

May 27, 1958

E. TRAUB ET AL

2,836,479

ELECTRICAL RECORDING APPARATUS

Filed July 16, 1952

2 Sheets-Sheet 1

FIG. 1

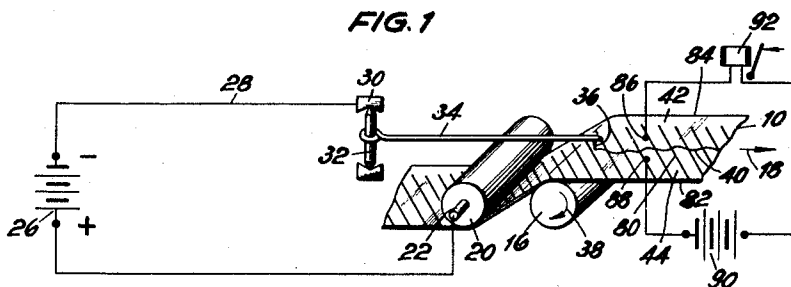


FIG. 2

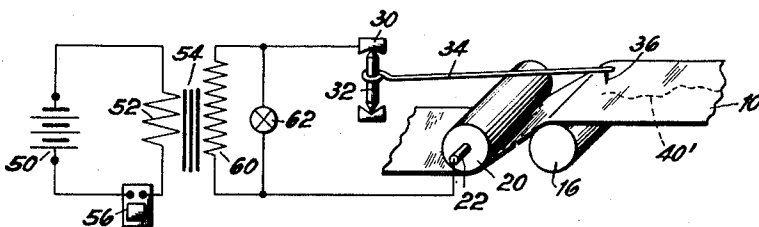


FIG. 3

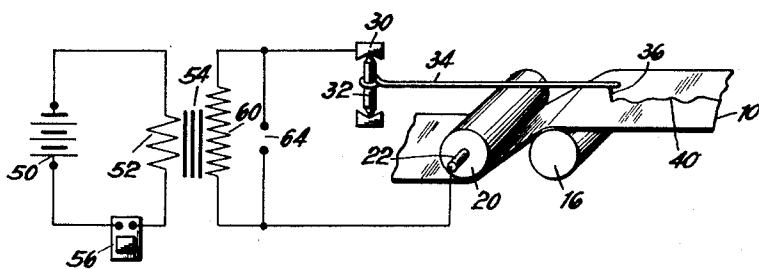
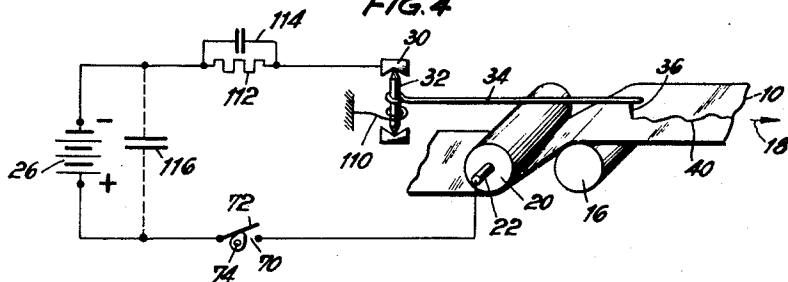


