SYPRIS
TEST & MEASUREMENT

F.W. BELL

9000

SERIES
GAUSSMETERS

Operation & Maintenance Manual

MODEL

9640 GAUSSMETER

UN-01-190 Rev. A ECO No. 12309 Item No. 359640

MODEL 9640

9000 SERIES GAUSSMETERS

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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

MODEL 9640 GAUSSMETER DESCRIPTION

I-A INTRODUCTION

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 Sypris Test & Measurement.

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 ±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 ±0.25% of full scale plus ±0.02 gauss, and the internal calibration accuracy is ±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 ±0.25% of full scale, plus ±0.02 gauss (instrument), plus ±0.3% of reading (internal calibration), plus ±1.0% of reading (probe) for a total system accuracy of ±0.25% of full scale, plus ±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) <u>For Incremental Measurements</u>: ±1% to ±3% of incremental range depending on probe type and absolute field magnitude.

(c) <u>For ac fields</u>: 0 to 60 Hz; dc field accuracy plus ±1% of reading 60 to 400 Hz; dc field accuracy plus ±10% of reading.

(d) <u>Meter Scale Tracking Error</u>: For dc field meter readout; ±1% of full scale. For ac field meter readout 10 to 400 Hz; ±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) STABLILITY

(a) Line Voltage: Error unmeasureable for ±10% line voltage changes.

(b) Temperature effects excluding probe influences: Approx ±3% of reading total over the range of -0° C to +70° 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 kΩ 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 Ω (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

Front Panel

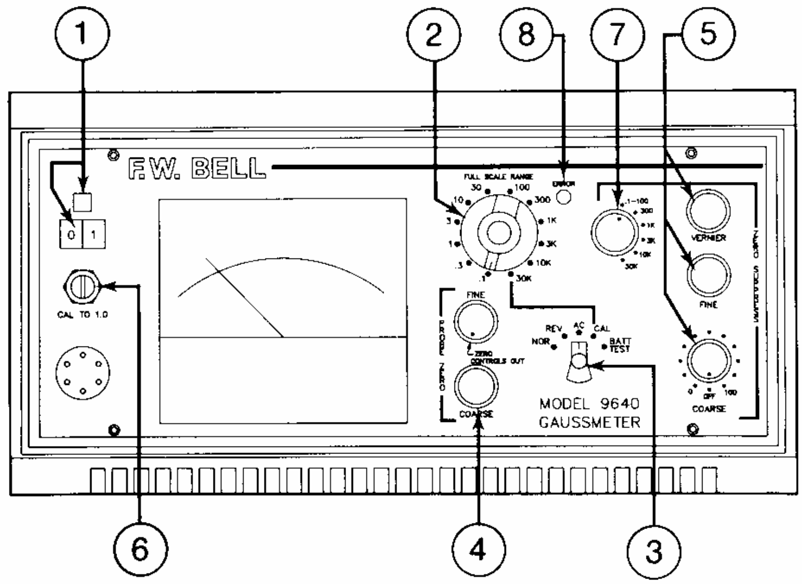

Figure II-A
Front Panel

(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

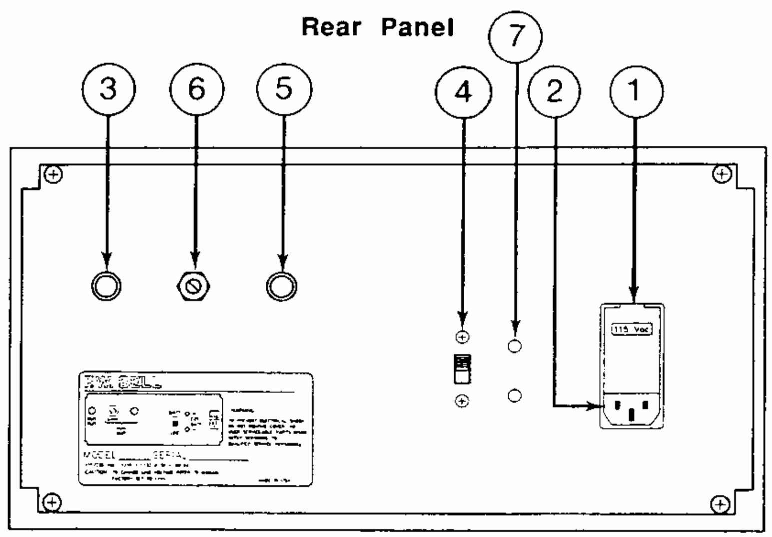

Figure II-B
Rear Panel

(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.

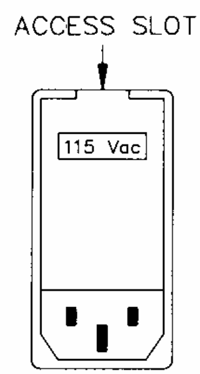

Figure II-C
Rear Panel Power Receptacle

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 <1Ω 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) External Battery Terminals (option)

These terminals are installed on the 9640AUX only.The 9640AUX is a modified 9640, with binding posts added to the rear of the cabinet to allow instrument operation from an external dc power source of 9 to 18 volts. The BATT-LINE switch function remains the same as outlined in this manual except the external dc input will automatically take over operation of the instrument in the event of ac power loss (with BATT-LINE in the BATT position and an external dc supply connected to the binding posts).

(8) Overall Dimension

7.53 in (19.1 cm) high
13.47 in (34.2 cm) wide
14.21 in (36.1 cm) deep

(9) 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

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 ±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 ±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

OPERATING INSTRUCTIONS

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 Sypris Test & Measurement 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

SECTION IV continued
Operating Instructions

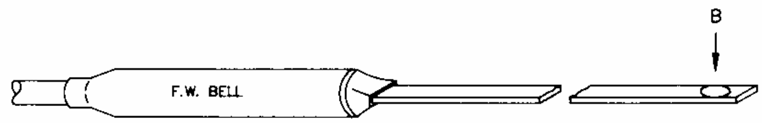

Figure IV-A
Probe Orientation Versus Readout Polarity

(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 Sypris Test & Measurement 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 intern al 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 de-magnetized by slowing 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.

