

May 31, 1932.

H. C. HAYES

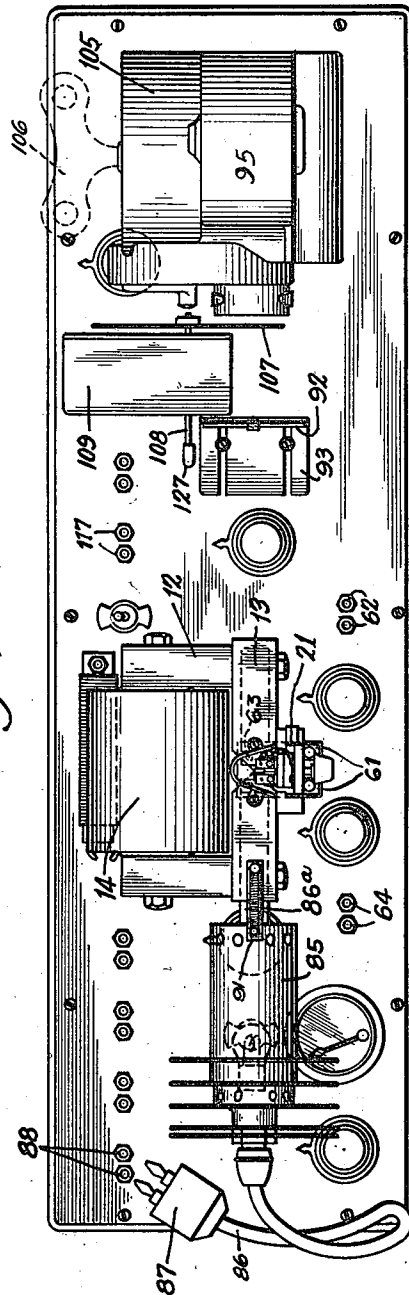
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OSCILLOGRAPH

Filed May 15, 1928

5 Sheets-Sheet 1

Fig. 1,



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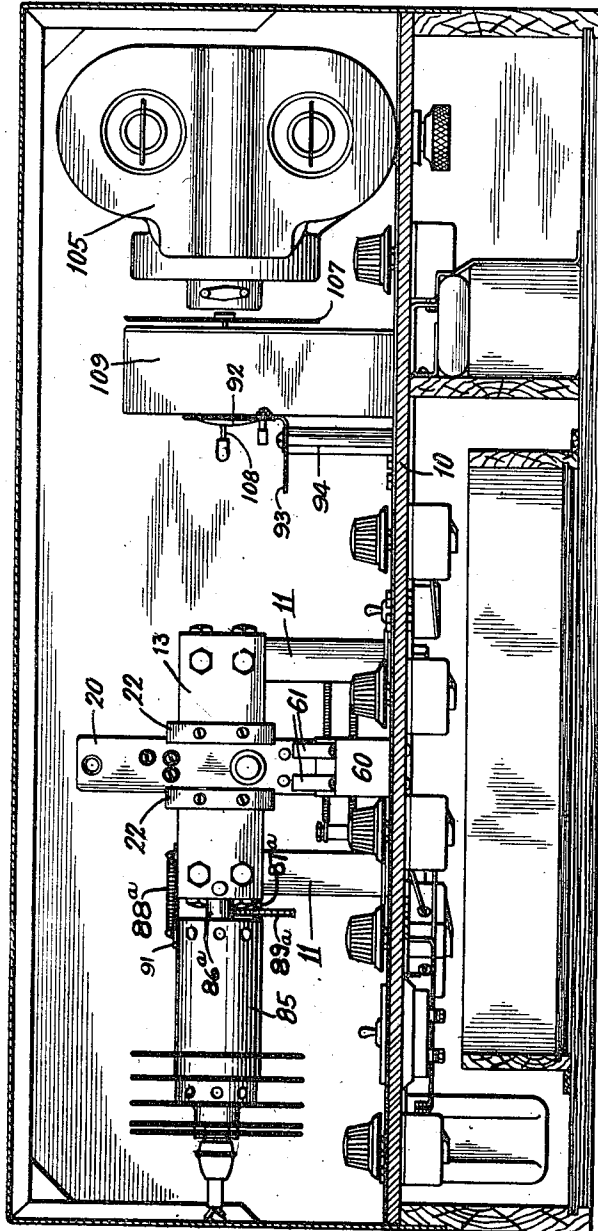
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5 Sheets-Sheet 2