FIG. 4



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FIG. 5

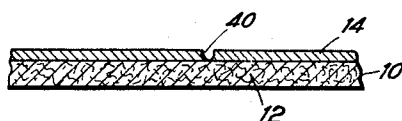


FIG. 6

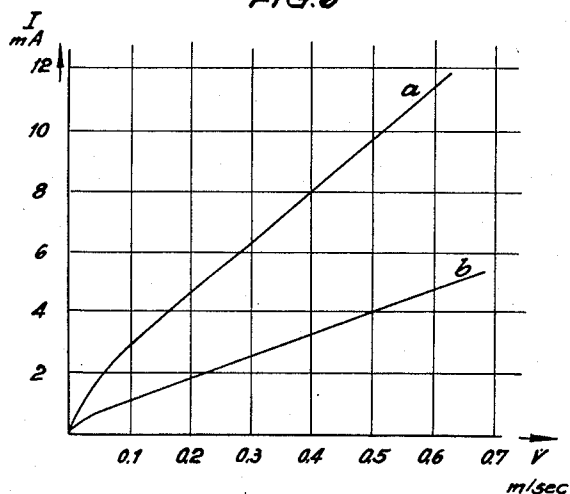


FIG. 7

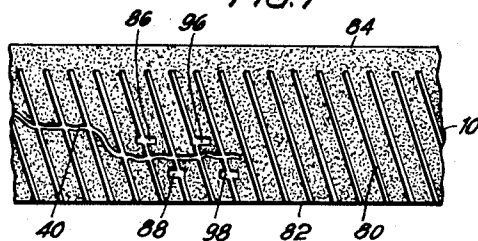
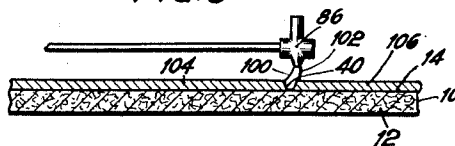


FIG. 8



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ELECTRICAL RECORDING APPARATUS

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Application July 16, 1952, Serial No. 299,152

19 Claims. (Cl. 346—74)

The present invention relates to an electrical recording apparatus, and more particularly to an apparatus for electrically recording readings of an instrument.

The present application is a continuation-in-part of the copending application, Serial No. 195,372, filed November 13, 1950, for "Recording Instrument With Electrical stylus."

It is an object of the present invention to provide a recording apparatus of the type described in which the recording line is extremely fine.

It is another object of the present invention to allow very accurate recordings to be made.

It is a further object of the present invention to provide means for determining the period of the deflections of the recording pointer.

An electrical recording apparatus according to the present invention comprises in its broadest aspect a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms/sq. cm., a recording element having an electrically conductive recording point, means for moving at least one of the elements with the recording point of the recording element permanently in close proximity to the metal coating of the record carrying element, and means for imparting a potential difference to the electrically conductive recording point and the metal coating whereby a trace of the relative motion between the recording element and the record carrying element is produced on the metal coating by the electric discharge between the recording point and the metal coating caused by the potential difference imparted to the same.

Preferably the metal coating has a specific surface resistance of 2-10 ohms/sq. cm.

Preferably the metal coating consists of a zinc cadmium alloy having a zinc content below 30%.

The potential difference between the recording point and the metal coating preferably does not exceed 50 volts and should be kept even below 14 volts.

In a preferred embodiment of the present invention a current source is connected to the electrically conductive recording point and said metal coating and a condenser is connected in parallel to the current source.

Preferably at least one electrical resistor is inserted between the current source and the electrically conductive recording point and a capacitor is connected in parallel with the electrical resistor.

A preferable embodiment of the present invention comprises in combination a recording element consisting of a dielectric strip and a metal coating having a specific surface resistance of 1-50 ohms/sq. cm., and covering one side of the strip, means for imparting a longitudinal motion to the strip, a movable pointer forming part of an instrument, the pointer carrying out swinging motions substantially transversely to said strip, a needle rigidly secured to the end of the pointer with its point in close proximity to, and separated by an air gap from the metal coating, and means for imparting a potential difference to the needle and the metal coating whereby a trace of the

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motion of the pointer is produced on the metal coating by the electrical arc discharge between the point of the needle and the metal coating caused by the potential difference imparted to the same.

5 Preferably means are provided for interrupting the electric current flowing between the recording point of the metal coating during predetermined intervals of time. Preferably a semi-incandescent lamp or a spark gap is mounted in parallel to the recording point and the metal coating.

10 In a further development of the present invention the metal coating has a plurality of substantially parallel insulating lines extending from one edge of the strip to points being spaced apart from the other edge of the strip and the metal coating, and a pair of auxiliary electrodes is arranged so as to contact the metal coating at predetermined places, respectively, a relay being connected in series to the auxiliary electrodes so that the relay circuit is interrupted whenever the conductive connection formed by the metal coating between the auxiliary electrodes is interrupted by the trace produced in the metal coating. Preferably the auxiliary electrodes have a width being larger than the width of the insulating lines on the metal coating. Preferably each of the auxiliary electrodes consists of two parts, preferably thin wires, having different lengths, connected in parallel, the two parts of wires being arranged relatively to each other so that when one of them is moving across one of the insulating lines, the other one of the parts or wires is in contact with the metal coating.

