OPERATING INSTRUCTIONS
for
H. H. SCOTT **TYPE 450-B**
SOUND LEVEL METER
ANSI TYPE 3

SCOTT INSTRUMENT LABORATORIES
division of
H. H. SCOTT, INC.
Maynard, Mass. U.S.A.

Rev. 1

029-1173-052

TECHNICAL SPECIFICATIONS

The 450-B Sound Level Meter measures Sound Level in Decibels (dB) in accordance with the new ANSI Standard for Sound Level Meters, and meets all requirements for Sound Level Meter, type 3.

Sound Level Range:	26 to 141 dB (re .0002 dynes/cm² RMS).
Frequency Range:	25 to 8000 Hz.
Weighting:	Std. A, B, C Weighting, USASI.
Microphone:	Omnidirectional Rochelle-salt crystal.*
Amplifier:	All silicon solid-state, 7 transistors.
Meter:	2½″ D'Arsonval taut-band, two speeds.
Battery:	30 volt NEDA 210 (Eveready 413 or equal).
Battery Life:	Approx. 50 hours intermittent use.
Controls:	Main Attenuator, WEIGHTING, USE-CAL, FAST-SLOW, ON button, BATTERY check button, sensitivity adjustment.
Input Jack:	Takes Switchcraft 750 plug. 400 megohms impedance. 6 microvolt sensitivity.
Output Jack:	Takes Switchcraft 750 plug. 10 K min. load impedance. 1.5 volt output.
Environmental conditions:	See Operating Instructions.

*The type 450-B-1 incorporates a ceramic microphone in place of the Rochelle-salt unit in the standard 450-B. The temperature limit for the 450-B-1 is 85°C or 185°F.

INTRODUCTION

Sound is actually rapid variations in air pressure. It could be measured in pressure units (such as pounds per square inch) and in terms of peak-to-peak, average, or RMS variation from the steady-state atmospheric pressure. As a convenience (to express the extremely wide range of sound pressures using small numbers) a logarithmic unit has been adopted called the DECIBEL, abbreviated dB. The *Sound Presure Level* (SPL) in dB is defined as

$$SPL = 20 \log_{10} \frac{P}{P_O}$$

where P is the RMS sound pressure and P_O is the standard reference pressure—.0002 dynes/cm^2 (2×10^{-4} microbar) RMS.

The Type 450-B Sound Level Meter measures *Sound Level* which is Sound Pressure Level, but weighted by a specific frequency characteristic A, B, or C, as described herein. It reads Sound Level *directly* on its unique self-scaling meter; no need to add two numbers or interpolate between dial markings. It is easy and fast to use, highly stable and accurate.

A few moments spent reading the Instructions will be well worthwhile, even though the operation will be quite obvious to many.

NOTE: For safety in storage and shipping, the battery for this instrument is packed separately in the leather case. Install the battery as instructed in the Maintenance section of this manual before attempting to use the instrument.

CAUTION

THE MICROPHONE IN THE TYPE 450-B WILL BE DESTROYED BY TEMPERATURES OVER 125°F. DO NOT STORE WHERE TEMPERATURES MAY REACH THIS LIMIT.*

*The type 450-B-1 incorporates a ceramic microphone in place of the Rochelle-salt unit in the standard 450-B. The temperature limit for the 450-B-1 is 85°C or 185°F.

OPERATING INSTRUCTIONS

BASIC OPERATION of the 450-B is printed on the under side of the instrument. In order to further emphasize these steps, they are repeated in bold type in the detailed instructions which follow, then amplified or discussed.

1. Check Battery, Push On Button and Bat Button. The Meter Should Read Over Cal-Bat. If Low, Remove Back and Replace Battery.

