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H. R. HEGBAR

2,489,131

ELECTRON DISCHARGE DEVICE OF THE CAVITY RESONATOR TYPE

Filed Nov. 17, 1943

2 Sheets-Sheet 1

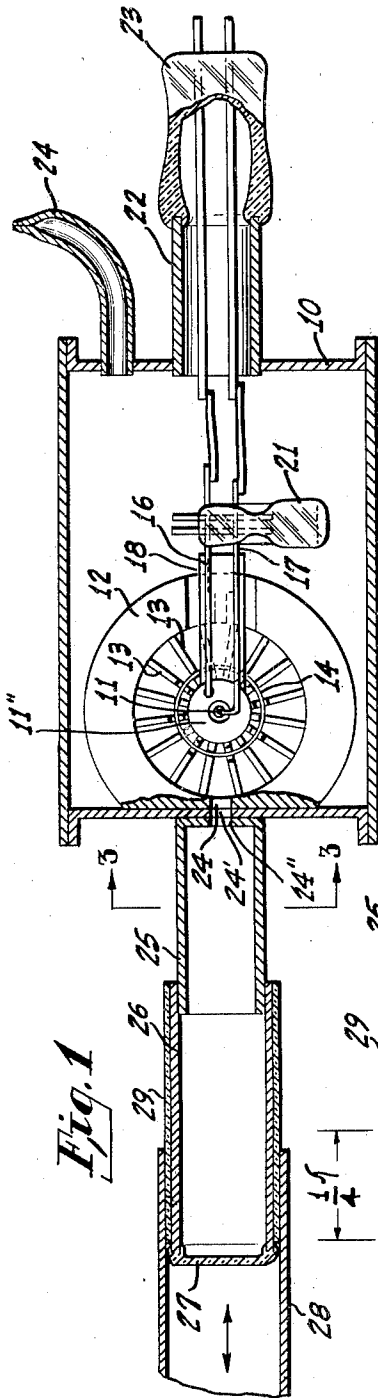
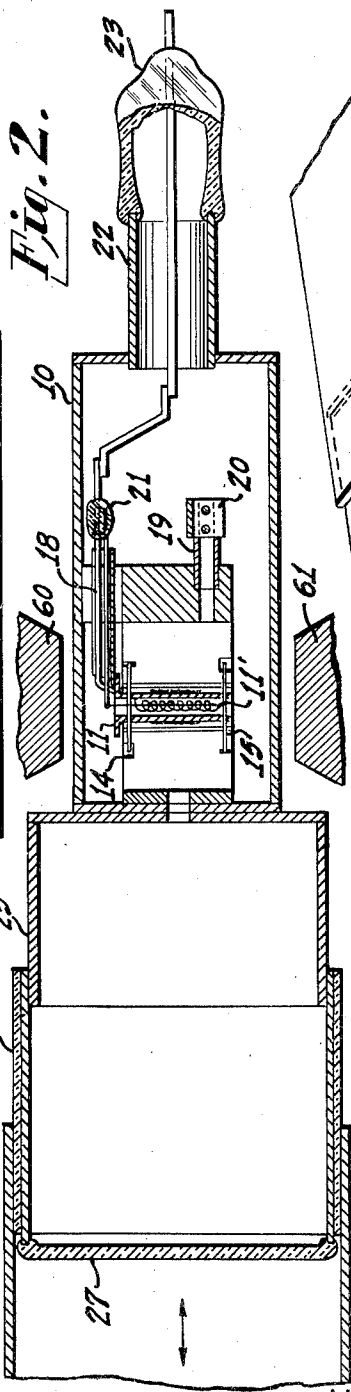


Fig. 2.



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Fig. 8.

