Dec. 22, 1942. J. J. VIENNEAU 2,305,651

STRIP CORE ASSEMBLING MACHINE

Filed May 10, 1941 2 Sheets-Sheet 1

Fig. 2.

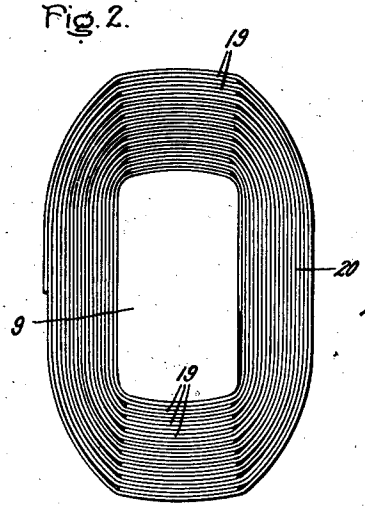



Fig. 3.

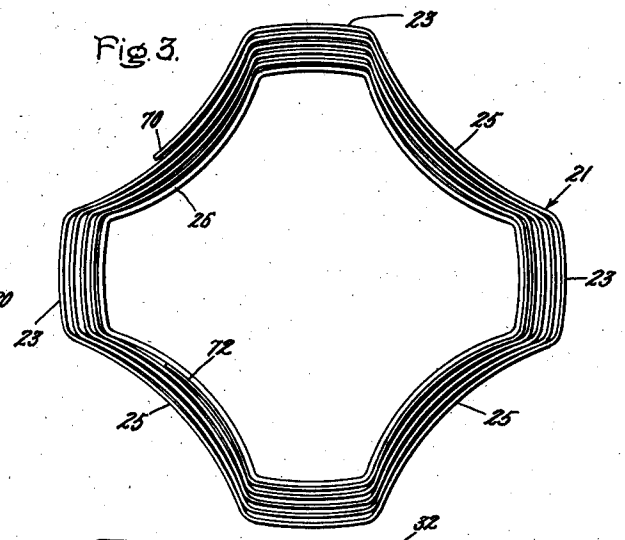



Fig. 1.

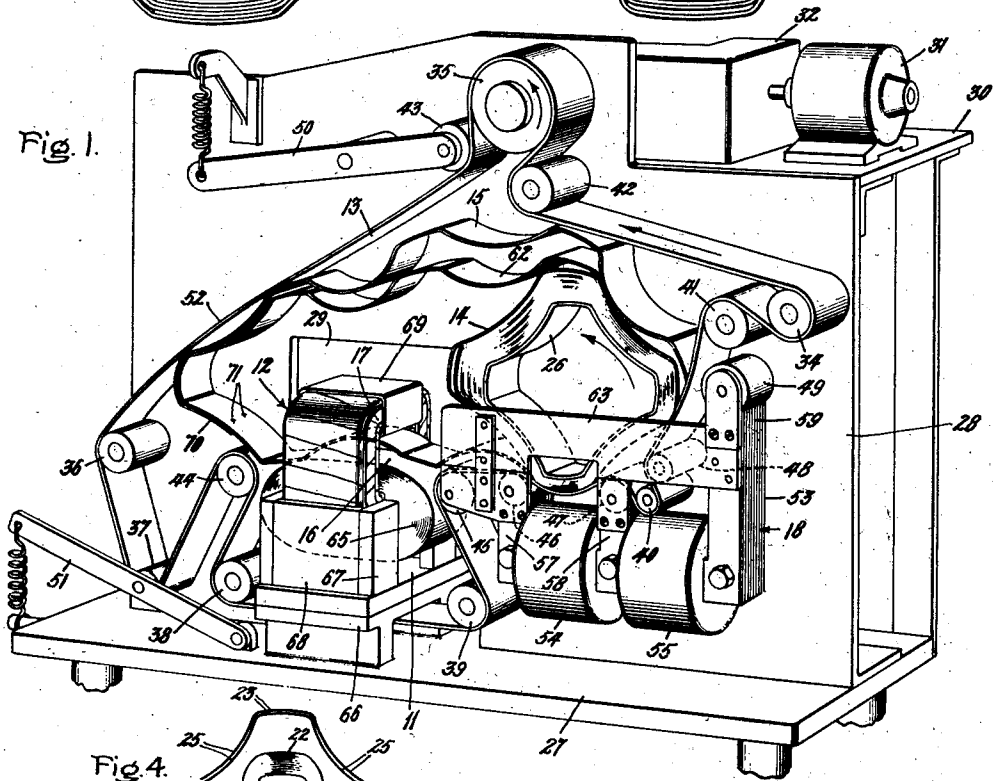
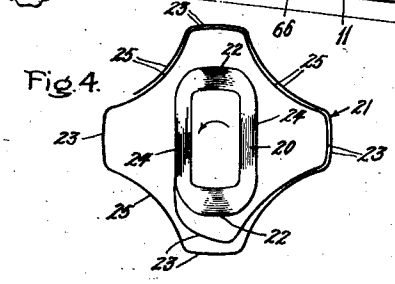



Fig. 4.




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STRIP CORE ASSEMBLING MACHINE

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Fig. 5.

