March 19, 1935. K. C. BUGG 1,994,684

FORMATION OF WIRE COILS

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Fig. 1.

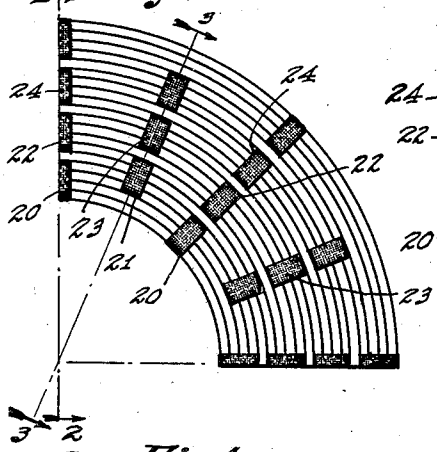


Fig. 2.

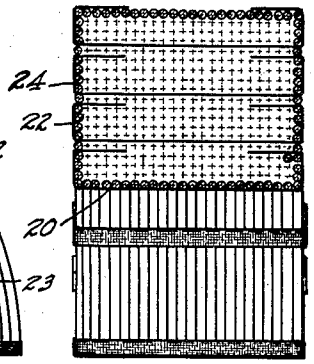


Fig. 3.

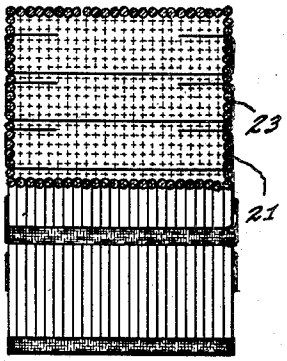


Fig. 4.

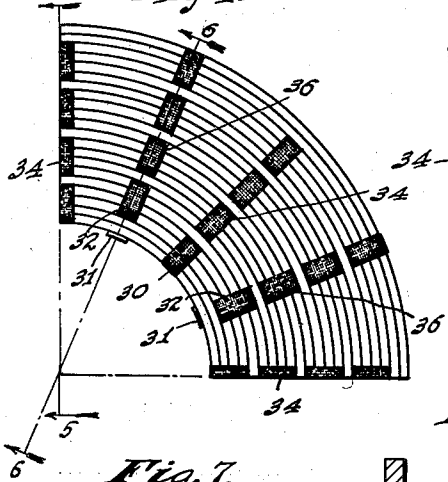


Fig. 5.

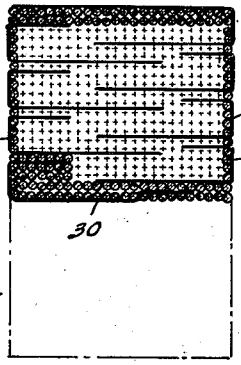


Fig. 6.

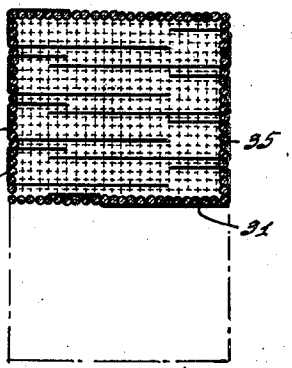
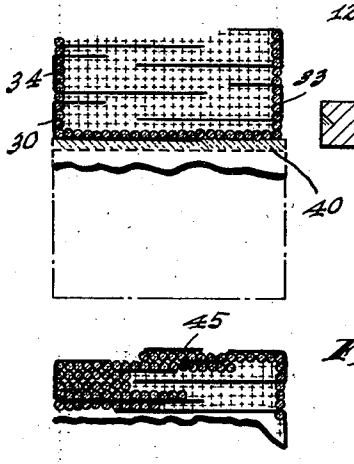
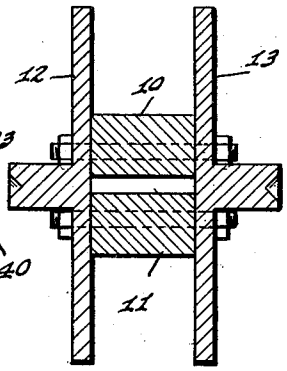


Fig. 9.

