

April 6, 1937.

G. R. KILGORE

2,075,855

MAGNETRON

Filed Feb. 29, 1936

2 Sheets-Sheet 1

Fig. 1

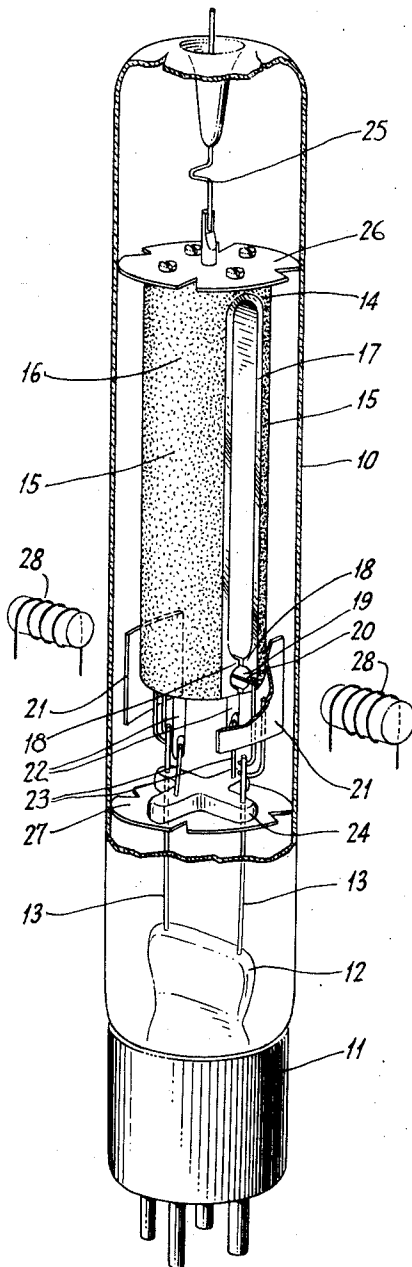


Fig. 2

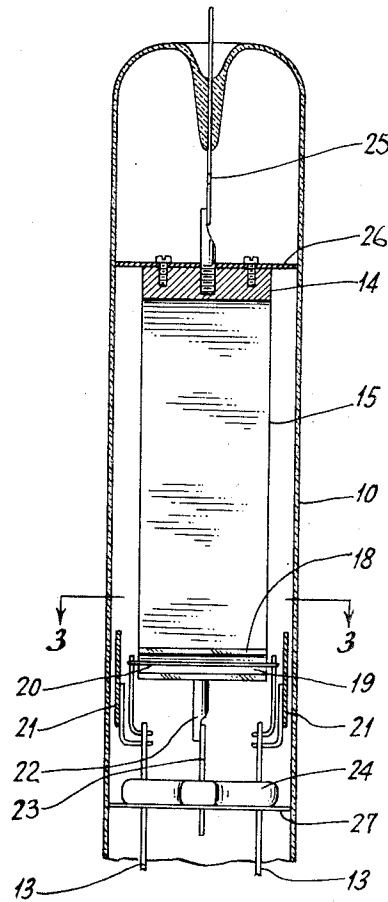
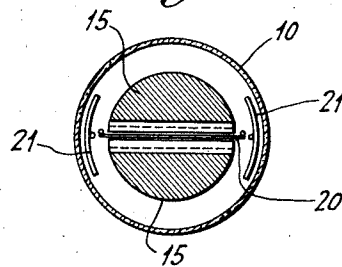


