June 24, 1941. H. N. WAGAR 2,247,214

OSCILLOGRAPH APPARATUS

Filed May 13, 1939

FIG. 1

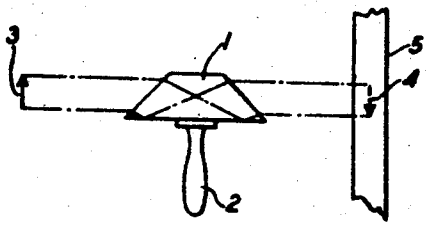


FIG. 2

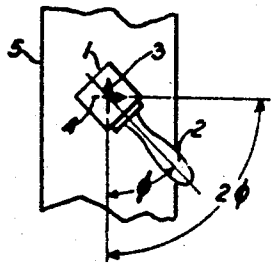


FIG. 3A

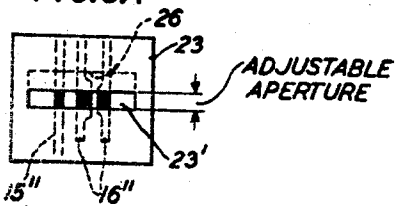
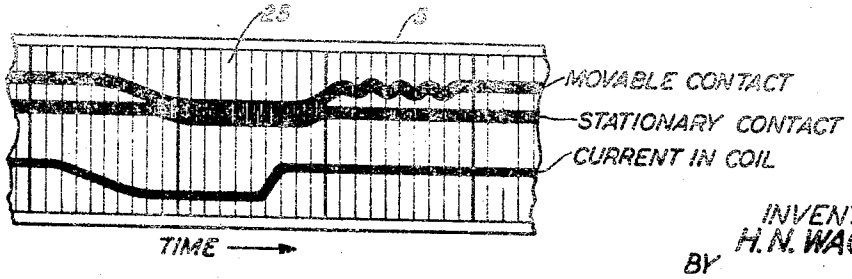


FIG. 3

FIG. 4



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UNITED STATES PATENT OFFICE

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OSCILLOGRAPH APPARATUS

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5 Claims. (Cl. 234—6)

This invention relates to recording devices and more particularly to string galvanometer oscillographs for making records of rapidly changing physical phenomena.

In the development of electromechanical apparatus it is very helpful if the actual mechanical response thereof to electrical energy changes are fully known. Heretofore those skilled in the art have constructed oscillographs having a plurality of electroresponsive recording elements adapted to record a plurality of electrical phenomena simultaneously on a single moving record sheet. Examples of this type of apparatus are disclosed in U. S. Patents 1,871,361, granted August 9, 1932, and 1,958,611, granted May 15, 1934, and in Bell Laboratories Record, September 1937, page 26. In these patents all the movable galvanometer recording elements are parallel, they move in the same direction and are in substantially the same place so that the images of their shadows appear sharply on the record sheet. Oscillographs are normally so constructed that their galvanometer recording elements move transversely to the motion of their record sheets as it is evident from the nature of their structure that all components of motion appearing at the record strip to move in the same direction as the record strip are not recorded. However, in studying the actual motion of electromechanical apparatus simultaneously with its related electrical energy changes, it is very seldom possible to have these conditions met. The movable parts of associated electromechanical apparatus are seldom so positioned that the motions thereof readily appear transverse to the motion of the record strip unless special optical apparatus is employed.

It is accordingly an object of this invention to provide a suitable optical system in combination with a recording device whereby continuous records may be made of the mechanical movements of an electromechanical apparatus irrespective of their angular directions with respect to the record strip.

It is a further object of this invention to provide a means whereby these records may be made simultaneous with their related electrical phenomena.

The foregoing objects are attained by providing in combination with a recording device of the oscillograph type an optical adjusting means adapted to orient the directions of motion of the recording images at the record strip so that they move transversely to the direction of motion of said strip.

The invention may be more particularly described in connection with the accompanying drawing in which:

Fig. 1 illustrates the optical inverting effect of a trapezoidal prism;

Fig. 2 illustrates the optical rotating or orienting property of the prism of Fig. 1;

Fig. 3 discloses a particular embodiment of the invention;

Fig. 3A is a portion of Fig. 3; and

Fig. 4 is a portion of a record strip illustrative of the results obtained from a simple application of this invention.

