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ELECTRIC DISCHARGE DEVICES

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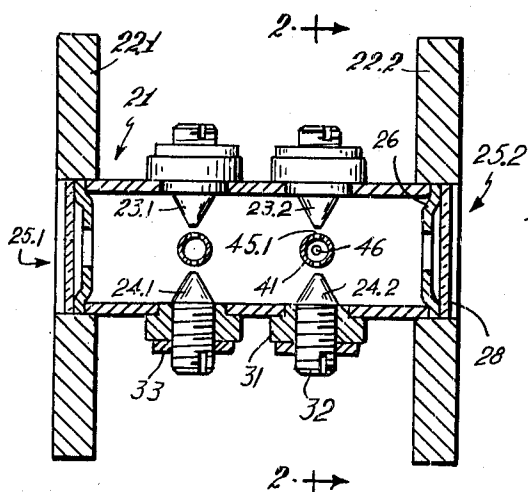


Fig. 1

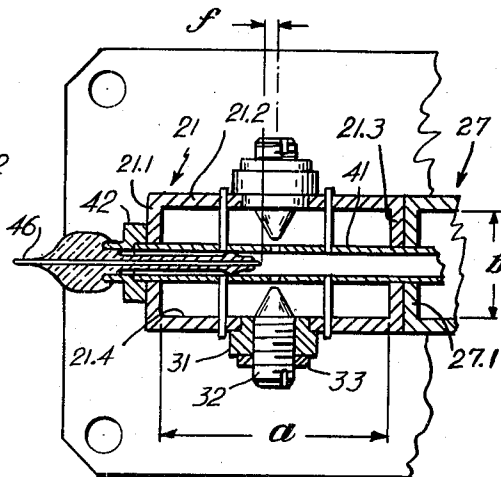


Fig. 2

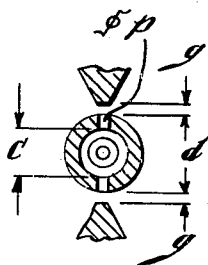


Fig. 3

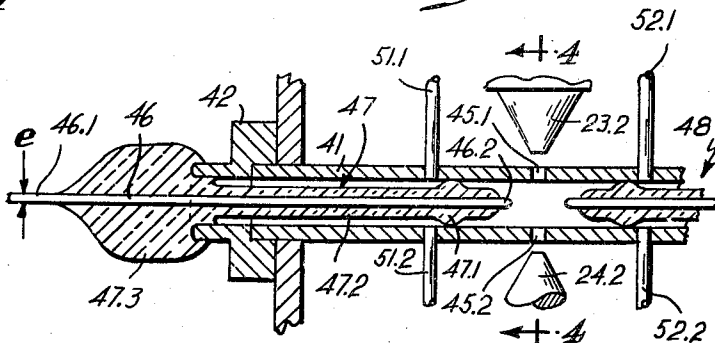


Fig. 4

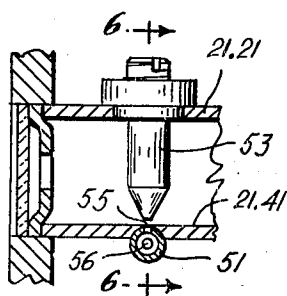


Fig. 5

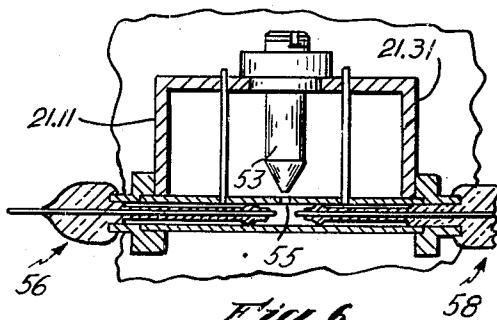


Fig. 6

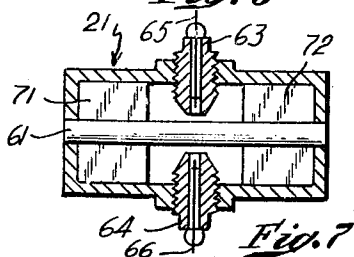


Fig. 7

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ELECTRIC DISCHARGE DEVICES

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22 Claims. (Cl. 315—39)

The field of the present invention is generally that of electric discharge devices within wave guide sections which constitute gas or vapor filled envelopes, and more particularly of tubes for duplexing systems with principal gap electrodes as well as auxiliary keep alive electrodes.

