Jan. 7, 1958 T. L. DUTT 2,819,425

GAS FILLED ELECTRIC DISCHARGE DEVICES

Filed Dec. 14, 1951 2 Sheets-Sheet 1

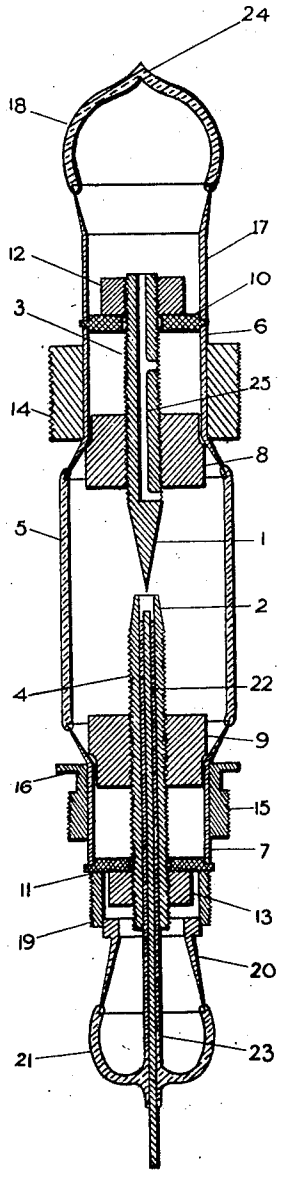


FIG. 1.

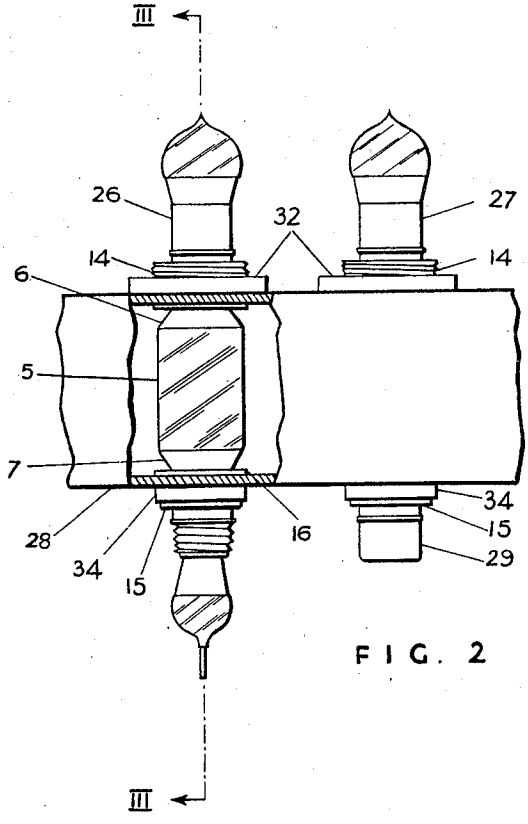


FIG. 2

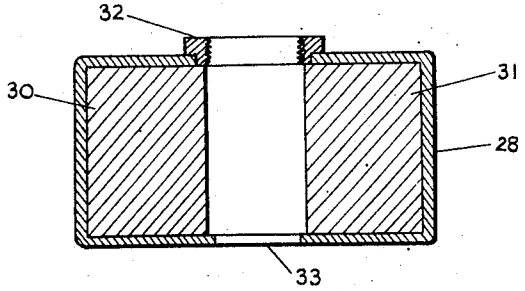


FIG. 3.

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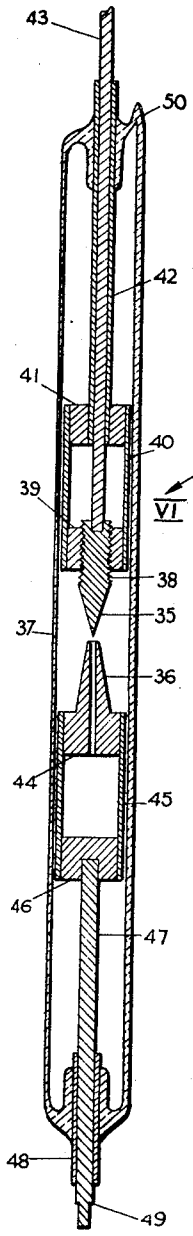


FIG. 4.

