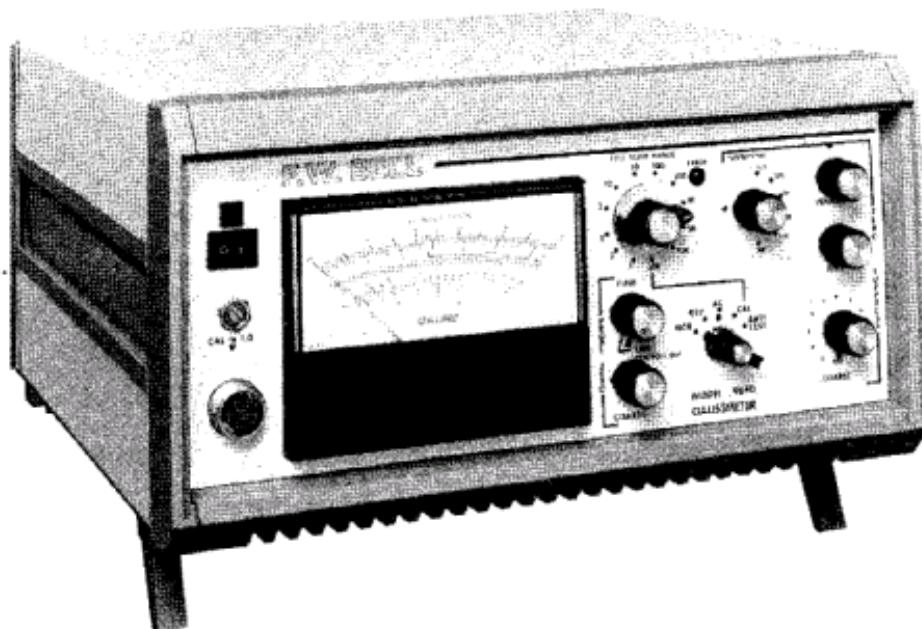


MODEL
9640

9000
SERIES
GAUSSMETERS



MODEL 9640 GAUSSMETER
Operation and Maintenance Manual

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International Electrical Symbols

(Insert in front of page 1 of the 9640 manual)



Caution! Refer to this manual before using the meter.



Caution! Risk of electric shock.

SAFETY INSTRUCTIONS: (Inserted in front of page 1 of the 9640 manual behind the International Electrical Symbols sheet)



GENERAL:

For safe and correct use of this gaussmeter it is necessary that both operating and servicing personnel follow generally accepted safety procedures plus the safety cautions and warnings specified.

If it is determined that safety protection has been impaired, the gaussmeter must be made inoperative and be secured against any unintended operation. For example, safety may be impaired if the gaussmeter fails to perform or shows visible damage.



WARNING:

The opening of covers or removal of parts might expose live parts and accessible terminals which can be dangerous.



WARNING:

Any interruption of protective earth conductors or disconnection of the protective earth terminals inside or outside of the gaussmeter can create a dangerous condition.



WARNING:

The hall probe is a non-contact measuring device. The probe is not to contact a surface which exceeds a voltage of 30V r.m.s. (42.4V peak) or 60V d.c.



CAUTION:

For continued protection replace the fuse with the same type (5 X 20mm, slow blow, 125mA at 250V for 230 volt operation or 250mA at 250V for 115 volt operation).

EMC APPLICATION NOTE: (add to Section II-B, note (7) External Battery)

External battery or power supply connection requires some of the following special considerations:

- Use a shielded cable 0.5m (1.6ft) or less.
- Place a ferrite bead around the cable as close to the gaussmeter battery jacks as possible. Use a ferrite bead such as Steward part number 28A2025-0A0A or equivalent. The Steward part is a type 43 ferrite block 18.3mm high X 17.8mm wide X 32.5mm long with a 7.1mm diameter hole centered through the length of the block.
- If an external power supply is used, select one that conforms to the European standards.



All input and output voltages, except line (mains) are less than 20volts.

INSTRUMENT PREPARATION: (place behind Safety Instructions)

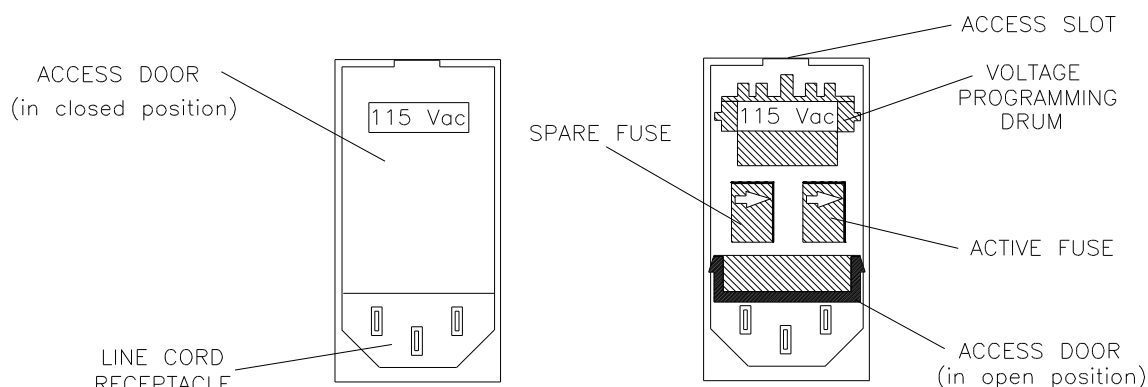
AC POWER CONNECTION



W A R N I N G ! FOLLOW THESE INSTRUCTIONS OR DAMAGE MAY RESULT !!!

Figure 1.0 depicts the rear-panel power module containing the line cord receptacle, line fuse and the voltage programming drum. You can select operation from either 115 or 230 Vac service. The selected voltage will appear through the window in the module. **If this does not match your service do the following:**

- 1) Turn the power switch to the OFF (o) position and remove the line cord.
- 2) Insert a narrow flat screwdriver behind the access slot and gently pry open the access door. Flip the door down.
- 3) Grasp the voltage programming drum and pull it straight out of the module.
- 4) Rotate the drum to show the correct voltage, then insert the drum into the module.
- 5) Reverse the position of the fuses.
- 6) Close the access door and insert the line cord.



**FIGURE 1.0
POWER RECEPTACLE MODULE**

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9640CE SPECIFICATIONS (replaces Section II-A of the 9640 manual)

Measurement Ranges:	0.1 to 30 kG Full Scale in 10db steps 1.0 to 300 kG Full Scale 1mG to 2 G	(1X probes) (10X probes) (X100 probes)
DC Field Suppression Range:	0 to 30 kG may be suppressed to zero 0 to 300 kG may be suppressed to zero 0 to 2 G may be suppressed to zero	(1X probes) (10X probes) (X100 probes)
Suppression Scale Expansion:	1 to 1000 times in a 1, 3 sequence	
Accuracy: DC accuracy at output connector	Internal Calibration Reference ----- Linearity and Offset Errors: -----	+/- 0.3 % of reading +/- 0.25% of full scale +/- 0.02 Gauss (1X Probes) +/- 0.2 Gauss (10X Probes) +/- 0.2 mG (X100 Probes)
EMC: In an RF field of 3V/M <i>DC accuracy at output connector</i>	<i>Internal Calibration Reference -----</i> <i>Linearity and Offset Errors: -----</i>	<i>+/- 0.3 % of reading</i> <i>+/- 0.25% of full scale</i> <i>+/- 0.2 Gauss (1X Probes)</i> <i>+/- 2.0 Gauss (10X Probes)</i> <i>+/- 2.0 mG (X100 Probes)</i>
AC measurements at output connector	0 - 60 Hz , dc accuracy plus ----- 61Hz - 400 Hz, dc accuracy plus -----	+/- 1% of reading +/- 10% of reading
DC incremental measurements	Depending on probe type and field magnitude	+/- 1% to +/-3% of incremental range
DC measurements at analog meter	dc output accuracy plus -----	+/- 1% of full scale
AC measurements at analog meter	10Hz to 400 Hz, ac output accuracy plus ----	+/- 2% of full scale
Probe	-----	(see probe specifications)
Stability: Output error with line voltage change	(line voltage +/- 10%) -----	error unmeasurable
Temperature effects (instrument only)	+/- 3% of reading over the temperature range	(0 °C to 50 °C)

Output connector, rear panel

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Output voltage	1.0 volts Full Scale	
Source impedance	1 k ohm (approximately)	
Frequency Response	dc to 400 Hz	
Response Time	0.4 mS (approximately)	0 to full scale step
RMS noise	< 100mV (- 20dB below full scale) typical	0.1 gauss range
	< 20mV (- 35dB below full scale) typical	0.3 gauss range
	< 6mV (- 45dB below full scale) typical	1 G to 30 kG range

Auxiliary Output connector, rear panel

Output voltage	1.0 to 5.0 volts full scale (adjustable)	
Source impedance	< 1 ohm (current limited at 5.0mA)	
Frequency Response	dc to 400 Hz	
RMS noise	< 100mV to 500mV (- 20dB below F.S.) typical	0.1 gauss range
	< 20mV to 100mV (- 35dB below F.S.) typical	0.3 gauss range
	< 6mV to 30mV (- 45dB below F.S.) typical	1 G to 30 kG range

Power Requirements

Line voltage/ frequency	115 +/- 10% or 230 +/- 10%	50 to 60 Hz
Line current / fuse rating	250 mA or 125 mA	
Fuse voltage rating	250 volts	
Fuse blow rate	T (Slow)	
Fuse size	5 X 20mm	

External battery or supply

Voltage	9Vdc to 18Vdc
Current	160 mAdc, nominal

Internal Battery

Voltage	12Vdc
Battery life	60 hours (typical)
Manufacturer / number	Eveready 732 (NEDA No. 926)

Weight:

Net	14 lbs (6.4 kg)
Shipping	21 lbs (9.5 kg)

Size (approximate):

13.5" Wide x 7.0" High x 14.2" Deep
(34.2 cm W x 17.7 cm H x 36.1 cm D)

Temperature Range

Operating	0°C to 50°C
Storage	-20°C to 70°C

Humidity Range

0°C to 35°C	80% RH Max
35°C to 50°C	50% RH Max

Altitude Range

6562 ft (2000m)

SIMPLIFIED OPERATING INSTRUCTIONS FOR THE MODEL- 9640 GAUSSMETER

- 1) Check the rear panel power receptacle to insure that the voltage showing is the voltage you will be using, 115 volts ac or 230 volts ac. If it is necessary to change this setting, refer to Section II-B for further information.
- 2) Connect the Model 9640 Gaussmeter to the appropriate power source. Connect the probe to the Model 9640. Turn the instrument on and allow 5 minutes for warm-up.
- 3) To calibrate the Model 9640 Gaussmeter using its internal calibration feature, turn the coarse ZERO SUPPRESS switch to the OFF position and set the FUNCTION switch to CAL. The RANGE switch must be in 30 kG position. Adjust the CAL screwdriver adjustment to obtain a full-scale (1.0) meter reading or a 1.0 volt dc reading on any external readout instrument connected to the output BNC connector.
- 4) The probe is zeroed using the COARSE and FINE adjustments on the instrument. Set both controls to about mid-setting. Rotate the RANGE switch counterclockwise and adjust the COARSE control to bring the reading near zero while reducing the RANGE setting. On the 0.1 gauss range the FINE control may be used for better resolution of the zero adjustment. See Section IV-B2 for details on the effects of the Earth's magnetic field and other residual fields on the zero adjustment.
- 5) The Model 9640 is ready to measure magnetic fields. For complete details on any of the above procedures, consult appropriate section of the manual.

SECTION I

I-A INTRODUCTION

MODEL 9640 GAUSSMETER DESCRIPTION

The MODEL 9640 gaussmeter is a precision magnetic flux measuring instrument, featuring high stability, solid-state construction. It has been designed especially for use with 3rd generation Hall effect magnetic field probes manufactured by F.W. Bell Inc.

A wide range of standard transverse and axial, as well as special probes, are available. All probes are directly interchangeable without recalibration. Factory calibration of probes is carried out with reference to a laboratory standard magnet. This standard is measured by the Nuclear Magnetic Resonance (NMR) technique and provides traceability to the natural physical standard. The user can then set this calibration into the instrument by the use of the simplified high accuracy built-in CAL procedure.

Measurement range extends from 1 mG (milligauss) per scale division (100 mG full scale) to 30 kG (kilogauss) full scale. Both dc and ac fields can be measured directly using the 4 1/2 inch panel meter. DC polarity is preserved for direction information when tracing and plotting fields. AC fields of up to 400 Hz appear as an rms value for sine wave fields.

Zero suppression and scale expansion controls permit incremental measurements. Any dc field reading of 30 kG or less may be suppressed to zero and sensitivity increased to a maximum of 1000 times, thus providing full scale output for 0.1% changes in field.

A BNC connector is provided on the rear panel. Output voltage is 1 volt full scale and is proportional to the field for dc and ac fields up to 400 Hz. An auxiliary output amplifier is also included providing increased output voltage and power, via rear panel BNC connectors, to drive external equipment. To obtain high accuracy measurements, a high resolution indicating instrument such as a digital voltmeter can be connected to the BNC connectors. The internal calibration procedure may also be carried out using this indicating instrument to achieve the best possible accuracy.

Because of automatic change-over to battery operation, the Model 9640 is ideal for fixed installations where constant, noninterrupted service is required in the event of power line failure, as well as applications requiring portability.

Simplicity of operation, wide measurement range and high accuracy make the Model 9640 a versatile instrument for measurement in the laboratory or in the field, as well as for production testing and process control.

