

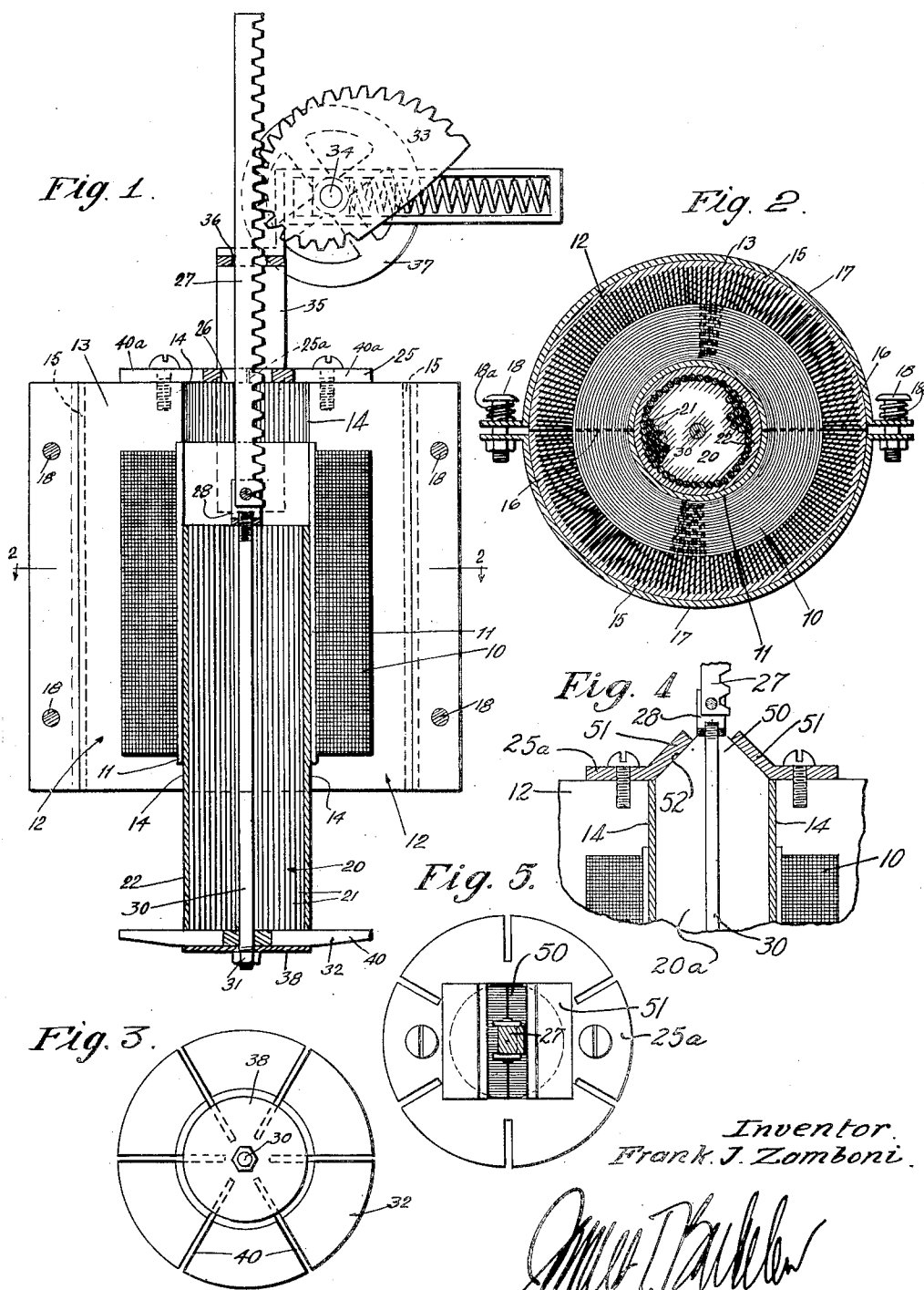
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F. J. ZAMBONI

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REACTANCE COIL

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Inventor.
Frank J. Zamboni.

James T. Buckner

Attorney.

