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SOLID STATE WIDE RANGE

BAND-PASS FILTER

MODEL 3103(R) SERIAL NO. 278

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION
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ILLUSTRATIONS

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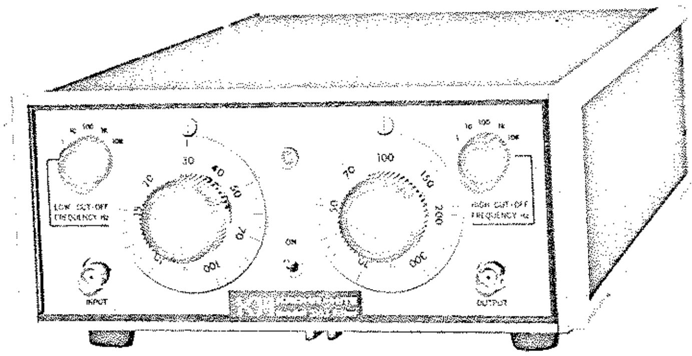
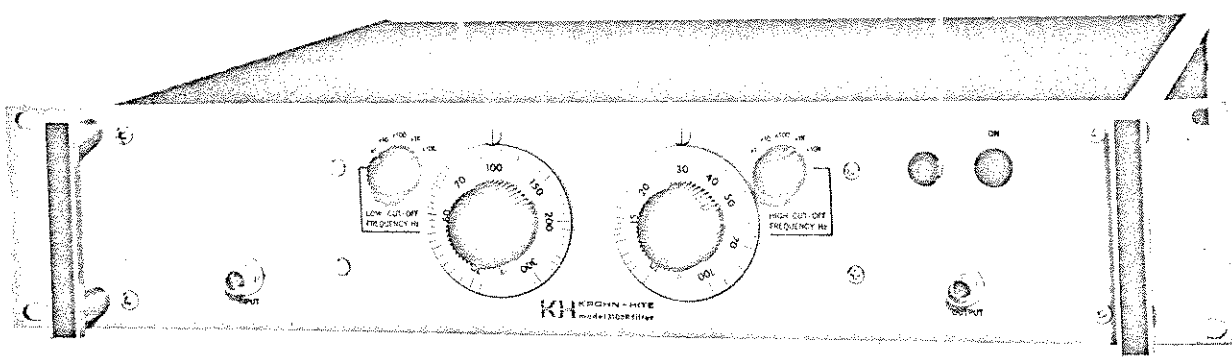


Model 3103



Model 3103R

Figure 1. Model 3103 and 3103R Filters

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 3103(R), illustrated in Figure 1, is a solid state variable electronic band-pass Filter with a low cutoff frequency range adjustable continuously from 10 Hz to 1 MHz and a high cutoff range from 30 Hz to 3 MHz. The pass-band gain is unity (0 db), with attenuation rate of 24 db per octave outside the pass-band, and a maximum attenuation of 80 db. Maximum input signal amplitude is 3 volts rms and output hum and noise is less than 150 microvolts.

As shown in the Simplified Schematic Diagram, Figure 2, the Filter consists basically of an input amplifier, a variable low-pass section (high cutoff frequency), and a variable high-pass (low cutoff frequency) section all connected in series. Both cutoff frequencies are tuned capacitively in decade steps by the band multiplier switch, and continuously within each decade by the frequency dial which varies four cascaded resistor-filter elements. A response switch S1 selects the desired filter characteristics.

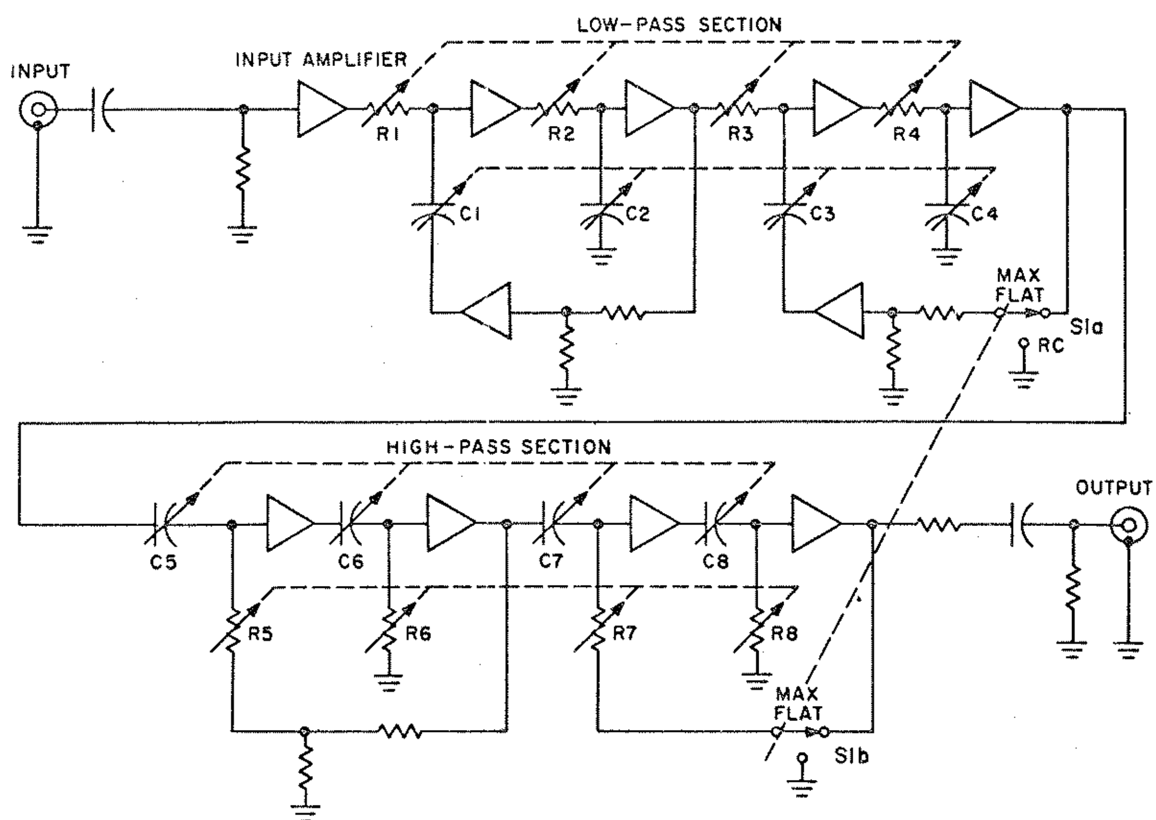


Figure 2. Simplified Schematic Diagram

1.2 SPECIFICATIONS

Frequency range: Low-cutoff frequency independently adjustable from 10 Hz to 1 MHz in five bands.

Band	Multiplier	Frequency (Hz)
1	1	10 - 100
2	10	100 - 1,000
3	100	1,000 - 10,000
4	1,000	10,000 - 100,000
5	10,000	100,000 - 1,000,000

High-cutoff frequency independently adjustable from 30 Hz to 3 MHz in five bands.

Band	Multiplier	Frequency (Hz)
1	1	30 - 300
2	10	300 - 3,000
3	100	3,000 - 30,000
4	1,000	30,000 - 300,000
5	10,000	300,000 - 3,000,000

Frequency dials: Separate low-cutoff and high-cutoff dials are individually calibrated with single logarithmic scales reading directly in Hz.

Cutoff frequency calibration accuracy: ±10% with RESPONSE switch in MAXimum FLAT (Butterworth) position; less accurate in RC position. Relative to mid-band level, the Filter output is down 3 db at cutoff in maximum flat position, and approximately 13 db in RC position.

Bandwidth: Continuously variable within the cutoff frequency limits of 10 Hz and 3 MHz.

Attenuation slope: Nominal 24 db per octave.

Maximum attenuation: Greater than 80 db. See Section 5.2.

Insertion loss: Zero db ± 1/2 db.

Frequency Response: Standard response is 4th order Butterworth, maximally flat. A RESPONSE switch on rear of chassis converts to simple RC response optimum for transient-free performance.

Input characteristics:

Maximum Input Amplitude: 3 volts rms, decreasing to 2.5 volts at 3 MHz.
Impedance: 100k ohms in parallel with 50 pf.
Maximum DC Component: 200 volts.

Output characteristics:

Maximum Voltage: 3 volts rms, decreasing to 2.5 volts at 3 MHz.
Maximum Current: 10 milliamperes rms.
Internal Impedance: Approximately 50 ohms.

Floating (ungrounded) Operation: A chassis GROUND switch is provided on rear of chassis to disconnect signal ground from chassis ground.

Front panel controls:

Hum and noise: Less than 150 microvolts.

LOW CUTOFF FREQUENCY dial and multiplier switch.

HIGH CUTOFF FREQUENCY dial and multiplier switch.

Power-ON switch.

Terminals: Front panel and rear of chassis, one BNC connector for INPUT, one for OUTPUT.

Power requirements: 105-125 or 210-250 volts, single phase, 50-400 Hz, 15 watts.

Dimensions and weights: Standard bench Model 3100, 8 5/8" wide, 3 1/2" high, 15" deep, 11 lbs net, 22 lbs shipping.
Rack-mounting Model 3100R, 19" wide, 3 1/2" high, 15" deep, 13 lbs net, 24 lbs shipping.

Note: for detailed definition of specifications refer to Section 5.2.

1.3 FILTER CHARACTERISTICS

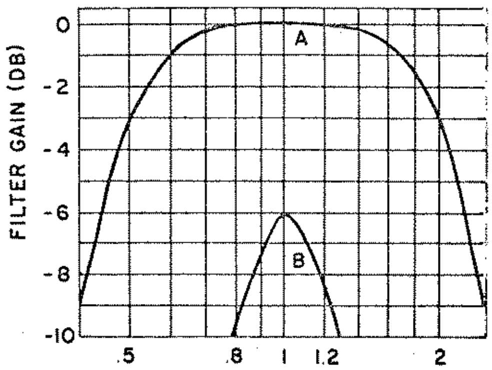


Figure 3. Normalized Filter Response

BANDWIDTH ADJUSTMENT

The flexibility of adjustment of bandwidth is illustrated in Figure 3. Band-pass operation in the MAXimally FLAT or Butterworth mode for two different bandwidths 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.

(A)

(B)

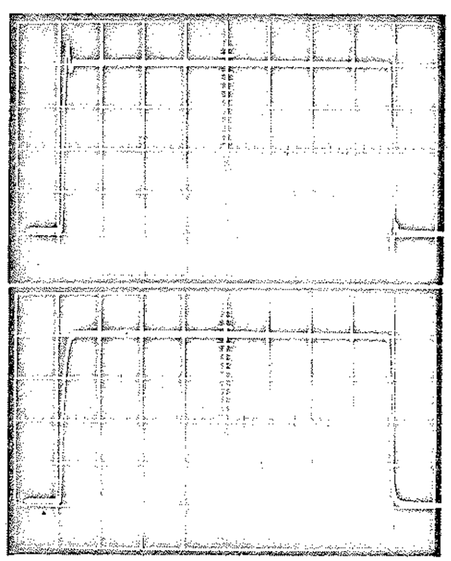


Figure 4. Response to 10 kHz Square Wave with Cutoffs at 10 Hz and 1 MHz. (A) Butterworth, (B) Simple RC

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 the Simple RC mode, optimum for transient-free filtering. Figure 4 shows a comparison of the Filter output response in these modes to a square wave input signal.

