

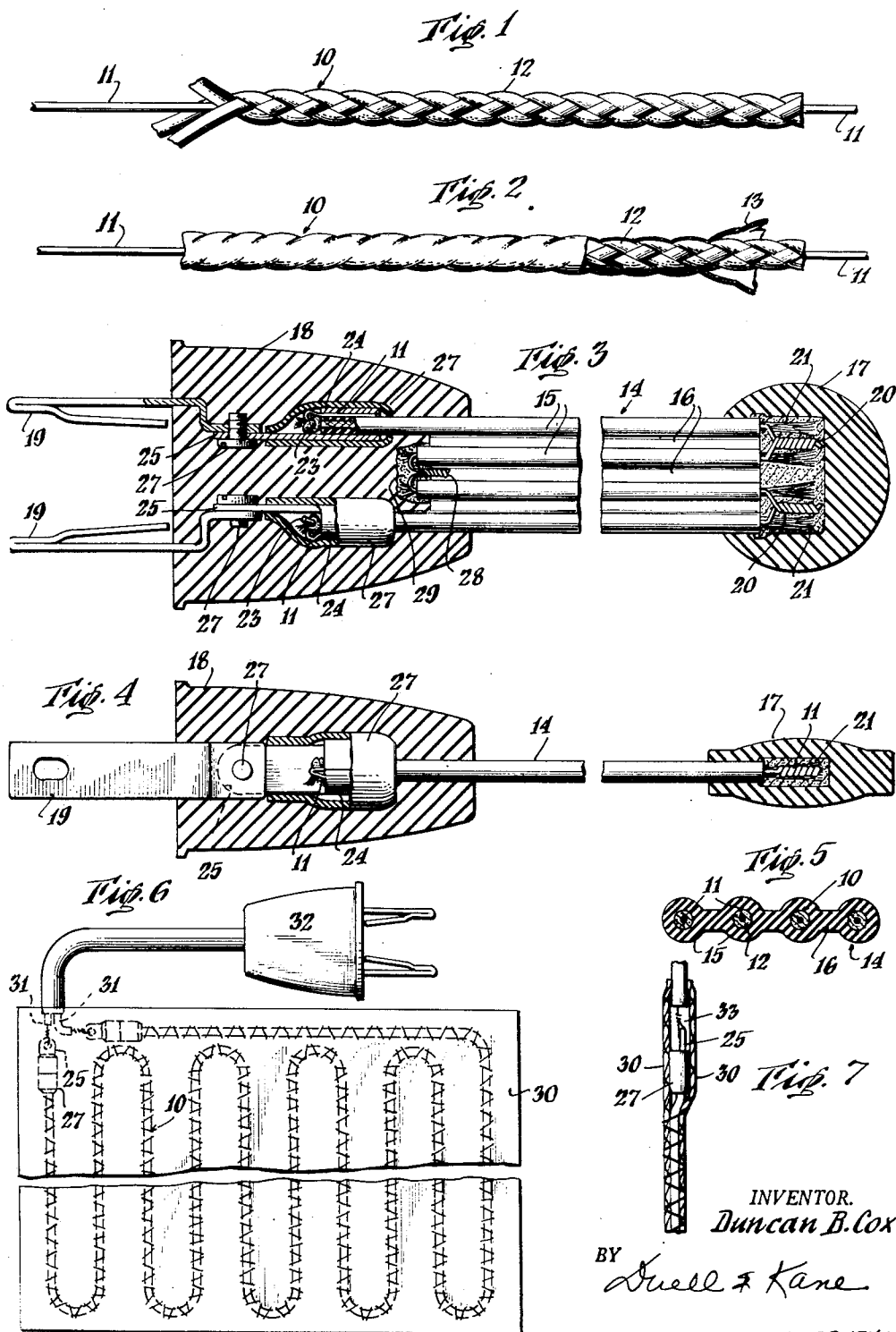
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ELECTRIC HEATING ELEMENT

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ELECTRIC HEATING ELEMENT

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3 Claims. (Cl. 219-46)

1

2

This invention relates to an improved type of electrical conductor and resistance element and has particular relation to a device suitable for use as a heating element.

It is an object of the invention to provide a device of the above character which will be self-fusing when it becomes overheated and, therefore, is particularly safe for use as a heating element and which at the same time is so constructed and assembled that it is adequately strong and can withstand the tensile stresses to which devices of this type are subjected.

