W. F. SPRENGNETHER INSTRUMENT CO., INC.

4567 Swan Avenue

St. Louis 10, Mo.

OPERATING INSTRUCTIONS FOR PORTABLE BLAST AND VIBRATION SEISMOGRAPH

1. Remove the top cover and orient instrument with "to blast" pointing directly to the blast or source of vibration.

2. Rotate the three leveling screws counter-clockwise until the instrument is clear of any projections of the surface on which it is located.

3. Center the bubble in the circular level vial by means of the three leveling screws.

4. Unclamp the pendulum system by rotating the large knob marked "clamp" counter-clockwise until it stops, about one full turn.

5. Turn light switch to "Test" position and observe light traces at the translucent viewing strip.

6. This viewing strip has three marks which identify the proper position for the light spots. These marks are identified as longitudinal, vertical, and transverse.

7. The longitudinal trace can be adjusted to coincide with its reference point by turning the single leveling screw at the right end of the instrument.

The transverse trace is adjusted to coincide with its reference point by turning either of the leveling screws at the left end of the instrument.

The vertical trace is adjusted by the knurled knob marked "Vert."

The longitudinal component responds to motion in the direction of the length of the instrument case. The transverse responds to motion across the width of the instrument case.

8. When the light spots are aligned with their respective index, the instrument is properly leveled. If there should be any error noted on the circular level vial it should be adjusted by the three Phillips head screws at its edge until the bubble is centered.

9. Assuming a loaded camera is in place, the instrument is now ready to operate. The operation can be controlled either by the switch on the face of the instrument or by a remote switch and cord assembly.

When the switch on the panel is used, it is necessary to turn it to the "Run" position to record.

When using the remote switch, place the remote cord plug in the jack receptacle on the panel. The panel switch should be in the "OFF-REMOTE" positions for this type of operation.

Depressing the button in the cord pendant switch will turn the instrument on and the button must be held down as long as it is desired to record. Releasing the button turns the instrument off.

Extensions up to several thousand feet for this remote cord can be made by using standard phone-type jack and plugs. Resistance of this lead is not critical and standard 2-18 lamp cord can be used for this purpose.

With the dual magnification instrument, the light spots are aligned with the selector switch in the "low" position. Light traces are so adjusted that the high magnification traces will fall into the correct position at this same adjustment. If it is desired to run in the "High" magnification range, the switch must be rotated to the "high" position after the initial adjustment has been made on the "low" position.

The timing interval on the time marks is .02 second, every .2 second being indicated by a heavier timing line. The accuracy of these timing lines is 0.1%.

When recording blasts, some means of coordination between the person detonating the blast and the seismograph operator is essential to assure the blast is recorded.

Several methods of coordinating can be used—the most desirable being direct communication between blaster and instrument operator by voice or visual signals.

Whistles, horns, sirens or other signals to base a count down can also be used when it is impractical to use visual or voice contact.

Stop watches can be used to coordinate time between blaster and instrument operator using two accurate stop watches which are started simultaneously and setting a predetermined time lapse before firing.

In any of the above instances the instrument should be started 5 to 10 seconds before the blast and should continue to operate 5 to 10 seconds after the blast. With experience, the operator can learn to control this time more closely.

10. Do not touch the instrument or move near it until it is certain that the event has been recorded.

11. After the recording, the switch should be moved to its "off" position.

12. Turn clamp knob clockwise to "clamp" position, being sure to rotate fully until it reaches its stop.

Never move the instrument unless the pendulums are clamped.

13. An interlock switch has been provided to prevent the batteries from being exhausted if the operator fails to turn the light switch to the "off" position. This switch is actuated by a plunger which is depressed when the instrument cover is in place.

14. The camera is designed to use a standard Kodak 116 spool for storing the recording paper, an anvil to hold the paper in proper position at the aperture and a driven spool which takes up the paper.

The supply spool is held in place by the fixed pin at one side and the projecting pin on the removable knurled screw. Proper pressure is applied to the paper supply spool by a spring brake system to assure uniform paper motion.

When loading the camera, wind enough photographic paper, about 15-20 feet emulsion out, on a Kodak 116 spool. Remove the knurled screw on the camera and place the loaded spool on the fixed locating pin, depressing the friction spring downward with the loaded spool. Insert the knurled screw and tighten firmly.

The paper should **not** be taped to the supply spool as it will jam the camera at the end of the run. We suggest that the paper be cut tapered and use the slots provided in the spool.