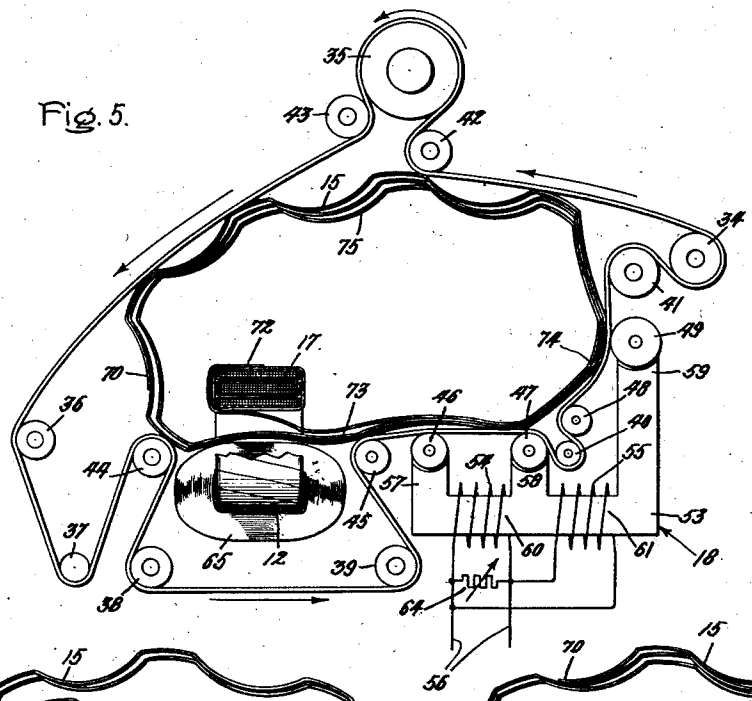



Fig. 6.

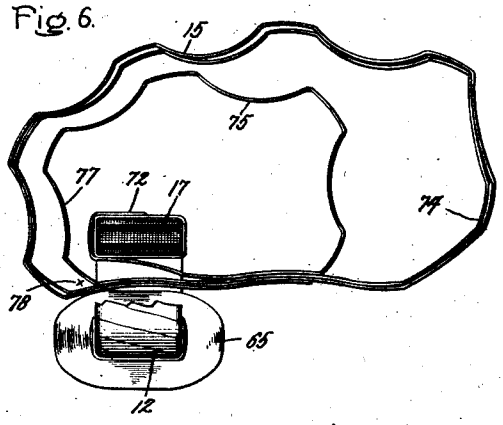



Fig. 7.

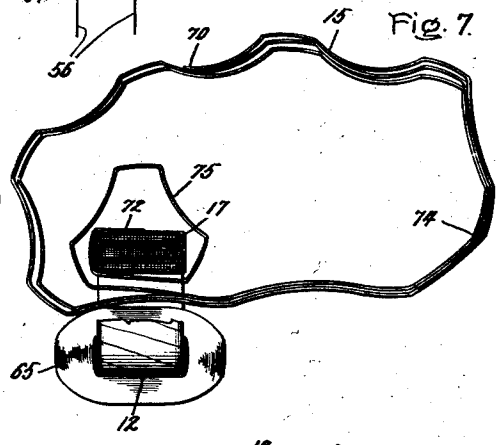



Fig. 8.

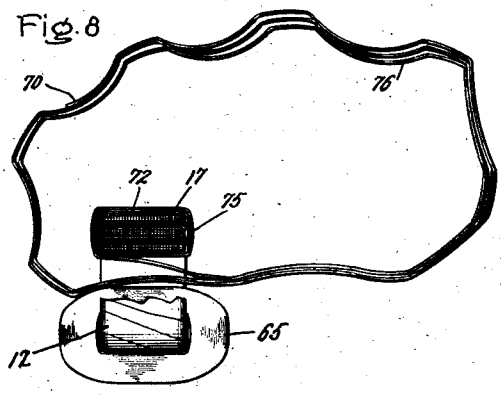
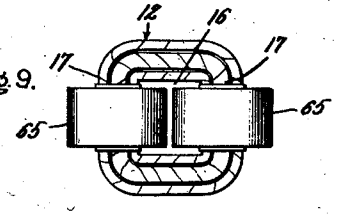



Fig. 9.




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# UNITED STATES PATENT OFFICE

2,305,651

## STRIP CORE ASSEMBLING MACHINE

Jacob J. Vienneau, Pittsfield, Mass., assignor to General Electric Company, a corporation of New York

Application May 10, 1941, Serial No. 392,895

15 Claims. (Cl. 242—4)

This application is a continuation, in part, of my copending application, Serial No. 318,868, filed February 14, 1940, on improvements in Electromagnetic induction apparatus and method of making the same.

The present application relates to continuous strip manipulating apparatus and concerns particularly arrangements for assembling wound strip magnetic cores with conductive winding structures.

It is an obect of my invention to provide an improved machine for handling stiff metallic strip material, winding it from coils of one size and rewinding it into coils of another size, particularly non-circular coils without reversing the layers of strip from inside to outside, or vice versa, for rapidly applying long lengths of magnetic strip material to fully preformed and preinsulated inductive winding structure, passing the strip through the conductive winding window and winding it around the conductive winding leg without substantially straining the material beyond an elastic limit or injuring its magnetic properties in order to form a strain-free low loss magnetic core linking the conductive winding structure.

Another object of my invention is to provide a non-structural arrangement for holding a coil of strip or a portion of magnetic material in place during handling.

Other and further objects and advantages will become apparent as the description proceeds.

In carrying out my invention in its preferred form I provide a support for a conductive winding structure and a belt arrangement for supporting a coil of magnetic strip and passing the strip through the window of the conductive winding and around the winding leg. The belt arrangement consists of a belt suitably supported by pulleys to form an outline of sufficient size to embrace a loop of magnetic strip which is large enough to surround both the conductive winding leg and a coil of the magnetic strip placed adjacent the support for the winding structure. The belt is driven peripherally for unwinding the strip from the outside of the coil of strip to the inside of a larger loop which is embraced by the belt and which passes around the winding leg and through the winding window. After all of the strip has passed through the winding window into the larger loop the inner end of the strip is caught on the winding leg and the motion of the belt serves to wrap the strip, layer by layer, around the winding leg from the inside of the larger loop thus collapsing successive portions of the larger loop upon the winding leg. An electromagnet having pole pieces at the outer surface of the belt is provided for holding the coil of strip in place at one side of the conductive winding structure within the larger loop in order to avoid the necessity for a separate structural holding means.

