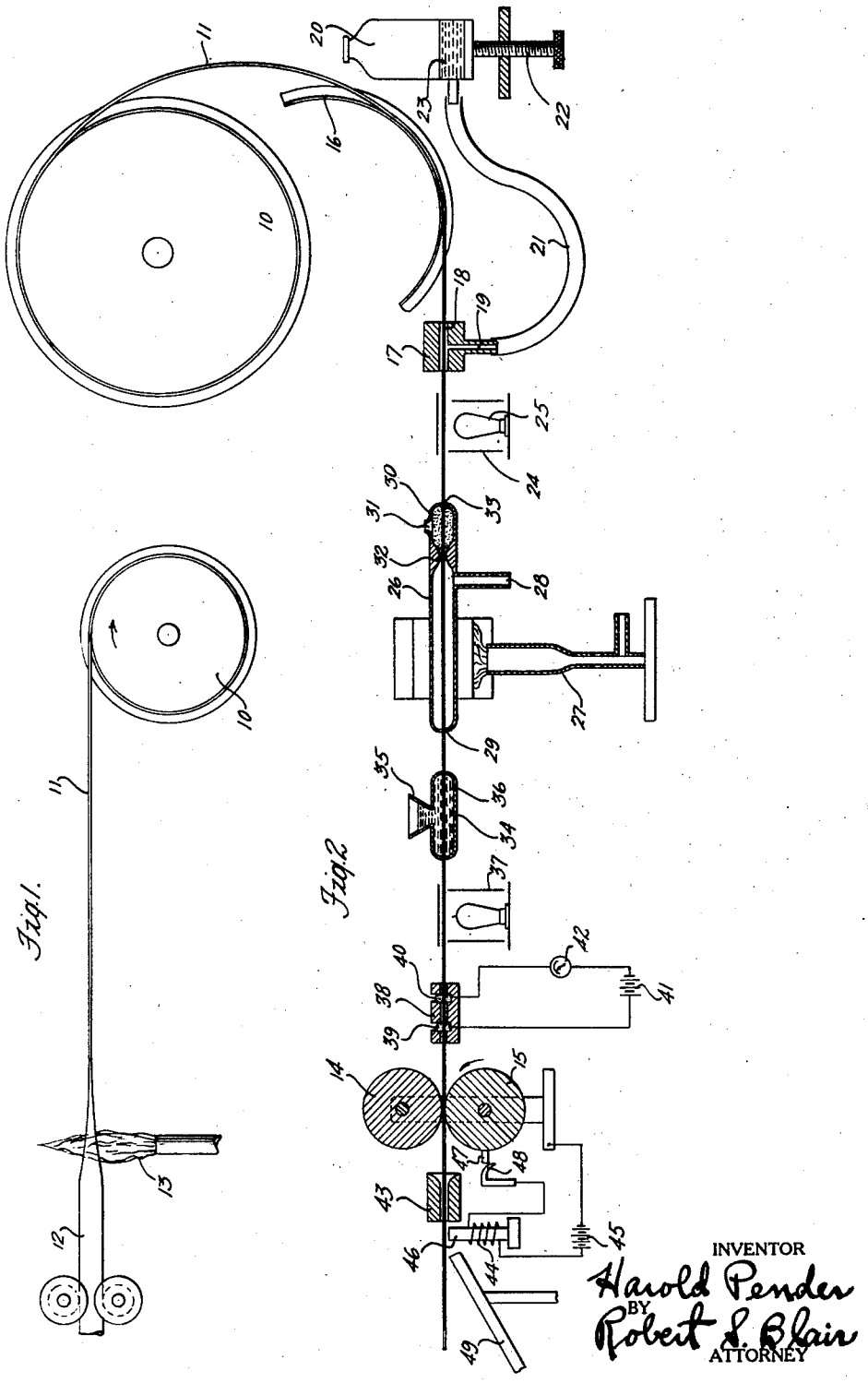
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ELECTRICAL RESISTANCE AND FORMATION OF THE SAME

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ELECTRICAL RESISTANCE AND FORMATION OF THE SAME

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This invention relates to electrical resistance devices or media and to the formation or manufacture of the same.