15. The paper recommended for use in this camera is Kodak Fast Projection Extra Thin Spooled Emulsion Out. The amount of paper which may be used depends on the individual operator and conditions at the recording place. The maximum capacity of the spool is 20 feet.

16. After trying several methods of fastening the paper to the take-up spool, it was found most desirable to use masking or scotch tape and winding one or two turns on the take-up spool.

17. Slip the camera cover over the end, aligning the index pin in the slot in the cover. This is important because it positions the light aperture properly. Failure to observe this may result in loss of timing lines or traces, or both.

18. Insert the camera into the opening with the knob in the bottom position. The camera will be felt to engage the driving mechanism and locating assembly. Rotate the knob counter-clockwise until the drive system engages the camera take-up spool.

19. Close the camera door. Push in and rotate the knob on the door until the arrow is horizontal and pointing to the end of the box.

20. Batteries:

Light source and timing light batteries—located under the rectangular cover. Use two No. F4P1 Burgess or Eveready 744, or RCA VS009 batteries and two No. 2 flashlight cells.

Light source and timing lamps—located under small rectangular cover, adjacent to the viewing screen. **Use only GE PR6 bulbs.**

To replace bulbs:

a. Remove two screws holding cover in place.

b. Lift cover on which light source bracket is mounted.

c. Unscrew lamp base mounting from lamp housing.

d. Remove contact assembly and insert new bulb. Place bulb in mounting so that the small support wire will be in a position above or below the filament when it is placed in the lamp housing. The lead wires should extend downward from the lamp housing when it is in position.

Do not attempt to remove lamp housing as this will disturb the adjustment for proper alignment with the mirror system.

Should this adjustment be disturbed, corrections may be made by loosening the allen set screw which holds the lamp housing in place and rotating it until the light spots can be observed on a white paper held in the camera housing compartment when the lamp housing bracket is in place. This should be checked also to make sure the light image will fall correctly on the translucent viewing screen, while at the same time providing the brightest image on the white paper.

The photographic paper may be developed with Kodak D72 developer and Kodak acid fixer, used as directed on the containers. This paper can be handled in a room illuminated by a **ruby red** safety bulb or Kodak red filter safe light.

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SPRENGNETHER PORTABLE BLAST AND VIBRATION SEISMOGRAPH

DYNAMIC MAGNIFICATION FACTOR TABLE
Steady State Sinuoidal Motion

Based on the equation:

$$V = \frac{Vo}{\sqrt{\left[\left(\frac{T_e}{T_n}\right)^2 - 1\right]^2 + 2h\left(\frac{T_e}{T_n}\right)^2}} = \frac{Vo}{U}$$

To determine the dynamic magnification, V, for any earth frequency, multiply the static magnification of the instrument by the factor 1/U from the table. The ground amplitude is then the trace amplitude divided by this dynamic magnification.

This table is for a mechanical seismograph having a natural period, T_n, of 0.75 second and damping, h, of 0.55 critical.

earth frequency f_e (c/s)	earth period T_e (sec)	magnification factor 1/U
0.5	2.00	0.147
0.57	1.75	0.195
0.67	1.50	0.269
0.75	1.33	0.342
0.80	1.25	0.392
1.00	1.00	0.602
1.33	0.75	0.909
2.00	0.50	1.08
2.11	0.47	1.089
3.00	0.33	1.06
4.00	0.25	1.04
5.00	0.20	1.03
10.00	0.10	1.01
20.00	0.05	1.002

For an instrument with this period and damping, the maximum magnification occurs for an earth frequency of 2.11 cycles per second.

The static magnification of this instrument is:

L: 50
V: 50
T: 50

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SPRENGNETHER PORTABLE BLAST AND VIBRATION SEISMOGRAPH

DYNAMIC MAGNIFICATION FACTOR TABLE - Trace beginning suddenly from rest as a sine wave.