This should be checked before every use, and also during and at the end of any extended use, to be sure that the battery has not fallen below its useful end voltage during measurements. If it is found to be down *after* a measurement it would be wise to install a fresh battery and repeat or re-check the later readings if possible. On most typical sound measurements, the instrument will not show serious error until the battery reads below 5. Note that to check battery it is necessary to depress *both* the BAT *and* the ON button. Also, most accurate battery indication is obtained with the main attenuator set well above the existing Sound Level. Either set attenuator fully clockwise (130-140) or press ON button *first,* adjust the main dial so the meter reads *below* the left heavy line, then press BAT button.

Battery replacement is described in a later section.

2. Select Weighting.

The WEIGHTING characteristics employed in all Sound Level Meters are carefully controlled filter networks which gave different emphasis or "weight" to the different frequency components in the sound being measured.

Originally, the three standard Weighting networks were designed to *approximate* the variation in frequency response of the average human ear as the volume or intensity of the sound varies; in other words to make the meter indication agree more closely with the

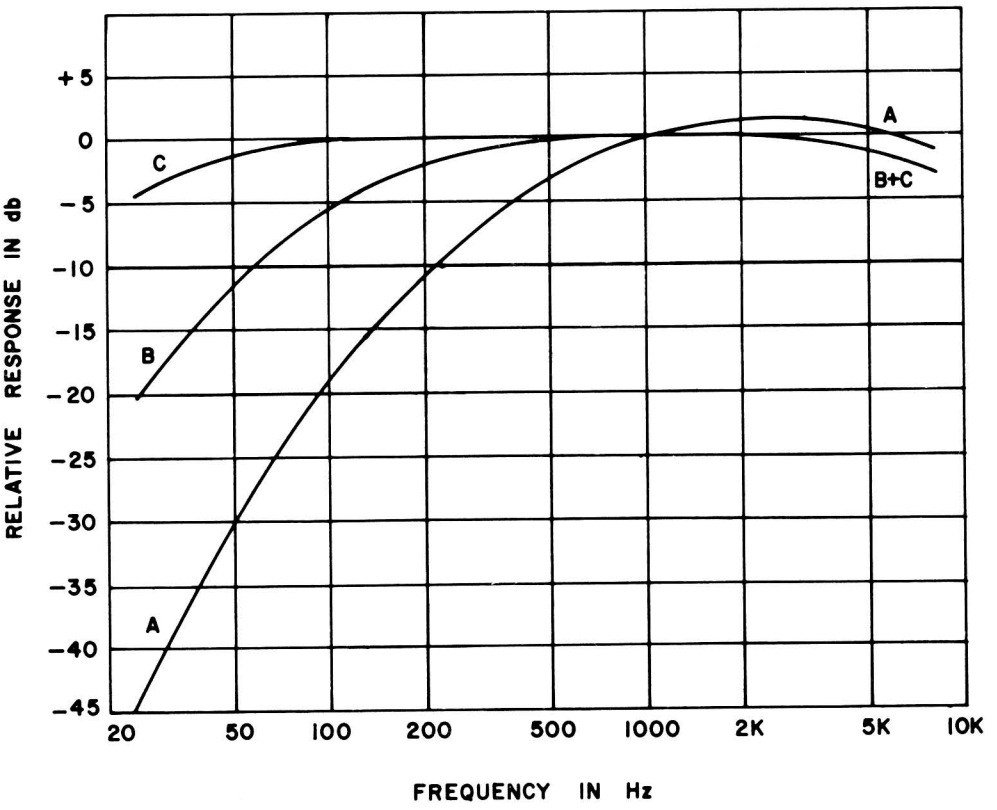

Fig. 1 USASI Weighting Characteristics

ear's impression of loudness. The standard A, B, and C Weighting Curves are approximations of the normal hearing response (Fletcher-Munson curves) at 40, 70, and 90 dB SPL, respectively. When such a "loudness approximation" is wanted, set WEIGHTING to "A" when the meter indicates up to 55 dB, on "B" between 55 and 85, and on "C" for indications over 85 dB. "C" Weighting is uniform, flat response, 32 Hz to 8 KHz.

