

Nov. 30, 1954

D. T. SCAG

2,695,978

CLAMPING MEANS FOR ELECTROMAGNETIC CORES

Filed April 27, 1951

2 Sheets-Sheet 1

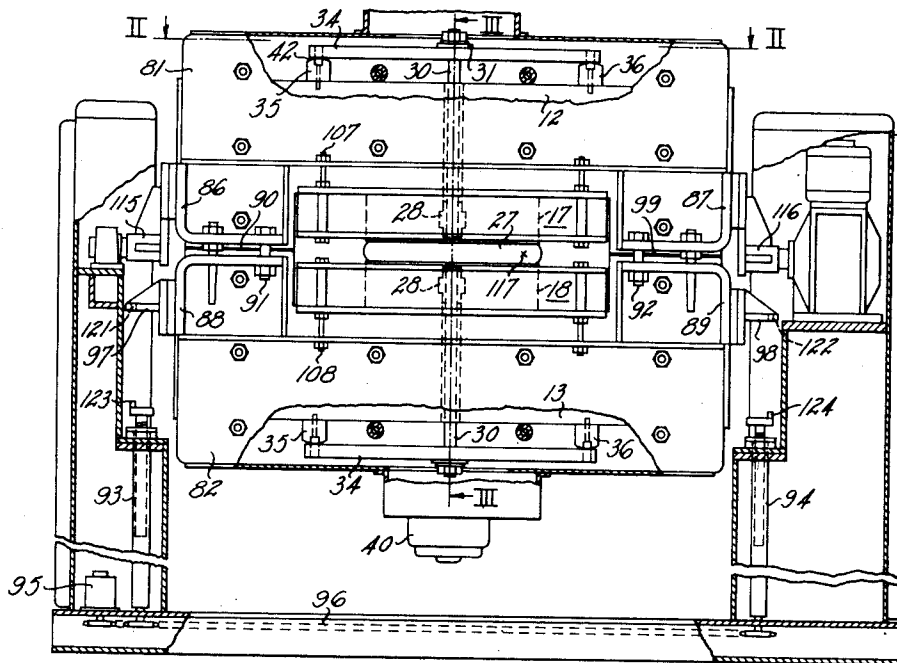


Fig. 1

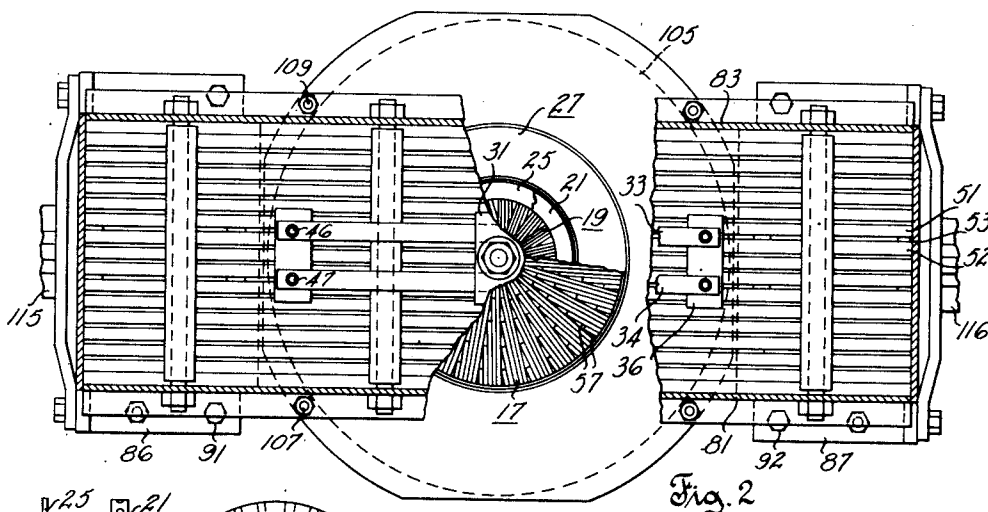


Fig. 2

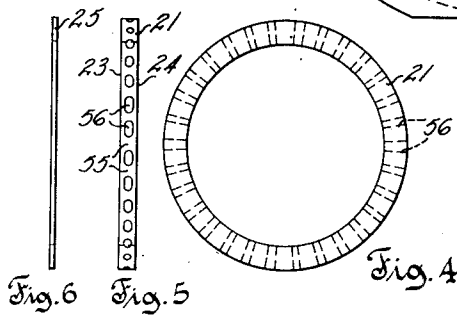


Fig. 4

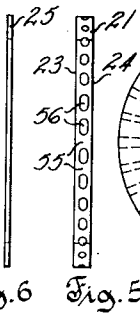


Fig. 5

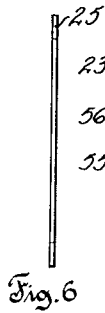


Fig. 6

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Nov. 30, 1954

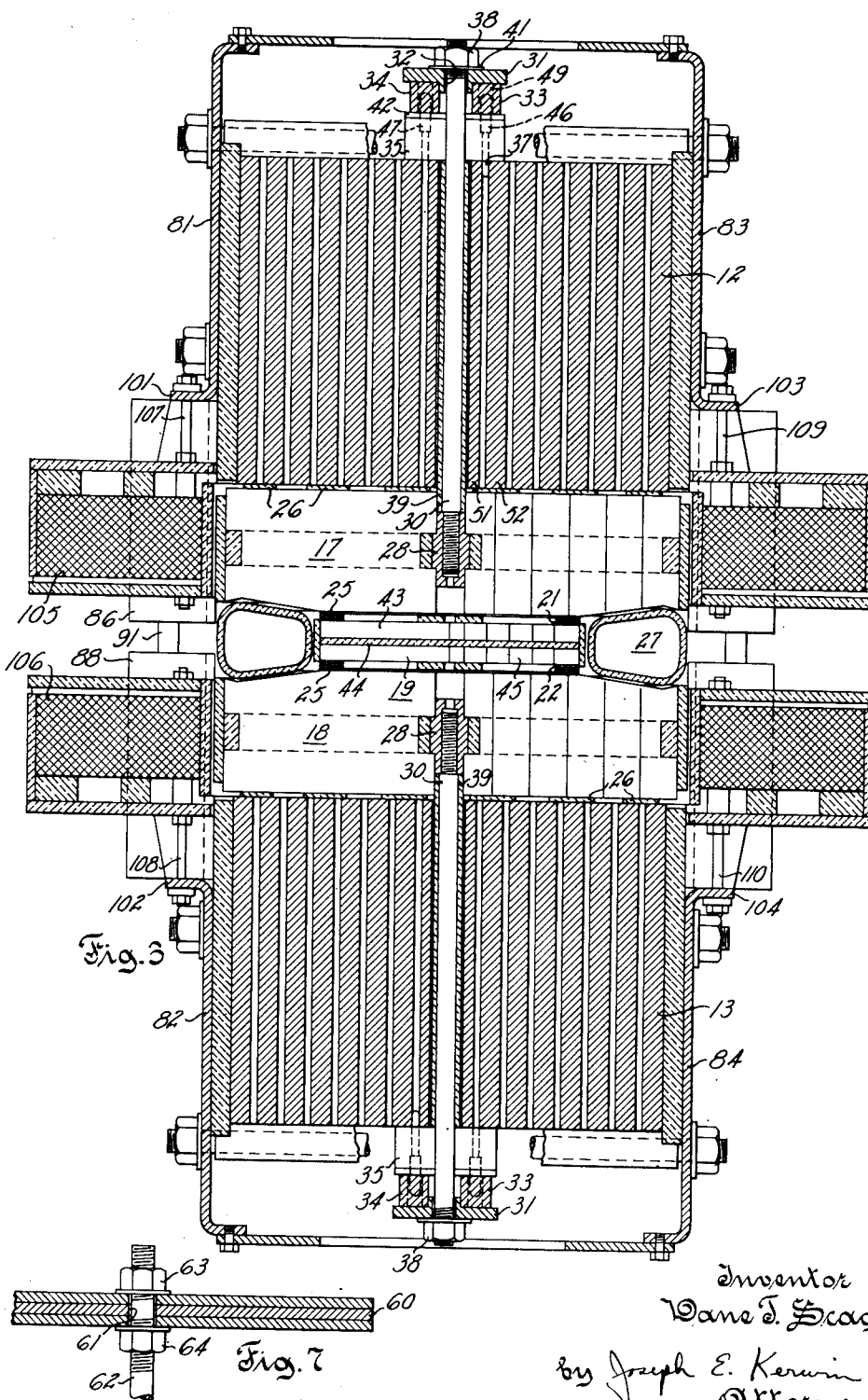
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2 Sheets-Sheet 2



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CLAMPING MEANS FOR ELECTROMAGNETIC CORES

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Application April 27, 1951, Serial No. 223,213

22 Claims. (Cl. 317—200)

This invention relates to electrical induction apparatus, and in particular to air cooled laminated magnetic core structures and the method of assembling such cores.

The laminated magnetic cores utilized in magnetic induction accelerators, such as betatrons, must be very accurately constructed and assembled. It is preferable that the cores of such accelerators be capable of being precisely adjusted after assembly.

To precisely control the position of the equilibrium orbit of these accelerators the final adjustment of the core structure should preferably be accomplished after an initial energization of the accelerator, as a fine adjustment of the reluctance of the magnetic path in the core is required to shift the equilibrium orbit to its proper position.

Even if the core elements of such accelerators are assembled very accurately, the unavoidable inaccuracies in the dimensions of the finished core may be too great to permit obtaining the necessary field pattern for efficient operation of the accelerator. In addition, the operation of such accelerators causes large magnetic forces which act on the core elements. The core assembly must be such that operation of the accelerator with the accompanying large forces will not alter the precisely assembled and adjusted structure.

The clamping structure for these cores must not have a tendency to loosen or the magnetic forces of the accelerator are likely to cause undesirable vibrations of the core elements. These vibrations will damage core elements and other parts of the accelerator, such as the electron accelerating tube.

Because of the large magnetic forces present the core elements must be tightly clamped together. It is, however, imperative that the core structure include sufficient air passageways to allow adequate air circulation to the inner portions of the core structure. The proper clamping of the core elements of such accelerators must therefore be effected without restricting the circulation of air to and through the core.

