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VARIABLE
BAND-PASS FILTER

Model 310-AB

SERIAL NO. 1342

KROHN-HITE INSTRUMENT COMPANY

CAMBRIDGE 39, MASS., U. S. A.

VARIABLE

BAND-PASS FILTER

Model 310-AB

INSTRUCTIONS

Manufactured by

KROHN-HITE INSTRUMENT COMPANY

CAMBRIDGE 39, MASS., U.S.A.

GENERALAGENT
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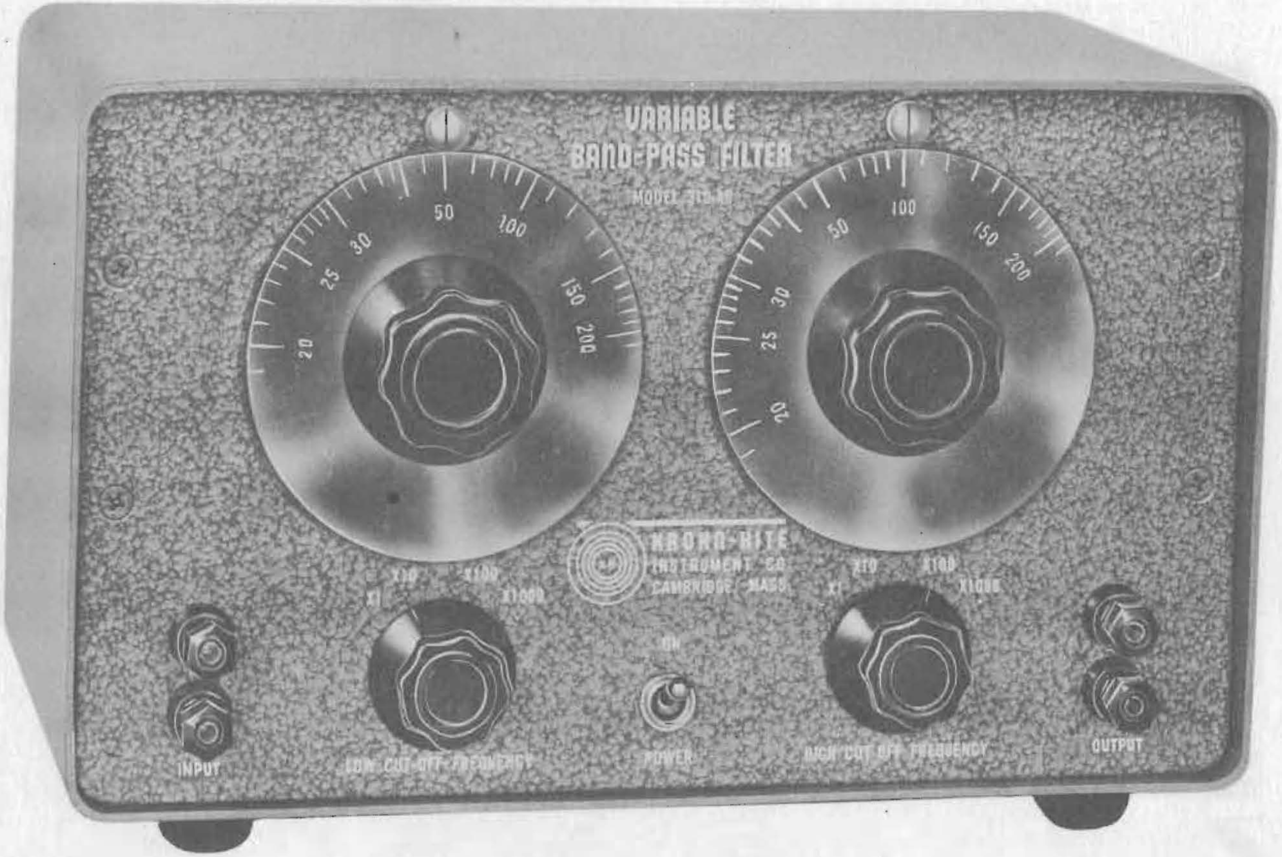


FIGURE 1 — Model 310-AB VARIABLE BAND-PASS FILTER

VARIABLE BAND-PASS FILTER

Model 310-AB

TECHNICAL SUMMARY

POWER REQUIREMENTS:

Source	105-125 volts, 50-60 cps.
Consumption	55 watts
Fuse Protection	1 ampere

FREQUENCY DIALS: Calibrated logarithmically from 19 to 210 for both high and low cut-off frequencies.

FREQUENCY RANGE: 20 to 200,000 cps. for both high and low cut-off frequencies.

Band	Multiplier	Frequency
1	1	20 - 200
2	10	200 - 2,000
3	100	2,000 - 20,000
4	1,000	20,000 - 200,000

FREQUENCY ACCURACY: Calibration ±10%

GAIN IN PASS BAND: Unity (0 db ±1 db)

ATTENUATION OUTSIDE PASS BAND: Each side, 24 db/octave with peaking factor to reduce attenuation at the cut-off frequencies. Maximum attenuation greater than 60 db.

