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MEANS FOR IMPROVING THE YIELD FROM BETATRON X-RAY GENERATORS

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FIG. 1

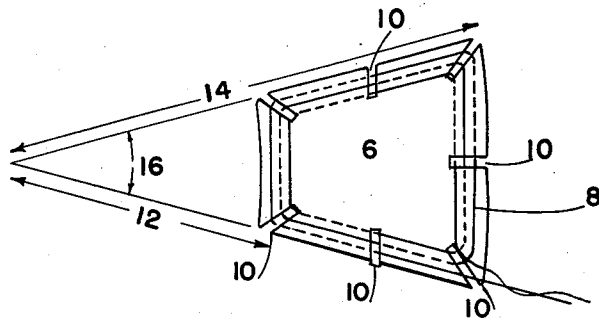


FIG. 2

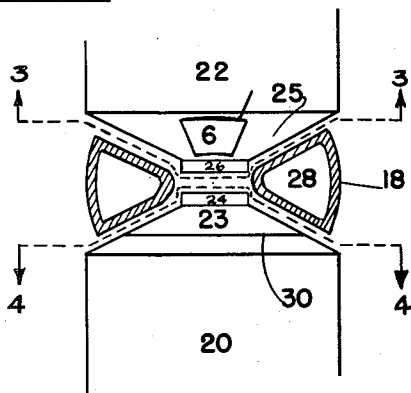


FIG. 3

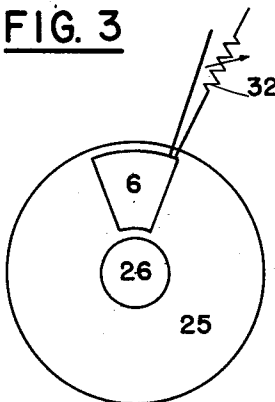
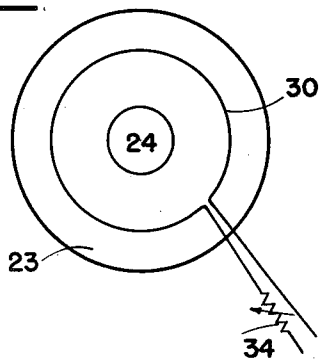


FIG. 4



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MEANS FOR IMPROVING THE YIELD FROM
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7 Claims. (Cl. 250—27)

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This invention relates to the magnetic induction accelerator and more particularly to coils for correcting the magnetic field of the magnetic induction accelerator.

In the practical operation of the magnetic induction accelerator it has heretofore been found that local field variations occur as a result of errors in manufacture or result from constructional accidents causing a departure from the desired optimum conditions, especially with respect to the similar phasing of the alternating field at the inner and outer portions, respectively, thereof.

It is therefore an object of our invention to correct the magnetic field of a magnetic induction accelerator.

Another object of our invention is to correct phase variations in the magnetic field emanating from the pole pieces of a magnetic induction accelerator.

In the attainment of the foregoing objects it is a feature of our invention to provide an attachable coil capable of inducing magnetomotive forces in the pole pieces of a magnetic induction accelerator.

The phases of this invention which I desire to protect herein are particularly pointed out in the appended claims. The invention itself together with further objects and advantages thereof can best be understood by reference to the following description of the accompanying drawings of which Fig. 1 is a schematic view suitably embodying the invention; Fig. 2 is the magnet and acceleration chamber assembly of a magnetic induction accelerator; Fig. 3 is a cross-section taken on a line 5—5 of Fig. 2 and Fig. 4 is a cross-section taken on a line 7—7 of Fig. 2.

Referring particularly to Fig. 1 there is shown a corrector coil comprising a trapezoidal shaped support 6. A number of turns of wire 8 is wound around the periphery of this support alternately above and below it between the slots 10 cut therein for the purpose of transposition. The shape of this support is determined by the angle of divergence 16 of the trapezoid and, as will be explained more fully later, the radial distances 12 and 14.

