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ELECTRON ACCELERATOR CONTROL SYSTEM

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Fig. 1.

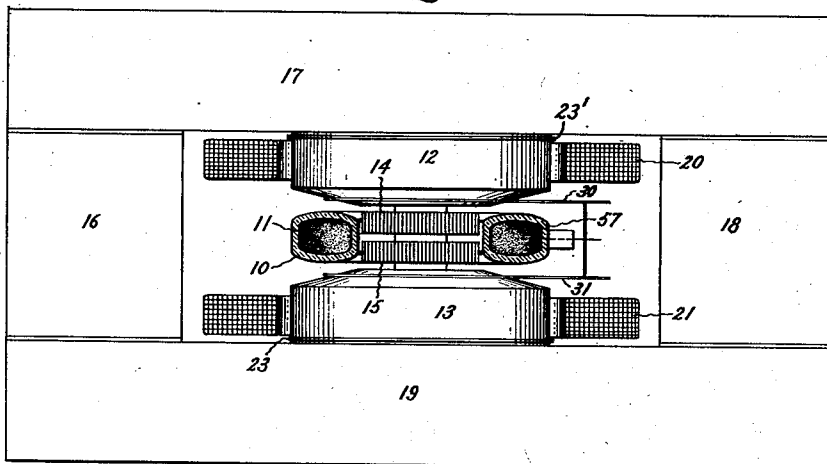


Fig. 2.

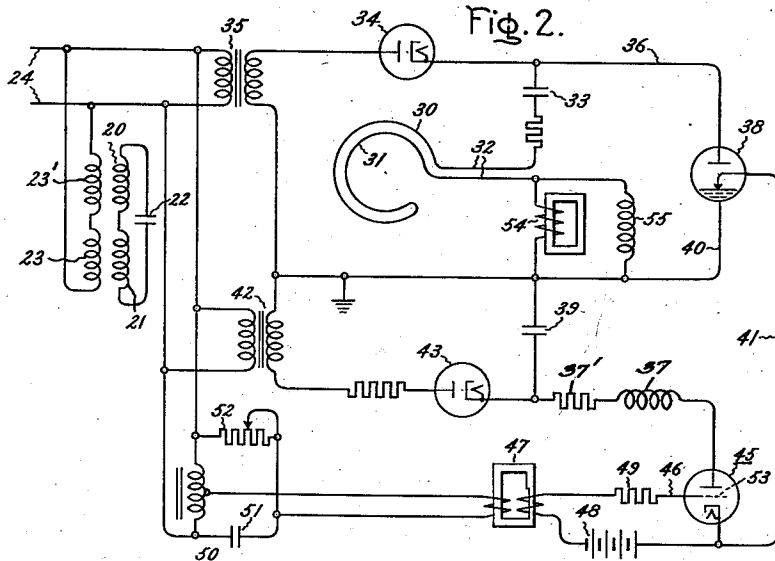


Fig. 3.

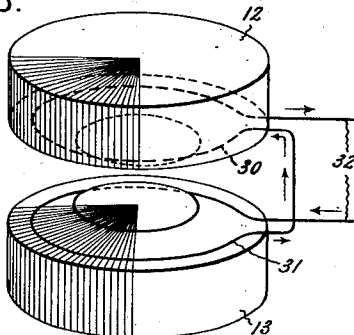
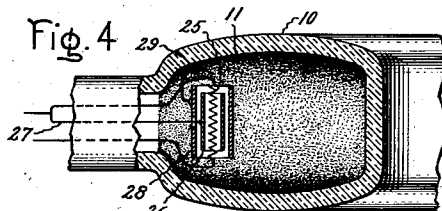


Fig. 4.



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ELECTRON ACCELERATOR CONTROL SYSTEM

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5 Claims. (Cl. 315-18)

The present invention relates to apparatus for accelerating charged particles, such as electrons, by means of magnetic induction effects.

Apparatus of the character referred to typically includes a closed vessel and a magnetic system for producing a time-varying magnetic field of such space distribution as to confine charged particles projected within the vessel to a circular orbit along which the particles are continuously accelerated as the magnetic flux through the orbit increases in magnitude. When the particles have been accelerated to a desired high velocity, they may be diverted from the accelerating orbit for producing desired useful effects.

