

- [54] **MAGNETIC CORE STRUCTURE**
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Related U.S. Application Data

- [63] Continuation-in-part of Ser. No. 55,532, July 16,
1970, abandoned.
[52] U.S. Cl.**336/96, 336/176, 336/210,**
336/211, 336/216
[51] Int. Cl.**H01f 27/24**
[58] Field of Search.....**336/175, 176, 211, 213, 216,**
336/217, 96, 165, 210

References Cited

UNITED STATES PATENTS

- | | | | |
|-----------|--------|----------------------|-----------|
| 2,937,352 | 5/1960 | Vienneau et al. | 336/216 |
| 3,227,982 | 1/1966 | Heffernan..... | 336/211 X |
| 2,519,495 | 8/1950 | Vesbitt et al. | 336/213 X |
| 3,125,705 | 3/1964 | Feinberg et al..... | 336/165 X |
| 3,362,066 | 1/1968 | Cooper..... | 336/216 X |
| 2,830,277 | 4/1958 | Kane | 336/216 X |

- | | | | |
|-----------|---------|----------------------|-----------|
| 3,135,938 | 6/1964 | Davis..... | 336/165 |
| 2,595,820 | 5/1952 | Somerville..... | 336/211 |
| 3,535,593 | 10/1970 | Schweitzer, Jr. | 336/176 X |
| 1,830,541 | 11/1931 | Harris..... | 336/176 |

FOREIGN PATENTS OR APPLICATIONS

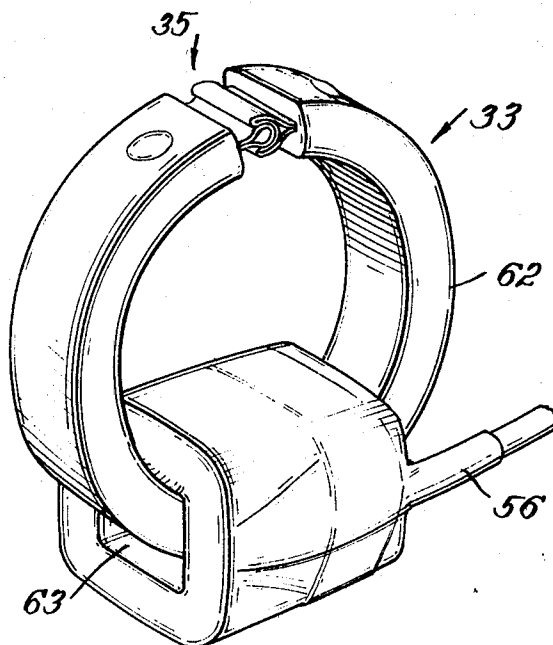
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|-----------|--------|--------------|---------|
| 1,807,835 | 5/1970 | Germany..... | 336/175 |
|-----------|--------|--------------|---------|

