June 9, 1942. H. T. RIGHTS ET AL 2,286,161

ELECTRICAL RESISTANCE UNIT

Filed Dec. 19, 1939

Fig. 1.

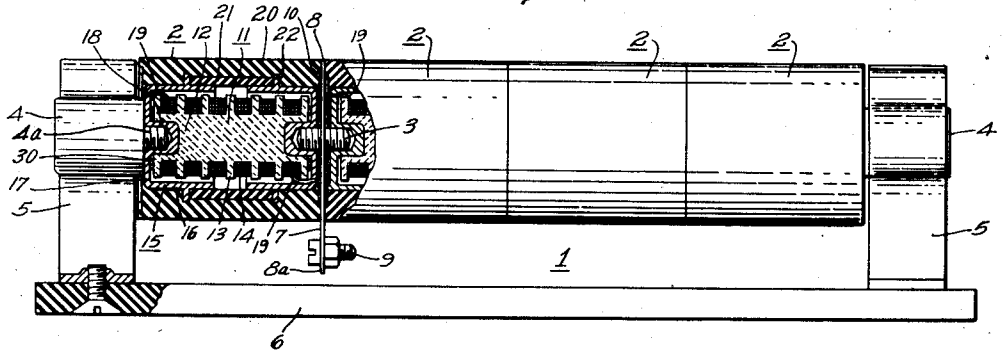


Fig. 2.

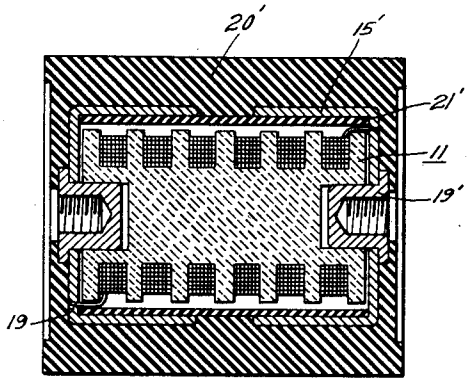
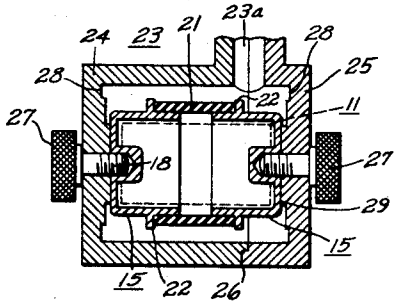


Fig. 3.



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ELECTRICAL RESISTANCE UNIT

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14 Claims. (Cl. 201—63)

This invention relates to electrical impedance devices and it has particular relation to electrical resistors for high voltage service.

In various electrical applications, impedance devices are required which must withstand high voltages. For example, high voltage resistors are employed as multipliers for high voltage measuring circuits. Since these resistors handle small currents at high voltages, they ordinarily are extremely fragile. For this reason they are particularly susceptible to unfavorable physical, chemical and electrical conditions.

Among the physical and chemical properties desired in such resistors may be mentioned resistance to corrosion produced by exposure to various chemical gases and liquids. Other desirable characteristics are adequate heat-transmission and sufficient structural rigidity. It is also desirable that such resistors permit of easy replacement and assembly in the field. Prior art resistors have failed to meet in various respects the foregoing requirements.

A number of electrical properties are also of great importance in high voltage resistors. For example, leakage resistance becomes of increasing importance as the voltage for which the resistor is designed increases. This is for the reason that high voltage resistors may break down along leakage paths. Moreover, as the resistance of a resistor increases, the percentage decrease in total resistance because of leakage increases, and the resulting accuracy of the resistor suffers in proportion. One of the most important problems presented in high voltage resistors is that due to voltage gradients adjacent to the resistor. Because of the high voltages employed, the gradient adjacent the resistor may be sufficient to produce a failure of the fragile resistance material.

In accordance with our invention, a high voltage resistor is constructed from a plurality of separable, sealed resistance sections. In the event of a failure of one section, the defective section may be removed from the resistor unit and replaced by a new section. In order to shield the resistor satisfactorily, we provide each of the resistance sections with a plurality of electroconductive shields. Each of these shields extends over a substantial portion of the resistance element in its respective section and restricts the maximum voltage drop between the resistance element and the shield to substantially less than the total voltage drop across the resistance element. A voltage tap may be provided conveniently between any pair of resistor sections, by inserting therebetween a plate of electro-conductive material.

It is, therefore, an object of our invention to provide a sealed electrical impedance unit of improved construction.

