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2,375,433

SEISMOGRAPH

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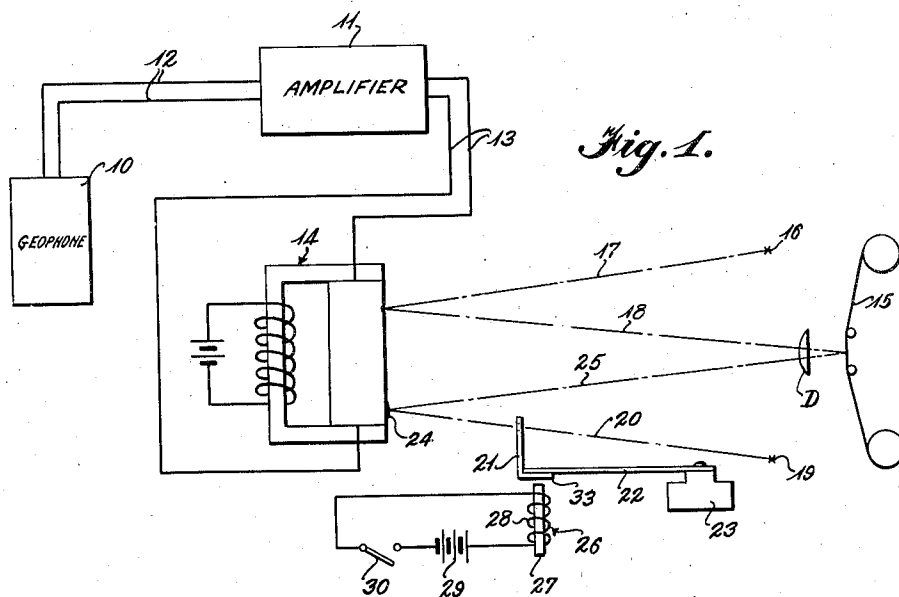


Fig. 1.

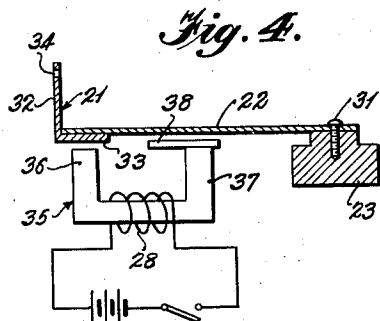


Fig. 2.

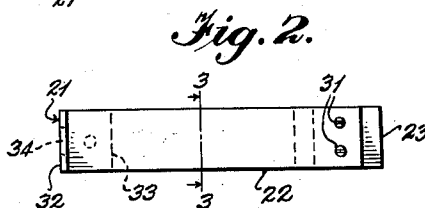


Fig. 3.