Based on the equation

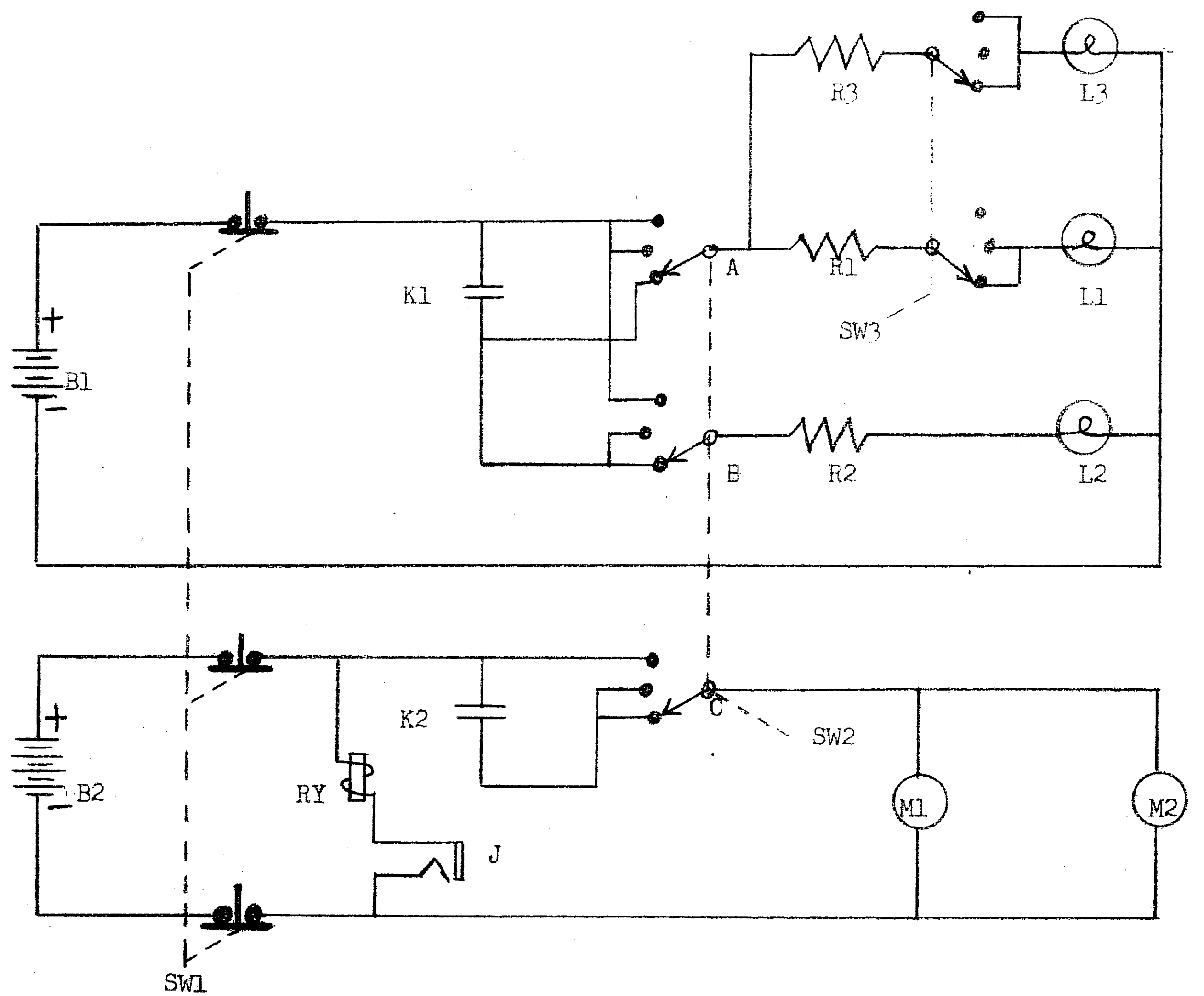
$$V = \frac{Vo}{1 + 2h\frac{Te}{Tn} + 0.57\left(\frac{Te}{Tn}\right)^2}$$

To determine the dynamic magnification, V, for the first maximum, multiply the static magnification factor of the instrument by the factor 1/U from the table for the earth period. The ground amplitude is then the trace amplitude divided by the dynamic magnification.

This table is for a mechanical seismograph having a natural period, T_n, of 0.75 second and damping, h, of 0.55 critical.

earth frequency f_e (c/s)	earth period T_e (sec)	magnification factor 1/U
0.5	2.00	0.125
0.57	1.75	0.150
0.67	1.50	0.182
0.80	1.25	0.226
1.00	1.00	0.287
1.33	0.75	0.374
2.00	0.50	0.502
3.00	0.33	0.625
4.00	0.25	0.699
5.00	0.20	0.752
6.67	0.15	0.806
9.00	0.11	0.847
10.00	0.10	0.864
11.00	0.091	0.876
12.00	0.083	0.886
14.00	0.071	0.901
15.00	0.066	0.907
20.00	0.05	0.934
25.00	0.04	0.943
50.00	0.02	0.971
100.00	0.01	0.990
200.00	0.005	0.993

WIRING DIAGRAM - DUAL MAGNIFICATION



B1 - 3 VOLTS
B2 - 12 VOLTS
J - REMOTE CONTROL JACK
K1 - N. O. RELAY CONTACT
K2 - N. C. RELAY CONTACT
L1 - LOW MAGNIFICATION LIGHT
L2 - TIMING LIGHT
L3 - HIGH MAGNIFICATION LIGHT
M1 - CAMERA MOTOR
M2 - TIMING MOTOR
RY - REMOTE CONTROL RELAY
SW1 - INTERLOCK SWITCH
SW2 - OPERATE SWITCH
SW3 - MAGNIFICATION SELECTOR SWITCH
R1 - 2.5 OHMS
R2 - .6 OHMS
R3 - 1.5 OHMS

INTERPRETATION OF VIBRATION RECORDS IN TERMS OF BUILDING DAMAGE.

