April 18, 1939. F. X. LAMB 2,154,685

ELECTRICAL RESISTANCE

Filed Nov. 21, 1936

Fig. 1.

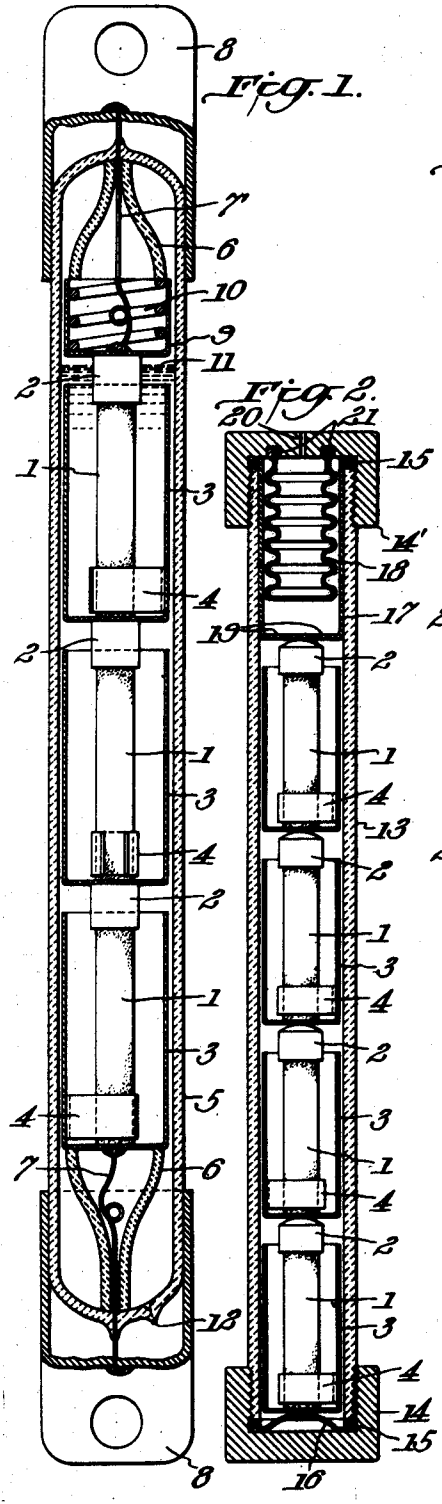


Fig. 2.

Fig. 3.

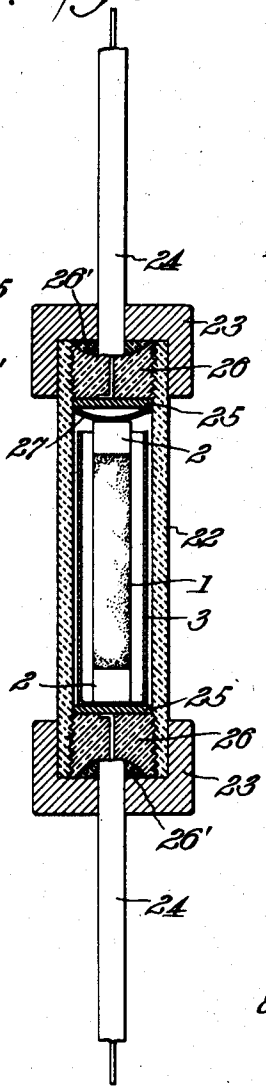


Fig. 4.

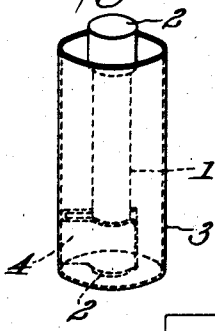
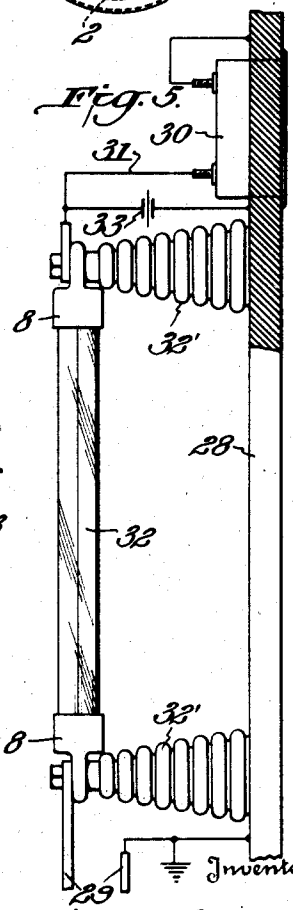


Fig. 5.



