June 3, 1952 R. R. LAW ET AL 2,599,263

ULTRAHIGH-FREQUENCY ELECTRON DISCHARGE DEVICE

Original Filed Aug. 15, 1944 2 SHEETS—SHEET 1

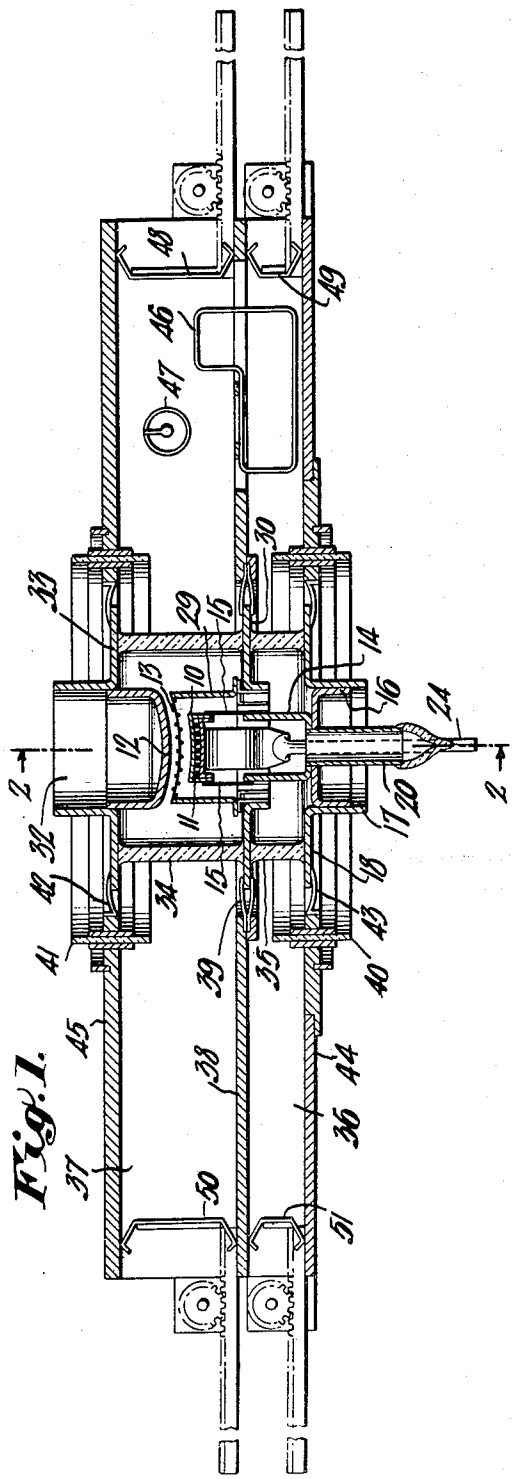


Fig. 1.

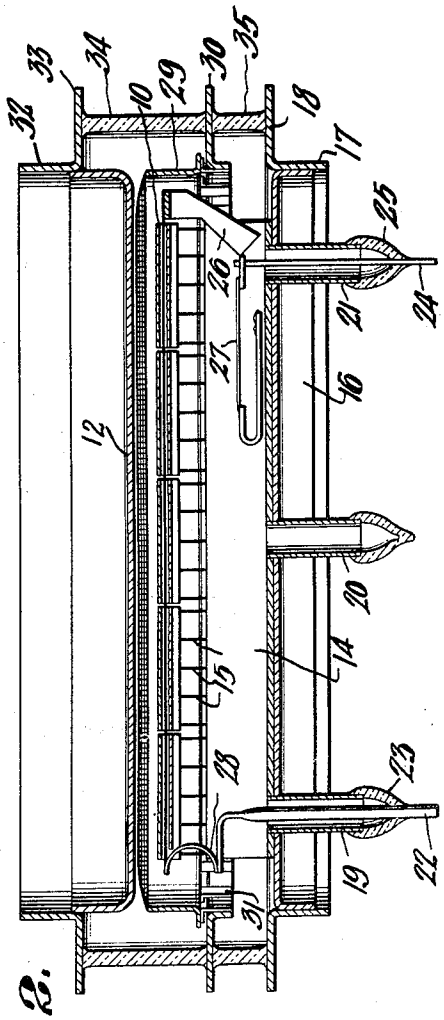


Fig. 2.

