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ELECTRONIC TRANSMITTING VALVE OF GREAT POWER FOR ULTRA-SHORT WAVES

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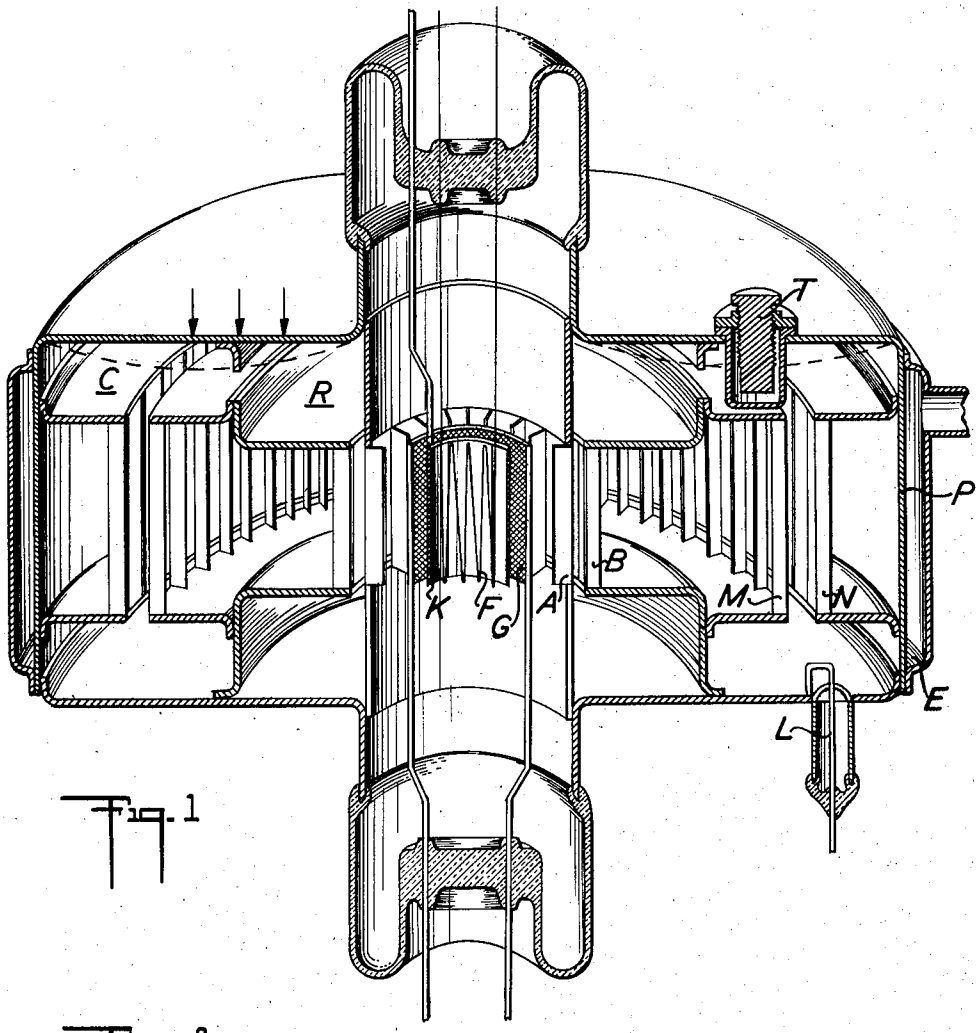
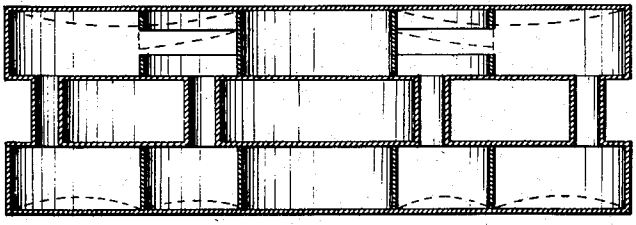


Fig. 1

Fig. 2



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AGENTS

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ELECTRONIC TRANSMITTING VALVE OF GREAT POWER FOR ULTRA SHORT WAVES

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5 Claims. (Cl. 315—6)

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This invention relates to electronic transmitting valves of great power for ultra-short waves.