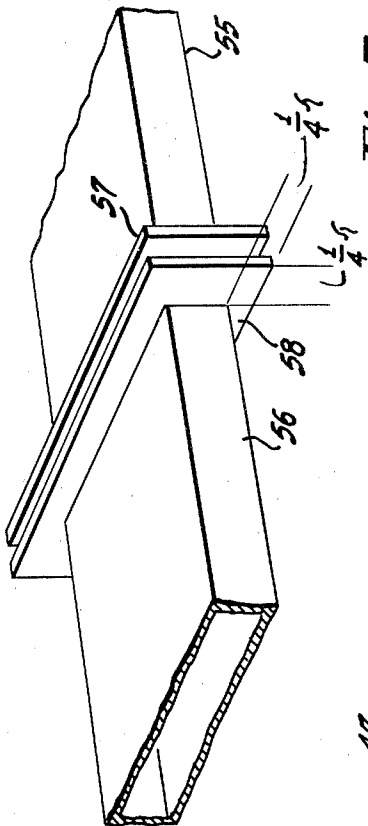


Fig. 7.

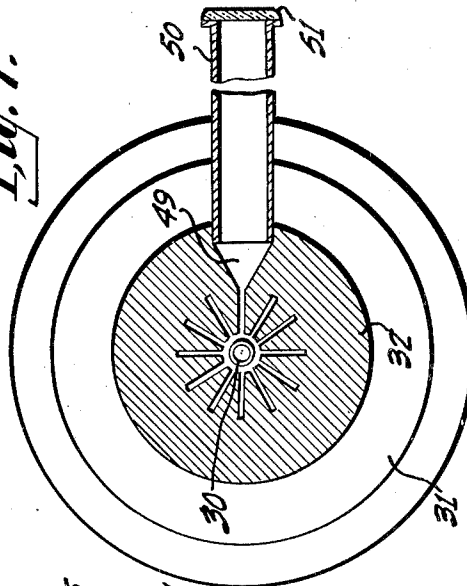


Fig. 5.

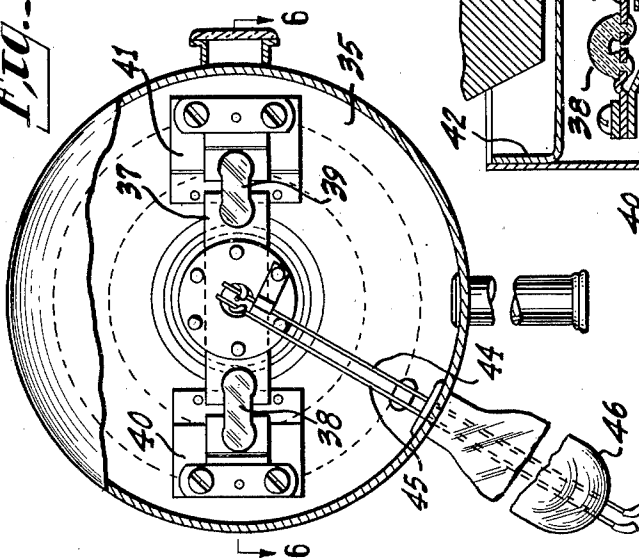
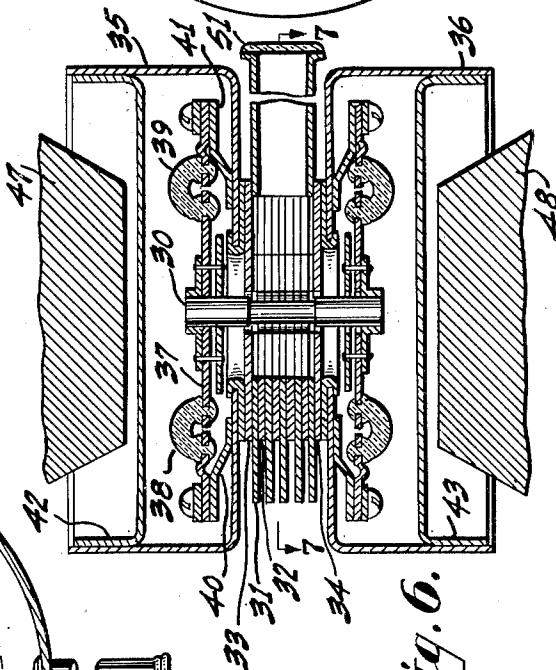


Fig. 6.