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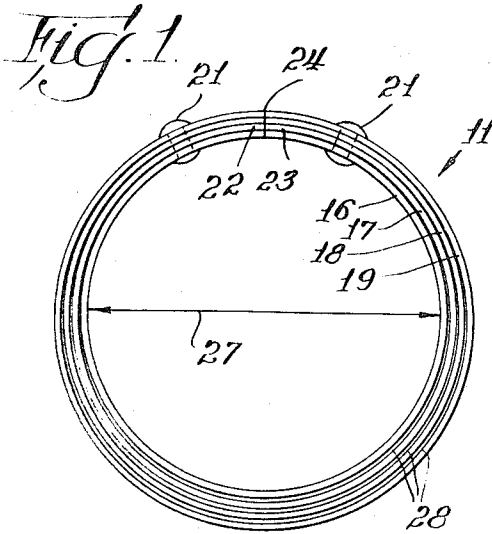
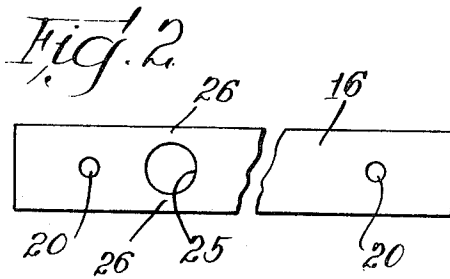
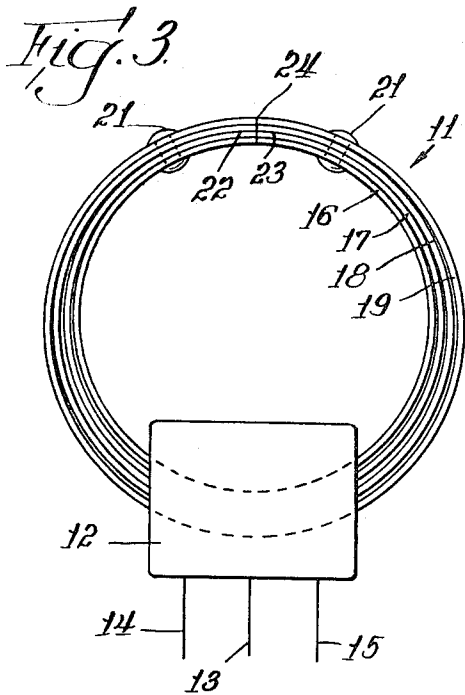
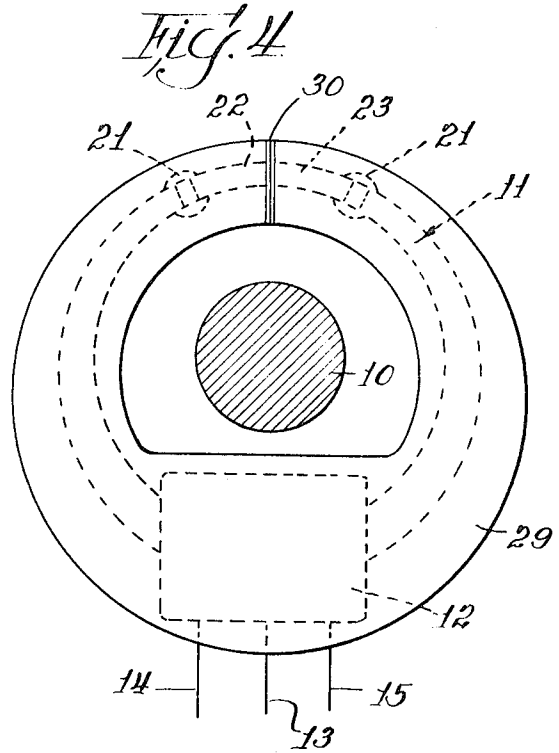
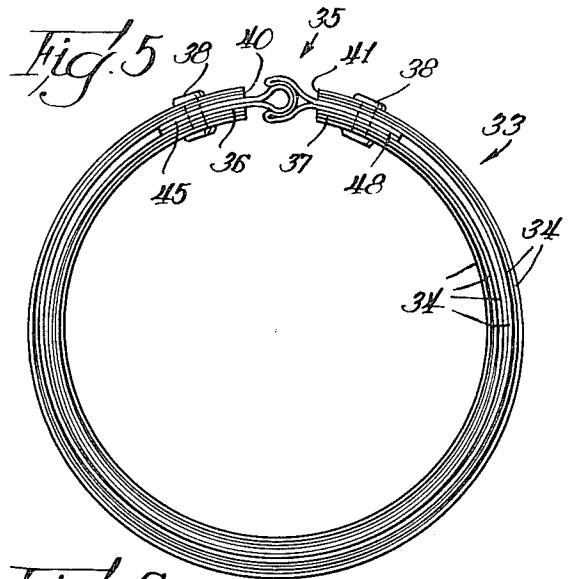
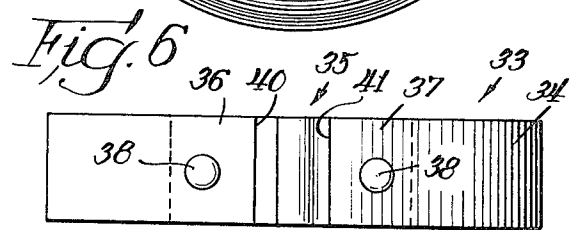
[57] **ABSTRACT**

