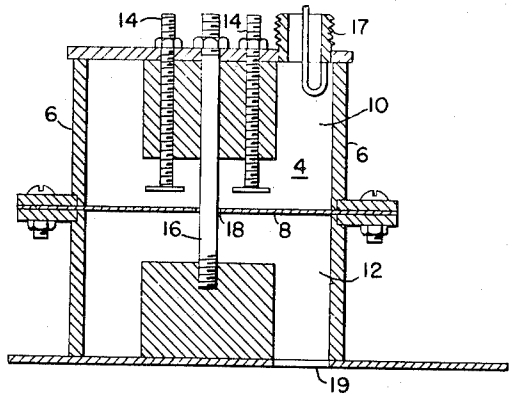
Dec. 4, 1956 C. J. MILLER 2,773,215

HIGH-FREQUENCY APPARATUS

Filed Jan. 22, 1952

Fig. 1.



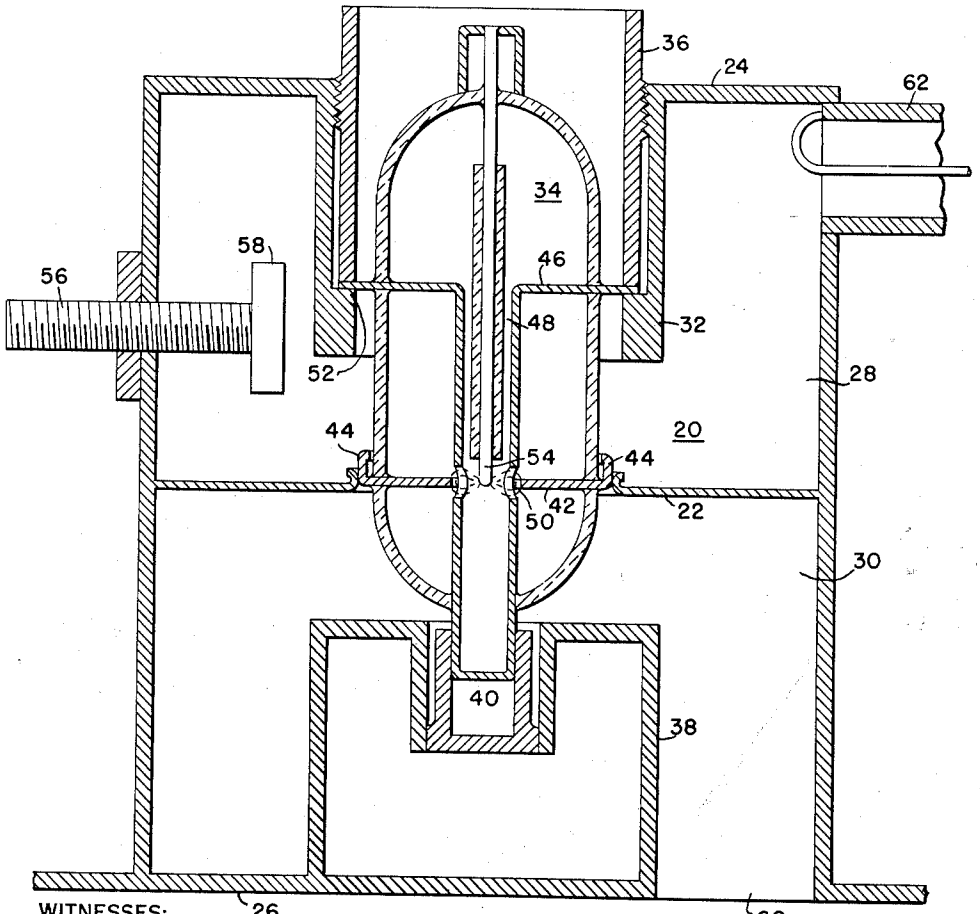


Fig. 2.