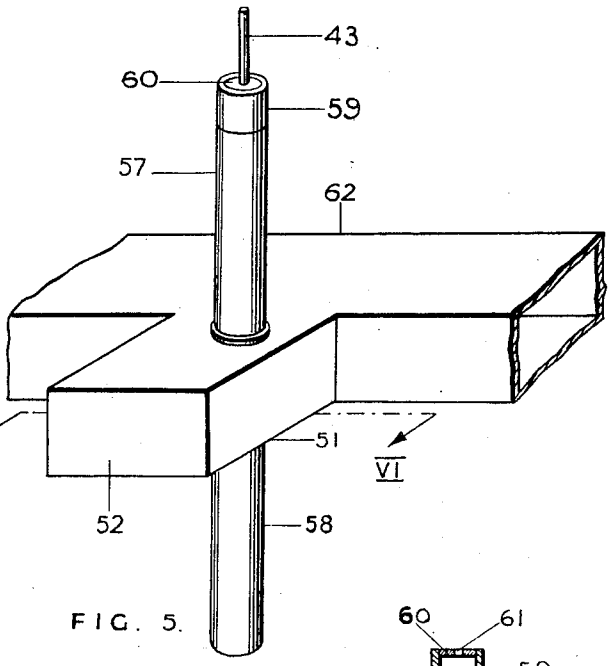


FIG. 5.

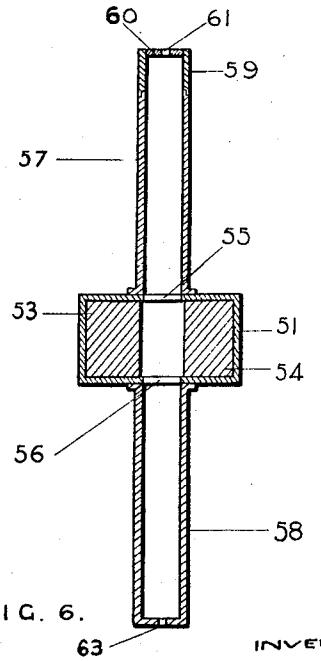


FIG. 6.

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GAS FILLED ELECTRIC DISCHARGE DEVICES

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6 Claims. (Cl. 315—35)

This invention relates to gas filled electric discharge devices. The invention is concerned in particular with such devices for use in gas discharge switches, and has particular, but not exclusive, application to the types known as bandpass TR switches and the so-called low Q ATR switches. The term "Q" used in this specification has its usual significance as applied to resonant electrical systems.

TR switches in general fall into one or other of two main types, namely high Q and bandpass TR switches. Similarly ATR switches fall into one or other of the types known as high Q and low Q ATR switches. The high Q type of TR or ATR switch consists in general of a gas filled electric discharge device having two main electrodes which form an integral part of a resonant cavity. If such a switch is required to be capable of operating over a comparatively wide band of frequencies it is necessary to make it tunable owing to the high Q of the cavity. For example, typical TR switches of the high Q type have a loaded Q of the order of 300. The necessity of making the switch tunable in these circumstances adds additional complications to the control of the radar apparatus in which the switch is used, and may lead to inefficiency due to mistuning of the switch. In order to avoid these disadvantages the bandpass type of TR switch and the low Q type of ATR switch may be used.

Hitherto, bandpass TR switches have in general consisted of a sealed off length of waveguide filled with gas and containing two or more low Q resonant elements spaced substantially one quarter of the mean operating wavelength (in the waveguide) apart along the waveguide and each resonant at a frequency substantially equal to the mean operating frequency of the TR switch, part of each resonant system forming the electrodes of a discharge gap, and resonant windows being provided across the waveguide at each end of the TR switch to couple it to further lengths of waveguide. Similarly, low Q ATR switches have in general consisted of a sealed off length of waveguide filled with gas and having a length substantially equal to one quarter of the mean operating wavelength (in the waveguide), the waveguide being short circuited at one end and being provided at the other end with a low Q resonant window resonant at the mean operating frequency of the ATR switch, which window forms a discharge gap and also serves to couple the switch into the side of a further length of waveguide.