Fig. 10.

Fig. 7.





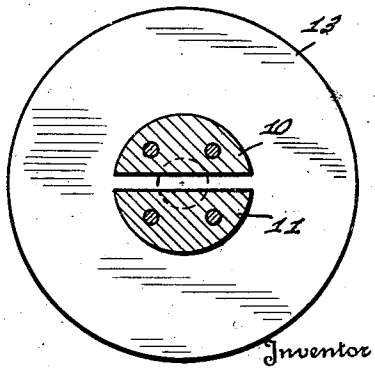


Fig. 8.

Inventor

KENLY C. BUGG

By Ashley Crouch

Attorneys

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Fig. 11.

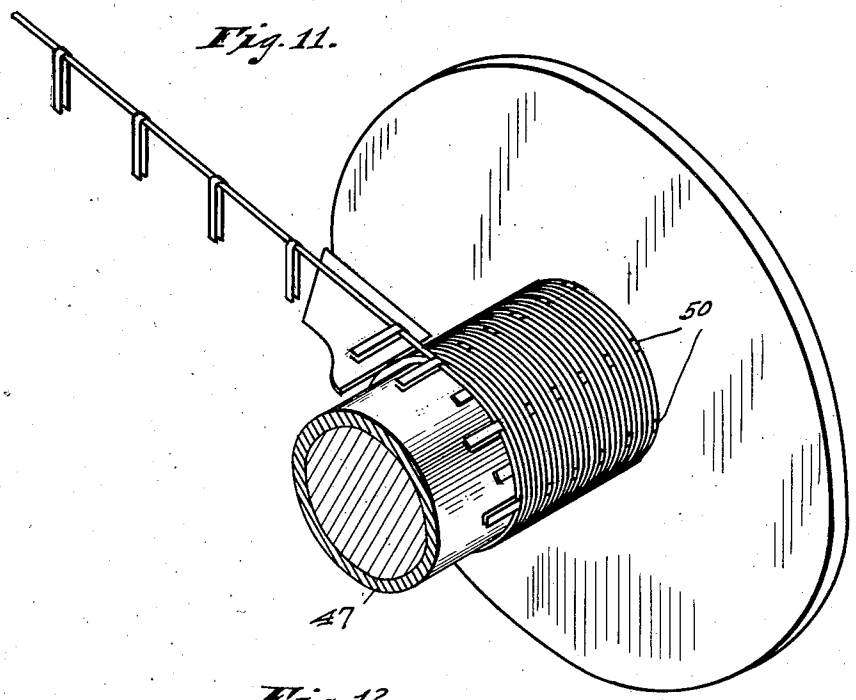


Fig. 12.

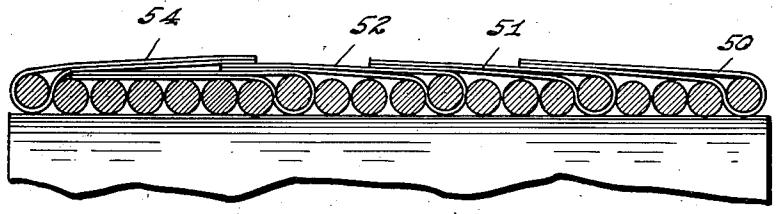


Fig. 13.

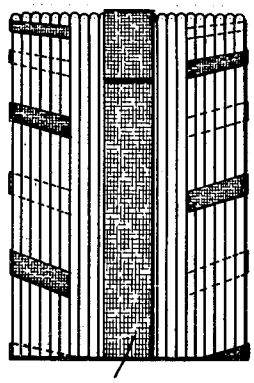
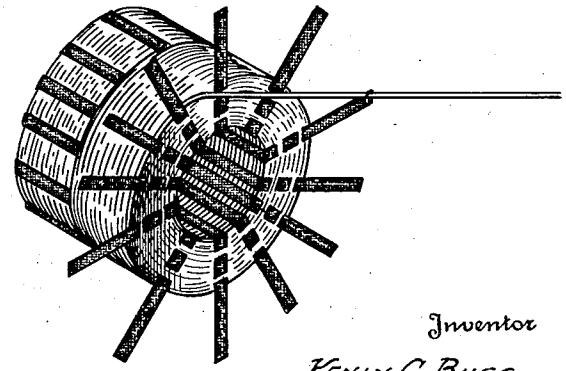


Fig. 14.



