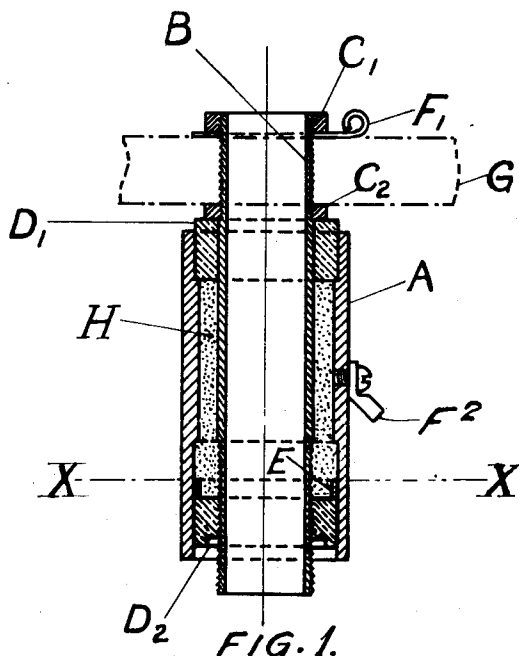
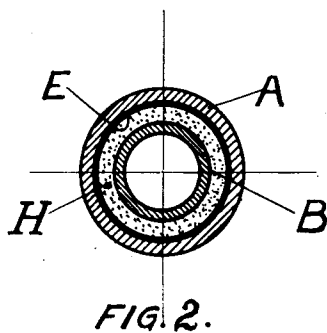


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RESISTANCE UNIT.
APPLICATION FILED MAR. 11, 1909.

1,086,726.

Patented Feb. 10, 1914.



WITNESSES:

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RESISTANCE UNIT.

1,086,726.

Specification of Letters Patent.

Patented Feb. 10, 1914.

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To all whom it may concern:

Be it known that I, JOHAN BURCHARDT OPSAHL, a subject of the King of Norway, residing at Madison, in the county of Dane and State of Wisconsin, have invented new and useful Improvements in Resistance Units, of which the following is a specification.

My invention consists in what is herein particularly set forth with reference to the accompanying drawings and pointed out in claims of this specification, its object being to provide simple, economical and efficient fireproof resistance units for electric-motors, starting-rheostats and other electric apparatus, each of said units being made to contain a non-metallic resistor interposed between terminals of high conductivity, the units as a whole having a temperature coefficient which is positive up to a certain degree of heat and then negative, in order to avoid overheating, melting or fusing, and arcing experienced in the use of metallic conductor resistance units of common knowledge.

Figure 1 of the drawings represents a vertical section view of a resistance unit in accordance with my invention, and Fig. 2, a horizontal section view of the same, the plane of the section being indicated by line X—X in Fig. 1.

Referring by letter to the drawings: A indicates an outer metallic tube terminal member, and B an inner metallic tube terminal member of one of my improved resistance units, it being within the scope of my invention to substitute a metallic rod for the inner tube. The inner terminal is exteriorly screw-threaded and the outer terminal is preferably countersunk at its ends to provide seats for plugs of suitable non-conductive material. The plug D' is generally fixed in its position, it being herein shown held tight on its seat by means of a screw-collar C² run on the protruding inner terminal, and the plug D² is preferably in screw-threaded engagement with the outer terminal A to provide for varying pressure against a powdered resistance compound H confined between said terminals. A thin metallic washer E is preferably interposed between the compound and the plug D² to have expansion and contraction with the outer terminal. The function of the washer E is to prevent the resistance compound from getting between the plug D² and the outer tube A to the impairment of the re-

sistance unit as a whole, said washer being set in on said plug before packing of said compound in said tube. Employed in connection with the aforesaid terminals are attaching devices F' and F², for conductor wires, and a mounting plate G of suitable non-inflammable material.

