

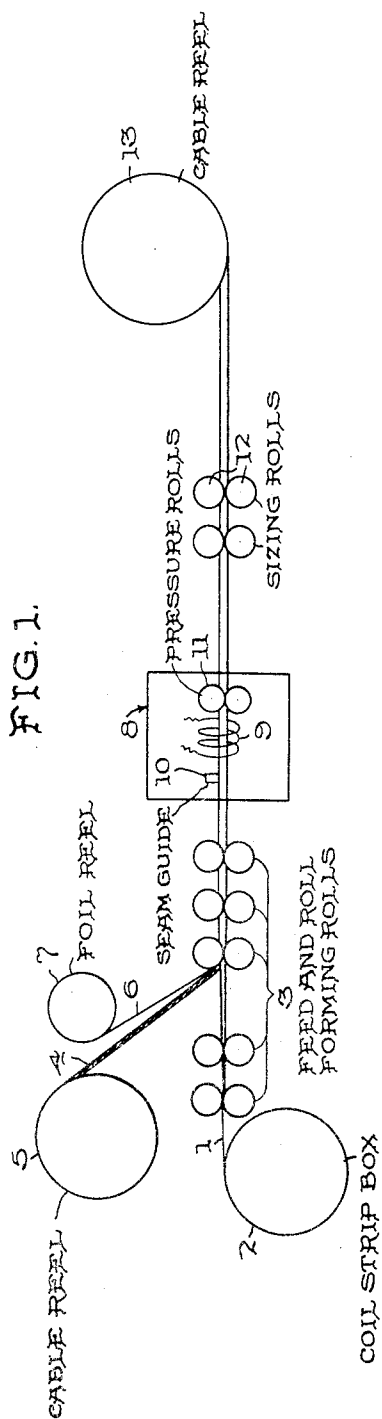
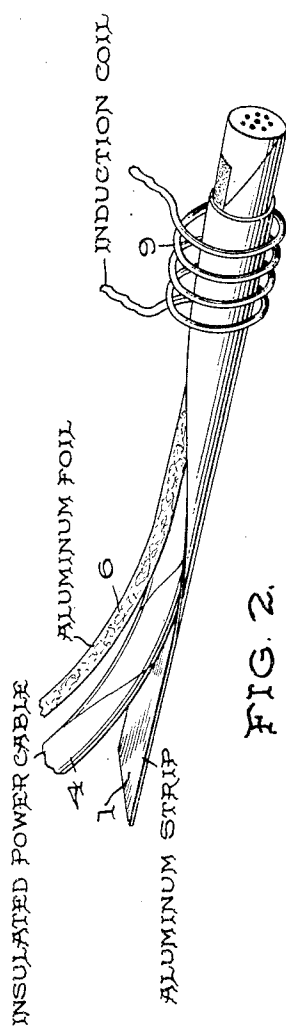
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ALUMINUM SHEATHED CABLE AND METHOD OF MAKING

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ALUMINUM SHEATHED CABLE AND METHOD OF MAKING

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This invention relates to sheathed cables and the process of making same. More particularly, the invention relates to sheathed cables utilizing an aluminum sheathing and the process for making same.

In the past, the conventional metal used for the sheathing of cable has been lead. One of the standard processes for applying lead sheathing to a cable is to extrude the metal about the cable using a vertical press provided with a single container or chamber for the extrusion metal. The use of this extrusion process, however, gives rise to various disadvantages, one being that where a long length of cable is to be covered with sheathing, it may entail making successive additions of metal to the press which may result in oxides or other foreign materials on top of the preceding metal addition being trapped in the body of the metal by the addition of another metal charge to the extrusion press. Such entrapped foreign materials often cause seams to be produced in the sheathing. Another disadvantage with the lead extrusion process utilizing a vertical press is that the extruded metal passes through a ninety degree turn in traveling from the container or chamber down to the mouth of the extrusion die thereby increasing the press load.