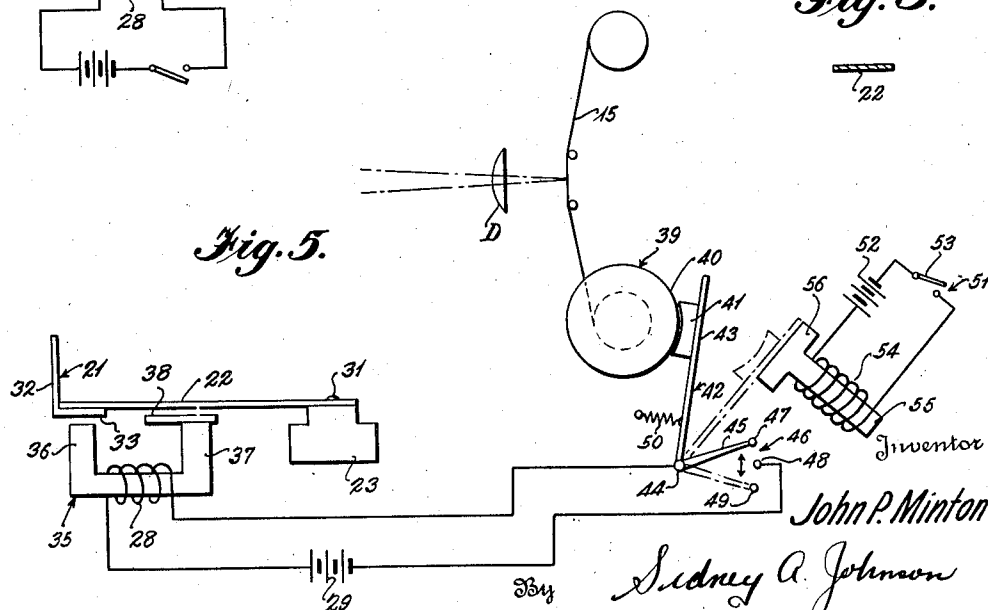
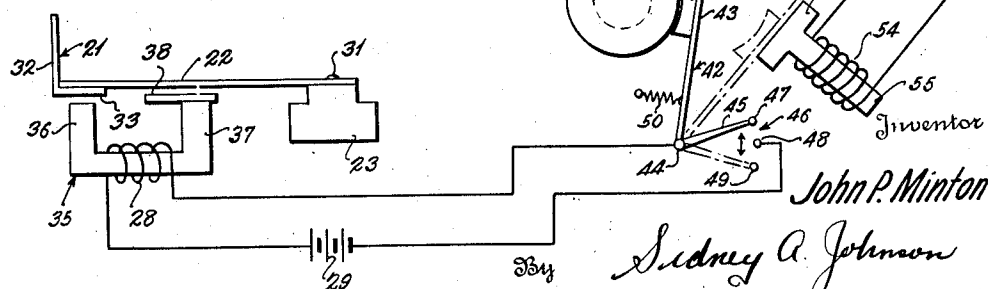


Fig. 4.



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UNITED STATES PATENT OFFICE

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SEISMOGRAPH

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3 Claims. (Cl. 234—36.5)

This invention relates to geophysical prospecting and more particularly to means for placing indications of elapsed time on a seismograph record, and is a continuation-in-part of my co-pending application, Serial No. 174,974, filed November 17, 1937.

In subsurface surveying, by the use of seismographic equipment, accuracy in time measurement is of great importance. An error of as much as a few thousandths of a second in measuring the over-all period of elapsed time required for seismic waves to travel from their point of origin to a substratum and be reflected or refracted to the recording point will frequently give rise to substantial errors in depth calculations of strata.

Considerable difficulty has been encountered in getting accurate timing marks recorded on the seismogram. Many factors must be considered in the design of timing apparatus, such for example, as changes in temperature, methods of intercepting rays of light which are being projected on to the moving photographic film, and the constancy of the interval of time between successive interceptions of the light rays. In seismograph timing, use has been made of electrically driven vibrating forks. In some instances forks having a shutter attached to one time, and adapted to be set into operation by delivering an impulse to one or both times manually have been used. Electrically driven forks have had the objection that more or less complicated additional circuits must be provided. The type of fork which depends for its energy on an initial impulse being delivered to it by hand has proven unsatisfactory, for the reason that it must be mounted in a position where it will intercept a beam of light in the optical system, thereby making it inconvenient for the operator to deliver a physical impulse to it in order to start it vibrating.

The primary object of this invention is the provision of means for recording photographically definite intervals of time, simply and accurately. The invention provides a vibrating reed having a predetermined natural frequency and having a substantially negligible thermal coefficient of expansion. Means are provided for electrically delivering an impulse to the vibrating reed by the same means and at the same time that the photographic film is set into motion, since the timing device does not serve any useful function until the photographic film has been set into motion. The reed, energized by the electrically delivered impulse, then vibrates at its natural frequency.

The reed carries, mounted on the end thereof, shutter means for intercepting a beam of light.