A better understanding of the invention will be afforded by the following detailed description considered in connection with the accompanying drawings, and those features which are believed to be novel and patentable will be pointed out in the claims appended hereto.

In the drawings Fig. 1 is a view in perspective of a machine constituting one embodiment of my invention; Fig. 2 is a view of a coil of magnetic strip material in the form in which it is annealed to prepare it for use as the core of an efficient electromagnetic induction apparatus; Fig. 3 is a view of the strip of Fig. 2 after it has been unwound and rewound into a larger loop of intermediate size; Fig. 4 is a diagram illustrating the operation of converting the strip from the form shown in Fig. 2 to that shown in Fig. 3; Figs. 5 to 8, inclusive, are diagrams partially illustrating the apparatus of Fig. 1 and explaining the various steps in the operation of applying a coil of strip to the winding leg of the conductive winding structure; Fig. 9 is a plan view of an electromagnetic induction apparatus, such as a transformer or reactor, for example, which has been assembled on the machine illustrated in Fig. 1. Like reference characters are utilized throughout the drawings to designate like parts.

In my aforesaid parent application I have described electromagnetic induction apparatus having a wound strip core with an elongated opening to fit a conductive winding structure having a winding cross-section of similar shape, and I have described a method of assembling such cores with the conductive winding structures without injuring the magnetic material. I explained also that electromagnetic induction apparatus with wound strip magnetic cores composed of material of suitable composition and suitably treated were highly efficient having low losses, low magnetizing current and light weight for a given kva. rating. I explained also that in larger kva. ratings advantages with respect to favorable reactance and cooling characteristics and spatial requirements affecting cost were obtained by utilizing a conductive winding structure having a winding leg with an elongated or rectangular cross-section and by employing a hollow cylindrical spirally wound strip magnetic core of the proper elongated shape

to fit the winding structure. I explained also a method of assembling the apparatus conveniently in spite of the fact that the coil of strip was not circular and must after surrounding the winding leg have substantially the same size and shape as in the original heat-treated coil of strip. In accordance with this method the strip was unwound from the original coil of strip and simultaneously rewound into a larger loop linking the winding structure. In a modification of the method the original coil of strip was first rewound into an intermediate loop or a loop of intermediate size, and the intermediate loop in turn was unwound and simultaneously rewound into a larger loop linking the winding structure. The machine disclosed in my present application is particularly well adapted for carrying out the process when the intermediate loop is employed, but my invention is not limited to utilizing a machine in this way, and includes using the machine for unwinding a coil of strip directly from the annealed coil into the larger loop which links the conductive winding structure.

In Fig. 1 I have shown a core-strip-applying machine forming one embodiment of my invention. It comprises a conductive-winding support 11 and means for supporting and manipulating the strip material which is to constitute the magnetic core. The winding support 11 is arranged for removably supporting a conductive winding structure 12, which may be fully preformed and preinsulated. For handling the strip material there is a belt 13 mounted in such a manner on pulleys as to provide a support for a coil of strip 14 beside the conductive winding structure 12 and to hold a larger loop 15 of the magnetic strip material which is being unwound from the coil of strip 14 and passed through the winding window 16 and around the winding leg 17 of the winding structure 12. The larger loop 15 is of sufficient size to surround both the winding leg 17 and the coil of strip 14. It may either be a substantially equilateral polygon as in my parent application, or elongated. Means are provided for retaining the coil 14 in a portion of the larger loop 15 not occupied by the winding leg 17. Such means are preferably not structural, i. e., they do not physically grasp or restrain the coil 14. In the specific arrangement illustrated, for holding the coil of strip 14 in the right-hand end of the larger loop 15 against the inner surface of that portion of the larger loop, I provide an electromagnet 18 having pole pieces resting against the outer surface of the belt 13. Thus, unwinding of the strip from the outside of the coil 14 into the inside of the larger loop 15 is caused to proceed regularly and the coil 14 is prevented from striking the winding leg 17 or bouncing back and forth which might damage either the winding structure or the magnetic properties of the magnetic material. The belt is driven in the direction indicated by the arrows in Fig. 1 in order to unwind the strip from the coil 14 into the larger loop 15, and when all of the strip has been transferred to the larger loop the belt is driven again in order to wrap the strip material around the winding leg 17. The electromagnet 18 serves at this time also to cause the operation to preceed uniformly with one inside layer at a time of the larger loop 15 being wrapped around the conductive winding leg 17.

When the entire process of preparing and applying the magnetic core is carried out by forming the intermediate loop of Fig. 3, the first part of the strip unwinding process is carried out in any suitable manner, or by means of a separate machine, and the use of the machine of Fig. 1 begins with the point where the intermediate loop of Fig. 3 has been formed.

As explained in my parent application, for obtaining low magnetizing current in the finished electromagnetic induction apparatus a substantial length of each layer of strip in the finished core should be in close surface contact with the adjacent layers of strip. For obtaining electrical efficiency the strip material is composed of an alloy such as high reduction, cold-rolled 3 per cent silicon steel and the strip is subjected to heat treatment to bring out its desirable properties. The heat-treated coil has the size and shape of the finished core in order that the material may be strain-free in the finished core. In order to avoid binding while assembling the strip with the conductive winding as a result of the fact that the turns of strip are not circular, shims or spacers 19 (Fig. 2) are placed between successive layers of strip of successive pairs or groups of layers of strip at the ends of the coil of strip 20 as it is being formed by winding upon a mandrel 9. A coil of strip of the form shown in Fig. 2 is then annealed or heat-treated and after it has cooled the strip material is unwound from the outside of the coil 20 into a larger loop. The direction of rotation of the coil 20 is indicated by the arrow in Fig. 4.