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ELECTRON DISCHARGE DEVICE OF THE
CAVITY RESONATOR TYPEHoward R. Hegbar, Princeton, N. J., assignor to
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9 Claims. (Cl. 315—39)

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My invention relates to electron discharge devices and associated circuits useful at ultra high frequencies and more particularly to magnetrons and output leads to be used therewith.

In certain types of magnetrons the anode segments or elements are interconnected by means of cavity resonator circuits and form together the anode structure for the magnetron. In one form of magnetron the electrode assembly comprises an elongated centrally positioned cathode and an anode member surrounding the cathode and provided with a plurality of cavity resonator circuits formed by cavities in the anode member and having communicating passages or slots between the cavities and the space between the cathode and anode member. The anode segments are formed by portions of the anode member positioned between adjacent communicating passageways, for example the slots lying parallel to the cathode. The anode structure may, of course, be made in various ways, either by utilizing a ring supporting inwardly and radially directed vanes or the anode assembly may be broached from a solid block or may be made by means of stacked sheets provided with proper slots and apertures.

In the usual multi-cavity magnetron of the type described, the output lead for coupling the device to an output lead comprises a coaxial line. Such output leads can be coupled to the magnetron resonators by means of a coupling loop placed in either a resonant cavity or in the magnetron end space adjacent the cavity resonators.

For a given length of coaxial output lead, measured from the output lead termination to the junction of the coupling loop and output lead, there is a certain size coupling loop which will permit the magnetron to work into a proper impedance for maximum power output. This assumes some fixed standing wave ratio in the waveguide system; that is, it assumes some fixed ratio between the maximum and minimum voltages of the standing waves in the system. It is advantageous that this standing wave ratio be near unity. In magnetron construction it is difficult to build tubes having output leads and coupling loops with identical electrical characteristics.

There are two general types of terminations used for magnetron coaxial output leads. One type has the center lead sealed through an insulating seal, preferably glass, and the other type has the center lead entirely within the wall of the evacuated container which may include the

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envelope or an extension from the envelope. This latter type may be termed the antenna termination. It is known that such output leads inserted in waveguides have the disadvantage of having corona form in some region adjacent the coaxial termination when operated at high power levels. Such corona forms at the coaxial output lead termination at power levels well below that at which the connected waveguide system could operate corona-free.

It is an object of my invention to provide an electron discharge device of the magnetron type having improved means for coupling the magnetron to a load.

It is a further object of my invention to provide an electron discharge device of the magnetron type, particularly of the cavity resonator type in which the output lead for different magnetrons have substantially identical electrical characteristics.

It is a further object of my invention to provide an output lead for a cavity resonator magnetron which is simple in construction and which is capable of accurate reproduction and which can be easily made.

A still further object of my invention is to provide an output lead which will operate at power levels above those normally associated with conventional output leads.

A still further specific object of my invention is to provide output leads which will eliminate the necessity for employing loops and seals for coaxial line type coupling arrangements.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a longitudinal section of one form of an electron discharge device and an output lead made according to my invention, Figure 2 is a longitudinal section taken at 90° to Figure 1, Figure 3 is a transverse section taken along the line 3—3 of Figure 1, Figure 4 is a perspective view showing the coupling arrangement between a waveguide and the output lead disclosed in Figures 1, 2 and 3, Figure 5 shows a modification of an electron discharge device and output lead made according to my invention, Figure 6 is a longitudinal section taken along the line 6—6 of Figure 5, and Figure 7 is a section taken along the line 7—7 of Figure 6, Figure 8 is a perspective of another method of coupling the output lead made according to my invention to a waveguide.

