June 22, 1948. J. M. LAFFERTY 2,443,917

WAVE GUIDE-DISCHARGE TUBE SOCKET ASSEMBLY

Original Filed Feb. 25, 1943 3 Sheets-Sheet 1

Fig. 1.

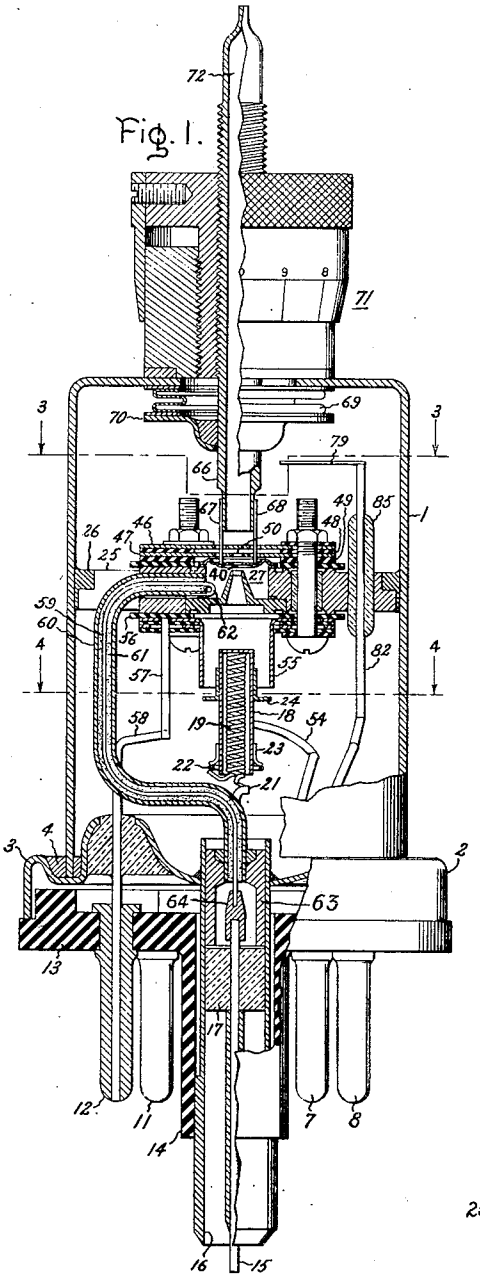


Fig. 3.

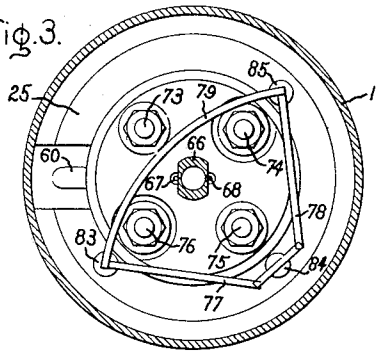


Fig. 4.

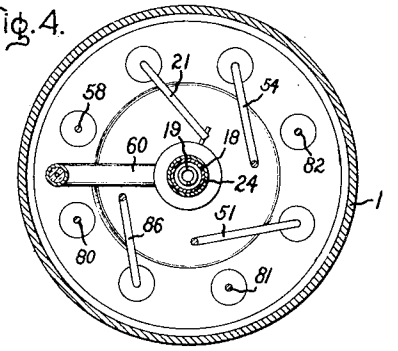


Fig. 5.

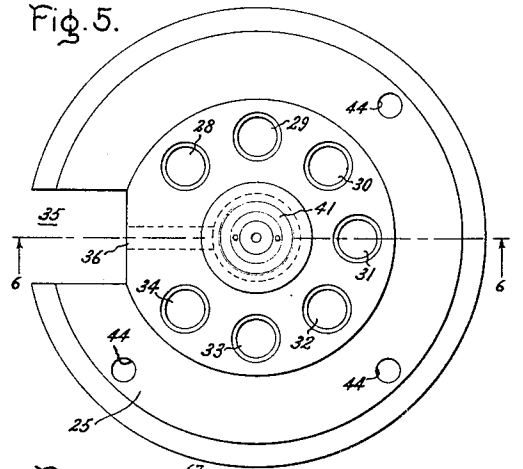
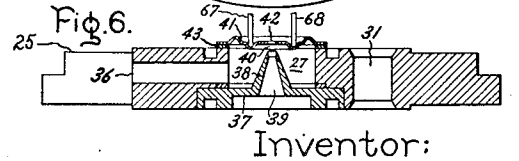


Fig. 6.



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Original Filed Feb. 25, 1943 3 Sheets-Sheet 2

Fig. 2.

