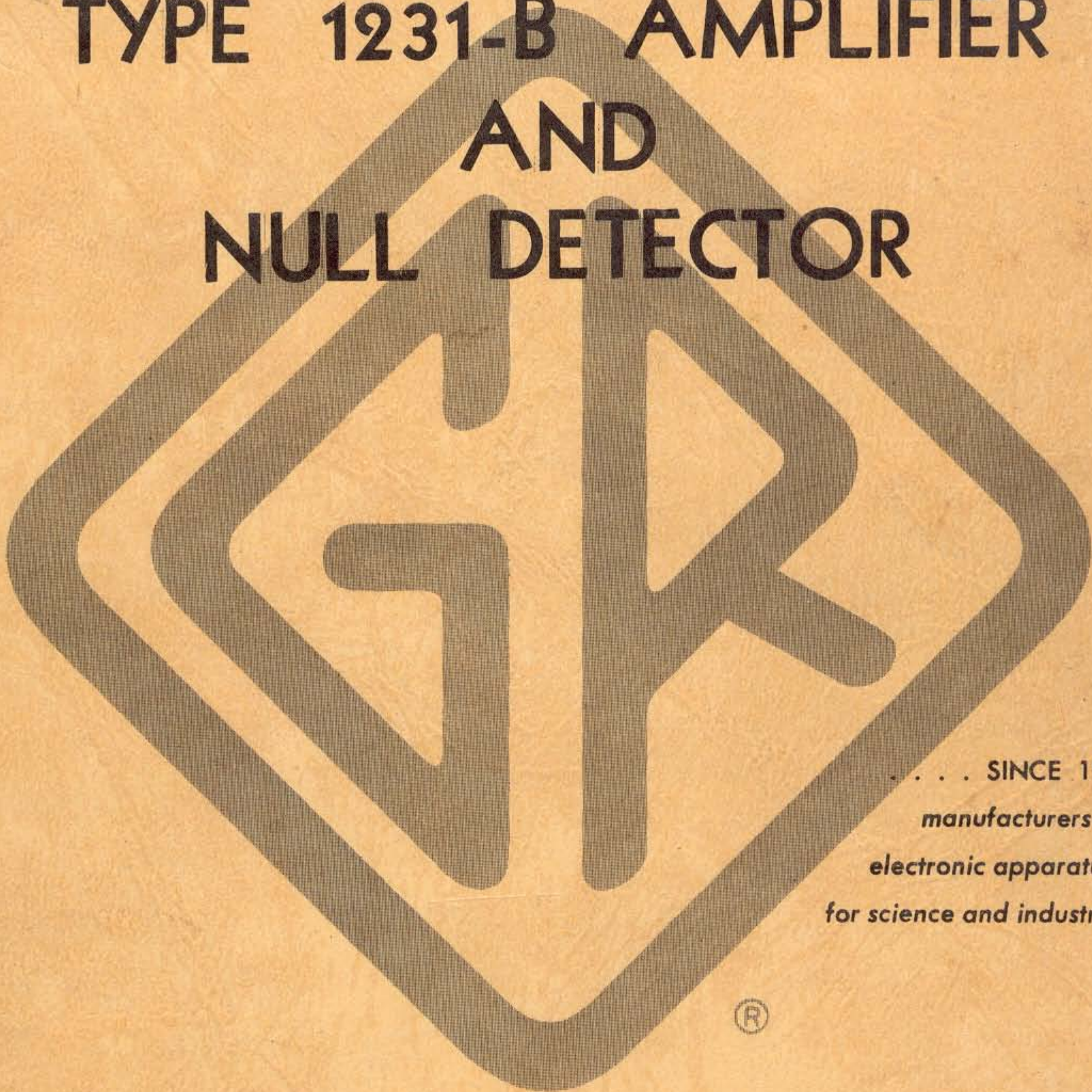


OPERATING INSTRUCTIONS

**TYPE 1231-B AMPLIFIER
AND
NULL DETECTOR**



... SINCE 1915
*manufacturers of
electronic apparatus
for science and industry*

G E N E R A L R A D I O C O M P A N Y
CAMBRIDGE 39, MASSACHUSETTS, USA

OPERATING INSTRUCTIONS

**TYPE 1231-B AMPLIFIER
AND
NULL DETECTOR**

Form 634-G
October, 1958

GENERAL RADIO COMPANY

CAMBRIDGE 39



MASSACHUSETTS

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SPECIFICATIONS

TYPE 1231-B AMPLIFIER AND NULL DETECTOR

Input Impedance: 1 megohm in parallel with $20\mu\mu\text{f}$; alternate 10-megohm input available.

Maximum Gain: Greater than 83 db at 1 kc with 1-megohm load.

Meter Scales: NORM scale, calibrated in volts with accuracy of $\pm 5\%$ of full scale; SENS scale, calibrated in db with arbitrary zero. DB ratios accurate within 30% of correct value in db, if one reading is above half scale.

Null-Detector Sensitivity: Less than $25\mu\text{v}$ input gives 1% indication on meter at 1 kc.

Amplifier Sensitivity: Less than $8\mu\text{v}$ input at 1 kc for 1% indication on SENS range of meter.

Output Impedance: Approximately 50,000 ohms.

Maximum Output Voltage: 5 volts into 20,000 ohms; 20 volts into one megohm.

Open-Circuit Noise and Hum Level: Less than 0.5 volt at full gain, battery operated; less than one volt, a-c operated with Type 1261-A Power Supply.

Battery Life: 200 to 250 hours at 8 hours a day.

Dimensions: Height, 8 in.; width, 12-1/4 in.; depth, 10-3/4 in.; over-all.

Weight: 23-3/4 pounds, including batteries, (cabinet model).

TYPES 1231-P2 AND -P3 TUNED CIRCUITS

Tuning Accuracy: $\pm 2\%$ at normal voltage levels.

Attenuation: At least 25 db to second harmonic.

Dimensions: Height, 4-1/8 in.; width, 3-9/16 in.; depth, 4 in.; over-all.

Weight: 3-7/8 pounds.

TYPE 1231-P4 ADJUSTABLE ATTENUATOR

Source Impedance: $30\text{ k}\Omega$, about equal to output impedance of crystal detector in slotted line.

Load Impedance: At least 1 megohm.

Insertion Loss: 3 db.

Attenuation Range: 80 db, readable to nearest tenth db.

Attenuation Accuracy: ± 0.3 db when operated between rated source and load impedances. Additional errors caused by source between $14\text{ k}\Omega$ and $60\text{ k}\Omega$ are less than ± 0.3 db.

Frequency Error: Negligible below 2 kc.

Maximum Input Power: 1/2 watt.

Terminals: Input, Type 938-W Binding Posts; output, shielded cable with Type 274-ND shielded plug to fit Type 1231-B input terminals.

Accessories Required: One Type 874-R32A Patch Cord for connections between slotted line and attenuator.

Dimensions: Height, 4-1/2 in.; width, 5-1/2 in.; depth, 5-1/2 in.; over-all.

Weight: 2 pounds, 11 ounces.



Figure 1. Type 1231-B Amplifier and Null Detector.

SPECIFICATIONS (CONT)

TYPE 1231-P5 ADJUSTABLE FILTER

Frequency Calibration: 50, 100, 200, 500 cps, 1, 2, 5, 10, 20, 50, 100 kc. $\pm 2\%$ at minimum voltages.

