United States Patent

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[33] **Netherlands**
[31] **6812445**

[54] **METHOD OF MAKING ADHESIVE-BONDED ELECTRICAL COIL**
4 Claims, 3 Drawing Figs.

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[51] **Int. Cl.** **B31c 13/800**
[50] **Field of Search** 156/169, 180, 172, 175, 182, 312, 327, 338, 322, 283; 174/119, 117.6; 336/205, 207

[56] **References Cited**

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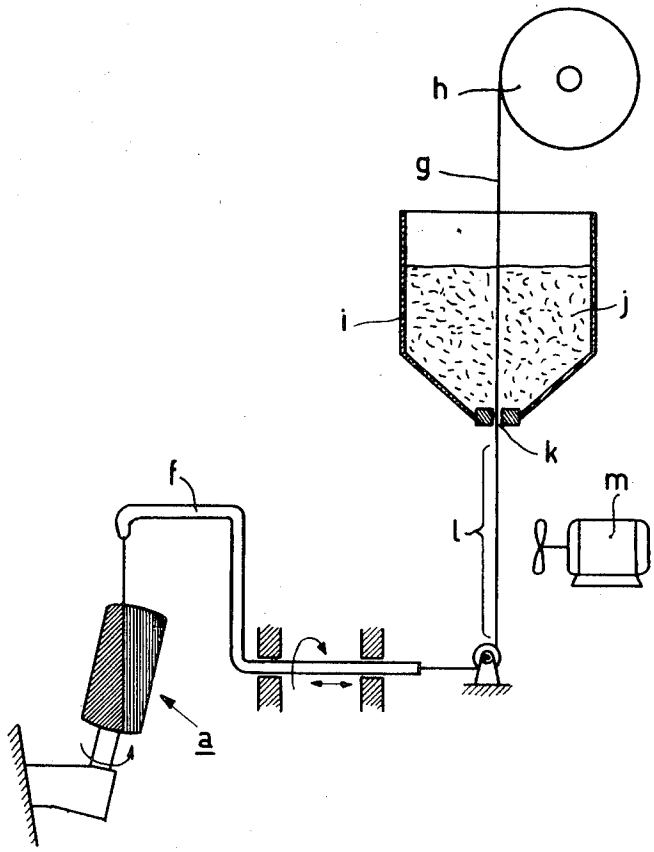
ABSTRACT: A coil which forms a dry and firmly coherent unit immediately after the winding process made by winding the coil from wire which has previously been provided with a dry layer of a contact adhesive, with the result that the wire becomes firmly fixed as soon as it contacts the previously wound part of the coil.



