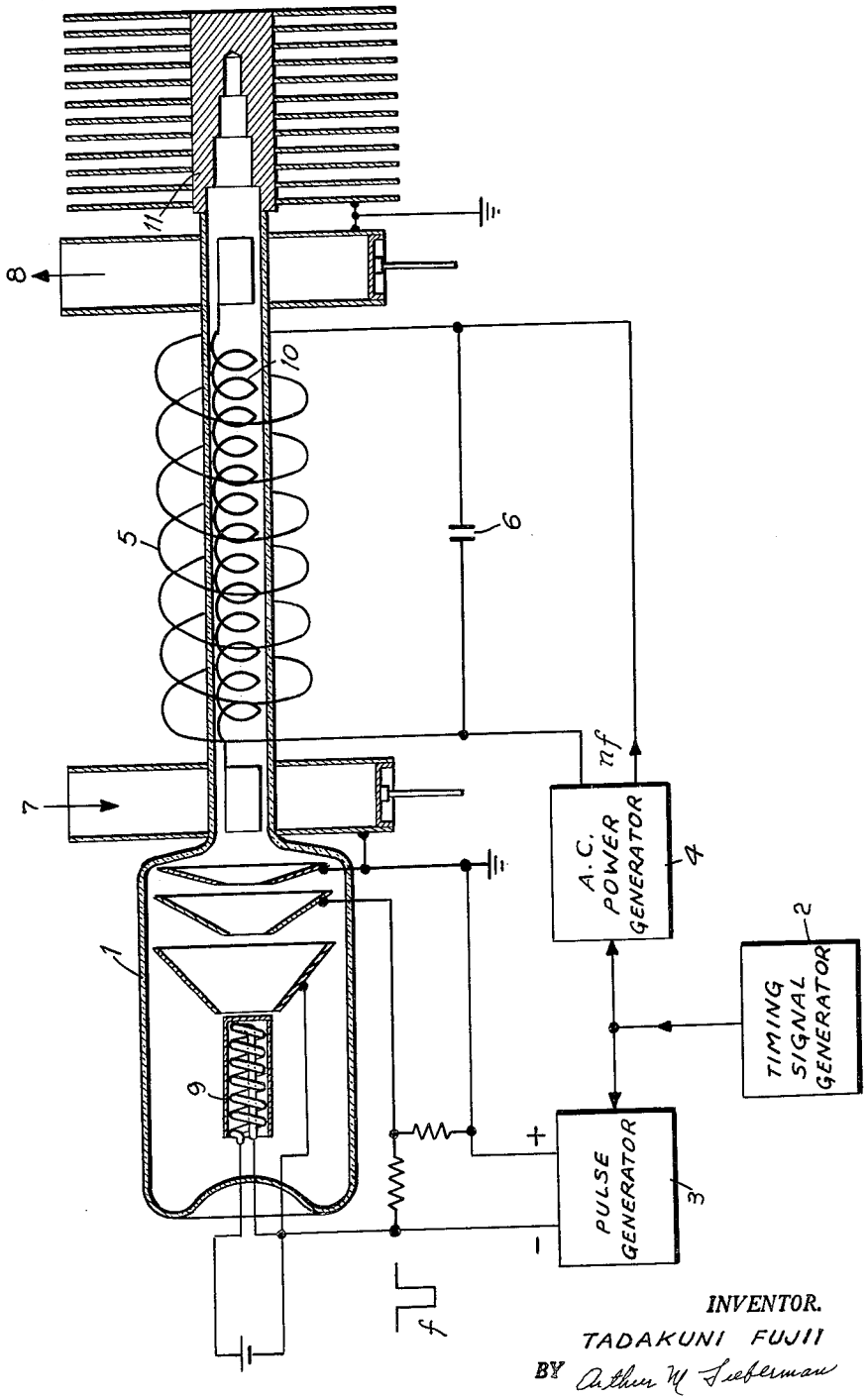
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ELECTRON BEAM TUBE MAGNETIC FOCUSING DEVICE

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ELECTRON BEAM TUBE MAGNETIC FOCUSING DEVICE

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This invention relates to electron beam focusing and more particularly to such focusing in a traveling wave tube.

In a traveling wave tube the electromagnetic wave propagates along an interaction circuit where there is projected an electron beam in field coupling relationship. Because of the relatively long length of the electron path and because of the space charge forces acting in an electron beam, it is generally necessary to provide focusing means to keep the electron flow cylindrical during its traveling past the interaction circuit. In the past such focusing has generally been provided by establishing a longitudinal steady magnetic field along the beam path. However, in practice the strong magnetic field and high fluxes required in the large gap for such magnetic focusing have necessitated in the use of large permanent magnets or solenoids which have added much to the bulk and weight of traveling wave tubes.