Insertion Gain: -7 to +15 db, depending upon frequency. Second-harmonic rejection: 28 to 46 db.

Terminals: Shielded cord and plug for connection to Type 1231-B jack-top terminals for external capacitors.

Accessories Available: Type 219 Decade Capacitors for tuning filter between frequencies provided.

Dimensions: Front Panel: height, 7 in.; width, 6-1/8 in. .

Cabinet: depth, 9-3/4 in.

Internal shield box: height, 6-1/4 in.; width, 4-1/2 in.; depth, 9 in.

Weight: 9 pounds, 12 ounces.

TYPE 1231-B AMPLIFIER AND NULL DETECTOR

Section 1 INTRODUCTION

1.1 PURPOSE. The Type 1231-B Amplifier and Null Detector (Figure 1) is designed for use as a high-gain amplifier, as a sensitive null indicator for bridge measurements, and as a standing-wave indicator for measurements with the Type 874-LBA Slotted Line. Used with a suitable crystal detector, it will indicate amplitude-modulated high-frequency voltages, and is also useful as a preamplifier for crystal microphones, vibration pickups, and oscilloscopes.

1.2 DESCRIPTION.

1.2.1 GENERAL. The Type 1231-B Amplifier and Null Detector is available in cabinet and relay-rack models, operated by either a battery (Burgess 6TA60, Army Signal Corps BA48) or an a-c power supply (Type 1261-A Power Supply). Type numbers used to designate the various models are indicated below:

- 1231-BM Cabinet model, battery operated
- 1231-BMA Cabinet model, a-c operated
- 1231-BR Relay-rack model, battery operated
- 1231-BRA Relay-rack model, a-c operated
- 1231-BRF Relay-rack model, battery operated with Type 1231-P5 Filter
- 1231-BRFA Relay-rack model, a-c operated with Type 1231-P5 Filter

1.2.2 CONTROLS. The following controls are on the panel of the Type 1231-B Amplifier and Null Detector:

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Name	Type	Function
GAIN	Continuous rotary control	Varies gain of amplifier or sensitivity of null detector.
ZERO COINCIDENCE	Cap-covered screw-driver adjustment	Makes the zero of the SENS meter range coincide with the zeros of the NORM meter ranges and the null detector.
ZERO SET	Continuous rotary control	Sets electrical zero at meter zero.
AMPL METER	Push buttons (2)	Provide choice of range for linear amplifier operation: NORM range for monitoring output during amplifier operation, SENS range for input voltages too low for NORM range or NULL DETECTOR.
NULL DETECTOR	Push button	Causes output stage to function as a logarithmic amplifier for null-detector operation.
BATT CHECK	Push buttons (2)	Check condition of the plate and filament batteries.
OFF	Push button	Turns off battery power supply.
INPUT	Push buttons (2)	<0.03 v - sets approximate maximum no-load gain at 85 decibels with maximum input voltage of less than 0.03 volt. <1 v - sets approximate maximum no-load gain at 55 decibels with maximum input voltage of less than 1 volt.
1MΩ - 10MΩ	Toggle switch	Selects input impedance of the amplifier.

1.2.3 CONNECTIONS. The following connections are on the panel of the Type 1231-B Amplifier and Null Detector:

Name	Type	Function
INPUT	Jack-top binding posts (2)	Input terminals.
FILTER	Telephone jack	Provides for connecting a filter to the output stage of the instrument.
OUTPUT	Jack-top binding posts (2)	Output terminals.

TYPE 1231-B AMPLIFIER AND NULL DETECTOR

1.2.4 ACCESSORIES. The following table lists accessories supplied with the various models of the Type 1231-B Amplifier and Null Detector:

Type	Accessories Supplied
1231-BM	Cabinet
1231-BMA	Cabinet, Type 1261-A Power Supply
1231-BR	Type 1231-P7 Connecting Panel
1231-BRA	Type 1261-A Power Supply, Type 1231-P7 Connecting Panel
1231-BRF	Type 1231-P5R Filter
1231-BRFA	Type 1261-A Power Supply, Type 1231-P5 Filter, Type 1231-P6 Connecting Panel*

* for Type 1610-A Capacitance Measuring Assembly, use Type 1231-P6-2 Connecting Panel

Section 2

PRINCIPLES OF OPERATION

2.1 GENERAL. The simplified circuit diagram (Figure 7) shows that the amplifier has three stages and a built-in vacuum-tube voltmeter, which consists of a diode rectifier, a d-c amplifier, and the panel meter.

2.2 LINEAR AMPLIFIER. During linear-amplifier operation, there is a choice of maximum no-load gain of 55 or 85 decibels, as selected by the input attenuator buttons at < 1 volt or < 0.03 volt respectively. A tapered wire-wound gain control allows continuous variation of the gain over a wide range.

2.3 SEMILOGARITHMIC NULL DETECTOR. During semilogarithmic null-detector operation, rectified dc from the vacuum-tube voltmeter diode is applied as gain-controlling bias to the last amplifier stage to produce the desired characteristics. An attenuator in the grid circuit allows meter current to be zero with no signal at the instrument terminals.

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2.4 USE WITH TYPE 874-LBA SLOTTED LINE. The Type 1231-B Amplifier can be used with the Type 1231-P2 Tuned Circuit and the Type 1231-P4 Attenuator as a standing-wave indicator for the Type 874-LBA Slotted Line. Since the amplifier should be tuned to the frequency of the oscillator, choose a filter that selects the modulating frequency used (refer to Section 5). With the amplifier gain set at maximum and the attenuator set at 30 db, full-scale deflection on the amplifier meter extends to r-f inputs with 50-percent modulation. For most accurate results, the ratio of the inputs obtained at a maximum and at a minimum on the line should be measured on the Type 1231-P4 Attenuator, rather than on the meter scale. To determine this ratio, measure the difference in attenuation required to produce the same meter reading for a voltage minimum as for a voltage maximum. If the crystal is operating in the square-law region, the actual decibel difference in r-f voltage is half the decibel difference measured by the attenuator or meter.

2.5 FREQUENCY RESPONSE. The maximum open-circuit voltage gain is over 70 decibels at 10 cycles, over 45 decibels at 100 kilocycles, and greater than 83 decibels at midband. The frequency characteristic is shown in Figure 2.

