June 19, 1951 G. R. P. MARIE 2,557,882

MODULATING SYSTEM

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FIG. 1.

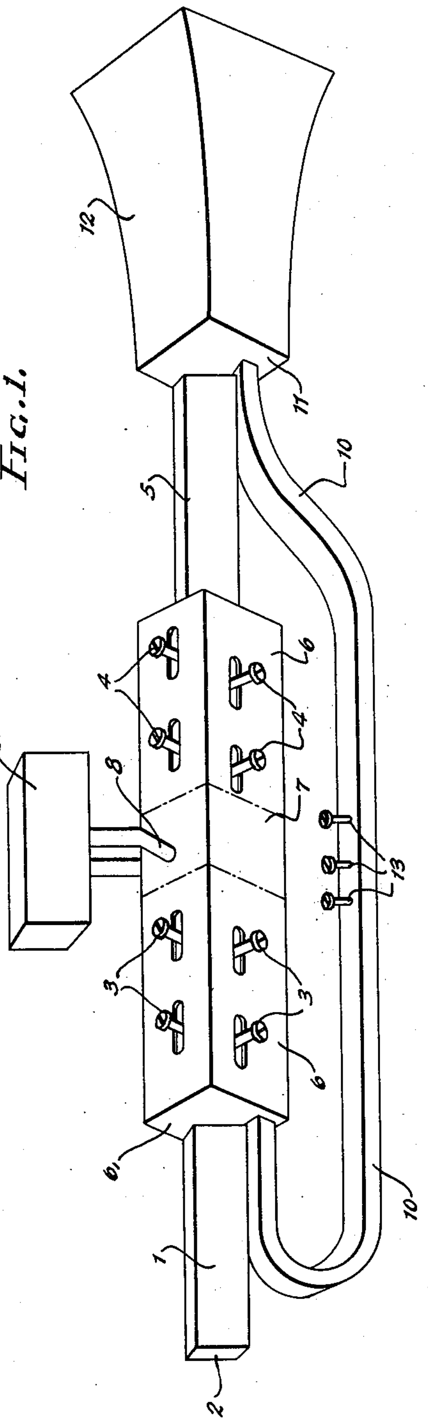
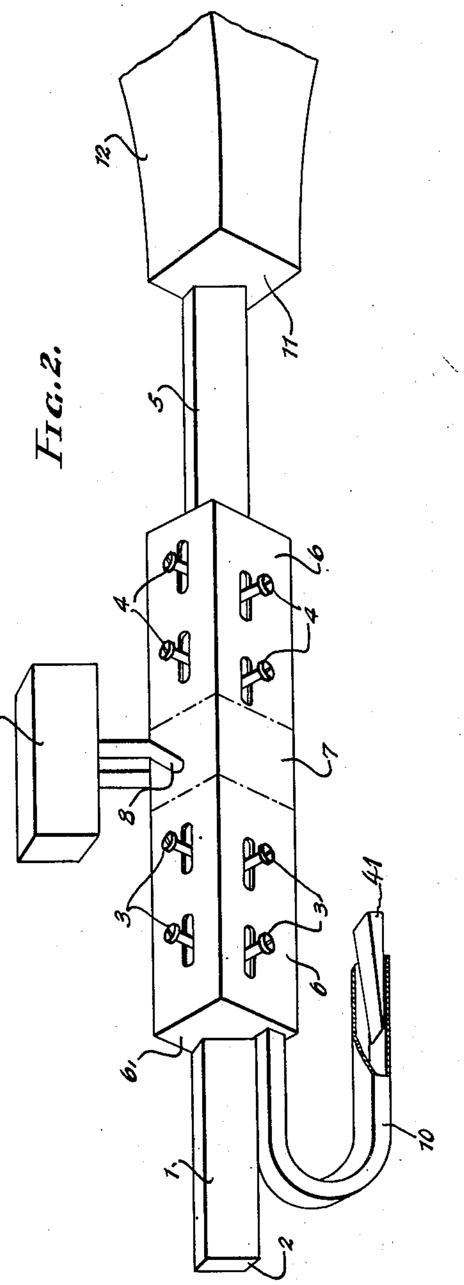


FIG. 2.



INVENTOR

GEORGES ROBERT PIERRE MARIE.

BY Ben. J. Chromy his ATTORNEY

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FIG. 3.

