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MANUFACTURE OF COMPOSITE METAL STRIPS

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FIG. 1

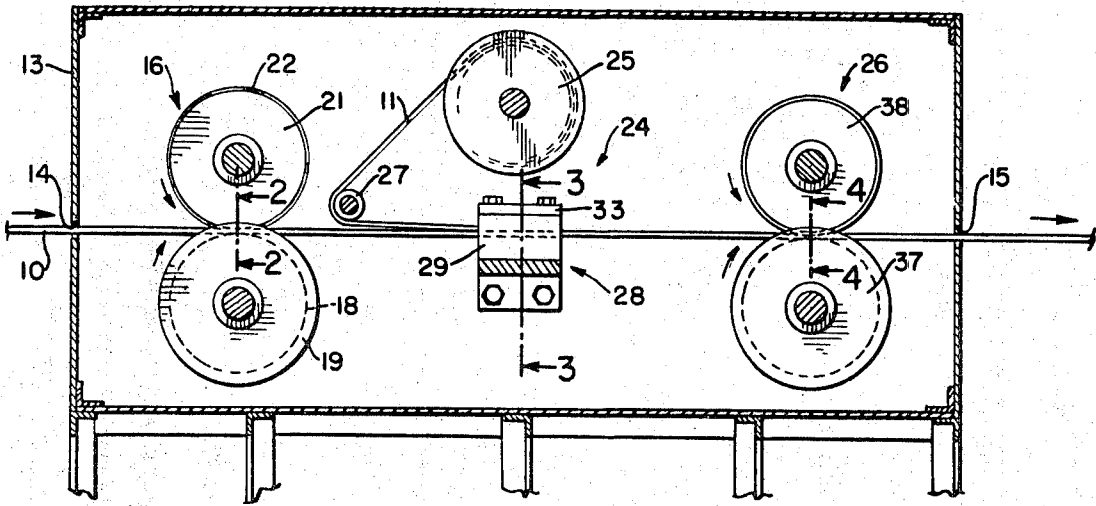


FIG. 2

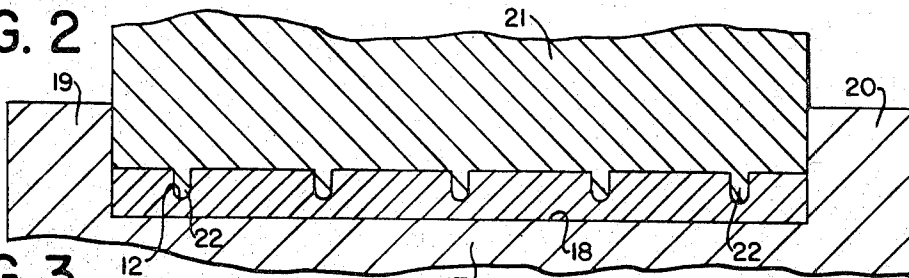


FIG. 3

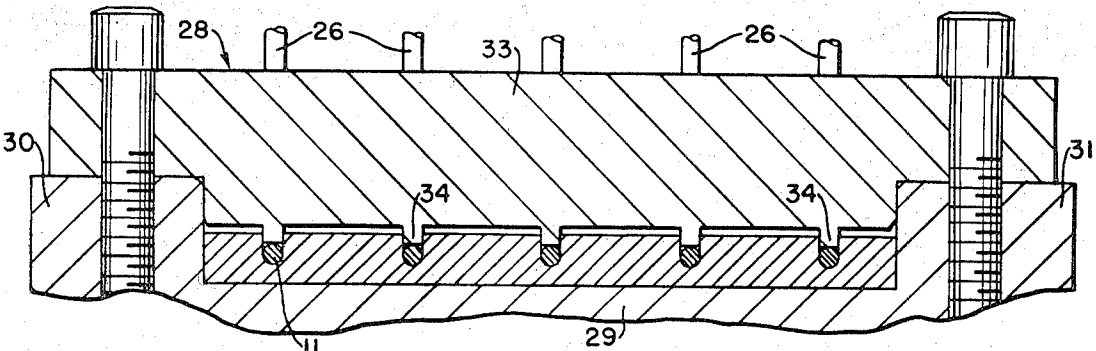


FIG. 4

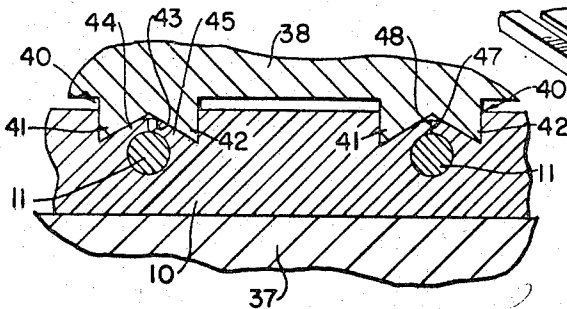
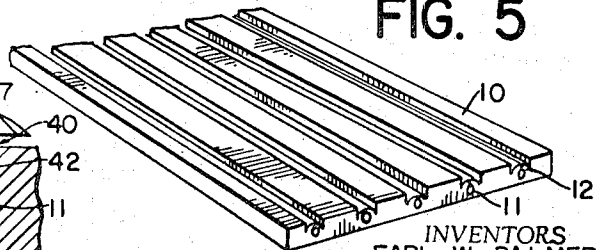


FIG. 5



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MANUFACTURE OF COMPOSITE METAL STRIPS

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Original application Jan. 5, 1966, Ser. No. 518,846, now Patent No. 3,421,866, dated Jan. 14, 1969. Divided and this application Aug. 7, 1968, Ser. No. 767,876
 Int. Cl. B21d 39/00; B23p 11/00, 23/04; B21b 15/00
 U.S. Cl. 29—599 12 Claims

ABSTRACT OF THE DISCLOSURE

A method and apparatus for the manufacture of metal strips which have elongated wires interlocked within the body of the metal strip. This manufacture involves forming a plurality of elongated laterally spaced grooves into one broad face of the strip and then positioning in each groove a wire having a smaller diameter than the depth of the groove. Thereafter integral strip or flap portions partially cut or severed from the metal strip along opposite sides of the groove adjacent the broad face of the strip are infolded relative to each other and are clinched about the wire to interlock the wire to the strip.

This is a divisional of copending application Ser. No. 518,846 filed Jan. 5, 1966, now Pat. No. 3,421,866.

This invention relates to composite metal strips and more particularly it relates to the manufacture of metal strips which have elongated wires interlocked within the body of the metal strip. The invention consists of a method and apparatus for manufacturing these metal strips.

In the fabrication of metal goods, particularly strip metal, the properties of the strip metal can be improved by forming a composite metal structure from separate and often very dissimilar metal members. This is particularly true when it is desirable to retain the basic strip form structure and improve its structural or physical properties.

