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CROSS FIELD CONTROL TUBE

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Fig. 1

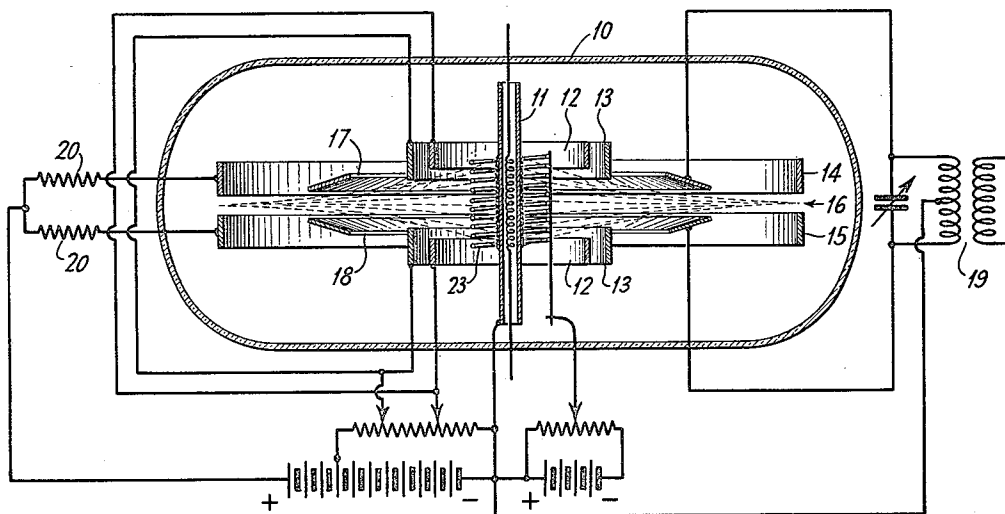


Fig. 2

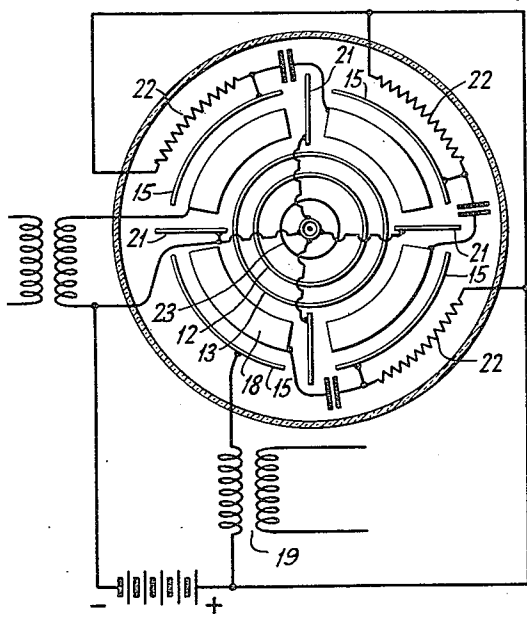
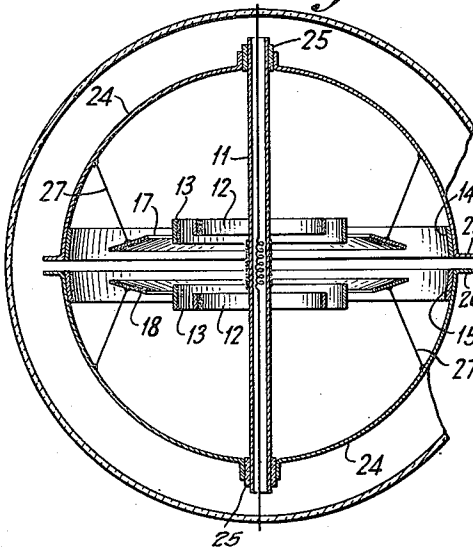


Fig. 3



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CROSS FIELD CONTROL TUBE

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5 Claims. (Cl. 250—152)

This invention relates to electron discharge de-
vices, and more particularly to tubes of the elec-
tron beam type in which the beam is deflected by
a transverse or cross control field.