UNITED STATES PATENT OFFICE

FRANK J. ZAMBONI, OF HAYNES, CALIFORNIA, ASSIGNOR TO NUWAY ELECTRIC COMPANY, OF LOS ANGELES, CALIFORNIA, A CORPORATION OF DELAWARE

REACTANCE COIL

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This invention relates to reactance or impedance coils, and particularly to further improvements in that general type of reactance coil set out in my application Serial Number 190,150 filed May 10, 1927, entitled "Circuit controlling reactance coil."

The major objects of the present invention include the provision of the reactance coil of improved simplicity, high efficiency, and wide range of action. With the present improvements I have succeeded in producing a reactance coil that gives a large reactance or impedance in a compact and small coil structure and also that has a wider range of action than any such coil of which I am aware.

The structures and arrangements by which the invention accomplishes its objects, together with further and detailed objects and corresponding accomplishments, will be best understood from the following specific description of my present preferred embodiment, reference for this purpose being had to the accompanying drawings, in which:

Fig. 1 is a central longitudinal section showing my improved coil;

Fig. 2 is a cross section on line 2—2 of Fig. 1;

Fig. 3 is a bottom end view of the coil, parts about the gap closing plate being omitted;

Fig. 4 is a fragmentary longitudinal section of a variational form of the invention; and

Fig. 5 is a top end view of the variational form of Fig. 4, parts being omitted.

In the drawings the coil winding is shown at 10 surrounding an interior tube 11 of non-magnetic material, such as fiber or the like. Tube 11 forms a convenient core upon which the coil may be initially wound or formed, if desired, and also forms a suitable guide for the magnetic core which is hereinafter described.

Surrounding the coil I provide a magnetic sheath 12 which extends both over the outer cylindric surface of the coil and also over its ends. This magnetic sheath is made up of U-shaped laminations 13 placed in radial planes as illustrated in Fig. 2, the inner ends of these laminations, as shown at 14, lying in cylindric surfaces which form continua-

tions of the inner cylindric surface of tube 11. This is clearly shown in Fig. 1. The laminations are so placed that, at their inner ends or edges, they lie against or substantially against each other, but, due to their radial placements, they are necessarily spaced apart at their outer edges. The space between these laminations is filled with some suitable insulating material, and also preferably a material which may be molded into the interstitial spaces between laminations so as to form the laminated magnetic sheath into a unitary body. For instance, the laminations of a magnetic sheath may be molded or cast in bakelite or similar material; and when this molding is performed the bakelite may be molded to a diameter slightly greater than the exterior diameter of the lamination formation, so as to provide, outside the edges of the laminations, a continuous exterior sheath 15 of the bakelite or similar material. Thus molded, the bakelite not only insulates adjacent laminations and aids in preventing eddy currents and hysteresis losses and heating, but also forms the whole laminated body into a unitary mass which may be handled without any danger of any of the laminations becoming displaced.

This annular molded laminated body may either be molded in place around the complete coil winding 10, or it may be molded in halves, or cut into halves after molding, and placed in halves around the winding. For instance, a line of division is indicated at 16 in Fig. 2.

The coil and its laminated sheath, thus formed into a unitary body, may be mounted upon the operating mechanism, or the operating mechanism mounted upon it, in any suitable manner. As an instance showing a suitable mounting, I have here shown a split cylindric sheath 17 surrounding the laminated sheath, and held together by clamp screws 18 as indicated. This outer structural sheath may be of any suitable material, but preferably is of non-magnetic material, as for instance brass. It will be recognized that the presence of a magnetic material in sheath 17 would not destroy the magnetic operation of the reactance coil, but it

would cut down its efficiency by affording a ready field for the generation of eddy currents, causing consequent losses and heating. And it is one of the objects of my invention, along with the accomplishment of high efficiency and wide range of action in a small sized device, to minimize heating effects as far as possible. Consequently, the exterior sheath 17 is composed of a non-magnetic material such as brass.

