ=10⁻⁶, p=10⁻¹²
VOLTAGES EXPLAINED IN INSTRUCTION BOOK SERVICE NOTES
=PANEL CONTROL =REAR CONTROL
●=SCREWDRIVER CONTROL WT=WIRE TIE TP=TEST POINT
COMPLETE REFERENCE DESIGNATION INCLUDES SUBASSEMBLY LETTER, C-R1, B-R1, ETC.

4 0 4 F SWITCH NUMBERING
FRONT, REAR
CONTACTS. FIRST CONTACT CW FROM STRUT SCREW ABOVE KEY IS 01.
SECTION. SECTION NEAREST PANEL IS 1.
ROTORS SHOWN CCW

CONNECTIONS
OUTPUT LEAVES SUBASSEMBLY
INPUT FROM DIFFERENT SUBASSEMBLY
OUTPUT REMAINS ON SUBASSEMBLY
INPUT FROM SAME SUBASSEMBLY

Figure 6-10. Phase-sensitive detector diagram. C

ELECTRICAL PARTS LIST

PHASE SHIFTER BOARD (D)   P/N 1238-4710

REFDES	DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
R 1	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R 2	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R 3	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R 4	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R 5	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R 6	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R 7	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R 8	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R 9	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R 10	RES COMP 62 K OHM 5PCT 1/4W	6099-3625	81349	RCR07G623J
R 11	RES COMP 62 K OHM 5PCT 1/4W	6099-3625	81349	RCR07G623J
R 12	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J

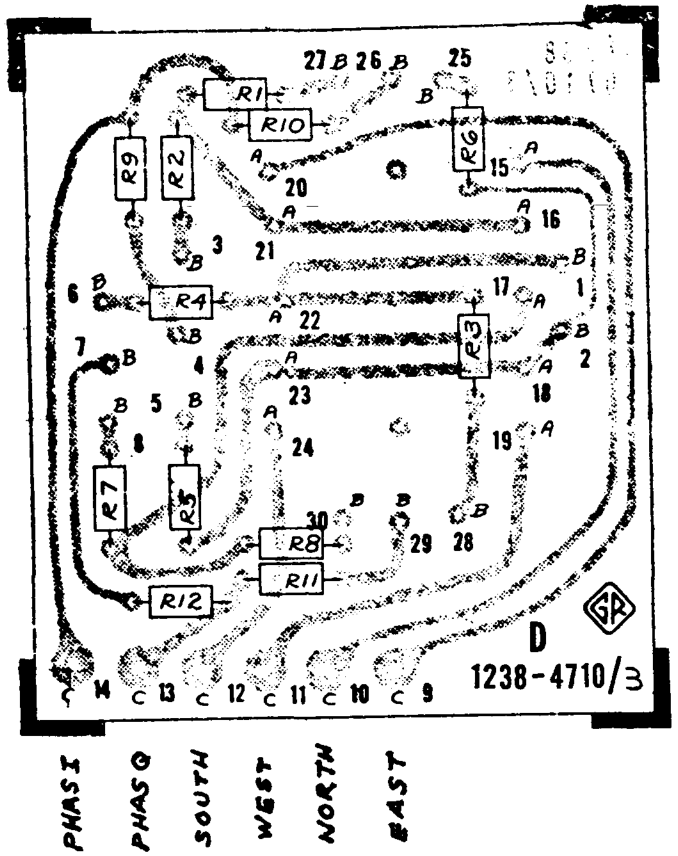


Figure 6-11. D-board assembly, showing etched circuit, (P/N 1238-4710).

RESISTANCE IS IN OHMS, K=10^3, M=10^6
CAPACITANCE IS IN FARADS, μ=10^{-6}, p=10^{-12}
VOLTAGES EXPLAINED IN INSTRUCTION BOOK SERVICE NOTES
▭ =PANEL CONTROL ⬚ =REAR CONTROL
● =SCREWDRIVER CONTROL WT=WIRE TIE TP=TEST POINT
COMPLETE REFERENCE DESIGNATION INCLUDES SUBASSEMBLY LETTER, C-R1, B-R1, ETC.