It is an object of this invention to provide an improved laminated core structure for induction apparatus.

Another object of this invention is to provide an improved method of assembling a core structure to obtain a precise iron core.

Another object of this invention is to provide a core structure having a clamping arrangement which compensates for internal changes of the dimensions of the core, which changes result from energization and operation of the apparatus embodying the core.

Another object of this invention is to provide an improved clamping arrangement for laminated core members which are subjected to relatively large magnetic forces.

Another object of this invention is to provide a clamping arrangement for core elements of relatively large induction apparatus.

Still another object of this invention is to provide an air cooled core structure for magnetic electron accelerators.

Objects and advantages other than those above set forth will be apparent from the following description when read in connection with the accompanying drawing, in which:

Fig. 1 is an elevation view partly in section of a magnetic induction accelerator;

Fig. 2 is an enlarged sectional view of the accelerator taken along line II—II of Fig. 1 with parts of the accelerator broken away;

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Fig. 3 is an enlarged sectional view of the accelerator taken along the line III—III of Fig. 1;

Fig. 4 is a plan view of an air duct spacer shown partly in Fig. 2;

Fig. 5 is a side view of the spacer shown in Fig. 4; and

Fig. 6 is a side view of a shim shown partly in Fig. 2; and

Fig. 7 is a sectional view of a modification of the tension bar bias clamp illustrated in the accelerator of Fig. 1.

This invention is particularly adaptable to core structures utilized in betatron type magnetic induction electron accelerators capable of producing relatively high energy X-rays, particularly betatrons which are capable of accelerating electrons to twenty million electron volts or more. The core structure of such apparatus is somewhat similar to a three legged transformer core.

The core of the illustrated accelerator includes a pair of abutting U-shaped yokes 12, 13 and a center leg which includes the poles 17, 18 and the wafer 19 between the poles. The U-shaped yokes are each built up by superposing layers of magnetic laminations in a manner similar to conventional stacking of transformer cores. These U-shaped yokes abut against each other to provide the outer two legs of the three legged core. As shown in Figs. 2 and 3, packages 51, 52 of the laminations are separated by spacer strips 53 so there will be air ducts between the packages of laminations of the yokes.

While the yokes may have conventional stacked layers of laminations, the center leg of the core of the accelerator is radially symmetrical. This means that the magnetic laminations of the leg are generally radially disposed and form a magnetic element of circular cross section. The wafer includes also the nonmagnetic disk 44 between the two superposed radially laminated elements 43, 45. The disk 44 is included in the core structure to obtain a predetermined reluctance in the magnetic path.

As shown in Fig. 2 the laminations of the yokes extend crosswise of most of the laminations of the poles. To prevent the laminations of the yokes from short circuiting laminations of the poles and causing circulating currents in the poles, insulation 26, preferably paper is inserted between the poles and the yokes. The insulation preferably comprises several spaced concentric rings.

The core structure of this accelerator is air cooled, and the center leg of the core structure must include air ducts or air passageways to allow the fans to force air to circulate to the inner portions of the core. Fan 40 circulates air in pole 18 and yoke 13, and a similar fan (not shown) circulates air in pole 17 and yoke 12. The poles have axial air passages 57 between their laminations, but these passageways do not extend to the peripheral surface of the poles. Air, therefore, will not flow from outside of the poles to the inside thereof through the poles themselves. A more detailed showing of a preferred radially laminated pole is illustrated in U. S. 2,468,786, W. C. Sealey et al., May 3, 1949, titled Electromagnetic Core Assembly and Method.

Between the upper flat surface of the wafer 19 and the adjacent flat surface of the upper pole 17 there is a one piece ring shaped spacer 21. A similar spacer 22 may be disposed between the lower flat surface of wafer 19 and the lower pole 18. These ring shaped spacers have planar upper and lower surface portions 23, 24 on which one or more flat ring shaped nonmagnetic shims 25 may be placed. The reluctance of the apparatus can be finely controlled by varying the number of shims to exactly position the equilibrium orbit in the accelerating tube 27. Because of the effect that the reluctance of the magnetic core has on the equilibrium orbit the adjacent edge surfaces of the wafer and poles must be parallel at all times and yet the gaps between the poles and wafer must be adjustable. By providing the one piece spacer rings with flat parallel upper and lower surfaces on which the flat ring shaped shims entirely rest, the wafer and poles are always properly spaced.

Besides providing a flat unbroken base for the shims the spacers are designed to withstand the relatively large forces of the core clamping structure and the large forces of the alternating magnetic field. These spacers have a

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cross section comprising a series of supports 55 which are integral with and interconnect the planar surface portions 23, 24. The integral I-beam cross section of the spacer thus formed is strong enough not only to allow firm and tight clamping but, what is more important, to withstand the large magnetic forces acting on the elements of the center leg during operation of the accelerator.

In addition, these spacers which comprise a structural part of the center leg of the core and affect the reluctance of the magnetic field include radial openings forming air ducts 56 for allowing the air to circulate and cool the inner portions of the laminations of the center leg. The area of the radial openings is of the same order of magnitude as the cross sectional area of the air passages of the poles.