Fig. 2,



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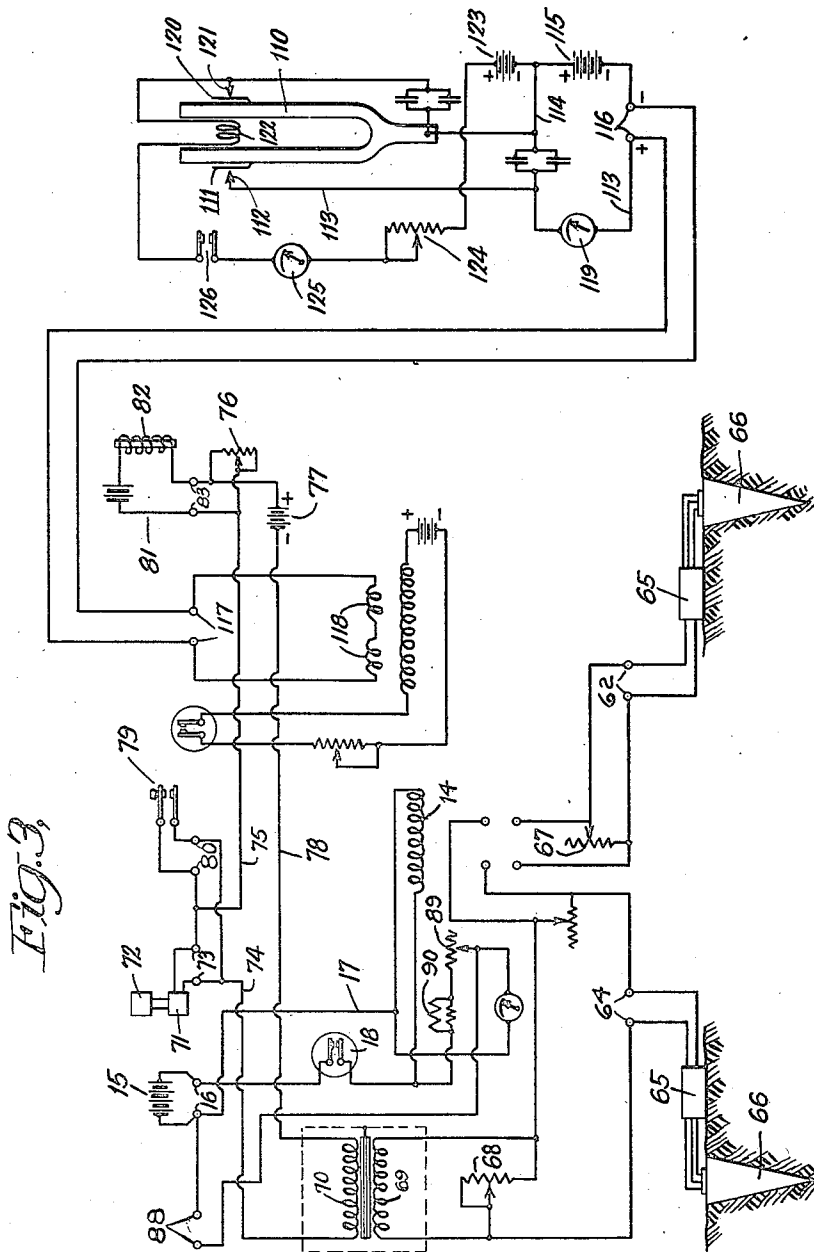
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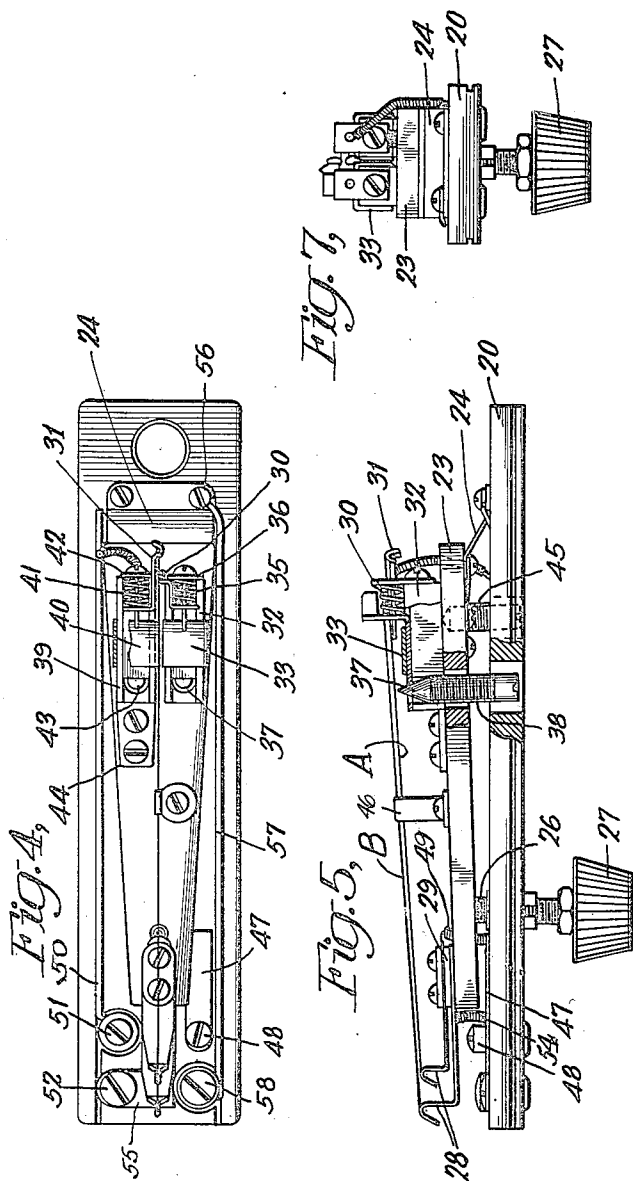
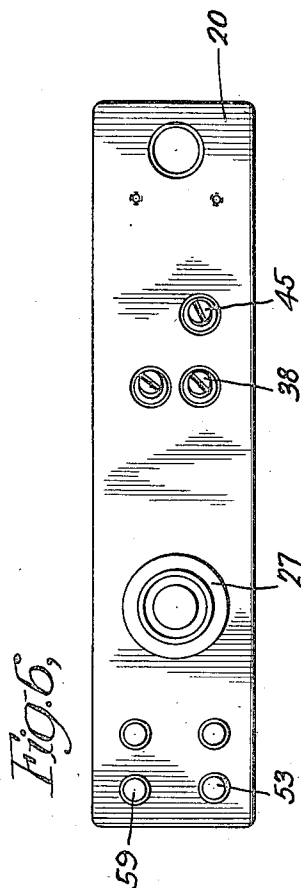
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5 Sheets-Sheet 4



