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TRUE-INTEGRATING ENVIRONMENTAL NOISE MONITOR AND SOUND EXPOSURE--ETC(U)
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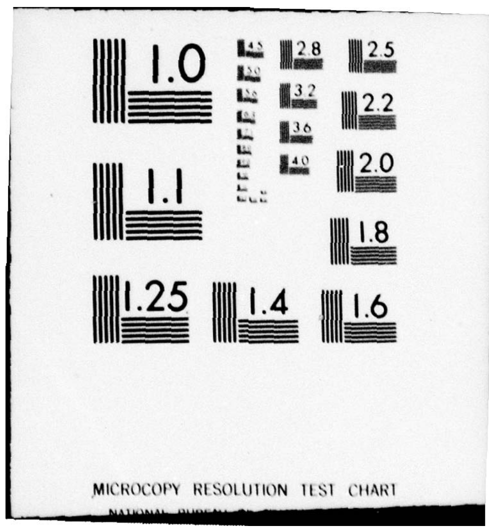
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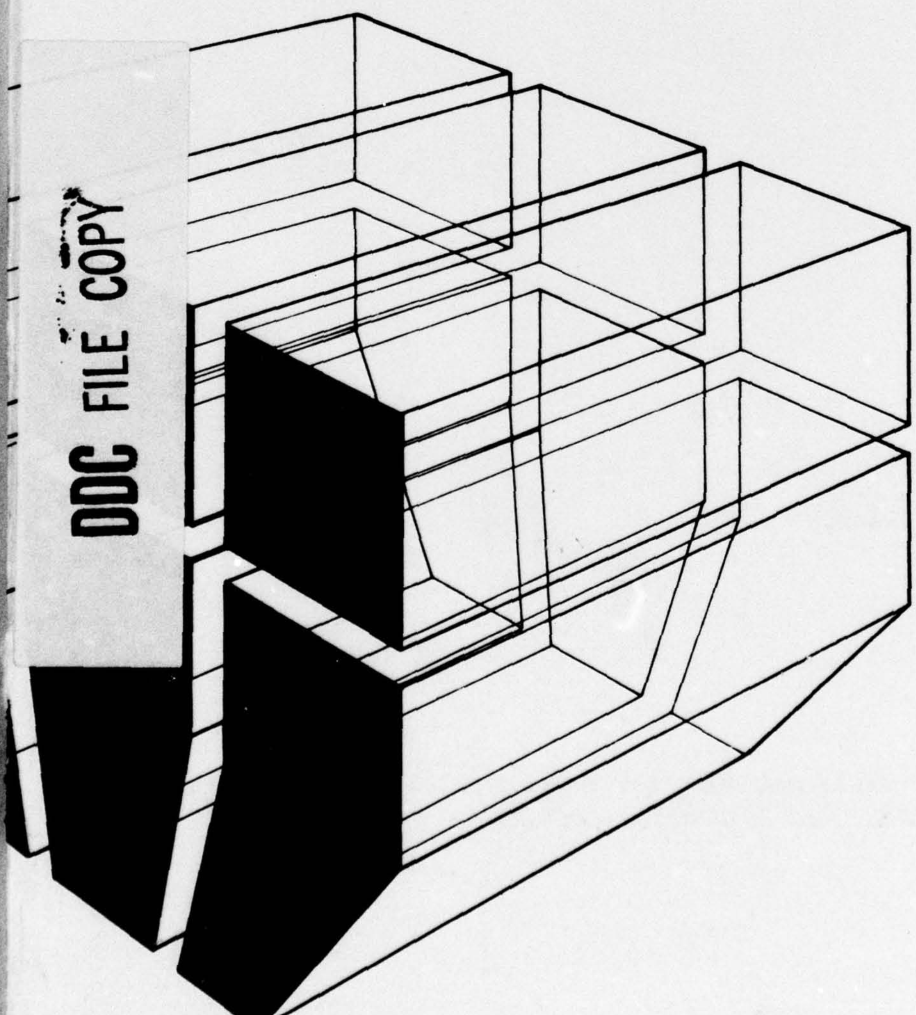
TECHNICAL REPORT N-41
May 1978
Prediction of the Noise Impact Within
and Adjacent to Army Facilities

TRUE-INTEGRATING ENVIRONMENTAL NOISE MONITOR AND SOUND EXPOSURE LEVEL METER
VOLUME I: USER'S GUIDE



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by
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 14 CERL-TR-N-41	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER 9
4. TITLE (and Subtitle) 6 TRUE-INTEGRATING ENVIRONMENTAL NOISE MONITOR AND SOUND EXPOSURE LEVEL METER. VOLUME I. USER'S GUIDE.		5. TYPE OF REPORT & PERIOD COVERED FINAL rept.,
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 P. D./Schomer, A. J./Averbuch M. W./Weisberg		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS CONSTRUCTION ENGINEERING RESEARCH LABORATORY P.O. Box 4005 Champaign, IL 61820		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 16 4A762720A896 ~~02~~-001 17 03
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 11 May [redacted]78
		13. NUMBER OF PAGES ~~20~~ 12 23p.
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service
Springfield, VA 22151

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

impulsive noise
monitoring unit
user instructions

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes desirable features and factors in environmental noise monitors, in general, and in particular, monitors which measure the impulsive noise created by military sources. Particular emphasis is placed on the need to have a true-integrating detector to properly measure these impulsive sources. Based on these needs, a noise monitor has been designed and constructed. This report summarizes the operations and components of this monitoring unit. Volume II describes the construction, parts lists, layouts, and schematics of the monitoring unit. 405 279

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FOREWORD

This research was conducted for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under Project 4A762720A896, "Environmental Quality for Construction and Operation of Military Facilities"; Task 03, "Pollution Control Technology"; Work Unit 001, "Prediction of the Noise Impact Within and Adjacent to Army Facilities." The QCR number is 1.03.011. Mr. F. P. Beck, DAEN-MCE-P, is the OCE Technical Monitor.

The work was performed by the Environmental Division (EN), U. S. Army Construction Engineering Research Laboratory (CERL). Dr. R. K. Jain is Chief of EN.

COL J. E. Hays is Commander and Director of CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

TRUE-INTEGRATING ENVIRONMENTAL NOISE MONITOR AND SOUND EXPOSURE LEVEL METER VOLUME I: USER'S GUIDE

1 INTRODUCTION

Background

The Environmental Protection Agency (EPA) has recommended the day-night average level (L_{dn}) as the measure to use for assessing normal environmental noise, and the C-weighted day-night level ($L_{C_{dn}}$) as the measure for assessing impulsive noises (for example, from artillery, armor, sonic boom, etc.). Explicit in the EPA's recommendation is a requirement to directly integrate the instantaneous square of the sound pressure as a function of time. In a practical sense, this direct integration can be approximated for most continuous noise sources by integrating the output of a root-mean-square (RMS) detector (for example, like the detector employed in the normal sound-level meter). However, in the case of highly impulsive noises and especially for single events, the integration of an RMS detector output may yield erroneous results, because the quantity found is the impulse response of the detector itself rather than the true square of the pressure as a function of time.

