Operating Instructions

Model SS-1
Ranger Seismometer

Document 300190
Revision NC
November 2001

Warranties, Disclaimers & Trademarks

Copyright © 2001 Kinemetrics, Inc.

The trademarks used throughout this manual, registered or not, are: Kinemetrics, QuickTalk, QuickLook, Mt. Whitney, Etna, EpiSensor, HypoSensor, Internatonal Business Machines, IBM-PC, FerriShield, Microsoft, MS-DOS, Windows, General Seimiconductor Industiries, Inc., TransZorb, Hayes, Smartmodem, and Crosstalk.

This publication is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability, fitness for a particular purpose, or non-infringement. Kinemetrics, Inc. and its affiliates assume no responsibility for errors or omissions in this publication or other documents which are referenced by or linked to this publication.

References to corporations, their services and products, are provided "as is" without warranty of any kind, either expressed or implied. In no event shall Kinemetrics, Inc. be liable for any special, incidental, indirect or consequential damages of any kind, or any damages whatsoever, including, without limitation, those resulting from loss of use, data or profits, whether or not advised of the possibility of damage, and on any theory of liability, arising out of or in connection with the use or performance of this information.

This publication could include technical or other inaccuracies or typographical errors. Changes are periodically added to the information herein; these changes will be incorporated in new editions of the publication.

All rights reserved. No part of this publication may be copied, photocopied, reproduced, transmitted, transcribed, or reduced to any electronic medium or machine-readable form without prior written consent of Kinemetrics, Inc.

Kinemetrics, Inc., 222 Vista Avenue, Pasadena, CA 91107 USA

Phone: (626) 795-2220 ■ Fax: (626) 795-0868

E-mail: services@kmi.com

Technical Support: support@kmi.com

Website: www.kinemetrics.com

Kinemetrics SA, Le Tresi 3, 1028 Preverenges, Switzerland

Phone: 21.803.2829 ■ Fax: 21.803.2895

E-mail: kmi_sa@bluewin.ch

Table of Contents

Getting Started

General Description

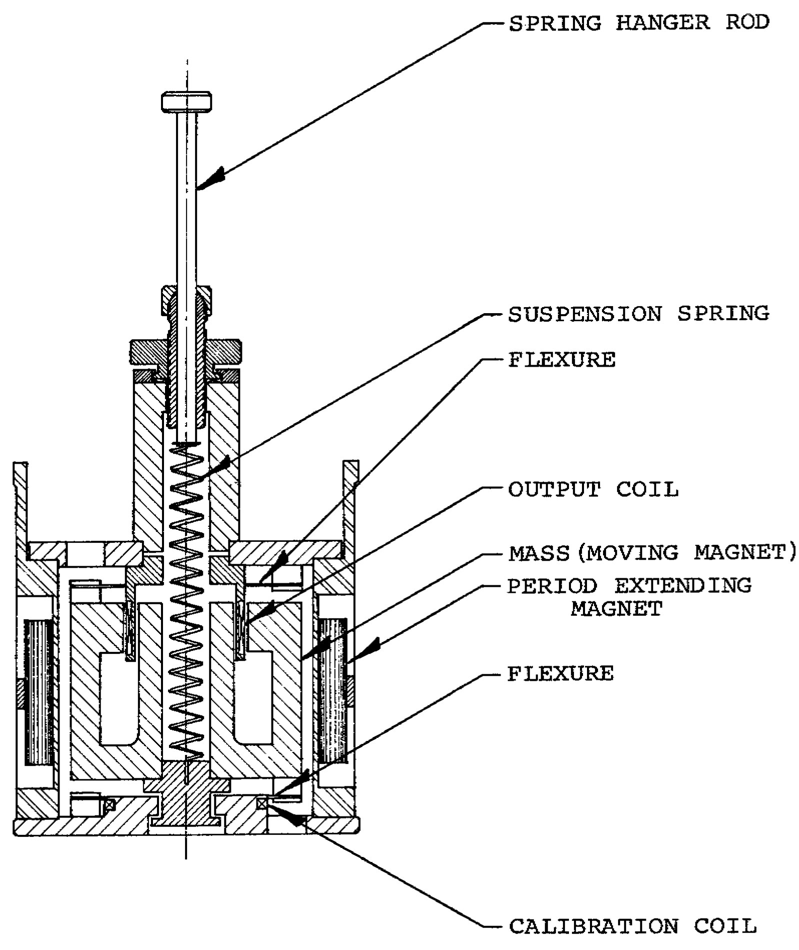
The SS-1 Ranger Seismometer is a versatile, high-sensitivity, portable seismometer specifically designed for a variety of seismic field applications under adverse environmental conditions. The Ranger combines high sensitivity, field selectable mode (horizontal or vertical) and rugged water-tight construction, in a package measuring only 5½ inches in diameter by 12 inches long and weighing only 10.9 pounds. A separate calibration coil in the base provides a simple means of field calibrating the Ranger using only a known-voltage battery and a fixed precision resistor. Under normal usage, the Ranger should provide years of data acquisition with little, if any, maintenance.