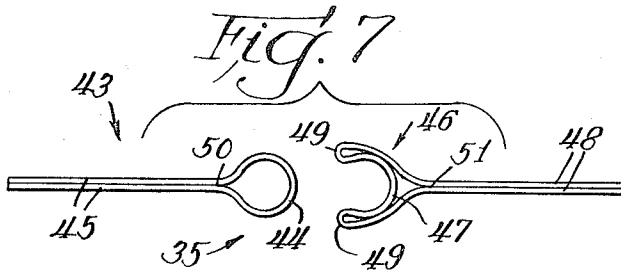
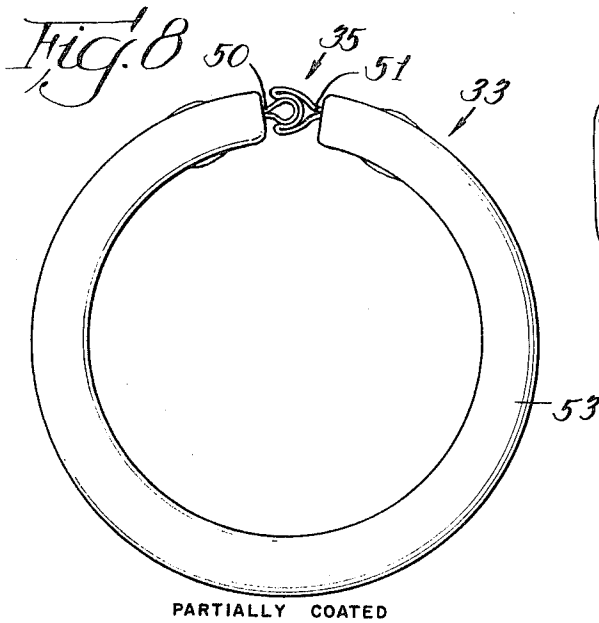
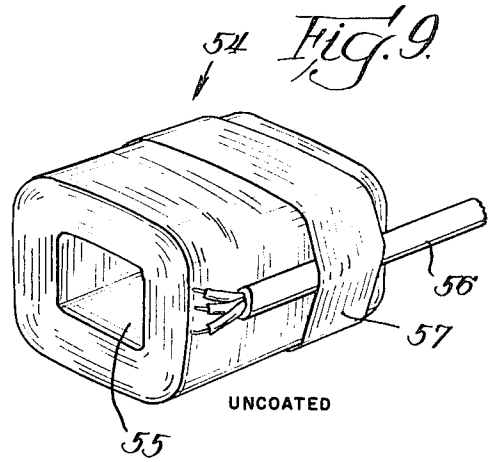
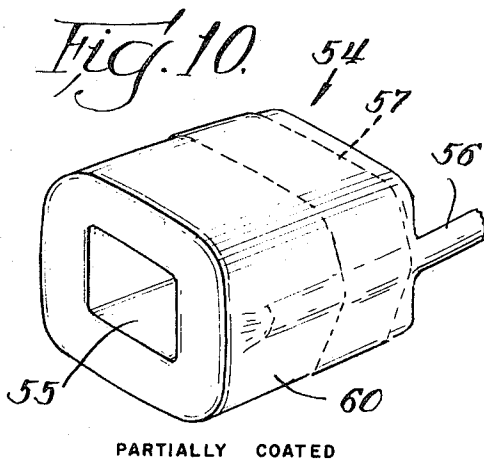
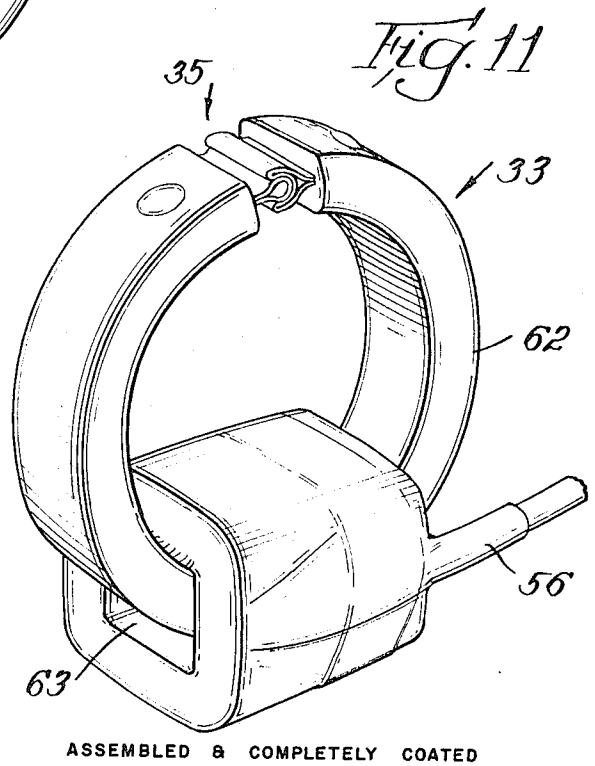
A circular magnetic core structure comprises a plurality of laminations of prestressed oriented silicon steel secured together near their juxtaposed ends which are biased into mutual engagement and are separable to receive an alternating current carrying conductor to induce into the core alternating magnetic flux which induces alternating current into a coil on the core corresponding to the current in the conductor. The core and coil are encapsulated in insulating material. In one embodiment self curing cement is applied to the juxtaposed ends after the core is applied to the conductor to seal them together. In another embodiment the ends are provided with interlocking separable coupling extensions of corrosion resisting magnetic material.