It is a further object of our invention to provide an electrical resistance unit constructed of a plurality of separate, sealed resistance sections which may be readily assembled and disassembled.

It is another object of our invention to provide an electrical resistance unit constructed from a plurality of resistance sections fastened together by concealed fastenings.

It is another object of our invention to provide an electrical resistance unit constructed of a plurality of resistance sections rigidly united to each other.

It is a still further object of our invention to provide a sealed electrical resistance unit which may have taps readily inserted therein.

It is a further object of our invention to provide an electrical resistance having means for controlling the potential gradient adjacent the electrical resistance elements employed therein.

It is still a further object of our invention to provide an improved method for fabricating impedance elements.

Other objects of our invention will be apparent from the following description taken in conjunction with the accompanying drawing, in which:

Figure 1 is a view in side elevation with parts in section of an electrical resistance unit embodying our invention;

Fig. 2 is a view in section of a modified construction for resistance section embodying our invention, and

Fig. 3 is a view in section of a mold suitable for use in constructing the resistance unit illustrated in Fig. 1.

Referring to Figure 1, an electrical resistance unit 1 is illustrated which includes four similar sealed resistance sections 2. The resistance sections are cylindrical in shape and are united to each other by means of stud bolts 3 located along the axis of the resistance sections. These stud bolts not only serve to unite the sections mechanically but also may be employed for connecting terminals of the resistance elements included in these sections. The exposed ends of the resistance unit may have terminals 4 attached thereto in the form of cylindrical electroconductive members which are united to the ends of the resistance unit 1 by suitable screw extensions 4a. The terminals 4 may be received

in clips or jaws 5 similar to those conventionally employed for mounting electrical fuses. In Fig. 1 the clips 5 are attached to a panel 6 of insulating material.

Since the resistance unit 1 is made up of a plurality of distinct resistance sections, a tap 7 may be inserted readily between any two desired resistance sections. As illustrated, this tap comprises a disc 8 of electro-conductive material such as brass which may be united to one of the stud bolts 3 in any suitable manner as by soldering. This disc is provided with a projection 8a which carries a connecting bolt 9.

Preferably an annular projecting seat 10 is provided on each end of the resistance sections 2 concentric with the ones thereof. If such a seat is employed, contact between adjacent resistance elements is confined to points adjacent the peripheries thereof with a resultant increase in the rigidity of the entire resistance unit.

Each of the resistance sections 2 includes a resistance element 11 of any conventional construction. For example, it is common in the art to employ wound resistors and resistors formed of a resistance composition such as a carbon-containing, ceramic material. For the purpose of illustration, we have shown a resistance element of the wound wire or spool type comprising a core 12 of ceramic material, such as porcelain, having a number of annular partitions 13 between which resistance wire 14 is wound.

In order to shield the resistance element 11, a cup-shaped, electro-conductive member 15 is positioned over each end of the resistance element. This cup-shaped shield has a cylindrical wall portion 16 which closely embraces the resistance element 11, and which extends for slightly less than half the axial length of the resistance element. The shield also includes an end wall 17 which carries a threaded depression or socket 18 for reception of the stud bolts 3 or terminals 4. Preferably the sockets 18 extend into recesses provided in the core 12 in order to utilize the space occupied by the complete section efficiently. The terminals 19 of the resistance element 11 may be connected to the shields 15 in any suitable manner as by passing them through openings provided in the shields and soldering the terminals to the shield.

It would be possible to shield the resistance element 11 with only one shield as by extending one of the shields 15 to cover substantially all of the resistance element. This construction is less desirable, however, for the reason that the maximum potential drop between the shield and the resistance element then would be substantially equal to the total voltage drop across the resistance element. By employing a shield which extends for approximately half the actual length of the spool, the maximum voltage drop between the shield and the spool is limited to approximately one-half the voltage drop across the resistance element. Consequently, the stress between the shield and the resistance element is greatly reduced, and the possibility of corona formation is decreased. The possibility of corona formation may be reduced still further by rounding the edges of the shield 15.

Complete sealing of each resistance section is effected by bridging the shields 15 with an insulating material 20. It will be noted from Fig. 1 that the space immediately adjacent the resistance element 11 is free of insulating material. It is possible to employ in this space a suitable impregnating or insulating material such as oil, wax or asphaltum. It is preferred, however, to omit such material for several reasons. Since these materials have high dielectric constants, the presence of discontinuities such as those produced by air bubbles would result in high local heating effects due to the capacity existing between the shields 15. A further objection to this material resides in the possibility of loss as from absorption or leakage. In addition, readily thermoplastic materials are objectionable because of the possibility of their melting in the event that the resistance element is operated at a high temperature.