One of the objects of this invention is to provide a medium of high electrical resistance which is practical and efficient. Another object is to provide a resistance medium or device having certain desired characteristics in operation and free from certain undesirable characteristics. Another object is to provide an electrical resistance medium which is of simple construction and inexpensive. Another object is to provide a device of the above nature which is durable and capable of dependable service. Another object is to provide a practical art of producing such media or devices which may conveniently be carried on with speed and accuracy of results. Another object is to provide simple and inexpensive apparatus for carrying on such an art. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing, in which is shown one of the various possible embodiments of the mechanical features of this invention,

Figure 1 illustrates somewhat diagrammatically a preferred method of forming a part of the resistance device, and

Figure 2 shows somewhat diagrammatically an apparatus for the formation of an electrical conducting medium of high resistance.

Similar reference characters refer to similar parts in both views of the drawing.

Referring now to the drawing in detail, there is shown in Figure 2 a roll 10 upon which is wound a continuous fiber-like or thread-like member of non-conducting material shown passing from the roll 10 at 11. This non-conducting fiber or thread is preferably of glass, glass having certain advantageous characteristics which will be later pointed out, but it is to be understood that other non-conducting material might be employed to advantage.

This glass fiber 11 is preferably formed as is illustrated in Figure 1. A glass rod 12, for example, about three-eighths of an inch in diameter, is fed endwise through a heating medium, in this instance shown as a gas flame 13. As the rod is fed through the heating medium 13 its end is softened, and this softened end is grasped, drawn out, and wound upon the roll 10, forming the fiber 11. The roll 10 is driven, in the direction indicated by the arrow in Figure 1, at a rate of speed which is predetermined with respect to the rate of feed of the rod 12, into the heating medium 13. Preferably the roll or spinning wheel 10 and the mechanism driving the rod 12 through the heating medium 13 are both driven from a common source of power, so that there is thus maintained a constant ratio between the speed at which the filament 11 is pulled out and the speed at which the rod is moved into the heating medium. In this manner the glass fiber or thread 11 is drawn out in a uniform diameter, providing the diameter of the glass rod 12 is uniform. Preferably the heating element 13, the speed of movement of the rod 12 and the speed of rotation of the roll 10 are so proportioned that the glass fiber 11 is uniformly drawn out to a diameter in the neighborhood of two-hundredths of an inch. It is to be understood, however, that any desired diameter of the fiber 11 may be obtained, and that the diameter desired may vary with varying conditions of use.

Referring now again to Figure 2, the glass fiber 11 is drawn from the roll 10 and, after passing through various mechanisms which will be described in detail herein, is gripped between a pair of driven rollers 14 and 15. The peripheries of these feed rollers 14 and 15 are preferably covered with a yielding material such as leather, and these rollers grip the glass fiber 11, drawing it from the roll 10 through the various mechanisms which will presently be described.

Referring now to the right-hand side of

Figure 2, the glass fiber 11 as it is drawn from the roll 10 first passes over a curved and trough-shaped guide 16. The guide 16 at its lower end properly positions the glass fiber for passage through a coating device 17. This device 17 is preferably in the form of a T-tube having a horizontal passage 18 through which the fiber 11 is drawn and a vertical passage 19 communicating at its upper end with the first passage. A container such as a bottle 20 contains the material, in the form of a fluid, with which the fiber 11 is to be coated in the coating device 17. The lower end of the bottle 20 is connected by a flexible tube 21 with the mouth of the vertical passage 19 in the coating device. The bottle 20 is preferably adjustable in a vertical direction, as by means of an adjusting screw 22.

