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METHOD OF APPLYING A FIBROUS COATING TO A FILAMENT OR WIRE

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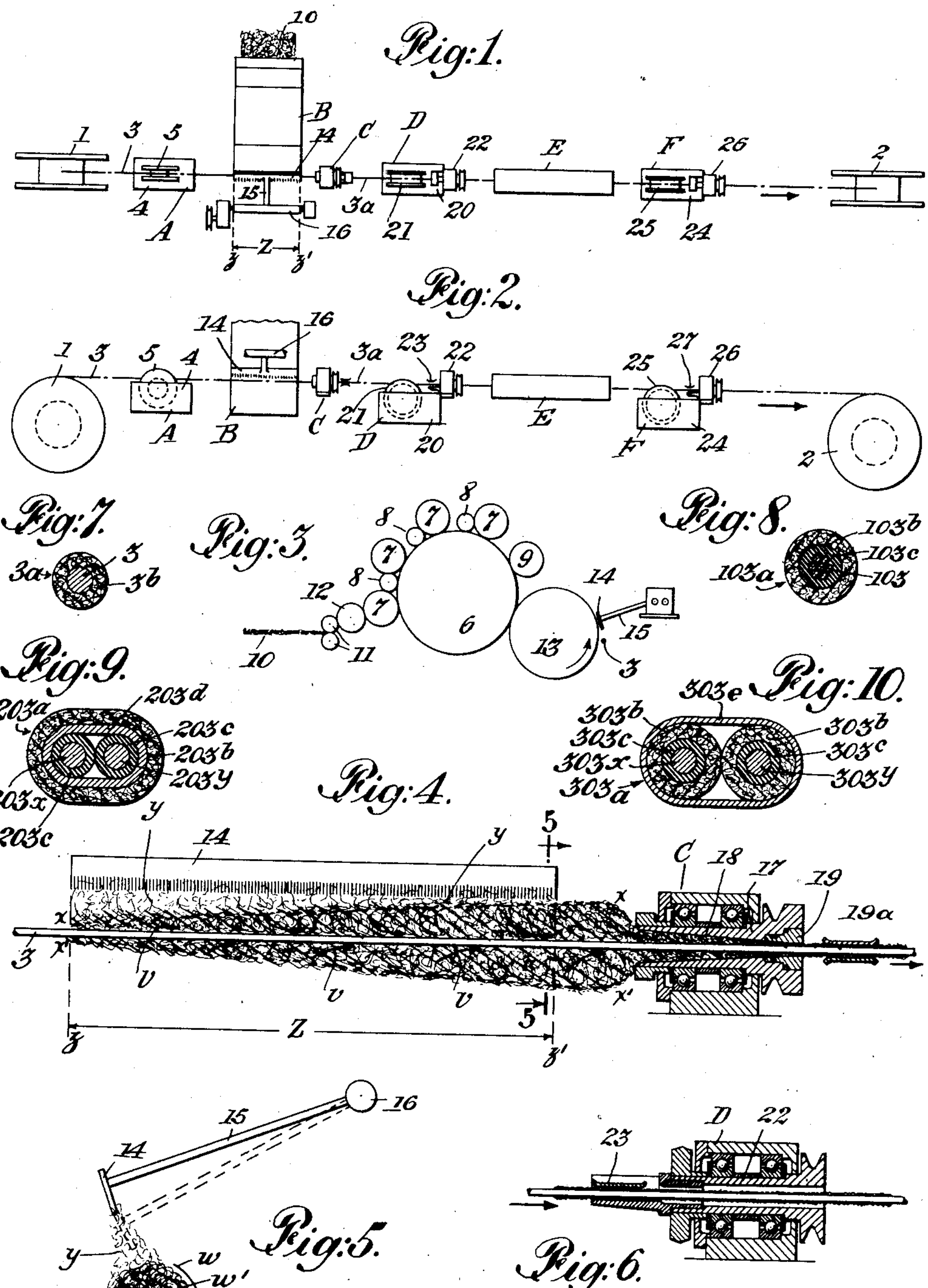

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METHOD OF APPLYING A FIBROUS COATING TO A FILAMENT OR WIRE

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Our invention consists in the novel features hereinafter described, reference being had to the accompanying drawing which shows the manner in which our improved process is carried into effect, and one form of apparatus which may be conveniently employed therefor, and said invention is fully disclosed in the following description and claims.

This application is a continuation in part of our former application for Letters Patent of the United States, filed August 6th, 1930, and given Serial No. 475,680, as to all matters common to both applications.