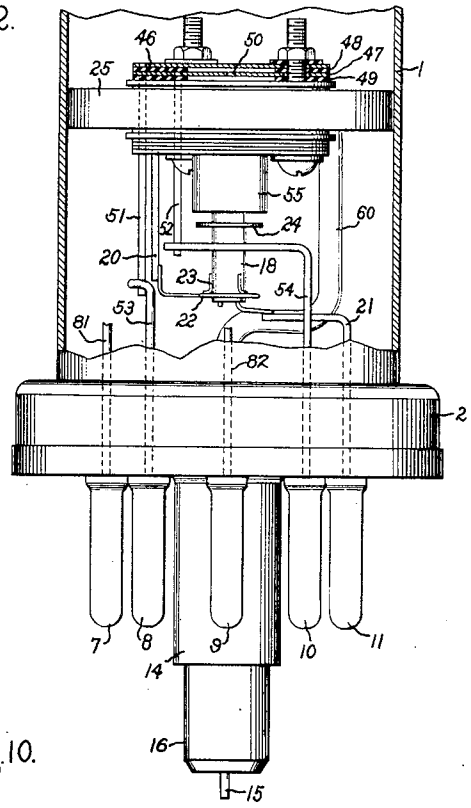


Fig. 10.

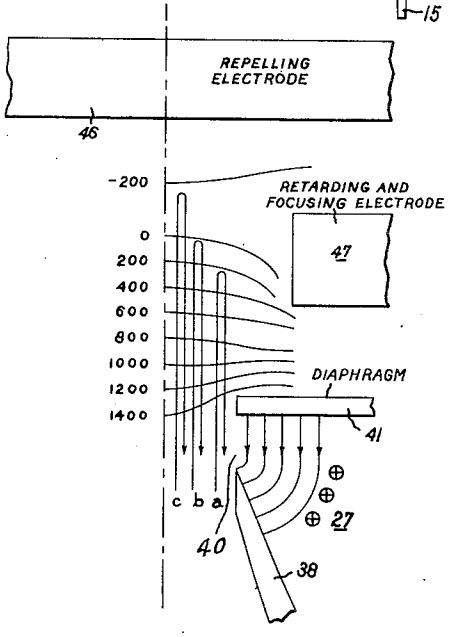
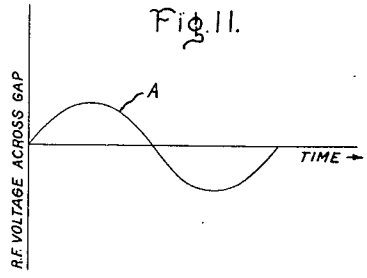


Fig. 11.



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June 22, 1948. J. M. LAFFERTY 2,443,917

WAVE GUIDE-DISCHARGE TUBE SOCKET ASSEMBLY

Original Filed Feb. 25, 1943 3 Sheets-Sheet 3

Fig. 7.

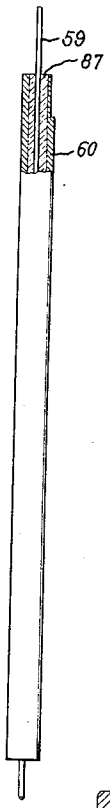


Fig. 8.

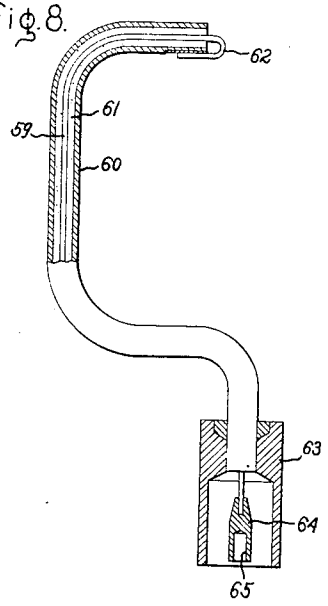
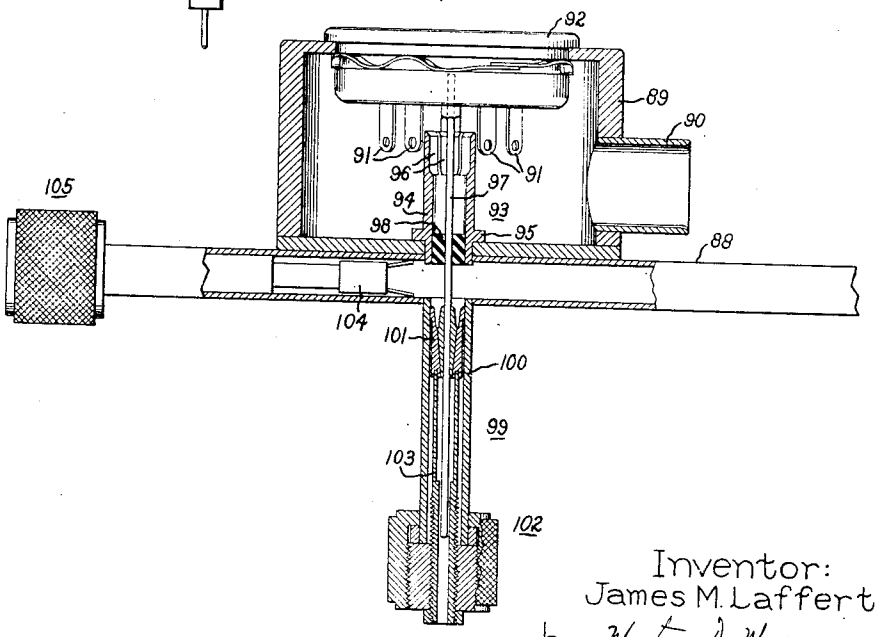


Fig. 9.