30 The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

40 Fig. 1 is a perspective view of the recording mechanism according to the invention together with wiring diagrams of the electrical circuits connected thereto;

Fig. 2 is a similar view of another embodiment of the invention;

45 Fig. 3 is a similar view of a modification of Fig. 2; Fig. 4 is a similar view of still another modification of the present invention;

Fig. 5 is a cross-section on an enlarged scale of a part of Fig. 4;

50 Fig. 6 is a diagram for explaining the operation of the device shown in Fig. 4;

Fig. 7 is a plan view on an enlarged scale of the recording element shown in Fig. 1; and

55 Fig. 8 is a side elevation, partly in section, on an enlarged scale of part of Fig. 5 and one of the auxiliary electrodes.

Referring now to the drawings and first to Fig. 1, a record-carrying element 10 consists of a dielectric base or strip 12 shown on an enlarged scale in Figs. 5 and 8 and a metal coating 14 having a specific surface resistance of 1 to 50 ohms/sq. cm. and preferably of 2 to 10 ohms/sq. cm. The measurement of these resistance values is preferably carried out by placing two measuring electrodes spaced apart from each other by 1 cm. on a strip having a width of 1 cm. and being metallized by depositing the metal from the vapor state or by cathodic evaporation. If the resistance values mentioned hereinabove are ascertained according to this method the thickness of the metal coating 14 is in the order of 0.3 to 0.002 microns.

It has been discovered that only within the limits of the specific surface resistance given hereinabove is

obtained the special advantage of the metal coating 14 for recording purposes as to a faithful reproduction of the amplitudes as more fully described hereinafter. Metal coatings having a higher specific surface resistance involve the drawback that they have too low a mechanical resistance. On the other hand, metal coatings having a lower specific surface resistance, allow only very low speeds of recording. However, with metal coatings having a specific surface resistance of 1 to 50 ohms/sq. cm. a small power is sufficient for burning or melting the metal so as to obtain a clean record even if the recording speed and the amplitude to be recorded are subject to a great deal of fluctuations. This is particularly important in case quantities have to be recorded which are subject to a very fast change in time and with large amplitude so that in order to obtain a sufficient resolving power a large speed of the dielectric strip 12 is necessary. The recording speed being the vector sum of the speed of the dielectric strip and the speed which causes the deflection of the needle 36 more fully described hereinafter, can reach considerable values, for instance of 10 m./sec. and more.

Furthermore, the very small thickness of the metal coating 14 allows to insert into the electric circuit more fully to be described hereinafter resistors, condensers, inductors or combinations of the same which are more fully disclosed with reference to Fig. 6 and owing to the low power needed for the recording have to be dimensioned for a low load. Also the current sources have to supply only a low power. All these factors cooperate in rendering the recording line 40 or 40' more fully to be described hereinafter very uniform so that the metal coating 14 is subdivided over the entire length of the recording line 40 into two parts 42 and 44 more fully described hereinafter and electrically insulated against each other. This is important with regard to the evaluating methods more fully described hereinafter with respect to combinations with control devices such as those more fully described hereinafter which all require for their operation a clean separation of the parts 42 and 44 by the recording line 40 and/or an exact definition of the distance of the recording line 40 from the edge 82 shown in Fig. 7 of the strip 12 or another reference line.

The metal coating 14 covers one side of the strip 12 so as to metallize the same. The strip 12 is flexible and is moved over a roller 16 in the longitudinal direction of the strip 12 by a suitable driving means (not shown) so that the recording element 10 moves in the direction of the arrow 18. Another roller 20 is arranged parallel to and at a short distance from the roller 16, the recording element 10 forming an S-shaped curve and being touched by the rollers 16 and 20, respectively, on the side of the strip 12 and the side of the metal coating 14. The roller 16 consists preferably of dielectric material whereas the roller 20 consists of electroconductive material, for instance carbon, and is in conductive connection with the metal coating 14. The axle 22 of the roller 20 is connected by a wire 24 to the positive terminal of a current source 26 the negative terminal of which is connected by a wire 28 to the bearing 30 of an axle 32 forming part of a measuring instrument (not shown). The current source 26 is preferably a battery supplying a voltage of less than 50 volts and preferably less than 14 volts. The bearing 30 and the axle 32 are made from electrically conductive material. The axle 32 carries a pointer 34 also made of electrically conductive material and carrying at its free end a metal needle 36 arranged with the point thereof in close proximity to the metal coating 14 and is preferably in sliding contact with the same.