The object of our invention is to produce cheaply and rapidly an electric conductor provided with an insulating coating of unspun, untwisted fibres compacted upon the conductor, or filament, or upon an interior coating or covering previously applied thereto, in such manner that the fibres of the coating from the inner to the outer surface thereof, are in a compacted condition which may be likened to a felted condition, and is therefore having all parallelism of the fibres completely destroyed, so that they lie in all directions in the coating and are minutely and thoroughly intermingled and interengaged, so that the bending of the covered conductor, no matter how sharply nor to what extent, cannot open up a path between the fibres to the conductor or the interior covering thereof. By this arrangement of the fibres in the coating there can be no exposure of the conductor nor impairment of the insulating value thereof by bending or other rough usage to which the conductor may be subjected. The particular fibres employed may be silk or cotton, linen, asbestos, or other fibres, according to the character of use to which the insulated conductor is to be put, and our unique method of applying the fibres to the conductor is hereinafter fully set forth. It will be understood that the fibre coating may be followed by other coatings of insulating or protecting materials commonly used in the wire and cable industry, if desired.

We are aware that it has previously been proposed to wind bands or laps of fibres or threads, arranged in substantial parallelism spirally around a conductor or filament, the edges of each coil of such bands or laps being in contact with the edges of adjacent coils, but in such case the bending of the covered conductor will cause a separation between the adjacent edges of said coils on the outer side of the bend, in a direction lengthwise of the conductor, and the consequent impairment of the insulating value of the covering or coating. It has also been proposed to lay parallel fibres longitudinally of the conductor to produce a coating, but in this case also the bending of the conductor will place the parallel longitudinal fibres on the outer side of the bend under longitudinal tension, and those on the inner surface of the bend under longitudinal compression, both of which effects tend to loosen the parallel fibres from the conductor, separate them in directions transversely of the conductor and impair the value of the insulation.

It has also been proposed to wind loosely associated parallel fibres around a conductor which is moved continuously in a longitudinal direction. This has been accomplished usually in two ways, either by rotating the conductor and simultaneously moving it longitudinally past a film of loosely associated parallel fibres carried toward the conductor, with the parallel fibres disposed angularly thereto, and secondly by continuously moving the conductor longitudinally while holding it against rotation. In the first case complicated and expensive mechanism is required to continuously rotate the supply and take-up reels from and to which, respectively, the conductor is transferred, about the axis of the section of conductor between them, which is being covered, and at the same time to rotate said reels upon their own axes to effect a longitudinal movement of the said section of the conductor, and such mechanism cannot be practically operated at very high speed. In the second case the mechanism for supplying the film of parallel fibres must be continuously rotated around the longitudinally moving conductor, requiring complicated mechanism, which likewise cannot practically be operated at high speed. But in both types of processes, the original parallelism of the fibres persist substantially in the coating, although the combined rotary and longitudinal relative motion between conductor and fibres may somewhat vary the angularity of the fibres to the axis of the conductor, and on bending the covered conductor the adjacent parallel or nearly parallel fibres tend to separate from each other on the outer side of the bend at all points in the thickness or depth of the coating, and thus impair the insulating value of the coating.

It has also been proposed to feed a film of parallel fibres, and to simultaneously feed a conductor lengthwise in the same direction as the fibre film and centrally thereof, and by transversely movable rubbing belts wrap the fibre film around the conductor. This, however, results in laying the fibres nearest the conductor parallel thereto and to each other, and bringing the opposite edges of the film together, the outermost fibres only being deflected laterally by the rubbing belts, and the bending of the conductor tends to separate the longitudinal parallel fibres on the outside of the bend, and split apart the edges of the film, thus depreciating the value of the insulating coating.

We have mentioned the prior processes and the products thereof to assist in a clear understanding of our present invention, and to assist in distinguishing it from the disclosures of the prior art.

According to our present invention, we effect the longitudinal movement of a conductor, while holding it against rotation, which enables us to use stationarily supported reels, and simple means for rotating them on their own axes, at any desired speeds. We then bring to a longitudinal portion of the conductor of any desired length, and which has been coated with any suitable adhesive material, a supply of loosely associated, interengaged and interentangled fibres, in which all parallelism of the fibres has been completely destroyed, so that they constitute a formless mass. The fibres may be brought to a point near the conductor in a state of substantial parallelism, if desired, as a matter of convenience, and to enable the ordinary carding instrumentalities to be employed, but in such case the fibres are acted upon, for example, by a comb or other suitable device, to not only remove them from the contiguous card element, but to utterly destroy and break up the parallelism of the fibres, and deliver them, preferably downwardly, so that they fall by gravity, in the loosely associated and intermingled and interengaged condition as a formless mass, to the conductor continuously throughout a predetermined distance longitudinally thereof, which we will call the application zone.