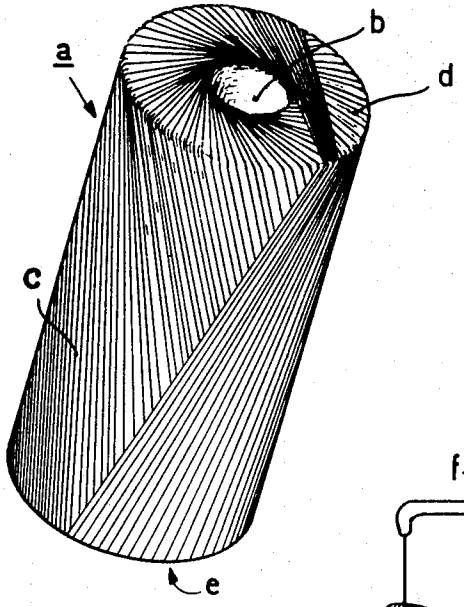


fig.1

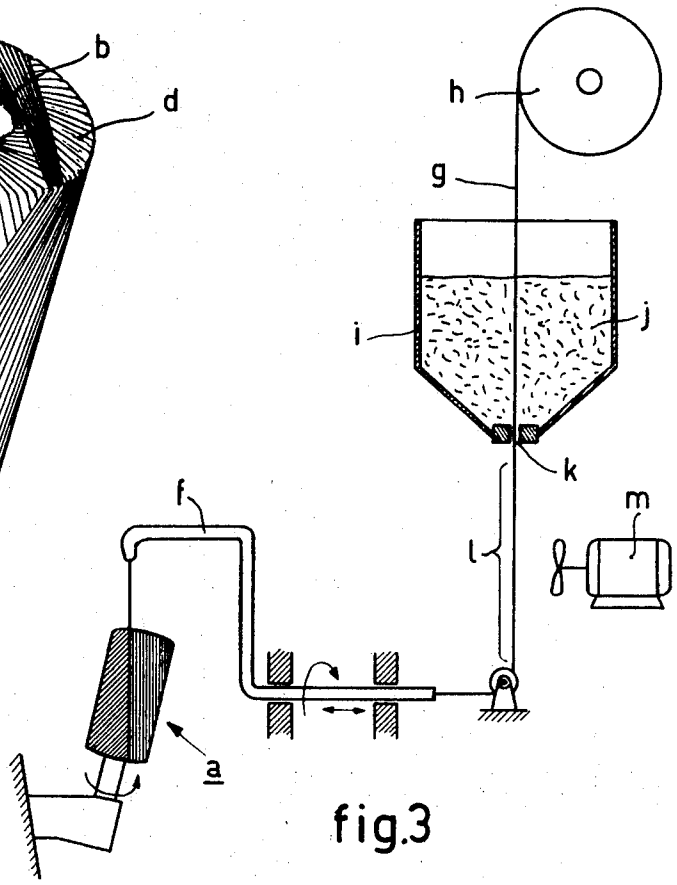


fig.3

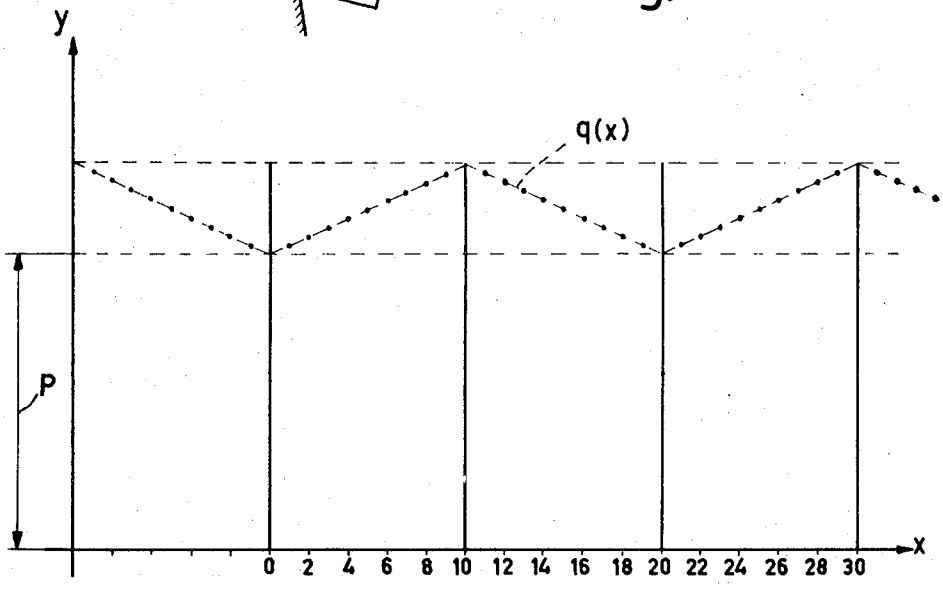


fig.2

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METHOD OF MAKING ADHESIVE-BONDED ELECTRICAL COIL

The invention relates to a coil, turns of which are firmly joined together by bonding, especially to a coil for electrical apparatus which is made of an electrically conductive material.

Such coils are usually wound from wire or strip material. For the sake of simplicity for the purpose of this specification the term "wire" is defined as including "strip." Swiss patent specification 442.499 described an essentially cup-shaped armature of the above mentioned kind, which is used in a small electric motor and which, after having been completely wound, is provided with a layer of enamel. After drying, the windings are firmly joined to one another by bounding so that the armature is a rigid unit.

It is also known to wind coils of the above mentioned kind, for example loudspeaker coils, from electrically conductive wire provided with a covering of a material which has the property of softening at elevated temperatures. After the coils have been wound, they are heated so that the outer portion of the insulating covering softens and in turn adheres together. After cooling there is a firm bond between the wires.

The first-mentioned of the two known coils has the distinct disadvantage that the wound coil must be covered with a sticky, comparatively slow drying substance, the covering operation is regarded as highly undesirable in mass manufacture, since the mechanization for such an operation is readily fouled up by the covering substance, and because the adhesive substance is frequently deposited on component parts connected to the coil, such as the rotor shaft. This is obviously undesirable and increases the reject percentage.