SECTION II

SPECIFICATIONS

II-A ELECTRICAL AND PERFORMANCE SPECIFICATIONS

(1) MEASUREMENT RANGES

Measurement of static (dc) or varying (ac to 400 Hz) magnetic field strength in the range of 0.1 gauss full scale to 30,000 gauss full scale in 10 dB steps as follows:

1X probes	0.1, 0.3, 1.0, 3.0, 10, 30, 100, 300, 1 kG, 3 kG, 10 kG, 30 kG
10X probes	1.0, 3.0, 10, 30, 100, 300, 1 kG, 3 kG, 10 kG, 30 kG, 100 kG, 300 kG

(2) CALIBRATION

(a) Internal calibrating procedure is referenced to a standard NMR magnet traceable to the natural physical standard and to probe deviation curves, in accordance with MIL-STD-793-1 (WP) Appendix A.

(b) Internal calibration error does not exceed $\pm 0.3\%$.

(3) ZERO SUPPRESSION RANGE AND SCALE EXPANSION

Any dc field up to 30 kG may be suppressed to zero. The sensitivity may then be increased by means of the range switch to a maximum of 1000 times (6 switch positions).

(4) AVAILABLE STANDARD PROBES

One hundred different Hall effect field probes are available to meet the challenging requirements of virtually any application. Please see the Model 9640 Gaussmeter Probes literature sheet for probe models and prices. Consult the factory for special probe requirements.

(5) ACCURACY

(a) Accuracy is the sum of accuracies of the instrument, the probe and the calibration source. The instrument accuracy is $\pm 0.25\%$ of full scale plus ± 0.02 gauss, and the internal calibration accuracy is $\pm 0.3\%$ of reading. For example, the Model 9640 Gaussmeter used with the Model HTB4-0608 probe, calibrated with the internal calibration output; the total accuracy is $\pm 0.25\%$ of full scale, plus ± 0.02 gauss (instrument), plus $\pm 0.3\%$ of reading (internal calibration), plus $\pm 1.0\%$ of reading (probe) for a total system accuracy of $\pm 0.25\%$ of full scale, plus $\pm 1.3\%$ of reading, plus ± 0.02 gauss. The ± 0.02 gauss is an instrument error. When the 10X probe is used the specification then becomes ± 0.2 gauss.

(b) For Incremental Measurements: $\pm 1\%$ to $\pm 3\%$ of incremental range depending on probe type and absolute field magnitude.

(c) For ac fields: 0 to 60 Hz; dc field accuracy plus $\pm 1\%$ of reading 60 to 400 Hz; dc field accuracy plus $\pm 10\%$ of reading.

(d) Meter Scale Tracking Error: For dc field meter readout; $\pm 1\%$ of full scale. For ac field meter readout 10 to 400 Hz; $\pm 2\%$ of full scale.

(e) Improved accuracy obtainable by using probe deviation curves and, at specific test points, by reference to a known calibration field.

SECTION II continued Specifications for the Model 9640 Gaussmeter

(6) STABILITY

- (a) Line Voltage: Error unmeasurable for $\pm 10\%$ line voltage changes.
- (b) Temperature effects excluding probe influences: Approx $\pm 3\%$ of reading total over the range of -0° C to $+70^\circ \text{ C}$ (can be removed by using internal calibration feature).
- (c) Temperature effects and zero temperature stability will be determined by the type probe being used. Consult the Model 9640 Gaussmeter Probes literature sheet for complete specifications of the probe being used.

(7) BNC CONNECTOR REAR PANEL

- (a) Output voltage: 1.0 volts dc FS
- (b) Source impedance: 1 k Ω approx.
- (c) Maximum ac field frequency: 400 Hz
- (d) Response time for full scale step input: 0.4 msec approx.
- (e) RMS Noise:
 - 0.1 gauss range 20 dB below full scale approx.
 - 0.3 gauss range 35 dB below full scale approx.
 - 1 G to 30 kG range 45 dB below full scale approx.

(8) AUXILIARY BNC CONNECTOR

- (a) Output voltage: 1.0 to 5.0 volts dc FS adjustable
- (b) Source impedance: $< 1 \Omega$
(current limited above 5 mA)
- (c) Maximum ac field frequency: 400 Hz
- (d) Response time for full scale step input: 0.4 msec approx.
- (e) RMS Noise:
 - 0.1 gauss range 20 dB below full scale approx.
 - 0.3 gauss range 35 dB below full scale approx.
 - 1 G to 30 kG range 45 dB below full scale approx.

(9) POWER REQUIREMENTS

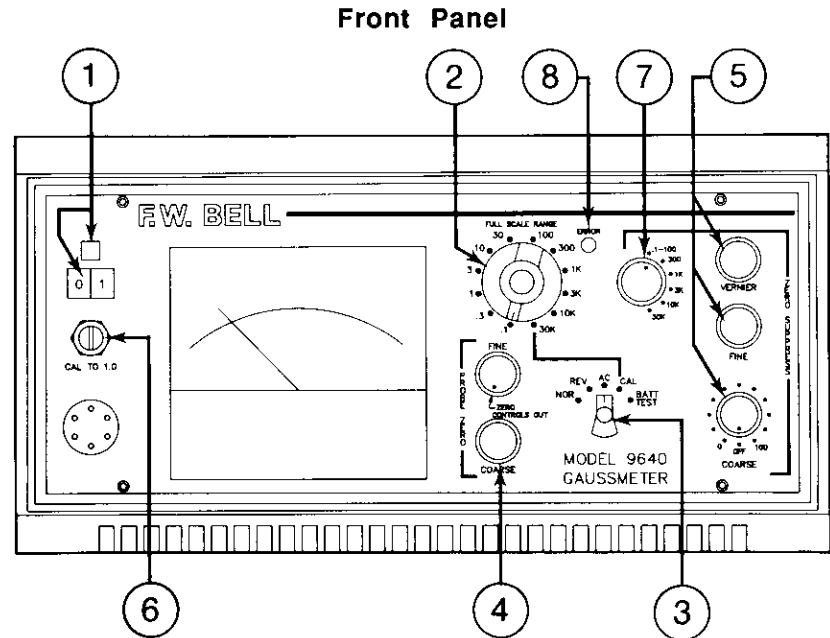
- (a) Line input:

Volts.....	90-125 V	or	180-250 V
Frequency.....	50-60 Hz		50-60 Hz
Current.....	0.038 A		0.019 A
Power.....	4 W		4 W

- (b) Internal battery: 12 V dry battery, Eveready 732; (NEDA No. 926)
automatic take over in case of failure in line voltage (approx. 60 hrs. life with continuous use).

SECTION II continued Specifications for the Model 9640 Gaussmeter

II-B PHYSICAL SPECIFICATIONS, CONTROLS AND CONNECTORS



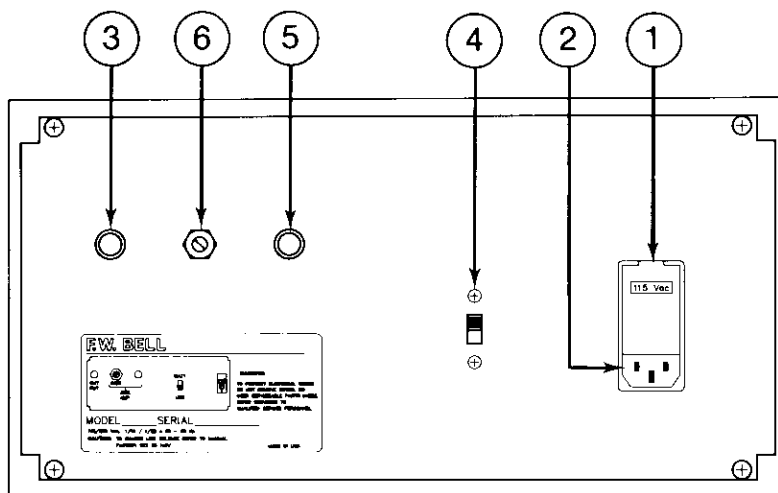
**Figure II-A
Front Panel**

- | | |
|------------------------------|--|
| (1) Power Switch/Pilot Light | The rocker switch turns on the primary power to the instrument. The pilot light indicates when the instrument is operating on line voltage only, no indication of battery operation is provided. See cautionary note in Section II-B2d. |
| (2) Range Switch | The full scale range is set by this switch in 10 dB steps marked in the 1, 3, 10 sequence. It covers the range from 0.1 gauss to 30 k gauss, the full range of the instrument. |
| (3) Function Switch | This switch selects the mode of operation. It includes the measurement positions for dc fields of both normal and reverse polarities, and for ac fields, the calibration position for internal CAL, and a battery test position to check the internal battery condition or external dc input voltage. |
| (4) Probe Zero Controls | COARSE and FINE zeroing controls are provided to balance each individual probe for zero output in the absence of a magnetic field. They will also suppress small residual fields up to approximately 30 gauss. By turning the FINE control full counter-clockwise past the switch, the zero controls can be disconnected, permitting the instrument to be used with special probes having their own zero controls. |

SECTION II continued Specifications for the Model 9640 Gaussmeter

- | | |
|-------------------------------|--|
| (5) Zero Suppression Controls | Three controls COARSE, FINE and VERNIER are used to suppress the field reading. When the COARSE control is switched from its off position, the meter circuit generates true zero center operation for simplified positive and negative deviation measurements. |
| (6) CAL FS Control | The screwdriver CAL control is used to calibrate the instrument using the internal calibration feature as well as calibration to a standard magnet. Calibration through external indicating instruments is also possible with connection to the BNC connector. |
| (7) Suppression Range Switch | This switch is used to select the incremental scale expansion ranges. |
| (8) Error Light | This light illuminates whenever the incremental expansion ranges are exceeded. |

Rear Panel



**Figure II-B
Rear Panel**

- (1) Power Receptacle/
Fuse Holder/
Line Voltage Switch

This is a multi-purpose receptacle that accepts an international instrumentation power line cord. The middle (ground) contact is connected to the chassis. This receptacle also contains the line fuse, storage space for a spare fuse and a line voltage selector.

**WARNING! See Next Note before
applying power to the gaussmeter or
damage may result!!**

SECTION II continued Specifications for the Model 9640 Gaussmeter

(2) Power Receptacle

READ THIS CAREFULLY!

The MODEL-9640 gaussmeter has been factory-configured to operate on a line voltage of 115 Vac. If operation at 230 Vac is required, perform the following steps or *damage may result*:

a) See figure II-C. This is the line power cord receptacle designed to accept an international instrumentation line cord. This assembly also contains the line fuse and voltage selector. Remove the line cord.

b) Near the top of the assembly is a slot. Insert a narrow screwdriver and *gently* release the access door (the door will not open unless the line cord is removed). The door will swing down.

c) Remove the voltage selector drum (marked "115 VAC") by pulling straight out.

d) Remove both fuse holders (marked with a "→") by pulling straight out. The left-hand holder is used to hold a spare fuse. The right-hand fuse holder is the actual in-circuit fuse. The gaussmeter is shipped with a 230 Vac /32 mA fuse in the spare location, and a 115 Vac /63 mA fuse in the active location. Reverse the positions of the holders and reinstall, making sure that the "→" points to the right.

e) Rotate the voltage selector drum to read "230 VAC" and reinstall.

f) Close access door. The "230 VAC" legend should be visible through the access door window. Reinstall the line cord.

ACCESS SLOT

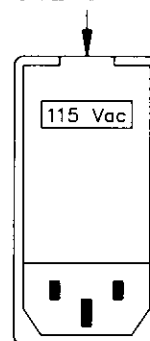


Figure II-C
Rear Panel Power Receptacle

SECTION II continued Specifications for the Model 9640 Gaussmeter

(3) BNC Connector	The standard BNC connector provides an output voltage proportional to the full-scale field, for use with external instrumentation. The polarity is positive for upscale meter readings and negative for downscale indications. The outer shell is grounded to the chassis.
(4) Battery Line Switch	This switch selects the input power used by the instrument. In the line position the Model 9640 will operate on the line power only (115 or 230 V). In the BATT. position, the instrument will operate on internal battery by means of the automatic takeover feature if line power is not supplied. NOTE: WHEN THE SWITCH IS IN THE BATT. POSITION THE INSTRUMENT MUST BE TURNED OFF USING THE POWER SWITCH. Merely pulling the plug or turning off the power source to the line cord will only cause the instrument to switch over to its internal battery thus shortening the battery life. It is, therefore, suggested that the BATT-LINE switch be left in the LINE position, unless battery power or the automatic takeover feature is desired.
(5) Auxiliary BNC Connector	The standard BNC connector provides the output from the auxiliary dc amplifier. The output voltage is adjustable from 1 volt to 5 volts for full scale meter reading. The output impedance is $<1\Omega$ and will drive up to 5 mA output current before limiting occurs for short circuit protection. The auxiliary amplifier operates only when the instrument is supplied with line power. No output will be obtained when the instrument is operated from the battery.
(6) Gain	The auxiliary amplifier gain is adjusted by the GAIN control to obtain the 1 to 5 volt output for full scale.
(7) Overall Dimension	7.53 in (19.1 cm) high 13.47 in (34.2 cm) wide 14.21 in (36.1 cm) deep
(8) Weight	Shipping 21 lbs (9.5 kg) Net 14 lbs (6.4 kg)

SECTION III

INSTALLATION AND PRE-OPERATION ADJUSTMENTS

III-A POWER

To install the battery, remove the rear left and right plastic bumpers, by removing the 2 screws in each bumper. Now slide the top panel toward the rear of the unit and remove. Take off the battery mounting clamp strip near the power transformer on the top of the sub chassis with its terminal socket facing the power transformer, and slide the battery can lip under the clamp strip near the range switch. Replace the removed strip, clamping the battery lip to the chassis. Connect the lug attached to red wire to the positive battery terminal, the lug on the white wire to the negative terminal, and replace the top panel and rear bumpers. The battery used is a 12 volt dry battery NEDA No.926 - Eveready 732.