Adjacent to the end of the application zone, where the conductor leaves it, there is provided a rapidly moving rotating surface. This is most conveniently provided by drawing the conductor through a rapidly revolving hollow device usually designated a whirl, the inner face of which decreases in diameter in the direction of longitudinal movement of the conductor. This rotating part or whirl is rotated at very high speed (for example, 3500 R. P. M. is a desirable speed), and it performs two functions hereinafter set forth.

As each point in the conductor enters the application zone, the fibres which are brought into immediate contact with its adhesively treated surface, will be caused to adhere at some part of each fibre to the conductor, and be drawn along with it, each fibre tending to draw along other of the non-parallel fibres with which it is loosely interengaged, and as each point in the conductor passes through the application zone, additional fibres are added to the exterior portions of the fibres so drawn along. The result is that a loose cloud or floss of loosely associated interengaged fibres is continuously formed upon the portion of the conductor within the application zone, which increases in diameter from the entering end of said zone to the leaving end thereof, and after leaving the said zone, this formless mass or floss is drawn with the conductor into contact with the before-mentioned rapidly rotating surface, that is, specifically into the end of greatest interior diameter of the whirl. The frictional engagement between the rotating surface or whirl imparts its rotary motion to the outermost fibres of the said formless body of fibres or floss, and not only carries them around with the whirl, but by reason of the interengagement of fibre to fibre, imparts a rotary motion to the entire formless mass from the entering end of the application zone to the whirl or other rotating surface. The effect is to cause the entire mass to rotate continuously around the conductor, and to assume an approximately conical form, the interconnected fibres pulling each other along, and this mass is being continuously formed and continuously rotated and continuously drawn into the whirl as long as the machine is in operation.

As the conductor is held from rotation, the fibres directly and adhesively attached thereto, will not be rotated at all, but will also be held against rotation as they are drawn along, while they in turn tend to retard the rotary movement of the fibres interengaged therewith, with the result that the speed of rotation of the exterior portions of the mass of fibres is least at the entering end of the application zone, and gradually increases therefrom to the whirl, producing a spiral twisting effect upon the entire mass of loosely associated fibres, and the exterior fibres are wrapped around the conductor, at continuously increasing speed, causing a continuous rearrangement circularly of the fibres between the conductor, where they are not rotating to the outer surface of the mass, and tending to partially condense the mass of fibres. Furthermore as the whirling mass is drawn longitudinally with the conductor solely by the delicate and tenuous interengagement of fibre to fibre from the innermost fibres adhesively engaging the conductor, to the outermost fibres just deposited on the exterior of the rotating conical mass, the innermost fibres attached to the conductor move more rapidly than the outermost fibres in a direction longitudinally of the conductor, and there is a continuous re-arrangement, longitudinally of the conductor, between those innermost fibres attached to the conductor, and moving with it, and the exterior fibres. In other words, there is a momentum lag in respect to the outer fibres not adhesively connected to the conductor, as they are deposited on the rotary and longitudinally moving mass, and are gradually set in motion both rotarily and longitudinally by the interengagement with the fibres upon which and among which they fall.

These two re-arrangements of the fibres, circularly and also longitudinally, while they are clinging together merely by their interengagement, tends to draw the fibres into closer relation to each other and to the conductor, and to bring them into compact intermingled and non-parallel relation.

When the whirling mass of fibres passes through the whirl, the longitudinal movement of the outermost fibres is retarded to a greater extent by friction with the whirl, and the re-arrangement of the fibres longitudinally and circularly continues as the fibres are gradually condensed upon themselves and upon the conductor, while retaining the non-parallel relation, and compacted into a hard, close compacted body, completely enclosing the conductor. It will be understood that as the inner surface of the whirl gradually decreases in diameter, the surface speed of the inner face in contact with the fibres likewise decreases, and the fibre coating or covering is gradually compressed and condensed, while the differential of speed between the inner surface of the whirl and the non-rotating conductor filament lessens in a direction from the entering end to the leaving end of the whirl. In some instances the covered conductor may be passed through a second whirl, or a succession of whirls, to smooth and polish the exterior surface of the coating and a waterproofing, or other surfacing material, may be applied to the outer surface of the coating, between successive whirls, or otherwise, as may be desired. Obviously successive coatings can be applied one after another in the manner described, if an extremely heavy coating is desired, but we have found ordinarily that the thickness of the coating can be regulated by varying the speed of longitudinal feed of the conductor or the length of the application zone, or the feed of fibres thereto, one or more, or all, to obtain the desired results.