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OSCILLOGRAPH

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5 Sheets-Sheet 5

Fig. 8,

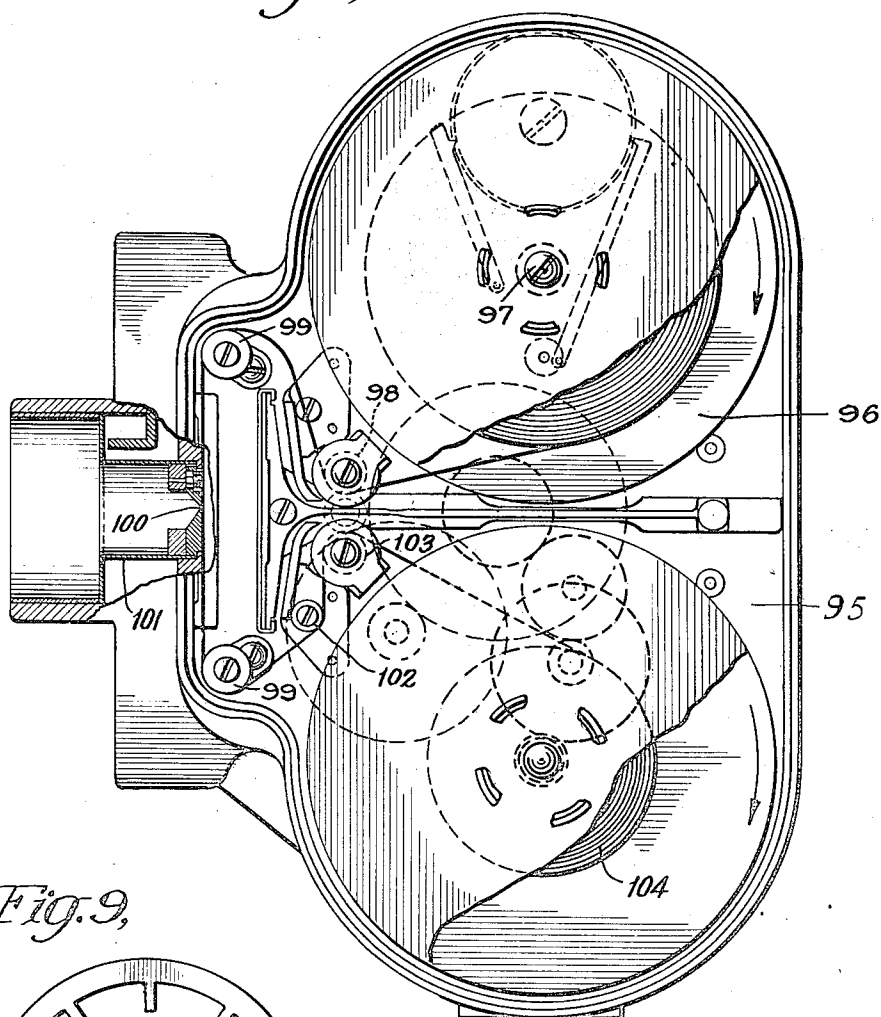
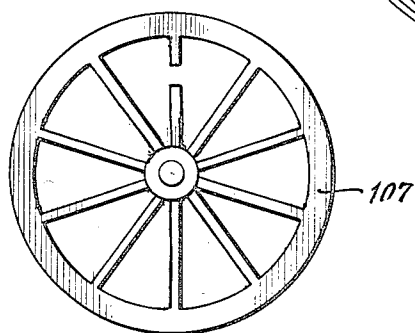


Fig. 9,



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OSCILLOGRAPH

Application filed May 15, 1928. Serial No. 277,967.