Current practice however, indicates that the "A" Weighting network, with heavily attenuated low-frequency response, provides perhaps the most useful and accurate "single number" indication of the *annoyance factor* or *noisiness* of a sound, *regardless of its level.* This is based on the conclusions of a number of acousticians that the high frequencies are much more annoying or objectionable than low frequencies of equal intensity, in terms of interfering with work or communication, creating discomfort, complaints, etc. Thus the "A" network is often used to measure

office and factory noise, traffic and aircraft noise, etc. even though those are often well above the nominal 55 dB level.

One particular feature of the 450-B is the location of the A Weighting network, virtually at the input of the amplifier. This allows the A Weighting to be used at higher sound levels without overloading. Other Sound Level Meters, whose A networks follow several amplifier stages, overload in the presence of strong low-frequency components such as are often encountered in measuring jet aircraft noise, for instance.

Since the differences between the C, B, and A responses to a given noise are directly related to the low-frequency content of the noise, methods have been developed whereby the noise spectrum (normally obtained by octave-band analysis) can be approximated by simple mathematical operations on the three weighted sound levels. Even without calculations, the *spread* in these three figures can be direct indication of the relative amount of low-frequency strength in the overall signal while the ear, being somewhat non-linear at low levels, and subject to "masking" of low frequencies by the presence of high frequencies, may not be aware of relatively strong low-frequency components. This is particularly important in air conditioning and ventilating work and architectural studies in general.

In cases where time permits, you should, therefore, take readings using *all three* WEIGHTING positions at all sound levels. Where the timing of the event makes this impossible, try to make at least C and A Weighted readings. If this is not possible, use A, B, or C in accordance with the Sound Level ranges outlined above to give *approximate loudness;* use C where measurement of actual Sound Pressure Level is desired (regardless of the level); use A (again, regardless of level) where a single-number evaluation of noisiness of annoyance factor is desired.

3. Set Use-Cal Switch to Use.

This shorts out the calibration insert resistor and grounds one side of the microphone. Leave this switch in the USE position at all times except during calibration.

Set Fast-Slow Switch.

This switch connects a large capacitor across the DC terminals of the meter, which slows down the movement of the pointer giving a more readable "average" of rapidly fluctuating sounds. On steady sounds the reading is the same on FAST or SLOW. On pulsing or fluctuating sounds, choose either meter speed depending on whether you wish to *observe the fluctuations* or more easily read the *average level.*

4. Hold On Button Down.

In the 450-B the ON button was purposely placed to the *left* so the instrument could be conveniently held in the *left* hand, leaving the right hand free to record the readings. If readings are not being recorded (in general, they should) the 450-B *can* be operated with the right hand by reaching the thumb *over* the upper portion of the dial to press the ON button.

Rotate Main Dial to Obtain Meter Reading Between 0 and 10.

The main dial may be operated by either thumb against its knurled outer edge, or by turning the center knob in the conventional manner with the other hand. Turn the dial so the numbers move in the direction you wish the pointer to move: For example, if the pointer is below 0 turn the dial *counter-clockwise* (moving the dial numbers to the right). When the proper attenuator setting is reached, the meter pointer will read between 0 and 10, and the attenuator calibrations which line up with the two white lines (continued on the meter face) set the "scale." For example, if the pointer indicates 8 when the figure 70 on the dial is over the

left white line and 80 over the right, the meter covers the range from 70 to 80 dB and the Sound Level would be 78 dB.

Note two points regarding the meter. When the instrument is off, or when on but set for much too high a scale, it is normal for the meter pointer to be *off scale left,* even against its internal stop. This is called a suppressed-zero meter, and results in a more linear Decibel scale calibration. Secondly, it will do no harm at all to the meter to cause the pointer to bang or "pin" against the right hand stop. The amplifier is designed to protect the meter against overload and the taut band movement is mechanically much more rugged than the older pivot-jewel construction. Do not be alarmed, therefore, if the meter pins when you first press the ON button—simply turn the main dial clockwise until the pointer moves downscale.

