KINEMETRICS

OPERATING INSTRUCTIONS
FOR
MODEL SH-1
INTERMEDIATE PERIOD
HORIZONTAL SEISMOMETER

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1.0 GENERAL DESCRIPTION

The SH-1 Horizontal Seismometer is an intermediate period, portable, field seismometer. It is contained in a rugged weathertight housing which measures 9½ x 4½ x 10 inches high and weighs 16 pounds. The housing includes a window for viewing the position of the mass, and a means of caging the mass for protection of the seismometer when it is being moved.

The basic elements of the SH-1 Seismometer are identified in Figure 1. The mass is suspended above the flexure on a vertical boom so that the flexure torque is nearly cancelled by the gravity torque. The natural period is set by adjusting the height of the mass on the boom. The mass is locked in that position by the clamp screw. The coil board is attached to the boom so that the coils move relative to the magnets and generate an output signal in response to movement of the mass. In the standard wiring configuration, the signal coils are connected in series. The coils also contain a separate winding for application of a calibration pulse.

1.1 Typical Characteristics

Natural period	5 seconds
Coil resistance	3800 ohms
Critical damping resistance	12,000 ohms
Generator constant	180 volts/meter/second
Maximum ground movement	±2 mm
Calibration coil force constant	.08 newton/ampere

2.0 SET-UP

2.1 Installation

The SH-1 Seismometer should be installed on a hard base, such as a concrete floor. Any material which may tend to flow under pressure will not make an adequate base. For example, the sharp points on the three feet tend to slowly sink into asphalt tile floors, and as with any extended period seismometer, may result in drift of the mass position. When emplacement on soft materials cannot be avoided it is recommended that the feet be placed on pieces of hard material of relatively large area, such as tile or brick, or special foot pads available from Kinemetrics.

2.2 Electrical Connections

Electrical connections are shown in Figure 2. A mating connector (PT06E-8-4P(SR)) is supplied with the seismometer. All connections to the output coil should be made with a high-quality, plastic-insulated, shielded, twisted-pair cable. The shield should be grounded at one end only, preferably at the amplifier (or galvanometer) end.