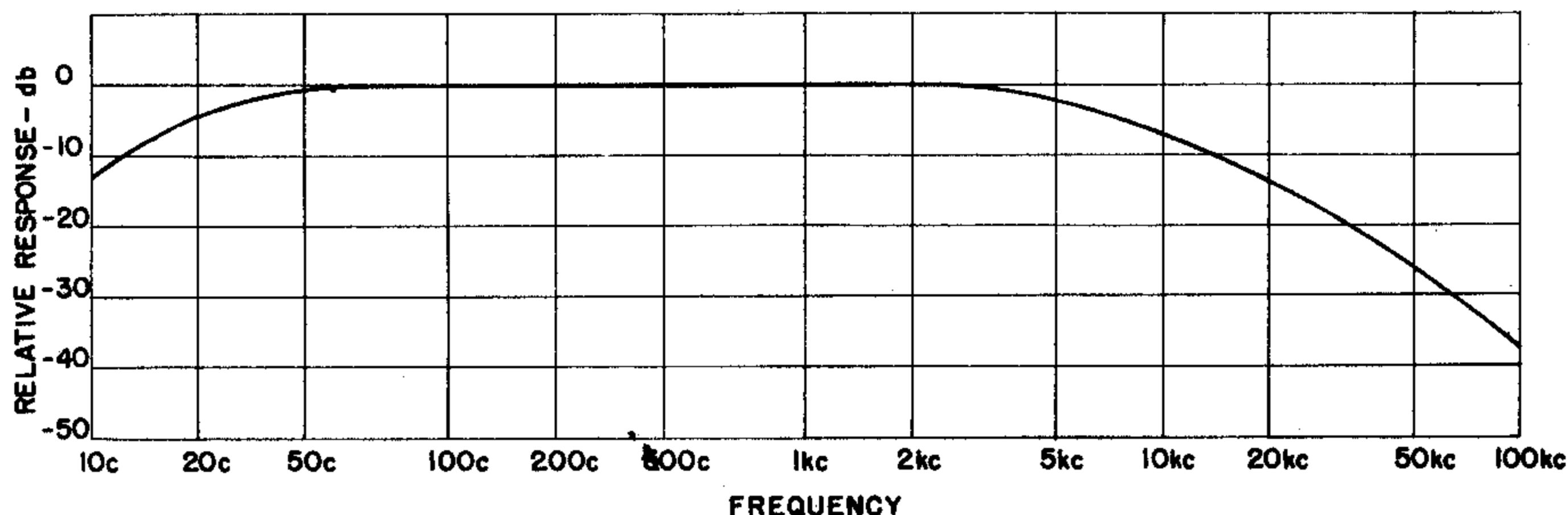


Figure 2. Frequency Response Curve.

Section 3 INSTALLATION

3.1 BATTERY. Battery-operated models are shipped with the battery in place. To install or replace battery (Burgess 6TA60, Army Signal Corps BA48, or equivalent), first remove the instrument from the cabinet (refer to Section 6.2). Install the battery on the hangers at the rear of the chassis and plug the battery cable into the socket.

3.2 A-C POWER SUPPLY. For a-c operation the Type 1261-A Power Supply is provided in place of the battery. The 115-volt socket is installed above the hole in the base of the cabinet, where the line cord is

TYPE 1231-B AMPLIFIER AND NULL DETECTOR

inserted. The panel switch of the instrument must be left ON and the switch in the line cord used to turn the power supply ON and OFF. With both the panel switch and line cord switch ON, measure the filament voltage by pushing the FIL button. Note the meter reading. Push the button on top of the power supply and again note the meter reading. Turn the screw-driver adjustment on top of the power supply until both meter readings are equal. To keep the hum level low, do not ground the case of the power supply to the instrument shield.

3.3 RELAY-RACK MODEL. The Type 1231-P7 Connecting Panel is installed to fit the standard 19-in. relay-rack. When the Type 1231-P5 Adjustable Filter is included, the Type 1231-P6 Connecting Panel is used. (See Figure 3.)

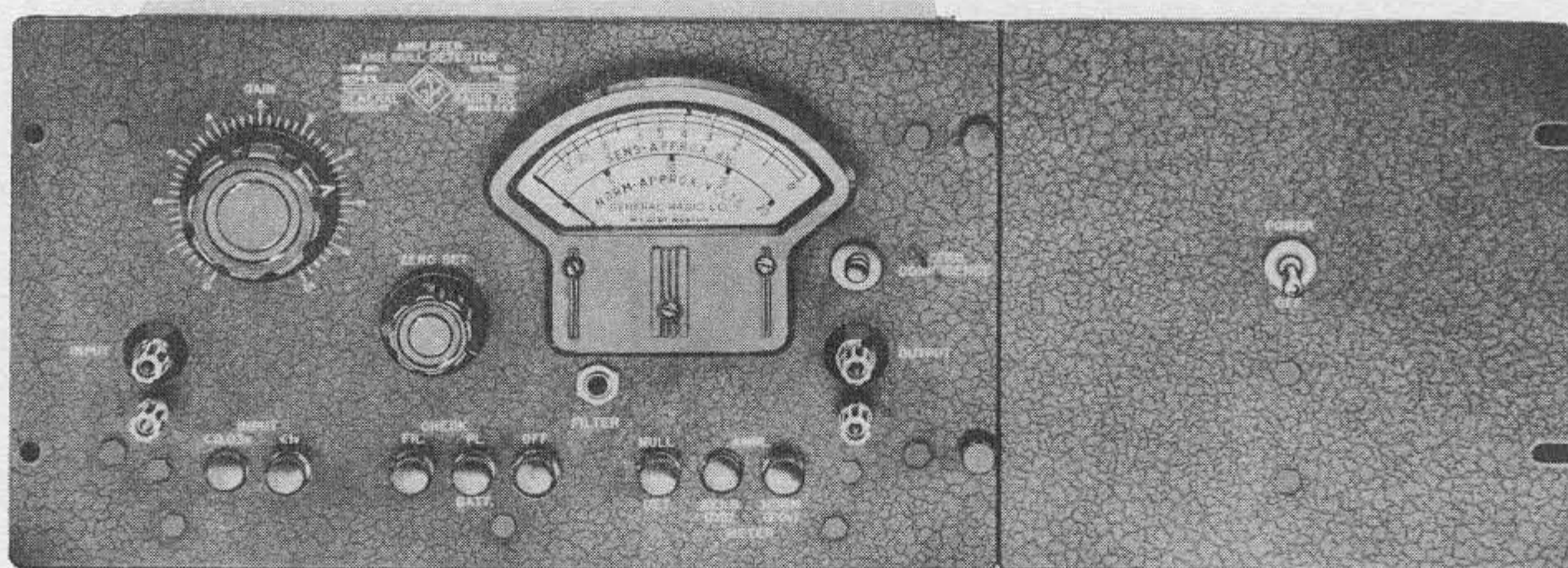


Figure 3a. Type 1231-P7 Connecting Panel.