(GRANTED UNDER THE ACT OF MARCH 3, 1883, AS AMENDED APRIL 30, 1928; 370 O. G. 757.)

The invention relates primarily to instruments employed for the indication or recording of slight electrical impulses or disturbances of various kinds. Instruments of the type contemplated usually comprise some form of string galvanometer and any suitable means for reproducing in magnified form the vibrations produced in the galvanometer string as a result of the electrical impulse imposed upon it. The reproduction of the wave generated in the galvanometer string may either be in the form of a temporary visual indication or in the form of a permanent record. If a visual indication is formed it is usually in the nature of an image reflected or otherwise focused upon a translucent screen while the permanent record if formed is usually produced by suitable photographic means.

A primary object of the present invention has been to provide a simple and compact device having the above characteristics and one which is capable of receiving and reproducing impulses from several sources simultaneously. To this end, in lieu of the single galvanometer string usually employed in devices of this character, a plurality of such strings are provided and all are mounted in a single container or holder in such a way as to be in very close proximity and in a definite plane. By virtue of the novel arrangement contemplated by the present invention, a single beam of light necessitating only a single source and a single set of condensing and focusing lenses has been found sufficient for the forming of two distinct records. Furthermore, a single record medium or a single indicating device such as a screen, is all that is required for the reproduction of the distinct vibrations of the two separate strings. It is quite customary in the construction of string galvanometers to provide some means for damping the vibrations of the string and in this connection the present invention contemplates the damping of both of the strings by means of a single drop of oil suitably located. Heretofore it has been quite customary to employ permanent magnets in the construction of the galvanometer portions of an oscillograph but

in accordance with the present invention greater sensitivity is provided through the use of an electro-magnet to generate the magnetic field in which the pair of galvanometer strings are vibrated.

Improved means are also provided by the present invention for producing a permanent record of the vibrations and for indicating on the record short intervals of time by which the characteristics of the electrical impulses are more readily determined.

Other objects and advantages of the invention will appear from the detailed description which follows, and which is to be considered in connection with the accompanying drawings, in which

Figure 1 is a plan view of the oscillograph,

Figure 2 is an elevational view of the oscillograph partly in section.

Figure 3 is a diagrammatic showing of the electrical circuits embodied in the novel instrument and related devices.

Figures 4, 5, 6 and 7 are top, side, bottom and end views of the holder which carries the pair of galvanometer strings.

Figure 8 is a sectional elevational view of the camera of the oscillograph.

Figure 9 is a detail of the time marking disk.

Referring now particularly to Figures 1 and 2, it will be seen that the instrument comprises a base member 10 which is adapted to support the various features of the oscillograph. This base member is so formed as to provide a space between an upper and a lower side for the storage of batteries required in the operation of the device and for the maintenance of small tools and accessory or repair parts. If desired, a drawer may be provided in this space for this purpose. Into this space, furthermore, portions of the devices supported by the upper plate may extend. A pair of uprights 11 is secured by means of bolts or other suitable devices to the upper plate of the base member and these uprights are adapted to support an electro-magnet forming part of the galvanometer. The magnet comprises a frame 12, a part of which forms the core of the magnet, and two branches of which have secured thereto pole

pieces 13 which face each other and have only a small air gap between them. A coil 14 is mounted on the magnet frame and when suitably connected to a source of current serves to produce an intense magnetic field between the two tapered noses of the pole pieces.

Referring to Figure 3, it will be seen that the current for energizing the coil 14 may be derived from a battery 15 which is connected to a pair of binding posts or sockets 16 carried by the upper plate of the base. From these binding posts one branch 17 of the circuit leads directly to one end of the coil, while the circuit from the other binding post is led through a switch 18 to the opposite end of the coil. It will be clear that when the switch 18 is closed, a current will flow through the coil of the magnet and set up the desired magnetic field. In this field and substantially half way between the points of the poles, a pair of galvanometer strings of suitable material and dimensions will be supported by means of a holder which will now be described.