Inventor

KENLY C. BUGG,

By Ashley & Mack

Attorneys

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UNITED STATES PATENT OFFICE

1,994,684

FORMATION OF WIRE COILS

Kenly C. Bugg, Farmington, Mo., assignor to Hoosier Lamp & Stamping Corporation, Evansville, Ind., a corporation of Indiana

Application November 4, 1933, Serial No. 696,620

12 Claims. (Cl. 206—59)

In the manufacture of wire, particularly that of wire used in the electrical industry, and in the manufacture of the various articles into which such wire enters, the wire is frequently wound upon spools for convenience in handling and storage. The use of spools for this purpose has been recognized as having a number of serious drawbacks; but spools have continued in use ever since the inception of the electrical industry because no satisfactory substitute for them has ever been discovered.

The disadvantages attending the use of spools are many. In the first place, spools require a relatively large capital investment on the part of the manufacturer and are subject to depreciation and damage which increase the cost of wire and the cost of articles formed from wire. In addition, when spooled wire is shipped, transportation charges must be paid on the spool as well as on the wire; and if the spool is to be returned to its starting point, additional transportation charges are incurred. For example, when a wire manufacturer sells a spool of wire to a customer, the customer is charged both for the wire and the spool, and the spool must be returned to the manufacturer before the customer receives credit for it. This same condition obtains in factories where spooled wire may be passed from one department to another; and rather complicated accounting methods may be necessary to keep track of the spools.

A further disadvantage which follows from the use of spools, and a disadvantage which is perhaps of even greater importance than those already set forth, is the difficulty which attends the unwinding of wire from spools. This is especially notable in the case of wire of the smaller sizes, where the wire may be of insufficient cross-sectional area to sustain the tensile stresses imposed upon it as the result of the inertia of the reel or spool from which it is unwound. Many attempts have been made to overcome this disadvantage by the use of end take-off devices by means of which the spool is maintained stationary and the wire fed from it by a rotating arm. These devices are rather complicated and their use does not give complete satisfaction.

Additional disadvantages of spools are the possibility of damage to the wire as the result of accidentally produced roughened spots on the spool surfaces and the fact that the spool must be considered as a factor in determining the most economical size of package to meet any given set of conditions.

It is the object of my invention to eliminate the necessity for spools and to eliminate the many disadvantages attendant upon the use of spools in the manufacture, handling, storage, and shipment of wire and also to overcome disadvantages which are present when wire is unwound from a spool. A further and more specific object of my invention is to produce a coil of wire which will be self-supporting and from which, without the need of any complicated take-off device, the wire can be withdrawn axially while the coil remains stationary.

In carrying out my invention I form a coil of wire upon a collapsible spool which is generally similar to the spools now in use except that it is demountable so that the finished coil of wire, with or without an internal supporting core, can be removed from it as a unit. As the wire is wound upon the spool I embody in the resulting coil short pieces of flexible material which are disposed generally longitudinally of the coil and which are folded over and around turns and layers of the wire. These pieces of flexible material are not tied upon themselves, but are held in place solely by being clamped between successive turns or layers of wire. The last layer of wire applied to the coil, or a portion of such last layer covers the free ends of any pieces of flexible material which have not been previously covered, and the extreme outer end of the wire is anchored to the body of the coil in any convenient manner. When the coil is completed, the spool upon which it has been formed is taken apart and the coil removed.