CUTOFF RESPONSE

The attenuation characteristics of the Filter are shown in Figure 5. 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 13 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.

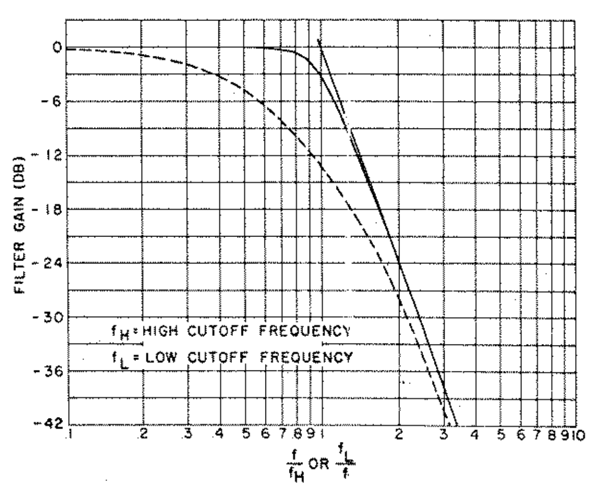


Figure 5. Normalized Attenuation Characteristics

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 6 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 the Simple RC mode.

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 1.5 = +110°

Phase shift due to high cutoff (f_L)

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

from Figure 6 .5 = -80°

Total phase shift

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

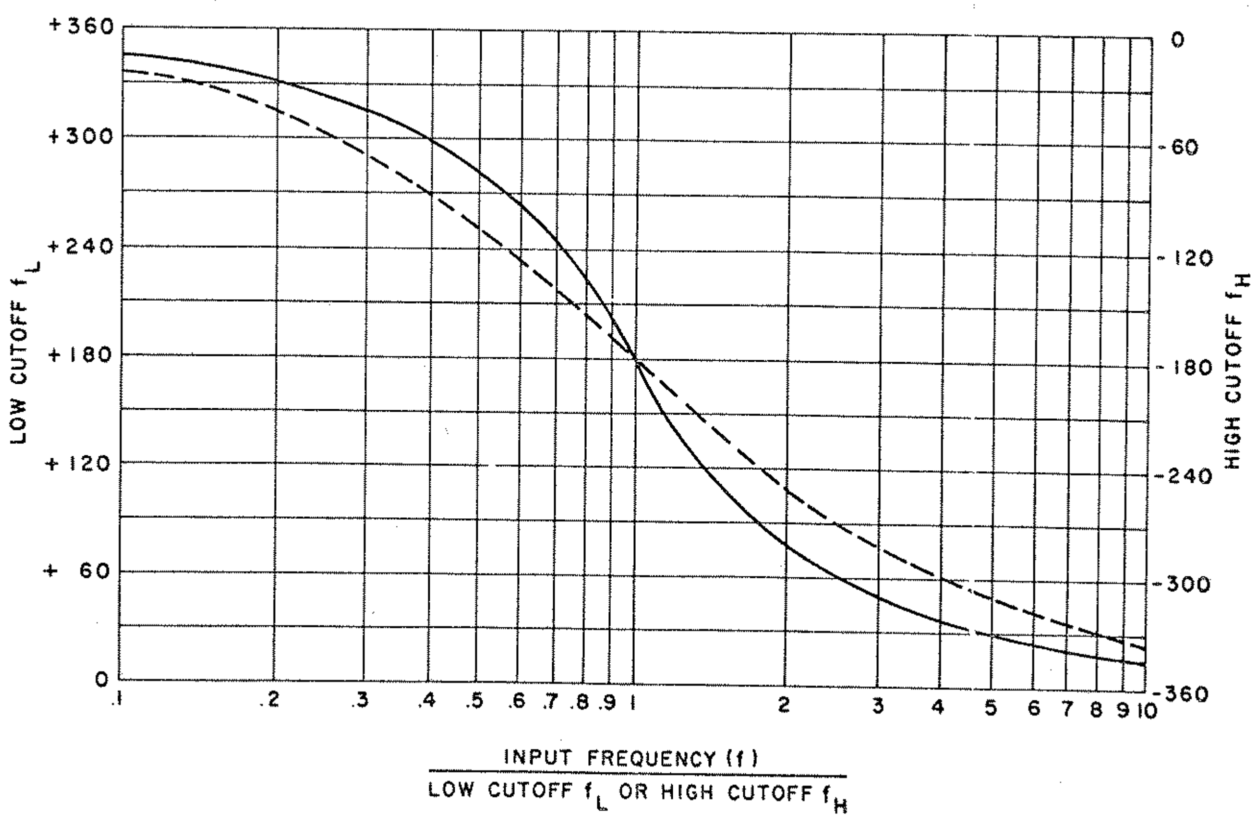


Figure 6. Normalized Phase Characteristics

SECTION 2

OPERATION

2.1 INTRODUCTION

On receipt of the Filter, carefully unpack and examine it for damage that may have occurred in transit. If signs of damage are observed, file a claim with the transporting agency immediately, and notify Krohn-Hite Corporation. Do not attempt to use the Filter if damage is suspected.

Rack-mounting models (designated by a suffix "R" after the model number) mount with four machine screws in the standard 19" rack space. No special brackets or attachments are needed.

2.2 FRONT PANEL CONTROLS

The front panel of the Filter includes two frequency dials and associated multiplier switches used to set cutoff frequencies; a power-ON-off switch and indicator light; two BNC coaxial connectors, one for the INPUT signal and one for the OUTPUT signal.

Each frequency dial is calibrated with a single logarithmic scale reading directly in Hz. The dials are 2 1/4 inches in diameter with an effective scale length of approximately 6 inches per band, giving a total effective scale length of approximately 30 inches for the frequency range. The left-hand dial (LOW CUTOFF FREQUENCY) and band multiplier switch select the low cutoff frequency while the right-hand dial (HIGH CUTOFF FREQUENCY) and multiplier switch select the high cutoff frequency.

The LOW CUTOFF FREQUENCY multiplier switch has five positions, covering the frequency range as follows:

Band	Multiplier	Frequency (Hz)
1	1	10 - 100
2	10	100 - 1,000
3	100	1,000 - 10,000
4	1,000	10,000 - 100,000
5	10,000	100,000 - 1,000,000

The HIGH CUTOFF FREQUENCY multiplier switch has five positions, covering the frequency range as follows:

Band	Multiplier	Frequency (Hz)
1	1	30 - 300
2	10	300 - 3,000
3	100	3,000 - 30,000
4	1,000	30,000 - 300,000
5	10,000	300,000 - 3,000,000

2.3 OPERATION

To operate the Filter, proceed as follows:

a. Make appropriate power connections as described in Section 2.5.

b. Make appropriate connections to the INPUT and OUTPUT connectors of Filter. The rms voltage should not exceed 3 volts.

c. Set cutoff frequencies by means of the band multiplier switches (CUTOFF FREQUENCY) and the frequency dials. The minimum pass-band is obtained by setting the high cutoff frequency equal to the low cutoff frequency.

d. Turn power switch to ON.

NOTE

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

e. For normal Filter operation the FLOATING/CHASSIS GROUND switch, located on the rear of the chassis, should be in the CHASSIS position. If the Filter is used in a system where ground loops make ungrounded or floating operating essential, this switch should be in the FLOATING position.

f. When filtering consists principally of separating frequency components of a signal (frequency domain(the RESPONSE switch, located on the rear of the chassis, should be in the MAX-FLAT position. If the Filter is used to separate pulse-type signals from noise (time domain) this switch should be in the RC position.

2.4 TERMINALS

BNC coaxial connectors are provided on the front panel and on the rear of the chassis for both INPUT and OUTPUT connections.

2.5 LINE VOLTAGE AND FUSES

The Filter, as normally shipped, is connected for operation from an a-c power source of 105-125 volts, 50 to 400 Hz, and uses a 1/8 ampere slow-blow line fuse that is mounted on the rear of the chassis. It may be modified to operate from a 210-250 volt line by removing the two jumpers connecting terminals 1 to 3, and 2 to 4 of the power transformer, and adding a jumper between terminals 2 and 3 of the power transformer. A 1/16 ampere slow-blow fuse should be used for 210-250 volt operation.

SECTION 3

CIRCUIT DESCRIPTION

3.1 INTRODUCTION

As shown in the Simplified Schematic Diagram, Figure 2, the Filter consists of an input amplifier for input isolation, a four-pole low-pass filter section (High Cutoff Frequency) with four RC filter networks adjustable by means of a ganged potentiometer assembly and band switch, a four-pole high-pass filter section (Low Cutoff Frequency) with four RC filter networks and a similar ganged potentiometer assembly and band switch. Both cutoff frequencies are tuned capacitively in decade steps by the band switch, and continuously within each decade by the potentiometer assembly.

The Schematic Diagram of the Filter, Figure 8, is attached to the inside rear cover. Bold lines on the Filter schematic show the main signal paths, while the dashed lines indicate feedback signal paths.

3.2 DETAILED DESCRIPTION

INPUT AMPLIFIER

The signal input is capacitor-coupled to the input amplifier, consisting of emitter followers Q201 and Q202, via current limiting resistors R201 and R202, which in conjunction with clamping diodes, CR201 and CR202 prevent damage in the event of excessive input signal. The input amplifier isolates the input and provides the low impedance source necessary to drive the first RC filter network.

LOW-PASS SECTION

The Low-Pass Section consists of a pair of two-pole filters each containing two RC filter networks. Both two-pole filters are adjusted for the proper response to provide a Butterworth characteristic when cascaded.

All RC filter networks are isolated from each other by a buffer amplifier which consists of two emitter followers. The emitter followers, Q205 and Q206, isolate the output of the first two-pole filter from the input of the second two-pole filter. A portion of the output of the first two-pole filter is fed-back via the attenuator consisting of R225 and R227 to obtain the desired response characteristic of the first two-pole filter. An emitter follower, Q207, is used to prevent loading of this attenuator.

The desired response characteristic of the second two-pole filter is effected by feeding back a portion of the output of the second two-pole filter network via the attenuator consisting of R247, R248 and P206. Q212 is an emitter follower to prevent loading of this attenuator. An amplifier consisting of Q210 and Q211 is used to isolate the low-pass section from the high-pass section and also provide the additional gain required on band 5 of the high-pass section.

HIGH-PASS SECTION

The High-Pass Section also consists of a pair of two-pole filters, each adjusted for the proper response to give a Butterworth characteristic when cascaded. As in the low-pass section emitter followers are used to isolate all the RC filter networks. Q303 and Q304 act as a buffer amplifier between the output of the first two-pole filter and input of the second two-pole filter. This amplifier also provides the gain necessary to compensate for the loss through the filter. The feedback attenuator network consisting of R317 and R318 is used to obtain the desired response characteristic for the first two-pole filter and similarly R326, R327 and P305 modify the response of the second two-pole filter. Q308 and Q309 are buffer followers to provide isolation from the output.

RC/BUTTERWORTH RESPONSE

To provide minimum overshoot to fast rise pulses S202 is used to disconnect the feedback to the second two-pole filters of both the low-pass and high-pass sections.