As was mentioned above, the material with which the fiber 10 is coated in the coating device 17, is contained in the form of a liquid or a solution in the bottle 20. This material, indicated at 23, comprises preferably minute particles of a suitable electrical conducting material suspended in a suitable solution. A satisfactory material is carbon in the form of extremely minute (almost colloidal) particles suspended in solution. The character of the solutions employed will later be pointed out more fully herein. By adjusting the height of the bottle 20, the solution fills the tube 21 and rises through the passage 19, filling the passage 18 through which the glass fiber 11 is drawn. Capillary action prevents the solution from flowing out of the ends of the horizontal passage 18. As the glass fiber is drawn through the passage 18 it is coated with a thin layer or film of the solution of conducting material; the thickness of the film deposited upon the fiber may be controlled by adjustments of the height of the bottle 20.

The glass fiber thus emerges from the coating device 17 covered with a thin moist coating of the conducting material contained in solution in the bottle 20. The fiber now passes through a drying device 24 which is heated by suitable means illustratively shown as an electric light bulb 25. In this drier 24 the moist conducting coating or film is dried.

The glass fiber now passes through a heating device or furnace 26 wherein it is subjected to a more intense heat, wherein all moisture is positively driven from the glass fiber and from the conducting coating thereon, and wherein certain other changes take place, which will later be described. This furnace preferably takes the form of an elongated tube as shown, heated, for example, by means of a Bunsen burner 27. Air is preferably excluded from the furnace 26 as the coated glass fiber passes therethrough, and it is found advantageous to substitute for the air an atmosphere of certain gases. For this purpose hydrogen is found to be particularly advantageous. A supply of hydrogen is connected with the interior of the heating tube adjacent its right-hand end at 28, and the hydrogen is permitted to escape gradually through the opening 29 at the left-hand end, through which the glass fiber passes from the furnace. In order to prevent exit of hydrogen from the right-hand or entering end of the furnace, this end is sealed by suitable means such as mercury 30 which prevents exit of the hydrogen, but permits ready drawing of the glass fiber 11 therethrough. The mercury is introduced through an upper opening 31 and cannot flow out through the restricted passages 32 and 33 on either side thereof through which the glass fiber 11 is drawn. The atmosphere of hydrogen, among other advantages attained thereby, prevents oxidation of the conducting film.

From the furnace 26 the glass fiber is drawn through a second coating device 34. In this coating device there is applied to the glass fiber, exterior of the conducting coating, a coating of a suitable protective material in the nature of a binder which is adapted to hold the conducting coating in place upon the glass fiber and prevent its accidental rubbing off. The device 34 preferably takes the form of a T-tube having a funnel-shaped upper mouth 35 through which the coating solution 36 is introduced. Capillary action prevents the solution from running out of the two horizontal openings through which the glass fiber is drawn. The material 36 preferably comprises a solution of rosin in benzol, and a thin coating of this solution is deposited exterior of the conducting film as the glass fiber passes through the device 34.

Upon emerging from the coating device 34 the glass fiber passes through a heating device or drier 37 similar to the drier 24. In the drier 37 the benzol is driven off and a thin layer or coating of rosin remains over the conducting film. By adjusting the concentration of the benzol-rosin solution, the thickness of the coating given in the device 34 is made such that it gives ample protection to the conducting coating, but yet this protective coating is so thin that it does not materially insulate the conducting coating.

The glass fiber now preferably passes through a device 38 containing two mercury contacts 39 and 40 and spread a predetermined distance apart. Across these two contacts is connected a battery 41 and a suitable resistance measuring device 42, which may be an ordinary "megger". The megger 42 thus gives a constant reading of the resistance of the conducting film per given length of the glass fiber, and this resistance will remain substantially constant and uniform.

The coated glass fiber now passes through

between the feeding rollers 14 and 15 which, as was mentioned above, draw the fiber through the series of devices just described. Emerging from the feed rollers 14 and 15, the glass fiber passes through a suitable guide 43. Adjacent the left-hand end of the guide 43 is a solenoid 44 fed by the battery 45 and provided with a plunger 46. The lower feed roller 15 is provided on its periphery with a projecting contact 47 which, at each rotation of the roller, strikes a spring contact 48, completing the circuit of the solenoid 44. Thus at each rotation of the roller 15 the plunger 46 is drawn upwardly and breaks off the glass fiber emerging from the left-hand end of the guide 43. The coated glass fiber is thus cut into predetermined lengths by the plunger 46 and these lengths are received in a suitable trough 49.