To operate the Model 9640 Gaussmeter as a portable unit, disconnect the power cord from the power source and the unit for convenience, and place switch in BATT position. (The pilot lamp will not operate *except* on line power.)

(1) POWER REQUIREMENTS

The Model 9640 can be operated from one of two types of power: standard ac line voltage (115 V or 230 V, 50-60 Hz, 4 watts) or internal battery (dry battery 12 volt, NEDA No. 926 - Eveready 732). The BATT-LINE switch selects either line power only in line position, or automatic battery takeover in the BATT position. In BATT position the instrument automatically selects the power source on the basis of the following criteria. Power is always drawn from the line when connected to a 115 V (or 230 V) ac source. If the line power is not supplied, the instrument will operate from the internal battery. If the 115 V line fails, the Model 9640 would switch over to the internal battery.

Because of the automatic change over, it is important that the instrument always be turned off by the power switch when the BATT-LINE switch is in the BATT position. Pulling the plug or turning off the power source will only cause switching over to battery power. Also the auxiliary amplifier will not operate from the battery or external dc input.

(2) OPERATION

Before turning the instrument on, make certain the power to be used matches the voltage and frequency ratings of the gaussmeter. Battery condition can be checked prior to turning on by using the BATTERY TEST position of the FUNCTION switch.

When the FUNCTION switch is set at BATT TEST the meter is connected to the battery and dc input circuitry. The meter monitors the internal battery. With the instrument operating, the meter must indicate within the range marked BATT. If the indication is over or under the range, then the voltage is either too high or too low for proper operations. The battery condition can also be checked prior to instrument turn on to monitor the effects of the instrument load on the source.

Connect a probe to the input socket. It is important that the plug is pushed firmly into the panel socket observing the key slot, then the clamp ring screwed on until it is snug. Check the meter mechanical zero by aligning the pointer with its image in the mirror. If necessary adjust the screw on the meter face to exactly zero reading. Set the panel control as follows:

RANGE switch to 30 K
FUNCTION switch to NOR

SECTION III continued Installation and Pre-Operation Instructions

COARSE ZERO SUPPRESSION switch to OFF
SUPPRESSION RANGE switch to .1-100 G

Turn the power switch on and allow a few minutes warm up before making any measurements or calibrating.

III-B PROBE ZEROING ADJUSTMENTS

To reduce the residual probe output to zero, the probe zero controls are used. Set the FINE control to about mid setting. Rotate the RANGE switch counterclockwise until a reading is obtained on the meter. Adjust the ten-turn COARSE control to bring the reading near zero while reducing the RANGE setting. Below the 1 gauss range, the FINE control may also be used for better resolution of zero adjustment. Make sure the COARSE ZERO SUPPRESSION switch is OFF when zeroing the instrument.

Because the Earth's magnetic field is well within the measurement capabilities of the gaussmeter, the effects of this and residual fields from other sources on zeroing must be considered, especially when measurements are made on the higher sensitivity ranges (100 G and below). Check Section IV-B2 for details on types of zeroing.

III-C CALIBRATION PROCEDURE

(1) GENERAL

The calibration procedure should be carried out before using the instrument for magnetic field measurements. It should also be checked whenever probes are changed. Allow sufficient time for warm up stability before calibrating.

Calibration consists of adjusting the element control current in accordance with the sensitivity of the probe and gain of the amplifier by using one of the following two methods.

(2) CALIBRATION AGAINST INTERNAL CAL SIGNAL

Calibration against the internal CAL signal is a simple, easy to apply technique which will, in most cases, produce the best possible accuracy. Calibration against a reference magnet can produce better accuracy only if the reference magnet is better than $\pm 0.3\%$ and the probe linearity curve is known.

The accuracy and stability of the internal calibration signal is dependent only on precision, high stability resistors and the initial factory calibration. Therefore, long-term, high stability is a characteristic of this technique. It is recommended that, unless a very high accuracy reference magnet and probe linearity data are available, the internal calibration be used.

After the instrument and the probe have warmed up (5 min.) set the RANGE switch to the 30 K range and the FUNCTION switch to CAL. Adjust the CAL screwdriver adjustment to obtain a full-scale (1.0) meter reading [or a full-scale reading (1-V range) on any external readout instrument connected to the BNC connector]. The gaussmeter and probe are then calibrated to the accuracy shown in the specifications under Section II-A4. Because the adjustment is the same for all probes, it is not necessary to recalibrate each time the probe is changed.

SECTION III continued Installation and Pre-Operation Instructions

(3) CALIBRATION AGAINST A REFERENCE MAGNET

Greater accuracy can be achieved by the use of a reference magnet, provided the magnet has an accuracy of better than $\pm 0.3\%$ and the probe linearity data are known. Deviation error curves are available with most F.W. Bell Gaussmeter Probes at a nominal charge. Curves may be obtained at the time of purchase or after purchase by returning the probe to F.W. Bell.

The linearity curve is machine drawn using a precision electromagnet and is an error plot for the particular probe measured. It is a plot of the probe's deviation from the true value over the measurement range.

The curve is plotted with the actual flux density along the horizontal X-axis and the deviation from the true value, in gauss, vertically along the Y-axis. Thus, the locus of deviation errors of, for example, 1% of the actual field, will appear on the sheet as diagonal line passing through the 1% of value points.

To calibrate using the linearity curve and reference magnet, the following procedure should be used. It is important that the absolute zero procedure be carried out prior to calibration by this method (see Section IV-B2). The probe must be carefully positioned in the field to the correct location and orientation to respond to the correct field magnitude (maximum reading) without alignment errors. Set the RANGE switch to the proper range giving the maximum onscale meter reading (or external readout instrument reading). Add the reference magnet specified field, in gauss, to the deviation, in gauss, read from the linearity curve at that flux density. Adjust the CAL FS control to obtain a reading equal to the sum. For example, if the reference magnet were specified at 9.8 kG and the deviation from the curve was 10 G, then the adjustment would be made to obtain 9.79 kG on the meter (or external readout instrument if used).

(4) AC FIELD CALIBRATION

No separate ac field calibration is necessary. If the gaussmeter has been properly calibrated for dc fields, then the ac signal at the BNC connector for ac fields will be calibrated to the same accuracy, with the exception of the effects of the frequency response.

The frequency response is essentially flat to 60 Hz. From 60 to 400 Hz the response may vary up to about 10% or 1 dB. Above 400 Hz the response rolls off rapidly and the gaussmeter is unusable for measurements. The reduced accuracy for ac measurements indicated in the specifications is for the panel meter readout and is a result of the additional errors introduced by the ac detector circuit. These errors are not present in the signal at the BNC connector and therefore, higher accuracy ac measurements can be obtained through the use of high accuracy ac external readout instruments.

SECTION IV

IV-A THE PROBE

(1) GENERAL

The standard probes are divided into two basic categories depending on field direction response: Transverse and Axial. Figure IV-A shows a Transverse Probe and indicates the polarity. In addition, special probes of all types can be designed to meet unusual requirements. Contact F.W. Bell, Inc. for information and quotations.

Caution: Although the probes are quite rugged, reasonable care should be exercised in handling. Avoid excessive shock, pressure, bending or otherwise straining the element mount. The element can be fractured if overstressed since it is brittle as well as rigid. Since the device housing is a good conductor of heat it should be protected and prevented from touching very hot or cold objects.

Note: Probes are supplied for various flux measurement ranges. For accurate readings, make sure the probe being used is within its specified range of measurement. When 10 kG probes are used for measurement higher than 10 kG, increased deviation from linear response will result. Such measurements would not be accurate as absolute reading, but might be useful where only a relative indication is sufficient.

Requirements	Suggested Probe Configuration
general use; durable	HEAVY DUTY
measure flux density in awkward places	FLEXIBLE
measure flux density in a small gap	STANDARD DUTY (laboratory use)
measure homogeneous fields* from 0.001 G to 2 G; high sensitivity	MAGNAPROBE
high linearity; low temperature coefficient; accurate field measurement to 100 kG	10X PROBE**
multi-axis field measurement	2-AXIS PROBE; 3-AXIS PROBE
withstand low temperature (down to -269° C)	CRYOGENIC
monitor instantaneous difference between two field points; field mapping, homogeneity testing	DIFFERENTIAL

* averages flux along 9" probe length

** 10X probe sensitivity is one-tenth standard probe (1X) sensitivity

OPERATING INSTRUCTIONS

SECTION IV continued Operating Instructions

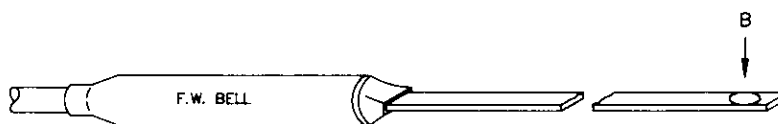


Figure IV-A
Probe Orientation Versus Readout Polarity

(2) PROBES

A transverse probe, as its name implies, has its flux response direction transverse to the probe handle axis. In Figure IV-A, notice that the flux vector is shown entering the Hall element at right angles (90°) to the plane of the element surface. This is the direction of the maximum Hall output. Magnetic fields entering the element at some other angle to the surface cause an output response proportional to the 90° component. That is, the response will be $B \cos \theta$ where B is the field magnitude and θ is the angle of the field to the perpendicular.

The axial probe has its flux response direction parallel and on axis with the probe handle. The element is encapsulated on the end of the probe extension tube. If the field is directed at some angle with respect to the probe axis, only the axial component will produce an output, just as the transverse component will only produce output for transverse probes.

IV-B MEASUREMENT PROCEDURE

(1) GENERAL

After completing the pre-operational adjustments described in Section III, the unit is ready for operation. Allow sufficient time after turn-on for the unit and probe to reach operating temperature (5 min.). It is advisable to position the probe securely in the measurement position using a probe-holding fixture or clamp whenever possible. It may be difficult or impossible to obtain a good field measurement unless the probe is stable. The probe may be hand-held only when operating on the higher ranges (100 G and above) and the field is fairly uniform over a reasonable area.

When using F.W. Bell probes, errors in readings due to temperature changes at the probe can be corrected by using the mean probe temperature coefficient and computing corrections (see Section IV-B5).

(2) ZEROING

Since the probes do not have exactly zero output in a zero field, it is necessary to electrically zero the gaussmeter before taking any readings. Two types of zeroing are possible: Absolute and Relative.

Absolute zero is required whenever it is desired to know the actual field at the probe. As its name implies, the controls are adjusted to give zero reading at zero field. Because of the ever-present Earth's field and possible stray fields from other sources, it is necessary to shield the probe to achieve zero field during the time of adjustment. The zero gauss chamber accessory available for the probe is a dual mu-metal can assembly which effectively shunts all external stray fields around the internal volume. By slipping this chamber over the probe end, a zero field condition is created at the element and the gaussmeter is adjusted for zero output by the procedure of Section III-B.

SECTION IV continued Operating Instructions

Use care not to place the zero gauss chamber in a strong magnetic field. Also it must not be allowed to come into direct contact with a magnet, since it may become slightly magnetized and will not provide a true zero. It can be demagnetized by slowly passing the chamber through the ac field of a demagnetizer coil carrying ac line current.

The zero chamber provides a "true" zero reference. Readings taken in the presence of the Earth's ambient field will generally have the Earth's field, or some component of it, included in the reading of the unknown field. Thus, it may be necessary to subtract the ambient field reading from the total to obtain the value of the unknown field. To avoid this subtraction, the method of relative zeroing may be used. In this case, the gaussmeter is zeroed after the probe has been placed in the measurement position, without using the zero gauss chamber. The ambient field is therefore zeroed out electrically in the gaussmeter. This method is successful only if the field to be measured can then be presented to the probe without changing the probe position with relation to the ambient field, and without altering the ambient field at the probe during measurement. The change in field at the probe will be measured by the gaussmeter as an absolute value, and the ambient field excluded from the reading. Since the probe position must remain fixed during measurement, this method is not always practical. The zero controls are capable of suppressing residual fields of up to about 30 G.

Since the ambient field seldom exceeds 1 G, the precautions mentioned above, apply only when measuring fields less than 500 or 1000 G. If a magnet has an iron structure which will modify the ambient field by its presence, it may be necessary to take several measurements in different orientations with respect to the Earth's field. Obtain the two extreme values and use the mean value between these as the correct value.

The zero adjustments should be checked frequently, if possible, during the course of a measurement particularly when using low ranges. If a change in temperature occurs at the probe, rezeroing may be necessary. Zero drift versus temperature is small and is not compensated. The zero controls are never used to shift the calibration of the gaussmeter.

(3) CALIBRATION CHECK

A calibration check can easily be made at any time during a series of measurements without disturbing the probe by using the internal calibration procedure. Refer to Section III-C2 on calibration.

(4) OPERATION

(a) DC Fields

For absolute dc field measurements set the FUNCTION switch to NOR, the ac ZERO SUPPRESSION switch to OFF, and the RANGE switch to a range higher than the expected field.

Note: It is recommended that the SUPPRESSION RANGE switch be placed in the .1 - 100 G position when suppression is not in use.

With a field at the probe the meter will read up scale if the direction aligns with the probe sensitivity direction as described in Section IV-A2. If the meter tends to read below zero, the field direction is reversed and the probe can be turned over or the FUNCTION switch can be reset to REV. Switch the RANGE switch to a range which gives the greatest on scale meter reading. To

SECTION IV continued Operating Instructions

read the magnitude of the field, adjust the probe for maximum reading. If a desired direction component of a field is to be measured, set the probe so the sensitive direction aligns with the desired component. The meter will then read the component.

The measured value is determined from the meter reading and RANGE switch setting. All absolute measurements are from the black meter scales. The RANGE switch indicates the full scale value, in gauss, of the meter reading. For example, if the RANGE switch is set on 10 kG and the meter reads 1.0 on the black 0-to-1 scale, then the field is 10 kG. If the meter reading were 0.5, the field would be 5,000 G. When the RANGE switch is on a 3 range (3 kG, 300 kG, etc.), the meter reading is taken from the lower black scale. A RANGE switch setting of 300 G and a meter reading of 2 on the lower scale would indicate 200 G.

