Aug. 23, 1966 J. D. WOERMBKE 3,268,757

ELECTRICAL DISCHARGE DEVICE

Filed July 7, 1961

Fig. 1.

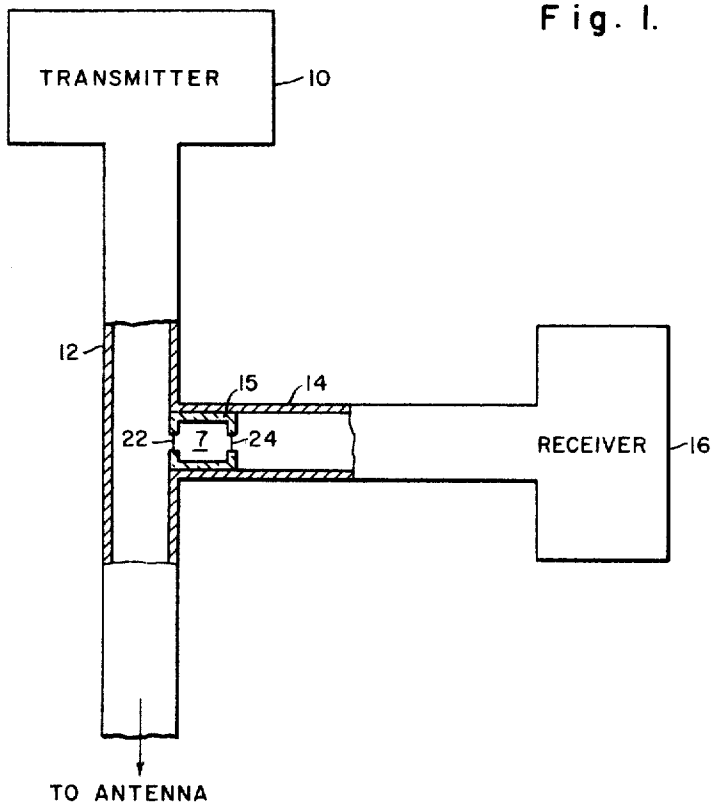


Fig. 2.

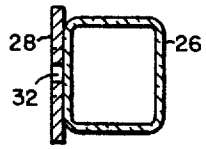
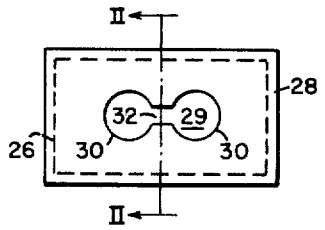


Fig. 3.



WITNESSES

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ELECTRICAL DISCHARGE DEVICE

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This invention relates, in general, to gas filled electrical discharge devices and more particularly to atmospheres for filling transmit-receive switches, hereafter referred to as "T–R switches," used in conjunction with radar equipment.

T–R switches have been widely used in radar circuits to permit a sensitive receiver of ultra short-wave signals, for example, 3000 megacycles, to be operatively connected to the same antenna of a radar set to which the transmitter is connected. The T–R switch functions to short circuit the receiver the moment a pulse from the transmitter is transmitted to the common antenna and thus prevents an influx of power into the receiver, from the transmitter, which would damage the sensitive receiver.

To effect the above purpose, the T–R switch must change with great rapidity from a nearly non-conductive state to a sufficiently conductive state when the pulse wave front appears, and must change back again to the non-conductive condition with great rapidity when the transmitted pulse has terminated. To effect this change, it is necessary that the gas within the switch shall rapidly increase in ionization so that a space discharge may be initiated by a relatively small voltage rise, i.e., it should have a comparatively low breakdown voltage, and it should deionize rapidly when the voltage is removed so that the return signal may be admitted to the receiver.

One form of T–R switch comprises a chamber which contains a quantity of ionizable gas such as argon. A resonant microwave aperture or iris is located in one wall of the chamber. With the incidence of high power level electromagnetic waves, a very high voltage occurs between opposite edges of the iris causing ionization of the gas within the chamber. This ionized gas forms a low resistance path between the opposite edges of the iris through which an arc discharge is established and which, in turn, effectively short circuits the path across the iris causing the reflection of incident radiation.

It has been suggested, in the prior art, that a small quantity of an electron attachment gas, such as iodine, be admixed with the ionizable gas contained in the chamber of the T–R switch for the purpose of rapidly attracting electrons from the ionized gas and hence deionize the gas at the termination of the transmitted pulse. Iodine has a low vapor pressure at room temperature but is heated within the switch by arc loss effects, so that its vapor pressure is increased to usable levels if the switch is operated at a sufficiently high incident power level. Frequently, however, microwave T–R switches are required to operate over a broad range of incident power levels, the lower limits of which are not sufficiently high to heat the iodine to a usable level.