POWER SUPPLIES

The Power Supplies deliver a plus 10 and minus 10 regulated voltage. It consists of a bridge rectifier CR101 and filter capacitors C101 and C102 to provide the necessary unregulated d-c voltage. The minus 10 volt regulated supply is a typical series type using a zener reference, Z101 and amplifiers Q108 and Q105 which drive a series regulator Q106. To prevent damage when short circuits of the regulated voltage occur, a current limit circuit consisting of Q102 and R103 turns off the minus 10 volt supply if the current in R103 exceeds a predetermined value. The plus 10 volt supply uses the minus 10 volts as a reference. A divider network consisting of R113 and R114 sets the proper voltage level for the amplifiers Q107 and Q104, which drive the series regulator Q103. Q101 and R102 limit the current in the plus 10 volt supply.

SECTION 4

MAINTENANCE

4.1 INTRODUCTION

If the Filter is not functioning properly and requires service, the following procedure may facilitate locating the source of trouble. Access to the Filter is accomplished easily without any hand tools by removing the top and bottom covers. It is first necessary to loosen (not remove) the two thumb screws centered on each side at the rear of the chassis and then pulling out the two side covers. This unlocks the top and bottom covers which then may be pulled out.

The general layout of major components, test points, screwdriver controls and adjustments is shown in Figure 7. Detailed component layouts for the three printed circuit cards are included in the Schematic Diagram, Figure 8 which is attached to the inside rear cover. Various check points are shown on the Schematic Diagram and are also marked on the printed circuit cards. To allow for ease of service, PC 302 and PC 303 have been provided with a swing-out mounting. Removal of one screw toward the center of the instrument will allow the card to lift and provide access to the components.

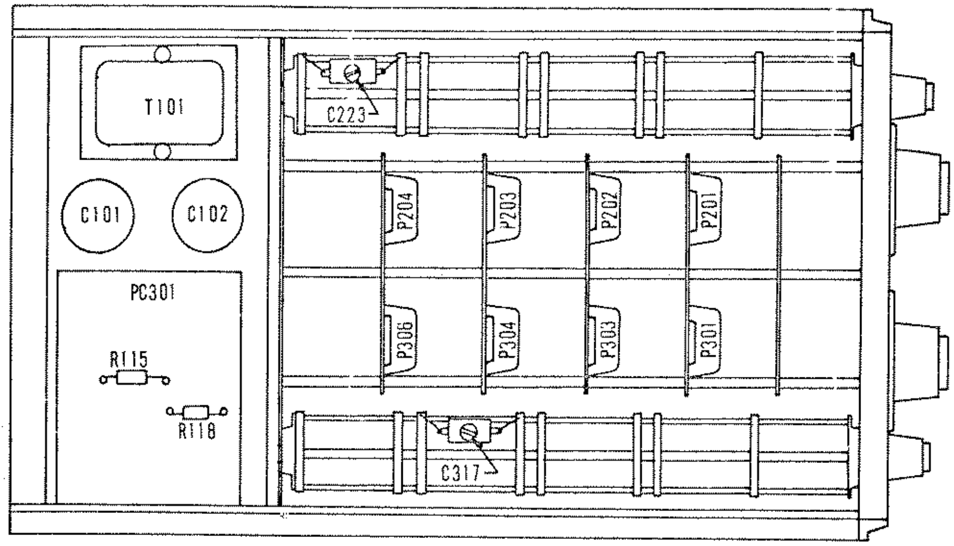
Many troubles may easily be found by visual inspection. When a malfunction is detected, make a quick check of the unit for such things as broken wires, burnt or loose components, or similar conditions which could be a cause of trouble. Any trouble-shooting of the Filter will be greatly simplified if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

4.2 POWER SUPPLY

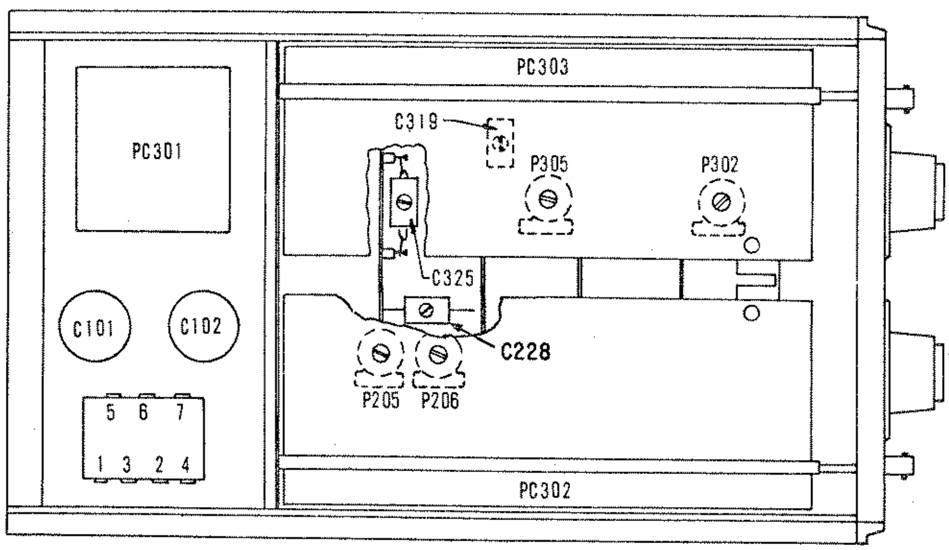
If the Filter does not seem to be working properly, the two power supplies should be checked first. The supplies may be checked most easily at the three terminal barrier strip, located at the bottom rear of the chassis. In general, red leads are tied to the plus 10 volt ±5% supply, while grey leads are tied to the minus 10 volt ±5% supply. If the two supplies appear to be correct, refer to the signal tracing analysis, Section 4.3.

If the minus 10 volt supply is slightly out of tolerance and exceeds its upper limit of minus 10.5 volts, R115 should be increased or R118 should be reduced. When the minus 10 volt supply is slightly below its lower limit of minus 9.5 volts, R115 should be decreased or R188 increased.

If the minus 10 volt supply is correct and the plus 10 volt supply is slightly out of tolerance, R113 or R114 may be defective. A fuse, F101 (1/8A for 115v or 1/16A for 230V operation), located at the rear of the instrument, is provided to protect the power supply from short circuits and overloads. The rating of this fuse was selected for proper protection of the instrument, and it should be replaced with one of the same type and rating.



TOP VIEW



BOTTOM VIEW

Figure 7. Top and Bottom View of Chassis

Two regulated supplies are used to provide plus 10 volts and minus 10 volts with respect to the chassis. The minus 10 volt supply uses a zener (Z101) as its reference, while the plus 10 volt supply uses the minus supply as its reference. This fact should be kept in mind when doing any work on the supply, as an error in the minus will be reflected in the plus. Both supplies are provided with current limiting circuits that will shut down the supply when excessive current is being drawn from it. Because of this, an apparent power supply malfunction may be caused by an overload elsewhere in the Filter.

If the supply does not appear to be working properly, the error signal thus developed should be traced through the regulator loop to find the faulty component. Correct voltages for various points in the supply are shown on the Schematic Diagram, Figure 8. As an example of the method of trouble-shooting, let us assume that the minus 10 volt supply is very low. This should make the base of Q108 more positive than normal, while making its collector more negative. The base of Q106 should then be made more positive than normal and the collector more negative, thus correcting the output of the supply. If a faulty component is present in the regulating loop this corrective action would be blocked. That component would then be found at the point in the loop where the action was blocked. The plus supply uses approximately the same type of circuit and the same basic method of trouble-shooting may be used there as well.

4.3 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 both the low and high cutoff frequencies to 300 Hz. Connect a 300 Hz 1 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.

Table 1 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.

Table 1.

TEST POINT VOLTAGES

LOW CUTOFF FREQUENCY: 300Hz
HIGH CUTOFF FREQUENCY: 300Hz
RESPONSE SWITCH: MAX FLAT
INPUT: 1 VOLT RMS, SINE WAVE 300Hz

Card Number	Test Point	Correct Signal Level (rms volts)*	
PC 302 Hi Fr Cutoff	27	1.0	.9
	25	0.9	.87
	24	0.7	.66
	23	0.7	.66
	20	0.5	.46
	19	0.5	.46
	18	0.7	.66
	13	0.7	.66
	11	0.6	.58
	5	0.6	.64
PC 303 Lo Fr Cutoff	23	0.5	.48
	21	0.5	.48
	18	0.4	.32
	16	0.5	.39
	15	0.7	.66
	12	0.6	.48
	10	0.5	.44
	5	0.5	.42
	6	0.5	.42

*Variations of up to ±10% in all readings can be expected.

The test points basically trace the signal through the entire Filter, and they should be checked in the order given.

4.4 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 there is trouble in a capacitive element, this will show up only on a particular multiplier band. If there is a problem in a resistive 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 S201 and S301 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 two higher bands are 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.

SECTION 5

CALIBRATION AND ADJUSTMENT

5.1 INTRODUCTION

The following procedure is provided for the purpose of facilitating the calibration and adjustments of the Filter in the field. The steps outlined follow very closely the operations which are performed on the instrument by our Final Test Department, and strict adherence to this procedure should restore the instrument to its original specifications. It should be noted that some of the tolerances given in this procedure are much tighter than our general specifications. This is to ensure, in test, that all general specifications are met with adequate safety factor. These nominal tolerances, therefore, should not be used for purposes of accepting or rejecting the instrument. If any difficulties are encountered, please refer to Maintenance, Section 4. If any questions arise which are not covered by this procedure, please consult our Factory Service Department.

5.2 DETAILED SPECIFICATIONS

CUTOFF FREQUENCY CALIBRATION

The high and low cutoff frequencies, as defined below, should be within ±10% of the corresponding dial reading, KROHN-HITE Filters are calibrated to conform to passive Filter terminology. The cutoff frequency in the maximally flat or Butterworth mode is the frequency at which the gain of the Filter is 3 db down from the gain at the middle of the pass-band. This pass-band varies with separation of the cutoff frequencies as shown in Figure 3. In the Simple RC or transient-free mode, this cutoff frequency gain is approximately 13 db down.

PASS-BAND GAIN

The Filter output voltage under open circuit conditions will be within ± 1/2 db of the input voltage for all frequencies within the pass-band.

To determine the pass-band gain accurately, the high and low cutoff frequencies must be separated by a factor of at least four, and the measuring frequency must be the geometric mean of these frequencies.

ATTENUATION SLOPE

A Typical attenuation curve is shown in Figure 5. At the cutoff frequency, in the maximally flat or Butterworth mode, the slope is approximately 12 db per octave, and at the 12 db point the slope has essentially reached its nominal value of 24 db per octave. The slope of the straight portion of the curve may vary slightly from 24 db per octave at certain frequencies because of cross-coupling effects.

MAXIMUM ATTENUATION

This Filter has a maximum attenuation specification of 80 db which applies over most of the frequency range. At the high frequency end this attenuation is reduced due to unavoidable cross coupling between input and output.

OUTPUT IMPEDANCE

The Filter will operate into any load impedance providing the maximum output voltage and current specification is not exceeded. For a matched load impedance of 50 ohms the insertion loss will be approximately 6 db. Lower values of load resistance will not damage the instrument but will increase the distortion. Higher values of external load may be used with no sacrifice in performance and correspondingly lower insertion loss. In KROHN-HITE Filters, there is no requirement for the load impedance to match the output impedance.