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Referring to Figure 1, the magnetron employs a metallic evacuated envelope 10 of rectangular transverse section containing a magnetron mount assembly which includes preferably an indirectly heated cathode 11 surrounded by and coaxial with the anode assembly comprised of a heavy ring member 12 and the radially positioned vanes lying parallel to cathode, which form between the vanes 13 cavity resonators of more or less U-shape. These vanes 13 are connected together by means of ring-like straps 14 and 15 which engage alternate vanes to insure a proper mode of operation. The cathode is heated by means of the heater 11' and an electron shield 11'' at the top of the assembly. Cathode heater leads 16 and 17 are shielded from the anode assembly by means of the shield 18, the cathode heater assembly and leads being supported by means of the tubular member 19 and bracket 20 supported from the anode assembly and the insulating supporting member 21, preferably of glass. The cathode heater leads extend through the tubular shield member 22 and are sealed vacuum-tight by means of the insulating cup-shaped member 23. The envelope may be exhausted through the tubular member 24 which is tipped-off after evacuation.

In accordance with my invention the anode assembly has a portion removed from one side thereof and a coupling perforation extending normal to the cathode so as to provide communication from one resonator between two vanes to the exterior of the anode assembly. The envelope 10 is also provided with a registering coupling aperture 24'. In accordance with my invention I provide an output lead which includes a tubular member having an elongated rectangular transverse section, the first section 25 of which is also provided with a coupling aperture 24'' registering with the apertures in the anode assembly and in the wall of the casing. This member 25 is in turn received with a second rectangular tubular member 26, the other end of which is sealed vacuum-tight by means of closure member 27 permeable to electromagnetic waves. The end sealed of this member 26 is in turn coupled to the end of waveguide member 28 and insulated therefrom by member 29. A quarter wave overlap is employed so that minimum impedance is provided for any R.-F. current inside the waveguide. A magnetic field for the magnetron is provided by magnets 60 and 61.

It will be observed that the waveguide 28 is so oriented with respect to the anode that so-called $H_{0,1}$ wave is generated within the output lead, the longer axis of the guide lying parallel to the cathode. Inasmuch as circulating currents flow in the walls of the cavity resonator such that the magnetic lines of force are parallel to the cathode, these magnetic lines extend through coupling aperture 24, 24', 24'' to excite the output lead and coupled waveguide. This is the simplest configuration of any rectangular hollow tube wave. With this arrangement radiation from the waveguide will be most effective. This feature is unique to the $H_{0,1}$ wave and rectangular hollow tube and makes it especially adaptable as a radiator.

The $H_{0,1}$ is also referred to as the $TE_{0,1}$ mode of wave propagation through waveguides. In this mode of propagation, the electric field is transverse to the propagation and has no component along the axis of propagation. The magnetic field lies parallel to the direction of propagation and has no component transverse to the direction of propagation. In other words, the mag-

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netic field lies along the axis of the tube. In this form of wave the electric field has one peak having a maximum intermediate the short ends of the waveguide.

In Figures 5 to 7, inclusive, is shown a different type of magnetron with a modification of an output lead made according to my invention. As shown in Figures 5 and 6, the indirectly heated cathode 30 is surrounded by a laminated anode assembly comprising a plurality of stacked punched plates 31, 32, 33 and 34, these plates being so punched that a plurality of radially directed slots of substantially uniform width are provided in the anode structure. These slots act as cavity resonators with the inner ends of the fingers acting as anode segments. Top and bottom cup-shaped members 35 and 36 are closed by means of telescoped cup-shaped members 42 and 43 to provide a vacuum for the electrodes within the envelope so provided, the plates being vacuum sealed by means of, for example, silver solder between the plates. The cathode assembly is supported within the anode assembly by means of the brackets 40 and 41 supporting the bridge 37 by means of the insulating U-shaped elements 38 and 39. Electromagnets 47 and 48 are inserted within the cup-shaped member to provide the magnetic fields. As shown in Figure 5 the cathode heater is supplied by means of cathode heater leads 44 and 45 sealed in the envelope by means of insulating cup-shaped element 46.