The magnet and acceleration chamber assembly of a conventional magnetic induction accelerator is depicted in Fig. 2 in which there is

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shown a closed glass vessel 18 defining within its interior the continuous annular acceleration chamber 28. The magnet assembly comprises a pair of juxtaposed circular pole pieces 24 and 26 respectively supported on conically tapered parts 23 and 25. The tapered parts are in turn mounted on main poles 20 and 22. A more complete description is given in United States Patent 2,297,305 to Kerst. As disclosed in this patent, the acceleration chamber includes an electron injection comprising a thermionic cathode and other electrode structure capable of injecting electrons tangentially into the electron orbit of the acceleration chamber whenever the magnetic field of the betatron is at a minimum. Also, means including saturable means are provided to disturb the magnetic field whenever the magnetic field approaches a maximum so as to shift or eject the electrons, while near maximum velocity, from the electron orbit whereby the ejected electrons impinge upon a target located within the acceleration chamber.

The wire wound support 6 of Fig. 1 is here shown between the glass vessel 18 and the pole piece 25. A view of this support 6 in said position is shown in Fig. 3 by a cross-section taken on line 5—5. Here the pole piece 26 and the tapered pole 25 are shown as defining the radial distances 12 and 14 previously mentioned. A suitable variable resistor 32 is shown in series with the coil 8 to provide a means of varying the strength of the coil's field. The variable resistance acts effectively to vary the total impedance of the circuit thereby to control the current flow there-through from an electrical power source. Hence, the amount of current flow through the coils will determine the strength of the resultant field produced by the coil. The corrector coil operates to cancel the phase variations of the magnetic field caused by residual magnetic fields due to hard spots in the pole faces, eddy currents and other similar causes by producing an opposing magnetic field to such disturbing erratic magnetic fields. By locating the corrector coil upon the main poles in an optimum position, such as shown in Fig. 3, and by providing a magnetic field of sufficient strength to overcome the erratic magnetic fields, the magnetic field of the pole pieces will be phase corrected. Originally, finding the optimum position of a coil was largely

a trial and error method, however, recently means were developed to make an accurate survey of the magnetic field and hence to establish quantitatively to what extent such a coil would be needed and where it should be placed. The action of this coil is to make the magnetic field in all azimuths of the pole pieces have the same phase. This means that the magnetic field at a given radius from the center of the pole and at any instant is the same for any azimuth. The effect is important only for the short time in the neighborhood of and following the injection of electrons, which is at small or minimum magnetic field intensity.

A coil was designed for a particular magnetic induction accelerator as follows: ten turns of #20 copper wire 8 were wound on a 0.010" piece of fishpaper 6, the inner and outer radii 12 and 14 were determined as aforementioned and the angle of divergence 16 was about 22 degrees. After winding 0.005" fishpaper sheets were fastened on either side of the wound support for mechanical protection and to a lesser extent electrical insulation. This coil, operating on the magnetic induction accelerator for which it was designed, gave a hundred percent increase in X-ray output.

In Fig. 2 there is also shown a second type of coil 30 shown more particularly in Fig. 4 in which the coil 30 is shown as wound around the pole piece 23 and having a resistor 34 in series therewith to vary the coil's magnetic field. This type of coil is to be used in case one pole as a whole is out of phase with its mate.

While the invention is herein described by reference to particular embodiments thereof, it will be understood that numerous modifications may be made without actually departing from the true spirit and scope of the invention.

Having thus described our invention, what we claim is:

1. In combination with a magnetic induction accelerator containing an electromagnet having pole pieces out of phase with one another, means for correcting said phase differences, said means including an electrically energizable coil having its magnetic axis parallel to and displaced from the magnetic axis of said electromagnet adjustably positioned adjacent one of said pole pieces so as to induce a magnetomotive force in said one of said pole pieces, said magnetomotive force being of such magnitude and in such a direction as to compensate for said phase differences thereby causing the pole pieces to be in phase with one another.