The poles 17, 18, respectively, are held in position and biased tightly against the yokes 12 and 13 with paper insulation 26 between the poles and yokes. Similar biasing or clamping means are used for each pole, and the following description of the clamping means for pole 17 is similar to that for pole 18.

The stud 30 is secured in a center plug 28 and is fixed at the center of pole 17. The stud 30 extends through the yoke 12, and insulation 39 is provided between the stud and yoke. The end of the stud that projects through the yoke 12 is secured by the biasing means comprising the nut 38, a T-shaped cross plate 31, steel tensioning bars 33, 34, and spacer blocks 35, 36.

The T-shaped cross plate of this biasing and clamping means for the pole has a central aperture 32 through which the end of the stud 30 extends. The stud is secured by a washer 41 and the nut 38. The washer 41 abuts against the T-shaped cross plate 31. The cross plate rests on the pair of tension bars 33, 34 which are spaced from the upper edge surface of the yoke. The stud extends between the two tension bars and force applied to the T-shaped cross plate by tightening the nut on the stud is transmitted equally to each of the tension bars. The cross plate is positioned at the midpoint of the lengthwise dimensions of the tension bars. The ends of the tension bars are spaced from the upper edge surface of the laminations of the yoke by the spacer blocks 35, 36.

A pin 37 is press fit into the air duct between two adjacent packages 51, 52 of laminations of the yoke, and the upper portion of the pin 37 extends out from between the two packages of laminations and into a hole in the bottom of a spacing block to hold the spacing block in a fixed position with respect to the yoke. The upper face 42 of each of the spacing blocks is curved having a convex bearing surface as shown in Fig. 1. There are two holes in the upper face of each block, and pins 46, 47 are partly inserted into these two holes. The upper portions of the pins 46, 47 extend from the upper surface of the spacing block into apertures 49 in the end of the tension bar. The ends of the tension bars rest on the curved bearing surfaces of the spacing blocks.

The biasing means for holding the upper end of the stud 30 makes it possible to very tightly and firmly clamp the pole to the yoke by exerting a relatively great tension on the stud. This biasing means compensates for internal changes of the dimensions of the core and also lessens the amount of the internal changes which normally result from energization and operation of the accelerator. Such changes are the result of diminution of the thickness of the insulating material in the core, and because of the continued tight clamping of the pole to the yoke the degree of compression of insulating material in the core is reduced. The amplitude of vibrations of the poles and other core elements caused by the magnetic forces of the energized accelerator are not as great as they would be with other clamping means. The tension bars maintain the pole tightly against the yoke even though there may be some change in the thickness of insulation 26.

The tension bars extend along the direction of the major dimension of the yokes. For a twenty-four million electron volt betatron it has been found desirable to use a pair of the steel tension bars approximately 29 inches long having 1.250 inch square cross section with the bars capable of approximately .250 inch deflection at the center of their lengthwise dimensions to impose approximately a three thousand pound tension on the stud.

The clamping structure for the core also includes U-shaped plates 81, 83 bolted to yoke 12 and similar U-

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shaped plates 82, 84 bolted to yoke 13. Angle members 86, 87 and 88, 89, respectively, are fastened by suitable means (not shown), for example, by welding, to the plates 81, 82 and similar angles are fastened to plates 83, 84. These angle members extend outwardly normal to the surface of the plates, and bolts 91, 92, respectively, join adjacent angle members 86, 88 and 87, 89 clamping the yokes 12, 13 together at the outer legs of the yoke or core. This yoke clamping structure also tightly and firmly clamps the center leg between the yokes.

Proper clamping of the center leg is preferably accomplished after shims have been added to the center leg and the equilibrium orbit is positioned. Since the final adjustment of the core structure is accomplished by shimming the center leg after assembly, it is necessary to provide some relatively easy method of separating the yokes to insert or remove shims and to force the yokes together in their clamped position. This is accomplished by affixing jack pads 97, 98 to the lower yoke 13, and providing jack screws 93, 94 which can be operated by the motor 95 and the chain drive 96 to lower and raise the yoke 13. The jack screws are utilized to clamp the lower yoke 13 against the upper yoke 12. Firm clamping of the lower yoke is possible because the upper yoke 12 has affixed thereto support means 115, 116 by which the upper yoke is firmly held while the lower yoke is clamped.

After the jack screws have clamped the lower yoke in position against the upper yoke, the bolts 91, 92 are inserted and tightened to hold the yokes in the clamped position. Then the jack screw is lowered.

An interlock is provided between the jack screws 93, 94 and the pads 97, 98 so that the jack screws do not engage the pads unless the accelerator is in a vertical position. The pads have clearance holes 121, 122 for the pins 123, 124 which extend upwardly from the jack screws. No only does this interlock prevent engagement of the jack screws with the pads when the accelerator is not in a vertical position but the pins prevent the lower yoke from creeping off of the jack pads during lowering or raising of the lower yoke.

The clamping of the center leg through the yoke clamping structure is accurately accomplished by placing paper shims 90, 99 between the outer legs or abutting edges of the yokes. Sufficient paper shims are first added so that when the yokes are clamped together the wafer in the center leg can just be turned. The yokes are then unclamped and separated by jacking down the lower yoke. Approximately five mils of the paper shim is then removed from each of the joints between the outer legs of the yokes, and the lower yoke is raised by the jack screws, reclamped to the upper yoke and the bolts 91, 92 are inserted and tightened. The removal of five mils of shim from the joints between the outer legs assures that the poles, ring spacers and wafer are tightly clamped together between the yokes by the yoke clamping structure.

