♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

1981-B
Precision Sound-Level Meter

User and Service Manual

IET LABS, INC.
formerly manufacturer by
GenRad

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- Combinations of functions, special ranges, ratings, or accuracies.
- Replacement for discontinued models from other manufacturers.
- Calibration and repair services - NIST traceable.
- Compliant with ISO 9001, ISO 17025, ANSI Z540-1-1994, and MIL-STD-45662A.

Capabilities

- **R**: 20 μΩ-1 TΩ
- **C**: <1 pF - 1 F
- **L**: 100 μH-100 H
- Accuracy to 1 ppm
- Resolution to 0.1 ppm
- Voltage to 20 kV
- Power to over 1000 W
- Programmable IEEE-488 or BCD

WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable IET specifications. If within one year after original shipment, it is found not to meet this standard, it will be repaired or, at the option of IET, replaced at no charge when returned to IET. Changes in this product not approved by IET or application of voltages or currents greater than those allowed by the specifications shall void this warranty. IET shall not be liable for any indirect, special, or consequential damages, even if notice has been given to the possibility of such damages.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTIBILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.

WARNING

OBSERVE ALL SAFETY RULES
WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

Dangerous voltages may be present inside this instrument. Do not open the case
Refer servicing to qulified personnel

HIGH VOLTAGES MAY BE PRESENT AT THE TERMINALS OF THIS INSTRUMENT

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS.

USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE CONDUCTORS WHEN USING THIS INSTRUMENT.

Use extreme caution when working with bare conductors or bus bars.

WHEN WORKING WITH HIGH VOLTAGES, POST WARNING SIGNS AND KEEP UNREQUIRED PERSONNEL SAFELY AWAY.

CAUTION

DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON THE FRONT PANEL OR THE OPERATING GUIDE LABEL.

Specifications

Handbook of Noise Measurement

This book, by Dr. A. P. G. Peterson and Ervin E. Gross, Jr., of the GenRad Engineering Staff covers thoroughly the subject of noise and vibration measurement. Copies are available from GenRad at $9.00 each, postpaid in the United States and Canada.

GR P/N 5301-8111

Measurement Range and Response Characteristics: SOUND LEVEL RANGES: 30 to 80 dB(A) and 70 to 120 dB(A), selected by side-panel switch. Minimum measurable level with 1/2-in. electret microphone, 35 dB(A) typical. 0-dB reference is 20 μPa.* FREQUENCY RESPONSE: "A" weighting. DETECTOR CHARACTERISTICS: Rms response. Crest-factor capacity, X5 at full scale. Dynamics: fast and slow, switch selected. US PATENT: No. 3681618.

Displays: ANALOG: Meter, with two 50-dB scales calibrated in 1-dB increments. DIGITAL READOUT: 4-digit with decimal point, "LED". 7-segment numerals; increments 0.1 dB. DIGITAL-DISPLAY MODES: OFF, for minimum battery drain; CONTINUOUS, like meter except present reading can be "captured" by pushbutton; MAXIMUM, automatically holds highest level in measurement interval, until reset by pushbutton.

Microphone and Preamplifier: MICROPHONE: GR 1/2-in. electret-condenser**, 2 response types (see description). MICROPHONE CONNECTOR: input impedance approx 2 GΩ, parallel 3 pF. AC OUTPUT: weighted, 500 mV nominal full scale, behind 5 kΩ. DC OUTPUT: approx 10 mV/dB, linear, 500 mV nom fs, behind 100 kΩ. Both outputs are short-circuit-proof; both receive subminiature phone plugs (.097 in, 2.5 mm dia). PREAMPLIFIER: plugs into "nose cone" of instrument and receives microphone. Preamplifier with microphone is easily removed for remote mounting with extension cable (10 to 60 ft, see supplied and available accessories, below).

Calibration: FACTORY: The sound-level meter with microphone is fully tested and calibrated to all specifications; acoustical response and sensitivity are measured in a free field by comparison with a Western Electric Type 640AA Laboratory Standard Microphone whose calibration is traceable to the U.S. National Bureau of Standards. FIELD: G.R. 1562-A or 1567 Sound-Level Calibrators are available for making an overall pressure calibration. Calibrator included in systems 1981-9760, -9761, -9762, -9763.

Option: Digital data output capability; ask GR factory for details.

Power: Removable battery pack containing 3 AA-size nickel-cadmium rechargeable cells with charger interlock. Battery life between recharges, 5 to 10 hours depending on digital display usage. Battery charger (supplied), for 115/220 V ac 50-60 Hz operation; full recharge accomplished in about 4 hours. Instrument may be operated continuously from AC power by using charger; in this case battery pack is trickle-charged. Three AA-size primary cells (not rechargeable) may be used in place of the battery pack.

Environment: TEMPERATURE: −10° to +50°C operating, +15° to +50°C battery charging, −25° to +60°C storage with battery pack supplied. HUMIDITY: 0 to 90% R.H., operating within ±0.5 dB and storage.

Mechanical: (-9750 or -9751): DIMENSIONS (wxhxd): 87x280x59 mm (3.4x11x2.3 in.). WEIGHT: 0.8 kg (28 oz) net, 1.8 kg (4 lb) shipping. Systems (-9760, -9761): DIMENSIONS: 480x380x160 mm (19x15x6.3 in.). WEIGHT: 8 kg (17 lb) shipping. Sets (-9762, -9763): WEIGHT: 3.6 kg (8 lb) shipping.

Supplied: BASIC PKG: Rechargeable battery pack, battery charger, wrist strap, carrying pouch, jeweler's screwdriver for calibration, plugs to fit output jacks, extension cable length 3 m (10 ft).
1981-9750: Basic package. 1981-9751: same.
1981-9760: Basic pkg, 1567 Sound-Level Calibrator and adaptor, spare battery pack, extension cable length 18 m (60 ft), tripod, windscreen, light-stand adaptor, and attache-type carrying case.
1981-9761: (Same as -9760).
1981-9762: Basic pkg, 1567 Sound-Level Calibrator, with case and accessories.
1981-9763: (Same as -9762).

Available: (GR catalog number and description.)

EXTENSION CABLES:
1933-9600* cable, 3 m (10 ft).
1933-9601* cable, 18 m (60 ft).

ADAPTOR CABLES, for connection to outputs, all 3 ft (0.9 m) long:

1560-9677	Subminiature phone plug to GR 274 double banana plug.
1560-9679	Subminiature phone plug to BNC male.
1560-9678	Subminiature phone plug to standard (0.250 inch dia.) phone plug.
1560-9680	Subminiature phone plug to standard phone jack.

OTHER ACCESSORIES:

1981-9602*	Spare Rechargeable Battery Pack.
1560-9609	Dummy microphone, 35 pF with BNC jack.
1981-9660*	Rigid carrying case, includes space for calibrator. tripod, and miscellaneous small accessories.
1560-9522*	Windscreen for microphone (package of 4 pcs.)
1560-9590*	Tripod, will mount 1981 or an external preamp.
1562-9701	Calibrator, Type 1562-A, for calibration at five frequencies. (Includes coupler adaptor for 1981 microphone).
1567-9701*	Calibrator, Type 1567, single frequency. This calibrator includes a coupler adaptor for the 1/2-inch microphone of the 1981.
1985-9700	Recorder, dc strip-chart recorder with 10-cm scale for 50-dB span of sound levels (full scale can be set to 500 mV) and 12 feed rates from 2 cm/h to 60 cm/min, uses Z-fold paper.

*Starred items are the types listed above under "supplied".

Description	Catalog Number
Precision Sound-Level Meter with flat random-incidence response Electret-Condenser Microphone. Conforms to IEC 651, and to ANSI S1.4-1971, Type S1A (use 1567 or 1562-A Sound-Level Calibrator).	**1981-9750**
Precision Sound-Level Meter with flat perpendicular-incidence response Electret-Condenser Microphone. Conforms to IEC 651.	**1981-9751**

*Ref: "The International System of Units (SI)", U.S. Dept. of Commerce, National Bureau of Standards, NBS Special Publication 330. SD Cat. No. C 13.10:330/2,U.S. GPO, Wash., D.C., 20402.

** U.S. Patent 4,070,741

Condensed Operating Instructions

Battery Check. Slide the Power switch (see illustration) to the BAT position and hold it there briefly. The meter pointer should swing above midscale (the line labeled BAT) and hold steady (no more than 1-dB of droop). The digital display should be 888.8. Otherwise, replace or recharge the battery pack; refer to para 2.1. (For immediate use, three AA-size alkaline cells can be substituted.) Repeat the battery check at least every half hour of use.

Elementary Performance Check. Slide the Power switch ON, the RANGE switch to 70-120 dB, and DIGITAL DISPLAY switch to MAX. Remove the slip-on protective cap from the microphone. Press and release the CAPTURE DISPLAY button to erase the digital display numbers (in a quiet room). Speak or whistle within a foot of the microphone. The meter should respond and the digital display should retain the maximum level.

Meter Speed of Response. Set the FAST/SLOW switch to SLOW for general purposes (and whenever the meter fluctuates 3 dB or more on FAST).

CAUTION

A continuing measurement of 115 dB(A) or more indicates a hazard to your hearing. Immediately protect personnel with suitable ear muffs or plugs.

Calibration. For best accuracy, use a GR 1567 or 1562 Sound-Level Calibrator as follows:

a. Check that the calibrator battery has adequate voltage. (Refer to calibrator instruction manual if necessary.)

b. Install a ½-in. coupler/adaptor on the calibrator. If there is a choice of frequencies, select 1 kHz.

c. Turn the calibrator ON. (The output is audible).

d. Slide the 1981 Power switch ON, the RANGE switch to 70-120 dB, and the DIGITAL DISPLAY switch to CONT.

e. Stand the instrument upright (microphone up). Be sure you have removed the slip-on protective cap from the microphone. Slowly seat the calibrator so the top of the microphone disappears up inside the adaptor.

f. The meter should read 114.0 ±0.5 dB. If it does not, use the jewelers' screwdriver (supplied) to turn the CAL screw to bring the meter pointer and digital display (which should agree within 1 dB) to 114.0 dB(A). If the temperature or atmospheric pressure is unusually high or low, refer to the footnote*.

g. Gently remove the calibrator and turn it off.

h. Repeat calibration at reasonable intervals, such as twice a day or just before critical measurements.

Orientation. If your microphone is the "flat-random-incidence-response" type (commonly specified in U.S.A., supplied with GR 1981-9750), the shortest path from sound source should be along a 70° line to the microphone. Grazing incidence (90°) gives practically the same results.

If your microphone is the "flat-perpendicular-incidence-response" type (commonly specified in many countries, supplied with GR 1981-9751), the shortest path from the sound source should be along the 0° line to the microphone.

Observer Position. Preferably place yourself the same distance from the sound source as the microphone. Hold the sound-level meter about arm's length away from your body. Do NOT stand between source and microphone; do NOT place your hand within 12 cm (5 in.) of the microphone, for good measurements.

For best measurements, mount the microphone and preamplifier on a tripod; and remove both sound-level meter and observer from the sound field. The preamplifier can be unplugged from the nose cone, after you loosen a captive setscrew accessible through a hole in back of nose cone. Refer to para 2.3 and 2.4.

Wind Screen and Protective Cap. For any measurements outdoors or near a fan, install a windscreen over the microphone, but not pressed on as far as it will go. (Outer surface of windscreen should come to the line between top of preamplifier and base of microphone.) For protection during storage, a slip-on cap should be used. Remember to remove it from the microphone before making measurements.

Range. The 70-120-dB range is recommended for general purposes. To measure low-level sounds (below the level of conversation), slide the RANGE switch to 30-80 dB.

Digital Display. Slide the DIGITAL DISPLAY switch to CONTINUOUS for a 4-digit display that essentially duplicates the analog (meter) reading. One advantage of this display is its resolution, 0.1 dB. Other advantages are the "Capture" and "maximum" functions described below.

Capture Display. You can capture the measurement at any moment of your choice, without looking at the displays.

a. Slide the DIGITAL DISPLAY switch to CONT, beforehand.

b. At the desired moment, press the CAPTURE DISPLAY button. The digital display will be "frozen" as long as you hold the pushbutton.

Maximum Display. The instrument can automatically capture the maximum reading in a measurement period; you do not have to watch the displays.

*The recommended calibrators normally provide sound at this level. Refer to calibrator instruction manual for corrections, which may be significant (more than 0.2 dB) OUTSIDE of these ranges: temperature −5° to +35° C, altitude >600 m, barometer within 60 mm (Hg) of normal [23° to 95° F, 2000 ft, 2.4 in.(Hg)].

a. Slide the DIGITAL DISPLAY switch to MAX, beforehand.

b. Press the CAPTURE DISPLAY button shortly beforehand and release it at the beginning of the measurement period.

c. If there is a chance of a loud noise occuring soon after the measurement period, press and hold the CAPTURE DISPLAY button at the end of the period, to capture the desired reading and prevent its being replaced by a larger one.

d. If there is no chance of such a noise occurring, which might affect your measurement, read the digital display and record the value. To make another measurement, return to step b.

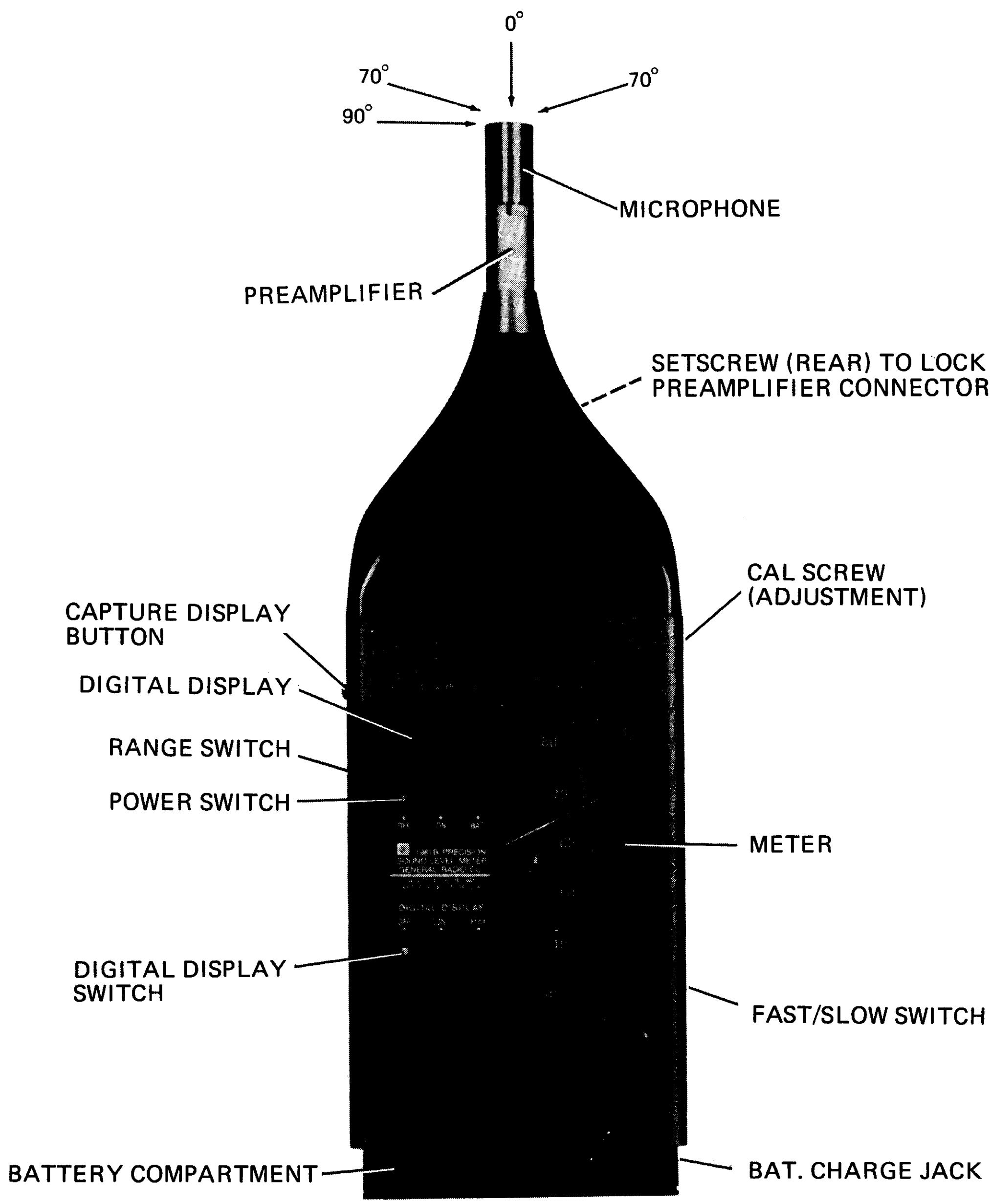
To Charge the Battery Pack. Do not attempt to recharge any battery except the 1981-9602 pack, supplied.

a. On the 1981-0420 Battery Charger, set the line-voltage switch as is appropriate (either 104 to 127 V or 198 to 242 V ac).

b. Plug the charger into the 1981 BAT CHARGE jack. Connect the charger line cord to a suitable power line (refer to NOTE in para 2.6.1c).

c. From a normal discharged condition, charge the pack for 4 hr, with the 1981 Power OFF. (Charging takes much longer with Power ON.) For partial discharge, charge approx 15 min for each 30 min of discharge.

d. Instrument should operate for 5 hr with digital display in use (10 hr otherwise), on a full charge. Refer to para 2.6.



The 1981 Precision Sound-Level Meter. U.S. Patent No. 3,681,618.