Our improved process is extremely simple and rapid in operation, so that great economy is effected, with greatly increased output. As a result of our process a coating is applied which partakes throughout from its inner to its outer surface of the character of felt, in which the contiguous fibres are non-parallel and are interentangled and engaged and compacted into a hard mass. The bending of the covered conductor, therefore, or rough treatment to which it may be subjected, cannot effect a separation of fibres either laterally or longitudinally of the conductor, which will expose the conductor or materially impair the insulating value of the coating. We are also able to use extremely short fibres, since no parallelism thereof is either desired or obtained.

While other fibres may be employed in carrying out our process, we prefer to use short staple asbestos fibres, not only on account of their electrical insulating value, but also on account of their heat resisting qualities. In the covered conductor filament, which is produced by our process, the fibres are in compacted non-parallel condition throughout, and there is no parallelism of the fibres at any point or points in the coating. Hence in the bending of the conductor the fibres lying as they do in all directions intermingled in compacted relation, can change their position sufficiently to accommodate the necessary longitudinal expansion of the covering on the outer side of the bend and the longitudinal compression on the inner side of the bend without the possibility of opening a path to the conductor filament and without weakening the insulating value of the covering.

Referring to the accompanying drawing,

Fig. 1 is a diagrammatic plan view representing a suitable apparatus for carrying our invention into effect.

Fig. 2 is a diagrammatic view of the same apparatus in elevation.

Fig. 3 is a diagrammatic sectional representation of a carding apparatus which may be conveniently employed for insuring the continuous delivery of loosely associated fibres in non-parallel condition to the longitudinally movable conductor filament.

Fig. 4 is an enlarged diagrammatic view illustrating the feeding of the fibres to the conductor through the friction zone and the final condensing thereof by means of a rotary whirl in which arrows have been employed to indicate the longitudinal re-arrangement of the fibres between the exterior of the revolving floss or mass and the conductor filament.

Fig. 5 is a diagrammatic sectional view on the line 5—5 of Fig. 4, in which a series of arrows of different lengths at different distances from the conductor filament are employed to indicate the re-arrangement circularly of the fibres within the rotating floss or mass of non-parallel fibres.

Fig. 6 is a detail view of one of the smoothing whirls illustrated in Figs. 1 and 2.

Fig. 7 is a cross section of a conductor produced by our process in which the fibrous felted coating is applied directly to the metallic conductor.

Fig. 8 is a similar section, showing the fibrous felted coating applied over an insulating covering surrounding the metallic conductor.

Fig. 9 is a similar section showing a "heater cord" comprising a plurality of metallic conductors each surrounded by an insulated coating and united by a surrounding coating around which the fibrous felted coating is applied.

Fig. 10 is a similar section showing a similar "heater cord" in which the fibrous coating is applied to each conductor filament over an insulating coating thereon, and the covered conductors are surrounded by an outer braided covering.

While our improved process may be carried out by hand or by various instrumentalities, we have illustrated in the accompanying drawing, diagrammatically, suitable mechanical means which may be arranged in a machine with the rotating parts operated at the desired speeds in the usual or any preferred manner, and it has been found highly efficient in carrying our invention into effect. In this apparatus, 1, represents a stationarily supported rotary supply spool or reel, for the conductor filament, to be covered, and 2, represents a similar stationarily supported and suitably rotated spool or reel upon which the covered conductor filament is wound. 3 represents the conductor filament to be coated, which may be a bare metal wire of any desired diameter, or it may be a wire to which some previous coating has been applied, and which is to be covered by the fibre coating of our invention, or the conductor filament may comprise a plurality of metallic wires, or a plurality of metallic wires independently insulated from each other, and we therefore use the term conductor filament as including any of these forms of core, or any other forms of core upon which the fibrous coating of our invention is applied. In the drawing, 3*a*, indicates the conductor filament, after the application of the fibre coating thereto.

As will be understood, the conductor filament is drawn from the reel, 1, and passes preferably in a straight line through the machine and the covered conductor filament is wound up on the reel, 2. As both reels are stationarily mounted, that is to say, mounted in stationary bearings, the conductor is thereby held against rotary movement.

Adjacent to the reel, 1, is located an adhesive applying apparatus, A, of any desired or usual form for applying an adhesive coating to the conductor filament. For example, we have shown in the diagrams this element of the machine as comprising a receptacle, 4, and having portions for engaging the conductor filament in a well known way, to apply a liquid adhesive material thereto, which may be of any desired character.