INTERNALLY GENERATED HUM AND NOISE

The internally generated hum and noise measurement is based on the use of a Ballentine Model 310 Voltmeter, or equivalent. The measurement is made with the input connector shorted, with no other external signal connections to the instrument, and the voltmeter leads shielded.

DISTORTION

Filter distortion is a function of several variables and is difficult to specify exactly. In general, if the Filter is operated within its ratings, distortion products introduced by the Filter and not present in the input signal will not exceed 0.5% of the output signal. In most cases distortion will be considerably less than 0.5%.

5.3 TEST EQUIPMENT REQUIRED

a. Oscillator - capable of supplying at least 3 volts rms from 10 Hz to 10 MHz with frequency calibration better than ±1%, distortion less than 0.1% and frequency response within ± 0.2 db.

b. AC VTVM - frequency response, 10 Hz to 10 MHz; full scale sensitivity from 10 mv to 10 volts rms with db scale; input capacitance should be less than 20 pf.

c. Oscilloscope - having direct coupled horizontal and vertical amplifiers with equal phase characteristics to at least 20 kHz and vertical sensitivity of 10 mv per division.

d. Vacuum Tube Voltmeter - 15 volts dc full scale.

e. Variable Auto-transformer - to adjust line voltage.

f. A-C Voltmeter - to measure line voltage.

5.4 POWER SUPPLIES

With the Filter operating at 115 or 230 volts line, whichever is applicable, check the plus and minus 10 volt supplies with respect to chassis ground. The floating/chassis grounding switch, located at the rear of the chassis, should be in the chassis position. The supplies may be checked most easily at the three terminal barrier strip, located at the bottom rear of the chassis. In general, red leads are used for the plus 10 volt ±5% supply, while grey leads are used for the minus 10 volt ±5% supply. If the minus 10 volt supply is slightly out of tolerance and exceeds its upper limit of minus 10.5 volts, R115 should be increased or R118 should be reduced. When the minus 10 volt supply is slightly below its lower limit of minus 9.5 volts, R115 should be decreased or R118 increased.

5.5 DETAILED TEST PROCEDURE

Table 2 contains detailed test procedures to check the Filter performance. The procedures are to be performed in the given order (1 through 17). Throughout the procedures, low cutoff is abbreviated LCO and high cutoff is abbreviated HCO. Note that low cutoff dial and multiplier refers to the left-hand frequency dial and band multiplier switch, and that high cutoff dial and multiplier refers to the right-hand frequency dial and band multiplier switch. For all steps, the AC input line voltage should be at 115 or 230 volts, whichever is applicable.

The general layout of major components, test points, screwdriver controls and adjustments is shown in Figure 7. To obtain access to the trim capacitors C228, C319 and C325, it is necessary to remove the screws that secure the large hinged printed circuit cards.

In the event the Filter does not meet the correct tolerance as specified in each step of the detailed test procedure, reference should be made to Section 4, Maintenance.

TABLE 2. DETAILED TEST PROCEDURE

		FREQUENCY SETTING				INPUT SIGNAL	
STEP	PROCEDURE	LCO Dial	LCO Multiplier	HCO Dial	HCO Multiplier	VOLTS (RMS)	Frequency
1.	LCO dial calibration at 30	30	X10	100	X10K	1.0	300Hz
	Connect scope vertical input to Filter output. Connect scope horizontal input and oscillator to Filter input. Set response switch (rear of chassis) to max flat position. Adjust LCO dial to close the ellipse at about a 135 degree angle. If necessary, loosen LCO dial screws and set dial to 30.						
2.	LCO dial gain calibration at 30	30	X10	100	X10K	1.0	300Hz
	Switch LCO frequency multiplier to X1 position. Connect AC VTVM to Filter output. Adjust oscillator output until VTVM indicates exactly 20 db. Return LCO frequency multiplier to X10 position. Adjust P305 until VTVM indicates 17 db. If P305 requires adjustment, recheck 20 db reference level.						
3.	LCO dial gain calibration at 11	11	X10	100	X10K	1.0	110Hz
	Switch LCO frequency multiplier to X1 position. Adjust oscillator output until VTVM indicates exactly 20 db. Return LCO frequency multiplier to X10 position. Adjust LCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 10.0 to 12.0 for Filters with calibration accuracy specification of 10%, and from 10.5 to 11.5 for Filters with 5% calibration accuracy.						
4.	LCO dial gain calibration at 90	90	X10	100	X10K	1.0	900Hz
	Switch LCO frequency multiplier to X1 position. Adjust oscillator output until VTVM indicates exactly 20 db. Return LCO frequency multiplier to X10 position. Adjust LCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 80 to 100 for 10% Filters, and from 85 to 95 for 5% Filters.						
5.	Unity gain adjustment at 5kHz.	70	X1	45	X10K	1.0	5kHz
	With VTVM, compare AC signal on input Filter with AC signal on output. If necessary, adjust P302 for unity gain.						
6.	X10K band calibration	11	X100	100	X10K	0.5	1MHz
a.	Switch LCO multiplier to X10K position. Adjust P205 for minumum change (less than 0.3 db) in output amplitude when switching LCO multiplier from X100 position to X10K position.						
b.	Change input frequency to 55 kHz, switch LCO multiplier to X100 position. Adjust oscillator amplitude until VTVM indicates exactly 14db on output of Filter. Switch LCO multiplier to X10K position. If necessary, adjust C317 until VTVM indicates output of Filter is down 24 db and repeat part a.						
c.	Change input frequency to 110kHz. Switch LCO multiplier to X1K position. Adjust oscillator amplitude until VTVM indicates exactly 14 db on output of Filter. Switch LCO multiplier to X10K position. Adjust LCO dial until VTVM indicates 11 db. Tolerance is a dial setting from 10 to 12 for 10% Filters, and from 10.5 to 11.5 for 5% Filters. If off (dial reading high) increase C319 and decrease C317 and if dial reading is low, decrease C319 and increase C317. Repeat parts a and b respectively.						

TABLE 2. DETAILED TEST PROCEDURE (Cont.)

STEP	PROCEDURE	FREQUENCY SETTING				INPUT SIGNAL	
		LCO Dial	LCO Multiplier	HCO Dial	HCO Multiplier	VOLTS (RMS)	Frequency
6.d.	Set LCO dial to 90. Set output frequency to 900 kHz. Switch LCO multiplier to X1K position. Adjust oscillator amplitude until VTVM indicates exactly 14db on output of Filter. Switch LCO multiplier to X10K position. Adjust C325 until VTVM indicates 11 db.						
e.	Set LCO dial to 30. Set input frequency to 300kHz. Switch LCO multiplier to X1K position. Adjust oscillator amplitude until VTVM indicates exactly 14 db on output of Filter. Set LCO multiplier to X10K position. Adjust LCO dial until VTVM indicates 11 db. Tolerance is a dial setting from 27 to 33 for 10% Filters, and from 28.5 to 31.5 for 5% Filters. If out of tolerance, divide the error between 11 and 90 on the dial.						
7.	LCO dial gain calibration at 30 on all bands						
a.	X1 Calibration	30	X1	100	X10K	1.0	As noted
	Connect VTVM to Filter output. Set oscillator frequency to 300Hz. Adjust oscillator output until VTVM indicates exactly 20 db. Change frequency to 30 Hz. Adjust LCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 27 to 33 for 10% Filters, and from 28.5 to 31.5 for 5% Filters.						
b.	X100 Calibration	30	X1	100	X10K	1.0	3kHz
	Adjust oscillator output until VTVM indicates exactly 20 db. Set LCO frequency multiplier to X100 position. Adjust LCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 27 to 33 for 10% Filters, and from 28.5 to 31.5 for 5% Filters.						
c.	X1K Calibration	30	X100	100	X10K	1.0	30kHz
	Adjust oscillator output until VTVM indicates exactly 20 db. Set LCO frequency multiplier to X1K position. Adjust LCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 27 to 33 for 10% Filters, and from 28.5 to 31.5 for 5% Filters.						
8.	HCO dial calibration at 100	100	X10	100	X10K	1.0	1000Hz
	Connect oscillator output to scope horizontal input; adjust scope for horizontal deflection of 20 divisions. Remove oscillator output from scope horizontal input and connect to scope vertical input; adjust scope for vertical deflection of 20 divisions. Remove oscillator output from scope and connect to Filter input. Connect scope horizontal input to input of Filter and scope vertical input to Filter output. Adjust LCO dial to close ellipse at about a 45 degree angle. Switch HCO multiplier to X10 position. Adjust HCO dial to close ellipse at about a 135 degree angle. If necessary, loosen HCO dial screws and set dial to 100.						
9.	HCO dial gain calibration at 100	10	X1	100	X10	1.0	1000Hz
	Switch HCO frequency multiplier to X100 position and adjust oscillator output until VTVM indicates exactly 20 db. Return HCO frequency multiplier to X10 position. Adjust P206 until VTVM indicates 17 db.						
10.	HCO dial gain calibration at 32	10	X1	32	X10	1.0	320Hz
	Switch HCO frequency multiplier to X100 position and adjust oscillator output until VTVM indicates exactly 20 db. Return HCO frequency multiplier to X10 position. Adjust HCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 29 to 35 for 10% Filters, and from 30.5 to 33.5 for 5% Filters.						
11.	HCO dial gain calibration at 280	10	X1	280	X10	1.0	2800Hz
	Switch HCO frequency multiplier to X100 position and adjust oscillator until VTVM indicates exactly 20 db. Return HCO frequency multiplier to X10 position. Adjust HCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 250 to 310 for 10% Filters, and from 265 to 295 for 5% Filters.						

TABLE 2. DETAILED TEST PROCEDURE (Cont.)