Fig. 3



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Fig. 4

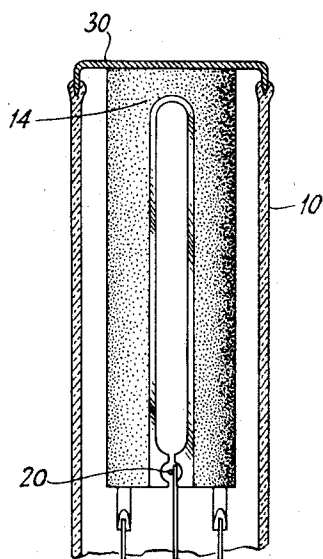


Fig. 5

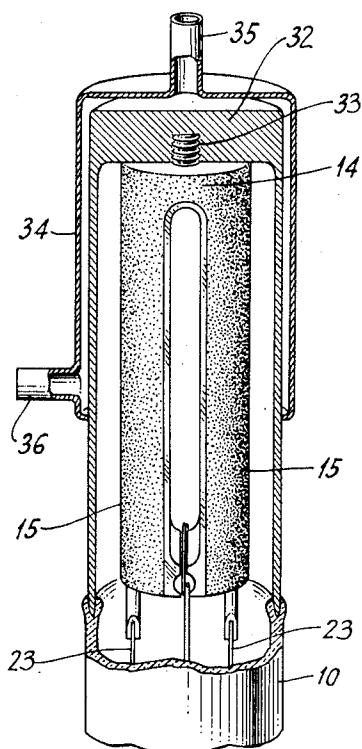
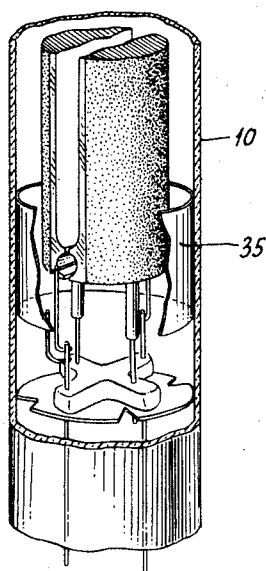


Fig. 6



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2,075,855

MAGNETRON

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mesne assignments, to Radio Corporation of
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Application February 29, 1936, Serial No. 66,379

5 Claims. (Cl. 250—27.5)

My invention relates to electron discharge de-
vices for use at high frequencies, more particu-
larly to improvements in devices of the so-called
magnetron type in which the electrode system is
positioned within a magnetic field.

The conventional magnetron comprises a
straight thermionic cathode, usually in the form
of a filament, an anode coaxial with and sur-
rounding the thermionic cathode and a magnet
for producing a strong magnetic field parallel
to the cathode. The anode, which may be of the
multi-segment type, is usually the so-called split
anode with two semi-cylindrical sections.

The magnetron tube is particularly useful at
very high frequencies, that is, frequencies of the
order of 300 megacycles and higher. In order to
function at these high frequencies the tubes must
have very small electrodes. It is difficult to pro-
vide for such tubes an external circuit which will
have inductance and capacity low enough to re-
spond to the higher frequencies at which the tube
can operate. One partial solution of this prob-
lem is to use internal circuit magnetrons, in which
the oscillator circuit comprises a loop of wire in-
side the tube envelope and connected directly to
the electrode system. Such a magnetron and its
associated circuit will function at high frequen-
cies, but the power output is limited to only a few
watts by the heat generated during operation of
the tube. Blackening or roughening the surface,
for example, of the anode increases the heat dissi-
pation of a tube, but is of little practical effect
with small anodes, and also increases the high
frequency resistance of the anode because sub-
stantially all of the high frequency currents flow
on the surface. Another difficulty encountered
in magnetron tubes with glass envelopes is the
softening of the glass near the ends of the anode
and cathode due to the concentration of the elec-
trons on the glass envelope at these points.

It is an object of my invention to provide an
improved electron discharge device of the magne-
tron type operable at ultra-high frequencies and
having a comparatively high power output. An-
other object of my invention is to provide such a
high power magnetron in which the softening of
the glass envelope adjacent the ends of the cath-
ode and anode is eliminated.

The novel features which I believe to be charac-
teristic of my invention are set forth with particu-
larity in the appended claims, but the invention
itself will best be understood by reference to the
following description taken in connection with the
accompanying drawings in which Figure 1 is a
perspective view with parts broken away of an

electron discharge device of the magnetron type
embodying my invention; Figure 2 is an enlarged
longitudinal section of the upper part of Figure 1;
Figure 3 is a transverse section taken along the
line 3—3 of Figure 2; Figures 4, 5 and 6 show
modifications of my invention.

The preferred embodiment of my invention,
shown in Figures 1, 2 and 3, is a magnetron of the
split anode type which comprises an evacuated en-
velope 10 provided with a conventional base 11
and press 12. The electrode assembly is sup-
ported on the press by a pair of lead and support
wires 13. In accordance with my invention the
electrode assembly is provided with a directly con-
nected internal circuit and comprises a U-shaped
member 14, preferably of copper, having semi-
cylindrical legs 15 having a large heat absorbing
capacity, the inside facing surfaces of which are
flat and parallel. The heat radiation of these
legs is increased by a black coating 16, preferably
carbon, on only their outside surfaces, as shown
in the drawing. Preferably no coating is ap-
plied along the margin 17 adjacent the inside sur-
faces of the legs 15. The lower free ends of the U-
shaped member 14 are provided with inwardly ex-
tending portions 18 having oppositely disposed
semi-cylindrical surfaces providing a central cir-
cular bore 19. These two extensions constitute the
anode segments of the split anode magnetron.
The U-shaped portion constitutes the internal cir-
cuit directly connected to the two segments of the
anode. The legs of the U-shaped member can be
considered as elongated parallel extensions of the
anode segments and as electrically connected at
the ends remote from the anode segments to pro-
vide an internal circuit. A straight thermi-
onic cathode 20, preferably a heavy filament, is
supported axially of the central bore or cylindri-
cal chamber 19 on the leads 13, as best shown in
Figure 2. A pair of shields 21, also supported on
and electrically connected to the leads 13 adja-
cent the anode at the opposite ends of the cath-
ode, shield the glass envelope 10 from the elec-
trons which would otherwise be concentrated on
it. These shields are preferably of non-magnetic
metal, such as molybdenum, so as not to interfere
with the magnetic field which is induced parallel
to the cathode during operation of the tube. On
each of the lower free ends of the legs 15 of the
U-shaped member 14 is a support comprising a
heavy wire or rod 22 and a smaller wire 23 fused
into a member 24 of glass or ceramic material car-
ried on the lead wires 13. The wires 23 may be
connected to pins in the base to serve as a con-
nection to external transmission lines, or they