In accordance with my invention one of the slots is coupled to the output lead by a flared coupling opening or chamber 49 extending from the outer end of the slot to the outer wall of the anode assembly. The coupling chamber 49 receives the tubular waveguide output lead 50, which may be of rectangular shape and vacuum sealed by means of the window closure 51 permeable to electromagnetic wave. The coupling chamber serves as a transition device for matching the impedance of the magnetron slot to that of the output lead. As in the case shown in Figure 1, $H_{0,1}$ waves are generated which travel down along the waveguide output lead 50 with maximum efficiency. In the arrangement shown in Fig. 8, the wave guide 55, which may be the one directly coupled to the magnetron through the aperture, is coupled to a second wave guide 56, the wave guides being provided with lips 57 and 58. Each of the lips is a quarter wave length wide at the operating frequency and extends transversely of the wave guide. The high impedance at the outer edges of the lips produces a low impedance at the inner edges of the lips which minimizes leakage from the wave of high frequency energy passing through the wave guides.

The output leads may be made of any suitable metal, or combination of metals. In particular, such a suitable combination of metals as Kovar and copper may be used. The surfaces of the leads may be plated to increase the electrical conductivity. Other shapes of cavity quarter wave joints may be used to connect output leads to waveguide systems.

The coupling perforation described permits accurate reproduction and makes possible the manufacture of magnetrons having nearly identical operating characteristics. Perforations may be punched or drilled to closer tolerances than loops and coaxial lines may be fabricated. Thus only very small tuning changes are required in the waveguide system when magnetrons are interchanged.

The output lead and termination have no regions in air in which excessive electrical in-

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tensities are produced relative to those in the waveguide system. Thus, this combination may be used at higher power levels with no corona.

While I have indicated the preferred embodiments 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.

What I claim as new is:

1. An apparatus for use at high radio frequencies, including a cavity resonator, means for providing an electron discharge for exciting said resonator, said resonator having an aperture extending through a wall thereof, and a waveguide adjacent said resonator and having an aperture opening into the aperture in said resonator, said wave guide comprising an elongated hollow tubular member having its end remote from the apertured wall sealed by a closure member permeable to electromagnetic waves, said waveguide having a rectangular shaped transverse section and being oriented with respect to said cavity resonator so that $H_{0,1}$ type electromagnetic waves are developed within the waveguide.

2. An electron discharge device having an envelope of elongated flattened rectangular shaped transverse section, an electrode assembly within said envelope and including a cathode surrounded by an anode means having a plurality of cavity resonators, the longitudinal axis of said cathode and anode means lying parallel to the shorter axis of said envelope, said anode means having one side abutting one end of the wall of said envelope, said anode means having an aperture extending therethrough and opening into one of said resonators, said envelope having an aperture registering with the aperture in said anode means and a waveguide extending from and secured to said envelope and having an aperture registering with the apertures in said envelope and said anode means, said waveguide having a rectangular transverse section the longer axis of which lies parallel to the longitudinal axis of said cathode, said waveguide having the end remote from said envelope closed by means permeable to electromagnetic waves.

3. An electron discharge device having a metal elongated envelope of rectangular-shaped transverse section, an electrode assembly mounted within said envelope and including a cathode lying parallel to the shorter axis of said rectangular envelope, an anode assembly surrounding said cathode, said anode assembly having a plurality of cavity resonators opening into the space surrounding said cathode, said anode assembly being flattened and having its shorter axis parallel to the shorter axis of said envelope, said anode assembly contacting one end of said envelope, the end of said envelope and said anode assembly having registering apertures opening into one of said resonators, and a waveguide supported by one end of said envelope and having apertures opening into the aperture in said envelope and said anode assembly, said waveguide having a rectangular-shaped transverse section, the longer axis of said waveguide lying parallel to said cathode, and means permeable to electromagnetic waves closing the end of said waveguide remote from said envelope.

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4. An electron discharge device having an envelope of flattened rectangular shaped transverse section, an electrode mount assembly within said envelope and including an elongated cathode surrounded by an anode block including a plurality of cavity resonators, the interior of said envelope communicating with the space between the cathode and the anode block, said anode block having a passageway extending therethrough and opening into the interior of one of said cavity resonators, said electrode assembly being adjacent one end wall of said envelope, said end wall of said envelope having an aperture opening into the aperture in said anode block, and a hollow waveguide having an elongated transverse section and extending from an outside wall of said envelope and communicating with the apertures in the wall of said envelope and said anode block, the longer transverse axis of said waveguide lying parallel to the axis of said cathode.