(b) Incremental DC Fields

To measure a small deviation in a larger field, zero suppression and scale expansion are used. Obtain an absolute field measurement as described above. With the meter reading the field, set the SUPPRESSION RANGE switch to the same range position as the RANGE switch. Advance the COARSE suppression switch. Adjust the switch until a near zero meter reading is obtained on the RED zero center incremental scale. Adjusting the FINE ten-turn control and VERNIER control permit a precise zero reading. At this point the initial absolute field reading has been suppressed to zero and the meter circuit has switched to zero center operation. To expand the scale for incremental measurements the RANGE switch is used. Rotate the RANGE switch for more sensitivity.

The error light must not illuminate when scale expansion is applied. Trimming the FINE and VERNIER SUPPRESSION controls will achieve more accurate zero suppression.

To determine the incremental deviation in the absolute field, the RANGE switch, SUPPRESSION RANGE switch, and red meter scales are interpreted. The RANGE switch indicates the incremental range and the meter indicates the value. If the RANGE switch knob were on the 10 G range and the meter read +0.6 on the upper red scale the absolute field would have increased 6 G. If the switch were on the 30 G range and a reading of -2 was observed on the lower red scale, then the field had decreased by 20 G.

The maximum scale expansion permissible is limited to 1000 times the absolute range. Attempting to increase the expansion beyond 1000 times will cause the error light to illuminate.

(c) Operating Example

Deviations in an 8.5 kG field are to be measured by the following steps:

- (1) The absolute field is measured and produces a meter reading of 0.85 on the upper black scale when the RANGE switch and SUPPRESSION RANGE switch are set on 10 k range.
- (2) The COARSE ZERO SUPPRESS switch is advanced from OFF until the meter reads just above zero on the red incremental scale.
- (3) The FINE SUPPRESSION control is advanced until a better zero is obtained.

SECTION IV continued Operating Instructions

temperature is known relative to the temperature at which it is calibrated, correction for the temperature effects can be applied to the measurement readings.

To correct for temperature influence, the following formula can be used:

$$B_a = B_g \left(1 - (t_{pm} - t_{pc}) \frac{t_c}{100} \right)$$

where: B_a = the actual value of the field being measured (unknown)
 B_g = the value of the field as indicated by the gaussmeter
 t_{pm} = temperature of probe at time of field measurement in degrees C
 t_{pc} = temperature of probe at time of calibration in degrees C (25° C when using internal CAL method)
 t_c = temperature coefficient of probe in % per degree C

This formula will correct the gaussmeter reading (B_g) to give the actual field (B_a) for measurements under different temperature conditions. Notice that if the t_c is a negative number, the minus sign must be carried into the formula. Note also that the temperature effects are on the absolute field readout of the instrument. Therefore when operating incrementally the temperature effects are correspondingly increased. The temperature change which produces a 0.1% change in the absolute field measurement will produce a full scale deviation when 1000 times scale expansion is used. Care should be taken, when making high sensitivity incremental measurements, to minimize temperature changes at the probe.

IV-C OUTPUT BNC CONNECTOR

(1) OUTPUT BNC CONNECTOR

The output BNC connector provides the electrical output of the instrument. It provides the highest resolution, stability and accuracy capability of the Model 9640. The voltage available is 1 volt for full scale meter reading and is directly proportional to the instantaneous field at the probe, for frequencies from dc to 400 Hz. The source resistance is 1 k Ω and the BNC connector can be loaded with any desired impedance, thus permitting connection to any type of external indicating instrument.

High resolution and accuracy can be achieved by connecting a digital voltmeter (DVM) to the BNC connector. Set the DVM to its 1 volt full scale range and calibrate the gaussmeter as described in Section III-C using the DVM as the readout instrument. By using only the decade ranges (0.1, 1, 10, etc.) on the gaussmeter, the DVM will read directly in gauss with full scale being equivalent to the full scale range setting of the gaussmeter.

Because of the stability and backup battery power, the Model 9640 is ideally suited to long-term field monitoring applications. By connecting a chart recorder or other recording device to the BNC connector, the Model 9640 becomes a gauss-to-volts transducer for these applications.

SECTION IV continued Operating Instructions

(2) AUXILIARY OUTPUT BNC CONNECTOR

The auxiliary BNC connector is connected to the output of the auxiliary dc-to-400 Hz amplifier. The output voltage is adjustable by means of the GAIN control from 1 volt to 5 volts at full scale. The output impedance of the BNC connector is less than 1Ω and short-circuit-protected by current-limiting above 5 mA. This output may be used to drive lower sensitivity indicating equipment such as galvanometer pen recorders, electronic gates, etc. Because the auxiliary amplifier operates only when line power is supplied, the output BNC connector must be used for electrical output when the instrument is operated from battery power.

IV-D PROBE DEVIATION CURVES

Machine-drawn error curves can be obtained at a nominal charge for any probe, at the time of purchase or by returning the probe to F.W. Bell Inc. The use of the probe deviation curves for calibrating is described in Section III-C3.

To use the curves to correct the field measurements, locate the field value, as indicated on the gaussmeter, on the horizontal axis of the curve. Use the right half of the curve for positive or normal direction fields and the left half for negative or reverse direction fields. Read the deviation in gauss from the curve. If the deviation is positive (above the axis), the probe output is high and the error is to be subtracted from the indicated value. Negative probe deviations are added to the readings to obtain the corrected value.

IV-E TOTAL FLUX DETERMINATION

The Hall effect sensing device is inherently responsive to magnetic flux density and not to total flux lines. It is not dependent on rate-of-change of flux as is a search coil.

From the basic definitions:

$$\text{GAUSS} = \text{WEBERS PER SQUARE METER} \times 10^4$$

$$\text{GAUSS} = \text{LINES PER SQUARE INCH} \times .1550$$

The Hall probe is equally useful in homogeneous, uniform low-gradient fields and in high-gradient fields, although the low-gradient fields are capable of more accurate measurement. If the flux density is uniform and unidirectional over a given area, the total flux through the area is found by multiplying the area in question.

$$(\text{Flux}) \text{ WEBERS} = \text{GAUSS} \times \text{SQ. METERS} \times 10^{-4}$$

$$= \text{GAUSS} \times \text{SQ. CM} \times 10^{-8}$$

$$(\text{Flux}) \text{ LINES} = \frac{\text{GAUSS} \times \text{SQ. INCHES}}{.1550}$$

When the Hall generator is moved in a plane, the component of flux normal to this plane will be indicated. If the field varies in magnitude over the area, it is necessary to integrate the values of flux density over the area in question. The flux density value indicated by the probe output is the effective value over the active area of the Hall generator. The standard transverse probe area is extremely small, only about 0.003 square inch, and sensitivity is essentially uniform over this area.

SECTION IV continued Operating Instructions

Absolute measurements of total flux of magnets having odd shape or high length-to-diameter ratio are best made using the search coil and standard fluxmeter methods. In many cases, however, valuable data can be obtained by air-gap flux density measurements when the magnet is mounted in its working structure. Also, accurate comparison data can be obtained on almost all magnets of various sizes and shapes using a Hall probe to measure pole face density in comparison to a magnet selected as a standard of reference.

SECTION V

V-A GENERAL

THEORY OF OPERATION

The basic principle of magnetic flux measurement used in the Model 9640 Gaussmeter may be described as a flux-modulated carrier-amplifier system. A locally generated ac carrier signal is fed as an exciting current to the Hall element. The flux to be measured at the probe modulates the ac carrier within the Hall sensor, producing an ac output voltage which is accurately proportional to flux density. The flux-modulated ac carrier output is amplified by the carrier amplifier and then restored to a flux-proportional voltage by the synchronous demodulator without loss of polarity (field direction) information. The demodulator drives the panel meter and BNC connectors.

If the field is time-varying, the demodulated output will be instantaneously proportional to the flux waveform up to 400 Hz. A separate ac detector is connected to the synchronous demodulator output to produce a dc meter reading for ac fields.

V-B THE SENSING ELEMENT

The Hall generator used for magnetic flux sensing is a semi-conductor device operating on the Hall effect principle. It consists of a thin rectangular wafer of high-purity indium arsenide with 4 leads attached. (See Figure V-A.)

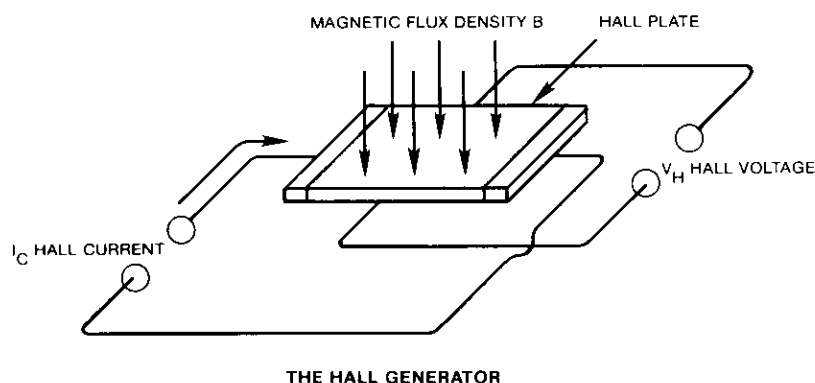


Figure V-A
Sensing Element

The application of control current I_C to the Hall generator results in a flow of charge carriers through the semiconductor material in the direction of its long dimension. When the Hall generator is placed in a magnetic field, the Lorentz force, acting on the moving charges, deflects them at right angles to the direction of their motion through the Hall plate. This is the same force that deflects the electron beam in a cathode ray tube.

The resulting build-up of charge carriers along the sides of the wafer produces the Hall voltage, and this voltage appears as an output at connections made on each side of the element. Hall voltage V_H is directly proportional to the flux density B and to the magnitude of control current I_C .

$$V_H = K_H (B \times I_C)$$

The three factors V_H , I_C and B are mutually perpendicular. If the magnetic flux vector B is not perpendicular to the face of the Hall generator, the Hall output will be proportional to the component of B that is perpendicular to the

SECTION V continued Theory of Operation

element. The constant of proportionality K_H is called the Hall sensitivity constant, and is approximately 0.075 volt per kG-ampere for 1X probes, and 0.0075 volt per kG-ampere for 10X probes.

V-C CIRCUIT OPERATION

(1) INTRODUCTION

This section describes the overall gaussmeter circuit operation. Check the simplified block diagram, Figure V-B, the detailed block diagram, Figure VIII-A, and the complete schematics, Figure VIII-C. Because of the unique circuit design it is recommended that a thorough understanding of the circuit operation be acquired before attempting to service or adjust the instrument.

(2) GENERAL OPERATION DESCRIPTION

The Hall element is supplied with exciting current, I_c , from the 5 kHz current regulated oscillator, (see Figure V-B). The Hall output voltage, V_H , (the flux-modulated carrier signal) is connected to the gaussmeter input summing circuit. At the summing circuit the zeroing voltage from the zero controls, the zero suppression voltage and the feedback voltage from the range attenuator are subtracted from the Hall output. The difference is amplified to produce the proper output depending on the range in use. The amplifier output feeds the range attenuator which sets the proper gain, controls, and stabilizes the amplifier by means of overall loop feedback. The zeroing voltages are obtained from the zero control circuits which adjust and attenuate a sample of the control current. The amplifier output feeds the synchronous demodulator which converts the amplified flux-modulated carrier into a flux-proportional output voltage. This output voltage then feeds the BNC connector and meter for dc fields. For meter reading of ac fields, the ac detector is connected between the output and meter to convert the flux-proportional ac output to dc.

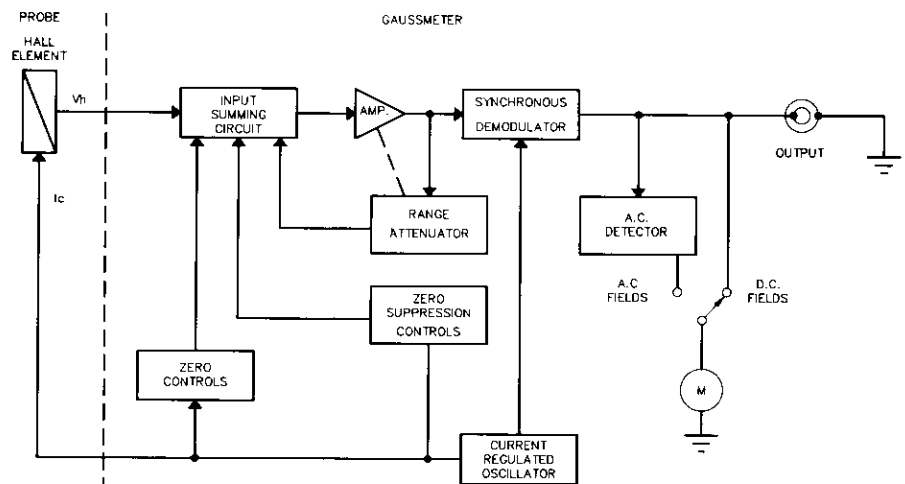


Figure V-B
Simplified Block Diagram

SECTION V continued Theory of Operation

(3) DETAILED OPERATING DESCRIPTION

(a) General

This circuit is divided into 6 basic functional groups: the probe, the input section, the amplifier section, the detector and meter, the current-regulated oscillator, and the power supply. Figure VIII-A, the complete block diagram, shows all essential operating functions; however, various circuit details have been eliminated or altered for clarity. Check the complete schematic Figure VIII-B for all circuit details.

(b) The Probe

The excitation current is supplied to the element through pins A and D of the probe plug and the Hall output voltage is connected to the gaussmeter through pins C and E. A calibrating resistor, mounted in the probe plug across pins B and F, accurately programs the amplifier gain to the proper value according to the sensitivity of the particular Hall element.