The Ranger is a spring-mass instrument with electromagnetic transduction. Its permanent magnet assembly is the seismic mass while the coil is attached to the frame. The Ranger can be used either horizontally or vertically and is well suited to field or laboratory use. The relationship between major parts is shown schematically in Figure 1. The mass is supported by two circular flexures, which constrain it to a single degree of freedom. A helical spring is used to suspend the mass. When the seismometer is used vertically, the suspension spring is fully extended; when used horizontally, the spring is unstressed. The force of the suspension spring is controlled by positioning a hanger rod attached to the spring. The basic natural period of the mass, flexures, and suspension spring is extended by the addition of small rod-magnets installed around the mass. These period-extending magnets interact with the magnetic field of the mass, effectively producing a negative restoring force. In order to achieve the desired period, the field strength and position of the period-extending magnets are carefully adjusted at the factory.

Typical Specification

Natural Period, T_N	1second
Coil Resistance, R_C	5500 ohms
Critical Damping Resistance	6500 ohms
Generator Constant, G_O	340 volts/meter/sec
Total Mass Travel	2mm
Mass weight	1.45 kg
Motor Constant of the Calibration Coil Calibration Coil	.4 newtons/amp

Figure 1: General Construction



Setup

Installation

The SS-1 Ranger Seismometer may be used either vertically or horizontally. Tripod mounting feet are provided for both horizontal and vertical installation. In general, the seismometer should not be installed within six inches of any steel or magnetic object. Further, when working with two or more of these seismometers, care should be taken to see that they never come within six inches of each other.

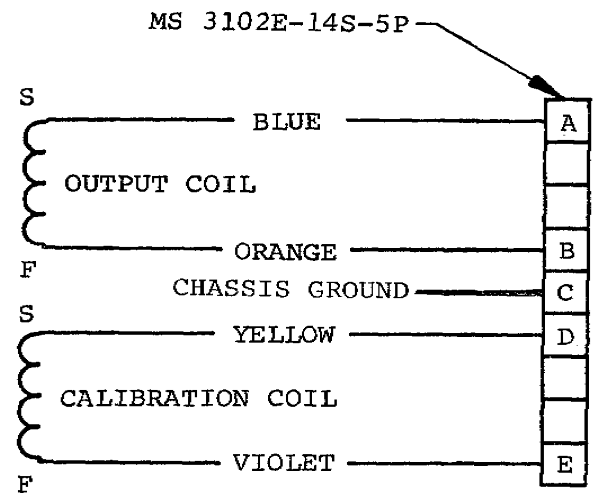
Electrical Connections

Electrical connections are shown in Figure 2. A mating connector (MS 3106E-14S-5S) 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.

The polarity conventions are:

> When the ground moves up, the voltage at pin A is positive with respect to pin B.
>
> When a positive voltage is applied to pin E with respect to pin D, the mass moves downward producing a positive voltage at pin A.

Figure 2: Electrical Connections



Unclamping the Mass

To unclamp the mass, turn the transport lock (see Figure 4) fully counterclockwise.

