United States Patent

Lehner

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[54] **SEISMOMETER**

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[52] **U.S. Cl.** **340/17,** 73/71.1

[51] **Int. Cl.** **G01v 1/16**

[58] **Field of Search** 340/17; 73/70, 71.1

[56] **References Cited**

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[57] **ABSTRACT**

A compact portable seismometer which can be readily leveled and set up in the field, comprising a pivotally mounted arm with a hollow outer end, and a stop that can be screwed into and out of the hollow end to prevent or allow arm pivoting, as well as providing a limit to the range of oscillations. A pair of windows in the housing, through which the arm can be observed, is covered as the stop is screwed down to prevent arm pivoting and is uncovered as the stop is screwed up to allow pivoting, thereby protecting the windows from dirt. The arm is about as wide as the windows so that when a flashlight is shone into one window, movement of the arm to its central position, prevents any light from being seen at the other window, thereby facilitating set-up at night.

8 Claims, 6 Drawing Figures

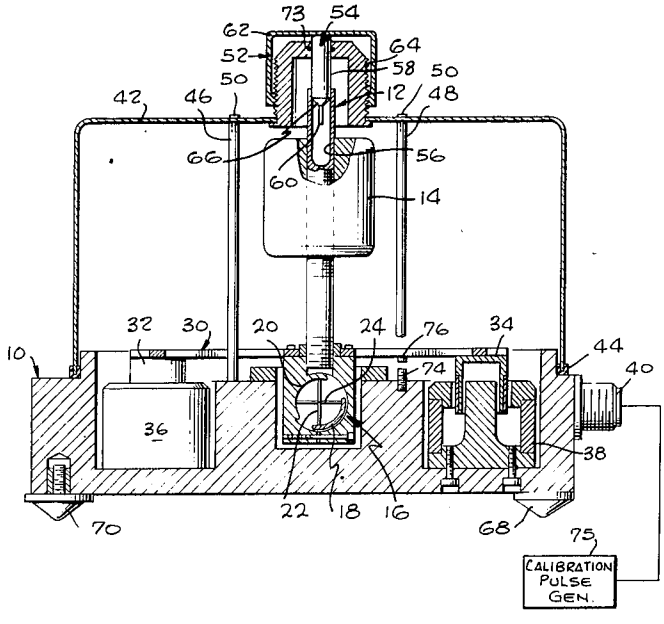

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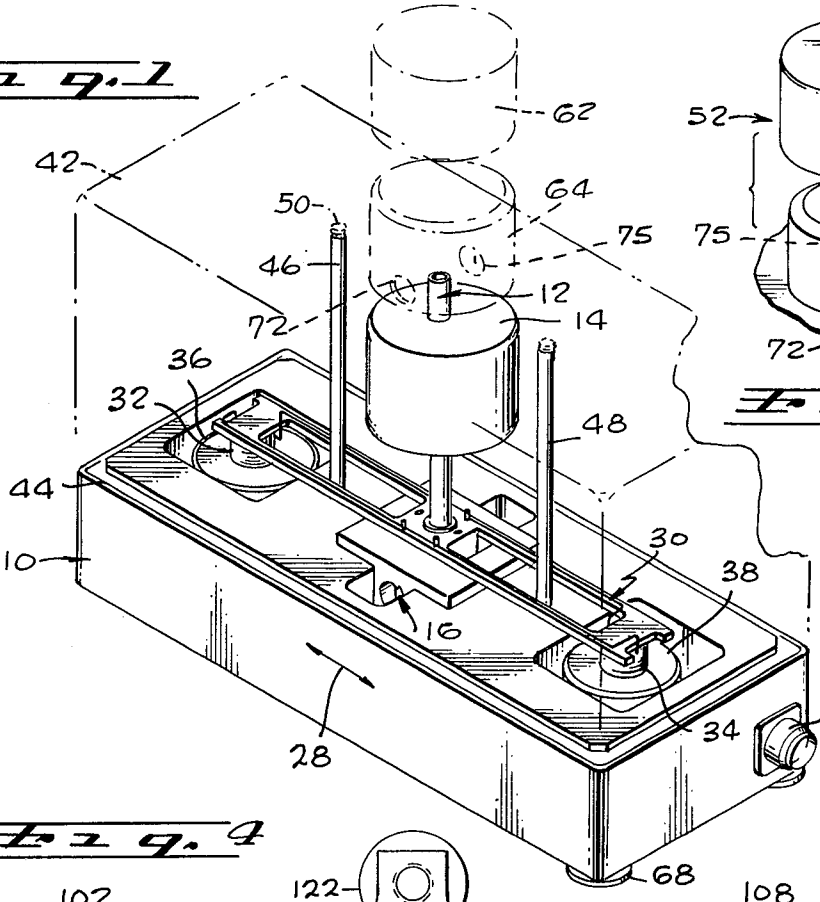
Fig. 1