The supporting structure 115, 116 for the upper yoke not only fixes the position of the upper yoke so that the lower yoke can be abutted and clamped to the upper yoke by the jack, but also includes a motor operated trunnion for rotating the entire accelerator. The upper yoke support trunnion has an axis of rotation which passes through the X-ray target 117 of the accelerator, whereby the accelerator can be rotated about a horizontal axis through the focal spot of X-ray.

The plates 81, 82, 83 and 84 have outwardly turned flanges 101, 102, 103 and 104, respectively. The coils 105, 106 providing the magnetization of the core are adjustably attached to these flanges by means of the bolts 107, 108, 109 and 110.

Fig. 7 illustrates a modification of the biasing clamp for the poles in which the tension bars 33, 34 have been replaced by a single laminated bar 60 which may have a hole 61 located at the center of its lengthwise dimension, through which hole the stud 62 projects. The laminated tension bar may be secured with respect to the stud by any suitable means, such as the pair of nuts 63, 64 which are tightened against the upper and lower surfaces of the tension bar.

There are many inherent advantages in the core structure which has been described.

The biasing clamping means considerably reduces one of the maintenance problems of the betatron. The compression of the paper insulation between abutting surfaces of the poles and yokes causes continual maintenance and adjustment of the core when clamping means

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previously available are used for these core elements. A five or ten mil change in thickness of the insulation 26 can reduce the tension on the stud which clamps the pole against the yoke to as little as 5% of the tension required on that stud to hold the pole firmly abutted to the yoke during operation of the apparatus.

While it may be desirable to make an inspection of the studs and deflection of the bars after the betatron has been initially energized and operated for a short period of time, the improved clamping means is such that the considerable deflection of the bars as compared to compression of the insulation 26 continuously tensions the studs a predetermined amount so that the poles are always tight against the yoke. During the lifetime of the betatron the paper insulation may compress .030 inch to .060 inch. With prior art clamping structures periodic inspection and tightening of the pole clamping means are required. If the inspection and retightening of the prior art clamping means is to be successful to prevent vibration and damage to the core elements or accelerating tube of the betatron, it will be necessary that the inspection and tightening of the stud be frequently accomplished. However, with the improved pole clamping means disclosed herein, the tension bars are deflected approximately four or five times the expected maximum lifetime compression of the insulation. At the most it will only be necessary to inspect and adjust the deflection of the tension bars after the first few hours of operation of the apparatus. An inspection of the clamping of the poles is very simple as it can be accomplished merely by measuring the deflection of the tension bars by measuring the distance from the bars to the upper surface of the yoke. The deflection of the tension bars is likely to then be of the order of ten to twenty times the total future compression of the insulating paper which may occur during the lifetime of the apparatus. Further inspection and tightening of the clamping of the poles will be unnecessary and yet the poles will not loosen, causing vibration or damage to the betatron parts.

During the operation of the apparatus there normally is a tendency for the tension bars to gradually move or creep with respect to the yoke. This creeping or moving of the tension bars is prevented by the pins which project into the ends of the tension bars and which are associated with the spacer blocks and yokes. The spacer blocks are preferably at least partly of insulating material so that the tension bars are insulated from the laminations of the yoke. The tension bars are anchored to and insulated from the yokes in an efficient manner without necessitating an expensive or complicated clamping structure.

The method of clamping the yokes together so as to transmit the clamping force of the yoke clamping structure to the center leg assures a firmly, solidly clamped core structure.

The elements of the core structure are so designed and assembled that the core becomes a very precise iron core with efficient air cooling. A fine adjustment of the core can be accomplished during final assembly and continued efficient operation of the accelerator embodying the core after assembly and initial operation is assured.

It is claimed and desired to be secured by Letters Patent:

1. A magnetic induction device comprising at least two U-shaped yokes, a leg element and a clamping means; said yokes formed of a plurality of packages of laminations, said packages being superposed with spacers between said packages to provide air ducts between adjacent of said packages; said leg element being the center leg of said device and including two radially symmetrical laminated poles, a radially symmetrical laminated wafer, and insulated spacer means; each of said poles having a first one of its surfaces defined by edges of its laminations abutted to one of said yokes with insulation between said yoke and said abutting pole, said wafer positioned between said poles, said spacer means including a pair of one piece rings, each of said rings having planar upper and lower faces and a plurality of radial passageways between its outer and inner arcuate edges and its said faces with solid insulating material between adjacent of said passageways connecting the upper and lower faces, said rings being on opposite sides of said wafer between said wafer and said poles, said clamping means comprising a pair of studs, each of said studs respectively fixed to one of said poles and

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extending along the axis of its radially symmetrical laminations through the yoke adjacent said pole, biasing means associated with the end of said stud which extends through said yoke, said biasing means including a pair of bars spaced from the outer surface of said yoke, means associated with said bars to tension said stud, and clamping structure associated with the legs of said U-shaped yokes to firmly abut said yokes against each other and to force said two pole pieces against said ring spacers and said wafer.