(4) To apply scale expansion the RANGE switch is rotated to the 10 G range for maximum expansion.

(5) The FINE and VERNIER SUPPRESSION controls are trimmed to obtain a precise zero.

(6) The instrument is now operating in its incremental mode. An increase or decrease of 10 G in the 8.5 kG field will indicate as a plus or minus full scale meter reading on the red zero center incremental scale.

(d) AC Fields

For ac field measurements the FUNCTION switch is set to the AC position. The direction response of the Hall element is the same as for dc fields and alignment of the probe and field direction must be considered as described above. The meter is calibrated to read the rms value for a sine wave flux. If the field has much harmonic content, the reading will not be the true rms value. The ac detector is an averaging type circuit. For the non-sinusoidal wave forms within the 400 Hz band width, the average value can be obtained by multiplying the meter reading by 0.9. The meter reading and RANGE switch setting determine the field measurement just as in the case of dc field measurements. The frequency response for ac field measurements using the meter is from 10 Hz to 400 Hz. Frequencies outside this range will not indicate correctly on the meter. The amplifier system, however, is capable of operating from dc to 400 Hz, and measurements below 10 Hz can be made by using a dc coupled oscilloscope or low frequency voltmeter connected to the BNC connector. AC fields cannot be read incrementally because the suppression controls can suppress only steady dc fields or the dc component of an alternating field.

(e) Overloading

Because the amplifying system used in this gaussmeter will amplify ac and dc fields simultaneously, attempting to measure a small ac field in the presence of a large dc field or a small dc field in the presence of a large ac field can overload the amplifier and cause erroneous measurements. Also when making incremental dc field measurements any ac ripple on the field can cause difficulty especially at high scale expansion. When measuring dc fields absolute or incremental, especially on the sensitive ranges, check for ac fields by switching to AC. If an ac reading exceeding 1/3 of full scale on the range in use is encountered, the dc measurement may be in error. Switch to the next less sensitive range. If the dc reading has not changed, the ac component of the field has not overloaded the amplifier. If at any time there is a discrepancy between ranges of more than 2% of full scale on the meter, there is the possibility that the amplifier is being overloaded, and the above tests should be made. Also, when making ac measurements the component of any dc fields must be kept below 10% of the range in use. This can usually be accomplished by using the ac controls to suppress the small Earth's field or residual fields. Relative zeroing as described in Section IV-B2 will remove any dc fields up to 30 G. If this is not sufficient to prevent overloading, the suppression controls may be used or a less-sensitive-than-normal range can be used to prevent the undesired dc field from overloading the amplifier.

(5) TEMPERATURE EFFECTS

All probes exhibit a certain temperature coefficient. This value can be found in the specifications for the type of probe being used. If the probe 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 kΩ 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 the time of purchase or by returning the probe to Sypris Test & Measurement. 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:

GAUSS = WEBERS PER SQUARE METER X 10^4
GAUSS = LINES PER SQUARE INCH X .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 undirectional over a given area, the total flux through the area is found by multiplying the area in question.

(Flux) WEBERS = GAUSS X SQ. METERS X 10^{-4}
= GAUSS X SQ. CM X 10^{-8}
(Flux) LINES = $\dfrac{\text{GAUSS X SQ. INCHES}}{.1550}$

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

THEORY OF OPERATION

V-A GENERAL

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.)

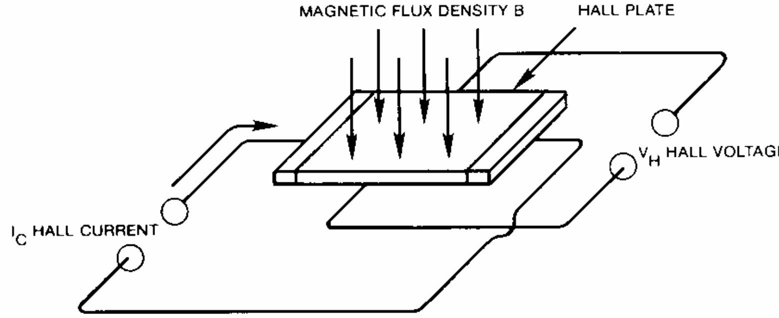

Figure V-A
Sensing Element

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 Lorenz 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.

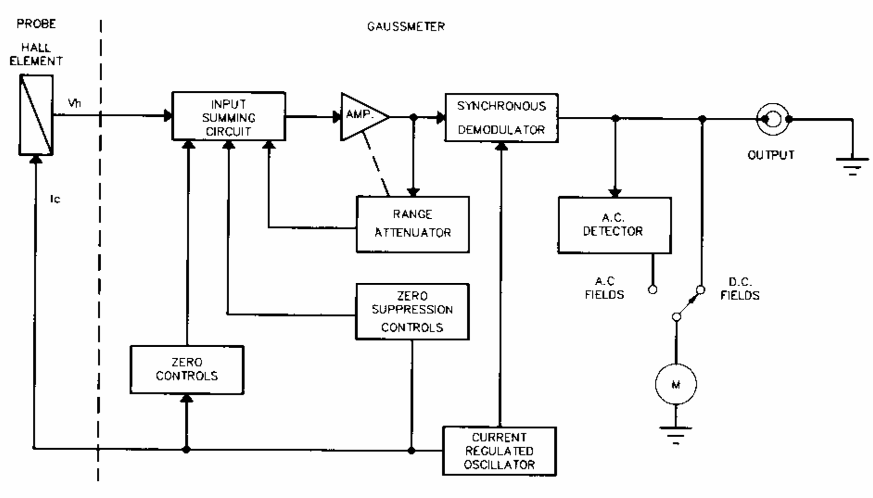

Figure V-B
Simplified Block Diagram

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.

(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 Ω (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.

