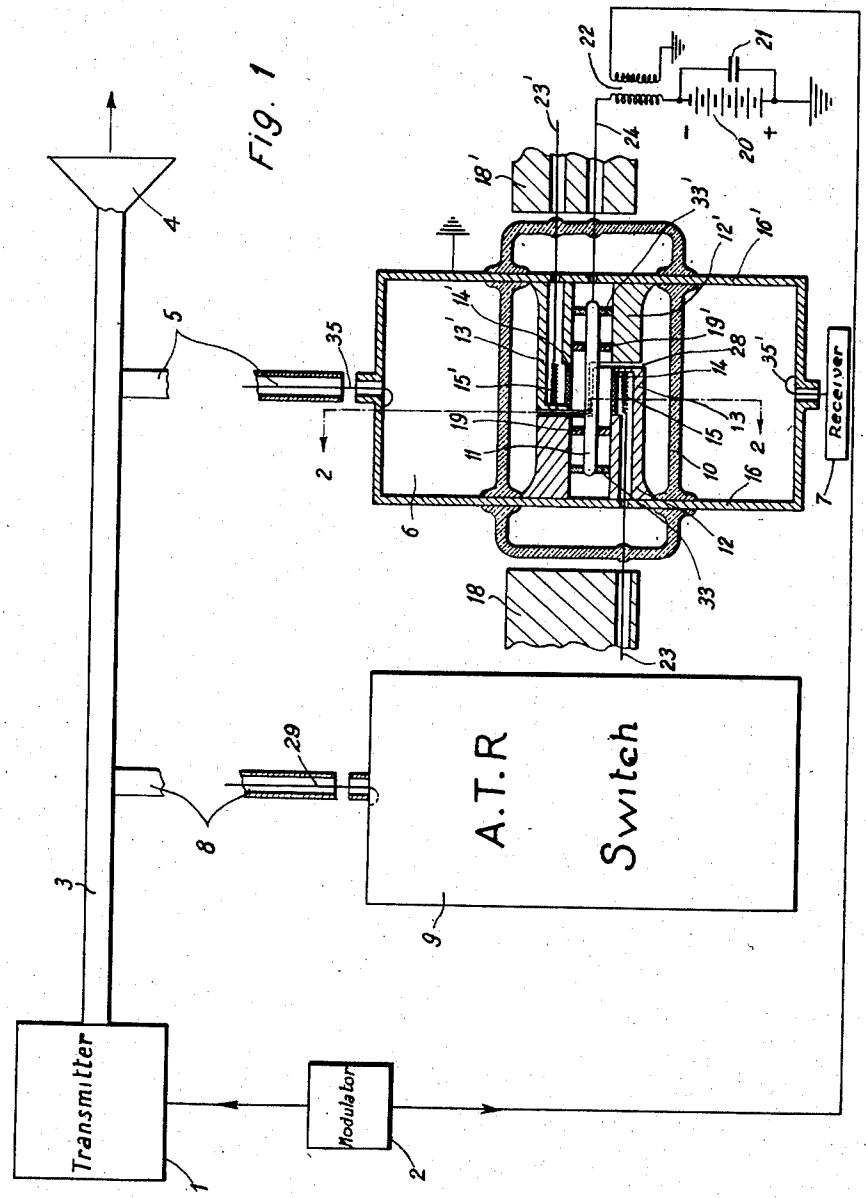
Oct. 14, 1958 A. LERBS 2,856,518

TRANSMITTER-RECEIVER SWITCHES

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Fig. 1



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Fig. 2

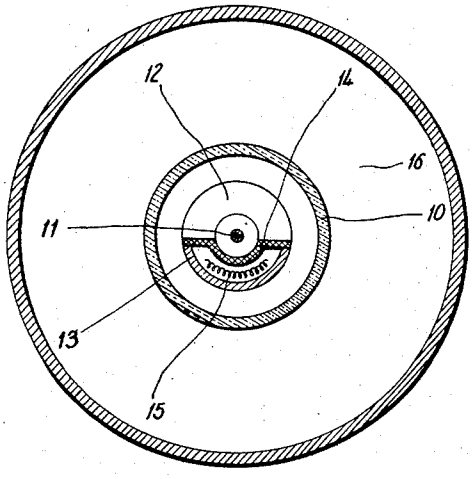
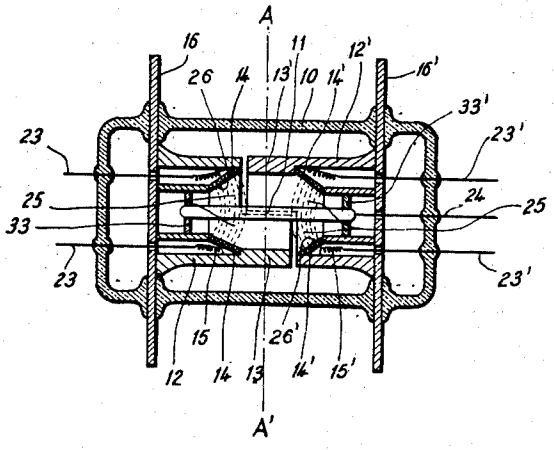