INPUT CHARACTERISTICS:

IMPEDANCE: Approximately 6 megohms in parallel with 20 mmfd.

MAXIMUM INPUT AMPLITUDE: 5 volts rms.

MAXIMUM D-C COMPONENT: 400 volts.

OUTPUT CHARACTERISTICS:

IMPEDANCE: 500 ohms.

INTERNALLY GENERATED NOISE: Less than 1 millivolt.

FORM: Overall dimensions; 12" wide, 7" high, 8" deep. Weight 17 lbs.

TUBE COMPLEMENT: 5-12AT7, 1-12AU7, 1-6BQ7A, 1-6AU5, 1-6X5

DESCRIPTION

The Model 310-AB VARIABLE BAND-PASS FILTER, shown in Figure 1, is an adjustable filter whose gain is unity in the pass band, and drops outside the pass band at a rate of 24 db/octave. This completely electronic and easily portable instrument operates from an a-c source of 105 to 125 volts, 50 to 60 cycles per second. An integral power supply furnishes the heater voltages and the d-c voltages required for operation. The filter is easy to operate and requires no initial warm-up period or adjustment, and is ready for operating when shipped.

Both the high and low cut-off frequencies are independently adjustable from 20 to 200,000 cps. This provides maximum flexibility of adjustment of both the band center frequency and the band width. Two identical frequency dials and multiplier switches are used for the cut-off frequencies. Each dial is single scale, direct reading, and calibrated logarithmically from 19 to 210. The associated multiplier switch selects one of the four decade band.

The 310-AB improves upon the 310-A by offering lower internally generated noise, and lower output level bounce caused by line voltage fluctuations.

THEORY OF OPERATION

The basic circuit of one of the high cut-off sections of the filter is shown in Fig. 2.

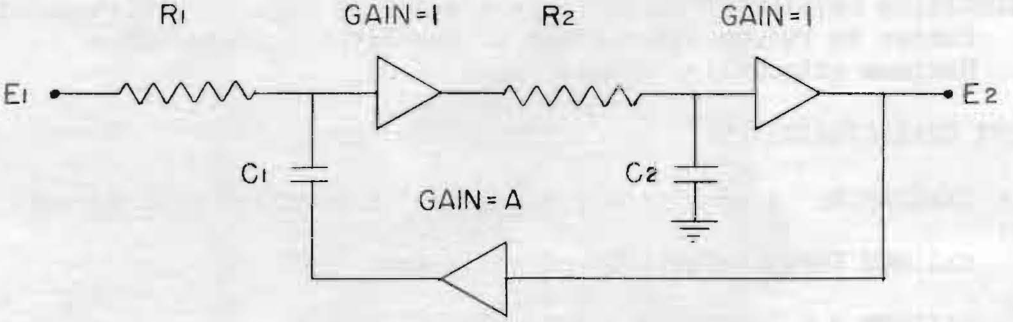


FIGURE 2-FUNDAMENTAL CIRCUIT OF ONE HIGH CUT-OFF SECTION

This basic circuit consists of two high cut-off RC sections coupled by unity gain buffer amplifiers. A feedback signal of AE_2 is fed back to the first capacitor. If both capacitors are the same, this circuit has a transfer characteristic of:

$$\frac{E_2}{E_1} = \frac{1}{j^2\omega^2\,(R_1C\;R_2C) + j\omega\,[R_2C + (1-A)R_1C] + 1}$$

At the cut-off frequency where

$$j^2\omega^2 R_1C\ R_2C + 1 = 0 \text{ and } \omega_{co} = 1/\sqrt{R_1CR_2C}$$

The gain of the circuit is:

$$G_{co} = \frac{1}{\sqrt{R_2/R_1} + (1\text{-}A)\sqrt{R_1/R_2}}$$

Thus the G_{co} can be controlled by adjusting "A" and the ratio R_2/R_1. The peaking of the response curve for three different values of G_{co} is shown in Fig. 3.