The coil of wire as thus formed may be unwound by either of two different methods. The coil might, for example, be mounted for rotation about its own axis upon a suitable spindle or arbor and the wire withdrawn tangentially. A preferable method, however, is to support the coil stationarily and to withdraw the wire axially of the coil. Whichever method is employed for unwinding the coil, the strips of flexible material do not interfere, for they are successively freed as they are uncovered by the successive removal of the layers of wire in the unwinding operation. If the unwinding is performed by axial withdrawl of the wire, the pieces of flexible material, after having their outer ends freed, form yielding fingers which project generally radially outwardly at the end of the coil and act as a light brake preventing the withdrawal from the coil of more than one turn of wire at a time. This is especially of value in the case of fine wire.

The accompanying drawings are illustrative of my invention: Fig. 1 is an end elevation of a

coil of wire which has been formed in accordance with my invention; Figs. 2 and 3 are axial sections through the coil in different planes and on the lines 2—2 and 3—3 of Fig. 1 respectively; Fig. 4 is an end elevation of a coil wound by a slightly different process; Figs. 5 and 6 are axial sections through the coil of Fig. 4 on the line 4—4 and 5—5 respectively; Fig. 7 is a fragmental axial section through a coil embodying a central permanent core, but otherwise similar to the coil of Figs. 4, 5, and 6; Fig. 8 is a fragmental axial section of a coil showing how it is finished exteriorly; Fig. 9 is an axial section through a demountable spool suitable for use in the winding of coils embodying my invention; Fig. 10 is a transverse section of such a spool; Fig. 11 illustrates still another method of forming a coil of wire upon a permanent core in accordance with my invention; Fig. 12 is an axial section illustrating a slight modification of the process illustrated in Fig. 11 to adapt the application of my invention to a situation in which the coil does not have a permanent core; Fig. 13 is a side elevation of a finished coil produced by either of the methods illustrated in Figs. 1 to 6 inclusive; and Fig. 14 illustrates the manner in which wire may be withdrawn from a coil embodying my invention.

The spool upon which my coil of wire is wound may take a number of different forms. That shown in Figs. 9 and 10 comprises a collapsible mandrel formed of two generally semicylindrical parts 10 and 11 which are removably secured between two heads 12 and 13. In the assembled spool, there is a slight gap between the two parts 10 and 11, so that when the heads are removed, these two parts can be moved toward each other to decrease the effective outside diameter of the mandrel and permit its withdrawal from the coil.

In winding a coil of the type shown in Figs. 1, 2, and 3 a series of strips or tapes of flexible material 20 are first brought into association with the spool. Each of these strips extends generally axially along the outer surface of the spool-mandrel and has its ends bent outwardly along the inner surfaces of the two heads 12 and 13. The exact number of strips 20 which are to be used will vary with the size of the mandrel and also with the size of the wire to be wound, larger coils and smaller wire requiring more of the strips 20.

With the strips 20 disposed as just described, the winding of the wire is begun at one end of the mandrel, closely adjacent one head of the spool and over the strips 20. The wire is wound in a continuous layer until the opposite spool-head is reached, and then a second layer is wound in the opposite direction, in the usual manner of winding wire upon spools.

At the conclusion of the winding of the second layer, a second set of strips, here designated as strips 21, is laid in place. These strips extend generally axially along the outer surface of the second layer of wire and have their ends bent outwardly to extend radially on the faces of the spool-heads 12 and 13. Conveniently, the strips 21 are disposed angularly between the strips 20, as is clear from Fig. 1.

After the strips 21 have been placed as just set forth, the winding of the wire is continued until two more layers have been wound. Upon the completion of these two layers, the opposite ends of the strips 20 are folded inwardly over the layers of wire which have been wound, and the winding progresses until another layer has been completed and the ends of the strips 20 completely covered. During the winding of this fifth layer, the ends of the strips 21 remain in their respective radial positions.

When the fifth layer has been completed, a third set of strips 22 is put in position. These tapes may occupy the same axial planes as do the tapes 20 which have just been covered by the fifth layer of wire; and, as in the case of the first two sets of tapes, each of the tapes 22 extends along the outer surface of the wire which has been wound and has its outer ends bent to extend radially along the inner faces of the heads 12 and 13.

