SOLID STATE

BAND-PASS FILTER

MODEL 3500 SERIAL NO. ________

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION

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Model 3500

Figure 1. Model 3500 Filter

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 3500 Filter, shown in Figure 1, is a variable, electronic band-pass filter that operates at frequencies from 20Hz to 200kHz. The filter consists basically of an input amplifier, a variable high-pass section, a variable low-pass section, and an output amplifier. The high-pass and low-pass sections are connected in series. The overall gain of the Filter is unity(0db). The cutoff frequencies of both the high-pass and low-pass sections can be adjusted independently over the full frequency range of 20Hz to 200kHz.

An optional rack-mounting kit, (Part No. RK-38) is available from Krohn-Hite, for installing the unit in a standard 19" rack spacing.

1.2 GENERAL SPECIFICATIONS

Frequency Range

Continuous coverage from 20Hz to 200kHz for both high cut-off and low cut-off frequencies independently. Frequency range is covered by separate calibrated dials and four-decade band switches. Center frequency and width of pass band in band-pass mode are continuously adjustable over the entire frequency range.

BAND	MULTIPLIER	FREQUENCY (Hz)
1	1	20 - 200
2	10	200 - 2,000
3	100	2,000 - 20,000
4	1K	20,000 - 200,000

Frequency Dials

Each dial is engraved and individually hand-calibrated with a single logarithmic scale reading directly in cycles per second, from 19 to 210. Dials are 2 inches in diameter with an effective scale length of 6 inches per band, giving a total effective scale length of 24 inches for the range of 20Hz to 200kHz.

Accuracy of Cut-off Frequency Calibration

±10% with "Response" switch in "max-flat" (Butterworth) position; less accurate in "Low Q" position. Relative to mid-band level, the filter output is down 3db at cut-off in "max-flat" position, and approximately 12db in "Low Q" position.

Bandwidth

Continuously variable within the cutoff frequency limits of 20Hz and 200kHz. For minimum pass-band (Butterworth response) the two cutoffs are set to the same frequency, resulting in an insertion loss of 6db at that frequency, with 3db points at factors of .8 below it and 1.25 above it.

Response Characteristics

Choice of 4 pole Butterworth (maximally flat response) for frequency domain operation and Low Q (damped response) for transient-free time domain operation, selected by means of a switch on rear of chassis.

Pass-Band Gain

Zero db ±1 db in pass band.

Input Characteristics, Impedance

Approximately 10 megohms in parallel with 50 pf. Maximum input amplitude: 5 volts rms up to 2MHz. Maximum dc component: 100 volts.

Output Characteristics, Impedance

Approximately 50 ohms. Maximum Voltage ±7 volts peak. Maximum Current ±5 ma peak. Internally generated hum and noise: Less than 200 microvolts. (Slightly higher for 400 Hz operation.)

Attenuation Slope

Nominal 24db per octave each side of pass-band.

Maximum Attenuation

Greater than 60 db.

Controls

Front panel; LOW CUT-OFF FREQUENCY dial and multiplier switch. HIGH CUT-OFF FREQUENCY dial and multiplier switch. POWER OFF-ON switch. Rear panel; RESPONSE switch, GROUND switch, 115/230V LINE switch.

Terminals

Front panel, two BNC connectors, one for INPUT and one for OUTPUT. Rear of chassis, two BNC connectors, one for input and one for output. An additional multi-purpose binding post for CHASSIS GROUND is provided on the rear panel. An AC power receptacle with detachable line cord is also provided.

Power Requirements

105-125 or 210-250 volts, single phase; 50-400 Hz, 10 watts. Hum and noise are increased by a factor of approximately two for 400Hz operation.

Fuse Protection

1/8 ampere slow-blow for 115 volts, 1/16 ampere slow-blow for 230 volts.

Dimensions and Weights

Model	Overall Dimensions (inches)			Weight (lbs.)	
3500	8 1/2 wide	3 1/2 high	13 deep	9 net	14 shipping

1.3 FILTER CHARACTERISTICS

Bandwidth Adjustment

The flexibility of adjustment of bandwidth is illustrated in Figure 2. Band-pass operation in the MAXimally FLAT or Butterworth mode for two different band-widths is illustrated by curves A and B. Curve B shows the minimum pass-band width obtained by setting the two cutoff frequencies equal. In this condition the insertion loss is 6 db, and the -3 db cutoff frequencies occur at 0.8 and 1.25 times the mid-band frequency. The minimum pass-band for a 0 db insertion loss is shown by curve A with the cutoffs set at 0.5 and 2 times the mid-band frequency.

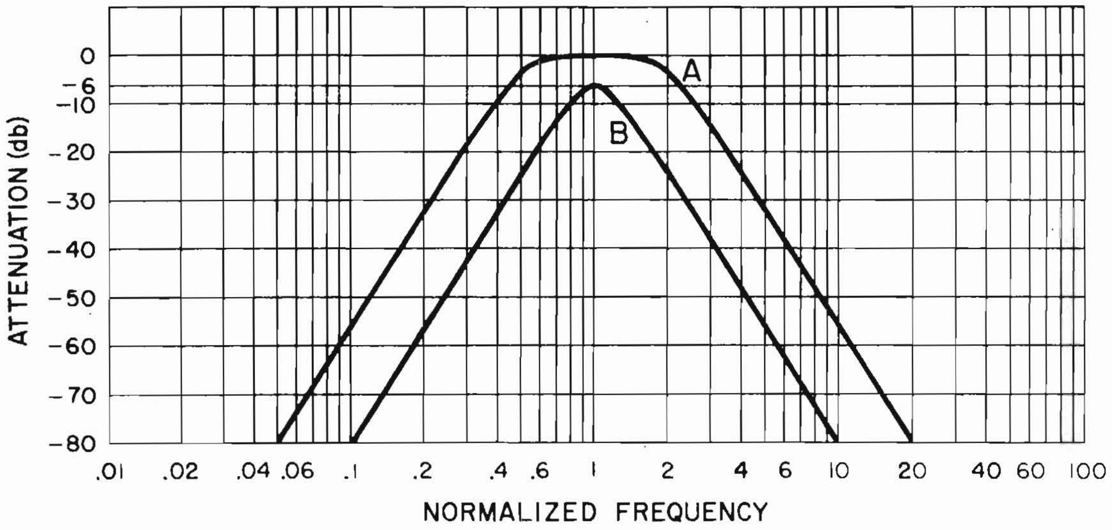
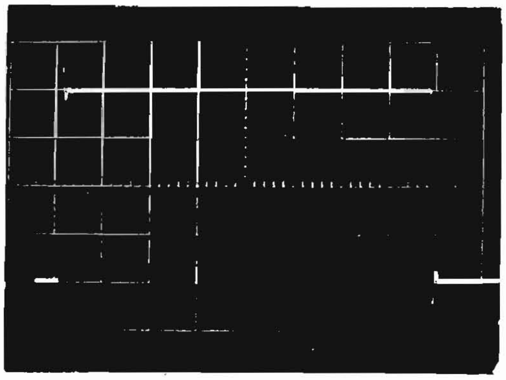


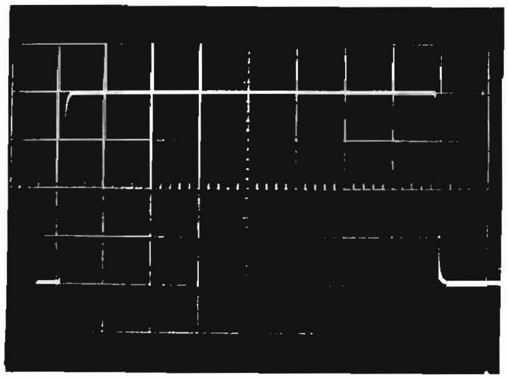
Figure 2. Normalized Frequency

Transient Response

The frequency response characteristic of this Filter closely approximates a fourth-order Butterworth with maximal flatness, ideal for filtering in the frequency domain. For pulse or transient signal filtering, a response switch is provided to change the frequency response to Low Q, optimum for transient-free filtering. Figure 3 shows a comparison of the Filter output response in these modes to a square wave input signal.