As best shown in Figures 4, 5, 6 and 7, the holder comprises a main supporting plate 20 which is adapted to slide in a pair of grooves 21 formed in blocks 22 secured in any suitable way to the pole pieces of the electromagnet. A secondary supporting plate 23 is secured to the plate 20 by means of a thin strip 24 of resilient material, such as spring brass, the construction being such that the end of plate 23 to which this strip is secured is spaced a slight distance, which may be about one quarter of an inch, from the main plate 20 while the opposite end of the plate 23 is urged by the resilience of the springy supporting strip toward the base plate. An adjustable screw 26 having a knurled head 27 and turning in a screw threaded bushing in the base plate 20, is adapted to hold the free end of secondary plate 23 at any desired distance from the main plate. At the left hand end of the plate 23 there is secured a pair of L-shaped string supporting members 28. These members may be secured in any suitable way to the plate 23 as by the screws shown and are separated a slight distance by a piece of some suitable insulating material 29. Similar string holding elements 30 and 31 are carried at the opposite end of the plate 23 for the purpose of supporting the opposite ends of the two galvanometer strings. The elements 30 and 31, however, are not directly secured to the plate 23 but are adjustably mounted thereon in such a way as to permit a variation in the tension of the strings. The element 30 is slidable in a block 32 which is secured in any suitable way to the plate 23. A clamp or strap 33 may be passed over the upper edge of the block 32 and secured to the sides of the latter for holding the element 30 within a groove in the block in which the element is slidable. A spring 35 is com-

pressed between a plate 36 secured to the block 32 and an upstanding portion of the element 30. This spring serves to force the element toward the left in Figure 5 until its end engages the tapered portion 37 of a screw 38 which passes through threads formed in the block 32. It will be apparent that upon turning the screw 38 the tapered portion 37 will engage the end of element 30 and force the latter toward the right in Figure 5 to thereby increase the tension on the string which is connected between the element 30 and the lowermost of the elements 28. This will hereinafter be termed the B string. A somewhat similar arrangement is provided for supporting the element 31 to which the upper end of the other string, which will hereinafter be termed the A string, is connected. Thus the element 31 is slidably mounted in a groove in a block 39 and a clamp or strap 40 is provided to hold the element in place. A spring 41 acting between a plate 42 secured to the block and an upstanding portion of the element 31 serves to force the latter toward the left of Figure 4 until its end engages the tapered portion of a screw 43. However, in place of securing the block 39 directly to the plate 23, as in the case of block 32, it is fastened thereto by means of a resilient member 44 formed of any suitable material, such as spring brass, and which may be secured at one end to the plate 23 and at its other end to the block 32. The resilient member serves to urge the block toward the plate 23 until it is engaged by the point of a set screw 45, which is carried by threads in the plate 23. The ends of the holding members 28, 30 and 31, are suitably bent so that the two strings supported between them will be directly superimposed and will therefore appear as one in Figure 4, but will appear as two separate strings separated by a very slight distance which may be as little as 1/64th of an inch or possibly even less, as shown in Figure 5. The distance between the two strings at the left hand end is fixed or may be adjusted to any suitable extent by merely permanently bending the elements 28 while the amount of separation at the right hand end may be controlled by the screw 45. It should be understood that in the taking of a record from the strings, only a relatively small section intermediate the two ends will be effective, and the degree of separation at this point may be readily regulated by the screw 45. For the purpose of damping the vibrations of the strings, a clip 46 formed preferably of thin sheet metal, is mounted on the plate 23 at a point about midway of the length of the strings. A drop of oil caught between the two ends of the clip is adapted to surround both strings at this point and produce the desired damping effect.

The element 28 which supports the lower end of the A string, is connected by means of

a flexible wire 49 to a plate 47, which serves to electrically connect the A string to a binding post 48. The element 31 which supports the opposite end of the A string, is connected by a flexible wire to a conductor 50 which serves to electrically connect the upper end of the A string to a binding post 51. Similarly the lower end of the B string is connected to a binding post 52 having a contact point 53 on the opposite side of the plate 20. For this purpose a flexible connector 54 and a plate 55 are employed between the element 28 and binding post 52. The upper end of the B string is connected through its block and through the resilient spring member 24 to the screw 56 which is connected by a conductor 57 to a binding post 58 affording a contact element 59 on the opposite side of the plate 20. A block 60 (Fig. 2) secured to the upper plate of the base 10 carries a pair of contact elements 61 which are adapted to engage and make electrical contact with the points 53 and 59 connected to the opposite ends of the B string. Suitable electrical connections are then made from the contact elements 61 to plugs or sockets 62. On the opposite side of the string holder, a pair of contact elements 63 also carried by the block 60 are adapted to engage the upper set of binding posts 48 and 51 to which the opposite ends of the A string are connected. These contact members 63 are then connected in a similar way to plugs or sockets 64 carried by the upper plate of the base.