Accordingly, it is the general object of this invention to provide a new and improved T–R switch which is effectively operable over a wide range of incident radio frequency power levels.

It is another object of this invention to provide a gaseous atmosphere for electron discharge devices.

It is a more particular object of this invention to provide a gaseous atmosphere for electron discharge devices, which atmosphere will ionize and deionize with great rapidity over a wide range of incident power levels.

Briefly, this invention accomplishes the above cited objects by providing a T–R switch having an enclosed

atmosphere comprising a plurality of types of attaching gases or agents. The attaching gases are selected so that each acts as the dominating attaching agent at different levels of incident radio frequency power so that the T–R switch will effectively operate over a much wider range of incident radio frequency power than T–R switches of the prior art.

The aforementioned and other objects are effected by this invention as will be apparent from the following description read in conjunction with the accompanying drawing, in which:

FIGURE 1 is a schematic showing the basic components of a radar system employing a T–R switch;

FIG. 2 is a side elevation view, in section, of a T–R switch in accordance with the invention; and

FIG. 3 is an elevational front view showing one form of iris which may be utilized with the invention.

Referring particularly to FIG. 1, there are shown the basic components of a radar transmitter-receiver system. This includes a transmitter **10** which generates pulses of short duration which are transmitted through a waveguide **12** to a radiating antenna (not shown). Returning signals are intercepted by the same antenna and returned through waveguides **12** and **14** to a receiver **16**.

In order that the receiver **16** may not be damaged by the transmitted signal, which is of much higher power level than the received signal, it is necessary that means be provided to effectively block the transmitted signal from the reeciver during the transmitting period. This is accomplished by interposing in the waveguide **14** an electronic switching device indicated generally at **7**, ordinarily referred to as a T–R switch. This switch comprises generally a sealed enclosure **15** having microwave irises **22** and **24** through which radio frequency wave energy may pass and contains an ionizable gas adapted to support a discharge. With the incidence of high power electromagnetic waves, a discharge is established within the enclosure which effectively short circuits the waveguide **14** and prevents the transmitter energy from entering the receiver.

In order that the returning signal, which is at a much lower power level than the transmitted signal, may not also be blocked from the receiver, it is, of course, imperative that the T–R switch return to a non-conductive state within a matter of microseconds after the termination of the transmitting pulse. The rate at which the T–R switch will return to the non-conducting state is governed largely by the rate at which the gas within the envelope returns to the deionized state after the transmitter voltage has been removed. The rate at which this deionization will occur is largely governed by the nature of the gaseous atmosphere within the envelope.

In FIGS. 2 and 3 there is shown in greater detail, a T–R switch similar in function to that described in connection with FIG. 1. The switch comprises a sealed envelope **26** which is made of some suitable material such as glass or quartz and is filled with a gaseous atmosphere as will be explained later.

A metallic diaphragm **28** having an aperture or iris indicated generally at **29** is bonded by suitable means such as soldering or brazing to an external wall of the envelope **26**. The iris **29** is of such shape and dimensions so as to be resonant at the operating frequency of the radar system. By way of example, as shown in FIG. 3, the iris is in the form of two separated circular openings **30**, **30**, connected by a slot **32** symmetrical to a line extending between the centers of the openings **30**, **30**. The circumferences of the openings constitute inductive portions and the margins of the slot **32** constitute capacitive portions of the iris. The iris acts to concentrate the incident radio frequency field at its constricted portion

to define a discharge gap within the envelope **26** and to reduce the power level necessary to initiate the discharge. This concentration also aids in the reduction of arc loss after discharge has been established.

The envelope **26** is hermetically sealed and contains a gaseous atmosphere. This gaseous atmosphere comprises, in part, an ionizable body gas to facilitate discharge within the envelope **26** upon the incidence of radio frequency power from the transmitter. The ionizable body gas may consist of any of the noble gases, that is helium, neon, argon, krypton, xenon or radon. These gases are readily ionizable and serve to provide, in their ionized state, a low resistance discharge path. While these gases will ionize in a sufficiently short time and at a low incident voltage to effect the proper switching of the tube, their cutoff time, that is the time in which it takes for the gases to deionize is comparatively long and thus these gases acting alone may not cease to conduct within a sufficiently short time to permit the returned pulse to be admitted into the receiver.