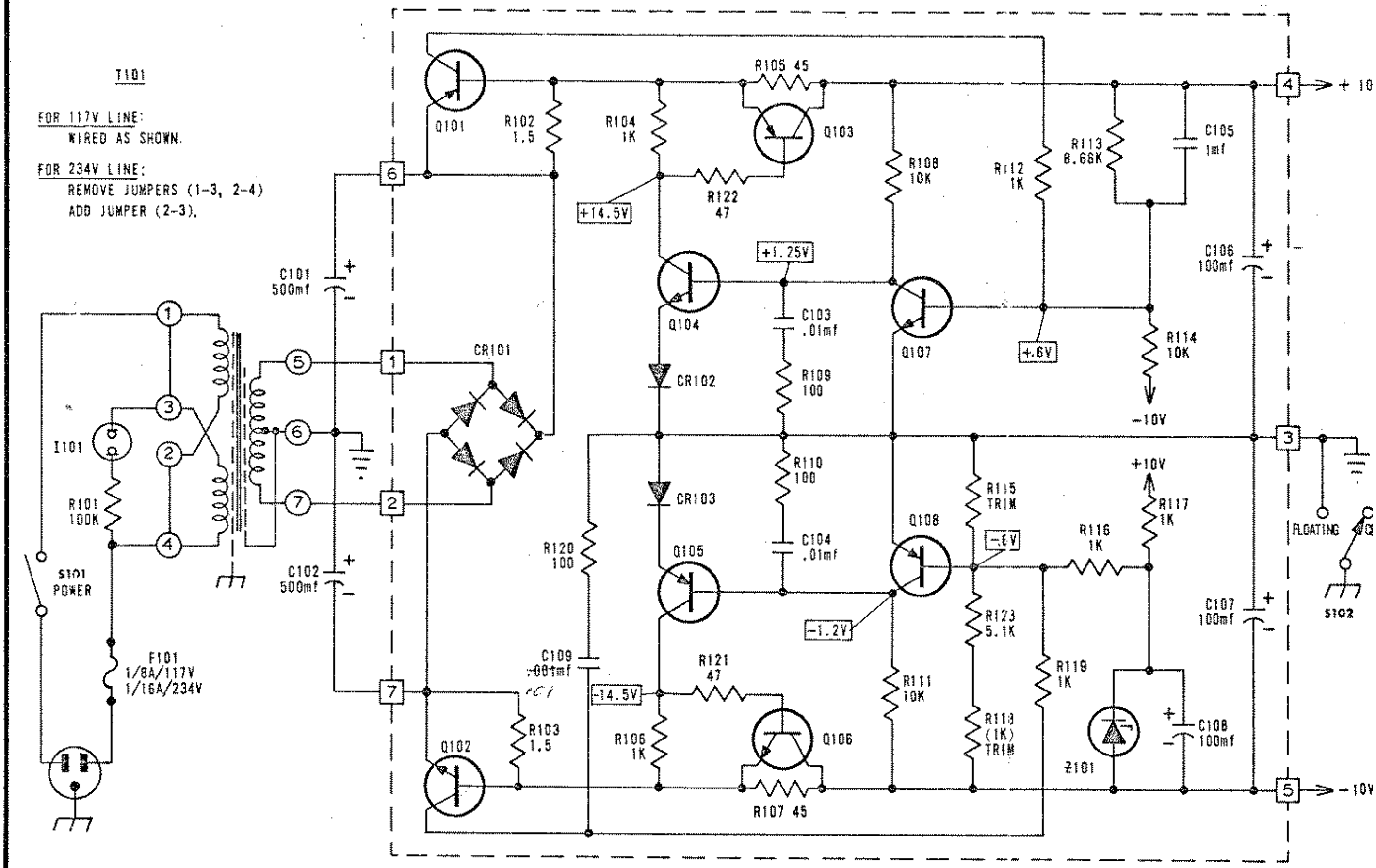
STEP	PROCEDURE	FREQUENCY SETTING				INPUT SIGNAL	
		LCO Dial	LCO Multiplier	HCO Dial	HCO Multiplier	VOLTS (RMS)	Frequency
12.	HCO dial gain calibration at 100 on all bands						
a.	X10K band calibration	10	X1	30	X10K	1.0	30kHz
	Adjust oscillator output until VTVM indicates exactly 20 db. Change oscillator frequency to 300 KHz. Adjust C223 until VTVM indicates 17 db. Set filter dial to 300 and oscillator to 3 MHz. Adjust C228 until VTVM indicates 17 db. Check 100 on the dial with the oscillator set at 1 MHz. (It may be necessary to divide the error by readjusting C223 and C228.)						
b.	X1K band calibration	10	X1	100	X10K	1.0	100kHz
	Adjust oscillator output until VTVM indicates exactly 20 db. Switch HCO multiplier to X1K position. Adjust HCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 90 to 110 for 10% Filters, and from 95 to 105 for 5% Filters.						
c.	X100 band calibration	10	X1	100	X1K	1.0	10kHz
	Adjust oscillator output until VTVM indicates exactly 20 db. Switch HCO multiplier to X100 position. Adjust HCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 90 to 110 for 10% Filters, and from 95 to 105 for 5% Filters.						
d.	X1 band calibration	10	X1	100	X10	1.0	100Hz
	Adjust oscillator output until VTVM indicates exactly 20db. Switch HCO multiplier to X1 position. Adjust HCO dial until VTVM indicates 17 db. Tolerance is a dial setting from 90 to 110 for 10% Filters, and from 95 to 105 for 5% Filters.						
13.	Maximum attenuation at 900Hz	100	X100	100	X100	3.0	900Hz
	Output signal should be below 300 microvolts.						
14.	Maximum attenuation at 110kHz	100	X100	100	X100	3.0	110kHz
	Output signal should be below 300 microvolts.						
15.	Maximum input voltage	100	X1	100	X10K	3.0	110kHz
	Check that output signal is not distorted.						
16.	Output impedance	10	X1	100	X10K	1.0	1kHz
	Connect 50 ohm resistor to Filter output. Output signal should decrease to approximately 0.5 volts.						
17.	Hum and Noise	10	X1	100	X10K	0	
	Connect VTVM only to Filter output and a shorting jumper across the input connector. Replace all covers. Output signal level should be below 150 microvolts. Caution! If output level is greater than 150 microvolts, monitor output to be sure excessive output is not due to radio or television station interference.						

MODEL 3103(R)

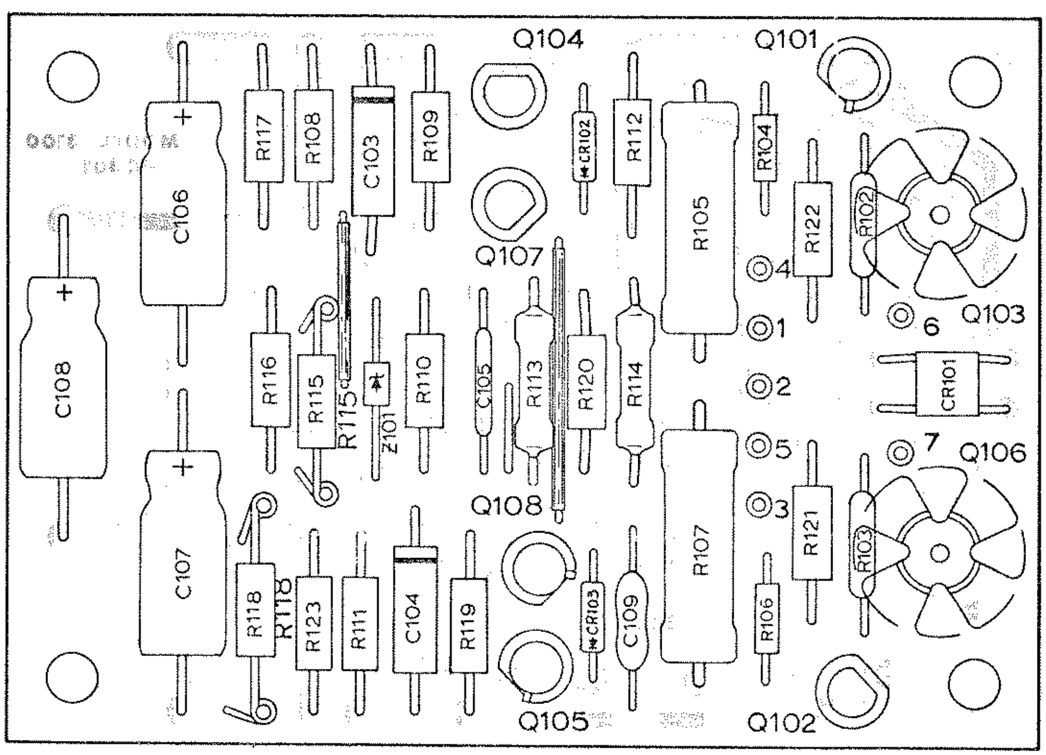
The following modifications and corrections are not reflected on the Schematic dated 3/17/67 and may be added at the discretion of the customer.

Change Order No.	Starting with Serial No.	Modifications & Corrections
2396	Bench: 139 & above Rack: 108 & above	Change R109 from a 100 ohm 1/2 w 20% to a 51 ohm 1/2 w 5%
2404	Documentation	Calibration accuracy from ±10% to ±5%
2413	Documentation	The low end of P206 should not be shown tied to ground. It is left open.
2419	Bench: 186 & above Rack: 125 & above	Change R234 from 100 ohm 1/2w 20% to 220 ohm 1/2w 20%
2427	Documentation	Omit center arm arrow and jumper X10, X100, and X1K on S301A.
2435	Bench: 206&above Rack: 135 &above	Change Q103 from (37918) to (2N4234) Change Q106 from (2N3053) to (2N4237)
2442	Bench: 206 & above Rack: 130 & above	Change R245 (51 ohm) to a short
2462	Bench: 227 & above Rack: 138 & above	C311 & C326 Change from .01mfd to .22mfd 50 volt ceramic. Change R341 and R344 from 3.6 ohm ½w 5% to 10 ohm ½w 5%

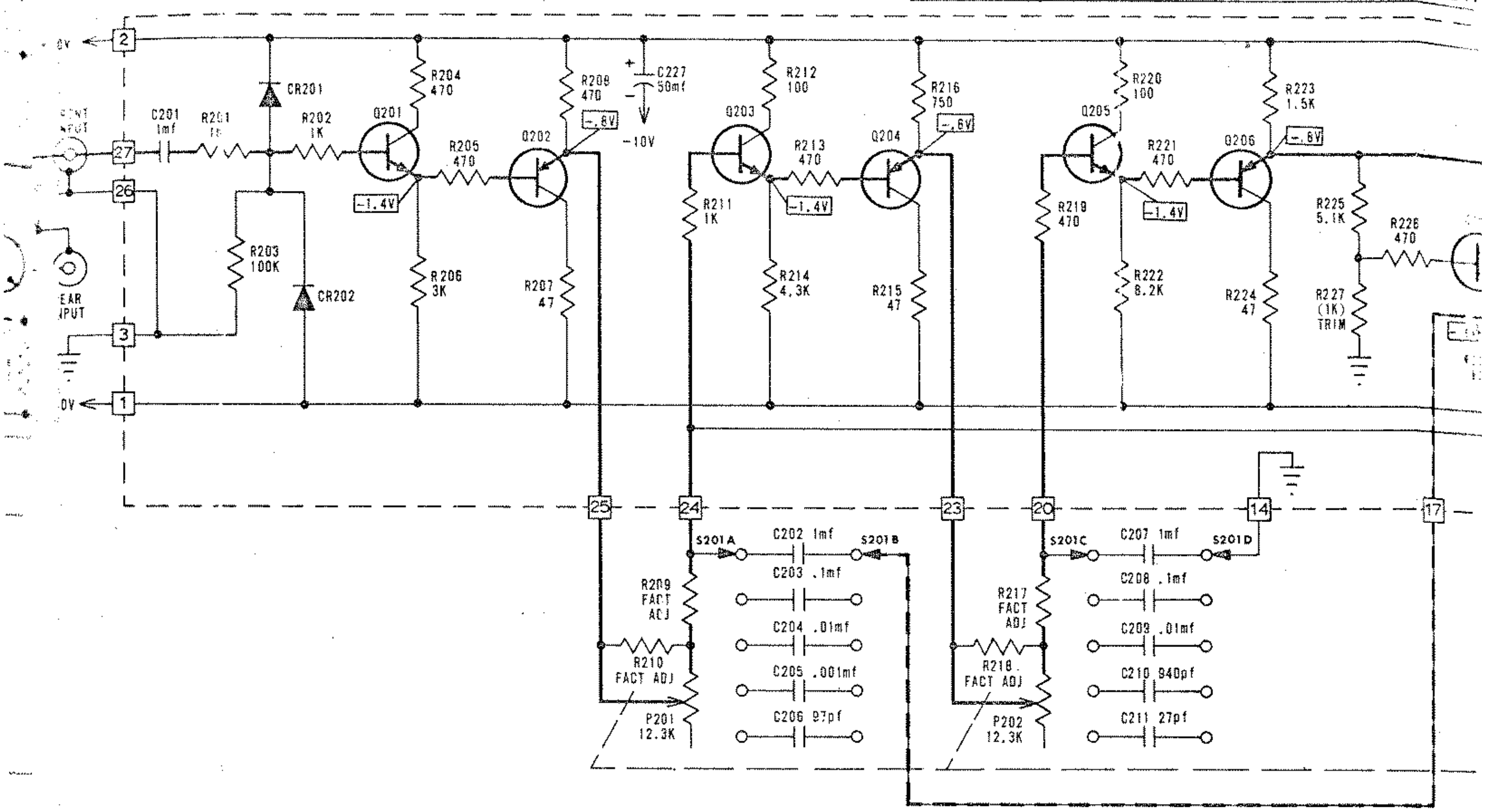
POWER SUPPLY SECTION (PC301)