2. A three legged core comprising at least two yokes, a leg element and a clamping means; said yoke members formed of a plurality of packages of laminations, said packages being superposed with spacers between said packages to provide air ducts between adjacent of said packages; said leg element being the center leg of said core and including two laminated poles, a laminated wafer, and insulated spacer means; each of said poles having a first one of its surfaces abutted to one of said yokes with insulation between said yoke and said abutting pole, said wafer positioned between said poles, said spacer means including a ring having a planar face and a plurality of passageways, said ring being between said wafer and one of said poles; said clamping means comprising a pair of studs, each of said studs fixed respectively to one of said poles and extending through the yoke adjacent said pole, biasing means associated with the end of said stud which extends through said yoke, said biasing means including at least one bar spaced from the outer surface of said yoke, means associated with said bar to tension said stud, and clamping structure associated with the outer legs of said core firmly abutting said yokes against each other and forcing said two pole pieces against said ring spacer and said wafer.

3. A magnetic induction device comprising at least two U-shaped yokes, a leg element and a clamping means; said yokes formed of a plurality of packages of laminations, said packages being superposed with spacers between said packages to provide air ducts between adjacent of said packages, said leg element being the center leg of said device and including two radially symmetrical laminated poles, a radially symmetrical laminated wafer, and insulated spacer means; each of said poles having a first one of its surfaces defined by edges of its laminations abutted to one of said yokes with insulation between said yoke and said abutting pole, said wafer positioned between said poles, said spacer means including a pair of one piece rings, each of said rings having planar upper and lower faces and a plurality of radial passageways between its outer and inner arcuate edges and its said faces with solid insulating material between adjacent of said passageways connecting said upper and lower faces, said rings being on opposite sides of said wafer between said wafer and said poles; said clamping means comprising a pair of studs, each of said studs respectively fixed to one of said poles and extending along the axis of its radially symmetrical laminations through the yoke adjacent said pole, biasing means associated with the end of said stud which extends through said yoke, said biasing means including a laminated bar spaced from the outer surface of said yoke, means associated with said bar to tension said stud, and clamping structure associated with the legs of said U-shaped yokes to firmly abut said yokes against each other and to force said two pole pieces against said ring spacers and said wafer.

4. A magnetic induction device comprising at least two yokes, three core leg elements and clamping means; said yokes being formed of a plurality of packages of laminations superposed in spaced relation to provide air ducts between adjacent of said packages; one of said leg elements being the center leg of said device and including two radially symmetrical laminated pole pieces, a wafer having radially symmetrical laminations, and spacer means; each of said pole pieces having a flat surface abutted against a surface defined by edges of laminations of one of said yokes with insulation between said yoke and said pole piece, said pole pieces having air passages extending in a direction substantially normal to the abutted surface of said yoke, said wafer positioned between said pole pieces, said spacer means comprising a pair of one piece rings, each of said rings having planar upper and lower surfaces and having a plurality of radial passageways between its inner and outer arcuate edges with insulating material connecting said

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upper and lower surfaces between adjacent of said passageways, said rings being on opposite surfaces of said wafer between said wafer and said pole pieces, said clamping means associated with each of said other two of said leg elements and with said yoke, said leg elements positioned between said yoke members with said other two of said leg elements forming the outer two legs of said device, said clamping means firmly abutting said other two of said leg elements and forcing said two pole pieces, said ring shaped spacers and said wafer to form a solid center leg of said device.

5. A magnetic induction device comprising a pair of U-shaped yokes, a center leg, and clamping means, said yokes being formed of a plurality of superposed, spaced packages of laminations providing air ducts between said packages, said leg including at least two radially laminated core elements, insulating elements, and a spacer element disposed intermediate said core elements, said spacer element having parallel planar upper and lower surface portions and connecting supports between said upper and lower surface portions to provide radial air passageways defined by said surface portions and said supports, said core elements each abutted against a different one of said yokes with said insulating elements between abutting surfaces of said core elements and said yokes, said core elements having air passages extending in a direction substantially normal to the joints between said core elements and said yokes, said clamping means associated with said yokes fixedly joining said yokes together and solidly clamping said elements forming said solid center leg between said yokes.

6. A three legged magnetic core comprising two U-shaped yokes, a center leg and clamping means, said yokes being formed of a plurality of layers of stacked flat laminations with means spacing layers of said laminations to provide air ducts between layers; said center leg being between said two yokes and including in series stacked core elements comprising a first pole, a first spacer, a wafer, a second spacer and a second pole; said poles and said wafer being laminated steel elements, said poles having radially symmetrical laminations and air passages internal their peripheral edge surfaces; at least one of said spacers comprising a solid ring shaped insulating element coaxial with said poles having radial openings for air passage with flat upper and lower surfaces and at least one flat ring shaped shim coaxial with said insulating element and abutting one of the flat surfaces of said insulating element; said clamping means fixedly joining said yokes together and solidly clamping said center leg between said yokes.