The most desirable cable sheath should have the properties of being resistant to corrosion, preventing moisture from contacting the cable, being able to provide mechanical protection for the cable, being sufficiently pliable to permit flexing and handling of the cable without rupturing, being of a material which can be readily applied to the cable without stressing or damaging the cable, and being relatively light and low in cost. While lead has been generally used in the past, there are certain disadvantages incident to the use of this metal in cable sheathing. Lead is one of the heavier metals and allowances have to be made thereby in handling. The cost and availability of lead today are not conducive to the use of large quantities of the metal in sheathing for cable. Repeated stressing of lead sheathed cable often results in rupture of the sheathing thereby admitting moisture within the protective covering. Also, the creep characteristics of lead are not too satisfactory.

In an effort to find a material more suitable for cable sheathing than lead, it has been proposed to use aluminum whose corrosion resistance, lightness and high mechanical properties make it a very desirable sheathing material. Various processes for applying aluminum sheathing on cable are known, but there are disadvantages incident to the use of these processes heretofore known. One such process is directed to the extrusion of aluminum sheathing about the cable in a manner similar to the extrusion of lead sheathing. Due to the physical properties of aluminum, however, it necessitates much higher extrusion temperatures and greatly increased extrusion press pressures. Another known process is to roll form sheet aluminum stock and join the edges together by means of cold welding. This manner of joining has not been found to be entirely satisfactory since the soundness of the seam or joint formed by cold welding is difficult to control giving rise to poor joint efficiency with a tendency for the protective sheathing to open upon bending or flexing of the cable. Aluminum sheathing has also been applied to cable by helically winding or wrapping strip metal about the cable and welding the turns of strip together by a spiral welding process but this process has the disadvantages of being slow and of the tendency to damage the insulation surrounding the conductor as a result of pro-

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longed exposure to welding temperatures. Still another process for applying aluminum sheathing to cable is to insert the cable in a heavy wall extruded tube bloom and subject the tubing to a great reduction in cross sectional area thereby collapsing and elongating the tube about the cable. This process is limited in the length of sheathed cable which can be produced in any one operation and also suffers from the disadvantage that the cold reduction of the extruded tube necessitates an annealing operation in order to soften the worked sheathing and the annealing temperatures for aluminum are higher than can be tolerated by the insulation around the conductor.

It is therefore the primary object and purpose of this invention to provide a novel method for applying sheathing to cable which overcomes many of the disadvantages attendant in processes heretofore known.

Another object is to provide a novel method for applying aluminum sheathing to cable which gives rise to high rates of production.

A more specific object is to provide a novel method for sheathing cable by means of induction welding wherein sound welds, high strength and flexibility of the sheathing are attained with no damage occurring to the insulation.

Another object is to provide an aluminum sheathed cable having the desirable properties of sound welds, high strength, corrosion resistance, and flexibility.

It has been discovered according to the invention that aluminum metal can be applied as sheathing to cable in a simple yet efficient manner by utilizing a welding process commonly known as induction welding. Aluminum strip of suitable composition and dimensions is passed continuously through a roll forming machine. Simultaneously therewith an insulated cable is fed into the formed aluminum trough just preceding that stage of roll forming where the edges of the strip are brought substantially together. The insulated cable and surrounding aluminum jacket or sheathing are then passed through a high frequency inductive means which causes a concentration of induced current at the seam edges resulting in fusion of the edges together. The heating of the seam edges is a localized heating of short time duration thereby not appreciably heating up the main body of the aluminum sheathing. After fusion of the seam edges, the sheathed cable is passed through sizing rolls which will give the sheathing a slight reduction in size such that it is formed in close conformity with the insulated cable without imparting any significant work-hardening to the sheathing. Aluminum sheathed cable produced in this manner has the desirable characteristics of high strength, flexibility, lightness, and good corrosion resistance without damage to the insulation.

The invention will now be more fully described with reference to the accompanying drawings which are, however, only to be regarded as illustrating a preferred embodiment and in no way as limiting the scope of the invention.

Figure 1 is a diagrammatic illustration showing a preferred arrangement of apparatus for performing the method of invention including the forming rolls, induction station, and sizing rolls.