(A)



(B)

Figure 3. Square Wave Response

Cutoff Response

The attenuation characteristics of the Filter are shown in Figure 4. With the response switch in the MAXimally FLAT or Butterworth mode, the gain, as shown by the solid curve, is virtually flat until the -3db cutoff frequency. At approximately two times the cutoff frequency the attenuation rate coincides with the 24 db per octave straight line asymptote. In the Simple RC mode, optimum for transient-free filtering, the dotted line shows that the gain is down approximately 12 db at cutoff and reaches 24 db per octave attenuation rate at five times the cutoff frequency. Beyond this frequency the filter attenuation rate and maximum attenuation, in either mode, are identical.

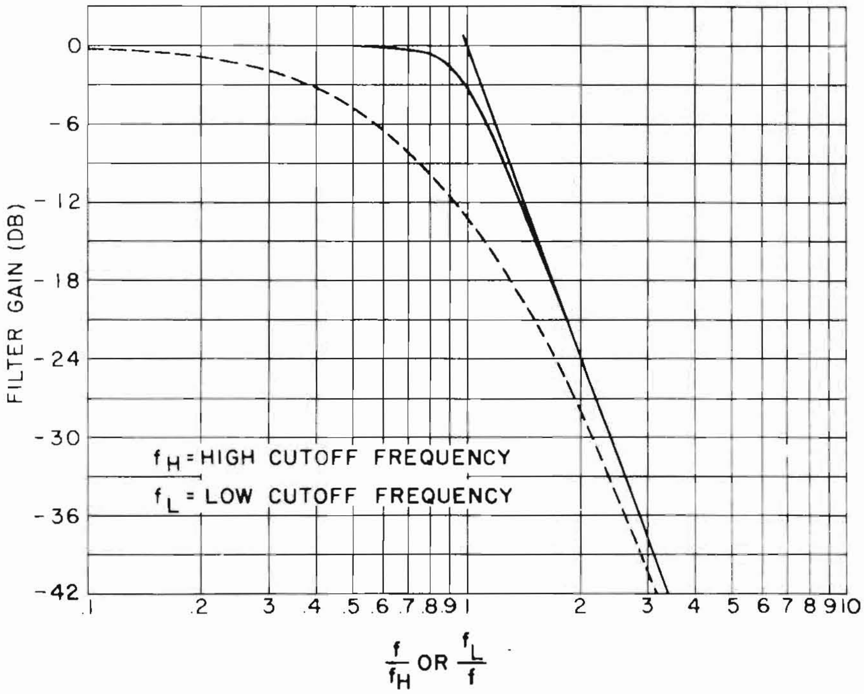


Figure 4. Normalized Attenuation Characteristics

Phase Response

The phase angle at any frequency is the sum of the angles due to the high-pass and low-pass sections of the Filter. Figure 5 gives the phase characteristic for either section in degrees lead (+) or lag (-), as a function of the ratio of the operating frequency f to low cut-off frequency f_L or high-cutoff frequency f_H.

The solid curve is for the maximally flat or Butterworth mode and the dotted curve is for Low Q.

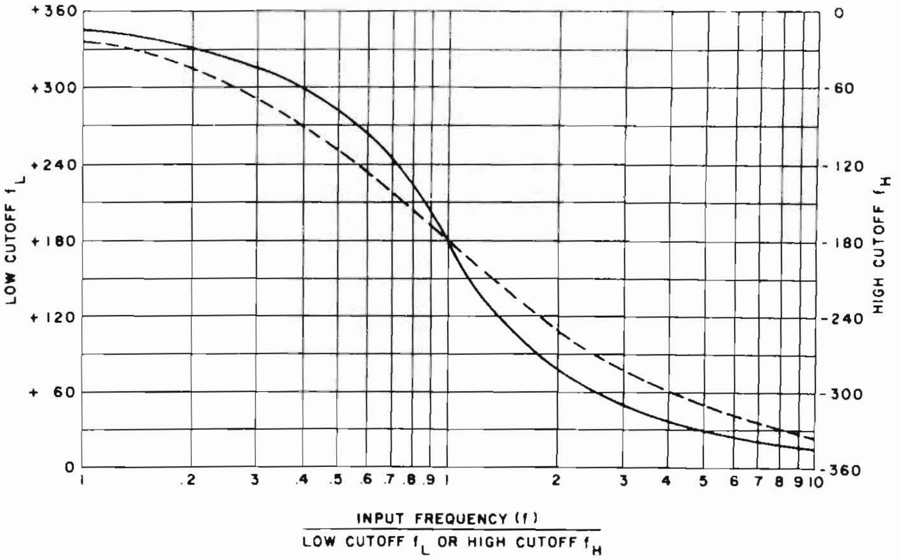


Figure 5. Normalized Phase Characteristics

Example

Determine the phase shift through the filter, in the maximally flat or Butterworth mode with the low cutoff (f_L) at 200 Hz, the high cutoff (f_H) at 600 Hz and an input frequency (f) at 300 Hz.

Phase shift due to low cutoff (f_L)

$$\frac{f}{f_L} = \frac{300}{200} = 1.5$$

from Figure 6 $\quad 1.5 = +110^{\circ}$

Phase shift due to high cutoff (f_L)

$$\frac{f}{f_H} = \frac{300}{600} = .5$$

from Figure 6 $\quad .5 = -80^{\circ}$

Total phase shift

$$= +110^{\circ} - 80^{\circ} = +30^{\circ}$$

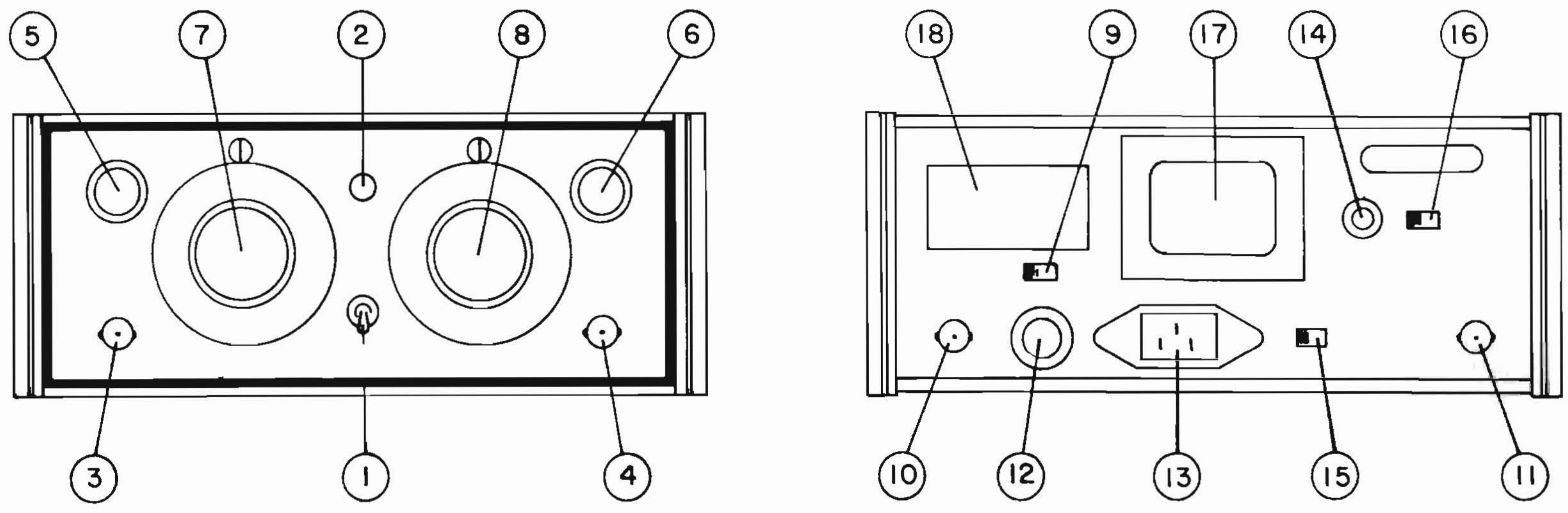


FIGURE 6. FRONT AND REAR PANELS

(1) POWER SWITCH (ON/OFF)
(2) INDICATOR LIGHT
(3) INPUT CONNECTOR (BNC TYPE)
(4) OUTPUT CONNECTOR (BNC TYPE)
(5) MULTIPLIER SWITCH (HIGH PASS)
(6) MULTIPLIER SWITCH (LOW PASS)
(7) FREQUENCY DIAL (LOW CUTOFF)
(8) FREQUENCY DIAL (HIGH CUTOFF)
(9) 115/230V LINE SWITCH
(10) OUTPUT CONNECTOR (BNC TYPE)
(11) INPUT CONNECTOR (BNC TYPE)
(12) FUSE 1/8A SLO-BLO 117V
1/16A SLO-BLO 234V
(13) POWER RECEPTACLE
(14) CHASSIS GROUND CONNECTOR (BINDING POST)
(15) GROUND SWITCH (FLOATING / CHASSIS)
(16) RESPONSE SWITCH (MAX FLAT / LOW Q)
(17) POWER TRANSFORMER
(18) NAMEPLATE

SECTION 2

OPERATION

2.1 INTRODUCTION

The Filter is adjusted and checked carefully before shipment to insure that it meets all specifications. It is then aged and again tested to be sure that it is ready for use. The Filter is shipped complete, and after unpacking, is ready to be turned on and used.