may terminate as shown in Figure 2, just below the mica spacer 27. Other methods may then be employed to couple the internal circuit to the transmission lines. The U-shaped member 14 is electrically connected at the top to a flexible lead 25 to provide a voltage connection for the anodes at the lower end of the U-shaped member 14. This flexible lead also allows expansion and contraction of the electrodes during operation of the tube. The bottom lead 13 could be made flexible instead of the top lead 25. The mount is spaced from the walls of the tube envelope at the upper end by the mica spacer 26 secured to the U-shaped member 14 and at the lower end by the mica spacer 27 supported on the lead and support wires 13, the edges of the spacers contacting the wall of the envelope of the tube. Electro-magnets 28 positioned at opposite ends of the cathode on the outside of the envelope provide a strong magnetic field longitudinal of the cathode during operation of the tube.

The conventional internal circuit member used with a magnetron comprises a wire loop connected to the anode segments. The heat dissipation by as well as heat conduction from the anodes is very limited inasmuch as the anode surfaces are of small area and the internal wire loop is of small cross section as well as small area. Blackening the surfaces of the anode segments is ineffective because the surfaces are too small to radiate and thus dissipate much heat. Roughening or blackening the wire loop of the internal circuit member is objectionable because the resistance of the wire surfaces to high frequency current which flow mainly on and near the surfaces of the conductors is increased, thus increasing the power losses in the magnetron. I have solved both the problem of heat conduction from the anode segments and heat dissipation to increase the power output of a magnetron by my invention, at the same time decreasing the resistance to the flow of high frequency currents.

The legs 15 of the U-shaped member 14 have a large area and transverse cross section, one of their dimensions being preferably as great as the anode segments themselves. These legs have a large mass in comparison with the anode segments. As heat developed at the internal surfaces of the anode segments is quickly conducted away and dissipated by the legs 15, the anode segments are kept comparatively cool. While the legs naturally dissipate heat by radiation, I make them much more efficient radiators by roughening and coating them with carbon. While this roughening and coating with carbon increases the emissivity of the internal circuit portion of the magnetron, it increases the high frequency resistance at its surface to the flow of high frequency currents and in the ordinary loop type of circuit would reduce the maximum output of the tube. In accordance with my invention I provide a large conducting surface of comparatively low high frequency resistance for the high frequency currents by forming the legs 15 with large flat parallel surfaces of a width corresponding to the length of the anode segments. In this way the resistance of the internal circuit is reduced and the current density is decreased over that in the conventional loop wire so that the generated heat is decreased. These inside surfaces and a slight margin on the outside of the legs near these flat surfaces are not coated with carbon. At the same time I obtain the advantage of being able to rapidly conduct the heat away from the surfaces carrying the high frequency currents and dissi-

pate it through the envelope of the tube. By making a magnetron tube in accordance with my invention I have been able to increase the output of the tube to from a few watts output, which is the output of the conventional magnetron, to 50 watts output at a wave length of 60 centimeters with an efficiency greater than thirty percent. The shields 21 are effective in preventing the electrons which pass the ends of the anode from bombarding the glass. This bombardment is particularly bad in magnetrons because of the focusing effect of the magnetic field.

The principal advantages of a magnetron made in accordance with my invention are: a decrease in resistance, increased heat conduction from the tube elements, increased radiating surface, a reduction of dielectric losses and a circuit which will tune to higher frequencies than the external circuit type of magnetron. While shown as applied to a magnetron, my invention is equally applicable to other types of tubes in which it is desired to have a large power output at high frequencies.

In Figure 4 I show modified form of magnetron made in accordance with my invention in which the upper end of the envelope has been replaced by a metal cup-shaped member 30 secured to the internal circuit element 14, for example, by welding, and fused to the glass envelope 10 to provide an envelope for the tube elements. The cup-shaped member 30 could be made integral with the member 14. The member 30 can be used as the connecting element and also acts as an external heat radiator for the end of the internal circuit element 14.