After passing from the adhesive applying apparatus, A, the conductor filament passes longitudinally through what we term the application zone, indicated at *z*, and extending between the dotted lines, *z*—*z'*, within which zone loosely associated non-parallel fibres are continuously supplied to the adhesive coated conductor filament in substantially the same quantities throughout the longitudinal extent of said zone. We have found it convenient to use an ordinary form of carding mechanism, indicated at B in the drawing, and which in this instance comprises the card cylinder, 6, provided with the usual associated work rolls, 7, stripper rolls, 8, fancy roll, 9, and doffer roll, 13, although the particular arrangement of the various rolls is not important. The fibres are conveniently introduced into the carder, B, in the form of a sliver or roving, 10, of the desired width, between suitable feed rolls, 11, and carried into the carder by a transfer roll, 12. All of these rolls are of substantially the same length as the application zone, Z. The carding mechanism is placed so that the fibres will be brought to the conductor filament in a direction angularly and preferably perpendicularly thereto, or in other words, the rolls have their axes substantially in parallelism with the direction of longitudinal movement of the conductor filament, and the outer face of the doffer, 13, is closely adjacent to the taut conductor filament, 3, as clearly shown in Fig. 3. This carding mechanism is so constructed and arranged that the fibres which are conveniently fed thereto in the form of the roving or sliver, 10, but which may be fed in other ways, are combed and laid uniformly on the rollers throughout their length, but are gradually thinned out until when they reach the doffer roll, they are no longer in the form of a roving, but are simply individual fibres held by the card teeth or an extremely thin floss of extremely loosely associated fibres, although by reason of the carding action they will be at that time in a state of substantial parallelism.

Adjacent to the outer face of the doffer, 13, we arrange a fibre delivery device, 14, which may be conveniently made in the form of a comb, disposed parallel to and slightly above the conductor filament and being of a length substantially equal to the length of the application zone, Z, and to which is imparted an extremely rapid vertical reciprocation. To this end the comb, 14, is conveniently supported by an arm (or arms), 15, secured to an oscillating shaft, 16, mounted in bearings and provided with any suitable means for imparting oscillating motion to the shaft, 16, at very high speed. This comb is located almost directly above the path of the moving conductor filament and its speed of oscillation or reciprocation is so timed with respect to the doffer roll, that isolated groups of fibres extending transversely throughout the length of the doffer roll are continuously removed therefrom, disassociated entirely with the remaining fibres in the doffer roll, and thrown down upon the traveling conductor filament in such manner that all parallelism of the fibres is completely destroyed.

Situated adjacent to the leaving end of the application zone, Z, is a condensing device, C, which is preferably in the form of what is termed a whirl, comprising a rotary body, 17, having a passage therethrough which decreases in diameter from the entering to the leaving end, the inner surface of said passage indicated at 18 in Fig. 4, being therefore nearly conical and terminating at the leaving end in an aperture, which determines the size of the covered conductor filament. The whirl may conveniently be provided with a removable part, 19, containing the portion of the passage of smallest diameter, which may be removed and replaced with another of the same or different diameter to compensate wear which will naturally be most severe at this portion of the inner friction surface of the whirl, and also to vary the exterior diameter of the covered filament where a larger or smaller size of the completed covered filament is desired. The whirl may also be provided at its smaller end with a smoothing or polishing plate, or plates, indicated at 19*a*, if desired, said plate or plates being formed of spring material and being fastened at one edge so as to have a slight yielding movement.