The inner movable core of the reactance coil, designated generally by the numeral 20, is preferably composed of soft iron wires 21 extending lengthwise of the core. These soft iron wires, assembled into a cylindric bundle, are also cast or molded in a suitable dielectric molding material, and here again bakelite or similar material is suitable. And the bakelite is also here molded to an external diameter somewhat larger than the external diameter of the cylindric wire formation, so that an exterior continuous and smooth-surface sheath 22 is formed around the magnetic wires. This sheath is of a suitable diameter to slide fairly freely, but in a close fit, within tube 11 and within the circular end formations 14 of the exterior sheathing laminations 13, forming at once a smooth sliding exterior surface for the core and at the same time interposing around the magnetic wires of the core a non-magnetic sheath which prevents the wires from coming into direct iron to iron contact with the ends 14 of the exterior laminations.

I have found it necessary or highly desirable, in an adjustable reactance coil of the type here described, not only to have all the magnetic forces perfectly balanced in order to prevent vibration, but also to have no iron-to-iron contacts at the relatively sliding surfaces of the relatively moving parts. Not only will an unbalanced magnetic force set up vibrations between sliding parts, no matter how closely they may be fitted, but also I find that the sliding parts cannot be fitted tightly enough to prevent loud humming noises being set up if the sliding parts are, at their sliding surfaces, an iron-to-iron contact. So I provide the non-magnetic sheath 22 around the inner core to break what otherwise would be an iron-to-iron contact between the end portions of the core and the end portions 14 of the exterior laminated sheathing.

And at the same time I have found that, in order to obtain the highest possible reactance efficiency from a coil of given size and to obtain the highest possible range of reactance in any such coil, it is necessary to have, as nearly as possible, a complete or all-iron magnetic path around the coil when the parts are moved to the position for greatest reactance. Accordingly in my present improved device I leave the ends of the core wires 21 uncovered by insulating material. And preferably the ends of the core, after formation, are finished

off so as to make their ends flat and true and so as to make each wire 21 present its ends in the flat and true end surfaces of the core. And also the end surfaces of the exterior laminated sheath 12 are preferably finished off flat and true, and so that each lamination 13 presents an end edge in those flat and true surfaces. Then, at one end of the coil structure, the upper end as shown in Fig. 1, I mount a magnetic disk or plate 25 in direct magnetic contact with the upper ends of laminations 13, and allow the disk 25 to overhang inwardly the inner ends 14 of the laminations. In the particular form here shown this disk 25 has a central aperture 26 to pass the rack 27 by which the core is moved; but, whether or not disk 25 has such an aperture, the magnetic action is the same. Rack 27 is attached at its lower end to a bracket 28 which in turn is mounted upon the upper end of core 20. A secure mounting for this bracket may be obtained by running a rod 30 lengthwise through the core, the rod being screw-threaded at its upper end into bracket 28 and having a nut 31 on its lower end. And this rod and nut also afford ready means for assembling the gap closing plate 32 upon the lower end of the core, as will now be described.

The gear 33 is mounted on a shaft 34 which is supported in suitable bearings upon a bracket 35 which may be mounted upon the exterior metal sheathing 15 if so desired, this bracket 35 having an opening 36 which forms a guide for rack 27 to hold it in mesh with gear 33. The gear may be rotated by any suitable means which may be operatable at any suitable point, either at the coil or at a distance from it. For the purposes of illustration here I have merely shown a hand wheel 37 on shaft 34.

Mounted on the lower end of core 20 is the gap closing plate 32 of suitable magnetic material, as soft iron. This plate 32 is in direct iron-to-iron contact with the lower ends of core wires 21, and is held in tight iron-to-iron engagement by the nut 31 and washer 38. Again to minimize eddy currents and heat losses this plate 32 may be radially cut as indicated at 40; and the upper gap closing plate 25 may also be similarly cut as indicated at 40^a. The rod 30 may either be of magnetic or non-magnetic material; it may be somewhat preferable to make it of non-magnetic material so that its projecting end or ends will not form points from which magnetic losses may occur. And the bracket 28 and rack 27, as well as bracket 35, gear 33, etc., are also preferably formed of non-magnetic material so that no paths for magnetic or heat losses are formed.