In order to keep the space between the shields and the resistance element free of insulating material, a preformed tube of insulating material 21 may be slipped between the shields in snugly overlapping relationship before completion of the attachment of the terminals 19 to the shields. The tube, together with the shields, form an enclosure for the resistance element which prevents the entrance of the insulating material 20 during manufacture of the resistance section.

If desired, each of the shields may be provided with one or more projections or preferably with an annular rib or flange 22 which operates as a spacer for the tube 21. The flange 22 not only serves to strengthen the shield, but it increases the strength of the bond between the shield and the insulating material 20.

After assembly, the resistance element, shields and tube may be inserted in a mold, and the insulating material 20 may be formed thereon by a casting or molding process. This completes the sealing of the resistance section and provides a construction of great strength and rigidity.

Materials suitable for the various parts thus for described are well known in the art. For example, the electro-conductive parts such as the shields, stud bolts, terminals and taps may be formed of a suitable electro-conductive metal such as brass. The molding or casting material 20 may be of any suitable composition, such as natural or synthetic resin, examples of which are phenol-formaldehydes, poly-styrenes, vinyl acetates and methy-methacrylates. By forming the tube 21 of the same material, an intimate bond is obtained between the insulating material 20 and the tube 21 which results in a homogeneous and sturdy structure. If desired the molding or casting material may include fillers which are well known in the molding art.

The molded or cast material 20 may be applied in various ways. For example, in Fig. 3 a mold 23 having a gate 23a, is illustrated which may be employed for this purpose. The mold 23 is provided with a main body portion 24 having a cylindrical recess for reception of the resistance element and a cover portion 25 which is detachably united to the portion 24 along a parting line 26. An assembly comprising one of the resistance elements 11, a pair of shields 15 and a tube 21 is positioned within the mold 23 concentric with the cylindrical recess.

Some of the materials employed require the application of considerable pressure. In order to preclude movements of the assembly positioned within the mold 23, a pair of machine screws 27 may be passed through the walls of the mold 23 and threaded into the sockets 18 carried by the shields 15. These screws hold the assembly firmly in place during the molding operation. After completion of the molding or casting operation, the screws may be removed and the mold parts separated to release the resistance section.

The mold may be formed with annular recesses 28 for forming the protuberance or seats 10 and with extensions 29 for permitting exposure of portions of the shields 15 through the insulating material 20. If the recesses 28 and extensions 29 are not provided in the mold, the desired contour of the resistance section may be provided by suitable machining operations.

It is believed that the assembly of a complete resistance unit is obvious from the foregoing discussion. A number of resistance sections 2 may be provided in order to make up the desired overall resistance. One of the stud bolts 3 then is placed between each pair of the resistance sections and the resistance sections are rotated relatively to each other in order to bring their adjacent seats 10 firmly into engagement with each other. When the necessary number of resistance sections is assembled, terminals 4 are rotated into threaded engagement with the exposed sockets 18 to form a complete resistance unit. If a tap is desired, one of the stud bolts 3 may be provided with a conductive tap by soldering thereto one of the discs 8 having a suitable tap bolt 9.

The resulting resistance unit has a smooth, polished surface which may be readily cleaned. Since the resistance elements all are completely enclosed, the possibility of corrosion and damage to the resistance element is greatly reduced. It is believed that the flexibility of the construction also is apparent. By carrying in stock a number of resistance sections of the most widely employed size and a number of additional resistance sections of intermediate sizes, practically any desired resistance may be obtained by suitable selection and assembly of resistance sections. Moreover, if in operation one of the resistance sections should become defective, it may be readily removed from adjoining resistance sections and replaced by a new resistance section without requiring a withdrawal of the resistance unit from service for a long period.

Under some conditions the resistance elements may be subjected to vibration which would cause them to move relatively to the shields 15. If desired, this movement may be prevented by including between the ends of the resistance element and the shields light spring washers 30.

Each shield 15 may be provided with an exterior knurled, corrugated or striated surface on each side of the rib 22 in order to increase the bond between the material 20 and the shield, and to prevent rotation of the tube 21 relative to the shield. Generally, these precautions are unnecessary.