The Construction Engineering Research Laboratory (CERL) has designed and constructed monitors for its own use and for the Federal EPA; in addition, CERL has studied the features of commercial noise monitors for the Federal EPA[1] and participated in the National Academy of Science's efforts to define noise assessment procedures for Federal activities.[2] These studies have made apparent certain physical characteristics within the design of the monitor for measuring Army-specific noises.

[1]P. D. Schomer and A. J. Averbuch, *Analysis of Environmental Noise Monitors*, Technical Report N-21/ADA040005 (CERL, April 1977).

[2]*Guidelines for Preparing Environmental Impact Statements on Noise*, Report of Working Group 69 on Environmental Impact of Noise, Committee on Hearing, Bioacoustics, and Biomechanics, Assembly of Behavioral and Social Sciences (National Research Council of the National Academy of Sciences, 1977).

Mechanical Requirements

The monitoring and microphone systems should be light enough and small enough so that one person can conveniently set up and take apart the system.

The operation of the system should be such that one person can conveniently turn on, start up, and obtain data, as well as calibrate the system.

The unit should be designed for outdoor use. Since the unit must be operated, measurements made, settings adjusted, etc., during inclement weather, the front panel should be weatherproof, so that opening the lid will not adversely affect the unit. This requirement is especially important when considering units which use paper or magnetic tape for data recording within the monitor. For these units, moisture is a serious problem, especially at very cold temperatures.

The unit should be particularly designed for cold weather use. The switches and other mechanical devices must be designed to be used by operators wearing gloves and bulky clothing.

Operations should be as simple and straightforward as possible. The functional areas of the front panel should be logically grouped and designed to be easily understood by technicians.

When digital readout is used, the readout device should be easy to read in sunlight.

All necessary controls should be easily accessible without requiring use of extraordinary tools, such as long, thin screwdrivers for deeply recessed holes, etc.

Bayonette cable connectors should be used, since they are less prone to damage than threaded connectors.

Paper charts or magnetic tapes should be avoided, if possible, because of the difficulties caused by dirt and moisture (especially in cold temperatures); low-cost solid-state memory is preferable. When mechanical recording devices are employed, they must be constructed in such a way that they can be easily used by technicians wearing gloves and must be especially protected from the elements.

Power Supply Requirements

The units should be capable of extended battery operation on either internal or external batteries.

The batteries should be capable of being removed and changed easily without impeding monitor operation.

The 120-V option should only be employed in conjunction with internal, noninterruptable power supplies.

When using 120-V power, the monitor system should be unaffected by transients and other disturbances on the power lines.

Operating Environment

The monitor should operate in an environment ranging between -25 to 50°C without adverse effect on its performance.

Temperature changes should not cause noticeable variation in gain, sensitivity, or other performance factors.

Data Output

Monitors which perform data reduction in the field and provide immediate results are preferable to those requiring subsequent laboratory analysis. With reduction performed in the field, correct operation can be checked onsite and other related work accomplished during the monitoring period. Furthermore, analysis time in the laboratory is greatly reduced. Data should be available directly on the front panel and readable by an operator.

High-speed data output should be provided so that the operator need not record large quantities of numbers; manual data recording is an error-prone procedure and difficult for the operator in very cold weather. The high-speed recording device need not be contained in the monitor proper. It may be carried to the site by the operator.

Calibration

It should be easy for one person to perform the overall system calibration.

A remotely operated acoustical calibrator built into the microphone system is highly desirable so that the system calibration can be performed without actually going to the microphone.

Single frequency calibration should take only a few seconds and not require extended integration periods to achieve sufficiently accurate results.

The system should be capable of calibration in any operating mode.

Analog Output

An analog output should be conveniently provided for connection to other analog recording devices and headphones. It should be possible to connect these devices to the analog output without affecting the monitor system performance.

Packaging

Units should be designed for rough handling and field use in dusty, inclement environments.

The use of military-grade inclosures for the equipment is desirable, since these inclosures are intended for strenuous use.

Purpose

The purposes of this report are (1) to summarize features desirable in environmental noise monitors, (2) to describe the CERL true-integrating environmental noise monitor's operating features, and (3) to provide user operating procedures. Volume II of this report provides details of the monitor's construction, parts lists, layouts, and schematics. Because of the versatility and the resulting complexity of this instrument, the user operating procedures are intended to supplement hands-on instruction and to act as a reference.

Outline of Report

Before designing any monitoring system, it is necessary to know those features which have already been proved to be desirable and useful. These specifications have been listed above and include requirements for mechanical and power supply features, as well as specifications for operating environment and packaging. Computed data, analog signal outputs, and desirable calibration features are also specified.

Chapter 2 briefly summarizes the theory of operation of the CERL monitoring system. The system has three data-gathering modes (integrating sound-level meter, single event, and blocks of data), calibration modes, and a standby status. Chapter 3 describes these operational features. Chapter 4 identifies the functional areas on the front panel of the monitoring unit, explains the operation of each, and identifies all switches and connectors. Chapter 5 provides a step-by-step description of the operational procedure.

After reading Chapter 5, the user should be able to calibrate the unit and operate it in each of its three modes.

Mode of Technology Transfer

Purchase specifications will be developed for these monitors after field testing is completed.

2 THEORY OF OPERATION

The CERL true-integrating environmental monitor contains six major parts.

1. The analog section. This section includes the filter networks, the sample and hold amplifiers, and the analog to digital (A/D) converter.

2. The squaring and integrating network. This hardware circuit squares and integrates each A/D sample. Associated with the squaring and the integrating network is a shift register which holds the most recent values. Also associated with the integrating network is an inhibit which is controlled by channel 1 threshold, and an inhibit which is controlled by wind speed threshold.

3. The peak detector. This circuit holds the maximum value of the A/D on the selected channel in any data set.

4. The microprocessor controller. This control circuit interfaces between the data acquisition hardware and the data output devices. It also defines the functions of most of the front panel switches. The control circuits are associated with this part.

5. The power supply. The power supply (an uninterruptable type) operates from 120-V alternating current (ac), but has an internal 12-V direct current (dc) storage battery to operate the unit for 3 hours if the power fails. Because of the 12-V dc operation capability, an external 12-V battery can be used to operate the unit for an extended period of time. (At least 1 day in very cold weather, and 2 days at moderate temperatures [above 10°C.])

6. The program. The controlling microprocessor program is essentially a switch testing routine. The microprocessor tests for any actions called for by the user or external devices by examining various front-panel switches, external switches, and signal lines. These requests are handled by the microprocessor as they are received and take approximately 2 msec to be recognized. Whenever data in the buffer is ready to be stored in memory, an interrupt occurs and the microprocessor immediately handles the data, storing it in memory or accomplishing whatever other action is required. After processing an interrupt, the microprocessor returns to its switch testing loop.

The memory is set up in a wraparound mode where space is made available for new data as the old data is read out to an external device. (This allows simultaneous data entry and data output, with the microprocessor memory acting as a buffer.)

3 OPERATIONAL FEATURES

The monitor is designed to have three basic data-gathering modes of operation, a calibration mode, and a standby status. The data-gathering modes of operation are (1) integrating sound-level meter, (2) single event, and (3) blocks of data.

Several features are common to these three data-gathering modes.