Unpack the Filter carefully and inspect it for damage that may have occurred during shipment. Check the case for damage, and check for loose sub-assemblies and parts. Check all front panel controls for freedom of operation. The recommended operating procedure is described below.

The rms voltage of the input signal should not exceed 5 volts. The dc component of the input signal should not exceed 100 volts.

2.2 FRONT PANEL CONTROLS

The front panel controls consist of two identical frequency dials and associated multiplier switches used to set cut-off frequencies, a power on-off switch, and an indicator light.

Each frequency dial is calibrated with a single logarithmic scale reading directly in cycles per second from 19 to 210. The dials are two inches in diameter with an effective scale length of approximately six inches per band, giving total effective scale length of approximately 24 inches for the 20Hz to 200kHz frequency range. The left-hand dial (LOW CUT-OFF FREQUENCY) and band multiplier switch select the low cut-off frequency, and the right-hand dial (HIGH CUT-OFF FREQUENCY) and multiplier switch select the high cut-off frequency.

Each of the two multiplier switches has four positions, covering the frequency ranges as shown in Section 1.2.

2.3 REAR PANEL CONTROLS

The rear panel controls consist of a RESPONSE switch, a GROUND switch, and a 115/230V LINE switch. The RESPONSE switch is used to select either a Butterworth (max-flat) or a Low Q response. The GROUND switch is provided to disconnect the signal ground from the chassis. The LINE switch is used when changing from 115V to 230V AC operation.

2.4 OPERATION

To operate the Filter, proceed as follows:

a. Make appropriate power connections as described in Section 2.6.

b. Make appropriate connections to INPUT and OUTPUT terminals of filter.

c. Set cut-off frequencies by means of the band multiplier switches (CUT-OFF FREQUENCY) and the frequency dials.

d. Turn POWER switch to ON.

NOTE

The left-hand band multiplier switch and frequency dial are used to select the low cut-off frequency and the right-hand controls select the high cut-off frequency.

The minimum pass-band is obtained by setting the high cut-off frequency equal to the low cut-off frequency.

2.5 TERMINALS

INPUT - A BNC type connector is provided on the left side of the front panel. A parallel BNC coaxial connector is located on the rear of the chassis.

OUTPUT - A BNC type connector is provided on the right side of the front panel. A parallel BNC coaxial connector is located on the rear of the chassis.

CHASSIS GROUND - An additional combination-type binding post is provided on the rear panel.

AC INPUT - A power receptacle with detachable line cord is located on the rear panel.

2.6 LINE VOLTAGE AND FUSES

The Filter may be operated from an AC power source of either 105-125 volts, 50-400 Hz, or 210-250 volts, 50-400 Hz. A 115/230V LINE switch, located on the rear panel, selects the filter's mode of operation. When the AC line is 115V, move the LINE switch to the 115V position. In this mode, a 1/8 ampere slo-blo fuse must be used. When the filter is to be operated from 230 VAC, move the LINE switch to the 230V position, and replace the fuse with a 1/16 ampere slo-blo type.

SECTION 3

CIRCUIT DESCRIPTION

3.1 INTRODUCTION

As shown below in the simplified block diagram, Figure 7, the filter consists of an input amplifier, for isolation; a four pole low-pass section (high cutoff frequency), with four R. C. filter networks which are adjustable by means of a gauged potentionmeter assembly and bandswitch; and a four pole high pass section (low cutoff frequency), with four R. C. filter networks and a similar ganged potentionmeter assembly and bandswitch. Both cutoff frequencies are tuned continuously within each decade by the potentionmeter assemblies. The capacitors are tuned in decade steps by the bandswitch.

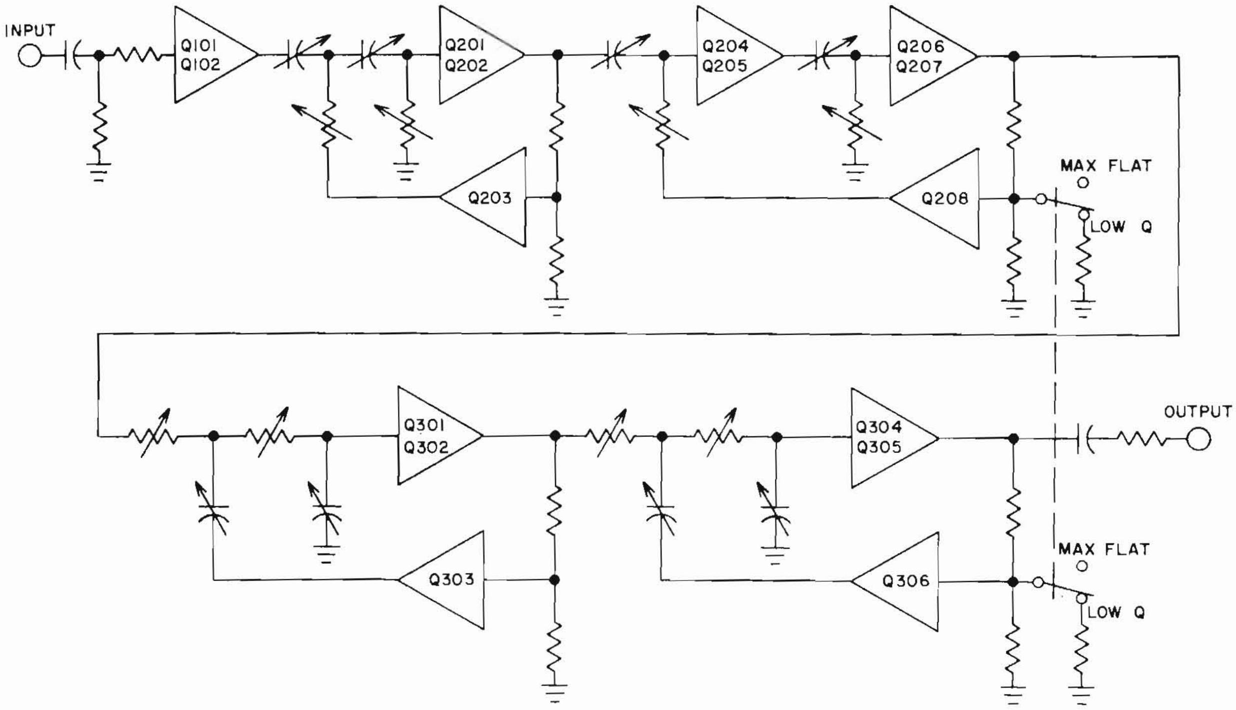


Figure 7. Simplified Schematic Diagram

3.2 DETAILED DESCRIPTION

3.2.1 Input Amplifier

The input signal is capacitor coupled through C101 to the input amplifier consisting of Q101 and Q102. The input impedance determined by R101 is 10 megohms. The high input impedance of the F. E. T. Q101 is negligible. The input amplifier is provided to isolate the input signal and supply a low impedance driving source for the first R. C. network.

3.2.2 High Pass Section

The high pass section consists of a pair of two pole filters, each adjusted to provide the proper Butterworth response characteristics when cascaded. Buffer amplifiers are used to isolate the two pole R. C. networks. The Buffer Amplifier, consisting of Q201 and Q202, following the first 2 pole network provides isolation and drives the next R. C. network. Q203 furnishes feedback to the emitter follower stage for corner frequency peaking. The signal then enters another Buffer Amplifier stage consisting of Q204 and Q205, again providing isolation and a low impedance source to drive the next R. C. network. Q206 and Q207 perform as a buffer amplifier between the high-pass and low-pass sections with Q208 providing enough feedback to Q204 to produce the correct Butterworth response. With switch S901 in the grounded position, the feedback is reduced to produce the Low Q (damped response) for transit free time domain operation.