Such TR and ATR switches are capable of operating over a comparatively wide band of frequencies without requiring tuning, owing to the low Q of the resonant elements. However bandpass TR switches and low Q ATR switches constructed as described above have certain disadvantages due to the complicated form of construction.

It is an object of the present invention to provide a gas filled electric discharge device suitable for use in an improved form of gas discharge switch.

It is a further object of the invention to provide improved forms of construction for bandpass TR switches and low Q ATR switches which avoid the aforesaid disadvantages of the known forms described above.

In this specification the term "a low Q resonant system" means a resonant system having a loaded Q of the order of 1 to 10.

Two arrangements in accordance with the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a central sectional view of a gas filled electric discharge device in accordance with the invention;

Figure 2 is a side elevation, partly cut away to show internal details, of a bandpass TR switch incorporating a discharge device such as is shown in Figure 1 and a second similar discharge device;

Figure 3 is a sectional view on the line III—III in Figure 2 with the discharge device removed;

Figure 4 is a central sectional view of a second gas filled electric discharge device in accordance with the invention;

Figure 5 is a perspective view of a low Q ATR switch incorporating a discharge device such as is shown in Figure 4; and

Figure 6 is a sectional view on the line VI—VI in Figure 5 with the discharge device removed.

Referring to the drawings, the discharge device shown in Figure 1 has two main electrodes 1 and 2 of conical shape, the electrodes 1 and 2 being formed on the ends of circular cylindrical brass rods 3 and 4 which are threaded externally. The electrodes 1 and 2 are coaxially disposed in a tubular glass envelope 5 which is filled with gas and whose ends are sealed to feather edged tubular copper members 6 and 7. Inside the members 6 and 7 are seated circular cylindrical copper bushings 8 and 9 whose bores are threaded so that the rods 3 and 4 may be screwed through them. The bushings 8 and 9 extend into the envelope 5 slightly beyond the seals between the envelope 5 and the members 6 and 7. The members 6 and 7 are soldered respectively to metal plates 10 and 11 provided with central holes through which the rods 3 and 4 pass, and the rods 3 and 4 are held in position by nuts 12 and 13 screwed onto the ends of the rods 3 and 4 and abutting against the plates 10 and 11 so as to seat the bushings 8 and 9 firmly in the members 6 and 7. Around the member 6 is soldered a brass tube 14 which is threaded externally, and around the member 7 is soldered a tubular brass member 15 part of which is threaded externally and which is provided with an outwardly projecting flange 16. A feather edged tubular copper member 17 is soldered to the plate 10 and has sealed to it a glass dome 18. A brass tube 19 is soldered to the plate 11 and has soldered to it a feather edged tubular copper member 20 to which is sealed a glass dome 21. The discharge device is provided with an auxiliary priming electrode to assist in starting the discharge between the main electrodes 1 and 2, and the priming electrode takes the form of a metal rod 22 sealed through the dome 21 and extending through an axial hole in the rod 4. The rod 22 is provided with a glass sheath 23 to insulate it from the rod 4.

Referring now to Figures 2 and 3, the TR switch illustrated therein includes two discharge devices 26 and 27, and a length of rectangular waveguide 28. The discharge device 26 is of the form shown in Figure 1, while the discharge device 27 is of similar form but has no priming electrode 22, and in this case the tube 19, member 20 and dome 21 are replaced by a brass cap 29. The discharge devices 26 and 27 are mounted in the waveguide 28 respectively in association with two inductive irises, each of which consists of two identical thin metal plates 30 and 31 extending across the waveguide 28 perpendicular to its longitudinal axis, the discharge devices 26 and 27 each being disposed in the gap be-