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ULTRAHIGH-FREQUENCY ELECTRON DISCHARGE DEVICE

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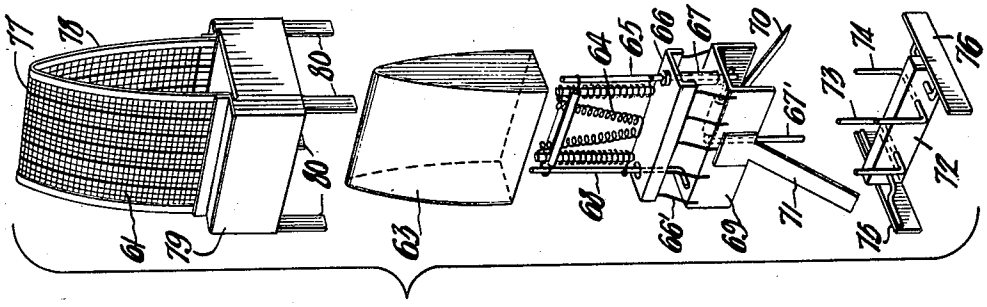


Fig. 5.

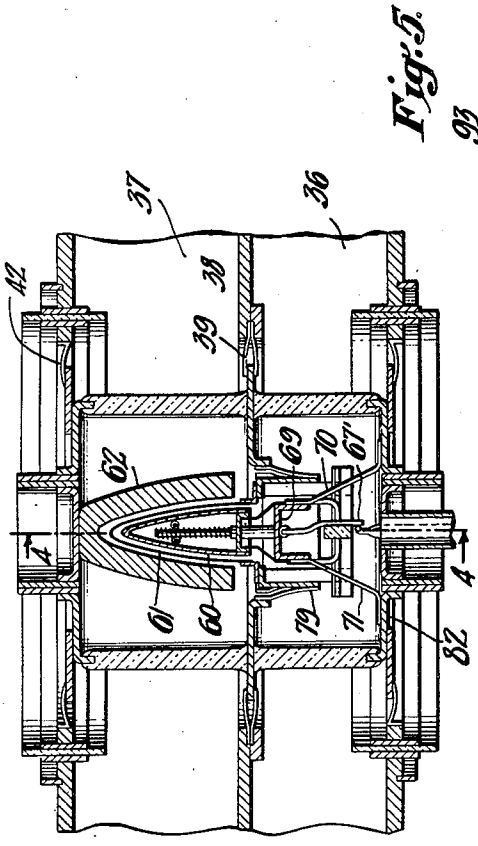


Fig. 3.

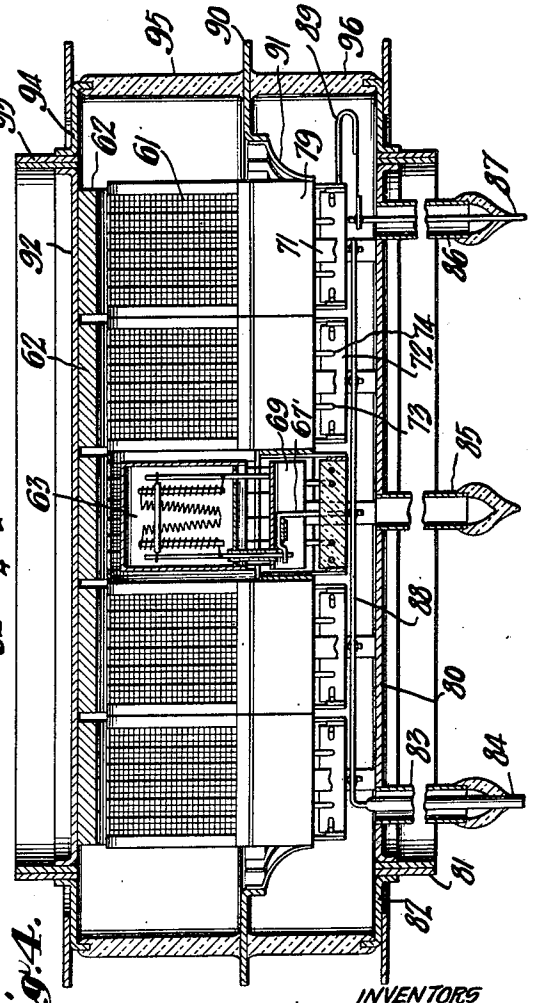


Fig. 4.

