May 12, 1942. H. L. DRIFTMEYER 2,282,854

STATIONARY INDUCTION APPARATUS

Original Filed Sept. 28, 1939 2 Sheets-Sheet 1

Fig. 1.

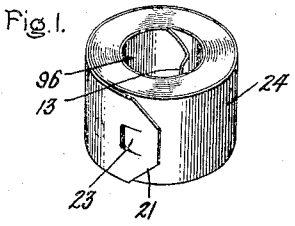


Fig. 3.

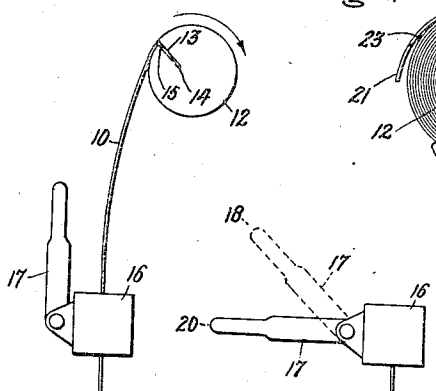


Fig. 4.

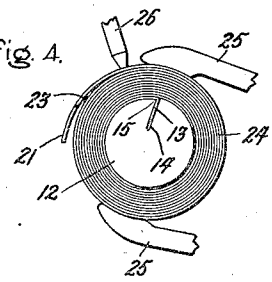


Fig. 2.

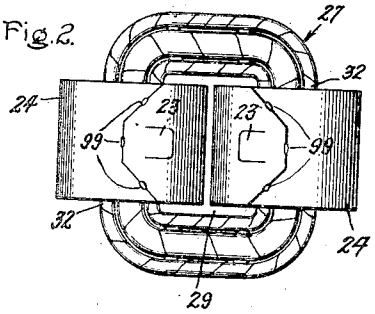


Fig. 5.

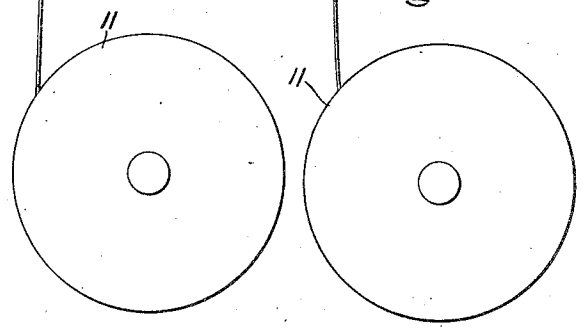


Fig. 6.

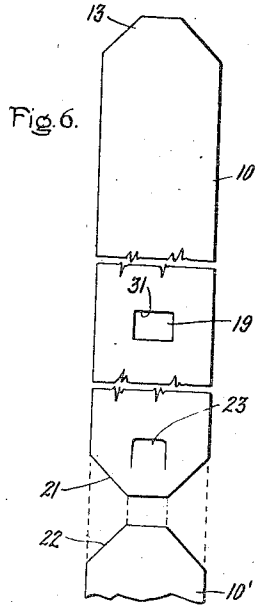
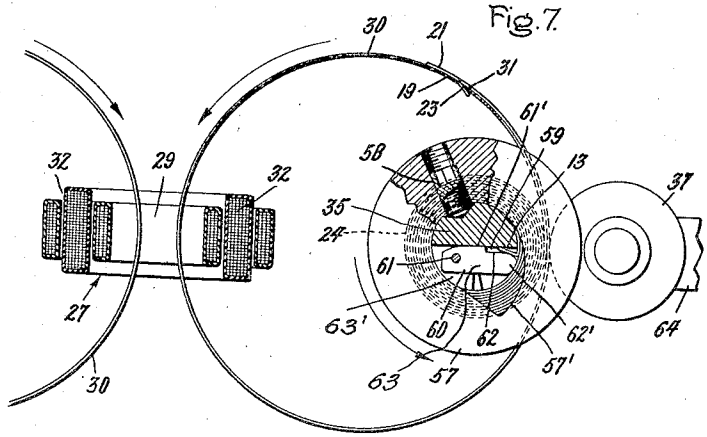


Fig. 7.