Fig. 3



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Fig. 4

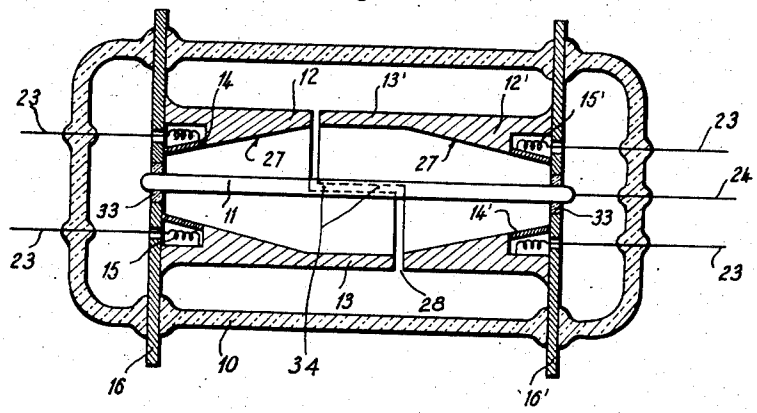
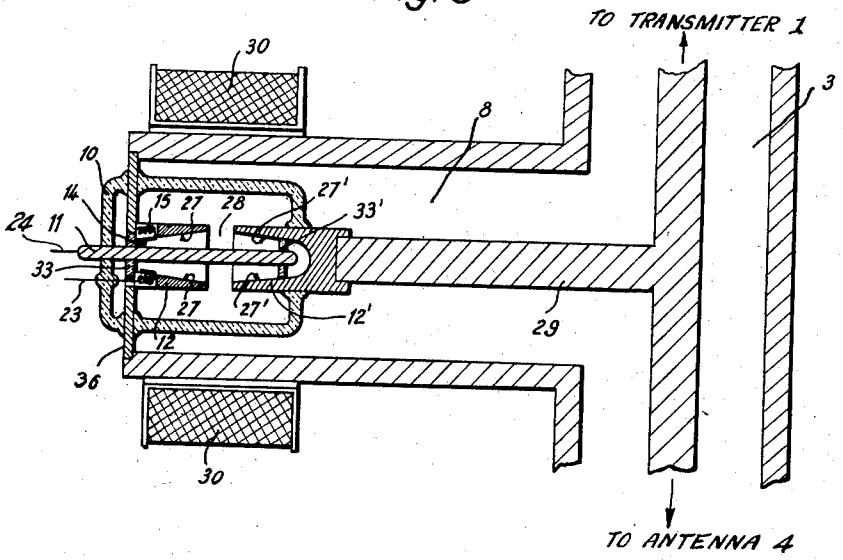