Try to make all readings between 0 and 10. The calibrations below 0 and above 10 are for scale overlap and are more difficult to read accurately, especially on fluctuating sounds.

Read the Sound Level Directly in Decibels.

The Sound Level is the average pointer indication with the scale of the meter set by the two attenuator figures at the white lines. In reporting or recording the Sound Level, you must also report the WEIGHTING used. Thus it is customary to say "The C Sound Level was 86 dB; the A Sound Level was 72 dB." It is also current usage to add the Weighting after dB—72 dBA. For a complete sound survey, you should also record such items as the measuring position, angle, distance from major noise source (perhaps with the aid of a sketch), background level without major source, date, time, temperature, type and serial number of both the measuring instrument and any machinery or devices being measured. Your own experience will soon indicate which of these factors are important to you, but remember it is al-

ways easier to record *more* data than you need than to go back later to check on something you did not record.

The use of the safety wrist strap is strongly recommended when the 450-B is used outdoors or whenever other than office or laboratory conditions prevail (climbing ladders, on balconies, etc.). Screw the strap into the threaded bushing in the case and slip your hand down through the loop, then grasp the instrument.

5. To Check Calibration set Main Dial to Cal. (100-110). Connect Cal. Cord to 105-125v. AC Power Line. Set Weighting to C. Set Use-Cal Switch to Cal. Press On Button. If Meter Does Not Read Cal. Adjust the Sens. Adj. at Left.

This procedure checks the stability of gain of the amplifier by the insert voltage method at 60 Hz. A small portion of the AC line voltage is sampled, passed through a symmetrical diode clipper to give essentially a square wave of constant amplitude, regardless of line voltage fluctuations, case-to-ground stray capacitance, etc. This signal is applied through a precision resistor and a resistor chosen to give an insert voltage in series with the microphone which is equal to the sensitivity of that particular microphone at 106 dB SPL. If the amplifier gain has changed slightly since the original acoustic calibration in the H. H. Scott Laboratory, it can be reset using the SENS. ADJ. control, accessible with a small screwdriver through a hole in the side of the case. If the shift is beyond the range of this control (about 9 dB), or if the microphone is open, calibration cannot be performed and the instrument must be returned to our Laboratory for service. This calibration check should be performed at 70°F±10° because the diodes have a relatively large temperature coefficient. If it is absolutely necessary to perform this calibration check at other temperatures, please consult our Laboratory for appropriate correction factors to use.

It is suggested this calibration check be performed before and immediately after any field trips or loans of the instrument to others, or after any mishaps or suspected mishap such as dropping the instrument, exposure to high temperature, water, etc. This test will not detect a *shorted* microphone (which might occur on high temperature exposure) but if this calibration check indicates proper operation and still the instrument *fails* to register sound level, the trouble is definitely in the microphone itself, which must be replaced.

This calibration check is also valuable for re-setting the 450-B for normal use, after the CAL. ADJ. control has been re-adjusted for use with accessory microphones or vibration pickups.

6. External Connections.

Both INPUT and OUTPUT jacks accept Switchcraft Tini-plug type 750 or equal, available from local electronic supply stores or from H. H. Scott, Inc.

The INPUT jack is for connection of remote microphones, special microphones, vibration survey pickup, etc. The internal microphone is removed from the input on insertion of a plug in this jack. The input impedance at this jack is 400 megohms which allows the use of very low-capacitance microphones. The calibration of external microphones is up to the customer and beyond the scope of this booklet. However, we would be glad to discuss any special requirements and recommend calibration methods.

A Vibration Survey Pickup Type 450-X3 is available for approximate or comparative measurements of structural vibration. A High Intensity Microphone system is also available on special order which extends the range of the 450-B by approximately 50 dB so that it then covers the range from 76 to 191 dB. Contact Scott Instrument Laboratories for further information.