Figure 1 is a diagrammatic illustration of a complete seismograph unit, showing the application of the instant invention thereto;

Figure 2 is a plan view of the vibrating element and its base;

Figure 3 is a sectional view taken along the lines 3—3 of Figure 2, showing the relative dimensions of a section of the reed;

Figure 4 is a side elevation of the vibrating element showing a modified form of the impulse delivering means; and

Figure 5 is a diagrammatic illustration of a further modification of the invention showing common control means for both the starting means for the reed and for the camera that is used for recording the time indications as well as the seismic waves.

Referring to the drawing in detail, and particularly to Figure 1, there is shown diagrammatically a conventional seismograph comprising a geophone 10 adapted to be impinged by seismic waves to generate electrical signals corresponding to them. These electrical signals are conducted to the amplifier 11 by means of conductors 12. The amplified signals are conducted from the amplifier by means of conductors 13 to a recorder 14 where they are recorded on a moving sensitized paper or photographic film 15. The recorder used in practice is usually that of a vibrating string or coil type galvanometer. Assuming a coil type recording galvanometer is used, a light ray from the source 16 traverses the path 17 to a mirror on the vibrating element, not shown in detail, thence over the path 18 through a lens D to the photographic film or sensitized paper 15. Simultaneously with the recording of the signals which correspond to the seismic waves, there is also placed on the moving photographic film or sensitized paper 15 indications of elapsed time in the form of transverse lines. These lines are generated by the interception of a beam of light from the source 19 which follows the path 20 through a shutter 21 carried by a vibrating reed 22, which in turn is secured to the base 23. This beam of light is reflected from a fixed mirror 24 on the recording galvanometer 14 and follows the path 25 through the lens D to the moving sensitized paper or photographic film 15. The reed 22 is caused to start vibrating through the medium of an electromagnet 26 and associated circuit which comprises the core 27, the winding 28, the battery 29 and the switch 30. The battery 29, on closing the switch 30, energizes the core 27

to draw the free end of the reed downwardly against it where it is held until it is desired to start it vibrating, then the switch 30 is opened, thus de-energizing the core 27 and permitting the reed to swing into vibration.

As shown in the plan view of Figure 2, the base 23 to which the reed 22 is secured by means of screws 31 or other conventional means, is made relatively large and is formed of solid metal, such as iron, brass, etc., having a relatively large mass. The base 23 is firmly anchored to the housing of the recording instrument, not shown. Forming the base 23 of relatively large mass eliminates the possibility of introducing into the vibrating reed 22, that is secured thereto, harmonics which would tend to distort or render inaccurate the timing lines formed thereby. Another advantage obtained by having the base of a large mass relative to the reed is that there is no tendency of the vibrating reed to set the mass into vibration resulting in rapid loss of the energy initially given to the reed. Since substantially all of the starting energy remains in the reed, it will vibrate over a considerable period of time before it comes to rest. Preferably the mass of the base is several hundred times that of the reed.

The reed 22 is formed of a material of substantially zero thermal coefficient of expansion. An example of such material is that of chromium-nickel-steel having approximately 12% chromium and 36% nickel. This material is sold on the market under the trade name of "Elinvar." Where a timing reed is used for marking seismograph records, in which extreme accuracy is required, the ordinary iron or steel reed does not have sufficient accuracy. These instruments are used in the open under all types of climatic conditions, involving a range of temperatures of as much as 150° F. or greater. By making the reed of a metal which has a zero thermal coefficient of expansion, or nearly so, the length of the reed and hence the frequency of vibration is practically constant. I have found that a reed made of "Elinvar" is accurate over a temperature range of from -30° F. to 120° F. within one part in five thousand, whereas the ordinary iron or steel reeds have a frequency variation of from five to ten times as great.

As shown in Figure 3, the reed is wide in comparison to its thickness. The ratio of width to thickness should be within the range of from 8 to 1, to 10 to 1. This is a necessary condition in order that on normal vibration thereof, torsional forces will not be present which will tend to produce irregular or slanting timing lines.