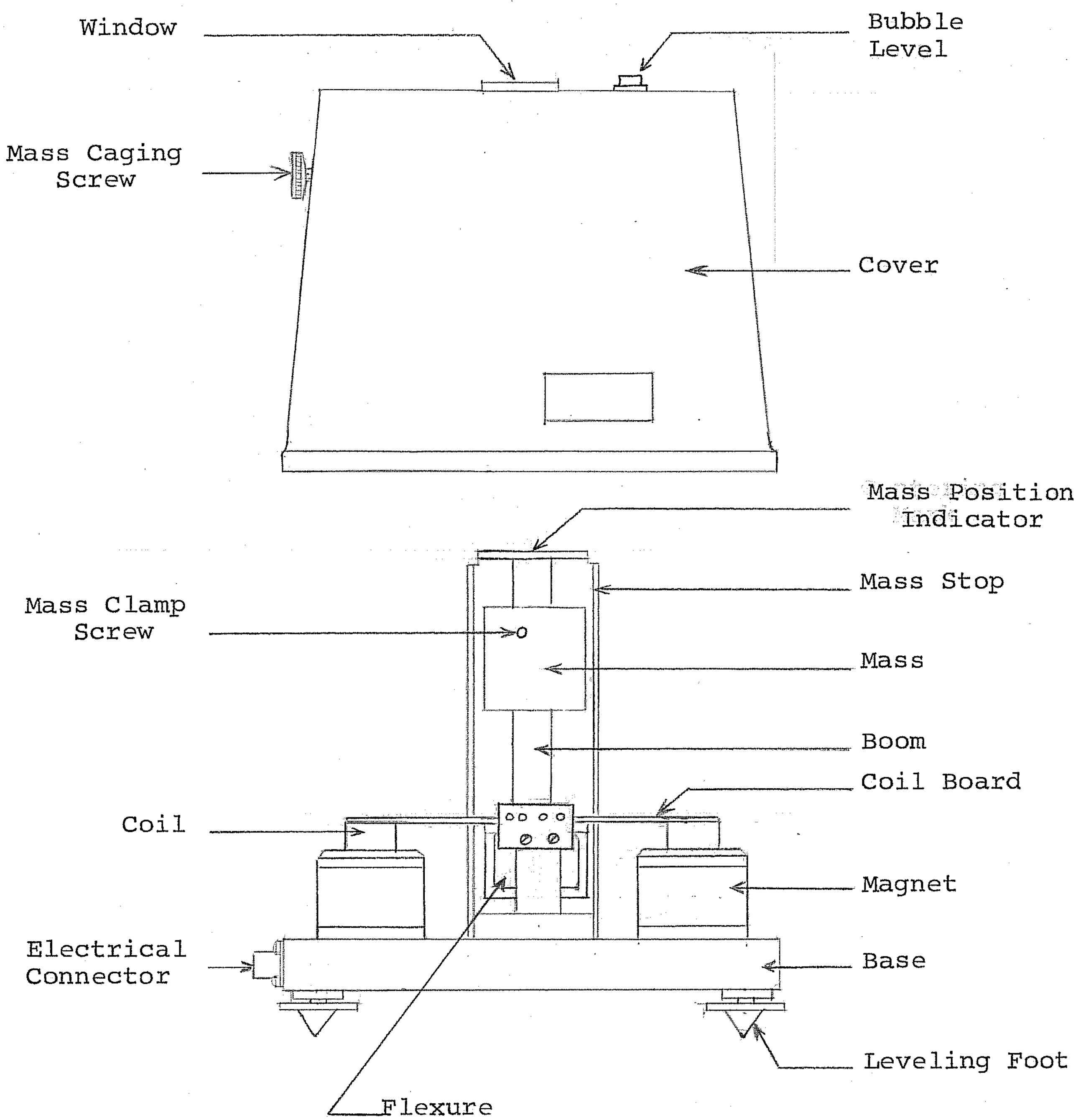
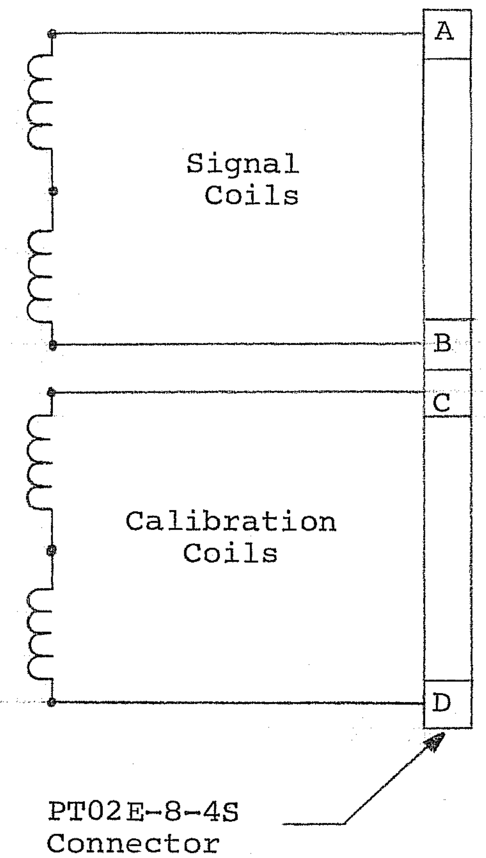


Figure 1
SH-1 Seismometer



<u>Coil Polarity</u>

Signal Coil:	Mass movement away from connector end produces positive voltage at A (B common).
Calibration Coil:	Positive voltage at C (D common) produces mass movement away from connector end.
Note:	Magnets are poled so that coils are connected in a hum-bucking configuration.

Figure 2

Electrical Connections

2.3 Uncaging the Mass

To free the mass, turn the caging screw counterclockwise until its limit stop is reached. Avoid forcing against the stop as this may damage the screw retainer.

2.4 Mass Centering

Before centering the mass, it is necessary to level the seismometer base. There are two ways to determine that the base is level. The recommended method is to use the small bubble level attached to the top of the cover. This method does not require removal of the cover which is especially important for field installations since dust or dirt inside the seismometer will interfere with proper operation. Also, it will provide an adequate measure of level for nearly all applications. An alternative method to determine that the base is level is to remove the cover and place a precision level directly on the base. This should be done only in a clean environment where no dust or dirt particles will get inside the seismometer. To level the seismometer base, first adjust the two leveling feet at the end opposite from the connector until the base is level in the transverse direction. Then adjust the single leveling foot at the connector end to level the base in the lengthwise direction.

To center the mass, adjust the single leveling foot at the connector end of instrument. The mass is centered when the line on top of the boom is aligned with the black lines on top of the mass stop, see Figure 3. The red lines on the mass stop indicate the proper operating range for the mass. The seismometer characteristics will be within the specifications when the mass is positioned between the red lines. When the mass is positioned outside the red lines, the seismometer will usually continue to function, but the characteristics (natural period, damping, generator constant) may deviate from specified values.

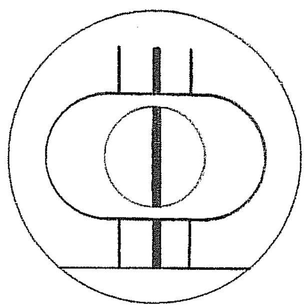


Figure 3

Mass Centering

3.0 CHECKOUT

All adjustments of the seismometer are made at the factory. A calibration data sheet is supplied with each unit. However, if it is desired to check these values, the following procedure is recommended.