It will be observed that the larger loop 21 to which I refer as the intermediate loop, has a peripheral length which is in an integral number of times an aliquot fraction of the peripheral length of the layers in the original coil of strip 20. By an "aliquot fraction" I mean a length or portion of strip material which occurs an integral or whole number of times in a single turn or layer of strip. Thus, the portions of corresponding radius of curvature fit together in the successive layers of the intermediate loop 21. Where the original coil of strip 20 has the shape shown, this means that the ends 22 of the coil (Fig. 4) form short portions 23 of the intermediate loop 21 and the sides 24 of the coil 20, which in this case are straight, form the longer concave portions 25 of the larger loop. Strip portions of similar shape in the core 20 occur twice in each turn of strip so that the peripheral length of the intermediate loop 21 should be an integral number of times one-half the perimeter of the coil of strip in the coil 20. In this case the perimeters of the turns of strip formed in the intermediate loop 21 are four times one-half the perimeters of the turns of strip in the original coil 20 so that the intermediate loop 21 forms what may for convenience be referred to as a four-sided figure. However, the invention is not limited to the ratio of two-to-one between the perimeters in the intermediate loop and the original coil. For example, in the case of a coil of strip which had been wound on a square mandrel or mandrel with four similar sides, the aliquot fraction might be a fourth instead of a half as illustrated in Fig. 2 of the present application. In the case of square cross-sectional conductive windings, such as mentioned on page 17 of my original application, Serial No. 318,868, the lengths of turns in the intermediate "larger loop" might be a whole number of times one-fourth the length of turn of the original coil of strip without interfering with the alignment of the portions of approximately equal curvature in adjacent turns of the intermediate loop.

Portions of strip of similar shape and size are repeated four times in each turn of the original coil of strip in the case of the aforesaid cores for square cross-section windings. When all of the strip has been transferred to the intermediate loop 21 the shape shown in Fig. 3 results. It will be understood that in order to avoid confusion in the drawings the number of layers of strip in all of the figures has been made considerably less than the actual number of layers ordinarily employed. To prevent the intermediate loop 21 from collapsing it is desirable to insert a light mandrel 26 inside the loop 21 as shown in Fig. 3. The mandrel 26 may consist of a strip of steel bent to the proper shape with ends fastened to form a closed loop.

The formation of the intermediate loop before the strip material is applied to the winding structure has the advantage that the operation illustrated in Fig. 4 permits the spacers 19 to drop out before the machine of Fig. 1 is employed in which the axis of rotation of the coil of strip is shown as horizontal. The use of an intermediate loop 21, as the coil 14 of Fig. 1, I believe, also permits the use of higher speeds in the machine of Fig. 1, and makes more convenient the holding of the coil 14 by the electromagnet 18. Furthermore, any adhesions between the turns of the coil 20 from the annealing process are removed by the operation represented by Fig. 4 making it unnecessary to apply power for that purpose in the machine of Fig. 1. The relatively heavy mandrel 9 of Fig. 2 necessarily used during the heat treatment may also thus be removed before the strip is placed in the machine of Fig. 1. Nevertheless, the same principle of operation would be involved if the coil 20 were placed in the machine at the position of the four-sided coil 14.

Having shown the use of a substantially equilateral larger loop in my parent application for linking the strip material with the conductive winding structure, I am showing herein an arrangement employing a flattened larger loop which makes the machine more compact and less expensive. However, the pulleys carrying the belt 13 may be so arranged as to accommodate an equilateral larger loop in order to avoid flexing the strip back and forth during its travel along the belt, when it is desired to reduce to a minimum any possibility of damage to the magnetic properties of the strip material.

My machine is not limited in its use to handling non-circular coils of strip. Removable guiding means such as padded rollers or a belt within the larger loop 15 may be provided to minimize any tendency for it to collapse while it is being built up. Lateral guides may of course also be provided. Furthermore, my machine is not limited to using only one endless belt to provide the surface elements contacting the larger loop 15, instead of separate belts or rollers suitably placed.

The machine illustrated in the drawings comprises a bed plate 27 to which is attached a vertical plate 28 with an opening 29 to accommodate the conductive winding structure 12 and its support 11. A shelf 30 may also be provided secured at the back of the vertical plate 28 for supporting a driving motor 31 and a gear box 32.