1. One- or two-channel operation can be used. With one-channel operation, the integrator operates at a 50-kHz sample rate; with two-channel operation, it operates on each channel with a 25-kHz sample rate. For two-channel operation, either one microphone system may feed both channels, or two separate microphone systems can be used. Standard network weightings of A, C, D_1, and flat, and a ground or shorted input position are provided on each channel. Because of the versatile two-channel operation, different applications are possible, such as measuring outdoors and indoors at the same time with a single unit or using A- and C-weighting at the same time with a single microphone, etc.

2. When data is collected, it is usually either stored in the monitor memory for later transmittal to external devices, or transferred immediately to an external device. The external devices include a thermal printer,

an analog tape recorder for recording frequency shift-coded digital data, and a Wang 600 computing calculator. The Wang calculator can be used to further analyze and subdivide the data on an interactive basis. Data may be output to any of the devices while the unit gathers more data; in addition, the data can be read on the front panel display and recorded manually.

For all three data-gathering modes, the basic data storage format is variable. Since there is a fixed length of memory (1024 to 4096 words in 1024-word increments), the user can choose between many data sets with little data per set or fewer sets with more data per set. The data for each set may include L_{eq} for channel 1, L_{eq} for channel 2, the peak level on the channel selected, the accumulated nonwindy time in the set, the computed gain constant for channel 1, the computed gain constant for channel 2, and the time of day at the end of the sample.

Data output to the tape recorder or printer always begins with a header, which includes such items as unit serial number, data, and a summary of the unit's set up data during the period that data was gathered.

3. A wind speed detector is used in conjunction with the unit. If the wind exceeds the preset threshold and the Wang computing calculator is not connected, then this "windy" data is not accumulated with the normal or "nonwindy" noise data. The wind threshold signal is, however, available to the Wang calculator. The wind speed threshold is adjustable in 3-km/hour steps, ranging from 6 to 51 km/hour.

4. A peak detector is available to operate on either channel 1 or channel 2. The peak detector holds in a register the maximum pressure squared value that is read during the measurement period.

5. An adjustable threshold is provided on channel 1, and data on this channel is accumulated only when the threshold level is exceeded. When the threshold is exceeded, a 2-μsec pulse called "threshold up" is generated. A delay time (adjustable internally within the monitor over the range 0.1 to 9.9 sec) is started. If the threshold is exceeded during this interval (nominally 2 sec), the timer is reset. If the delay time passes and the threshold is not exceeded, a 2-μsec signal called "threshold down" is generated.

With the monitor operated in the master position, the threshold up/down signals are available at an outside bulkhead connector. These can be used to operate an external device, such as a second monitor operating in the single-event manual mode.

6. The power selections for the unit include turning the unit off, operating it on 120-V ac power, or operating it in an uninterruptible mode (the power source may be 120-V ac or 12-V dc battery). In the uninterruptible mode, if the ac power fails, then an internal 12-V battery (which is constantly kept charged in this mode) takes over and runs the unit for up to 3 hours. An external 12-V battery (which can run the unit for 2 to 3 days) can be used in this position. The external battery also keeps the internal battery charged; the internal battery enables the external battery to be disconnected so that it can be charged without loss of power to the unit. Fuses are provided on the ac line and on the external battery line. Because of the uninterruptible feature provided by the internal battery, an acoustic signal warns of a blown fuse in the ac line input which might otherwise go undetected. An ammeter in series with the external battery line is used to warn of a blown fuse in that line.

Integrating Sound-Level Meter Mode

In the sound-level meter mode, the unit displays sound level during each time interval after the "start" switch has been pressed and until the "sample" switch is pressed. The "display" switch must be depressed momentarily after the unit is started with the rotary switch pointing to the desired data in order to view results. After the "sample" switch is pressed, the unit displays the L_{eq} or sound exposure level (SEL) for the entire time between "start" and "sample" and stores this data in memory. The accumulation time in the sound-level meter mode is adjustable from 0.1 to 99.9 sec per display, with 0.1 sec as a default value. The actual data-gathering time between pressing "start" and "sample" is extended by the monitor to be an integral number of time intervals. The unit needs approximately 2 msec to recognize the "start" or "sample" commands. When the unit is in this mode, data is stored in the memory only for the first time "sample" is pressed after a "start" command; the integrator is zeroed every time "start" is pressed.

When "start" is pressed, the tape recorder motor control is activated; when "sample" is pressed, the motor control is turned off. This feature can be used to control an external analog recorder. The analog signal can be put on one channel of the recorder, and the time of recorder activation can be put on a second channel, using a frequency shift code.

Single-Event Mode

The single-event mode is somewhat similar to the sound-level meter mode. The start command zeroes and resets the integrator, and the sample command causes data to be stored in memory as in the sound-level meter mode. One key difference between the sound-level meter mode and the "single-event mode" is that for the latter, "start" and "sample" cause action to take place virtually immediately (does not need to be recognized by the microprocessor). Moreover, the time interval between "start" and "sample" can be any arbitrary length from as little as approximately 50 μsec to many hours; the time interval is not integrally related to any other time. During single-event mode of operation, no data is available in the display until "sample" has been pressed at least once. Another difference is that data is stored each time "sample" is pressed. Thus, if one presses "start," then "sample," and then "sample" again, one will store two sets of data: the first set for the time between "start" and the first pressing of "sample," and the second set for the time between "start" and the second pressing of "sample." Turning the function switch to the most recent value desired and pressing the "display" switch will cause display of the quantity stored when "sample" was depressed.

There are two submodes of the single-event mode: one is a manually triggered operation, and the other is a threshold-triggered operation. In manual operation, the front panel "start" and "sample" switches control the operation. Alternatively, CMOS-compatible BNC inputs are located on the front panel to control "start" and "sample." A 12-V 2 μsec or more positive pulse is sufficient to activate the input. Also, when the control is in the slave position, a bulkhead connector on the side can be used with CMOS-compatible signals to control "start" and "sample." These signals may originate from a second monitor operating with its control in either the master (threshold) or slave (manual) position.

This master/slave setup provides great flexibility. For example, one monitor can be operating as a master in block mode, while a second unit operates as a slave in single-event mode. For example, in addition to getting the hourly blocks of data, one could get a separate record of each large event, such as each large blast or each aircraft flyover, etc. Even in single-event or sound-level meter modes, the master/slave setup can be used to analyze the higher level portion of an event separately from the entire event.

With threshold triggering, a single event starts when the preset level on channel 1 is exceeded. The accumulation continues for at least 2 sec. If, during this 2-sec interval, the threshold is exceeded again, then the 2-sec counter is reset. (The 2-sec time can be changed by switches internal to the unit over the range from 0.1 to 9.9 sec). In this mode of operation, the unit can be set to automatically record particularly noisy occurrences such as aircraft flyovers, truck passbys, blast impulses, etc. To view the most recent value, "display" must be continually depressed.

When the threshold is high, the motor control for an auxiliary analog tape recorder is turned on. Filtered or unfiltered analog data can be taken from the front panel to one channel of this analog tape recorder. The current time is put on the second analog channel in a frequency shift-coded digital format each time a single event occurs in the threshold-triggered mode of operation. In the manually triggered mode, the tape recorder turns on when "start" is depressed and turns off when "sample" is depressed.