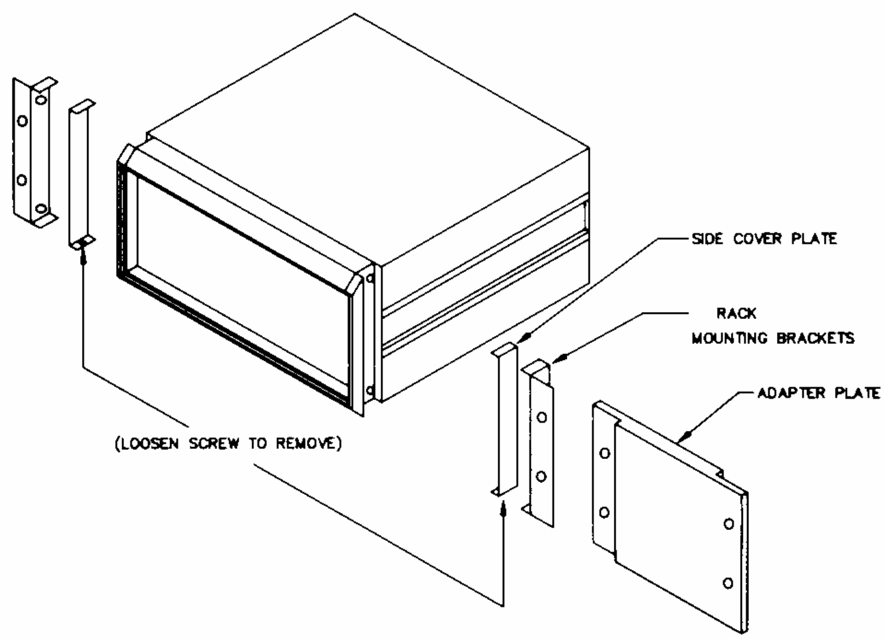

Figure VIII-A
Rack Mounting Installation

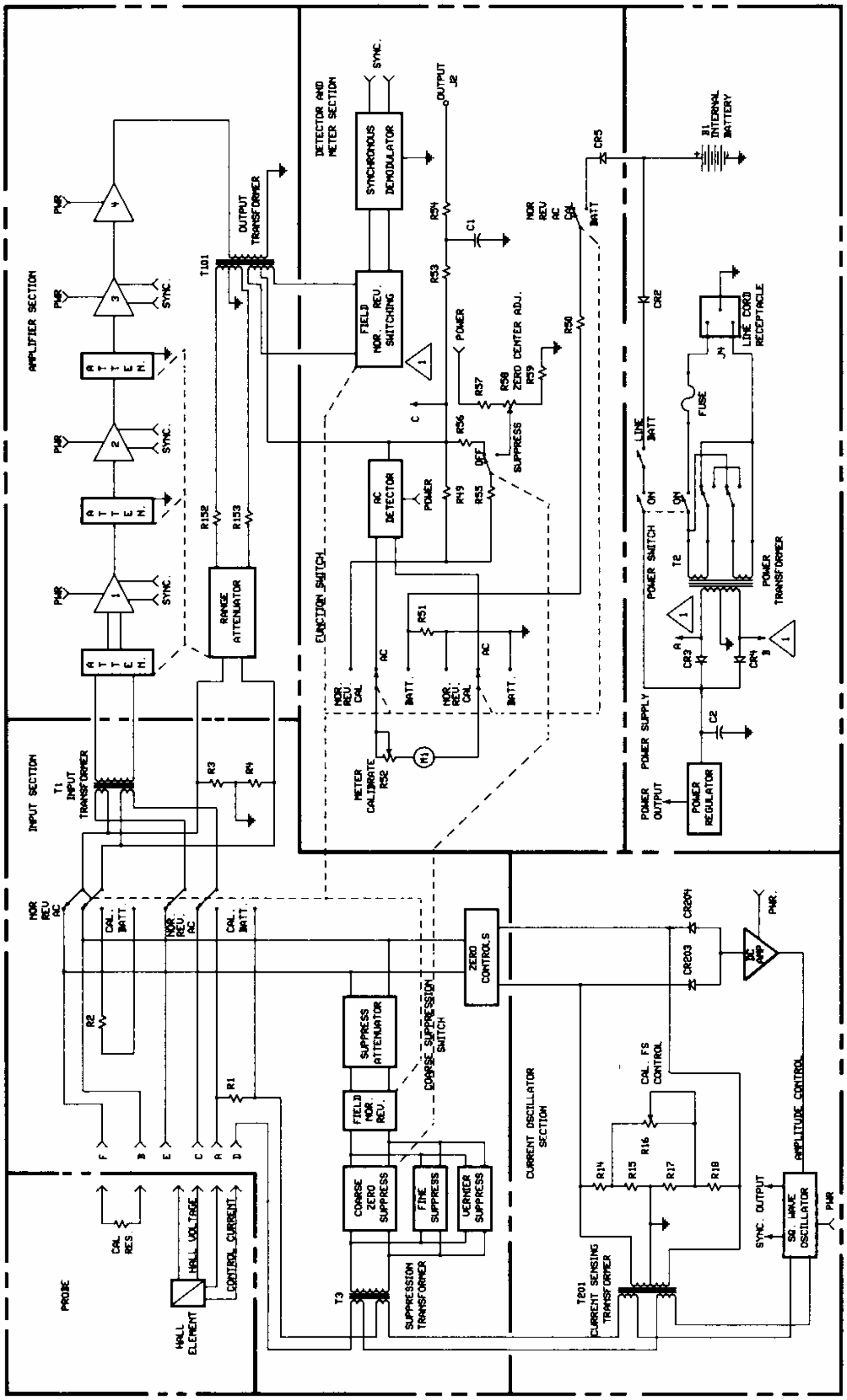

Figure IX-A
Block Diagram

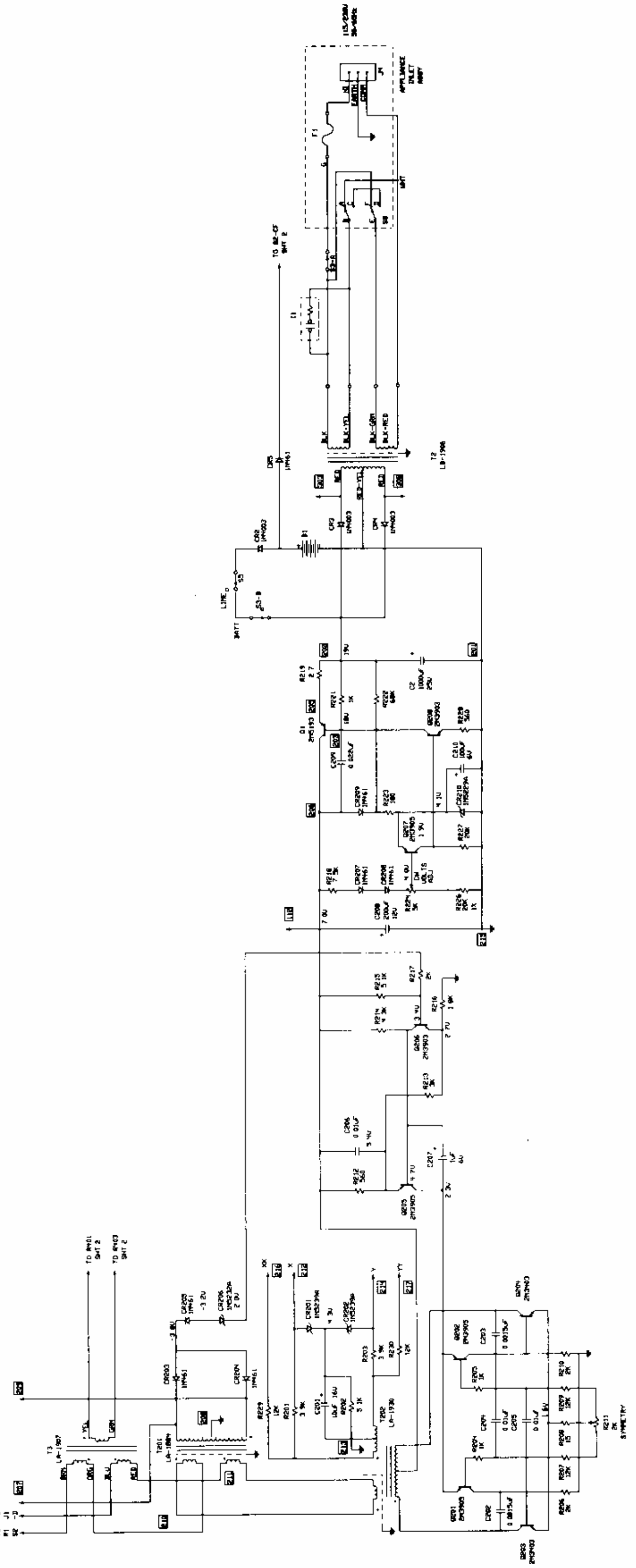

Figure IX-B
Schematic Diagram #1

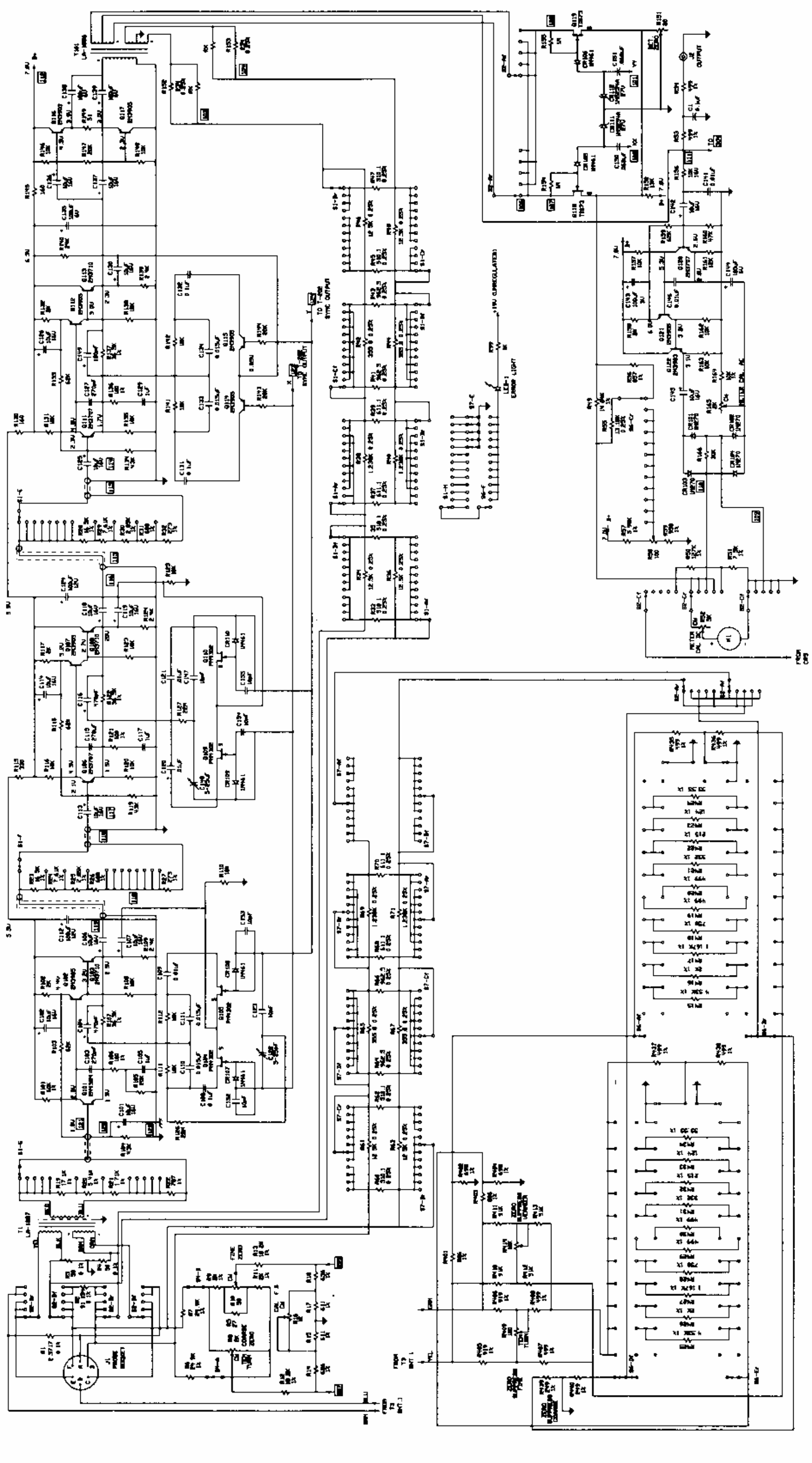