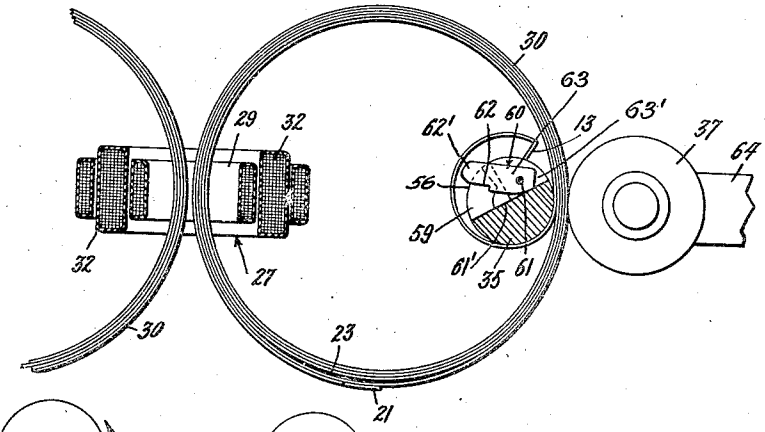
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Fig. 8.



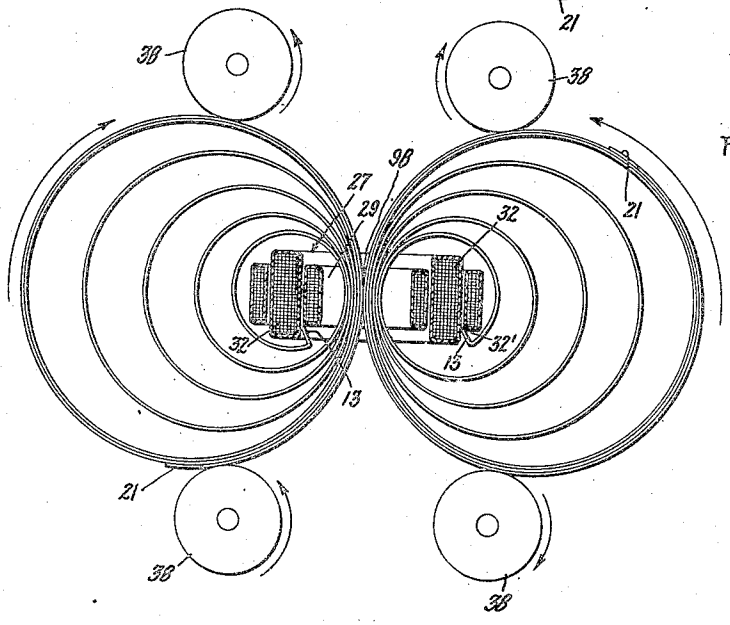
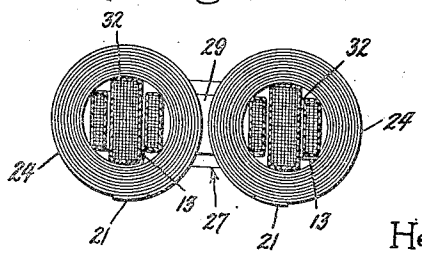


Fig. 9.

Fig. 10.



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by Harry E. Dunham
His Attorney.

Patented May 12, 1942

2,282,854

UNITED STATES PATENT OFFICE

2,282,854

STATIONARY INDUCTION APPARATUS

Herbert L. Driftmeyer, Fort Wayne, Ind., assignor to General Electric Company, a corporation of New York

Original application September 28, 1939, Serial No. 296,940. Divided and this application June 20, 1941, Serial No. 398,944

1 Claim. (Cl. 175—356)

This application is a division of my copending application Serial No. 296,940, filed September 28, 1939.

My invention relates to wound strip core stationary induction apparatus and concerns particularly the coiled strip forming the core.

It is an object of my invention to provide improved, faster arrangements for applying the wound strip core to the conductive winding structure of stationary induction apparatus, such as transformers and reactors of the wound core type.