2. In a magnetic induction accelerator having an evacuated acceleration channel encircling pole pieces of an alternating current-excited field magnet, a thin support member of insulating material disposed between one of said pole pieces of said magnet and said channel and positioned adjacent one side of said one pole piece, and a field-correcting coil supported by said support member, said coil being energized continuously in direction and amount to substantially cancel the residual flux therethrough from said magnet when the flux from the remainder of the magnet is at a minimum in each cycle of said energization.

3. In a magnetic induction accelerator employing a field magnet periodically energized in opposite directions and having an accelerating channel surrounding pole pieces of the magnet, a flat field correcting coil having sides arranged substantially radially from the center of a said

pole piece and arcuate members completing said coil, the arcuate members having a common arc center, means supporting the coil in adjustable location between said channel and magnet, and means controlling the current in the coil, whereby direct current energization thereof is adjustable to effect a maximum degree of phase equalization in the flux from the magnet.

4. In a magnetic induction electron accelerator having a magnet energized by alternating current and an acceleration channel encircling pole pieces of the magnet, a thin coil support adjustable between the channel and said pole pieces of said magnet, a correcting coil mounted on said support having a resistance in series therewith and terminals for energization thereof, and means for adjusting the direct current resistance between said terminals, whereby a phase change in the portion of the magnetic field induced by said magnet and passing through the correcting coil as said magnet is alternately energized is effected in proportion to direct current energization of said correcting coil, the amount of said phase change being controllable by said adjusting means.

5. In a magnetic induction accelerator having a field magnet with proximately disposed poles and energized with alternating current, said accelerator having an annular accelerating channel between said poles, a device for testing the uniformity of phase of the magnetic field produced by said current comprising a thin trapezoidal support insertable between said channel and either of said poles and movable circumferentially and inwardly and outwardly with respect to the pole center, a coil disposed about the periphery of said support and secured thereto, and means for varying the magnitude of current in said coil in response to direct current energization thereof, whereby the coil is adjustable in position and magnitude of phase-correcting effect on the field of said magnet as the field approaches zero on each cycle.

6. In an alternating current magnetic induction accelerator containing electromagnetic pole pieces and an electron channel disposed about a space between said pole pieces, said channel having means for inserting a stream of electrons tangentially within said channel when said field is at a minimum and means for disturbing the field through the pole pieces when the field approaches maximum in order to eject said electrons at near maximum velocity, additional corrector coil means energized by direct current and lying between said pole pieces and the sides of said channel for disturbing the normal phase relationship of the magnetic field induced by said pole pieces, and means variably controlling the amount of said disturbance of phase relationship, whereby said relationship may be made to equalize to thereby increase the percentage of electrons inserted in said channel at said minimum field.

7. In an alternating current magnetic induction accelerator having proximately disposed pole pieces and an electron channel therearound and equipped with means injecting electrons into said channel at minimum field conditions and other means upsetting the normal field distribution at approximately maximum field conditions thereby to eject said electrons at high velocity, additional means comprising a field producing corrector coil between said channel and said pole pieces at a set distance from the centers of the pole pieces, said additional means producing a field in phase

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quadrature to the field of said accelerator induced by said alternating current for altering the phase of a portion thereof, and means for varying the strength of field from said additional means, whereby the resultant phase change in said field portion increases the acceptance of electrons accelerated in said channel and the ejection of said electrons at high velocity.

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References Cited in the file of this patent
UNITED STATES PATENTS

Number	Name	Date
1,722,167	Wilson -----	July 10, 1928
2,193,602	Penney -----	Mar. 12, 1940
2,284,406	D'Entremont -----	May 26, 1942
2,297,305	Kerst -----	Sept. 29, 1942
2,331,788	Baldwin -----	Oct. 12, 1943
2,412,617	Jenkins -----	Dec. 17, 1946
2,421,583	Stuart, Jr. -----	June 3, 1947
2,491,345	Westendorp -----	Dec. 13, 1949
2,572,414	Wideroe -----	Oct. 23, 1951
2,586,494	Wideroe -----	Feb. 19, 1952