7. A three legged magnetic core comprising two U-shaped yokes, a center leg and clamping means, said U-shaped yokes having their ends abutted to define upper and lower portions of said core, said yokes being formed of a plurality of layers of stacked flat laminations with means spacing layers of said laminations to provide air ducts between layers; said center leg being between said two yokes and including stacked core elements comprising a first pole, a first spacer, a wafer, a second spacer and a second pole; said poles and said wafer being laminated steel elements, said poles having radially symmetrical laminations and air passages internal their peripheral edge surfaces; at least one of said spacers comprising a solid ring shaped insulating element coaxial with said poles having radial openings for air passage with flat upper and lower surfaces and at least one flat ring shaped shim coaxial with said insulating element and abutting one of the flat surfaces of said insulating element; said clamping means including similar biasing means associated with each of said poles, each said biasing means including at least one bar connected to one of said poles, said bar spaced from one of said yokes and deflected thereby biasing said one pole toward said one yoke.

8. A three legged magnetic core comprising two U-shaped yokes, a center leg and clamping means, said U-shaped yokes having their ends abutted to define upper and lower portions of said core, said yokes being formed of a plurality of layers of stacked flat laminations with means spacing layers of said laminations to provide air ducts between layers; said center leg being between said two yokes and including stacked core elements comprising a first pole, a first spacer, a wafer, a second spacer and a second pole; said poles and said wafer being laminated steel elements, said poles hav-

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ing radially symmetrical laminations and air passages internal their peripheral edge surfaces, at least one of said spacers comprising a solid ring shaped insulating element coaxial with said pole pieces having openings for air passage and flat upper and lower faces and at least one flat ring shaped shim coaxial with said insulating element and abutting one of the flat faces of said insulating element, said clamping means including similar biasing means associated with each of said poles, each said biasing means including a laminated bar connected to one of said poles, spaced from one of said yokes and deflected to bias said one pole to said one yoke.

9. A three legged magnetic core comprising two U-shaped yokes, a center leg and clamping means, said U-shaped yokes having their ends abutted to define upper and lower portions of said core, said yokes being formed of a plurality of layers of stacked flat laminations with means spacing layers of said laminations to provide air ducts between layers; said center leg being between said two yokes and including stacked core elements comprising a first pole, a first spacer, a wafer, a second spacer and a second pole; said poles and said wafer being laminated steel elements, said poles having radially symmetrical laminations and air passages internal their peripheral edge surfaces; at least one of said spacers comprising a solid ring shaped insulating element coaxial with said poles having radial openings for air passage and flat upper and lower surfaces and at least one flat ring shaped shim coaxial with said insulating element and abutting one of the flat surfaces of said insulating element; said clamping means including similar bias means associated with each of said poles, said biasing means comprising a stud fixed to a first one of said poles, said stud extending from said one pole through a first one of said yokes and fastened to the approximate center of the lengthwise dimension of at least one bar, the ends of said bar spaced from said first yoke, and said bar deflected at its center tensioning said stud and biasing said first pole against said first yoke.

10. A magnetic induction device including a radially symmetrical laminated pole piece, a stacked parallel laminated core element, insulation between abutting faces of said pole piece and said core element, and clamping means comprising a stud fixed to said pole piece and having one of its ends extending through said core element, biasing means associated with said end of said stud to tension said stud.

11. A magnetic induction device including a radially symmetrical laminated pole, a stacked parallel laminated core element, and clamping means comprising a stud having one end fixed to said pole and having means associated with its other end for biasing a face of said pole against a face of said core element defined by edges of the laminations of said core element; said biasing means including a force apply shoulder fixed to said other end of said stud, a T-shaped element having a surface in contact with said shoulder, a pair of bars centered by said stud and said T-shaped element with respect to the lengthwise dimension of said bars, and spacing means supporting the ends of said bars; said spacing means being fixed with respect to the laminations of said core element and having means connecting with said bars preventing said bars from moving about the longitudinal axis of said stud.

12. A magnetic induction device including a radially symmetrical laminated pole, a stacked parallel laminated core element, and clamping means comprising a stud having one end fixed to said pole and having means associated with its other end for biasing a face of said pole against a face of said core element; said biasing means including a shouldered element fixed to said other end of said stud, a T-shaped element having a surface in contact with said shouldered element, at least one bar centered by said stud and said T-shaped element, and spacing means supporting the ends of said bar from said core member.

13. A magnetic induction device including a radially symmetrical laminated pole, a stacked parallel laminated core element, and clamping means comprising a stud having one end fixed to said pole and having means associated with its other end for biasing a face of said pole against a face of said core element; said biasing means including a pair of bars centered by said stud with respect to the lengthwise dimension of said bars,

and spacing means supporting the ends of said bars; said spacing means being fixed with respect to the laminations of said core element and having means connecting with said bars preventing said bars from moving about the longitudinal axis of said stud.

14. A magnetic induction device including a radially symmetrical laminated pole, a stacked parallel laminated core element, and clamping means comprising a stud having one end fixed to said pole and having means associated with its other end for biasing a face of said pole against a face of said core element; said biasing means including at least one bar centered by said stud with respect to the lengthwise dimension of said bar, and spacing means supporting the end of said bar; said spacing means being fixed with respect to the laminations of said core element and having means connecting with said bar preventing said bar from moving about the longitudinal axis of said stud.