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UNITED STATES PATENT OFFICE

2,599,263

ULTRAHIGH-FREQUENCY ELECTRON DISCHARGE DEVICE

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Original application August 15, 1944, Serial No. 549,513. Divided and this application April 23, 1948, Serial No. 22,753

10 Claims. (Cl. 315—6)

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Our invention relates to electron discharge devices particularly useful at ultra high frequencies, and more particularly to such devices having high power output and which can be utilized with tunable cavity resonator circuits.

This application is a division of our copending application, Serial No. 549,513, filed August 15, 1944, which issued on September 6, 1949 as U. S. Patent No. 2,481,026, and assigned to the same assignee as the present application.

Certain types of triode electron discharge devices having cathode, grid and anode electrodes provided with planar surfaces of disc-shape have been found satisfactory for moderate power at moderately high frequencies. However, as the power is raised the overall size of the tube and circuit, usually of the cavity resonator type, must diminish, thus bringing about a reduction in the power output. For example, inasmuch as the tube elements must be relatively small compared to a wavelength, at 3000 megacycles it would be inadvisable to use a cathode much smaller than one centimeter in diameter. Thus at 3000 megacycles, such a tube would be limited to peak power outputs of ten kilowatts.

While elongated electrode structures such as described and claimed in a copending application of Russell R. Law, Serial No. 542,717, filed June 29, 1944, which issued on May 24, 1949 as patent No. 2,471,037, and assigned to the same assignee as the present application, permit extension of the dimensions of the circuit and tube elements along a longitudinal axis without affecting the frequency, the higher frequencies require smaller transverse cross sections, resulting in difficulties of assembly and operation. As pointed out in a copending application of Russell R. Law, Serial No. 549,514, filed August 15, 1944, which issued on March 21, 1950 as patent No. 2,501,181, and assigned to the same assignee as the present application, external circuits of satisfactory size and operated at a harmonic mode may be utilized, such circuits being of desirable size and tunable. For such operation, electron discharge devices having envelopes and suitable electrode connecting leads to be engaged by the cavity resonator circuits are required. Conducting flanges supporting and connected to the electrodes and sealed through the envelope of the tube offer the most satisfactory low loss connecting means which can be merged into the cavity resonator circuit walls. It is desirable to employ standard technique for the manufacture of such tubes if possible. It is also desirable to have the voltage nodes of the generated R. F. voltages at the seals

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between the leads and the envelope to avoid voltage breakdown at the seals.

To eliminate or substantially reduce electron transit time difficulties, close spacing of the electrodes is necessary, introducing construction difficulties and increasing the problem of heat dissipation with its inherent deformation of electrodes due to temperature changes. Where long electrodes are utilized it is essential that cathode heating power be conserved, and to provide large power outputs a large cathode area is necessary.

It is, therefore, an object of our invention to provide an electron discharge device of improved design useful at ultra high frequencies, more specifically in the range above 1000 megacycles.

A further object of our invention is to provide such a device capable of large power outputs.

A still further object of our invention is to provide such a device utilizing cavity resonators and in which electrodes are suitably supported from leads which can be merged into the cavity resonator walls.

More specifically, it is an object of our invention to provide such an electron discharge device which will operate in a mode such that at least one of the dimensions of the electrodes is independent of the frequency at which the device is to be operated.

A further object of our invention is to provide an electron discharge device which will permit the use of external circuits operated in a harmonic mode and which is so designed that the voltage nodes occur at the seals.

A still further specific object of our invention is to provide such a device in which close electrode spacing is possible but in which rigid support is obtained.

A still further object of our invention is to provide a cathode of comparatively large emitting area. These and other objects will appear hereinafter.

