1-157-0001, 1-157-0002, 1-157-0103 & 1-157-0105 Portable Vibration Meters

Operation and Maintenance Manual

P/N 992229-25-0000 Rev. A.

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SECTION 1 – DESCRIPTION

1.1 INTRODUCTION

This technical manual contains operation and maintenance instructions for the Portable Vibration Meter Type 1-157-0001; 1-157-0002; 1-157-0103 and 1-157-0105 manufactured by the CEC Vibration Products.

1.2 PURPOSE AND USE

Vibration Meter Type 1-157 is an all solid-state portable vibration meter offering laboratory accuracy. It is designed to be used with a self-generating linear vibration transducer to indicate displacement (mils peak-to-peak) or velocity (ips average) This type of vibration meter is used to monitor vibrations generated by environmental test equipment (electrodynamic vibration exciters), internal combustion or turbine engines (aircraft or industrial), hydraulic pumps, electric motors, pneumatic devices, or any type of machinery.

1.3 SYSTEM DESCRIPTION

A typical system in which the vibration meter may be employed is illustrated in Figure 1-1. As illustrated, a vibration transducer (mounted on the device to be monitored) supplies the initial signal to the vibration meter. Plug-in accessory filters are used to eliminate portions of the frequency spectrum permitting a better evaluation of the frequencies to be monitored. The fixed filters (high-pass, low-pass, or band-pass) attenuate all frequencies, permitting study of all remaining frequency components of vibration. Signals coming through the fixed filters may then be evaluated on the vibration meter.

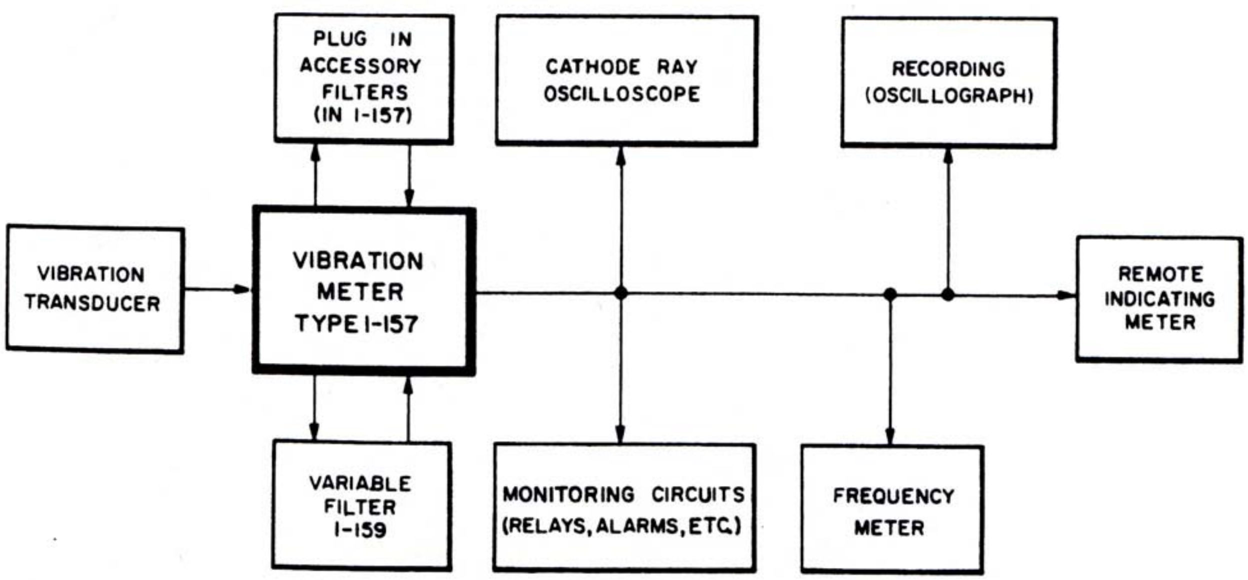


Figure 1-1. Block Diagram of Typical System

The vibration meter contains an internal test circuit for testing the battery power supply. The vibration meter will accept the output of six low-impedance velocity transducers having a source impedance of 100 to 1100 ohms, and may be absolutely calibrated for transducers with sensitivities between 50 and 150 mV/ips. The vibration meter also provides individual channel sensitivity adjustments.

The oscilloscope indicated in Figure 1-1 permits a visual presentation of the signal waveforms, while the recording oscillograph makes a permanent copy of the data for review at any future date. The

frequency meter indicates the frequency of the output signal. The remote indicating meter may also be used to allow the equipment operator to adjust the vibration source. If desired, a monitor circuit may also be connected to initiate an alarm system. Table 1-1 is a list of accessories, which can be used with the Vibration Meter Type 1-157.

1.4 PHYSICAL DESCRIPTION

1.4.1 General

The vibration meter consists of a case assembly, chassis assembly, and an internally contained plug-in power supply (AC or battery).

1.4.2 Chassis Assembly

The chassis assembly contains all the electrical components, selector switches, control knobs, receptacles, and associated hardware. Attached to the rear of the chassis frame is a connector plug (Shown on Figure 1-4). This plug is inserted into the external filter receptacle whenever the instrument is not connected to an external filter. The chassis has three receptacles for CEC Type 1-003 plug-in, high-pass filters (low-pass or band-pass filters may also be used). On the rear of the chassis assembly are six receptacles for transducer inputs, a receptacle for an external meter, a receptacle for an oscilloscope, and a receptacle for an oscillograph. In addition, there is a provision for an additional circuit (alarm) if so desired. On the Vibration Meter Type 1-157-0001 the rear panel has an opening for the external power cord and fuse access. The Vibration Meter Type 1-157-0002 incorporates a battery identification plate in place of the external power opening shown on Figure 1-5. The front panel assembly (see Figure 1-6) incorporates all external controls, adjustments, and a meter. All selector positions, meter data, and identification markings are clearly identified on the front panel.

1.4.3 Power Supply

The Vibration Meter Type 1-157-0001 incorporates an AC power supply as shown on Figure 1-7. The power supply may be wired for high or low voltage by changing the strapping as shown on Figure 1-8. The low-voltage range is 90 to 140 volts RMS at 50 to 400 Hz and the high-voltage range is 180 to 260 volts RMS at 50 to 400 Hz. The AC power supply utilizes a 6-foot power cord and incorporates a 1/16 amp, slow-blow fuse.

The Vibration Meter Type 1-157-0002 incorporates a battery (DC) power supply as shown on Figure 1-9. This power supply contains two 9-volt batteries connected in series. Battery connections are 7snap-on type, making replacement of one or both batteries very easy.

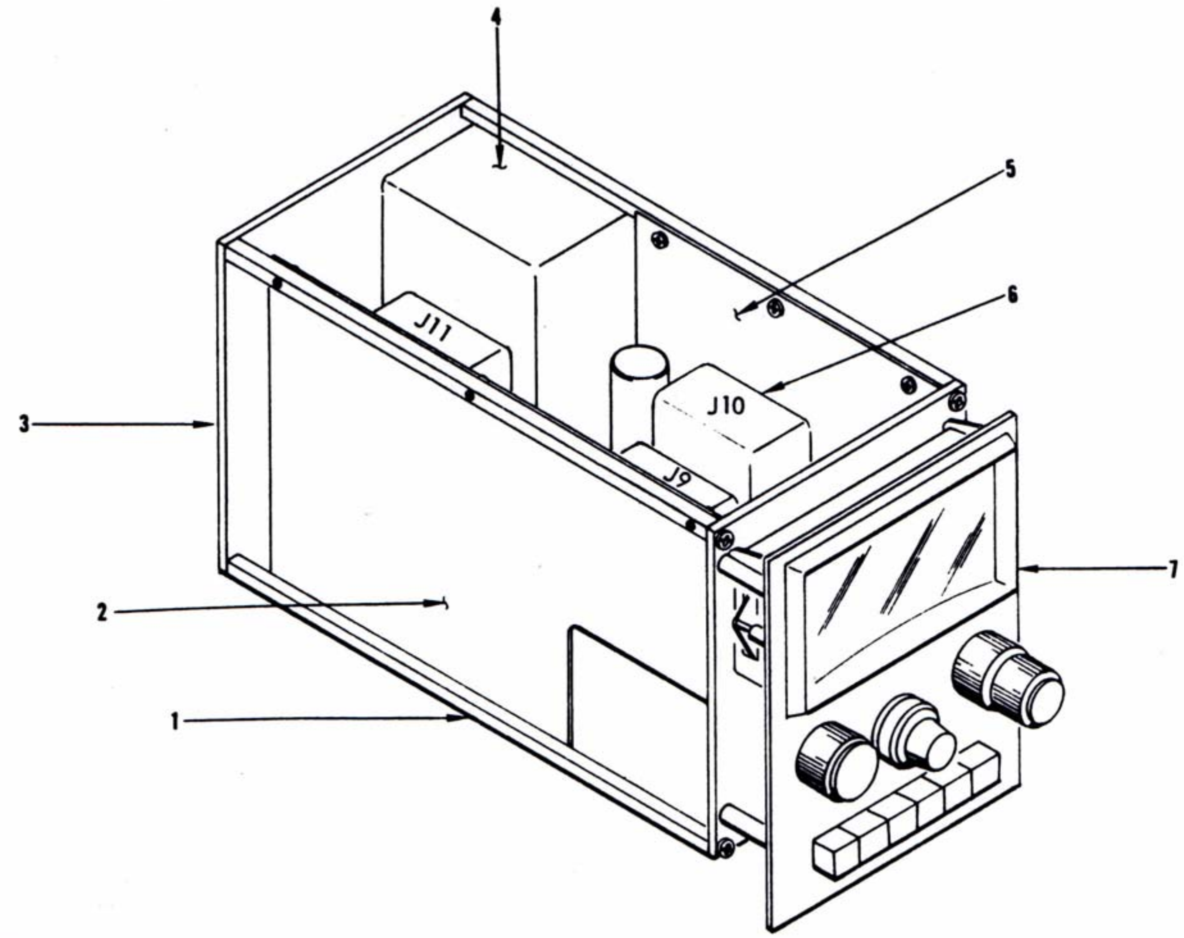
1.4.4 Technical Characteristics

The technical characteristics for the vibration meter, including operating features and leading particulars are listed in Table 1-2.