15. A magnetic induction device including at least two laminated magnetic core elements, compressible insulating material, and clamping means, said elements assembled with said compressible insulating material between the adjacent faces of said elements, said clamping means including a stud fixed to one of said elements and extending through the other of said elements and biasing means, said biasing means including a pair of spacing blocks supported on and insulated from said other of said elements, means for fastening each of said spacing blocks to said other of said elements, each of said spacer blocks having a face thereof having a bearing surface, a pair of bars extending between said two spacer blocks and having their extreme ends supported on said bearing surfaces of said blocks, means for holding said ends of said bars on said bearing surfaces and means at the center of the lengthwise dimension of said bars for adjustably connecting said end of said stud to said bars and deflecting center of said bars to tension of said stud.

16. A magnetic induction device including at least two laminated magnetic core elements, compressible insulating material, and clamping means, said elements assembled with said compressible insulating material between the adjacent faces of said elements, said clamping means including a stud fixed to one of said elements and extending through the other of said elements and biasing means, said biasing means including a pair of spacing blocks supported on and insulated from said other of said elements, means for fastening each of said spacing blocks to said other of said elements, at least one bar extending between said two spacer blocks and having its extreme ends supported on said blocks, means for holding said ends of said bar on said blocks and means at the center of the lengthwise dimension of said bar for adjustably connecting said end of said stud to said bar and deflecting center of said bar to tension of said stud.

17. A magnetic induction device including at least two laminated magnetic core elements, compressible insulating material, and clamping means, said elements assembled with said compressible insulating material between the adjacent faces of said elements, said clamping means including a stud fixed to one of said elements and extending through the other of said elements, said stud connected to biasing means including a pair of spacing blocks insulated from said other of said elements, means for preventing said spacing blocks from moving with respect to said other of said elements, at least one bar extending between said two spacer blocks and having its extreme ends supported on said blocks, and means at the center of the lengthwise dimension of said bar for adjustably connecting said end of said stud to said bar and deflecting center of said bar to tension of said stud.

18. A magnetic core including first and second core elements movable as a unit into different positions, and clamping means therefor comprising a first support attached to said first core element, a second support attached to said second core element, and detachable means fastening said elements together, said second support comprising pads connected to said second core element, and means for moving said second core element with respect to said first core element including an interlock engageable with said pads only when said core elements are in a predetermined position, said core elements clamped together by said means abutting said second core element against said first core element.

19. A magnetic core including upper and lower core elements movable as a unit into different positions, and

clamping means therefor comprising a first support attached to said upper core element, a second support attached to said lower core element, and detachable means fastening said elements together, said second support comprising pads connected to said lower core element, and means for moving said lower core element with respect to said upper core element including an interlock engageable with said pads only when said core elements are in a predetermined position, said core elements clamped together by said means raising said lower core element against said upper core element.

20. A magnetic core including upper and lower core elements and clamping means therefor comprising a first support attached to said upper core element, said first support including a trunnion for rotating said core about a horizontal axis substantially between said two core elements when said core elements are fastened together, a second support attached to said lower core element, and detachable means fastening said elements together, said second support comprising pads connected to said lower core element, and means for moving said lower core element with respect to said upper core element including an interlock engageable with said pads only when said core elements are in a predetermined position, said core elements clamped together by said means raising said lower core element against said upper core element, said means being separated from said second core element when said core elements are fastened together by said detachable means.

21. A magnetic core comprising upper and lower U-shaped yokes, a center leg and clamping means, said yokes being formed by a plurality of superposed spaced packages of laminations providing air ducts between said packages, said center leg including at least two radially symmetrical laminated poles, a radially symmetrical laminated wafer and insulating material, said wafer being disposed between said poles, said clamping means comprising a first clamping structure and a second clamping structure, said first clamping structure comprising two units, each of said units associated with a separate one of said poles and comprising a stud and a bar, one end of said stud fixed to its associated said pole and the other end of said stud connected to its associated said bar intermediate the ends of said bar to thereby bias a face of said pole against a face of said yoke, said insulating material interposed between said faces of said pole and of said yoke, said second clamping structure including a first support attached to said upper yoke, a second support attached to said lower yoke, said second support comprising pads connected to said lower yoke, means for moving said lower yoke with respect to said upper yoke including an interlock engageable with said pads only when said yokes are in a predetermined position, and detachable clamping means associated with the outer legs of said yokes firmly abutting the outer legs of said yokes against each other to force said two poles toward each other, thereby clamping said wafer between said poles in said center leg.

22. A magnetic core comprising a first U-shaped yoke, a second U-shaped yoke, a center leg and clamping means; said center leg including two radially symmetrical laminated poles, a radially symmetrical laminated wafer disposed between said poles, and insulating material; said clamping means comprising a first clamping structure associated with said poles and a second clamping structure comprising a pair of studs and biasing means, each of said studs having one end fixed to one of said poles and having its other end associated with said biasing means to force a face of said pole against a face of said yoke, said insulating material interposed between said faces of said pole and of said yoke, said second clamping structure including detachable clamping means associated with the outer legs of said yokes firmly abutting the outer legs of said yokes against each other and forcing said two poles against said wafer to clamp said wafer firmly in said center leg.

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