March 3, 1936. F. HAUFFE ET AL 2,032,932

ELECTROSTATIC DEVICE

Filed March 20, 1935

Fig. 1.

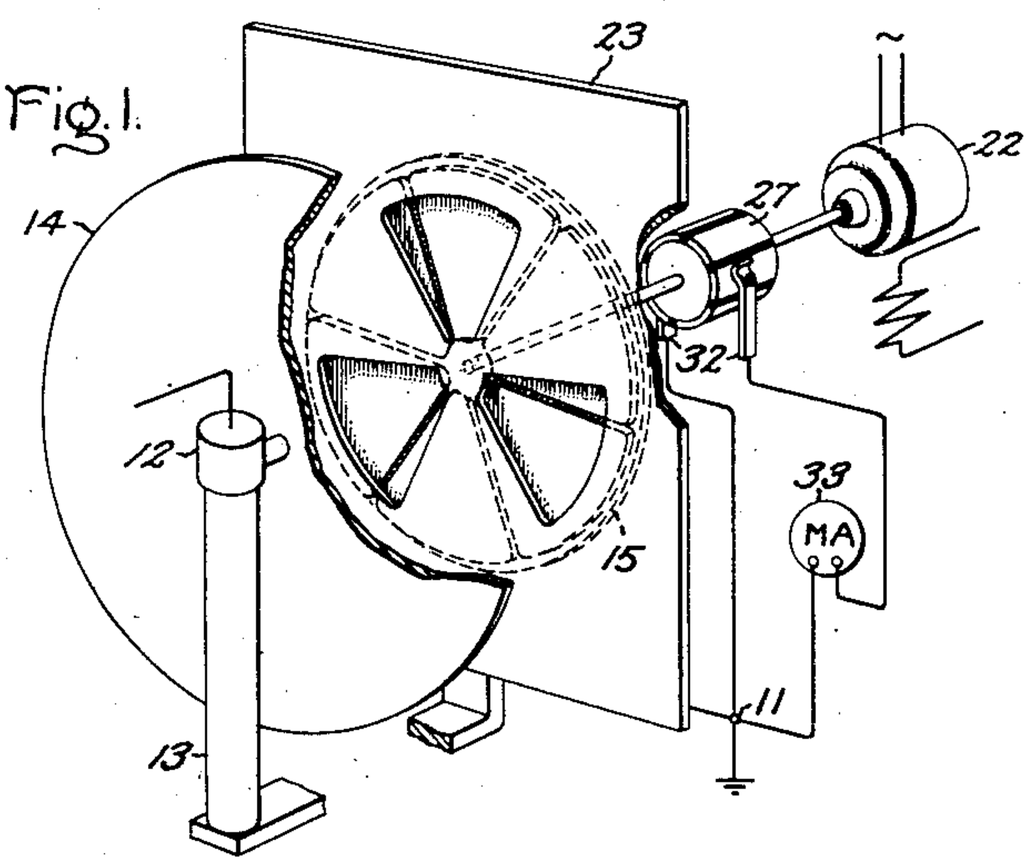


Fig. 2.