For example, the mechanical strength of a metal strip can be improved considerably by interlocking at least one and preferably a plurality of elongated laterally spaced wires within the body of the metal strip without destroying the basic structure of the metal strip itself. In this way a normally softer metal can be reinforced by incorporating wires made from a metal which might have for example, greater hardness or spring than the metal strip. For a further example, metal strips which have superconducting wires interlocked within the body of a metal strip which is not superconducting at the temperatures at which the wires are superconductive are particularly useful in many practical applications of superconductivity.

The composite metal strip of the invention is comprised of a metal strip having at least one and advantageously a plurality of elongated laterally spaced grooves formed into one broad face of the strip. A wire, having a smaller diameter than the depth of the groove, is positioned in each groove in flush contact therewith. Integral strip or flap portions partially cut or severed from the metal strip along opposite sides of the groove adjacent the broad face of the strip are infolded relative to each other and are clinched about the wire to interlock the wire to the strip. It has been found that composite metal strips formed in this way can be characterized as being reinforced in that they generally have more elastic properties than the

metal strip alone and are more resistant to bending along the plane of the metal strip. Of course the choice of metal wire influences the properties of the composite strip. In one useful application the metal wires are formed from a superconducting metal and the metal strip is formed from a metal which has normal conductivity but is not superconducting at the low temperatures at which the wire is a superconductor. It is preferable in this application that the metal strip have good conductive properties, both thermal and electrical, at this low temperature.