tween one of the pair of plates 30 and 31 with parts of the members 6 and 7 disposed inside the waveguide 28. Each broad face of the waveguide 28 is provided with two circular holes, each of which is centrally disposed with respect to one of the irises. The two holes in one of the broad faces have soldered in them metal bushings 32 which are threaded internally. Each of the discharge devices 26 and 27 is inserted into the waveguide 28 through the appropriate bushing 32 until the threads on the tube 14 engage with those on the bushing 32. The device is then screwed in until the flange 16 makes good contact with the internal surface of the waveguide 28 around the hole 33. In order to ensure good electrical contact between the flange 16 and the waveguide 28, a spring washer (not shown) may be inserted between them. The discharge devices 26 and 27 are secured in position by means of nuts 34 screwed onto the tubular members 15.

When each of the discharge devices 26 and 27 has been screwed in, the electrode assembly of each forms together with the corresponding iris a low Q resonant system. The resonant frequency of the two resonant systems is determined by a pretuning operation during the manufacture of the devices 26 and 27 (which will be described later), and for each resonant system is made equal to the desired mean operating frequency of the TR switch. The two inductive irises are spaced apart along the waveguide 28 a distance substantially equal to one quarter of the mean operating wavelength (in the waveguide 28) of the TR switch, allowance being made for the presence in the waveguide 28 of the glass envelope 5 of the discharge devices 26 and 27. When incorporated in a radar apparatus using a common aerial for transmission and reception the TR switch will be connected between the receiver on the one hand and the transmitter and the aerial on the other hand, with the discharge device 26 nearer the receiver. The gas filling of the discharge device 27 may consist of one of the rare gases, such as argon, together with water vapor, which is included in order to ensure a short recovery time for the gas filling. Since the power level of the R. F. discharge in the device 26 will be comparatively low, the recovery time of its gas filling will be comparatively short, and in many cases the expedient of including water vapor in its gas filling will be unnecessary, so that the gas filling may for example consist solely of argon. In such a case the characteristics of the gas filling of the device 26 will remain comparatively constant throughout its life, particularly as the level of the R. F. discharge is low, and there will therefore be little variation of the breakthrough of the TR switch during this period.

The manufacture of the discharge device shown in Figure 1 is carried out as follows. The members 6 and are sealed respectively to two short glass tubes having equal diameters, and the bushings 8 and 9 are inserted in the respective tubes. The free ends of the glass tubes are then joined together to form the envelope 5. The tube 14 and the plate 10 are then soldered to the member 6, and the tubular member 15 and the plate 11 are soldered to the member 7. The rods 3 and 4 are then inserted through the respective plates 10 and 11 with the electrodes 1 and 2 innermost and are screwed through the bores of the respective bushings 8 and 9, the rods 3 and 4 being held in position by the nuts 12 and 13.

At this stage of the assembly the main electrodes 1 and 2 are spaced apart at approximately the desired distance, and the final adjustment is made as follows. The part of the discharge device thus far assembled is inserted in a rectangular waveguide in association with an inductive iris, the arrangement being exactly the same as well be the case when the discharge device forms part of the TR switch. The electrode assembly together with the iris then forms a low Q resonant system. The spacing of the main electrodes 1 and 2 is adjusted by screwing the rods 3 and 4 in one direction or the other through the bushings 8 and 9 until the resonant system has a resonant frequency equal to the desired means operating frequency of the TR switch. The main electrodes 1 and 2 are then fixed in their final positions by means of the nuts 12 and 13 screwed onto the rods 3 and 4.

The assembly is then removed from the waveguide and manufacture of the discharge device is completed as follows. To the plate 10 is soldered the member 17 which has sealed to it the glass dome 18 which at this stage is provided with a pumping stem which is shown sealed off at 24. In order to facilitate the pumping and filling with gas of the whole device, a duct 25 is provided through the rod 3, the duct 25 extending from the space inside the envelope 5 to the space inside the dome 18. The tube 19 is soldered to the plate 11, and the member 20, which has sealed to it the glass dome 21, is soldered to the tube 19 after the priming electrode 22 has been inserted in the axial hole in the rod 4, care being taken to ensure that the spacing between the inner ends of the electrodes 2 and 22 has its desired value. The discharge device is then evacuated, baked, filled with the desired gas filling, and sealed off in the usual manner at 24.