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Patented June 22, 1948

2,443,917

UNITED STATES PATENT OFFICE

2,443,917

WAVE GUIDE DISCHARGE TUBE SOCKET ASSEMBLY

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Original application February 25, 1943, Serial No. 477,065. Divided and this application July 26, 1945, Serial No. 607,113

4 Claims. (Cl. 178—44)

1

My present invention is a division of my application S. N. 477,065, filed February 25, 1943, now Patent No. 2,421,273, and relates to high frequency electric discharge devices and systems and more particularly to ultra high frequency electric discharge devices of the space resonant type employing velocity modulation principles.

It is an object of my invention to provide a new and improved construction for an ultra high frequency electric discharge device wherein connection to the ultra high frequency circuit and manipulation of the device as a whole is facilitated.

In accordance with my invention, there is provided a new and improved construction for an ultra high frequency electric discharge device wherein connection to the ultra high frequency parts or elements of the device may readily be made and wherein the arrangement of the elements and the supporting and enclosing structures are compact and susceptible of ready manipulation for use in ultra high frequency systems.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims. Figs. 1 and 2 are cross-sectional longitudinal views of an electric discharge device of the velocity modulation type built in accordance with my invention, and Figs. 3–6, inclusive, are detailed cross-sectional views of this discharge device. Figs. 7 and 8 illustrate the high frequency concentric transmission line construction employed and also illustrate steps in the method employed for forming the transmission line assembly into the desired configuration for use in the device shown in Fig. 1. Fig. 9 shows in cross-sectional view a socket arrangement for receiving the discharge device base terminals or prongs for adaptation to an ultra high frequency system such as a dielectric wave guide. Fig. 10 is an enlarged diagrammatic sketch showing a possible distribution of equipotential lines of force in the retarding and reversing regions of the discharge device, and which also illustrates the paths of electrons having different amounts of energy and the probable paths of such electrons. Fig. 11 shows the manner of variation of the radio frequency or the ultra high frequency modulating voltage which appears across the modulating gap within the space resonant cavity.

Referring now to Fig. 1, my invention is there illustrated as applied to an ultra high frequency electric discharge device comprising an enclosing envelope 1, preferably of rigid construction, comprising a metal such as iron, and which defines at least in part an evacuated space within which are positioned the various elements or electrodes of the discharge device described hereinafter. The envelope 1 is supported by and sealed to a base member 2 which comprises a flanged metallic part 3 provided with an annular trough in which the lower end of envelope 1 is seated and which contains a suitable sealing means such as a solder 4. A plurality of prongs or terminal posts 5–12, inclusive, are supported by an insulating part 13 of base member 2 in insulated relation and which serve as externally accessible contacts for the electrodes of the discharge device. Only six of the aforementioned terminal posts are visible in the views shown in Figs. 1 and 2.

2

An orientation protuberance for guiding the insertion of the base member 2 and the terminal posts into an associated socket is provided and is preferably centrally located. The orientation protuberance may comprise a tubular extension 14 of insulating material formed integral with part 13 and having a central opening through which extends a concentric transmission line comprising an inner conductor 15 and an outer tubular conductor 16, which is sealed to the top surface of part 3. The transmission line just described is terminated near its upper end by means of a sealing insulator 17 within conductor 16 and which not only serves as mechanical support and positioning means for the inner conductor 15, but also serves as the means for sealing these elements to maintain the desired degree of evacuation within the envelope of the discharge device.

Within the envelope 1 and preferably centrally located near the lower part of the defined space, I provide a thermionic cathode which may be of the indirectly heated type comprising a metallic cylinder 18, preferably coated on the exterior of the upper closed end with an electron emissive material, such as an alkaline earth metal, to serve as a source of electrons. A cathode heating element 19 is centrally positioned within the cylinder 18 and is supplied with energizing current through a pair of conductors 20 and 21, the former of which is shown in Fig. 2. Conductor 21 is connected to terminal post 11. Conductor 20, shown in Fig. 2, may be of sufficient rigidity to position firmly and hold the cathode assembly in the position illustrated, being supported from an insulated part of the anode structure assembly to be described presently. The cathode structure may comprise at its lower extremity a metallic ring 22 supported by conductor 20 and which serves as a support for the cathode cylinder 18, to which it is attached by means of a plurality of circumfer-

entially spaced supporting members 23 which are welded not only to the ring 22 but also to the cathode cylinder 18. This cylinder, as stated above, may be rigidly supported by conductor 20 attached to the anode assembly. I employ an electrostatic shield comprising a flanged cylinder 24 which is welded to the exterior surface of the cathode cylinder 18.