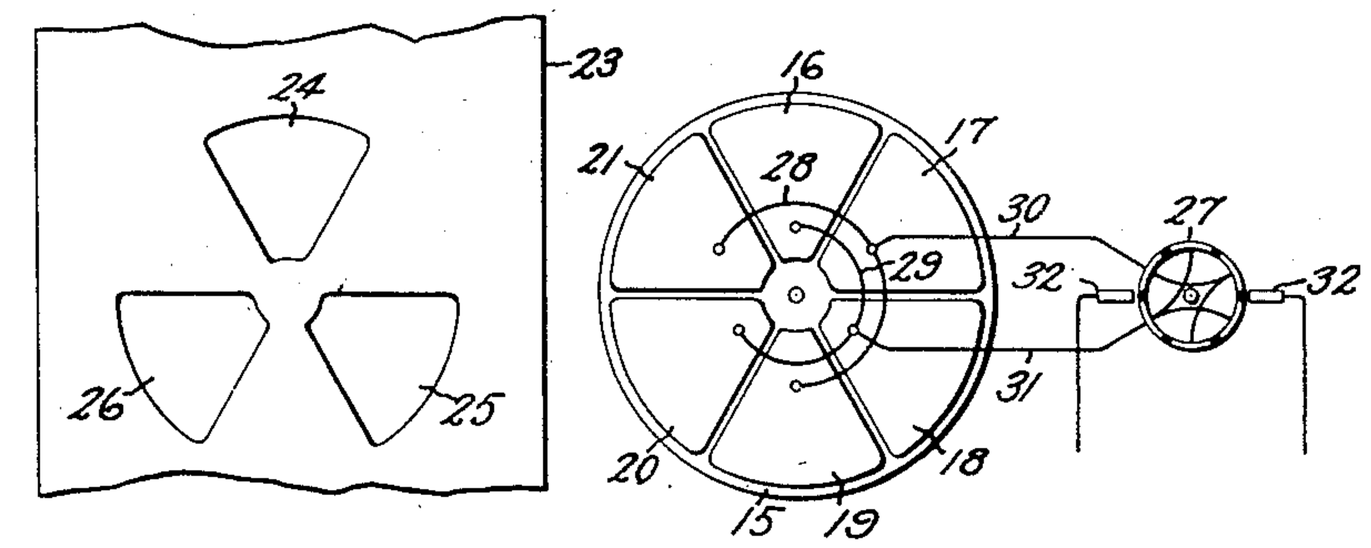
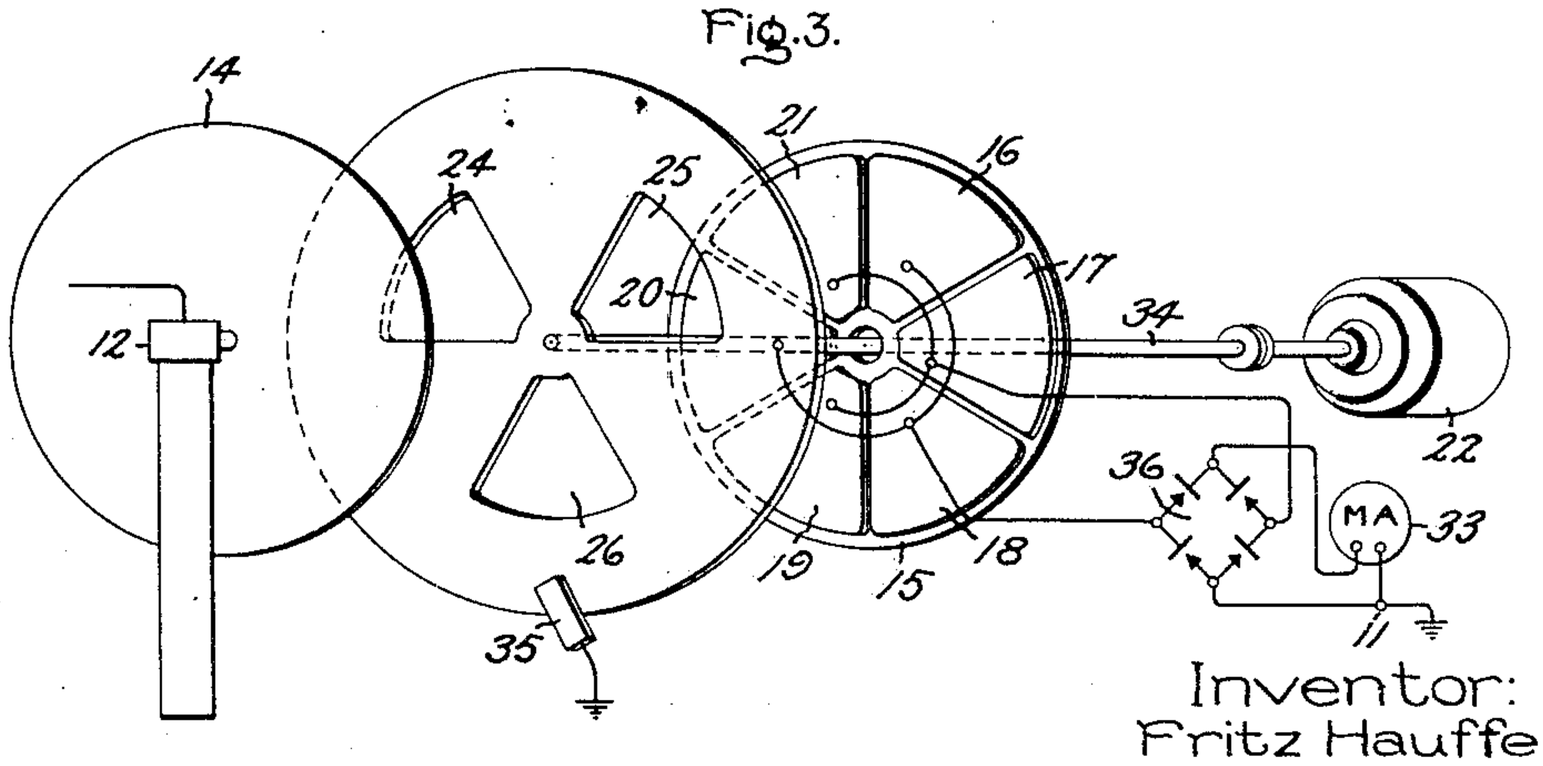