The pulleys for carrying the belt 13 are mounted on spindles carried by suitable bearings (not visible) mounted on the vertical plate 28. The pulleys are so arranged as to form the belt into a hollow figure of suitable outline for supporting the larger loop 15 and passing it through the winding window 16. The arrangement is preferably such that none of the belt-carrying pulleys projects within the space designed to accommodate the larger loop 15. To this end the pulleys may be divided into two classes referred to for the sake of convenience as belt-supporting pulleys such as the pulleys 34, 35, 36, 37, 38, 39 and 40 and belt-guiding pulleys such as the pulleys 41, 42, 43, 44, 45, 46, 47, 48 and 49. The first group of pulleys contacts the inner surface of the belt 13 but are mounted outside the outline or space within which the larger loop 15 is to be confined. The second group of pulleys contacts the outer surface of the belt 13 and causes it to lie along the desired outline, so that the portions of the belt around the belt-supporting pulleys are looped back outside of this outline. One or more of the pulleys, preferably one having a relatively large arc of surface in contact with the belt, such as the pulley 35, serves as a driving pulley and is connected through the gear box 32 to the motor 31. One or more of the pulleys such as the pulleys 43 and 37 are rotatably mounted on spindles carried by spring-pressed lever arms such as the arms 50 and 51 to serve as belt tighteners and means for relieving the pressure of the larger loop 15 on the belt 13 for avoiding sudden changes in the velocity of the strip in the larger loop 15 which might injuriously jar the strip due to flexing of the loop during its rotations. The pulleys may be mounted ifdesired so that certain portions of the belt such as the portion 52 are deflected to form a convex outline for better accommodating the shape of the figure formed by the belt to variations in the larger loop 15 as the strip travels around its periphery and as the number of layers of strip therein changes. The belt tighteners 50 and 51 thus serve to adjust the belt 13 for keeping it in contact with the larger loop 15 at all times.

The magnet 18 is preferably an electromagnet for the sake of obtaining a strong magnetic attractive force and comprises a core 53, preferably laminated if alternating current is to be employed and magnetizing coils 54 and 55 to which a suitable source of current 56 is connected. If direct current is employed, there will of course be less tendency for the magnet 18 to produce hum and vibrate the strip but alternating current is more readily attainable in factories and may be used. The core 53 is three-legged having two short legs 57 and 58 and a long leg 59 joined by yokes 60 and 61 (Fig. 5). The core legs 57, 58 and 59 terminate in pole pieces arranged along the edge of the outline defined by the belt 13 at the portion thereof to the right of the coil support 11. In order to avoid frictional drag on the belt 13, the pole pieces of the magnet 18 are preferably in the form of journaled rollers of magnetizable material. They are mounted with very short air gaps between their surfaces and the ends of the core legs 57, 58 and 59, which are made with concave end surfaces to fit the roller pole pieces. In the arrangement shown the pulleys 46, 47 and 49 to which reference has already been made constitute the roller pole pieces of the magnet 18. The magnetizing coils 54 and 55 may be so wound as to produce magnetic flux flowing in opposite directions in the yokes 60 and 61 so that the pole piece 47 is of one polarity and the other two pole pieces 46 and 49 are of the other polarity. It will be observed that the pole pieces 46 and 47 are mounted along the lower outside surface of the belt 13 to the right of the coil support 11 to hold the strip coil 14 down in this space and

prevent it from bouncing out of position. The pole piece 49 is mounted at the outside surface of the belt at the right-hand end of the outline formed thereby to prevent the strip coil 14 from bouncing to the left or being drawn to the left, the portion 62 of the strip being fed off the outside surface of the strip coil 14.

Although I have described a specific location of the electromagnet 18 and the arrangement of the pole pieces, it will be understood that my invention is not limited to the specific arrangement illustrated, as the best position and arrangement of the magnet depends upon the shape of the outline formed by the belt 13 and the arrangement of this outline in relation to the position of the coil support 11 as well as the angle at which the conductive winding structure 12 is mounted in the coil support. For example, if the conductive winding structure 12 were supported with its magnetic axis vertical instead of horizontal, it would be advantageous to have the relationship of the larger loop 15 and the strip coil 14 such that the larger loop 14 is below the coil support. In this case gravity might be relied upon to hold the strip coil 14 in the desired portion of the larger loop 15 and the magnet 18 might be utilized merely as a guide to prevent transverse displacement of the strip coil 14, or the magnet 18 might be dispensed with entirely in such a case. Preferably, however, mechanical aid such as a guard 63 and a portion of the front surface of the vertical plate 28 are also employed for insuring against transverse displacement of the strip coil 14 or its being dropped. The magnet 18 is supported in some suitable manner, for example, by means of bolts or stay rods extending through the core 53 and secured to the vertical plate 28. However, in case the surface of the plate 28 is utilized as a back guide for the strip in the coil 14 of the larger loop 15 and if the magnet core 53 is mounted flat against the plate 28, it will be desirable to employ a non-magnetic material in the plate 28 in order to avoid weakening of the flux produced by the magnet 18.

If desired, one or more suitable adjusting devices such as a rheostat 64 may be connected across or in circuit with one or both of the magnet coils 54 and 55 in order to adjust the strength of the flux produced or, if desired, to adjust the relative strengths of the fluxes acting between the pole pieces 46 and 47 and between the pole pieces 47 and 49. The invention is not limited to the use of a magnet with three pole pieces as illustrated.

The belt 13 may be composed of any suitable material such as leather, linen or an impregnated fabric. However, it is preferably composed of a material such as treated fabric which is thin enough to allow adequate magnetic flux to pass from the pole pieces of the magnet 18 to the coil of strip 14 and also to have sufficient flexibility to accommodate itself to the shape of the sharp bends in the larger loop 15 as these portions come in contact with the belt 13, thus minimizing the possibility of jars and injury to the magnetic material of the strip.

The coil support 11, as illustrated for the arrangement where the magnetic axis of the mounting structure 12 is to be horizontal, may consist of a platform 66 on the bed plate 27 and a movable replaceable jig 67. Thus, various jigs may be employed for supporting conductive coils of various shapes and sizes with the windows or openings in the proper relation to the belt guiding pulleys 44 and 45. It is to be understood that the jig 67 has box-like or U-shaped portions 68 of the proper shape for receiving the conductive winding structure 12 and the inner surfaces of the portion 68 of the jig 67 may be padded to avoid injury to the winding structure 12. The jig 67 may readily be designed so as to support the winding structure 12, either before any strip has been wound upon it or after a strip core has been wound upon one or more of the winding legs thereof. It will be understood, however, that different jigs or suitable blocks and adjustments in the same jigs may be provided in order to support the winding structures in the various positions that may be necessary if a plurality of winding legs thereof are to have magnetic strip material applied. In the specific arrangement illustrated the winding structure 12 is designed to receive two cores 65 and has two winding legs, but it will be understood that electromagnetic induction apparatus having a greater or less number of cores may be assembled by a machine such as illustrated in the drawings.