The OUTPUT jack makes available the full output signal to drive monitor headphones, analyzers, recorders, oscilloscopes, remote meters, etc. Load impedance should be 10,000 ohms or higher in order not to affect the accuracy of the internal meter which is *not* switched out of the circuit by insertion of a plug. The output voltage is about 1.5v. RMS at full scale indication, and the output amplifier is linear to over 10 dB above full scale.

The 450-B has an excellent signal-to-noise ratio at all attenuator settings, making it quite suitable for driving analyzers and recorders. In this respect it actually exceeds the requirements for Sound Level Meter, type 2 per ANSI.

Typical internal noise levels in octave bands are given in Fig. 2 on page 15. Although for ease of measurement the microphone was replaced with an equivalent impedance, the table describes the overall performance well since self-noise in the microphone is negligible. To convert these figures to Signal-to-Noise ratio or Dynamic Range, subtract the table value from the upper range limit and add 10 dB.

Cal. Cord Is Std. TV Power Cord.

A cord is supplied with the 450-B but should it be lost, any standard TV "cheater" cord can be used. This cord supplies calibration signal *only,* not power for operation of the 450-B. *Operating* power comes from the internal battery at all times.

CAUTION

The Microphone in This Instrument Will Be Destroyed by Temperatures Over 125°F. Do Not Store Where Temperatures May Reach This Limit.*

This caution cannot be too strongly emphasized. More service repairs are due to

*The Type 450-B-1 with ceramic microphone can safely be stored at temperatures up to 185°F (85°C).

microphones being "cooked" than any other cause. The danger point is easily reached in closed cars, boats, etc., in the sun, (even on a desk in the direct sun *indoors*). Short exposure to high temperatures during measurements will do no harm. Generally if it is comfortable for your hand holding the instrument it is safe for the few seconds required for reading. It is *leaving* the instrument where the high temperature may build up over a period of hours that does the damage.

ENVIRONMENTAL CONDITIONS

Normal ranges of temperature (up to 120°F) and relative humidity from 0 to 90% will not affect the 450-B or the accuracy of its readings. By its almost complete enclosure in a metal case, it is virtually immune to the effects of electrostatic fields. Its response to magnetic fields is very low; a one Oersted field at 60 Hz gives a reading of 46 dB in the worst orientation.

The 450-B is quite well sealed against dust and dirt and the main attenuator switch is of the semi-enclosed molded type for additional protection. Nevertheless it is wise to keep the instrument in its leather case (or in a plastic bag in an emergency) when not actually in use. Perhaps more dangerous than dust or dirt are strong chemical fumes and oily vapors which can adhere to the printed circuit board attacking the circuit or altering the resistance of the insulation.

The 450-B is as rugged mechanically as such a sensitive instrument can be. It is primarily a hand-held instrument and the normal shocks and vibrations it receives while hand-held or carried in its leather case are no problem. Treat it as you would a camera of similar value. Since it is a hand-held device, it is normally not subject to error due to vibration of the case. Its vibrational response is very low, and when hand-held, the spurious response due to microphonics is at least 30 dB below the actual response (with the microphone) for all ranges.

SOUND MEASURING TECHNIQUES

As with almost any measuring instrument, the technique used in making the measurement, rather than the basic precision of the instrument, often determines the usefulness and accuracy of the measurements. This is especially true in making accurate Sound Level measurements.

This problem is quite complex and beyond the scope of this booklet except for a few general suggestions which follow. For more detailed and technical discussion, we suggest you order a copy of "Noise Measuring Techniques" by Hermon H. Scott, available at $.50 a copy, or read one of the standard texts on acoustic measurements.