The optical properties of trapezoidal prisms are well known in the optical art but by way of completeness a brief description is given herewith of the particular properties employed by this invention. In Fig. 1 a trapezoidal prism 1 is mounted on a handle 2 for convenience of description. The rays from an erect object 3 passing through prism 1 will form an inverted image 4 on a screen or record strip 5. In this figure the projection of image 4 viewed from object 3 would be collinear with the object but inverted. However, if the prism is rotated about its principal optical axis through an angle Φ as shown in Fig. 2 the image will appear to be rotated through an angle 2Φ and in the same direction as the prism. This property of rotation or orientation is employed in this invention to orient the images of angularly displaced movable objects in order to obtain a true and accurate record of the motions thereof.

A specific application of the above-described optical principle is disclosed in Fig. 3 in connection with an oscillograph of the type more particularly described in the aforementioned U. S. Patent 1,958,611 and in "Electronics" August 1931, pages 70 and 71. Briefly, however, the record strip handling portion of the oscillograph comprises a supply roll 6 of sensitized paper enclosed in a light-tight compartment (not shown) of conventional design. The strip 5 from roll 6 is run at substantially uniform speed past the printing point 7 where the images are photographically printed. The strip is then passed into a temporary storage chamber 8 and finally through suitable processing baths 9 and 10 where the photographic record is developed and washed.

The optical system comprises a light source 11, condenser lenses 13, focussing lenses 19, prism 20, projector lenses 21, prism 22, mask 23 with aperture 23' and cylindrical lens 24. An occulting or timing disc 12 is inserted between light source 11 and condenser lenses 13 and its motion is such as to form parallel spaced timing bars 25

on the record sheet 5 as shown in Fig. 4. The galvanometer 14 is of the type disclosed in the aforementioned U. S. Patent 1,871,361 and although only one string 15 is used for illustration, it is obvious that more may be used. The image of string 15 is focussed in the plane of contacts 16 and is oriented by prism 20 so that it is parallel with the length of contacts 16, as indicated by dotted line 15', whereby its direction of motion is the same as the direction of motion of contacts 16. For a specific illustration of the invention contacts 16 are shown to be operated by coil 16' in series with battery 18, switch 17 and galvanometer string 15.

The rotated image 15' of string 15 and the image of contacts 16 are focussed on an apertured screen 23 by projector lenses 21 and are oriented by prism 22 so that their apparent directions of motion at the screen are all transverse to the direction of motion of the record strip 5. It is to be understood that masking screen 23 is actually very close and parallel with record strip 5 and is shown extended therefrom in Fig. 3 only for the sake of clarity. Cylindrical lens 24 also is of relatively small dimensions and consequently occupies very little space. Its purpose is to concentrate the light emerging from aperture 23' into a narrow line transversely across record strip 5 and at the printing line 7.

The height, that is to say the narrow dimension of aperture 23', is made adjustable by any convenient means, not shown. This adjustment is desirable for this particular disclosure in order to mask out unwanted light from above and below the margin of the contact points. This is better shown in Fig. 3A where the images of the contacts 16'' and the galvanometer string 15'' are shown viewed from the record strip side, the dotted portion representing the masked areas. Now if the aperture height is increased as indicated by the dotted rectangle, a light space 26 will be unmasked to register on the record strip thereby rendering it a little more difficult to read. The specific form of mask and the shape of the open space thereof will depend upon the type of oscillograph used and upon the configuration of the mechanical structure observed. The cylindrical lens 24 compresses the emergent light from aperture 23' into a narrow line as previously stated.

In order to more easily observe the vibratory action of objects in contact, particularly where one of them is very large, it is frequently found desirable to depart from complete masking as above described by increasing the height of the aperture just enough to allow a small light leak through space 26. It is evident that this will form a narrow light trace between the shadows of the two contacting objects, the shape of which corresponds with their vibratory motion. In the specific case of the relay contact herein disclosed, this trace may manifest itself in two ways. First, if the width of the trace momentarily increases this indicates that there is a relative motion between the two contact springs commonly called contact chatter or rebound and, second, the wavy form of the trace indicates the magnitude and direction of the en masse vibratory motion of the closed contacts.