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ELECTRICAL RESISTANCE

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6 Claims. (Cl. 201—65)

This invention relates to electrical resistances, and particularly to electrical resistances for use in high voltage measuring circuits.

It has been the practice to place high voltage resistors in large ventilated metal boxes, the resistance cards or spools of wire being mounted in several decks or stages in the case of relatively high voltages. Such resistors were not protected from the atmosphere nor from the effects of high potential gradients. The resistor assemblies were of large size and the total length of resistance wire was frequently of the order of several miles. The probability of defects was very high and it was difficult and inconvenient to inspect the resistors. Furthermore, the leakage resistance between terminals, and from terminals to ground, was often of such low value as to cause errors in voltage readings.

Objects of the present invention are to provide high voltage resistors which are small in size and light in weight. An object is to provide high voltage resistors having a high leakage resistance which increases as the voltage range increases. Further objects are to provide high voltage resistors which are electrostatically shielded and which are mounted in casings that are almost completely filled with oil and then evacuated. More specifically, an object is to provide high voltage resistors including a plurality of resistance units mounted within a tubular insulating casing, each unit having a metal shell which conducts heat from the units to the outer casing, provides a controlled potential gradient along the resistor, locates the resistance units within the tube and protects the same from damage due to vibration and shock, and permits manufacture of a resistor of unlimited range since any number of units can be added in series, each unit being automatically shielded and cooled by its protective shell.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawing, in which:

Fig. 1 is a longitudinal and substantially central section through a resistor which includes three resistance units;

Fig. 2 is a similar section through another form of the invention in which four resistance units are used;

Fig. 3 is a central section through a single unit resistor;

Fig. 4 is a perspective view of one of the resistance units; and

Fig. 5 is a somewhat side elevation, with parts in section, of an instrument panel on which a voltmeter and a resistance are mounted.

Referring first to Fig. 4 of the drawing, the reference numeral 1 identifies a small resistance unit of the "cartridge" type which comprise a carbonaceous or a wire resistance on a cylinder of insulating material, or which may take the form of a cylinder formed from a mixture of ceramic and carbonaceous material. Conductive metal caps 2 are secured to the ends of the resistance cylinder to serve as the terminals for the unit. The unit or resistance cartridge is mounted within and positioned axially of a metallic shell 3 of substantially larger diameter than the cartridge by a clip 4 which is secured to the shell 3 adjacent the bottom wall thereof to receive the lower cap 2 of the resistance cartridge. The cartridge is of somewhat greater length than the shell 3 to leave the upper cap 2 exposed for contact with the bottom wall of a similar unit or with an appropriate terminal.

As shown in Fig. 1, a plurality of these resistance units are mounted within a tubular casing 5 of insulating material which may be, and preferably is a borate glass such as sold commercially under the trade-mark "Pyrex". Spacing sleeves 6 are provided at each end of the glass tube and a lead-in 7 which extends through the lower spacer 6 is soldered to the lower wall of the shell 3 of the adjacent resistance unit and to the mounting lug 8 which is cemented to the insulating tube. At the opposite end of the tube a terminal cup 9 is held in firm contact with the end cap of the adjacent resistance unit by an internal spring 10 which bears against the adjacent spacer 6. The terminal or lead-in wire 7' at this end of the tube is soldered to the terminal cap 9 and to the mounting lug 8.

The tubular casing 5 is preferably almost completely filled with light oil and the tube is sealed off at the tip 12. Other materials that may be used as an insulating and heat conducting medium are, for example, wax, asphaltum, pitch and mica dust. The pressure within the casing will vary by a few pounds as the temperature varies from room temperature to the operating temperature, and the pressure during operation of the units can be made substantially normal atmospheric pressure by exhausting the casings to reduce the pressure somewhat below atmospheric at room temperature.

It will be noted that the tube 5 is of but slightly larger diameter than the shield cans 3 of the resistance units, and the resistance units are thus automatically centered within the tube merely by

dropping the units into the tube. The electrostatic shields provide a good heat transfer from the resistances to the outer casing 5, and also establish a definite potential gradient along the resistor. In the example shown in Fig. 1, there is a potential drop along the resistor in three definite stages, with a sharp voltage change between the upper edge of each shield can 3 and the adjacent metallic surface. The leakage resistance within the tubular casing is very high and is constant as it is not possible for dust or moisture to collect between adjacent units or between the inner terminals of the assembly. The leakage resistance along the exterior of the glass tube 5 is subject to variation, but is exceedingly high when the casing is kept reasonably free from dust and moisture.