(c) Input Section

The FUNCTION switch, in the operating position, connects the Hall voltage output directly to the input transformer. The primary winding of the transformer is split with the two resistors R3 and R4 inserted between the halves and grounded, to form a balanced to ground summing point. The input transformer, in effect, sees the difference between the Hall input voltage and the summing point voltage. The summing point voltage consists of the feedback voltage from the range attenuator, the zero injection voltage from the zero controls, and the zero injection voltage from the zero suppression controls. Also shunting across R3 and R4 is the calibrating resistor or network in the probe. By varying this CAL resistor, the feedback factor of the range attenuator is adjusted, and the overall amplifier gain is programmed very accurately for proper calibration.

The zero injection voltage from the zero controls is obtained by sampling the element control current. The controls adjust and attenuate the voltage obtained from the current-sensing transformer T201. Because the Hall sensor zero and residual field output are proportional to control current, and the zero-injected voltage is derived from the current, cancellation of the zero field voltage is maintained even under the condition of current changes. Highest possible zero stability is, therefore, achieved.

The zero suppression controls also adjust and attenuate a sample of the element excitation current and feed it to the summing point across R3 and R4. This voltage then subtracts from the element output produced by the field, thus suppressing zero. The attenuator consists of two sections. The COARSE SUPPRESSION switch consists of two bridged tee attenuator sections switched in 10% steps from zero to full output. The FINE control and attenuator operates in parallel with this dual bridged tee to provide smooth control between the steps of the COARSE control. The VERNIER provides very fine control for precise zeroing. The output of this attenuator and the FINE and VERNIER controls feed into the 4-section attenuator connected to the range switch ring knob. This attenuator sets the range of the suppression voltage to correspond to the absolute range in use. During scale expansion this attenuation does not change, thus maintaining the zero suppression.

SECTION V continued Theory of Operation

During calibration the FUNCTION switch connects the internal gain programming resistor R2 in place of the resistor in the probe and disconnects the zero controls. The internal gain-calibrating resistor programs the gain to the proper value for the nominal Hall element sensitivity.

The input is switched from the probe output to a resistor R1 in series with the control current to the element which is calculated to produce a voltage equal to the nominal element output in a 31.622777 kG or $10\sqrt{10}$ kG field [full scale (1.0) on the 30 kG range]. The CAL control which varies the current is then adjusted to give full scale output (1.0). By this method of adjustment, any amplifier gain errors are compensated for by the control current adjustment, providing an internal calibration which is dependent only on the accuracy of the resistors R1, R2, R3 and R4 and the initial factory calibration which determines the probe-calibrating resistor.

(d) Amplifier Section

The input transformer secondary connects to the first attenuator which operates on the middle three ranges (30, 100, 300 G) to keep the input below the saturation level of the first amplifier. The first amplifier is a two-stage plus emitter follower direct coupled circuit with ac and dc feedback for stabilization. The voltage gain is 46 dB at the carrier frequency and is attenuated at all other frequencies by the synchronous filter. The filter consists of two transistor switches operating in synchronism with the carrier frequency and two RC filter networks inserted into the feedback network of the amplifier section. The action is that of a very narrow band pass filter synchronized to the carrier frequency. Very high rejection of noise and spurious signals is achieved, and easy alteration of band width is possible by changing the RC network.

The first amplifier feeds the second attenuator which operates on the first 4 ranges (0.3, 1, 3, and 10 G) to prevent overloading the second amplifier. The second amplifier is identical to the first and gives another 46 dB gain at the carrier frequency with synchronous filtering. Again the output feeds an attenuator which operates on the highest 4 ranges (1 kG, 3 kG, 10 kG, and 30 kG.)

A third 46 dB filter amplifier feeds a dual complementary unity gain output amplifier which drives the output transformer. The output transformer has two center tapped outputs, one for the range attenuator and the other for the synchronous demodulator. The 500 Ω range attenuator connects the output back to the summing point across R3 and R4, giving about a 40 dB feedback factor for high gain stability, high input impedance and high linearity.

The range attenuator consists of four 499 Ω "O" pads switched in sequence to give 10 dB steps to 110 dB total attenuation. Also connected to the range attenuator switch are the three dividers between the amplifiers which also operate in 10 dB steps to maintain the 40 dB feedback factor.

(e) Detector and Meter

The synchronous demodulator consists of two switching transistors driven by the sync signal from the carrier oscillator. When the FUNCTION switch is in the REV position, the output transformer signal polarity is reversed which changes the polarity of the demodulated output. The BNC connectors are connected to the demodulator through the ripple filter R53, R54 and C1.

SECTION V continued Theory of Operation

The meter is connected through the R49 calibration resistor for dc fields and CAL. For ac fields the meter is switched to the ac detector. The detector consists of a diode bridge connected in the current feedback loop of a two-stage-amplifier. High linearity ac to dc conversion of the flux-proportional demodulated output is, therefore, achieved. For battery test, the meter is switched to the attenuator formed by the R50 and R51 fed from the diodes which select the higher voltage; battery or external dc input.

(f) Current Regulated Oscillator

The element control current is supplied from the 5 kHz square wave current oscillator. The oscillator consists of an astable multivibrator driving a pair of push-pull output transistors into the output transformer. The output current amplitude is controllable by a dc control signal. This control signal is obtained from a dc amplifier with positive feedback for infinite gain. The input to the amplifier is then obtained from the current-sensing transformer T201 through a zener reference diode. By means of this feedback loop, the control current is regulated to obtain a high stability element excitation current.

The current is adjustable by the CAL control which varies the secondary load on the current sensing transformer. The current-sensing transformer also feeds the zeroing controls.

(g) Power Supply

The power to all circuits is supplied from the power regulator which provides +7 Vdc. The input to the regulator is obtained from the power transformer, rectifier diodes, and filter capacitor. At 117 Vac line voltage (or 234 V) the unregulated dc voltage is about 20 V. Because the internal battery and external input are less than 20 volts, the diodes in series with these power sources are reverse biased and no power is drawn from them. Therefore, if the ac line power fails, the internal battery will automatically take over, when the LINE-BATTERY switch is in the BATT. position.

SECTION VI

MAINTENANCE

VI-A INTRODUCTION

This section contains the necessary instructions and diagrams for maintaining the Model 9640 Gaussmeter. In addition to the schematic diagrams, a block diagram is provided to aid in troubleshooting.

CAUTION: Repair and adjustment of the instrument should be attempted in the field only where adequate test equipment and qualified personnel are available.

Refer to the warranty page for the procedure to be followed should factory repair service be required.

VI-B TEST EQUIPMENT

The following test equipment is required to test and adjust the Model 9640 Gaussmeter.

- (1) A high impedance dc voltmeter having 2% or better accuracy.
- (2) A high impedance ac voltmeter having 2% or better accuracy. The meter should be an average reading circuit calibrated in rms for sine wave voltages. A true rms reading meter will not read the same voltages because of the square wave forms.
- (3) A high quality oscilloscope having response to dc.

VI-C COVER REMOVAL

CAUTION - Always disconnect power cord from power line when removing or replacing cover.

To remove the top panel, it is only necessary to remove the four screws from the plastic bumpers on the rear of the unit and slide the top panel to the rear of the unit and off.

VI-D PERFORMANCE TESTS

This paragraph describes a rapid overall series of tests for proper operation. If difficulty is encountered, proceed to Section VI-E.

(1) PRELIMINARY

- (a) Make sure power cord is properly connected and fully seated in the receptacle on the instrument.
- (b) Check fuse for burnout. Correct fuse is:
63 mA 5 X 20 mm slow-blow for 115 V operation.
32 mA 5 X 20 mm slow-blow for 230 V operation.
- (c) Inspect the probe for damaged element or cable, or poor plug contacts.
- (d) Check meter mechanical zeroing.
- (e) Set controls as follows:
RANGE switch to 30 K
FUNCTION switch to CAL
COARSE SUPPRESSION to OFF

SECTION VI continued Maintenance

(f) Plug probe securely into front panel socket.

(2) LINE CURRENT CHECK

- (a) Connect to rated power source. Line current after warmup should be:
at 117 V line, 0.038 A nominal
at 234 V line, 0.019 A nominal

(3) CALIBRATION CHECK

- (a) With the instrument operating the meter should read near full scale.
(b) Adjust the CAL control. A full-scale meter reading should be obtainable with a small adjustment leeway on each side.
(c) Voltage at the BNC connector should be 1 volt dc for full-scale meter reading.

(4) ZERO TEST

- (a) Switch the FUNCTION switch to NOR. Adjust the zero controls to obtain a zero gauss chamber over the probe on the 0.1 G range.
(b) Set the RANGE switch to the 100 G range.
(c) Rotate the COARSE ZERO control over its range, switching the FUNCTION switch to REV when below-zero meter indications are obtained.
(d) A total of about 50 G adjustment range should be obtained.

(5) ZERO DETECTOR TEST

- (a) Again zero the instrument on the 0.1 G range with the FUNCTION switch at NOR.
(b) Switch to the 30 K range and measure the dc voltage at the output BNC connector. It should be less than 1 mV dc.

(6) NOISE CHECK

- (a) With the zero gauss chamber in place and a good zero on the 0.1 G range, switch the FUNCTION switch to AC.
(b) The residual meter reading should be less than 10% of full scale on the 0.1 G range.

(7) SUPPRESSION CIRCUIT CHECK

- (a) With the zero gauss chamber in place and a good zero on the 0.1 G range, set the FUNCTION to NOR, the range to 10 kG, the SUPPRESSION RANGE to 10 kG, and the FINE SUPPRESS and VERNIER to full counterclockwise.
(b) Advance the COARSE SUPPRESS from its OFF position to its 0 position.
(c) The meter should move from zero on the black scales to zero on the zero center red scales.

SECTION VI continued Maintenance

- (d) Continue to advance the COARSE SUPPRESS control. The steps should be approximately 10% of full scale in the negative direction on the upper red scale.
- (e) The FINE SUPPRESS control should produce a smooth continuous variation between the 10% steps of the coarse control.

VI-E ADJUSTMENT AND ALIGNMENT PROCEDURE

IMPORTANT—None of the adjustments described in this section should be disturbed unless the instrument is malfunctioning and the tests indicate adjustment is necessary. These tests and adjustments are designed to assure correct overall performance. Before making any adjustments, the Model 9640 should be turned on for at least one hour with the top panel in place. Line voltage should be at rated value (117 V or 234 V).

(1) METER MECHANICAL ZERO

For this test the meter terminals may be short-circuited with a jumper wire, or the instrument turned off, allowing a few seconds for complete discharge of all capacitors. The instrument must be in the normal horizontal operating position. Read the meter accurately by aligning the pointer with its image in the mirror. If necessary, adjust the screw on the meter face to bring the pointer to exactly zero.

(2) POWER SUPPLY VOLTAGE ADJUSTMENT

Adjust the R224 on the oscillator power supply circuit board to obtain +7 Vdc between terminal 206 and ground.

(3) OSCILLATOR SYMMETRY ADJUSTMENT

Connect the oscilloscope to terminal 212 and ground on the oscillator power supply board and adjust R211 on that board for a symmetrical square wave. Use the largest scope trace possible.

(4) DETECTOR ZERO ADJUSTMENT

Place the probe in the zero gauss chamber and zero the gaussmeter down to the 0.1 gauss range. Switch to the 30 K range and adjust R151 on the amplifier board to obtain zero dc voltage at the BNC connector. Use the highest sensitivity volt-meter range.

(5) METER CALIBRATION dc

Switch the RANGE switch to 30 K, the COARSE SUPPRESS control to OFF, and the FUNCTION switch to CAL. Adjust the CAL FS control to obtain exactly 1 volt at the BNC connector using the dc DVM. Adjust the potentiometer R52 on the circuit board on the back of the meter to obtain an exact full-scale meter reading. The more accurate the dc DVM used, the more accurate the setting of 1 volt output for full scale.

Switch the FUNCTION switch to NOR and zero the instrument to the 0.1 G range. Set the RANGE switch to 30 K, the FINE SUPPRESS and VERNIER to maximum counterclockwise, and COARSE SUPPRESS to 0.

Adjust R58 on the meter circuit board to obtain exactly zero on the zero center red scale.

SECTION VI continued Maintenance

(6) METER CALIBRATION ac

With the COARSE SUPPRESS switch to OFF, connect the ac DVM to the back panel BNC connector and place the probe in a source of ac field about 60 Hz. This field can be generated by any method: The external field of a power transformer, a coil operating from line power, etc. No particular accuracy is necessary, but a field of about 10 G is easy to use. Mount the probe in the field using a holding fixture. Zero the dc field, if any, using the zeroing controls and on the range which gives about a 1 volt reading on the ac DVM. Adjust the probe to provide exactly 1 volt on the ac DVM and adjust R165 on the amplifier board to obtain exactly full scale on the Gaussmeter meter with the FUNCTION switch on AC. It is recommended that the ac field used be above the 1 G range because stray dc fields will not be as apt to cause difficulty. Be sure there is no dc field reading in the NOR or REV position of the FUNCTION switch as these could cause errors. (See Section IV-B4c.)

NOTE:

Trimmer capacitors C122 and C148 are factory-adjusted for optimum performance and should not require readjustment. Adjustment of these trimmers can affect accuracy, therefore, do not attempt to make this adjustment without consulting the factory for advice. If, however, there is reason to believe alignment is necessary, consult the factory. Field adjustment is not recommended because special test equipment and procedures are required.