It will be readily understood that as the fibres are deposited on the sticky adhesive coating of the conductor, those which come in contact with this coating will adhere to the conductor filament, and be drawn along therewith, the exterior, fibres being drawn along in loosely associated non-parallel condition by interengagement of fibre to fibre, and that by the accretion of fibres during the passage of any point of the conductor filament through the application zone, Z, a mass of fibres of gradually increasing diameter will be formed and carried into the larger end of the passage in the whirl. This whirl or condensing device is rotated at extremely high speed, say 3500 R. P. M., and the exterior fibres of the flocculent mass coming into contact with the inner surface, 18, of the whirl, are carried around with it, thus imparting rotary movement to the entire flocculent mass from the entering end of application zone, Z, indicated by the dotted line, *z*, to the whirl. This is illustrated in Figs. 4 and 5 of the drawing, in which the conical mass of loosely associated non-parallel fibres is indicated within the dotted lines *x*—*x* and *x'*—*x'*, while the flocculent non-parallel fibres deposited by the comb, 14, also in non-parallel loosely associated relation, are indicated at *y*—*y*. By reference to Figs. 4 and 5, it will be understood that as the conductor filament, 3, is drawn along at predetermined speed, the flocculent mass of fibres will be continuously rotated throughout the application zone, Z, around the conductor filament, the innermost fibres attaching themselves to the conductor, as before stated, and being carried by the conductor more rapidly than the mass which is subject to a momentum lag as the outermost fibres are dragged along by fibre to fibre engagement with the attached fibres, and their longitudinal movement is slightly retarded by the fibre to fibre engagement with the flocculent mass *y*—*y*, continuously deposited by the comb, 14. In Fig. 4 this differential of longitudinal movement is indicated diagrammatically by means of arrows, V—V. In like manner, it will be understood that in the rotary movement of the flocculent mass of fibres continuously rotated through the instrumentality of the whirl, 17, there will be a similar lag, as the rotary movement of the whirl is transmitted to the outer fibres of the mass at one end and depends upon the fibre to fibre connection through the mass to set it in rotation. This is resisted by the momentum lag of the fibres as they are thrown down by the comb, and require an instant of time before they partake of the rotary movement and also by the retarding action exerted by the incoming fibres, *y*—*y*, on the exterior of the mass, and the retarding action of the innermost fibres which are attached to the wire by the adhesive coating and do not revolve at all. In Fig. 5 we have endeavored to illustrate this circular re-arrangement of the fibres by means of a series of arrows, W, W', W2 and W3 of different lengths to illustrate graphically the fact that the speed of rotation of the outermost fibres is greatest and that the rotation decreases in speed to the conductor filament where no rotation takes place. Likewise, there is obviously a differential of speed in the rotation of the outermost fibres from the entering portion of the application zone, indicated at z, most remote from the whirl, to the whirl itself, at which point the rotation of the mass will be substantially at the same speed as the whirl.

As a result of these differentials of speed of longitudinal travel and rotary travel of these loosely associated non-parallel fibres, there is effected two rearrangements of the fibres, circularly and also longitudinally, while they are clinging together merely by their interengagement, tending to draw the fibres into closer relation to each other and to the conductor and producing a partial condensation of the fibres in a compacted relation, in which there is no parallelism of the fibres throughout the entire mass as they are gradually consolidated. As soon as this mass reaches the whirl, 17, the longitudinal movement of the outermost fibres is retarded to a greater extent than the inner fibres, by friction with the whirl, and the rearrangement of the fibres longitudinally and circularly continues, so that the mass of the coating will be further condensed and compressed by the conical inner surface of the whirl, the surface speed of which gradually decreases in the direction of travel of the conductor filament, while the surface approaches the filament more and more closely, so that the loosely associated mass of fibres in non-parallel relation, as before said, is consolidated and compacted and condensed in said felted relation to produce a hard, tight, fibre covering, as before stated.

After the covering is thus applied, the covered conductor filament can be used as it is, or it can be subjected to further treatment if desired, according to the use to which the covered conductor filaments are to be subjected. For example, we have shown at D, means for applying a finishing compound which may be conveniently a waterproofing compound, and which is applied preferably in liquid form. The part, D, as shown, comprises a tank or reservoir, 20, having a liquid distributor, 21, or other suitable means in contact with the covered filament, 3a, for applying the finishing compound thereto, which may be shellac or any other suitable material. The covered and treated conductor filament is then preferably passed through a second whirl, indicated at 22, of any usual or desired construction, which is rotated at high speed and provided with an interior passage through which the covered filament passes without coming in contact with it, and with a smoothing plate, 23, for smoothing and polishing the covered filament. In Fig. 6 we have shown in detail section, such a whirl which will not be further described as the specific construction forms no part of our present invention.

We also prefer to provide a suitable dryer, indicated at E, and which may be of any usual or preferred type, heated by electric heating units or otherwise, through which the covered and finished conductor filament is drawn and thoroughly dried so that it will not be sticky. Obviously the finishing surface material tends to seal down any exterior fibres which may tend to project from the surface of the covered filament, and also to protect it from the effects of moisture.

In some instances it may be found desirable to further treat the covered filament with a dry powder, such as talc, or any other pulverulent material, and we have shown a device for this purpose, indicated at F, and comprising a receptacle, 24, for the powder, a rotary brush or other device, 25, for applying it to the dried and finished covered filament, and in connection therewith we prefer to employ another whirl, indicated at 26, similar to the whirl, 22, rotated at high speed and provided with a smoothing plate, 27, for smoothing and polishing the outer coating of the covered filament, which may be passed therefrom to the winding reel, 2, upon which it is wound.