I provide an anode structure defining a space resonant cavity or region. The anode structure may comprise a disk-shaped metallic part 25 and is preferably constructed of copper supported in the illustrated horizontal position by means of a ring 26 of solder adapted to engage appropriately formed shoulders on the periphery of disk 25. At the central part of the disk 25 there is provided a central opening defining a space resonant region or cavity 27. The details of the anode structure are shown in Figs. 5 and 6, the former of which is a plan view and the latter of which is an enlarged cross-sectional view. The disk 25 is provided with a plurality of annularly spaced apertures 28–34, inclusive, which are employed and adapted to receive assembly bolts or to permit the passage therethrough of conductors described hereinafter. The disk 25 is provided with a recess 35 which is in communication with the space resonant cavity 27 through a radial opening 36 preferably of circular cross section, and which houses one end of a concentric transmission line shown in Figs. 1 and 2 and illustrated in detail in Figs. 7 and 8.

As a means for defining one boundary of the space resonant cavity 27 and also for providing an entrance and directing structure for the electron beam, I provide an entrance part 37 preferably constructed of metal, such as copper, and which is adapted to be seated in a recess in the bottom face of disk 25. The entrance part 37 comprises a conical member 38 having a tapered aperture 39 through which the electron beam passes and which defines with one boundary of the space resonant cavity 27 a velocity modulating gap 40 for the electrons constituting the beam.

In order to control the natural frequency by controlling the physical dimensions of the space resonant cavity 27, I provide a deformable member, such as a flexible metallic diaphragm 41, which constitutes one boundary of the cavity and which is provided with a central aperture 42 to afford a communicating path between the cavity and the electron retarding and reversing regions described hereinafter. Diaphragm 41 is seated upon the upper surface of disk 25 or may be seated upon a metallic spacer 43. Disk 25 is also provided with apertures 44 which are adapted to receive and hold in insulated relationship conductors for supporting gettering means.

Returning now to Fig. 1, I provide control electrode means for establishing electron repelling and retarding electric fields and which may take the form of a pair of disks 46 and 47 which are insulated from each other and from the anode structure comprising disk 25 by means of annular dielectric washers 48 and 49, the latter disk being provided with a central aperture 50 to permit the passage of electrons therethrough into the region defined between disks 46 and 47.

In order to impress suitable potentials on the disks 46 and 47, I provide a pair of conductors 51 and 52, shown in Fig. 2, which extend through apertures 31 and 28 of anode disk 25 and are positioned or terminated in apertures provided by the first mentioned disks. Conductor 51 extends through disk 47, but not in electrical engagement therewith, and is terminated in disk 46, while conductor 52 is terminated in disk 47. This detail of construction is illustrated in Fig. 2 wherein conductors 51 and 52 are shown connected to lead-in wires 53 and 54 which are connected to terminal posts 8 and 10, respectively.

To focus the electrons emitted at the end of cathode cylinder 18, I provide a focusing electrode means which may comprise a flanged cylinder 55 shown in Fig. 1, the flanged part which serves as the supporting portion being electrically insulated from the anode disk 25 by means of an insulating spacer 56. A suitable negative focusing potential may be impressed on cylinder 55 by means of a conductor 57 which is seated in an aperture of the flanged part of the cylinder and which is connected to terminal post 12 through lead-in wire 58. In order to derive ultra high frequency energy from cavity 27, I provide a curved ultra high frequency concentric transmission line which extends from the cavity 27 to the base member 2 to facilitate external connection to the device. The concentric transmission line comprises an inner conductor 59, an outer tubular conductor 60 separated by a pulverized insulator, such as a vitreous material 61 which may be quartz. The inner conductor 59 extends into the cavity 27 and serves as an output electrode means and may take the form of a loop 62, whereby the transmission line is coupled to the cavity. The details of the transmission line and the method of forming it will be considered in detail in connection with the discussion relative to Figs. 7 and 8.

At the lower extremity of the transmission line comprising conductors 59 and 60, I provide an adaptor assembly shown in detail in Fig. 8 and which comprises a recessed metallic cylinder 63 supported at the lower end of the outer conductor 60. Within the recess of cylinder 63 there is provided an adaptor for the inner conductor 59 which comprises a metallic cup-shaped part 64, in turn being provided with a recess 65 which engages the upper end of the inner conductor 15 of the transmission line supported within the orientation protuberance 14 of the discharge device. The outside diameter of cylinder 63 is chosen so that the adaptor assembly snugly fits the inner surface of conductor 16.

To assure a good electrical contact between cylinder 63 and conductor 16 and between conductor 15 and part 64, respectively, the outer surfaces of cylinder 63 and part 64 are tinned prior to the assembly operation. After assembly of the elements in the positions shown in Fig. 1, upon the application of heat thereto, the tin forms a firm contact between the elements, that is between cylinder 63 and the inner surface of conductor 16 and between conductor 15 and part 64, respectively.