The novel features which we believe to be characteristic of our invention are set forth with particularly 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 Fig. 1 is a section transverse to the longitudinal axis of an electron discharge device and its associated circuit claimed in our copending application Serial No. 549,513, above referred to, Fig. 2 is a section taken along the line 2—2 of the electron discharge device shown in Fig. 1, Fig. 3 is a section taken transverse to the longitudinal axis of a modification of the electron discharge device

shown in Fig. 1 and embodying our present invention, Fig. 4 is a section taken along the line 4—4 of Fig. 3, and Fig. 5 is an exploded view of the unit cathode-grid arrangement made according to our invention.

An electron discharge device made according to our invention includes elongated linear electrodes provided with conducting leads and flanges which readily merge into the cavity resonator walls of cavity resonator circuits coupled to the electrodes.

Referring to Figs. 1 and 2, the electrode system comprises an indirectly heated cathode 10 having a cathode heater 11, an oppositely disposed anode 12 and an intermediate grid 13. The cathode is supported by means of conducting fingers or rods 15 from the cathode support 14 for reducing heat conduction from the cathode. The cathode 10 and support 14 are mounted in an elongated trough-like element 16 having secured to it a collar-member 17 provided with the transverse lip or flange 18. Tubular elements 19, 20 and 21 extend through the elements 14 and 16 and provide apertures through which the cathode heater leads 22 and 24 extend, being sealed in by cup-shaped elements 23 and 25. The lead 22 is connected to one end of the cathode heater by loop 28 and the other end of the cathode heater is connected by means of the conductor 26 to lead 24, the cathode proper being connected to the lead 24 by means of the conducting loop 27. The sealed-off tubular extension 20 serves as the exhaust tube.

The grid 13 is supported from the elongated grid collar 29 and in turn is supported from the grid flange and lead 30 by means of the conducting fingers 31. The anode is supported within the elongated collar-like element 32 provided with the flange 33. Elongated collar members 34 and 35, preferably of glass are sealed between the lips 33, 30 and 18 to provide an envelope for the electrode elements 10, 13 and 12. The cathode and grid electrodes and the flanges connected to the electrodes have rounded ends, so that the outlines of these elements represent elongated ellipses.

As shown in Fig. 1, a cathod-grid cavity resonator 36 is coupled between the grid and the cathode and an output cavity resonator 37 is coupled between the grid and the anode. The walls of the resonators are flat sheet-like elements 44, 38 and 45 closed at their ends by means of the sliding closure members 51, 49, 48 and 50. Coupling between the resonators is accomplished by means of the coupling loop 46 and the output taken by means of the coaxial line and loop 47.

The grid flange 30 is directly connected to the intermediate wall portion of the cavity resonators 38 by means of the spring fingers 39. The wall 44 is capacitively coupled to the spring fingers 43 contacting the flange 18 through the insulating collar 40 and the anode flange 33 is contacted by the spring fingers 42 coupled to the wall 45 through the insulating collar 41 preferably of mica. By this means it is possible to provide biasing voltages between the various electrodes by providing closed paths for the radio frequency currents flowing within the resonators. The mode of operation of the circuit associated with the electron discharge device shown in Figs. 1 and 2 is described in detail and claimed in the copending application of Law above referred to, Serial No. 549,514.

The cathode is made in a plurality of sections,

as shown, to permit expansion and contraction of the various parts of the cathode without causing buckling and shorting between the electrode elements. The elements have curved surfaces to insure the expansion of the electrode surfaces in the same dirction, thus avoiding shorts.

The modification shown in Figs. 3, 4, and 5 provides greater cathode area and utilizes unit construction. Such an arrangement facilitates construction of the electrodes and assembly of the device. The elongated hyperbolic transverse section of the electrode elements insures that any bowing which occurs in the grid will not cause shorting.

In the arrangement shown in Figs. 3 to 5, inclusive, nested electrodes are utilized, a wedge-shaped indirectly heated cathode 60 and a V-shaped grid 61 being positioned within a V-shaped anode 62.