In order that reed 22 may be set into vibration, an L shaped element 21, made of soft iron, is secured to the free end of the reed, by welding leg portion 33 of the element to the reed. Leg portion 32 extends vertically upwards from the end of the reed, and is provided with a window 34 in the form of a slit through which light rays are adapted to pass. The vibration of the reed carrying the element will intercept rays from the source of light 18 to expose the moving sensitized paper or photographic film 15 in the manner described above.

The soft iron element 21 in addition to defining a window through which light rays are projected, also provides by means of the portion 33 an armature whereby electromagnetic forces can be exerted on the assembled reed 22 and element 21 carried by the free end thereof. As described above, the purpose of placing these forces upon the assembled reed and element is

to draw it downwardly toward the magnet core 27 and hold it in the "down" position until it is desired to record waves, at which time the current supplied by the source 29 is cut off. The removal of this current from the winding 28 on the core 27 causes an immediate de-energization of the core 27 and a resultant release of the soft iron element which will start the element vibrating at its constant natural frequency. The reed 22 is of graduated length. The mass secured to the end thereof in the form of element 21 cannot as a result of changes in temperature affect the natural period of vibration of the reed.

As soon as the force exerted by the electromagnet 26 on the soft iron member 21 carried by the reed 22 is removed, the reed will vibrate at its natural frequency for a period of time that is sustained for as long as five or six seconds.

To those skilled in the art, it will be apparent that this period of time is ample to record seismic waves from any conventional spread-distance. It is at this point admitted that the instant invention would have no application in refraction surveying where as much as 25 or 40 seconds are required for recording dependent upon the distance traveled by the seismic waves.

On the other hand, when the conventional method of reflection seismic surveying is being carried out, or refracted waves over a surveyed distance are being recorded, this device not only has application but is more practical than any of the other means known in the art, such as electrically driven forks.

This novel timing device also affords the advantage that it is free from variations of frequency due to changes in temperature. Although the instant invention has been described in connection with chromium-nickel-steel, known by the trade name "Elinvar," it is obvious to those skilled in the art that other materials having a substantially zero coefficient of expansion would serve equally as well.

In Figure 4 there is shown a modified form of electromagnet for use in imparting the starting impulse to the vibrating element. This form of the invention differs from the impulse delivering means described in connection with Figure 1 in that the core 35 is substantially U-shaped. One arm 36 of the U-shaped core cooperates with the soft iron portion of element 21 to exert an attracting force thereon in the manner described above. The other arm 37 of the core 35 is provided with an elongated soft iron pole tip 38 so shaped to enable it to cover a substantial area of the vibrating reed 22, and which on energization of the electromagnet will exert an additional force on the reed 22 to attract it toward the electromagnet. This form of the invention has the advantage that with a relatively small source of D. C. supply to the winding 28 of the electromagnet, a stronger force will be exerted on the bottom of the vibrating element to draw it downwardly against the poles of the core and hold it in the "down" position until it is desired to release it for vibration to intercept the beam of light.

In Figure 5 there is shown still another modification of the present invention, in that common means are shown for setting vibrating element 22 into vibration and for starting the camera 39 to cause the photographic film or sensitized paper 15 to move past the lens D.

Although for purpose of illustration, the form of the device illustrated in Figure 4 is shown in connection with the novel starting means of Fig-

ure 5, it is obvious that the form of the invention shown in Figure 1 can be used equally as well. In Figure 5, the camera 39 is shown diagrammatically and the take-up roll 40 which may be driven by electric motor or conventional spring motor, is provided with a brake shoe 41 secured to one arm 42 of a lever 43 that is pivotally mounted at 44. The second arm 45 of the lever 43 has secured to it, at the end opposite pivot 44, a contact 46, for engaging the stationary contacts 47, 48 and 49. Contact 46, carried by the lever arm 45, and the stationary contacts 47, 48 and 49, serve to energize and de-energize the circuit of the electromagnet 26 in the manner hereinafter described.