As a means for mechanically controlling the form and position of the diaphragm 41, I provide externally accessible actuating means for exerting different amounts of pressure thereon, thereby controlling the dimensions of the space resonant cavity 27. This means may comprise an assembly supported by the flat top of the envelope 1 and may include an actuating rod 66 constituting a vertically adjustable or positionable member of the actuating means. Rod 66 is connected to the diaphragm 41 by a pair of rigid wires 67 and 68 which are welded to rod 66. Alternatively, instead of wires 67 and 68 being welded to the diaphragm 41, these rods may be seated in an annular groove provided in the diaphragm and the diaphragm formed to have a re-

siliency tending to restore the diaphragm to an upward or vertical position whereupon the diaphragm is maintained in contact with rods 67 and 68. In such instance, the control of the form of the diaphragm will be accomplished by the amount of downward vertical pressure exerted thereagainst. Within the enclosure provided by envelope 1 and supported by the inner surface of the envelope, I provide a sealing structure of deformable character which may comprise a metallic bellows 69 which is welded or soldered to the inner surface of envelope 1 and which is welded or soldered to a metallic cup 70 which in turn is sealed to the outer surface of rod 66.

Above the envelope 1 and in an externally accessible position, I provide a vernier adjustment 71 for the actuating rod 66 where, upon actuation, the rod 66 is moved to position the diaphragm 41 in minutely determinable degrees to obtain a desired control in the operating frequency of the device. The actuating rod 66 may be hollow, having an opening 72 extending longitudinally, thereby providing an evacuation channel or tubulation for the discharge device which after evacuation may be sealed at its top.

To maintain the elements including the anode disk 25, the repelling electrode 46, the focusing electrode 47, the focusing cylinder 55 and the interspaced insulating washers in the desired assembled spaced relationship, I employ suitable mechanical engaging means which may comprise a plurality of bolt and nut assemblies 73–76, inclusive, which are shown in the plan view in Fig. 3. Also shown in that figure are a plurality of gettering means which may include a vaporizable material supported by metallic strips and which is flashed during the evacuation process in order to absorb occluded gases. For example, I may employ getters carried by metallic strips 77, 78 and 79 which are supported by a plurality of vertical conductors 80, 81 and 82 shown in Fig. 4 and which are connected to three terminal posts supported by base member 2. The conductors 80–82, inclusive, extend through the anode disk 25 and are insulated therefrom by suitable glass insulators such as glass-to-metal seals 83, 84 and 85, a longitudinal view of seal 85 being shown in Fig. 1.

Fig. 4 is a cross-sectional view of the discharge device shown in Fig. 1 and represents the arrangement of some of the conductors, particularly the connections to the cathode. In this view there is shown conductor 86 which serves as the other lead-in conductor for the cathode heating element 19; this conductor is attached to the same metallic part of the anode structure as conductor 20 (Fig. 2) and thus completes a circuit to element 19. Conductors 20 and 86 serve as a cathode connection.

The method of making and forming the concentric transmission line comprising conductors 59 and 60 to assume the curved configuration shown in Fig. 8, without establishing excessively high voltage gradients between the conductors at the points of curvature and to minimize reflections, may be more readily appreciated by referring to Figs. 7 and 8. The concentric transmission line is initially constructed using straight conductors, and an insulating body in solid form, such as a vitreous or quartz tube, is placed between conductors 59 and 60. The vitreous tube insulator 87 may be manipulated in the manufacturing process in a number of ways. For example, the vitreous tube may be fused to the inner conductor 59 and formed to have a diameter

to permit insertion within the outer tubular conductor 60. Alternatively, the inner conductor 59 may be inserted in a longitudinal opening in the quartz tube 87 and the assembly inserted within the outer conductor 60.

To assure the uniform distribution of the dielectric, that is the insulating material afforded by tube 87, the concentric transmission line assembly shown in Fig. 7 is swaged to effect thorough pulverization of the quartz tube so that it constitutes after the swaging operation finely divided particles readily susceptible of assuming an even distribution within the outer conductor 60. The next step comprises the deformation or bending of the transmission line assembly into the configuration desired. Where it is desired to obtain a U-shaped configuration, such as that shown in Fig. 8, for adaptation in the discharge device shown in Fig. 1, pressure may be exerted in succession or simultaneously at appropriate positions to bend the line assembly. By virtue of the fact that the quartz is now in a pulverized state, upon bending of conductors 59 and 60 the particles assume an even and uniform distribution at the points of curvature, thereby affording adequate insulation at all points and effecting minimization of reflections and high voltage gradients at these positions.

Electric discharge devices built in accordance with my invention are susceptible of great freedom and flexibility of application to ultra high frequency systems. By virtue of the concentric transmission line outlet within the orientation protuberance 14, and because of the compact arrangement of this protuberance with respect to the terminal posts, the electric discharge device as a whole may be readily positioned in an appropriately designed socket to effect simultaneous connection to the terminal posts and to the concentric transmission line outlet.