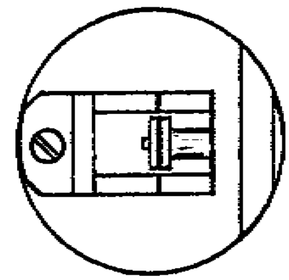
Mass Centering

NOTE: The seismometer is shipped with the suspension spring in a relaxed condition.

The mass is brought to the center of its span of travel by means of the spring hanger rod at the top of the instrument. After unclamping, make this adjustment as follows:

1. Unscrew and remove the access cover/handle.
2. While holding the spring hanger knob with one hand, loosen the collet nut with the other hand.
3. Move the spring hanger rod until the mass is fairly near center*. Centering is determined by the coincidence of two lines, which are visible thru the viewing port. With the mass reasonably centered, tighten the collet nut.
4. Fine centering of the mass is now achieved by means of the mass-centering nut. Turn this nut until the two lines, as seen thru the viewing port, coincide (Figure 3).

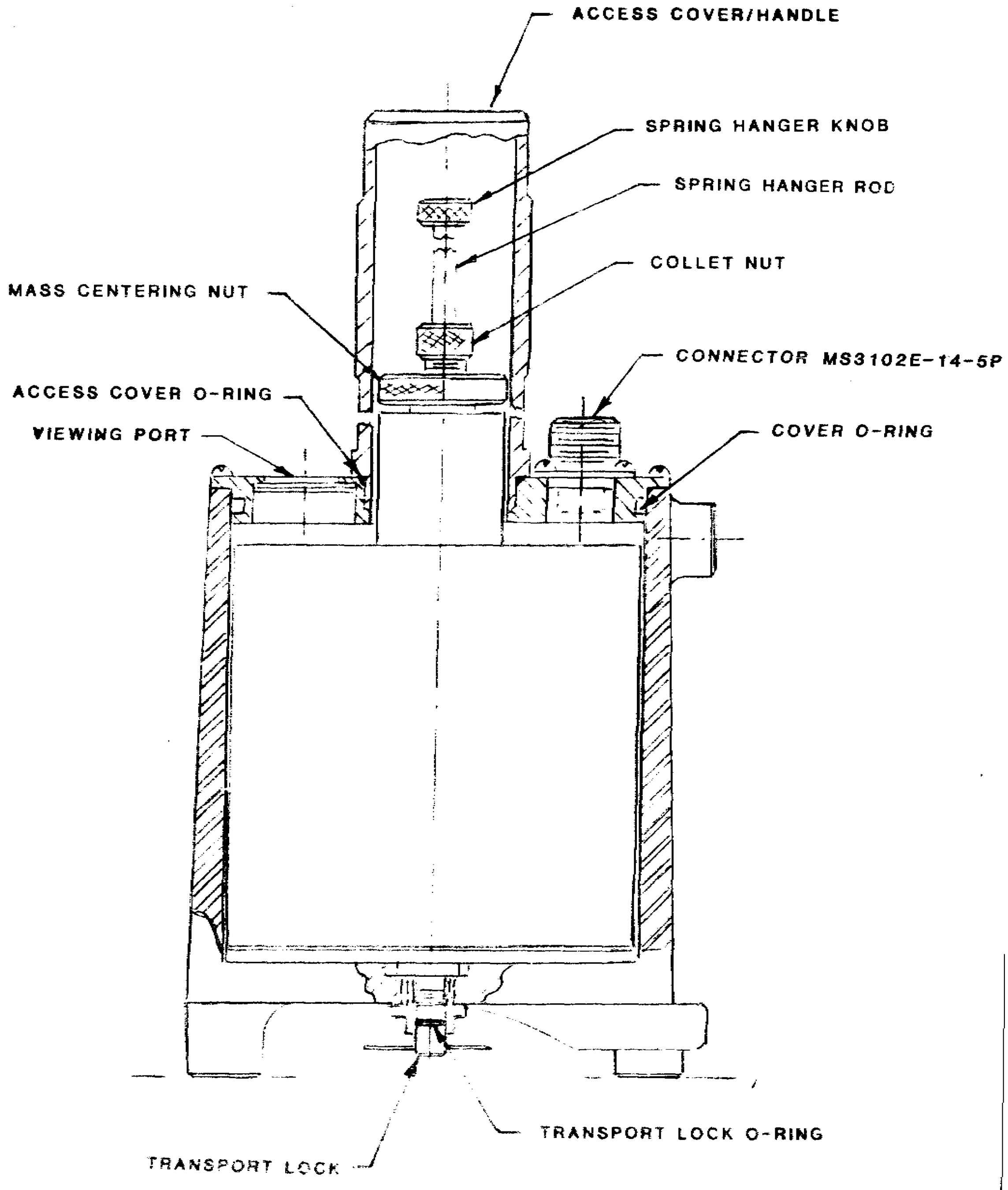
Figure 3: Mass Centered



5. Replace the access cover/handle, being sure that its gasket is properly seated.

* When operated as a Vertical Seismometer, the spring hanger rod will be essentially fully extended. When operated as a Horizontal Seismometer, the knob of the spring hanger rod will be quite close to the collet nut. When changing from Vertical to Horizontal, or vice versa, it is necessary to recenter the mass in accordance with steps 1 through 5 above.