A further object of the invention is to provide a device of the above character in which a tension or stress member is associated with the conductor or resistance wire in such a manner that the tensile stresses are sustained directly by the member rather than by the wire.

Another object of the invention is to provide improved heating devices incorporating conductors or resistance elements of the above type in which the assembly and connection is so arranged that the tensile stresses are necessarily transmitted through the tension member.

In the accompanying drawing:

Fig. 1 is a view of an improved conductor or resistance element embodying my invention;

Fig. 2 is a similar view of the conductor or resistance element having an outer insulating and protective casing applied thereto;

Fig. 3 is a partially sectional view with the central portion omitted of a heating tape having my improved resistance element incorporated therein;

Fig. 4 is a partially sectional view at right angles to Fig. 3;

Fig. 5 is a cross sectional view of the heating tape shown in Figs. 3 and 4;

Fig. 6 is a diagrammatic plan view of an electric heating blanket having my improved resistance element incorporated therein; and

Fig. 7 is a detailed view of the connection between the resistance element and lead wires.

My improved conductor and resistance element is shown most clearly at 10 in Figs. 1 and 2 and comprises generally an elongated attenuated conductor 11 made of a low fusing metal surrounded by a stress carrying insulating casing 12, the latter being usually covered by an additional insulating and protective casing as shown at 13 in Fig. 2.

The wire 11 may be made of any metal or alloy which fuses at a relatively low temperature. For this purpose I prefer to use lead or zinc or alloys of lead or zinc containing small percentages of

one or more of the following—copper, antimony, tin, bismuth, arsenic or silver. Tin, cadmium, bismuth by themselves or as the major constituents of an alloy can also be used in place of lead or zinc; but these are not economically attractive at the present time.

The diameter of the conductor may vary in accordance with the desired resistance for the metal being used. I have found, however, that the practical lower limit is .005" and the practical upper limit is .036" and the diameter should be confined within these limits. Where the conductor or resistance is to be used in a heating unit of the type shown in Figs. 3, 4 and 5 and hereinafter more fully described, I have found that satisfactory results are obtained by making the conductor out of 4% antimonial lead with a diameter of .0119". This alloy melts at about 572° F., but in the form of extremely fine wire and when covered by a suitable layer of glass fiber insulation it provides a high degree of safety against fire hazards, in that it will readily fuse and open the circuit if inadvertently connected to too high a potential or if a short circuit should develop due to any mechanical damage to the insulation. I have also found that if a heating cable, blanket or pad using this new resistance element is allowed to operate under conditions which restrict the heat dissipation, excessive temperatures, which might cause a fire if any of the commonly known resistance wires were used, are prevented by the fusing of the conductor.

Resistance wire of the types and in the sizes used in my invention are extremely flexible and can withstand without damage a very large number of repeated sharp bends. However, the stress which such wire can withstand without stretching is extremely low, both because the metal is soft and weak and because of the relatively fine diameter. For example, the .0119" 4% antimonial lead wire will break with an applied load of less than one-half pound. Although the wire can stretch without breaking, any stretching reduces the diameter of the wire and causes an increase in its resistance which is approximately proportional to the amount of stretch. If more than a nominal increase in resistance occurs as the result of local stretching, the area affected will release more heat in operation than adjacent areas. This causes a local hot spot, which, in turn, will further increase the local heat dissipation because of the relatively large temperature coefficient of resistance of the wire. Therefore, wire which has been subject to local stretching is not suitable for use as a heating element. I

have found that it is possible to eliminate any local stretching by applying a tension member or stress-carrying insulating casing, preferably in the form of a special tubular braid 12 of glass fiber, to the wire as the first operation after it is drawn. When this braid is being applied, the wire is subjected to only enough tension to cause it to unroll from its spool, a force of one or two ounces, but the braid is withdrawn from the braiding machine under high tension, so that virtually all of the stretch in the fibers which exists as the result of the braided construction is removed before the braid comes in contact with the wire. A special impregnation treatment is then used to prevent the braid from loosening up and contracting in length when the tension is removed. Among the materials which I have found suitable for this impregnation are compounds of high melting waxes and water-emulsions of plasticized polyvinyl chloride. The tension on the braid must be maintained during and after the application of the impregnating compound, until it has set either by cooling, as in the case of the hot melt, or by evaporation of the water, heat curing and cooling, as in the case of the emulsion. Thereafter, no special care is needed in handling the resistance element with its impregnated braided covering, since the braid provides adequate protection for the wire.