When the flexible strips 22 have been placed, one layer of wire is wound over them, and the ends of the strips 21 are then folded inwardly and covered by a seventh layer or wire. Following the winding of the seventh layer of wire, a fourth set of tapes 23 is put in position, and covered by two layers of wire. Then the ends of the tapes 22 are folded inwardly and covered with a single layer of wire, another set of tapes 24 put in place, and this process is continued until a coil of the desired diameter is built up.

To permit the use of shorter pieces of flexible material and to avoid the necessity of folding the two ends of each piece used, I may wind the coil in the form illustrated in Figs. 4 to 6. Here, instead of using pieces of tape which extend the full length of the spool-mandrel and have their ends bent outwardly to extend radially along the inner faces of both spool-heads 12 and 13, I use pieces of flexible material which are materially shorter. In winding a coil of this kind, I first bring into association with the spool a series of pieces of flexible material 30 each of which is bent at substantially right angles at an intermediate point. The strips of flexible material 30 are all located at one end of the spool, one leg of each strip extending radially outwardly along the inner face of one of the spool-heads and the other leg extending along the outer surface of the mandrel toward but not to the other end thereof.

After the strips 30 have been disposed as just set forth, the winding of the wire is started beginning at the folds in the tapes 30. Before the winding of the wire has progressed for half the length of the spool, however, a second set of strips of flexible material 31 are put in position. These strips are similar to the strips 30, but are disposed at the opposite end of the spool with their radially extending legs lying along the face of the head at that end and their axially extending legs lying along the mandrel and overlapping to a slight extent the wire which has already been wound. Each of the strips 31 is disposed angularly between two of the strips 30.

Following the placing of the strips 31, the winding of the wire is proceeded with; but before the first layer of wire is completed, those ends of the strips 30 which have been in contact with the mandrel are bent outwardly so that they will not be covered by any of the later-wound turns of the first wire-layer. Following this operation, the first layer of wire is completed and a second layer wound. This second layer covers the inner ends of the strips 30 and 31.

Before starting the third layer of wire I place in position a third set of similar tapes 32 at that end of the spool from which the winding started, these tapes being angularly disposed intermediate the first set of tapes 30 and, conveniently, respectively co-planar with the tapes 31. The winding of the third layer of wire is then started, but before that layer is completed a fourth set of tapes 33 is put in position at the

same end of the spool at which the tapes 31 are located. The tapes 33 are arranged angularly intermediate the tapes 31 and respectively coplanar with the tapes 30; and their axially extending legs are covered by the third layer of wire. A fourth layer of wire then may be wound without the placing of any further pieces of tape; and at the completion of the winding of the fourth layer the projecting ends of the tapes 30 and 31 are folded inwardly and covered by a fifth layer. On the fifth layer of wire are disposed two sets of tapes 34 and 35 located respectively at opposite ends of the spool, and the axially extending legs of these tapes are covered with two layers of wire. Following this, two more sets of tapes 36 and 37 are put in place, and covered with two layers of wire; and then the ends of the tapes 32 and 33 are folded inwardly and the winding proceeded with.

This process is continued until a coil of the desired external diameter is built up.

In cases where it is permissible or desirable to wind the coil upon a hollow tube or other element which will remain within it, the necessity of bringing the ends of the tapes 30 and 31 through the first wire-layer may be eliminated; as the prime purpose of bringing the ends of the tapes 30 and 31 outwardly through the first layer of wire to be clamped between the first and second layers is to secure such tape-ends in place. When the coil is to be wound upon a permanent core, such as the card board tube 40 illustrated in Fig. 7, the inner ends of the tapes 30 and 31 will be held in place by reason of the fact that they are securely clamped against the tube 40 by the turns of the first wire-layer.