Figure 4: Seismometer and Case Assembly



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 procedures are recommended.

Natural Period

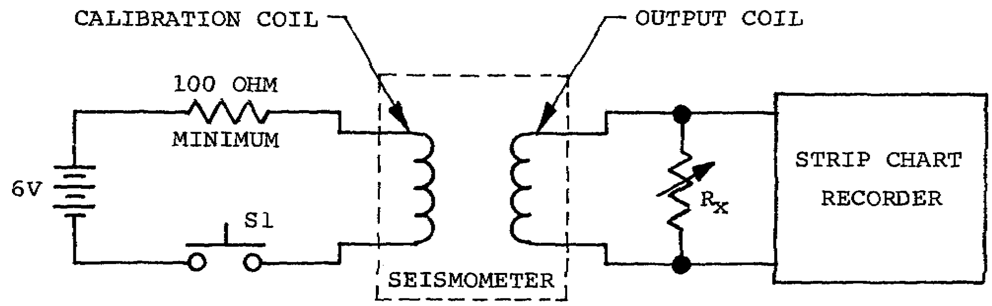
If the seismometer is connected to a recorder, the period can be measured by pulsing the calibration coil (Figure 5) and recording the oscillations of the mass. The time—per—unit cycle is the natural period, T_n.

A better method that avoids the influence of damping is driving the calibration coil with a sine wave and observing the phase shift between input and output on an oscilloscope. The test setup for this method is shown in Figure 6.

NOTE: If the background noise is very high, good results can be obtained by driving the output coil rather than the calibration coil. For this type of hookup, connect the function generator to the output coil through a 10K ohm resistor. The remainder of the connections are as shown in Figure 6.

Adjust the frequency of the function generator until the Lissajous figure closes to a straight line. The frequency at which the Lissajous figure closes is the natural frequency f_n. The natural period T_n is $1/f_n$.

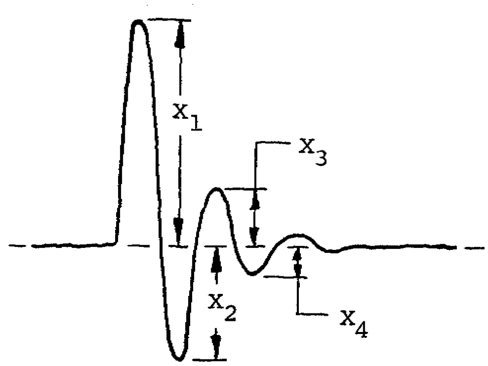
Figure 5: Test Setup for Damping Checks



NOTE: 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.

NOTE: S1 should be a normally-open pushbutton switch.