Turning now to the second arrangement in accordance with the invention, the discharge device shown in Figure 4 has two main electrodes 35 and 36 coaxially disposed in a tubular glass envelope 37 provided with a gas filling, for example of argon and water vapor. The electrode 35 is formed on the end of a circular cylindrical metal rod 38 which is threaded externally and is screwed into a metal bushing 39 which is soldered inside one end of a metal tube 40 which fits closely inside the envelope 37. Inside the other end of the tube 40 is soldered a metal bushing 41, in which is soldered a metal tube 42 which is sealed through one end of the envelope 37. A metal rod 43 is soldered to the rod 38 and passes through the tube 42, being soldered to the tube 42 at its outer end. The electrode 36 forms part of a metal block 44 which is soldered inside one end of a metal tube 45 which fits closely inside the envelope 37. Inside the other end of the tube 45 is soldered a metal block 46 to which is soldered a metal rod 47. The rod 47 passes through a metal tube 48, which is sealed through the second end of the envelope 37, and is soldered to the tube 48 at its outer end. The outer end of the rod 47 is reduced in diameter so as to form a shoulder 49 on the rod 47. The envelope 37 is provided with a pumping stem which is shown sealed off at 50. It will be appreciated that in the discharge device described above there are no complicated glass to metal seals, and for this reason this form of construction is particularly suitable where the device must be of small dimensions, as in the case where it is to be used in a gas discharge switch designed for operation at high frequencies, say of the order of 10,000 mc./s.

Referring now to Figures 5 and 6, the ATR switch illustrated therein includes a single discharge device of the form shown in Figure 4 (of which only part of the rod 43 is visible in Figure 5), and a length of rectangular waveguide 51. The waveguide 51 is short circuited at one end 52 and near the other end has disposed across it an inductive iris consisting of two identical thin metal plates 53 and 54 extending across the waveguide 51 perpendicular to its longitudinal axis. The discharge device is inserted in the waveguide 51 in association with the iris, being disposed in the gap between the plates 53 and 54 with the ends of the tubes 40 and 45 projecting slightly beyond the broad faces of the waveguide 51 into the waveguide 51. The broad faces of the waveguide 51 are provided respectively with circular holes 55 and 56 which are centrally disposed with respect to the iris. Soldered to opposite broad faces of the waveguide 51 are tubular metal members 57 and 58 whose longitudinal axes pass

through the centres of the holes 55 and 56. The internal diameters of the members 57 and 58 and the diameters of the holes 55 and 56 are made very slightly greater than the external diameter of the envelope 37 of the discharge device. The outer end of the member 58 is closed and is provided with a hole 63 through which the outer end of the rod 47 passes when the discharge device is mounted in the switch, the shoulder 49 on the rod 47 abutting against the inner side of the end of the member 58. The member 57 is provided with a tubular metal cap 59 which is removable to allow the discharge device to be inserted through the member 57, the holes 55 and 56 and the member 58. The cap 59 is closed with a metal disc 60 which is provided with a hole 61 through which the rod 43 passes when the discharge device is mounted in the switch, the outer end of the tube 42 abutting against the inner side of the disc 60. The disc 60 is preferably provided with a spring clip (not shown) to press it inwards so as to ensure good electrical contact between the disc 60 and the end of the tube 42 and between the outer end of the member 58 and the shoulder 49 on the rod 47. It will be seen that when the discharge device is mounted in the switch the members 57 and 58 respectively form the outer conductors of two coaxial lines whose inner conductors are respectively formed by the tubes 40 and 42 and the tube 45, the rod 47 and the tube 48. The total lengths of these coaxial lines are both made equal to one and a half times the mean operating wavelength of the ATR switch, the tubes 40 and 45 both having lengths equal to one third of this distance. Thus at the mean operating frequency of the ATR switch there are effective short circuits between the inner ends of the tubes 40 and 45 and the adjacent broad faces of the waveguide 51, so that there is no appreciable loss of energy around the tubes 40 and 45 from the waveguide 51 at this frequency.