Through the use of periodically varying magnetic fields it has been found that the bulk of magnetic apparatus could be considerably reduced. This is due primarily to better utilization of the magnetic fields. By arranging a plurality of small permanent magnets periodically in the axial direction of the electron beam a focusing arrangement is created. This type of construction, however, still contains disadvantages from the point of view of size and weight of the tube.

An object of the invention is to provide a simplified and more efficient traveling wave tube.

A further object of the invention is to provide in a traveling wave tube an electron beam focusing device which is light in weight and requires A.C. power for its operation.

A feature of the present invention is to produce a magnetic field for focusing the electron beam by utilizing alternating current to flow through an air-cored solenoid, instead of direct current through a conventional iron-cored solenoid of a traveling wave tube, for the purpose of allowing the tube to operate satisfactorily under pulsed conditions.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawing, wherein

The single FIGURE illustrates a traveling wave tube which has a magnetic focusing system in accordance with the present invention.

In the figure, I denotes the traveling wave tube and 2 the timing-signal generator. An A.C. power generator 4 produces an output voltage which is synchronized with the pulses produced by the pulse generator 3 whose output frequency is *f*. The focusing solenoid 5 and capacitor 6 connected in parallel across said solenoid 5 is used to form a resonant circuit whose resonant frequency is equal to the frequency *nf* (where *n* is a positive integer), the output frequency of the A.C. generator. The input and output waveguides 7 and 8 of the said traveling wave tube 1 are coupled at both ends of the propagating structure.

The electrons emitted from the electron gun 9 are accelerated by means of the output pulse voltage, shown in the figure by a downwardly directed rectangular pulse, developed by the pulse generator 3 to form an electron beam. This stream travels along the axis of the tube and is finally collected at electrode 11 where it is dissipated as heat. Spaced closely around the beam is a helix 10 capable of propagating a slow wave. The helix is proportioned so that the phase velocity of the wave is small with respect to the velocity of light and is approximately the same as the velocity of the electron beam; whereby the two may mutually interact along the length of the tube. The focusing magnetic field is produced by the air-cored solenoid 5 which is of conventional construction. A resonant circuit comprising solenoid 5 and capacitor 6 is resonant at the output frequency of the said A.C. power generator 4. The current flowing in solenoid 5 is then synchronized with the pulsed electron-beam accelerating voltage. Both the pulse generator 3 and the A.C. power generator 4 are excited by the timing signal generator 2. Thus, the ratio of the output frequencies of the two generators 3 and 4 are always kept constant. The phase relationship between the two outputs is such that the intensity of the magnetic field produced by the said solenoid 5 and the output voltage of the said pulse generator 3 are both maximum simultaneously.

A common practice with conventional traveling wave tubes utilizing pulsed operation is that the electron-beam accelerating voltage is pulsed and a constant magnetic field is provided at all times. Keeping the magnetic field energized during the non-operating periods of time is evidently a waste of power. Such a method had to be resorted to heretofore on account of the difficulty in abruptly changing the amount of current flowing through the coil. This is due to the inductance of the solenoid being very large. Thus, the magnetic energy stored in the magnetic field is prohibitively large.

According to the present invention, however, the magnetic energy stored in the coil can be converted into electrostatic energy by being stored in the capacitors during the non-operating period by means of arranging the focusing solenoid coil to form a part of a resonance circuit. Therefore, alternating current, instead of direct current will flow through the focusing coil. Furthermore, in the present invention, an air-cored solenoid can be used instead of the more conventional iron-cored solenoid provided the frequency of the current through the solenoid is selected high enough.

Bulkiness and heavy weight have been considered among the defects of conventional traveling wave tubes even in the case of a tube with a periodic-focusing magnet and, consequently, the traveling wave tube of the present invention deserves a great deal of merit in view of its small size and light weight.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only

by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claim.

What is claimed is:

In a travelling wave tube having an electron emitting cathode, means for accelerating said electrons, a radio frequency wave propagating structure, means for focusing the electrons emitted from said cathode comprising a solenoid disposed coaxially of said structure, a capacitor shunting said solenoid and forming therewith a resonant circuit, a single phase generator connected across said solenoid for energizing said resonant circuit at the resonant frequency, pulse power means connected to said accelerating means, and synchronizing means connected to said power means and said generator for insuring a phase relationship of maximum pulse power at maximum A.C.

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