The first question is *where* and *how* to hold the instrument. The noises you will wish to measure are composed of some combination of *directional* sound (originating at a specific point and travelling under "free-field" conditions to the measuring point) and *reflected* or *diffuse* sound (that which has reflected or reverberated around the room and has no well defined origin or direction, or originates from many scattered sources). Accurate measurement of directional sounds is more difficult because

1. The Sound Level varies with the distance from the source (actually in pure free-field situations, it drops 6 dB each time the distance is doubled).
2. The microphone of any Sound Level Meter, while nominally non-directional, is in fact somewhat directional, especially at the higher frequencies. Therefore the reading will vary as the angle between the microphone and the sound source is changed.
3. With basically directional sounds, there can be serious problems with reflection or refraction of the sound by nearby physical objects such as the floors, walls, furniture, the body of the measurer and even the small 450-B itself. These effects, also, are usually more

pronounced at high frequencies, but one effect, that of "standing waves" or resonances in a room can and does cause troubles even at very low frequencies.

When measuring completely diffuse or reverberant sound, these problems diminish considerably. You can make a quick survey to determine which type of sound predominates by simply turning the 450-B at several angles and moving it at arm's length (or turning yourself around) while watching the meter. If the reading stays relatively constant, diffuse sound prevails; if the reading varies considerably, directional sound predominates and one or more of the problem factors above is present.

If diffuse sound predominates, orientation of the 450-B is relatvely unimportant, although it is good practice to hold the meter as far away from your body as possible. If directional sound predominates, hold the meter well away from the body and off to one side, with the microphone at an angle of about 45° to the source of sound. If standing waves are easily observed (sound level varies up and down as meter is moved along a straight path) you can read maximum and minimum and take the average. If a single location must be measured, try to pick a point as far as possible from large reflecting surfaces or objects.

Wind is often a problem in outdoor measurements. Wind blowing on the microphone creates sound *within* the microphone. There is no truly effective wind shield for microphones. The best way to determine if this is a problem is to monitor the 450-B with high-impedance headphones plugged into the OUTPUT jack. You can easily hear the "wind noise" this way and judge its level compared to the desired signal. If it is comparably loud or even masks the desired signal, try rotating the 450-B for minimum wind noise or just wait for lulls in the wind velocity. As stated above—there is no pat

cure, but you should be aware of the problem. Even a slight breeze can be a problem in measuring low Sound Levels.

This leads to the general problem of *background noise level.* In the typical sound measurement, there is one sound or group of sounds you *want* to measure, and another group of sounds you do *not* wish to measure, or which are not pertinent to your problem. For example, you may wish to measure the sound of a punched-card sorter, but it is operating in a room with many other similar and dis-similar machines, plus a noisy air conditioning system and a paging system *designed* to be louder than the machinery. You do four things:

1. Try to *turn off* as many background noise sources as possible (obvious, but often overlooked).
2. Make measurements *as close as possible* to the machine in question, reducing the relative contribution of the background noise.
3. Make measurements from exactly the same position with and without that machine operating. The *difference* is a measure of the reliability of your measurement or the error due to background. In some cases it is possible to make a correction for the effect of background noise from this difference measurement.
4. Make *all* readings with *all three* WEIGHTING networks. It may be possible to substantially reduce the effect of background noise by using the B or A Sound Levels—especially if the noise you are measuring is largely middle and high-frequencies, such as business machines often are, and the background is very low-frequency, such as air conditioning or traffic rumble. In any event, having all three measurements will allow more intelligent analysis of the results and the effect of the background noise.

MAINTENANCE

Periodic calibration check and battery replacement are really the only maintenance required. To replace the battery remove the back case by turning the ¼-turn fastener counter-clockwise as indicated. If the old battery has leaked any electrolyte (unlikely with modern batteries) remove the deposit first with a dry brush (old toothbrush) while holding the unit in a position so the powder falls *out* of the unit, not into it. Then clean the battery contacts with a damp cloth if necessary.

The battery should be checked periodically even when the instrument is not in use, and should be *removed* from the instrument if it is to be stored for a few months or longer.

Insert the new battery with the + end toward the microphone. If installed backwards no harm will be done since there is a blocking diode in the circuit; the instrument simply will not function.