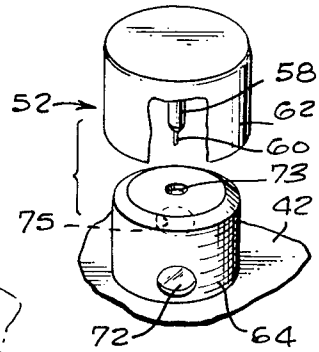
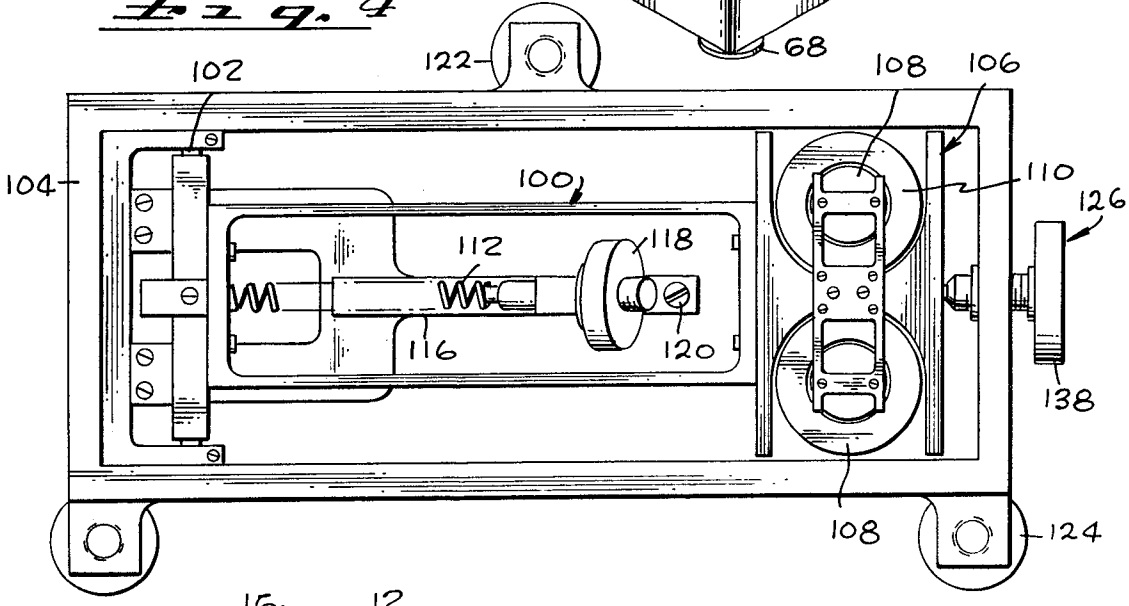