5. An electron discharge device including a cathode and an anode block having a central chamber, said cathode being within said chamber, said anode block having a plurality of radially-extending slots of substantially uniform width communicating with the chamber between the cathode and the anode block and forming resonators, the end of one of said slots remote from said cathode opening into a coupling chamber having side walls diverging toward the outside of said anode block, and a tubular output lead extending from said block and opening into said coupling chamber, said tubular output lead having a rectangular shaped transverse section and being oriented with respect to said one slot and coupling chamber so that $H_{0,1}$ type electromagnetic waves are developed within the output lead.

6. An electron discharge device including an anode block, said anode block being provided with a central chamber and having a plurality of radially extending slots of substantially uniform width communicating with said chamber, and a cathode mounted within said chamber, the end of one of said slots remote from said cathode opening into a coupling chamber having side walls diverging toward the outside of said anode block, a tubular output lead extending from said block and having one end opening into said coupling chamber and having its other end sealed by a closure member permeable to electromagnetic waves said tubular output lead having a rectangular shaped transverse section and being oriented with respect to said one slot and coupling chamber so that $H_{0,1}$ type electromagnetic waves are developed within the output lead, and means for providing a magnetic field between said cathode and anode block.

7. An electron discharge device comprising an electrode assembly including an indirectly heated cathode, an anode assembly coaxial with and surrounding said cathode, said anode assembly including a plurality of laminations having radially extending slots of substantially uniform width registering with each other, one group of registering slots opening into a coupling chamber having an increasing transverse section moving from the inside to the outside of said anode assembly, said chamber opening into a hollow output lead of rectangular section having its longer axis parallel to the longitudinal axis of the cathode, closure members for the ends of said electrode assembly for providing an evacuated space for the electrode assembly and means

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for providing a magnetic field between said cathode and anode block and parallel to said cathode.

8. An electron discharge device comprising an electrode assembly including an indirectly heated cathode, an anode assembly coaxial with and surrounding said cathode, said anode assembly including a plurality of laminations having radially extending slots of substantially uniform width registering with each other, one group of registering slots opening into a coupling chamber having an increasing transverse section moving from the inside to the outside of said anode assembly, an elongated tubular output lead having one end opening into said chamber, closure members for the ends of said electrode assembly for providing an evacuated space for the electrode assembly, means for providing a magnetic field between said cathode and anode block and parallel to said cathode, and a closure member permeable to electromagnetic waves and sealing the said other end of said tubular output lead.

9. An apparatus for use at high radio frequencies, including a cavity resonator, means for providing an electron discharge for exciting said resonator, said resonator having an aperture extending through a wall thereof, and a hollow wave guide extending outwardly from the outside wall of said resonator and opening into the aperture in said resonator, said wave guide comprising an elongated tubular member having its end remote from the apertured wall of said resonator sealed by an insulating medium permeable

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to electromagnetic waves, said wave guide having a transverse lip at the outer end thereof having a width equal to a quarter wavelength of the operating frequency for coupling to a waveguide provided with a like lip.

HOWARD R. HEGBAR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,684,947	Daumann	Sept. 18, 1928
2,063,342	Samuel	Dec. 8, 1936
2,200,023	Dallenbach	May 7, 1940
2,223,082	Van Mierlo	Nov. 26, 1940
2,247,077	Blewett et al.	June 24, 1941
2,283,935	King	May 26, 1942
2,298,949	Litton	Oct. 13, 1942
2,351,744	Chevigny	June 20, 1944
2,372,193	Fisk	Mar. 27, 1945
2,402,184	Samuel	June 18, 1946
2,404,086	Okress et al.	July 16, 1946
2,408,409	Bowen	Oct. 1, 1946
2,408,903	Biggs et al.	Oct. 8, 1946
2,446,825	Gurewitsch	Aug. 10, 1948
2,450,023	Spencer	Sept. 28, 1948

FOREIGN PATENTS

Number	Country	Date
215,600	Switzerland	Oct. 16, 1941