In finishing any of the wire-coils so far described, the radially projecting ends of the last sets of tapes are secured as indicated in Figs. 7 and 13. After the winding of what is to be the last full layer of wire has progressed for several turns, the projecting tape-ends at that end of the coil from which the winding is then proceeding are folded over into contact with the outer cylindrical surface of the coil to be covered by successively wound turns of that layer. The last complete layer of wire is then finished by carrying the winding operation to the opposite end of the coil. A few turns of wire are then wound back along the coil and the remaining outwardly projecting tape-ends folded over such wire turns and clamped in place by a few additional turns. The wire is then cut off and its extreme outer end held in place in any convenient fashion, as by means of a strip of adhesive tape 45 which covers the outer wire-end and is stuck to the body of the coil.

It will be apparent that in any of the coils described the folded-over pieces of tape, each of which embraces several turns of wire at least and has its ends clamped in place between subsequently wound turns of wire, securely bind the various turns of the coil together and result in the formation of a rigid self-supporting unit. In the above description of the coils and the method of winding them I have been specific as to the number of layers of wire embraced by the various folded-over pieces of tape merely for clearness of illustration; as in the practice of my invention in its preferred form the number of wire-layers embraced by each piece of tape will vary generally inversely as the diameter of the wire. Thus, the embracing of four layers of wire by each piece of tape, as above described, is suitable for wires of about 20 B. & S. gage. For fine wires, such as wires in the neighborhood of 40 B. & S. gage, each piece of tape may embrace 20 to 30 layers of wire; and for large wires, say wires of 8 gage or larger, each piece of tape may embrace but a single layer.

Further for clearness of illustration, I have in the sectional views shown each of the tapes as located in an axial plane of the coil; but it may be desirable to dispose the tapes at a slight angle to the axis so that when folded back upon themselves one leg of each tape is not directly over the other.

When a coil of either of the types so far described is to be unwound, the piece of adhesive tape 45 on the outside of the coil is removed to free the outer end of the wire. If desired, the coil may be mounted for rotation about its own axis on any convenient type of fixture and the wire removed tangentially, the coil rotating under the influence of tension in the wire as the wire is fed from it. I prefer, however, to remove the wire from the coil by the method illustrated in Fig. 14. Here, the coil is held stationarily and the wire withdrawn from it axially. As is clear from the drawings, the successively freed tape-ends assume a position in which they extend generally radially outward from the end of the coil and each of them acts as a light brake which prevents more than one turn of wire from being withdrawn from the coil at a time. This is especially advantageous in the case of fine wire the removal of which from a coil has, in the past, always been attended with considerable difficulty. It is to be noted that in removing the wire from the coil in this fashion it is not brought into contact with the surfaces of any rigid members which might injure the insulation on the wire or otherwise damage it.

As the pieces of tape are completely uncovered by the wire they fall successively away from the coil. Because of their shortness, their fall is free and they do not tend to become entangled with the wire being withdrawn.

In Figs. 11 and 12 I have illustrated the formation of a coil by still a different method. This method is especially adapted for wire of the larger sizes, say wire one-eighth inch or larger in diameter.

In forming a coil as illustrated in Figs. 11 and 12 I apply at spaced intervals to the first turn of wire a set of folded-over pieces of flexible material 50. If the wire is wound upon a permanent core 47 as it is in Fig. 12 the ends of these folded-over pieces 50 may be disposed along the surface of that core to be covered by successively wound turns in the first layer of wire; but if there is to be no permanent core, as in Fig. 13, both ends of each folded-over piece are brought out between the first and second turns of the wire to be clamped between the first and second layers of wire.