Introduction—Section 1

1.1 SOUND; THE SOUND LEVEL METER.

"Sound" includes many categories, such as music, noise, voices, and pure tones. We are concerned with measurement of audible sounds. Sound is a variation in normal atmospheric pressure. When the pressure variations repeat at a frequency in the range of 20 to 20,000 cycles per second and have sufficient amplitude, they are audible. The apparent loudness which a listener attributes to a given sound depends primarily on the magnitude of this variation and also on its frequency (or component frequencies). He may feel pleasure, annoyance, or pain or even experience loss of hearing, either temporary or permanent. These effects depend upon the characteristics of the sound: magnitude, frequency, duration and rate of occurrence, and also on the listener himself. Sound level is a scientifically definable property of sound, defined with "frequency weighting" for specific purposes, such as to make measurements correlate more closely with loudness as perceived by an average person.

The basic instrument for measurement of sound is a "sound-level meter", such as the 1981. It responds to sound pressure at its microphone and gives you a reading in "decibels" (dB). To be more precise, if a sound-level meter reads 85 dB, the ratio of the sound pressure at the microphone to a reference sound pressure is 85 dB. In mathematical terms, 20 times the logarithm_{10} of that ratio is 85, in this example. The reference, a widely accepted standard for sound measurements, is 20 μPa. Note: Pa (pascal) = N/m^2 (newton per square meter). Thus, a sound-pressure level of 0 dB corresponds to a sound pressure of 20 μPa, approximately the threshold of human hearing.

The logarithmic nature of decibel measure results in a convenient scale for an impressively large range of sound levels (120 dB is equivalent to 20,000,000 μPa). A number of possible situations in sound measurement involve combinations of sounds. There is an addition of sound energy, but not of decibels. For example, if a vacuum cleaner across the room causes a 70-dB(A) measurement, two of them will measure 73 dB(A) and four of them 76 dB(A). If a riveting machine at a certain distance is measured at 110 dB(A), two of them will measure 113 dB(A). Generally, each factor of 2 in sound power is an addition of 3 dB; each factor of 10, an addition of 10 dB.

The apparent loudness that we attribute to a sound varies with the sound pressure and (in a less obvious way) with the frequency of the sound. (The way loudness varies with frequency depends also on the sound pressure.) The frequency dependence is taken into account to some extent by "weighting" networks within an instrument that measures sound-pressure level. Such an instrument, with weighting network, is called a sound-level meter.

If the frequency of a certain sound is 1000 Hz, a high soprano note, weighting has no effect. In this example, an "A" weighted instrument like the 1981 and another sound-level meter with "flat" weighting (flat frequency response) would both agree. But if the frequency is 100 Hz, a low bass note, the "A" weighted instrument would indicate 20 dB lower than the "flat" weighted one. The "A" weighted sound-level meter (not the other) generally gives you the same reading for sounds that seem equally loud, over a wide range of frequencies.

Several kinds of weighting (for various purposes) have been standardized by the American National Standards Institute (ANSI) to assure uniformity in sound-level measurement. These are designated A, B, C, and others. We indicate weighting characteristic in parentheses after "dB", thus: the GR 1981-B measures from 30 to 120 dB(A).

More elaborate instruments are available to determine the frequency components present in a given sound and for recording the time history of sounds. However, a precision sound-level meter like the 1981 remains the basic tool for measuring sound as it affects people.

For further information, refer to the Handbook of Noise Measurement,* which explains sound and vibration, their effects on people, measurement units, instrumentation, techniques, control, legislation, standards, and many related topics.

*Peterson, A.P.G., and Gross, E.E. Jr., *Handbook of Noise Measurements*, published by GenRad, Concord, Mass.

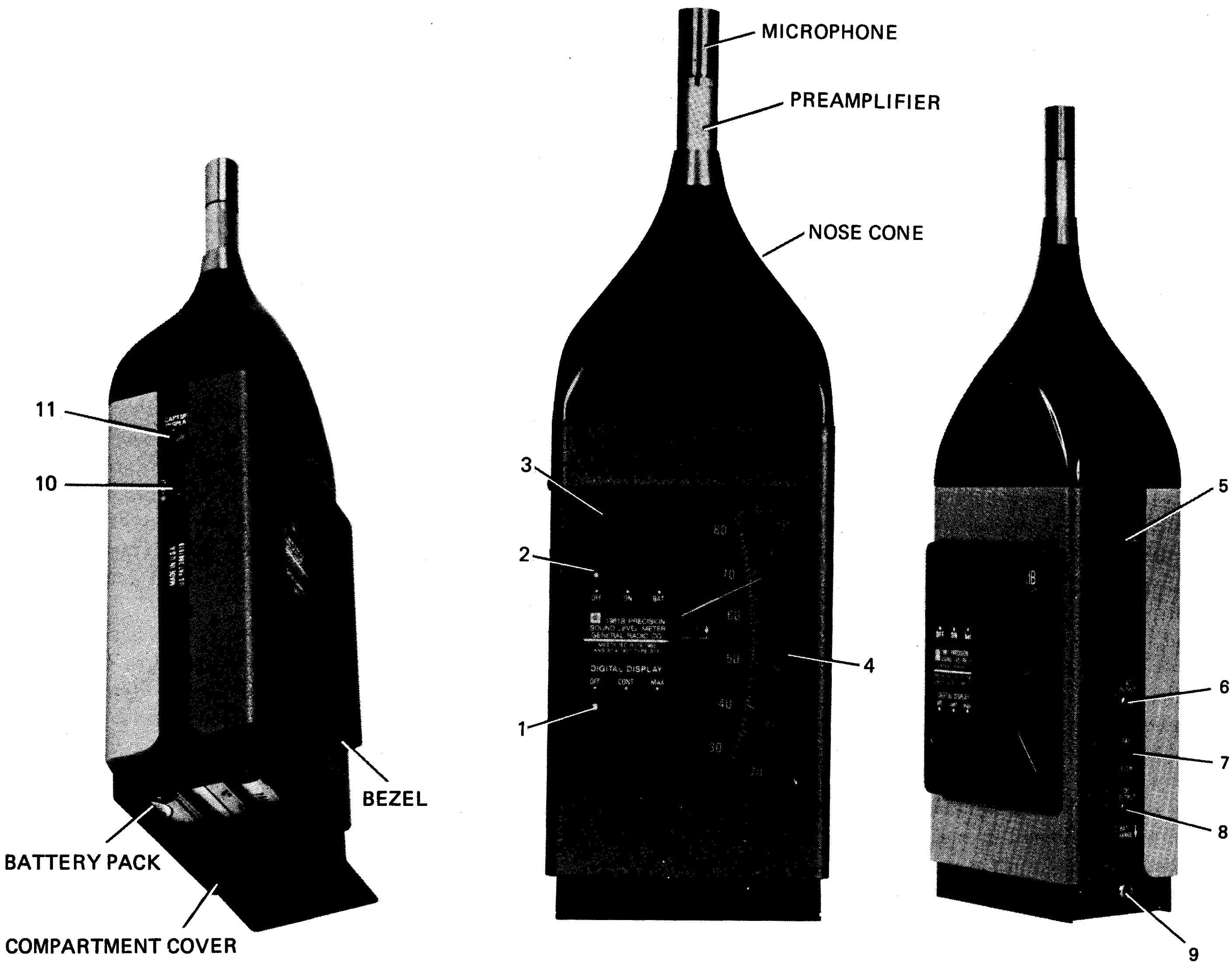


Figure 1-1 (A, B, C). Controls, connectors, and indicators.

1.2 PURPOSE.

The GR 1981-B Precision Sound-Level Meter performs a wide range of measurements. It will measure accurately the noise generated by consumer appliances, office and industrial machinery, and vehicles. Several features make this instrument ideal for measurements essential to transportation noise studies and control. It is also a particularly useful tool for industrial noise control (OSHA) and is generally useful for making sound-level measurements in any application where the sound level lies between 35 dB (typical of a very soft whisper) and 120 dB (typical level near the runway when a big jet plane takes off).

The digital display makes this sound-level meter supremely useful for industrial plant noise and community noise surveys, for which many measurements must be taken. The readout numbers are precise and easy to see.

The characteristics of the 1981 have been optimized for measurement of vehicle noise. Its wide analog display ranges (50-dB span on each range, without the need for range switching) and its digital display with a memory provide for

Table 1-1

CONTROLS, INDICATORS, AND CONNECTORS

Fig. 1-1 Item	Name*	Description	Function
1	DIGITAL DISPLAY Switch (B-S4)	Slide switch, 3 positions: OFF, CONT, MAX.	OFF inhibits digital display (reduces load on battery). CONT selects continuously updated digital dispaly. MAX retains digital display of highest measurement since last release of item 11.
2	Power Switch (B-S3)	Slide switch, 3 positions: OFF, ON, BAT. (Spring return from BAT to ON.)	OFF disconnects instrument from dc power (but does not inhibit battery charging). ON enables normal operation. BAT causes meter to indicate battery condition (see item 4).
3	Digital Display	4-digit numerical readout with fixed decimal point after 3rd digit; red light-emitting-diode type.	Displays sound level, as selected by item 1, in 2 ranges, selected by item 10, covering 30 to 120 dB(A) in increments of 0.1 dB. Indicates "888.8" when item 2 is held on BAT.
4	Meter (A-M1)	Analog meter with 3-in. scales, 30 to 80 and 70 to 120 dB(A), and BAT check mark at midrange.	Continuously indicates sound level at microphone (regardless of item 1) if power ON. Indicates battery condition if item 2 at BAT, or rest position of pointer (bottom of scale) if item 2 is OFF. Battery indication not calibrated in volts.
5	CAL Screw (C-R5)	Screwdriver adjustment potentiometer, 10 turns.	Overall calibration of sound-level meter. (Set displays to proper value while a calibrator provides a known sound level at the microphone, attached or remote.)
6	AC OUTPUT Jack (A-J2)	Subminiature phone jack will accept Switchcraft 850 series "Microplug" (2.5 mm, .097 in. dia).	Connects ac signal for external equipment such as ac level recorder, oscilloscope, headphones. Weighting is like "A" except below 20 Hz. Approx ac voltage: 1.6, 28, 500 mV at bottom, mid, and full meter-scale deflections, respectively. Source: 5 kΩ.
7	FAST/SLOW Switch (A-S2)	Two-position slide switch.	Selects either of 2 time constants with which detector responds to changes in sound level. Time constants are 1/8 and 1 s.
8	DC OUTPUT Jack (A-J4)	Subminiature phone jack, like item 6.	Connects dc signal for external equipment such as dc recorder. Approx voltage: 0 to 500 mV linear, from bottom to full meter-scale deflection. Source: 100 kΩ.
9	BAT CHARGE Jack (G-J5)	Miniature phone jack will accept Switchcraft 750 series "Tiniplug" (3.5 mm, 0.14 in. dia).	Connects from battery charger directly to battery pack (through an interlock that is open-circuited if you are using other battieres), regardless of switch positions, items 1, 2. Use GR 1981-0420 Battery Charger.
10	RANGE switch (A-S3)	Slide switch, 2 positions: 30-80 and 70-120 dB.	Selects either of 2 overall sensitivities, corresponding to the 2 ranges of the meter, item 4.
11	CAPTURE DISPLAY Button (A-S1)	Pushbutton, spring returned.	Depressing and holding the button locks digital display at present reading. If item 1 is at MAX, releasing this button resets digital display to present sound level, ready for a new max measurement.
	Tripod mount (not shown)	Threaded hole in rear cover, 1/4-20 thread (inch).	Standard mount, as on cameras, for fastening to tripod or wrist strap.

*** Reference designators such as (B-S4) are supplied for comparison with service information (Sections 3, 4, and 5).**

rapid and accurate measurements. You can "capture" a sound-level measurement at any particular instant and hold it on the digital display; or the instrument can be set to capture and retain the maximum sound-pressure level during a measurement interval.

The 1981 is capable of making all vehicle noise measurements that have been promulgated by various government authorities, in addition, it will make measurements required by the Occupational Safety and Health Act (OSHA) of 1970 (84STAT. 1590).

The 1981 complies fully with the following standards:

IEC Recommendation Publication 179-1965; Precision Sound-Level Meter.

ANSI Standard Specification for Sound-Level Meters, S1.4-1971, Type S1A (Precision, Special Purpose, A-weighting only). To comply fully with Type 1 requirements, the 1981 must be used with either a 1562 or 1567 Sound-Level Calibrator.

1.3 DESCRIPTION.

The GR 1981-B Precision Sound-Level Meter is a light-weight, battery-operated instrument. It features both analog and digital indicators with 2 wide display ranges, 30 to 80 and 70 to 120 dB, each one continuous over a full 50-dB span. Its frequency weighting meets the "A" characteristic as specified by ANSI and IEC. It features a true rms detector with both "fast" and "slow" time constants. On the digital display (numerals) you can read the same level as the meter continuously or capture that level at the push of a button. Additionally, the digital display can present and retain the maximum sound-level during a measurement interval. The unit can be operated from either a nickel-cadmium rechargeable battery (supplied with instrument) or from standard alkaline cells (three type AA cells required).

Mechanically, the instrument package consists of a wrap-around chassis, with a high-impact ABS "nose cone" that has a removable preamplifier and microphone in the tip, a battery compartment, and front bezel. The circuitry is mounted on high quality glass-epoxy printed-circuit boards interconnected with "printed" cables.

The instrument will drive external equipment such as an ac or dc recorder. The microphone can easily be unscrewed from the preamplifier for replacement. The microphone and preamplifier together can be unplugged and located remotely with an accessory cable (which is plugged into the "nose cone").

1.4 CONTROLS, INDICATORS, AND CONNECTORS.

Figure 1-1 (A,B,C) illustrates the sound-level meter. Table 1-1 further describes the individual controls, indicators, and connectors.

1.5 MICROPHONE AND ACCESSORIES.

Microphone. The microphone used on the 1981 is a ½" electret-condenser type (outside diameter 1.27 cm). Two versions are available, one optimized for sound coming from random directions, the other for sound arriving perpendicular to the diaphragm, ie., along the axis of the cylindrical shape of the microphone.

Characteristics of each type of microphone, measured while it is mounted remotely on the preamplifier, are shown in para 2.3.5.

Each microphone is individually calibrated and its calibration certificate is supplied.

Supplied. Refer to Tables 1-2, 1-3, and 1-4 for accessories supplied with each of the 1981-family of precision sound-level meters, sets, and systems.

Figure 1-2 illustrates a 1981 system especially suited for vehicle noise and community noise measurements.

Available. Refer to Table 1-5 for additional accessories that are recommended for extending the usefulness of the 1981 family of precision sound-level meter systems.

Figure 1-2. Precision noise measurement system, 1981-9760 or -9761. The tilting sleeve adaptor, with both sleeves, is shown mounted on the tripod.

Table 1-2

INSTRUMENT AND ACCESSORIES SUPPLIED
WITH PRECISION SOUND-LEVEL METERS 1981-9750 AND -9751

Quantity	Description	Part Number
1	Precision Sound-Level Meter, instrument only (includes 1981-4000 preamplifier)	1981-3100
1	Microphone, 1/2" diam, "random", with -9750, "perpendicular", with -9751	*
1	Battery pack (assembly)	1981-9602
1	Battery charger	1981-~~0420~~ 0425
1	Wrist strap	1981-0410
1	Screwdriver (jeweler's, for calibration)	1565-0440
2	Subminiature phone plug (Switchcraft no. 850 "Micro-Plug")	4270-1110
1	Extension cable, 3 m (10 ft) long	1933-9600

*See Table 1-5.

Table 1-3

INSTRUMENTS AND ACCESSORIES SUPPLIED
IN PRECISION SOUND MEASUREMENT SETS 1981-9762 AND -9763

Quantity	Description	Part Number
1	Precision Sound-Level Meter, instrument only (includes 1981-4000 preamplifier)	1981-3100
1	Microphone, 1/2" diam, "random", in -9762; "perpendicular", in -9763	*
1	Battery pack (assembly, for SLM)	~~1981-9602~~ 1981-2050
1	Battery charger	1981-~~0420~~ 0425
1	Wrist strap	1981-0410
1	Screwdriver (jeweler's, for calibration)	1565-0440
2	Subminiature phone plug (Switchcraft no. 850 "Micro-Plug")	4270-1110
1	Sound-Level Calibrator (with the following battery and case)	1567-9701
	Battery (for calibrator, like Burgess no. 2U6, one required)	8410-3200
1	Extension cable, 3 m (10 ft) long	1933-9600
1	Adaptor (fits calibrator to 1/2-in. microphone)	1562-9601

*See Table 1-5.

Table 1-4

INSTRUMENTS AND ACCESSORIES SUPPLIED
IN PRECISION NOISE MEASUREMENT SYSTEMS 1981-9760 AND -9761

Quantity	Description and Comment **	Part Number
1	Precision Sound-Level Meter, instrument only (includes 1981-4000 preamplifier)	1981-3100
1	Microphone, 1/2" diam, "random", in -9760; "perpendicular", in -9761	*
2	Battery pack (assembly, for SLM)	1981-9602
1	Battery charger	1981-~~0420~~ 0425
1	Wrist strap	1981-0410
1	Screwdriver (jeweler's, for calibration)	1565-0440
2	Subminiature phone plug (Switchcraft no. 850 "Micro-Plug")	4270-1110
1	Sound-Level Calibrator	1567-9701
1	Battery (for calibrator, like Burgess no. 2U6)	8410-3200
1	Adaptor (fits calibrator to 1/2-in. microphone)	1562-9601
1	Extension cable, 3 m (10 ft) long	1933-9600
1	Extension cable, 18 m (60 ft) long	1933-9601
1	Windscreen (foam-plastic sphere; use when outdoors)	1560-7551
1	Tripod (to hold SLM or preamplifier/adaptor, or camera; tilting swivel head and sleeves for preamp included)	1560-9590
1	Light-stand adaptor (enables light stand to serve as extra tall tripod)	1981-1200
1	Carrying case (attache case with compartments formed in foam plastic; holds everything listed above, with instruction manuals, microphone calibration certificate, and space for data sheets)	1981-9660

*See Table 1-5. **See para. 2-4.