The most efficient electronic valves, generators or amplifiers of ultra-short waves at present known for obtaining larger useful powers, in continuous operation, employ as the method of current control velocity modulation in an electron beam and include as oscillating circuits, electromagnetic cavity resonators coupled inductively with the beam. Among the various systems in which these methods have been actually employed is the device known by the name of klystron. As is known the klystron is essentially composed of two cavity resonators traversed by an electron rectilinear pencil. The first of the two cavities which have forms of revolution about the axis of the electron beam modulates the beam in its velocity and the second takes high frequency energy from the body of the said beam, in which the density is modulated following a displacement of the electrons in a space more or less partially exempt from high frequency field separating the apertures of the above-mentioned cavities.

Even though the klystron system enables a useful power to be obtained well above that which can be furnished by ordinary electron valves, the increase of this power towards high values, desirable for many important applications, is nevertheless limited in this system by the fact that with the known forms of cavity resonators, the impedance of the one which plays the part of a collector of high frequency energy, diminishes very rapidly when, commencing from a certain comparatively slight value, the diameter of the internal conductor is increased, said conductor being necessary in order to obtain the retracted form of profile producing a high degree of exchange of energy between the modulated beam and the high frequency field of the said cavity. An analysis of the phenomenon of excitation of electromagnetic oscillation in a cavity resonator, by means of a beam modulated in density, shows that the factor determining the magnitude of the high frequency power set in action is the product ZJ of the impedance of the cavity, from the point of view of the beam, by the current induced in the electrodes between which is developed the field acting on the electrons. To obviate the difficulty previously mentioned in the increase of the power of a klystron, it has been suggested to employ cavity resonators of retracted profile having as axis of revolution an axis external of the said retracted profile but still paralel to the beam. But owing to the fact

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of empolying a symmetry with respect to an axis parallel to the beam, there remain, in practical embodiments of powerful valves, very great difficulties which arise from the direct current energy, which is not transformed into high frequency energy, having necessarily to be dissipated on electrodes having comparatively very small surfaces.

The present invention relates to a valve having evelocity modulation control, the design of which is such that there can be given to the product ZJ a value considerably higher than in the klystron and which does not possess, to the same extent, the drawbacks of that apparatus from the points of view of: dissipation of energy, focalisation, space charge effect, etc.,—drawbacks more particularly attaching to devices employing a symmetry about an axis parallel to the axis of a rectilinear electron pencil.

According to the present invention, a device is employed with control by velocity modulation (or focalisation of phase) the construction of which is characterised by the following features:

(a) The device possesses an axis of revolution perpendicular to the electron beam;

(b) The device comprises one or more cavities traversed by the whole of the beam and extending axially about the cathode;

(c) The cavities have a profile of retracted form; and

(d) If necessary the profile of retracted form is symmetrical with respect to a plane normal to the axis of the cathode and extending through the center of the height of the cathode.

To explain more fully the principle of the present invention, reference will be made to the following detailed description of certain embodiments taken with accompanying drawing wherein

Figure 1 is a perspective sectional view which represents by way of non-restrictive example an auto-oscillator constructed in accordance with the present invention, and

Figure 2 is a view in section illustrating the principle of the invention with many details omitted.

In Figure 1 there will be found successively, starting from the axis, a cathode K, of cylindrical form, heated by a filament F; a cylindrical control grid G, cavity resonators R and C, an electron collector P and a cooling jacket E. To ensure proper working, these cavities will be raised to suitable positive potentials with respect to the cathode K. The potentials may be the same for C and R, or may be different, in