SECTION VII

AUXILIARY AMPLIFIER

VII-A AUXILIARY AMPLIFIER

The auxiliary output amplifier provides increased output voltage and power, via the BNC connector, to drive external equipment. The rear panel output BNC connector is connected to the output of the auxiliary dc to 400 Hz amplifier. The output voltage is adjustable by means of the GAIN control from 1 volt to 5 volts at full scale. The output impedance of this BNC connector is less than 1Ω and protected from short-circuit by current-limiting above 5 mA. This BNC connector may be used to drive lower sensitivity indicating equipment such as galvanometer pen recorders, electronic gates, etc. Because the auxiliary amplifier operates only when line power is supplied, the auxiliary amplifier cannot be used with the instrument is operated from battery power.

VII-B SPECIFICATIONS

Rear Panel Auxiliary Output BNC Connector

- | | |
|-------------------------------|--------------------------------------|
| 1. Output voltage: | 1.0 to 5.0 Vdc, FS adjustable |
| 2. Source impedance | $<1\Omega$ (max output current 5 mA) |
| 3. Maximum ac field frequency | 400 Hz |
| 4. RMS noise: | |
| 0.1 gauss range | 20 dB below full scale approx. |
| 0.3 gauss range | 35 dB below full scale approx. |
| 1 G to 30 kG range | 45 dB below full scale approx. |

SECTION VIII

INSTALLATION OF OPTION

VIII-A INSTALLATION OF RACK MOUNTING OPTION

The Rack Mounting Kit (Item # 119510) consists of two mounting brackets with four metric flat head screws and an adapter plate with two 1/4-20 screws.

- (1) To convert a standard bench instrument into a 19" rack mountable unit, loosen the small slotted screw on bottom of each Side Cover Plate, as shown in Figure VIII-A. Remove the side cover plate.
- (2) Install the Rack Mounting Brackets, using the four metric flat head screws provided.
- (3) Attach the Adaptor Plate to either the left or right side Rack Mounting Bracket.
- (4) The instrument can now be mounted on a 19" wide rack or cabinet.