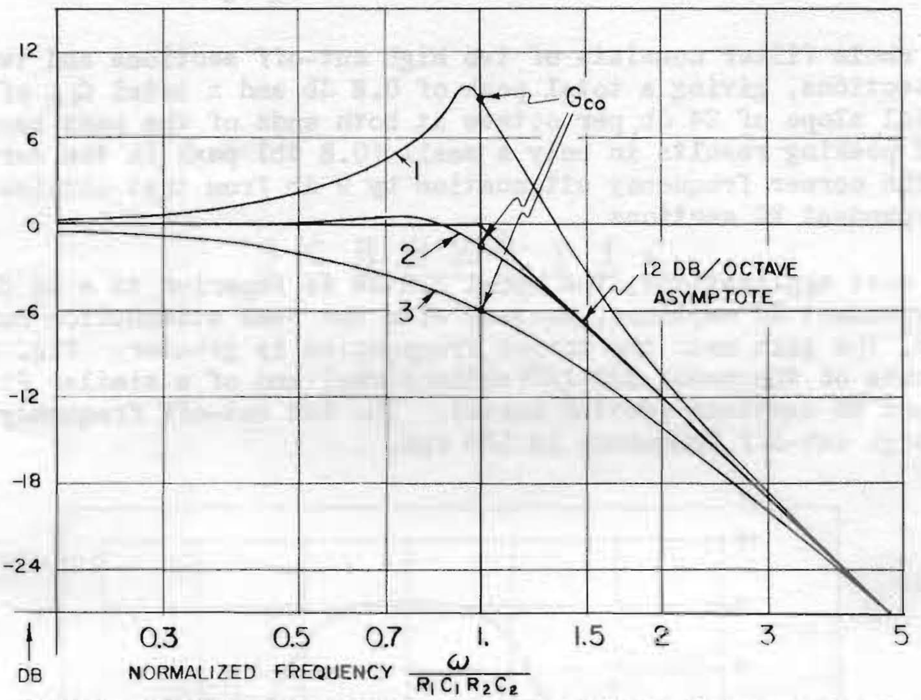


FIGURE 3-EFFECT ON CORNER PEAKING CAUSED BY CHANGING G_{co}

Curve 2 is the one used in the filter and is achieved by setting A = 0.92 and R_2/R_1 = 1.06 giving a G_{co} for one 12 db/octave section of approximately -1.5 db. The basic circuit of one of the low cut-off sections of the filter is shown in Fig. 4.

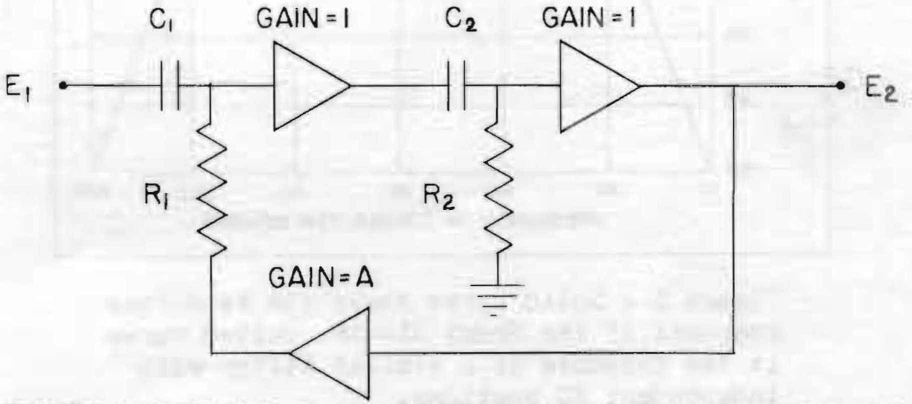


FIGURE 4-FUNDAMENTAL CIRCUIT OF ONE LOW CUT-OFF SECTION

The equations for this circuit are:

$$\frac{E_2}{E_1} = \frac{j^2\omega^2 R_1C\ R_2C}{j^2\omega^2 R_1C\ R_2C + j\omega\,[R_1C + (1\text{-}A)R_2C] + 1}$$

$$\omega_{co} = 1/\sqrt{R_1C\ R_2C}$$

$$G_{co} = \frac{1}{\sqrt{R_1R_2} + (1\text{-}A)\sqrt{R_2/R_1}}$$

The response curves for this circuit come out symmetrical with those of Fig. 3 about the $\omega = 1.0$ axis. Again, curve 2 is the one used in the filter and is achieved by setting $A = 0.92$ and $R_1/R_2 = 1.06$.

The whole filter consists of two high cut-off sections and two low cut-off sections, giving a total peak of 0.8 db and a total G_{co} of -3 db and a total slope of 24 db per octave at both ends of the pass band. This choice of peaking results in only a small (0.8 db) peak in the curve, but reduces the corner frequency attenuation by 9 db from that obtained by four independent RC sections.

For most applications, the Model 310-AB is superior to a 24 db filter with independent RC sections, because with the same attenuation outside the pass band, the gain near the corner frequencies is greater. Fig. 5 shows the response of the Model 310-AB (solid curve) and of a similar filter with independent RC sections (dotted curve). The low cut-off frequency is 40 cps. and the high cut-off frequency is 160 cps.