Figure IX-C
Schematic Diagram #2

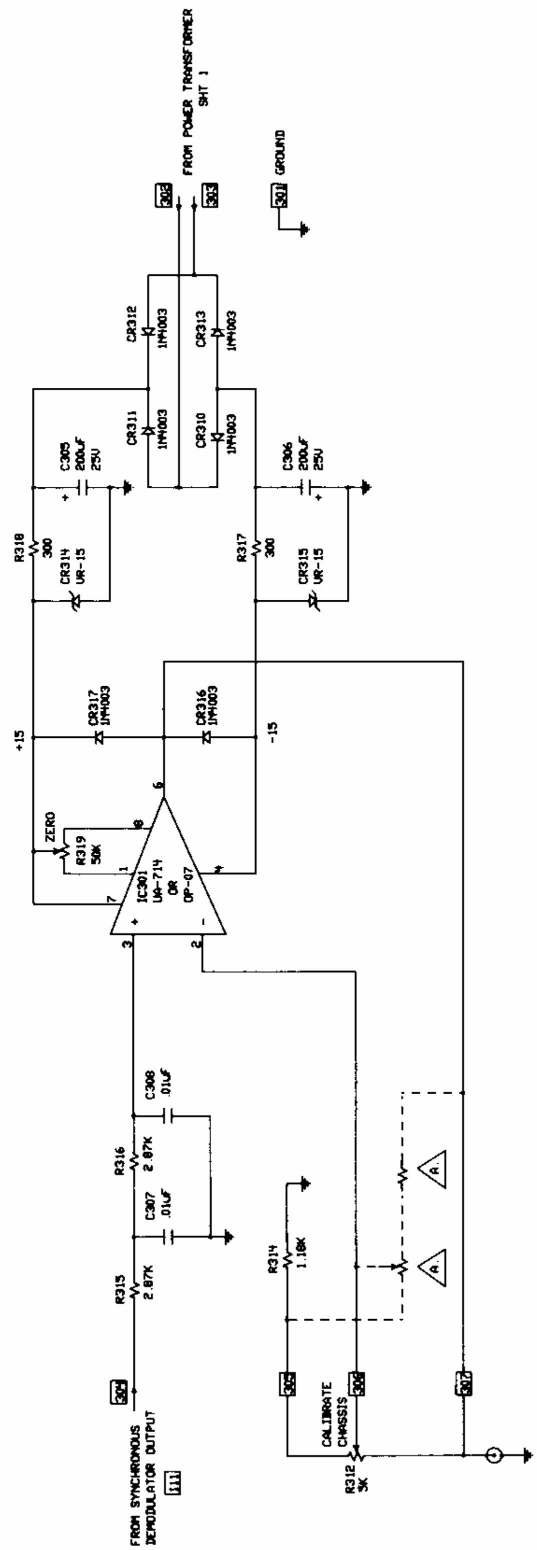

Figure IX-D
Schematic Diagram #3

SECTION X MODEL 9640 PARTS LIST
ABBREVIATIONS

Cer	Ceramic	K	kilo or 10^3
CF	Carbon film	µ	Micro or 10^{-6}
Comp	Compostion	M	Mega or 10^6
EC	Electrolytic can type	MME	Molded miniature epoxy
EM	Electrolytic miniature type	Ω	ohm
F	Farad	p	Pico or 10^{-12}
Film	Metal film	V	Working Volts
Fixed	Fixed	Var	Variable
FOP	Factory adjusted for optimum performance	W	Watt
HM	Hot molded	WW	Wire Wound

