Feb. 5, 1957 N. T. WILLIAMS ET AL 2,780,748

AUTOMATIC RADAR SWITCH

Filed Feb. 27, 1951

Fig. 1.

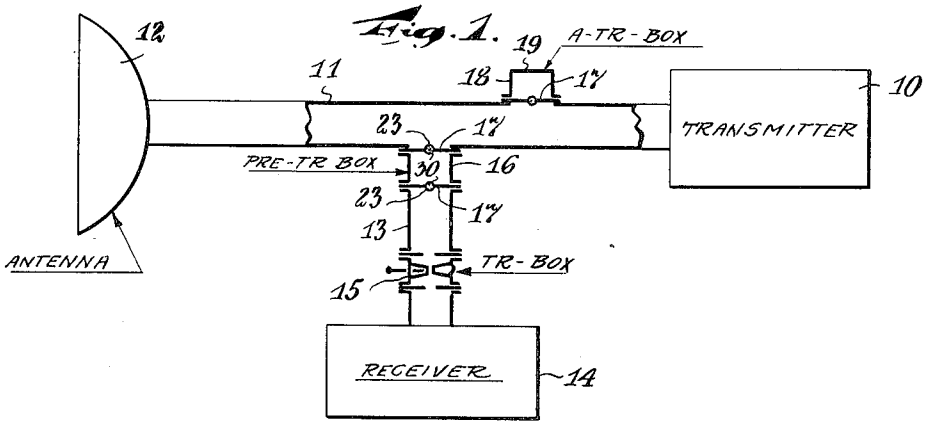


Fig. 2.

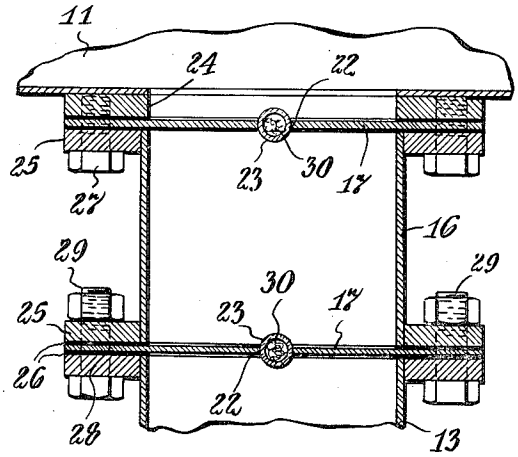


Fig. 3.

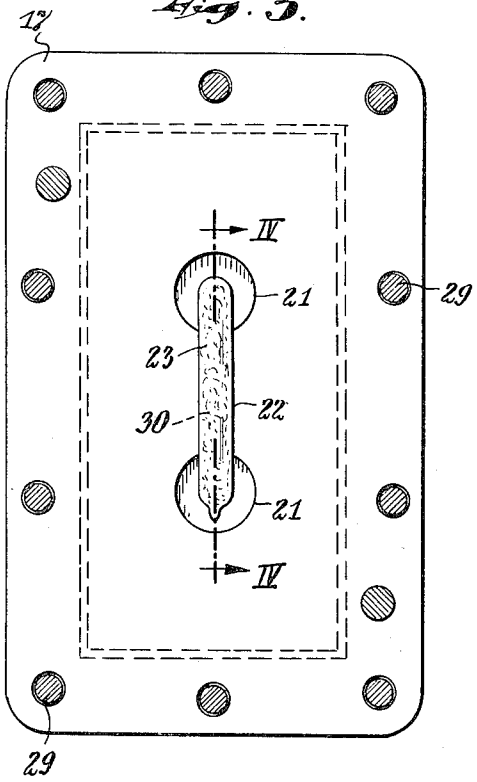
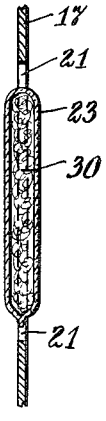


Fig. 4.