A major problem in the operation of magnetic induction apparatus of the type specified consists in the provision of suitable means for diverting orbitally moving electrons after their acceleration has proceeded to the desired degree. For example, the effective utilization of the accelerated electrons may be carried out by constraining the electrons to move in a new course in which they will be intercepted by an X-ray-producing target. Heretofore, this desired result has been attained by contracting or expanding the electron orbit.

In accordance with the present invention, means have been provided whereby the accelerated beam of electrons may be controllably displaced axially, for example, upwardly or downwardly from the plane in which they are accelerated, in order to bring them into intercepting relation with a target.

The target then may consist of a flat plate with plane bottom surface of appreciable extent in the direction of the electrons in order to produce so-called "thick target radiation" which is more efficient than "thin target radiation." The target must be accurately adjustable parallel to the plane of the orbit in order for the electrons to penetrate the full thickness. In the case of orbit contraction or expansion, the target would have to be accurately curved in order to obtain the same effect.

In general, such displacement is accomplished in accordance with the invention by auxiliary field-producing means which near the end of the accelerating period produces a symmetrical modification of the magnetic field of such character as to permit axial displacement of the path of gyration of the accelerated particles.

The features which I desire to protect herein are pointed out with particularity in the appended claims. The invention itself, together with further objects and advantages thereof, may best be understood by reference to the following de-

scription taken in connection with the accompanying drawing, in which Fig. 1 is a partially sectionalized view of an induction accelerator embodying my invention; Fig. 2 is a diagram of connections; and Fig. 3 is a conventionalized view of a portion of the magnetic structure and the deflecting coils whereby the magnetic field is modified to displace the electron stream.

Referring particularly to Fig. 1, there is shown in section a ring-shaped glass vessel 10 providing within it an annular chamber in which electrons may be accelerated to a desired velocity. The vessel 10 is sealed and preferably highly evacuated. It may be operated while connected to a vacuum pump (not shown). A high resistance coating 11 (indicated by stippling), such as an extremely thin layer of conductive material, such as silver, is applied to the interior surface of the vessel to prevent wall charging.

The accelerating mechanism comprises a magnetic structure having rotationally symmetrical (i. e. circular) pole pieces 12, 13 which are coaxial with the annular vessel 10. These pole pieces are constituted of laminated iron held in assembly (by means not shown). The oppositely facing central pole faces are of essentially planar character. Near their outer edges, the poles are of tapered configuration. For decreasing the magnetic reluctance of the path between the opposed pole faces, there is provided an insert in the form of two laminated iron cylinders or disks 14, 15. An externally closed magnetic circuit between the base portions of the pole pieces is provided by iron cores 16, 17, 18 and 19.

The magnetic structure is excited by means of a pair of series-connected coils 20 and 21 which surround the pole pieces 12 and 13 and which produce a time-varying flux in the magnetic circuit.

The coils 20 and 21 are shown in Fig. 2 as connected in series with one another and across a condenser 22 which is assumed to be of such capacity as to resonate with the inductance of the coils at a frequency corresponding to the desired frequency of operation of the apparatus. To supply the losses of the resonant circuit thus formed, the coils 20 and 21 may be coupled to primary coils 23, 23' which are directly energized from an alternating current power source represented by the mains 24. A relatively small amount of power supplied to the coils 20 and 21 will serve to maintain the resonant system in excited condition.

Within the closed vessel 10 (Fig. 1) and also within the region of influence of the magnetic field produced there is provided a thermionic

cathode 25, Fig. 4. This cathode is surrounded by a grid 26 which is connected to the cathode by the conductor 27. The grid in turn is enclosed by a shield 28 which is connected to the conductive coating 11 as indicated at 29. The circuit connections and structural details of an electron accelerator of the kind shown in Fig. 1 are well understood and are described in prior patents and publications.

A novel feature of my present invention is shown in Fig. 3. The pole pieces 12, 13 here are shown somewhat diagrammatically. They are surrounded by reversely wound series-connected coils 30, 31 which when suitably energized displace axially the annular electron stream in the evacuated chamber 10. The course of energizing current in the coils 30, 31 and the supply conductors 32 is indicated in Fig. 3 by arrows to be in opposite direction in the series-connected coils.