In Fig. 1 the device is shown in an intermediate position. In the lowermost position of the core, out, or practically out, of the coil winding, the reactance effect of the coil is re-

duced to a very small amount. As the core is moved upwardly the reactance effect increases until, as the core is moved to its uppermost position, the reactance effect becomes a maximum. In this uppermost position the upper end surface of the core is moved up tightly into iron-to-iron engagement with the upper gap closing plate 25; and at the same time the lower gap closing plate 32 is moved up tightly into similar engagement with the lower end surface of the laminated sheathing 12. Thus there is a complete and unbroken iron magnetic path around the coil, and a very high reactance effect is obtained. And at the same time there is a substantially complete absence of all humming noises, because the iron-to-iron contacts are not at sliding surfaces which cannot be closely fitted together but are at endwise abutting surfaces which can be drawn up tightly together by proper operation of the mechanism which moves the core; and further because all the parts, even though not in iron-to-iron contact, are closely fitted together.

I have found that if the width of the upper ends 14 of laminations 13 be made substantially greater than the width of the lower ends 14 (which lower end width may be that just required to give the desired flux density in the sheath 12), that the operation as core 20 is moved downward from its extreme upward position is greatly improved, humming noises being further reduced and the core moving with less resistance. This I believe to be due to prolonging and delaying the disruption of the magnetic circuit through the movable core 20. With the core 20 in its extreme upward position, an iron clad magnetic circuit exists from the sheath 12 through the core, as has been explained. When the core 20 is initially moved downward, the complete iron clad circuit is immediately broken, but fairly strong fields persist through the air-gaps between magnetic plate 25 and core 20, and between gap closing plate 32 of core 20 and the lower end of iron sheath 12; and a strong field also exists through the non-magnetic material between ends 14 of sheath 12 and core 20 as long as the upper end of the core is not moved downward out of magnetic association with the upper ends 14. If, then, this latter field be preserved substantially intact until the fields between magnetic plate 25 and core 20 and between gap closing plate 32 and sheath 12 are considerably weakened, and then, as the core is further withdrawn, the field from the ends 14 to the core 20 be gradually pinched out, a smoother and more gradual disruption of the magnetic field is obtained. Accordingly, in a reactance coil of substantially the proportions shown I prefer to make the width of the upper ends 14 of substantially twice the width of the lower ends 14, the width of the lower ends being just sufficient to provide a proper flux

in the sheath 20. Increasing the width of the lower ends 14 has some effect in the same direction, however I prefer to construct the coil as above set out. It is of advantage in all cases, however, to make the width of the lower ends 14 sufficiently great that a fairly strong field may persist through the non-magnetic sheath 22 to the iron core as the core is lowered.

There is still, however, a rapid disruption of flux as the core leaves the upper ends 14, and to further smooth out the action I may make some such provisions as are shown in Figs. 4 and 5. As there shown, the laminated core 20^a is provided with a beveled or otherwise tapered upper end 50 projecting, when the core is home, beyond the end of the magnetic sheath 12. The magnetic plate 25^a is provided with tongues 51 bent upwardly in correspondance with the bevel of the core end 50, as shown, the flat surfaces 52 of the beveled core-end making iron-to-iron contact with the tongues 51 when the core is home. It will be apparent that as the core is moved downward, the beveled end will cause the magnetic field to be disrupted at a more gradual rate than before and thus make for greater smoothness and ease of operation.

To maintain at all times, and under all conditions of heat expansion and contraction, a close, but sliding fit of the core in the surrounding structure, I prefer to make further provisions as follows. The split 16 of the laminated body is aligned with the joint in the split case 17. Springs 18^a are used on bolts 18, tending to press the halves of the laminated body together. The tube 11 is also split on the same line, and coil 10 is fitted somewhat loosely in the laminated body and around sleeve 11. Plate 25 being likewise radially split, as indicated at 25^a in Fig. 1, the whole exterior body can contract and keep a tight fit on the core.