As stated above the tubular stress-carrying casing is preferably made in the form of a braid and from glass fibers. Glass fiber is particularly suited for this application due to its high strength (about 250,000 p. s. i.) and the fact that it has less stretch up to its breaking point than any other available insulating fiber.

A preferred braiding construction uses a fiber glass yarn, which yields 5000 yards per pound, and consists of eight strands with eleven picks per inch. This braid is withdrawn from the braiding machine at twice the speed usually used in applying braided insulation to wire. This higher speed reduces the angle between the strands and the wire from approximately 45° to approximately 26°, which decreases the stretch of the finished braid up to its breaking point and also increases its strength. Although this type of braid gives poor coverage and is too loose for ordinary insulation use, after the special impregnation treatment it has a tensile strength of more than 30 pounds and provides the type of covering which is needed to protect the weak resistance wire.

The preferred tubular braid construction with only eight braiding ends is rough on the outside and also on the inside. For many applications it is desirable to provide a smooth outer surface. This may be accomplished by providing the casing 13 shown in Fig. 2 in the form of a coating of waterproof material having the required dielectric strength and abrasion resistance. I have found that a suitably-compounded high-molecular-weight vinyl chloride resin with a minimum thickness of .010" makes a very satisfactory coating and this can readily be applied as a plastisol or the extrusion process. Dielectric lacquer coatings may also be applied in the usual manner.

The roughness on the inside of the tubular braid presents an important advantage and I, accordingly, prefer to leave this roughness intact. The advantage resulting therefrom can best be illustrated by the following experiment. An antimonial lead wire .020" in diameter and 10' long was laid on a smooth insulating sheet with all parts of the wire touching the sheet. When

gradually heated by an electric current this wire failed to act as a fuse as expected but increased in temperature with increases in current until it was red hot, and the temperature was 500° F. above the melting point. With adequate support on a smooth surface the oxide layer on the outside of the wire acts like the skin on a sausage to contain the molten metal and prevent rupture. When the same experiment was repeated with the wire laid against a rough surface, rupture and interruption of the circuit took place below the expected temperature. The following is offered as a possible explanation: the wire heats unevenly, points touching the support being much cooler than those which bridge between high spots. These areas which are not as directly cooled by conduction reach higher than the average temperatures and, due to the positive temperature coefficient of resistance, develop more heat than adjacent spots. When the local temperature is close to the melting point the wire is tremendously weakened, and, being unsupported collapses with a rapid local reduction in cross sectional area. This greatly increases the heat dissipation at the spot of incipient failure and causes the wire to quickly reach a temperature at which it agglomerates in the low spots and ceases to be a conductor, whereupon the whole system quickly cools off.

No noticeable local overheating of a heating element, including the glass braid and protective covering, takes place during the fusing process as described above. Probably this is due to the fine wire size and the rapidity of the phenomena. Regardless of whether the foregoing explanation is correct the rough inside surface of the preferred braid construction appears to be advantageous in decreasing the temperature at which fusing takes place. The fusing temperature can of course readily be varied within wide limits, as for example if the proper proportions of tin, lead and bismuth are used an alloy melting at only 205° F. can be obtained.

My improved conductor and resistance wire may be used for many different purposes particularly as a heating element for various appliances such as the heating tape shown in Figs. 3-5 inclusive, or the heating blanket shown diagrammatically in Figs. 6 and 7.

In using the conductor and resistance wire the device should be assembled so that any applied tensile stresses are carried by the casing and cannot cause stretching of the wire itself. Since the wire is brought outside the casing only at the two ends of a given length, for the purpose of making electrical connections, it is at these two points only that special precautions need be taken. A variety of constructions have been found suitable to accomplish this purpose. In Figs. 3-5 inclusive, I have shown a heating tape or ribbon in the form of an elongated strip or ribbon 14 having longitudinal corrugations 15 formed therein interconnected by the flat webbed portions 16.