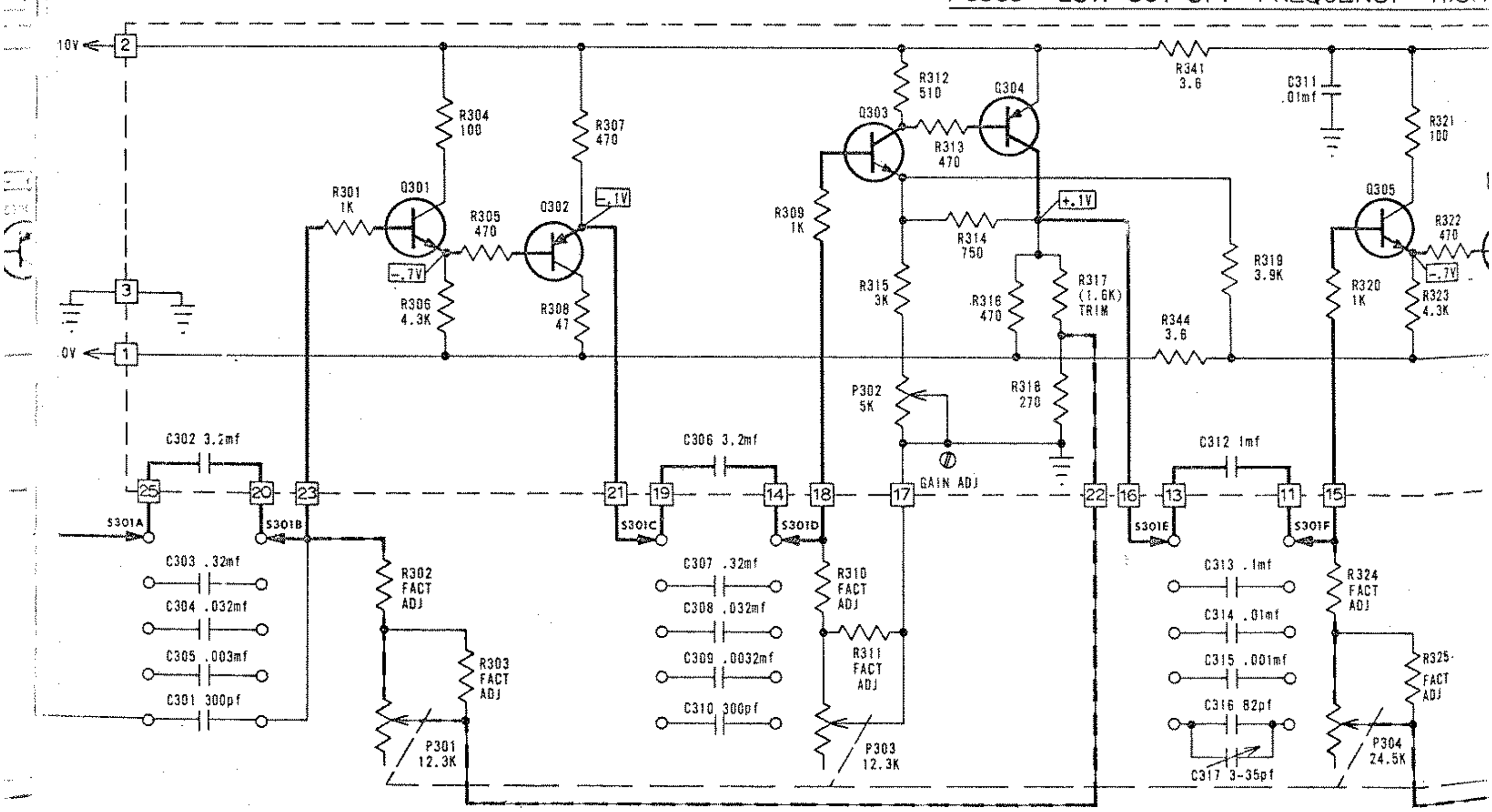
PC301



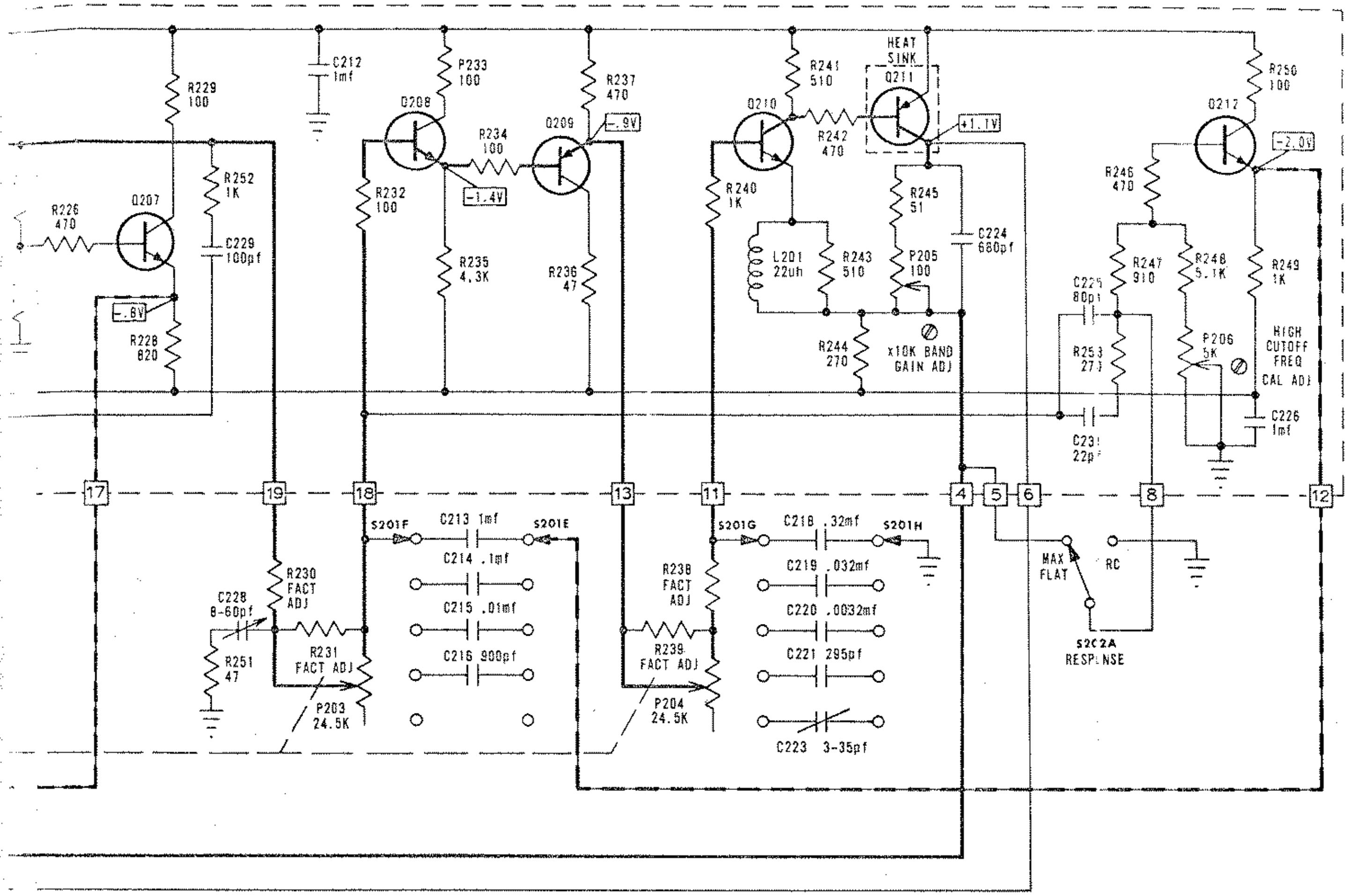
PC302 HIGH CUT-OFF FREQUENCY (LOW



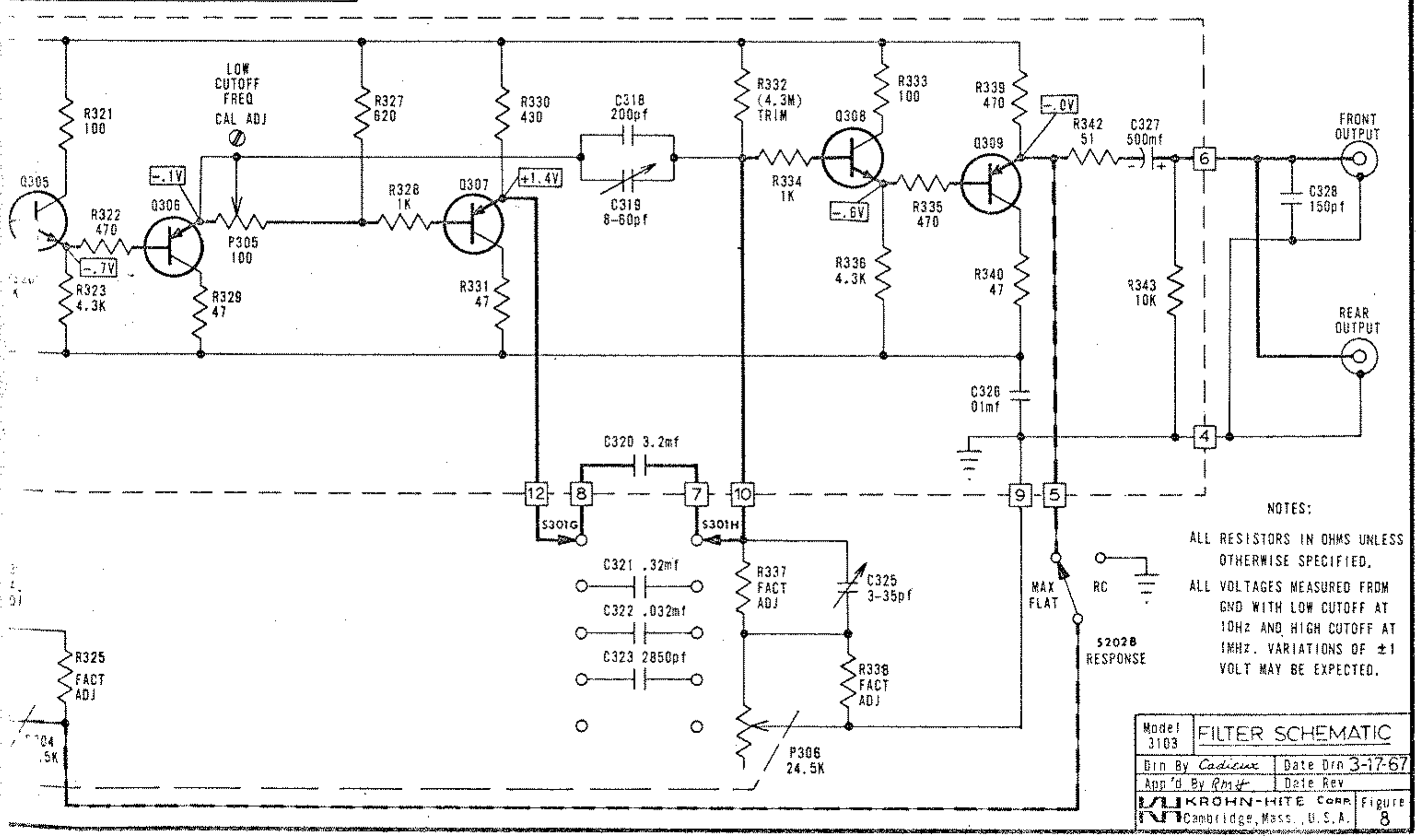
PC303 LOW CUT-OFF FREQUENCY HIGH



NCY (LOW PASS SECTION)