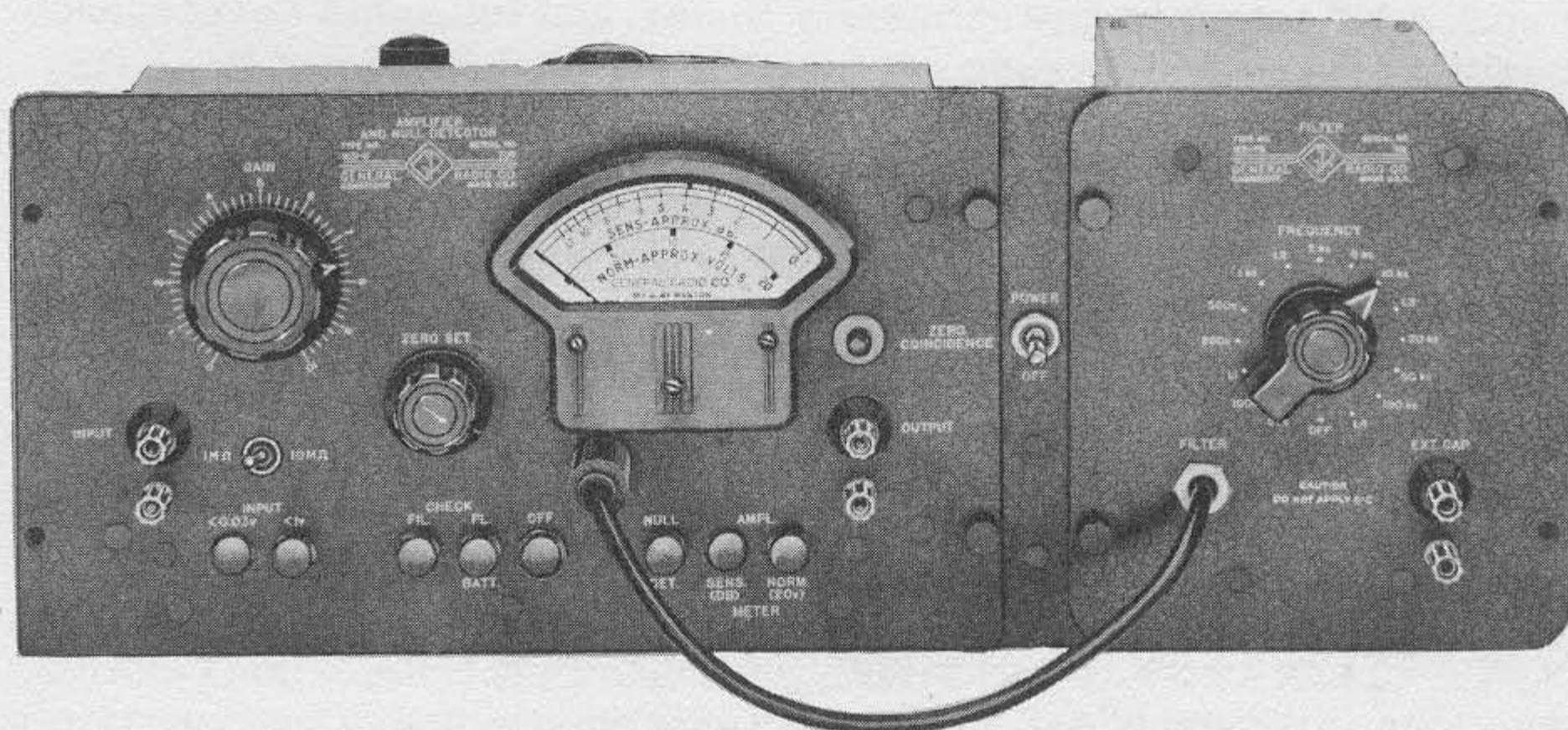


Figure 3b. Type 1231-P6 Connecting Panel and Type 1231-P5 Filter.

Section 4

OPERATING PROCEDURE

4.1 GENERAL. The following procedure should be followed when the Type 1231-B is first set up.

a. Turn the power on by pushing either the NULL DET button or one of the AMPL METER buttons.

b. Zero the meter by turning the ZERO SET knob with the INPUT terminals short-circuited. If the zero of the SENS range does not coincide with the zero of the NORM and NULL DET ranges, remove the ZERO COINCIDENCE cap and set the screw-driver adjustment until there is no change in meter indication as the meter is switched between the SENS and NORM ranges.

c. To check the battery, push the BATT CHECK PL and FIL buttons, and note the meter indications. If the indication with either button pushed is below the BATT mark on the meter, replace the battery.

d. Select the input impedance by means of the $1\text{ M}\Omega$ - $10\text{ M}\Omega$ switch.

4.2 USE AS AN AMPLIFIER. For ordinary use, operate with the NORM button pushed; then meter deflection is approximately linear, and full scale corresponds to 20 volts. When the input voltage is too low to give satisfactory meter indications, operate with the SENS button pushed. The meter deflection is approximately linear, and full scale corresponds to 2 volts.

4.3 USE AS A NULL DETECTOR. When using the Type 1231-B as a null detector first remove all load from the OUTPUT terminals. Then select maximum no-load gain by means of the INPUT attenuator buttons. With the $< 1\text{ v}$ button pushed, maximum no-load gain is 55 db. With the $< 0.03\text{ v}$ button pushed, maximum no-load gain is 85 db and the meter is more sensitive. Increasing the gain setting also increases sensitivity.

Use the NULL DET button for preliminary balances, the SENS button for final balance.

4.4 OPERATION AS STANDING-WAVE INDICATOR. (Refer to Operating Instructions for Type 874-LBA Slotted Line.)

4.4.1 FREQUENCY SELECTION. Tune the amplifier to the modulation frequency with an appropriate filter (refer to Section 5).

TYPE 1231-B AMPLIFIER AND NULL DETECTOR

4.4.2 TEST FOR ADEQUATE R-F INPUT FOR LOW VSWR MEASUREMENT ASSUMING 50% MODULATION.

- a. Find the voltage maximum on the line.
- b. Set the Type 1231-B for maximum sensitivity and set the Type 1231-P4 Attenuator for attenuation less than 30 db.
- c. Find the voltage minimum on the line.
- d. If the meter reading at the minimum is greater than one-fourth of full scale, the r-f input to the line is adequate. If the meter reading is less than one-fourth of full-scale, increase the r-f input or the probe coupling.

4.4.3 MEASURING STANDING-WAVE RATIO. For most accurate results, the ratio of the outputs obtained at a maximum and at a minimum on the line should be measured on the Type 1231-P4 Attenuator, rather than on the meter scale.

- a. At the voltage maximum, note the attenuation and the amplifier meter reading.
- b. At the voltage minimum, vary the attenuation of the Type 1231-P4 Attenuator until the amplifier meter reading is the same as that noted in step a.
- c. If the crystal is operating in the linear region, the difference in attenuation at these two points is the standing-wave ratio ($SWR = 20 \log_{10} \frac{E_{max}}{E_{min}}$) expressed in decibels.
- d. If the crystal is operating in the square-law region, the actual db difference in r-f voltage is half of the db difference measured.

Section 5 ACCESSORIES

5.1 TUNED CIRCUITS. Types 1231-P2 (400 and 1000 cycles) and -P3 (60 cycles) Tuned Circuits (Figure 4) can be used as interstage filters with the Type 1231-B for suppressing harmonics, noise, and hum in single-frequency measurements. A telephone plug on each filter plugs into a panel jack on the Type 1231-B Amplifier and Null Detector. Filters thus connected are isolated by amplifier stages from the effects of varying input and output impedances and at the same time are at a high

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Figure 4. Type 1231-P3 Tuned Circuit
(Identical in Appearance to Type 1231-P2).