Table 1-5

ACCESSORIES AVAILABLE

Name	Description	Catalog Number
Microphones*	Electret-condenser, 1/2 in. dia: – flat random-incidence response – flat perpendicular-incidence response.	 1962-9610 1962-9611
Battery Pack	Assembly containing 3 rechargeable Ni-Cd cells.	1981-9602
Sound-Level Calibrator	Generates a tone with exactly known sound-pressure level, at any of 5 selectable ANSI-preferred frequencies. The 1562-6130 Adaptor and battery are included (uses Burgess PM6 battery).	1562-9701
Sound-Level Calibrator	Generates 1-kHz tone with exactly known sound-pressure level. Includes 1562-6130 adaptor. Battery included (uses Burgess 2U6).	1567-9701
Cables	Fits calibrator to 1/2-in. microphone.	
——	Extension cable for connecting preamplifier to sound-level meter, length 90 cm (3 ft)	1933-9613
——	Same, except length 3 m (10 ft)	1933-9600
——	Same, except length 6 m (20 ft)	1933-9612
——	Same, except length 18 m (60 ft)	1933-9601
——	Has subminiature phone plug (like Switchcraft 850 series "Micro-plug"), length 0.9 m (3 ft), with double banana plug (GR 274 series).	1560-9677
——	Same, except with standard (1/4-in.) phone plug	1560-9678
——	Same, except with BNC plug (male).	1560-9679
——	Same, except length 0.6 m (2 ft) with standard (1/4-in.) phone jack.	1560-9680
Windscreen	Sphere of foam plastic, fits over 1/2-in. microphone, Package of 4.	1560-9522
Tripod	Telescoping legs and center post permit adjustment, 38 to 144 cm (15 to 56.5 in.). Accessories included: tilting Sleeve Adaptor (1560-2560) for mounting sound-level meter, camera, or either of the following sleeves: 1/2-in. sleeve holds 1981-4000 or 1560-P42, 3/4-in. sleeve holds 1972-9600 preamplifiers.	1560-9590
Light-Stand Adaptor	Additional accessory will clamp onto photographic light stand, such as Alumilite AL-12, which extends to 3.6 m (12 ft), or onto any rod up to 9 mm diam (0.36 in.). Tilting sleeve adaptor from tripod fits on this adaptor.	1981-1200
Recorder	Dc strip-chart recorder with 10-cm scale for 50-dB span of sound levels (full scale can be set to 500 mV) and 12 feed rates from 2 cm/hr to 60 cm/min, uses Z-fold paper.	1985-9700

* U.S. Patent 4,070,741

New Calibrators

1986 Omnical Sound-Level Calibrator: new-generation, multi-function calibration

The 1986 is GenRad's newest calibrator, and the only calibrator available with multiple levels, multiple frequencies and tone burst signals. It is also the only portable sound-level calibrator that allows you to check nearly all of the characteristics of a sound-level meter specified by IEC and ANSI standards. The unit couples easily to a wide variety of GenRad's and other manufacturers' microphones, making it ideal for virtually any acoustic instrument or system.

Five calibrated output levels range from 74 to 114 dB in 10-dB steps, allowing precise calibration in selected measurement ranges in addition to attenuator and linearity checks. Six frequencies are selectable from 125 Hz to 4000 Hz in octave steps, allowing a thorough check of total instrument response, including the microphone.

1987 Minical Sound Level Calibrator: quick, accurate field checks

The 1987 Minical Sound-Level Calibrator is designed to allow quick, accurate field checks of acoustic instrument sensitivity. It produces a single-frequency output of 1000 Hz at sound-pressure levels of either 94 or 114 dB; it features a high-impact-resistant case and a special package design that make it resistant to moisture, dust and mechanical shock. The 1987 Minical incorporates the same design features for accuracy and stability as those noted for the 1986 Omnical. It also couples to the same variety of microphone sizes

The 1987 is ideal for quick, daily calibration checks of sound-level meters and other acoustic instruments where sensitivity should be ascertained before and after measurements.

Operation–Section 2

2.1 SETUP.

2.1.1 Battery Installation and Removal. Figure 2-1.

The batteries go in a compartment on the bottom of the 1981-B Precision Sound-Level Meter. Use this procedure:

a. Slide the battery compartment cover off to the right (Push with your thumb, away from the notched end).

b. Observe the polarity marked on the batteries and match it to the marking molded in the battery compartment. The label "This Side Up", on the battery pack, applies while the instrument is upside down, as pictured.

c. Install the battery pack by placing the proper end at an angle against the coiled springs. Push first to compress the springs, then to seat the other end in position. When you release the pack, the coil springs will push the pack into contact at the opposite end.

d. Replace the cover, oriented as shown in Figure 1-1.

NOTE

A new battery pack is, in general, partly or fully discharged; charge it for 4 hr, with the Power Switch OFF. Refer to para 2.6. The fully charged battery pack will provide 4 to 5 hr of continuous operation.

The 1981 may also be used with any other type of AA cell (3 cells required). Ordinary carbon-zinc cells will run the 1981 for about the same length of time as the rechargeable pack. Alkaline cells will provide power for 8 to 10 hours. Install AA cells one at a time in the same manner as the rechargeable pack. Follow the polarity instructions which are molded into the inner surface of the battery compartment, i.e., middle cell, + to right; other 2 cells, + to left.

CAUTION

Do NOT attempt to recharge any battery other than the rechargeable pack supplied for the 1981. Any attempt to charge non-rechargeable cells can cause them to overheat and explode.

Do NOT attempt to defeat the interlock that is intended to prevent recharging of miscellaneous AA cells.

Removal. To remove the battery pack, press it so as to compress the spring contacts and tip the pack, as pictured. It is then easy to withdraw the pack for replacement.

2.1.2 Battery Check.

After the battery has been installed, slide the Power Switch to BAT and hold it there for a moment. The meter pointer will move upscale and the digital display will read "888.8". This display places a heavy drain on the batteries, to prove their condition. If the pointer holds steadily above the BAT mark on the face of the meter, the battery has

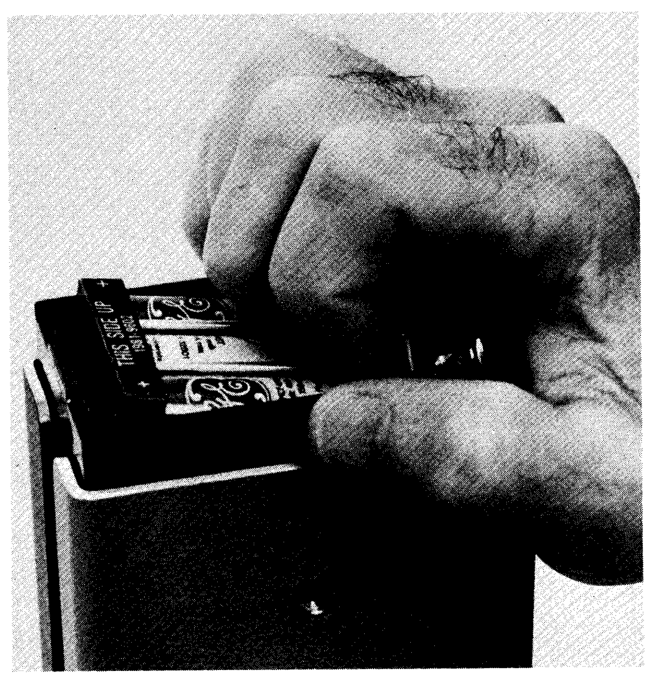


Figure 2-1. Removal of the battery pack.

adequate capacity to ensure operation at full rated accuracy. If the reading is below the BAT mark, either recharge or replace (see para 2.6); otherwise the instrument cannot be expected to perform properly.

NOTE

Repeat the battery check 2 or 3 times each hour of operation, as a routine precaution.

The meter serves as a battery indicator while you hold the Power Switch in the BAT position. Since battery voltage is related to its potential energy, the meter reading will give you some idea of how much operating time remains before the battery becomes impotent. This property is most useful when non-rechargeable cells are in use; less so with the nickel-cadmium rechargeable battery pack, because it maintains a relatively constant output voltage during use, until nearly all its energy has been spent.

Figure 2-2. Calibration, with the 1567 Sound-Level Calibrator.

2.1.3 Uncovering the Microphone.

Before using or calibrating the sound level meter, be sure the microphone is uncovered (except for windscreen, see para 2.4.7). The microphone, normally atop the "nose cone", is cylindrical in shape with a smooth outer surface and several dozen holes in the upper (sensing) end. It can be unscrewed without tools from the preamplifier. The threads are fine and require caution in handling. Protect the top of the microphone, when not in use, with the plastic dust cap (provided) that pushes on and can easily be pulled off. (The preamplifier can be withdrawn upwards, unplugged, after a setscrew has been turned ccw; see para 2.2.6.)

2.1.4 Acoustic Calibration. **Figure 2-2.**

To ensure that the entire system is operating properly, calibrate before and after a series of measurements. (The system may include, for example, accessory cables and preamplifier.) Use GR 1562 or 1567 Sound-Level Calibrators* as follows, *in the same environment as the measurements*, Refer also to para 2.5.

a. Slide the 1981 Power switch ON, RANGE switch to 70-120 dB, and DIGITAL DISPLAY switch to CONT.

b. Fit the 1/2-inch microphone adaptor 1562-6130 into the sound-level calibrator.

c. Turn the calibrator ON and check its battery. (The 1567 BATTERY meter should indicate "OK". If you are using the 1562, follow instructions on its panel. Replace batteries if necessary, referring to the calibrator instruction manual.)

d. Place the calibrator over the microphone of the 1981. If you are using the 1562 calibrator, set its frequency to 1 kHz.

e. The meter and display should read 114 ±0.5 dB under normal conditions. If they do not, carefully turn the CAL screwdriver control, located on the right side panel, for a reading of 114 dB (normally). Use a jeweler's screwdriver (supplied).

NOTE

The calibration level is a function of atmospheric pressure (altitude) and ambient temperature. If you are far above sea level or if the air is much hotter or colder than normal room temperature, refer to the calibrator instruction manual for correction data.

In addition you can check the system frequency response if you have the five-frequency 1562 Sound-Level Calibrator. See para 4.3.1.

*Suitable calibrators are included in 1981 sets and systems listed in para 1-5.

Calibration Service. In the interests of maintaining accuracy in sound measurements, another calibration service is provided for owners of General Radio sound-level meters. If you bring yours in to one of our offices, we will be pleased to check its calibration by means of an acoustic calibrator.

2.1.5 Meter Window.

To avoid scratching the meter window or affecting the meter reading unnecessarily, do not rub or mark on the window without observing the precautions given in the Service Section (para 4.6).

2.2 USE OF CONTROLS, INDICATORS, AND CONNECTORS. (Refer to Figure 1-1 and Table 1-1).

2.2.1 Power Switch.

The Power Switch is a three-position slide switch that controls *all* power to the 1981 and enables the battery check. The ON position is in the center: OFF, left; and battery-check (BAT) to the right (spring-returned). A red dot, uncovered by the slider, serves as a reminder when the instrument is ON. The only warmup time required is that for the indicators to stabilize (typically 1 s).

2.2.2 FAST-SLOW Switch.

This switch selects the dynamic characteristics of the indicators. On steady sounds the reading of the meter will be the same for either the SLOW or FAST positions. Generally, take a measurement initially in the FAST position. However, most sounds do not have a constant level. The reading often fluctuates over a range of a few decibels or more during a measurement interval.

Use the FAST position if the fluctuations are less than 4 dB. Note the maximum and minimum readings. To be precise, include this range in your measurement, as for example:

85 to 91 dB(A), or 88 ±3 dB(A).

Switch to the SLOW position to obtain an average reading when the fluctuations on the FAST position are more than 3 or 4 dB.

In the SLOW position, the sound-level meter's averaging period is about 1 second. Sound-level changes slower than that cause fluctuations in the readings. To obtain a single-number average reading, observe maximum and minimum readings. If the difference is less than 6 dB (max – min), simply average the 2 "SLOW" values. For example, if the extremes are 83 and 89 dB(A), the average is 86 dB(A). However, if the range of fluctuation is greater than 6 dB, the average sound-pressure level is usually taken to be 3 dB below the maximum SLOW level. In selecting this maximum level, it is also customary to ignore any unusually high levels that occur infrequently. For example, if the significant maximum is 94 dB, report the measurement as: 91 dB(A) average.

The meter needle will fall 10 dB in about 2 s (SLOW) or 1/3 s (FAST) following the abrupt cessation of a loud sound.

It should be noted that any standardized sound-level measurement procedure will specify whether the FAST or SLOW dynamic characteristic should be selected, or specifically how to determine which to use.

2.2.3 DIGITAL DISPLAY and CAPTURE DISPLAY Switches.

OFF. The OFF position of the DIGITAL DISPLAY switch disables the digital display circuitry, to extend battery life. It is not necessary to turn the digital display off when turning the instrument off, because the Power Switch controls all power to the 1981.

CONT. The CONT position turns on the digital display, so that it provides a continuously updated digital readout of sound-level. New numbers appear at the rate of 7 readings per second. If you want to hold the current value in the display, depress the CAPTURE DISPLAY pushbutton. (The button may be operated by the left thumb when the 1981 is being held as described in para 2.3.) The reading which was in the display when the switch was pressed will remain for as long as you depress the switch, giving you time to observe the reading and record it. To resume continuous readings, release the pushbutton.

MAX. To obtain a digital display of the highest level in a varying sound, for instance, the maximum sound level as a vehicle passes by, set the DIGITAL DISPLAY switch to MAX. Just before the desired measurement, press the CAPTURE DISPLAY button for a moment to reset this display to tne current sound level. As the sound level increases, the display reading will increase. When the sound level subsides, the digital display will retain its highest value.

If a higher sound level is anticipated before this value can be recorded, press the CAPTURE DISPLAY switch to hold the value in the display. It will be "captured" as long as the switch is depressed.

Even if there is no need to "capture" the maximum reading, one must press the CAPTURE DISPLAY button momentarily and release it to begin a new MAX level measurement. In summary, the CAPTURE DISPLAY pushbutton holds the current reading in the digital display when depressed and resets the digital display to the current sound-level when released.

2.2.4 Digital Display Range.

The digital display provides numerical indication of some sound levels that are "off scale" for each setting of the RANGE switch. On the 30 to 80-dB range, usable displays go as low as the instrument "noise floor" (about 28 dB(A) with the microphone supplied) and as high as 95 dB(A); on the 70 to 120-dB range, as low as 60 dB(A) and as high as 135 dB(A). However any display that is not within the selected range (30-80 or 70-120) may be inaccurate; the specifications do NOT apply. Use such displays only for relative measurements or approximations; or use special calibration. (Also see para 2.3.7.)

2.2.5 Output Jacks.

General. The 1981 provides at its AC OUTPUT jack a weighted replica of the input (microphone) signal, taken prior to detection. Its level is about 500 mV when the meter reads full scale. A dc signal proportional to meter deflection is available at the DC OUTPUT jack, also 500 mV full-scale. Both signals are well isolated, so that any load impedance including a short circuit can be connected to either output jack without producing a change in reading in excess of 0.1 dB. Two subminiature phone plugs (GR P/N 4270-1110) are provided for making up cables to connect external equipment to the 1981. Certain complete cables are offered as accessories. Consult para 1.5 and the GR literature for available accessories.

AC Output. The signal available at this jack can be applied to an oscilloscope, ac level recorder, earphone, analyzer, tape recorder, etc. The weighting is similar to the instrument's A-weighting characteristic with the exception that the attenuation rate below 20 Hz is 18 dB per octave at this jack (24 dB/octave at the meter).

The voltage at this jack is proportional to sound-pressure level, and reaches about 500 mV (behind 5 kΩ) when the meter reaches full scale. For meter readings 10, 20, 30, 40, 50 dB below full scale, the AC OUTPUT levels are about 158, 50, 15.8, 5, 1.6 mV, respectively.

It is sometimes useful, when the microphone is remotely located, to monitor the sound being measured by using earphones plugged into the AC OUTPUT jack.

DC Output. This jack provides a dc signal linearly proportional, in dB(A), to the sound level being measured. The range is 0 to 500 mV (approx) behind a source impedance of 100 kΩ. For meter readings 10, 20, 30, 40, 50 dB below full scale, the DC OUTPUT voltages are about 400, 300, 200, 100, 0 mV, respectively.

The DC OUTPUT can be used to trigger an alarm or event counter, or other dc-operated device with suitable sensitivity. It can also be used with a dc recorder to provide a permanent record of a changing sound level or to perform statistical analyses of sound level versus time.

The appropriate dc recorder has a sensitivity better than 250 mV or 2.5 μA for full scale deflection. The following requirements are necessary for the recorder's trace to accurately represent sound-level as defined by IEC and ANSI standards: the response time of the recorder should be less than 0.1 second for full scale deflection, overshoot less than 1 or 2%, and linearity better than 1% of full scale. These characteristics duplicate those of the 1981 analog display (the meter).

To calibrate the recorder for use with this sound-level meter, turn the recorder on and turn the 1981 Power Switch OFF. Set the recorder zero adjust control for bottom scale deflection. This will correspond to a sound level of 30 dB(A) for the 30-80 range or 70 dB(A) for the 70-120 range. Then turn the Power Switch ON and apply a calibration signal. Adjust recorder sensitivity for the desired scale factor on the recording, preferably an integral number of dB per division on the graph paper. For example, if you use a GR acoustic calibrator with an output level of 114 dB, set the RANGE switch to 70-120 dB and set the recorder sensitivity for a deflection of 44 divisions. Then the recorder sensitivity is 1 dB per division, with the 70-dB(A) point at bottom scale. Recheck the recorder zero adjustment since its sensitivity and zero adjustments may interact. Repeat both adjustments as required.