Blocks of Data Mode

In the blocks of data mode of operation, data is accumulated for fixed time periods. There are two major subdivisions: "seconds" and "minutes." In the "seconds" mode, each block (time period) may have a length of 0.1 to 99.9 sec. The analog recorder motor control is always threshold controlled during this submode. This mode is intended primarily for use with the external Wang computing calculator, where the calculator accomplishes a complete amplitude statistical distribution analysis, based on the short time samples provided by the monitor.

In the "minutes" submode of operation, the accumulation time may range from 1 to 999 min. The analog recorder motor control may be threshold- or clock-controlled. Clock control provides for turning on the analog recorder for a variable length of time and at a variable rate. The recorder activations occur regularly at a rate which is adjustable from 1 to 999 min.

(The activation duration is adjustable from 1 to 999 sec, but must be at least 2 sec because of recorder mechanical activation time requirements.) Threshold control provides for turning on the external recorder when the threshold is exceeded. The threshold up duration controls the recorder time. In the "minutes" submode, calibration can be accomplished manually or automatically every 6 hours (see also **Calibration** section).

In the "minutes" submode, a second area of memory accumulates L_{dn} data. Each L_{dn} day begins at 0000 hours, and new L_{dn} data is stored at the end of each 24-hour period. The data stored may include the L_{dn} for channel 1, the L_{dn} for channel 2, the daytime and nighttime L_{eq}'s (SELs), and the accumulated non-windy time during the day and during the night.

"Start time" controls the time at which data collection begins in the minutes mode. This can be thought of as an alarm clock type of feature.

Unlike the sound-level meter or single-event modes, "start" and "sample" have different meanings in the blocks of data mode. If the "start time" has not been entered, then depressing "start" causes block mode operation to begin. Depressing "sample" causes the latest accumulation of data to be transferred to a holding register, but this data is not stored in memory. Rather, data is stored only at the end of a defined block.

The most recent value may be viewed by pressing the "display" switch. If a new sample is taken while the switch is down, the display will be updated.

In the "blocks of data (minutes)" mode, the amalgamation of features described above results in a unit whose operations will remain uninterrupted indefinitely; the batteries can be changed, data can be output, and calibration can be accomplished automatically without loss in operation.

Calibration

Calibration is simple and virtually error-proof. The user first enters the calibrator level for each channel of operation (e.g., 90.3 or 120.4 decibels [dB], etc.). Then either the channel 1 or channel 2 calibration mode is entered. To view any results in this mode, the function switch must be moved to the most recent value position and the "display" switch pressed. Once in this mode, pressing the "start" command zeroes the accumulator, zeroes the gain constant, and causes the unit to display a new L_{eq} each half second. Pressing "sample" causes the unit to finish out the current half-second interval and calculate L_{eq} (or SEL) for the entire time between pressing "start" and "sample." The unit then displays this value and calculates a gain constant based on the known calibrator level and the measured L_{eq}. Pressing "start" a second time rezeroes the accumulator and restarts the calibration process; pressing "sample" only a second time has no effect.

The unit is primarily designed to operate in conjunction with a B&K type 4921 outdoor microphone system and its built-in electrostatic actuator calibrator. When this system is used, the 4921's built-in microphone calibrator source is turned on and off by the monitor. Because of the remotely controlled electrostatic actuator, automatic calibration is therefore possible.

In the blocks of data (minutes) mode, the unit accomplishes self-calibration every 6 hours by carrying out a set of precise steps. It first checks that the ambient noise is sufficiently (15 dB) below the calibrator level, operates the calibrator, and then rechecks the ambient noise level to further insure that it is sufficiently below the calibrator level. When these three steps are accomplished properly, the unit then checks that the new gain constant is within 0.7 dB of the old gain constant and that the peak level detected during the calibration interval is within 5.0 dB of the RMS level of the calibration period. If any of these tests fail, then the unit attempts to recalibrate. This series of steps can be repeated five times until it is ascertained whether calibration is possible during this 6-hour period. After five failures, calibration is skipped and the old gain constant is used for the next 6 hours. This series of operations is performed on channel 1 or on both channels, depending on the setting of the analog input selector switch.

Data Output

Data output is to any of three external devices: the Wang calculator on an interactive basis, a paper tape printer, or magnetic tape on a batch basis.

Data output to the tape recorder or printer always begins with a header, which includes such items as unit serial number, date, etc. Figure 1 illustrates a typical data output to the paper tape printer. The first section on the paper tape is the header information, followed by the blocks of data which have been gathered. Since this data is from 24-hour sampling in the blocks of data mode, the third set of data on the tape is L_{dn} data.

Figure 2 illustrates just the header and identifies the printed data. Figure 3a illustrates a single data block from this tape and identifies the data printed with respect to the original memory pattern chosen. In this particular example, the operator chose to store channel 1 level, channel 2 level, peak, sample length, channel 1 gain, channel 2 gain for the regular data blocks, time of day.

Since six items were chosen in the memory format and 2048 words of storage are in the standard configured monitor, there is room for 292 blocks of data in the monitor memory. This means that if 1-hour blocks are chosen, then data must be read out every 292 hours or slightly sooner, although from a technical standpoint the monitor should be checked more often than that. Similarly, if 1-min blocks of data are used, then the data must be read out every 292 minutes.

Figure 3b illustrates a single L_{dn} data block consisting of eight pieces of information: the channel 1 L_{dn}, the channel 2 L_{dn}, the lengths of the day and nighttime samples, and the day and nighttime levels on channels 1 and 2. This information is available only once per day. Since 64 words are available, this memory will fill up in 8 days. The unit stores partial L_{dn} data on the starting day at midnight and then for a full 24-hour period from one midnight to the next.

4 SWITCHES AND CONNECTORS

This chapter describes the functions of each switch and the use of each connector. Figure 4 illustrates the front panel and shows each functional area.

In the channel 1 area, the rotary switch sets the weighting on channel 1, which may be A, C, D_1, or flat. In "ground" position, a short circuit is essentially connected in place of one of the weighted or unweighted outputs. The analog input BNC terminals can be used to input a signal or to view the signal being input through the side bulkhead connector. The filter output is the analog signal which goes to the A/D converter after weighting.

The channel 2 area operates exactly like the channel 1 area.

The tape monitor control is a seven-pin connector. Two pins are used for motor control of an external analog tape recorder. Two other pins are used to provide operating power (5-V dc). One pin has a signal indicating whether the wind threshold has been exceeded. The sample-time BNC contains a frequency shift-coded digital signal which records on one channel of an analog recorder the individual times when the tape motor control is activated.

The analog input selector selects (1) one microphone and one channel operation, or (2) one microphone and two channel operations, or (3) two microphones and two channel operations. With one-channel operation, the sample rate is 50 kHz; with two-channel operation, the sample rate is 25 kHz on each channel.

The speaker/headphones section allows output to an 8-ohm load. Channel 1 or channel 2 can be selected, and can be either filtered or unfiltered. A volume control is provided for gain adjustment; turning the volume control fully counter-clockwise turns off the power amplifier and conserves power.

The digital data input is not used in normal monitoring procedures.