404F SWITCH NUMBERING
F — FRONT, REAR
04 — CONTACTS, FIRST CONTACT CW FROM STRUT SCREW ABOVE KEY IS 01.
4 — SECTION, SECTION NEAREST PANEL IS 1.
ROTORS SHOWN CCW

CONNECTIONS
→ OUTPUT LEAVES SUBASSEMBLY
▶— INPUT FROM DIFFERENT SUBASSEMBLY
—▷ OUTPUT REMAINS ON SUBASSEMBLY
▷— INPUT FROM SAME SUBASSEMBLY

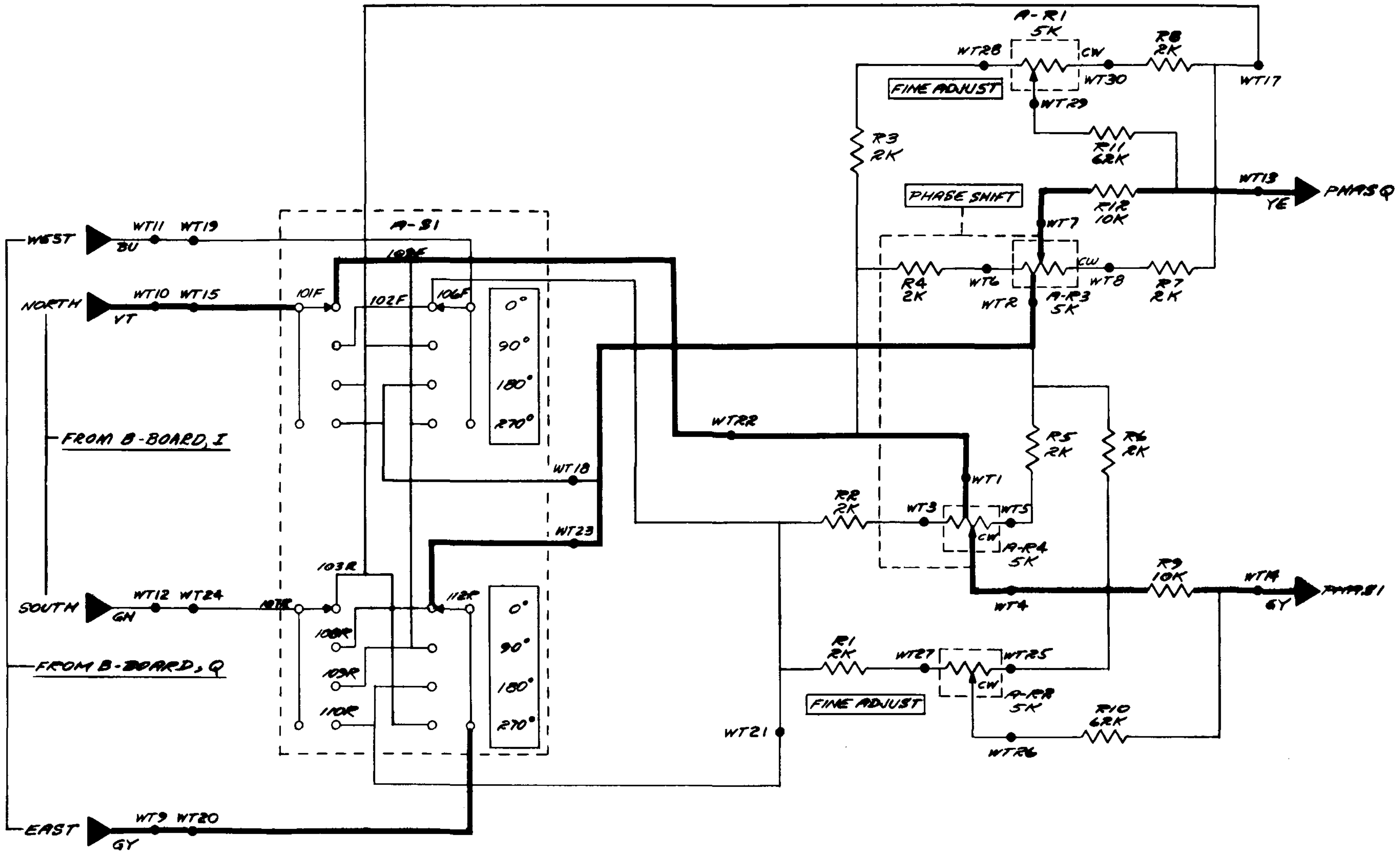


Figure 6-12. Phase shifter schematic diagram. D

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