Figure 2 is a perspective view, with parts removed, showing the feeding of the insulated cable into the trough of the aluminum sheathing as partially formed together with a protective foil strip and the passage of forward portions of the cable assembly through an induction coil.

As can be seen from Figure 1, suitable aluminum sheathing strip material 1 is fed from the coil box 2 through a series of power driven roll stands 3. The roll stands 3 not only perform the function of forming the strip 1 into tubular shape but they also act as feed rolls. The roll stands are spaced apart such that at a point during the roll forming of the strip 1 an insulated cable 4 may be fed from a cable reel 5 down between two of the roll stands and positioned in the trough of the partially formed strip. This assembly of the partially roll formed sheathing strip and the enclosed cable is thereafter passed through the remaining roll stands whereby the strip is formed into open seam tubing closely surrounding the insulated cable. It is contemplated, within the scope of the invention, that prior to feeding the strip

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1 into the first roll stand 3, the strip 1 may be passed through suitable edge shears (not shown) in order to properly trim the edges in preparation for the subsequent edge welding operation in those instances where the edges of the coiled strip are unduly rough or uneven. Such an edge shearing operation also may be beneficial in removing objectionable oxide formation.

After leaving the roll stands 3, the aluminum sheathed cable assembly then passes into a heating station 8 wherein the two opposed seam edges of the aluminum sheathing are fused together. Thereafter the welded cable assembly is passed through sizing rolls 12 which give the aluminum sheathing a slight reduction in diameter in order to closely conform the sheathing to the insulated cable and then the sheathed cable may be wound on reel 13.

The heating station 8 generally comprises a conventional high frequency induction heating coil 9 the longitudinal axis of which is parallel to the axis of the sheathed cable assembly passing through the center thereof. The coil may be of hollow copper tubing or other suitable material through which cooling fluid may be circulated. The frequencies employed may vary over a wide range of from 2,000 cycles or less for large cables up to as high as 500,000 cycles per second for very small cables, depending upon factors such as the speed of travel of the cable assembly through the induction coil and the diameter and wall thickness of the roll formed tubing wherein the smaller the diameter of the tubing, the higher must be the frequency to produce a satisfactory weld.

As the two opposed sheathing seam edges of roll formed strip 1 enter the coil 9, the edges are spaced apart a small but predetermined distance. During progressive movement of the tubing through the coil 9, the spaced seam edges are progressively caused to be forced into contact with each other at a point near the outer or right hand end of the coil. The high frequency coil, when energized, sets up an alternating electromagnetic field which in turn causes effective alternating current voltage to be induced in substantially only that portion of the cable sheathing located between the inner and outer ends of the coil. It is known that the strength of the electromagnetic field of a coil drops off very rapidly relatively close to the physical ends of the coil. As mentioned above, the seam is held open throughout the major and preferably the entire length of coil 9. Due to the spacing of the opposed seam edges there will not be a flow of current across the seam edges. When the seam edges are forced into contact at a point at or near to the outer end of the coil 9, current will be caused to flow across the seam at the point of contact. The quantity of current which will be caused to flow across the seam at the point where the edges are forced into contact with each other is directly related to the voltage which has been induced in that portion of the cable sheathing which at that instant is in the electromagnetic field set up by the coil 9. By maintaining the spaced seam edges apart for a distance which will prevent any appreciable arcing, substantially all of the current flow induced in the cable sheathing section within the electromagnetic field of coil 9 at any one instant will be concentrated at the point where the opposed seam edges are brought together, thus giving rise to a very intense heat at this point causing the fusion of the opposed seam edge surfaces together.

While the manner of heating the opposed seam edges is one primarily of resistance type, often times an arc will develop for a relatively short distance before the point where the seam edges are forced together. This arcing does not appreciably heat up the opposed seam edges and furthermore there is a tendency for the slight amount of arcing which may occur to remove any oxide film which may be present on the opposed edge surfaces of the seam edges and thus insure the production of a sound seam freed of impurities.