this latter case an insulating separation, not shown in the drawing, having to be provided in the construction of the device. In the most simple embodiment, the electron collector P is raised to the same continuous potential as the walls of the cavity resonators C and R, but this arrangement is not restrictive. The cavity resonator R constitutes the electron gatherer termed as buncher, in which, the beam coming from the cathode K is modulated in its velocity. The cavity resonator C is the energy collecting resonator in which the beam, modulated in density, in consequence of the drift of the electrons between the field of R and the field of C produces high frequency energy by reduction of its kinetic energy. For well-known reasons, the cavity resonators C and R have a retracted profile. In the drawings, the cavities R and C are provided in their capacitative part, with orifices for the passage of the electrons which are constituted by apertures existing between the flat bars placed parallel to the axis of the cathode. These bars assist in limiting the high frequency electric fields acting on the electrons between A and B and between M and N (fields which at this spot, are directed normally to the axis of the cathode), but their presence is not indispensable. Suitable precautions are furthermore taken to ensure the rigidity of the apparatus, but they can be eliminated more or less completely without the apparatus ceasing to function. Their retraction gives room for larger apertures between the edges of the capacitative parts of the cavities and the electric field overflowing therefrom can act, with certain precautions, with respect to the dimensioning, in an efficient manner on the electrons. The two cavity resonators are coupled by the device Q. The cavity resonator C is coupled to the utilisation member by the device L. A movable piston T permits the wave length of the cavity resonator C to be varied and the adjustment to its best value of the relative detuning of the two cavities.

The operation of the apparatus will be understood, in its main effects, from that of the klystron; but it will be noted on the one hand that, according to the present invention, the dissipation surface presented by the electron collector P is comparatively large as compared with the usual flat arrangement, and on the other hand that the phenomena of space charge in the part of the beam located after the buncher grids are comparatively reduced. This arises from the electron beam possessing in this region, a very large section; it is also to be noted that by reason of the divergence of the electron flux the space charge phenomena diminish on moving away from the axis of the cathode.

With the arrangement illustrated in Figure 1, it is also clear that there can be imposed, at the operation level of the grids of the buncher cavity resonator R, a current of a considerably higher intensity than in the cases of devices having their axis of revolution parallel to the beam. The device is characterised by a comparatively low value of impedance of the beam, by thus indicating the ratio V_0/I_0 of the acceleration potential of the electrons to the intensity of the non-modulated conduction current imposed at the level of the first grid of the buncher.

With beams of such high intensity, it may happen that the energy captured by the high frequency grids A, B, M, N, is greater than the energy which can be normally dissipated by them. Consequently, the present invention provides for the suppression of the grids, which, by enlarging the high frequency fields which act on the electron beam, leads to a lower efficiency. The rigidity of the whole of each cavity resonator is then ensured by a few bars connecting the two parts of the cavity separated by the electron beam. These bars, according to well-known practice, may be protected from electron bombardment by electrodes suitably placed and raised to suitably chosen potentials.

It is possible without modifying the distance between the grids, to vary independently the resonance wave lengths of the two cavities by employing the elastic deformations of their walls, as is illustrated in Figure 2, where there is indicated by dotted lines the positions of the walls after deformation. Such deforming means in itself being well known is not illustrated but is indicated by arrows in Figure 1 at the left and above the resonators. In the case of the auto-oscillator or of the amplifier with reaction, the coupling of the two cavities may be effected in the known manner by one or more coupling loops. If the two cavities have a common wall, the coupling may be effected by one or more apertures made in the common wall. There will preferably be given to this aperture the form of a circular slot along a parallel. It will then be possible, according to the invention, to vary the coupling of the two cavities by elastic deformation of the wall which supports one of the cylinders which limit the coupling slot, as is indicated in Figure 1 where there is illustrated by dotted line deformations permitting of simultaneously varying the coupling and the tunings of the two cavities. The common wall of the two cavity resonator may be reduced to the elements necessary for maintaining the inner walls of the cavity. These elements may furthermore be made of dielectric material shown in Figure 1 without reference numeral as column-like supporting stays between the two inner walls, the device then comprising only a single cavity provided with two capacitative spaces.

The coupling of the external cavity with the utilising member and in amplifiers, of the inner cavity with the excitation member, can be effected in a known manner by means of loops and lines.

In view of the described characteristics of the velocity modulation tube forming the subject matter of this invention, and of its various advantages, it is obvious that it is readily applicable to an amplifier.