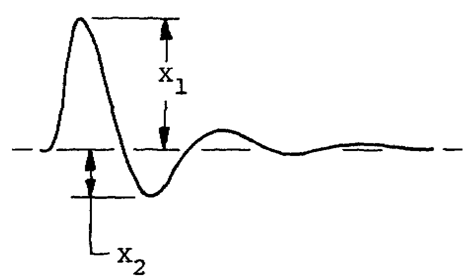
OPERATION: Close switch S1 and allow the recorder trace (i.e., seismometer mass) to settle down. Open S1 and record the oscillations. The record should appear as shown:



Typical Record

with R_X = Infinity

overshoot ratio = $\frac{X_2}{X_1} = \frac{X_3}{X_2}$

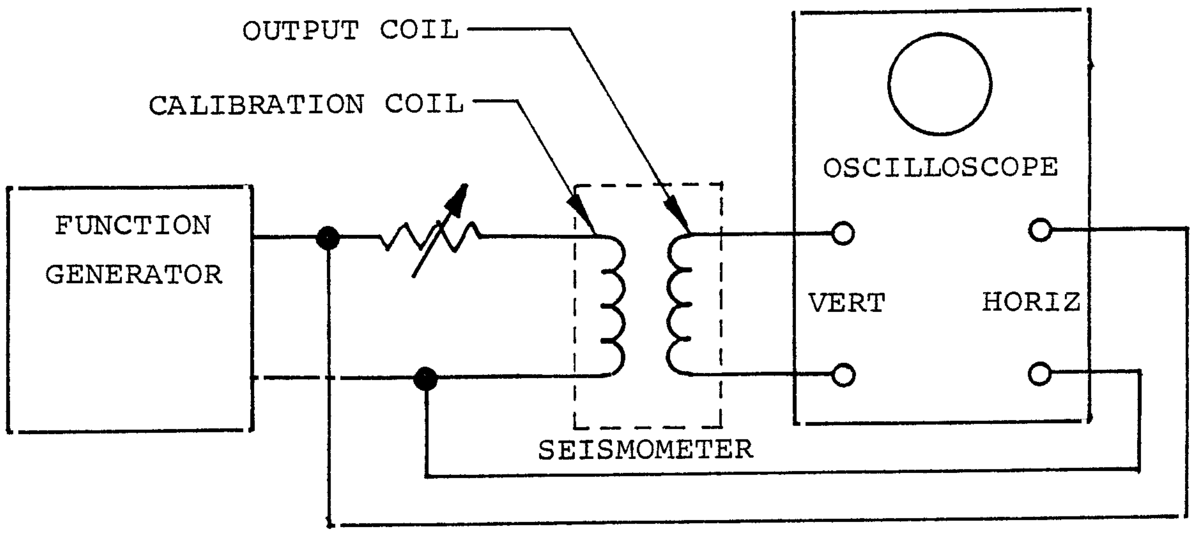


Typical Record

with R_X adjusted for

about 1/3 critical damping

Figure 6: Test Setup for Natural Frequency



Damping

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

$$R_X = \frac{CDR}{h_t - h_m} - R_C$$

where:

R_X = resistance of external circuit, ohms

CDR = critical damping resistance, ohms

h_t = total damping ratio with external resistance R

h_m = damping ratio 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 5. First, run a record without an external resistor (R_X infinity). Compute the overshoot ratio, X_2/X_1 and convert to damping ratio by means of Table 1. The value obtained with no external resistance is the internal damping, $h_{m.}$

Next, set R_X to 5000 ohms and run another record. From this overshoot ratio, determine the damping for R_X = 5000 ohms. The value of CDR may now be computed from

$$CDR = (h_t - h_m) \qquad (R_c + R_X).$$

Generator Constant

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

$$G_O = \sqrt{4\pi M \cdot f_n \cdot CDR}$$

where:

G_O = the output in volts/meter/second

M = seismometer mass in kilograms (1.45 nominal)

F_n = natural frequency of the seismometer in Hertz, or $\frac{1}{\text{natural period } (T_n)}$

CDR = critical damping resistance, ohms.

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

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

$$G_L = G_O \frac{R_X}{R_X + R_C}$$

where:

G_O = open circuit generator constant in volts/meter/second

R_X = external damping resistance, ohms

R_C = coil resistance, ohms

Operation

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 6. The resulting record will show the damped response of the system.

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

Clamping the Mass

If the seismometer is to be moved to a new location, the mass must be clamped before transportation. To do this, turn the transport lock fully clockwise; apply firm finger torque to securely clamp the mass.