The cathode, heater and grid elements shown in the exploded view in Fig. 5 can be assembled as a unit and then assembled on the cathode support before being inserted together with similar units within the tube envelope. Referring to Fig. 5, each cathode element includes the wedge-shaped shell 63 having outwardly bowed surfaces, or surfaces which are convex outward, the shell being assembled over the heater 64 and secured to the transverse conducting enclosure member 66 of U-shaped cross section. One side of the cathode heater is connected to the support rod 65 and the other to the support rod 68. The support rod 65 is provided with an insulating collar 67 extending through member 66 and a second U-shaped conducting member 69, the conductor 65 being electrically connected to the cathode lead 67', insulatingly supported from the under side of the element 69, the element 66 being supported by means of the rod-like conducting fingers 66' from the member 69. The conductor 68 is connected to the member 69 which is provided with a pair of ribbon-like supporting and connecting tabs or leads 70 and 71. The cathode and cathode heater support include an insulating member 72 having U-shaped supporting elements 73 and 74 and provided with end supporting elements 75 and 76. The members 73 and 74 are secured to the member 69. Each element of the grid 61 also having surfaces which are convex outward and provided with strengthening ribs 77 and end ribs 78 is supported from the box-like shield 79 having conducting legs 80 which are fastened to the elements 75 and 76 to provide a unitary cathode-grid structure. In assembly the conductors 70 and 71 are welded to the elongated cathode supporting structure made up of central element 80 provided with collar 81 and flange 82. Tubular members 83 and 86 provide apertures through the element 80 through which the cathode heater and leads 84 and 87 extend and are sealed, the tube 85 providing the exhaust tube which is sealed after exhaust. The conductor 84 is electrically connected to longitudinally extending conductor 88 to which each of the cathode heater leads 67' is connected. The conductor 87 by means of conductor 89 may be connected to one of the cathode elements 69, all of which are connected through the straps 70 and 71 to the flange 82, thus providing a circuit through all of the heaters in parallel. The grid is connected to the grid lead and flange 90 by means of the conducting fingers 91. The anode elements are supported from the elongated anode conducting element 92 provided with the collar 93 and flange 94. The insulating collars 95 and

96, preferably of glass, are sealed between the flanges 94, 90 and 82 to provide an envelope for the elements within the envelope.

The electrical length of the cathode is a transverse cross sectional length as shown in Fig. 3 and should not be more than one-quarter wave-length long to prevent nodes on the cathode proper. For 1200 megacycles a length of cathode of approximately six centimeters folded in the middle is the proper transverse length of section. The broad base for the cathode eliminates the necessity for support at the top of the cathode. This is also true of the grid. A mesh grid is preferably utilized to obtain proper lateral support. The grid supporting wires can provide the necessary grid strength.

With the electron discharge device shown in Figs. 1 and 2 and utilizing the circuit shown in Fig. 1, it is possible to operate the tube and circuit between a range of 1320 and 2050 megacycles, a peak power output of 26 kilowatts being obtained at 1300 megacycles at about six kilovolt anode potential, the output being limited only by radio frequency spark-over.

The V-shaped electrodes having convex surfaces in Figs. 3–5 are claimed in a divisional application of Louis Pensak, Serial No. 254,077, filed October 31, 1951, assigned to the same assignee as the present application.

While we have indicated the preferred embodiments of our invention of which we are now aware and have also indicated only one specific application for which our invention may be employed, it will be apparent that our 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 our invention as set forth in the appended claims.

What we claim as new is:

1. An electron discharge device having elongated cathode, grid and anode electrodes, each of said electrodes including a plurality of like elements, each cathode element including a wedge-shaped member and a cathode heater received within said cathode member, a pair of superimposed spaced conducting elements having transverse U-shaped sections, one of said conducting elements closing the end of said cathode member, a plurality of rod-like conductors extending between said conducting elements of U-shaped transverse section, tabs extending from opposite sides of the other of said conducting elements of transverse U-section and a grid support comprising an elongated insulating member having supporting elements secured thereto and to said other conducting element, and a grid element disposed over each cathode member and heater and having a box-like shield surrounding the conducting element of transverse U-section, said box-like shield having a plurality of supporting fingers secured to said grid support.

2. A cathode for an electron discharge device including a wedge-shaped member and a cathode heater received within said member, a pair of superimposed spaced conducting elements having transverse U-shaped sections, one of said conducting elements closing the end of said cathode member, rod-like conductors extending between said elements of U-shaped transverse section, tabs extending from opposite sides of the other of said conducting elements of transverse U-section and a grid support comprising an elongated insulating member and supporting means extending between said other conducting element and said elongated insulating member.