NAME	PART NUMBER	USE
10-Hz High-Pass Filter 30-Hz High Pass Filter 40-Hz High Pass Filter 70-Hz High Pass Filter 110-Hz High-Pass Filter 155-Hz High-Pass Filter 200-Hz High-Pass Filter	1-003-0010 1-003-0030 1-003-0040 1-003-0070 1-003-0110 1-003-0155 1-003-0200	Used to attenuate frequencies below the specified filter frequency. With these filters, typical frequency response is down 5% at the specified filter frequency, and down 95% at half the specified filter frequency.
*		Band-pass and low-pass filters also available upon special order.
Vibration Transducer	Any self-generating vibration transducer with a sensitivity of 50 to 150 mV/in/sec. Typical transducers manufactured by CEC Vibration Products Inc., Covina, CA are as follows: 4-102, 4-103, 4-106; 4-118, 4-123, 4-125, 4-126, 4-128, 4-130, 4-131, 4-137.	Used as a vibration pickup to convert mechanical vibrations into AC voltage signals for application to the vibration meter. Velocities from 0.05 to 50 ips may be read directly on the meter. Displacements from 0.0005 to 0.5 inches peak-to-peak may also be read directly on the meter.
Transducer Input Cable **	1695000-XXXX (For complete part number, add length of cable in inches in place of the X's. (Example: 25-foot long cable is P/N 169500-0300.)	Used to connect Type 4-125, 4-126 or 4-128, 4-130, 4-131, 4-137 Vibration Transducers to Vibration Meter.
Power Cable, Dual **	172138-XXXX (For complete part number, add length of cable in inches in place of the X's. (Example: 25-foot long cable is P/N 172138-0300.)	Used to connect the Vibration Meter Type 1-157-0001 and the Variable Filter Type 1-159 to a single AC power source.
Cable Assembly **	172137-XXXX (For complete part number, add length of cable in inches in place of the X's. (Example: 25-foot long cable is P/N 172137-0300.)	Used to connect the Vibration Meter Type 1-159 to the External Filter receptacle of the Vibration Meter Type 1-157.

* Other frequencies from 10 to 300 cycles available upon request.
** Consult factory for other cables available.

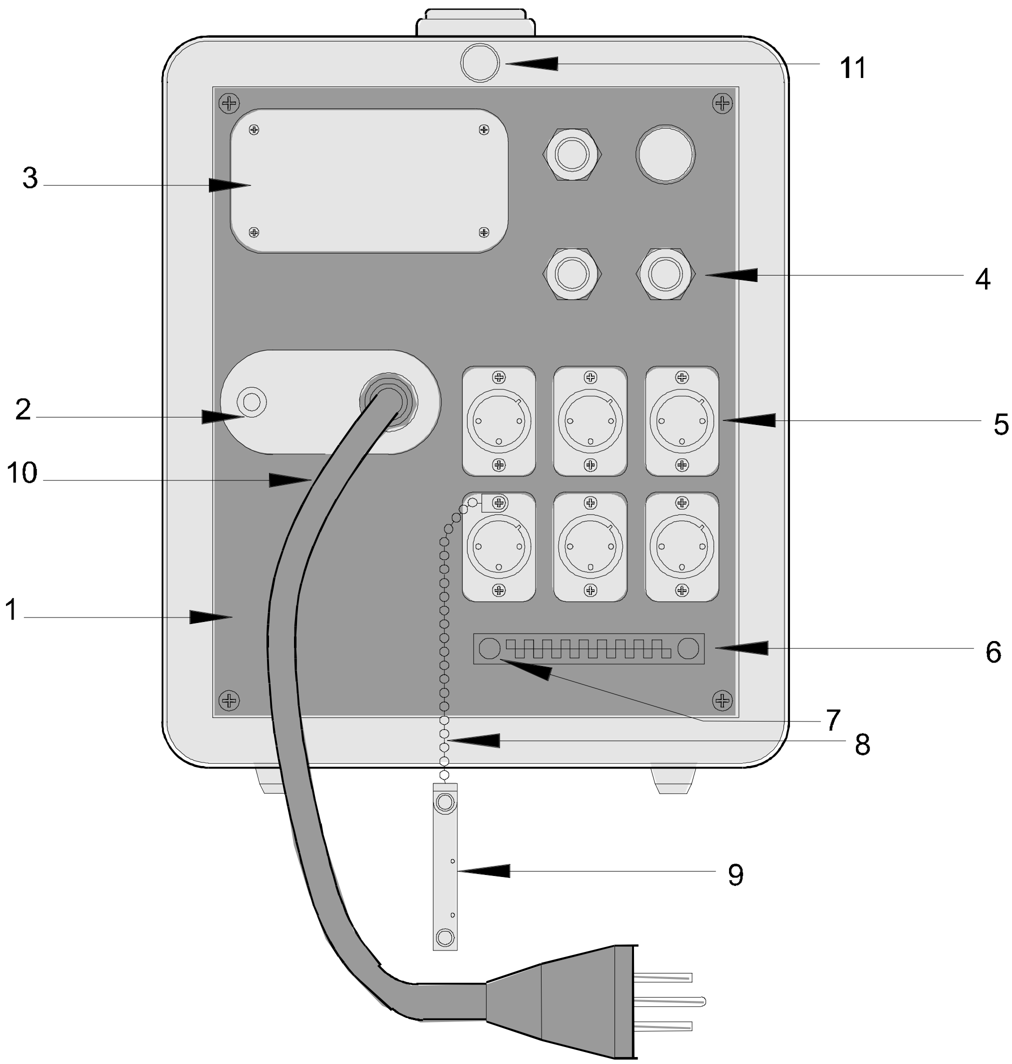
Table 1-1. Accessory Equipment (not supplied)



KEY:

1. Vibration meter chassis assembly
2. Regulator-Amplifier Board Assembly
3. Rear Panel
4. Power supply bracket assembly
5. Precision divider and oscillator board assembly
6. Plug-in filter (J9, J10, and J11)
7. Front panel assembly