The principal object of the invention is to pro-
vide a cross field control tube of the beam type
which has a large output current and in which
the entire emission of a filamentary or indirectly
heated cathode may be utilized. Another object
is to provide such a tube in which very high
amplification may be obtained. Still another ob-
ject is to provide a compact and symmetrical
tube construction. A further object is to provide
a tube of this type suitable for use in ultra short
wave work.

In accordance with the invention, a new cross
field control tube is so made that the electron
beam is lenticular or in the form of a disc, at the
center of which the cathode is situated. The
new tube has the great advantage in accordance
with this beam shape, that the entire electrode
mounting becomes cylindrically or rotationally
symmetrical and that very high amplification
factors may be obtained. The disc-shaped or len-
ticular beam is produced by an annular cylindri-
cal lens system coaxially arranged with respect to
the cathode whereby the said beam is deflected by
an annular cross field, or controlled transversally,
and finally impinges on anodes likewise annular
and which are loaded with any desired outer re-
sistances. The rotationally symmetrical con-
struction assures the utilization of the entire
emission of the axial cathode in the disc-shaped
beam, i. e. the concentric arrangement of all
electrodes enables all the electrons leaving the
cathode in different radial directions to be uni-
formly accelerated and concentrated, and
furthermore, as in the case of modern amplifier
tubes, a favorable symmetry of the system is as-
sured during manufacture and during use.
Finally, border disturbances unavoidable in case
of the band-shaped beam are entirely eliminated
by the disc beam which is closed on itself. The
new tube can be built with a uniform disc-shaped
beam and uniform annular electrodes in which
case the beam is uniform throughout its entire
peripheral extent, and becomes identical to two
space charge tubes connected in push pull as
regards its action, or the tube may be divided
into several sector like individual tubes through
radial or diametrical splitting of the entire struc-
ture, whereby the various individual tubes may
have different functions assigned to them, or they
may be connected in series or cascade.

In producing ultra-short wave oscillations with

a tube of this construction, considerable disturb-
ances may appear due to the comparatively high
capacity of the annular deflection plates as well
as due to the annular anodes which, for the pur-
pose of obtaining a sufficient deflection sensi-
tivity, must be of comparatively large diameter.
In trying, for instance, to make up a resonance
circuit with the anode rings of rather large
dimensions by connecting them to a short Lecher
wire system or by joining them to a bent wire,
then at the respective high frequencies the ex-
citation conditions could not be the same over all
the circumference of the cross field tube, since
the annular electrodes as such represent a line
with distributed capacity and induction, thus
making quasi-stationary conditions impossible.

This disadvantage of the tube for ultra-short
wave work is avoided in accordance with the in-
vention by extending the rotational symmetrical
structure of the cross field tube also to the ex-
cited resonance system in the plate circuits, so
that the excitation conditions for this system are
uniformly distributed over the entire circum-
ference. To this end, the anode rings are con-
nected to metallic hemispheres situated on the
ends of the cathode axis, so that a resonance cir-
cuit is obtained having the shape of a hollow
body with the disc-like ray taking its course in
the center plane of said hollow bodied resonance
circuit. The feed back is obtained in the simplest
manner by galvanic connections in which the de-
flection rings are joined at several places to suit-
able points in the interior of the metal hemi-
spheres and have applied to them all or part of
the oscillatory potentials.

Illustrative examples of cross field tubes made
in accordance with the invention are shown in
cross section in the accompanying drawing, in
which Figure 1 is a longitudinal section along a
vertical plane of one form of tube; Figure 2 is a
cross-section along a horizontal plane of a modi-
fication, and Figure 3 is a longitudinal section
along a vertical plane of a form of tube suitable
for ultra-short wave work.