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

In carrying out my invention in its preferred form, particularly in connection with stationary induction apparatus having two parallel winding legs each carrying an annular core or core part, I wind strips of magnetic material flatwise spirally to form a pair of coils of strip with the turns having the same size and shape as they are to have in the finished magnetic cores, I subject the coils of strip to heat treatment to bring out the most favorable magnetic properties and to give the material a permanent set, I then bring the coils of strip in proximity to the conductive winding structure and transfer the strip from the original coils to the winding legs. The two coils may be applied to the conductive winding structure simultaneously. Each coil is unwound and simultaneously rewound into a larger loop passing through the opening or window of the conductive winding structure. For the sake of speed and certainty in unwinding the original coil and rotating the larger loop, I cause the coils of strip to be driven from the inner end by driving spindles each arranged to engage the inside end of the strip and then release it automatically when all the material of the original coil has been unwound. When all the material has been transferred to the larger loops they are collapsed to form the finished magnetic cores closely embracing the winding legs. In the collapsing process the larger loops are reduced to smaller size by rotation of collapsing rollers frictionally engaging the outer surfaces of the larger loops. The two loops are tangent in the center of the winding window and rotate together in the same tangential direction at the point of tangency (but in opposite angular directions), thereby facilitating the collapsing process by the frictional engagement between the two loops and by the mutual reaction tending to prevent either strip from being pushed to the opposite side of the winding window by the collapsing rollers.

The invention will be understood more readily from the following detailed description when considered in connection with the accompanying drawings and those features of the invention which are believed to be novel and patentable will be pointed out in the claims appended hereto.

In the drawings, Fig. 1 is a perspective view of one of the wound-strip annular magnetic cores utilized in one embodiment of my invention. Fig. 2 is an illustration of a finished transformer constructed in accordance with my invention. Fig. 3 is a schematic diagram illustrating an initial step in the process of producing wound cores, namely, the first part of the process of winding the strip into a coil. Fig. 4 is a schematic diagram showing a further step in the process at which the strip has been wound into the coil. Fig. 5 is a schematic diagram representing a step in the process at which the strip is cut off at the completion of the coil. Fig. 6 shows the strip as it would appear if unwound from the coil and laid out flat, portions thereof being broken out. Fig. 7 is a fragmentary plan view partially in section of an assembling machine showing another step in the process of applying the strip to the conductive winding structure at the point where the unwinding of the original coil of strip and the rewinding of the larger loop to the window of the winding structure has just begun. Fig. 8 is a view corresponding to Fig. 7 showing the point in the process at which very nearly all of the strip has been transferred from the original coil and passed through the window of the winding structure. Fig. 9 is a view corresponding to the previous two views showing the condition preparatory to the collapsing of the larger loops around the winding legs, and Fig. 10 is a horizontal sectional view of the completed transformer corresponding to the previous views and showing the final result of the core-applying process.

In order to apply the magnetic strips to the conductive winding legs in such a manner that the strip will have the most desirable magnetic properties, the strip is first wound up into coils which may be given suitable heat treatment to bring out the magnetic properties. As shown in Fig. 3 a strip 10 of magnetic material from a large reel 11 is wound upon a mandrel 12 by securing the end 13 of the strip in a slot 14 in the mandrel and rotating the mandrel. The slot 14 is not exactly radial, but forms a portion of a

chord of the substantially circular cross-section of the mandrel 12, such that a bend 15 is formed in the strip, making an angle of somewhat less than 90 degrees. The mandrel 12 is not exactly circular in cross-section, but has a slightly reduced radius at the portion of the slot 13 on the counterclockwise side of said slot. The difference in radius on either side of the slot 13 is the thickness of the strip 10 in order that when a complete turn of strip has been wound upon the mandrel 12 there will be no bulge above the bend 15 in the strip and the succeeding layers will lie flatly, substantially circularly above one another, as shown in Fig. 4. Actually the surfaces of the mandrel 12 and the successive layers of strip are along a spiral having a radius increasing an amount equal to the thickness of the strip 10 for each complete revolution or turn.