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HIGH-FREQUENCY APPARATUS

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10 Claims. (Cl. 315—41)

My invention relates to high-frequency apparatus and, more particularly, to a power-responsive switch for use in a high-frequency apparatus.

In accordance with the prior art of which I am aware, switches for radar transmission and reception apparatus have been built to respond to the high power produced by the transmitter so as to isolate the receiver from the transmitter circuit and thereby prevent burning out of the crystals in the receiver by the large power produced by the transmitter. Such devices are commonly referred to as transmit-receive devices or T/R boxes. In the prior art, these devices have consisted of a high Q cavity coupled between the receiver and a junction with the transmission line extending between the transmitting tube and the antenna. Normally, energy from the antenna which is being received by the antenna is propagated through the cavity to the receiver with substantially no attenuation. However, when the transmitter produces a high-power pulsed signal, a gas discharge tube in the cavity at the point of maximum electric stress breaks down disruptively and provides about 50 decibels attenuation to the oscillations attempting to cross the cavity so as to reach the receiver. This attenuation is produced by a detuning of the cavity when the gas discharge tube breaks down.

While a T/R box, as described above, is capable of protecting a receiver in some cases, there are, nevertheless, many cases in which the protection afforded by such a device is inadequate. As a consequence of the inadequacy of such protection, various types of complicated pre-T/R arrangements have been provided to give additional protection to the receiver. However, such systems are complicated, cumbersome, and expensive.

It is, accordingly, an object of my invention to provide a T/R box which will provide ample protection for the receiver on even the highest power systems.

Another object of my invention is to provide a simple and inexpensive device for protecting the receiver in high-power radar apparatus.

An ancillary object of my invention is to provide an improved device for controlling the flow of high-frequency electromagnetic oscillations.

Another object of my invention is to provide a new and useful electronic apparatus.

The novel features which I consider characteristic of my invention are set forth with more particularity in the appended claims. The invention, however, with respect to both the organization and the operation thereof, together with other objects and advantages may be best understood from the following description of specific embodiments when read in connection with the accompanying drawing, in which:

Figure 1 is a showing in section of an apparatus embodying my invention; and

Figure 2 is a showing in section of an apparatus embodying my invention in which a removable gas discharge tube is employed.

In accordance with one embodiment of my invention,

I provide a high Q cavity resonator **4** having walls **6** of electrically conducting material. The cavity resonator **4** is divided into two parts, an upper part **10** and a lower part **12**, by a central wall **8** extending across the cavity **4**. Extending into the upper part **10** of the cavity **4** are two probes **14** which are adjustably mounted so that the distance which they extend into the cavity **4** may be adjusted so as to tune the cavity. Through the center of the cavity **4** in a direction perpendicular to the center wall **8**, there is a rod **16** of electrically conducting material. The rod **16** extends through a hole **18** in the center wall **8** of the cavity **4**. The hole **18** in the center wall **8** of the cavity **4** through which the center rod **16** extends is slightly larger than a cross section of the rod **16** so that the rod **16** does not make direct electrical contact with the center wall **8**, but so that the distance between the rod **16** and the center wall **8** is small. An opening **19** is provided in a wall of the bottom part **12** of the cavity **4** for connecting a section of waveguide thereto so as to supply oscillations to the cavity **4**. A coaxial cable **17** is connected through a wall of the upper part **10** of the cavity **4** so as to derive electrical oscillations from the cavity.

In accordance with the operation of this embodiment of my invention, oscillations are supplied to the bottom part **12** of the cavity **4**. If the energy of these oscillations is sufficiently small, the whole cavity resonator **4** comprising the top part **10** and the bottom part **12** will resonate as one cavity, and power will pass out through the coaxial cable **17** connected to the top part **10** of the cavity **4** with relatively little attenuation. However, if the power of the oscillations supplied to the lower part **12** of the cavity **4** becomes sufficiently great, as, for example, when the transmitter of the system is supplying oscillations to the antenna, the gas between the center wall **8** and the center rod **16** will break down and a discharge will occur between the center wall **8** and the center rod **16**. When this discharge occurs, the entire cavity **4** is detuned and in addition the two parts **10**, **12** of the cavity **4** are effectively isolated from each other. Thus, there is provided a large attenuation due to the detuning of the cavity **4** as is done in the devices of the prior art, and, in addition, the two parts **10**, **12** of the cavity **4** are effectively isolated. This isolation of the two parts of the cavity greatly increases the attenuation of high-frequency oscillations passing through the cavity.