A system of electrical connections, comprising also a feature of my invention, whereby the coils 30, 31 are excited when the electrons have been accelerated, is shown in Fig. 2. The coils 30, 31 receive an impulse of current from the condenser 33 which is charged through a thermionic rectifier tube 34, charging current is received from the secondary of a transformer 35, the primary winding of which is supplied from the mains 24. The discharge circuit 36 of the condenser 33 contains an ignitron 38, that is, a mercury cathode trigger tube which may be rendered conductive at a predetermined instant. It is rendered conductive by a discharge received from another condenser 39 through the conductors 40, 41. The condenser 39 is charged by a transformer 42 through a rectifier 43 as indicated. The conductor 41 contains a Thyatron tube 45, connected in series with an inductor 37 and a resistor 37'. The grid circuit 46 of the Thyatron 45 is connected to the secondary winding of a peaking transformer 47 and contains a biasing battery 48 and a resistance 49. The primary winding of a peaking transformer 47 is energized by current received through the phase shifter 50, which comprises as usual a capacitor 51 and a variable resistance 52. When the grid 53 of the Thyatron 45 receives a positive charge an impulse of current is conducted through the Thyatron 45 from the capacitor 39. This impulse discharge renders the ignitron 38 conductive and energizes the coils 30, 31.

The discharge of current through the reversely connected coils 30, 31 is conducted through a saturating reactor 54 which may have a reactance coil 55 connected in shunt thereto.

The reactor 55 has a high inductance at low values of discharge current and a negligible inductance at high values. It tends to prolong the discharge through tube 38 after the current drops below saturation of the reactor 54. The reactor 55 permits the current in the reactor 54 to reverse and therefore nearly doubles the time during which reactor 54 is operating in its non-saturated range, giving nearly double the time for the ignitron 38 to become deionized.

Assuming the magnetic field generated by the coils 30, 31 to be so oriented as to lift the accelerated electron stream, X-rays will be generated by

the impact of the electrons on target 57, Fig. 1. The electron stream may be otherwise utilized in a desired manner. Similarly, the stream of electrons can be displaced downwardly by appropriate reverse excitation of the coils 30, 31.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electron accelerator comprising an evacuated chamber, means for introducing electrons into said chamber, means for producing a time-varying magnetic field for imposing an accelerating magnetic force on said electrons so oriented as to constrain said electrons to move in a predetermined orbit in said chamber, means for modifying the magnetic field to displace axially the orbit of said electrons, and means for energizing said modifying means at a predetermined point of the cycle of the time-varying field.

2. An electron accelerator comprising means for producing a stream of electrons moving in a circular orbit, means for impressing on said orbit a time-varying magnetic field for accelerating said electrons, electric windings located above and below said electron stream, said coils being connected in series and wound in opposite directions, means for energizing said coils to displace in an axial direction the orbit of said electron stream, and means for timing the energization of said coils with said time-varying field.

3. An electron accelerator comprising an annular evacuated chamber, means for producing an electron discharge therein, means for producing a time-varying magnetic field oriented to accelerate said electrons in a definite orbit in said chamber, electric coils connected and wound to generate a magnetic field whereby said orbit may be axially displaced, an electric circuit connected to said coils containing a source of current, a trigger discharge device in said circuit, and means for activating said device at a time when said electrons have received a desired acceleration by said time-varying field.

4. An electron accelerator comprising an annular evacuated chamber, means for producing a stream of electrons therein, means for imposing thereon a time-varying magnetic field for accelerating said electrons in a restricted orbit, a target axially displaced from said orbit, electric windings oriented with respect to said orbit to generate a magnetic field whereby said electron stream may be deflected perpendicular to the plane of said windings and upon said target, and means for energizing said windings in predetermined time relation to said accelerating field to axially displace the orbit of said electrons into a position in which impingement thereof on said target will result.

5. An electron accelerator comprising an annular evacuated chamber, a source of electrons in said chamber, magnetic means for accelerating said electrons in an annular path in said chamber, a target displaced from the orbit of said electrons, means for displacing the electron orbit in an axial direction in intercepting relation with said target, and means for energizing said displacing means when a predetermined acceleration of said electrons has been attained.

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