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AUTOMATIC RADAR SWITCH

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3 Claims. (Cl. 313—201)

Parts of radar equipment of the present day comprise, inter alia, TR boxes and Pre-TR boxes for protecting the receiving apparatus against powerful signals from a proximate source yet enabling weak reflected signals to pass to the receiver. For maximum effectiveness, the TR and Pre-TR boxes should possess and maintain short recovery time throughout their useful life. It will be understood that these boxes are usually gas-filled and the gas ionizes from effects of a powerful signal, the ionization providing a short-circuit path across the line to the receiver. Radar apparatus is desirably operated in the range of 1200 megacycles, and above, and the interval between pulses is extremely short, and it is in those intervals that the weak signal is received, so the importance of prompt deionization will be apparent. One suggestion is to shorten recovery time by filling the box with small objects, such as quartz pellets. This, however, proved to be impractical because the amount of dielectric added in order to increase the surface the required amount, threw the resonant frequency of the box far beyond desirable limits and increased the insertion loss. Again, beneficial results have been obtained by providing a resonant aperture or iris for the box and by situating a gas-filled tube in and extending the full length of the capacitative portion of that iris. However, even this reduction of gas volume does not fully achieve the desired rapidity of recovery. As a further aid to quick deionization, water vapor is frequently used, but, due to absorption by the glass or other walls confining the gas, the life of such a tube is progressively less effective and comparatively short. A remedy for the water-absorption loss of introducing a chemical water reservoir, specifically, sodium hydroxide, has been tried, but here again, the results are not satisfying as the equilibrium pressure between water vapor and sodium hydroxide is temperature dependent. As the temperature rises, the water vapor pressure increases and the arc loss climbs way beyond permissible limits and even to such an extent as to cause the bonding cement on the outside of the tube to char.

The present invention overcomes the difficulties and deficiencies explained above and provides structure for exceedingly short recovery time so as to give maximum conductive period for the incoming signal.

Specifically, an object of the invention is to provide a large surface-to-volume ratio in an ionic tube and yet without adding large amounts of dielectric material.

Additionally, the invention contemplates utilization of a filler material in an ionic tube not only providing the large surface-to-volume ratio, but maintaining the ratio constant and without packing resulting from use.

Other objects of the invention will become apparent to persons skilled in the art to which it appertains as the description proceeds, both by direct reference thereto and by inference from the context.

Referring to the accompanying drawing, in which like numerals of reference indicate similar parts throughout the several views:

Fig. 1 is a somewhat diagrammatic view of a radar system with our invention incorporated therein;

Fig. 2 is a longitudinal section of a protective device or box utilizing the present invention and showing the tube of our concept in cross section;

Fig. 3 is an elevational face view of an end wall of a cavity resonator, said wall having an ionic tube of our invention in the iris of said wall; and

Fig. 4 is a longitudinal section of said tube and associated portion of the resonator end wall, taken on line IV—IV of Fig. 3.

Use of reflection of radio waves for various purposes, such as determination of altitude of an airplane to ground, for locating one airplane from another or from a fixed station, and for other purposes, is an accomplished fact, and is known under the general designation of radar. In such systems, the wave is generated, passed to the antenna and into space, reflects from the object addressed, returns to the antenna and thence to the receiver. A switch of automatic character has to be provided to keep the projected pulse from passing to the receiver either in the transmission stage or in the reflected stage should the reflection occur from an object very close to the transmitter and receiver. Such a switch is now commonly referred to as a TR-box, and though it operates at any moment over a comparatively narrow band, is tunable over a wide band for receiving purposes. Technically, a TR-box is a cavity resonator having a spark-gap therein which will discharge on application of high power, as from the transmitter, the spark discharge forming a short-circuit for the high power which therefore does not traverse the receiver. It has been found, however, that direct-coupled and harmonic leakage powers sometimes get past the TR-box and full protection for the receiver is not attained. Thus it has been found that a Pre-TR box is desirable and often necessary.

According to the present invention, the usual radar equipment, including a tunable TR-box is employed, and a Pre-TR box is provided in advance of the TR-box, the construction overcoming the necessity to evacuate the entire Pre-TR box or to maintain a gas filling for the entire Pre-TR box, but instead, to confine the gas-filled chamber to a relatively small volume at the crucial position for effective operation and with use of a glass container that can be readily sealed and can be expected to have long life and be non-leaking, and which is relatively inexpensive and readily replaced. The same construction of tube and location in a resonant cavity orifice at an end of a resonator comprising an A-TR box constitutes a protective device to maintain an open line to the transmitter between pulses.