The resistance compound H is mixture of non-metallic conductive powder (such for instance as carbon or graphite) and a non-conductive powder (such for instance as silicon dioxid) the components of said compound being such that will not fuse together at any temperature that may arise in the resistance unit. The said compound itself has a negative temperature coefficient, and attempts have heretofore been made to successfully employ the same as an element of a resistance unit by inclosing the same in a receptacle of non-conductive material such as slate, marble, porcelain and the like, but these materials are poor conductors and radiators of heat, as well as useless for severe service, unless bulky to an excessive degree, and the temperature coefficient being heavily negative with rising temperature it is out of the question to use such units for field rheostats. Furthermore if such an imperfect resistance unit be employed in connection with an electric motor, it will be insufficient for starting up said motor, unless built excessively bulky and for intermittent operations at long intervals, as the rise in temperature and drop in resistance is too quick and heavy.

To offset the drop in the resistance of the non-metallic compound element of my improved resistance unit for a certain period, sufficient for instance for the starting of an electric-motor, I make use of the expansion of the metallic elements of said unit in which the total resistance depends upon three factors: 1. The ratio of the mixture of the conductive and non-conductive component of the non-metallic resistance compound. 2. The pressure under which the compound is originally placed. 3. The temperature of the compound.

The resistance decreases with the increase of temperature in the unit, but increases with the decrease of pressure to which the aforesaid compound is exposed. Hence I provide for a decrease of pressure incidental to the increase of temperature, this result being accomplished by confining said compound between inner and outer terminals of

high conductivity. Now, when electric-current is switched on to the unit and a rise of temperature therein results, the outer terminal of said unit will expand more than the inner terminal thereof, and consequently there will be a decrease of pressure upon the intermediate compound. Hence by appropriate proportioning of the components of said compound, as well as of the diameters and lengths of said terminals, and of the pressure to which the aforesaid compound is primarily subjected, the total resistance of the unit may be accurately determined.

For a starting rheostat, I provide that the temperature coefficient of my improved resistance-unit shall be positive up to a certain degree of heat, to allow for sufficient starting time but heavily negative thereafter when the decrease in the resistance, due to the increase of temperature, overcomes the increase of said resistance, due to decrease of the pressure that results from the difference in the expansion of the terminals between which the resistance compound of said unit is packed. The change from positive to negative of said temperature coefficient takes place when the heat dissipated in the unit exceeds the conductive and radiating capacity of said unit. The resistance will then drop very rapidly until the heat dissipated in said unit is within the capacity of the same or the protective device of the rheostat has opened the circuit. Hence it makes no difference whether the resistance is cut out too quick or too slow or not at all, and there can be no fusing or arcing in the resistance unit and no danger of fire.

In any form of my resistance-unit its outer tubular terminal is always exposed to air, and if the inner terminal of said

unit be tubular, as herein shown, it will also be exposed to air, which air expanding under heat and passing upward will cause a ventilating draft in said inner terminal to retard expansion of the same, this being a desirable result.

I claim:

1. A resistance unit comprising inner and outer metallic tube terminals, an interposed non-metallic resistance powder, and non-conductive plugs arranged with relation to said terminals to confine the interposed powder.

2. A resistance unit comprising inner and outer terminals of high conductivity and a non-metallic resistance material confined between the terminals, whereby said unit as a whole has a temperature coefficient that is positive up to a certain degree of heat but thereafter negative due to the increase of temperature.

3. A resistance unit comprising an outer metallic tube terminal, an inner metallic terminal, an interposed non-metallic resistance powder, non-conductive closures for the ends of the outer tube terminal and through which the inner terminal extends, and an expansion washer arranged between said powder and a tube closure.

4. A resistance unit comprising inner and outer metallic tube terminals and an interposed non-metallic resistance powder, the inner tube terminal constituting a passage for air expanded under heat therein, whereby a ventilating draft results in said unit to retard expansion of the same.

In testimony whereof I have hereunto subscribed my name in the presence of two witnesses.

JOHAN BURCHARDT OPSAHL.

Witnesses:

GEORG ROSÉN,
DAVID ROSS.