In order to accurately control the spacing of the opposed seam edges such that they do not contact one another during passage through the coil 9 until they reach the pre-determined point of contact in the zone of the outer end of the coil to insure a concentrated flow of induced current across the seam at this pre-determined point, a suitable seam guide 10 and pressure rolls 11 may be provided in the heating station 8. There are various conventional seam guides used in the longitudinal welding of tubing, one of which comprises a vertically and laterally adjustable fin suitably mounted above the open

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seam and extending downwardly between the opposed seam edges to thereby hold the seam edges apart to prevent arcing therebetween. To provide against any passage of induced current from one seam edge to the other by means of the seam guide or stationary fin, the fin may be composed of metal plates or sheets suitably insulated from one another. This seam guide also functions to prevent any tendency of the roll formed tubing to turn or twist, thereby properly positioning the open seam for passage into the induction heating coil 9. Furthermore, by proper vertical adjustment of the seam guide, it can be caused to exert a positive downward pressure upon the insulated cable thereby spacing the upper surface of the cable a small but effective distance from the opposed seam edges such that during the welding thereof any tendency of damage to the insulation by welding heat or flash is substantially eliminated. Such spacing of the open seam from the cable may also be accomplished by modifying the roll forming procedure such that the tubing or sheathing closely conforms to the cable around the entire circumference thereof except in the zone of the open seam which is shaped such that the open seam is spaced a satisfactory distance from the cable.

Pressure rolls 11, which may be positioned closely adjacent the outer end of coil 9, are provided to exert positive pressure on the sides of the tubing to cause the opposed seam edges to contact one another in the zone of the outer end of the coil. By varying the position and thickness of seam guide 10 and the position and pressure of rolls 11, the spacing and point of contact of the seam edges can be accurately controlled to give the greatest concentration of induced current flow and welding speed for any given set of conditions including the wall thickness and diameter of the sheathing and the frequency of the induction coil and the spacing of the coil from the sheathing.

By the use of high frequency induction heating of the seam edges of the aluminum sheathing, the heating is one of a very localized character. Only a very narrow longitudinal portion of the sheathing will be heated, and this portion is confined primarily to the area of the opposed seam edges. Since substantially all of the heating occurs along the seam edges of the sheathing, the main body of the sheathing will not be subjected to any appreciable heating such that the insulation surrounding the conductor will be damaged. By means of this form of heating, aluminum sheathed cable may be satisfactorily produced at speeds of sixty feet per minute or more. It has been found that the overall heat rise in the sheathing does not exceed about 200° F. which is well below the permissible 400° F. which the conventional insulation will withstand without damage.

During the process of welding the opposed seam edges of the tubing, a certain amount of welding flash may be produced due to the pressure upon the tubing exerted by the pressure rolls 11. A portion of this welding flash or extruded metal will tend to project downwardly into the tubing from the inner side of the weld seam. In order to prevent any damage to the insulation of the cable occurring by reason of contact with such welding flash, it is contemplated, within the scope of the invention to provide a protective strip or tape 6 on the upper area of the cable 4. The protective strip or tape 6 is fed from reel 7 and positioned on cable 4 such that it directly underlies the open seam of the tubing or sheathing. The strip 6 which can be made of any suitable material, such as aluminum foil, not only functions to protect the insulated cable from welding flash, but it also insures protection of the insulation from excessive heat produced during the fusion of the opposed seam edges. Where such a protective strip is used, the seam guide 10 can be vertically adjusted such that the lower edge thereof exerts a positive pressure upon the cable and covering strip to maintain the strip in proper position on the cable during the welding operation.

It has been found where the protective strip material is aluminum foil, that for most conventional sizes of aluminum sheathed cable, foil approximately 1/2 inch wide by .002 inch in thickness is satisfactory. The wall thicknesses of the aluminum sheathing which may be rapidly and satisfactorily welded by means of the invention may cover a wide range by proper selection of the frequency and the welding speed although the generally preferred range varies from about .032

inch to about .064 inch depending on the diameter of the cable to be sheathed.