Fig. 8



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Fig. 5

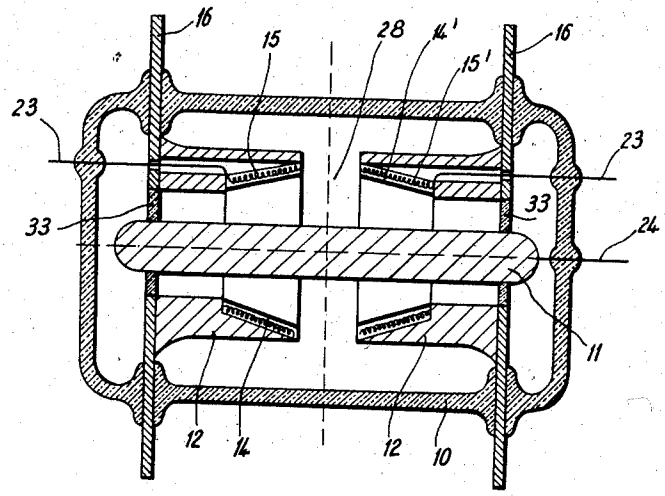
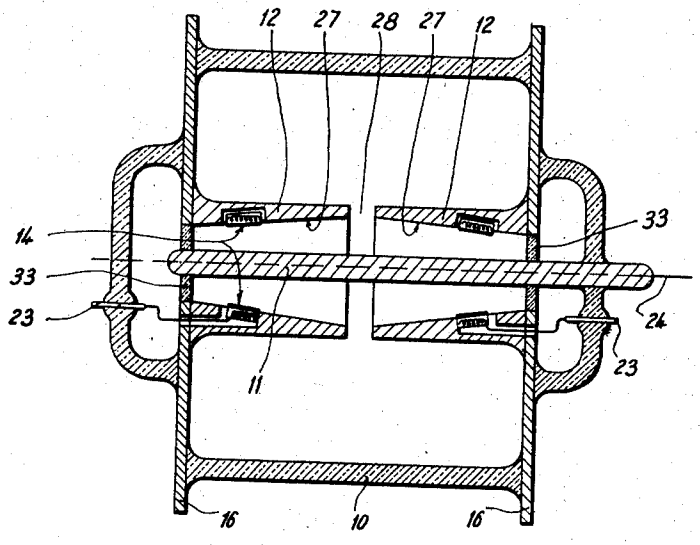


Fig. 6



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Fig. 7

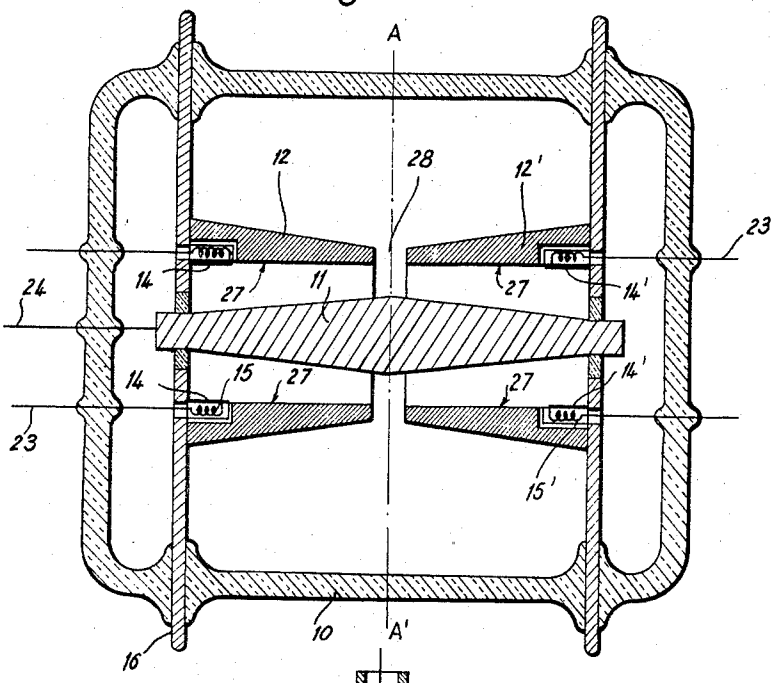
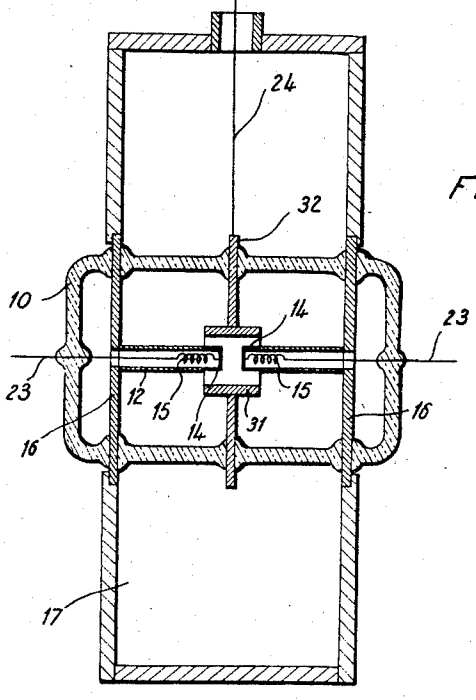


Fig. 9



United States Patent Office 2,856,518
Patented Oct. 14, 1958

2,856,518

TRANSMITTER-RECEIVER SWITCHES

Alfred Lerbs, Paris, France, assignor to Compagnie Generale de Telegraphie Sans Fil, a corporation of France

Application July 29, 1955, Serial No. 525,335

Claims priority, application France July 30, 1954

9 Claims. (Cl. 250—17)

In pulse duplex radars, i. e. those having a common antenna for both receiver and transmitter, it is current practice to use electronic switches called transmitter-receiver switches (T. R.), anti-transmitter-receiver switches (A. T. R.) designed, respectively, to block the antenna-receiver channel, while the transmitter is emitting, so that the energy radiated by the latter is directed to the antenna only and is prevented from reaching the receiver, and to block the transmitter-antenna channel when said transmitter is inoperative, so that the energy collected by the aerial is entirely fed to the receiver.