Referring now to the diagram of Figure 3, it will be seen that the plugs or sockets 62 may be connected in any suitable way to the source of the electrical impulse which it is desired to reproduce by means of the B string. For example, these terminals may be connected to an amplifier 35 which is adapted to receive an electrical impulse from any suitable generating source, such as 66. The latter may, for example, be a magneto-electrical device or a type of microphone which is inserted in the ground and which may be affected by sound or similar waves transmitted through the earth. Preferably a variable resistance 67 will be provided across the terminals of the B string for the purpose of controlling the magnitude of the impulse imposed upon the string. The plugs or sockets 64 may be connected to the same type of source of electrical impulse or to an entirely different kind of source as desired. Furthermore, the connections from the sockets 64 to the contact elements for the A string may be precisely the same as from the sockets 62 to the B string; however, as shown in Figure 3, it is preferred to modify these connections slightly in order to permit impulses from several sources to be applied to the A string at will. Thus, while the connection from one of the terminals 64 to one end of the A string is direct, the connection from the other

terminal may be passed in series through a resistance 68 and from there to the opposite end of the A string. It will be apparent that a circuit is thus completed, with only a small added resistance, to affect the A string in just the same way that the B string is affected under the control of a detector 66. The resistance 68 is relatively small compared with the resistance of the string and the balance of the circuit so that it does not tend to modify the effect produced to any considerable extent.

Now in addition, the A string is subject to the control of a secondary coil 69 of a transformer which may be connected in parallel across the resistance 68. It will be clear that any impulse set up in the secondary 69 by virtue of a change in the current flowing in the primary coil 70 of the transformer, will set the A string into vibration just as when the detector 66 for this string is operated. In Figure 3 a number of separate means is disclosed for effecting the desired variation in current in the primary winding 70. For example, a relay 71, which may be affected by any suitable controlling source, as by means of a radio receiver 72, may be connected to terminals 73 which in turn are connected by a pair of conductors 74 and 75 together with a variable resistance 76, a source of current 77 and a connection 78 to the opposite ends of the primary coil 70. Similarly a telegraph key 79 may be connected to terminals 80 which are placed in parallel with the terminals 73. Thus, any signal which may be desired, consisting of dots and dashes, may be transmitted to the primary winding 70 and by virtue of the secondary winding 69 may affect the A string of the galvanometer. A third source of impulse for affecting the current in the primary winding 70 is illustrated in the upper right hand corner of Figure 3. This may be controlled by a rupture occasioned in a circuit 81 passing through a coil 82 surrounding a charge of explosive by virtue of the discharge of the latter. The circuit 81 may, as shown, be connected to terminals 83 which are in parallel with the resistance 76 and by means of which a sudden change in the current in the primary winding 70 may be made to take place upon the breaking of the circuit at 82. Obviously any number of other sources or causes of variation in the current in the primary winding 70 might be added to the circuits disclosed for the purpose of affecting the A string of the galvanometer. Furthermore, the B string might be connected up in a similar way to be affected from several distinct sources. On the other hand, the operation of each of the strings might, if desired, be limited to the control from the single source represented by the related detector 66.

For the purpose of reproducing the vibra-

tions of the pair of galvanometer strings, either visually or in the form of a permanent record, a beam of light is directed toward the strings and passes on beyond to a screen or the lens or focal opening of a recording camera. It will be apparent that the points or small sections of the strings located in the path of this beam of light will cast a shadow in the image on the screen or upon the moving photographic record strip and will therefore produce a line on the latter which in the negative will appear as white on black. Furthermore, as the strings are vibrated due to the reception of an impulse in the manner indicated, the shadow points which they cast will move in a vibratory path transversely of the record strip and by virtue of the constant and uniform feed of the latter will produce a wave form which is substantially the same as that produced in the strings themselves.

Referring now to Figure 1, it will be noted that a suitable source of light is provided such as an electric lamp not shown but which is enclosed within the tube 85. An electrical connection 86 to a plug 87 provides means for placing the lamp in circuit with the terminals 88 which in turn are connected to a suitable source of current. This source, may, as shown in Figure 3, be the same as is employed to energize the electro-magnet coil 14. For this purpose a direct connection may be made between one of the terminals 88 and one of the terminals 16 connected to a battery or other source of electricity. The remaining terminal 88 is preferably connected to a variable resistance 89 and an extra resistance 90 by means of which the intensity of the light created by the lamp may be controlled. The return circuit to the opposite terminal of the source of electricity may then be passed through the same switch 18 which controls the coil of the magnet. Within the tube 85, there will preferably be located suitable condensing lenses for the purpose of concentrating the rays of light and producing a relatively thin flat beam. Connected to the tube 85 and movable therewith is a smaller tube 86a which passes through an opening in the pole pieces 13 of the electro-magnet and is slidable therein. This tube is suitably cut away at a point adjacent the pair of galvanometer strings so that the holder for the latter may be readily inserted and withdrawn in the manner already indicated. Within the tube 86a suitable lenses will also be provided for the purpose of concentrating the light rays and bringing them to a focus upon the film within the camera. A screw 87a is fitted into threads formed in one of the pole pieces 13 and at its other end is adapted to engage a portion of the tube 85. A spring 88a connected between a pin on the tube 85 and a screw on the pole piece 13 serves to draw the tube against the end of