PARTS LIST MODEL 9640

Schematic Ref.	Value	Spec		Type		Item No.
R1	2.3717 Ω	1/10W	1/10%	WW	Fixed	318370
R2	91.54 Ω	1/10W	1/10%	WW	Fixed	318420
R3	50 Ω	1/10W	1/10%	WW	Fixed	318400
R4	50 Ω	1/10W	1/10%	WW	Fixed	318400
R5	27 Ω	1/4W	5%	CF	Fixed	311485
R6	24.9 k	1/4W	1%	Film	Fixed	316151
R7	24.9 k	1/4W	1%	Film	Fixed	316151
R8	2 kΩ			WW	Var	321710
R9	2 kΩ	1/4W	1%	Film	Fixed	316150
R10	50 Ω	(Part of S4)		HM	Var	321140
R11	2 kΩ	1/4W	1%	Film	Fixed	316150
R12	18.2 kΩ	1/4W	1%	Film	Fixed	316480
R13	18.2 kΩ	1/4W	1%	Film	Fixed	316480
R14	656 Ω	1/4W	1%	Film	Fixed	315966
R15	611 Ω	1/4W	1%	Film	Fixed	315965
R16	1Ω			HM	Var	321130
R17	611 Ω	1/4W	1%	Film	Fixed	315965
R18	656 Ω	1/4W	1%	Film	Fixed	315966
R19	17.1 kΩ	1/8W	1%	Film	Fixed	316470
R20	5.41 kΩ	1/8W	1%	Film	Fixed	316260
R21	1.71 kΩ	1/8W	1%	Film	Fixed	316130
R22	787 Ω	1/8W	1%	Film	Fixed	315065
R23	16.5 kΩ	1/8W	1%	Film	Fixed	316460
R24	7.68 k	1/8W	1%	Film	Fixed	316301
R25	2.05 kΩ	1/8W	1%	Film	Fixed	316160
R26	608 Ω	1/8W	1%	Film	Fixed	315960
R27	273 Ω	1/8W	1%	Film	Fixed	315870
R28	16.5 kΩ	1/8W	1%	Film	Fixed	316460
R29	7.68 k	1/8W	1%	Film	Fixed	316301
R30	2.05 kΩ	1/8W	1%	Film	Fixed	316160
R31	608 Ω	1/8W	1%	Film	Fixed	315960
R32	273 Ω	1/8W	1%	Film	Fixed	315870
R33	510.1 Ω	1/8W	1/4%	Film	Fixed	315250
R34	12.5 kΩ	1/8W	1/4%	Film	Fixed	315290
R35	510.1 Ω	1/8W	1/4%	Film	Fixed	315250
R36	12.5 kΩ	1/8W	1/4%	Film	Fixed	315290
R37	611.1 Ω	1/8W	1/4%	Film	Fixed	315260
R38	1.238 kΩ	1/8W	1/4%	Film	Fixed	315280
R39	611.1 Ω	1/8W	1/4%	Film	Fixed	315260
R40	1.238 kΩ	1/8W	1/4%	Film	Fixed	315280
R41	962.5 Ω	1/8W	1/4%	Film	Fixed	315270
R42	355.8 Ω	1/8W	1/4%	Film	Fixed	315230
R43	962.5 Ω	1/8W	1/4%	Film	Fixed	315270
R44	355.8 Ω	1/8W	1/4%	Film	Fixed	315230
R45	510.1 Ω	1/8W	1/4%	Film	Fixed	315250
R46	12.5 kΩ	1/8W	1/4%	Film	Fixed	315290
R47	510.1 Ω	1/8W	1/4%	Film	Fixed	315250
R48	12.5 kΩ	1/8W	1/4%	Film	Fixed	315290
R49	14.04 kΩ	1/2W	1%	Film	Fixed	316990
R50	127 kΩ	1/4W	1%	Film	Fixed	316650
R51	7.5 kΩ	1/4W	1%	Film	Fixed	316300
R52	5 kΩ			Film	Var	322046
R53	499 Ω	1/4W	1%	Film	Fixed	315919
R54	499 Ω	1/4W	1%	Film	Fixed	315919
R55	13.18 kΩ	1/8W	1/4%	Film	Fixed	315300
R56	857 Ω	1/8W	1%	Film	Fixed	316010
R57	5.90 kΩ	1/4W	1%	Film	Fixed	316265
R58	100 Ω			Film	Var	322039
R59	950 Ω	1/4W	1%	Film	Fixed	316040
R60	510.1 Ω	1/8W	1/4%	Film	Fixed	315250
R61	12.5 kΩ	1/8W	1/4%	Film	Fixed	315290
R62	510.1 Ω	1/8W	1/4%	Film	Fixed	315250
R63	12.5 kΩ	1/8W	1/4%	Film	Fixed	315290
R64	962.5 Ω	1/8W	1/4%	Film	Fixed	315270
R65	355.8 Ω	1/8W	1/4%	Film	Fixed	315230
R66	962.5 Ω	1/8W	1/4%	Film	Fixed	315270
R67	355.8 Ω	1/8W	1/4%	Film	Fixed	315230
R68	611.1 Ω	1/8W	1/4%	Film	Fixed	315260
R69	1.238 kΩ	1/8W	1/4%	Film	Fixed	315280
R70	611.1 Ω	1/8W	1/4%	Film	Fixed	315260
R71	1.238 kΩ	1/8W	1/4%	Film	Fixed	315280
R72	510.1 Ω	1/8W	1/4%	Film	Fixed	315250
R73	12.5 kΩ	1/8W	1/4%	Film	Fixed	315290
R74	510.1 Ω	1/8W	1/4%	Film	Fixed	315250
R401	806 Ω	1/4W	1%	Film	Fixed	316000
R402	698 Ω	1/8W	1%	Film	Fixed	315968
R403	806 Ω	1/4W	1%	Film	Fixed	316000
R404	698 Ω	1/8W	1%	Film	Fixed	315968
R405	919 Ω	1/4W	1%	Film	Fixed	316030
R406	919 Ω	1/4W	1%	Film	Fixed	316030
R407	499 Ω	1/4W	1%	Film	Fixed	315919
R408	499 Ω	1/4W	1%	Film	Fixed	315919
R409	100 Ω			WW	Var	321720
R410	91 kΩ	1/4W	5%	CF	Fixed	311580
R411	91 kΩ	1/4W	5%	CF	Fixed	311580
R412	51 kΩ	1/4W	5%	CF	Fixed	311574
R413	51 kΩ	1/4W	5%	CF	Fixed	311574
R414	10 kΩ			HM	Var	321150
R415	4.53 kΩ	1/8W	1%	Film	Fixed	316225
R416	2 kΩ	1/8W	1%	Film	Fixed	316150

PARTS LIST MODEL 9640

Schematic Ref.	Value	Spec		Type		Item No.
R417	1.167 kΩ	1/8W	1%	Film	Fixed	316070
R418	750 Ω	1/8W	1%	Film	Fixed	315064
R419	499 Ω	1/8W	1%	Film	Fixed	315919
R420	499 Ω	1/8W	1%	Film	Fixed	315919
R421	332 Ω	1/8W	1%	Film	Fixed	315888
R422	215 Ω	1/8W	1%	Film	Fixed	315849
R423	124 Ω	1/8W	1%	Film	Fixed	315199
R424	55.55 Ω	1/8W	1%	Film	Fixed	315650
R425	4.53 kΩ	1/8W	1%	Film	Fixed	316225
R426	2 kΩ	1/8W	1%	Film	Fixed	316150
R427	1.167 kΩ	1/8W	1%	Film	Fixed	316070
R428	750 Ω	1/8W	1%	Film	Fixed	315980
R429	499 Ω	1/8W	1%	Film	Fixed	315919
R430	499 Ω	1/8W	1%	Film	Fixed	315919
R431	332 Ω	1/8W	1%	Film	Fixed	315888
R432	215 Ω	1/8W	1%	Film	Fixed	315849
R433	124 Ω	1/8W	1%	Film	Fixed	315199
R434	55.55 Ω	1/8W	1%	Film	Fixed	315650
R435	499 Ω	1/8W	1%	Film	Fixed	315919
R436	499 Ω	1/8W	1%	Film	Fixed	315919
R437	499 Ω	1/8W	1%	Film	Fixed	315919
R438	499 Ω	1/8W	1%	Film	Fixed	315919
R439	249 Ω	1/8W	1%	Film	Fixed	315855
R440	249 Ω	1/8W	1%	Film	Fixed	315855
C1	0.1 mF	200V		MME	Fixed	324550
C2	1000 mF	25V		EC	Fixed	323930