3.2.3 Low Pass Section

The low pass section also consists of a pair of two pole filters each adjusted to provide the proper Butterworth response when cascaded.

The pair of two pole R. C. networks are isolated from each other with a buffer amplifier which is made up of two emitter followers.

The output from the high-pass section is fed into the first two-pole R. C. network before the buffer amplifier consisting of O301 and Q302. A portion of the output from O302 is fed back to the R. C. network via Q303 to obtain the desired characteristics from this two pole section. The buffer amplifier also provides a low impedance source for driving the next pair of R. C. filters. Q304 and Q305 provide isolation and a low impedance source to drive the output. A portion of the output from Q305 is fedback through amplifier Q306 to obtain the proper Butterworth response characteristics. With switch S901 in the grounded position the feedback is reduced to a low Q (damped response) for transit free time domain operation. The output from Q305 passes through C303 and R411 to the output terminals.

3.2.4 RC/Butterworth Response

To prevent ringing and overshoot, caused by fast rise-time pulses, the filter may be operated in the low Q position. S901 is provided to reduce the feedback to the second two pole filter in each section.

3.2.5 Power Supplies

A dual power supply is incorporated, providing plus and minus 15 volts. One full wave bridge rectifier (CR501, CR504, CR505, CR506) and filter capacitors C501 and C502 provide the necessary unregulated d-c voltage levels.

The + 15V supply consists of Q502 (used as a Zener Reference), amplifier Q503, and series regulator Q501. A change in the regulated output is fed through Q502 and CR502 to the emitter of Q503, and, attenuated in the divider R511 and R501, R506, to the base of Q503. The resulting change in Q503 current drives the base of series transistor Q501 in the proper direction to restore the regulated voltage to + 15V. The -15V supply works in the same manner.

Additional feedback is provided to both amplifiers via R505 and R508 to minimize power supply ripple.

SECTION 4

INCOMING ACCEPTANCE AND INSPECTION

4.1 INTRODUCTION

The following procedure should be used to verify the Filter operation within specifications. These checks may be used for incoming inspection and periodic specification checks. Tests must be made with all covers in place. If the instrument is not operating within specifications refer to Section 5 before attempting any detailed maintenance.

4.2 TEST EQUIPMENT REQUIRED

The following test equipment is required to perform these adjustments:

a. RC Oscillator, with frequency range .01Hz to 1MHz, frequency accuracy ±0.5% to 100KHz, frequency response better than ±.05db and distortion less than .02%, Krohn-Hite Model 4100A or equivalent.

b. Oscilloscope, with DC to 50MHz bandwidth, vertical input sensitivity of 1mv/cm, Tektronix type 544, with type 1A5 plug-in, or equivalent.

c. AC Voltmeter, capable of measuring 100 microvolts to 10 volts RMS, Ballantine Model 314A or equivalent.

d. DC Voltmeter, capable of measuring 1 millivolt to 20 volts, Fluke Model 8000A or equivalent.

e. Variable auto-transformer for adjusting line voltage.

4.3 DIAL ACCURACY

a. Set high cutoff to 200KHz. Set response switch to max flat position. Set low cutoff dial to 20, 40, 100, 200 on each of the multiplier positions. At each point, set oscillator to frequency corresponding to dial and multiplier setting. With 1 volt input, output should read between 0.6V and 0.8V (-3db±1.5db) at all frequencies except 200KHz will read approximately 0.5 volts (-6db) due to interaction of high cutoff setting.

b. Repeat measurements with response switch in low Q position. Output reading should be approximately 0.25 volts (-12db) at all frequencies except 200 KHz.

c. Set low cutoff to 20Hz. Set response switch to max flat position. Set high cut off dial to 20, 40, 100, 200 on each of the multiplier positions. At each point, set oscillator to frequency corresponding to dial and multiplier setting. With 1 volt input, output should read between 0.6V and 0.8V (-3db±1.5db) at all frequencies except 20 Hz. 20Hz will read approximately 0.5V (-6db) due to interaction of low cutoff frequency.

d. Repeat measurements with response switch in Low Q position. Output reading should be approximately 0.25V (-12db) at all frequencies except 20Hz.

4.4 ATTENUATION SLOPE

a. Set high cutoff to 200 KHz and response switch to max flat position. Set low cutoff dial to 60. On each low cutoff multiplier position set oscillator to one half the frequency indicated by the low cutoff dial and multiplier setting. Output should read -24db±3db from input at each frequency.

b. Set low cutoff to 20Hz. Set high cutoff dial to 60. On each high cutoff multiplier position, set oscillator to twice the frequency indicated by the high cutoff dial and multiplier setting. Output should read -24db±3db from input at each frequency.

4.5 PASS-BAND GAIN

Set low cutoff to 20Hz and high cutoff to 200KHz. Set oscillator to 1 volt. At 50 Hz, 500 Hz, 5 KHz and 50 KHz the output should be 1±.1 volt (0db±1db).

4.6 MAXIMUM ATTENUATION

a. Set both cutoff frequencies to 200KHz. Set oscillator input to filter at 5 volts, 20KHz. Output of filter should measure less than 5 millivolts (-60db).

b. Set both cutoff frequencies to 20KHz. Set input to filter to 5 volts, 200KHz. Output of filter should measure less than 5 millivolts (-60db).

4.7 OUTPUT CHARACTERISTICS

a. Maximum Voltage:

Set low cutoff to 20Hz and high cutoff to 200KHz. Set input frequency to 1KHz and increase input voltage until clipping is observed on output. Output should measure greater than 14 volts peak to peak before clipping is observed.

b. Maximum Current:

Connect 50 ohm resistor across output. Adjust input to obtain 0.5 volts peak to peak across 50 ohm resistor. Output should show no observable distortion.

c. Impedance:

Set output to 0.1 volt rms open circuit. Connect 50 ohm resistor to output. Voltage should drop to 0.05 volts.

4.8 HUM AND NOISE

Remove oscillator. Short input to filter. Output should measure less than 200 microvolts rms.

SECTION 5

MAINTENANCE

5.1 INTRODUCTION

If the Filter is not functioning properly and requires service, the following procedure may facilitate locating the source of trouble. Access to the interior of the filter is accomplished by removing the four screws centered at the rear of each cover; sliding off the side covers will unlock the top and bottom covers.

The general layout of major components, test points, screwdriver controls and adjustments is shown in Figure 9. Detailed component layout of the printed circuit card, Figure 11, is located on foldout attached to the inside rear cover. Various check points and voltages are shown on the Schematic Diagram and are also marked on the printed circuit card.

Many troubles may easily be found by visual inspection. When a malfunction is detected, make a quick check of the unit for such things as broken wires, burnt or loose components, or similar conditions which could be a cause of trouble. Any trouble-shooting of the Filter will be greatly simplified if there is an understanding of the operation of the circuit. Before any detailed troubleshooting is attempted, reference should be made to Circuit Description, Section 3, to obtain this understanding.

5.2 POWER SUPPLY

If the filter does not seem to be working properly the two power supplies should be checked first. If the plus 15 and minus 15 volt supplies appear to be correct refer to signal tracing analysis, Section 4.3.

Any malfunction of the power supplies will generally cause a large error in the plus or minus 15 volt supplies. Small errors of the plus or minus supplies may be corrected by adjusting R506 and R509 respectively. If the minus 15 volt supply is correct and the plus 15 volt supply is incorrect, check the reference voltage from the emitter of Q503 to the collector of Q502. If this reference voltage is 8.4±.5 and the plus 15 volt supply is high, the base to emitter voltage of Q503 will be reduced, decreasing its collector current lowering the emitter to base voltage and turning off Q501. This will increase the emitter to collector voltage of Q501, correcting the plus 15 volt supply. The failure will be found where this action is blocked. If the plus 15 volt supply is low, the current in Q503 will be increased, turning on Q501. If the supply voltage is low and Q503 and Q501 appear to be operating properly, the cause is most likely excessive current in the main filter section. An incorrect minus 15 volt supply may be traced in a similar manner.