the screw 87. It will be apparent that turning of the screw 87a by means of the knurled wheel 89a secured thereto will provide means for longitudinally shifting the tube 85 as well as the connected tube 86a. This serves to modify the relation between the lenses in the latter tube and the strings as well as the record strip or film within the camera, so that a clear and sharp focus may be obtained. A link 91 is preferably provided in conjunction with the spring 88a to prevent excessive movement of the tubes 85 and 86a which might result in the breaking of the galvanometer strings. This link may be secured at one end to the pole piece 13 and be provided with a slot surrounding the pin on the tube 85 to which the spring 88a is attached. A short distance from the camera there is provided a cylindrical lens 92 which is carried by a holder 93 mounted on a pair of supporting rods 94 secured to the upper plate of the base 10. The camera 95 may be of any suitable construction and comprises essentially means for feeding a photographic film past a narrow opening at a constant and uniform rate. The desired speed of travel of the film will depend largely upon the frequency of the waves produced in the strings of the galvanometer. It has been found that a speed of about one foot per second is quite satisfactory for the purpose of reproducing sound or similar waves detected by the devices 66.

Referring to Figure 8, it will be seen that a supply roll 96 is provided within the camera casing and is mounted for rotation upon a suitable stud 97. The record film from the roll 96 is passed around a guide roller 98 and then around a pair of rollers 99 intermediate which a narrow slit 100 is provided in a plate which substantially closes an opening 101 at the front of the camera. From the lower roller 99 the film is led around suitable guides 102 and 103 onto a storage roll 104. Any suitable means may be provided for feeding the film at a substantially uniform rate and winding it on the storage roller. A synchronous motor might be provided for this purpose, or a spring motor such as may be housed in the portion 105 (Fig. 1) of the casing, may be provided. This motor should be connected by suitable gearing to the roll 104 and should preferably be controlled as to speed of operation by means of any suitable form of governor mechanism. A detachable key 106 is provided for winding the spring of the motor whenever necessary.

It will be clear from the foregoing description that a permanent record of the vibrations of the galvanometer strings may be produced upon the camera film by virtue of the shadows formed in the beam of light focused upon the film. The strings in vibrating will have that point on each which is in the path

of the relatively flat beam of light oscillated transversely so that as the film is advanced at a fairly rapid rate of say one foot per second, the point shadows produced by the strings will trace a wavy line whose form depends upon the nature and frequency of the vibrations of the strings.

For many purposes it may be desired to determine small periods of time, as for example, intervals of 1/100th of a second, with a fair degree of accuracy. While the movement of the film within the camera may be at a sufficiently uniform rate for many purposes other uses of the oscillograph embodying the present invention may call for greater accuracy in the determination of the time element. For this reason means are provided for producing with great accuracy a series of lines upon the film, the space between which may represent any desired interval of time preferably 1/100th of a second. Obviously any other time interval might be adopted if desired.

The line forming means comprises a wheel 107 (Figs. 1 and 9) having a series of thin spokes which are adapted to pass in front of the opening 101 of the camera at the desired rate to produce the time lines. This wheel is mounted upon a shaft 108 of a synchronous motor 109 which is driven at a uniform rate. The shaft may either be the main shaft of the motor or one directly geared thereto through reduction gearing. In order to insure the necessary uniformity in the operation of the motor 109, it is controlled directly by a tuning fork 110 (Fig. 3). This tuning fork is adapted to control the frequency of the interruptions or impulses of the current passed through the pole coils of the synchronous motor 109. Thus on one branch of the tuning fork there is mounted a contact member 111 which is carried toward and away from a fixed contact 112 upon vibrations of the fork. Whenever these two contacts are brought together, a circuit will be closed through a conductor 113, a conductor 114, and a source of electricity, such as a battery 115, to a pair of terminals 116. The latter may be suitably connected to terminals 117 provided on the oscillograph and which, as shown in Figure 3, are connected to the pole coils 118 of the motor. In the connection 113 there may be provided a suitable ammeter 119, if desired. It will be clear, therefore, that the interruptions or impulses of the current in the circuit through the pole coils will depend directly upon the frequency of the tuning fork.

Now for the purpose of maintaining the fork in continuous operation a contact 120 is provided on the opposite branch of the fork and adapted to cooperate with a fixed contact 121. When these two contacts are closed, a circuit is completed through a coil 122 of an electromagnet which serves to draw

the two branches of the fork toward each other. The circuit through the coil 122 may be made through the conductor 114 to a battery or other source of current 123 and from the opposite side of the battery to a variable resistance 124 for controlling the current passing through the coil. An ammeter 125 and a switch 126 may also be provided in this branch of the circuit for determining the amount of current which is being used and for controlling the operation of the device.