The operation of the device so far described is as follows:

When the roller 16 moves in the direction of the

curved arrow 38 the dielectric strip 12 of the record carrying element 10 with the metal coating 14 moves in the direction of the arrow 18, that is, in longitudinal direction of the recording element 10. Simultaneously the pointer 44 of the measuring instrument (not shown) carries out swinging motions substantially transversely to the recording element 10 and the metal coating 14. Furthermore, a potential difference is imparted by the current source 26 to the needle 36 of the pointer 34 and the metal coating 14, the needle 36 being preferably connected to the negative terminal of the current source 26 and the metal coating 14 over the roller 20 to the positive terminal of the current source 26. In consequence thereof a discharge of electric current is caused between the needle 36 and the metal coating 14 which produces in the metal coating an insulating line 40 according to the positions of the pointer 34 and subdividing the metal coating into two parts 42 and 44 being separated from each other by the line 40. Since the metal coating 14 is extremely thin, its thickness being in the order of 0.3 to 0.002 microns, the needle 36 will burn an extremely fine line 40 into the metal coating 14 which has well-defined margins and is free of slag, beads of molten metal and other irregularities.

Referring now to Fig. 2 a current source 50 is connected to the primary winding 52 of a transformer 54. The primary winding 52 is connected in series to a buzzer 56 being under the influence of a restoring spring 58. The secondary winding 60 of the transformer 54 has many more turns than the primary winding 52 and is connected to the bearing 30 and the axle 22 of the roller 20. The needle 36 of the pointer 34 is not in contact with the metal coating 14 but is separated from the same by a small air gap across which a spark discharge is initiated by the voltage induced in the secondary 60 of the transformer 54 which has a very high value owing to the periodical sudden interruption of the primary current flowing in the primary winding 52. When the secondary voltage disappears the spark discharge is extinguished. Thus the line 40 formed on the metal coating 14 consists of a succession of separate markings instead of a continuous line such as 40 shown in Fig. 1.

A semi-incandescent lamp 62 is connected across the secondary 60. The semi-incandescent lamp 62 can be omitted; however, it should be provided if the speed of the deflection of the pointer 34 is large because the semi-incandescent lamp 62 aids in obtaining very uniform recording markings on the metal coating 14.

Referring now to Fig. 3 showing a modification of Fig. 2, the semi-incandescent lamp 62 is replaced by a spark gap 64 having the same effect as the semi-incandescent lamp 62.

The embodiments according to Figs. 2 and 3 are used if the friction of the needle 36 on the metal coating 14 would cause an inadmissible dampening of the motion of the pointer 34 of the instrument. The record carrying element 10 can be moved as in the embodiments according to Figs. 2 and 3 at a distance apart from the needle 36 which amounts to a few tenths of a millimeter, so that the needle 36 is not in touch with the metal coating 14. However, the spark generated between the needle and the metal coating has sufficient energy in view of the small thickness of the metal coating to record a continuous and clean recording line 40'. In this arrangement the voltage has to be higher than the limiting voltage of the arc, i. e. it has to be at least 14 volts.

Referring now to Fig. 4 the axle 32 of the measuring instrument is provided with a spiral spring 110 urging the axle 32 into a rest position in which the pointer 34 is not deflected. The needle 36 consists of tungsten or platinum wire having a diameter of preferably 0.15 mm. In consequence thereof the needle 36 rests on the record-carrying element 10 and especially on the metal

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coating 14 thereof with a very low pressure so that only very little friction prevails between the metal coating 14 and the point of the needle 36.

The structure of the record carrying element 10 is shown on an exaggerated scale in Fig. 5. The strip 12 consists preferably of paper having a thickness of about 0.03 mm. and carries a metal coating 14 consisting preferably of zinc and having a thickness of approximately 0.03 microns so that the metal coating 14 has a specific surface resistance of about 4 ohms/sq. cm.