Considering now more particularly the nature of the material employed in forming the conducting film upon the glass fiber, it has been pointed out above that a satisfactory material is carbon in the form of minute particles suspended in a solution. Excellent results are obtained by employing either a suspension of carbon in an aqueous solution of glue-like material or a suspension of carbon in a liquid hydrocarbon. As an example of the latter, a solution of lamp black and linseed oil may be employed. As an example of the first, a mixture of Le Page's glue and lamp black in substantially equal parts mixed into a paste and then diluted with water to the desired consistency gives satisfactory results. Another solution which gives excellent results is the commercial Higgins carbon drawing ink. This ink is a solution of carbon and appears to contain a glue-like constituent.

In the furnace 26, the temperature employed is preferably kept within the limits of 700° and 1350° F. The best results are obtained when a temperature in the neighborhood of 1200° or 1300° F. is employed. An effect of this baking in the furnace 26 is to drive off the volatile constituents of the glue or other material mingled with the carbon, leaving practically a pure carbon film. The glue is carbonized by the heat and the particles of carbon resulting therefrom appear to fill the interstices between the carbon particles which were suspended in the solution, so that a solid uniform coating of carbon results.

From the above, it will be seen that there is provided herein a simple and highly practical method and apparatus for constructing a resistance medium or device, and that the resultant product is one embodying practical advantages of the greatest importance. The glass fiber being non-porous and the conducting film being thoroughly dried and covered with a non-hydroscopic coating, the resistance device is stable in its resistance, being unaffected by changes in temperature and not susceptible to variations in its moisture content, due to weather conditions or other conditions of use. The conducting coating is deposited upon the glass fiber in such manner that it may be formed in an extremely thin film which is of a definite and substantially unvarying thickness throughout. These characteristics and others render this resistance device of particular advantage when used in wireless-receiving apparatus and other sound amplifiers, the device being particularly well adapted for use in the so-called "grid leak" circuit of wireless-receiving apparatus. It is found that this resistance device is non-microphonic, that is, it produces no hiss or "frying" noise when employed in a sound amplifying apparatus. Particular advantages are attendant upon the use of carbon as the conducting film, although this invention in its broadest aspects is not limited to the use of carbon. In addition to the advantages pointed out above, the temperature coefficients of glass and carbon are approximately the same, and therefore the glass-supporting fiber and the carbon film expand approximately equally under heat, so that there is no tendency to crack.

As many possible embodiments may be made of the mechanical features of the above invention, and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. The herein described art of forming an electrical resistance which consists in applying to the surface of a non-porous, non-conducting, heat resistant fiber, a fluid film containing minute particles of carbon and a material adapted when baked at suitable temperatures to form a conductive substance filling the interstices between said carbon particles, and then baking said fiber at said suitable temperature to form a conductive coating of substantially uniform continuity.

2. The herein described art of forming an electrical resistance which consists in giving to a pliable non-conducting, heat resistant fiber a continuous, progressive, endwise movement, applying to the surface of said fiber as it moves a film of carbonaceous material, and then baking said film to provide a carbon coating of substantially uniform continuity.

3. The herein described art of forming an electrical resistance which consists in giving to a pliable non-conducting, heat resistant fiber a continuous, progressive, endwise movement, applying to the surface of said fiber as it moves a film of carbonaceous material, and then baking said film at a temperature in excess of 700° F. to provide a

carbon coating of substantially uniform continuity.

4. The herein described art of forming an electrical resistance which consists in giving to a pliable non-conducting, heat resistant fiber a continuous, progressive, endwise movement, applying to the surface of said fiber as it moves a film of carbonaceous material, and then baking said film at a temperature between the limits of 700° F. and 1350° F. to provide a carbon coating of substantially uniform continuity.