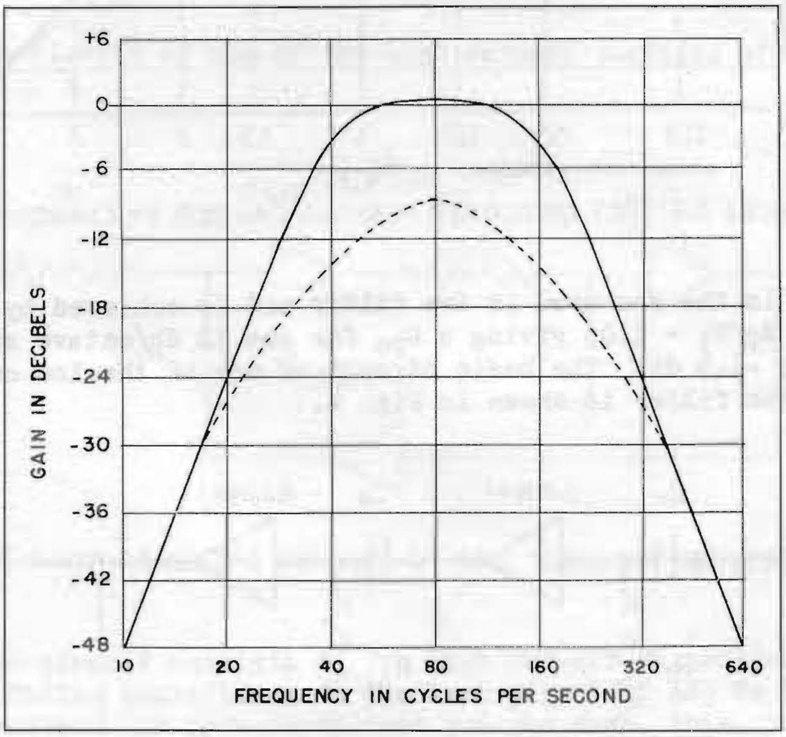
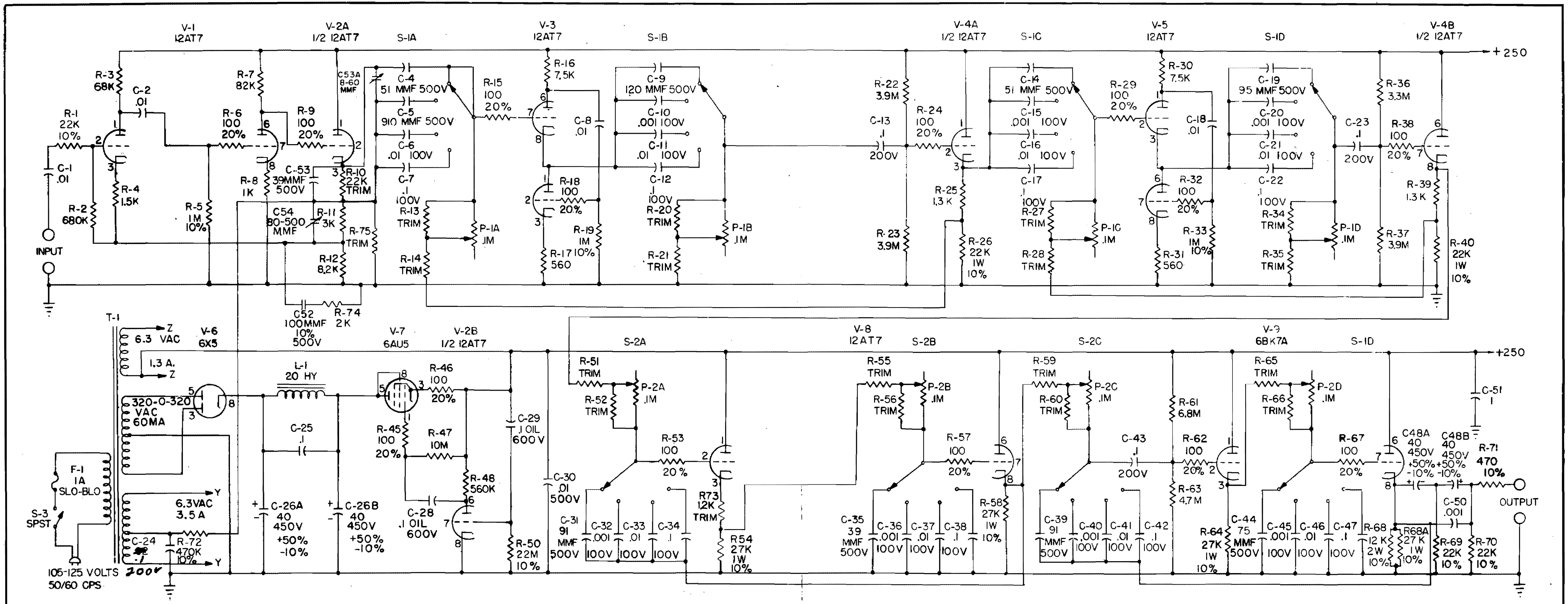
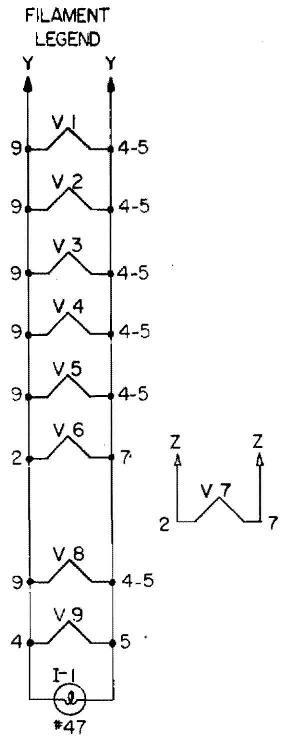


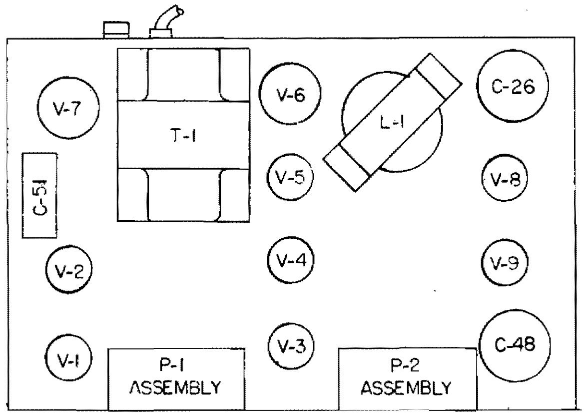
Figure 5 - Solid curve shows the Band-Pass response of the Model 310-AB. Dotted curve is the response of a similar filter with independent RC sections.