5.3 SIGNAL TRACING ANALYSIS

If the power supplies appear to be correct but the Filter is not working, the following signal tracing analysis should locate the area of malfunction:

Set response switch to low Q position. Set both the low and high cutoff frequencies to 1KHz. Connect a 1KHz 5 volt rms sine wave signal to the input terminals. If the test signal does not appear correctly at the output, the area of the malfunction may be localized by determining where in the Filter the signal first deviates from normal.

Figure 8 shows various test points with their correct signal levels. If a test point is found whose signal level differs appreciably from the correct value, the circuitry immediately preceding that test point should be carefully checked.

TEST POINTS	CORRECT SIGNAL LEVEL (RMS VOLTS)
1	5.0
2	4.9
3	2.8
4	2.8
5	2.6
6	1.6
7	1.6
8	1.3
10	1.3
13	.43
14	.70
15	.67
16	.18
17	.31
18	.30
20	.14

Figure 8. Test Point Voltages

5.4 TUNING CIRCUITS

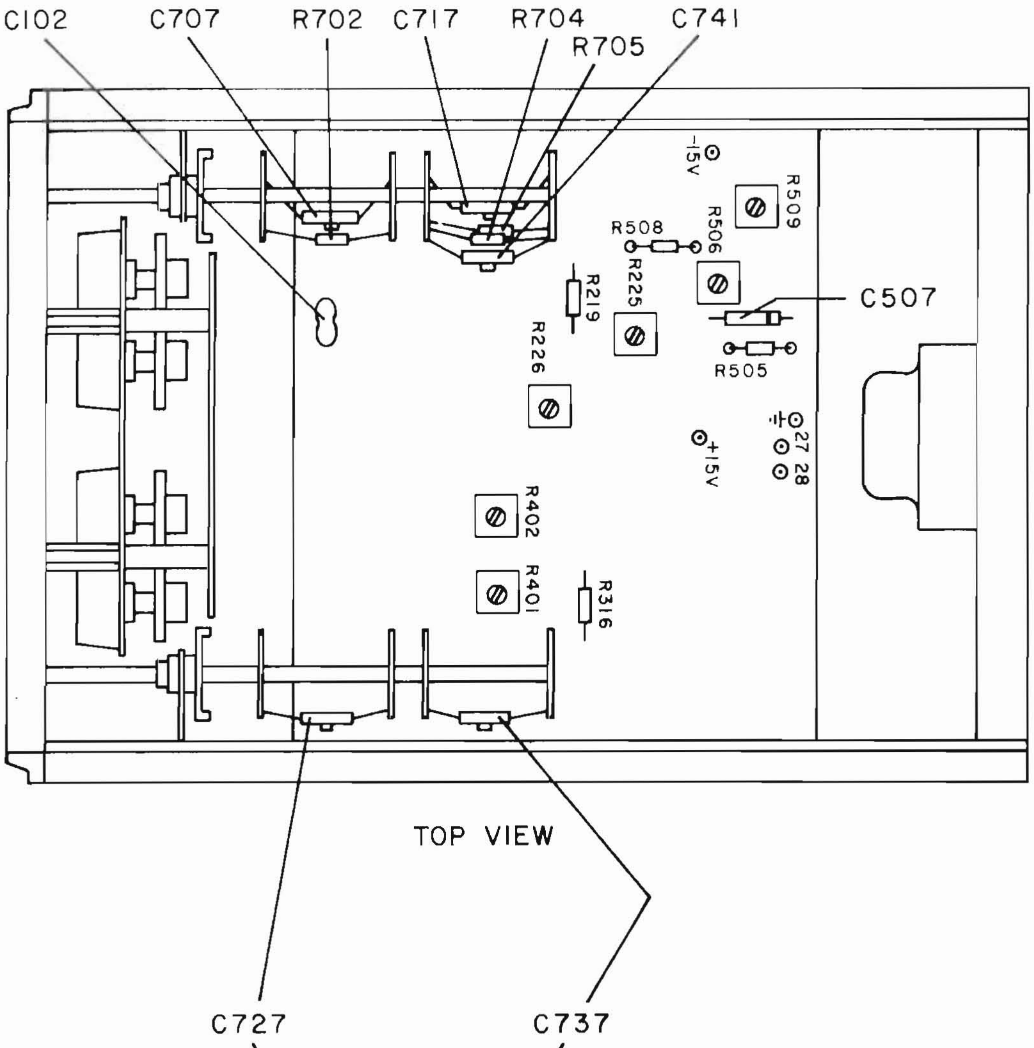
If signal tracing shows one of the tuning circuits to be faulty, it should be determined if the trouble is in the resistive or capacitive element. If the trouble is in a capacitive element associated with the lowest or highest multiplier range, the malfunction will appear only on these positions. Any other defective tuning capacitors will introduce an error in adjacent bands. If there is a problem in a resistant element, the trouble will be of a general nature and will show up on all multiplier bands.

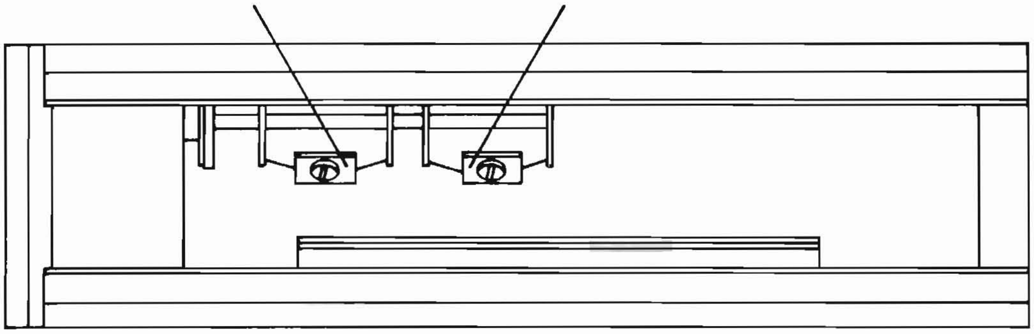
The range-determining capacitors associated with the band multiplier switches S701 and S702 are specially selected for close capacitance tolerance. All capacitor values fall within ±5% of the specified value, but in order to maintain accurate frequency calibration over the entire dial range and also between decade ranges, the capacitors are matched within ±2% of each other and generally within ±2% in decade ratios.

The values of capacitance used on the highest band is selected to compensate for stray capacitance and are therefore not completely in decade ratios of those used on the lower bands.

For replacement purposes, a capacitor within ±1% of the specified value can be used with negligible effect on the overall calibration accuracy. If more than one capacitor on a particular range is to be changed, it is recommended that several other capacitors on the switch be carefully measured on a capacitance bridge to determine the average percentage deviation from the nominal value. Any capacitors except those used on the two highest frequency ranges may be measured to determine this tolerance. Replacement can then be made with capacitors of the exact value, and calibration will not be impaired.

Each of the variable resistance elements consists of four potentiometers ganged together with a gear assembly. Each potentiometer has series and shunt trims to insure proper tracking. The trims and the angular orientation of the potentiometers are carefully adjusted at the factory. If it becomes necessary to change one of these potentiometers in the field, it should be replaced only with a unit supplied by the factory complete with proper trims. The angular orientation should then be carefully adjusted following the procedure supplied with the parts.





SIDE VIEW

FIGURE 9. TOP AND SIDE VIEW OF CHASSIS

SECTION 6

CALIBRATION AND ADJUSTMENT

6.1 INTRODUCTION

Before attempting any adjustments the procedure in Section 4 should be followed to determine if adjustments are necessary. The following procedure is provided for the purpose of facilitating the adjustment and calibration of the filter in the field, and adherence to this procedure should restore the filter to its original specifications. If any difficulties are encountered, please refer to Maintenance, Section 5. If any questions arise which are not covered by this procedure, please contact our factory service department. The location of all major components, modular sub-assemblies, test points, screw driver controls and adjustments are shown in Figure 9.

Access to the interior of the filter is accomplished easily by removing the four screws centered at the rear of each cover; sliding off the side covers will unlock the top and bottom covers.

6.2 TEST EQUIPMENT REQUIRED

AS LISTED IN SECTION 4.2 .

6.3 INITIAL SETUP

a. Set low cutoff dial to 60, multiplier to x10.

b. Set high cutoff dial to 200, multiplier to x1K.