Suitable batteries are:

Eveready 413, 413E
Burgess U20
RCA VSO85
Ray-O-Vac A210
Mallory RM413 (long-life mercury type)

Should the 450-B get dirty, clean with a damp cloth (with detergent if necessary) or with alcohol, carbon tet, or the "safety" solvent substitutes for carbon tet. *Under no circumstances* use acetone, MEK, toluene, etc. which certainly would remove the case marking, damage the meter window, and might even damage the case enamel.

If your 450-B fails to meet the calibration check, or meets it (and the battery check) but fails to indicate normal Sound Level, it must be returned to the Laboratory for service. A brief statement of our Warranty is on the back cover. The Serial Number of your 450-B is stamped in the case just over the right end of the meter window.

130-140			120-130			110-120			100-110			90-100			80-90			70-80			60-70			50-60			40-50			30-40			SOUND LEVEL RANGE
A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	WEIGHTING
70	70	70	60	60	60	52	52	52	44	44	44	38	38	38	32	32	32	23	25	25	22	24	25	22	24	24	22	24	23	22	24	23	OVERALL (20-20 KHz)
*	*	*	*	*	*	*	*	*	*	*	*	27	27	27	18	18	18	10	18	18	10	16	16	6	16	16	6	16	15	7	15	16	37.5-75 Hz
*	*	*	*	*	*	*	*	*	32	32	32	23	23	23	16	17	18	10	16	17	5	15	15	5	15	15	5	14	14	5	14	14	75-150 Hz
*	*	*	*	*	*	*	*	*	32	32	32	25	25	25	19	20	20	9	15	17	8	15	17	8	14	16	8	14	16	8	14	15	150-300 Hz
*	*	*	*	*	*	41	41	41	32	32	32	25	25	25	20	20	20	9	12	15	9	12	15	8	11	14	8	11	15	8	12	15	300-600 Hz
61	61	61	52	52	52	42	42	42	34	34	34	27	27	27	21	21	21	11	13	14	11	12	14	11	12	14	10	11	14	10	12	14	600-1200 Hz
63	63	63	53	53	53	44	44	44	36	36	36	30	30	30	24	24	24	14	14	14	14	14	14	13	14	14	13	14	13	13	14	13	1200-2400 Hz
65	65	65	55	55	55	46	46	46	38	38	38	32	32	32	26	26	26	16	16	13	16	16	13	15	15	12	15	15	12	15	15	12	2400-4800 Hz
65	65	65	55	55	55	47	47	47	39	39	39	32	32	32	26	26	26	16	16	12	16	16	12	16	16	11	16	16	11	15	15	10	4800-9600 Hz

Fig. 2 Typical Internal Noise in terms of Equivalent Sound Level in Octave Bands.
* Noise in these bands at the output of the 450-B is too low to measure, but is more than 75db below full scale meter indication in all cases.