SCHEMATIC

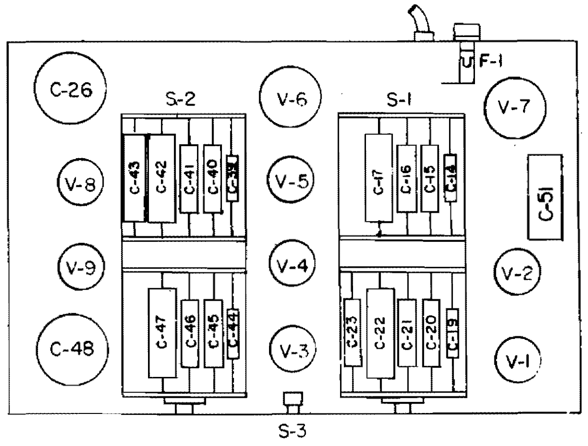
FIGURE 8







TOP VIEW



BOTTOM VIEW

NOTES:
1) SECONDARY VOLTAGES OF T-1 MEASURED WITH 115 VAC ON PRIMARY
2) ALL RESISTORS 1/2W 5% AND IN OHMS UNLESS OTHERWISE SPECIFIED.
3) ALL CONDENSERS IN MFD 20% 400V UNLESS OTHERWISE SPECIFIED.
4) ALL COMPONENTS MARKED TRIM ARE FACTORY ADJUSTMENTS
5) ALL CAPACITORS SWITCHED BY S-1 AND S-2 HAVE A BASIC TOLERANCE OF±5% OF THE VALUE SHOWN. IN ANY ONE INSTRUMENT THESE CAPACITORS ARE SELECTED TO FALL IN DECADE STEPS WITHIN 2%, EXCEPT ON THE HIGHEST FREQUENCY BAND WHICH IS COMPENSATED FOR STRAY CAPACITANCES

FIGURE 8

MODEL 310AB
SCALE:
DATE: 6-22-54
APPROVED BY D.c.F.
DRAWN BY J.N.
4-15-59
SCHEMATIC DIAGRAM
KROHN-HITE INSTRUMENT COMPANY
CAMBRIDGE, 39, MASSACHUSETTS
DRAWING NUMBER 310A-B-1

Phase characteristics are shown in Fig. 6. The total phase characteristic is found by adding the two separate phase curves together.