In pulse radio direction and range finding equipment where a common antenna is essential to accurate location of a target it is the function of a duplexing system alternately to transmit the powerful signal from the magnetron to the antenna while protecting the highly sensitive crystal receiver from this signal pulse, and to pass the returning echo pulse from the antenna to the receiver. For that purpose so-called transmit-receive tubes (commonly referred to as TR tubes) are employed as switching devices on the one hand to short-circuit the transmission line leading to the receiver in order to protect the crystal during the high power pulse transmission, and on the other hand to allow the low level echo signal from a target to reach the receiver with minimum attenuation. TR tubes are therefore in essence switches actuated by the high power transmitted pulse, and in the absence of this pulse they are matched sections of transmission line.

Devices according to the invention are particularly applicable to gap-discharge TR tubes of which the herein described practical embodiments are characteristic examples, whether used in pairs with short slot hybrids or equivalent devices to form a radar subassembly known as a balanced duplexer, or used as so-called anti-transmit-receive tubes (commonly referred to as ATR tubes) to form a subassembly known as a branched guide duplexer; in either case the purpose is to provide maximum efficiency of transmission and reception in radar or similar equipment using a common antenna. However the devices herein described are also applicable to filters, cavities and other wave guide devices.

The essential desirable characteristics of a TR tube are low attenuation of the transmitted pulse that is low arc loss, low attenuation of the received echo signal that is low insertion loss, high power handling, long life, short recovery time, and broad band width. In previous designs the optimal conditions for any one of these characteristics are not necessarily favorable for other characteristics and therefore the overall design of discharge devices of this type has necessarily been a compromise between two or more of the characteristics.

Objects of the invention are to provide gap tuning elements and keep alive structures for devices of the above indicated type, preferably in combination but also for separate use, and particularly also in cooperation with dual element input and output windows which are the subject matter of the application Serial No. 657,585, filed on May 7, 1957, for the purpose of materially improving one or more of the above-mentioned characteristic properties without material detrimental effect on other characteristics: to provide a gap tuning element capable of initiating discharges at very low power level to constitute an effective barrier to high level signals until the main barrier discharge occurs at a window; to provide a gap

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tuning element which favors broad band matching of the TR tube; to provide a keep alive structure which is particularly suitable for gap structures, of the above indicated type and which combines the favorable characteristics of the conventional keep alive arrangements while avoiding their defects; to provide a keep alive structure which retains permanently low leakage and low radio frequency noise; to provide a gap and keep alive structure which inherently prevents short circuiting and which removes the locus of gas discharge from the electromagnetic field in the transmission lines; to provide devices of the above type all characteristics of which are uniformly favorable, which lower the arc as well as the insertion loss and which give considerably longer tube life as compared with conventional devices of this type; to provide a new double gap resonant tuning structure which has a greater Q range than conventional devices of that type and which has an improved performance when the gaps are fired; to provide a TR tube construction which permits the use of two keep alives each acting independently on two gaps of a double gap structure; and to provide such devices which are mechanically simple and can be manufactured with the requisite precision; and generally speaking to provide devices of this type which have an essentially improved practical design from the point of view of reproducibility and flexibility.

A brief summary of the invention will serve to indicate various aspects of its nature and substance for accomplishing the above objects, as follows.

In one of its broader aspects, the invention employs within a wave guide section, transversely elongate electrode means having an outer surface region which extends between opposite wall portions of the guide section and which forms a discharge gap or gaps with complementary electrode means extending from a third wall portion toward the elongate electrode means; the elongate electrode means can extend freely through the wave guide section, or can be near or embedded in a wall portion. The elongate transversely extending electrode can form discharge gaps with various types of complementary electrodes, such as conical or post electrodes of conventional type, or other such as skew-wise extending elongate electrodes. In an important practical embodiment of the invention, the elongate electrode is placed between two pointed electrodes such as truncated cones extending from opposite portions such as the wider walls of a wave guide and with their common axis intersecting the axis of the elongate electrode which extends between the two other, narrower, wall portions of the guide section.