The change in reactance, for a given movement of the core, is comparatively rapid when the core is close to plate 25. To make the core control more delicate in that position, a core moving means of variable ratio of any suitable kind is provided. I show here, by way of illustration, a variable pitch gear 33, designed so that a given amount of rotation of shaft 34 will, at any position of the core, give more nearly a constant variation of the reactance. This arrangement, however, is merely to be taken as typical of any variable ratio core moving means.

I claim:

1. An adjustable reactance coil, comprising a coil winding substantially cylindric in form, a magnetic sheathing surrounding the cylindric outer surface of the coil and extending over its ends, a magnetic core movable lengthwise within the coil, magnetic gap closing plates one mounted on the end of the exterior sheathing and with which one

end of the core is adapted to contact, and the other mounted on the other end of the core and adapted to contact with the other end of the magnetic sheathing.

2. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over its ends to cylindric surfaces which are substantially continuations of the cylindric opening through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior cylindric covering of non-magnetic material, the ends of the magnetic core being exposed, a magnetic gap closing plate mounted on one end of the exterior magnetic sheathing and overhanging the cylindric opening and adapted to be engaged by one end of the core, and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the core and adapted to contact with the other end of the magnetic sheathing.

3. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over its ends to cylindric surfaces which are substantially continuations of the cylindric opening through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior cylindric covering of non-magnetic material, the ends of the magnetic core being exposed, a magnetic gap closing plate mounted on one end of the exterior magnetic sheathing and overhanging the cylindric opening and adapted to be engaged by one end of the core, and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the core and adapted to contact with the other end of the magnetic sheathing; said magnetic gap closing plates being radially split.

4. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over its ends to cylindric surfaces which are substantially continuations of the cylindric opening through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior cylindric covering of non-magnetic material, the ends of the magnetic core being exposed, a magnetic gap closing plate mounted on one end of the exterior magnetic sheathing and overhanging the cylindric opening and adapted to be engaged by one end of the core,

and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the core and adapted to contact with the other end of the magnetic sheathing; said core being composed of longitudinally extending magnetic wires molded in a body of di-electric material and the di-electric material extending outwardly to a diameter beyond the magnetic wires to form said non-magnetic covering around the magnetic core of wires.

5. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over its ends to cylindric surfaces which are substantially continuations of the cylindric opening through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior cylindric covering of non-magnetic material, the ends of the magnetic core being exposed, a magnetic gap closing plate mounted on one end of the exterior magnetic sheathing and overhanging the cylindric opening and adapted to be engaged by one end of the core, and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the core and adapted to contact with the other end of the magnetic sheathing; said exterior sheathing being composed of sheet laminations placed in radial planes and a molding of di-electric material extending around the laminations and into the interstitial spaces between them.

6. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over its ends to cylindric surfaces which are substantially continuations of the cylindric opening through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior cylindric covering of non-magnetic material, the ends of the magnetic core being exposed, a magnetic gap closing plate mounted on one end of the exterior magnetic sheathing and overhanging the cylindric opening and adapted to be engaged by one end of the core, and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the core and adapted to contact with the other end of the magnetic sheathing; said exterior sheathing being composed of sheet laminations placed in radial planes and a molding of di-electric material extending around the laminations and into the interstitial spaces between them, and said mold-

ing of di-electric material extending outwardly to a diameter beyond the outer edges of the laminations to form a continuous exterior sheath of di-electric material.

5 7. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over
10 its ends to cylindric surfaces which are substantially continuations of the cylindric opening through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior
15 cylindric covering of non-magnetic material, the ends of the magnetic core being exposed, a magnetic gap closing plate mounted on one end of the exterior magnetic sheathing and overhanging the cylindric opening and
20 adapted to be engaged by one end of the core, and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the
25 core and adapted to contact with the other end of the magnetic sheathing; said core being composed of longitudinally extending magnetic wires molded in a body of di-electric material and the di-electric material extending outwardly to a diameter beyond the
30 magnetic wires to form a non-magnetic sheath around the magnetic core of wires; said exterior sheathing being composed of sheet laminations placed in radial planes and
35 a molding of di-electric material extending around the laminations and into the interstitial spaces between them, and said molding of di-electric material extending outwardly to a diameter beyond the outer edges
40 of the laminations to form a continuous exterior sheath of di-electric material.