The strip 10 is passed through a die and cutter head 16 located between the reel 11 and the mandrel 12. The die and cutter 16 has an operating lever 17 and an internal mechanism, not shown, with three positions. In the first position, with the lever 17 perpendicular, as shown in Fig. 3, the strip may pass freely through the head 16. By moving the lever 17 to the second position 18, represented by the dotted lines in Fig. 4, a punch is brought against a die block, such as to cut a rectangular opening 19, as shown in Fig. 6. By moving the lever 17 to the third position 20, in which the handle 17 is horizontal, as shown in full lines, the strip is cut off and simultaneously a hook 23 is punched near the end of the strip. The cut-off forms the final end 21 of the strip 10 as well as the initial end 22 of the next strip 10', corresponding in shape to the initial end 13, which is the end that is inserted in the slot 14 of the mandrel 12.

The opening 19 is punched near the outer end of the strip by bringing the lever 17 into the position 18 after nearly a complete length of strip has been wound upon the mandrel 12. After rotating the mandrel 12 a short distance further, approximately two or three turns, the die operating lever 17 is brought to the position 20 so as to cut off the strip and form the hook 23. The mandrel 12 is then rotated until all of the strip has been wound up to form the coil 24. If desired, shoes 25 pressing against the surfaces of the coil 24 may be employed to insure that the strip is wound tightly. After the coil 24 has been formed, the end of the strip 21 is preferably fastened down in some suitable manner to avoid unwinding of the strip during anneal. This may be done, if desired, by spot welding, utilizing a welding electrode 26 carried by a pivoted arm (not shown) connected to a welding transformer having the electrical circuit completed through the shoe 25. The coil is then ready to be subjected to suitable heat treatment for bringing out its best magnetic loss and magnetizing current properties and giving the material a permanent set. It will be understood that the coil 24 has the turns of the same size and shape as the core of the completed induction apparatus. It will also be understood that the mandrel 12 is so constructed that the coil 24 may be slipped off endwise.

In order to transfer the strip material from the coils, such as the coil 24, to a conductive winding, a pair of coils is placed on driving spindles 35 adapted to engage the bent ends 13, as shown in Fig. 7. A conductive winding structure 27 is placed between a pair of such coils, only one of which is shown in Fig. 7, and the outer ends of the coils are unfastened so that they may be slipped through the opening or window 29 of the conductive winding structure 27. The outer end 21 of the strip 10 is brought around and fastened to the next underlying layer of strip to form a larger loop 30. The fastening may be accomplished quickly by drawing the hook 23 through the opening 19 and pulling the strip back tightly so as to cause the hook 23 to grasp the material at the edge 31 of the opening 19. The spindle 35 is rotated to force rotation of the coil 24 and the larger loop 30, and consequently causes transference of the material from the outside of the coil 24 to the inside of the larger loop 30. The rotation of the drive spindles 35 is continued until substantially all of the material has been transferred to the larger loops 30, as shown in Fig. 8, whereupon the drive spindles 35 are removed. The inner bent ends 13 of the strip are placed in suitable recesses in the winding legs 32. For example, in the case of a cruciform section coil the bent ends 13 may be caused to occupy the corner 32' between the high and low voltage windings. The process as carried out in the foregoing manner avoids any possibility of bending the strip material so far as to strain it beyond the elastic limit and permits bringing the material back to the original size and shape of turn so that it will be free from elastic strains and it will have more favorable magnetic properties.

The transformer and reactor assembling machine comprises a table (not shown), a pair of turn tables (not shown) for supporting and driving the coils of strip 24 of Figs. 1 and 4, a pair of core-driving spindles 35, one of which is shown partially in section in Fig. 7, adapted to fit into sockets in the turn tables, a driving motor (not shown) arranged to rotate the turn tables and spindles 35, a pair of idling pressure rollers 37 (one shown) for holding the strip in the coils 24 until unwound, two pairs of collapsing rollers 38 for quickly collapsing the larger loops when completed, and a suitable clamping arrangement (not shown) for holding the conductive-winding structure 27 while the core strip material is being applied.

A collar 57 is provided on the upper portion of the spindle 35 in order to serve as a guide for the strip on the coil 24 as the coil 24 is being unwound. A set screw 58 may be provided for adjustably securing the collar 57 at the proper height for the width of strip in the coil 24.