Fig. 2

Fig. 4



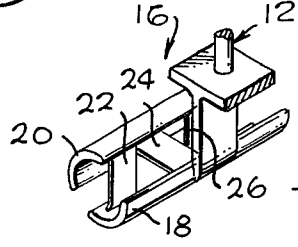


Fig. 1a

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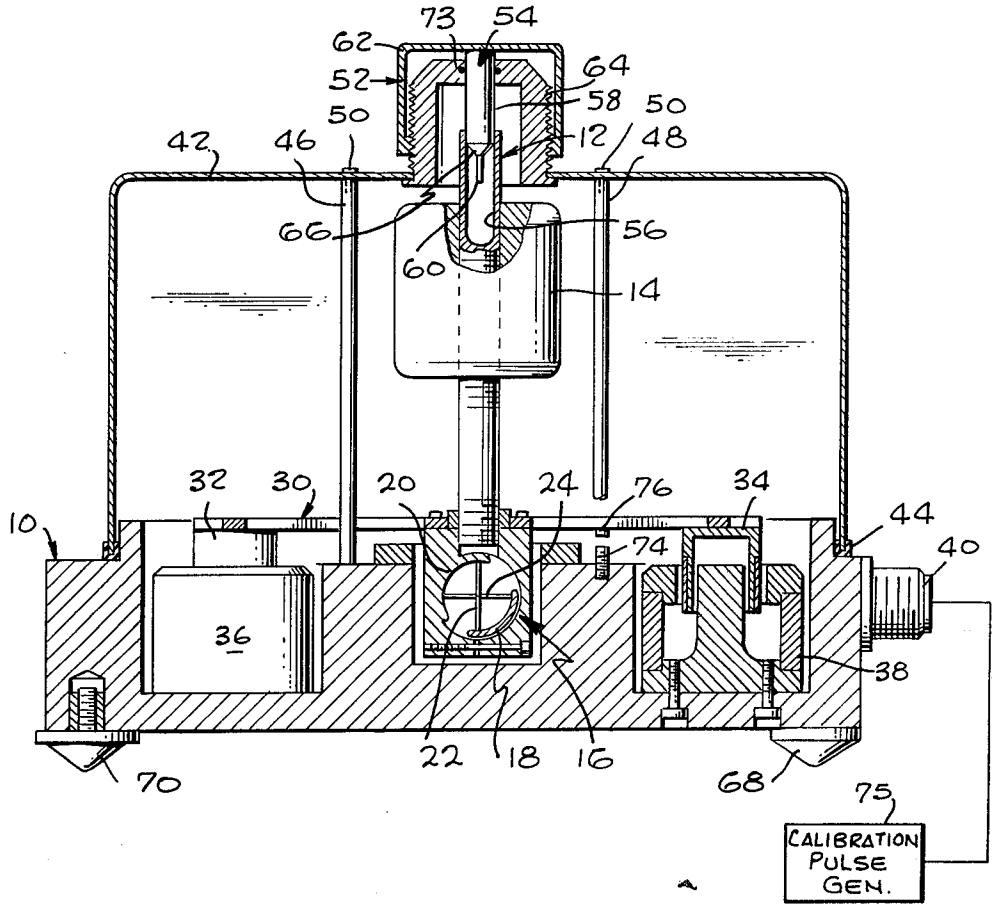
Fig. 3



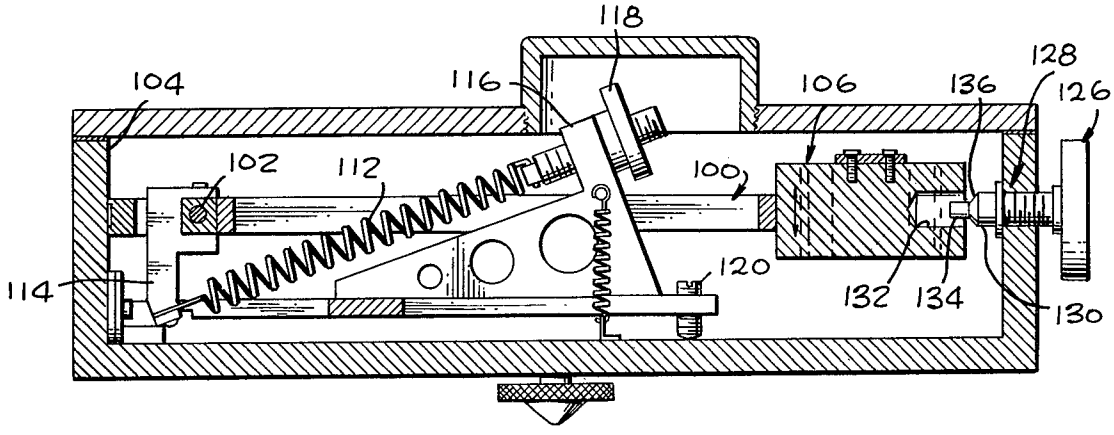


Fig. 5

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SEISMOMETER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to seismometers and, more particularly, to a novel compact and portable seismometer.