6.4 POWER SUPPLY

a. Short filter input. Connect d-c voltmeter between signal ground and plus 15 volts. (positive end, C505)

b. Adjust R506 for 15 ± 0.2 volts.

c. Connect d-c voltmeter between signal ground and minus 15 volts. (negative end of C506)

d. Adjust R509 for 15 ± 0.2 volts.

e. Remove short.

6.5 LOW-CUTOFF SECTION RESPONSE

a. Connect oscillator output to filter input.

b. Set oscillator to 6KHz and adjust amplitude for 1 volt at filter input.

c. Connect AC voltmeter to point "10".

d. Adjust R226 for reading of 1V, $\pm$.02V

e. Set oscillator to 600Hz.

f. Adjust R225 for a reading of .7 volts at point "10".

6.6 LOW-CUTOFF DIAL SETTING

a. Set oscillator frequency to 3 KHz.

b. Adjust voltage for 1 volt at point "10".

c. Set oscillator to 300 Hz.

d. Adjust low cutoff dial for .063 volts (-24db from 1 volt) at point "10".

e. If necessary, loosen dial set screws and set dial at 60.

6.7 LOW CUTOFF X1K MULTIPLIER CALIBRATION

6.7.1 Step 1

a. Set low cutoff dial to 20, multiplier to x1K.

b. Set oscillator to 100KHz and connect AC voltmeter to point "4".

c. Adjust voltage at point "4" for 1V rms.

d. Switch oscillator to 5KHz.

e. Adjust C707 for .06 volts (-24.5db from 1 volt) at point "4".

f. Repeat steps b through f until no additional adjustment is required.

6.7.2 Step 2

a. Set oscillator to 100KHz and connect AC voltmeter to point "10".

b. Adjust voltage at point "10" for 1 volt rms.

c. Switch oscillator to 10KHz.

d. Adjust C717 for .063 volts (-24db from 1 volt) at point "10".

e. Repeat steps a through e until no additional adjustment is required.

6.8 200KHZ CALIBRATION

a. Set low cutoff dial to 200, multiplier to x1K.

b. Set oscillator to 600 KHz.

c. Adjust oscillator for 1 volt at point "10".

d. Switch oscillator to 200KHz.

e. Trim C741 for 0.7±.05 volts at point "10".

6.9 HIGH CUTOFF DIAL SETTING

a. Set low cutoff dial to 20, multiplier to x1.

b. Set high cutoff dial to 60, multiplier to x10.

c. Set oscillator frequency to 100 Hz.

d. Adjust oscillator voltage for 1 volt at filter output.

e. Switch oscillator to 1.2 KHz.

f. Adjust high cutoff dial for .063 volts (-24 db from 1 volt) at output.

g. If necessary, loosen dial set screws and set dial at 60.

6.10 HIGH CUTOFF X1K MULTIPLIER CALIBRATION

a. Set high cutoff dial to 60, multiplier to x1K.

b. Set oscillator to 6 KHz.

c. Adjust oscillator voltage for 1 volt at filter output.

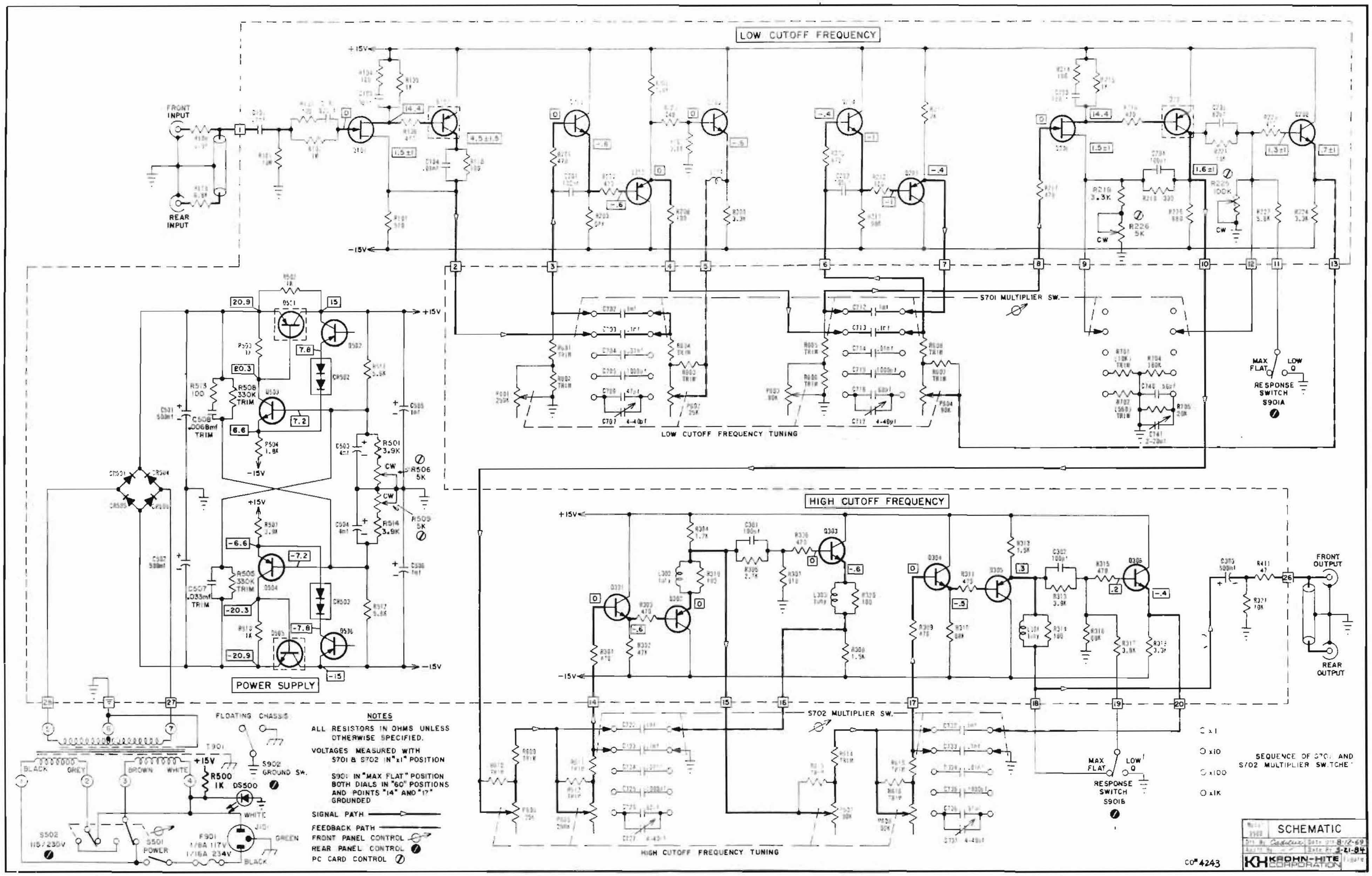
d. Switch oscillator to 48KHz.

e. Adjust C727 for a reading of .94 volts at filter output.

f. Switch oscillator to 60 KHz.

g. Adjust C737 for a reading of 0.7$\pm$.05 volts at filter output.

h. Repeat steps d through g until no further adjustment is required.