It may be, therefore, necessary to admix with these body gases some electron attaching agent for the purpose of removing electrons from the ionized atmosphere, thus increasing the speed with which the atmosphere within the envelope **26** will deionize and hence, interrupt the arc discharge. Care, however, must be taken in the selection of the electron attaching agents for although they increase the speed at which the gaseous atmosphere deionizes, they also increase the power level necessary to initially ionize the body gas. In the case of T–R switches designed to operate over a wide band of incident radio frequency power input, the problem of selection of the proper electron attaching agent is particularly acute. If too much attaching agent is used, then the initial breakdown voltage of the switch may be too high and damage may result to the receiver. On the other hand, if too little attaching agent is used, then it may be insufficient at high input levels to effectively deionize the body gas. The latter will result in a slow recovery time.

In accordance with this invention, two distinct attaching agents are used in the atmosphere within a single T–R switch. The first of these agents is predominant at relatively low incident radio frequency power levels and the second is predominate at higher power levels. A typical example of an atmosphere embodying the present invention comprises a body gas of argon at a partial pressure of from 4 to 6 millimeters of mercury, a first attaching agent chlorine at a partial pressure of from 0.8 to 1.5 millimeters of mercury, and a second attaching agent iodine at about 0.3 millimeter of mercury partial pressure all at 20° C. The chlorine acts as the predominate attachment agent at the lower power input levels. The iodine which has a very low vapor pressure at room temperature but which increases rapidly with a rise in temperature, acts as the dominating attachment agent at the higher power input levels by virtue of its increased partial pressure. This increase in pressure is caused by the increase of gas temperature occasioned by the greater arc heating at these higher power levels. This attachment gas combination yields the desired initial low firing level, since the ratio of chlorine plus iodine to the body gas (argon) is low, while simultaneously providing for a fast recovery time at both high and low incident radio frequency power levels.

It is recognized that the chlorine may be replaced as the low power level attachment agent by gases such as bromine, carbon tetrafluoride or sulfur tetrafluoride.

While a specific embodiment of the invention has been shown and described in this application, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the essential features of the invention.

I claim:

1. A gaseous discharge device comprising an envelope, means defining a discharge gap within said envelope, and a gaseous atmosphere within said envelope comprising an ionizable body gas admixed with chlorine and iodine.

2. A gaseous discharge device comprising an envelope, means defining a discharge gap within said envelope, and a gaseous atmosphere within said envelope comprising a body gas taken from the group consisting of helium, neon, argon, krypton, xenon and radon admixed with iodine and another electron attachment agent taken from the group consisting of chlorine, bromine, carbon tetrafluoride and sulfur tetrafluoride.

3. An envelope, means defining a discharge gap within said envelope, and a gaseous atmosphere within said envelope consisting of a body gas taken from the group consisting of helium, neon, argon, krypton, xenon and radon and two different electron attachment agents one taken from the group consisting of chlorine, bromine, carbon tetrafluoride and sulfur tetrafluoride and the other iodine, the two electron attachment agents being such that at low incident radio frequency power levels one acts as the dominating attachment agent and at higher incident radio frequency power levels the other becomes the dominating attachment agent by virtue of its increased partial pressure.

4. A gaseous discharge device comprising an envelope, means defining a discharge gap within said envelope, and a gaseous atmosphere within said envelope comprising argon at a partial pressure of from 4 to 6 mm. of mercury, from 0.8 to 1.5 mm. of mercury partial pressure of chlorine, and approximately 0.3 mm. of mercury partial pressure of iodine at 20° C.

5. An envelope, means defining a discharge gap within said envelope, a gaseous atmosphere within said envelope comprising a body gas taken from the group consisting of helium, neon, argon, krypton, xenon, and radon and first electron attachment agent of iodine and second electron attachment agent taken from the group consisting of chlorine, bromine, carbon tetrafluoride and sulfur tetrafluoride, said first electron attachment agent being predominate at higher internal envelope temperatures and said second electron attachment agent being predominate at lower internal envelope temperatures.

6. A T–R switch comprising a resonant apertured diaphragm defining a discharge gap, an envelope affixed to one side of said diaphragm to provide a discharge path through said envelope and a gaseous atmosphere within said envelope comprising argon at a partial pressure of from 4 to 6 mm. of mercury, from 0.8 to 1.5 mm. of mercury partial pressure of chlorine, and approximately 0.3 mm. of mercury partial pressure of iodine at 20° C.

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