Transistors and Diodes

CR2	1N4003	328090
CR3	1N4003	328090
CR4	1N4003	328090
CR5	1N461	328010
Q1	2N5193	329201

Transformers

T1	Input Transformer LA-1887	326260
T2	Power Transformer LB-1906	326270
T3	Suppression Transformer LA-1907	326280

Switches

S1	Range Switch Assembly	201575
S2	Function Switch Assembly	201147
S3	Power Switch	334590
S4	Zero Out Switch (Part of Fine Zero Control, R10)	321140
S5	Batt Line Switch	333660
S6	Zero Suppression Switch Assembly	201577
S7	Suppress Range Switch Assembly	201576

Meter

M1	0-100 mA Meter MB-1927	310530

The following parts are on the amplifier circuit board assembly, 201125

Schematic Ref.	Value	Spec		Type		Item No.
R101	10 kΩ	1/4W	1%	Film	Fixed	316350
R102	2 kΩ	1/4W	5%	CF	Fixed	311540
R103	62 kΩ	1/4W	5%	CF	Fixed	311576
R104	43 kΩ	1/4W	5%	CF	Fixed	311572
R105	10 kΩ	1/4W	5%	CF	Fixed	311557
R106	100 Ω	1/4W	1%	Film	Fixed	315790
R107	36.5 kΩ	1/4W	1%	Film	Fixed	316550
R108	10 kΩ	1/4W	5%	CF	Fixed	311557
R109	2.4 kΩ	1/4W	5%	CF	Fixed	311542
R110	10 kΩ	1/4W	5%	CF	Fixed	311557
R111	10 kΩ	1/4W	5%	CF	Fixed	311557
R112	10 kΩ	1/4W	5%	CF	Fixed	311557
R115	330 Ω	1/4W	5%	CF	Fixed	311521
R116	10 kΩ	1/4W	5%	CF	Fixed	311557
R117	2 kΩ	1/4W	5%	CF	Fixed	311540
R118	62 kΩ	1/4W	5%	CF	Fixed	311576
R119	43 kΩ	1/4W	5%	CF	Fixed	311572
R120	10 kΩ	1/4W	5%	CF	Fixed	311557
R121	100 Ω	1/4W	1%	Film	Fixed	315790
R122	36.5 kΩ	1/4W	1%	Film	Fixed	316550
R123	10 kΩ	1/4W	5%	CF	Fixed	311557
R124	2.4 kΩ	1/4W	5%	CF	Fixed	311542
R125	10 kΩ	1/4W	5%	CF	Fixed	311557
R126	22 MΩ	1/4W	5%	CF	Fixed	311636
R127	22 MΩ	1/4W	5%	CF	Fixed	311636
R130	160 Ω	1/4W	5%	CF	Fixed	311514
R131	10 kΩ	1/4W	5%	CF	Fixed	311557
R132	2 kΩ	1/4W	5%	CF	Fixed	311540
R133	62 kΩ	1/4W	5%	CF	Fixed	311576
R134	43 kΩ	1/4W	5%	CF	Fixed	311572
R135	10 kΩ	1/4W	5%	CF	Fixed	311557
R136	100 Ω	1/4W	1%	Film	Fixed	315790
R137	36.5 kΩ	1/4W	1%	Film	Fixed	316550
R138	10 kΩ	1/4W	5%	CF	Fixed	311557
R139	2.4 kΩ	1/4W	5%	CF	Fixed	311542
R140	24 kΩ	1/4W	5%	CF	Fixed	311566
R141	10 kΩ	1/4W	5%	CF	Fixed	311557
R142	10 kΩ	1/4W	5%	CF	Fixed	311557
R143	20 kΩ	1/4W	5%	CF	Fixed	311564
R144	20 kΩ	1/4W	5%	CF	Fixed	311564
R145	160 Ω	1/4W	5%	CF	Fixed	311514
R146	10 kΩ	1/4W	5%	CF	Fixed	311557
R147	20 kΩ	1/4W	5%	CF	Fixed	311564
R148	10 kΩ	1/4W	5%	CF	Fixed	311557
R149	51 Ω	1/4W	5%	CF	Fixed	311502
R150	13 kΩ	1/4W	5%	CF	Fixed	311560
R151	20 Ω			Film	Var	322074
R152	237 Ω	1/4W	1/4%	Film	Fixed	315852
R153	237 Ω	1/4W	1/4%	Film	Fixed	315852
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