It will be noted that in a complete resistance unit each pair of shields 15 acts as a condenser. When the resistance unit is designed for alternating current service, it may be desirable to compensate for the capacity of the condenser formed by the shields. This may be accomplished by providing the resistance element 11 with inductance for compensating fully, or in part, for the capacity existing between the shields. As usually constructed, the resistance elements 11 are non-inductively wound by reversely winding a portion of the turns thereof relative to the remainder of the turns. By proper control of the winding, the relationship between the capacity of the shields 15 and the inductance of the resistance element may be controlled as desired.

In Fig. 2, we have illustrated a modified form of resistance section embodying our invention. Referring to this figure, the resistance element 11 corresponds to the resistance element 11 described with reference to Fig. 1. However, in Fig. 2, the resistance element 11 is surrounded by an insulating tube 21' which is slightly longer than the length of the resistance element 11. Electro-conductive shields 15' in this case are fitted over the insulating tube 21' and insulating molding or casting material 20' is then formed about the assembly. The shields 15' illustrated in Fig. 2 differ slightly from the construction of the shields 15 of Fig. 1. The shields 15' are of a two-piece construction wherein a socket 19' is inserted in an opening provided in the end wall of each shield 15'. The socket may be attached to the shield in any suitable manner as by soldering. Moreover, in Fig. 2 the shield 15' is not provided with a strengthening and spacing rib or flange.

The shields 15' in Fig. 2 have their ends separated by a portion of the insulating material 20'. As above explained, this construction is believed less desirable than that shown in Fig. 1, because of the variations possible in the dielectric properties of the insulating material 20'.

Although we have described our invention with reference to certain specific embodiments thereof, it is obvious that numerous modifications thereof are possible. Therefore, we do not wish our invention to be restricted except as required by the appended claims when interpreted in view of the prior art.

We claim as our invention:

1. In an electrical resistance unit, a pair of spaced, cup-shaped, electroconductive members each having a substantially cylindrical wall portion completely closed at one end by an end portion, said cylindrical wall portions being spaced from each other along a common axis and having their open ends adjacent each other, an insulating cover surrounding said wall portions and bridging the space therebetween, said insulating cover intimately engaging said wall portions to form with said electroconductive members a substantially sealed casing, an electrical resistance element positioned within said casing, said resistance element being spaced from and substantially surrounded by said electroconductive members, and means for connecting each terminal of said resistance element to an adjacent, separate one of said electroconductive members, whereby said electroconductive members electrically shield said resistance element.

2. In an electrical resistance unit, a pair of spaced, cup-shaped, electro-conductive members having adjacent open ends for defining a substantially cylindrical space therewithin, an insulating cover externally bridging said electroconductive members and bonded to said electroconductive members for forming therewith a substantially sealed casing, a resistance element within said casing, said resistance element having terminals operatively connected to said electro-conductive members, and having a recess formed in an end thereof, a protuberance associated with said casing and extending within said recess, said protuberance having attaching means accessible externally of said casing.

3. In a casing for an electrical impedance element, an insulating cover having a substantially cylindrical recess, a separate electro-conductive facing positioned substantially interiorly of each end of said recess, each of said electro-conductive facings extending over a substantial portion of the wall of said recess, and forming with said insulating cover a substantially sealed and shielded casing, and a projection on each of said fac-

ings extending into said recess, each of said projections including attaching means accessible only from the interior of said casing.

4. In an electrical impedance unit, an insulating cover having a substantially cylindrical recess, an electro-conductive facing for each end of said recess, each of said electro-conductive facings extending over a substantial portion of the wall of said recess, and forming with said insulating cover a substantially sealed and shielded casing, and a projection on each of said facings extending into said recess, each of said projections including attaching means accessible only from the exterior of said casing, said insulating cover comprising an insulating sleeve extending between said projections and closely embracing a portion of each of said facings, an insulating body in contact with an additional portion of each of said facings and in contact with said insulating sleeve, and an electrical impedance positioned in said casing and having terminals connected respectively to said facings.

5. In a casing for an electrical impedance element, an insulating cover having a substantially cylindrical recess, and an electroconductive facing for each end of said recess to form with said insulating cover a substantially closed casing, each of said electroconductive facings comprising a cylindrical portion lining a substantial portion of the interior wall of said recess and an end portion, said end portion having a tapped recess accessible externally of said casing.

6. In an electrical impedance unit, a substantially sealed casing comprising an insulating cover having a cylindrical recess therein, a pair of spaced electro-conductive facings lining a substantial portion of said cylindrical recess, each of said electro-conductive facings having an end wall portion for closing the ends of said cylindrical recess, and having a tapped recess in said end wall portion accessible externally of said casing, and an annular raised seat on each end of said casing adjacent the periphery thereof and concentric with said tapped recess; and an impedance element in said recess having its terminals conductively connected to said electro-conductive facings.