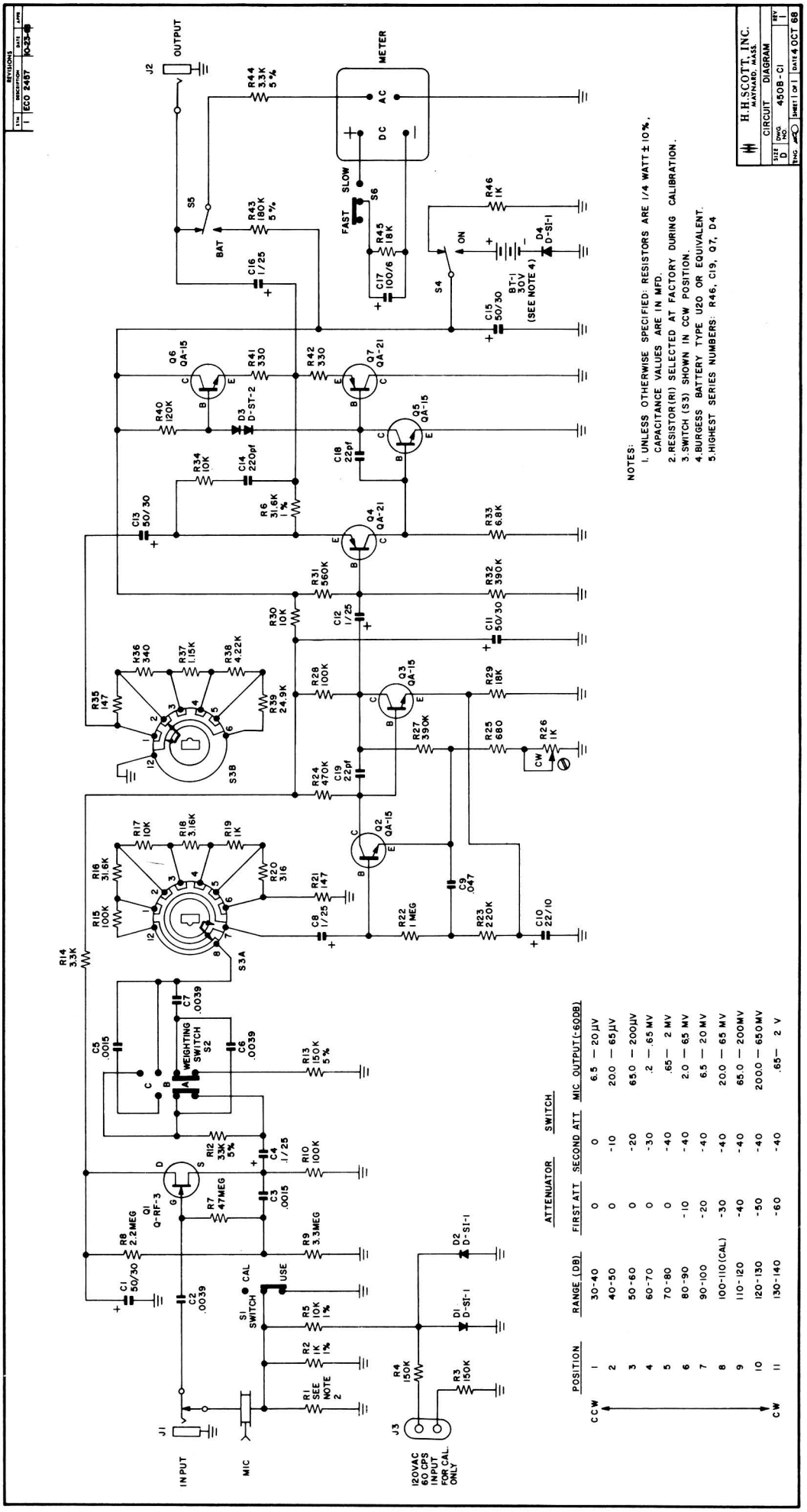

Fig. 3 Schematic Diagram

WARRANTY

All products of Scott Instrument Laboratories Division are guaranteed, unless otherwise stated, to be free from defects in materials and workmanship for one year from date of purchase. This guarantee does not include tubes, fuses, batteries, lamps, semiconductors and piezo-electric crystals or ceramics, but many of these are Warranted by the Manufacturer.

The Warranty covers replacement of defective parts, including all labor at our Laboratory, transportation charges both ways to be born by the purchaser.

In cases where the instrument is outside the warranty period, we recommend it be shipped to our Laboratory for repair. Estimates will be sent if requested before repairs are made.

If trouble develops, please write or phone, giving full particulars—especially serial number. We will then issue return shipping instructions which should be *carefully followed* to ensure safe shipment at minimum expense.

SCOTT INSTRUMENT LABORATORIES
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H.H. SCOTT®


TYPE 450B
SOUND LEVEL METER
USASI TYPE 3
SCOTT INSTRUMENT LABORATORIES
DIVISION OF
H.H. SCOTT, INC.
MAYNARD, MASS., U.S.A.
INPUT
OUTPUT
ON
BAT
A B C
WEIGHTING
USE
CAL
FAST
SLOW
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