In another important aspect of the invention the elongate electrode is hollow having an exposed outer surface portion extending transversely between two opposite wall portions of the guide and having in this surface portion a perforation transversely through a wall portion of the hollow body leading into the guide proper, and further comprising metallic rod means extending into the hollow body and terminating near the perforation, whereby the hollow body provides a gap electrode as pointed out above, whereas the rod means provides a keep alive device for a gap formed near the perforation. In an important practical embodiment, the metallic rod means which forms the auxiliary keep alive electrode has the shape of a wire in the axis of the tubular principal electrode within which it is appropriately supported and from which it extends towards the outside through a seal. In the aforementioned important practical embodiment with two gaps, the hollow principal electrode has two diametrically opposite perforations facing the two post electrodes and one or two auxiliary keep alive electrodes are mounted therewithin as mentioned above.

In gaseous gap discharge tubes of the duplex type wherein two guide sections are placed adjacent to each other, two wave guide walls, such as two narrower walls can be placed near to or contacting each other with an elongate electrode penetrating both adjacent walls and extending into both wave guide sections; in an embodiment of this type these elongate electrodes can be tubular and contain keep alive electrodes terminating at perforations of the tubular main electrodes, and this arrangement then provides a connection between the two wave guide sections such that the gas or vapor filling will always be identical. Electromagnetic inductances can be formed in such tubes by structures such as rods or baffle plates extending between the guide section walls and the elongate electrodes.

Although the herein described embodiment uses a tubular principal electrode in combination with a keep alive electrode therewithin as outline above, it should be understood that the concepts of transversely elongate principal electrodes and of keep alive arrangement therein can be used independently. For example the elongate principal electrode can be solid and used together with a conventional keep alive electrode within one or two of the post electrodes. Or a keep alive arrangement according to invention, for example one arranged near or within one of the wave guide walls can be used together with two conventional post electrodes.

These and other objects and aspects of the invention will appear from the following description of several typical embodiments illustrating its novel characteristics.

The description refers to a drawing in which

Fig. 1 is a longitudinal axial section of a wave guide portion constituting a TR tube incorporating the invention, with the post electrodes shown in elevation;

Fig. 2 is a section on lines 2—2 of Fig. 1 again with the post electrodes shown in elevation;

Fig. 3 is a section similar to Fig. 2 but in larger scale and with two auxiliary keep alive electrodes;

Fig. 4 is a section on lines 4—4 of Fig. 3;

Fig. 5 is a longitudinal section similar to Fig. 1, of an embodiment of the invention which has a tubular principal electrode in a wall section of the guide and a single post electrode;

Fig. 6 is a section on lines 6—6 of Fig. 5; and

Fig. 7 is a further embodiment with a solid elongate principal electrode and an electromagnetic inductance device in the form of baffle plates.

Figs. 1 and 2 indicate at 21 a wave guide section constituting a transmit-receive tube which, as well known is sealed at both ends with resonant coupling windows, highly evacuated and instead filled with gas of exact predetermined composition and pressure. Numerals 22.1 and 22.2 indicate two flanges of the wave guide section with the aid of which it can be joined to other sections of the system. 23.1, 23.2 and 24.1 and 24.2 are conical electrode posts which, while in themselves well known in the art are components of the present invention as will be described below. The two sealing windows or irises are indicated at 25.1 and 25.2, and these are constructed in accordance with the teachings of the above-mentioned copending application Serial No. 657,585, filed on May 7, 1957. As described in that application, the windows according to one of its embodiments comprise an iris component indicated at 26 and a dielectric sealing component indicated at 28.

The principal electrodes 23.1 to 24.2 are of conventional design, with bushings 31, conically pointed and threaded electrode posts 32, and lock nut means 33. It will be understood that the length of projection of these electrodes can be varied in any desirable manner including remote control by means of mechanical or solenoid devices, as well known in the art. By means of such devices the gaps can be adjusted and the posts can also be used as shutters for closing a desired wave guide component such as one leading to the receiver.

The elongate principal electrode according to the invention is indicated in Figs. 1 to 4 as consisting, in this embodiment, of a tubular body 41 which is secured in the opposite wall portions 21.1 and 21.3 of the guide section 21, by means of a bushing 42 made of metal that is suitable for forming a seal in the manner to be described below.