Fig. 9 illustrates one arrangement for connecting an electric discharge device of the type shown in Figs. 1 and 2 to an ultra high frequency transmission system which comprises a dielectric wave guide 88 of the hollow pipe type defined by a plurality of conductive or metallic members through which electromagnetic waves may be propagated. A terminal box 89 may be seated directly on the top surface of the wave guide and is provided with a tubular inlet channel 90 for conductors which are to be connected to prongs 91 of a socket 92 adapted to receive the base and terminal posts of base member 2 of the discharge device shown in Fig. 1. Within the terminal box 89 there is provided a contact assembly 93 adapted to make electrical contact with the concentric transmission line comprising conductors 15 and 16. The assembly comprises a tubular member 94 provided with a flanged part 95 which is seated on the upper surface of the bottom plate of the terminal box and which is provided near its top with a plurality of annularly spaced resilient contact fingers 96 adapted to receive the lower portion of the outer conductor 16 and to maintain firm electrical contact therewith. An inner conductor 97 is adapted to contact inner conductor 15, thereby completing the connection of the high frequency concentric line in the orientation protuberance 14 to the transmission line constituting the tubular member 94 and conductor 97. Conductor 97 at its uppermost part may be hollow providing an opening, the inside diameter of which is sufficient to permit the insertion of the inner conductor 15 therein and to engage closely

the latter to establish electrical connection to the ultra high frequency system.

Conductor 97 may be maintained in the desired central position by means of an annular insulator 98. A portion of the conductor 97 serves as excitation means or electrode means for establishing the energization of the wave guide and may take the form illustrated in Fig. 9 where it extends completely through the guide and is terminated in a tuning plunger assembly 99 comprising an outer tubular conductor 100 and a vertically positionable plunger 101 having a plurality of resilient fingers to engage the inner surface of conductor 100. Vertical movement of plunger 101 may be effected by means of an adjusting means 102 which is connected to plunger 101 through a hollow cylinder 103. Additional tuning means comprising a plunger 104 may also be associated with the wave guide and this plunger in turn may be operated by the adjusting means 105.

The operation of the embodiment of my invention described above will be considered with particular reference to Figs. 1 and 2 and the schematic arrangement of certain of the electrode elements shown in Fig. 10, when the device is operated as an oscillator. Generally speaking, the electric discharge device is of the velocity modulation type wherein the electron beam is velocity modulated periodically so that successive groups of electrons are alternately accelerated and decelerated, tending to group the electrons in the beam after the beam has traversed the velocity modulation gap. The particular form of electric discharge device described above operates in accordance with reflex principles. After undergoing velocity modulation, the electrons are given an opportunity to assume a charge density distribution incident to the effect of the velocity modulation and are reversed in the direction of travel to re-enter the space resonant cavity, delivering energy to the electro-magnetic field thereof or to an associated electrode construction. In the device described above, an electron beam is established by virtue of a unidirectional potential impressed across the anode structure comprising disk 25 and the cathode cylinder 18. The electrons of the electron beam initially assume a velocity determined by the accelerating potential impressed on the anode structure and the electrode geometry. A negative potential with respect to cathode cylinder 18 is impressed on the focusing cylinder 55 which tends to restrict the size of the electron beam, confining it to a relatively small transverse area in order that a large percentage of the electrons pass through the space resonant cavity 27 through the conical part 38. Assuming an excitation of the cavity 27 by virtue of sporadic motion of the electrons therethrough during the starting operation, cavity 27 will be set in oscillation and there will be established across the modulating gap 40 an alternating ultra high frequency potential incident to the electromagnetic field within the cavity 27. By virtue of the alternating nature of this potential, electrons which are in the effective region of gap 40 during periods of time when the diaphragm 41 is positive with respect to the conical part 38 will undergo an acceleration. During the following half cycle, that is the negative half cycle when diaphragm 41 is negative in potential with respect to conical part 38, the electrons will undergo a deceleration. The curve A in Fig. 11 represents the radio frequency voltage appearing across the modulating gap 40. Consequently, the electrons after traversing the space resonant cavity 27 proceed through aperture 42 of diaphragm 41 into the region of the field produced by the focusing and retarding electrode 47 which may be maintained at a negative potential with respect to the anode. Furthermore, the potential of the retarding electrode 47 may also be negative with respect to the cathode as well as being negative to the anode structure. The distance which the electrons proceed in their paths beyond diaphragm 41 is a function of the kinetic energy of each electron. It is well understood that the energy of an electron may be referred to a voltage which will accelerate the electron to a particular velocity establishing that amount of kinetic energy, and consequently the kinetic energy of the electrons may be referred to a retarding field which is just sufficient to stop the motion of the electrons. The faster electrons obviously travel farther in this field, before they are stopped or reversed, than the slower electrons.

The probable paths of electrons within the fields produced by retarding electrode 47 and repelling electrode 46 are represented by curves *a*, *b* and *c* in Fig. 10. The equipotential lines shown in Fig. 10 were obtained from tests conducted on an enlarged electrode construction employing an electrolytic solution and probe for determining the equipotential lines, and for the condition where a 1600 volt difference was present between the anode structure and the cathode and where the repelling electrode 46 and the retarding electrode 47 were maintained at negative 500 and 100 volts, respectively. The field distribution is plotted showing only one-half the region, and it is to be understood that the other half region is similar in configuration to that illustrated. The curved lines extending from diaphragm 41 to the conical part 38 represent the contour of the electric lines of force present in the cavity during one-half cycle that is the positive half cycle, during which the electrons are accelerated. The circled crosses represent the corresponding direction of the magnetic component of electromagnetic field during the same half cycle. During a half cycle of opposite polarity the electric component and the magnetic component, of course, are reversed in direction. The curve *a* represents a low velocity electron which traverses a distance corresponding to the 200 volt equipotential line and is reversed in its direction of travel and focused so that it re-enters the cavity 27. An electron of greater kinetic energy corresponding in its path to curve *b* travels a greater distance before reversal and as illustrated is reversed within the vicinity of the zero potential line. Lastly, an electron of even greater velocity proceeds in the direction of the repelling electrode 46 and enters the negative field produced thereby, undergoing a reversal in the vicinity of the negative 200 volt line.