NCY HIGH PASS SECTION

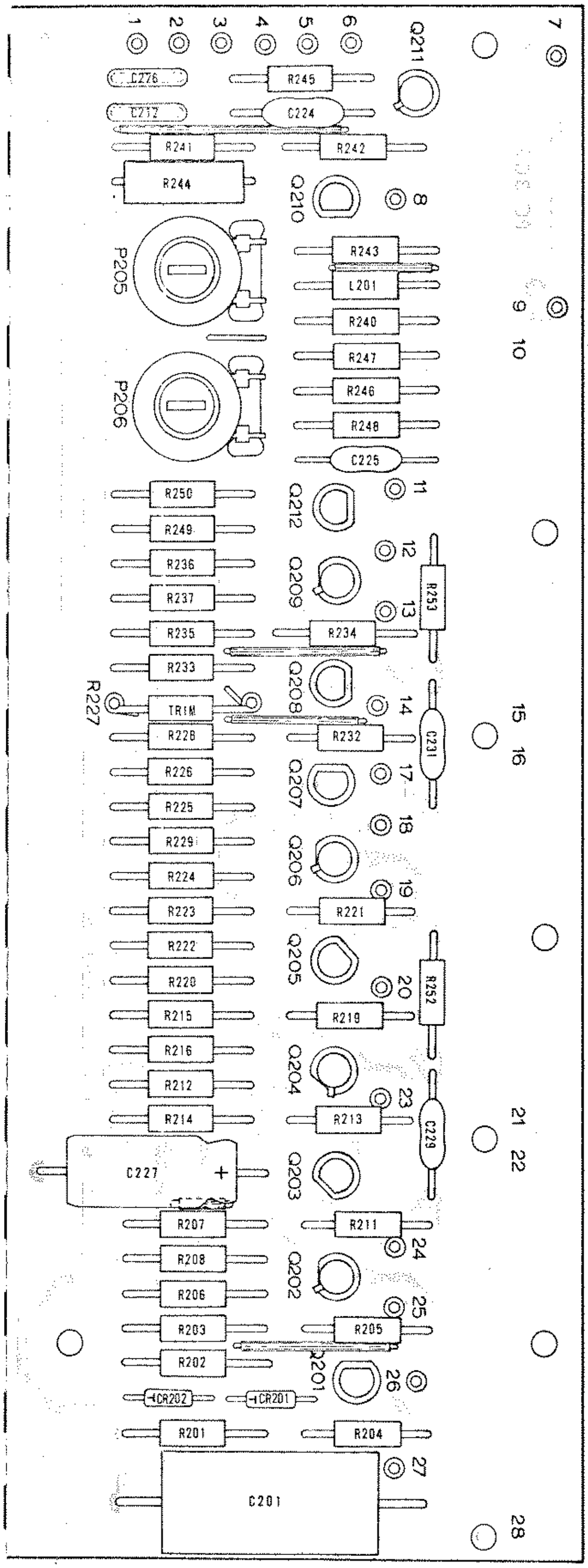


NOTES:

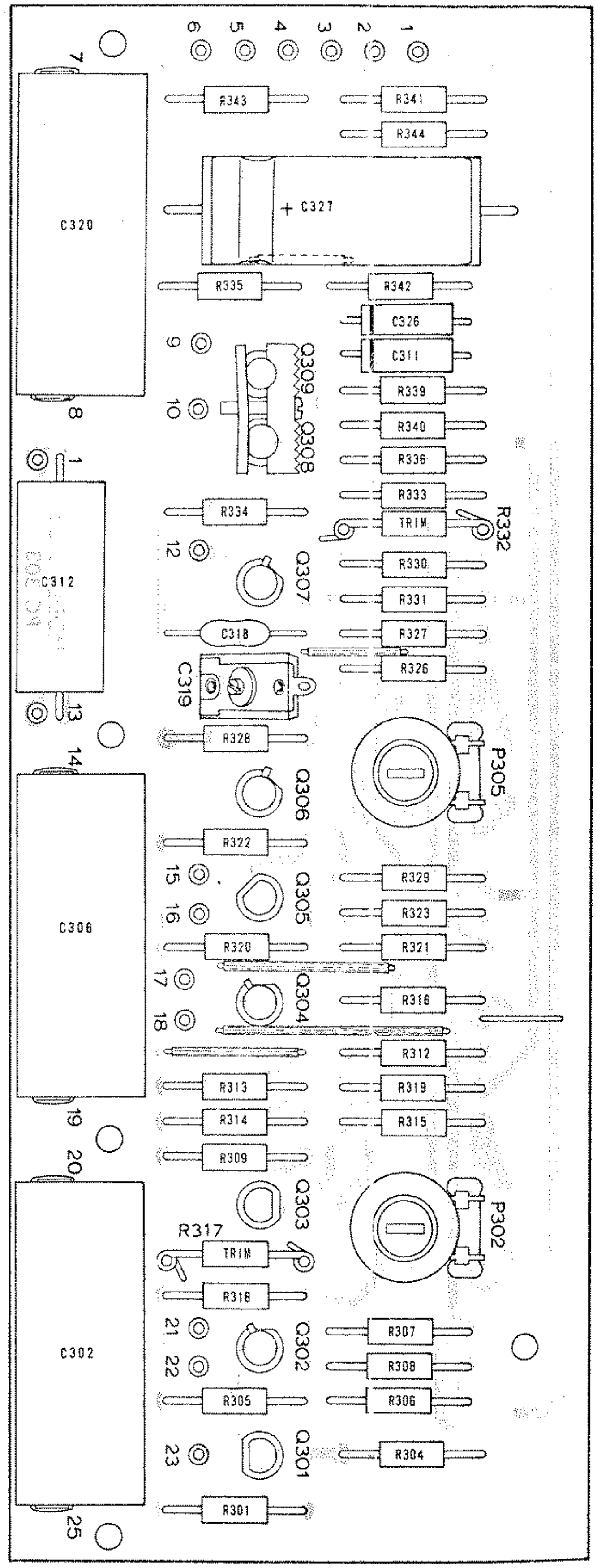
ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED.

ALL VOLTAGES MEASURED FROM GND WITH LOW CUTOFF AT 10Hz AND HIGH CUTOFF AT 1MHz. VARIATIONS OF ±1 VOLT MAY BE EXPECTED.

Model 3103	FILTER SCHEMATIC	
Drn By Cadieux	Date Drn 3-17-67	
App'd By RMH	Date Rev	
KROHN-HITE CORP. Cambridge, Mass., U.S.A.		Figure 8



PC 302
HIGH CUTOFF FREQUENCY
(low pass section)



PC 303
LOW CUTOFF FREQUENCY
(high pass section)

RESISTORS

Symbol	Description			Mfr.	Part No.
R101	100K	10%	1/2W	AB	EB1041
R102	1.5	5%	1W	IR	AS-1
R103	1.5	5%	1W	IR	AS-1
R104	1K	5%	1/2W	AB	EB1025
R105	45	5%	5W	IR	AS-5
R106	1K	5%	1/2W	AB	EB1025
R107	45	5%	5W	IR	AS-5
R108	10K	5%	1/2W	AB	EB1035
R109	100	20%	1/2W	AB	EB1012
R110	100	20%	1/2W	AB	EB1012
R111	10K	5%	1/2W	AB	EB1035
R112	1K	10%	1/2W	AB	EB1021
R113	8.66K	1%	1/2W	IR	CEC-TO
R114	10K	1%	1/2W	IR	CEC-TO
R115	Trim			AB	Type EB
R116	1K	5%	1/2W	AB	EB1025
R117	1K	10%	1/2W	AB	EB1021
R118	Trim			AB	Type EB
R119	1K	10%	1/2W	AB	EB1021
R120	100	20%	1/2W	AB	EB1012
R121	47	20%	1/2W	AB	EB4702
R122	47	20%	1/2W	AB	EB4702
R123	5.1K	5%	1/2W	AB	EB5125
R201	1K	10%	1/2W	AB	EB1021
R202	1K	10%	1/2W	AB	EB1021
R203	100K	10%	1/2W	AB	EB1041
R204	470	20%	1/2W	AB	EB4712
R205	470	20%	1/2W	AB	EB4712
R206	3K	5%	1/2W	AB	EB3025
R207	47	20%	1/2W	AB	EB4702
R208	470	5%	1/2W	AB	EB4715
R209	Trim			AB	Type EB
R210	Trim			AB	Type EB
R211	1K	20%	1/2W	AB	EB1022
R212	100	20%	1/2W	AB	EB1012
R213	470	20%	1/2W	AB	EB4712
R214	4.3K	5%	1/2W	AB	EB4325
R215	47	20%	1/2W	AB	EB4702
R216	750	5%	1/2W	AB	EB7515
R217	Trim			AB	Type EB
R218	Trim			AB	Type EB
R219	470	20%	1/2W	AB	EB4712
R220	100	20%	1/2W	AB	EB1012
R221	470	20%	1/2W	AB	EB4712
R222	8.2K	5%	1/2W	AB	EB8225
R223	1.5K	5%	1/2W	AB	EB1525
R224	47	20%	1/2W	AB	EB4702
R225	5.1K	5%	1/2W	AB	EB5125
R226	470	20%	1/2W	AB	EB4712
R227	1K	5%	1/2W	AB	EB1025
R228	820	5%	1/2W	AB	EB8215
R229	100	20%	1/2W	AB	EB1012
R230	Trim			AB	Type EB
R231	Trim			AB	Type EB
R232	100	20%	1/2W	AB	EB1012
R233	100	20%	1/2W	AB	EB1012
R234	100	20%	1/2W	AB	EB1012
R235	4.3K	5%	1/2W	AB	EB4325
R236	47	20%	1/2W	AB	EB4702
R237	470	5%	1/2W	AB	EB4715