In the past water cooling of the anode of a magnetron has not been feasible due to the small size of the anode or anode segments and the complications introduced by sealing the intake and exhaust tubes of the cooling system in the glass envelope which construction introduces stresses in the glass envelope at the seals due to temperature differentials of the cooling medium and glass envelope. My invention has made it possible to overcome these difficulties and use water cooling to advantage.

In the modification shown in Figure 5 a metal tubular member 32 closed at one end is secured to the circuit element 14 by a screw member 33, the lip of the tubular member 32 being sealed to the glass envelope 10 to close the end of the envelope. A water cooling jacket 34 is secured to the member 33 and is provided with an in-take 35 and an exhaust 36. The heat is both radiated from the surface of the legs 15 to the walls of the tubular member 32 as well as conducted to the metallic member 32 through the ends of the circuit element 14. This heat of course is absorbed and carried out by the cooling fluid passed through the water jacket 34. In this modification the internal circuit is connected to the transmission lines by means of the anode leads 23.

In Figure 6 I show a modification of the electron shield for the glass envelope. This modification comprises a cylindrical member 35 supported against the glass wall of the envelope 10. It may be coated on the wall of the envelope.

A magnetron made in accordance with my invention is simple and effective and capable of large power outputs due to the novel construction of the anodes and internal circuit member. While I have shown the anodes and internal circuit member as formed from a copper cylinder, it is apparent that the anodes and the internal circuit member could be made in various other ways; for example, by forming the anodes and legs sep-

arately and securing them together and properly spacing them by means of another member at the ends of the legs opposite from the ends carrying the anode segments.

5 While I have indicated the preferred embodiment of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

15 What I claim as new is:

1. A magnetron having an envelope containing an elongated U-shaped member, the legs of which have a comparatively large transverse cross section and are of comparatively large mass, the inner facing surfaces of said legs being closely spaced, flat and parallel, a pair of anode segments at the free ends of said legs on the inside surfaces thereof and having oppositely disposed semi-cylindrical surfaces providing a cylindrical chamber the axis of which is parallel to the flat surfaces of the legs of said U-shaped member, a straight thermionic cathode positioned axially of said cylindrical chamber and means for inducing a magnetic field longitudinally of said cathode.

2. A magnetron having an envelope containing a pair of anode segments having oppositely disposed semi-cylindrical surfaces forming a cylindrical chamber, each of said anodes being provided with an elongated extension, said extensions being parallel and electrically connected at the ends remote from said anodes to provide a U-shaped internal circuit connected to said anode segments, the facing surfaces of the extensions opposed to each other being flat and parallel and of a width co-extensive with the length of said anodes, said extensions having comparatively thick transverse cross sections in comparison with said anodes, a straight thermionic cathode disposed axially of said anode segments and means for inducing a magnetic field longitudinally of said cathode.

3. A magnetron having a tubular envelope containing a longitudinally extending U-shaped member, the legs of which have a comparatively large transverse cross section of semi-cylindrical form, the facing surfaces of the legs being flat

and parallel, anode extensions at the free end of said legs on the facing surface thereof provided with oppositely disposed semi-cylindrical surfaces forming a cylindrical chamber extending parallel to and co-extensive with the flat surfaces of said legs, a blackened coating on the semi-cylindrical surfaces of said legs to increase the heat emissivity of said legs, a straight thermionic cathode positioned axially of the cylindrical chamber and means for producing a magnetic field longitudinally of said cathode.

4. A magnetron having a tubular envelope containing a longitudinally extending U-shaped member, the legs of which have a comparatively large transverse cross section of semi-cylindrical form, the inner facing surfaces of the legs being flat and parallel, the anode extensions at the free ends of said legs on the inside surface thereof provided with oppositely disposed semi-cylindrical surfaces forming a cylindrical chamber extending parallel to and co-extensive with the flat surfaces of said legs, a blackened coating on the semi-cylindrical surfaces of said legs to increase the heat emissivity of said legs, a straight thermionic cathode positioned axially of said cylindrical chamber, means for producing a magnetic field longitudinally of said cathode, and non-magnetic shields positioned between the ends of the anode segments and the envelope of the tube at opposite ends of said straight thermionic cathode.

5. A magnetron having an elongated envelope closed at one end with a tubular metal member and containing an elongated U-shaped member, the legs of which have a comparatively large transverse cross section and are of comparatively large mass, the inner facing surfaces of said legs being closely spaced, flat and parallel, a pair of anode segments at the free end of said legs on the inside surfaces and having oppositely disposed semi-cylindrical surfaces providing a cylindrical chamber, the axis of which is parallel to the flat surfaces of the legs of said U-shaped member, a straight thermionic cathode positioned axially of said cylindrical chamber and means for producing a magnetic field longitudinally of said cathode, the end of said U-shaped member opposite from said anode segments being within and secured to said tubular metal member, and a cooling jacket surrounding said tubular metal member.

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