PARTS LIST MODEL 9640

Schematic Ref.	Value	Spec		Type		Item No.
R166	30 kΩ	1/2W	5%	CF	Fixed	311568
C101	10 µF	16 V		EM	Fixed	323310
C102	10 µF	16 V		EM	Fixed	323310
C103	270 pF	1 kV		Cer	Fixed	325470
C104	570 pF	1 kV		Cer	Fixed	325500
C105	1 µF	100 V		MME	Fixed	324930
C106	10 µF	16 V		EM	Fixed	323310
C107	10 µF	16 V		EM	Fixed	323310
C108	0.1 µF	200 V		MME	Fixed	324550
C109	0.1 µF	200 V		MME	Fixed	324550
C110	0.015 µF	200 V		MME	Fixed	324500
C111	0.015 µF	200 V		MME	Fixed	324500
C112	100 µF	12 V		EM	Fixed	323160
C113	10 µF	16 V		EM	Fixed	323310
C114	10 µF	16 V		EM	Fixed	323310
C115	270 pF	1 kV		Cer	Fixed	325470
C116	470 pF	1 kV		Cer	Fixed	325500
C117	1 µF	100 V		MME	Fixed	324930
C118	10 µF	16 V		EM	Fixed	323310
C119	10 µF	16 V		EM	Fixed	323310
C120	0.01 µF	200 V		MME	Fixed	324490
C121	0.01 µF	200 V		MME	Fixed	324490
C122	5-25 pF	600 V		Cer	Var	325820
C123	10 pF	1000 V		Cer	Fixed	323310
C124	100 µF	12 V		EM	Fixed	323160
C125	10 µF	16 V		EM	Fixed	323310
C126	10 µF	16 V		EM	Fixed	323310
C127	270 pF	1 kV		Cer	Fixed	325470
C129	1 µF	100 V		MME	Fixed	324930
C130	10 µF	16 V		EM	Fixed	323310
C131	0.1 µF	200 V		MME	Fixed	324550
C132	0.1 µF	200 V		MME	Fixed	324550
C133	0.015 µF	200 V		MME	Fixed	324500
C134	0.015 µF	200 V		MME	Fixed	324500
C135	100 µF	12 V		EM	Fixed	323160
C136	10 µF	16 V		EM	Fixed	323310
C137	10 µF	16 V		EM	Fixed	323310
C138	100 µF	6 V		EM	Fixed	322980
C139	100 µF	6 V		EM	Fixed	322980
C141	0.01 µF	200 V		MME	Fixed	324490
C142	10 µF	16 V		EM	Fixed	323310
C143	100 µF	3 V		EM	Fixed	322800
C144	100 µF	6 V		EM	Fixed	322980
C145	10 µF	16 V		EM	Fixed	323310
C146	0.0015 µF	200 V		MME	Fixed	324410
C147	10 pF	200 V		Cer	Fixed	325250
C148	5-25 pF	600 V		Cer	Var	325820
C149	180 pF	1 kV		Cer	Fixed	325400
C150	.068 F	100 V		MME	Fixed	324260
C151	.068 F	100 V		MME	Fixed	324260
C152	10 pF	1 kV		Cer	Fixed	325250
C153	10 pF	1 kV		Cer	Fixed	325250
C154	10 pF	1 kV		Cer	Fixed	325250
C155	10 pF	1 kV		Cer	Fixed	325250

Transistors & Diodes

Schematic Ref.	Value	Spec	Type	Item No.
CR101		1N270		327990
CR102		1N270		327990
CR103		1N270		327990
CR104		1N270		327990
CR105		1N461		328010
CR106		1N461		328010
CR107		1N461		328010
CR108		1N461		328010
CR109		1N461		328010
CR110		1N461		328010
CR111		1N5254A		328520
CR112		1N5254A		328520
Q101		2N4384		329120
Q102		2N3905		329040
Q103		2N3710		329000
Q104		2N4302		329100
Q105		2N4302		329100
Q106		2N3707		328990
Q107		2N3905		329040
Q108		2N3710		329000
Q109		2N4302		329100
Q110		2N4302		329100
Q111		2N3707		328990
Q112		2N3905		329040
Q113		2N3710		329000
Q114		2N3905		329040
Q115		2N3905		329040
Q116		2N3903		329030
Q117		2N3905		329040
Q118		TIS73 or 2N4859A		329290
Q119		TIS73 or 2N4859A		329290
Q120		2N3707		328990
Q121		2N3905		329040
Q122		2N3903		329030

The following parts are on the power supply – current oscillator circuit board assembly 201126

Schematic Ref.	Value	Spec		Type		Item No.
R201	3.9 kΩ	1/4W	5%	CF	Fixed	311547
R202	5.1 kΩ	1/4W	5%	CF	Fixed	311550
R203	3.9 kΩ	1/4W	5%	CF	Fixed	311547
R204	1 kΩ	1/4W	5%	CF	Fixed	311533
R205	1 kΩ	1/4W	5%	CF	Fixed	311533
R206	2 kΩ	1/4W	5%	CF	Fixed	311540
R207	12 kΩ	1/4W	5%	CF	Fixed	311559
R208	15 Ω	1/4W	5%	CF	Fixed	311650
R209	12 kΩ	1/4W	5%	CF	Fixed	311559
R210	2 kΩ	1/4W	5%	CF	Fixed	311540
R211	2 kΩ			Film	Var	322059
R212	560 Ω	1/4W	5%	CF	Fixed	311527
R213	3 kΩ	1/4W	5%	CF	Fixed	311544
R214	4.3 kΩ	1/4W	5%	CF	Fixed	311548
R215	5.1 kΩ	1/4W	5%	CF	Fixed	311550
R216	1.8 kΩ	1/4W	5%	CF	Fixed	311539
R217	2 kΩ	1/4W	5%	CF	Fixed	311540
R218	7.5 kΩ	1/4W	1%	Film	Fixed	316300
R219	2.7 Ω	2 W	5%	WW	Fixed	319830
R221	1 kΩ	1/4W	5%	CF	Fixed	311533
R222	68 kΩ	1/4W	5%	CF	Fixed	311577
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

PARTS LIST MODEL 9640

Schematic Ref.	Value	Spec		Type		Item No.
R228	560 Ω	1/4W	5%	CF	Fixed	311527
C201	10 µF	6 V		EM	Fixed	323310
C202	0.0015 µF	200 V		MME	Fixed	324410
C203	0.0015 µF	200 V		MME	Fixed	324410
C204	0.01 µF	200 V		MME	Fixed	324490
C205	0.01 µF	200 V		MME	Fixed	324490
C206	0.01 µF	200 V		MME	Fixed	324490
C207	1 µF	6 V		EM	Fixed	322910
C208	200 µF	12 V		EM	Fixed	323170
C209	0.022 µF	200 V		MME	Fixed	324510
C210	100 µF	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 Ref.	Value	Spec		Type		Item No.
R312	5 kΩ		10%	WW	Var	315081
R314	1.18 kΩ	1/8 W	1%	Film	Fixed	315100
R315	2.87 kΩ	1/8 W	1%	Film	Fixed	315100
R316	2.87 kΩ	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 kΩ			Cer	Var	322055
C305	200 µF	25 V		EM	Fixed	323400
C306	200 µF	25 V		EM	Fixed	323400
C307	0.01 µF	200 V		MME	Fixed	324490
C308	0.01 µF	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/µA714				330040
J301		JUMPER				–

WARRANTY

Sypris Test & Measurement 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.

Sypris Test & Measurement 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 Sypris Test & Measurement and Sypris Test & Measurement neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of Sypris Test & Measurement 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:
Sypris Test & Measurement
Repair Department
6120 Hanging Moss Road • Orlando, FL 32807
Phone: 407-678-6900