One way in which the electric discharge device described above may be operated is by impressing a negative potential on the retarding electrode 47 and a still greater negative potential on the repelling electrode 46. For example, a negative unidirectional voltage of 300 volts may be impressed on the retarding electrode 47 and a negative unidirectional potential of 500 volts may be impressed on the repelling electrode 46, the anode structure being maintained at a positive potential of 1000 volts. The focusing cylinder 55 may be maintained at a negative potential of 100 volts. It is to be understood that the above values of voltage are merely representative of voltages

which may be applied in the operation of my device and are in no way critical or limiting.

Electrodes 46 and 47 serve two purposes. One is to impress on the electron beam proper radial voltage gradients, and the other is to control the grouped electrons incident to the velocity modulation effect so that these electrons return and pass through gap 40 in the proper phase relationship with respect to the electric component of the electromagnetic field within cavity 27.

The electric discharge device may be operated in a number of ways in addition to that described above. One example of an alternative manner of operation is by impressing on the repelling electrode 46 a potential electrically near the cathode potential and the electrode 47 at a positive potential with respect to the cathode. In this manner of operation, all electrons which gain velocity passing through the velocity modulation gap 40 are collected by electrode 46. The electrons which lose velocity due to the decelerating effect of the gap are reflected. Consequently, the returned electron beam is conduction-current modulated.

In accordance with one aspect of my invention, I have found that highly satisfactory operation of the device and minimization of losses may be obtained by maintaining a relatively large ratio between the unidirectional accelerating voltage and the high frequency component of voltage. The change in velocity, under these conditions, in comparison with the initial velocity of the electrons in the beam is small. Consequently, practically equal numbers of electrons approach and leave the gap, and the currents induced in the cavity by approaching electrons are offset by currents of opposite sign induced by currents of the departing electrons.

Where the discharge device is operated by impressing progressively negative potentials on electrodes 47 and 46, I have found that optimum operation is obtained when the field incident to these electrodes is such that the zero potential line lies within the vicinity of electrode 47, causing the electrons to travel a minimum distance before reversal but not sacrificing the utilization of the proper phase relationship between the returned electrons and the electromagnetic field in order to obtain large power outputs.

Considering the transit time of the electrons within the space resonant cavity 27 and in the field produced by the repelling electrode 46 and retarding electrode 47, it may be generally stated that the transit time or the time-phase relationship of the electrons is such that there is a net positive energy transfer from the electrons to the field of the cavity. The velocity modulated electrons, after undergoing reversal within the field produced by electrodes 46 and 47, because of the grouping of the electrons by virtue of the velocity modulation, assume a charge-density distribution. The velocity modulation effect has such a time-phase relation with respect to the charge-density variations of the beam, that the electrons within the regions of large charge density are slowed down, and those of small charge density are accelerated. Thus, there is a net reduction in the average speed of the electron beam which is just sufficient to supply the external power derived from the cavity by loop 62 and the power dissipated as a loss in the cavity.

The transit time in order to effect optimum transfer of energy from the electron beam to the field cavity may be generally stated as being $(n+3/4)$ cycles, where n is zero or any positive integer, and where the transit time is measured in the path of an electron during its excursion from the diaphragm 41 outward into the field space of the retarding and repelling electrodes and returned across the gap 40 to the uppermost plane of conical part 38. In order to obtain the most effective utilization of space and to obtain a discharge device of small proportions, it is important that the distance traveled by the electrons after velocity modulation to acquire the desired charge density modulation be minimized. Consequently, I have found that it is desirable to utilize a zero value or a small value of n so that the electrons assume the desired charge-density modulation distribution without entailing the passage through a great longitudinal distance either in the forward direction of travel or in the reverse direction of travel. Of course, to utilize space most effectively in a discharge device of this nature, the high frequency modulating voltage appearing across the modulating gap 40 should be maintained at an appreciable value to impart to the electrons the desired velocity modulation characteristic within the distance or space under consideration. By employing an appreciable value of modulating voltage in combination with a relatively small transit time, such as $3/4$ or $7/4$ cycles referred to the cavity excitation, I provide an efficient arrangement for exciting the cavity without involving the use of long electron paths, and which permits the construction of discharge devices of smaller dimensions than that afforded by the prior art constructions or methods of operation.