The second of the said known coils can be made without the occurrence of the said manufacturing difficulties; however, there still are the disadvantages that the wound coil must be subjected to an additional operation by means of special equipment and that it will only be a rigid unit after this operation. The latter difficulty is particularly inconvenient in those cases in which, unless the turns have been rigidly joined together, the coils tend to spontaneously unwind entirely or partially or in which the turns tend to slide from the coil. This disadvantage is increased, if during the winding process special end connections must be formed, as is the case in a rotor coil which must be provided with end connections to be connected to the commutator or to slip rings.

Finally, it should be kept in mind, that with small delicate coils used in large numbers in electrical apparatus, the occurrence of damage increases with the amount of handling and manipulation during manufacturing. Additional manipulative steps are sought to be avoided and attempts are made to convert the coil into a sturdy coherent unit at the earliest possible stage of manufacture.

It is an object of the invention to provide a coil of the above-mentioned kind which is of a high quality, having neat and regular shapes, small dimensional tolerances, and which is suitable for rapid manufacture on automatic machines.

The invention is characterized in that the turns are firmly joined together by a "contact adhesive." The term "contact adhesive" is to be understood to mean any kind of adhesive which has the property that layers thereof will adhere to one another in a dry state. Also included are the commercially available adhesive which in addition to this property have the properties that dry layers have adhesive force substantially only in cooperation with layers of adhesive of the same kind, also some adhesives contain highly volatile solvents so that thin layers will dry extremely quickly.

The coil according to the invention is preferably made by means of a method which is characterized in that the wire before being wound on the coil is provided with a contact adhesive, after which any superfluous contact adhesive is removed, and then the covered wire is dried.

In practice, it has proved possible to provide the adhesive on the wire and to dry it by means of very simple contrivances provided on the winding machine and situated between the

supply reel and the winding mechanism. In view of the rapid drying of the contact adhesive the distance between supply reel and winding mechanism need not be extraordinarily long. During the winding process the dry layer of adhesive covering the wire is not troublesome since it does not adhere to the guide rollers of the winding machine or to other components. End connections can also be readily and automatically formed on the winding machine without the occurrence of difficulties such as sliding away of wires, etc. The coil is a sturdy unit immediately after being wound and need not undergo additional operations, because the turns are firmly joined together.

An embodiment of a coil according to the invention is characterized in that the windings which bear on the coil former and the coil former are firmly joined together by a contact adhesive. The advantage of this embodiment consists in that relative movement of the coil and the coil former is prevented. Furthermore, during the winding process the turns which have not as yet engaged the other turns are fixed with respect to the coil former.

A preferred embodiment of a coil according to the invention is characterized in that the wire is provided with a thin covering of contact adhesive throughout its length. This embodiment ensures maximum adherence of the turns to one another. The latter coil is characterized in that the wire is passed through a container filled with a liquid contact adhesive, any superfluous adhesive being removed by pulling the wire through a calibrated aperture. It is possible to apply a covering of adhesive which after drying is only 1 micron thick. Even with very thin wire such a thin covering of contact adhesive scarcely influences the space factor of the coil. The highly regular winding pattern, which is readily obtained owing to the fact that each turn is immediately fixed in position, advantageously influences the space factor. Hence, it has been found in practice that coils according to the invention can be manufactured so as to have a better space factor than known coils wound by the same winding method.

A further embodiment of the invention relates to a bobbin-shaped coil the turns of which extend both along a cylindrical surface in a substantially axial direction and along the axial boundary surfaces in a substantially diametrical direction. Such a bobbin-shaped coil is known and described in the U.S. Pat. No. 2,513,410, in which the coil wound on a coil former and used with an electric motor rotor. Such rotors have the attractive property that they can be rapidly and simply wound, because the coil is regularly distributed about the entire circumference, so that during winding no indexing movements are required. In addition, the coil has the same transverse dimension throughout so that a small airgap is sufficient. Hitherto, with comparatively large length diameter ratios it has not been possible to wind such coils, but this invention provides a solution of this problem. It has been found, however, that an undesirable effect occurs owing to the fact that during winding the turns become immediately fixed on the coil as soon as they contact previously wound turns, and there will be a certain buildup of the substantially diametrically crossing turn parts at the axial boundary surfaces of the coil. This has two detrimental consequences: firstly the axial dimension of the coil will be greater than in the said known coil and secondly the tensile force of the winding wire may cause certain parts of the structure to be torn from the remaining parts, with the result that the shape at the axial ends of the coil will be irregular and consequently the winding pattern on the cylindrical surface of the coil will also be disturbed.