The present invention has also for one of its objects a velocity modulation device in which the cavities have the same arrangement as in the device previously described, but which differs essentialy therefrom in that the cathode is formed by a cylinder surrounding the external cavity acting as modulator, whereas the anode is constituted by a cylinder arranged internally with respect to the inner cavity acting as a collector. The anode can then be cooled in a simple manner by a current of water circulating in the interior of the cylinder. The fact that the surface presented for the dissipation of energy is less than in the preceding device is compensated for by the fact that the quantity of energy dissipated per square cm. may be greater than in the preceding case, the form of the anode lending itself well to rapid cooling.

What we claim is:

1. Velocity modulation tube having a symmetry of revolution about an axis, comprising a

cathode for generating an electron beam directed in a plane normal to said axis, two cavity resonators concentric with said axis and each having a cross section with a re-entrant profile and provided in the opposite walls of the cavity with a pair of grids for traverse successively by said beam, means providing a drift space between the output grid of the first cavity resonator and the input grid of the second cavity resonator, the portions of the said cavity resonators outside said re-entrant sections being adjacent each other and having exterior walls de-liminating a common space, and wall means limiting the said portions of their adjacent sides, said wall means providing an intercommunicating opening between said portions extending continuously about said axis, means whereby an elastic deformation of one of said exterior walls varies the said opening and thereby the coupling between the resonators, a collector concentric with said axis and located to receive the electrons emerging from the second cavity resonator, and means coupled to one of said resonators for extracting ultra high frequency energy therefrom.

2. Velocity modulation tube having a symmetry of revolution about an axis, comprising a cathode for generating an electron beam directed in a plane normal to said axis, two cavity resonators concentric with said axis and each having a cross section with a re-entrant profile and provided in the opposite walls of the cavity with a pair of grids for traverse successively by said beam, means providing a drift space between the output grid of the first cavity resonator and the input grid of the second cavity resonator, the portions of the said cavity resonators outside said re-entrant sections being adjacent each other and intercommunicating continuously about said axis and their exterior walls deliminating a common space, stays arranged in this space for maintaining the rigidity of the cavity walls, a collector of a structure concentric with said axis and located to receive the electrons emerging from the second cavity, and means coupled to one of said resonators for extracting ultra high frequency energy therefrom.

3. Velocity modulation tube having a symmetry of revolution about an axis, comprising a cathode for generating an electron beam directed in a plane normal to said axis, two cavity resonators concentric with said axis and each having a cross section with a re-entrant profile and provided in the opposite walls of the cavity with a pair of grids for traverse successively by said beam, means providing a drift space between the output grid of the first cavity resonator and the input grid of the second cavity resonator, the

portions of said cavity resonators outside said re-entrant sections being adjacent each other and intercommunicating continuously about said axis and their exterior walls deliminating a common space, stays of dielectric material arranged in this space for maintaining the rigidity of the cavity walls, a collector of a structure concentric with said axis and located to receive the electrons emerging from the second cavity and means coupled to one of said resonators for extracting ultra high frequency energy therefrom.

4. Velocity modulation tube having a symmetry of revolution about an axis, comprising a cathode for generating an electron beam directed in a plane normal to said axis, two cavity resonators concentric with said axis and each having a cross section with a re-entrant profile and provided in the opposite walls of the cavity with a pair of grids for traverse successively by said beam, means providing a drift space between the output grid of the first cavity resonator and the input grid of the second cavity resonator, the portions of the said cavity resonators outside said re-entrant sections being contiguous to each other through a common wall, an annular window provided in said wall to couple the resonators together, flat walls limiting said cavities and extending normal to said axis, adjusting means operating to deform simultaneously the said flat walls and the width of the said coupling window, a collector concentric with said axis and located to receive the electrons emerging from the second cavity and means coupled to one of said resonators for extracting ultra high frequency energy therefrom.

5. Velocity modulation tube according to claim 1, wherein the deformation means deforms said exterior walls simultaneously to vary said opening, thereby varying the coupling between resonators, and the tuning itself of said resonator.

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