2.2.6 Input Connections.

Nose Cone. The ½-in. electret-condenser microphone and preamplifier assembly can be removed easily to measure sound at a location away from the meter itself, as follows:

a. Slide the Power Switch to OFF.

b. Loosen the setscrew that is accessible through a small hole in the rear of the nose cone about 1½ turns, using an appropriate-sized slotted screwdriver. Notice that the screw is captive. (It stops after being loosened enough.) However, do NOT force this screw against the stop or the nose cone may be broken.

c. Pull the microphone-preamplifier assembly directly up, out of the nose cone. The portion to be pulled up is about 4.5 cm long (1.8 in.), as illustrated with the Condensed Operating Instructions.

d. Connect the preamplifier to an extension cable. (See Table 1-4, para 1.5.) The end that connects to the preamplifier has a spring-loaded detent. Depress this so that it will engage the hole in the outer shell of the preamplifier, for assembly. (For removal, depress the detent again.) Mount the preamplifier on a tripod or other suitable support.

e. Connect the other end of the cable to the instrument in a way similar to the following step.

f. To return the microphone-preamplifier assembly to its usual place, disconnect the cable. Orient the preamplifier so the hole near the bottom edge of its shell aligns with the setscrew (which must be "out", i.e., ccw). Refer to Figure 4-2C. Insert the preamplifier gently. Turn it slightly back and forth until it engages a keyway in the connector. Then it will penetrate about 2 mm (.08 in.) deeper into the nose cone. Press the assembly together gently (another 2 mm). Seat the setscrew firmly (cw), to lock the assembly and assure a good ground connection to the preamplifier shell.

BAT CHARGE Jack. This provides direct connection to the rechargeable battery pack, through an interlock that is open-circuited if you are using other battieres. (See para 2.6.)

2.2.7 RANGE Switch.

This switch selects either of 2 sound-level ranges, corresponding to the 2 scales on the meter. Select "70-120 dB" for calibration and for general purposes unless the sound being measured is known to be less than 70 dB(A), which is about the level of a lively conversation. Select "30-80 dB" for lower-level measurements.

2.3 MEASUREMENT TECHNOLOGY.

2.3.1 Introduction.

Painstaking care is exercised in the design and manufacture of Type 1 instruments, but this only assures that the use of a "Precision" instrument will contribute negligible error to the measurement results. In order to make valid, repeatable measurements, it is helpful to recognize that the results of a measurement are determined by a number of factors, among which are the following:

1. The phenomenon being measured.
2. The effect of the measurement process on the phenomenon being measured.
3. The environmental conditions.
4. The calibrations of the transducers and instruments at the time they are used.
5. The way the transducers and instruments are used.
6. The observer.

Even if you do not need to measure sound according to a standard procedure, it is often wise to try to do so, if an appropriate standard can be found. The standards have been prepared to help obtain valid data. They are useful guides for the inexperienced, and they help the experienced to keep in mind the required steps in a measurement procedure. They help to make comparisons of measured results more meaningful.

NOTE

The general standard ANSI S1.13-1971, "Standard Methods for the Measurement of Sound-Pressure Levels," isparticularly recommended. See also para 2.7 for vehicle noise measurements.

An obvious but important rule in any measurement task is to review the results to see if they are reasonable. If they are not, try to track down possible sources of trouble, particularly simple things like background noise, poor connections, plugs in the wrong places, no power, low batteries, controls set incorrectly, damaged equipment, stray grounds, and electrical interference pickup. If nothing can be found that can be corrected to bring the data into line, perhaps the data seem unreasonable only because of a limited understanding of the phenomena or of the measurement process.

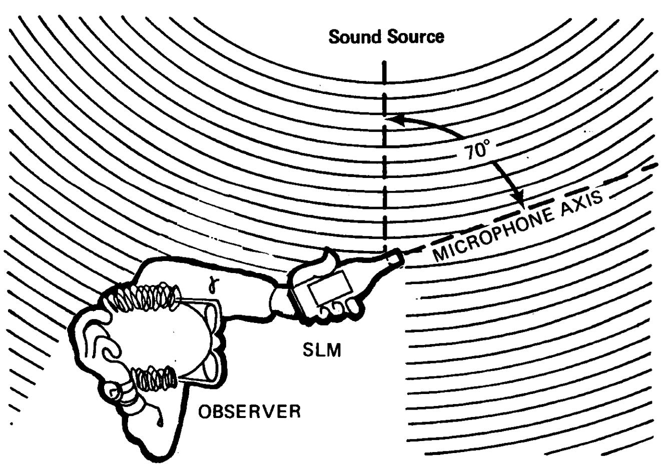


Figure 2-3. Orientation of hand-held sound-level meter with "random" microphone for best results and preferred position of observer.

The results of a noise measurement may be a key factor in resolving a noise problem. In addition, the experience and data often help you in doing a better job on another noise problem. Careful records of noise measurements can be valuable for future reference on subsequent problems, and this possibility should be kept in mind when you tackle a noise problem.

A recognition of the accuracy limitations of acoustic and vibration measurements is important in order to be reasonable in the approach to a measurement problem. Thus, consistency to ±0.1 dB or better is attainable in only a few laboratory calibration procedures and not in general acoustical measurements. Field calibrations of sound-level meters at one frequency with a calibrator may be consistent to ±0.5 dB or slightly better. In general measurements, a consistency of ±1 dB is difficult to attain, even under carefully controlled conditions.

2.3.2 Effects of Instrument Case and Observer.

NOTE

For precise measurements in a very dead room, such as an anechoic chamber, the instruments and the observer should be outside, with only the source, microphone, extension cable, and a minimum of supporting structure in the dead room.

You the observer can affect the measured data if you are close to the microphone. When measurements are made in an ordinary room (a "live" room, such as an office or shop) and the microphone is not very close to the sound source, the effect is usually not important. But if measurements are made near a source, it is advisable to stand well to the side of the direct path between the source and the microphone.

For many measurements, it is most convenient to be able to carry the sound-level meter around. When you make hand-held measurements, for best results, hold the sound-level meter as described in the following paragraphs.

NOTE

If the microphone is mounted on the sound-level meter, do NOT make measurements with your hand on the "nose cone". Support the main chassis for best results.

Even the instrument case itself disturbs the sound field at the microphone somewhat, as shown by the characteristic curves in later paragraphs. However, there is practically no effect below 1000 Hz; and, for most noises, little error in measuring sound level will result if the microphone remains on the instrument.

NOTE

Error curves were obtained using pure tones under free-field conditions (in an anechoic chamber). These curves may be considered "worst-case". For normal industrial or community noise environments, the error will be considerably smaller.

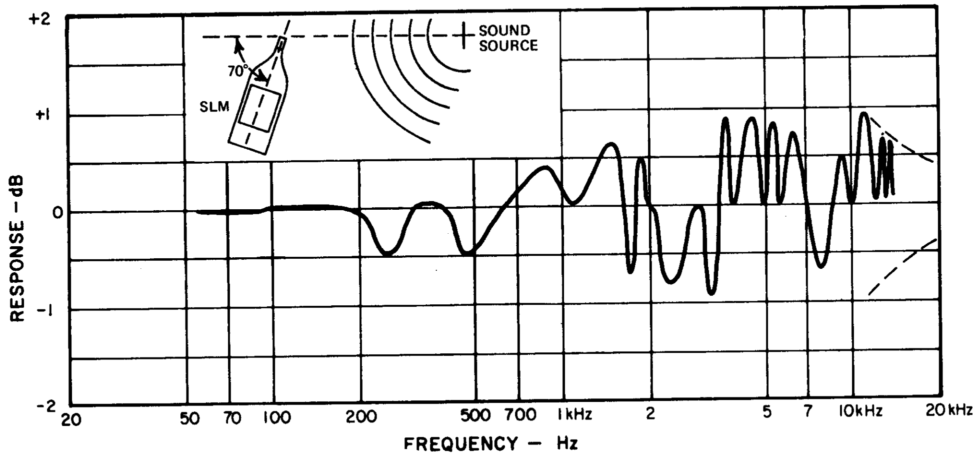


Figure 2-4. Typical error introduced by 1981 instrument case in 70°-incidence free-field frequency response level.

2.3.3 Position, Using Random Response Microphone. Figure 2-3.

If your microphone is the flat-random-incidence-response type (part of 1981-9750, -9760, or -9762), position it as follows:

Microphone on SLM.

a. Hold the instrument in your left hand.

b. Stand so the sound source is at your left side.

c. Hold the 1981 out at arm's length and point it 70° away from the sound source. Notice that this 70° angle can be horizontal as pictured, or vertical (point the microphone 70° above the sound source), or in between.*

Microphone Remote (with preamplifier).

a. Mount on tripod or other non-bulky support.

b. Maintain the same 70° angle between the microphone and the sound source.

*Very little error is introduced if you increase this angle from 70° to 90°. Then the sound arrives at the microphone with "grazing incidence."

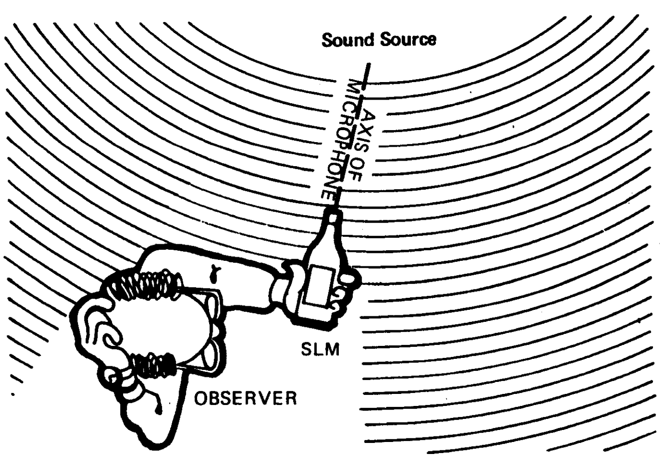


Figure 2-5. Orientation of hand-held sound-level meter with "perpendicular" microphone for best results and preferred position of observer.

Figure 2-4 shows the small errors that may be introduced by the presence of the instrument case alone, when these rules are followed.

2.3.4 Position, Using Perpendicular Response Microphone. Figure 2-5.

If your microphone is the flat-perpendicular-incidence-response type (part of 1981-9751, -9761, or -9763), position it as follows:

Microphone on SLM.

a. Hold the instrument in your left hand.

b. Stand so that the sound source is at your left side and slightly to the front.

c. Extend the 1981 to arm's length and point the microphone towards the sound source.

Microphone Remote (with preamplifier).

a. Mount on tripod or otherwise support microphone without introducing bulky objects into vicinity.

b. Point the microphone at the sound source.

Figure 2-6 shows the small errors that may be introduced by the presence of the instrument case alone, when these rules are followed.

2.3.5 Characteristic Response Curves. Figures 2-7 and 2-8.

For reference, here are microphone characteristics (response vs. frequency and direction) for laboratory free-field conditions.

NOTE

All these curves show high-frequency phenomena. Below 1 or 2 kHz (the highest pitch of a soprano voice) the frequency responses are flat, corrections zero, directional pattern circular, i.e., performance practically ideal.

Microphones Alone. Two sets of curves are given: one for flat-random-incidence-response ("random") microphones, the other for flat-perpendicular-incidence-response ("perpendicular") microphones.

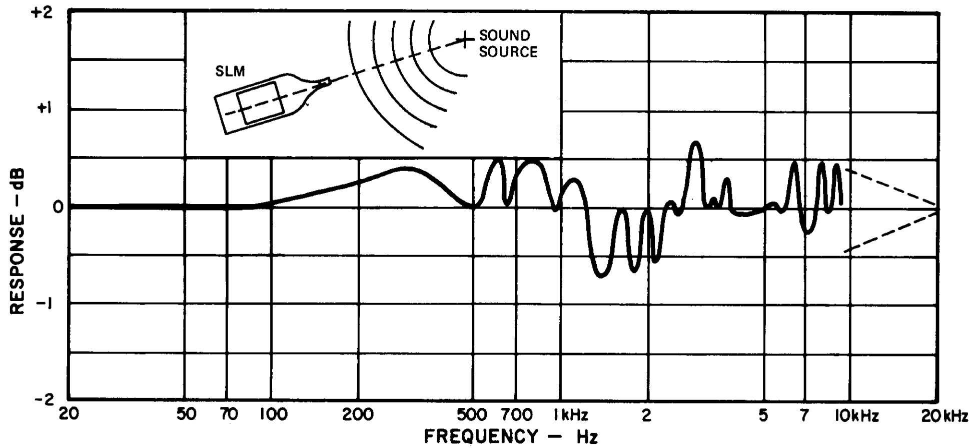
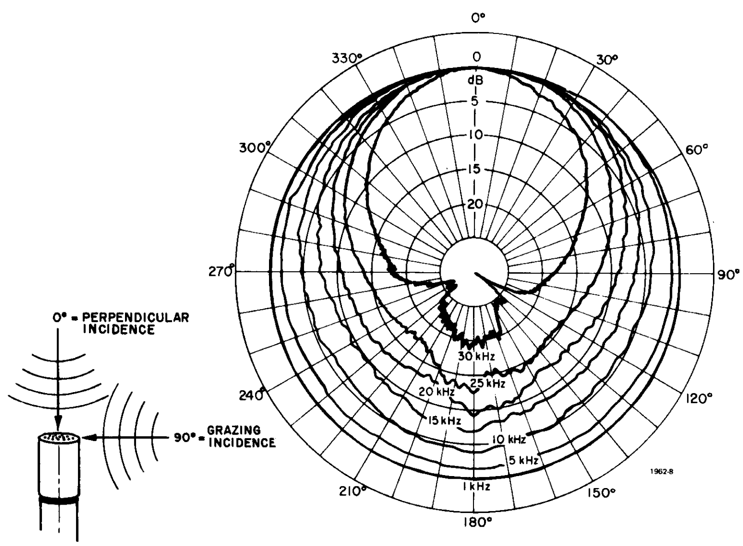
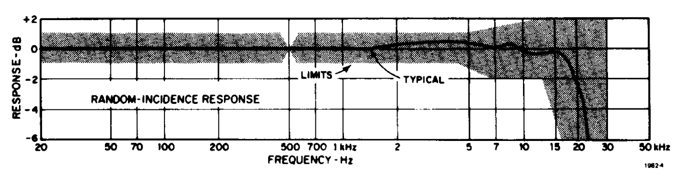


Figure 2-6. Typical error introduced by 1981 instrument case in perpendicular-incidence free-field frequency-response level.

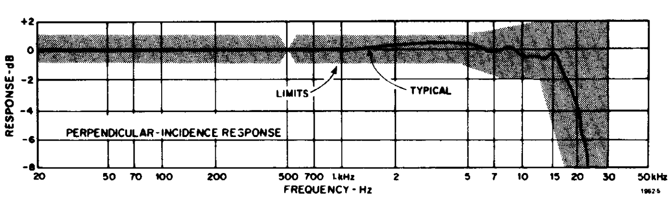


Typical directional response of either microphone.



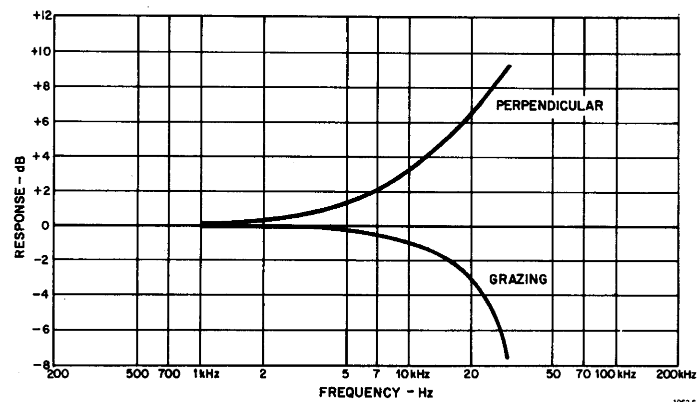
Typical frequency response to random-incidence sound. (Acceptable in gray area.)

Figure 2-7. Characteristics of the ½-in. flat-random-incidence-response electret-condenser microphone.

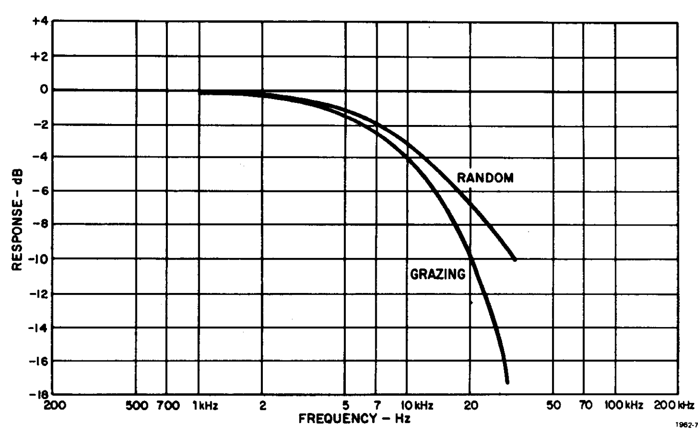


Typical frequency response to perpendicular-incidence sound. (Acceptable in gray area.)

Figure 2-8. Characteristics of the ½-in. flat-perpendicular-incidence-response electret-condenser microphone.



Corrections to be added algebraically to random-incidence response level to find perpendicular- and grazing-incidence free-field response levels.



Corrections to be added algebraically to perpendicular-incidence response level to find random- and grazing-incidence free field response levels.