The power switch has three positions. The first two are "on" and "off," and the third allows uninterruptible operations.* The fuse warning reset is used to turn off the external battery fuse alarm.

The function control section (Figure 5) is the heart of the unit's setup and operation. This section includes the large rotary function switch, which is color-coded for two separate uses, depending on the position of the function shift switch. The 12-switch register is normally used to enter three binary-coded decimal digits, but it can also be used to enter the memory format. The L_{eq}/SEL switch results in display of either L_{eq} or SEL values.

All switches in the function area except the L_{eq}/SEL switch are interrelated. Pressing "display" enables the current value to be shown as determined by the position of the large rotary function switch and the function shift switch. For example, if the rotary switch were in the "mini-sample recorder" position, the "function shift" in the black position, and the "display" switch depressed, then the display might show 5, indicating that the record time in seconds of the mini-sample recorder was 5 sec. To change this value, one

*If external power is lost, an internal battery will supply power for up to 3 hours.

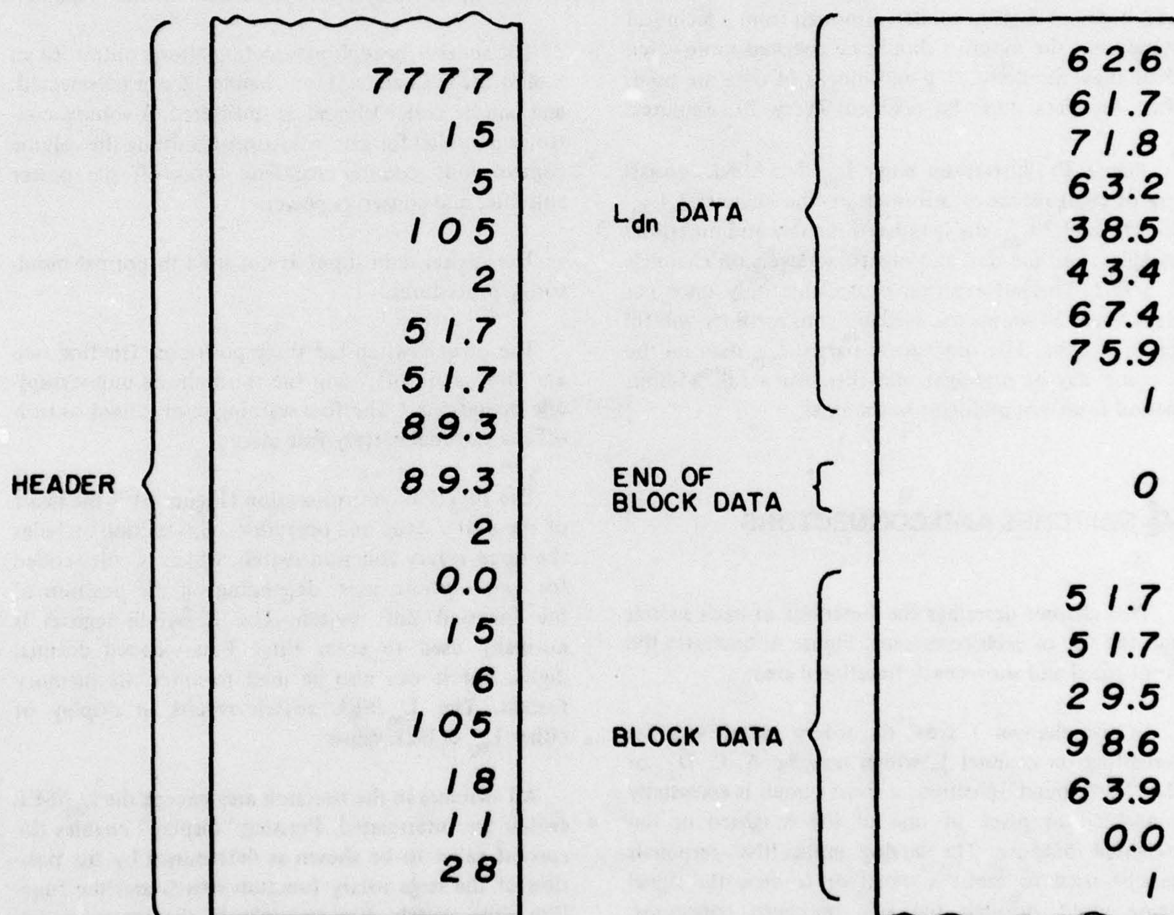

Figure 1. Typical data output.

STORAGE FORMAT	7777
INTERVAL IN MINUTES	15
RECORD TIME SECONDS	5
THRESHOLD	105
PEAK DETECTOR CHANNEL	2
GAIN CONSTANT CH 2	51.7
GAIN CONSTANT CH 1	51.7
CALIBRATOR LEVEL CH 2	89.3
CALIBRATOR LEVEL CH 1	89.3
NUMBER OF CHANNELS IN USE	2
ACCUMULATION TIME (SECONDS)	0.0
ACCUMULATION TIME (MINUTES)	15
MODE	6
UNIT SERIAL NUMBER	105
AT TIME OF DUMP	
MINUTE	18
HOUR	11
DAY OF YEAR	28

Figure 2. Header information.

TIME OF DAY HOUR-MINUTE	16.00
GAIN CONSTANT CH 2	51.7
GAIN CONSTANT CH 1	51.7
SAMPLE LENGTH (dB)	29.5
PEAK	98.6
L_{eq_2}	63.9
L_{eq_1}	0.0
BLOCK NUMBER	1

Figure 3a. Data block information.

END OF TAPE	0
CH 2 L_n	62.6
CH 2 L_d	61.7
CH 1 L_n	71.8
CH 1 L_d	63.2
TIME NIGHT PERIOD	38.5
TIME DAY PERIOD	43.4
L_{dn} CH 2	67.4
L_{dn} CH 1	75.9
BLOCK NUMBER	1

Figure 3b. L_{dn} data information.