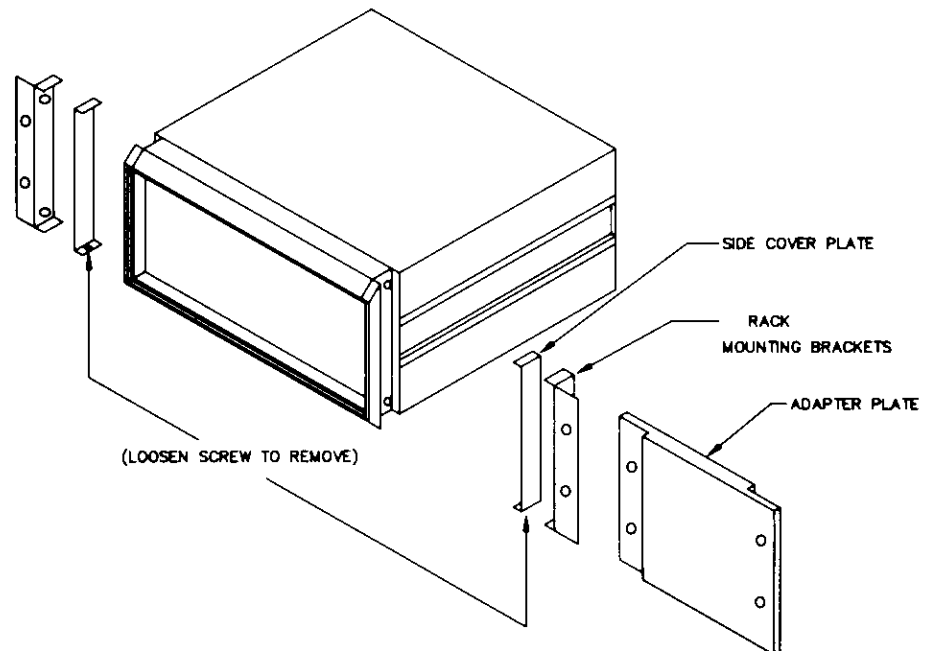


Figure VIII-A
Rack Mounting Installation

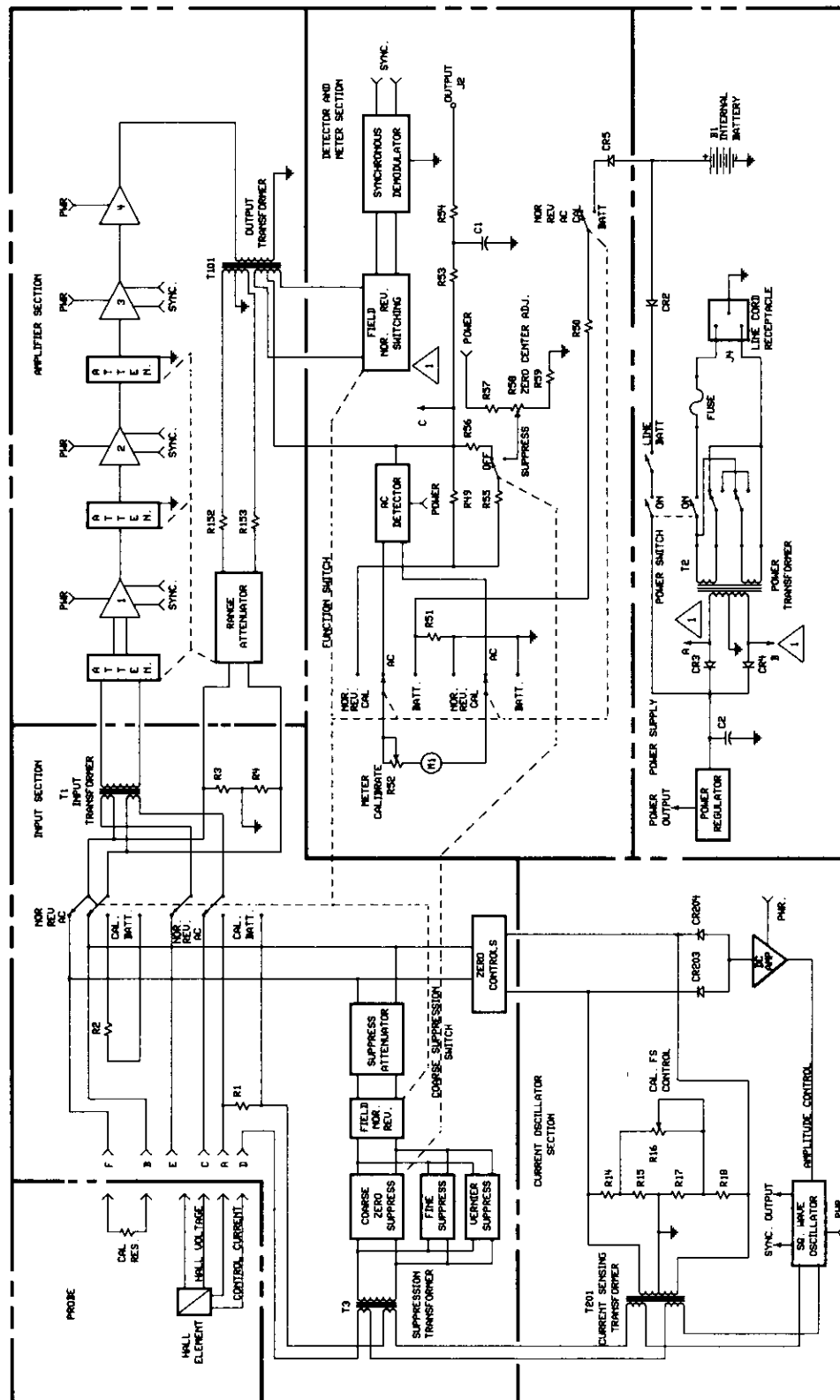


Figure IX-A
Block Diagram

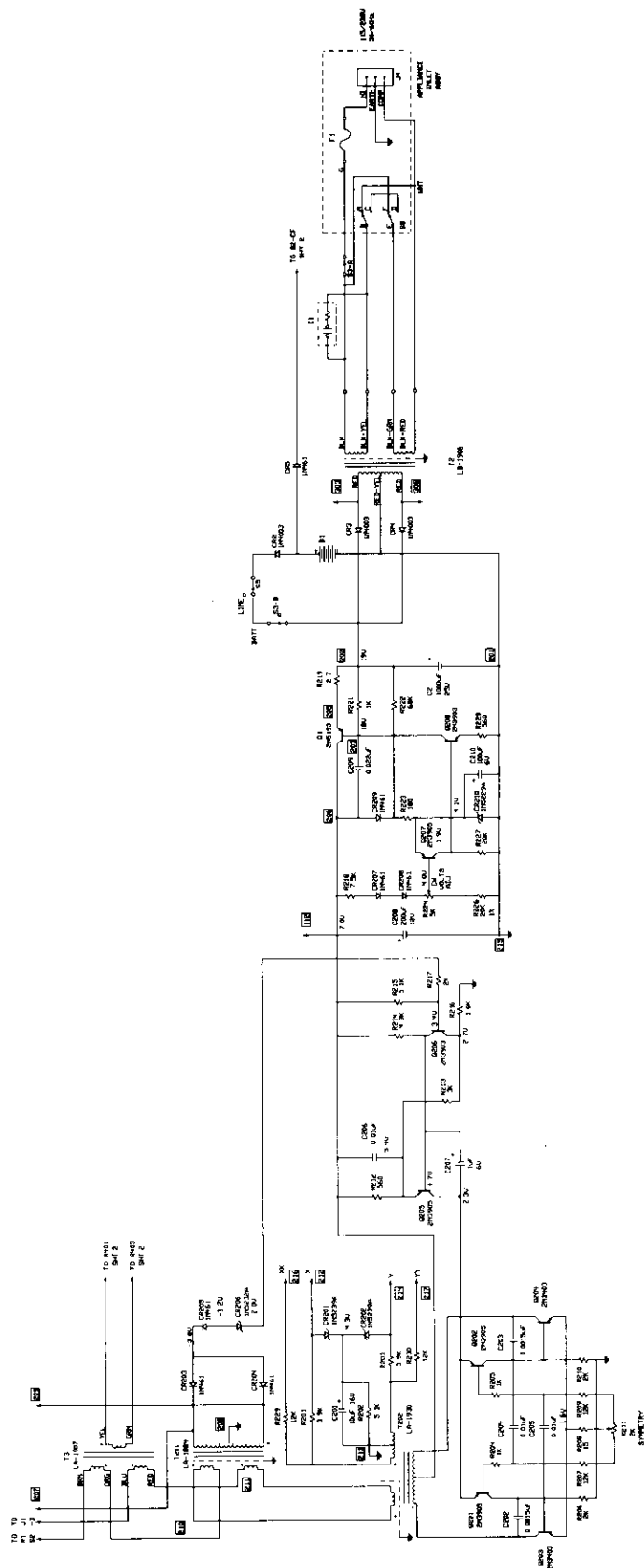


Figure IX-B
Schematic Diagram #1

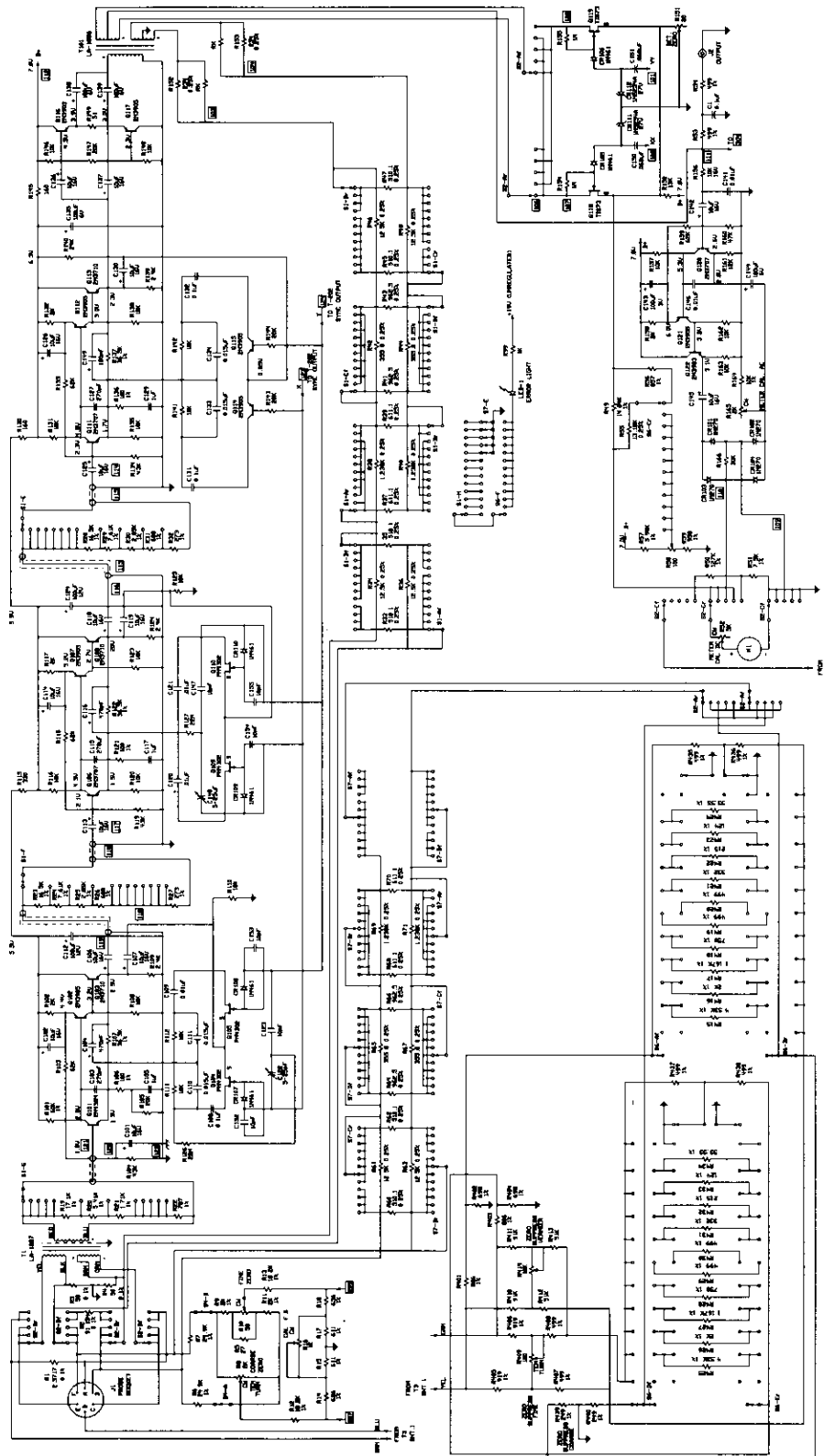


Figure IX-C
Schematic Diagram #2

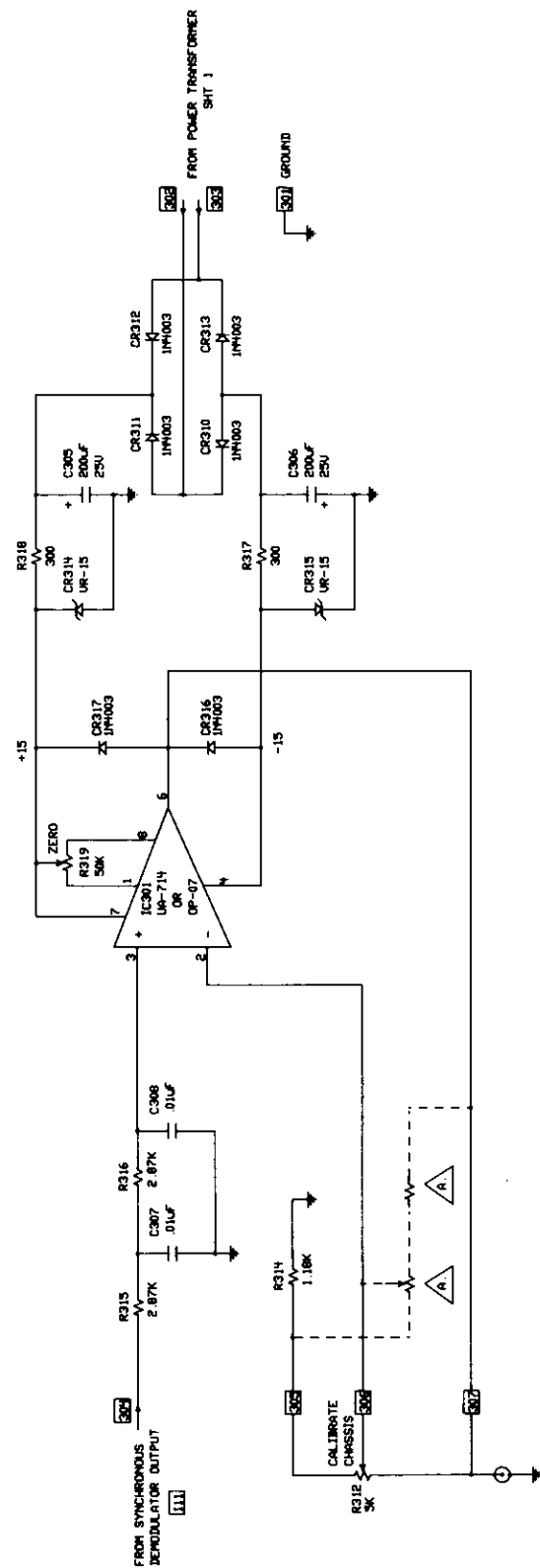


Figure IX-D
Schematic Diagram #3

Cer.....Ceramic
 CF.....Carbon film
 Comp.....Compostion
 EC.....Electrolytic can type
 EM.....Electrolytic miniature type
 F.....Farad
 Film.....Metal film
 Fixed.....Fixed
 FOP...Factory adjusted for optimum performance
 HM.....Hot molded

N.....Nano or 10⁻⁹
 μMicro or 10⁻⁶
 M.....Mega or 10⁶
 MME.....Molded miniature epoxy
 Ωohm
 p.....Pico or 10⁻¹²
 V.....Working Volts
 Var.....Variable
 W.....Watt
 WW.....Wire Wound

PARTS LIST MODEL 9640

Schematic						Schematic					
Ref.	Value	Spec	Type	Item No.		Ref.	Value	Spec	Type	Item No.	
R1	2.3717 Ω	1/10W 1/10%	WW Fixed	318370		R46	12.5 k Ω	1/8W 1/4%	Film Fixed	315290	
R2	91.54 Ω	1/10W 1/10%	WW Fixed	318420		R47	510.1 Ω	1/8W 1/4%	Film Fixed	315250	
R3	50 Ω	1/10W 1/10%	WW Fixed	318400		R48	12.5 k Ω	1/8W 1/4%	Film Fixed	315290	
R4	50 Ω	1/10W 1/10%	WW Fixed	318400		R49	14.04 k Ω	1/2W 1%	Film Fixed	316990	
R5	27 Ω	1/4W 5%	CF Fixed	311485		R50	127 k Ω	1/4W 1%	Film Fixed	316650	
R6	24.9 k	1/4W 1%	Film Fixed	316151		R51	7.5 k Ω	1/4W 1%	Film Fixed	316300	
R7	24.9 k	1/4W 1%	Film Fixed	316151		R52	5 k Ω		Film Var	322046	
R8	2 k Ω		WW Var	321710		R53	499 Ω	1/4W 1%	Film Fixed	315919	
R9	2 k Ω	1/4W 1%	Film Fixed	316150		R54	499 Ω	1/4W 1%	Film Fixed	315919	
R10	50 Ω	(Part of S4)	HM Var	321140		R55	13.18 k Ω	1/8W 1/4%	Film Fixed	315300	
R11	2 k Ω	1/4W 1%	Film Fixed	316150		R56	857 Ω	1/8W 1%	Film Fixed	316010	
R12	18.2 k Ω	1/4W 1%	Film Fixed	316480		R57	5.90 k Ω	1/4W 1%	Film Fixed	316265	
R13	18.2 k Ω	1/4W 1%	Film Fixed	316480		R58	100 Ω		Film Var	322039	
R14	656 Ω	1/4W 1%	Film Fixed	315966		R59	950 Ω	1/4W 1%	Film Fixed	316040	
R15	611 Ω	1/4W 1%	Film Fixed	315965		R60	510.1 Ω	1/8W 1/4%	Film Fixed	315250	
R16	1 Ω		HM Var	321130		R61	12.5 k Ω	1/8W 1/4%	Film Fixed	315290	
R17	611 Ω	1/4W 1%	Film Fixed	315965		R62	510.1 Ω	1/8W 1/4%	Film Fixed	315250	
R18	656 Ω	1/4W 1%	Film Fixed	315966		R63	12.5 k Ω	1/8W 1/4%	Film Fixed	315290	
R19	17.1 k Ω	1/8W 1%	Film Fixed	316470		R64	962.5 Ω	1/8W 1/4%	Film Fixed	315270	
R20	5.41 k Ω	1/8W 1%	Film Fixed	316260		R65	355.8 Ω	1/8W 1/4%	Film Fixed	315230	
R21	1.71 k Ω	1/8W 1%	Film Fixed	316130		R66	962.5 Ω	1/8W 1/4%	Film Fixed	315270	
R22	787 Ω	1/8W 1%	Film Fixed	315065		R67	355.8 Ω	1/8W 1/4%	Film Fixed	315230	
R23	16.5 k Ω	1/8W 1%	Film Fixed	316460		R68	611.1 Ω	1/8W 1/4%	Film Fixed	315260	
R24	7.61 k Ω	1/8W 1%	Film Fixed	316310		R69	1.238 k Ω	1/8W 1/4%	Film Fixed	315280	
R25	2.05 k Ω	1/8W 1%	Film Fixed	316160		R70	611.1 Ω	1/8W 1/4%	Film Fixed	315260	
R26	608 Ω	1/8W 1%	Film Fixed	315960		R71	1.238 k Ω	1/8W 1/4%	Film Fixed	315280	
R27	273 Ω	1/8W 1%	Film Fixed	315870		R72	510.1 Ω	1/8W 1/4%	Film Fixed	315250	
R28	16.5 k Ω	1/8W 1%	Film Fixed	316460		R73	12.5 k Ω	1/8W 1/4%	Film Fixed	315290	
R29	7.61 k Ω	1/8W 1%	Film Fixed	316310		R74	510.1 Ω	1/8W 1/4%	Film Fixed	315250	
R30	2.05 k Ω	1/8W 1%	Film Fixed	316160		R401	806 Ω	1/4W 1%	Film Fixed	316000	
R31	608 Ω	1/8W 1%	Film Fixed	315960		R402	698 Ω	1/8W 1%	Film Fixed	315968	
R32	273 Ω	1/8W 1%	Film Fixed	315870		R403	806 Ω	1/4W 1%	Film Fixed	316000	
R33	510.1 Ω	1/8W 1/4%	Film Fixed	315250		R404	698 Ω	1/8W 1%	Film Fixed	315968	
R34	12.5 k Ω	1/8W 1/4%	Film Fixed	315290		R405	919 Ω	1/4W 1%	Film Fixed	316030	
R35	510.1 Ω	1/8W 1/4%	Film Fixed	315250		R406	919 Ω	1/4W 1%	Film Fixed	316030	
R36	12.5 k Ω	1/8W 1/4%	Film Fixed	315290		R407	499 Ω	1/4W 1%	Film Fixed	315919	
R37	611.1 Ω	1/8W 1/4%	Film Fixed	315260		R408	499 Ω	1/4W 1%	Film Fixed	315919	
R38	1.238 k Ω	1/8W 1/4%	Film Fixed	315280		R409	100 Ω		WW Var	321720	
R39	611.1 Ω	1/8W 1/4%	Film Fixed	315260		R410	91 k Ω	1/4W 5%	CF Fixed	311580	
R40	1.238 k Ω	1/8W 1/4%	Film Fixed	315280		R411	91 k Ω	1/4W 5%	CF Fixed	311580	
R41	962.5 Ω	1/8W 1/4%	Film Fixed	315270		R412	51 k Ω	1/4W 5%	CF Fixed	311574	
R42	355.8 Ω	1/8W 1/4%	Film Fixed	315230		R413	51 k Ω	1/4W 5%	CF Fixed	311574	
R43	962.5 Ω	1/8W 1/4%	Film Fixed	315270		R414	10 k Ω		HM Var	321150	
R44	355.8 Ω	1/8W 1/4%	Film Fixed	315230		R415	4.53 k Ω	1/8W 1%	Film Fixed	316225	
R45	510.1 Ω	1/8W 1/4%	Film Fixed	315250		R416	2 k Ω	1/8W 1%	Film Fixed	316150	