For the former, Figure 2-7 shows response vs frequency, measured in a reverberant sound field. Also shown are corrections to be added (algebraically) to obtain free-field response levels for a sound source perpendicular and grazing (respectively 0 and 90° from the axis). For the latter (perpendicular) the response level vs trequency is measured with the sound source at 0° from the axis; corresponding corrections are given.

2.3.6 Interfering Noises. **Figure 2-9.**

Background Noise. Ideally, when a sound source is measured, the measurement should determine only the direct airborne sound from that source, without any appreciable contribution from noise produced by other sources. In order to ensure such a separation, the measurement space may need to be isolated from external noise and vibration. As a test to determine that this requirement has been met, the American National Standard Method for the Physical Measurement of Sound, S1:2, specifies the following:

"If the increase in the sound-pressure level . . . with the sound source operating, compared to the ambient sound-pressure level alone, is 10 dB or more, the sound-pressure level due to both the sound source and ambient sound is essentially the sound-pressure level due to the sound source. This is the preferred criterion."

If background noise level and apparatus sound (noise) level are each steady, a correction can be applied to the measured data according to the graph. Proceed as follows:

a. Select the test position for the microphone according to specifications of the pertinent code or procedure, if any.

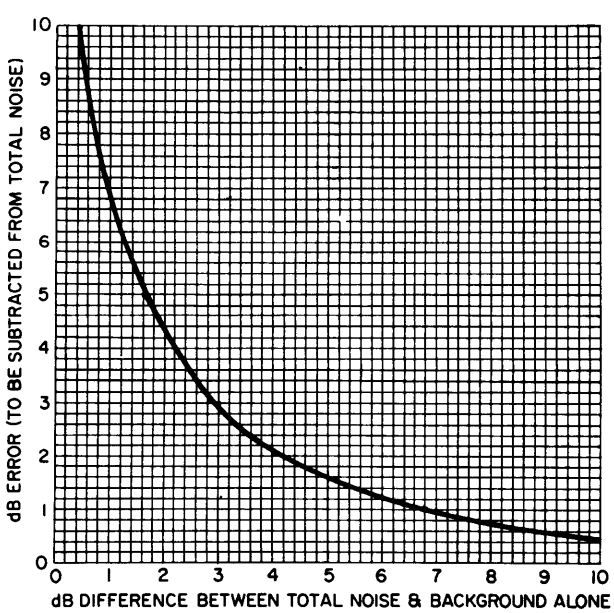


Figure 2-9. Background noise correction for sound-level measurements.

b. Otherwise select a position appropriate to your goals. Refer to the *Handbook of Noise Measurement* (see para 1.1), especially the portions mentioned in the following discussion.

c. Orient the microphone as described in para 2.3.3 and 2.3.4 of this manual.

d. Measure the background noise with the "device under test" (DUT) quiescent.

e. Measure the "total" sound level with the DUT operating.

f. Evaluate the significance of background noise in your measurement, and take steps to reduce if it necessary, as discussed below.

The difference between the sound level with the apparatus operating and the background level determines the correction to be used. If this difference is less than 3 dB, the apparatus noise is less than the background noise; then the level obtained by use of the correction should be regarded as only indicative of the true level and not as an accurate measurement. If the difference is greater than 10 dB, the background noise is negligible and the reading with the apparatus operating is the desired measurement.

An example of a situation intermediate between those two is as follows. The background noise level is 77.5 dB, and the total noise with the "device under test" operating is 83.5 dB. The correction, from the above-mentioned graph, for a 6.0-dB difference, is 1.2 dB, so that the corrected level is 82.3 dB.

If this difference between background level and total noise level is small, an attempt should be made to lower the background level. Usually the first step is to work on the source or sources of this background noise to reduce the noise directly. The second step is to work on the transmission path between the source and the point of measurement. This step may mean simply closing doors and windows, if the source is external to the room, or it may mean erecting barriers, applying acoustical treatment to the room, and opening doors and windows, if the source is in the room. The third step is to improve the difference by the method of measurement. It may be possible to select a point closer to the apparatus, or an exploration of the background noise field may show that the microphone position can be shifted within the specifications to a minimum of this noise (yet allowing proper orientation with respect to the device under test). Refer to the GR *Handbook of Noise Measurement* by Peterson and Gross, published by General Radio; Chapter 8, Techniques, contains particularly appropriate paragraphs about sound measurements and sound fields.

If your concern is measuring very low sound levels, below about 45 dB(A), the following considerations may be important.

Noise Floor. The noise flocr (sometimes known as the system noise level) is the apparent measurement obtainable when there is no significant sound signal. It is possible to measure the noise floor as follows:

a. Place the sound-level meter (or at least the microphone and preamplifier) in a very quiet location, where the sound-pressure level is below 15 dB. See below.

b. Slide the Power switch ON, the DIGITAL DISPLAY switch to CONT, and the RANGE switch to 30-80 dB.

c. Read the digital display.

Some suggestions for suitably quiet locations are as follows:

1. In a vault or acoustic chamber known to attenuate ambient noises at least 30 dB. (Measure noise floor at a time when level outside the chamber is known to be less than 45 dB(A).)
2. In a mine or deep cave that has no audible noises such as dripping of water or rumble due to operating machinery, road, railroad, or city noises.

NOTE

The noise floor of this instrument, with the microphone provided, is about 30 dB(A). For an evaluation of instrument noise (without microphone), see para 4.5.9.

Combinations. If the measured background noise is 10 dB or more above the noise floor, the latter is negligible. Otherwise, it is a significant part of the apparent background noise. (The error in measurement of background noise can be estimated with the graph of Figure 2-9. For example: measured noise floor is 30 dB(A), apparent (measured) background noise is 35 dB(A), graph shows "error" is 1.6 dB and so true background noise is 33.4 dB(A).) Of course, reduction of the true background noise cannot ever reduce the apparent background noise below the noise floor. The preceding discussion of background noise ("ambient sound" in the quotation), was about apparent background noise.

2.3.7 Very Loud Sounds. **Figure 2-10.**

The 1981 Sound-Level Meter may be exposed to sound-pressure levels above 120 dB. To preserve measurement accuracy under such conditions, one needs an understanding of the signal handling capabilities of the instrument. The figure shows the maximum (peak) sound-pressure level, vs frequency, that can be handled linearly by the 1981. At this peak level, there is a 1-dB compression of a sinewave with equivalent peak level.

The sound level indicated by the digital display or meter is dependent on the sound-pressure level applied to the microphone and the instrument's weighting characteristic (see graph, para 3.4). For example, a 100 dB(A) indication for a 20-Hz sound requires sound pressure at the microphone to be 150 dB. In general, if the sound-pressure level is high and the frequency low enough, the instrument can be overloaded even though the meter pointer is on scale. If extremely high sound pressure at very low frequency is suspect, make further analysis using suitable equipment, before proceeding with measurements using this or any other sound-level meter.

2.3.8 Recording of Data.

An important part of any measurement program is obtaining and recording sufficient data. The use of data sheets designed specifically for a noise problem helps to make sure that the desired information will be recorded. Below is a "check" list of important items to help you in recording measurement data or preparing suitable data sheets:

1. Description of space in which measurements are made. Nature and dimensions of floor, walls, and ceiling. Description and location of nearby objects and personnel.

2. Description of device under test (primary noise source). Dimensions, name-plate data and other pertinent facts including speed and power rating. Kinds of operations and

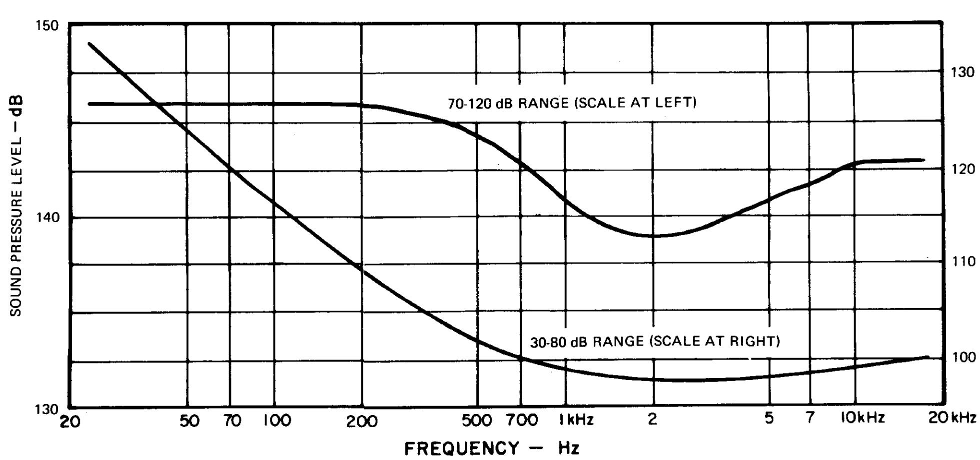


Figure 2-10. Peak sound-pressure overload level for 1-dB gain compression in the 1981 Sound-Level Meter.

operating conditions. Location of device and type of mounting.

3. Description of secondary noise sources. Location and types. Kinds of operations.

4. Type and serial numbers on all microphones, sound-level meters, and accessories used. Length and type of microphone cable.

5. Positions of observer.

6. Positions of microphone. Direction of arrival of sound with respect to microphone orientation. Tests of standing-wave patterns and decay of sound level with distance.

7. Ambient temperature, humidity, barometric pressure and resultant corrections, if any.

8. Results of maintenance and calibration tests.

9. Weighting network ("A" for 1981) and dynamic characteristic (FAST or SLOW) of indicator.

10. Measured sound levels at each microphone position. Extent of meter fluctuation.

11. Background noise levels at each microphone position, with device-under-test not operating.

12. Cable and microphone corrections.

13. Date and time.

14. Name of observer.

When the measurement is being made to determine the extent of noise exposure of personnel, the following items are also of interest:

1. Personnel exposed – directly and indirectly.
2. Time pattern of exposure.
3. Actions taken to control noise and protect personnel.
4. Audiometric examinations – dates, methods, equipment, results, etc.

2.4 USE OF ACCESSORIES.

Various accessories are available for use with the 1981 Sound-Level Meter. Their use is briefly described in this section. For complete information consult their respective instruction manuals. Some or all of these accessories are available in the various 1981 systems that are catalogued. See para 1.5 for complete listings of accessories supplied.

2.4.1 Sound-Level Calibrator (1562 or 1567).

The sound-level calibrator is used to make an overall calibration check on the sound-level-meter system, including the microphone, preamplifier, and extension cable (if used). The calibrator uses an adaptor to fit the 1/2-inch microphone (other adaptors are available). The 1562 generates a sound-pressure level of 114 dB at five switch-selectable frequencies from 125 to 2000 Hz. The 1567 generates a sound-pressure level of 114 dB at 1 kHz only. Refer to para 2.1 and para 4.3 for specific calibrator use information.

Figure 2-11. Battery charger connected to the sound-level meter.

2.4.2 Screwdriver (1565-0440).

The screwdriver is for adjustment of the CAL control located on the right side of the instrument.

2.4.3 Battery Pack (1981-9602).

Spare battery packs are available in addition to the one normally supplied with the instrument. One spare pack is included with each 1981-9760 and -9761 system. The pack contains three nickel-cadmium AA-size cells. They are of a premium grade and will provide thousands of charge/discharge cycles and several years of life when they are properly maintained. Para 2.6 describes in detail the recommended procedures for charging and maintaining these cells.

2.4.4 Battery Charger (1981-0420). Figure 2-11.

The battery charger consists of a transformer and rectifier circuit assembled in a compact case, intended for table-top use. Nominally, the charger supplies sufficient current to recharge the batteries in approximately 4 hours if the Power Switch is OFF. The 1981 may be operated while recharging, but then the 1981 consumes most or all of the charger output current. Refer to para 2.6 about rechargeable batteries. The charger output current and the recharge time are somewhat dependent upon the line voltage. The charger will operate properly from 50- to 60-Hz ac power lines with voltage in either range: 104 to 127 or 198 to 242 V, only. To use the charger:

a. Set the line-voltage switch on the bottom of the charger to the appropriate setting.

b. Connect the small phone plug to the 1981 at the BAT CHARGE jack on the right side of the battery compartment (refer to NOTE in para 2.6.1c). Turn the Power Switch OFF.

c. Connect the power plug to an ac power outlet.

d. Allow 4 or 5 hours for charging; then disconnect both plugs of the charger.

e. Perform a battery check regularly as you use the sound-level meter; recharge the battery promptly when low.

2.4.5 Microphone Extension and Exchange. Figure 2-12.

Extension. Frequently, formal test procedures specify use of a sound-level meter with its microphone located remotely from the instrument and observer, thus eliminating the effects on measured sound level due to their presence in the test vicinity.

The microphone-and-preamplifier assembly supplied with this sound-level meter can easily be removed to a location away from the instrument, by use of an extension cable, as described in para 2.2.6. In brief, the procedure is as follows:

a. Power OFF.

b. Loosen setscrew.

c. Pull preamp/mike assembly up and away.

d. Plug extension cable into nose cone and preamplifier.

e. Support the preamplifier with microphone at the desired position and orientation, preferably with a tripod such as GR 1560-9590.*

*Included with the 1981-9760 and -9761 systems. Also available separately; see para 1.5 and GR catalog information.

Figure 2-12. Remote location of microphone on tripod is demonstrated by this motor-vehicle noise measurement setup.

f. Calibrate the sound-level-meter system including preamp and connecting cable, as described in para 2.1.4. (Recalibrate also after replacing the microphone on the "nose cone".)

Exchange. To remove the microphone (for exchange or replacement), unscrew it from the preamplifier as follows:

a. Power switch OFF.

b. Unscrew the microphone, which is 2 cm long (0.8 in.). Be careful of the fine threads when installing another microphone.

c. If you leave the microphone off, protect it and the upper end of the preamplifier from dirt and damage.

2.4.6 Extension Cables **Figure 2-13.**

The cables (1933-9600, 3 m long and/or 1933-9601, 18 m long) enable the connection of a remote microphone and preamplifier to the sound-level meter, as mentioned above. Such a setup is often required for vehicle noise measurement in order to eliminate the disturbance produced by the operator upon the sound field arriving at the microphone. A reel is supplied for convenient storage of the longer cable.

Notice how the cable was originally placed on the reel; the cable was wound starting at its middle. This method allows you to unreel both ends as needed for applications of less than the full cable length. (The unused length stays on the reel.)

If an extension of greater length than 18 m (60 ft) is required, consult GenRad.

2.4.7 Microphone Windscreen (1560-9522, Package of Four).

It is good practice to use a windscreen for all outdoor measurements. A windscreen over the microphone will reduce the effects of wind, which generates low-frequency noise that can produce significant errors in your measurement. The windscreen also protects the microphone from damage by airborne contaminants.

The windscreen reduces wind noise significantly without a serious effect on the frequency response. (Sounds that are predominately below 15 kHz will produce almost identical readings on the 1981 whether or not you have the windscreen in use.

The windscreen is a sphere, 6 cm (2.5 in.) diameter, made of reticulated polyethylene foam, with a hole for the microphone. To use:

a. Place the windscreen over the microphone so that its outer edge is flush with the connector end of the microphone. Do NOT seat the microphone as far into the windscreen as the hole allows.

b. Remove the windscreen and wash or replace it when it becomes soiled.

NOTE

Do not attempt sound measurements in wind gusts of 24 km/hr (15 mph) or greater.

2.4.8 Tripod (1560-9590).

A tripod provides a means of supporting the instrument or remote microphone at a fixed position and height. The GR Tripod is designed to accept a variety of sound equipment including the sound-level meter and preamplifiers. The tilting head can be swiveled through 360° by rotating the center post of the Tripod. The head can be tilted 90° (vertical to horizontal) in one direction and in the opposite direction as far as 20° from the vertical. The latter position is the proper mounting angle for a preamp with a flat-random-incidence microphone when the sound source is at the same elevation in a free field. (A free field is typically found outdoors away from obstructions or in an anechoic chamber.)

Height Adjustment. Each of the tripod legs and its center post are telescoping for compact storage and versatility in use. Adjust the tripod for the desired height, from 37 to 140 cm (14.5 to 56 in.) as follows:

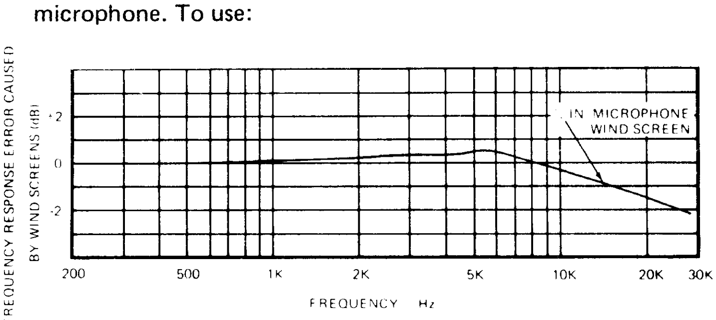
a. Extend the legs by loosening the knurled locking nuts (smallest first) and pulling out the telescoping sections. Tighten securely (largest nut first) at the desired length.

b. Extend the center post by loosening the thumb screw at its side, pulling it up, and clamping it at the desired height with the thumb screw.

c. Keep the tilting sleeve adaptor (see below) in place to retain the inner tube of the center post as you loosen the locking nut on the center post. Swivel the very top assembly, and if necessary raise it, to the desired position before retightening this locking nut.

NOTE

Be sure the 9 knurled locking nuts in the legs of the tripod are tightened securely so it will not collapse in use.



Effect of windscreens on microphone response.

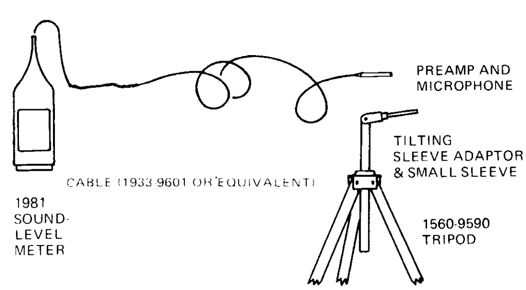


Figure 2-13. Remote-microphone sound measurement setups. Refer to para 1.5 for listing of several lengths of cable.