In order to minimize the possibility of damaging the insulation of the conductive winding structure 12, particularly the portion along the inner surface of the winding leg when the strip is being uncoiled from the coil 14, it may be desirable to provide a snap-on metal protector 69 which fits around the winding leg and prevents the inwardly bent or temporarily concave portions of the strip of the larger loop 15 from dragging against the inside surface of the winding leg 17. The protector 69 is of course removed before the larger loop 15 is collapsed upon the winding leg 17.

When using the machine for producing electromagnetic induction apparatus such as that illustrated in Fig. 9 and when an intermediate loop such as loop 21 in Fig. 3 is employed, it will be understood that the operation of the machine begins with the application of a coil of strip 14 of intermediate size to the winding structure and other means are employed for producing the four-sided coils of strip 14. My invention of course is not limited to employing four-sided intermediate loops as such as intermediate loops may have either a greater or less times the perimeter of the original coil of strip, than the coil 14 illustrated.

The first step in the application of a wound strip core to one of the winding legs of a preformed and preinsulated conductive winding structure is usually to place the winding structure 12 in the jig 67 which has been removed from the machine, then to mount the jig 67 on the platform 66. Then the coil of strip 14 having a mandrel 26 therein to prevent collapsing of the coil 14 is placed upon the belt 13 to the right of the coil support 11. If the end portion 70 (see Fig. 3) has been fastened down to the underlying layer by means of spot welds, clips or the like, the connection is broken and the strip material is drawn off from the outside of the coil 14 in order to begin the formation of the larger loop 15. To facilitate holding the coil 14 in place the current at this time may be applied to the coils of the magnet 18 and the motor 31 may be run slowly. The strip end 70 is passed by hand through the winding window 16 back to the outside surface of the coil 14. Enough of the strip is thus unwound from the coil 14 to permit forming a complete larger loop 15 of one turn. The end 70 is preferably fastened down to the adjacent portion of the next layer of strip by means of one or two tack welds as shown at 71 in Fig. 1.

The belt 13 travels in such a direction as to cause the strip to feed from the outside layer of the coil 14 to the inside of the larger loop 15. This operation continues until all of the strip material has been transferred to the larger loop whereupon the motor is stopped. The inner end 72 of the strip is then allowed to hook itself around the winding leg 17 (Fig. 5) and the motor is again started, which causes the larger loop 15 to travel in the same peripheral direction as before. However, owing to the fact that the portion of the strip 73 at the bottom of the larger loop, excluding the inner layer, is traveling to the right, whereas the end 72 is hooked around the winding leg 17, the inner layer of strip is forced to break away from the larger loop at the point 74. The magnetism of the magnet 18 acting upon the strip material of the larger loop nevertheless attracts the remaining layers of strip against the belt while allowing the inner layer 75 to collapse as represented in Fig. 6. Continued peripheral travel of the larger loop 15 results in further collapsing of the inner layer as represented in Fig. 7. When the operation has continued as far as indicated in Fig. 8, one and one-half turns of strip have been wrapped around the winding leg 17. At this stage the relationship of the strip material is the same as in Fig. 5 and further travel of the larger loop 15 causes the layer of strip 76, which is now the inside layer, to break away from the remainder of the larger loop and to be collapsed upon the winding leg 17 as described in connection with Figs. 6, 7 and 8.

It will be understood, of course, that several rotations of the strip material constituting the original inner layer 75 of the larger loop 15 are required to wrap all of this material around the winding leg 17, or to collapse this original inside layer upon the winding leg 17. However, as soon as the portion 77 (Fig. 6) of the inner layer 75, which is not required to form the first layer of strip on the winding leg 17, has reached a point 78, it follows along the remainder of the larger loop and is held by the magnet 18. Successive portions of the original inside layer of strip 75 of the larger loop 15 are applied to the winding 17. Each time the larger loop 15 makes a complete rotation a complete turn of strip is added to the winding leg. Thus the inside layer 76 in Fig. 8 constitutes a portion of the strip material in the inside layer 75 in Fig. 5 plus a length of strip formerly in the second layer of the large loop.

When all of the strip material has been applied to the winding leg, it will be understood that the conductive winding structure is removed from the jig 67 and turned over in order to permit the core to be applied to the other winding leg.