The form of the invention shown in Fig. 2 includes an insulating tube 13 having threaded ends which are sealed by the terminal caps 14, 14' and gaskets 15. The assembly of resistance units rests upon a spring strip or washer 16 which forms the terminal connection at that end of the tube and the upper terminal connection is provided by the elongated cup or shell 17 that is pressed into engagement with terminal cap 14' by the spring washer 16 and the column of resistance units. A Sylphon bellows 18 within sleeve 17 is subjected to the fluid pressure within the tube 13 through openings 19 in the end wall of the sleeve 17, the bellows being vented to atmosphere by a passage 20 in the cap 14' and being soldered to the cap, as indicated at 21, to seal the tubular casing. The bellows serves as a breather to prevent pressure changes within the casing 13 as the temperature of the resistor varies. The casing 13 may be almost completely filled with a liquid or plastic insulating compound to provide a more rapid and uniform transfer of heat from the resistances to the wall of the casing.

One or more resistance units may be sealed into a glass tube 22, as shown in Fig. 3, by cementing end caps 23, of metal or insulating material, to the tube. The insulated terminal wires 24 pass through the end caps and are soldered to metal disks 25 that are held in place by plugs of insulating material 26 that are threaded into the ends of the tube 22, the wires being sealed into the plugs 26 by cement 26'. The shell 3 of the resistance unit rests upon one disk 25 and a spring washer 27 is placed between the exposed terminal cap 2 of the unit and the other metal disk.

A typical installation of a high voltage resistance in a measuring circuit is shown in Fig. 5. The instrument panel 28 is assumed to be of metal and grounded on one side of the high voltage line 29. One terminal of the voltmeter 30 is grounded on the panel and a lead 31 connects the other terminal to the resistance 32 which, as illustrated, is of the type shown in Fig. 1. The resistance assembly is mounted on standoff insulators 32' by the terminal caps 8 of the casing, and a low voltage insulator 33 is connected between the instrument lead 31 and ground to protect the operator from high voltage in the event that the measuring circuit is opened between the lead 31 and ground. The number of resistance units within the elongated casing will depend upon the maximum voltage on the line 29 but, for any given voltage, the space required for the resistance and its supporting insulators is only a fraction of the space required for the known types of high voltage or instrument resistances.

The invention is not limited to the several illustrated embodiments as various changes which may be made in the resistance units and in the means for assembling a plurality of those units in a casing fall within the spirit of my invention as set forth in the following claims.

I claim:

1. A high voltage resistor comprising a resistance unit of the cartridge type having end terminal caps, a metallic shield of substantially larger diameter than said unit having means at one end thereof for supporting the unit substantially axially within and spaced from the shield, means providing an electrical connection between said shield and one terminal cap of the unit, said shield extending along approximately the entire length of said unit to constitute an electrostatic shield and to establish a predetermined voltage gradient along said unit, an insulating casing enclosing said shield and unit, and terminal means on said casing electrically connected to the respective terminal caps of said resistance unit.

2. A resistor as claimed in claim 1, wherein said casing is approximately filled with an insulating and heat conducting medium.

3. A high voltage resistor comprising an elongated casing of insulating material, a plurality of resistance units within said casing, a metallic shell for each unit and of substantially larger diameter than the unit, conductive means at one end of each shell for detachable connection to a unit to support the same in spaced relation to the shell, each unit being longer than its shell, said shells and units being alined axially of said casing with adjacent terminals of each pair of units electrically connected, whereby the several shells constitute electrostatic shields for the several units and determine the voltage gradient along the alined shells and units, and terminal means at the ends of the casing electrically connected to the adjacent unit terminals.

4. A resistor as claimed in claim 3, wherein said shells loosely engage the inner wall of said casing to position said units substantially in alinement along the axis of the casing.

5. A resistor as claimed in claim 3, wherein the space within said casing is freed from air and approximately filled with an insulating fluid.

6. A high voltage resistor comprising an elongated hermetically sealed casing of insulating material, terminals secured to said casing, a plurality of resistance units longitudinally alined within said casing, each unit having terminals at the ends thereof, an electrostatic shield for each resistance unit, said shields being each electrically connected to one terminal of the associated resistance unit and extending in radially spaced relation to the same toward the shield of the adjacent resistance unit, and means electrically connecting the several units in series between said casing terminals.

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