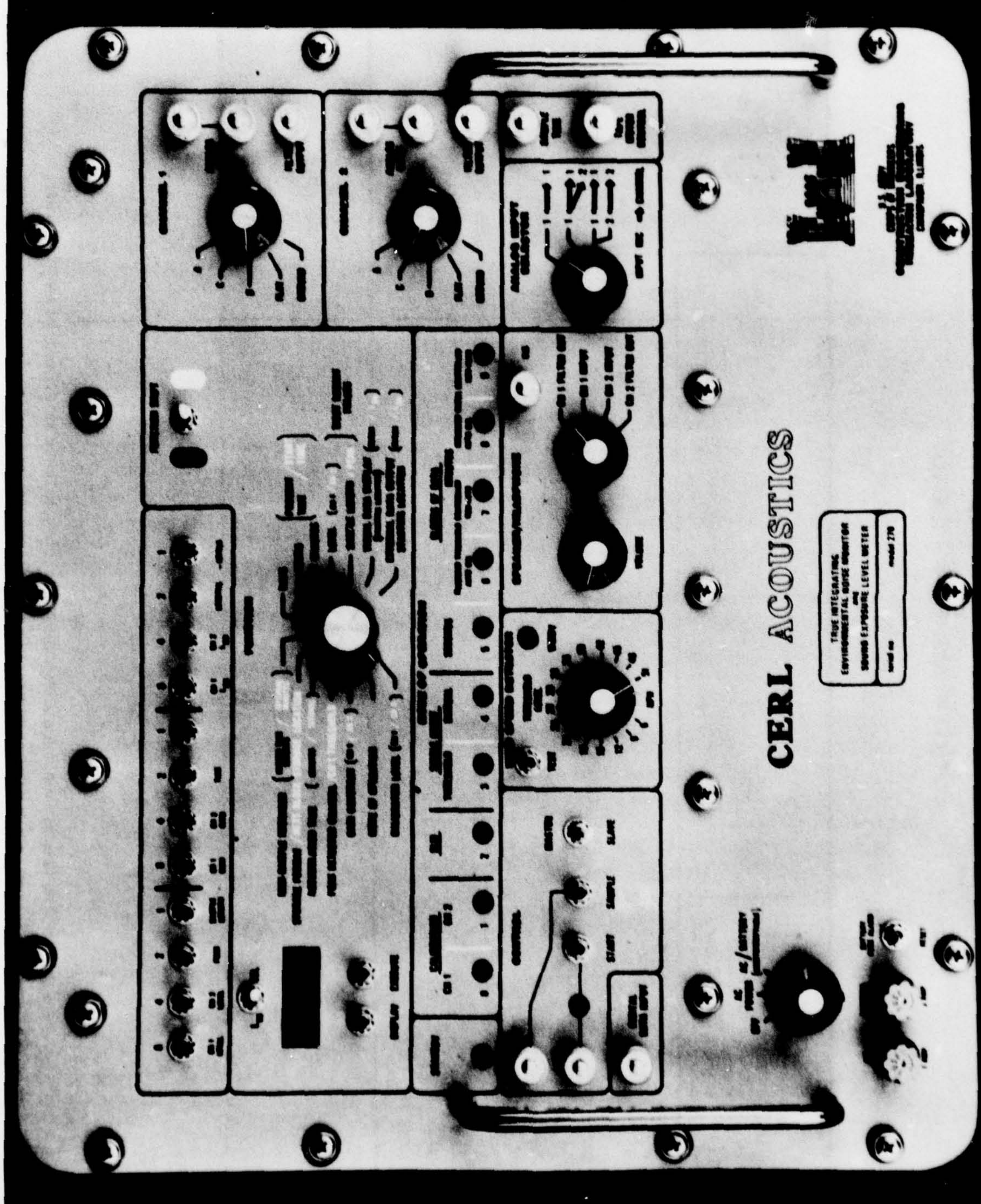

Figure 4. Front panel of the True-Integrating Noise Monitor and Sound-Level Meter.

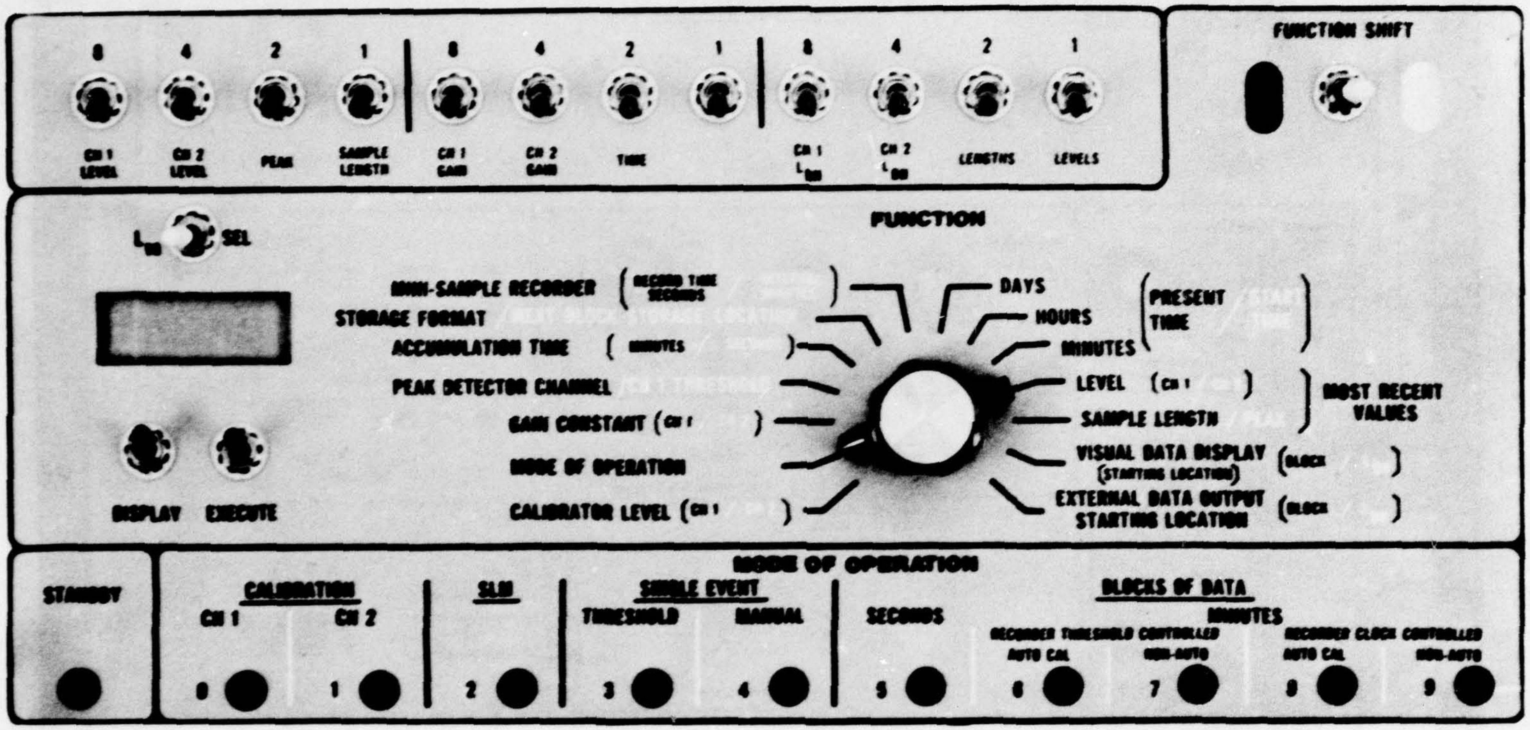

Figure 5. The function control section includes the rotary function switch and the switch register.

would set the desired time in binary-coded decimal format in the switch registers. For example, if the desired time was 36 sec, one could obtain the 3 by turning up the "2" and "1" switches above the words "time" and "blank" (2 plus 1 equals 3) and obtain the 6 by turning up the "4" and the "2" switches above "channel 2 L_{dn}" and "levels" (4 plus 2 equals 6). With these switches set and the "display" switch depressed, pressing "execute" causes the new value for mini-sample recorder record time in seconds to be stored in the memory and displayed.

The following explains the meaning of each of the positions of the function switch, working in clockwise order (see Figure 5).