When the discharge device is inserted in the waveguide 51, its electrode assembly together with the iris forms a low Q resonant system. The resonant frequency of the resonant system is determined by a pretuning operation during the manufacture of the discharge device (which will be described later), and is made equal to the desired mean operating frequency of the ATR switch. The waveguide 51 has a length substantially equal to one quarter of the mean operating wavelength (in the waveguide 51) of the ATR switch, allowance being made for the presence in the waveguide 51 of the glass envelope 37 of the discharge device. When incorporated in a radar apparatus using a common aerial for transmission and reception the ATR switch forms a branch from a waveguide 62 which is connected between the transmitter on the one hand and the receiver and the aerial on the other hand.

The manufacture of the discharge device shown in Figure 4 is carried out as follows. The tube 40, the bushings 39 and 41, and the tube 42 are first soldered together, the tube 42 having a glass button sealed around it near its outer end, and the length between the inner end of the tube 40 and the outer end of the tube 42 being accurately fixed at its desired value. The rod 43, soldered to the rod 38, is then inserted through the bushing 39 into the tube 42 and the rod 38 is screwed into the bushing 39. The rod 43 is not soldered to the tube 42 at this stage. This part of the assembly is then inserted into a length of glass tubing which forms the main part of the envelope 37 and the glass button sealed to the tube 42 is sealed to one end of the tubing. The external diameter of the tubing is carefully chosen so that it is very slightly less than the diameter of the holes 55 and 56 in the waveguide 51. The tube 45, the blocks 44 and 46, and the rod 47 are soldered together, the length between the inner end of the tube 45 and the shoulder 49 on the rod 47 being accurately fixed at its desired value. The rod 47 is inserted in the tube 48, which has a glass button sealed around it, and this part of the assembly is then inserted into the glass tubing through its open end. The glass button sealed to the tube 48 is sealed to the open end of the glass tubing. The distance between the outer end of the tube 42 and the shoulder 49 on the rod 47 is fixed accurately by means of a jig, so that the distance between the inner ends of the tubes 40 and 45 has its desired value. The rod 47 is then soldered to the tube 48 at its outer end.

At this stage of the manufacture the main electrodes 35 and 36 are spaced apart at approximately the desired distance, and the final adjustment is made as follows. The discharge device is inserted in a rectangular waveguide in associatiton with an inductive iris, the arrangement being exactly the same as will be the case when the discharge device forms part of the ATR switch. The electrode assembly together with the iris then forms a low Q resonant system. The spacing of the main electrodes 35 and 36 is adjusted by screwing the rod 38 in one direction or the other through the bushing 39 by means of the rod 43 until the resonant system has a resonant frequency equal to the desired mean operating frequency of the ATR switch.

The discharge device is then removed from the waveguide and the rod 43 is soldered to the tube 42 at its outer end to fix the electrode 35 in its final position. The discharge device is then evacuated baked, filled with the desired gas filling, and sealed off in the usual manner at 50.

It will be appreciated that, while certain practical embodiments of the invention have been described above, a discharge device of the form shown in Figure 1 is not restricted to use in TR switches, nor is a discharge device of the form shown in Figure 4 restricted to use in ATR switches. Furthermore discharge devices according to the invention may be used in other forms of gas discharge switch, such as gas discharge attenuators and Pre-TR switches. The inductive elements with which the discharge devices are associated need not be irises, as described above, but may take the form of one or more inductive posts disposed across the waveguide in which the discharge device is mounted.