The carbon roller 20 is connected to the positive terminal of a battery 26 supplying a voltage of about 30 volts. The negative terminal of the battery 26 is connected to the bearing 30 over a resistor 112 having preferably a resistance of about 400 ohms. The resistor 112 is shunted by a capacitor 114 of about 1μ f. Since the needle 36 is very thin a high current density is generated at the point of the needle which causes a large Joule heat which is only slightly carried away by the metal coating 14 owing to the slight thickness thereof so that the Joule heat is sufficient, even at a high recording speed, for burning a recording line 40 into the thin metal coating 14.

The line 40 is burned into the metal coating 14 as follows: If the battery 26 is switched in at first a current flows through the metal cover 14 and the needle 36 which is determined by the magnitude of the voltage of the battery 26 and the resistances of the circuit such as that of resistor 112. This current melts, and sometimes even evaporates, the metal surrounding the point of the needle 36. By this the electrical resistance between the needle 36 and the metal coating 14 is increased so that the current decreases and is eventually entirely interrupted at the disappearance of the last portion of the molten metal if the record carrying element 10 and the needle 36 do not carry out any relative motion. If, however, the record carrying element 10 is continually moved in the direction of the arrow 18 during the burning process, the needle 36, even if it is not deflected, comes into contact with fresh portions of the metal coating 14 so that a continuous recording line 40 is generated. During this process a mean burning current I prevails which results from current impulses following one another and diminishing quickly to zero. Fig. 6 shows two curves representing the mean burning current I measured in ma. plotted against the recording speed v measured in m./sec. The curve a shows the dependency of the mean burning current on the recording speed for a metal coating consisting of zinc and having a thickness of 0.06 microns corresponding to a specific surface resistance of 2 ohms/sq. cm., the burning voltage U amounting to 24 volts. The curve b gives the dependency for a zinc coating having a thickness of 0.012 microns corresponding to a specific surface resistance of 10 ohms/sq. cm., the voltage U being 36 volts. It will be seen from these curves that the battery 26 can be dimensioned for a very low power at these extremely thin metal coatings. For instance at a recording speed of 0.5 meters/sec. and a thickness of the zinc coating of 0.012 microns the battery 26 has to supply a load of 36 volts. 4 ma. = 0.144 watts. The current impulses generated at the moment at which the needle 36 touches the not yet melted portions of the zinc covering 14 can increase up to the 30 fold value of the mean current I . In order to render possible a dimensioning of the battery 26 for the mean current I preferably a condenser 116 having a capacity of about 10μ f. is connected in parallel to the battery 26, the condenser 116 operating as an energy storing element. The condenser 116 has to be provided if the battery 26 is replaced by an alternating current source and a rectifier dimensioned for the mean current I .

Since the energy used for burning the line 40 is very small in the device shown in Fig. 4 the current can be interrupted by a switch 70 consisting of a movable switch arm 72 actuated by a return force exerted in a conven-

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tional manner (not shown) and by a rotating cam disc 74 so as to open and close the switch 70 once per revolution of the cam disc 79. The switch 70 interrupts the current at a low loading of the contacts thereof even with a high switching frequency. The line 40 is thus interrupted a predetermined number of times during unit time, e. g. a second, so that the period of the oscillations of the pointer 34 can be read with great accuracy from the line 40 traced in the metal coating 14.

As particularly suitable for the recording described hereinabove have been found beside the metal coating consisting of zinc metal coatings consisting of cadmium and more especially of an alloy of zinc and cadmium having a zinc content not exceeding 30% because the latter have a particularly low melting point (not exceeding 500° C.) and thus admit of the use of small voltages of less than 10 volts. Also, the metal coatings consisting of zinc cadmium alloys involve a further advantage that they are very resistant to atmospheric influences. Record carrying elements having a zinc cadmium coating the thickness of which amounts to about 0.01 micron can be stored for a long time without appreciable disintegration of the material of the metal coating.