1. "Calibrator level" is the level of the external calibration signal presented to the microphone. For levels between 60.5 and 99.9 dB, the three digits are set in the switch register and the data entered. For levels between 100.0 and 160.4, only the tens place, the units place, and one-tenth place are entered. Only calibrators having output levels ranging between 60.5 and 160.4 are allowed. Default values are 9C.0 dB when the unit is turned on.

2. "Mode of operation" is adjusted by entering the digit (0 through 9) as indicated on the front panel. Corresponding light emitting diodes (LEDs) indicate the mode of the monitor. The unit comes on in standby mode and remains in standby mode until the "start" switch is pressed. There is no shift position for "mode of operation."

3. The "gain constant" is normally calculated by the monitor during the calibration procedure. The user can enter a different gain constant to account for external amplifiers or other factors, if desired. Negative values can be entered by setting the left-most switch in the switch register. This feature allows for a range of ±79.9 dB.

4. Entering a "1" or a "2" selects the peak detector to operate on either channel 1 or channel 2. When the analog input selector is in the single-channel position, the selected channel is always channel 1.

The "channel 1 threshold" selects the threshold level, which is used to control data collection on channel 1 and other operations as explained in Chapter 3. The threshold may be any practical value above 0 dB and is adjustable in 1-dB increments (typically 0 to 199 dB). The nighttime (2200-0700 hours) threshold is automatically lowered by 10 dB. If the highest switch register bit is set while reading in threshold so that displayed values are between 800 and 999 (which is 800 plus the true threshold value), then the nighttime 10-dB reduction feature is deleted.

5. In the sound-level meter mode, the "accumulation time" is adjustable from 0.1 to 99.9 sec, with 0.1 sec as default. Data-gathering time is restricted to integral accumulation times. The blocks of data mode allows for the input of accumulation time in minutes or seconds. In this mode, the accumulation time reflects block length.

6. "Storage format" is the only position which uses the labels on the switch register rather than their numerical values. In all data-gathering modes, turning up any of the first seven switches from the left causes that value to be stored as part of each data block. For example, turning up the first eight, the first four, the first one, and the second two causes channel 1 and channel 2 levels, the sample length, and the time at the end of each block to be stored. There are 2048 words of main storage available, but 1024 to 4096 words in 1024-word increments may be installed. The monitor will automatically compensate for the memory size used.

In the blocks of data (minutes) mode, L_{dn} is also stored. The four right-hand switches control this format. Length implies two data words, which are the number of good daytime samples and the number of good nighttime samples. Levels may imply two or four data words of storage and are the daytime L_{eq} and the nighttime L_{eq} for channel 1 or channel 2, or both, depending on whether L_{dn} is requested for channel 1 or channel 2, or both. There are 64 words of storage allocated for L_{dn} data.

Next storage block number points to the next block in memory where the regular data (non-L_{dn}) is to be stored.

7. When the mini-sample recorder is clock-controlled, record time duration in seconds and interval (repetition period) in minutes may be set.

8. Days, hours, and minutes are entered, respectively, in that order. "Present time" sets or displays the internal clock's date and time, and "start time" controls or displays the unit's activation date and time in

blocks of data mode (minutes). If "start hour" is entered without "start day," the current day is assumed.

9. "Most recent values" are available in any mode of operation. Depressing "sample" (directly or remotely) causes data to be transferred from the integrator to the holding register. Depending on mode, this data may or may not be transferred to memory, as explained in Chapter 3. The data in the holding register is viewed by using the most recent values positions. Depressing "execute" causes no operation in these positions, but "display" must be depressed in order to view them.

10. In addition to transferring stored data to the external devices, the stored data can be visually displayed on the front panel. Each block of data (regular or L_{dn}) is sequentially numbered in memory. With the function switch in VISUAL DATA DISPLAY (starting location) position, and the FUNCTION SHIFT in black, depressing "display" causes display of the block number of the next set of data to be displayed. This is followed sequentially by the various data stored in that set at a rate of one number per second. Depressing "display" a second time causes the next block number to be displayed, followed sequentially by the data in that set. Operation in the L_{dn} position is similar, but shows L_{dn} data rather than regular data.

If the user wants to move to a different data set in memory, then he/she enters the block number (1 to 999) in the switch register, depresses "execute," depresses "display" (while still holding "execute"), and then releases "execute." This causes the visual data display to transfer to the new starting location and sequentially display the data in that block. Depressing "display" will show the data in the next block, etc.

11. The "external data output starting location" points to the first block of data (regular or L_{dn}) which will be transmitted to an external device. This value can be changed by inputting any block number between 1 and 999.

The user should note that the numerical difference between the "external data output starting location" in the normal mode and the "next storage block number" is the number of sets of data which will be output to the external device. There is no end to memory in the traditional sense; rather, data is stored in a "wrap-around" fashion. As data is output to an external device, these locations immediately become available for new data storage.

There are five side-panel connectors (labeled J17 through J21 in Figure 6). Connectors J19 and J20 are microphone 1 and microphone 2 inputs, respectively. These connectors incorporate transmitting of the 12-V dc power to the microphone system, transmitting the signal leads from the wind speed detector, and transmitting the acoustical signal from the microphone to the monitor. Only one wind speed detector should be used, although connections are available through both connectors.

Connector J17 is used to transfer digital data to the external recording devices. This device may be a tape recorder, paper tape printer, or Wang calculator. The monitor automatically recognizes the device by means of special pin connections. Pressing "start" on the tape recorder or printer interface initiates data transfer.

Connector J18 is wired to be used with one of two external cords for either ac or battery operation.

Connector J21 is used to send control signals to an external unit or device when operation control is in the master position, or to receive control signals from an external device when the unit is in the slave position. The wind detector output is sent through this connector, also allowing one anemometer to be used with several monitors. The monitor with the attached anemometer controls the wind threshold level.

5 TYPICAL STEP-BY-STEP OPERATION

1. Calibration. Calibration is performed on each channel used. Note that if two channels are used with one microphone, then both channels must usually be calibrated. Calibrator values are entered by turning up the correct switches in the switch register, rotating the function switch to the desired channel, and then depressing "display" and "execute" simultaneously. The position of the rotary function switch is not recognized until "display" (or "display" and "execute") is depressed.

To calibrate:

(a) Enter the calibrator levels to be used for channel 1 and channel 2. For example, 90.3 is entered as 903, and 120.4 is entered as 204.

(b) Go to the "mode of operation" position and enter the digit "0" (calibration of channel 1).