Perforations 45.1, 45.2 (Figs. 3 and 4) are made transversely of the walls of the tubular electrode 41, in alignment with apices of the two post electrodes 23.2 and 24.2. An auxiliary keep alive electrode assembly according to the invention comprises a wire 46 of suitable alloy held in place by a glass body 47 which has a supporting bead 47.1, an insulating coating 47.2 and a sealing and insulating support 47.3 from which protrudes the outer end 46.1 of the electrode wire, where it can be connected to the keep alive voltage supply source. The inner end 46.2 of the keep alive electrode wire is free from insulation and reaches practically towards the center line of the perforations 45 in the manner to be elaborated below. It will now be evident that by means of this construction two keep alive electrodes can be applied to one double gap as shown in Fig. 3, or that, as shown in Fig. 2, a tube with at least one perforation in each one of two adjacent wave guide sections 21, 27, with adjacent wall portions 21.1, 27.1 can serve to establish a pneumatic communication between the two sections.

A second keep alive device of identical construction is indicated at 48 of Fig. 3.

Devices of this type require inductance for balancing the capacitance of the electrodes, and this can be provided by the rod system 51.1, 51.2, 52.1, 52.2. Instead, as will be described below, solid baffles can be used for the same purpose. In either case, the tubular electrode lends itself well for mounting such inductances.

As previously mentioned, each one of the gaps, whose length is marked g in Fig. 4, can be separately adjusted if desirable, by provision such as indicated at 31, 32, 33 of Figs. 1 and 2.

Figs. 5 and 6 illustrate an embodiment with a single tubular electrode which extends transversely between the wave guide walls 21.11 and 21.31, being embedded in the longer guide wall 21.41. Otherwise it can have the same construction as that described above with reference to Figs. 1 to 3, especially the combination with a keep alive electrode by way of a perforation 55 opposite the apex of the electrode post 53. Fig. 6 also illustrates the use of two auxiliary electrodes 56 and 58 with this single gap device.

Fig. 7 shows a solid rod electrode 61 of the elongate type according to the invention, in combination with two post electrodes 63, 64, each of which is equipped with conventional keep alive electrodes 65, 66, respectively. This embodiment also illustrates the above mentioned use of solid baffles as inductive balancing impedance.

In an actual successfully operative embodiment according to Figs. 1 to 4, the dimensions which are indicated in these figures were as follows.

$a=.900''$	$e=.025''$
$b=.400''$	$f=.020''$
$c=.104''$	$g=.005''$
$d=.125''$	

The window construction of this embodiment was that described in detail with reference to Figs. 1 and 2 of the above identified patent application.

Characteristic electric data indicating the quality of this example are as follows.

Insertion loss	db	.5
Arc loss	db	.10
Bandwidth	percent	15
Peak power rating	kw	500
Average power rating	watts	500
Frequency	kmc	9

The operation of devices that incorporate this invention and the selection of the configurations, mounting, combinations and dimensions of the various components for any given purpose is governed by the following considerations.

The tuning elements in microwave circuitry incorporating the invention are employed to provide small gaps where the electric field is high thereby producing discharges at low power levels, to provide a preliminary barrier to high level signals until the main discharge at the window becomes effective, and to provide broad band matching of the tube sections of the wave guide.

The power level of the gap discharge which takes place when the high sending energy begins to flow—and which initiates high fields at the input window that in their turn cause the finally effective shunting discharge which lasts for the duration of the transmitted pulse—is determined by the gap spacing g (Fig. 4) and the Q of the tuning elements. Reduction of the gap g decreases the power level at which the initial arc discharge takes place and decreases the leakage power of the tube. It was found that the new gap structure with an elongate electrode permits substantial reduction of the g dimension and hence of the power level at which the initial arc discharge takes place and that it also decreases the leakage power of the tube; furthermore it provides a considerably greater range of Q as compared to conventional designs, and improves performance when the gaps are fired.