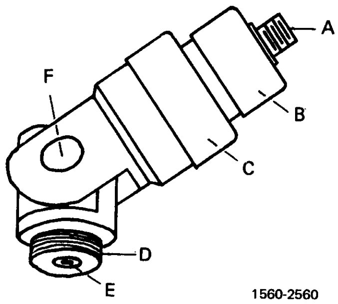


Figure 2-14. Tilting sleeve adaptor. A = top stud, B = smaller clamping nut, C = larger clamping nut, D = bottom stud which screws onto top of tripod, E = set screw for adjusting friction in: F = pivot.

Sleeve Adaptor (Head). **Figure 2-14.**

With this tripod are included a tilting Sleeve Adaptor 1560-2560 and 2 sleeves. This adaptor usually serves as the head of the tripod center post. Without the sleeves, the top stud (1/4-20 thread) will fit the tripod mounting hole on the back of the sound-level meter, or under most cameras. At the bottom end is a set screw with which you can vary the tightness of the tilting pivot. This end is threaded to fit either the center post of the tripod or the light-stand adaptor. Mounting instructions follow:

Sound-Level Meter.

a. Tilt Sleeve Adaptor (head) to approx 70° from vertical, i.e., from the axis of the tripod center post.

b. Remove each sleeve after loosening its knurled clamping nut, 1/4 turn.

c. Tighten each clamping nut gently, by hand. (If inadvertently removed, be sure to replace each nut with its split locking ring oriented so beveled edge is down.)

d. Screw the instrument onto top stud, approx 4 turns. Unscrew slightly, if necessary, to orient microphone upwards.

e. Clamp instrument by turning the smaller clamping nut snugly against the chassis.

Preamplifier and Microphone.

a. Tilt Sleeve Adaptor (head) to approx 20° from vertical. In one direction there is a stop at this angle.

b. Remove larger sleeve after loosening its clamping nut 1/4 turn. Tighten nut gently by hand (see step c, above). If the smaller clamping nut has been tightened without its sleeve in place, loosen 1 turn.

c. Insert non-slotted end of smaller sleeve into clamping nut as far as it will go (3/8 in.) Orient slot where you want cable to pass through (downward). Tighten clamping nut.

d. With its cable in slot, slide preamp backwards into sleeve far enough for firm support but NOT so far that its cable is stressed.

Tightness of the Pivot. The stiffness of the pivot in the sleeve adaptor is adjustable as follows:

a. Raise the inner tube of the tripod center post, so you can get a good grip on it. Unscrew the tilting Sleeve Adaptor 1560-2560 from its top.

b. Tighten or loosen the set screw, E, using a 0.125-in. hex wrench, a small fraction of a turn until the pivot is free enough for convenience but tight enough to support sound-level meter reliably. (Hex wrench is supplied with tripod.)

c. Replace securely on center post.

2.4.9 Light-Stand Adaptor, 1981-1200.

It may be desirable in some measurement situations to use a commercially available photographic light stand to provide extension of the microphone height up to 12 feet above ground level. It is recommended that a stand similar to an Alumilite AL-12 be considered. For attaching the tripod Sleeve Adaptor head to this and similar light stands, use the Light-Stand Adaptor.*

The Light-Stand Adaptor will fit onto any rod up to 3/8 in. (9.5 mm) diam and at least 3/8 in. long, to which it can be clamped with 3 set screws. For firmest support, keep 2 setscrews backed off while tightening the 3rd; then tighten the first 2 moderately.

2.4.10 Subminiature Phone Plugs (4270-1110).

The mini-phone plugs are used to make connection to the AC and DC OUTPUT jacks. Make your cables to reach peripheral instruments as desired; use shielded wires.

2.4.11 Strip-Chart Recorder (1985-9700).

For permanent records of sound level vs time (for example, during vehicle pass-by, machine operation, or cyclic processes, etc.) the GR 1985 Dc Strip-Chart Recorder is recommended. See Table 1-5 and refer to the 1985 instruction manual.

2.5 ENVIRONMENT.

2.5.1 Temperature.

The 1981 is rated to operate over the temperature range from −10° to 50°C with minimal variation in sensitivity. Over the center portion of this range (10° to 35°C), the overall sensitivity, including microphone, varies less than ±0.5 dB. (The temperature coefficient of the microphone is supplied in its calibration certificate as dB to be added or subtracted from each measurement.)

However, for measurements in cold (−10° to 10°) or hot air (35° to 50°C), recalibrate your sound-level-meter system in the measurement environment. (See para 2.1.)

CAUTION

Allow all components of the system and the calibrator to stabilize at the ambient temperature before calibration and before proceeding with measurement. Be sure to take into account the temperature coefficient of the calibrator, as specified in its instructions.

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*Included with the 1981-9760 and -9761 systems. Also available separately; see para 1.5 and GR catalog information.

The battery imposes limits on temperature range for operation and storage, and narrower limits for charging. These are the important temperature ranges:

1. Normal operation: –10 to 50°C (14 to 122°F). See above.
2. Battery charging: +15 to 50°C (59 to 122°F).
3. Storage without batteries: –40 to 60°C (–40 to 140°F).

2.5.2 Magnetic Fields.

Shielding provided within the 1981 reduces the effects of an external magnetic field to a minimum. The response of this sound-level meter to a magnetic field of 80 A/m (1 oersted) at 50 or 60 Hz is less than 58 dB(A) on either meter or digital display at 400 Hz.

Magnetic fields will generally be encountered when you operate the instrument in close proximity to heavy electrical equipment. Magnetic interference can be recognized by a reading that does not correlate subjectively to the sound present, and which fluctuates widely when the instrument is turned slightly. This type of interference can be minimized by suitable orientation of the 1981, or by placement of the preamplifier with microphone near the noise source so you can locate the sound-level meter away from the magnetic field.

2.5.3 Vibration. **Figure 2-15.**

The response of the 1981 Sound-Level Meter to vibration is generally negligible. Refer to the figure for details. The lower curve represents response to sound caused by the shaker; the upper curve, response to that sound and the vibration, simultaneously.

2.6 BATTERY CHARGING AND MAINTENANCE.

The 1981 is supplied with a rechargeable battery pack (1981-9602) containing three AA-size nickel-cadmium cells. They are of premium grade and will provide thousands of charge-discharge cycles if they are used properly, as described below. Although an occasional deviatio will not ruin the battery, these procedures should be followed to establish habits that will maximize battery life.

2.6.1 Charging the Battery.

a. Install the battery pack in the 1981 (see para 2.1).

b. Set the line-voltage selector switch on the bottom of the 1981-0420 Battery Charger to whichever position is appropriate for the available power-line voltage. To slide this switch, use the tip of a small screwdriver (not a sharp object).

c. Plug the battery-charger output cable into the BAT CHARGE jack on the right side of the 1981.

NOTE

Care should be taken to push the battery-charger phone plug all the way into the 1981-B BAT CHARGE jack so that it seats firmly. Likewise, when extracting the phone plug, ensure that it is removed completely from the jack so that there is no physical contact between the plug and jack.

d. Connect the battery-charger line cord to the ac power line.

e. Full recharge will be accomplished in 4 to 5 hours if the Power Switch is OFF.

If the 1981 is operated while the charger is connected, the batteries will receive only a trickle charge. So be sure the Power Switch is OFF if you intend to charge the battery.

Avoid overcharging. The practice of leaving the charger connected for a longer period of time than is required to replenish the full charge in the battery is not necessarily

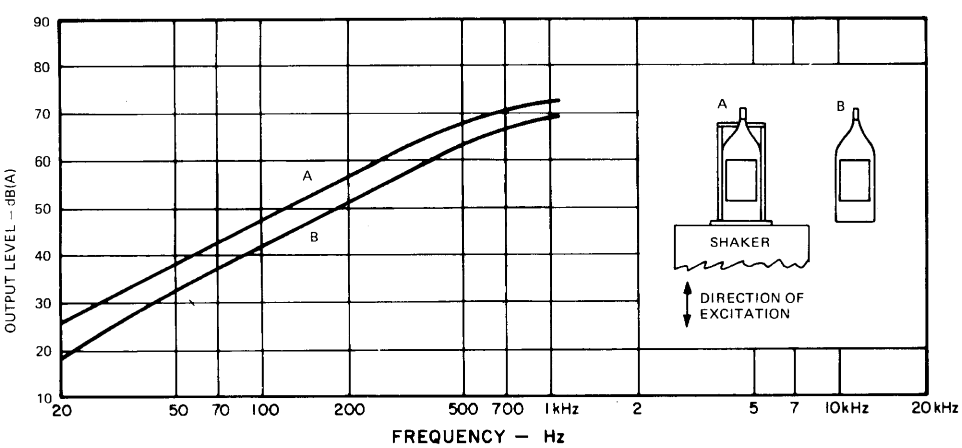

Figure 2-15. Influence of mechanical vibration on the 1981 Sound-Level Meter with microphone. Curve A = output from SLM attached rigidly (in 3/8-inch aluminum frame) to shaker that vibrates at 1.0 m/s^2 in most sensitive direction (perpendicular to plane of microphone diaphragm). Curve B = output from reference SLM in same sound field. The range switch of each SLM was set to 70-120 dB(A).

harmful. The battery absorbs the excess energy and dissipates it as heat. Overcharging produces excess gas within the cells and tends to build up the internal pressure. The cells contain chemicals that normally reabsorb this gas when the pressure rises. A safety vent protects against the possibility of bursting. However, since overcharging does place some strain on the battery, try to avoid overcharging repeatedly. If the battery is not fully discharged before recharging, the optimum charge time is about 1/2 to 2/3 of the discharge time.

Temperature has some effect on the capacity of the battery pack, or the length of time for which it will provide power for the 1981. If the battery is recharged at 40°C, it will provide only 60% of the capacity available after a room-temperature or low-temperature charge. Also, if the 1981 is operated below 0°C, the battery will produce only about 90% of its rated capacity.

Avoid very cold charging. There is a low-temperature limit for charging because the gas-absorbing chemical reactions do not work at low temperatures. Even moderate charging below a temperature of 15°C is liable to generate enough gas to open the safety vent. Therefore, be sure to keep the temperature above 15°C (59°F) while charging the battery.

If the safety vent opens, (an occurrence that is difficult to detect) the battery loses some of its electrolyte. The result is degradation and ultimately failure of the battery i.e., loss of capacity to store electrical energy.

CAUTION

Do NOT attempt to recharge any battery other than the rechargeable pack supplied for the 1981. Any attempt to charge non-rechargeable cells can cause them to overheat and explode. Do NOT attempt to defeat the interlock that is intended to prevent recharging of miscellaneous AA cells.

2.6.2 General Maintenance.

Extreme Discharge. Do not allow the batteries to become completely discharged. That would not happen during normal operation, because the instrument would fail to pass its routine "battery check" (para 2.1) before that. Be sure to set the Power Switch OFF, as soon as you are through using the instrument. The red dot that appears when this switch is ON will serve as a reminder.

"Memory". Ni-Cd batteries have a tendency toward losing capacity if they are not regularly and properly discharged and recharged. (An apparently full charge will not last the normal 4 hr of operation.) This phenomenon, called "memory", may happen if the batteries are not used for a long time or if, for many cycles, you use only a small fraction of their capacity. However, "memory" is usually not a failure of the battery, since it can be reconditioned.

If you encounter "memory", use the following procedure to provide satisfactory reconditioning.

a. Discharge the batteries fully by letting the 1981 run with the DIGITAL DISPLAY switched OFF for approx 24 hr.

b. Perform a slow charge by charging with the 1981 Power ON and DIGITAL DISPLAY OFF for 24 hr.

c. Repeat the reconditioning cycle again if necessary.

Moderation. Ni-Cd batteries respond well to moderation in both recharge cycles and temperature. To prolong their life, do not needlessly expose them to extreme conditions.

Line Voltage. For maximum battery life be sure the line voltage is well within the selected range shown on the battery-charger line-voltage switch.

Fire. Do not dispose of any batteries in a fire or trash to be burned.

Storage. Ni-Cd batteries may be stored in either a charged or a partially discharged condition. The batteries will self-discharge at a rate of 10 to 25% per month, so it is normal to recharge them after prolonged storage. If "memory" is encountered, perform the reconditioning procedure described above.

2.7 MOTOR-VEHICLE NOISE MEASUREMENTS.

2.7.1 Introduction.

An excellent discussion of vehicle noise, causes, remedies, measurements, and calculations is given in Acoustics/Signal Analysis Application Note 1, Motor Vehicle Noise Measurement, form no. JN863-1274, available from GenRad. Refer also to the following article, which is substantially the same: Arnold P.G. Peterson, "Motor Vehicle Noise Measurement", *Sound and Vibration,* vol. 9, no. 4, April 1975, pp 26-33.

In the measurement of motor-vehicle noise, the site, the location and orientation of the microphone, and the position of the observer must be carefully controlled to ensure accurate and repeatable results.

Typical standards for these measurements are:

1. HPH 83.3 – Sound Measurement Procedures, Department of California Highway Patrol, May 1973.
2. ISO R362 – Measurement of Noise Emitted by Vehicles.
3. SAE J986 – Sound Level for Passenger Cars and Light Trucks.
4. SAE J366a – Exterior Sound Level for Heavy Trucks and Buses.
5. Part 202 of Title 40 of the Code of Federal Regulations, Environmental Protection Agency, pertains to interstate motor carriers engaged in interstate commerce.
6. Section 1036 of the Exhaust System Calibration Law of the California Highway Patrol, January 1977.

General guidelines for vehicle noise measurement follow. Before making measurements refer to the standard or law governing your particular measurement for exact details.

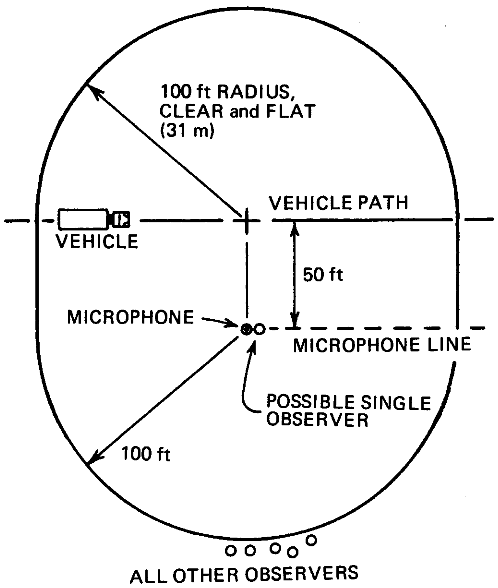

Figure 2-16. Vehicle-noise measuring site, per HPH 83.3.

Table 2-1

CORRECTIONS FOR MICROPHONE PLACEMENT
OTHER THAN 50 FT AWAY.

Distance from Microphone to Roadway Centerline		dB(A) Correction Factor
35 to 39 ft.	(approx 11 m)	–3
39 to 43 ft.	(12 to 13 m)	–2
43 to 48 ft.	(approx 14 m)	–1
48 to 58 ft.	(15 to 17 m)	0
58 to 70 ft.	(18 to 21 m)	+1
70 to 83 ft.	(22 to 25 m)	+2
83 to 99 ft.	(25 to 30 m)	+3
99 to 118 ft.	(30 to 36 m)	+4

2.7.2 Measuring Sites. **Figure 2-16.**

Recommended measuring sites are generally clear, open areas including a vehicle path (roadway) and carefully chosen positions for microphones. The surface of the ground within the site should be substantially level and free from sound-absorbing material such as powdery snow, long grass, loose soil, or ashes.

HPH 83.3.

For this standard for measuring noise from vehicles operating on highways, there should be no sound-reflecting objects within a 100-ft (31-m) radius of the microphone and a 100-ft radius of the point nearest the microphone on the vehicle path. The microphone is placed 50 ft from the center of the vehicle path, as shown. The difference in ground level between the point under the microphone and the nearest point on the vehicle path must not exceed 2.5 ft.

Under certain conditions, measurements may be made on sites where the distance from the center of the vehicle path to the microphone is other than 50 ft. Then a correction factor (see Table 2-1) may be added to the measured value to determine the equivalent 50-ft sound-level. This corrected measurement can then be compared to a specified limit based on the standard distance.

ISO R362. **Figure 2-17.**

A different measuring site is defined by ISO Recommendation R362, Measurement of Noise Emitted by Vehicles. The microphone is placed 7.5 meters from a center on the vehicle path. The surface of the ground must be hard and smooth (paved) for a 20-m radius. No sound-reflection objects are permitted within a 50-m radius of that center. Sound levels on both sides of the vehicle must be measured in the recommended procedure.

2.7.3 Microphone Placement.

The microphone should preferably be mounted on a preamplifier, on a tripod, and an extension cable used to remove the sound-level meter and observer from the near field of the microphone.

Microphone Mounted on Tripod. **Figure 2-18.**

Use of the tripod keeps all observers away from the near field of the microphone and allows you to handle the sound-level meter conveniently without being restricted by the requirements on placement of the microphone (height, angle, etc).