Fig. 3.



Inventor:
Fritz Hauffe,
Claus Fröhmer,
by Harry E. Dunham
Their Attorney.

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2,032,932

ELECTROSTATIC DEVICE

Fritz Hauffe, Berlin-Friedenau, and Claus Fröhmer, Berlin-Charlottenburg, Germany, assignors to General Electric Company, a corporation of New York

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8 Claims. (Cl. 171—95)

Our invention relates to electrostatic devices and concerns particularly such devices arranged as voltmeters.

The principal object of our invention is to produce an electrostatic voltmeter of high sensitivity, especially one which is suitable for high-voltage circuits. Other and further objects and advantages will become apparent as the description proceeds.

The features of our invention which are believed to be novel and patentable are pointed out in the claims appended hereto. A better understanding of the invention may be obtained by referring to the following description taken in connection with the accompanying drawing in which Fig. 1 represents schematically, partially in perspective, one embodiment of our invention; Fig. 2 represents in elevation several elements of the apparatus of Fig. 1, separated to avoid confusion but showing the relative position of the parts of the several elements; and Fig. 3 represents another embodiment of our invention.

The apparatus illustrated in the drawing includes a grounded low-potential terminal 11 and a high-potential terminal 12 mounted on an insulating part 13. A plate 14, which may be circular in shape, is attached to the high-potential terminal 12 to serve as a high-potential electrode. There is provided opposite the electrode 14 and substantially parallel thereto a rotatable disc 15 carrying a plurality of sectors 16 to 21 of conducting material symmetrically arranged about the center of rotation of the disc 15. Suitable means, such as the motor 22, are provided for rotating the disc 15 and the conducting sectors at a uniform speed. In the case of alternating-current circuits, the motor 22 may take the form of a synchronous motor fed by a current of the same frequency as that of the voltage to be measured.

A grounded shield 23 composed of conducting material or faced with conducting material is interposed between the high-potential electrode 14 and the rotatable disc 15 with its conducting sectors 16—21. The shield 23 is provided with sector-shaped openings 24, 25 and 26, symmetrically placed about a central point and registering with alternate conducting sectors of the disc 15 when it is in the proper angular position. There are, however, only half as many openings in the shield 23 as conducting sectors on the disc 15.

In order to produce an indicating current of constant polarity, a commutator 27 is provided which is mechanically connected to the disc 15 or arranged to rotate synchronously with it. The commutator 27 has as many segments as there are conducting sectors on the disc 15, and corresponding segments and sectors are electrically connected. Alternate sectors on the disc 15 are also electrically connected. If desired, alternate sectors 16, 18, and 20 may be connected by a conductor 29, alternate sectors 17, 19, and 21 by a conductor 28, and the corresponding alternate segments of the commutator 27 may likewise be connected to form two groups. Then only two connectors 30 and 31 need be provided to effect the connection between corresponding disc sectors and commutator segments.

Brushes 32, cooperating with the commutator 27, are provided for drawing off the electrostatic charges collected by the conducting sectors on the disc 15 and a current-responsive device 33 is provided for measuring the amount of the charge collected. For the sake of safety, it is preferable to ground the circuit of the instrument 33 in some suitable manner as by connecting one of the brushes 32 to the grounded terminal 11. It is obviously a decided advantage of our invention that the arrangement permits grounding or keeping at low potential all the apparatus with which an operator is most likely by inadvertence to come in contact.