9 Claims, 11 Drawing Figures



ASSEMBLED & COMPLETELY COATED





MAGNETIC CORE STRUCTURE

This application is a continuation, in part, of application Ser. No. 55,532, filed July 16, 1970, now abandoned.

Among the objects of this invention are: To provide an openable magnetic core without pivotal connections for embracing an alternating current carrying conductor; to form the core of flexible laminations having sufficient inherent resiliency, when assembled, to permit separation of the ends to admit the conductor and then close the gap and bias the ends into juxtaposition; to seal the juxtaposed ends of the core to prevent corrosion and noise; to apply a coil to the core for induction therein of alternating current corresponding to flow of alternating current in the conductor; to encapsulate the core and coil; and to provide the separable ends of the core with interlocking coupling extensions of corrosion resisting magnetic material.

In the drawings:

FIG. 1 is a view, in side elevation, of a magnetic core formed of laminations or strips of prestressed oriented silicon steel.

FIG. 2 is a plan view of one of the laminations or strips before it is prestressed.

FIG. 3 is a view, similar to FIG. 1, showing the application of the coil or secondary winding to the core.

FIG. 4 illustrates how the core and winding, in assembled relation and encapsulated, are applied to an alternating current carrying conductor.

FIG. 5 is a view, similar to FIG. 1, showing the core with interlocking coupling end extensions.

FIG. 6 is a top plan view of FIG. 5.

FIG. 7 is a side elevation view, of an enlarged scale, of the corrosion resisting coupling extensions.

FIG. 8 is a view, in side elevation, of the core encapsulated in plastic insulating material.

FIG. 9 is a perspective view of the coil or secondary winding and conductor cable.

FIG. 10 is a view, similar to FIG. 9, showing the coil or secondary winding encapsulated in plastic insulating material.

FIG. 11 is a perspective view of the assembled core and coil or secondary winding having a commonly encapsulated in plastic insulating material.

In FIG. 4 there is illustrated at 10 an alternating current carrying conductor that is embraced by a circular magnetic core 11 which extends through a coil or secondary winding 12 that may be provided with a center tap 13 and terminal conductors 14 and 15. The magnetic core 11 is constructed without employing a hinged joint such as is conventional for magnetic cores of the clip-on type. However, the magnetic core 11 is constructed in such manner that it can be opened to receive the conductor 10 and to embrace it with a relatively low reluctance magnetic circuit. A preferred construction is illustrated in FIGS. 1-4. Here it will be observed that the magnetic core 11 is formed of a plurality of strips or laminations of oriented silicon steel each having relatively little inherent resiliency. For illustrative purposes four such strips are shown at 16, 17, 18 and 19. The strips or laminations are of increasing length with the shortest being the innermost strip 16. FIG. 2 shows a plan view of the strip 16, for example. It includes rivet openings 20 spaced from the ends for receiving rivets 21 to hold the individual ends together so that the juxtaposed end portions 22 and 23 are in en-

agement along a joint 24. Each of the strips or laminations has an opening 25 formed therein to provide saturable sections 26 for limiting the magnetic flux that is induced in the magnetic core 11. This is of particular importance when it is recalled that the current flow in the conductor 10 may be of the order of several thousand amperes under certain fault current conditions. The diameter indicated at 27, FIG. 1, of the inner strip or lamination 16 is such as to readily accommodate the conductor 10 in a manner illustrated in FIG. 4. Clearance 28 is provided between the strips or laminations of sufficient dimension to permit relative freedom of motion of the several strips or laminations.