In known systems, the T. R. switch is usually disposed at the end of a stub of predetermined length, connecting the receiver to the transmitter-antenna line; the A. T. R. switch is connected to the same line by a second stub arranged between the transmitter and the first stub and spaced from the latter by a quarter wavelength.

It is known to design T. R. and A. T. R. switches in the following manner:

The switch comprises a gas filled cavity resonator having two reentrant electrodes bounding a gap. On the one hand, the application between the electrodes of a voltage higher than the ionisation potential derived from the transmitter causes an arcing discharge to occur and the resistance of the gap approaches a short-circuit. On the other hand, the energy derived from the aerial delivers an ultra-high frequency potential difference lower than the ionisation potential of the gas and is not sufficient to cause the arcing to occur.

Experience shows that such gas-filled tubes are short-lived and do not adequately protect the receiver when operating at high powers.

The present invention relates to a new switch for pulse duplex radars avoiding the above mentioned disadvantages. The switch according to the invention comprises an evacuated tube having a smooth anode electrode and a pair of hollow cathode electrodes coaxial therewith and separated by a gap. One at least of this pair of hollow electrodes carries an electron emissive source.

A uniform axially directed magnetic field is provided in the envelope and its intensity is such that the electrons emitted by the cathode do not impinge on the smooth electrode, when the latter is positively biassed with respect to the hollow electrodes, the magnetic field being greater than the critical magnetic field. The anode is normally negatively biassed with respect to the cathodes. A control direct current pulse, synchronized with the transmitter ultra-high frequency pulse, is applied between the hollow electrodes, on one hand, and the smooth electrode, on the other hand, to bias the latter positively with respect to the hollow electrodes.

Thus, the cathode is emitting during the pulses, producing a cloud of electrons, which, under the combined action of the electric and magnetic fields, does not reach the anode. Under the action of the ultra-high frequency signals emitted by the transmitter a high frequency field

is provided in the cavity resonator, and the electrons are alternately attracted and repelled by the hollow electrodes thus short-circuiting the receiver.

The invention will be better understood from the following description given by way of example considered in conjunction with the appended drawing in which:

Fig. 1 is a longitudinal section of a first embodiment of a T. R. switch according to the invention, and very diagrammatically shows the corresponding circuitry of a pulse radar system;

Fig. 2 is a cross-section of the switch on line 2—2 of Fig. 1;

Figs. 3 to 9 are longitudinal sections of modifications of the switch according to the invention.

According to the embodiment shown in Figs. 1 and 2, the switch according to the invention comprises a vacuum-tight envelope **10** having a rotational symmetry. The electrode system of the switch comprises an anode **11**, shaped as a smooth rod, and coaxial with the envelope **10**. Two identical hollow electrodes **12** and **12'** surround the anode **11**. These electrodes **12** and **12'** are cylindrical and coaxial. The anode **11** is supported inside these cylindrical electrodes **12** and **12'** by insulating cross-bars **33** and **33'**. The respective walls of the electrodes **12** and **12'** are symmetrically cut away at the free ends of the latter over the half of their respective periphery and remaining portions **13** and **13'** overhang each other. The inner surface of at least one among the segments **13** and **13'** is completely, or partly, covered with an emissive coating **14** or **14'**, heated by filaments **15** or **15'**. Insulating rings **19** and **19'** limit the space where the electrons emitted by the cathode circulate. Heating connections **23** and **23'** to the filaments **15** and **15'** respectively pass through pole pieces **18** and **18'**, walls **16** and hollow electrodes **12** and **12'** respectively.

The walls **16** and **16'** of a cavity resonator **6**, surrounding the envelope **10**, are sealed to the frontal edges of the latter and support the electrodes **12** and **12'**. The cavity is coupled, for instance by means of a loop **35** and a stub **5**, to a transmission line **3**, connecting a transmitter **1** to the antenna **4** of the latter and, through a loop **35'**, to the radar receiver **7**. Pole pieces **18** and **18'** provide an axially directed magnetic field within the envelope **10**.