The transmitter or other wave-generator 10, Fig. 1, is productive of high pulse energy of desired frequency preferably promulgated as $TE_{1,0}$ waves longitudinally through a wave-guide transmission line 11, which is of metal and rectangular in cross-section, said waves radiating from the antenna as a so-called line-of-sight beam. The antenna includes a parabolic device as part thereof which can be moved about for directing the wave path or beam in a desired direction and toward an object. The beam will be reflected from an object in its path and on its return course, in the interval between transmitted pulses, is intercepted by the parabolic device and directed back to the wave-guide 11 and to the receiver through the Pre-TR box, which is a broad band resonator that will, without tuning, pass the signal, and through the TR-box, which is a resonator tuned to the incoming signal. Between transmitted pulses, the Pre-TR box and the TR-box are not functioning to short-circuit the receiver branch, since during that interval the power is weak. The receiver is constructed to receive the very weak reflected pulses, but would be ruined if subjected

to the high power outgoing pulses from the transmitter. Protection is afforded by the Pre-TR box and TR-box in the receiver or branch line. Full value of the weak reflected signal is made effective on the receiver by avoiding loss in the transmitter by inclusion of another protective device or A-TR box in the transmission line between the transmitter and receiver.

In the specific showing of the drawing, there is illustrated a radar system with a high frequency high-power generator or transmitter **10** connected by a wave-guide transmission line **11** to an antenna **12**. A side branch wave-guide receiver line **13** projects transversely from the transmission line and connects with a receiver **14**. In this branch line, in advance of the receiver, is a tunable TR-box **15**, and also in said branch line, between said TR-box and the transmission line, there is a Pre-TR box **16** constructed in accordance with the present invention. The Pre-TR box **16** comprises a resonator having one end wall **17** toward the transmission line and another end wall **17** toward the receiver. Also between the transmitter and branch line, located at one side of and opening into the transmission line **11**, is an A-TR box **18**. This A-TR box has its end wall toward the transmission line corresponding in construction to and designated by the same reference numeral as the two end walls **17** of the TR-box **15**. The other end wall **19** of the A-TR box is solid and spaced from and parallel to the front wall **17**, said A-TR box having a quarter-wavelength depth and constituting a resonator, and by opening into the transmission line functions to terminate the transmission line thereat and prevent weak incoming signals from passing to and becoming dissipated in whole or in part in the transmitter or generator. Both of the end walls of the Pre-TR box and the end wall **17** of the A-TR box toward the transmission line are of similar construction, and description of one will suffice for all, and for brevity each will be designated a control wall.

Referring to Figs. 2, 3 and 4 each said control wall of the Pre-TR box and of the A-TR box has a resonant iris therethrough. Each iris is in the form of two separated circular openings **21**, **21** connected by a slot **22** symmetrical to a line extending from the center of one opening **21** to the center of the other opening **21**. The circumferences of the openings constitute inductive portions and the margins of the slot **22** constitute capacitative portions of the iris.

The slot **22** of the iris is physically closed by a glass gas-filled tube **23** extending longitudinally of said slot with the edges of the slot in contact with the said tube for the full length of said edges. Considered from electrical aspects, however, the tube does not necessarily close the slot, as the received reflected weak waves may pass freely transversely through the tube and slot due to the resonant nature of the iris and broad-band nature of the box resonator for which the said control wall having said iris constitutes an end. This unimpeded passage of weak pulses travelling in the wave-guide at the iris sets up a voltage across the slot from one longitudinal margin to the other thereof, of such low value as to not be effective to ionize the gas in the tube **23**, but adequate to pass the wave pulse. But with high power electromagnetic waves travelling in the wave guide, exceedingly high voltage occurs across the slot **22** from one margin to the other thereof, causing ionization of the gas in the contiguous tube **23** and that ionized gas thereupon forms a discharge path short-circuiting the path across the slot and reflects the wave seeking to pass through the iris in direction longitudinally of the resonator or box.

