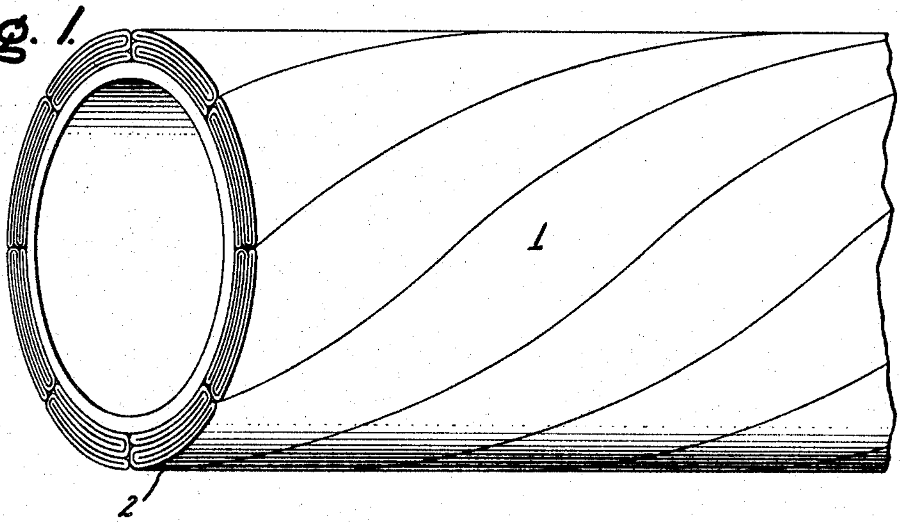
May 7, 1968 S. P. MINNICH 3,382,315

TRANSPOSED STRIP CONDUCTOR

Filed Aug. 24, 1966

Fig. 1.



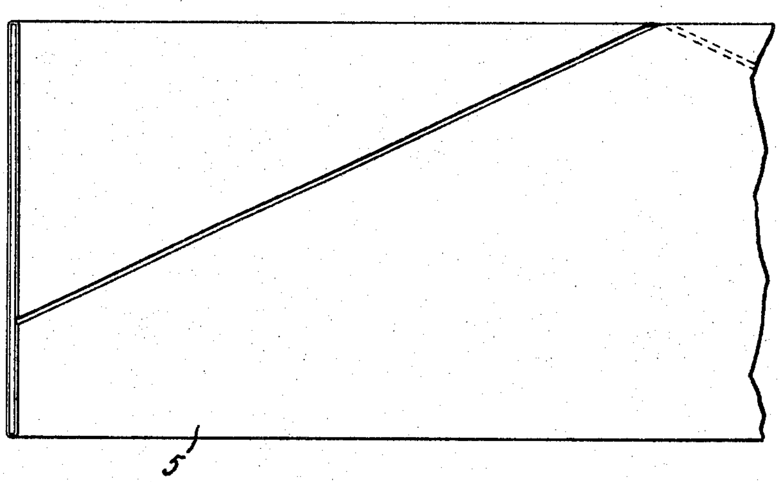


Fig. 3.

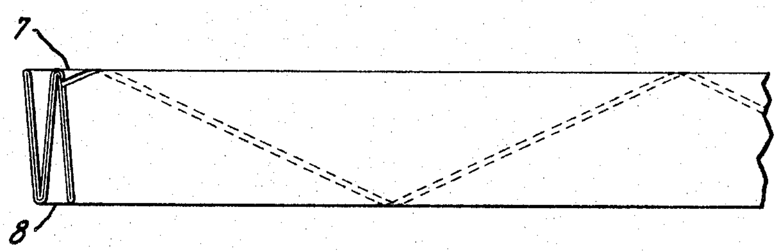
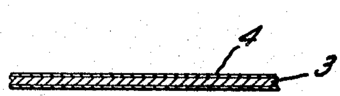


Fig. 4.

Fig. 2.



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3,382,315
TRANSPOSED STRIP CONDUCTOR

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Filed Aug. 24, 1966, Ser. No. 574,761
6 Claims. (Cl. 174—34)

My invention relates to an improved conducting strip and method for making an improved conductive strip. My invention is particularly adapted to electric conductors operating at very low temperatures.

Conventional conductive strips have limited applications at low temperature operation because the surface of such a strip is utilized by conductive currents only along the skin at normal potentials and frequencies. In such bar or conductive strip, a great deal of the material is electrically functionless.

An alternative is to divide the bar up into smaller strips or wires, thus increasing the surface area for the amount of material used. To provide insulation and proper spacing, film must be placed between these small wires. In order to obtain equal current distribution and linkage of magnetic flux, these small wires must be transposed. One difficulty with building up a cable from small wires is that a large overall cross-section of cable is needed due to poor packing of round wires. A need exists for an electrical structure which will pass a large amount of current for a given overall cross-section of conductor.

At low temperatures, conductive materials exhibit a very low resistance to passage of current. Thus, the conductivity of a material such as purified copper may be about 500–1000 times its conductivity at ambient temperature. At these temperatures the current in round copper or aluminum conductors, at 60 cycles, will flow through the outer skin only and penetrate to a depth of about 0.36 mm.

It is an object of my invention to pass a maximal amount of current through a minimal amount of material with the least possible loss from eddy currents.

It is a further object of my invention to utilize current carrying material to the maximum possible amount.