The body of the strip or ribbon is made of a plastic material having good dielectric properties. For this purpose, I prefer plasticized polyvinyl chloride. Embedded in the plastic body of the strip or ribbon in alignment with the ribs thereof are the conductors or resistance wires 11. Where the casing 12 is impregnated with plasticized polyvinyl chloride it can be locally bonded or heat-sealed to the body of the ribbon by the application of dielectric heat at each end of the strip, after stripping the wires bare for a short distance to make connections to the

5

blades of the plug at one end, and on the other end between the conductors. The body of the strip can then be mechanically fastened in the plug by the use of conventional solderless terminals or otherwise and will transfer stresses from the plug into the braided reinforcement without stressing the wire.

In the illustrated embodiment of the tape heating element the stress-carrying braid 12 is impregnated with a wax and, therefore, cannot be made to adhere to the body of the strip 14. One end of the ribbon or tape 14 is provided with a plastic button 17 and the other end with a conventional plug 18 having contact prongs 19.

The conducting wires 11 are connected together and soldered inside the plastic button 17 in the manner indicated at 20 so as to provide a complete circuit. The plastic button 17 is secured by fusing to the plastic body of the ribbon as shown, so that tension forces applied to the button will be transmitted to the body of the ribbon. The latter is strong but has such a low modulus of elasticity that it readily stretches when stressed. Thus a tension force applied to the button tends to slip the body of the ribbon along the casings 12 and would stretch or break the wires 11. To prevent this action the casing 12 is unraveled from the connected ends of the conductor as shown at 21 and is embedded in a suitable plastic or resin coating, which adheres thereto, such as polyamide. The polyamide resin is applied hot and strikes through the wax impregnation, adhering to the glass fibers and serving as a stop to limit the outward movement of the plastic body of the ribbon. In this manner any tensile loads will be transmitted through the glass braid casing and do not break or stretch the conducting wires.

Provision must also be made at the plug end of the tape to transmit the tensile stresses through the glass braid casing rather than through the conducting wires. This may take the form shown in Figs. 3 and 4 in which the two outer resistance elements are extended beyond the plastic body of the tape and tied into simple knots as shown at 23 and a flexible acetate cement is preferably applied to the knotted area of the glass braid casing. Provided the braid is not unraveled at the point the knot is tied, such knots do not adversely affect the wire.

The glass casing preferably terminates just beyond the knotted area, but the conducting wire 11 is extended therebeyond and is folded back upon the resistance element in a small loop as shown. The looped portion of the conductor and the entire resistance element immediately beneath the knot is then encased in the tubular sleeve 24 of a solderless terminal connector 25 which, in turn, is connected by means of a screw 27 to the end of prong 19. The tubular neck 24 is tightly compressed around the resistance element to insure contact with the wire and prevent corrosion and so that if any attempt is made to withdraw it from the end of the element it will engage the knot 23. The neck portion of the terminal connector is preferably encased in an insulating sleeve 27 made of a vinyl resin or the like.

The two adjacent or inner resistance elements of the tape are extended slightly beyond the body of the tape at the plug end thereof as shown in Fig. 3 and the glass braid casing is unraveled therefrom and the two wires are secured together as shown at 28. The connected wires and the unraveled glass casing are then embedded

6

in polyamide resin which adheres to the glass fibers as shown at 29. The polyamide serves to protect the connected wires when they are inserted in the plug. Also, due to the adherence of the polyamide to the glass fibers it serves as an additional stop to prevent outward movement of the plastic body of the tape.

If tensile forces are applied to the plug 18 they will be transmitted to the terminal connectors 25 which, in turn, will transmit them to the glass braid casing due to the interengagement of the necks of the terminal connectors with the knots 23. Thus, it will be seen that tensile stresses are not transferred to the conductors but are carried directly by the glass braid casing.