Tapes of the type illustrated in Figs. 12 and 13 are applied to the wire at such intervals that each of them will overlap wire-turns embraced by other tapes, so that the tapes form an overlapping series preventing axial separation of opposite end-turns. Thus, in Fig. 12, the tapes 50 on the first turn of wire at the right-hand end of the coil overlap the fifth turn which is embraced by a second set of tapes 51. These, in turn, overlap the ninth turn embraced by a third set of tapes 52, and so on. The supply of such pieces of tape as those denoted as 50, 51, and 52 is stopped at a point such that none will be laid which will extend outwardly beyond the left-

hand end of the coil, and the first layer of wire is completed, the last turn being supplied with a set of tapes 54 the ends of which are directed rightwardly, or oppositely to those which have previously been embodied in the coil. As the second layer of wire is wound, additional sets of tapes are embodied in the same manner as in the winding of the first layer, but because the first wire-layer provides a core similar to the tube 47 shown in Fig. 11, the tapes on the second and succeeding wire-layers may be laid, as in Fig. 11, to be covered by subsequently wound turns of the same layer.

In finishing a coil of the type just described, a few turns of wire are wound to cover the ends of the last set of tapes put in position and the extreme end of the wire secured to the body of the coil in any convenient fashion.

It will be noted that a coil of wire wound by any of the methods above described is a unitary article completely tied together, although none of the pieces of tape used completely encircle it. In the coil illustrated in Figs. 1, 2, and 3, the tapes 20 enclose the first four layers of wire while the tapes 21 enclose the third, fourth, fifth, and sixth layers. The tapes 22 enclose the sixth, seventh, eighth, and ninth layers, while the tapes 23 enclose the eighth, ninth, tenth, and eleventh layers. A similar radial overlapping of the tapes is provided in the coil of Figs. 4, 5, and 6. This overlapping of the ties effected by the successively placed sets of tapes is not necessary, however. The only essential is that end turns of wire in the coil be held against outward axial movement; and this in turn requires either that single pieces of tape extend from one end of the coil to the other, as in Figs. 1, 2, and 3, or that the end turns at opposite ends of the coil be tied together by a succession of axially overlapping tapes, as in the other arrangements.

The material which I use for the tapes may be of various kinds. Because the wire must bend the tapes as it is unwound, the character of the material used in the tapes should be co-ordinated with the size and tensile strength of the wire. That is, the tape should not be of a material stiff enough to impose any dangerous tensile stresses on the wire which must bend the tapes as it is unwound.

For wire of 30 B. & S. gage and larger I have found the paper tying ribbon used in the wrapping of packages to be satisfactory. This tape or ribbon has considerable tensile strength, running well over one hundred pounds per inch of width; and widths in the neighborhood of $\frac{3}{16}$ or $\frac{1}{4}$ inch have proven satisfactory for my purpose. Smaller wire, however, may require tape of a more flexible nature, such as a narrow fabric ribbon.

In some situations it may be impossible to use paper or fabric ribbon for tying the wire-coil. For example, my method may be used to great advantage in the process of annealing wire. The customary method of annealing wire embodies the wrapping of the wire upon a spool which must be relatively strong and rigid, and therefore heavy, to avoid distortion as a result of the heat changes to which it is subjected. When using my method of wire-coiling to form a coil of wire that is to be annealed, it is necessary that the tying material be incombustible in nature and it is also at least desirable to use as the tying material some substance which will not have a coefficient of expansion greatly different from that of the wire itself in order to prevent loosening of the wire coil or the imposition of great stresses as the temperature of the coil changes during the annealing process. Thus, thin copper ribbon may be used as the tying material in coils of copper wire destined for the annealing oven.

Coils wound in accordance with my invention may have a wide variety of applications. For example, the application of my invention is not limited to coils which are intended directly for the market; as it may find use in plants which make the wire, insulate it, and wind it into coils embodied in the finished pieces of electrical apparatus. Thus, coils may be formed by my invention from wire as it comes from the drawing dies, and such coils may then be transported to apparatus adapted to apply the insulation. From the insulation-applying apparatus, the wire may be re-wound in accordance with my invention and transferred to machines which will wind the wire into such coils as are used in electrical apparatus of various kinds. In all such operations, as well as in the storage of wire, the cost of the spools and the expense of handling and transporting them and the trouble of keeping track of them is eliminated; and in addition there are also eliminated the difficulties encountered in the unwinding of wire from spools.