2. Description of the Prior Art

One type of seismometer includes a pivotally mounted arm that is spring-biased towards a neutral position, but which can oscillate about that position. Portable seismometers of this type are often subjected to adverse conditions, including shocks and dirt. Also, such seismometers often must be set up at night, as where a seismological team that is sent to an area which experiences a large earthquake, to record aftershocks, arrives at night. A seismometer which could be easily set up and later easily repacked for transport under adverse field conditions, would be an important aid to seismologists.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, a seismometer is provided which is compact and portable, and which is easy to set up and repack in the field. The seismometer includes a supporting base and an arm having an inner end pivotally mounted on the base and having a weight near its outer end. The entire mechanism is sealed against air currents, dust and moisture by a cover mounted on the base. A stop is threadably mounted on the cover for screwing down to engage the upper end of the arm and prevent pivoting of it during transportation, and to screw up to allow the arm to pivot freely within a limited range. The upper end of the arm has a hollow region for receiving the stop. The stop has an upper portion of a diameter only slightly smaller than the hollow arm region to completely fill it and prevent any movement of the arm when the stop is screwed down. The top also has a small diameter lower portion which is the only portion remaining within the hollow arm region when the stop is screwed up, this small stop portion allowing arm pivoting within a wide but controlled range.

A pair of windows is provided in the protective case, for enabling viewing of the pivoting arm. When setting up the seismometer at night, a flashlight can be shone through one window, and its light can be viewed through the other window unless it is blocked by the arm being in its center position. The windows are protected from mud and the like by a window cover that is attached to the arm stop. The window cover covers and uncovers the windows as the stop is screwed in and out, respectively, so that the windows are protected during transport but are uncovered during use.

The novel features of the invention are set forth with particularity in the appended claims. The invention will be best understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a seismometer constructed in accordance with the present invention, the cover thereof being shown only in phantom lines;

FIG. 1A is a partial perspective view of the pivot device of the seismometer of FIG. 1;

FIG. 2 is a partial perspective view of the stop mechanism of the apparatus of FIG. 1;

FIG. 3 is a sectional side view of the apparatus of FIG. 1;

FIG. 4 is a sectional side view of a seismometer constructed in accordance with another embodiment of the invention; and

FIG. 5 is a sectional top view of the seismometer of FIG. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1, the seismometer includes a housing with a base 10 and a cover 42 extending over the base to protect the seismometer mechanism. A boom or arm 12 extends vertically from the base and has a weight 14 near it upper end. A pivot assembly 16 pivotally supports the lower end of the arm on the base. The pivot assembly 16, which is also shown in FIG. 1A, includes a first bearing member 18 fixed to the arm 12, a second bearing member 20 fixed to the base, and three leaf springs 22, 24 and 26 extending between the bearing members. The leaf springs not only pivotally support the arm on the base, but bias the arm toward a neutral position wherein it extends vertically from the base. It the base is moved in the direction of either arrow 28, the weight 14 tends to remain stationary and causes the arm to pivot with respect to the base. The leaf springs of the pivot assembly tend to return the arm towards a vertical position, but with a low enough force so that the arm pivots very slowly. For an arm of about 10 centimeters length and a weight of about 1 kilogram, sturdy pivots of the crossed spring type are readily manufactured which produce a period of about 5 seconds.

Pivoting movements of the arm 12 are sensed by a sensor assembly including a crossarm 30 fixed to a lower end portion of the arm and a pair of coils 32, 34 mounted at opposite ends of the crossarm. Each coil extends into a permanent magnet 36, 38 that is mounted on the base, so that movements of the coils into or out of the region within the magnets causes the generation of currents in the coils. The coils are electrically connected through wires to a socket 40 at the side of the base. A sensitive voltmeter or the like can be connected to contacts at the socket 40 to sense the amount of current generated by movements of the arm, and therefore to measure the amplitude and duration (up to a few seconds) of an earth tremor.

The cover 42 which extends over the base 10 protects the mechanism against damage, dust and moisture during transportation and storage, and also shields the arm 12 and other movable portions against air currents that could produce false readings. The lower edge of the cover rests on a rubber seal 44 that extends along the rim of the base, while the top of the cover lies just above a pair of posts 46, 48 that extend upwardly from the base. A pair of screws 50 that extend through holes in the cover 42 and in the top of the posts hold down the cover. Each screw has a washer to help seal the hole in the cover through which it extends, the washers and the seal 44 around the base being provided to achieve an hermetic seal to keep out dust and moisture that

might otherwise enter when the seismometer is used in the field.