Anode **11** is negatively biassed, by a direct current supply source **20** and through a lead **24**, with respect to cavity resonator **6** and cathodes **14** and **14'** which are grounded. The pulse generating device of the radar, for instance a modulator **2**, is connected by means of a transmission line and a transformer **22** to bias positively the anode **11** during each radar pulse. A capacity **21** shunts the supply source **20** to ground.

The switch according to the invention operates as follows:

Modulator **2** generates direct current pulses which simultaneously modulate transmitter **1** and are fed through transformer **22** to anode **11**. The latter is thus raised to a positive potential, during the duration of each pulse, causing the cathodes **14** and **14'** to emit. The magnetic field is chosen higher than the critical magnetic field i. e. such that the electrons emitted by the cathodes **14** and **14'** never reach the anode **11** and fall back on segments **13** and **13'**. Advantageously segments **13** and **13'** are provided with a surface having a high secondary emission factor. If the amplitude of the direct current control pulse is sufficiently high, the surfaces thus bombarded may emit secondary electrons, which increases the number of electrons circulating in the space bounded by anode **11**, segments **13** and **13'** and rings **19** and **19'**. Simultaneously, the signal incoming from transmitter **1** creates a high frequency field within the cavity of the resonator **6**. The electrons emitted by sources **14** and

14' are alternately attracted by electrode 12 and electrode 12'. A strong ultra-high frequency current short-circuiting the cavity is thus created in the gap 28 separating these two electrodes. Under these conditions, as viewed from the input loop 35, the switch presents a zero impedance during the time intervals when the transmitter is emitting and the receiver is thus short-circuited. During the time intervals in which the transmitter is not emitting, the short-circuit vanishes, the cavity is viewed under an infinite impedance from loop 35 and, as the cavity is in parallel with the receiver, the latter receives energy from the aerial.

In the embodiment shown in Fig. 3, the inner wall of the portions 12 and 12' of the hollow electrodes is flared, at 26 and 26' respectively, toward the free end of the latter, and the cathodes 14 and 14' are supported on these flared portions. The electric fields 25 and 25' thus established have an axial component directed towards the plane of symmetry A—A' of the system. The electrons emitted by cathodes 14 and 14' are therefore concentrated in the vicinity of this plane of symmetry i. e. in the space between the electrodes, thus increasing the efficiency of the device. Instead of being flared over a portion only of its inner wall, the hollow electrode may have its inner wall flared over the entire length comprised between the wall 16 or 16' and the portion 13 or 13', as shown in Fig. 4.

Figs. 5 and 6 show variations which are identical to Figs. 3 and 4 respectively, except that the hollow electrodes have no cut-away portions and accordingly segments 13 and 13' are eliminated.

Fig. 7 is similar to Fig. 6 with the difference that the inner surface of electrodes 12 is cylindrical and the outer surface is tapered. Anode 11 has the shape of two symmetrical frusto-cones the common base of which lies in the plane of symmetry A—A'.

The above-described switches may be used as T. R. or A. T. R. switches. In this latter case the switch is connected as shown in Fig. 1.

The tube of Fig. 8 is more particularly adapted to be used as the A. T. R. switch 9 of Fig. 1 and to be matched to a coaxial line, for instance, the coaxial line 8.

In this embodiment cathodes 14 are carried by electrode 12 only. Electrode 12' is directly connected to the inner conductor 29 of the coaxial line 8, the envelope of which is sealed at the end by plate 36 thus forming a resonant stub. The magnetic field will, in this case, be produced by an electromagnet 30.

As in the case of the previous figures and in the same manner, the resonant stub associated to the tube is short-circuited during the duration of the transmitter pulses. The electrons emitted by cathode 14 impinge on surface 27' of electrode 12' and cause a secondary emission. The secondary electrons fall back on surface 27 of electrode 12, so that the phenomenon is repeated again and again.

The cavity resonator is then short-circuited by the wall 36 and the length of the line 8 is selected in such a manner as to restore to line 3 an infinite impedance.

Conversely, between the pulses, the cavity presents an infinite impedance and the impedance viewed from the point where lines 8 and 3 are connected is nil. The transmitter 1 is then short-circuited.