8. An adjustable reactance coil, comprising a coil winding substantially cylindric in form, an internal cylindric tube which the
45 coil surrounds, an external laminated magnetic sheathing for the coil comprised of sheet laminations each substantially U-shaped, said laminations being assembled in radial planes so that the laminated sheathing so formed extends around the outer cylindric surface of
50 the winding and inwardly over its ends, the inner ends of the laminations lying in cylindric planes which are substantially continuations of the inner cylindric surfaces of said
55 interior tube, a magnetic gap closing plate mounted on one end of the exterior laminated sheathing and inwardly overhanging the cylindric opening at the inner ends of the laminations, a mold of di-electric material surrounding said laminations and extending into the interstitial spaces between them, a magnetic core longitudinally movable through the interior tube, said core being composed of an inner and substantially cylindric assembly of
65 longitudinally extending magnetic wires, a

molding of di-electric material around said magnetic wires and extending into the interstitial spaces between them, said molding being extended outwardly to an external diameter somewhat larger than the cylindric
70 diameter of the wire formation so as to provide a continuous outer di-electric sheathing for said core, said core as thus constructed fitting closely but slidably in said inner tube, the ends of said magnetic wires being un-
75 covered and exposed and one such end being adapted to contact with said magnetic gap closing plate, and another magnetic gap closing plate mounted upon the other end of the core in direct magnetic contact with the core
80 wires at that end, and said last mentioned gap closing plate extending outwardly to a diameter beyond the diameter of the core and adapted to contact directly with the ends of the exterior sheathing laminations.

9. An adjustable reactance coil, comprising a coil winding substantially cylindric in form, a magnetic sheathing surrounding the cylindric outer surface of the coil and extending over its ends, a magnetic core movable lengthwise within the coil, magnetic gap closing
90 plates one mounted on the end of the exterior sheathing and with which one end of the core is adapted to contact, and the other mounted on the other end of the core and adapted to contact with the other end of the magnetic sheathing, and variable ratio core moving means.

10. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over
100 its ends to cylindric surfaces which are substantially continuations of the cylindric openings through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior cylindric covering of non-magnetic material, the
105 ends of the magnetic core being exposed, a magnetic gap closing plate mounted on one end of the exterior magnetic sheathing and overhanging the cylindric opening and adapted to be engaged by one end of the core, and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the core and adapted to contact with the other end of the magnetic sheathing, and variable ratio
110 core moving means.

11. An adjustable reactance coil, comprising a coil winding substantially cylindric in form, a magnetic sheathing surrounding the cylindric outer surface of the coil and extending over its ends, a magnetic core movable lengthwise within the coil, magnetic gap closing
115 plates one mounted on the end of the exterior sheathing and with which one end of the core is adapted to contact, and the other
120 core moving means.

125 130

mounted on the other end of the core and adapted to contact with the other end of the magnetic sheathing, the magnetic sheathing being split diametrically into halves, and yielding means pressing the said halves together around the core.

12. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over its ends to cylindric surfaces which are substantially continuations of the cylindric openings through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior cylindric covering of non-magnetic material, the ends of the magnetic core being exposed, a magnetic gap closing plate mounted on one end of the exterior magnetic sheathing and overhanging the cylindric opening and adapted to be engaged by one end of the core, and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the core and adapted to contact with the other end of the magnetic sheathing, the magnetic sheathing being split diametrically into halves, and yielding means pressing the said halves together around the core.

13. An adjustable reactance coil, comprising a coil winding substantially cylindric in form, a magnetic sheathing surrounding the cylindric outer surface of the coil and extending over its ends, a magnetic core movable lengthwise within the coil, the magnetic coil sheathing being split diametrically into halves, and yielding means pressing the halves together.