After the welded aluminum sheathed cable passes through the heating station 8, it is progressively fed through suitable sizing rolls 12 and then wound on cable reel 13. The pressure rolls 12 may include one or more roll stands each comprising a plurality of rolls surrounding the circumference of the sheathing. The amount of reduction of the sheathing needed to provide it with the necessary close conformity with the cable 4 is dependent upon the diameter and clearance of the sheathing in the welded condition with respect to the cable. It is generally found desirable to roll form the sheathing strip stock 1 into tubing having a diameter closely approximating that of the cable 4 in order that only a slight reduction be necessary in the sizing operation. By doing this, the amount of work hardening imparted to the aluminum sheathing will be reduced to a minimum thereby greatly facilitating the ability to handle and use the sheathed cable without the danger of rupturing the sheathing.

Depending upon the condition of the seam edges of the aluminum sheathing strip stock relative to oxide formation, it is contemplated, within the scope of the invention, to subject that area of the opposed seam edges of the sheathing within the heating zone produced by the induction coil 9 to the action of a suitable stream of an inert gas such as helium or argon. By means of this shielding atmosphere, any tendency of the sheathing to be subject to oxide formation in the heated condition, particularly with regard to the seam edges which are to be fused together, is reduced to a minimum.

The process of the invention is eminently suited to the production of aluminum sheathed cable using "2S" or commercially pure aluminum although other aluminum alloys may be used in the process with satisfactory results. For general purpose application, it has been found generally desirable to utilize annealed aluminum coiled strip stock for the sheathing such that the formed and welded sheathing will be relatively soft and easily formed and handled without the tendency to rupture thereby admitting moisture within the sheathing. In certain instances, however, it may be desirable to utilize tempered aluminum strip stock for the sheathing.

Although the preferred embodiment of the invention set forth hereinbefore does not include the use of a cooling chamber through which the progressively welded sheathing may pass prior to entry into the sizing rolls, it may in certain cases be desirable to increase the rate of heat extraction from the welded zone by this means. When utilizing "2S" or other high purity aluminum as the material for the sheathing, the use of such a cooling chamber will not affect the properties of the metal inasmuch as these metals are not susceptible to heat treatment.

By means of the instant invention, it is possible to satisfactorily weld aluminum sheathed cable at speeds commercially applied to the welding of tubes made from various metals and yet produce a sound seam weld without damage to the insulation on the cable. The exterior surface of the resulting sheathing will be perfectly smooth and comparable to the surface of seamless extruded or drawn tubing. The aluminum sheathed cable of the invention also possesses the desirable characteristics of resistance to corrosion, high strength, and flexibility without rupture.

Although an advantageous embodiment of the invention has been herein illustrated and described, it will be understood that various changes may be made therein without departing from the true spirit and scope thereof as defined by the appended claims.

What is claimed is:

1. A process for continuously applying aluminum sheathing to insulated power cable comprising progressively trimming the edges of metal strip material, progressively forming said strip into open seam tubing, simultaneously with said step of forming said strip into tubing progressively disposing insulated power cable within said tubing such that the portion of said cable underlying the open seam is slightly spaced therefrom, passing said cable and closely surrounding tubing progressively through a high frequency alternating electromagnetic field thereby inducing alternating current

voltage within that portion of said tubing located within said electromagnetic field, maintaining the opposed seam edges of said tubing in spaced relation during substantially the entire path of travel through said electromagnetic field, said spacing being sufficient to prevent arcing across said edges, causing said spaced seam edges to be progressively brought into contact at a point adjacent the outer end of said electromagnetic field thereby resulting in substantially all of the induced electric current in that section of the tubing within said electromagnetic field to concentrate and flow across the seam at said point of contact between said edges, the heat produced by said concentrated current flow fusing said seam edges together, and thereafter subjecting progressively edge fused portions of said tubing to a relatively small reduction in diameter thereby closely conforming said tubing to said insulated cable.

2. A process according to claim 1 wherein the heated edges of the seam are subjected to a protective atmosphere of an inert gas.