Fig. 9 shows another embodiment of the invention wherein the anode is formed by a cylinder 31, secured to a disc 32 sealed to the wall 10 of the tube. With regard to the shape and the arrangements of electrodes 12, 13 and 14, similar variations might be derived from each of the embodiments illustrated in Figures 1 to 8.

Disc 32 might, of course, be substituted by a plurality of radial rods fitted in the wall of the tube.

The above described tube according to the invention has no inertia due to ionisation in contradistinction to what occurs in conventional tubes and has a longer life.

I claim:

1. Ultra-high frequency switch comprising: a vacuum electron tube having an elongated smooth anode; a pair of aligned hollow electrodes, separated by a gap, coaxial with said anode and having surfaces facing the surface of the anode; at least one emissive cathode carried by the surface of at least one of said hollow electrodes facing said anode; means for raising said hollow electrodes to a positive potential with respect to said anode; means for reversing said potential at predetermined time intervals; means for establishing in the space between said anode and hollow electrodes a uniform, axially directed, magnetic field for preventing the electrons omitted by said cathode from reaching said anode; and means for feeding to said gap the ultra-high frequency energy to be switched.

2. Ultra-high frequency switch comprising: a vacuum electron tube having an elongated smooth anode; a pair of aligned hollow electrodes, separated by a gap, coaxial with said anode and having surfaces facing the surface of the anode; at least one emissive cathode carried by the surface of at least one of said hollow electrodes facing said anode; means for raising said hollow electrodes to a positive potential with respect to said anode; means for applying positive pulses to said anode for causing said cathode to emit during the duration of said pulses; means for establishing in the space between said anode and hollow electrodes a uniform, axially directed, magnetic field for preventing the electrons emitted by said cathode from reaching said anode; a cavity reservoir having walls, said hollow electrodes being secured to said walls to form reentrant electrodes therein, and means for feeding to said resonator the energy to be switched.

3. A switch as claimed in claim 2 wherein said hollow electrodes surround said anode.

4. A switch as claimed in claim 3 wherein each of said hollow electrodes has at its free end a cut away portion, the respective cut away portions of the two electrodes being symmetrical and overhanging each other.

5. A switch as claimed in claim 3 wherein the interior surface of said hollow electrodes comprises a portion flared toward said gap.

6. A switch as claimed in claim 5 wherein said emissive cathode is carried by at least one of said flared portions.

7. A switch as claimed in claim 3 wherein the surface of said anode is in the shape of two similar frusto cones connected by their respective bases.

8. In a pulse modulated radar circuit: a transmitter for radiating ultra-high frequency energy, means for generating direct current pulses for pulsing said energy; an ultra-high frequency transmitter-receiver switch comprising: a vacuum electron tube having an elongated smooth anode; a pair of aligned hollow electrodes, separated by a gap, coaxial with said anode and having surfaces facing the surfaces of the anode; at least one emissive cathode carried by the surface of at least one of said hollow electrodes facing said anode; means for raising said hollow electrodes to a positive potential with respect to said anode; means for applying said pulses to said anode for causing said cathode to emit during the duration of said pulses; means for establishing in the space between said anode and hollow electrodes a uniform, axially directed, magnetic field for preventing the electrons omitted by said cathode from reaching said anode; and means for feeding to said gap a part of said ultra-high frequency energy.

9. In a pulse modulated radar: a transmitter for generating ultra-high frequency energy; means for generating direct current pulses for pulsing said energy; an aerial and a transmission line for connecting said transmitter to said aerial; a coaxial stub having an inner and an outer conductor having respective ends and respectively connected to said transmission line by one of said ends; a plate short-circuiting the outer conductor at its other end; an anode; a first and a second coaxial hollow electrode separated by a gap and aligned with said inner conductor, said hollow electrodes having surfaces facing the surface of the anode, said first hollow electrode being secured to

said plate, said second electrode being secured to said inner conductor; an evacuated envelope surrounding said electrode and said gap; at least one emissive cathode carried by the surface of at least one of said electrodes facing said anode; said anode being an elongated smooth member surrounded by said electrodes and coaxial therewith; terminal connections for raising said hollow electrodes to a positive potential with respect to said anode; means for feeding said direct current pulses to said anode for enabling said cathode to emit during the duration of said pulses; magnetic means for establishing in said space

between said anode and hollow electrodes a uniform, axially directed, magnetic field for preventing the electrons emitted by said cathode from reaching said anode; means for reversing said potential at predetermined time intervals and means for feeding to said gap the ultra-high frequency energy to be switched.

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