5. The herein described art of forming an electrical resistance which consists in giving to a pliable non-conducting, heat resistant fiber a continuous, progressive, endwise movement, applying to the surface of said fiber as it moves a film of carbonaceous material, and then baking said film at a temperature in excess of 700° F. in a non-oxidizing atmosphere to provide a carbon coating of substantially uniform continuity.

6. The herein described art of forming an electrical resistance which consists in giving to a pliable non-conducting, heat resistant fiber a continuous, progressive, endwise movement, applying to the surface of said fiber as it moves a film of carbonaceaus material, then baking said film to provide a carbon coating of substantially uniform continuity, and then applying to said coating a protective non-hydroscopic covering.

7. The herein described art of forming an electrical resistance which consists in giving to a pliable, non-conducting, heat resistant fiber a continuous, progressive, endwise movement, applying to the surface of said fiber as it moves a film of carbonaceous material, then baking said film to provide a carbon coating of substantially uniform continuity, and then applying to said coating a protective non-hydroscopic covering of a resinous substance.

8. The herein described art of forming an electrical resistance which consists in giving to a glass fiber of sufficiently small diameter to be pliable, a continuous, progressive, endwise movement, applying a fluid film of carbonaceous material of controlled thickness to said fiber as it moves by one point in its path of movement, and baking said film as said fiber moves past another point in its path of movement.

9. The herein described art of forming an electrical resistance which consists in giving to a glass fiber of sufficiently small diameter to be pliable, a continuous, progressive, endwise movement, applying a fluid film of carbonaceous material of controlled thickness to said fiber as it moves by one point in its path of movement, and baking said film as said fiber moves past another point in its path of movement by surrounding said member at said last point with a heated gas.

10. The herein described art of forming an electrical resistance which consists in giving to a glass fiber of sufficiently small diameter to be pliable, a continuous, progressive, endwise movement, applying a fluid film of carbonaceous material of controlled thickness to said fiber as it moves by one point in its path of movement, and baking said film as said fiber moves past another point in its path of movement by surrounding said member at said point with a non-oxidizing gas heated to a temperature in excess of 700° F.

11. The herein described art of forming an electrical resistance which consists in drawing a glass fiber from a source of supply past a plurality of points for successive stages of treatment, applying a carbon coating to said fiber at one of said points, and baking said coating at a subsequent point.

12. The herein described art of forming an electrical resistance which consists in drawing a glass fiber from a source of supply past a plurality of points for successive stages of treatment, applying a carbon coating to said fiber at one of said points, baking said coating at a subsequent point, and depositing a protective covering over said coating after said fiber has passed said baking point.

13. The herein described art of forming an electrical resistance which consists in drawing a glass fiber from a source of supply past a plurality of points for successive stages of treatment, applying a carbon coating of controlled thickness to said fiber at one of said points, baking said coating at a subsequent point, and depositing a protective covering over said coating after said fiber has passed said baking point.

14. The herein described art of forming an electrical resistance which consists in applying to the surface of a non-porous, non-conducting, heat resistant fiber, a fluid film containing minute particles of carbon and a material adapted when baked at suitable temperatures substantially above 700° F. to form a conductive substance filling the interstices between said carbon particles, and then baking said fiber at said suitable temperature to form a conductive coating of substantially uniform continuity.

15. The herein described art of forming an electrical resistance which consists in applying to the surface of a non-porous, non-conducting, heat resistant fiber, a fluid film containing minute particles of carbon and a material adapted when baked at suitable temperatures in the neighborhood of 1000° F. to form a conductive substance filling the interstices between said carbon particles, and then baking said fiber at said suitable temperature to form a conductive coating of substantially uniform conductivity.

16. The herein described art of forming an electrical resistance which consists in applying to the surface of a non-porous, non-conducting, heat resistant fiber, a fluid film

containing minute particles of carbon and a material adapted when baked at suitable temperatures to form a conductive substance filling the interstices between said carbon particles, and then baking said fiber at said suitable temperature in a non-oxidizing atmosphere to form a conductive coating of substantially uniform conductivity.

In testimony whereof, I have signed my name to this specification this fourteenth day of May, 1925.

HAROLD PENDER.