Fig. 4 discloses a portion of a record strip which may be obtained from studying the action of a particular pair of relay contacts such as 16 of Fig. 3. The traces are actually caused by compressed shadow images of small portions of the galvanometer string and relay contacts. Lines 25 are the timing lines produced by occulting disc 12. The meaning of such an oscillogram is at once obvious to anyone skilled in this art and requires no further description.

In using the above-described apparatus to observe the action of relay contacts 16 simultaneously with their associated electrical phenomena the contacts are inserted into the optical path between prism 20 and projector lens 21, as shown. It is immaterial what angle they assume so long as they operate in a plane substantially parallel with record strip 5. Projector lenses 21 are then adjusted to bring the shadow images 16'' of the contacts in focus at strip 5 and consequently substantially in focus on the mask 23. Since the actual motion of contact 16 may be at any arbitrary angle, prism 22 is rotated to orient the motion of their images transverse to the record strip as seen on mask 23. The height of the aperture is then adjusted to mask out any unwanted light, in this case that appearing around the margins of the contact points as previously described.

Focussing lenses 19 are then adjusted to bring the shadow image 15'' of string 15 into sharp focus at strip 5. This will occur when a real image 15' is formed in the plane of the contacts 16 in a manner well known. However, since prism 22 was rotated, the final image 15'' also suffered rotation but is not necessarily in the required position at aperture 23', with its motion transverse to that of record strip 5. Prism 20 is rotated to orient final image 15'' into the correct position.

It is obvious that a plurality of strings could be used so that for example a second string could record the current through or voltage across contacts 16 and a third string the voltage or current changes in some other electrically related or even unrelated circuit. Moreover, any electromechanical system having a movable part capable of insertion in the optical system may be substituted for the specific contacts herein disclosed for illustrative purposes.

What is claimed is:

1. In a recording device having a light sensitive record strip moving in a fixed direction, a galvanometer, a movable element therefor responsive to an electric phenomenon, a mechanically movable body the motion whereof is operatively related to said phenomenon and which is movable in a plane parallel to said record strip and at any fixed angle with respect to its direction of motion, optical means adapted to transmit images of said movable element and said body to said record strip, and optical adjusting means adapted to orient the direction of motion of said images into a line transverse to the motion of said record strip.

2. In a recording device having a light sensitive record strip moving in a fixed direction, a mechanically movable body movable in a plane substantially parallel to said record strip and at any variable angle with respect to its direction of motion, optical means adapted to transmit an image of said body to said record strip, and optical adjusting means adapted to orient the direction of motion of said image into a line substantially perpendicular to the motion of said record strip.

3. In a recording device having a light sensitive record strip moving in a fixed direction, an oscillograph with at least one movable element responsive to an electric phenomenon, an optical

system for producing an image of said element and for recording any motion thereof on said strip, a mechanical body movable in response to said phenomenon along a fixed axis and in a plane substantially parallel with said strip and at any angle with respect to its direction of motion, an optical projection means interposed in said optical system adapted to record the motion of said body on said strip, and means for orienting the direction of motion of said projection into a line substantially transverse to the direction of motion of said strip.

4. In a recording device having a light sensitive record strip moving in a fixed direction, an oscillograph with at least one movable element responsive to an electric phenomenon, an optical system for producing an image of said element and for recording any motion thereof on said strip, a mechanical body movable in response to said phenomenon along a fixed axis and in a plane substantially parallel with said strip and at any angle with respect to its direction of motion, an optical projection means interposed in said optical system adapted to record the motion of said body on said strip, and means for orienting the direction of motion of said projection into a line substantially transverse to the direction of motion of said strip, said means comprising a trapezoidal prism.

5. In a recording device having a light sensitive record strip moving in a fixed direction, an oscillograph with at least one movable element responsive to an electric phenomenon, an optical system for producing an image of said element and for recording any motion thereof on said strip, a mechanical body movable in response to said phenomenon along a fixed axis and in a plane substantially parallel with said strip and at any angle with respect to its direction of motion, an optical projection means interposed in said optical system adapted to record the motion of said body on said strip, a prism interposed in said optical system for orienting the direction of motion of the image of said oscillograph element so that it is in the same direction as the motion of said body and another similar prism also interposed in said system for orienting the direction of motion of both the image of said element and the projection of said body into a line substantially transverse to the direction of motion of said strip.

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