In the operation of devices built in accordance with my invention and employing the above described structure, I have found that the electron beam to some extent is focused by the positive ions from gas molecules produced by the impact of the electron beam upon them. Thus, positive ions then neutralize the negative charge of the electrons of the beam and thereby prevent the mutual repulsion of the electrons to limit the beam spreading. This effect occurs at pressures greater than 10^{-6} mm. of mercury. That such a gas focusing action occurs is readily apparent by an examination of a device after operation by observance of the discoloration or marking at the center of the cathode emitting surface and the repelling electrode 46. As the pressure is reduced, of course fewer ions are focused and the same field which accelerates the electrons also removes the ions formed, thereby reducing the amount of focusing due to the positive ions.

The operating frequency of the electric discharge device may be controlled either by controlling the physical dimensions of the space resonant cavity 27 or by controlling the voltage impressed on the electrodes including the voltage on the anode structure and the voltage on electrodes 46 and 47. Considering first the control of the operating frequency by virtue of the change in the physical dimensions of the cavity, the position of diaphragm 41 controls one boundary of the cavity and consequently controls its natural frequency. Ready adjustment of the position of the diaphragm 41 is obtained by manipulation of the vernier 71. I have found that in electric discharge devices built in accordance with the above described principles and construction, the operating frequency of the discharge device may be varied throughout a range of 6000 megacycles and that the discharge device has an effective and substantial power output when operating at 30,000 megacycles.

The operating frequency, as stated above, may also be controlled by variation of the voltages impressed on the repelling electrode 46 and the retarding electrode 47, in this manner controlling the transit time of the electrons in the beam and consequently controlling the phase of charge maxima or charge minima of the charge-density modulated electrons which are returned to the space resonant cavity 27 with respect to the field thereof. By using this method of controlling the operating frequency, I have found that an additional finer adjustment of range of 90 megacycles frequency control may be obtained.

I have found that the above described construction of an ultra high frequency electric discharge device is peculiarly adaptable for the production of discharge devices of exceedingly small size.

While I have shown and described my invention as applied to an electric discharge device employing electrodes of particular configuration, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an ultra high frequency system, a structure adapted for removeably positioning an electric discharge device having an envelope enclosing a plurality of electrodes, a base member sealed to said envelope including a plurality of terminal posts external to said envelope connected to said electrodes and an external orientation protuberance housing a concentric transmission line connected to one of said electrodes, said structure comprising a wave guide of the hollow-pipe type, a socket having resilient contact means adapted to receive and removeably position said terminal posts, and a section of concentric transmission line inter-positioned between said wave guide and said socket including inner and outer conductors adapted resiliently to engage the corresponding members of said first mentioned transmission line, whereby upon insertion of said discharge device in said socket conductive connection is made between said lines, said second mentioned transmission line extending into said wave guide and serving as energizing electrode means therefor.

2. In an ultra high frequency system, a structure adapted for removeably positioning an electric discharge device having an envelope enclosing a plurality of electrodes, a base member sealed to said envelope including a plurality of terminal posts external to said envelope connected to said electrodes and an external orientation protuberance housing a concentric transmission line connected to one of said electrodes, said structure comprising a wave guide of the hollow-pipe type, a socket having resilient contact means adapted to receive and removeably position said terminal posts, and a section of concentric transmission line including inner and outer conductors adapted resiliently to engage the corresponding members of said first mentioned transmission line and fixedly positioned with respect to said socket whereby upon insertion of said discharge device in said socket conductive connection is made between said lines, said second mentioned transmission line extending into said wave guide and serving as energizing electrode means therefor.

3. In an ultra high frequency system, a structure adapted for removeably positioning an electric discharge device having an envelope enclosing a plurality of electrodes, a base member sealed to said envelope including a plurality of terminal posts external to said envelope connected to said electrodes and an external orientation protuberance housing a concentric transmission line connected to one of said electrodes, said structure comprising a wave guide of the hollow-pipe type, a socket having resilient contact means adapted to receive and removeably position said terminal posts, a section of concentric transmission line including inner and outer conductors adapted resiliently to engage the corresponding members of said first mentioned transmission line and fixedly positioned with respect to said socket whereby upon insertion of said discharge device in said socket conductive connection is made between said lines, said second mentioned transmission line extending into said wave guide and serving as energizing electrode means therefor, and a tunable section of transmission line constituting an extension of said first mentioned section for tuning said wave guide.

4. In an ultra high frequency system, a structure adapted for removeably positioning an electric discharge device having an envelope enclosing a plurality of electrodes, a base member sealed to said envelope including a plurality of terminal posts external to said envelope connected to said electrodes and an external orientation protuberance housing a concentric transmission line connected to one of said electrodes, said structure comprising a terminal box, a wave guide of the hollow-pipe type affixed to said box, a socket having resilient contact means adapted to receive and removeably position said terminal posts supported by said box, and a section of concentric transmission line including inner and outer conductors adapted resiliently to engage the corresponding members of said first mentioned transmission line and fixedly positioned with respect to said socket within said box whereby upon insertion of said discharge device in said socket conductive connection is made between said lines, said second mentioned transmission line extending into said wave guide and serving as energizing electrode means therefor.

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

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