In a magnet coil formed of superconducting wire alone, if for any reason any part of the wire reaches a temperature above the critical point where superconductivity is lost, the resistance introduced causes an abrupt decrease in the high current flowing in the coil, creating forces that may destroy the coil. With the superconductive wire embedded in strip of good electrical and thermal conductivity, however, the wire may be loaded much more heavily because it is efficiently cooled by the strip, and if a "normal" spot does occur, it is shunted by a relatively large mass of material of excellent conductivity, avoiding catastrophic changes in current. In fact, a coil made from the composite strip may be deliberately overloaded to the point where appreciable resistance is indicated, and brought back to normal fully superconductive operation without sudden drastic changes in current flow.

The method of forming these composite strips also offers certain advantages both in its simplicity and in the improved product it forms. The method consists of forming a plurality of elongated laterally spaced grooves into one broad face of the strip and positioning a wire in each groove so that it is in flush contact with the metal strip defining the grooves. Integral strip portions are separated by partially cutting them away from opposite sides of the groove adjacent the broad face of the strip and these integral strip portions are then infolded toward each other and clinched about the wire to interlock the wire to the strip. This method is also preferably formed in a continuous operation.

While simple in general principle, the method of forming these composite strips required finding and applying new concepts before successful operation was achieved. For example, repeated attempts to roll grooves of the desired configuration into strip of the desired thickness were unsuccessful; the upper corners of the groove were always rounded off at precisely the point where a maximum amount of metal was needed for clinching. The idea of over-filling the roll pass, by feeding in strip thicker than desired on the exit side, finally gave satisfactory groove configuration. For grooved strip 0.040 inch thick, the roll should be fed with strip thicker than 0.040 inch, up to as much as 0.050 inch thick. Likewise, in clinching the wire, it is essential that no elongation of the strip be permitted to result from this operation, or the embedded wire may be deformed or unduly stressed. The proportion of the cross section displaced in clinching must be carefully related to the residual cross section to obtain satisfactory results.

The apparatus for performing the method of the invention consists of means for forming elongated grooves into one broad face of the strip as it is fed therethrough. It further includes wire positioning means located adjacent the groove forming means which serves to position the wire within the groove so that it is in flush contact with the portion of the metal strip. Additionally, means are provided for separating the integral strip portions on opposite sides of the grooves and infolding the strip portions toward each other and clinching them about the wire to interlock the wire to the strip. This apparatus is also preferably formed to perform the operation on a continuous basis.

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A preferred embodiment of the invention is described hereinbelow with reference to the drawing wherein:

FIG. 1 is a side elevation partly in section of apparatus for performing the method of the invention;

FIG. 2 is an enlarged section taken along the lines 2—2 of FIG. 1;

FIG. 3 is an enlarged section taken along the lines 3—3 of FIG. 1;

FIG. 4 is a greatly enlarged section taken along the lines 4—4 of FIG. 1; and

FIG. 5 is a fragmentary perspective of the composite metal strip of the invention.

Referring now to the drawings, apparatus is shown for manufacture of a composite metal strip which as shown in FIG. 5 consists of a metal strip 10 and a plurality of laterally spaced elongated wires 11 which are positioned within grooves 12 formed in the body of the metal strip. In order to understand the small size of the strips which are used in this application it is to be noted that the wire in one application had a diameter of 0.012 inch and the width of the groove was essentially the same size as the wire. The metal strip had a width of 0.50 inch and the thickness of the strip was 0.040 inch with the depth of the grooves being 0.020 inch. Five such wires were provided and they were spaced apart about 0.087 inch.

In another application the wire and strip sizes were the same as above, but nine wires were embedded with a spacing of about 0.050 inch. This represents the maximum number of 0.013 inch diameter wires that can be embedded in a 0.500 inch wide strip, since a greater number leaves insufficient strip between wires for reliable and proper clinching action.

The composite metal strip can be constructed so as to produce a composite metal structure which increases the strength of the metal strip. For example piano wire has been used in a relatively soft copper strip and it has been found that the physical properties of the composite strip, particularly in its resistance to bending and its elastic memory upon bending is greatly increased.

It is also intended to use the composite metal strip constructed as shown and described in superconductor applications. In such an application the wires are made from a superconductive material, the choice of which, from among those that can be fabricated as wire, depends chiefly on the superconductivity characteristics. Niobium-zirconium alloys have been used. Copper and aluminum have been used successfully as the strip metal; both metals are easily and economically formed into metal strips.