LOW CUTOFF FREQUENCY
HIGH CUTOFF FREQUENCY
FRONT INPUT
REAR INPUT
FRONT OUTPUT
REAR OUTPUT
POWER SUPPLY
S701 MULTIPLIER SW.
S702 MULTIPLIER SW.
LOW CUTOFF FREQUENCY TUNING
HIGH CUTOFF FREQUENCY TUNING
MAX FLAT
LOW Q
RESPONSE SWITCH S901A
RESPONSE SWITCH S901B
FLOATING CHASSIS
S902 GROUND SW.
S501 POWER
S502 115/230V
F901 1/8A 117V 1/16A 234V
DS500
R500 1K
BLACK
GREY
BROWN
WHITE
GREEN
T901
J101
NOTES
ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED.
VOLTAGES MEASURED WITH S701 & S702 IN "x1" POSITION
S901 IN "MAX FLAT" POSITION
BOTH DIALS IN "60" POSITIONS
AND POINTS "14" AND "17" GROUNDED
SIGNAL PATH
FEEDBACK PATH
FRONT PANEL CONTROL
REAR PANEL CONTROL
PC CARD CONTROL
SEQUENCE OF S701 AND S702 MULTIPLIER SWITCHES
x1
x10
x100
x1K
SCHEMATIC
KROHN-HITE CORPORATION
CO# 4243

RESISTORS

Symbol	Description	Mfr.	Part No.
R101	10M 10% 1/4W	AB	CB1061
R102	1M 10% 1/4W	AB	CB1051
R103	100 10% 1/4W	AB	CB1011
R104	1K 10% 1/4W	AB	CB1011
R105	1K 10% 1/4W	AB	CB1021
R106	470 20% 1/4W	AB	CB4712
R107	510 5% 1W	AB	GB5115
R108	6.8K 10% 1/4W	AB	CB6821
R109	6.8K 10% 1/4W	AB	CB6821
R110	100 10% 1/4W	AB	CB1011
R201	470 20% 1/4W	AB	CB4712
R202	470 20% 1/4W	AB	CB4712
R203	68K 10% 1/4W	AB	CB6831
R204	1.6K 5% 1/4W	AB	CB1625
R205	240 5% 1/4W	AB	CB2415
R206	3.6K 5% 1/4W	AB	CB3625
R208	100 20% 1/4W	AB	CB1012
R209	3.3K 10% 1/4W	AB	CB3321
R210	470 20% 1/4W	AB	CB4712
R211	2K 5% 1/4W	AB	CB2025
R212	100 20% 1/4W	AB	CB1012
R213	68K 10% 1/4W	AB	CB6831
R214	100 10% 1/4W	AB	CB1011
R215	1K 10% 1/4W	AB	CB1021
R216	470 20% 1/4W	AB	CB4712
R217	470 20% 1/4W	AB	CB4712
R218	3.3K 10% 1/4W	AB	CB3321
R219	330 10% 1/4W	AB	CB3311
R220	680 10% 1W	AB	GB6811
R221	10K 5% 1/4W	AB	CB1035
R222	5.6K 10% 1/4W	AB	CB5621
R223	470 20% 1/4W	AB	CB4712
R224	3.3K 10% 1/4W	AB	CB3321
R225	100K POT	BKM	72PM
R226	5K POT	BKM	72PM
R301	470 20% 1/4W	AB	CB4712
R302	47K 10% 1/4W	AB	CB4731
R303	470 10% 1/4W	AB	CB4712
R304	1.2K 10% 1/4W	AB	CB1221
R305	2.7K 5% 1/4W	AB	CB2725
R306	470 20% 1/4W	AB	CB4712
R307	910 5% 1/4W	AB	CB9115
R308	1.5K 10% 1/4W	AB	CB1521
R309	470 20% 1/4W	AB	CB4712
R310	68K 10% 1/4W	AB	CB6831
R311	470 20% 1/4W	AB	CB4712

Symbol	Description	Mfr.	Part No.
R500	1K 10% 1/4W	AB	CB1021
R312	1.5K 10% 1/4W	AB	CB1521
R313	3.9K 5% 1/4W	AB	CB3925
R314	100 20% 1/4W	AB	CB1012
R315	470 20% 1/4W	AB	CB4712
R316	68K 5% 1/4W	AB	CB6835
R317	3.9K 10% 1/4W	AB	CB3921
R318	3.3K 10% 1/4W	AB	CB3321
R319	100 20% 1/4W	AB	CB1012
R320	100 20% 1/4W	AB	CB1012
R321	10K 10% 1/4W	AB	CB1031
R411	47 10% 1/4W	AB	CB4701
R501	3.9K 10% 1/4W	AB	CB3921
R502	1K 10% 1/4W	AB	CB1021
R503	1K 10% 1/4W	AB	CB1021
R504	1.8K 10% 1/2W	AB	EB1821
R505	330K 10% 1/4W	AB	CB3341
R506	5K POT	BKM	72PM
R507	3.9K 10% 1/4W	AB	CB3921
R508	.022mf 10% 100V	CD	WMF1S22
R509	5K POT	BKM	72PM
R510	1K 10% 1/4W	AB	CB102T
R511	5.6K 10% 1/4W	AB	CB5621
R512	5.6K 10% 1/4W	AB	CB5621
R513	100 20% 1/4W	AB	CB1012
R514	3.9K 10% 1/4W	AB	CB3921
R601	TRIM 10% 1/4W	AB	TYPE CB
R602	TRIM 10% 1/4W	AB	TYPE CB
R603	TRIM 10% 1/4W	AB	TYPE CB
R604	TRIM 10% 1/4W	AB	TYPE CB
R605	TRIM 10% 1/4W	AB	TYPE CB
R606	TRIM 10% 1/4W	AB	TYPE CB
R607	TRIM 10% 1/4W	AB	TYPE CB
R608	TRIM 10% 1/4W	AB	TYPE CB
R609	TRIM 10% 1/4W	AB	TYPE CB
R610	TRIM 10% 1/4W	AB	TYPE CB
R611	TRIM 10% 1/4W	AB	TYPE CB
R612	TRIM 10% 1/4W	AB	TYPE CB
R613	TRIM 10% 1/4W	AB	TYPE CB
R614	TRIM 10% 1/4W	AB	TYPE CB
R615	TRIM 10% 1/4W	AB	TYPE CB
R616	TRIM 10% 1/4W	AB	TYPE CB
R701	10K 10% 1/4W	AB	CB1031
R702	560 10% 1/4W	AB	CB5611
R704	180K 10% 1/4W	AB	CB1841
R705	20K 5% 1/4W	AB	CB2035
R901	100K 10% 1/4W	AB	CB1041

CAPACITORS

Symbol	Description	Mfr.	Part No.
C101	.1mf 20% 100V	ERT	8131-100-651-104M
C102	620pf 10% 500V	ELM	DM19C621K
C103	1000pf 20% 500V	SP	C023B501E102M
C104	.01mf 20% 500V	SP	C023B501G103M
C201	100pf 10% 500V	ELM	DM15C101K
C202	100pf 10% 500V	ELM	DM15C101K
C203	680pf 10% 500V	ELM	DM19C681K
C204	100pf 10% 500V	ELM	DM15C101K
C205	68pF 5% 500V	ELM	CH15C680J
C301	100pf 10% 500V	ELM	DM15C101K
C302	100pf 10% 500V	ELM	DM15C101K
C303	500mf 10% 25V	SP	TT501N025G1A1P
C501	500mf 50V	SP	62D4S063
C502	500mf 50V	SP	62D4S063
C503	4mf 50V	SP	62D4S063
C504	4mf 50V	SP	62D45063
C505	1mf 20% 35V	SP	196D105X0035D8
C506	1mf 20% 35V	SP	196D105X0035DB
C507	.033mf 10% 100V	CD	WMF1S33
C508	.022mf 10% 100V	CD	WMF1522
C701	10mf +1% -3% 50V	TRW	X663F
C702	1mf +1% -3% 200V	TRW	X663F
C703	.1mf +1% -3% 200V	TRW	X663F
C704	.01mf +1% -3% 200V	TRW	X663F
C705	1000pf 5% 500V	ELM	CM19C102J
C706	47pf 10% 500V	ELM	DM15C470K
C707	4-40pf TRIMMER	ELM	T50310
C711	10mf +1% -3% 50V	TRW	X663F
C712	1mf +1% -3% 200V	TRW	X663F

Symbol	Description	Mfr.	Part No.
C713	.1mf +1% -3% 200V	TRW	X663F
C714	.01mf +1% -3% 200V	TRW	X663F
C715	1000pf 5% 500V	ELM	CM19C102J
C716	82pf 10% 500V	ELM	DM15C820K
C717	4-40pf TRIMMER	ELM	T50310
C721	10mf +1% -3% 50V	TRW	X663F
C722	1mf +1% -3% 200V	TRW	X663F
C723	.1mf +1% -3% 200V	TRW	X663F
C724	.01mf +1% -3% 200V	TRW	X663F
C725	1000pf 5% 500V	ELM	CM19C102J
C726	62pf 10% 500V	ELM	DM15C501K
C727	4-40pf TRIMMER	ELM	T50310
C731	10mf +1% -3% 50V	TRW	X663F
C732	1mf +1% -3% 200V	TRW	X663F
C733	.1mf +1% -3% 200V	TRW	X663F
C734	.01mf +1% -3% 200V	TRW	X663F
C735	1000pf 5% 500V	ELM	C19C102J
C736	51pf 10% 500V	ELM	DM15C510K
C737	4-40pf TRIMMER	ELM	T50310
C740	56pf 10% 500V	ELM	DM15C560K
C741	1.5-20pf TRIMMER	ELM	T50210
C801	6.8pf 10% 500V	ASP	9212-68910