As shown in Figure 1, the tube comprises a
highly evacuated envelope or bulb 10 which en-
closes the electrodes and which has at the center
a cathode 11, shown as of the indirectly heated
type. The shape of the tube as a whole is that
obtained by rotation of the cross section of Fig-
ure 1 about the cathode as an axis. About and
concentric with this cathode are two pairs of
annular beam forming electrodes of different di-
ameters, such as a pair of metal rings 12 of equal
diameters, and a second pair of rings 13, also of

equal diameter, but larger than the rings 12, the adjacent edges of the rings of each pair being spaced to form two annular beam forming slots in registry. These pairs of annular beam forming or lens electrodes may be connected to be at different potentials so that the electrical field between them and the beam forming slots acts as an annular cylindrical lens, which concentrates the electron rays emitted by the cathode in all directions, so that as a whole there is produced a disc-shaped beam which is lenticular or has the form of a frustum of a double cone, such as indicated in cross-section in Figure 1. At the point of the intersection, or focal line of the radial electron rays, and in the median plane of the beam two annular anodes 14 and 15 of equal diameter are mounted concentric with the cathode and spaced to leave a narrow slot 16 between their edges. By suitable adjustment of the lens electrode voltages the focal line of the electron beam or the circumference of the symmetry surface of the double cone beam may be made to coincide with this slot 16 between the anodes. In order to deflect the disc-shaped beam throughout its entire periphery toward one or the other anode deflection or control rings 17 and 18 concentric with the cathode and in vertical alignment are disposed between the lens electrodes and the anodes. Upon application of a potential difference between the rings 17 and 18, for example through an input circuit 19, there appears an annular cross field and in accordance with the direction of the latter, the disc-shaped beam will be deflected either towards anode 14 or towards anode 15 so that the electron current passes either to anode 14 or to anode 15. The two anode rings may be loaded by any desired outer resistors 20 and may operate in push pull. In order to attain as great steepness of the characteristic as feasible, there will preferably be used on the one hand a deflection field with as high intensity as feasible, i. e. the radial width of the deflection rings will be chosen as large as possible, and their spacing will be adapted as much as possible to the shape of the disc-shaped beam while, on the other hand, the diameter of the anode rings will preferably be chosen just as large as the electron-optical focal distance of the cylinder lens system permits so as to obtain as large a geometrical ratio of movement of the beam to its circumference as feasible.

Since the principle of the cross field control is applied to cathode ray tubes for television, and has been suggested in various cases for use in amplifier-and-transmitter tubes, a further description of the functioning of the subject matter of the invention is unnecessary.

Figure 2 illustrates a modification of the invention utilizing a radial or diametrical division of the electrodes in such manner that two or several sector-like cross ray tube systems are obtained in one bulb. This division need, of course, be made only in the deflection rings and the anode rings, while the cylindrical lens represented by the slots in the lens electrodes may remain a unit, or may be covered up at the most at the places of the radial separating gaps, so as to provide interspaces between the individual sector-like electron beams, whereby mutual influence is avoided. Such mutual influence will be completely suppressed, as indicated in Figure 2, if, in the separating spaces obtained in this way, radial sheet metal shields 21 extending lengthwise of the cathode and preferably connected to it are inserted. Obviously the individual cross field tubes

thus produced are like individual tubes and may be used in various ways; for instance, one sector as transmitter, a second one as modulation stage, a third one or a still further one as preliminary amplifier, or a multiple stage receiver apparatus with high-frequency stages detector, and audio-frequency stages may be accommodated within a single multiple cross field tube. In this way a mixer tube can be obtained in which one sector is employed for the production of the intermediate frequency, and another one for the production of the local oscillation; if necessary, further sectors may be employed as preliminary or subsequently connected high-and-intermediate frequency amplifiers, or as second rectifier, etc.

The cascade-like series connection of such cross field tubes or of the individual sector stages of a multiple tube is considerably simplified as compared with ordinary space charge tubes in that no elements whatsoever for the blocking of the anode voltage with respect to the deflection plates are required. The anodes may be connected directly with the deflection plates, or with segments of the following tube. In a cascade amplifier designed for sector-like individual stages the accommodation of the coupling resistors and coupling lines in the tube bulb is feasible and simple, as indicated in Figure 2, where connections are made through load resistor 22 and condensers from one sector to the following sector, all the connections being inside the bulb.