If desired, the weight of strip material to be handled at one time may be diminished and the operation may be facilitated by dividing the coil of strip into sections and handling only one section at a time in the machine. For example, if the coil of strip 14 handled by the machine is to be a loop of intermediate size, such as the intermediate loop 21 of Fig. 3, a plurality of such loops may be made up each containing only a portion of the strip material from the original coil of strip 20. Thus, in carrying out the operation represented by Fig. 4 the material from the coil of strip 20 is unwound from the outside surface of the coil into the inside of the intermediate size loop 21 until the desired number of layers of the original coil of strip have been transferred to the intermediate loop 21. Then the strip is cut and a mandrel, such as the hollow mandrel 26 shown in Fig. 3, is inserted within the loop thus far formed to prevent it from collapsing. Such an intermediate size loop is laid aside and a second intermediate size loop is formed in the same manner by unwinding additional strip material from the original coil of strip 20. The strip is then severed again and the second intermediate size loop is laid aside with a mandrel such as the mandrel 26 within it to prevent collapsing. This operation is continued until the desired number of intermediate size loops has been formed according to how much reduction is desired in the amount of material to be handled by the machine at one time. Obviously, the intermediate size loops thus formed have successively smaller dimensions. The smallest one, that is, the one formed from the innermost layers of strip of the original coil of strip 20 is placed in the machine of Fig. 1 first, as the coil of strip 14, and the material thereof is unwound into the larger loop 15 and applied to the conductive winding leg 17 in the manner already described. The next size intermediate loop, that is, the intermediate loop formed from the next layers of strip of the original coil 20 is then placed in the machine and the material is applied to the conductive winding structure surrounding the first layers, that is, around the first section of the core in the same manner as the strip was previously wound directly against the winding leg. Care is taken to see that the inner end of the strip in the second section of the coil is placed against the outer end of the first section of the core, so that all of the turns of the strip material in the finished core have the same size, shape and relationship with respect to the order of turns as if the entire core had been applied as a single continuous strip of material. If it is desired to form a finished core having two or more sections separated by a space for cooling or other purposes, it will be understood that such spacing must be provided in the original coil of strip by winding in dummy turns, or in some other manner, in order that the strip material in the original coil 20 of Fig. 2 will be annealed with the same shape and size of turns as it has to have in the finished core.

In accordance with the provisions of the patent statutes, I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

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

1. A machine for assembling a magnetic core of the wound type with a conductive winding structure having a window for the magnetic core and a winding leg adjacent the winding window, said machine comprising means for supporting the conductive winding structure, a belt passing around the conductive winding structure with means for supporting a portion of the belt in alignment with the window of the winding structure for holding a coil of magnetic strip material at one side of the said window and for holding a larger loop of magnetic strip material surrounding the coil and adapted to pass through the winding window, magnetic attraction means having pole pieces outside of said belt at one portion thereof for attracting the coil of strip against a portion of the larger loop and against the belt

at one side of the coil support, and driving means for producing peripheral motion of the belt to cause the strip material to unwind from the coil of strip to pass through the winding window and to rewind simultaneously into the inside of a larger loop and for producing peripheral motion of the belt also to wrap the strip material from the larger loop around the winding leg.

2. A machine for assembling a magnetic core of the wound type with a conductive winding structure having a window for the magnetic core and a winding leg adjacent the winding window, said machine comprising means for supporting a conductive winding structure, a belt passing around the conductive winding structure with means for supporting a portion of the belt in alignment with the window of the conductive winding structure for holding a coil of magnetic strip of material in a different location from the said winding structure and for holding a larger loop of magnetic strip material surrounding the coil leg and adapted to pass through the winding window, said belt having an arrangement for subjecting the coil of strip to a force attracting it against a portion of the larger loop and against the belt in a different location from the winding support, and means for supporting and peripherally driving the belt to unwind the strip material from the coil, to pass it through the winding window and to rewind it simultaneously into the inside of the larger loop linking the conductive winding structure.

3. A machine for assembling a magnetic core of the wound type with a conductive winding structure having a window for the magnetic core and a winding leg adjacent the winding window, said machine comprising means for supporting the conductive winding structure, an endless belt with means for so supporting it as to cause its surface to define an outline, which outline passes through the winding window and which outline is of sufficient size to surround both the conductive winding leg and a coil of strip material which is to be applied to the conductive winding leg, whereby the belt is adapted to support such a coil of strip in a different location from the winding structure in alignment with the winding window, means for peripherally driving the belt to cause the strip material to unwind from the coil of strip and to rewind simultaneously into a larger loop having an outer surface circumscribed by the outline defined by said belt, whereby the strip material is progressively passed through the winding window.

4. Apparatus for unwinding a non-circular coil of strip having an initial set tending to collapse its turns into a smaller coil and for simultaneously rewinding the strip material into a loop larger than the first-mentioned coil of strip, said apparatus comprising the combination of a mandrel fitting within the first-mentioned coil of strip for preventing its collapse during handling and a peripherally driven belt having means for supporting it with its surface defining an outline of greater perimeter than the first-mentioned coil of strip, and circumscribing a figure having a perimeter substantially equalling an integral number of times an aliquot fraction of the perimeter of the first-mentioned coil of strip for transferring the strip material from he outer surface of the first-mentioned coil of strip into the inner surface of a larger loop circumscribed by the said outline defined by the belt whereby the belt supports the larger loop and moves it peripherally feeding portions of the strip material of a given radius of curvature from the first-mentioned coil of strip into the larger loop against portions of strip of corresponding radius of curvature.

5. Apparatus for unwinding a non-circular coil of strip and for simultaneously rewinding the strip material into a larger loop, said apparatus comprising peripherally driven endless belt means, means for supporting it with its surface defining an outline of greater perimeter than the first-mentioned coil of strip and circumscribing a figure having a perimeter substantially equaling an integral number of times an aliquot fraction of the perimeter of the first-mentioned coil of strip for transferring the strip material from the outer surface of the coil of strip into the inner surface of a larger loop circumscribed by the outline defined by the belt, whereby the belt supports the larger loop and moves it peripherally, feeding portions of the strip material of a given radius of curvature from the coil of strip into the larger loop against portions of strip material of corresponding radius of curvature.