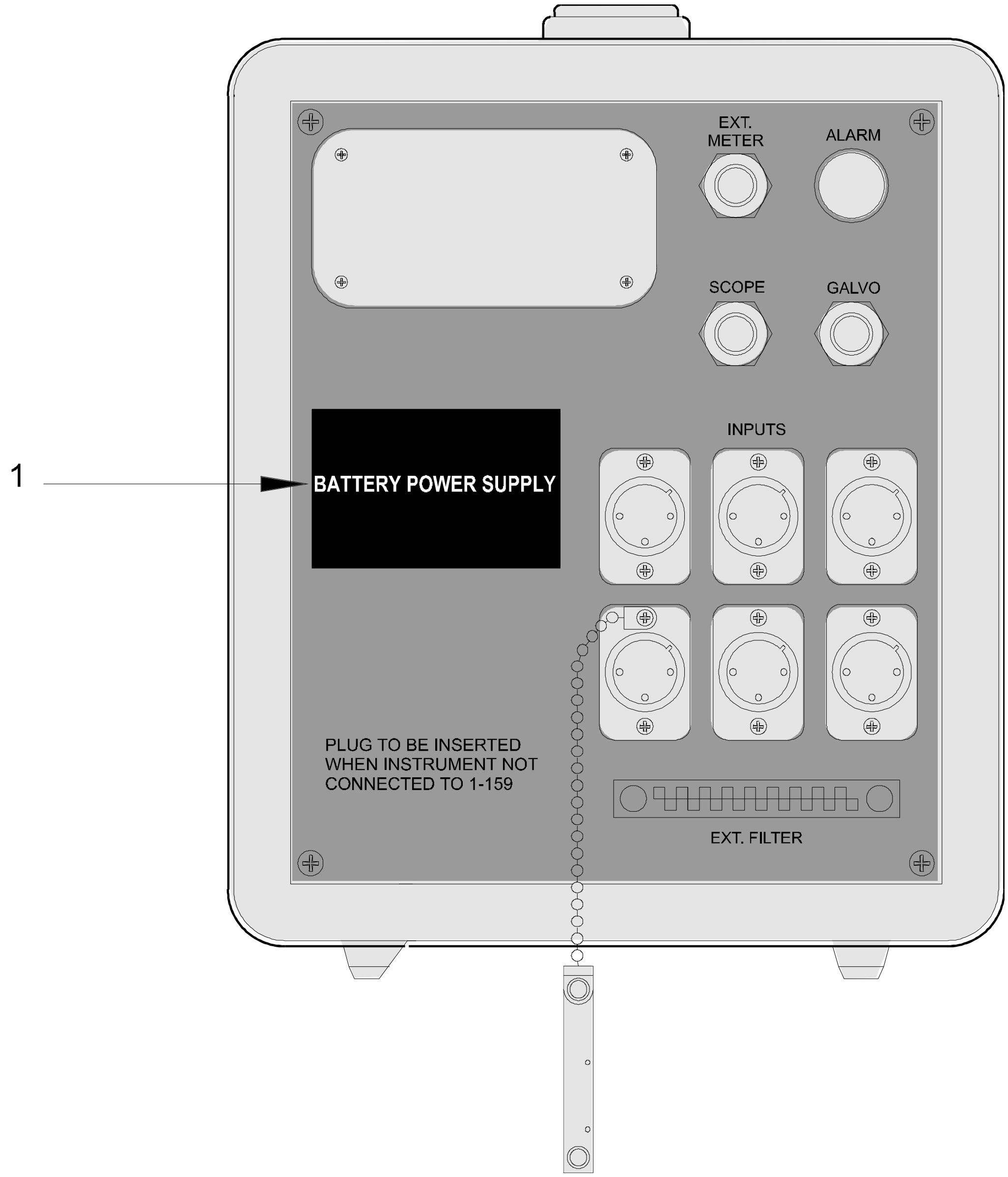
Figure 1-3. Chassis Assembly



KEY:

1. Rear Panel
2. Fuse
3. Identification plate
4. Jack plug (J12, J13, J14)
5. Connector receptacle (J1 thru J6)
6. Connector receptacle (J7)
7. Chain coupling
8. Bead chain
9. Connector plug
10. Connector and cord assembly (used on the 1-157-0001 only)
11. Pawl fastener

Figure 1-4. Portable Vibration Meter Type 1-157-0001, Rear View



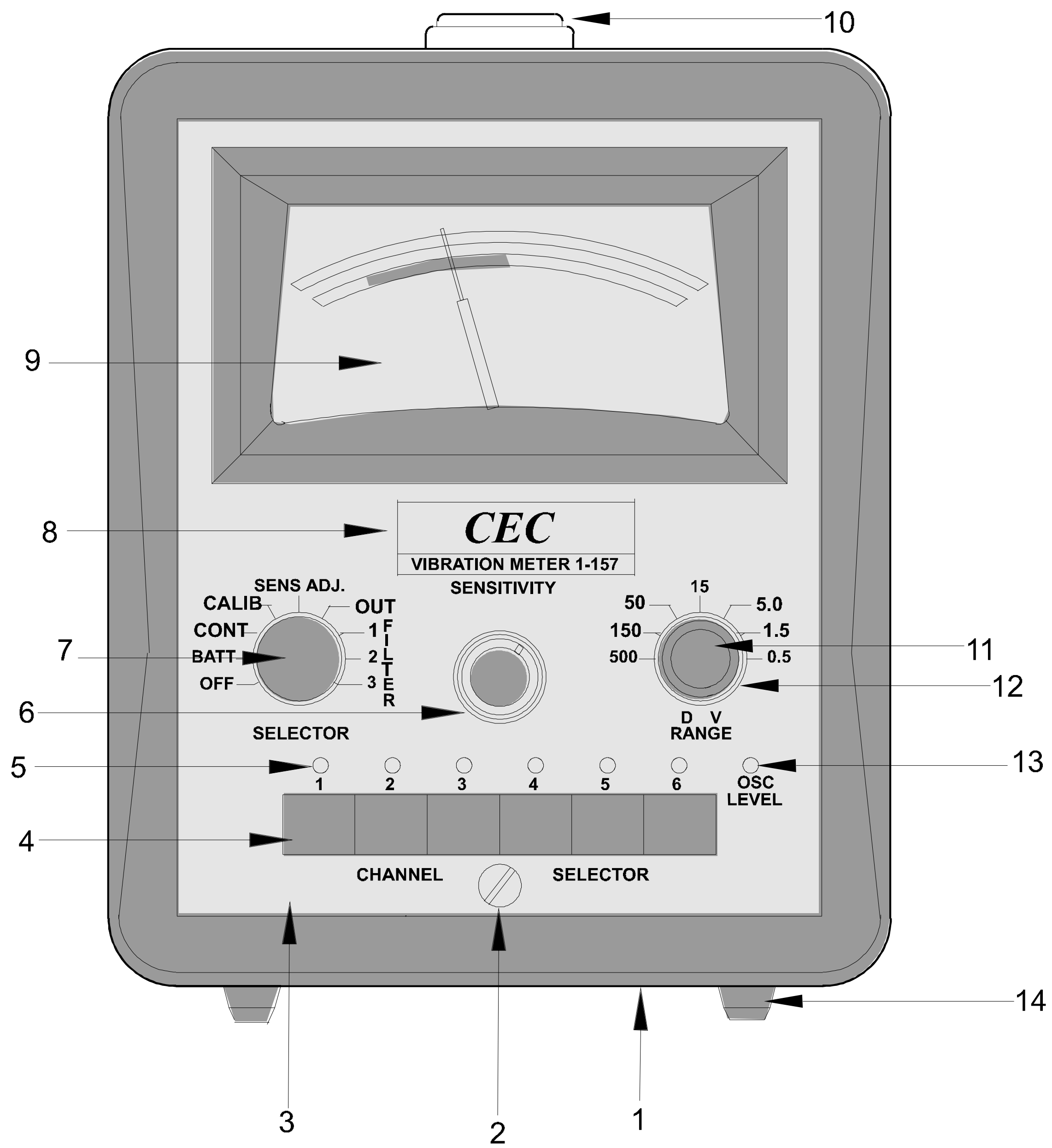
KEY:

1. Battery identification plate.

NOTE:

See Figure 1-4 for remaining details.

Figure 1-5. Portable Vibration Meter Type 1-157-0002, Rear View



KEY:

1. Case assembly
2. Camlock
3. Front panel assembly
4. Channel selector switch S1 (six)
5. Channel gain pots R1 thru R6
6. Duodial sensitivity control R64
7. Selector switch S3
8. Nameplate
9. Indicating meter M1
10. Carrying handle
11. Mode switch S4
12. Range switch S2
13. Oscillator level R79
14. Rubber foot (four)