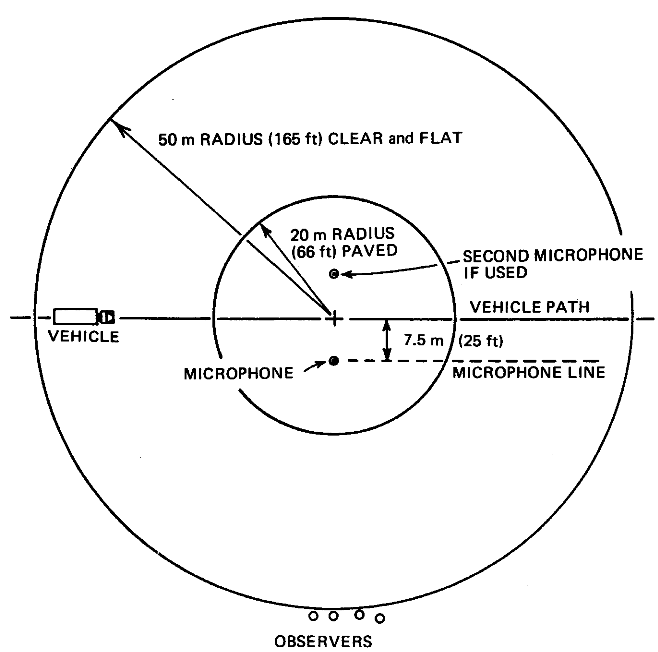

Figure 2-17. Vehicle-noise measuring site, per ISO R362.

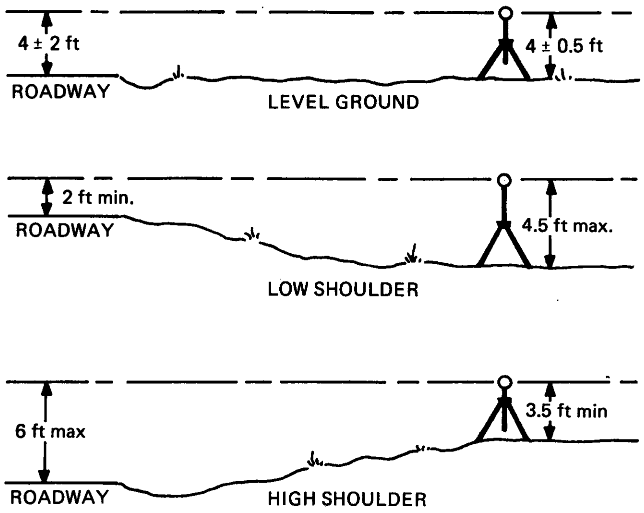

Figure 2-18. Microphone height, according to HPH 83.3 specifications. Ground level at microphone must be within ±2.5 ft of roadway elevation.

a. Set up the tripod to hold the microphone at the specified height – for HPH 8.3.3, 4 ± 0.5 ft above the ground (see sketch); for ISO R362, 1.2 m above the ground. Refer to the official specifications.

b. Clamp the swivel head of the tripod so the microphone angle is correct for sound coming horizontally from the vehicle at the nearest point on its path. Refer to para 2.3. In brief, if you are using a "flat-random-incidence-response" microphone (HPH) point the perforated end upwards (toward the zenith) or tipped as much as 20° toward the nearest point on the vehicle path. If you are using the "flat-perpendicular-incidence-response" microphone (ISO), point it horizontally toward the nearest point on the vehicle path.

Sound-Level Meter Mounted on Tripod.
An alternative method, though much less convenient, is to mount the sound-level meter with microphone on the tripod. The microphone location and orientation must be the same as described above. As operator, you should be sure to stand or sit the same distance from vehicle path as the microphone is. (That way your body is least disturbing to the near field.) Also, insofar as possible, keep your arms and anything you may be holding at this same distance from the vehicle path and well away from both microphone and tripod.

In general, only the observer making the measurement is permitted near the instrument. Other observers must remain at least twice the distance from the vehicle path to the microphone away from the instrument, i.e., outside the "measuring site".

NOTE

If you must be inside the site and use a clip board or book for data sheets, hold it snug against your body or lay it flat on the ground during any measurement.

Sound Level Meter, Hand Held. A third method, not recommended for an extended series of measurements, nor for the best accuracy, is to hold the complete sound-level meter in your hand.

a. Hold the instrument so as to position and orient its microphone as described above or as specified in the procedure you are following.

b. Keep your body in the plane of the microphone line, i.e., the same distance from the vehicle path as the microphone. Keep all other observers outside of the measurement site.

c. Be sure to hold the sound-level meter by its main chassis, never by the "nose cone". (Refer to para 2.3.)

2.7.4 Equipment Setup.

The following procedure summarizes equipment setup for motor-vehicle noise measurements. Refer to the referenced paragraphs in this manual for further details.

a. Install the smaller sleeve (remove the larger) on the tilting adaptor on top of the tripod. Adjust its legs for the specified height at the proper microphone position, a specified distance from the vehicle path. (Para 2.4.8)

b. Remove the microphone/preamplifier assembly from the 1981-B Sound-Level Meter and place the latter at the observer's position. (Para 2.4.5.)

c. Connect the cable to the preamplifier and push it into the sleeve on the tripod. Connect the other end of the cable to the 1981.

d. Check the batteries of the 1981 and the calibrator (para 2.1). Repeat the 1981 battery check about twice an hour, routinely.

NOTE

For a day-long task, carry spare batteries. A fresh set of alkaline cells should last 8 hrs; a full charge in Ni-Cd cells, 4 hrs of "on" time.

e. Remove the microphone dust cap, point the microphone up, and perform the acoustic calibration (para 2.1).

f. Place the windscreen on the microphone (para 2.4.7).

g. Orient the microphone properly, as described above (for HPH, "random" microphone, point perforated end up or inclined 20°; for ISO "perpendicular", point it horizontally, i.e., inclined 90° toward nearest part of vehicle path).

h. Locate the 1981 at an observation position, preferably outside the perimeter of the measuring site.

NOTE

When the sound-level meter is to be hand held, a, b, c, and h do not apply.

2.7.5 Measurement Procedure.

a. Set the 1981 controls as follows:

Power Switch . . . . ON
DIGITAL DISPLAY . . . . MAX
RANGE Switch . . . . 70-120 dB
FAST-SLOW Switch. FAST (unless otherwise specified by the standard procedure you are following).

b. At the beginning of the measurement of a particular vehicle, press and release the CAPTURE DISPLAY button to clear the digital display (para 2.2.4). Observe background level, on the meter, before and after the vehicle passes.

c. As the vehicle passes by, the digital display reading will increase to the maximum sound level and remain there as the sound level subsides. Watch the meter. If an extraneous peak such as a backfire occurs, the measurement is invalidated.

d. The background noise, both before and after the vehicle has passed by, must be more than 10 dB lower than the value retained in the display, for a valid measurement (para 2.3.6).

e. Read the desired sound level from the digital display. Record this value and other required data.

If a higher noise level is liable to occur before that value can be recorded, press and hold the CAPTURE DISPLAY pushbutton just after the desired maximum and hold it until the record is made. (The higher level can be observed, meanwhile, on the meter.) Alternatively, if the second (higher) level is particularly important, read the first one quickly and let the digital display "capture" the second one.

f. Repeat the battery check and acoustic calibration procedures at intervals (para 2.1). Service the battery as required (para 2.6).

2.7.6 Precautions.

Be sure to place a windscreen over the microphone after calibration. The windscreen reduces the effect of wind noise and protects the microphone diaphragm from dirt and other airborne contaminants. Measurements are not recommended when the average continuous wind speed exceeds 10 mph or the wind gusts exceed 15 mph.

Measurements should not be made under high-voltage transmission lines or near large transformers or large electrical machinery because they can affect instrument operation (para 2.5.2).

2.8 General Noise Measurement.

The 1981-B Precision Sound-Level Meter is well suited to industrial noise control measurements such as those relating to the OSHA Act. Two 50-dB-wide display ranges cover all general-purpose needs, with a minimum of range switching and yet with 0.1-dB resolution. To comply with "OSHA", use SLOW response, as follows:

a. Set the 1981 controls as follows:

Power Switch . . . . ON
DIGITAL DISPLAY . . . . CONT
FAST-SLOW Switch . . . . SLOW.
RANGE Switch . . . . as is appropriate.*

b. Check the battery and calibrate as in para 2.1.

c. Hold the sound-level meter in one or both hands, by the main chassis (not the nose cone), in front of you, so you can see the displays.

d. Stand with the noise source at your side (left or right) so the microphone is located where you wish to measure sound level. The sound should be traveling across the end of the microphone (grazing incidence), as illustrated in Figure 2-3 or toward the end of the microphone (Figure 2-4), depending on the type of microphone.

e. In order to capture a reading, press the CAPTURE DISPLAY pushbutton.

f. If you wish to capture a maximum level, switch DIGITAL DISPLAY to MAX and press CAPTURE DISPLAY momentarily. Then, after the noise peak, read the digital display. Press the pushbutton again momentarily to reset the display, for another maximum measurement.

*In a machine shop, noise levels can be expected to be above 70 dB(A); in offices and stores, below 80 dB(A).

Theory—Section 3

3.1 GENERAL.

Figures 3-1, 3-2.

A sound-level meter comprises four main elements, as shown in the block diagram of an elementary sound-level meter. The microphone produces an electrical signal proportional to the applied sound pressure. This ac electrical signal is applied to an amplifier with frequency-selective networks that establish the "weighting." The amplification is adjustable, in order to provide for proper calibration of the instrument. After amplification and weighting, the ac signal is applied to the detector, where it is changed into a dc signal suitable for application to the readout device. The detector has closely controlled response-time characteristics, and produces a dc signal proportional to the effective, or root-mean-square, value of the weighted ac input signal. The detector output signal is applied to the readout device, which may be a meter, digital display unit, or both.

The circuit elements of the 1981-B Precision Sound-Level Meter are shown in the Elementary Block Diagram. This diagram also shows the location of the electronic circuitry on the etched-circuit boards. Refer also to the Over-all Block Diagram and schematic diagrams in Section 5.

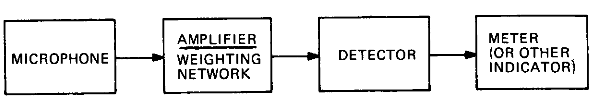

Figure 3-1. Block diagram of elementary sound-level meter.

NOTE

Each full reference designator used in the schematic diagrams, block diagrams, parts lists and circuit description includes a prefix letter which indicates the subassembly in which the particular component is found. The subassembly prefix letters are shown on Figure 3-2. Not shown is subassembly "A" which is the instrument chassis. Generally, since it is clear from context, the subassembly prefix letters are omitted from the various diagrams and descriptions for the sake of brevity. Examples: C-R8 designates resistor No. 8 on the C board; D-C10 designates capacitor No. 10 on the D board. The instrument may contain A-R1, B-R1, C-R1, etc.

The preamplifier assembly which is plugged into the nose cone contains the 2-stage, low-noise amplifier, Q1 and Q2. The preamplifier matches the very high impedance of the microphone to the much lower impedance level of

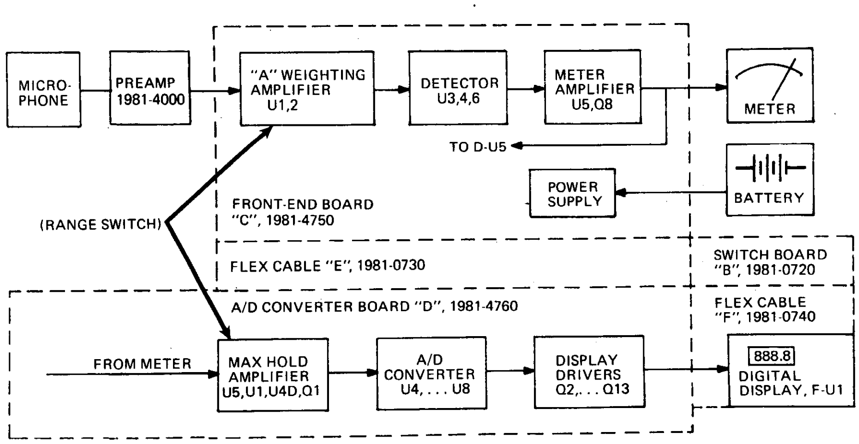

Figure 3-2. Elementary block diagram of the 1981 Precision Sound-Level Meter.

the extension cable (if used) and the following circuitry. (The signal-power gain is more than 30 dB).

The Front-End Board "C" incorporates the rest of the circuitry essential to sound-level display on the analog meter. Amplifier stages U1 and U2 amplify the input signal voltage by a factor (at 1 kHz) of 2.5 if the RANGE switch is set to 70-120 dB, or 250 if that is set to 30-80 dB. The A-weighting frequency response characteristic is provided by 6 resistor-capacitor networks in the U1-U2 circuit. This characteristic is in accordance with IEC-179 and ANSI S1.4-1971 Type 1 standards. The detector circuit, comprising U3, U4, and U6, provides a dc output voltage that is proportional to the logarithm of the rms value of the input signal. The detector response times for FAST and SLOW are also in accordance with IEC-179 and ANSI S1.4-1971 Type 1 standards. The detector output signal is amplified by U5 and Q8, and applied to the meter. A drive signal, called FMDT, for the digital display circuit is derived from the meter circuit.

Also on the Front-End Board "C" is the power supply circuit composed of Q3 through Q7. This circuit, supplied with unregulated power from the Ni-Cd battery (3.6 Vdc), develops precisely regulated voltages of +6.4 Vdc and −6.4 Vdc. These regulated voltages are used as primary power by most of the circuits in the instrument.

The digital display circuit occupies the A/D Converter Board "D". The designation A/D stands for "analog-to-digital". The analog signal from the meter circuit is applied to the maximum-hold amplifier U5, U1, Q1, and U4D. This circuit has its dc offset switched by the RANGE switch, an amount equivalent to the 40-dB difference between the two ranges. Also, this circuit operates in two modes under the control of the front-panel DIGITAL DISPLAY switch. In the CONTINUOUS mode, this amplifier serves as a level shifter and amplifier to transform the meter signal to the value required by the A/D converter circuit. In the MAXIMUM mode, the circuit becomes, in addition, an operational peak detector giving an output that is proportional to the maximum value of its input. Logic circuitry actuates the circuit from the front-panel controls. The A/D converter circuit provides a digital output for the digital display based on the analog signal from the maximum-hold circuit. Para 3.2 describes its principles of operation. The output of the A/D converter is buffered by display drivers, Q2 through Q13, and applied to the four-digit LED display device F-U1. Logic in the A/D converter circuit implements the CAPTURE DISPLAY mode of operation by inhibiting the converter while storing the present value in the display circuitry.

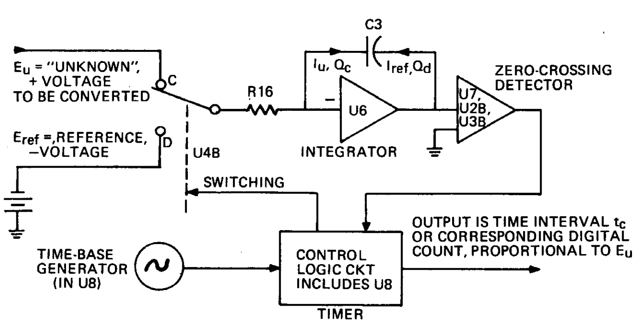

Figure 3-3. Dual-slope A/D converter, elementary block diagram.

3.2 PRINCIPLES OF THE 1981 A/D CONVERTER.

Figures 3-3, 3-4.

The analog-to-digital converter uses a dual-slope integration technique. This scheme is widely accepted because of its simplicity and accuracy. The basic configuration and operation are shown in the accompanying figures. Capacitor C3 is successively charged and discharged, with an "unknown" voltage (the analog input) and a reference, respectively. The charge time is controlled and the discharge period measured by the timer. The following expressions describe this process and define its result:

$$Q_c = I_u t_c; \quad I_u = \frac{E_u}{R_{16}}; \quad Q_c = \frac{E_u t_c}{R_{16}}$$

$$Q_d = I_{ref} t_d; \quad I_{ref} = \frac{E_{ref}}{R_{16}}; \quad Q_d = \frac{E_{ref}}{R_{16}} t_d$$

$$Q_c = Q_d; \quad \frac{E_u t_c}{R_{16}} = \frac{E_{ref} t_d}{R_{16}}$$

$$\frac{t_d}{t_c} = \frac{E_u}{E_{ref}}$$

Where: Q_c = charge placed on C3 by "unknown" voltage (input)
Q_d = charge removed from C3 by reference voltage
I_u = charge current, from "unknown"
I_{ref} = discharge current, from reference
t_c = charge time, fixed by timer
t_d = discharge time, proportional to unknown, measured by timer.

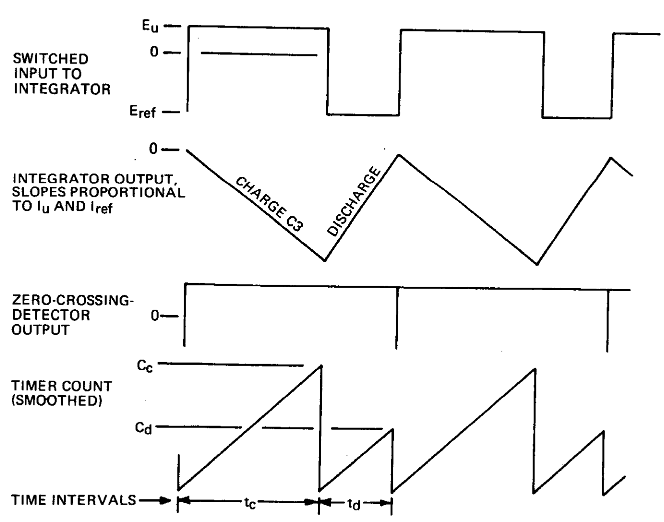

Figure 3-4. Elementary waveform and timing diagram for dual-slope A/D converter.

Thus, the ratio of the discharge time to charge time equals the ratio of the "unknown" voltage to the reference voltage. If the time intervals t_c and t_d are known in arbitrary units equal to the period of the timer's clock, then the proportionality becomes:

$$\frac{C_d}{C_c} = \frac{E_u}{E_{ref}} \; ; \; C_d = \frac{E_u\, C_c}{E_{ref}}$$

Where: C_d = count accumulated during discharge time t_d
C_c = count accumulated during charge time t_c.