While the conductor filament provided with a fibre coating in accordance with our process is capable of use either without any exterior coating or with an exterior coating, preferably liquid shellac or a waterproof compound, it is to be understood that after applying the fibre coating as herein described, additional coating or coatings of other materials, insulating or non-insulating, may be applied upon the covered conductor filament, or upon intermediate coating or coatings thereon, and these additional coatings may be applied in liquid, semi-liquid, or plastic form, or may be wrapped, twisted or braided around the covered conductor filament, in accordance with the practice generally used in the wire and cable industry.

Obviously variations can be made in the mechanism for carrying our process into effect, and we therefore do not limit ourselves to the specific devices which are herein shown and described.

In Fig. 7 we have illustrated one form of the improved covered conductor produced by our process. In this figure the completed conductor is indicated at 3a, and comprises the metallic conductor filament, 3, which may be single as shown, or a plurality of wires, upon which the coating, 3b, of unspun, untwisted fibres (preferably asbestos) in non-parallel and compacted condition is directly applied in accordance with our process.

In Fig. 8 is illustrated a covered conductor, 103a, in which the filament includes the metallic wire or conductor, 103, here shown for example, as a plurality of wires twisted together, but which may be a single wire, and surrounded by a coating, 103c, of insulating material, as rubber or other suitable insulating material, around which insulating coating the coating 103b, of unspun, untwisted, fibres, preferably asbestos, in non-parallel and compacted condition, is applied, in accordance with our process.

In Fig. 9 we have shown, in cross section, a double conductor, 203, such as is termed "heater cord" in which the filament comprises two metallic conductors, 203x, 203y, each of which may consist of a single wire as shown, or a plurality of wires, each conductor being surrounded by a preliminary coating, 203c, of insulating material as rubber, the conductors being united by an insulating casing, 203d, which is surrounded by a coating, 203b, of unspun, untwisted fibres, preferably asbestos, in non-parallel and compacted condition, in accordance with our process.

In Fig. 10 we have shown a similar heater cord in which each conductor, 303x, or 303y, is provided individually with an insulated coating, 303c, as rubber for example, around which is formed the fibrous coating of unspun untwisted fibres, preferably asbestos, indicated at 303b, and the insulated and covered conductors are held together and protected by an outer coating, 303e, which may be, for example, a fibrous braid, or other suitable exterior coating.

It is to be understood that the specimens illustrated in Figs. 7 to 10 of the product produced by means of our process are by way of example, and that other combinations including the fibrous coating comprising fibres, preferably asbestos, unspun, untwisted, in non-parallel and compacted condition throughout the coating and applied in accordance with our process, may be made.

What we claim and desire to secure by Letters Patent is:

1. The process of applying a fibrous insulating coating to conductor filaments which consists in continuously moving a conductor filament longitudinally, continuously applying an adhesive thereto, continuously delivering to said adhesively coated filament, throughout a zone of predetermined length extending longitudinally of the filament, loosely associated non-parallel fibres, and continuously forming a flocculent mass of fibres of increasing thickness from the entering to the leaving end of said zone, and simultaneously establishing relative rotary motion between said filament and said mass of fibres, the fibres in contact with said adhesive being connected thereby to the filament and the outer fibres being connected to the filament by the interengagement of fibre to fibre, and by said relative rotary movement and the longitudinal movement of the filament effecting a re-arrangement of the fibres of said mass in longitudinal and also circular direction to partially condense said fibres in non-parallel relation, and continuously condensing and compacting said fibrous mass of fibres after leaving said zone radially upon themselves and upon the said filament in said non-parallel relation.

2. The process of applying a fibrous insulating coating to conductor filaments which consists in continuously moving a conductor filament longitudinally, continuously applying an adhesive thereto, continuously delivering to said adhesively coated filament, throughout a zone of predetermined length extending longitudinally of the filament, loosely associated non-parallel fibres, and continuously forming a flocculent mass of fibres of increasing thickness from the entering to the leaving end of said zone, and simultaneously acting on the exterior fibres of said mass adjacent to the leaving end of said zone, to impart rotary motion to the entire mass about the axis of the filament throughout said zone, while holding the said filament against rotation, and by means of said rotary motion and the longitudinal movement of the filament effecting a re-arrangement of the fibres longitudinally and rotarily to partially condense them in non-parallel relation, and continuously condensing and compacting said mass of fibres upon themselves and upon said filament after leaving said zone, in said non-parallel relation.