For receiving the end 13 of the magnetic strip and releasing it at the proper time, a self-opening slot 59 (see Fig. 7) is provided in the drive spindle 35. This self-opening slot 59 is formed by cutting a sector longitudinally out of the portion 56 of the spindle 35 and providing a pivoted latch 60 with a pivot axis 61 parallel with the axis of the spindle 35, but off center. The latch 60 is adapted to lie against edge 61' of the sector cut into the spindle portion 56. However, it has a portion 62 which is cut back sufficiently to form the self-opening slot 59. The outer tip, or nose 62' of the latch 60 extends lengthwise in the sector-shaped opening of the spindle portion 56, and is carried by two arms 63 through which pass the pivot pins 61 of the latch 60. The arms 63 are at the upper and lower ends of the lengthwise extending tip portion 62 and occupy transverse slots or recesses 63' in the spindle 35. To permit the latch tip 62' to swing away from

the surface 61' and open the slot 59, a notch 57' is cut in the collar 57.

The idle roller 37 is movably supported and resiliently biased by means of a spring toward the spindle 56 so as to bear against a coil carried by the spindle 35.

The collapsing rollers 38 are carried by swinging arms (not shown) and are rotatably driven.

Coiled strips 24 which have been heat treated are mounted on driving spindles 35 and the latter are rotated. The coils are mounted upon the spindles 35 by moving the pivoted latch 60 into the position shown in Fig. 7 and the spindles are placed through the openings or windows 96 in the coils 24 with the bent inner ends 13 of the coils inserted in the slots 59 in the driving spindle 35. The pressure of the rollers 37 causes the strip to be unwound uniformly and causes the linear speed of the adjacent portions of strip in the coil 24 in the larger loop 30 to remain approximately the same, so that the coil 24 and the loop 30 remain tangent and the strip will feed smoothly from the coil 24 to the inside of the loop 30. The two coils 24 are so placed on the turn tables 34 that they unwind by being rotated in opposite directions.

Owing to the fact that the latch 60 is pivoted off center it cannot be rotated away from the position shown in Fig. 7 without pressing against the inner surface of the coil 24. Just so long as the strip remains coiled in the form of the coil 24, the latch 60 is held in place, the bent end of the strip 14 is held in the slot 59 and the driven spindle 35 produces positive drive of the coil 24 and causes it to rotate and unwind into the larger loop 30, which is in turn caused to rotate thereby. After nearly all of the strip has wound into the larger loop so that there is no longer a complete turn of strip on the spindle portion 56, as shown in Fig. 8, the pivoted latch 60 is released permitting the slot 59 to open up. Thus, the bent inner end 16 of the strip is released and springs out as a result of the rotation of the spindle 35. This makes it unnecessary to stop the driving motor at the precise moment that the inner turn of coil 24 starts to unwind, and prevents the bent end 13 from being broken off or unduly strained. The spindles 35 may then be lifted out of their sockets whereupon the strip material in the larger loops 30 collapses to the position shown in Fig. 9 due to the permanent set which the material has acquired in the heat treatment. The outer ends of the strip are then unfastened and the bent inner ends 14 are positioned in recesses in the winding legs 32. It will be understood that friction of the strip upon the supporting table prevents the strip from collapsing completely as its permanent set would otherwise cause it to do. The driving rollers 38 are moved into frictional contact with the magnetic strip, rotating the loops 30 and collapsing them to the size and shape shown in Fig. 10. Since each loop exerts substantially the same pressure as the other at the point of tangency 98, the strip is kept approximately at the middle of the winding window 29 so as to minimize the possibility of scraping of the strip material on the conductive winding structure. The frictional contact at the point 98 also helps to keep the outer layers of both loops 30 in rotation. The directions of rotation are opposite so as to have the same linear direction of motion of the strip at the point of tangency 98. Although the permanent set of the material tends to keep it in the shape shown in Fig. 18, it may be advantageous to secure the outer ends 21 of the strip to the next adjacent lower layer in some suitable manner as by means of spot welds 99. When it is desired to disassemble a transformer or reactor, i. e. to remove the core, the entire procedure explained in the foregoing description is reversed with the directions of rotation of the rollers and shafts reversed.

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:

A flatwise spirally wound coil of strip having a tab punched at the end thereof to form a hook and having a slot punched in the strip a short distance from the end of the strip, adapted to receive the said hook for securing the outer turns of the coil in a larger loop when the outer turns of the coil are unwound.

HERBERT L. DRIFTMEYER.