In accordance with the embodiment of my invention shown in Figure 2, I provide a cavity resonator **20** of substantially cylindrical shape with walls of conducting material. Across the center of the cavity **20**, a center partition **22** of electrically conducting material is placed so as to be substantially parallel to the ends **24**, **26** of the cylindrical cavity **20**. The center partition divides the cavity resonator **20** into two parts, namely, an upper part **28** and a lower part **30**. In the upper part of the cavity, a hollow supporting cylinder **32** extends down into the cavity **20** so as to form an opening and a support for a gas discharge tube **34**. Threads are provided on the inside of the supporting cylinder for engaging a securing cylinder **36** which sets inside the supporting cylinder **32**. Extending upward from the bottom wall **26** of the cavity resonator **20** is a bottom support projection **38** having a hollow cylindrical opening **40** for engaging the bottom end of the gas discharge tube **34** and lending support thereto. The center partition **22** has a large hole therein near the center of the resonant cavity **20** to allow the insertion therethrough of a part of a gas discharge tube **34**.

The gas discharge tube comprises a tube partition **42** of electrically conducting material adapted to fit inside the large hole in the center partition **22** of the cavity resonator. Flanges **44** are provided on the tube

partition 42 for engaging the center cavity resonator partition 22 so as to maintain a "tight fit" between the tube partition 42 and the resonator partition 22. The tube partition 42 thus forms an extension of the resonator partition 22 so as to more effectively separate the upper and lower sections 28, 30 of the cavity 20. A tube boundary partition 46 is provided which forms, when the tube 34 is in place, part of the upper wall of the cavity resonator 20. The tube boundary partition 46 comprises a flat circular piece of metal adapted to fit inside the hollow support cylinder 32 extending downward from the upper wall 24 of the cavity resonator 20. In the center of the flat circular piece, there is a keep-alive chamber 48 comprising a hollow cylindrically shaped re-entrant portion which extends downward through a hole 50 in the tube resonator partition 42 to the hollow cylindrical opening 40 in the bottom support projection 38 which extends upward from the bottom wall 26 of the cavity resonator 20. The sides of the flat circular disc 46 rest on keep-alive chamber support projections 52 which extend inward from the sides of the re-entrant cylinder 32 extending downward from the upper wall 24 of the resonator 20. The securing cylinder 36 which has threads to engage the inner wall of the re-entrant cylinder 32 of the resonant cavity 20 is adapted to press down on the circular disc 46 so as to hold that disc tightly in place and thereby to effectively seal the sides of the disc 46 to the walls of the resonant cavity 20. A plurality of holes is provided in a wall of the keep-alive chamber 48 opposite the center tube partition 42, the center tube partition 42 being separated from the wall of the keep-alive chamber 48.

Inside the keep-alive chamber 48, there is provided a keep-alive 54 which is adapted to be impressed with an electric potential which is more positive than that of the center tube partition 42. The keep-alive 54 provides a continuous supply of free electrons in the region of the gap between the keep-alive chamber 48 and the center tube partition 42.