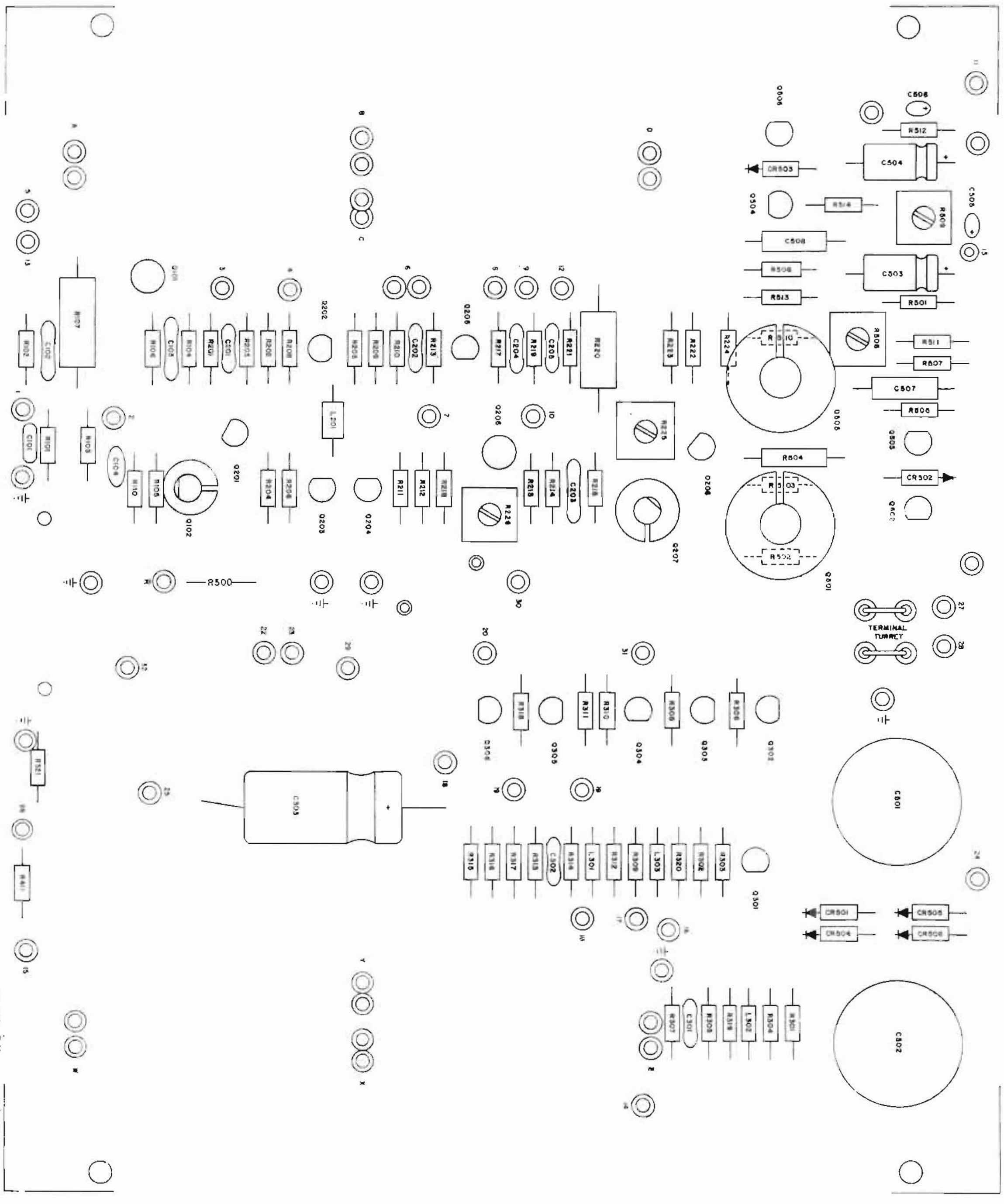
TRANSISTORS, DIODES, MISC.

Symbol	Description	Mfr.	Part No.
Q101	2N4302	AME	2N4302
Q102	MPS6518	MOT	MPS6518
Q201	MPS6515	MOT	MPS6515
Q202	MPS6518	MOT	MPS6518
Q203	MPS6515	MOT	MPS6515
Q204	MPS6515	MOT	MPS6515
Q205	MPS6518	MOT	MPS6518
Q206	2N4302	AME	2N4302
Q207	MPS6518	MOT	MPS6518
Q208	MPS6516	MOT	MPS6516
Q301	MPS6515	MOT	MPS6515
Q302	MPS6518	MOT	MPS6518
Q303	MPS6515	MOT	MPS6515
Q304	MPS6515	MOT	MPS6515
Q305	MPS6518	MOT	MPS6518
Q306	MPS6515	MOT	MPS6515
Q501	2N4234	MOT	2N4234
Q502	MPS3640	MOT	MPS3640
Q503	MPS6515	MOT	MPS6515
Q504	MPS6518	MOT	MPS6518
Q505	2N5189	RCA	2N5189
Q506	MPS3640	MOT	MPS3640
CR401	1N4149	TR	1N4149
CR501	1N4002	MSC	1N4002
CR502	MZ2361	MOT	MZ2361
CR503	MZ2361	MOT	MZ2361
CR504	1N4002	MSC	1N4002
CR505	1N4002	MSC	1N4002
CR506	1N4002	MSC	1N4002

Symbol	Description	Mfr.	Part No.
L201	FERRITE BEAD	STK	57-0181
L301	1uHy 10% 1/4W	DLV	1537-12
L302	1uHy 10% 1/4W	DLV	1537-12
L303	1uHy 10% 1/4W	DLV	1537-12
P601	250K 10% 2W	AB	J95728
P602	25K 10% 2W	AB	J93280D
P603	90K 10% 2W	AB	J95727
P604	90K 10% 2W	AB	J95727
P605	25K 10% 2W	AB	J93280D
P606	250K 10% 2W	AB	J95728
P607	90K 10% 2W	AB	J95727
P608	90K 10% 2W	AB	J95727
F901	FUSE, SLO-BLOW, 117V	BUS	MDL-1/8A
	FUSE, SLO-BLOW, 234V	BUS	MDL-1/16A
DS500	INDICATOR, LED	GI	MV5025
J101	RECEPTACLE, POWER	SWC	EAC-301
S701	SWITCH, ROTARY	KH	B-2657/C
S702	SWITCH, ROTARY	KH	B-2657/C
S901	SWITCH, SLIDE	CW	G-126
S902	SWITCH, SLIDE	CW	GF-123
S903	SWITCH, SLIDE	SWC	46256LFR
S904	SWITCH, TOGGLE	CK	U11
T901	TRANSFORMER, POWER	KH	B-2653/E

MANUFACTURERS CODE

AB	(01121)	[illegible]	Milwaukee, Wisc.
AMs	[illegible]	[illegible]	Mt. View, Calif.
[illegible]	[illegible]	[illegible]	DuBois, Pa.
BUS	[illegible]	[illegible]	St. Louis, Mo.
CD	[illegible]	[illegible]	Newark, N. J.
[illegible]	[illegible]	[illegible]	Watertown, Mass.
CW	[illegible]	[illegible]	Philadelphia, Pa.
[illegible]	[illegible]	[illegible]	East Aurora, N. Y.
ELE	[illegible]	[illegible]	Compton, Calif.
ELM	(72136)	Electromotive Mfg.	Willimantic, Conn.
ERT	(72982)	Erie Technological	Erie, Pa.
MOT	(04713)	Motorola Semiconductor	Phoenix, Ariz.
MSC		Micro-Semiconductor	Culver City, Calif.
RCA	(49671)	Radio Corp. of America	Harrison, N. J.
SP	(56289)	Sprague Electric Co.	North Adams, Mass.
STK	(78488)	Stackpole Carbon Co.	St. Mary's, Pa.
TR	(03877)	Transitron Electronics	Wakefield, Mass.
TRW	(84411)	TRW Corp.	Ogallala, Neb.



PC 307

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