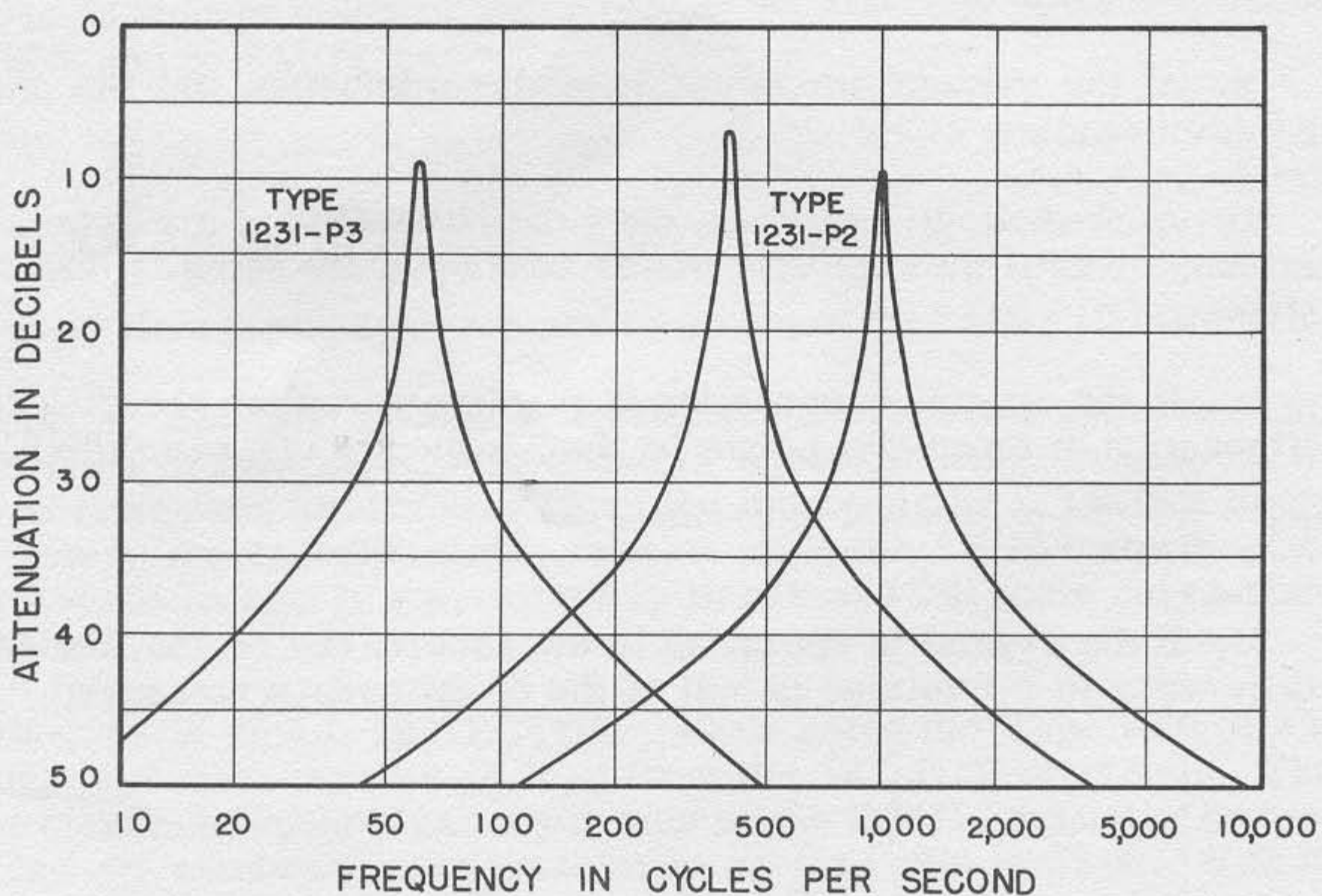


Figure 5. Attenuation Curve, Types 1231-P2
and -P3 Tuned Circuits.

enough voltage level along the amplifying chain to withstand effects of external fields. Figure 5 shows the attenuation vs frequency for the Types 1231-P2 and -P3 Tuned Circuits.

5.2 ADJUSTABLE ATTENUATOR. When used with the Type 1231-B amplifier and Null Detector and the Type 874-LBA Slotted Line to measure standing-wave ratio, the Type 1231-P4 (Figure 6) Adjustable Attenuator

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Figure 6. Type 1231-P4 Adjustable Attenuator.

increases both the range and accuracy of measurement over that obtainable with the amplifier alone. This high-impedance resistive voltage divider covers a range of 80 decibels, with three 20-db steps and a 20-db potentiometer.

5.3 ADJUSTABLE FILTER. The Type 1231-P5 Adjustable Filter (Figure 3) is a parallel-resonant, shielded filter for reducing harmonics and background noise in bridge measurements. Designed primarily to plug into the Type 1231-B Amplifier, the Type 1231-P5 Filter can be used as an antiresonant L-C element in the grid circuit of any Class-A amplifier where it is not subjected to direct current. The Adjustable Filter can be set to any one of 11 frequencies: 50, 100, 200, and 500 cycles, and 1, 2, 5, 10, 20, 50, and 100 kc. In order to obtain high selectivity with low insertion loss, four separate inductors are used:

- L1 (20 henrys) for 50 and 100 cycles, centricore;
- L2 (2 henrys) for 200 and 500 cycles, dust core;
- L3 (300 millihenrys) for 1, 2, and 5 kc, dust core;
- L4 (15 millihenrys) for 10, 20, 50, and 100 kc, dust core.

The selector switch has eleven frequency positions, four inductor positions, and an OFF position. Maximum accuracy of the indicated resonant frequencies will be attained only when the filter is used with the Type 1231-B Amplifier and Null Detector, and only when operating at vanishingly low levels in balancing bridges or other null circuits.

By the addition of external capacitance, this filter can also be tuned to any other frequency from 20 cycles to 100 kc. Both terminals of the

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filter are available on the front panel for attaching external capacitors. To choose the proper inductor for any operating frequency, take a compromise point of tolerable insertion loss and desirable discrimination against the second harmonic. Data for determining this point for any frequency are given in the graphs of Figure 7.

For convenience, the ranges of external capacitance needed to tune over the indicated ranges of frequency are given in the following table. In most cases these values could be obtained with the Type 1419-A Decade Capacitor. Resonance for any specific frequency is then indicated by a maximum of observed gain.

To Tune From	Down To	Set Switch At	And Add External Capacitance (μf)
50 c	20 c	50 c	0 to 2.66
100 c	50 c	100 c	0 to 0.381
200 c	100 c	200 c	0 to 0.951
500 c	200 c	500 c	0 to 0.266
1 kc	500 c	1 kc	0 to 0.238
2 kc	1 kc	2 kc	0 to 0.0634
5 kc	2 kc	5 kc	0 to 0.0177
10 kc	5 kc	10 kc	0 to 0.0507
20 kc	10 kc	20 kc	0 to 0.0127
50 kc	20 kc	50 kc	0 to 0.00354
100 kc	50 kc	100 kc	0 to 0.00051

Typical low-level characteristics of the Type 1231-P5 Filter, when used with the Type 1231-B Amplifier and Null Detector, are given in Table 1.

TABLE 1.

Frequency	Inductor Used	Resonant Z $M\Omega$	Resonant Q	Insertion. db	Discrimination vs Second Harmonic db
50 c	L1	0.28	45	6.4 loss	33
100 c	L1	1.02	81	2.7 loss	31
200 c	L2	0.070	27.6	15.0 loss	30
500 c	L2	0.47	75	7.3 loss	32
1 kc	L3	0.26	138	7.8 loss	42
2 kc	L3	0.86	228	3.0 loss	40
5 kc	L3	2.70	287	1.9 gain	34
10 kc	L4	0.17	175	3.8 loss	46
20 kc	L4	0.50	262	2.2 gain	44
50 kc	L4	1.06	214	5.6 gain	37
100 kc	L4	2.13	192	7.4 gain	28

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Figure 7a.
Insertion Loss,
Type 1231-P5 Filter.