Figure 1-6. Portable Vibration Meter, Front View

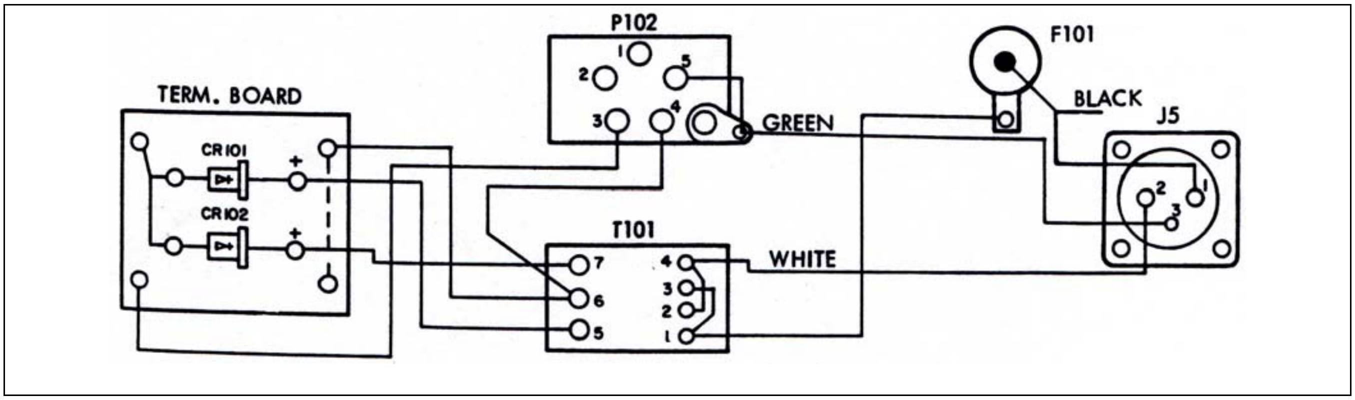


Figure 1-7. AC Power Supply Wiring Diagram

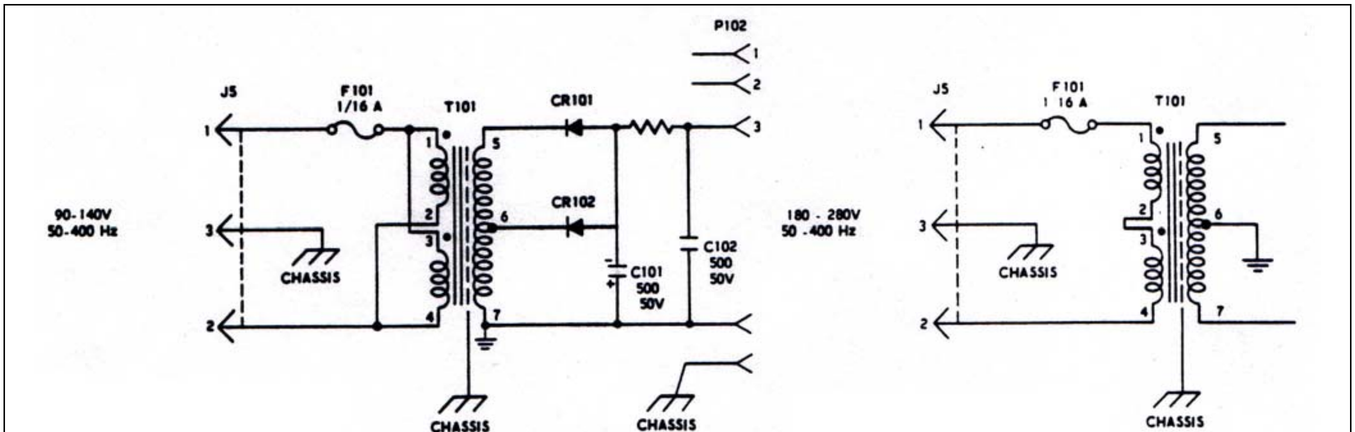


Figure 1-8. Power Transformer Strapping

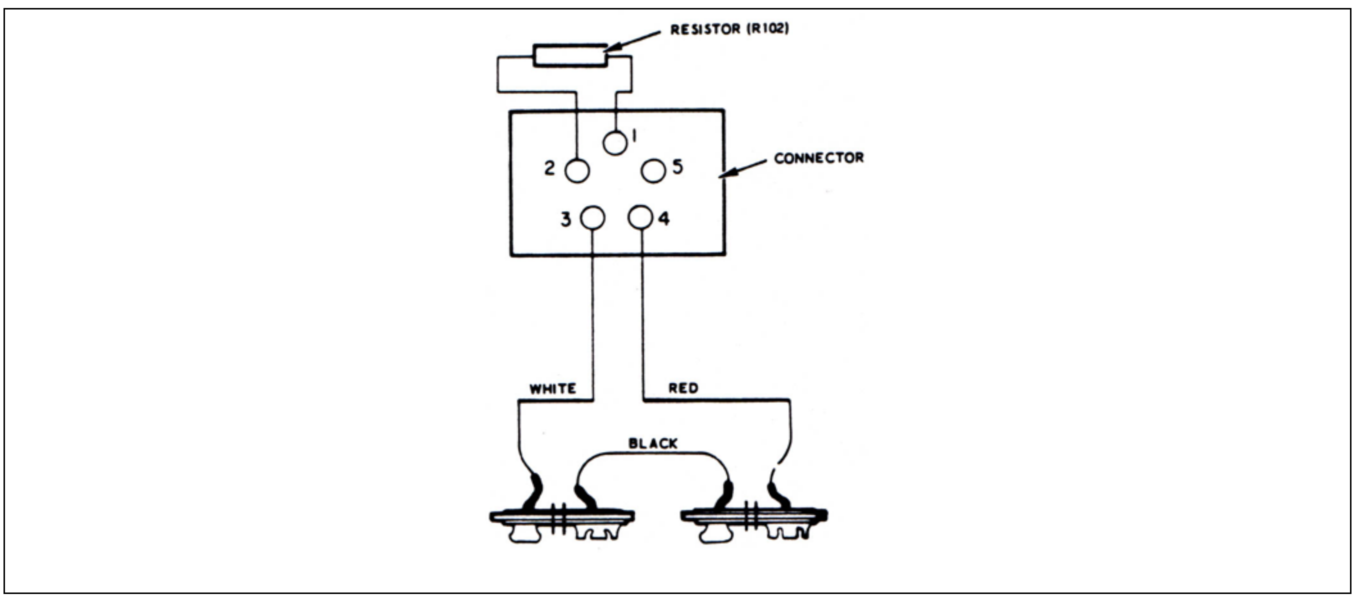


Figure 1-9. DC Power Supply Wiring Diagram

ITEM	CHARACTERISTIC
OPERATING RANGE	
Frequency	5 to 2,000 Hz (displacement) 5 to 20,000 Hz (velocity)
Displacement	0.5 to 500 mils peak-to-peak full scale
Velocity	0.05 to 50 ips average full scale
BASIC SENSITIVITY	47 mV/ips ±0.25% @ 77°F (25°C) value
Variations due to temperature	±0.2%/°C from 25°C value
ACCURACY	
Sensitivity Adjustment	±1%
Linearity	±2%
Precision Divider	±1% (range switch)
Frequency Response	±2%
Noise Level	2% of Full Scale
Input impedance	10K ohms ±5%
Scope Output	894 mV peak-to-peak ±20%
Galvo Output	785 µa peak ±3%
External Meter Output	500 µa peak ±3%
Battery Check	±0.15 volts
Continuity Test	±20%
Oscillator Frequency	50 Hz ±1%
Oscillator Stability	±0.5%
POWER	
AC Input Voltage	90 to 140 or 180 to 260 volts RMS at 50 to 400 Hz
Battery Input Voltage	18 volts DC (two 9-volt batteries)
Power Drain	1 VA for AC power
SIGNAL INPUT	
Transducer Sensitivity Adjustment Range	50 to 150 mV/ips
Input Channels	6
Maximum Input Voltage	10 volts RMS or overload of 40 times full scale on velocity or 10 times on displacement, whichever is less.
SIGNAL OUTPUT TERMINATIONS	
Scope	500,000 ohms min. (AC high impedance jack)
Galvo	100 ohms max. (AC low impedance jack)
Ext. Meter	200 ohms max. (DC low impedance jack)

Table 1-2. Technical Characteristics of Vibration Meter Type 1-157

ITEM	CHARACTERISTIC
TEMPERATURE RANGE	
Operating	+32°F to +122°F (0°C to +50°C)
Storage	-22°F to +160°F (-30°C to +71°C)
DIMENSIONS	
Width	6.84 inches max.
Length	14.00 inches max.
Height	8.22 inches max.
Weight	12.25 pounds (less internal filters)
CONTROLS	
Selector	9-position rotary switch: OFF – BATT – CONT – CALIB – SENS ADJ – FILTER OUT – 1 – 2 – 3
Channel Selector	Six pushbutton switches
Sensitivity	10-turn potentiometer for setting input level for channel sensitivity adjustment
Function Selector	Displacement or Velocity
Range Selector	0.5 to 500 range selector switch
Oscillator Level	Multi-turn potentiometer
Channel Sensitivity	Multi-turn variable resistor, sensitivity adjustment for each of six velocity vibration transducer channels.

Table 1-2. Technical Characteristics of Vibration Meter Type 1-157 (Cont'd)

SECTION 2 – INSTALLATION

2.1 INSPECTION

The vibration meter (see Figure 2-1) is shipped in an assembled condition, has been factory inspected and tested, and is ready for immediate operation upon receipt. After uncrating the vibration meter, visually inspect the unit for evidence of shipping damage. If a battery pack is employed, check the battery voltage as specified in Section 3.

2.2 INSTALLATION PROCEDURES

The vibration meter is not shipped with the 1-003 plug-in filters installed. To install a plug-in filter, first make sure AC power is removed, release the vibration meter chassis assembly from the case by turning the camlock (Key 2, Figure 1-6) one-half turn counterclockwise with a cross-point screwdriver, and unscrewing the pawl fastener (Key 11, Figure 1-4). Remove power before opening unit. Remove the chassis assembly by pulling it forward, out of the case assembly. Filters may be installed in octal receptacles J9, J10, or J11 by aligning the filter plug with the receptacle keyway and pressing the filter firmly into the receptacle. Secure the filter firmly in place with the filter attaching bracket screw. Replace the chassis assembly in the case assembly and lock the camlock and the pawl fastener.

NOTE: *A filter installed in the J9 receptacle is operated at the FILTER 1 position on the SELECTOR switch; J10 at the FILTER 2 position, and J11 at the FILTER 3 position.*

The power transformer T-101 for Vibration Meter Type 1-157-0001 is shipped from the factory strapped for 115 volt AC operation in detail A, Figure 1-8. If the vibration meter is to be operated using a 230 volt AC source, the strapping on transformer T-101 must be strapped as shown in detail B, Figure 1-9***. Remove power before opening unit.*** Remove the chassis assembly as directed in paragraph 2-4. Remove the power supply cover (see Figure 1-7) by turning the camlock one-half turn counterclockwise. Remove the power supply by unlocking the two camlocks that attach the power supply to the power supply bracket assembly (Key 4, Figure 1-3). Remove the power supply and change the strapping on T-101 as required in detail B, Figure 1-8.