As shown in FIG. 1 the strip 10 is continuously fed in a linear path into a chamber 13 which is substantially closed with the exception of an inlet opening 14 at one end of the chamber and an outlet opening 15 at the opposite end of the chamber through which the strip is allowed to pass. The chamber is shown because in some applications, for example if the metal strip was formed of aluminum, it would be desirable to maintain the strip within an inert atmosphere while the strip is being worked on in order to prevent oxidation of the strip metal surface within the grooves prior to confining the wire within the body of the strip. Any inert gas which will prevent oxidation of the aluminum can be used, or alternatively the chamber could be filled with an oil bath or some other liquid which will accomplish the same effect.

Positioned within the chamber 13 are a pair of groove forming rollers 16. The groove forming rollers consist of a bottom roll 17 which has a flat annular surface 18, as shown in FIG. 2 and flange portions 19 and 20 extending along opposite sides of the flat annular surface 18. A top roll 21 has a width substantially equal to the opening defined between the flange portions 19 and 20 and fits closely therebetween. The top roll 21 has a plurality of laterally spaced annular ribs 22 formed thereabout. The space between the top roll 21 and the flat surface 18 of the bottom roll 17 defines a groove forming station through which the metal strip is fed and grooves are

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formed by the annular ribs 22 of the top roll 21. The grooves are formed into one broad surface of the strip, usually approximately half way into the body of the strip and have a depth greater at least than the diameter of the wire which is to be fed into the grooves. The thickness of the grooves, however, should be substantially equal to the diameter of this wire so that there is flush contact therebetween. Immediately upon emerging from the groove forming rolls 16 the strip 10 is fed to a wire feeding station 24. A supply roll 25 containing as many strands of wire 11 as there are grooves is stripped from the roll and is passed around a guide roll 27 with the wires being fed into a wire positioning device 28. The wire positioning device 28 consists of a base member 29, shown in FIG. 3 which has upwardly extending flange portions 30 and 31. Secured to the flange portions 30 and 31 is a top plate 33. The top plate has a plurality of laterally spaced finger portions 34 which are of a width which permits them to be inserted into the grooves 11 to wipe the wires 12 into the base of the grooves 11. Alternatively, the fingers may be replaced with narrow wheels serving the same function.

The metal strip 10 with the wires in flush contact with the base and side portions of the metal strip defining the grooves 11 is then fed to a wire interlocking station 26. The interlocking station 26 is comprised of a bottom roll 37 which is of essentially the same construction as the bottom roll 17 of the groove forming rolls and has a top roll 38 which fits into the bottom roll 37 in the same manner as the top roll 21 of the grooving apparatus. Here, however, a plurality of laterally spaced annular cutting and clinching dies 40 are formed on the top roll 38. These clinching dies consist of a pair of sharp marginal cutting edges 41 and 42 which have an angular recess 43 therebetween. The cutting edges 41 and 42 are defined by surfaces which meet at an angle less than 90°, and preferably at about 60° as shown in FIG. 4, and are spaced about a distance slightly larger than the width of the groove 12. As shown in FIG. 4 when the metal strip 10 with the wire 11 contained in the groove 12 is fed through the clinching rolls 36 the sharp edges 41 and 42 cut through and into the broad surface of the metal strip. This cutting forms separate integral strip or flap portions 44 and 45 on opposite sides of the grooves which are displaced by the top roll 38 with the integral strip portions riding in the recess 43 and are simultaneously infolded toward each other. The edges 47 and 48 of the integral strip portions which once defined the marginal edge of the broad surface adjacent the grooves are joined together in substantially abutting relationship as the integral strip portions are clinched about the wire to interlock the wire to the strip.

The integral strip portions remain securely and integrally attached to the strip in the middle of the body of the strip and it is only the portion adjacent the broad face through which the grooves are cut that is infolded about the wire. By this interlocking, the basic structure of the metal strip remains the same in that there is no bending or distortion of the strip. Only portions of the strip are modified by being grooved and portions adjacent the groove are infolded to lock the wire in the strip; but even this grooving and interlocking does not destroy the basic continuity of the structure, rather it simply permits wires to be interlocked within the strip such that they are embedded substantially midway between the broad faces of the strip.