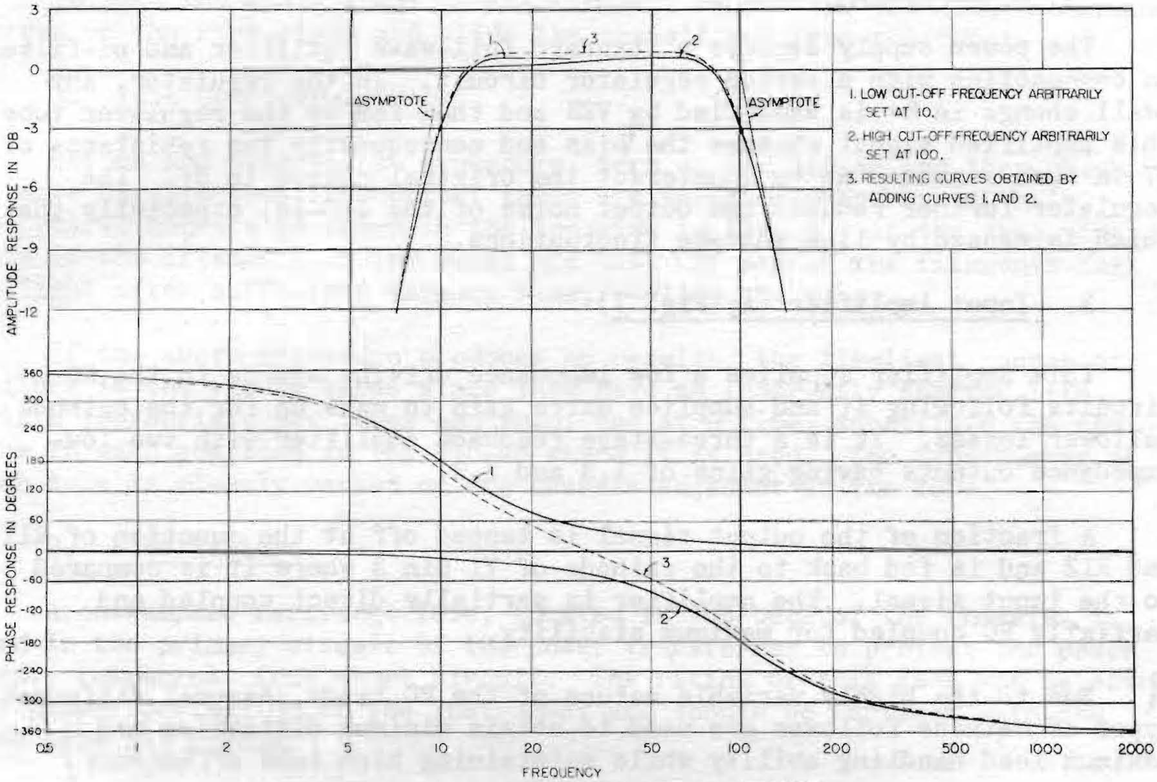


FIGURE 6 PHASE AND AMPLITUDE CHARACTERISTICS

For a narrow pass band, both dials may be set at the same frequency ω. The peak will occur at ω, 6 db down from the input. The points three db down from the peak will occur at 0.73ω and 1.37ω. 2ω and 3ω will be 16 db and 28 db down from the peak respectively.

CIRCUIT DESCRIPTION

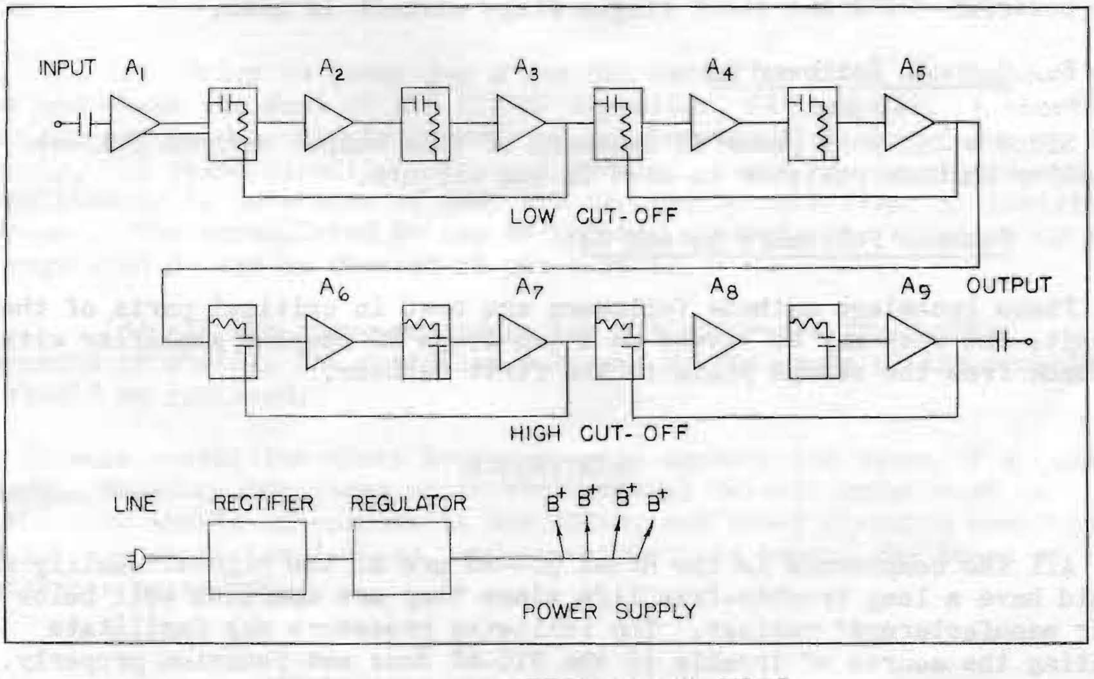


FIGURE 7-BLOCK DIAGRAM MODEL 310-AB

1. Power Supply

The power supply employs a standard full-wave rectifier and pi-filter in conjunction with a series regulator circuit. In the regulator, any small change in B+ is amplified by V2B and then fed to the regulator tube V7. This amplified signal changes the bias and consequently the resistance of V7 in such a manner as to counteract the original change in B+. The regulator further reduces the output noise of the 310-AB, especially that which is caused by line voltage fluctuations.

2. Input Amplifier (A_1 Fig. 7)

This amplifier supplies a low impedance driving source to the RC circuits following it and supplies extra gain to make up for the cathode follower losses. It is a three-stage feedback amplifier with two low-impedance outputs having gains of 1.3 and 3.3.

A fraction of the output signal is tapped off at the junction of R11 and R12 and is fed back to the cathode of V1 pin 3 where it is compared to the input signal. The amplifier is partially direct coupled and partially RC coupled for maximum stability.

Due to the highly variable nature of the RC loads, several different types of cathode follower are used to obtain minimum distortion and maximum load handling ability while maintaining high tube efficiency.

3. Cathode Followers A_3 and A_5

Since these RC circuits do not require as much driving power, a single stage cathode follower is used in the interest of overall instrument efficiency.