NOTE: *The identification plate on the AC power supply is engraved on both sides. If the power transformer is strapped for 230 volts AC operation, remove the two screws attaching the identification plate and turn the plate over. Always make sure the identification plate is installed with the side that properly identifies the strapping of the power supply facing out.*

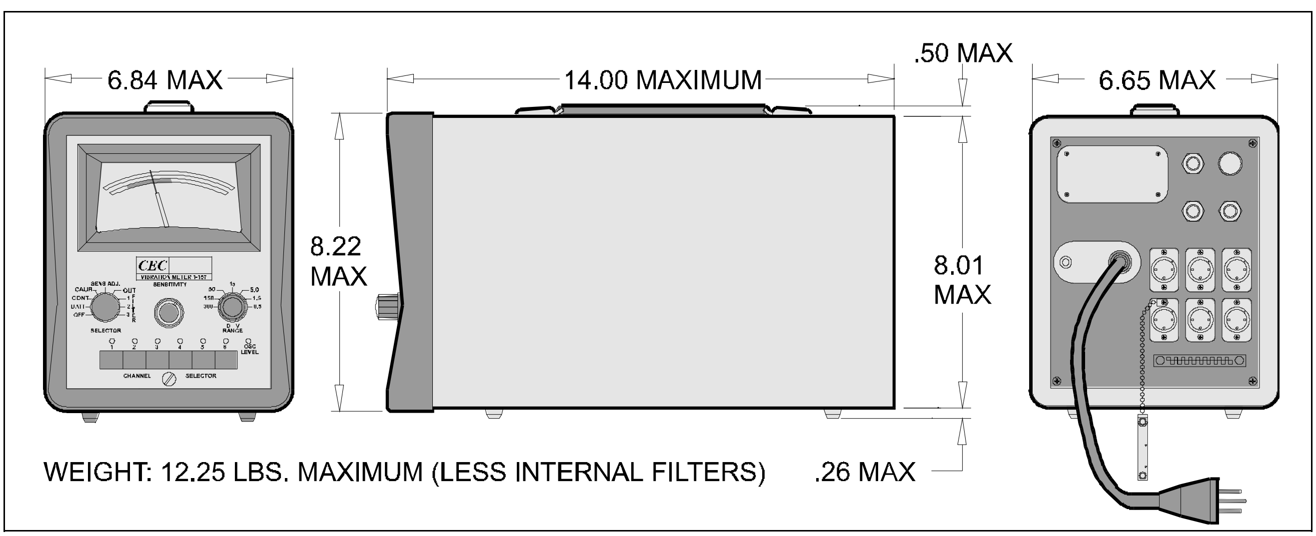


Figure 2-1. Vibration Meter Type 1-157, Dimensional Outline

SECTION 3 - OPERATION

3.1 CONTROLS AND INDICATORS

The functions of the controls and indicators are listed and described in Table 3-1. Locations of the controls and indicators for the vibration meter are shown on Figure 1-6.

3.2 ELECTRICAL CONNECTORS

Electrical connectors are listed and described in Table 3-2. Locations of the connectors are shown on Figure 1-4.

3.3 CALIBRATION

Equipment required for calibration. The test equipment (or equivalent) listed in Table 3-3 is required for calibration of the vibration meter.

3.4 VIBRATION TRANSDUCER – SENSITIVITY CALCULATION

The vibration meter is designed for direct reading when used with self-generating vibration transducers having resistances of 1100 ohms (or less) and velocity sensitivities between 50 and 150 millivolts per inch per second. Each channel may be calibrated to give direct readings with vibration transducers whose electrical characteristics lie within these ranges. There is no interaction between channels, thus fewer than six channels may be used. Vibration transducer calibration will be discussed first since this operation is essential to the proper operation of the vibration meter.

<u>Vibration Transducer Sensitivity Rating</u>

The sensitivity rating of velocity-responsive vibration transducers is determined with the following formula:

$S = E/V$ where:
S = the sensitivity rating, expressed as “millivolts per inch per second”
E = millivolts, i.e., (volts divided by 1000)
V = velocity in inches per second

<u>Sensitivity Rating</u>

S, is given in consistent units, i.e., if the input velocity is given in average inches/second, it may be multiplied by S to obtain average millivolts output; if the input is given in RMS inches/second, it may be multiplied by S to obtain RMS millivolts output, etc. Proper interpretation of the sensitivity rating is essential in avoiding confusion, especially since the vibration meter provides an average velocity readout but is often calibrated in systems in which an RMS velocity calibrator (electrodynamic vibration exciter) is used.

<u>Calculation of Corrected Sensitivity</u>

The sensitivity rating, S, can only be assumed correct when given in terms of operation into a load impedance equal to the input impedance of the vibration meter (10K ohms). All CEC vibration transducers are rated in terms of operation into a 10K ohm load. If vibration transducers rated for load impedances other than 10K ohms are used, it is necessary to calculate the “corrected sensitivity”.

Sample calculation when vibration transducer open-circuit voltage is shown on Figure 3-1.

Sample: With S_1 known to be 110 millivolts per inch per second and R_1 known to be 925 ohms, and using equation $S_2 = S_1 [R_2 / (R_1 + R_2)]$ = corrected sensitivity, the following sample calculation is given:

$S_2 = 110 [10,000 / (925 + 10,000)]$
$S_2 = 100.65$ millivolts per inch per second

INDEX NO.	CONTROL OR INDICATOR	Reference Designation	FUNCTION
4	CHANNEL SELECTOR Pushbuttons	S1	A six pushbutton control to electrically connect a selected transducer output to the input network of the vibration meter. This switch also connects the associated channel gain potentiometer to the function amplifier.
12	RANGE switch	S2	A seven-position switch to select signal attenuation through the precision divider. The setting of this switch indicates the full-scale meter reading. Range selections are 0.5, 1.5, 5.0, 15, 50, 150, and 500. For example, if 0.5 is selected, the 0-5 scale on the indicating meter represents 0 to 0.5.
7	SELECTOR switch	S3	A nine-position switch to select the functions of the vibration meter. One function allows the vibration meter to be used as a voltmeter to check its own battery voltage or the battery voltage of the 1-159-0002 Variable Filter. Another function allows the vibration meter to perform as an ohmmeter while checking transducer circuitry. In addition to selecting the internal or external filter, this switch also provides for calibration and sensitivity adjustments.
11	Mode switch	S4	A two-position switch to select the velocity or displacement measuring function, providing two modes of sensitivity for each measurement function. The meter indication must be multiplied by the setting of this control and the RANGE switch.
6	SENSITIVITY	R64	A ten-turn potentiometer used to set in the sensitivity of the transducer when selector switch is set to SENS ADJ. The potentiometer has a dial graduation of between 5 and 15 which corresponds to sensitivity settings of between 50 and 150 mV per inch-per-second.
5	Channel Gain Pots	R1 thru R6	Six potentiometers used to adjust the gain (sensitivity) of the function amplifier for each input channel.
13	OSC LEVEL	R79	A 20K variable resistor used to normalize the oscillator level.
9	Indicating Meter	M1	Indicates peak-to-peak displacement in thousandths of an inch (mils) and must be multiplied by setting RANGE switch. Also indicates average velocity in inches per second, and must be multiplied by setting the RANGE switch. The read-out depends upon position of mode selector switch (Velocity or Displacement).

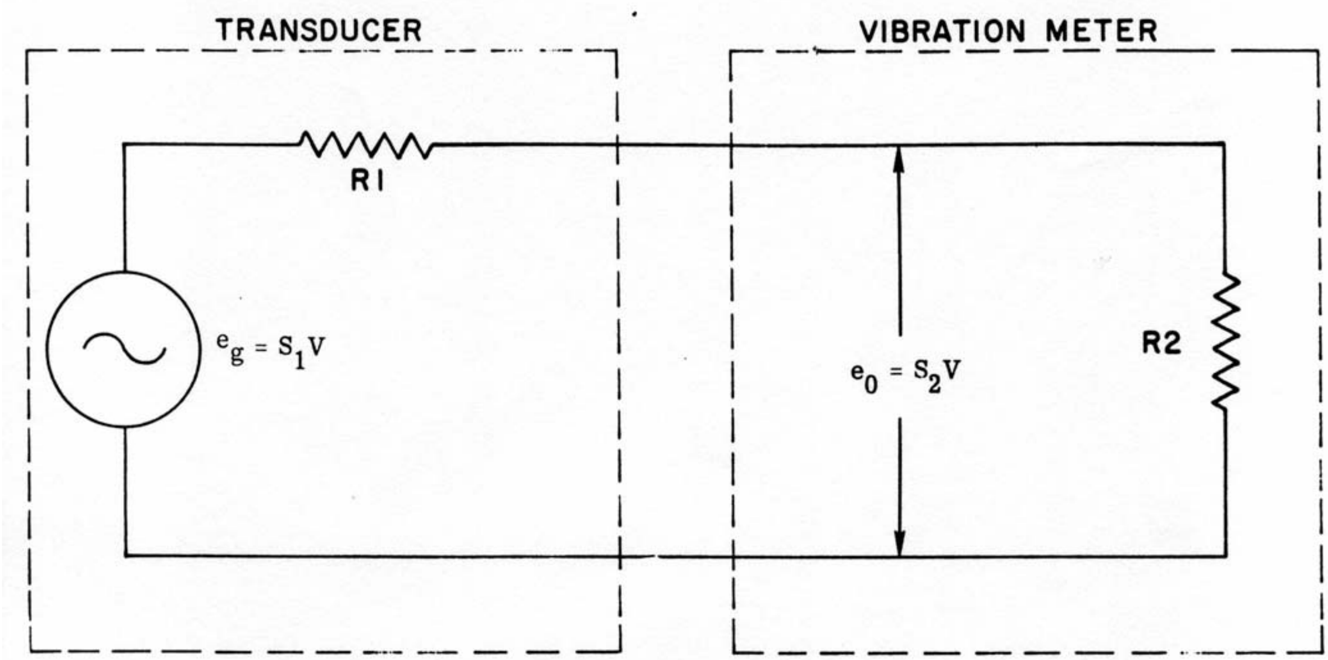
Table 3-1. Operating Controls and Indicators