The tape which is used in tying the coils together may bear indicia indicating the size and character of the wire, which is of advantage in comparison with the method of indicating such characteristics on the end of the spool; as indicia placed upon the end of the spool may become accidentally removed, while my pieces of tape are and remain intimately associated with the coil until it is completely used up. Further, the manufacturer who sells wire directly to the public can employ the faces of the tape for advertising matter.

In addition to being of value in the formation of coils in interplant processes and in coils of wire intended for sale to the general public, my invention may also be used to form coils adapted for embodiment directly in electrical apparatus.

I claim as my invention:

1. A coil of wire comprising a plurality of layers each formed of a multiplicity of turns of wire and a plurality of strips of flexible material each folded back on itself, embracing one or more turns of wire, and having its ends clamped between other turns of wire.

2. The invention set forth in claim 1 with the addition that some of the wire-turns embraced by one of said strips are also embraced by at least one other strip.

3. A coil of wire comprising a plurality of layers each formed of a multiplicity of turns of wire and a plurality of folded-over strips of flexible material held in place by wire turns in the body of the coil and embracing end turns of the coil.

4. The invention set forth in claim 3 with the addition that strips of flexible material embracing turns at one end of the coil overlap axially strips of flexible material embracing turns at the opposite end of the coil.

5. The invention set forth in claim 3 with the addition that each of said strips extends through the coil and embraces turns at both ends of the coil.

6. The invention set forth in claim 3 with the addition that said strips are arranged in series

in axially overlapping relationship from one end of the coil to the other.

7. A coil of wire comprising a plurality of layers each formed of a multiplicity of turns of wire and a plurality of strips of flexible material each embracing the end turns of a plurality of adjacent layers of wire and having its ends embedded within the coil.

8. The method of forming a coil of wire having a plurality of layers each embodying a multiplicity of turns of wire, which comprises winding the wire upon a suitable form and binding between adjacent layers of wire one end of each of a plurality of strips of flexible material while leaving the other ends of such strips projecting from the coil, winding one or more additional layers of wire, folding inwardly of the coil the projecting ends of said strips, and continuing the winding of the coil to bind such in-folded ends in place.

9. The method of forming a coil of wire, which comprises winding the wire upon a form in a plurality of layers each embodying a multiplicity of turns, during the winding of a layer laying a strip of flexible material along the coil with one end overlying the wound portion of such layer and the other end projecting from the coil, completing the winding of such layer to bind the strip in place, folding the projecting end of said strip inwardly of the coil to embrace the end turn of such layer, and winding additional wire-turns over such infolded end to bind it in place.

10. The method of forming a coil of wire, which comprises winding the wire upon a form in a plurality of layers each embodying a multiplicity of turns, during the winding of a layer laying along the coil a plurality of angularly spaced strips of flexible material with one end of each strip overlying the wound portion of such layer and the other end projecting from the coil, completing the winding of such layer to bind the strips in place, folding the projecting ends of said strips inwardly of the coil to embrace the end turn of such layer, and winding additional wire-turns over such in-folded ends to bind them in place.

11. The method of forming a coil of wire having a plurality of layers each embodying a multiplicity of turns of wire, which comprises winding the wire upon a suitable form and binding between adjacent layers of wire one end of each of a plurality of strips of flexible material while leaving the other ends of such strips projecting from the coil, winding one or more additional layers of wire, during the winding of one such additional layer folding inwardly of the coil the projecting ends of said strips to overlie and extend axially beyond the wound portion of such additional layer, and continuing the winding of such additional layer to bind the in-folded ends of said strips in place.

12. The method of forming a coil of wire, which comprises winding the wire upon a form in a plurality of layers each embodying a mutliplicity of turns, binding between adjacent layers one end of a strip of flexible material while leaving the other end of such strip projecting from the coil, winding one or more additional layers of wire, during the winding of one such additional layer folding inwardly of the coil the projecting end of said strip to overlie and extend axially inwardly beyond the wound portion of such additional layer, and continuing the winding of such additional layer to bind the in-folded end of said strip in place.

KENLY C. BUGG.