4. Cathode Followers A_6, A_7, and A_8

Slightly more power is demanded of these cathode followers; hence a more powerful 6BQ7A and 12AU7 single stage circuit is used.

5. Cathode Follower A_9

Since still more power is demanded of this output cathode follower, a smaller cathode resistor is used in the circuit.

6. Cathode Followers A_3 and A_4

These two-stage cathode followers are used in critical parts of the circuit, and each may be viewed as a two-stage RC coupled amplifier with feedback from the second plate to the first cathode.

MAINTENANCE

All the components in the Model 310-AB are of the highest quality and should have a long trouble-free life since they are operated well below their manufacturers' ratings. The following procedure may facilitate locating the source of trouble if the 310-AB does not function properly.

To take the chassis out of the cabinet, remove the two lower innermost screws on the rear plate and slide the chassis out from the front.

1. Tube Complement Check

Before any maintenance procedure, turn on the 310-AB and then check to make certain that the correct tubes are inserted properly in their respective sockets as shown in the top view in Fig. 8. At the same time, note if the filaments of the tubes are lit. If any of the filaments fail to light after sufficient warm-up time, replace the tube.

If the above procedure produces no results, the likeliest source of failure is the vacuum tubes since they have an inherently shorter life. Obtain appropriate new tubes and then, one at a time, substitute the new tube in each position in the 310-AB where it is used. The type number of each tube is clearly marked on the chassis adjacent to the tube.

2. Fuse Failure

A one-ampere cartridge fuse, located in the back of the chassis, is used in the primary circuit of the power transformer to protect the power supply components from short circuit. The rating of this fuse was selected for proper protection of the instrument and should be replaced with the same type and rating.

If a fuse failure is detected, the following procedure is recommended before replacing the fuse:

(a) Remove the 6X5 rectifier tube, V6, and disconnect the power cord. Measure the d-c primary resistance of the power transformer which should be 5 ohms. A lower resistance indicates a shorted primary.

(b) Insert a new fuse, connect the power, and then, with the 6x5 still out, check the primary and the secondary voltages of the transformer. If the voltages are correct, the transformer is functioning properly.

(c) Prior to inserting a new 6X5 rectifier tube, disconnect the power and check the dual 40 MFD filter capacitor, C26 and C27. A shorted capacitor can be detected by connecting an ohmmeter (low range) across it directly. If these capacitors are not shorted, check the regulated and unregulated B+ to determine if they are shorted to each other or individually to ground. The unregulated B+ can be located conveniently at pin 5 of V7. The regulated B+ can be checked at pin 1 of V2.

(d) If the above procedure has not uncovered any faulty components or wiring, the rectifier tube may be the cause of the trouble and should be replaced.

In most cases, the above procedure will uncover the cause of a fuse failure. However, occasions arise when unusual defects occur such as intermittent shorts in components and tubes, and short circuits resulting from foreign particles. These, unfortunately, are beyond the scope of this maintenance procedure.

3. Power Supply

If the 310-AB is not functioning when the rated line voltage is applied, and the instrument is powered as indicated by the pilot light or visible tube filaments, it is advisable to check the power supply.

The +380 volt unregulated supply voltage, as derived from the cathode of the rectifier tube V6, is filtered in a capacitor input single-section pi-filter consisting of C26, C27 and L1. The unregulated voltage should be checked at rated line voltage.

If the unregulated voltage deviates from its proper value, replace the rectifier V6. When replacing V6 brings about no change in the voltage level, check the total current drain by measuring the voltage across L1 which, under normal conditions, should measure 24 volts. If the voltage is appreciably higher than normal, the 310-AB is drawing excessive current. The excess current may be due to a low resistance path which may occur in the dual 40 MFD filter capacitor C26 and C27 or in the filter when the d-c output levels of any of the amplifiers are incorrect.

Since both stages of the a-c regulator are RC coupled, their d-c levels are independent so that the voltage levels of each stage can be checked independently according to the voltage chart Fig. 8. Too large a voltage drop across V7 suggests too much grid bias which could be caused by a leaky C28. The voltage at V2 pin 6 may vary quite a bit since this tube derives its bias from grid current which varies from tube to tube.

4. Input Amplifier A_1

Due to RC coupling from V1A plate pin 1 to V1B grid pin 7, there is no d-c feedback and the d-c levels are determined as follows:

V1B grid pin 7 is at 0 volts.

R7 and R8 set the voltages of V1B plate and cathode pins 6 and 8.

Voltage at V1B plate pin 6 appears on V2A grid pin 2 (no current flows through parasitic surpressor R9).

Voltage at V2A cathode pin 3 should be only a few volts more positive than V2A grid pin 2 due to cathode follower action.

Voltage at V1A cathode pin 3 is set by the voltage at V2A cathode pin 3, voltage divider R10-R11, resistor R12, and the current drawn by V1A.

Voltage at V1A plate pin 1 is determined by voltage at V1A cathode pin 3, R4 and R3.

If the voltages are checked in this order, a malfunction in the input amplifier can be most easily tracked down.