Coming to the function of TH tube gaps as barriers to high level signals until the main discharge occurs at the window, the time required for transfer of the discharge from the small gaps to the input window is likewise determined by g and Q . The effectiveness of this phase of operation is usually rated in terms of the power transmission through the element when the gaps are shorted. This transmission is considerably decreased by the present construction; transmission through a new double gap element is about -60 db as compared with -30 db of a standard iris and cone unit of the same Q .

Favorable broad band matching of TR tubes is accomplished by the use of one or more gap elements according to the invention spaced at appropriate distances such as quarter wave lengths apart from each other and a quarter wave length from the windows to form a multiple element band pass filter. Having in mind that band width is determined by the number and Q of the gap elements and windows, the improvement presented in the above tabulation of characteristic properties was obtained by means of a dual gap tuning element as shown in Fig. 1, all post and elongate elements being identical and the posts being adjusted to equalize the gap spacing on either side of the tubular transverse electrode to the value g given above.

The above described keep alive device which is particularly beneficial in combination with transversely tubular gap electrodes is used for the well known purpose of providing electrons in the gap for rapid firing when the transmitted pulse begins. This is accomplished by means of a direct current glow discharge between the keep alive electrode and a gap and tuning electrode. According to the present invention this glow discharge is located far enough from the tuning gap to prevent the excessive attenuation of low level radio frequency signals which is known as keep alive interaction. As compared with conventional keep alive electrode systems, namely the coaxial keep alive and the side arm keep alive, the system according to the invention combines the best features of these two previously suggested arrangements. The new system which is made possible by the hollow tuning element provides adequate space to prevent short circuiting and the gas discharge is removed from the electromagnetic field in the transmission life. Therefore optimum effectiveness and long life are assured, as com-

pared with the conventional coaxial keep alive that suffers from space limitations leading to erosion of the tip eventually producing a continuous metallic path between the keep alive electrode and the cone or post resulting in a short circuit, and also as compared with the detrimental properties of the conventional side arm keep alive which result in poor leakage power control and in a discharge path located in the electromagnetic field and therefore producing radio frequency noise.

The second keep alive described with reference to Fig. 4 considerably increases the reliability of a single TR tube. Also, this second keep alive can be pulsed to remove electrons from the gap and thereby to improve the recovery time of the tube.

The modifications shown in Figs. 5, 6 and 7 illustrate the adaptability of the system according to the invention. They show transverse elongate principal gap elements and keep alive elements according to the invention, used separately or in combination. Figs. 5 and 6 indicate the use of a single post electrode with tubular transverse electrode in combination with a double keep alive for the purpose mentioned above, whereas Fig. 7 shows the use of two posts electrodes on either side of a transversely elongate electrode which is in this instance solid.

As mentioned above, the new gap electrode and keep alive structures are especially beneficial with the dual window construction disclosed in the above mentioned application Ser. No. 657,585; as compared with conventional tubes made for equivalent purposes and power ratings, they exhibit better uniformity in all characteristics, lower arc loss by a factor of two to one, lower insertion loss by a factor of two to one, and longer tube life by a factor of two to one, at least partial elimination of sputtering and a more practical design from the standpoint of reproducibility as well as flexibility.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. A discharge gap device comprising: a wave guide section, elongate electrode means having a substantially linear outer surface region extending transversely between and electrically connected directly to opposite wall portions of said guide section; and complemental substantially linear electrode means electrically connected directly to and extending from a third wall portion toward said elongate electrode means; whereby said electrode means form a discharge gap at points located at a minimal distance from each other on the elongate and complemental electrode means, respectively.

2. A discharge gap device for mounting within a wave guide, comprising: a pointed electrode mounted on and electrically connected directly to a wall portion of the guide; and an elongate electrode electrically connected directly to and extending transversely between opposite wall portions of said guide, intersecting the axis of said pointed electrode, and having a linear surface portion freely exposed to said pointed electrode; whereby the pointed electrode and the surface of the transversely elongate electrode form a discharge gap.

3. A discharge gap device for mounting within a wave guide, comprising: two pointed electrodes mounted in alignment on and electrically connected directly to opposite wall portions of the guide; and an elongate electrode electrically connected directly to and extending transversely between opposite wall portions of said guide and intersecting the common axis of said pointed electrodes; whereby the pointed electrodes and the transversely elongate electrode therebetween form a double discharge gap.