3. An electron discharge device having a plurality of electrodes and including a cathode, said cathode comprising a wedge-shaped member and a cathode heater received within said member, a pair of superimposed spaced conducting elements, one of said conducting elements closing the end of said cathode and a plurality of rod-like conductors extending between said conducting elements, and a grid disposed over said cathode and heater and having a box-like shield surrounding the other conducting element and supported thereby in insulated relation.

4. A cathode for an electron discharge device including a wedge-shaped member and a cathode heater received within said member, and a pair of superimposed spaced conducting elements, one of said conducting elements closing the end of said cathode member and rod-like conductors extending between said elements, and conducting tabs extending from opposite sides of the other of said conducting elements.

5. A cathode for an electron discharge device including a wedge-shaped member and a cathode heater received within said member, a pair of superimposed spaced conducting elements having transverse U-shaped sections, one of said conducting elements closing the end of said cathode member and rod-like conductors extending between said elements of U-shaped transverse section, and tabs extending from opposite sides of the other of said conducting elements of transverse U-section, one end of the heater being electrically connected to said tabs, and the other end of the heater extending through but insulated from said conducting elements.

6. A unitary cathode-grid assembly for an electron discharge device including a cathode, said cathode comprising a wedge-shaped member and a cathode heater received within said cathode, a pair of superimposed spaced conducting elements, one of said conducting elements closing the end of said cathode, a plurality of rod-like conductors extending between said elements, a grid support including an insulating member, supporting means secured between the other conducting element and the insulating member, and a V-shaped grid disposed over said cathode and heater and having a box-like shield surrounding the other conducting element and supported from said grid support.

7. An electron discharge device having elongated cathode and grid electrodes, each of said electrodes including a plurality of like elements, each cathode element including a wedge-shaped member and a cathode heater received within said cathode and including a pair of superimposed spaced conducting elements, one of said conducting elements closing the end of said cathode, a plurality of rod-like conductors extending between said elements and tabs extending from opposite sides of the other of said conducting elements, and a grid support comprising an insulating member, supporting wires extending between the other conducting element and said insulating member, a grid disposed over each cathode member and heater and having a box-like shield, each of said grid box-like shields having a plurality of supporting fingers secured to a grid support, and an anode having a space within which said grid and cathode electrodes are received, and an elongated member having a flange and connected to said cathode tabs, a second flange, said second flange being connected to the grid box-like shields

and a third flange connected to said anode, and insulating collar-like elements sealed between said flanges for providing an envelope for said cathode, grid and anode electrodes.

8. An electron discharge device having elongated cathode and grid electrodes, each of said electrodes including a plurality of elements, each cathode element including a wedge-shaped member and a cathode heater received within said cathode and including a pair of superimposed spaced conducting elements, one of said conducting elements closing the end of said cathode, a plurality of rod-like conductors extending between said elements, and a grid element disposed over each cathode member and heater and having a box-like shield around the other conducting element, and rod-like conductors, and an anode having a space within which said grid and cathode elements are received, and an elongated member having a flange and connected to said cathode elements, a second flange connected with the grid box-like shields and a third flange connected to said anode and insulating collar-like elements sealed between said flanges for providing an envelope for said cathode, grid and anode electrodes.

9. A grid for an electron discharge device including a V-shaped portion, and a box-like shield secured to the ends of said portion, and a plurality of fingers extending from the unattached edge of the box-like shield.

10. A grid for an electron discharge device including a mesh member having a V-shaped transverse section, and strengthening ribs extending through said mesh, and a box-like shield secured to the ends of said member and supporting fingers of conducting material extending from the unattached edge of said box-like shield.

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LOUIS PENSAK.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,628,982	Hulsizer	May 17, 1927
1,718,632	Bullimore	June 25, 1929
1,838,201	Traver	Dec. 29, 1931
2,298,949	Litton	Oct. 13, 1942
2,410,054	Fremlin et al.	Oct. 29, 1946
2,416,302	Goodall	Feb. 25, 1947
2,416,315	Hartman	Feb. 25, 1947
2,419,578	Litton	Apr. 29, 1947
2,456,579	Burnside	Dec. 14, 1948
2,466,063	Varian	Apr. 5, 1949
2,471,037	Law	May 24, 1949