An opening of corresponding size and shape as the Pre-TR box and as the A-TR box is provided for each box through the wall of the wave-guide **11**, and for each box a frame **24** may be provided upon the margin of the wave-guide wall around the opening and secured to said wall as by soldering, brazing, or otherwise. The body of the box is provided with a peripheral flange **25** of corresponding size and shape to the said frame and juxtaposed thereto with the margin of the control wall **17** interposed therebetween. Copper or other gaskets **26** in whole or in part metal so as to be conductive, may be provided on the opposite faces of the control wall margins between the same and said frame and flange. Said control wall is clamped in its assembled position across the opening in the wave-guide by suitable means such as by a plurality of bolts **27** extending through the flange, gaskets and control wall margin into said frame. In the case of the Pre-TR box which has a duplicate control wall at its opposite end, the flange **25** and gaskets **26** are duplicated thereat and register with another flange **28** on the branch wave-guide **13**, bolts **29** being provided to clamp the duplicate control wall between said flanges.

Tube **23** is preferably longer than slot **22** so as to project into the circular openings **21**, **21** of the iris, one purpose for which being, when the gas in said tube ionizes, to obtain full effect of ionization throughout the entire capacitative area of the iris; and another purpose is to increase the volume of gas and thereby increase the life possibilities of the tube. For this latter purpose, the ends of the tube may be made bulbous, if desired, to occupy substantially the area of the circular openings. While it is preferable to utilize glass in the manufacture of said tube, other dielectric materials may be used. The tube may be held in place in the iris by any suitable sealing medium or cement at the edge of the iris juxtaposed to the outer wall of the tube.

The feature of the present invention resides in the inclusion, in the tube **23**, of a pervious body **30** the overall dimensions whereof are substantially those of the interior of said tube. The primary purpose of the filler or body **30** is to provide extensive surface area such that the ratio of surface area to the volume of the tube shall be very high, as, for example, sixty square centimeters of surface to one cubic centimeter of volume. In practice, a filler of glass or quartz wool, shreds or fibre, is lightly packed in the tube to fill the same. The fibre employed very successfully has approximate diameter of .0005" and with a tube having substantially 3.7 cubic centimeters volume, a filler of quartz wool weighing 150 millagrams has served the purpose very well. This results in approximately 214 square centimeters of wool surface, which, added to approximately 18 square centimeters of tube interior wall surface, gives a total of surface area approximating 232 square centimeters, or approximately 62 square centimeters of surface to one cubic centimeter of volume of the tube.

A tube with fibrous filler, such as described above, provides a total surface area of fibres, added to the inside surface area of the tube, affording the large surface-to-volume ratio desired, and also intercommunicating interstices between the multiplicity of fibres for the ionizable gas content of the tube. Since the individual fibres are very small in diameter, the entire filler body actually adds a relatively small mass of dielectric material and therefore does not substantially affect the resonant frequency, insertion loss, or Q of the box with which it is used. The glass or quartz wool filler **30** accomplishes a low arc loss so that heating of the tube is held to a minimum and has no ill effects on the sealing medium which holds the tube in place in the iris. The structure eliminates all need for inclusion of water vapor in the gas content of the tube and thus avoids difficulties of clean-up and heat-sensitiveness and deterioration from change of character of the gas content. In manufacture, more or less glass or quartz filler may be employed to give the tube the desired rating of recovery time. Furthermore, the filler is of somewhat resilient character so that it will tend to expand against the wall of the tube

and remain at all times in the placement thereof given in the fabricating operation of filler and tube, and does not settle or compact from effects of time or use.

We claim:

1. A device for use in an automatic radar switch, comprising an electrodeless sealed tube of dielectric material in its entirety, said tube being hollow and having an interior wall-area, and a pervious immobile filler in said tube extending throughout said hollow tube and in contact with said tube throughout all of said interior wall area, said filler being shreds of dielectric material low in mass and providing a total of surface area in excess of said wall area and having interstices between the shreds providing devious-course passageways through the tube in all diametric directions, said interstices having an ionizable gas therein.

2. A device for use in an automatic radar switch, comprising an electrodeless sealed tube of dielectric material in its entirety, said tube being hollow and having an interior wall-area, and a filler of lightly packed immobile small mass of quartz shreds in said tube, said filler extending throughout said hollow tube and being in contact with said tube throughout all of said interior wall area, the shreds of said filler being included in said hollow

tube in amount providing a total of surface area in excess of ten times said wall area and having interstices between the shreds providing devious-course passageways through the tube in all diametric directions, said interstices having an ionizable gas therein.

3. A device in accordance with claim 2 wherein the mass of said filler per cubic centimeter volume of said hollow is less than fifty milligrams.

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