INDEX NO.	CONNECTOR	Reference Designation	FUNCTION
5	INPUTS 1 thru 6	J1 thru J6	Connects each of six transducer outputs to vibration meter CHANNEL SELECTOR switches 1 thru 6.
6	EXT FILTER	J7	Connects the 1-159-0001 or 1-159-0002 Variable Filter to the precision divider or external battery check circuit. When no external filter is used, plug P7 must be connected instead. ***NOTE***: The 1-159 Variable Filter no longer available as of 01/01/00.
Not shown	Power Input	J8	Accepts either AC or battery power packs for source voltage.
Not shown	Internal Filter	J9 thru J11	Connects high-pass filters (internal) to the precision divider.
4	EXT METER	J12	Connects an external meter in series with M1. External DC meter should have a value of 0 to 500 microamperes and a resistance value of 200 ohms max.
4	GALVO	J13	A telephone-type jack (normally closed) used to connect a galvanometer to the meter amplifier. The galvanometer used should be of suitable sensitivity and frequency range, and have an internal resistance of 100 ohms or less. The vibration meter controls will affect the galvanometer and M1 simultaneously; however, M1 indications will not be altered by the use of a suitable galvanometer.
4	SCOPE	J14	Connects output of vibration meter to oscilloscope input. Oscilloscope must have an input impedance of 0.5 megohm or more.
	ALARM	J15	Not in use.

Table 3-2. Electrical Connectors

EQUIPMENT	NOMENCLATURE	FUNCTION
Hewlett Packard 200CD (or equivalent)	Oscillator	Furnishes test signal.
CMC Model 225B (or equivalent)	Frequency-Period Counter	Measures frequency.
Ballantine Model 710 (or equivalent)	AC to DC Converter	Rectifies oscillator transformer output to obtain accurate AC measurements.
Fluke Model 803 (or equivalent)	DC VTVM	Measure output of Ballantine 710
Gertsch Model RT-1 (or equivalent)	Ratio Transformer	Provides attenuation

Table 3-3. Test Equipment Required for Calibration



$$e_0 = eg \frac{R_2}{R_1 + R_2}$$

$$e_0 = S_2V$$

$$e_g = (S_1V)$$

$$e_0 = (S_1V) \frac{R_2}{R_1 + R_2}$$

$$(S_2V) = (S_1V) \frac{R_2}{R_1 + R_2}$$

Therefore:

$$S_2 = S_1 \frac{R_2}{R_1 + R_2}$$

where

S_1 = Open circuit sensitivity of transducer

S_2 = Transducer sensitivity when loaded with R_2

R_1 = Transducer internal impedance

R_2 = Load impedance
(10, 000 ohm input impedance
of the vibration meter)

V = Velocity excitation

e_g = Open circuit output voltage of transducer

Figure 3-1. Equivalent Circuit of a Vibration Transducer

If the manufacturer's specifications do not give the open-circuit sensitivity, but do state the sensitivity into a resistive load other than 10K ohms, the corrected sensitivity may be calculated as follows:

1. Designate S_3 as the sensitivity into a load other than 10,000 ohms, i.e., R_3.

2. Designate R_3 as the resistive load known.

3. Calculate S_1, the open circuit sensitivity.

4. From S_1 calculate S_2, the corrected sensitivity.

   Sample Calculation: With S_3 known to be 105 millivolts per inch per second, R_3 to be 50 K ohms, and R_1 to be 750 ohms, the following sample calculation is given:

   $S_1 = S_3$ [$(R_1 + R_3) / R_3$] or 105 [(750 + 50,000) / 50,000]
   S_1 = 106.5 + millivolts
   $S_2 = S_1$ [$R_2 / (R_1 + R_2)$] or 106.5 [(10,000) / (750 + 10,000)]
   S_2 = 99 millivolts per inch per second.

3.5 VIBRATION METER CALIBRATION

Remove the vibration meter chassis. Connect the test equipment as shown in Figure 3-2 and proceed as follows:

a. Place the SELECTOR switch in the CONT position.

b. Press CHANNEL 1 selector, making sure there is no transducer connected.

c. Adjust potentiometer R89 for full scale meter reading.

d. Place the RANGE switch to 0.5 and the Mode switch to D. Place SELECTOR switch in the FILTER OUT position.

e. Connect a jumper wire between the wiper arm of wafer S3E (SELECTOR switch) and ground.

f. Energize all test equipment and allow sufficient time for equipment warm-up.

g. Adjust output of the external oscillator to 50 cps ±0.1% on frequency-period counter.

h. Adjust ratio transformer output to 2.6085 mV ±0.1% on DC DVM.

i. Adjust R44 for full scale meter deflection on the indicating meter (M1).

j. Place the mode switch to V.

k. Adjust R41 for full scale meter deflection on M1.

l. Remove jumper from S3E to ground.

m. De-energize all test equipment, and replace vibration meter chassis assembly in case assembly.

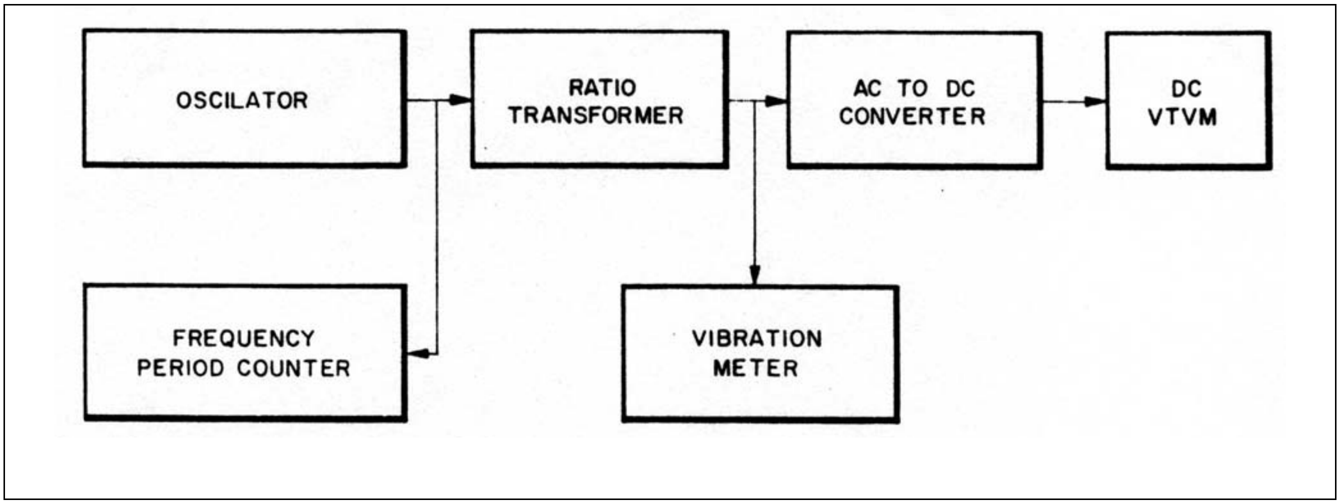


Figure 3-2. Test Equipment Setup

3.6 OPERATING PROCEDURES

Battery Check. To check the DC power pack in the Vibration Meter Type 1-157-0002, place the SELECTOR switch to the BATT position. The battery voltage is sufficient if the indicating meter (M1) reads one volt or greater on the 0.5 scale (above arrow on meter face).

To check the Variable Filter Type 1-159-0002 battery voltage, place the SELECTOR switch (on the Vibration Meter Type 1-157-0001 or 1-157-0002) to the OFF position. The variable filter battery voltage is sufficient if the indicating meter on the vibration meter reads one volt or greater on the 0 to 5 scale (above arrow on meter face).