3.1 Natural Period

If the seismometer is connected to a recorder, the period can be measured by pulsing the calibration coil (see Figure 4) and recording the oscillations of the mass. The time-per-unit cycle is the natural period, T_n. The recorder should have a very high input impedance, 1 megohm or higher, or it will contribute significant damping to the seismometer. All other signal coil shunting must be disconnected.

3.2 Damping

The damping is adjustable by changing the resistance across the output coil. The required resistance for any desired damping may be computed from:

$$R_x = \frac{CDR}{\left(h_t - h_m\right)} - R_c$$

where R_x = resistance of external circuit, ohms

CDR = critical damping resistance, ohms

h_t = total damping with external resistance R_x

h_m = damping with R_x = infinity

R_c = coil resistance, ohms

The values of CDR, h_m, R_c and R_x for $h_t = 0.7$ critical damping are given on the calibration data sheet. To check these values, the response to a step function must be recorded. The recommended test setup is shown in Figure 4. First, run a record without an external resistor (R_x = infinity). Compute the overshoot ratio, x_2/x_1 and convert to damping by means of Table 1. The value obtained with no external resistance is the internal damping, h_m.

Next, use R_x = 100K ohms and run another record. From this overshoot ratio, determine the damping for R_x = 100K ohms. The value of CDR may now be computed from

$$CDR = \left(h_t - h_m\right) \times \left(R_c + R_x\right)$$

3.3 Generator Constant

The generator constant or output of the seismometer can be computed from

$$G = \sqrt{\frac{13.9 \cdot CDR}{T_n}}$$

where G = the output in volts/meter/second

T_n = natural period of the seismometer in seconds

CDR = critical damping resistance in ohms

and (13.9) is a constant derived from physical characteristics of the seismometer including mass, moment of inertia, flexure torque constant, and geometric dimensions.

4.0 OPERATION

4.1 Normal Operation

Adjust the external resistance across the output coil to give the desired damping. Be sure to include the effect of the amplifier input impedance, or galvanometer coil resistance, as part of the external resistance.

If desired, a calibration run may be made at the beginning of each record. With the mass centered and the proper damping resistance across the output coil, pulse the calibration coil as shown in Figure 4. The resulting record will show the damped response of the system. Depending on the sensitivity of the system, R_{cal} should be selected to give an on-scale trace excursion of convenient amplitude, or so as not to exceed the dynamic range of associated electronics.

CAUTION: In making the calibration record and for actual operation, it is essential that switch S1 be open so that no resistance is connected across the calibration coil.

4.2 Loaded Generator Constant

The output of the seismometer with the damping resistance in the circuit (the loaded generator constant, G_L) represents the unattenuated seismometer output received at the input of the amplifier or galvanometer. It is computed from

$$G_L = G \cdot \frac{R_x}{R_x + R_c}$$

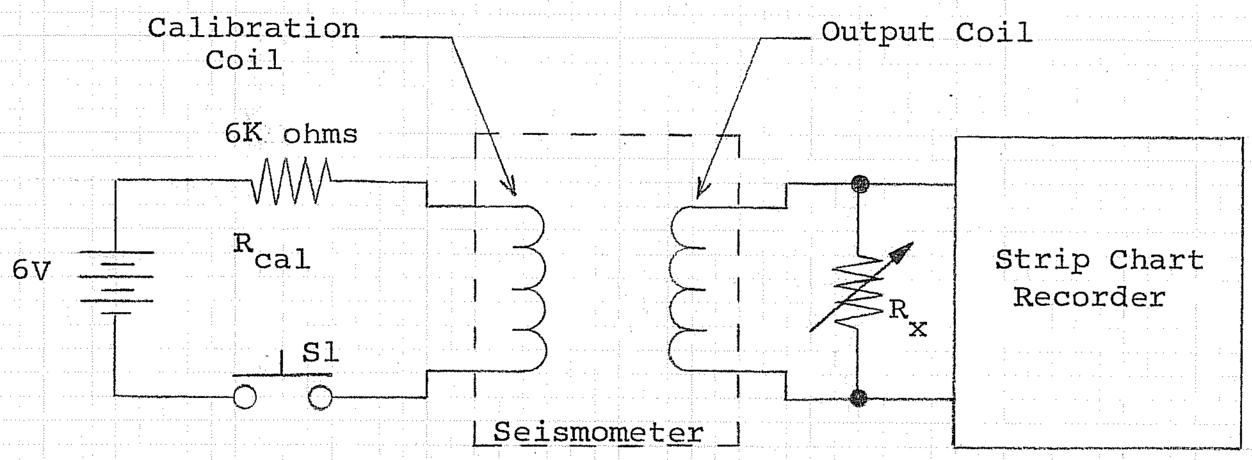
where G = open circuit generator constant in volts/meter/second

R_x = external damping resistance, ohms

R_c = coil resistance, ohms

4.3 Caging the Mass

If the seismometer is to be moved to a new location, the mass must be caged before transportation. To do this, turn the caging screw clockwise until the mass is held firmly against the mass stop. Do not overtighten.