Normally, spring 50, holds brake shoe 41, firmly against film take-up roll 40, contact 46, resting on dead contact 47. To place the apparatus in operation, manual switch key 51 is pressed down, thereby causing current to flow in the circuit made up of battery 52, switch 53, and coil 54. The closing of this circuit energizes coil 54, and soft iron magnet 55. Magnetic flux from pole piece 56 attracts soft iron lever arm 42, causing it to move from its original position, indicated in Figure 5 by the solid lines, to a position indicated by the dotted lines, where it is in firm contact with electromagnet polepiece 56. This movement of lever 42 causes a simultaneous movement of lever arm 45 from its original position, indicated in the drawing by the solid lines, to a position shown by the dotted lines. The motion of arm 45 causes contact 46 to pass over live contact 48, which is connected to one side of coil 28, on core 35, as shown in Figure 5. Current then flows from battery 29, to contact 48, and across to contact 46. Lever arm 45, is provided with suitable electrical conduction means (not shown), extending from contact 46, to the pivoted end of arm 45, from whence a connection is provided to the other side of coil 28. Current thus flows from contact 46, through these conductors to coil 28 and thence back to the battery 29. The closing of this circuit energizes coil 28 and core 35, drawing the free end of reed 22 down against the arm 36 of the U-shaped magnet. As soon as the contact 46 has moved away from the contact 48 to the second dead contact 49, the circuit is broken de-energizing coil 28 and core 35. This then releases the reed 22 which springs free and starts vibrating. Thus a single operation, namely, pressing switch key 51, simultaneously places the camera roll 40 in motion, and starts the reed 22 vibrating. Key 51 is held in the "down" position for sufficient time to allow a complete seismic record to be obtained.

In practicing the invention as disclosed in Figure 5 one is able to coordinate the starting of the camera and the timing device to the extent that a minimum of film will be wasted in recording a seismogram and such that the entire useful period of vibration of the vibrating element is utilized.

I claim:

1. A timing device for electric seismographs of the type adapted for use in placing transverse lines as indications of elapsed time on a seismogram that comprises in combination, a base, a reed having one end secured to said base, said reed being of a predetermined length determinable by the interval of time desired between the timing lines, electromagnetic means for delivering an impulse to said reed to start the reed vibrating, common means secured to the free end of said reed forming an armature for the electromagnet and defining an aperture through which light will pass at regulated intervals when the reed is vibrating to expose timing lines on the seismogram, said electromagnetic means comprising a substantially U-shaped core, a pole piece on one arm of said core adapted on energization of said core to exert a pull on the reed, the other arm of said core being adapted to exert a force on the armature carried by the free end of said reed, a winding on said core, and an energizing circuit to energize said winding and core to attract the reed and armature to the core, and means for de-energizing said core to release the reed to start it vibrating.

2. In a timing system for electric seismographs having a record sheet and driving means therefor, the combination of a timing device for placing transverse parallel lines as indications of elapsed time on said record sheet comprising a base, a thin elastic plate having one end secured to said base and the opposite end free to vibrate, a shutter carried by said free end of said elastic plate, an electromagnet, an energizing circuit for said electromagnet whereby upon energization thereof it will move said free end of said plate to an angular position to store energy therein for subsequent vibration during a substantial period of time, and common means for starting said driving means and for controlling said circuit to de-energize said electromagnet to initiate vibration of said elastic plate upon starting of said driving means.

3. In a timing system for electric seismographs having a record sheet and driving means therefor, the combination of a timing device for placing transverse parallel lines as indications of elapsed time on said record sheet comprising a base, a thin elastic plate having one end secured to said base and the opposite end free to vibrate, a shutter carried by said free end of said reed, an electromagnet for moving said free end of said reed to an angular position to store energy therein, an energizing circuit for said electromagnet, and common means for starting said driving means and in quick succession closing and opening said energizing circuit to initiate vibration of said reed upon starting of said driving means.

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