It will be further appreciated that gas discharge switches using discharge devices according to the invention have a number of advantages over the corresponding switches of hitherto known forms of construction. Thus the system which must be evacuated and filled with gas is considerably simplified, there being no need to evacuate and fill with gas a whole length of waveguide which would in general have to be of a different (and usually heavier) material from that normally used in the rest of the waveguide system in which the switch is incorporated. Furthermore each discharge device may be replaced separately without having to replace the whole switch. The waveguide part of the switch may thus form a permanent part of the apparatus in which the switch is used, and the necessity for maintaining close tolerances on the lengths of separate switches and for providing flanges at the ends of the switches for coupling them to further lengths of waveguide is thereby obviated; also with standard forms of discharge device, a range of gas discharge switches covering different frequency bands may be achieved merely by using the discharge devices in lengths of waveguide with different inductive elements instead of having to provide a completely different switch for each frequency band. Finally, the elimination of resonant windows in the construction of the switches leads to further simplification of manufacture and increased robustness of the final assembly.

I claim:

1. A fixedly pretuned gas filled electric discharge device for removable insertion into a waveguide of predetermined dimensions in association with an inductive element of predetermined dimensions disposed across the waveguide and which waveguide is shaped to removably receive said device and includes coupling means, said de-

vice comprising a hermetically closed tubular glass envelope filled with gas and enclosing an electrode assembly including a pair of main electrodes, means mounting said electrodes in substantial coaxial alignment for shiftable tuning movement inside the glass envelope, said envelope having an opening for tuning access to said electrodes, said electrodes being so pretuned by adjustment of their relative spacing that when the device is inserted into the waveguide the electrode assembly together with the inductive element will form a low Q resonant system which is resonant at a predetermined frequency, said envelope including cover means hermetically closing said opening and rendering the tuning means inaccessible, and coupling means engageable with the coupling means on the waveguide for detachably securing the device to the waveguide.

2. A fixedly pretuned gas filled discharge device according to claim 1, in which a pair of metal rods are provided on the ends of which the main electrodes are respectively formed, the device further including a pair of tubular metal members to whose ends the ends of the glass envelope are respectively sealed, a pair of metal bushings respectively disposed around the rods and seated in the tubular members, said bushing projecting respectively beyond those ends of the tubular members which are sealed to the glass envelope, and means for locating the device when it is inserted into the waveguide with those ends of the tubular members which are sealed to the glass envelope disposed inside the waveguide.

3. A fixedly pretuned gas filled discharge device according to claim 1, in which a pair of metal members are provided on which the main electrodes are respectively supported, said members fitting closely inside the glass envelope, further members sealed through opposite ends of the glass envelope and respectively supporting the first-named members, the device including means for locating the device when it is inserted into the waveguide with said first metal members projecting slightly into the waveguide.

4. A non-tuneable bandpass TR switch comprising a length of waveguide having at least two inductive elements disposed across it at distances apart along the waveguide substantially equal to an odd integral multiple of one quarter of the mean operating wavelength of the switch in the waveguide, and a number of fixedly pretuned gas filled electric discharge devices according to claim 1 equal to the number of inductive elements, each discharge device being removably mounted in the waveguide in association with one of the inductive elements and having been pretuned during manufacture so that its electrode assembly together with the associated inductive element forms a low Q resonant system which is resonant at a frequency substantially equal to the mean operating frequency of the switch.

5. A non-tuneable low Q ATR switch comprising a length of waveguide having a length substantially equal to an integral multiple of one quarter of the mean operating wavelength of the switch in the waveguide, the length of waveguide being short circuited at one end and having an inductive element disposed across it adjacent the other end, and a fixedly pretuned gas filled electric discharge device according to claim 1, the discharge device being removably mounted in the waveguide in association with the inductive element and having been pretuned during manufacture so that its electrode assembly together with the inductive element forms a low Q resonant system which is resonant at a frequency substantially equal to the mean operating frequency of the switch.

6. In a gas discharge switch, a length of waveguide having an inductive element disposed across it, and a fixedly pretuned gas filled electric discharge device according to claim 1, the discharge device being removably mounted in the waveguide in association with the inductive element and having been pretuned during manufacture so that its electrode assembly together with the inductive element forms a low Q resonant system which is resonant at a frequency substantially equal to the mean operating frequency of the switch.

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