Transducer Circuit Check. Place the SELECTOR switch to the CONT position. Depress the applicable CHANNEL SELECTOR pushbutton and observe the indicating meter. The indicator will deflect within the green zone if the transducer circuit is satisfactory. If the indicator deflects to full scale, the transducer circuit is open. If the indicator remains on zero, the circuit is shorted. Repeat for each channel to be used.

Normal operating procedures for the vibration meter, when used with the Variable Filter Type 1-159 or 1-003 plug-in filters are as follows:

a. Place the RANGE switch (Key 12, Figure 1-6) to 500.
b. Place the SELECTOR switch (7) to CONT.
c. Depress each CHANNEL SELECTOR (4) (for each channel in use), and check that meter deflection is within the green band.
d. Place the SELECTOR switch to CALIB and adjust the OSC. LEVEL (13) for full scale meter deflection.
e. Place the SELECTOR switch to SENS ADJ.
f. Depress CHANNEL SELECTOR 1 and set the SENSITIVITY control (6) for the sensitivity of the transducer (refer to section 3.4).
g. Adjust the channel gain potentiometer (5) for channel 1 for full scale deflection.
h. Repeat steps ‘a’ through ‘g’ for all remaining channels in use.
i. Place the SELECTOR switch to desired filter position.

***NOTE**: FILTER 1 position on the selector switch selects the filter installed in receptacle J9, FILTER 2 position selects the filter installed in receptacle J10, and FILTER 3 position selects the filter installed in receptacle J11. The FILTER OUT position bypasses the internal filters. When an external filter is connected, it may be used in conjunction with filters 1, 2, 3 and FILTER OUT positions.*

j. Place the Mode switch (11) to D if displacement readings are desired, or V if velocity readings are desired.
k. Rotate the RANGE switch for maximum on-scale meter deflection.
l. The Vibration Meter Type 1-157 is now set up for vibration monitoring.

Steps ‘d’ through ‘h’ must be repeated if transducers are changed.

SECTION 4 - THEORY

4.1 GENERAL

The theory of operation for the Vibration Meter Type 1-157, as presented in this section, is complemented by Figure 1-6. Figure 1-6 presents the vibration meter with CHANNEL SELECTOR 1 (S1) depressed, RANGE switch (S2) in the 0.5 position, SELECTOR switch (S3) in the OFF position, and the mode switch (S4) in the V position. Since each CHANNEL SELECTOR (1 through 6) is identical in function and operation, only CHANNEL SELECTOR 1 will be discussed.

SELECTOR switch (S3) is a multiwafer switch. Each wafer is suffixed with an alphabetical designator on Figure 1-6. Starting from the full counterclockwise position, switch S3 positions are placarded as follows: OFF, BATT, CONT, CALIB, SENS ADJ, FILTER OUT, 1,2, AND 3.

RANGE switch (S2) affects the operation of the vibration meter only when S3 is in the FILTER OUT, 1, 2, or 3 positions. The velocity/displacement mode switch (S4) is effective when S3 is in the CALIB, SENS ADJ, FILTER OUT, 1, 2, or 3 positions. CHANNEL SELECTOR 1 (S1) is effective when S3 is in the CONT, SENS ADJ, FILTER OUT, 1, 2, or 3 positions.

4.2 THEORY OF OPERATION

When S3 is in the OFF position, the vibration meter operates as a voltmeter and the indicating meter (M1) displays the difference between the battery voltage and the regulated B- voltage in the Variable Filter Type 1-159-0002. This difference in potential is displayed on the 0 to 5 (volts) scale of M1. The battery voltage is sufficient when the difference in potential is one volt or greater.

When S3 is in the BATT position, M1 displays the difference in potential between the Vibration Meter Type 1-157-0002 DC battery pack and the B- output of the regulator circuit. The battery voltage is sufficient when the difference displayed is one volt or greater.

When S3 is in the CONT position, the vibration meter operates as an ohmmeter and may be used to check the resistance of the transducer circuitry connected to any input channel. When the desired CHANNEL SELECTOR pushbutton is depressed, and if the circuit is satisfactory, the indicator will deflect within the green zone on the meter face. Should the channel be open, the indicator will deflect full scale. When the channel is shorted, the indication will be zero.

When S3 is in the CALIB position, the oscillator level can be normalized (this is accomplished by adjusting OSC LEVEL (R79) for full scale meter deflection.) The calibration oscillator provides a low distortion signal of precisely 50 cps and an amplitude equivalent to the output of a velocity transducer with a sensitivity of 47 mV/ips at 0.05 ips average (or 0.5 mils peak-to-peak) minus the losses that the signal would incur going through the vibration meter prior to the function amplifier. The oscillator signal is amplified, or amplified and integrated if S4 is in the D position, by the function amplifier and amplified by the meter amplifier. Current feedback is provided around the meter amplifier through the rectifier and filter, internal and external meters, and external galvanometer.

The function amplifier in the velocity mode has a maximum voltage gain (G_v = E out/E in) of approximately 20. In the displacement mode the gain (G_D) is G_v x 50/F, where F is in cps. The transfer admittance of the meter amplifier (Y = I out/E in) is approximately 0.01.

When S3 is in the SENS ADJ position, the calculated sensitivity (refer to paragraph 3-4) of the velocity transducer to be used may be integrated in the calibrated oscillator circuit. With S1 depressed, adjust the SENSITIVITY control (R64) until the calculated sensitivity value appears on the duo-dial. Thus if the calculated sensitivity of the transducer is 105 mV/ips, 10 would appear in the duodial and 50 on the vernier scale aligned with the index below the window. The channel gain potentiometer (R1) is then adjusted for a full scale meter deflection. The wiper of R64 taps off a voltage from the previously normalized calibration oscillator. This sensitivity adjustment must be repeated for all other channels to be used.

When S3 is in the FILTER OUT position, S1 depressed, S4 in the D position, and S2 adjusted to obtain the highest meter deflection available which is less than or equal to full scale, the displacement on channel 1 may be obtained. The peak-to-peak displacement (in mils) indicated is then (scale reading) x range / full scale; thus if S2 is set on 150 and the reading on the 0 to 15 scale is 12, then the indicated displacement is 12 x 150 / 15 or 120 mils peak-to-peak. The instrument senses average displacement and displays this as 3.14 times the average to readout in peak-to-peak values. The vibration meter indicates a true peak-to-peak value only for single frequency sinusoids.

With the vibration meter circuit set up as indicated in paragraph above and S4 in the V position, the indicator M1 will display velocity data. The same formulas specified in paragraph above hold true except each total is multiplied by 0.1 as shown on the meter dial, i.e., 0.1 x (scale reading) x range / full scale. The input signal may be filtered if a Variable Filter Type 1-159 is connected to J7. Filtering action takes place between the 3.33:1 and 3:1 dividers before the signal is sent to the function amplifier.

When CEC Type 1-003 plug-in filters are installed, the vibration signal may be high-pass filtered if S3 is in the FILTER 1, 2 or 3 position. This filtering takes place between J7 and the 3:1 divider.

Switch S2 controls the signal attenuation through the precision divider insuring the input to the filters and the function amplifier is held at the proper level. The precision divider is composed of four individual dividers which are connected in each RANGE switch setting as shown in Table 4-1.

4.3 DEFINITION OF TERMS AND FUNDAMENTAL RELATIONSHIPS, SIMPLE HARMONIC MOTION

a. S = mV/in/sec - mV/V = Sensitivity
mV = Millivolts (one millivolt = 0.001 volt)
V = Velocity, inches/second
F = Frequency, cycles/second
D = Displacement, Double amplitude, ie peak-to-peak displacement

1. mV Peak = $\left(\sqrt{2}\right)$ (mV rms)

2. V Peak = $\left(\pi / 2\right)$ (V Avg) = $\left(\sqrt{2}\right)$ (V rms)

3. V Avg = (2) (F) (D)

4. S = (mV Peak) / (V Peak) = (mV rms) / (V rms) = (mV Avg) / (V Avg)

b. Rms Millivolts vs Average Velocity:

$$S = \frac{mVPeak}{VPeak} = \frac{\sqrt{2mVrms}}{\pi / 2VAvg}$$

Therefore:

$$mV\ rms = -\frac{\pi SVAvg}{2\sqrt{2}}$$ or mV rms = (1.11) (S) (V Avg)

c. Rms Millivolts vs. rms Velocity:

$$S = \frac{mVPeak}{VPeak} = \frac{\sqrt{2mVrms}}{\sqrt{2Vrms}}$$

Therefore:

mV rms = (S) (V rms)

which also follows directly from the definition of consistent units given in paragraph 3-9.

d. Millivolts rms vs Peak-to-Peak Displacement:

$$mV\ rms = \frac{\pi SVAvg}{2\sqrt{2}}$$, from b. above

Also, v Avg = 2 F D, from 3 above.