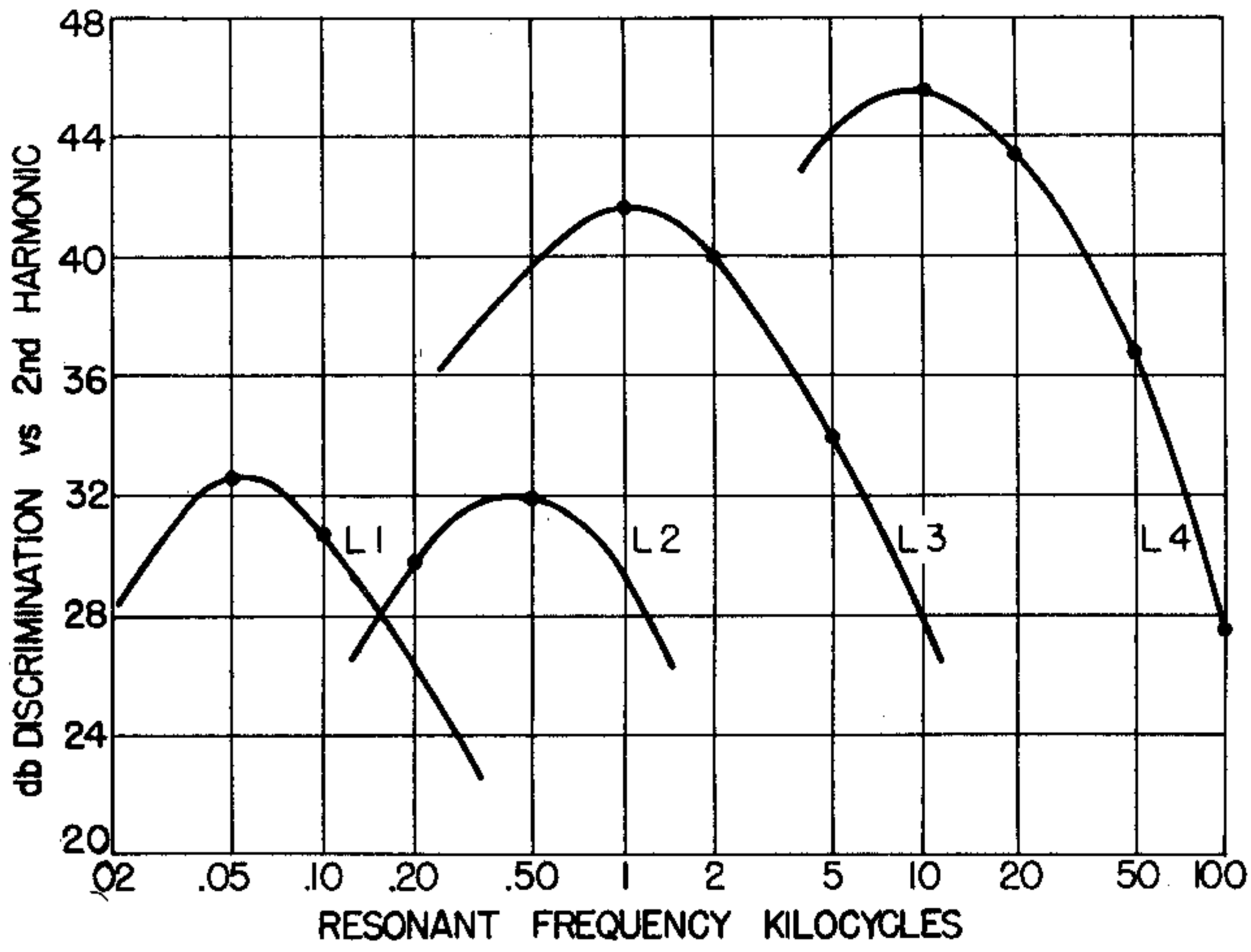
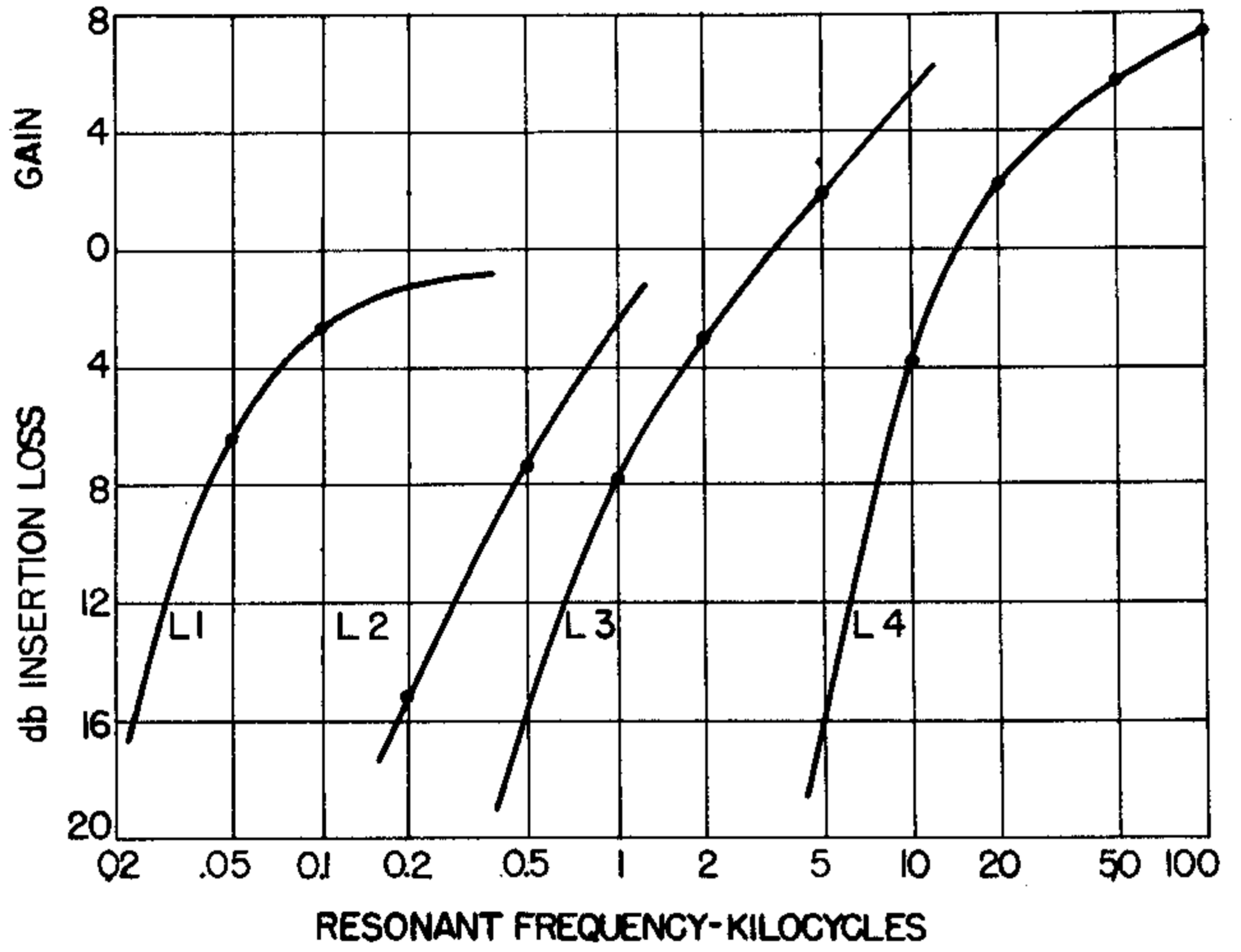


Figure 7b.
Second Harmonic
Discrimination,
Type 1231-P5 Filter.