The above-mentioned embodiment of the invention provides a solution of these difficulties in bobbin-shaped coils in which the turns are firmly joined together by means of a contact adhesive, and is characterized in that those wire portions of successive turns which traverse the axial boundary surfaces are spaced from the axis of the coil by a distance equal to a substantially constant distance plus a substantially periodically varying distance.

The bobbin-shaped coil according to this embodiment has remarkable flat axial ends, since the substantially diametri-

cally crossing wire portions are effectively spread over the axial boundary surfaces.

The invention will be further described with reference to the accompanying drawing of an embodiment thereof, in which:

FIG. 1 shows a completed bobbin-shaped coil which is wound on a coil formed and in which the turns are firmly joined to one another and to the coil former by a contact adhesive,

FIG. 2 is a part of a graph showing the distances by which those wire portions of successive turns of the coil shown in FIG. 1 which cross axial boundary surfaces are spaced from the axis, and

FIG. 3 schematically shows a winding machine for manufacturing the coil shown in FIG. 1.

Referring to FIG. 1, there is shown a bobbin-shaped coil *a* which is wound on a coil former, which is not shown in the Figure, and can be used as a rotor for a small battery-fed electric motor for use in a portable dictaphone, which rotor contains no iron. A rotor shaft can be inserted in the aperture *b*. The end connections required for the supply of current to the rotor are not shown. The turns extend along the cylindrical surface *c* of the coil in a substantially axial direction and across axial boundary surfaces *d* and *e* in a substantially diametrical direction.

In FIG. 2, the distances by which a number of those wire portions of successive turns which extend across the axial boundary surface *d* of the coil *a* have been plotted. In the graph, x is the serial number of the turn and y the respective distance. A plurality of turns has been arbitrarily numbered. For each turn the distance y is equal to a constant distance p plus a periodically varying distance $q(x)$. As the graph shown, the distance $q(x)$ varies according to a symmetrical triangular pattern.

The winding machine shows schematically in FIG. 3 has a part *f* commonly referred to as "flyer," which revolves and guides the wire on to the coil *a*, which also rotates about its axis. By imparting a reciprocating movement to the flyer *f*, for example by means of a disc-shaped cam, during the winding process the periodically varying distance $q(x)$ of FIG. 2 is obtained.

The winding wire *g* is unwound from a supply reel *h*, then passes through a vessel *i* containing liquid contact adhesive *j*, is stripped of any superfluous contact adhesive by being pulled through a calibrated aperture *k* and is dried at *l* by means of a fan *m*. When the path *l* to be travelled is long enough, drying may obviously be effected without special applicances or it may be effected by means of a heater instead of a fan.

Contact adhesives particularly suitable are of the polyvinyl or synthetic rubber/resin type, for example, the adhesive sold under the trade name "Bostik No. 1430" and manufactured by Bostik Ltd., Leicester, England. These adhesives have been found to be especially effective at an operational temperature range of 40°–80° C.; however, other adhesives may be equally effective at the same or other temperature ranges and such modification to the steps described should be apparent to those skilled in the art.

What is claimed is:

1. A method of making a coil comprising: applying a contact adhesive to an electrically conductive wire, drying the adhesive on the wire so that the wire is coated with a dry adhesive, and winding turns of the wire in a pattern onto a coil-former so that the wires adhesively contact each other.

2. A method of making a coil as claimed in claim 1 wherein the wire is contacted with the adhesive by passing the wire through a vessel containing a liquid adhesive, and then stripping superfluous adhesive from the wire by pulling the wire through a calibrated aperture in the vessel to provide a thin covering of adhesive on the wire.

3. A method of making a coil as claimed in claim 2 wherein the turns of wire are wound in a pattern which extends along the cylindrical surface of a cylindrical coil-former in a substantially axial direction and across the axial end surfaces in a substantially diametrical direction and are spaced from the axis of the coil by a periodically varying distance.

4. A method of making a coil as claimed in claim 3 wherein the calibrated aperture will provide a thickness of the covering of adhesive after drying of 1 micron.

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