A tuning probe 56 extends through a wall of one of the chambers formed by the center partition 22 and the walls of the cavity resonator. The tuning probe 56 is a rod of electrically conducting material which is mounted so that the distance which it extends into the resonant cavity 20 is adjustable. On the end of the tuning probe 56 inside the resonant cavity, a disc 58 of electrically conducting material is provided which has a diameter larger than the cross-sectional diameter of the rest of the tuning probe 56. The latter disc 58 is employed to increase the effectiveness of the tuning probe 56. A hole 60 is provided in a wall of the bottom part 30 of the cavity 20 for connecting thereto a waveguide. The waveguide opening 60 is provided for supplying electromagnetic oscillations to the lower part 30 of the resonant cavity 20. A coaxial cable 62 is connected through a wall of the upper part 28 of the resonant cavity 20 for deriving oscillations from the resonant cavity.

The waveguides and the coaxial conductor described herein are chosen as indicative of the types of conductors which might be employed. It is, of course, conceivable that almost any type of high-frequency conductor might be employed, under certain circumstances, with the apparatus shown in the drawing. The waveguide connected to the lower part 30 of the cavity 20 would normally be connected to the electrical conductor leading between an oscillation generator such as a klystron and an antenna in a radar apparatus.

The operation of my invention is believed to be substantially as follows. Where oscillations are being received by the antenna of a radar apparatus, these oscillations pass down the main conductor, between the high-frequency oscillator and the antenna, to the lower portion 30 of the cavity resonator. At this time, there is no substantial electric discharge across the gap 50 which separates the upper portion 28 of the cavity 20 from

the lower portion 30 of the cavity 20. Therefore, the oscillations pass through the gap 50 from the lower portion 30 of the cavity 20 to the upper portion 28 of the cavity 20 with only slight attenuation and the cavity 20 will proceed to oscillate as one large cavity. Oscillations will, therefore, pass out of the upper part 28 of the cavity 20 to a receiver with substantially no attenuation.

However, when the main transmitting oscillator of the radar apparatus emits electromagnetic oscillations of high power, these oscillations will proceed down the main waveguide and into the lower portion 30 of the cavity resonator 20. These high-power electromagnetic oscillations then start to pass through the gap 50 into the upper portion 28 of the cavity 20. As the high-power oscillations pass through the gap 50, they produce high-energy radio-frequency fields across the gap 50. The high-power radio-frequency fields across the gap 50 produce large accelerations in any electrons in the region, which electrons will cause the ionization of atoms or molecules in the region, and if the radio-frequency fields are sufficiently strong, the high-energy fields cause a disruptive breakdown of the gas, thus forming a continuous arc across the gap 50. When a continuous arc is formed across the gap 50, the gas in the region of the gap 50 becomes a conductor, thus effectively extending the center tube partition 42 across the gap 50 to the keep-alive chamber 48. Oscillations are, therefore, discouraged from passing from one section of the resonant cavity 20 to the other section of the resonant cavity 20.

The gas discharge across the gap 50 produces two effects. First, the resonant cavity is detuned, and, second, the two sections of the resonant cavity are effectively isolated from each other. These two effects together prevent substantially all of the oscillations entering the lower part 30 of the cavity resonator 20 from passing through the cavity 20 and out of the upper part 28 of the cavity resonator 20 to the receiver.

Electrons for starting the gas discharge across the gap 50 might be supplied by such accidental forces as cosmic rays. However, for quick response of the apparatus, it is desirable that a supply of free electrons be maintained in the region of the gap 50 at all times. This may be done in accordance with principles well known in the art by employing a keep-alive 54 substantially as described above.

Although I have shown and described specific embodiments of my invention, I am aware that other modifications thereof are possible.

I claim as my invention:

1. A high frequency apparatus comprising a cavity resonator, a wall of conducting material extending across said cavity resonator dividing said cavity resonator into a first part and a second part, said wall having a hole therethrough, a rod of conducting material extending through said hole, said rod having cross-sectional dimensions at the point where it passes through said hole which are substantially less than the dimensions of said hole, said rod being electrically separated from said wall, means connected to said first part for supplying high-frequency oscillations to said first part and means connected to said second part for deriving high-frequency oscillations from said second part.