Referring now to Figs. 7 and 8 and to the right-hand portion of Fig. 1, the metal coating 14 is provided with a plurality of equidistant substantially parallel insulating lines 80 extending from one edge 82 of the strip 12 and the metal coating 14 to points spaced apart from the other edge 84 of the strip 12 and the metal coating 14. At least one pair of auxiliary electrodes 86 and 88 is arranged so as to contact the metal coating 14 at predetermined places shown in the drawings at opposite sides of the line 40. A current source 90 and a relay 92 are connected in series to the auxiliary electrodes 86 and 88.

The operation of this device is as follows:

The relay circuit 90, 92 remains closed as long as the two electrodes 86 and 88 are conductively connected by the metal coating 14 so that the relay 92 is energized. If, however, the pointer 34 is deflected to such an extent that the recording line 40 lies between the auxiliary electrodes 86 and 88 as shown in Figs. 1 and 7, the conductive connection thereof is severed and the relay circuit will be interrupted so that the relay 92 is de-energized and actuates in consequence thereof a contact 94, operating switches or signalling means (not shown).

If the relay 92 is only to be de-energized if the pointer 34 has remained in the deflected position thereof for a predetermined time interval, two additional auxiliary electrodes 96 and 98 have to be connected in parallel with the auxiliary electrodes 86 and 88, respectively. The auxiliary electrodes 96 and 98 are arranged at a certain distance from the auxiliary electrodes 86 and 88, said distance corresponding to the predetermined time interval. If the pointer 34 swings back within the predetermined time interval, the recording line 40 will follow a course passing between the auxiliary electrodes 86 and 88 but not between the auxiliary electrodes 96 and 98 so that the relay 92 remains energized.

Preferably the auxiliary electrodes such as 86 have a width which is wider than the width of the insulating line, 80, this being indicated in Fig. 7. Preferably each auxiliary electrode such as 86, as shown in Fig. 8 consists of two parts such as two thin wires 100 and 102 of different lengths and connected in parallel which are so spaced from each other than when the auxiliary electrode such as 86 passes from one metallized subdivision 104 to the following one 106 one of the wires (100) is still in contact with the subdivision 104 while the other wire 102 is passing the insulating line 80 or is even in contact with the following metallized subdivision 106.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of electrical recording apparatuses differing from the types described above.

While the invention has been illustrated and described as embodied in an apparatus for electrically recording readings of an instrument, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 2-10 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; and means for imparting a potential difference not exceeding 36 volts between said electrically conductive recording point and said metal coating whereby any electric discharge between said recording point and said metal coating caused by said potential difference produces a trace of the relative motion between said recording element and said record carrying element on said metal coating.

2. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter, said metal having a melting point not exceeding 500° C.; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; and means for imparting a potential difference of less than 50 volts between said electrically conductive recording point and said metal coating whereby any electric discharge between said recording point and said metal coating caused by said potential difference produces a trace of the relative motion between said recording element and said record carrying element on said metal coating.

3. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; said metal consisting of a zinc cadmium alloy having a zinc content being below 30%; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; and means for imparting a potential difference of less than 50 volts between said electrically conductive recording point and said metal coating whereby any electric discharge between said recording point and said metal coating caused by said potential difference produces a trace of the relative motion between said recording element and said record carrying element on said metal coating.

4. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording ele-

ment permanently in close proximity to said metal coating of said record carrying element; and means for imparting a potential difference, not exceeding 50 volts between said electrically conductive recording point and said metal coating whereby any electric discharge between said recording point and said metal coating caused by said potential difference produces a trace of the relative motion between said recording element and said record carrying element on said metal coating.

5. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; and means for imparting a potential difference, not exceeding 14 volts between said electrically conductive recording point and said metal coating whereby any electric discharge between said recording point and said metal coating caused by said potential difference produces a trace of the relative motion between said recording element and said record carrying element on said metal coating.

6. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; a direct current source connected to said electrically conductive recording point and said metal coating; and a storage condenser connected in parallel with said direct current source whereby a potential difference not exceeding 50 volts is imparted between said electrically conductive recording point and said metal coating so that a trace of the relative motion between said recording element and said record carrying element is produced on said metal coating by the electric discharge current between said recording point and said metal coating caused by the potential difference imparted to the same, said direct current source being dimensioned to provide the mean electric discharge current produced between said recording point and said metal coating.

7. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter, said metal consisting of a zinc cadmium alloy having a zinc content being below 30%; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; energizing means for imparting a potential difference between said electrically conductive recording point and said metal coating whereby a trace of the relative motion between said recording element and said record carrying element is produced on said metal coating by the electric discharge between said recording point and said metal coating caused by said potential difference; and at least one resistor connected in circuit with said energizing means for regulating said potential difference.

8. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording ele-

ment permanently in close proximity to said metal coating of said record carrying element; a direct current source connected to said electrically conductive recording point and said metal coating whereby a potential difference not exceeding 50 volts is imparted between said electrically conductive recording point and said metal coating so that a trace of the relative motion between said recording element and said record carrying element is produced on said metal coating by the electric discharge between said recording point and said metal coating caused by the potential difference imparted to the same; at least one electrical resistor connected in series between said current source and said electrically conductive recording point; and a storage condenser connected in parallel with said direct current source, at least one plate of said condenser being connected between said resistor and said current source.

9. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; energizing means for imparting a potential difference between said electrically conductive recording point and said metal coating whereby a trace of the relative motion between said recording element and said record carrying element is produced on said metal coating by the electric discharge between said recording point and said metal coating caused by said potential difference; and at least one resistor and capacitor connected in parallel with each other and in circuit with said energizing means for regulating said potential difference.

10. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; a current source connected to said electrically conductive recording point and said metal coating; a condenser connected in parallel with said current source whereby a potential difference not exceeding 50 volts is imparted to said electrically conductive recording point and said metal coating so that a trace of the relative motion between said recording element and said record carrying element is produced on said metal coating by the electric discharge between said recording point and said metal coating caused by the potential difference imparted to the same; at least one electrical resistor inserted between said current source and said electrically conductive recording point; and a capacitor connected in parallel with said electrical resistor.

11. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; means for imparting a potential difference to said electrically conductive recording point and said metal coating so as to cause an electric current to flow between the same tracing on said record carrying element a trace of the relative motion between said recording element and said record carrying element; and means for interrupting said current periodically during predetermined intervals of time.

12. In an electrical recording apparatus, in combina-

tion, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; means for imparting a potential difference to said electrically conductive recording point and said metal coating so as to cause an electric current to flow between the same tracing on said record carrying element a trace of the relative motion between said recording element and said record carrying element; and means for closing and interrupting said current periodically during predetermined short intervals of time.

13. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; means for imparting a potential difference to said electrically conductive recording point and said metal coating so as to cause an electric current to flow between the same tracing on said record carrying element a trace of the relative motion between said recording element and said record carrying element; and means for interrupting said current during predetermined intervals of time.

14. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; means for imparting a potential difference to said electrically conductive recording point and said metal coating so as to cause an electric current to flow between the same tracing on said record carrying element a trace of the relative motion between said recording element and said record carrying element; means for interrupting said current during predetermined intervals of time; and a semi-incandescent lamp connected in parallel to said electrically conductive recording point and said metal coating.

15. In an electrical recording apparatus, in combination, a record carrying element consisting of a dielectric base and a metal coating thereon having a specific surface resistance of 1 to 50 ohms per square centimeter; a recording element having an electrically conductive recording point; means for moving at least one of said elements with said recording point of said recording element permanently in close proximity to said metal coating of said record carrying element; means for imparting a potential difference to said electrically conductive recording point and said metal coating so as to cause an electric current to flow between the same tracing on said record carrying element a trace of the relative motion between said recording element and said record carrying element; means for interrupting said current during predetermined intervals of time; and a spark gap connected in parallel to said electrically conductive recording point and said metal coating.

16. Apparatus for electrically recording readings of an instrument, comprising, in combination, a recording element consisting of a dielectric strip and a metal coating having a specific surface resistance of 1 to 50 ohms per square centimeter and covering one side of said strip; a plurality of equidistant substantially parallel insulating lines extending over said metal coating from one edge of said strip to points being spaced apart from the other

edge of said strip and said metal coating; means for imparting a longitudinal motion to said strip; a movable pointer forming part of said instrument, said pointer carrying out swinging motions substantially transversely to said strip; a needle rigidly secured to the end of said pointer with its point in close proximity to said metal coating; means for imparting a potential difference to said needle and said metal coating whereby a trace of the motion of said pointer is produced on said metal coating by the electrical discharge between said point of said needle and said metal coating caused by the potential difference imparted to the same; a pair of auxiliary electrodes being arranged so as to contact said metal coating at predetermined places, respectively; and a relay connected in series to said auxiliary electrodes so that the circuit in said relay is interrupted whenever the conductive connection formed by said metal coating between said auxiliary electrodes is interrupted by said trace produced in said metal coating.