In some uses it may be advantageous in the rotation symmetrical cross field tube to insert between the cathode and the cylindrical lens a suitable control electrode, for instance in the form of a grid 23 in order to control the amperage of the beam. In this manner there is obtained very simply the possibility of modulating a cross field transmitter with stable frequency, or of voluntarily or automatically controlling a cross field amplifier. Furthermore, with such an arrangement all circuits can be set up which were hitherto shown with hexodes.

A modification of the invention suitable for use in ultra-short wave work is shown diagrammatically in Figure 3, showing in cross-section a practical construction of a disc beam transmitter with hollow resonance system. In this structure the indirectly heated cathode 11 is an axial metal tube or sleeve containing a heating coil and having its central part covered with an oxide layer which emits electrons. The electron rays are then concentrated in accordance with the invention by the annular ring-shaped cylindrical electron lens, thereby producing a disc beam with slightly triangular cross-section, as indicated in the figure. The deflection rings 17 and 18, by means of the ring-shaped cross field appearing between them, deflect the disc beam at its entire circumference to the anodes 14 and 15 on which the disc beam impinges, either against the one anode or against the other anode.

In this modification the anodes are not narrow rings, as in Figure 1, but the edges of metal cups 24 shown as hemispheres in this modification. The hemispheres are mounted on the axial cathode tube and are insulated from it by small cylindrical insulators 25 so as to withhold the plate potential from the cathode, and together with the said cathode sleeve form the inductance of the resonance system excited in push-pull whose capacity is formed by the opposite edges of the metal cups 24. This capacity may, if desired, be increased by radial flanges 26 on the anodes. It is obvious that in place of the hemispheres any

other cup-like shape, such as for instance conical- or-cylindrical cups may be employed.

In order to obtain a feed back whereby self excitation is produced it is necessary, as is known, to return a part of the oscillation potentials obtained at the hemispheres to the deflector rings 17 and 18. In the example described this is accomplished by several short connection wires 27 connected from suitable points in the interior of the hemispheres 24 to the deflection rings. For the production of ultra-short waves a cross connection of these feed back lines, which must then be led through the disc beam, is not necessary, since it is possible in case of static feed back with phase reversal to adjust to positive values the phase balance through suitable choice of the electron transit time, i. e. the beam acceleration potential. The other operating conditions do not require further elucidation.

Fundamentally, the arrangement is suitable for an inductive feed back, for instance in accordance with the scheme of the known Huth-Kuehn circuit. To this end it is only necessary to connect to the deflection rings smaller spherical cups inside and concentric with the hemispheres 24 to establish a secondary system in the interior of the anode system. Since in this case some difficulties may be encountered as regards the exact tuning of the two circuits, the simple conductive coupling is generally preferable.

I claim:

1. An electron discharge device comprising a straight electron emitting cathode, annular electron lens electrodes coaxial with said cathode to concentrate the discharge from said cathode into a focused lenticular beam transverse to said cathode, an annular anode comprising two rings co-

axial with said cathode and spaced to provide between their edges an annular slot having the same median plane as said beam and at substantially the focal line of said beam, and two annular control electrodes surrounding and concentric with said electron lens electrodes and spaced to provide between them an annular slot having the same median plane as said beam, each of said annular electrodes having extending through it a plurality of radial slots to divide each annular electrode into a plurality of arcs, said slots being in radial alignment to divide the electrode system into a plurality of sectors, each containing an arc of a control electrode and an arc of the anode.

2. An electron discharge device as defined in claim 1 in which a radially positioned metal sheet in each slot extends through said electrodes to electrostatically shield each sector from the adjacent sectors.

3. An electron discharge device as defined in claim 1 in which the electrode system is divided by radial slots into a plurality of sector stages and comprising connections inside the bulb connecting said sector stages in cascade.

4. An electron discharge device as defined in claim 1 in which the electrode system is divided by radial slots into a plurality of sector stages, and comprising a load resistor for one of said stages mounted inside the bulb and connected to the control electrode of another stage.

5. An electron discharge device as defined in claim 1 in which only the anode and the control electrodes are divided by radial slots into sectors, and the beam forming electrodes are circumferentially continuous.

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