14. An adjustable reactance coil, comprising a coil winding substantially cylindric in form, a magnetic sheathing surrounding the cylindric outer surface of the coil and extending over its ends, a magnetic core movable lengthwise within the coil, a guide tube within the coil, the inner tube surface and the ends of the magnetic sheathing lying in one cylindric surface, the magnetic sheathing and the guide tube being diametrically split into halves, and yielding means pressing the said halves together around the core.

15. An adjustable reactance coil, comprising a coil winding substantially cylindric in form, a magnetic core surrounded by the coil and longitudinally movable therewithin, and an external laminated magnetic sheathing for the coil comprised of sheet laminations each substantially U-shaped, said laminations being assembled in radial planes so that the laminated sheathing so formed extends around the outer cylindric surface of the winding and inwardly over its ends, the inner ends of the laminations lying in a cylindric plane about the movable magnetic core, and

the width of the inner ends of the U-shaped laminations at one end of the coil being substantially greater than the width of the inner ends at the other end of the coil.

16. An adjustable reactance coil, comprising a coil winding substantially cylindric in external form and having an internal cylindric longitudinal opening through which a magnetic core may be moved, an external laminated magnetic sheathing for the coil comprised of sheet laminations each substantially U-shaped, said laminations being assembled in radial planes so that the laminated sheathing so formed extends around the outer cylindric surface of the winding and inwardly over its ends, the inner ends of the laminations lying in the cylindric plane of the coil opening, the width of the inner ends of the U-shaped laminations at one end of the coil being substantially greater than the width of the inner ends at the other end of the coil, a magnetic gap closing plate mounted on one end of the external laminated sheathing and inwardly overhanging the cylindric opening at the inner ends of the laminations, a magnetic core longitudinally movable through the internal coil opening, the ends of the magnetic core being uncovered and exposed and one such end being adapted to contact with said magnetic gap closing plate, and another magnetic gap closing plate mounted upon the other end of the core in direct magnetic contact with the core at that end, said last mentioned gap closing plate extending outwardly to a diameter beyond the diameter of the core and being adapted to contact directly with the ends of the external sheathing laminations.

17. An adjustable reactance coil, comprising a coil winding substantially cylindric in external form and having an internal cylindric longitudinal opening through which a magnetic core may be moved, an external laminated magnetic sheathing for the coil comprised of sheet laminations each substantially U-shaped, said laminations being assembled in radial planes so that the laminated sheathing so formed extends around the outer cylindric surface of the winding and inwardly over its ends, the inner ends of the laminations lying in the cylindric plane of the coil opening, the inner ends of the U-shaped laminations of the sheathing being substantially wider at one end of the coil than at the other, a magnetic gap closing plate mounted on the end of the laminated sheathing having the wider inner ends and inwardly overhanging the said inner ends, a magnetic core longitudinally movable through the internal coil opening, the ends of the magnetic core being uncovered and exposed and one such end being adapted to contact with said magnetic gap closing plate, and another magnetic gap closing plate mounted upon the other end of the core in direct magnetic con-

tact with the core at that end, said last mentioned gap closing plate extending outwardly to a diameter beyond the diameter of the core and being adapted to contact directly with the ends of the external sheathing laminations.

18. An adjustable reactance coil, comprising a coil winding substantially cylindric in form and with a cylindric interior opening therethrough, a laminated magnetic sheathing surrounding the exterior cylindric surface of the coil and extending inwardly over its ends to cylindric surfaces which are substantially continuations of the cylindric opening through the coil, a longitudinally movable core in the coil, said core being composed of magnetic material and an exterior cylindric covering of non-magnetic material, one end of the core being tapered and projecting beyond the end of the magnetic sheathing when the core is home, the ends of the magnetic core being exposed, a magnetic gap closing plate mounted on the end of the magnetic sheathing corresponding to the tapered core-end, overhanging the cylindric opening and adapted to be engaged by the tapered end of the core, and another magnetic gap closing plate mounted on the other end of the core in direct magnetic contact with that end of the core and adapted to contact with the other end of the magnetic sheathing.

In witness that I claim the foregoing I have hereunto subscribed my name this 24 day of December 1927.

FRANK J. ZAMBONI.