Although it is not essential that the edges 47 and 48 be in abutting relationship, this is desirable in many applications particularly if the metal strip material is aluminum and the inner wall surfaces which are in contact with the wire must be preserved from the formation of an oxidic layer. In this instance it would be desirable to cold weld the edges together to get a true seal. If, however, the metal strip were formed from copper, which is not susceptible to oxidation, the wire could be interlocked

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and clinched within the metal strip without abutting these edge portions.

We claim:

1. A method of manufacturing a composite strip having at least one wire interlocked within the body of a metal strip comprising:

- (a) forming at least one elongated groove into one broad face of the strip,
- (b) positioning a wire of a smaller diameter than the depth of the groove into the groove in flush contact therewith,
- (c) partially cutting integral strip portions from opposite sides of the groove adjacent the broad face of the strip, and
- (d) infolding the integral strip portions toward each other and clinching them about the wire to interlock the wire to the strip.

2. A method of manufacturing a composite strip according to claim 1 in which the integral strip portions are cut from two broad faces of the strip at an angle less than 90°.

3. A method according to claim 1 in which the integral strip portions partially cut from the broad face of the strip on opposite sides of the groove are infolded through substantially 90° so that the edges of the cut strip portions substantially abut.

4. A method according to claim 1 of forming a composite strip having a plurality of wires interlocked within the body of the strip in which a length of the metal strip is fed continuously through successive stations in which a plurality of elongated laterally spaced grooves are first formed in one broad face of the strip, a wire is then positioned in each groove, and strip portions are then partially cut from opposite sides of the groove adjacent the broad face of the strip and are infolded toward each other and clinched about the wire to interlock the wire to the strip.

5. A method according to claim 1 in which the grooves are formed in the metal strip by a rolling operation and the thickness of the strip is concurrently reduced to insure formation of full sharp corners at the upper edges of the rolled groove.

6. A method according to claim 1 in which the wires are formed from a superconductive metal and the metal strip has normal conductivity at the temperatures at which the wires are superconductive.

7. Apparatus for forming composite metal strips which have at least one wire interlocked within the body of the metal strip comprising:

- (a) groove forming means through which the metal strip is fed for forming at least one elongated groove in the metal strip,
- (b) wire positioning device for positioning a wire into said groove in flush contact with the groove, and
- (c) wire interlocking means for partially cutting integral strip portions from opposite sides of the groove adjacent the broad face of the strip and

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clinching the integral strip portions about the wire to interlock the wire to the strip.

8. Apparatus according to claim 6 for forming composite metal strips which have a plurality of wires interlocked within the body of the metal strip in which the groove forming means comprises a roll having a plurality of laterally spaced circumferential ridges thereon, and the wire interlocking means comprises a roll having a plurality of cutter and clinches ridges thereon, the cutter ridges being defined by surfaces meeting at an angle less than 90°.

9. Apparatus according to claim 7 in which said groove forming means is comprised of a pair of rollers one of which is flat and the other is formed with laterally spaced ridges to impart elongated laterally spaced grooves in a strip fed therethrough, the rollers being spaced apart a distance less than the thickness of the strip.

10. Apparatus according to claim 7 in which said wire positioning means includes a base member on which said strip rides and an index member having a plurality of finger portions extending therefrom which are positioned into the grooves of the metal strip and wipe the wire into the base of the groove.

11. Apparatus according to claim 7 in which said interlocking means comprises of a pair of rollers positioned one above the other with one of said rolls having laterally spaced cutting and clinching ridge dies thereon which are configured to partially cut integral strip portions at an angle of about 60° from opposite sides of the grooves adjacent the broad face of the strip and to infold and clinch the side portions about the wire to interlock the wire into the strip.

12. Apparatus according to claim 7 in which said strip is fed through the apparatus on a continuous basis and includes a chamber for surrounding the strip as it is being worked on by said apparatus and to maintain it in a controlled atmosphere.

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CHARLIE T. MOON, Primary Examiner

U.S. Cl. X.R.

29—33, 243.5, 509, 514