During transportation of the seismometer, the arm **12** must be locked in position to prevent damage. This is accomplished by a stop assembly **52** which is best shown in FIGS. **2** and **3**. The stop assembly includes a stop member **54** which can move in a hollow region **56** at the upper end of the arm **12**. The stop member includes an outer or upper portion **58** of approximately the same diameter as the hollow region **56** of the arm and a lower or inner portion **60** which is substantially smaller than the hollow region **56** of the arm. The stop member **54** is fixed to a cap **62** that is threadably mounted on a tube **64** that is fixed to the cover **42**. When the cap **62** is screwed down to the position shown in FIG. **3**, the large diameter portion **58** of the stop is received in the hollow region **56** of the arm, to prevent movement of the arm, thereby protecting the seismometer mechanism against damage when it is jolted. In order to use the seismometer, the cap **62** is screwed up until only the lower portion **60** of the stop member is within the hollow region **56** of the arm. The lower portion **60** limits pivoting of the arm, but only within wide limits that allow sufficient pivoting to make the intended measurements of earth tremors, and which prevent arm movement past a substantially linear operating region. It may be noted that the stop member also has a tapered portion **66** between the upper and lower portions, the tapered portion serving to gradually move the arm toward its neutral or center position to receive the upper stop portion **58** when the cap is screwed down.

When it is desired to set up the seismometer for measurements, it is necessary to first level the seismometer so that the arm **12** tends to assume a center or neutral position even in the absence of any stop. A pair of fixed legs **68** at one end of the base and an adjustable leg **70** at the other end, support the base on the ground and allow slight adjustments in its orientation in order to level the apparatus. During such leveling, it is necessary for the operator to view the arm **12** so he can determine when it is in the neutral position. To enable such viewing, a window **72**, shown in FIG. **2**, is installed in the tube **64** on which the cap **62** is threadably mounted. The window **72** and another window **75** on the side of the tube opposite window **72** are close to the arm **12** to facilitate accurate leveling of the mechanism.

In some situations, it is necessary to set up the seismometer at night in the field. It is difficult to observe the outer end of the arm **12** through a window by illuminating the window with a flashlight and observing the reflection. However, by providing two windows **72** and **75** on opposite sides of the neutral arm position, and by making the windows of a diameter about equal to the diameter of the arm, leveling can be made much easier. To level the mechanism, the operator shines a flashlight through one window **75** and peers through the other window **72**. As the seismometer becomes accurately leveled, the arm blocks more of the light. When the seismometer is accurately leveled, all of the light from the flashlight is blocked except, perhaps, for narrow slivers of light of the same width on either side of the arm.

When it is desired to pack up the seismometer for transportation, the cap **62** is screwed down all the way. The cap covers the window **72**, thereby protecting it against dirt and damage. However, when the cap **62** is screwed up to disengage the upper stop portion **58** from the arm **12**, the cap lies above the level of the window **72**, and the arm can be viewed through the window. Thus, movement of the stop member **54** into and out of the arm-holding position automatically covers and uncovers the viewing window.

It may be noted that the use of a threaded cap **62** helps to prevent dust from passing through the cover into the mechanism. To further guard the mechanism, a washer **73** is provided which seals the region between the stop member **54** and the walls of the tube **64** through which the stop member extends. It also may be noted that the upper stop portion **58** is slightly smaller in diameter than the hollow region **56** of the arm, so the stop can be screwed down much further than necessary without damaging the arm.

The use of a weight **14** located above its pivot point and of a low spring force tending to hold it in a neutral position above the pivot point, enables a long period of oscillation to be achieved with a relatively short arm. In many instances, it is desirable to enable variations in the period of the mechanism, as for example, to equalize the period of each of a group of seismometers used together. To enable such variations, the arm **12** is threaded, and the weight **14** is threadably engaged with the arm so that it can be screwed up and down. Largely because of the possibility of varying the period, it is desirable to provide means for readily calibrating the seismometer, that is, to determine the amount of arm movement that will result from the disturbance of predetermined magnitude. Such a calibration is readily accomplished by the use of a calibrating coil **74** mounted on the base, and a small magnet **76** mounted on the cross-arm **30**. Conductors (not shown) connect the calibrating coil **74** to contacts at the socket **40** through which electrical connections are made to the mechanism. By sending a current of predetermined magnitude through the coil **74** for a predetermined period of time, after the seismometer has been leveled, and noting the outputs generated by the coils **32, 34** the operator can determine the amount of arm movement which will result from a predetermined impulse or shock applied to the seismometer. A generator **75** may be employed that includes an electrical cell and a timing device for connecting the cell to the coil **74** for a predetermined period.