T.V. McEvilly

The following information is intended only as a guide in basic vibration analysis. Detailed treatment of the problem is presented in the following list of references which should be consulted freely:

Crandell, F. J. — "Ground Vibration Due to Blasting and Its Effect on Structures". JOURNAL BOSTON SOC. CIVIL ENG. Vol. 36, April 1949, pp. 222-245.

Edwards, A. T., and Northwood, T. D. — "Studies of Blasting Near Buildings". CRUSHED STONE JOURNAL, Vol. 36, No. 3, pp. 10-23, 1961.

Fish, B. G. — "Seismic Vibrations From Blasting". Parts I — IV MINE AND QUARRY ENGINEERING, Vol., 17, 1961.

Langefors, Westerberg, and Kihlstrom — "Ground Vibrations in Blasting" Parts I — III WATER POWER, Sept. 1958, p. 335 — Oct. 1958, p. 390 — Nov. 1958, p. 421.

Leet, L. D. — Vibrations From Blasting Rock. Cambridge, Mass., Harvard University Press, 1960.

Morris, G. — "Vibrations Due to Blasting and Their Effects on Structure". (2 Parts) THE ENGINEER, Vol. 190, p. 394, p. 414, 1950.

Morris, G., and Westwater, R — "Damage to Structures by Ground Vibration Due to Blasting". MINE AND QUARRY ENGINEERING, April 1953, pp. 116-118.

Rockwell, E. H. — Vibrations Caused by Blasting and Their Effects on Structures. Hercules Power Co., Wilmington, Delaware, 1934.

Thoenen, J. R., and Windes, S. L. — "Seismic Effects of Quarry Blasting". U. S. BUR. MINES BULLETIN NO. 442*.

* Note: Report of recent work in structural vibrations by the Bureau of Mines Should be in press in 1962. See last page.

In general, the problem under consideration in building vibration analysis is the prediction of possible structural damage based on measurable characteristics of seismic wave motion in or near the building. In the frequency range from 1.3 to 100 cps, the traces recorded by the Sprengnether Three-Component Portable Blast Seismometer are near-perfect representations of the displacement of the ground enlarged by the static magnification of the instrument. (Note: For strong motion of frequencies 50 to 100 cps, it is advisable to securely anchor the seismometer in place to prevent horizontal slippage.)

The consensus of results from the above mentioned investigators is that the descriptive ground motion quantity which best indexes building damage probability is the velocity of ground motion. The generally accepted values of velocity associated with various degree of damage are as follows:

VELOCITY	PROBABLE DEGREE OF DAMAGE
Above 7.5 inches per second	Major – serious structural failure through cracking, distortion, or shifting.
Above 5.5 inches per second	Minor — no apparent weakening of the structure; glass, plaster, masonry damage.
Above 4.0 inches per second	Threshold — very minor perceptible damages; plaster cracks, dislodgement of loose objects, etc.
Below 2.0 inches per second	Recommended safe vibration level.

The commonly used "energy ratio" of Crandell is a quantity proportional to the quotient $\frac{a^2}{n^2}$ where a and n are the ground acceleration and frequency, respectively. In the approximation of sinusoidal ground motion, the energy ratio is proportional to velocity squared. The widely accepted "safe" value of 3 of energy ratio is equivalent to a ground velocity of approximately 3.3 inches per second.

Regulations governing blasting vibrations exist in Pennsylvania, New Jersey and Massachusetts. Pennsylvania law limits ground displacement to 0.03 inches at or near most buildings. For frequencies up to 10 cps, this displacement implies ground velocity less than 2 inches per second. New Jersey and Massachusetts, in similar regulation, set maximum ground amplitudes corresponding to frequency ranges up to 80 cps (60 cps in New Jersey). These allowable frequency-amplitudes limits are equivalent to a ground velocity of 1.92 inches per second. These values are compatible with the generally accepted upper limit of 2 inches per second for safe vibration levels.