17. Apparatus for electrically recording readings of an instrument, comprising, in combination, a recording element consisting of a dielectric strip and a metal coating having a specific surface resistance of 1 to 50 ohms per square centimeter and covering one side of said strip; a plurality of equidistant substantially parallel insulating lines extending over said metal coating from one edge of said strip to points being spaced apart from the other edge of said strip and said metal coating; means for imparting a longitudinal motion to said strip; a movable pointer forming part of said instrument, said pointer carrying out swinging motions substantially transversely to said strip; a needle rigidly secured to the end of said pointer with its point in close proximity to said metal coating; means for imparting a potential difference to said needle and said metal coating whereby a trace of the motion of said pointer is produced on said metal coating by the electrical discharge between said point of said needle and said metal coating caused by the potential difference imparted to the same; a pair of auxiliary electrodes being arranged so as to contact said metal coating at predetermined places, respectively, said auxiliary electrodes having a width being larger than the width of said insulating lines on said metal coating; and a relay connected in series to said auxiliary electrodes so that the circuit in said relay is interrupted whenever the conductive connection formed by said metal coating between said auxiliary electrodes is interrupted by said trace produced in said metal coating.

18. Apparatus for electrically recording readings of an instrument, comprising, in combination, a recording element consisting of a dielectric strip and a metal coating having a specific surface resistance of 1 to 50 ohms per square centimeter and covering one side of said strip; a plurality of equidistant substantially parallel insulating lines extending over said metal coating from one edge of said strip to points being spaced apart from the other edge of said strip and said metal coating; means for imparting a longitudinal motion to said strip; a movable pointer forming part of said instrument, said pointer carrying out swinging motions substantially transversely to said strip; a needle rigidly secured to the end of said pointer with its point in close proximity to said metal coating; means for imparting a potential difference to said needle and said metal coating whereby a trace of

the motion of said pointer is produced on said metal coating by the electrical discharge between said point of said needle and said metal coating caused by the potential difference imparted to the same; a pair of auxiliary electrodes being arranged so as to contact said metal coating at predetermined places, respectively, each of said auxiliary electrodes consisting of two parts connected in parallel, said two parts being arranged relative to each other so that when one of said parts is moving across one of said insulating lines, the other one of said parts is in contact with said metal coating; and a relay connected in series to said auxiliary electrodes so that the circuit in said relay is interrupted whenever the conductive connection formed by said metal coating between said auxiliary electrodes is interrupted by said trace produced in said metal coating.

19. Apparatus for electrically recording readings of an instrument, comprising, in combination, a recording element consisting of a dielectric strip and a metal coating having a specific surface resistance of 1 to 50 ohms per square centimeter and covering one side of said strip; a plurality of equidistant substantially parallel insulating lines extending over said metal coating from one edge of said strip to points being spaced apart from the other edge of said strip and said metal coating; means for imparting a longitudinal motion to said strip; a movable pointer forming part of said instrument, said pointer carrying out swinging motions substantially transversely to said strip; a needle rigidly secured to the end of said pointer with its point in close proximity to said metal coating; means for imparting a potential difference to said needle and said metal coating whereby a trace of the motion of said pointer is produced on said metal coating by the electrical discharge between said point of said needle and said metal coating caused by the potential difference imparted to the same; a pair of auxiliary electrodes being arranged so as to contact said metal coating at predetermined places, respectively, each of said auxiliary electrodes consisting of two thin wires having different lengths and being connected in parallel, said two wires being arranged relative to each other so that when one of said wires is moving across one of said insulating lines, the other one of said wires is in contact with said metal coating; and a relay connected in series to said auxiliary electrodes so that the circuit in said relay is interrupted whenever the conductor connection formed by said metal coating between said auxiliary electrodes is interrupted by said trace produced in said metal coating.

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