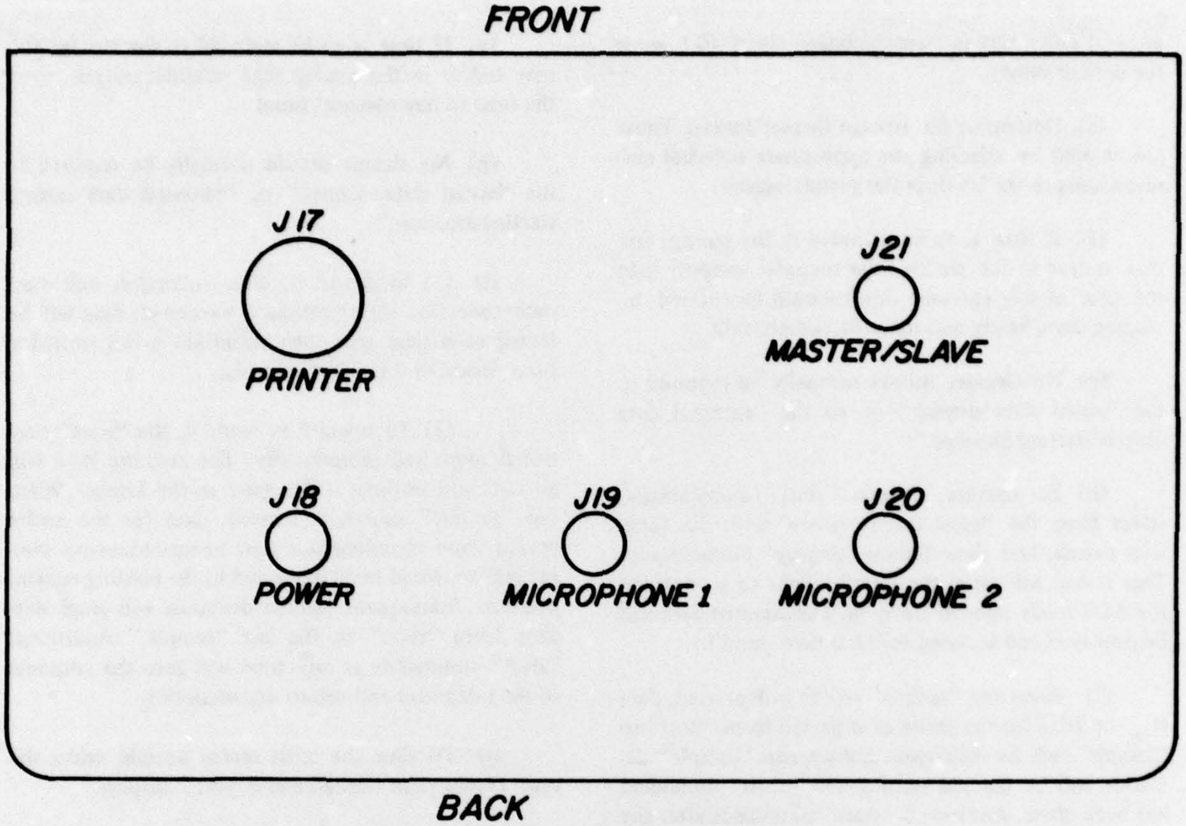

Figure 6. Monitor side connectors layout.

(c) The standby light should still be on, and the mode light should turn on automatically.

(d) Move the function switch to the "Level (CH1)" position and depress "display" momentarily. The display should show the raw L_{eq} being measured each half second.

(e) Depress "start" momentarily. The start light should come on, the standby light should turn off.

(f) If L_{eq} appears relatively constant, then after the desired time intervals, "sample" should be depressed momentarily. (If the L_{eq} has shown too much erratic action, the user may wish to depress "start" again.)

(g) After "sample" has been pressed, the L_{eq} for the entire start-sample period will appear in the display and the unit will calculate the gain constant, which is the numerical difference between the calibrator level and the raw L_{eq} value.

(h) The calculated "gain constant" can be read in the gain constant position and can be altered by any amount within the range of ±79.9 dB.

(i) Go to the "mode of operation" position and enter the digit "1" (calibration of channel 2).

(j) Repeat from step (c) for channel 2.

2. Sound level meter operation.

To operate:

(a) Calibrate the unit as described above.

(b) Enter mode 2.

(c) Determine a peak detector channel, if desired, and enter a 1 or 2 for channel 1 or channel 2.

(d) Determine the sound-level meter accumulation time in seconds over the range from 0.1 to 99.9

sec and enter this in "accumulation time" (0.1 sec is the default value).

(e) Determine the storage format desired. These are entered by selecting the appropriate switches corresponding to the labels in the switch register.

(f) If time is to be included in the storage format and/or in the analog tape recorder output, then the time of day (present time) should be entered, including days, hours, and minutes, respectively.

(g) No changes should normally be required to the "visual data display" or to the "external data output starting location."

(h) To operate, depress "start" momentarily, select from the "most recent values" with the function switch, and then depress "display" momentarily. This action will cause the standby light to go out and the SLM mode light to come on. The selected data will be displayed and updated for each time period.

(i) When the "sample" switch is depressed, data (L_{eq} or SEL) for the entire time period from "start" to "sample" will be displayed. Subsequent "sample" demands will be ignored until a new "start" command has been given. Additional "start" commands after the first "start" command zeroes the contents of the integrator and restarts the unit.

3. Single-event mode.

(a) Calibrate the unit as described above.

(b) Determine the threshold on channel 1, if desired, and enter the level. This must be done before mode 3 is entered or reentered.

(c) Enter the unit in mode 3 if the threshold will control the unit.

(d) Enter the unit in mode 4 if the front panel switches, the front panel BNC's, or the side panel input will control the unit. If the side panel inputs will be used, then the front panel master/slave switch must be in the slave position.

(e) Determine a peak detector channel, if desired, and enter the channel number.

(f) Determine the storage format desired and enter these according to the labels on the switch register.

(g) If time is to be included in the storage format and/or in the analog tape recorder output, enter the time of day (present time).

(h) No change should normally be required to the "visual data display" or "external data output starting location."

(i) (1) In mode 3, data collection will start each time that the threshold is exceeded; data will be stored each time that the threshhold is not exceeded for a period of 2 sec continuously.

(2) To operate in mode 4, the "start" control is depressed momentarily. The standby light will go out, and nothing will appear in the display. When the "sample" switch is pressed, data for the entire period from instantaneous start to instantaneous sample will be stored in memory and in the holding register position. Subsequent sample demands will store new data from "start" to the last "sample." Additional "start" commands at any time will zero the contents of the integrator and restart accumulation.

(j) To view the most recent sample, select the most recent value desired and depress "display."

4. Blocks of data mode.

(a) Calibrate the unit as described above.

(b) Enter the mode of operation desired, i.e., recorder threshold or clock-controlled, etc.

(c) Determine a peak detector channel, if desired, and enter the channel number.

(d) Determine the threshold on channel 1, if desired, and enter the level.

(e) Enter the accumulation time in seconds for mode 5, or in minutes for modes 6, 7, 8, or 9. The default values are 0.1 sec or 60 min, respectively.

(f) Determine the storage format desired and enter these according to the labels on the switch register (including the L_{dn} data storage for modes 6, 7, 8, or 9).

(g) If the mini-sample recorder will be used and will be clock-controlled, then enter the "recorder on time" in seconds and the "recorder interval" in minutes.

(h) Enter the current time in days, hours, and minutes, and the starting time (only if the alarm clock feature is desired) in days, hours, and minutes.

(i) Depress "start" only if no start time was entered and data collection will begin; otherwise, data collection will begin at the "start time" entered.

(j) To view the most recent sample, select the value desired and depress "display."

5. Data output.

(a) Data can be read on the front panel from any block, as described in Chapter 4.

(b) Data can be output to an external printer or recorder by connecting the device to monitor side connector J17 (see Figure 6) and pressing "begin" on the printer or recorder interface (the recorder must be turned on). The device will stop automatically when data transfer is complete.

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