When my improved conductor and resistance element is used in a heating blanket such as shown diagrammatically in Figs. 6 and 7 provision must likewise be made so that tensile stresses cannot stretch the wire. For this application I prefer to use a 4% antimonial lead wire having a diameter of .0104" and a resistance of approximately 1.43 ohms per foot. With a two inch spacing between the paths of the element this resistance results in the desired heat dissipation of 180 watts on 115 volts, if two parallel circuits are used. The stress-carrying casing is preferably in the form of a braid with 11 pics to the inch using glass fiber yarn having a yield of about 7500 yards per pound and a tensile strength in excess of 20 pounds. This braid is impregnated with a vinyl emulsion and the resin is set by the application of heat, followed by cooling. These operations are completed before releasing the tension which is applied as the braid is withdrawn from the braiding machine. Since the greatest possible flexibility is desired for the finished resistance element, but additional electrical insulation and mechanical protection are regained, I prefer to apply an outer casing of highly plasticized vinyl chloride in a thin layer, the resin being applied as a plastisol by dipping and cured by heating under tension to 350° F., the element being cooled before the tension is released. The element 10 so formed is shown in Figs. 6 and 7 stitched to a suitable fabric 30. The two terminal ends of the resistance element are arranged so as to be in proximate relationship as shown in Fig. 6 and are then connected to conventional lead wires 31 having an electric plug 32 at the end thereof.

The connection between the two ends of the resistance element 10 and the lead wires 31 is shown generally at 33 and is illustrated in detail in Fig. 7. This connection is similar to the connection between the resistance elements and the prongs of the plug 18. Thus, the resistance elements are tied into simple knots 23 and the knotted area is impregnated with a flexible cement. The conducting wires 11 are extended beyond the knotted areas and folded backwardly in a loop against the resistance element. The looped wire and resistance element immediately beneath the knot is encased in the sleeve 24 of the terminal connector 25 which, in turn, is connected to the lead wire 31.

Thus any forces in tension applied to the lead wires 31 will be transmitted through terminal connector 25 to the glass braid casing.

The heating tape shown in Figs. 3 to 5 is somewhat similar to that shown in my copending patent application Serial No. 81,550 and is used in a similar manner. Thus, the plug 18 is connected to a suitable electric outlet and due to the fact that the conductors have been connected

together to form a complete circuit the ribbon or tape will serve as a heating element and can be used to prevent water pipes or the like from freezing.

The heating blanket shown in Figs. 6 and 7 is connected to a source of electric current in the usual manner and can be used in the conventional manner of a heating blanket. Conventional thermostats and various types of automatic control are suitable for use with a heating blanket using my new conductor and resistance element, but are not shown since they form no part of my invention.

My improved resistance element provides a high degree of safety against fire hazards in that it will readily fuse and open the circuit if inadvertently connected to too high a potential or if a short circuit should develop due to any mechanical damage to the insulation or if the device is allowed to operate under conditions which restrict the heat dissipation and give rise to excessive temperatures.

My improved conductor and resistance wire can be used for many other purposes particularly where it is desired to have a heating element which is safe in operation and which can withstand reasonable tensile stresses and loads. It will thus be seen that I have provided an improved self-fusing electrical conductor and resistance wire having a tension or stress member associated therewith in such a manner that the tensile stresses are sustained directly thereby. Modifications may be made in the illustrated embodiment of my invention without departing from the invention as set forth in the accompanying claims.

I claim:

1. An electrical heating element comprising a plurality of elongated, attenuated, fragile wires arranged in parallel relationship, separate stress carrying insulating casings substantially non-stretchable in a longitudinal direction in the form of glass fibre tubular braids disposed around the aforesaid wires with the glass fibre strands disposed at a relatively small angle of less than 45° to the longitudinal axis of the braid, a second unitary casing made for material having a lower modulus of elasticity than the glass fibre tubular braids disposed around the first casings and wires and arranged in the form of a corrugated elongated ribbon, a plug having electrical contacts connected to certain of the wires at one end of the unit, certain of the wires being connected together at the opposite end to provide a complete electrical circuit, and insulat-

ing means encasing the wires at the said opposite end of said unit, said plug and insulating means having mechanical connection with the stress carrying insulating casings adjacent the two ends of the unit whereby tensile stresses applied to the two ends of the unit are carried directly by the stress carrying casings.

2. An electrical conductor comprising an elongated, attenuated, fragile metal wire, a stress carrying insulating casing substantially non-stretchable in a longitudinal direction in the form of a tubular braid disposed around the wire and made of glass fibre strands disposed at a relatively small angle of less than 45° to the longitudinal axis of the braid, a second insulating and protective casing made of a material having a lower modulus of elasticity disposed outside the first casing and means for transferring to the first casing any tensile stress which may be applied to the second casing.

3. An electrical conductor as set forth in claim 2 in which knots are formed adjacent the two ends of the first casing in engagement with the second casing for transferring tensile stress from the first casing to the second casing.

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