In many seismographic installations, it is necessary to provide three seismometers for measuring three orthogonal components of earth movements. Two seismometers of the type shown in FIG. **1** can be utilized for horizontal measurements, while a third seismometer of the type shown in FIGS. **4** and **5** can be utilized to measure vertical movements. In the seismometer of FIGS. **4** and **5**, an arm **100** is provided, with an inner end pivotally mounted by a pivot assembly **102** on a base **104**, the base serving as a case to enclose the mechanism. The outer end **106** of the arm is enlarged to add weight, and it carries a pair of coils **108** that can move into permanent magnets **110** to generate sensing currents. The weight of the arm is counteracted by a spring **112** that extends between an extension **114** of the arm and a spring adjusting mechanism **116**. The arm **100** can be adjusted so it ex-

tends horizontally when the apparatus is leveled, by turning a wheel **118** that varies spring tension. The period of oscillations is varied by adjusting a screw **120**. In order to utilize the seismometer, it should be leveled, and this is accomplished by adjusting leveling screws **122, 124** on the outside of the case.

The seismometer of FIGS. **4** and **5** has a stop assembly **126** for holding the arm steady during transport and to limit pivoting during use. The stop assembly includes a stop member **128** with a large diameter outer portion **130** which can closely fit a hollow region **132** of the arm, a narrow diameter inner portion **134** and a tapered portion **136**. The stop member is threadably mounted on the base or case **104** and can be turned by a knob **138**. In this particular model, no windows are shown for enabling visual leveling, although they can be provided.

Thus, the invention provides an accurate, compact and portable seismometer. The seismometer includes a stop assembly which enables rapid movement between a transport position wherein the arm must be held steady, and a use position wherein the arm must be free to pivot. The stop mechanism can also include means for covering and uncovering windows through which the arm can be viewed for leveling and which enable rapid leveling at nights. The mechanism also provides means for readily calibrating the seismometer by enabling a predetermined force to be applied to the arm.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art and, consequently, it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. A seismometer comprising:
a housing;
an arm having an inner end pivotally mounted on said housing, said arm having an outer end with a hollow region therein;
means for biasing said arm towards a predetermined position with respect to said housing;
means for indicating deviations of said arm from said predetermined position; and
a stop mounted on said housing for movement inwardly towards said outer end of said arm, and outwardly away from said outer end, said stop having a first portion within said hollow region to permit pivoting of said arm within wide limits, and a second portion spaced outwardly from said fist portion of a diameter approximately equal to the diameter of said hollow region to prevent pivoting of said arm when said second portion is moved into said hollow region.

2. The seismometer described in claim **1** wherein:
said housing has a window for enabling viewing of said arm; and including
attached to said stop for covering and uncovering said window as said stop moves inwardly and outwardly, respectively.

3. The seismometer described in claim **1** wherein:
said housing includes a window on either side of said outer end of said arm, said windows having a width approximately as large as the width of said outer end of said arm, so that most of the light shining through one of said windows windows will be blocked by said arm when it is in said predetermined position.

4. The seismometer described in claim **1** wherein:
said stop includes an intermediate portion tapering between said inner and outer portions, whereby to smoothly center said arm as said stop is moved inwardly.

5. A seismometer comprising:
a housing;
an arm pivotally mounted on said housing and having a free end which is biased towards a predetermined position with respect to said housing when it is leveled;
means for leveling said housing; and
a pair of windows mounted on said housing on either side of the position of said free end of said arm when it is in said predetermined position, so that an observer looking through one of said windows can see the amount by which said arm blocks light shining in through the opposite window.

6. The seismometer described in claim **5** wherein:
each of said windows has a width approximately equal to the width of said free end of said arm, so that substantially all of the light shining in through one window is blocked when said arm is in said predetermined position.

7. The seismometer described in claim **5** including:
an arm stop mounted on said housing for movement between first and second positions to closely engage and substantially release said arm, respectively; and
window cover means coupled to said arm stop to cover and uncover said windows as said stop moves between said first and second positions, respectively.

8. The seismometer described in claim **5** wherein:
said housing includes a tubular portion for receiving said free end of said arm, said windows mounted on said tubular portion; and including
a stop assembly threadably mounted on said tubular portion, including a stop for moving towards and away from said free arm end to closely engage and disengage it, and a cap for moving over and away from said windows to cover and uncover them as said stop closely engages and disengages said arm, respectively.

* * * * *