5. Remaining Stages

All of the remaining stages are types of cathode followers. Stages A2 and A4 can be considered as cathode followers by considering the bottom tube to be a simple d-c resistance.

In all cases, due to cathode follower action, the cathode of each stage will be a few volts higher than the grid of the same stage if the circuit is working properly. Also, there should be no voltage change in going from the cathode of one stage to the grid of the next direct coupled stage. The cathode followers are coupled in the following order:

R22 and R23 set the voltage at V4A grid pin 2.

Cathode follower action sets V4A cathode pin 3 a few volts higher.

This voltage on pin 3 is divided down by R25 and R26 and is used to set the level of V3 grid pin 7. Due to cathode follower action, this also sets the level of V3 pins 8 and 1.

R36 and R37 set the voltage at V4B grid pin 7.

Cathode follower action sets V4B cathode pin 8 a few volts higher.

This voltage on pin 8 is divided down by R39 and R40 and is used to set the level of V5 grid pin 2 and, as above, the level of V5 pins 3 and 6.

The voltage on pin 8 of V4B is also fed to V8A grid pin 2 which, as above, sets the level of V8A cathode pin 3.

The voltage at V8A cathode pin 3 is fed to V8B grid pin 7, which, as above, sets the voltage of V8B cathode pin 8.

R61 and R63 set the voltage at V9A grid pin 2 which, as above, sets the voltage of V9A cathode pin 3 a few volts higher.

The voltage at V9A cathode pin 3 is fed to V9B grid pin 7 which, as above, sets the voltage of V9B cathode pin 8.

Any break in these chains of slowly rising voltage from grid to cathode to grid to cathode indicates that that stage or its associated circuitry is mal-functioning and should be carefully checked.

6. Tuning Circuits

The tuning capacitors are switched four at a time by the band switches as shown in the circuit diagram Fig. 8.

The tuning resistances are varied by the tuning dial which turns four potentiometers through a system of gears. The trim resistors and angular orientation of these potentiometers are carefully adjusted at the factory for proper tracking and tuning, and no attempt should be made to readjust them.

GUARANTEE AND WARRANTY

KROHN-HITE Instruments are designed and manufactured in accordance with sound engineering practices and should give long trouble-free service under normal operating conditions. If your filter fails to provide satisfactory service and you are unable to locate the source of trouble, write to our Service Department, giving all the information concerning the failure.

Do not return the instrument without our written authorization for, in most cases, we will be able to supply you with the information necessary to repair the filter and thus avoid the transportation costs and problems. When it becomes necessary to return the instrument to our factory, kindly pack it carefully and ship it to us via express, prepaid.

KROHN-HITE Instruments are conservatively designed to provide continuous reliable service under normal laboratory conditions. The material and workmanship in every instrument is guaranteed for one year from the date of purchase. Any instrument developing defects during this period will be repaired and defective parts will be replaced without charge when the failure is the result of defective material or workmanship. Our warranty does not apply to vacuum tubes.

KROHN-HITE INSTRUMENT COMPANY reserves the right to make design changes at any time without incurring any obligation to incorporate these changes in instruments previously purchased.

Figure 9 lists the voltages and resistances between the pins of each socket and ground (except as noted). The meter used for the d-c measurements was a V.T.V.M. with an impedance of 11 megohms. All measurements were made with both dials set at 200 x 1000. All voltages measured with 115 vac line. Variations of 20% may be expected.

Voltage and Resistance Chart

TUBE			PIN NUMBER								
No.	Type		1	2	3	4	5	6	7	8	9
V1	12AT7	V	170	33	40	60	60	123	0	1.5	60
		R	*68K	690K	10K	480K	480K	*82K	1M	1K	480K
V2	12AT7	V	250	123	125	60	60	48	**	0	60
		R	*0	*82K	33K	480K	480K	*560K	22M	0	480K
V3	12AT7	V	120	0	1.6	60	60	240	118	120	60
		R	∞	1M	560	480K	480K	*7.5K	30K	∞	480K
V4	12AT7	V	250	110	126	60	60	250	118	133	60
		R	*0	3M	24K	480K	480K	*0	2.8M	24K	480K
V5	12AT7	V	230	125	126	60	60	126	0	1.5	60
		R	*7.5K	30K	∞	480K	480K	∞	1M	560	480K
V6	6X5	V	-	60	320AC	-	320AC	-	60	360	
		R	-		205	-	205	-		∞	
V7	6AU5	V	**	250	250	-	330	-	250	330	
		R	*10M	*0	*100	-	∞	-	*0	∞	
V8	12AT7	V	250	132	132	60	60	250	128	129	60
		R	*0	33K	30K	480K	480K	*0	40K	27K	480K
V9	6BK7A	V	250	84	115	60	60	250	116	118	0
		R	*0	3.5M	27K	480K	480K	*0	36K	8K	0

* These Resistances Measured To +250 Buss.

** High Impedance.

Figure 9 - Model 310 AB - TABLE OF VOLTAGE AND RESISTANCES MEASUREMENTS.

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