6. Apparatus for unwinding a non-circular coil of strip and for simultaneously rewinding the strip material into a larger loop, said apparatus consisting of strip supporting and conveying means defining an outline having a greater perimeter than the original coil of strip and circumscribing a figure having a perimeter substantially equal to an integral number of times an aliquot fraction of the perimeter of the coil of strip, said strip supporting means comprising movable means having a plurality of surface elements arranged around the aforesaid outline tangential thereto with means for moving said surface elements in a direction peripheral with respect to the said outline for passing strip material along the periphery of the said outline within it as a larger loop and transferring the strip material from the outer surface of the coil of strip to the inner surface of the larger loop circumscribed by said outline, whereby the coil of strip is initially contacted by such surface elements to rotate in a direction causing the outer layers of strip material to unwind and feed portions of the strip material of a given radius of curvature from the coil of strip into the larger loop against portions of strip material of corresponding radius of curvature.

7. Apparatus for unwinding a coil of strip having a natural set tending to collapse its turns into a smaller coil and for simultaneously rewinding the strip material into a loop larger than the first-mentioned coil of strip, said apparatus comprising a mandrel fitting within the first-mentioned coil of strip, a peripherally driven belt, means for supporting it with its surface defining an outline of greater perimeter than the first-mentioned coil of strip whereby the belt supports a larger loop circumscribed by said outline and moves it peripherally, feeding portions of the strip material from the first-mentioned coil of strip into the inside of the larger loop.

8. Apparatus for unwinding a coil of strip having an initial set tending to collapse its turns into a smaller coil and for simultaneously rewinding the strip material into a loop larger than the first coil of strip, said apparatus comprising a mandrel of a size to fit within the first-mentioned coil of strip, and strip supporting means defining an outline of greater perimeter than said first-mentioned coil of strip, said strip supporting means having surface elements tangential to the aforesaid outline with means for moving said surface elements in a direction

which is peripheral with respect to the said outline whereby the first-mentioned coil of strip is initially contacted by such surface elements to rotate in a direction causing the outer layers of strip material to unwind and to rewind simultaneously into a larger loop circumscribed by said outline.

9. Apparatus for unwinding a coil of strip and for simultaneously rewinding the strip material into a larger loop, said apparatus comprising a peripherally driven belt, means for supporting it with its surface defining a given outline having a greater perimeter than the original coil of strip whereby the belt supports a larger loop circumscribed by said outline and moves it peripherally feeding portions of the strip material from the outside of the first-mentioned coil of strip to the inside of the larger loop.

10. A machine for assembling a magnetic core of the wound type with a conductive winding structure having a window for a magnetic core and a winding leg adjacent the winding window, said machine comprising means for supporting the conductive winding structure and strip supporting means defining an outline, which outline passes through the winding window and which outline is sufficiently large to surround both the winding leg and a coil of magnetic strip material which is to be applied to the winding leg, said supporting means having surface elements tangential to the aforesaid outline with means for moving said surface elements in a direction peripheral with respect to the said outline, whereby the coil of strip is initially contacted by such surface elements to rotate it in a direction causing the outer layers of strip material to unwind and simultaneously to rewind into a larger loop circumscribed by said outline, and whereby the material passing to the larger loop is progressively passed through the winding window.

11. A machine for assembling a magnetic core of the wound type with a conductive winding structure having a window for a magnetic core and a winding leg adjacent the winding window, said machine comprising means for supporting the conductive winding structure, and strip supporting means defining an outline, which outline passes through the winding window and which outline is sufficiently large to surround both the winding leg and a coil of magnetic strip material which is to be applied to the winding leg, said supporting means having surface elements tangential to the aforesaid outline with means for moving said surface elements in such a direction as to be peripheral with respect to the said outline, whereby the coil of strip is initially contacted by such surface elements to rotate it in a direction causing the outer layers of strip material to unwind and simultaneously to rewind into a larger loop circumscribed by said outline and driven peripherally by said surface elements and whereby the material passing to the larger loop is progressively passed through the winding window, said strip supporting means including means for magnetically attracting a coil of strip against the driving surface elements at a portion of the outline beside the position at which the winding leg is supported for preventing unsteady movement of said coil of strip and for retaining the coil of strip and the layers of strip material of the larger loop in proper relation to one another.

12. Apparatus for unwinding a coil of strip and simultaneously rewinding it into a larger loop surrounding the original coil of strip comprising an endless belt, rotatable pulleys for supporting and guiding the belt in a position with its inner surface forming an outline which circumscribes the figure which it is desired to have the larger loop assume, magnetic attracting means for holding the coil of strip against the inner surface of one portion of said belt, and means for peripherally driving the belt to transfer the strip material from the coil to the larger loop, a pair of the aforesaid belt guiding rollers being composed of magnetizable material and constituting pole pieces of said magnetic attraction means.

13. Apparatus for supporting and peripherally moving a loop of strip comprising a plurality of layers, which apparatus comprises an endless belt, a plurality of supporting pulleys contacting the inner surface of the belt and a plurality of guiding pulleys contacting the outer surface of the belt, said guiding pulleys being mounted to bend the belt inward from lines joining the centers of adjacent supporting pulleys, whereby the inner surface of the belt defines an outline by which it is desired that the loop of strip material shall be circumscribed and none of said pulleys projects within said outline, one of said pulleys being rotatably driven.

14. Apparatus for feeding magnetizable material held against a moving strip comprising means for movably supporting said strip, and a magnet for applying a magnetomotive force to a portion of the said strip for holding such magnetizable material in place against such portion of the moving strip to avoid mechanical holding of the fed material while it is being fed, said magnet comprising a magnetized core and a plurality of rotatably mounted roller pole pieces in proximity to the surface of said strip opposite the surface against which the magnetizable material is to be held.

15. The method of holding a coil of magnetizable material in place against the inside of a peripherally moving larger loop of magnetizable material into which the material of the coil is to be wound, which method comprises passing a magnetic flux through that portion of the periphery of the larger loop against which the coil of strip is to be held.

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