2. Apparatus as defined in claim 1, wherein said rod is connected electrically to a wall of said first part opposite said hole and is connected to a wall of said second part opposite said hole.

3. A transit-receive tube comprising, an envelope of dielectric material, a partition of electrically conducting material extending across said envelope near one end of said envelope, said partition having a hole therein near the center thereof, a wall of electrically conducting material extending across said envelope near the other end of said tube from said partition and having a re-entrant projection therein extending through the hole in said

partition, said re-entrant portion having a hole in the wall thereof opposite said partition, a keep-alive extending along said re-entrant portion to the region of said hole in said re-entrant portion.

4. A transit-receive tube comprising, a first wall of electrically conducting material, said first wall having a re-entrant portion extending a substantial distance from said wall in a somewhat cylindrical shape, a hole in the wall of said re-entrant portion a substantial distance from said first wall, a partition of electrically conducting material surrounding said re-entrant portion in the region of said hole in said re-entrant portion and being separated from said re-entrant portion, said partition being substantially parallel to said first wall; a keep-alive extending through the interior of said re-entrant portion to the region of said hole in said re-entrant portion; and a vacuum-tight envelope enclosing said hole, said keep-alive, and a portion of said first wall, said partition, and said re-entrant portion.

5. A high frequency apparatus comprising walls defining a cavity resonator, said cavity resonator having a partition of electrically conducting material extending across said cavity resonator and having a hole therein, a first re-entrant portion in one end of said cavity resonator and a second re-entrant portion in the other end of said cavity resonator, a wall of electrically conducting material extending across said first re-entrant portion, and said last-mentioned wall having extending therefrom a keep-alive re-entrant portion of substantially cylindrical shape extending through said cavity resonator and through said partition to said second re-entrant portion, said keep-alive re-entrant portion having a hole in a wall thereof opposite said partition.

6. A high frequency apparatus comprising walls defining a cavity resonator, a dividing wall of conducting material extending therethrough and dividing said cavity resonator into a first part and a second part, said dividing wall of conducting material having an aperture therein, and a conductor extending through the aperture in said dividing wall for conducting energy from one part of said cavity resonator to the other part of said cavity resonator, said conductor being electrically separated from said wall where it extends through the aperture and means connecting said conductor to said defining walls of said cavity resonator.

7. A high-frequency apparatus comprising walls defining a cavity resonator, a dividing wall extending across said cavity resonator and dividing said cavity resonator into a first part and a second part, said dividing wall having an aperture therein, a conductor extending through

the aperture in said dividing wall for conducting energy from said first part to said second part of said cavity resonator, said conductor being electrically separated from said dividing wall where it extends through the aperture, means connecting each end of said conductor to a wall of said cavity resonator substantially opposite the aperture in said dividing wall, means connected to said first part for introducing high-frequency energy into said first part of said cavity resonator, and means connected to said second part for deriving high-frequency energy from said second part of said cavity resonator.

8. A transmit-receive tube comprising an envelope of dielectric material, a wall of conducting material extending across said envelope, said wall having an aperture therein, and a keep-alive electrode extending into the region of said aperture.

9. A transmit-receive tube comprising an elongated envelope of dielectric material, a conductor extending transversely of said envelope, said conductor having an aperture therein, a tubular member extending through the aperture in said conductor and longitudinally into said envelope for a substantial distance, said tubular member having an aperture therein substantially opposite said transversely extending member, and a keep-alive extending into said tubular member and terminating substantially opposite the aperture in said tubular member.

10. A transmit-receive tube comprising an elongated envelope of dielectric material, a conductor member extending transversely of said envelope and dividing said envelope into two parts, said transversely extending conductor member having an aperture therein, a hollow conductor extending from one end of said envelope and through the aperture in said transversely extending conductor member, said hollow member having an aperture therein substantially opposite said transversely extending conductor member, and a keep-alive extending from the other end of said envelope into said hollow member and terminating substantially opposite the aperture in said hollow member.

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