PARTS LIST MODEL 9640

Schematic					Schematic				
Ref.	Value	Spec	Type	Item No.	Ref.	Value	Spec	Type	Item No.
R417	1.167 kΩ	1/8W 1%	Film Fixed	316070	R103	62 kΩ	1/4W 5%	CF Fixed	311576
R418	750 Ω	1/8W 1%	Film Fixed	315064	R104	43 kΩ	1/4W 5%	CF Fixed	311572
R419	499 Ω	1/8W 1%	Film Fixed	315919	R105	10 kΩ	1/4W 5%	CF Fixed	311557
R420	499 Ω	1/8W 1%	Film Fixed	315919	R106	100 Ω	1/4W 1%	Film Fixed	315790
R421	332 Ω	1/8W 1%	Film Fixed	315888	R107	36.5 kΩ	1/4W 1%	Film Fixed	316550
R422	215 Ω	1/8W 1%	Film Fixed	315849	R108	10 kΩ	1/4W 5%	CF Fixed	311557
R423	124 Ω	1/8W 1%	Film Fixed	315199	R109	2.4 kΩ	1/4W 5%	CF Fixed	311542
R424	55.55 Ω	1/8W 1%	Film Fixed	315650	R110	10 kΩ	1/4W 5%	CF Fixed	311557
R425	4.53 kΩ	1/8W 1%	Film Fixed	316225	R111	10 kΩ	1/4W 5%	CF Fixed	311557
R426	2 kΩ	1/8W 1%	Film Fixed	316150	R112	10 kΩ	1/4W 5%	CF Fixed	311557
R427	1.167 kΩ	1/8W 1%	Film Fixed	316070	R115	330 Ω	1/4W 5%	CF Fixed	311521
R428	750 Ω	1/8W 1%	Film Fixed	315980	R116	10 kΩ	1/4W 5%	CF Fixed	311557
R429	499 Ω	1/8W 1%	Film Fixed	315919	R117	2 kΩ	1/4W 5%	CF Fixed	311540
R430	499 Ω	1/8W 1%	Film Fixed	315919	R118	62 kΩ	1/4W 5%	CF Fixed	311576
R431	332 Ω	1/8W 1%	Film Fixed	315888	R119	43 kΩ	1/4W 5%	CF Fixed	311572
R432	215 Ω	1/8W 1%	Film Fixed	315849	R120	10 kΩ	1/4W 5%	CF Fixed	311557
R433	124 Ω	1/8W 1%	Film Fixed	315199	R121	100 Ω	1/4W 1%	Film Fixed	315790
R434	55.55 Ω	1/8W 1%	Film Fixed	315650	R122	36.5 kΩ	1/4W 1%	Film Fixed	316550
R435	499 Ω	1/8W 1%	Film Fixed	315919	R123	10 kΩ	1/4W 5%	CF Fixed	311557
R436	499 Ω	1/8W 1%	Film Fixed	315919	R124	2.4 kΩ	1/4W 5%	CF Fixed	311542
R437	499 Ω	1/8W 1%	Film Fixed	315919	R125	10 kΩ	1/4W 5%	CF Fixed	311557
R438	499 Ω	1/8W 1%	Film Fixed	315919	R126	22 MΩ	1/4W 5%	CF Fixed	311636
R439	249 Ω	1/8W 1%	Film Fixed	315855	R127	22 MΩ	1/4W 5%	CF Fixed	311636
R440	249 Ω	1/8W 1%	Film Fixed	315855	R130	160 Ω	1/4W 5%	CF Fixed	311514
C1	0.1 mF	200V	MME Fixed	324550	R131	10 kΩ	1/4W 5%	CF Fixed	311557
C2	1000 mF	25V	EC Fixed	323930	R132	2 kΩ	1/4W 5%	CF Fixed	311540
Transistors and Diodes					R133	62 kΩ	1/4W 5%	CF Fixed	311576
CR2	1N4003			328090	R134	43 kΩ	1/4W 5%	CF Fixed	311572
CR3	1N4003			328090	R135	10 kΩ	1/4W 5%	CF Fixed	311557
CR4	1N4003			328090	R136	100 Ω	1/4W 1%	Film Fixed	315790
CR5	1N461			328010	R137	36.5 kΩ	1/4W 1%	Film Fixed	316550
Q1	2N5193			329201	R138	10 kΩ	1/4W 5%	CF Fixed	311557
Transformers					R139	2.4 kΩ	1/4W 5%	CF Fixed	311542
T1	Input Transformer LA-1887			326260	R140	24 kΩ	1/4W 5%	CF Fixed	311566
T2	Power Transformer LB-1906			326270	R141	10 kΩ	1/4W 5%	CF Fixed	311557
T3	Suppression Transformer LA-1907			326280	R142	10 kΩ	1/4W 5%	CF Fixed	311557
Switches					R143	20 kΩ	1/4W 5%	CF Fixed	311564
S1	Range Switch Assembly			201575	R144	20 kΩ	1/4W 5%	CF Fixed	311564
S2	Function Switch Assembly			201147	R145	160 Ω	1/4W 5%	CF Fixed	311514
S3	Power Switch			334590	R146	10 kΩ	1/4W 5%	CF Fixed	311557
S4	Zero Out Switch			321140	R147	20 kΩ	1/4W 5%	CF Fixed	311564
	(Part of Fine Zero Control, R10)				R148	10 kΩ	1/4W 5%	CF Fixed	311557
S5	Batt Line Switch			333660	R149	51 Ω	1/4W 5%	CF Fixed	311502
S6	Zero Suppression Switch Assembly			201577	R150	13 kΩ	1/4W 5%	CF Fixed	311560
S7	Suppress Range Switch Assembly			201576	R151	20 Ω		Film Var	322074
Meter					R152	237 Ω	1/4W 1/4%	Film Fixed	315852
M1	0-100 mA Meter MB-1927			310530	R153	237 Ω	1/4W 1/4%	Film Fixed	315852
The following parts are on the amplifier circuit board assembly, 201125					R154	1 MΩ	1/4W 5%	CF Fixed	311605
					R155	1 MΩ	1/4W 5%	CF Fixed	311605
					R156	10 kΩ	1/4W 5%	CF Fixed	311557
					R157	10 kΩ	1/4W 5%	CF Fixed	311557
					R158	2 kΩ	1/4W 5%	CF Fixed	311540
					R159	62 kΩ	1/4W 5%	CF Fixed	311576
					R160	47 kΩ	1/4W 5%	CF Fixed	311573
					R161	12 kΩ	1/4W 5%	CF Fixed	311559
					R162	10 kΩ	1/4W 5%	CF Fixed	311557
					R163	1.8 kΩ	1/4W 5%	CF Fixed	311539
					R164	10 kΩ	1/4W 1%	Film Fixed	311557
					R165	2 kΩ		Film Var	322059

Ref.	Value	Spec	Type	Ref.	Value	Spec	Type	Ref.	Value	Spec	Type
R166	30 kΩ	1/2W 5%	CF	Fixed	311568	CR104	1N270				327990
C101	10 μF	16 V	EM	Fixed	323310	CR105	1N461				328010
C102	10 μF	16 V	EM	Fixed	323310	CR106	1N461				328010
C103	270 pF	1 kV	Cer	Fixed	325470	CR107	1N461				328010
C104	570 pF	1 kV	Cer	Fixed	325500	CR108	1N461				328010
C105	1 μF	100 V	MME	Fixed	324930	CR109	1N461				328010
C106	10 μF	16 V	EM	Fixed	323310	CR110	1N461				328010
C107	10 μF	16 V	EM	Fixed	323310	CR111	1N5254A				328520
C108	0.1 μF	200 V	MME	Fixed	324550	CR112	1N5254A				328520
C109	0.1 μF	200 V	MME	Fixed	324550	Q101	2N4384				329120
C110	0.015 μF	200 V	MME	Fixed	324500	Q102	2N3905				329040
C111	0.015 μF	200 V	MME	Fixed	324500	Q103	2N3710				329000
C112	100 μF	12 V	EM	Fixed	323160	Q104	2N4302				329100
C113	10 μF	16 V	EM	Fixed	323310	Q105	2N4302				329100
C114	10 μF	16 V	EM	Fixed	323310	Q106	2N3707				328990
C115	270 pF	1 kV	Cer	Fixed	325470	Q107	2N3905				329040
C116	470 pF	1 kV	Cer	Fixed	325500	Q108	2N3710				329000
C117	1 μF	100 V	MME	Fixed	324930	Q109	2N4302				329100
C118	10 μF	16 V	EM	Fixed	323310	Q110	2N4302				329100
C119	10 μF	16 V	EM	Fixed	323310	Q111	2N3707				328990
C120	0.01 μF	200 V	MME	Fixed	324490	Q112	2N3905				329040
C121	0.01 μF	200 V	MME	Fixed	324490	Q113	2N3710				329000
C122	5-25 pF	600 V	Cer	Var	325820	Q114	2N3905				329040
C123	10 pF	1000 V	Cer	Fixed	323310	Q115	2N3905				329040
C124	100 μF	12 V	EM	Fixed	323160	Q116	2N3903				329030
C125	10 μF	16 V	EM	Fixed	323310	Q117	2N3905				329040
C126	10 μF	16 V	EM	Fixed	323310	Q118	T1S73				329290
C127	270 pF	1 kV	Cer	Fixed	325470	Q119	T1S73				329290
C129	1 μF	100 V	MME	Fixed	324930	Q120	2N3707				328990
C130	10 μF	16 V	EM	Fixed	323310	Q121	2N3905				329040
C131	0.1 μF	200 V	MME	Fixed	324550	Q122	2N3903				329030
C132	0.1 μF	200 V	MME	Fixed	324550	The following parts are on the power supply – current oscillator circuit board assembly 201126					
C133	0.015 μF	200 V	MME	Fixed	324500						
C134	0.015 μF	200 V	MME	Fixed	324500	R201	3.9 kΩ	1/4W 5%	CF	Fixed	311547
C135	100 μF	12 V	EM	Fixed	323160	R202	5.1 kΩ	1/4W 5%	CF	Fixed	311550
C136	10 μF	16 V	EM	Fixed	323310	R203	3.9 kΩ	1/4W 5%	CF	Fixed	311547
C137	10 μF	16 V	EM	Fixed	323310	R204	1 kΩ	1/4W 5%	CF	Fixed	311533
C138	100 μF	6 V	EM	Fixed	322980	R205	1 kΩ	1/4W 5%	CF	Fixed	311533
C139	100 μF	6 V	EM	Fixed	322980	R206	2 kΩ	1/4W 5%	CF	Fixed	311540
C141	0.01 μF	200 V	MME	Fixed	324490	R207	12 kΩ	1/4W 5%	CF	Fixed	311559
C142	10 μF	16 V	EM	Fixed	323310	R208	15 Ω	1/4W 5%	CF	Fixed	311650
C143	100 μF	3 V	EM	Fixed	322800	R209	12 kΩ	1/4W 5%	CF	Fixed	311559
C144	100 μF	6 V	EM	Fixed	322980	R210	2 kΩ	1/4W 5%	CF	Fixed	311540
C145	10 μF	16 V	EM	Fixed	323310	R211	2 kΩ		Film	Var	322059
C146	0.0015 μF	200 V	MME	Fixed	324410	R212	560 Ω	1/4W 5%	CF	Fixed	311527
C147	10 pF	200 V	Cer	Fixed	325250	R213	3 kΩ	1/4W 5%	CF	Fixed	311544
C148	5-25 pF	600 V	Cer	Var	325820	R214	4.3 kΩ	1/4W 5%	CF	Fixed	311548
C149	180 pF	1 kV	Cer	Fixed	325400	R215	5.1 kΩ	1/4W 5%	CF	Fixed	311550
C150	.068 F	100 V	MME	Fixed	324260	R216	1.8 kΩ	1/4W 5%	CF	Fixed	311539
C151	.068 F	100 V	MME	Fixed	324260	R217	2 kΩ	1/4W 5%	CF	Fixed	311540
C152	10 pF	1 kV	Cer	Fixed	325250	R218	7.5 kΩ	1/4W 1%	Film	Fixed	316300
C153	10 pF	1 kV	Cer	Fixed	325250	R219	2.7 Ω	2 W 5%	WW	Fixed	319830
C154	10 pF	1 kV	Cer	Fixed	325250	R221	1 kΩ	1/4W 5%	CF	Fixed	311533
C155	10 pF	1 kV	Cer	Fixed	325250	R222	68 kΩ	1/4W 5%	CF	Fixed	311577
Transistors & Diodes						R223	180 Ω	1/4W 5%	CF	Fixed	311515
						R224	2.5 kΩ		Film	Var	322058
						R226	20 kΩ	1/4W 1%	Film	Fixed	316490
						R227	20 kΩ	1/4W 5%	CF	Fixed	311564
CR101	1N270				327990						
CR102	1N270				327990						
CR103	1N270				327990						

PARTS LIST MODEL 9640

Schematic			Item		
Ref.	Value	Spec	Type	No.	
R228	560 Ω	1/4W 5%	CF Fixed	311527	
C201	10 μ F	6 V	EM Fixed	323310	
C202	0.0015 μ F	200 V	MME Fixed	324410	
C203	0.0015 μ F	200 V	MME Fixed	324410	
C204	0.01 μ F	200 V	MME Fixed	324490	
C205	0.01 μ F	200 V	MME Fixed	324490	
C206	0.01 μ F	200 V	MME Fixed	324490	
C207	1 μ F	6 V	EM Fixed	322910	
C208	200 μ F	12 V	EM Fixed	323170	
C209	0.022 μ F	200 V	MME Fixed	324510	
C210	100 μ F	6 V	EM Fixed	322980	

Transistors & Diodes

CR201	1N5293 A	9.1 V		328490	
CR202	1N5293 A	9.1 V		328490	
CR203	1N461			328010	
CR204	1N461			328010	
CR205	1N461			328010	
CR206	1N5232 A	5.6 V		328460	
CR207	1N461			328010	
CR208	1N461			328010	
CR209	1N461			328010	
CR210	1N5229 A	4.3 V		328430	
Q201	2N3905			329040	
Q202	2N3905			329040	
Q203	2N3403			328940	
Q204	2N3403			328940	
Q205	2N3905			329040	
Q206	2N3903			329030	
Q207	2N3905			329040	
Q208	2N3903			329030	

Transformers

T101	Output Transformer LA-1886	326250	
T201	Current-Sensing Transformer LA-1884	326240	
T202	Current Output Transformer LA-1930	326300	

Parts List for Auxiliary Amplifier

Schematic			Item		
Ref.	Value	Spec	Type	No.	
R312	5 k Ω	10%	WW Var	315081	
R314	1.18 k Ω	1/8 W 1%	Film Fixed	315100	
R315	2.87 k Ω	1/8 W 1%	Film Fixed	315100	
R316	2.87 k Ω	1/8 W 1%	Film Fixed	315100	
R317	300 Ω	1/4 W 5%	CF Fixed	311520	
R318	300 Ω	1/4 W 5%	CF Fixed	311520	
R319	50 k Ω		Cer Var	322055	
C305	200 μ F	25 V	EM Fixed	323400	
C306	200 μ F	25 V	EM Fixed	323400	
C307	0.01 μ F	200 V	MME Fixed	324490	
C308	0.01 μ F	200 V	MME Fixed	324490	
CR310		1N4003		328090	
CR311		1N4003		328090	
CR312		1N4003		328090	
CR313		1N4003		328090	
CR314		VR-15		328510	
CR315		VR-15		328510	
CR316		1N4003		328090	
CR317		1N4003		328090	
IC301		0P7/ μ A714		330040	
J301		JUMPER		-	

WARRANTY

F.W. BELL, INC. warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to replacing any defective parts thereof (excluding batteries). This warranty covers instruments which, within one year after delivery to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to our satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

F.W. BELL, INC. reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F.W. BELL, INC., and F.W. BELL, INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F.W. BELL, INC. instruments.

DAMAGE IN SHIPMENT

The instrument should be examined and tested as soon as it is received. If it does not operate properly, or is damaged in any way, immediately file a claim with the carrier. The claim agent will provide report forms. A copy of the completed form should be forwarded to us. We will then make the necessary arrangements for repair or replacement. All correspondence concerning this instrument should include model and serial numbers.

SHIPPING INSTRUCTIONS

Contact the factory for Return Material Authorization number (RMA #) prior to shipping. All returns must be shipped to the factory with an RMA #.

Use the original shipping carton and inserts, if possible, or pack the instrument in a sturdy container and surround the entire instrument with two to three inches of shock-absorbing material.

Ship to:

**F.W. BELL, INC. • Repair Department
6120 Hanging Moss Road • Orlando, FL 32807
Phone: 407-678-6900**