Section 6

SERVICE AND MAINTENANCE

6.1 GENERAL. This service information, together with the information given in the foregoing sections, should enable the user to locate and correct ordinary difficulties resulting from normal use. Major service problems should be referred to our Service Department, which will cooperate as much as possible by furnishing information and instructions as well as by supplying parts needed.

When notifying our Service Department of any difficulties in operation or service of the instrument, always mention the serial number and type number. Also include in correspondence a complete report of trouble encountered, with specific reference to the numbered paragraphs in the Operating Instructions pertaining to the trouble as well as any information concerning the use of the instrument and steps taken to eliminate the trouble.

Before returning an instrument or parts for repair, please write to our Service Department, requesting a Returned Material Tag, which includes shipping instructions. Use of this tag will insure proper handling and identification when an instrument or parts are returned for repair. A purchase order covering material returned for repair should also be forwarded to avoid any unnecessary delay.

6.2 CABINET REMOVAL. To remove the instrument from the cabinet, remove the black thumbscrew from each corner of the panel and slide the instrument out of the cabinet.

6.3 TUBE VOLTAGES AND RESISTANCE MEASUREMENTS. Table 2 gives the normal d-c voltages and d-c resistances from various tube-socket pins to ground. A deviation of 10 percent from any of these values is not necessarily abnormal.

6.4 ZERO COINCIDENCE. If either the battery, the Type 1D8GT tube (V3), or the Type 1N56-A diode is replaced, or as the battery ages, the ZERO COINCIDENCE control should be readjusted to make the electrical zero of the AMPL METER SENS range coincide with the zeros of the NORM and NULL DET ranges. The ZERO COINCIDENCE control is a screw-driver adjustment accessible through a hole in the front panel behind a snap button cover. With the instrument INPUT terminals short-circuited or with the GAIN control turned to zero, adjust the ZERO COINCIDENCE potentiometer until there is no change in meter indication as the instrument is switched between the SENS and NORM ranges.

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TABLE 2.

Tube (Type)	Pin	Volts to Ground	Res to Ground*
V1 (1L4)	1	0	0
	2	27	200 k
	3	24	400 k
	6	0	30 k
	7	1.4	2.5 Ω
V2 (1L4)	1	0	0
	2	29	720 k
	3	13	2.5 M
	6	0	0
	7	1.4	2.5 Ω
V3 (1D8GT)	2	1.4	2.5 Ω
	3	28	100 k
	4	40	85 k
	5	-4.5	bias cell battery
	6	87	50 k
	7	-0.2	0
	top cap		4.7 M
<p>Remove bottom plate to obtain access to tube terminals. Voltage measurements made with vacuum-tube voltmeter. Panel controls and switch settings: GAIN = 0; INPUT = <1 v, 1M; AMPL METER = NORM (20 v).</p> <p>*Resistance measured with battery disconnected.</p>			

6.5 METER SENSITIVITY. R19 is a factory-adjusted control, which normally does not require readjustment. If its setting has been disturbed it may be reset as follows:

a. Push the AMPL METER NORM button. Turn the GAIN control to zero and adjust the ZERO SET control for zero reading on the NORM meter scale.

b. Reset the GAIN control to maximum (10). Apply a 1-kc signal to the INPUT of the amplifier and increase the input voltage to give exactly 20 volts at the amplifier OUTPUT terminals, measured with a vacuum-tube voltmeter.

c. Adjust potentiometer R19 (mounted above ZERO COINCIDENCE potentiometer) until the amplifier meter reads exactly full scale for a 20-volt reading on the voltmeter.

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Section 7
PARTS LIST

	DESCRIPTION					PART NO. (NOTE A)		DESCRIPTION					PART NO. (NOTE A)
RESISTORS (NOTE B)	R1	1	M	± 1%	1/2 w	REF-2	R25	2700	±10%	1/2 w	REC-20BF		
	R1A	10	M	± 1%	1 w	REF-2-2	R26	68 k	±10%	1/2 w	REC-20BF		
	R2	30	k	± 1%	1/2 w	REF-2	R27	47 M	±10%	1/2 w	REC-20BF		
	R2A	300	k	± 1%	1/2 w	REF-2-2	CAPACITORS (NOTE C)	C1	0.05	±10%	600 dcwv	COM-50B	
	R3	270	k	±10%	1/2 w	REC-20BF		C2	0.2		200 dcwv	Part of	
	R4	56	k	±10%	1/2 w	REC-20BF		C3	2		200 dcwv		COWB-6
	R5	100	k	± 1%	1 w	REF-2		C4	0.25	±10%	600 dcwv	COL-43	
	R6	100	k			976-400		C5	0.2		200 dcwv	Part of	
	R7	2.2	M	±10%	1/2 w	REC-20BF		C6	1.0		200 dcwv		COWB-6
	R8	100	k	±10%	1/2 w	REC-20BF		C7	0.05	±10%	600 dcwv	COM-50B	
	R9	560	k	±10%	1/2 w	REC-20BF		C8	0.05	±10%	600 dcwv	COM-50B	
	R10	100	k	±10%	1/2 w	REC-20BF		C9	0.5	±10%	600 dcwv	COL-44	
	R11	180	k	±10%	1/2 w	REC-20BF		C10	0.01	±10%	600 dcwv	COM-45B	
	R12	2.2	M	±10%	1/2 w	REC-20BF		C11	0.02	±10%	600 dcwv	COM-50B	
	R13	2.2	M	±10%	1/2 w	REC-20BF		C12	0.8		300 dcwv	COW-4	
	R14	20	M	± 5%	1/2 w	REC-20BF		C13	2		200 dcwv	Part of	
	R15	47	M	±10%	1/2 w	REC-20BF		C14	500µf	±10%	300 dcwv		COWB-6
	R16	4.7	M	±10%	1/2 w	REC-20BF	MISC	B1	BATTERY, 1-1/2 v			2BAC-4	
	R17	50	k			POSC-11		D1	DIODE			1N56-A	
	R18	1.5	M	±10%	1/2 w	REC-20BF		M1	METER, 200µa			MEDS-36	
	R19	50	k			POSC-11		PL1	PLUG			CDMP-1344	
	R20	9.1	k	± 1%	1 w	REF-2		S1	SWITCH			SWPM-14	
	R21	680	k	±10%	1 w	REF-2		S2	SWITCH, dpdt			SWT-355,NP	
	R22	5	k			973-410							
R23	1500		±10%	1/2 w	REC-20BF								
R24	4700		±10%	1/2 w	REC-20BF								

NOTES

(A) Type designations for resistors and capacitors are as follows:

COL - Capacitor, oil
 COM - Capacitor, mica
 COW - Capacitor, wax
 COWB- Capacitor, wax, block

POSC- Potentiometer, composition
 REC - Resistor, composition
 REF - Resistor, film

(B) All resistances are in ohms unless otherwise indicated by k (kilohms) or M (megohms).

(C) All capacitances are in microfarads, unless otherwise indicated by µf (micromicrofarads).