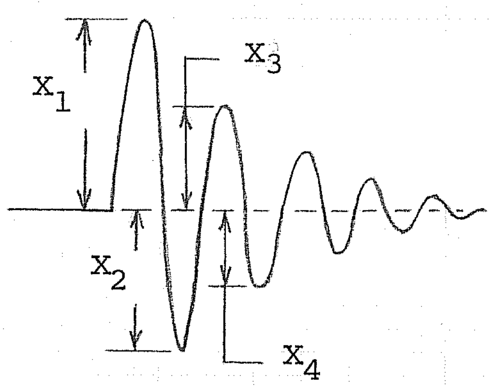


NOTE: To measure natural period, use R_x = infinity.

If the recorder does not have a very high input impedance, the effective value of R_x will be the variable resistance shunted by the input impedance.

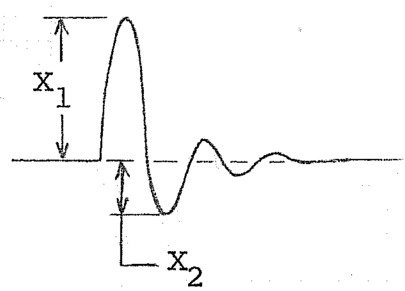
S1 should be a normally-open pushbutton switch.

OPERATION: Close switch S1 and allow the recorder trace (i.e., seismometer mass) to settle down. Open S1 and record the oscillations. The record should appear as shown:



Typical Record

with R_x = infinity



Typical Record

with R_x = 100K ohms

$$\text{Overshoot ratio} = \frac{X_2}{X_1} = \frac{X_3}{X_2}$$

Figure 4

Natural Period and Damping Tests

TABLE 1

OVERSHOOT RATIO VS. DAMPING

OVERSHOOT RATIO (E)	DAMPING (h)	OVERSHOOT RATIO (E)	DAMPING (h)
0.01	0.82609	0.51	0.20957
0.02	0.77970	0.52	0.20378
0.03	0.74480	0.53	0.19808
0.04	0.71565	0.54	0.19247
0.05	0.69011	0.55	0.18694
0.06	0.66713	0.56	0.18150
0.07	0.64608	0.57	0.17613
0.08	0.62658	0.58	0.17084
0.09	0.60833	0.59	0.16563
0.10	0.59116	0.60	0.16049
0.11	0.57489	0.61	0.15543
0.12	0.55942	0.62	0.15043
0.13	0.54465	0.63	0.14551
0.14	0.53051	0.64	0.14065
0.15	0.51693	0.65	0.13585
0.16	0.50387	0.66	0.13112
0.17	0.49127	0.67	0.12645
0.18	0.47911	0.68	0.12185
0.19	0.46735	0.69	0.11730
0.20	0.45595	0.70	0.11281
0.21	0.44490	0.71	0.10838
0.22	0.43417	0.72	0.10400
0.23	0.42374	0.73	0.09968
0.24	0.41359	0.74	0.09541
0.25	0.40371	0.75	0.09119
0.26	0.39409	0.76	0.08702
0.27	0.38470	0.77	0.08291
0.28	0.37554	0.78	0.07884
0.29	0.36660	0.79	0.07482
0.30	0.35786	0.80	0.07085
0.31	0.34931	0.81	0.06692
0.32	0.34096	0.82	0.06304
0.33	0.33278	0.83	0.05921
0.34	0.32478	0.84	0.05541
0.35	0.31694	0.85	0.05166
0.36	0.30926	0.86	0.04795
0.37	0.30173	0.87	0.04429
0.38	0.29435	0.88	0.04066
0.39	0.28710	0.89	0.03707
0.40	0.28000	0.90	0.03352
0.41	0.27302	0.91	0.03001
0.42	0.26617	0.92	0.02653
0.43	0.25945	0.93	0.02309
0.44	0.25284	0.94	0.01969
0.45	0.24634	0.95	0.01633
0.46	0.23996	0.96	0.01299
0.47	0.23368	0.97	0.00970
0.48	0.22750	0.98	0.00643
0.49	0.22143	0.99	0.00320
0.50	0.21545	1.00	0.00000