3. The process of applying a fibrous insulating coating to electric conductor filaments, which consists in continuously moving a conductor filament longitudinally while holding it against rotation about its longitudinal axis, continuously delivering to said conductor within an application zone extending longitudinally thereof, loosely associated non-parallel fibres, and causing the fibres immediately contiguous to said conductor to adhere thereto, thereby producing a formless mass of loosely associated non-parallel fibres gradually increasing in diameter from the entering end to the leaving end of said zone, bringing a rapidly rotating circular frictional surface continuously into contact with the outermost fibres of said mass, and thereby imparting rotary motion to the entire mass throughout said application zone, around the conductor filament, and by said rotary movement of said mass and the longitudinal movement of the filament inducing a combined circular and longitudinal re-arrangement of the fibres of said mass between the innermost and outermost fibres thereof, and continuously condensing said fibre mass upon the conductor filament with the fibres in non-parallel relation throughout the coating so formed.

4. The process of applying a fibrous insulating coating to electric conductor filaments, which consists in continuously moving a conductor filament longitudinally while holding it against rotation about its longitudinal axis, continuously delivering to said conductor within an application zone extending longitudinally thereof, loosely associated non-parallel fibres, and causing the fibres immediately contiguous to said conductor to adhere thereto, thereby producing a formless mass of loosely associated non-parallel fibres gradually increasing in diameter from the entering end to the leaving end of said zone, bringing a rapidly rotating friction surface into contact with the exterior fibres of said mass, adjacent to the leaving end of said zone, and thereby effecting continuous rotary movement of said mass of fibres around the conductor filament throughout said zone, increasing in speed gradually from the entering end of said zone to the point of initial contact with said rotating friction surface, and by said rotary movement of said mass of fibres and the longitudinal movement of said filament inducing a combined rotary and longitudinal rearrangement of the fibres between the innermost and outermost fibres, and continuously condensing said fibre mass upon the conductor filament with the fibres in non-parallel condition throughout the coating.

5. The process of applying a fibrous insulating coating to conductor filaments, which consists in continuously moving a conductor filament longitudinally, applying an adhesive thereto, forming a sliver of fibres including asbestos fibres, moving the sliver toward the filament, separating the fibres from the sliver and bringing them into non-parallel relation with each other, and continuously delivering said non-parallel fibres to the filament throughout a zone of predetermined length extending longitudinally of the filament, and forming a flocculent mass of fibres of increasing thickness from the entering to the leaving end of said zone, and simultaneously establishing relative rotary motion between said filament and said mass of fibres by acting on said mass adjacent to the leaving end of said zone, and continuously condensing and compacting said fibrous mass of fibres upon the filament after leaving said zone.

6. The process of applying a fibrous insulating coating to conductor filaments, which consists in continuously moving a conductor filament longitudinally, continuously applying an adhesive thereto, continuously feeding a sliver of fibres including asbestos fibres, arranged substantially parallel to each other and lengthwise of the sliver into proximity to the coated conductor, separating the fibres from the sliver and bringing them into non-parallel relation with each other, and continuously delivering them to said adhesively coated filament throughout a zone of predetermined length longitudinally thereof, and continuously forming a flocculent mass of fibres of increasing thickness from the entering to the leav-

ing end of said zone, bringing a rapidly rotating circular frictional surface continuously into contact with the outermost fibres of said mass adjacent to the leaving end of said zone, and thereby imparting rotary motion to the entire mass throughout said zone, around the conductor filament, holding said filament against rotation, and continuously condensing said fibre mass upon the filament with the fibres in non-parallel relation throughout the coating so formed.

7. The process of applying a fibrous insulating coating to conductor filaments, which consists in continuously moving a conductor filament longitudinally, continuously delivering to said filament, throughout a zone of predetermined length extending longitudinally of the filament, loosely associated non-parallel fibres, and continuously forming a flocculent mass of fibres of increasing thickness from the entering to the leaving end of said zone, and simultaneously establishing relative rotary motion between said filament and said mass of fibres, the fibres in contact with said filament adhering thereto and the outer fibres being connected to the filament by the interengagement of fibre to fibre, and by said relative rotary movement and the longitudinal movement of the filament effecting a re-arrangement of the fibres of said mass in longitudinal and also circular direction to partially condense said fibres in non-parallel relation, and continuously condensing and compacting said fibrous mass of fibres after leaving said zone radially upon themselves and upon said filament in said non-parallel relation.

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