For constructing the magnetic core 11 the strips or laminations are cut from a coil of the oriented silicon steel having relatively little inherent resiliency so as to have successively increasing lengths. The following indicates how the lengths are determined:

$$L_{16} = \pi (d + 2t)$$

$$L_{17} = \pi (d + 4t)$$

$$L_{18} = \pi (d + 6t)$$

$$L_n = \pi (d + 2nt)$$

Where

L = length of strip

d = Diameter 27

t = thickness of strip plus addendum for clearance 28

n = number of strip

After the strips or laminations have been cut to the indicated lengths the ends are pierced to provide the openings 20 for the rivets 21. Also the opening 25 is punched out to provide the saturable sections 26. Next the strips or laminations are individually coiled to a diameter less than the diameter indicated at 27 to prestress them. Finally they are assembled in the order of successively greater lengths outward and the rivets 21 are applied to the end portions 22 and 23. The result of the prestressing of the strips or laminations is to provide a self closing split magnetic core 11 by spring action having a positive and durable force to maintain the end portions 22 and 23 in engagement at the joint 24. However, the assembly has sufficient resiliency to permit the magnetic core 11, assembled as described, to be opened to about 75 percent of the diameter indicated at 27 to receive the conductor 10 without loss of closing force required to maintain the end portions 22 and 23 in engagement to provide a minimum reluctance magnetic circuit.

While the method of forming the magnetic core 11 from individual strips or laminations as described above is preferable, the magnetic core 11 can be formed in another manner. Instead of cutting the strips or laminations to the individual lengths, a strip of oriented silicon steel having relatively little inherent resiliency is coiled in spiral fashion about a suitable arbor with the inner diameter being substantially less than the desired final diameter such as that indicated at 27. After a sufficient number of turns in the spiral configuration have been formed in this manner, the spiral arrangement is unwound to provide the inner diameter 27 as desired. Then rivets or other holding means are inserted in spaced relation to what finally will be the joint 24. Finally a saw cut is made between the holding means or rivets with the result that the magnetic core 11 is formed which can be opened and self closed in the manner previously described.

After the magnetic core 11 has been formed by either of the methods above described, the secondary winding 12 is applied as indicated in FIG. 3.

In order to avoid corrosion of the magnetic core 11 it and the secondary winding 15 are encapsulated in conventional manner to provide the covering indicated at 29, for example of hardenable plastic neoprene rubber.

It is desirable that a film of insulation be provided between the juxtaposed end portions 22 and 23 to avoid corrosion and to reduce vibration to a minimum incident to induction of alternating magnetic flux in the core 11. Accordingly, after the assembly has been made as indicated in FIG. 4 a layer 30 of suitable self curing cement is applied to the faces of the end portions 22 and 23. This seals the end faces from the atmosphere and effectively reduces vibration and generation of noise at this point.

For illustrative purposes four strips of laminations have been shown and the clearance 28 therebetween has been exaggerated. A larger number of strips or laminations having a thickness of the order of 0.021 inch can be used with a smaller clearance.

Referring to FIGS. 5 and 6, reference character 33 designates, generally, a core that is formed of strips 34 of oriented silicon steel of increasing length. For illustrative purposes it is pointed out that 13 strips 34 are employed for the core 33. They are processed in accordance with the foregoing description for the core 11 so that the final construction is inherently self closing around the conductor 10. It will be understood that the strips 34 increase in length from the innermost strip to the outermost strip. Instead of having surface contact engagement between the ends of the core 33, as is the case for the construction shown in FIG. 3, for example, coupling members 35 are employed. The coupling members 35 are arranged to interconnect end portions 36 and 37 of the core 33 through which rivets 38 extend for holding them securely together. The end faces 40 and 41 are interconnected by the coupling members 35 instead of being in face to face contact. It is unnecessary then to accurately finish the end faces 40 and 41 and it is unnecessary to employ the cement 30, previously described, since the coupling members 35 can be formed of non-corrosive material as will be set forth hereinafter.

As illustrated in FIG. 7 the coupling members 35 include a tongue member 43 having a convex circular end portion 44 and laterally extending ends 45. The coupling members 35 also include a groove member 46 which has a concave circular end portion 47 provided with laterally extending ends 48. The distal ends 49 of the groove member 46 are semi circular in configuration. The sections 50 and 51 adjacent the tongue and groove members 43 and 46, respectively, provide saturable sections making it unnecessary to employ the opening 25, FIG. 2, for this purpose.