3. A process for continuously applying aluminum sheathing to insulated cable comprising the steps of continuously forming aluminum strip material into open seam tubing, simultaneously therewith continuously feeding cable into said tubing and continuously disposing a relatively narrow protective strip upon said insulated cable such that said strip directly underlies the open seam of said tubing, progressively moving said cable, strip and surrounding open seam tubing through a high frequency alternating electromagnetic field, progressively causing the opposed seam edges of said open seam tubing to come into contact with each other at a point adjacent the outer end of said electromagnetic field whereby substantially all of the electric current induced in that portion of said tubing within the electromagnetic field is caused to concentrate and flow across the seam at said point of contact resulting in high heat and welding of said seam edges together, and progressively subjecting successive portions of the welded tubing to a relatively small reduction in diameter thereby closely conforming said tubing to said insulated cable.

4. A process according to claim 3 wherein the frequency of the electromagnetic field is in the range of about 2,000 to about 500,000 cycles per second.

5. A process according to claim 3 wherein the heated edges of said seam are subjected to a protective atmosphere of an inert gas.

6. A process for continuously applying aluminum sheathing to insulated cable comprising the steps of continuously providing cable with closely surrounding open seam aluminum tubing, simultaneously therewith continuously providing a relatively narrow strip of aluminum foil on said cable such that it directly underlies said open seam in said tubing and is spaced therefrom, continuously passing said cable, strip, and closely surrounding open seam tubing through a high frequency alternating current electromagnetic field whereby alternating current voltage is induced in progressive portions of said tubing, progressively causing the opposed seam edges to come into contact with each other at a point adjacent the outer end of said electromagnetic field whereby substantially all of the induced current in that portion of said tubing within the electromagnetic field is caused to concentrate and flow across said point where said seam edges are brought into contact thereby resulting in high heat and welding of the seam edges together.

7. A process according to claim 6 wherein the frequency of said electromagnetic field is in the range of about 2,000 to about 500,000 cycles per second.

8. A process according to claim 6 wherein the heated edges of said seam are subjected to a protective atmosphere of an inert gas.

9. A process for continuously applying aluminum sheathing to insulated cable comprising progressively forming said strip into open seam tubing, simultaneously with said step of forming said strip into tubing progressively disposing cable within said tubing such that the portion of said cable underlying the open seam is slightly spaced therefrom, progressively passing said cable and closely surrounding tubing through a high frequency alternating electromagnetic field thereby inducing alternating current voltage within that portion of said tubing located within said electromagnetic field, progressively causing said spaced seam edges to be brought

into contact with each other whereby substantially all of the induced electric current in that portion of said tubing within said electromagnetic field concentrates and flows across the seam at the point of contact of said seam edges, the heat produced by said concentrated current flow fusing said seam edges together.

10. A process for continuously applying aluminum sheathing to insulated cable comprising the steps of progressively providing cable with closely surrounding open seam aluminum tubing such that the portion of said cable underlying the open seam is slightly spaced therefrom, progressively passing said cable and closely surrounding tubing through a high frequency electromagnetic inductive means whereby alternating current voltage is induced in progressive portions of said tubing, progressively causing the opposed seam edges to come into contact with each other at a point beyond the exit end of said inductive means whereby substantially all of the induced current concentrates and flows across said point where said seam edges are brought into contact thereby resulting in high heat and welding of the seam edges together.

11. A process for continuously applying aluminum sheathing to insulated cable comprising the steps of progressively providing cable with surrounding open seam tubing and simultaneously therewith progressively disposing a protective strip upon said cable such that said strip directly underlies the open seam of said tubing, progressively passing said cable, strip and surrounding tubing through a high frequency electromagnetic

inductive means whereby alternating current voltage is induced in progressive portions of said tubing, progressively causing the opposed seam edges to come into contact with each other at a point beyond the exit end of said inductive means whereby substantially all of the induced current concentrates and flows across said point where the seam edges are brought into contact thereby resulting in high heat and welding of said edges together.

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