Symbol	Description			Mfr.	Part No.
R238	Trim			AB	Type EB
R239	Trim			AB	Type EB
R240	1K	10%	1/2W	AB	EB1021
R241	510	5%	1/2W	AB	EB5115
R242	470	20%	1/2W	AB	EB4712
R243	510	5%	1/2W	AB	EB5115
R244	270	5%	1W	AB	GB2715
R245	51	5%	1/2W	AB	EB5105
R246	470	20%	1/2W	AB	EB4712
R247	910	5%	1/2W	AB	EB9115
R248	5.1K	5%	1/2W	AB	EB5125
R249	1K	5%	1/2W	AB	EB1025
R250	100	20%	1/2W	AB	EB1012
R251	47	20%	1/2W	AB	EB4702
R252	1K	20%	1/2W	AB	EB1022
R253	270	10%	1/2W	AB	EB2711
R301	1K	20%	1/2W	AB	EB1022
R302	Trim			AB	Type EB
R303	Trim			AB	Type EB
R304	100	20%	1/2W	AB	EB1012
R305	470	20%	1/2W	AB	EB4712
R306	4.3K	5%	1/2W	AB	EB4325
R307	470	5%	1/2W	AB	EB4715
R308	47	20%	1/2W	AB	EB4702
R309	1K	20%	1/2W	AB	EB1022
R310	Trim			AB	Type EB
R311	Trim			AB	Type EB
R312	510	5%	1/2W	AB	EB5115
R313	470	20%	1/2W	AB	EB4712
R314	750	5%	1/2W	AB	EB7515
R315	3K	5%	1/2W	AB	EB3025
R316	470	5%	1/2W	AB	EB4715
R317	1.6K	5%	1/2W	AB	EB1625
R318	270	5%	1/2W	AB	EB2715
R319	3.9K	5%	1/2W	AB	EB3925
R320	1K	20%	1/2W	AB	EB1022
R321	100	20%	1/2W	AB	EB1012
R322	470	20%	1/2W	AB	EB4712
R323	4.3K	5%	1/2W	AB	EB4325
R324	Trim			AB	Type EB
R325	Trim			AB	Type EB
R327	620	5%	1/2W	AB	EB6215
R328	1K	20%	1/2W	AB	EB1022
R329	47	20%	1/2W	AB	EB4702
R330	430	5%	1/2W	AB	EB4315
R331	47	20%	1/2W	AB	EB4702
R332	Trim			AB	Type EB
R333	100	20%	1/2W	AB	EB1012
R334	1K	20%	1/2W	AB	EB1022
R335	470	20%	1/2W	AB	EB4712
R336	4.3K	5%	1/2W	AB	EB4325
R337	Trim			AB	Type EB
R338	Trim			AB	Type EB
R339	470	5%	1/2W	AB	EB4715
R340	47	20%	1/2W	AB	EB4702
R341	3.6	5%	1/2W	AB	EB36G5
R342	51	5%	1/2W	AB	EB5105
R343	10K	10%	1/2W	AB	EB1031
R344	3.6	5%	1/2W	AB	EB36G5

CAPACITORS

Symbol	Description			Mfr.	Part No.
C101	500mf	+75% -10%	25V	SP	62D/D46219
C102	500mf	+75% -10%	25V	SP	62D/D46219
C103	.01mf	10%	100V	CD	WMFISIG
C104	.01mf	10%	100V	CD	WMFISIG
C105	1mf	+80% -20%	25V	SP	5C023105 D8250B3
C106	100mf	+75% -10%	25V	SP	30D107G025DH4
C107	100mf	+75% -10%	25V	SP	30D107G025DH4

Symbol	Description			Mfr.	Part No.
C108	100mf	+75% -10%	25V	SP	30D107G025DH4
C109	1000pf	20%	500V	SP	40C
C201	1mf	10%	200V	CD	BMM
C202	1mf	5%	50V	EP	BX4842
C203	.1mf	5%	50V	EP	BX4841
C204	.01mf	1%	500V	EL	DM20103F
C205	.001mf	1%	500V	EL	CM19C102F
C206	97pf	1%	500V	EL	CM15C970F

CAPACITORS (Cont.)

Symbol	Description			Mfr.	Part No.
C207	1mf	5%	50V	EP	BX4842
C208	.1mf	5%	50V	EP	BX4841
C209	.01mf	1%	500V	EL	DM20103F
C210	940pf	1%	500V	EL	CM19C941F
C211	27pf	5%	500V	EL	DM15C270J
C212	1mf	+80%	25V	SP	5C023105
		-20%			D8250B3
C213	1mf	5%	50V	EP	BX4842
C214	.1mf	5%	50V	EP	BX4841
C215	.01mf	1%	500V	EL	DM20103F
C216	900pf	1%	500V	EL	CM19C901F
C218	.32mf	5%	100V	EP	B1X324
C219	.032mf	5%	100V	EP	B1X323
C220	.0032mf	1%	300V	EL	CM20C322F
C221	295pf	1%	300V	EL	CM19C(295)F
C223	3-35pf			EL	T50310
C224	680pf	5%	500V	EL	DM19C681J
C225	80pf	1%	500V	EL	DM15C800F
C226	1mf	+80%	25V	SP	5C023105
		-20%			D8250B3
C227	50uf	+75%-10%	25V	SP	30D506G025CC4
C228	8-60pf			EL	T50410
C229	100pf	5%	500V	EL	DM15C101J
C231	22pf	5%	500V	EL	DM15C220J
C301	300pf	1%	500V	EL	DM15C301F
C302	3.2mf	5%	100V	EP	B1X325J
					B-2417/A
C303	.32mf	5%	100V	EP	B1X324
C304	.032mf	5%	100V	EP	B1X323
C305	.003mf	1%	300V	EL	CM20C302F
C306	3.2mf	5%	100V	EP	B1X325J B-2417/A
C307	.32mf	5%	100V	EP	B1X324
C308	.032mf	5%	100V	EP	B1X323
C309	.0032mf	1%	300V	EL	CM20C322F
C310	300pf	1%	500V	EL	DM15C301F
C311	.01mf	10%	100V	CD	WMF1S1
C312	1mf	5%	50V	EL	BX4248J
C313	.1mf	5%	50V	EP	BX4841
C314	.01mf	1%	500V	EL	DM20F103F
C315	.001mf	1%	500V	EL	CM19C102F
C316	82pf	5%	500V	EL	DM15C820J
C317	3-35pf			EL	T50310
C318	200pf	5%	500V	EL	DM15C201J
C319	8-60pf			EL	T50410(404)
C320	3.2mf	5%	100V	EP	B1X325J
					B-2417/A
C321	.32mf	5%	100V	EP	B1X324
C322	.032mf	5%	100V	EP	B1X323
C323	2850pf	1%	300V	EL	CM20C(2850)F
C325	3-35pf			EL	T50310
C326	.01mf	10%	100V	CD	WMF1S1
C327	500mf	+75%	15V	SP	34D507G015FJ4
		-10%			
C328	150pf	10%	500V	EL	DM15C151K

TRANSISTORS, DIODES & MISC.

Symbol	Description			Mfr.	Part No.
Q101	2N3136			MO	2N3136
Q102	2N3711			TI	2N3711
Q103	40319			RC	40319
Q104	2N3711			TI	2N3711
Q105	2N3136			MO	2N3136
Q106	2N3053			RC	2N3053
Q107	2N3711			TI	2N3711
Q108	2N3136			MO	2N3136
Q201	2N3711			TI	2N3711
Q202	2N3136			MO	2N3136
Q203	2N3711			TI	2N3711
Q204	2N3136			MO	2N3136
Q205	2N3711			TI	2N3711
Q206	2N3136			MO	2N3136
Q207	2N3711			TI	2N3711
Q208	2N3711			TI	2N3711
Q209	2N3136			MO	2N3136
Q210	2N3711			TI	2N3711
Q211	2N3136			MO	2N3136
Q212	2N3711			TI	2N3711
Q301	2N3711			TI	2N3711
Q302	2N3136			MO	2N3136
Q303	2N3711			TI	2N3711
Q304	2N3136			MO	2N3136
Q305	2N3711			TI	2N3711
Q306	2N3136			MO	2N3136
Q307	2N3136			MO	2N3136
Q308	2N3711			TI	2N3711
Q309	2N3136			MO	2N3136
CR101	MDA920-2			MO	MDA920-2
CR102	1N456			TR	1N456
CR103	1N456			TR	1N456
CR201	1N456			TR	1N456
CR202	1N456			TR	1N456
Z101	LMZ-10	±20%	10V	SM	LMZ-10-20
P201	12.3K	10%	2W	KH	A-2296/A-2300
P202	12.3K	10%	2W	KH	A-2296/A-2300
P203	24.5K	10%	2W	KH	A-2297/A-2300
P204	24.5K	10%	2W	KH	A-2297/A-2300
P205	100	30%	1/4W	CT	RS9846
P206	5K	30%	1/4W	CT	RS9847
P301	12.3K	10%	2W	KH	A-2296/A-2300
P302	5K	30%	1/4W	CT	U201R502B
P303	12.3K	10%	2W	KH	A-2296/A-2300
P304	24.5K	10%	2W	KH	A-2297/A-2300
P305	100	30%	1/4W	CT	U201R101B
P306	24.5K	10%	2W	KH	A-2297/A-2300
L201	22uh	10%	1/4W	DL	1537-44
T101	Transformer			KH	B2290E
S201	Rotary Switch			KH	C2394B
S301	Rotary Switch			KH	C2394B
S102	Slide Switch			CW	G123 (Recessed Button)
S202	Slide Switch			CW	G126
S101	Toggle Switch (3103)			AL	MST-105D
S101	Toggle Switch (3103R)			CH	8280K27H

MANUFACTURERS CODE

AB	Allen-Bradley Co.	Milwaukee, Wis.
AL	Alcoswitch	Lawrence, Mass.
CD	Cornell-Dubilier Elec.	Newark, N.J.
CH	Cutler-Hammer Inc.	Milwaukee, Wis.
CT	CTS Corp.	Elkhart, Ind.
CW	Continental-Wirt Electronics	Philadelphia, Pa.
DL	Delevan Electronics	East Aurora, N.Y.
EL	Electro Motive Mfg. Inc.	Willimantic, Conn.
EP	Elpac Inc.	Fullerton, Calif.
ER	Erie Products Inc.	Erie, Pa.
FR	Fairchild Semiconductor	San Rafael, Calif.
GE	General Electric Co.	Syracuse, N.Y.
IR	International Resistance Co.	Philadelphia, Pa.
KH	Krohn-Hite Corp.	Cambridge, Mass.
KL	Kelvin Associates	Van Nuys, Calif.
MO	Motorola Semiconductor	Phoenix, Ariz.
RC	Radio Corp. of America	Harrison, N.J.
SM	U. S. Semcor	Phoenix, Ariz.
SP	Sprague Electric Co.	No. Adams, Mass.
TI	Texas Instruments Inc.	Dallas, Texas
TR	Transitron Electric Corp.	Wakefield, Mass.
UC	Union Carbide Electronics	Mountain View, Calif.