The value of C_c is chosen to give the desired resolution and full-scale value. It is fixed by the timer design. For the 1981, C_c = 10,000, so:

$$C_d = \frac{E_u}{E_{ref}} \times 10{,}000.$$

Thus, the dual-slope A/D converter (by means of a time interval proportional to the input voltage) generates a digital number (a count) representative of its input. Furthermore, the conversion is independent of variations in the frequency of the count oscillator, the values of circuit components, etc. The only requirement on most of these is that they remain stable during each conversion cycle. The requirement for a stable reference level, E_{ref}, is met with voltage-regulator circuitry. Refer to para 3.6 for a description of the A/D converter circuit.

3.3 POWER SUPPLY.

The power supply circuit is located on Front-End Board "C", 1981-4750. The prefix "C" normally appended to the designators of parts on this board is omitted in the following description

The power supply uses Q4, Q5, and T1 connected as a self-excited dc-dc converter. Its frequency of oscillation is approx 50 kHz. Positive feedback for Q4 and Q5 is taken from the secondary of T1. CR1, CR2, CR3, and CR4 provide full-wave-rectified positive and negative dc voltages. The negative output is regulated directly; the positive supply voltage tracks the regulated negative voltage (since both voltages are derived from T1).

A constant 1-mA current is established through Q7, a two-terminal device comprising a FET with gate tied to source. Thus, Q7 supplies a constant current equal to its I_{DSS}. This current is divided between the base of Q3 and CR5, a temperature-compensated zener diode. For the sake of explanation, suppose the negative supply voltage changes erroneously in a positive direction; the change will couple to Q3 through CR5. Q3 will draw more current through series regulator Q6, thus increasing the drive level to Q4 and Q5. The supply output voltage is raised, correcting the original error. CR6 compensates for the temperature variation of V_{BE} of Q3.

3.4 PREAMPLIFIER, WEIGHTING, AND DETECTOR.

Preamplifier. This assembly, 1981-4000, contains miniature circuit board "P", 1933-4795. The very high input impedance is due to the characteristics of the field-effect transistor P-Q1 and the guard circuit. (The "high" lead from the microphone has its capacitance to ground effectively reduced by a shield which is driven in phase with the microphone signal.) The low-frequency input impedance is about 2.2 GΩ; the output impedance is about 3 kΩ.

Front-End Circuits. The Front-End Board "C", 1981-4750 comprises the A-weighting amplifier, detector, and meter amplifier, as well as the power supply described above. The prefix "C", normally appended to the designators of parts located on this board, is omitted in the description.

From the preamplifier, the input signal passes through weighting network C2, R3, C3, and R4. This network provides 2 cascaded high-pass RC sections, each with a cutoff frequency of 281 Hz. The signal is then amplified by U1, which has a voltage gain of 1 or 100, depending on whether the RANGE switch is set to 70-120 or 30-80 dB, respectively. The signal is then coupled to U2 by C5 and R2. C5 and R7 form a high-pass filter with a cutoff frequency of 20.2 Hz. R2 and C6 form a low-pass filter with cutoff freq 12.4 kHz. The signal is further amplified by U2, which utilizes CAL potentiometer R5 in its feedback loop, for overall ac gain calibration. The weighting network, R10 and C31, in this circuit acts as a low-pass filter with a cut-off frequency of 12.4 kHz. The signal passes through R11 and C7, a high-pass filter with a cutoff frequency of 20.2 Hz. These RC filters together comprise the A-weighting network.

Weighting. **Figure 3-5.**

This graph shows the A-weighting characteristic, as relative attenuation in dB vs frequency in Hz (zero dB at 1 kHz).

Detector and Meter Amplifier. The detector circuit, U3, U4, and U6, provides a dc output voltage proportional to the logarithm of the rms value of the ac input signal applied through C7. The detector response times for FAST and SLOW characteristics are established by C11 and C12, in series. For SLOW, A-S2 shorts out C11. The dc output voltage from the detector is amplified by meter amplifier U5 and Q8.

The meter responds to its current, equal to the applied voltage divided by the resistance of the meter movement in series with R25. The meter resistance increases with temperature, as does the dc output of the detector; temperature compensation is thus obtained. A compensated output voltage for the DC OUTPUT jack and the digital display circuit is derived from R25.

The battery-check circuit operates when the battery voltage is applied via the Power Switch to SO1-3. Q9, which is normally held off by voltage divider R34 and R33, conducts; this cuts off Q8, disconnecting the meter from the detector. The meter then functions as a voltmeter, with the battery voltage coupled through CR7 and R21. CR7 provides the necessary gating and some compensation for the variation of the Ni-Cd battery voltage with temperature. R21 establishes calibration with the BAT check mark on the meter face.

3.5 MAXIMUM-HOLD AMPLIFIER.

This circuit is located on A/D Converter Board "D", 1981-4760. The prefix "D", normally appended to the designators of parts in this circuit, is omitted from the following description.

The dc signal FMDT, representing sound level, from the meter circuit is applied to the maximum-hold circuit U5, U1, Q1, and C1. One SPST section of a CMOS switch, U4D, is used in this circuit. When the switch control signal (at pin 12 of U4 for this section) is high, the switch is closed; when low, the switch is open. U1 and Q1 comprise a dc amplifier and level shifter. U5 is a unity-gain buffer. The feedback network around U1 and Q1 includes dc offset that is switched by RANGE switch A-S3 so that the output voltage from Q1 is proportional to sound level in dB on one consistent scale that includes both ranges. (For example, the voltage there, at DV2, is +2.4 V for a measurement of 74 dB on either range. The constant of proportionality is 35 mV per dB.) When the digital display is in the CONTINUOUS mode, switch U4D is closed. The voltage on C1 simply tracks the operating level. When the circuit is in the MAXIMUM hold mode, switch U4D is open. While the input voltage increases, the voltage on C1 increases. Beyond its peak, when the input voltage starts dropping, CR1 is back biased and the feedback loop opens. The voltage at U1-6 goes to −0.7 V, where it is clamped by CR4. The voltage on C1 then decays negligibly, due to the low leakage through U4, CR1, and Q1. The maximum-hold circuit output voltage from Q1 (DV2, or essentially E_u referred to below) remains at precisely the value it had at the instant when the input voltage peaked; thus it represents the maximum sound level. The voltage on C1 stays constant until a higher input occurs or until U4D closes and resets it.

Control voltage for switch U4D is obtained from the "maximum-hold reset one-shot" U3A and U2A. For the CONTINUOUS mode, "MODA" is low, which jams the one-shot output U3-12 high; then switch U4D stays closed. In MAXIMUM hold mode, U3-12 is normally low, while U2-10 is high. U4D is then open. To reset the circuit, a high signal "RST" is generated by CAPTURE DISPLAY button A-S1. When A-S1 is released, the trailing edge of

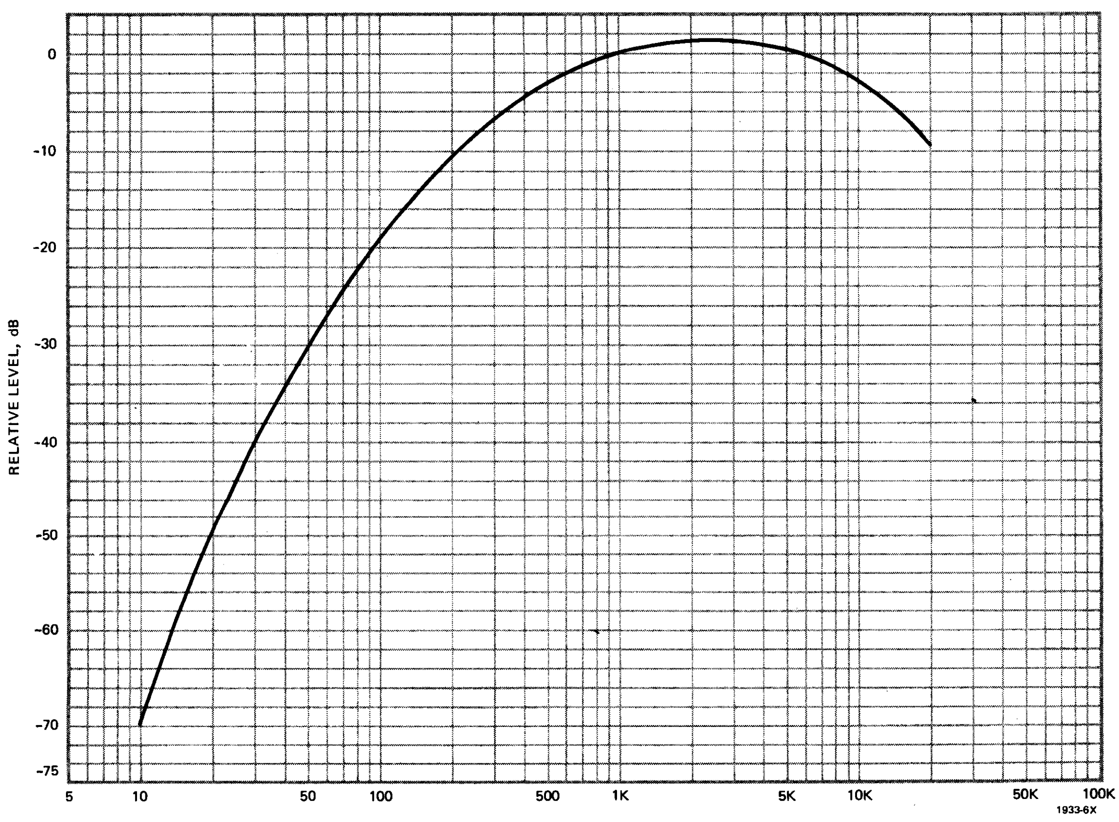

Figure 3-5. Frequency-response characteristic of the 1981 Sound-Level Meter. This is "A" weighting. This curve excludes the possible acoustic effects of any microphone and is valid for a 35-pF source impedance.

the inverted "RST" at U3-4 triggers the one-shot which produces a reset pulse about 20 ms wide. Since the one-shot triggers on the release of A-S1, this pulse is independent of the "RST" pulse width or of any contact bounce noise from A-S1. For 20 ms, then, this pulse closes U4D, closing the feedback around U1 and Q1, and re-establishing the voltage on C1 to the present input level. When the reset pulse terminates, U4D opens and the circuit resumes maximum-hold operation.

3.6 DESCRIPTION OF A/D CONVERTER Figures 3-6, 3-7.

The A/D converter is also located on A/D Converter Board "D", 1981-4760. The prefix "D" normally appended to the designators of parts in this circuit is omitted from the following description.

The heart of the A/D converter is a MOS LSI circuit, U8. This device comprises a four-decade counter with latches, multiplexing circuits, and a decoder for seven-segment display outputs. In the 1981, it times and controls the A/D converter and provides display drive signals. Understanding of the 1981 A/D converter is facilitated by reference to the accompanying timing diagram as well as the D-Board schematic in Section 5 and principles in para 3.2.

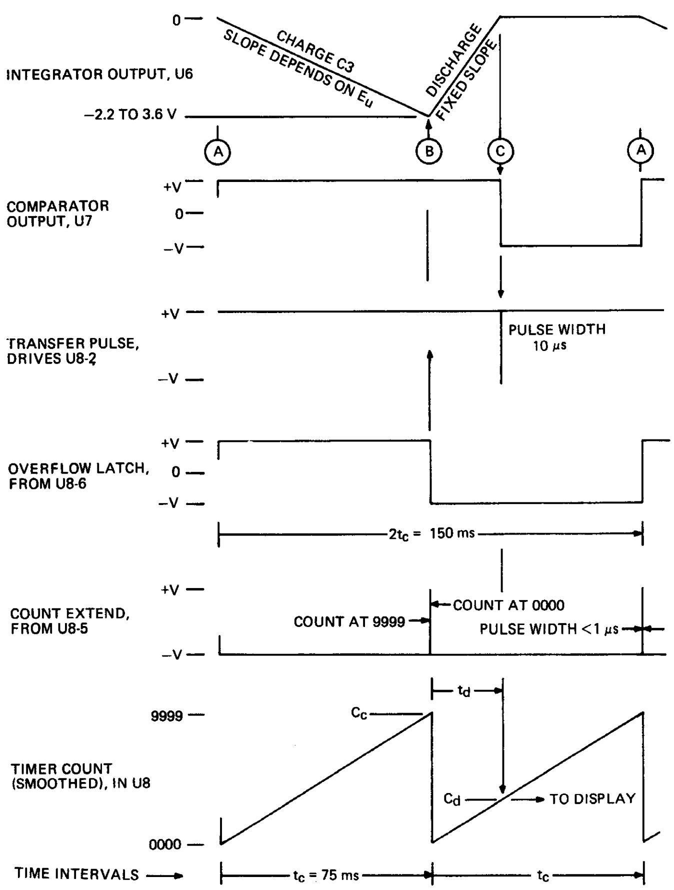

Figure 3-6. Waveform and timing diagram for the A/D converter in the 1981. For the readout range 70 to 120 dB(A), t_d range is approx 5 to 9 ms.

A complete conversion cycle takes place in approx 150 ms, so the A/D converter makes about 7 readings per second. A cycle begins with a reset pulse. Switch U4B connects the integrator circuit U6 to E_u, the analog voltage representing sound-level. Integrator capacitor C3 charges while the counter in U8 counts up from 0000. The next count beyond 9999 is (1)0000, where the (1) represents an overflow. Then, at time t_c, the charge on C3 has reached a level proportional to the "unknown" input voltage and the interval t_c. The overflow latch output, U8-6, by changing state at the (1)0000 count, causes U4B to disconnect E_u from the integrator, and U4A to connect the reference E_{ref} instead to the integrator. The polarity of the reference is such as to cause C3 to discharge, while U8 again starts counting up from 0000. Comparator U7 senses when C3 is completely discharged, i.e., when the integrator output voltage crosses zero. At that time, t_d, U8 has reached a count C_d. The comparator triggers the Transfer One-Shot U2B and U3B. The One-Shot's output pulse causes U8 to transfer the desired count C_d from its counter into the display circuit.

There is another step in the A/D converter cycle, which was not shown in the preceding description of an elementary dual-slope A/D converter. The counter in U8 continues counting up after the transfer pulse occurs. U4C shorts the integrator, holding C3 discharged in preparation for the next cycle. Reset gate U2C is enabled by the next Count Extend pulse, at U8-5, following the transfer pulse; this produces a reset pulse, which starts the next cycle.

The Capture Display Mode is initiated by depressing the CAPTURE DISPLAY pushbutton. When this switch (A-S1) is activated, a positive voltage (+V) is applied to input line "RST". This signal is inverted by U3D and applied to reset gate U2C. Counter/Decoder U8 is thereby inhibited. When this switch is depressed, the A/D converter completes its present cycle and then idles. The display indicates and holds the data present when CAPTURE DISPLAY was depressed. Normal indication is restored by releasing the CAPTURE DISPLAY button.

The LED display device F-U1 contains four seven-segment digits and four decimal points, each of which is treated as an eighth segment. (The 1981 uses only one decimal point.) F-U1 does not have the many external contacts that would be required for simultaneous illumination of any arbitrary combination of these many segments. The display device is internally wired in a matrix arrangement, as shown in Figure 3.7. The display is energized one digit at a time, rapidly so there is no visible flicker. To light a particular segment in a given digit, the appropriate segment lead is made positive while the appropriate digit lead is made negative. U8 provides this drive requirement. It contains an oscillator and decoder which scan the four digit lines at a rate of about

5 kHz. The output is such as to turn on Q9 through Q12 in succession. The duty cycle is about 12%. Simultaneously, the ROM in U8 looks at the count stored in the digit which is presently activated, decodes the count, and provides the proper drive to Q2 through Q8, which turn on segments to make the corresponding numeral appear in the display. When the third digit from the MSD (left-hand) is being scanned, Q13 conducts, thus lighting the third decimal point.

When the Power Switch is pushed over to BAT check, U3E-10 goes low. This brings the $\overline{\text{BLANK}}$ and COMPLEMENT lines of U8 low. Thus, all segments are lit and the display "888.8" results. "MODB" is brought low also through CR3, so U8 will be brought on during Battery Check even though the DIGITAL DISPLAY may be OFF. Generally, when the DIGITAL DISPLAY is switched OFF, line "MODB" is disconnected from the power supply, thus disabling U8.

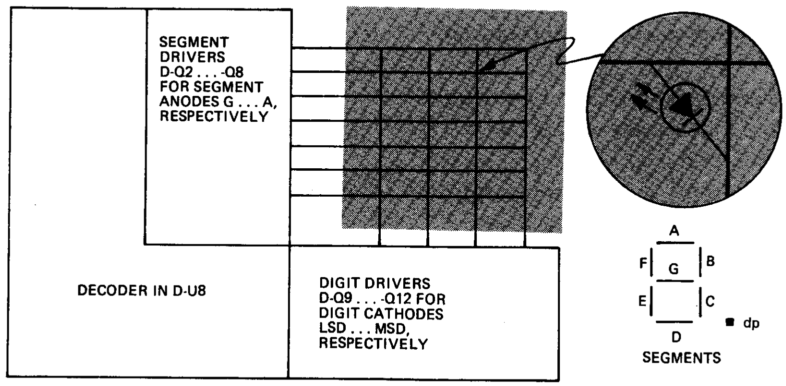

Figure 3-7. Digital-display-circuit matrix. Every crossing in the gray block represents a pair of connections to a particular segment of a digit in the display F-U1. As shown at the right, each segment is a light-emitting diode. (All those in each digit have a common cathode.)