4. A discharge gap device for mounting within a wave guide, comprising: pointed electrode means mounted on and electrically connected directly to wall means of the guide; an elongate electrode means electrically connected directly to and extending transversely between opposite

wall portions of said guide, intersecting the axis of the pointed electrode means; and conductor means extending transversely between and electrically connected directly to wall means of the guide and said elongate electrode means; whereby the electrode means form a discharge gap and the conductor means provide an electromagnetic inductance.

5. Device according to claim 4, wherein said conductor means includes two rods whose axes substantially intersect the axis of said elongate electrode means.

6. Device according to claim 4, wherein said conductor means includes baffle plates whose plane substantially intersects the axis of said elongate electrode means.

7. A discharge gap device for mounting within a wave guide, comprising: two pointed electrodes mounted in alignment on and electrically connected directly to opposite wall portions of the guide; an elongate third electrode extending between said two pointed electrodes transversely between opposite wall portions of said guide, said third electrode being electrically connected directly to at least one of said opposite wall portions, intersecting the axis of the pointed electrodes; and metallic rod means extending between said opposite wall portions and said third electrode; whereby the electrodes form a double discharge gap and the rod means provide an electromagnetic inductance.

8. A discharge gap device for mounting within a wave guide, comprising: two pointed electrodes mounted in alignment on and electrically connected directly to opposite wall portions of the guide; an elongate electrode electrically connected directly to and extending transversely between opposite wall portions of said guide and intersecting the axis of the pointed electrodes to form gaps therewith; and means for separate axial adjustment of said pointed electrodes; whereby the gaps between the elongate electrode and respective pointed electrodes can be separately adjusted.

9. A discharge gap device comprising: two sections of two wave guide means mounted adjacent to each other with wall portions facing each other; a tubular electrically conductive body extending transversely through both wave guide sections with sealed intersections of said wall portions, and having transverse perforations leading from the inside of the tubular electrode means into each one of the wave guide sections; whereby said tubular body constitutes a gap electrode in each guide section and interconnects the sections.

10. Device according to claim 9 wherein each guide section contains two stud electrodes pointing towards said tubular body, forming a double gap in each wave guide section.

11. Device according to claim 9, further comprising auxiliary electrode means mounted within said tubular body and extending from one end of the body towards one of said perforations.

12. Device according to claim 9 wherein said wall portions are joined.

13. A discharge gap device for mounting within a wave guide, comprising: pointed electrode means mounted on and electrically connected directly to a wall portion of the guide; elongate hollow electrode means having an exposed linear surface portion extending transversely of said guide between and electrically connected directly to two opposite wall portions thereof, intersecting the axis of said pointed electrode means, and having an opening opposite the apex region of the pointed electrode means; and auxiliary electrode means mounted to extend within said elongate hollow electrode means from without the guide to said opening; whereby the electrode means form a discharge gap between the apex region and the exposed surface portion, and the auxiliary electrode provides a keep alive means near the gap.

14. A discharge gap device for mounting within a wave guide, comprising: pointed electrode means mounted on and electrically connected directly to a wall portion

of the guide; elongate hollow electrode means having an exposed linear surface portion freely extending transversely of said guide between and electrically connected directly to opposite wall portions thereof intersecting the axis of said pointed electrode means, and having an opening opposite the apex region of the pointed electrode means; auxiliary electrode means; insulating means for suspending said auxiliary electrode means within said hollow electrode means to extend therefrom without to said opening; and means for sealing the hollow electrode means around the auxiliary electrode means; whereby the electrode means form a principal discharge gap between the apex region and the exposed surface portion, and the auxiliary electrode provides a keep alive means near the gap.

15. A resonant discharge gap device for mounting within a wave guide, comprising: two pointed electrodes mounted on and electrically connected directly to opposite wall portions of the guide; a tubular electrode extending between said two pointed electrodes transversely of said guide between and electrically connected directly to opposite wall portions thereof intersecting the axes of said pointed electrodes, said tubular electrode having two perforations opposite the apex regions of said two pointed electrodes; and an auxiliary electrode mounted on insulating support means such as to extend within said tubular electrode from without the tubular electrode to said perforations; whereby the three electrodes form a double discharge gap, and the auxiliary electrode provides a keep alive means near the gap.