In the use of this controlling mechanism for the synchronous motor, the tuning fork is set into operation by merely pinching the ends of the fork together with the fingers. The resulting vibration of one branch of the fork will cause the coil 122 to be alternately energized and de-energized at the frequency determined by the frequency of the fork itself, while the opposite branch of the fork will similarly control the frequency of interruptions in the current passing through the pole coils of the motor. Now to start the motor into proper operation, the shaft 108 must be manually set into operation at substantially the proper speed in synchronism with the current variations set up by the tuning fork. A knurled head 127 is provided at the end of the shaft 108 for this purpose. The wheel 107 is preferably provided with ten spokes and the wheel is rotated at a speed of 600 revolutions per minute under control of the fork so that a spoke will pass through the beam of light at a point near the opening 100 in the camera every 1/100th of a second. In order to demark intervals of 1/10th of a second, one of the spokes of the wheel will preferably be broken at some point, preferably the mid-point so that a broken line will appear upon the record for every tenth one of the time lines formed.

It will be apparent that various additional controls to those mentioned may be embodied in the oscillograph contemplated by the present invention, such as additional rheostats, if desired, and suitable indicating volt meters and ammeters may be placed in any of the circuits desired. Numerous changes of various kinds may be made in the construction of the device without departing from the spirit of the invention and it is desired to be limited only by the scope of the claims which follow:

The invention herein described may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon or therefor.

What I claim is:

1. In a device of the class described a plurality of filamentary elements adapted to be set into vibration by electrical impulses, a holder common to said elements, means for projecting a single beam of light across a

portion of all of said elements, and means for simultaneously recording the movements of said elements across said beam of light.

2. In a device of the class described a support, an electromagnet mounted on said support, a holder removably mounted on said support, a plurality of galvanometer strings secured to said holder, means for providing detachable electrical connections between said strings and said support and means for conducting impulses from different sources to said strings separately.

3. In a device of the class described a support, an electromagnet mounted on said support, a holder removably mounted on said support, a plurality of galvanometer strings secured to said holder, sliding electrical connections between said strings and said support, means for conducting impulses from different sources to said strings separately, and common means for indicating the vibrations of said strings.

4. In a device of the class described a support, an electromagnet mounted on said support, a holder removably mounted on said support, a plurality of galvanometer strings secured to said holder, slidable detachable electrical connections between said strings and said support, means for conducting impulses from different sources to said strings separately, and common means for recording the vibrations of said strings on a single record strip.

5. In a device of the class described a support, a magnet mounted on said support, a holder removably mounted on said support, a plurality of galvanometer strings secured to said holder, sliding electrical connections between said strings and contacts on said support, means for conducting electrical impulses from different sources to said contacts, means for casting a relatively thin beam of light across said strings, and common means for photographically recording the vibrations of said strings in response to said impulses.

6. In a device for supporting a plurality of galvanometer strings, a base plate, a secondary plate attached to said base plate, means for adjusting the position of one end of said secondary plate relative to said base plate, and means on said secondary plate for supporting the ends of said strings.

7. In a device for supporting a plurality of galvanometer strings, a base plate, a secondary plate attached to said base plate, means for adjusting the position of one end of said secondary plate relative to said base plate, and means on said secondary plate for supporting the ends of said strings, said last mentioned means at one end of said strings being adjustable to vary the tension of the strings.

8. In a device for supporting a plurality of galvanometer strings a base plate, a sec-

ondary plate attached to said base plate, means for adjusting the position of one end of said secondary plate relative to said base plate, means for attaching one end of each of said strings to said secondary plate in relatively fixed position, and means for adjustably attaching the opposite ends of said strings to said secondary base to permit variation of the tension of the strings.

9. In a device for supporting a plurality of galvanometer strings a base plate, a secondary plate attached to said base plate, means for adjusting the position of one end of said secondary plate relative to said base plate, means for attaching one end of each of said strings to said secondary plate in relatively fixed position, and means for adjustably attaching the opposite ends of said strings to said secondary base to permit variation of the tension of the strings, said last mentioned means being adapted to vary the relative positions of said strings.

10. In a device of the class described a base plate, a plurality of galvanometer strings, and means for securing said strings to said base, said means being adapted to permit the movement of all of said strings relative to said base and the movement of said strings relative to each other.

11. In a vibration recorder having a vibrating string, means for damping the vibrations of said string comprising a member mounted in close proximity to the center portion of said string and arranged to hold a small quantity of a liquid in contact with said portion of said string.

12. In a vibration recorder having two vibrating elements, means for damping the vibrations of said elements comprising a clip mounted adjacent a portion of said elements and arranged to hold a small quantity of oil or the like in contact with said elements.

13. In a vibration recorder having two vibrating strings, a support for said strings, and means for damping the vibrations of said strings comprising a member secured to said support and substantially surrounding a portion of said strings, said member being adapted to hold a drop of oil in contact with said portion of said strings.

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