It is apparent that the high-potential electrode 14 will produce an electrostatic field proportional in strength to the voltage to be measured. The charges collected by the sectors 16 and 21 as they are exposed by the openings in the shield 23 will, therefore, be dependent upon the voltage to be measured. As the two groups of sectors 16, 18, and 20, and 17, 19, and 21 are charged alternately and the connections to the current-responsive device 33 are alternated as often as a sector becomes fully exposed to the electrostatic field, the sectors will be discharged through the current-responsive device 33 and a current will flow in device 33 dependent upon the rate at which electric charge is collected by the sectors. The voltage measured by the device as shown is, of course, the voltage of the high potential electrode 14 with respect to ground "potential" and the ground terminal 11 serves as the low potential terminal of the apparatus.

Inasmuch as the charge acquired by a flat plate forming one of the plates of a condenser is proportional to the product of the voltage and the area of the plate, the increment of charge collected by one of the sectors 16 to 21 as they become exposed to the electrostatic field will be

$$dq = kE.ds$$

where k is a constant, E is the voltage and ds

is the increment of exposed area of one of the sectors as it rotates.

The current flowing in the instrument 33 will be the time derivative of the charge or

$$i=\frac{dq}{dt}=kE\frac{ds}{dt}$$

For a given speed of rotation of the sectors, the rate of change of exposed area

$$\frac{ds}{dt}$$

will be inversely proportional to the number of sectors on the disc 15. It is apparent, therefore, that the sensitivity of the apparatus will increase with the number of sectors. For example, by employing six sectors as shown, a current i is obtained which is three times that which would be obtained if there were only two semicircular sectors on the disc 15 and one semicircular opening in the shield 23, other conditions being unchanged.

Although we have illustrated an arrangement in which the shield 23 is stationary and the conducting sectors 16 to 21 are movable, it will be understood that our invention is not limited to this precise arrangement but obviously includes arrangements in which the shield 23, instead of the sectors, rotates or in which both shield and sectors rotate.

For example, in the arrangement of Fig. 3, the insulating disc 15 with the sectors 16 to 21 is stationary, having an axial opening therein to permit a shaft 34 driven by the motor 22 to project through the disc 15 and rotate the shield 23. Although the parts are shown separated for the sake of clearness in the drawing, it will be understood that the shield 23 and the disc 15 are preferably as close together as mechanical considerations permit. The shield 23 may be grounded, if desired, by a brush 35.

In the arrangement of Fig. 3, no commutator is needed and the conducting sectors 16 to 21 may be connected directly to the indicating instrument 33. If the instrument 33 is of a type responsive only to direct currents, a rectifier 36, for example, a bridge connected full-wave rectifier of the copper-oxide type, may be interposed in the circuit of the instrument 33.

While we prefer to utilize the shield 23 with its openings 24, 25, and 26 in order that the conducting sectors 16 to 21 will definitely be subjected to and withdrawn from the influence of the electrostatic field from the electrode 14, our invention is not limited to the precise arrangement shown but obviously includes any arrangement for subjecting a plurality of conducting surfaces to the influence of an electrostatic field proportional to a voltage to be measured and withdrawing the surfaces from the influence of the field, such as, for example, forming the electrode 14 as a plurality of coplanar sectors corresponding to the openings in the shield 23 and then omitting the shield 23.

While we have described the shield 23 and the disc 15 as being planar and the openings and conducting surfaces 24 to 25 and 16 to 21 as being sector-shaped since the electrode 14 is shown as planar, it will be understood that cooperating surfaces of some other shape may be employed.

In using the apparatus to measure alternating voltages, it will be understood that the motor 22 is to be driven at such a speed that each conducting sector is always fully exposed to the influence of the electrostatic field when the voltage has a given polarity, more particularly at a given point in the voltage wave, preferably the peak. In the arrangement shown, with six conducting segments, the motor 22 would accordingly be arranged to run at a speed in revolutions equal to one-sixth the frequency in cycles of the alternating voltage to be measured. For example, a twelve-pole synchronous motor might be employed, energized from the same power system as the voltage to be measured.