Preferably the tongue member 43 and groove member 46 are formed of strips of corrosion resisting metal such as relatively high permeability nickel iron. Their configuration is such as to have a snap fit so that mutual engagement takes place along more than one line. The snap fit between the tongue and groove members 43 and 46 minimizes the air gap effect of this construction and also tends to reduce vibration on energization of the core 33 with 60Hz flux. In FIG. 5 it will be observed that the laterally extending ends 45 and 48

of the coupling members 35 are positioned about midway between the outer and inner strips 34 and are held in place by the rivets 38.

In FIG. 8 it will be observed that the core 33, constructed as illustrated in FIG. 5, is encapsulated in a layer of insulating material 53. Preferably the material 53 is a hardenable plastic neoprene rubber. The core 33 is dipped in the insulating material in the fluid state in such manner as to cover the entire areas of the strips 34, except for the spaces therebetween including the end faces 40 and 41. Since the coupling members 35 are formed of corrosion resisting metal and since it is desirable to have the convex end portion 44 in intimate engagement with the concave end portion 47, the coupling members 35 are not coated with the insulating material 53.

In FIG. 9 the coil or secondary winding is illustrated at 54. It has a rectangular opening 55 therethrough. A multi-conductor cable 56 is employed for making the necessary connections to the coil or secondary winding 54. In order to hold the multi-conductor cable 56 in place a layer of tape 57 surrounds it and the coil or secondary winding 54 as shown.

In FIG. 10 there is illustrated the coil or secondary winding 54 with a coating 60 of insulating material. The same hardenable plastic neoprene rubber is employed here as is employed for the insulating material 53 for the core 33.

As shown in FIG. 11 the separately encapsulated core 33 is inserted in the rectangular opening 55 of the coil or secondary winding 54 and then the assembly is encapsulated in insulating material 62 so as to provide a unitary construction. Care is taken to provide space 63 at each end of the rectangular opening 55 for the purpose of increasing the flexibility of the strips 34 of oriented silicon steel which form the core 33.

I claim:

1. For combination with an alternating current carrying conductor a magnetic core having a secondary winding thereon, said core comprising: a plurality of circular strips of magnetic material individually prestressed radially inwardly and not subsequently annealed, capable of being endwise opened to admit said conductor and to be biased closed by said prestress with the ends of said strips juxtaposed, and having clearance, when biased closed, between adjacent strips at the portions thereof opposite said ends to increase the flexibility thereof, and means securing said ends of said strips together, said core being characterized by being repeatedly openable for application to and removal from said conductor.

2. The magnetic core and secondary winding according to claim 1 wherein said core and winding are encapsulated in insulating material.

3. The magnetic core and secondary winding according to claim 1 wherein separable coupling means extend laterally from said ends of said strips.

4. The magnetic core and secondary winding according to claim 3 wherein said coupling means comprises tongue and groove means.

5. The magnetic core and secondary winding according to claim 3 wherein said said coupling means is formed of corrosion resisting metal.

6. The magnetic core and secondary winding according to claim 5 wherein said corrosion resisting metal is relatively high permeability nickel iron.

5

7. The magnetic core and secondary winding according to claim 5 wherein said coupling means have saturable sections to limit induction in said secondary winding.

8. For combination with an alternating current carrying conductor a magnetic core having a secondary winding thereon, said core comprising: a plurality of circular strips of prestressed magnetic material capable of being endwise opened to admit said conductor and to be biased closed with the ends of said strips juxtaposed, means securing said ends together including separable coupling means extending laterally from said ends of said strips, said coupling means including tongue and groove means, said tongue means including a circular end having a snap fit with a pocket on said groove means.

9. For combination with an alternating current carry-

6

ing conductor a magnetic core having a secondary winding thereon, said core comprising: a plurality of circular strips of prestressed magnetic material capable of being endwise opened to admit said conductor and to be biased closed with the ends of said strips juxtaposed, means securing said ends together including separable coupling means extending laterally from said ends of said strips, said coupling means including tongue and groove means, said tongue means including a circular end having a snap fit with a pocket on said groove means, and insulating material encapsulating said core and winding, those portions of the encapsulated core at the ends of the encapsulated winding on the outer side of the former being spaced from the latter to increase the flexibility of said core in separating said ends to admit said conductor.

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