16. A resonant discharge gap device for mounting within a wave guide, comprising: two pointed electrodes mounted on and electrically connected directly to opposite wall portions of the guide; a tubular elongate electrode having a substantially linear outer surface region extending between said two pointed electrodes transversely of said guide between and electrically connected directly to opposite wall portions thereof, intersecting the axes of said pointed electrodes and having a linear portion freely exposed to said pointed electrode, said tubular electrode having two perforations opposite the apex regions of said two pointed electrodes; and two auxiliary electrodes mounted on insulating support means such as to extend within said tubular electrode from without either end thereof towards said perforations; whereby the tubular and pointed electrodes form a double discharge gap, and the auxiliary electrodes provide keep alive means near the gap.

17. A discharge gap device for mounting within a wave guide, comprising: an elongate hollow electrically conductive body having an exposed outer linear surface portion and being adapted for mounting transversely between and electrically connected directly to two opposite wall portions extending through at least one wall portion of the guide, and in said surface portion a perforation transversely through a wall portion of the hollow body and leading into the guide; and metallic rod means extending from without said wall portion into said hollow body and terminating near said perforation; whereby the hollow body provides a gap electrode and the rod means provide a keep alive device for a gap near said perforation.

18. In a discharge gap device as one of a plurality of gap electrodes for mounting within a wave guide: an elongate hollow electrically conductive body having an exposed surface portion arranged for extending linearly between an electrically connected directly to wall portions and through at least one wall portion of the guide and having transversely to its wall a perforation leading into the guide; metallic rod means extending within said hollow body from an end thereof near to said opening; and electrical insulator means for supporting the metallic rod means within the hollow body; whereby the body provides a gap electrode and the rod provides keep alive means therewithin at the perforation.

19. In a discharge gap device as one of a plurality

of gap electrodes for mounting within a wave guide: a tubular electrically conductive body open at both ends, arranged for extending transversely of the guide between and through opposite wall portions of the guide, said body being electrically connected directly to at least one of said opposite wall portions and having a transverse perforation leading into the guide; a conductor leading into the tubular body through one of its ends and terminating near said perforation; and supporting means for said conductor extending within said tubular body and including an insulating sealing bead; whereby the tubular body provides a gap electrode and the conductor provides keep alive means therewithin at the perforation.

20. In a discharge gap device as one of a plurality of gap electrodes for mounting within a wave guide: a tubular electrically conductive body open at both ends, arranged for extending transversely of the guide between and through opposite wall portions of the guide, said body being electrically connected directly to at least one of said opposite wall portions and having two perforations leading radially into the guide; a conductor leading into the tubular body through one of its ends and terminating near said perforations; and supporting means for said conductor extending within said tubular body and including a sealing bead; whereby the tubular body provides an intermediate electrode for a double gap near said two perforations and the conductor provides keep alive means therewithin at the perforations.

21. In a discharge gap device as one of a plurality of gap electrodes for mounting within a wave guide: a tubular electrically conductive body providing an elongate electrode having a substantially linear outer surface region, said body being open at both ends and extending transversely of said guide between and through opposite wall portions of the guide said body being electrically connected directly to at least one of said opposite wall portions and having a transverse perforation leading into the guide; two conductors extending into the tubular body one through each of its ends and sep-

arately terminating near said perforation; and supporting means for said conductors extending within said tubular body and including sealing beads one for each conductor near its end of the tubular body and supporting beads near the perforation; whereby the tubular body provides a gap electrode and the two conductors provide keep alive means therewithin at the perforation.

22. In a discharge gap device as one of a plurality of gap electrodes for mounting within a wave guide: a tubular electrically conductive body providing an elongate electrode having a substantially linear outer surface region, said body being open at both ends and extending transversely of said guide between and through opposite wall portions of the guide said body being electrically connected directly to at least one of said opposite wall portions and having two diametrically opposite transverse perforations leading into the guide; two conductors extending into the tubular body one through each of its ends and separately terminating near said perforation; and supporting means for said conductors extending within said tubular body and including sealing beads one for each conductor near its end of the tubular body and supporting beads near the perforations; whereby the tubular body provides a gap electrode and the two conductors provide keep alive means therewithin at the perforations.

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