7. In an electrical resistance unit, a tubular, substantially continuous, insulating member comprising a plurality of separate, substantially abutting tubular sections, a resistance element in each of said tubular sections, each of said resistance elements being spaced from the wall of its related tubular section and having a pair of terminals, means positioned substantially interiorly of each of said tubular sections for substantially sealing each resistance element in its related tubular section, and electroconductive means disposed interiorly of said tubular insulating member for electrically connecting a terminal of each of said resistance elements to a terminal of an adjacent one of said resistance elements.

8. In an electrical resistance unit, a substantially continuous tubular insulating member comprising a plurality of separate, substantially abutting tubular sections, a resistance element in each of said tubular sections, means positioned interiorly of said tubular insulating member for substantially sealing each resistance element in its related tubular section, said means including separate electroconductive means extending over a substantial part of each of said resistance elements for electrically shielding said resistance elements, and normally concealed means disposed interiorly of said tubular insulating member for connecting in series each pair of adjacent resistance elements, said last-named means comprising detachable securing means for detachably securing each of said tubular sections to an adjacent one of said tubular sections.

9. In an electrical resistance unit, a substantially continuous tubular insulating member comprising a plurality of separate tubular sections, a resistance element in each of said tubular sections, means for substantially sealing each resistance element in its related tubular section, comprising an electro-conductive member for closing each end of said related tubular section, each of said electro-conductive members having an extension for lining a substantial portion of the interior wall of said related tubular section, and having an externally accessible tapped recess positioned on the axis of the related tubular section; and an electro-conductive stud bolt positioned between each pair of tubular sections in threaded engagement with adjacent tapped recesses.

10. The method for constructing electrical impedance devices which comprises positioning an impedance element in an insulating tube, inserting a cup-shaped, electro-conductive member in each end of said insulating tube for enclosing and shielding said impedance element, attaching the terminals of said impedance element to said electro-conductive members, and molding insulating material around the resulting assembly.

11. The method for constructing electrical impedance devices which comprises positioning an impedance element in an insulating tube, inserting a cup-shaped, electro-conductive member in each end of said insulating tube for enclosing and shielding said impedance element, attaching the terminals of said impedance element to said electro-conductive members to form an intermediate assembly, placing the intermediate assembly in a mold, supporting said electro-conductive members temporarily in their proper positions, and molding insulating material around the intermediate assembly.

12. In an electrical resistance unit, an electrical resistance element having first and second terminals, and a sealed casing for said resistance element comprising shielding means substantially surrounding said resistance element, and an insulating structure surrounding and intimately engaging said shielding means, said shielding means including an electro-conductive first section positioned adjacent said first terminal, an electro-conductive second section positioned adjacent said second terminal, means for electroconductively connecting said first and second sections respectively to said first and second terminals, said sections extending towards each other from said terminals over substantial portions of said resistance element, and means supporting said resistance element in said sealed casing with a gaseous space between said resistance element and said casing.

13. In an electrical resistance unit, an electrical resistance element having first and second terminals, and a sealed casing for said resistance element comprising shielding means substantially surrounding said resistance element, and an insulating structure surrounding and intimately engaging said shielding means, said shielding means including an electro-conductive first section positioned adjacent said first terminal, an electro-conductive second section positioned adjacent said second terminal, means for electro-

conductively connecting said first and second sections respectively to said first and second terminals, said sections extending towards each other from said terminals over substantial portions of said resistance element, separate, electro-conductive threaded means carried by each of said sections and accessible externally of said resistance unit, said threaded means being axially aligned for facilitating the attachment of a plurality of similar resistance units, and a plurality of similar annular seats projecting from opposite ends of said resistance unit adjacent the periphery thereof, said seats being concentric about the axis of said threaded means.

14. In an electrical resistance unit, a pair of spaced, cup-shaped, electro-conductive shielding members having adjacent open ends for partially defining an enclosure, an electrical resistance element positioned within said enclosure, means electro-conductively connecting the terminals of said resistance element respectively to said shielding members, a pair of flanges carried respectively by said shielding members, an insulating sleeve bridging the space between said shielding members and abutting said flanges for completing the enclosure of said resistance element, and an insulating structure surrounding and intimately engaging said shielding members and insulating sleeve for sealing said enclosure.

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