In accordance with the provisions of the patent statutes, we have described the principle of operation of our invention together with the apparatus which we now consider to represent the best embodiment thereof but we desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What we claim as new and desire to secure by Letters Patent in the United States is:

1. A static voltage-responsive device comprising in combination, a high-potential electrode, a rotatable disc of insulating material carrying a plurality of sectors of conducting material symmetrical with respect to the center of rotation of said disc, a grounded shield between said high-potential electrode and said disc having half as many sector-shaped openings therein symmetrically placed around a center point as the number of sectors in said disc adapted to register with said conducting sectors, a commutator having segments electrically connected to corresponding sectors on said disc, alternate segments being also connected together, brushes, one of which is grounded, cooperating with said commutator to alternate connections as often as said conducting sectors are either fully exposed or fully covered by said shield, a current-responsive device connected to said brushes, and means for rotating said commutator and said disc.

2. A static voltage-responsive device comprising in combination, a high-potential electrode, a rotatable member including a plurality of insulated sectors of conducting material, a shield between said high-potential electrode and said rotatable member having half as many sector-shaped openings therein as the number of sectors in said rotatable member adapted to register with said sectors, a commutator having segments corresponding to said rotatable sectors, alternate rotatable sectors and alternate commutator segments being electrically connected, brushes cooperating with said commutator, a current-responsive device connected to said brushes, and means for rotating said commutator and said segments.

3. An electrostatic device comprising in combination a high-potential electrode, a charge-collecting member including a plurality of insulated sectors of conducting material, a shield between said high-potential electrode and said charge-collecting member having half as many sector-shaped openings therein as the number of sectors in said charge-collecting member adapted to register with said conducting sectors, said shield and said charge-collecting member being relatively rotatable, a commutator having segments electrically connected to corresponding sectors of said charge-collecting member, and brushes cooperating with said commutator, said brushes and said commutator being relatively rotatable.

4. A static voltage-responsive device comprising in combination, a high-potential electrode, a stationary member including an even number of

insulated sectors of conducting material, a rotating shield between said high-potential electrode and said stationary member having half as many sector-shaped openings therein as the number of sectors in said stationary member adapted to register with said sectors, alternate conducting sectors being connected, and a current-responsive device connected between adjacent conducting sectors.

5. A voltage-responsive device comprising in combination, a high-potential electrode, a charge-collecting member including a plurality of insulated areas of conducting material, a shield between said high-voltage electrode and said charge-collecting member having half as many openings therein as the number of said conducting areas on said charge-collecting member adapted to register with said conducting areas, said shield and said charge-collecting member being relatively movable, means for producing relative motion thereof, and a current-responsive device connectable between adjacent conducting areas on said charge-collecting member.

6. A voltage-responsive device comprising in combination, a high-potential electrode, a charge-collecting member including a plurality of insulated areas of conducting material, means for subjecting said areas to the influence of the electrostatic field from said high-potential electrode and withdrawing said conducting areas from the influence of said electrode alternately, a low-potential terminal, a current-responsive device having a terminal connected to said low-potential terminal and a second terminal, and means for connecting each of said conducting areas to the second terminal of said current-responsive device and to said low-potential terminal alternately.

7. A voltage-responsive device comprising in combination, a high-potential electrode, a charge-collecting member including a plurality of insulated areas of conducting material, means for subjecting said areas to the influence of the electrostatic field from said high-potential electrode and withdrawing said conducting areas from the influence of said electrode alternately, a low-potential terminal, and a current-responsive device having terminals connectable to adjacent conducting areas of said charge-collecting member, one of said current terminals being connected to said low-potential terminal.

8. A voltage-responsive device comprising in combination, a high-potential electrode, a charge-collecting member including a plurality of insulated areas of conducting material, means for removing the influence of the electrostatic field surrounding said high-potential electrode from said conducting areas alternately and, while the voltage to be measured has a predetermined polarity, subjecting said conducting areas alternately to the influence of said electrostatic field, a low-potential terminal, a current-responsive device having a terminal connected to said low-potential terminal and a second terminal, and means for connecting each of said conducting areas to the second terminal of said current-responsive device and to said low-potential terminal alternately.

FRITZ HAUFFE.
CLAUS FRÖHMER.