TYPE 1231-B AMPLIFIER AND NULL DETECTOR

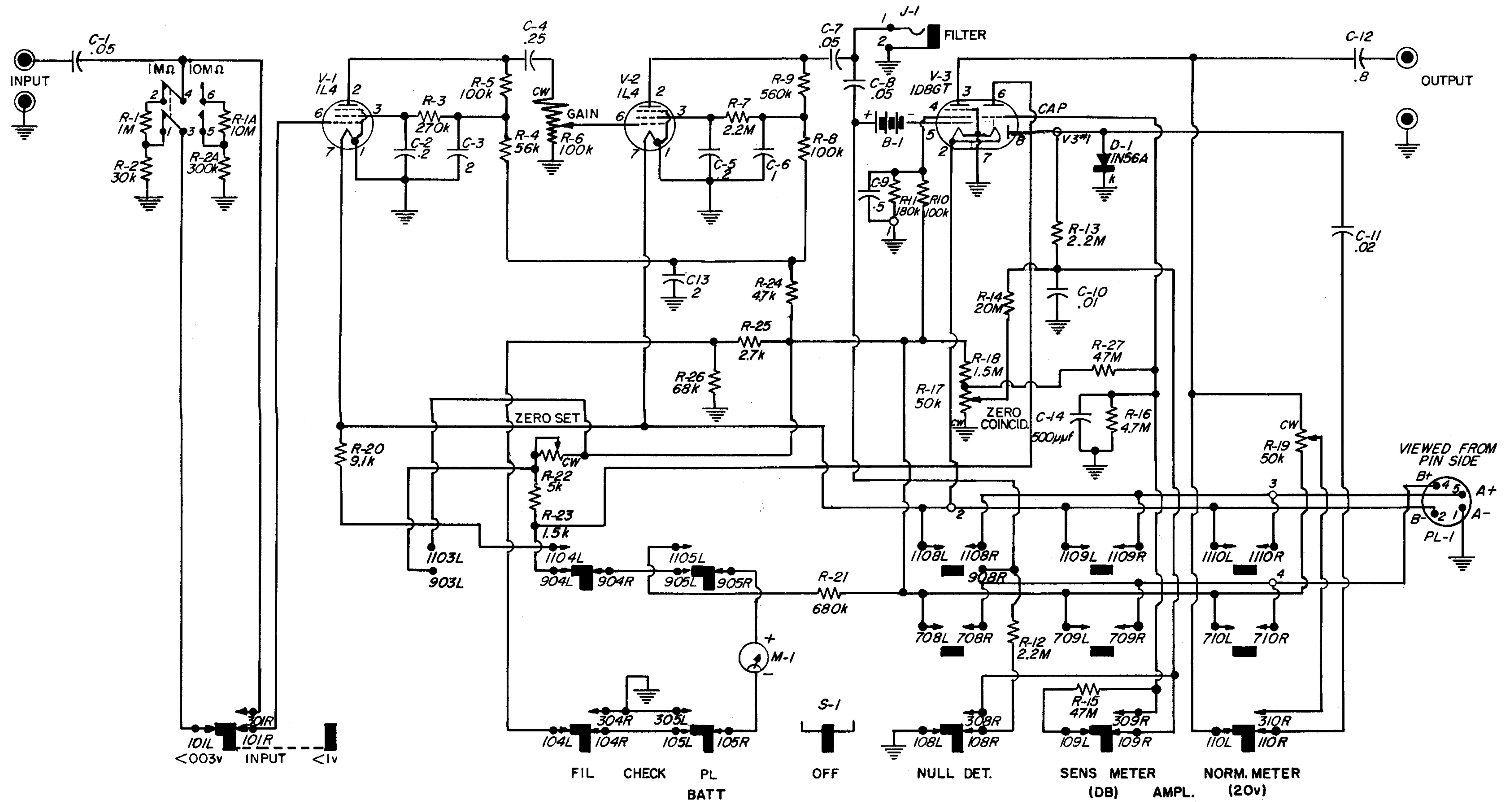


Figure 8. Schematic Diagram.

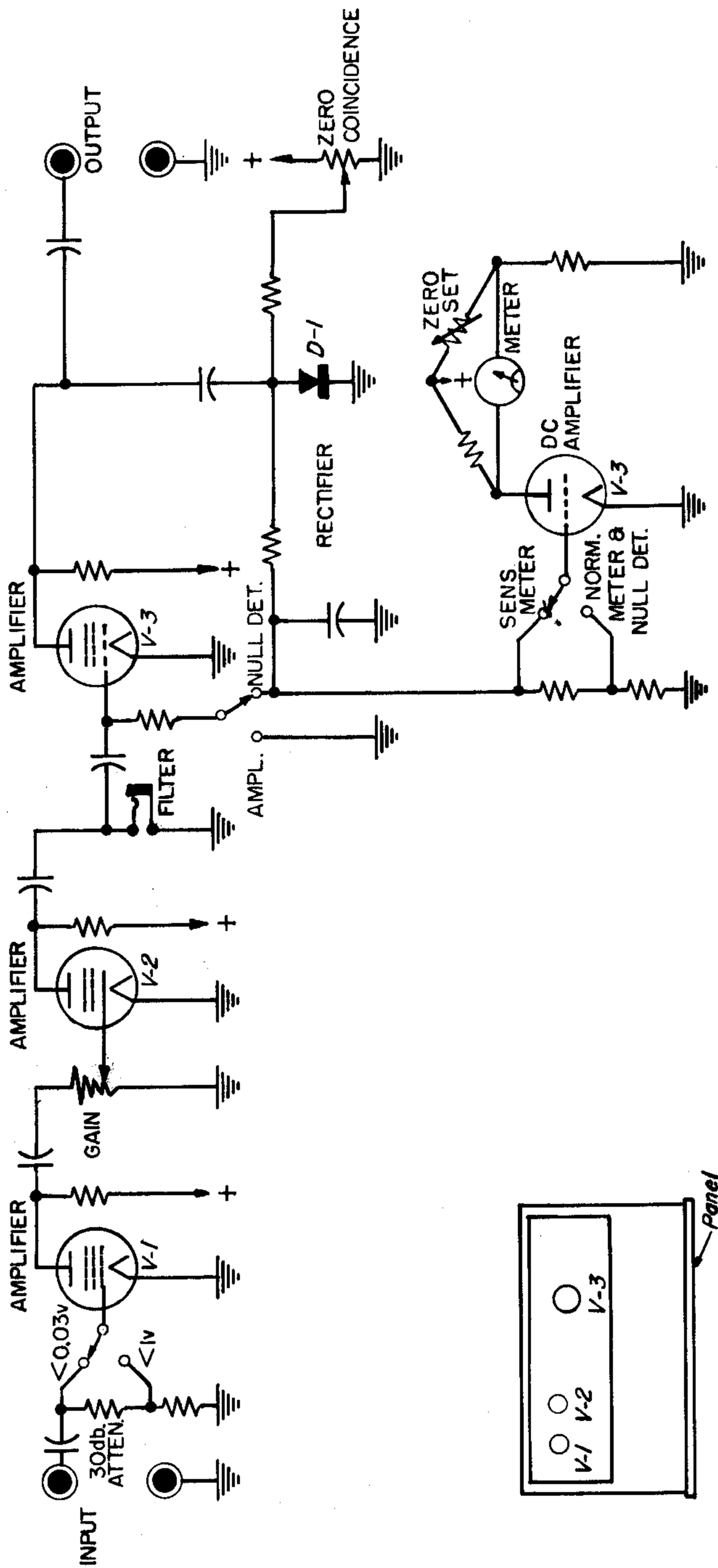


Figure 9. Elementary Schematic Diagram
(Includes Tube Layout).

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