It is a further object of my invention to provide a conductive strip which is particularly adapted for carrying large amounts of current at low temperatures.

It is a further object of my invention to provide a conductive strip which is particularly adapted for winding upon a form to make a highly conductive, low temperature cable.

My invention, in brief, is an apparatus and method for making a highly conductive strip or cable. The highly conductive strip is coated with a thin layer of insulating material. A thin ribbon of conductive material is wound in a regularly progressing manner upon a flat or round core mandrel to produce a helical shape made of a single ribbon. The wound ribbon is next slid off the mandrel and flattened so as to give the appearance of a flat strip. After being flattened, the conductive material is creased and folded in alternate directions so that the result will be pleated. The pleated composite strip thus produced will carry more current with less eddy current loss than conventional wiring using the same amount of material.

The laminated conductive strip above may be wound upon a form from which it may be removed and flattened. After flattening, a new strip may be folded again to form a new pleated composite strip. This process may be repeated again and again until a composite strip of size sufficient for the intended use is obtained.

Composite strips made as above may be used to form a cable by winding them in side by side relationship on a cylindrical form.

The process may be stopped at any time, for example, on production of the first strips and the product obtained, used. Obviously, the product can be put to any of numerous possible uses, for example, the conductor in the form of pleated strips could be used for transformer or generator windings. The first helical winding on a circular form can be used as a power transmission cable. The ends of the strip must be electrically connected so that current can be passed through all folds of the final conductive element to effect transposition.

Other uses for the folded strips are described in the application No. 574,777 filed Aug. 24, 1966 of Theodor A. Buchhold for "Transposed Low Temperature Strip Electric Cable," assigned to the General Electric Company.

The novel features which are believed to be characteristic of the invention are set forth in the appended claims. The invention itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic view in perspective of a transposed cable in accordance with this invention.

FIGURE 2 shows a copper ribbon with insulation.

FIGURE 3 shows a single copper ribbon wound onto a form.

FIGURE 4 shows a folded strip of six thicknesses.

An end product of this invention is shown in FIGURE 1 in which an electrically transposed conductive cable **1** is made of strips **2** spaced closely together.

The insulated strip shown in FIGURE 2 is constructed in the following way: A thin ribbon **3** of conductive material is selected for winding. This long thin ribbon of relatively pure conductive material is insulated by a thin layer of insulation **4** such as a plastic spray which will insulate and at the same time adhere closely to the conductive material. The insulated ribbon **5** is wound upon a flat or round form in a helical manner with the side of one winding adjacent to and spaced a small distance from the side of the succeeding winding. The angle at which the helix is wound will be determined by the width of the mandrel and the width of the conductive strip. The mandrel may be round, however, for reasons that will appear below, flat is preferred.

After being wound upon the mandrel the helical material is pressed flat to form a strip two ribbons thick.

The flattened conductive ribbon material is now in two layers The strip formed by these layers is folded into pleats; that is to say, the material is folded **7** and then folded **8** back upon itself. When finished, any number of pleats or folds are made depending upon the width and thickness of the material and size of the mandrel.

The layered conductive strip may be wound again upon a mandrel, pressed flat to yield a double thickness and pleated to form multiple layers. This process may be repeated again and again until a composite strip of suitable thickness is built up.

This conductive strip may be wound upon a form or a mandrel to provide a cable as shown in FIGURE 1. The ends of the conductive strips are electrically connected. In cases where a component of magnetic flux is perpendicular to the surface of the strip, a braided wire strip in which the small wires are insulated from each other may be used by folding it along its longitudinal axis. In this way there will be little eddy current caused by the flux lines passing through the surface of the braided wire strip because the individual wires of the braided strip present very little surface to the flux lines.

It is further understood that while solid conductive ribbons have been illustrated and described, any type of conductive flat or suitable braided wire or linear conductors will be subject to the same effect and the term "ribbon" or "strip" is here intended to include such conductors. Conductive strips or cables made in this fashion can have many uses; for example, power transmission, generator windings, motor windings, or transformer windings.

One of the principal advantages of this invention is that because of the thinness of the strips, minimal eddy currents are present in the conductor.

Another advantage is simplicity and ease of winding.

Another advantage is a saving of space and material for maximum electrical conductivity.

From the foregoing description, it can be appreciated that the invention provides a new and improved conductive structure wherein the electric current will be carried with a minimum power loss at low temperatures. It is believed obvious that other modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that changes may be made in the particular embodiments of the invention described which are within the full intended scope of the invention as defined by the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A composite strip comprising:

a strip folded into a series of folds along the longitudinal length of said strip,

said strip comprising two flat layers made of a single ribbon of conductive material wound in a regularly progressing manner to form said strip of conductive material,

said ribbon being made of thin elongated conductive material having insulation adhering to all its surfaces.

2. A composite strip as in claim 1 in which the ends of said ribbons are connected to effect electrical transposition.

3. A composite strip as in claim 1 in which said insulation is a very thin coat of plastic material.

4. A composite strip as in claim 1 in which the conductive ribbon is made of very pure copper.

5. A composite strip as in claim 1 in which the conductive ribbon is made of aluminum.

6. A composite strip as in claim 1 in which the ribbon is wound so that the trailing edge of one winding lies close to the leading edge of the preceding winding.

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