Therefore,

$$mV\ rms = \frac{\pi S(2FD)}{2\sqrt{2}} = \frac{\pi SFD}{\sqrt{2}}$$

or approximately:

mV rms = (2.22) (S F D)

RANGE Switch	Dividers				Attenuation Factor
	10:1	10:1	3.33:1	3:1	
.05	1:1	1:1	1:1	1:1	1
1.5	1:1	1:1	1:1	3:1	3
5.0	1:1	1:1	3.33:1	3:1	10
15	1:1	10:1	1:1	3:1	30
50	1:1	10:1	3.33:1	3:1	100
150	10:1	10:1	1:1	3:1	300
500	10:1	10:1	3.33:1	3:1	1000

Table 4-1. Table of RANGE Switch Operation

therefore:

$$MV_{RMS} = (S)\ (V_{RMS})$$

which also follows directly from the definition of consistent units given in paragraph 3-9.

d. Millivolts RMS vs. Peak-to-Peak Displacement:

$$MV_{RMS} = \frac{\pi S V_{Avg}}{2\sqrt{2}}$$, from b. above.

Also, $V_{Avg} = 2\ F\ D$, from 3 above.

Therefore,

$$MV_{RMS} = \frac{\pi S\ (2\ F\ D)}{2\sqrt{2}} = \frac{\pi S\ F\ D}{\sqrt{2}}$$

or approximately:

$$MV_{RMS} = (2.22)\ (S\ F\ D)$$

SECTION 5 - MAINTENANCE

5.1 MAINTENANCE INSTRUCTIONS

GENERAL

No specific periods are established for inspecting and testing the vibration meter. However, during normal use and operation the unit may require periodic maintenance. The amount and type of maintenance will be determined by amount of handling, usage, storage, and operating environment. By providing adequate maintenance, the user can insure satisfactory performance of the vibration meter for a long period of time.

DISASSEMBLY FOR MAINTENANCE

To remove the vibration meter chassis assembly, unlock the cam fastener located below the CHANNEL SELECTORS, unscrew the pawl fastener located at the rear of the vibration meter, and slide the chassis out the front of the case assembly. If further disassembly is required, disassemble the vibration meter in the same sequence as the index numbers assigned to the exploded views in Section Six of this manual.

INSPECTION

Inspect all parts in accordance with inspection criteria listed in Table 5-1. Inspect all parts for serviceability. Whenever doubt exists concerning serviceability, parts should be repaired or replaced.

REPAIR AND REPLACEMENT

Under normal conditions, very little repair or replacement should be required. However, if visual inspection or troubleshooting should indicate the need for replacing or repairing components or electrical parts, disassemble the vibration meter as necessary to reach the defective or damaged item. Remove and replace the component as required.

5.2 TROUBLESHOOTING

GENERAL

Table 5-2 lists the troubles, probable causes, and remedies for malfunctions that will not require the use of a test setup. Should the Vibration Meter Type 1-157 fail to function in a manner other than specified in Table 5-2, detailed troubleshooting will be required.

DETAILED TROUBLESHOOTING

Detailed troubleshooting of the vibration meter will require the use of the schematic shown in Figure 5-1. The test equipment (or equivalent) required for troubleshooting is listed in Table 5-3. Set up the test equipment for detailed troubleshooting as shown on Figure 3-2.

Check that all electrical connectors are firmly seated, and inspect for loose, shorted, or broken wiring connections before performing extensive troubleshooting.

For detail troubleshooting, refer to Table 5-4 for voltage values and Figure 5-1 for all remaining electrical parameters.

ITEM	INSPECTION CRITERIA
Capacitors	a. Signs of overheating and deterioration (wax drops, bubbles, cracks, etc.) b. Leakage
Potentiometers	a. Binding b. Abrupt changes in resistance with rotation (check with ohmmeter
Connectors	a. Bent, broken, or missing pins b. Corroded or pitted pins c. Loose mounting hardware and terminals
Insulators, spacers, boards	a. Cracks, breaks, burns b. Carbonized sections c. Loose mounting hardware and terminals
Resistors	a. Signs of overheating, such as charred paint, swelling, etc. b. Cracking, breaking
Transformer	a. Signs of overheating, such as leakage of potting compound, burnt odor, etc. b. Bent or broken contacts
Semiconductors	a. Signs of overheating, such as bubbles, scorched areas, etc b. Chips, cracks, damaged leads
Solder joints	a. Broken or loose joint b. Resin or cold solder joint c. Excess solder
Wiring	a. Signs of overheating b. Chafing c. Broken leads
All electrical parts	a. Short circuits b. Defective insulation c. Improper characteristics d. Corrosion
All mechanical parts	a. Looseness b. Corrosion

Table 5-1. Table of Inspection Criteria

ITEM	TROUBLE	PROBABLE CAUSE	REMEDY
1	Vibration Meter Type 1-157-0001 does not operate	No primary power is being supplied. AC power (line) cord P1 is defective. Fuse is blown. Power transformer T-101 is defective. (See Item 4)	Check primary power source. Check cord and plug; replace if needed. Replace fuse F1. Check transformer; replace if defective. (See item 4)
2	Vibration Meter Type 1-157-0002 does not operate	Batteries in DC power pack are defective. (See item 4)	Check battery voltage (refer to paragraph 3.16); replace defective batteries. (see item 4)
3	Vibration meter power source checks good, but meter does not reflect any transducer signals.	Defective transducer or transducer input circuit. CHANNEL SELECTOR switch defective (open)	Check transducer circuit (refer to paragraph 3.18); replace defective transducer or repair input cable. Connect input cable to another CHANNEL INPUT receptacle. If operation is satisfactory, remove and replace defective CHANNEL SELECTOR switch.
4	Indicating meter (M1) will not deflect.	Diode CR5 or CR6 is shorted. Contact on EXT METER receptacle (J12) is open. Resistor R60 (see figure 5-1) is open.	Replace defective diode. Repair contact or replace receptacle. Remove and replace defective resistor.
5	Indicating meter deflects full scale during battery check or normal operation.	Diode CR5 or CR6 is open. EXT METER receptacle is short circuited.	Remove and replace defective diode. Remove and replace receptacle.

Table 5-2. Troubleshooting Chart

PART OR TYPE NUMBER	NOMENCLATURE	APPLICATION
Fluke Model 803 (or equivalent)	DC VTVM	Measure output of Ballentine 710
Gertsch Model RT-1 (or equivalent)	Ratio transformer	Provides attenuation
Hewlett Packard 200CD (or equivalent)	Audio Oscillator	Supplies test signal
Ballentine Model 710 (or equivalent)	AC to DC converter	Rectifies oscillator transformer output to obtain accurate AC measurements
Triplett Model 630 A (or equivalent) meter of 20,000 ohms/volt)	Multimeter	Measures voltages and resistances
CMC Model 225B (or equivalent)	Frequency counter	Measures frequency
Tektronix Model 502A (or equivalent)	Oscilloscope	Visual observation of waveforms

Table 5-3. Test Equipment Required for Troubleshooting the Vibration Meter

	DC VOLTAGES (measured with an NILS Model 4300 DVM)			AC VOLTAGES (measured with a TEKTRONIX Type 502A oscilloscope)		
	VOLTS DC			mV peak-to-peak		
Trans	Collector	Base	Emitter	Collector	Base	Emitter
Q1	-13.5	-6.8	-6.1	0	75.0	75.0
Q2	0	-6.9	-7.5	0	7.2	7.2
Q3	0	-2.5	-3.1	0	7.2	7.2
Q4	-9.1	-2.9	-2.3	13.4	7.2	7.0
Q5	-9.1	-2.9	-2.3	13.4	7.1	7.0
Q6	-6.5	-9.1	-9.6	87	13.4	13.4
Q7	-1.0	-9.1	-9.6	45	13.4	13.4
Q8	-13.5	-6.4	-5.8	0	87	87
Q9	-2.5	-2.9	-3.5	165	7.1	7.1
Q10	-9.1	-3.5	-3.0	280	165	165
Q11	-9.1	-3.5	-3.0	250	165	165
Q12	-5.9	-9.1	-9.6	2.35v	280	265
Q13	-2.0	-9.1	-9.6	2.0v	250	265
Q14	-10.5	-5.9	-5.4	4.0v	2.35v	2.35v
Q15	-7.4	-3.1	-2.5	95	16	16
Q16	-7.4	-3.1	-2.5	104	16	16
Q17	-3.7	-7.4	-8.0	2.45v	95	64
Q18	-4.0	-7.4	-8.0	3.75v	104	64
Q19	-13.4	-8.4	-8.2	--	--	--
Q20	-21.0	-13.4	-13.2	--	--	--
Q21	-20.5	-13.2	-13.5	--	--	--

1. All voltages indicated are typical and may vary from unit to unit.
2. DC voltage measurements should be taken with transducer input connector shorted to ground, and SELECTOR switch S3 set to FILTER OUT position.
3. AC voltage measurements should be taken with SELECTOR switch S3 set to FILTER OUT position, wiper arm of S3E shorted to ground, mode switch S4 set to D, RANGE Switch S2 set to 500, and 2.6V RMS, 50 cps applied to transducer input connector.
4. All voltages measured with respect to pin E36.
5. See figure 5-1 for test points.

Table 5.4 Test Points and Voltage Values