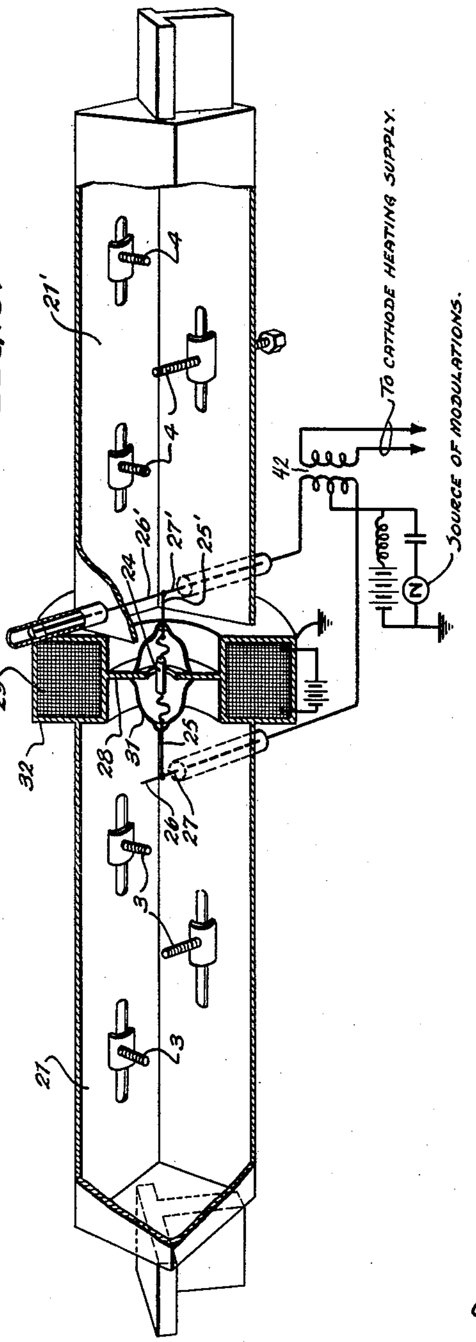


FIG. 6.

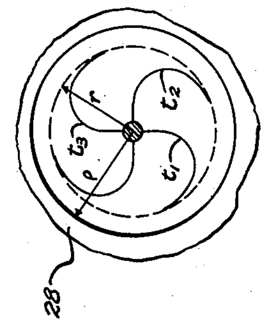


FIG. 5.

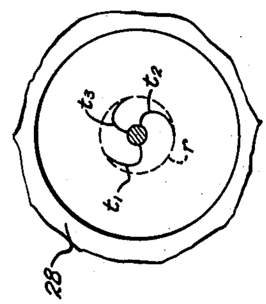
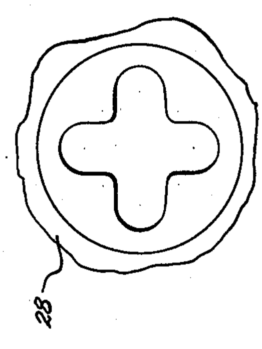


FIG. 4.



INVENTOR

GEORGES ROBERT PIERRE MARIE.

BY Ben. J. Chromy

His ATTORNEY

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MODULATING SYSTEM

Georges Robert Pierre Marié, Paris, France, assignor to Societe Francaise Sadir-Carpentier, Paris, France, a corporation of France

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8 Claims. (Cl. 332—5)

The present invention has for its object various improvements in modulating systems for ultra short waves chiefly guided waves.

It has already been proposed to provide for the modulation of said waves inside the guiding means therefor. This method consists generally in branching off from said guide a coaxial line element that is closed over a magnetron. In the absence of any natural oscillations, the magnetron acts after the manner of a variable capacity the variations of which are related with the anode voltage and with the intensity of the magnetic field applied thereto.

The connection between the coaxial line element and the guide or zone of said guide controlled by a modulator forms a transition point producing the usual phenomena of reflection and refraction of the waves.

Under such conditions, any modification in the capacity formed by the magnetron at the end of the coaxial element leads to a modification in the corresponding coefficients of reflection and transmission in the guide and it will be readily understood that through action on the latter the waves passing out of the guide or transmitted waves are finally amplitude modulated at the frequency of variation of the equivalent capacity of the magnetron.

Such prior methods show various drawbacks.

On one hand, the well-known drawbacks that are inherent to amplitude modulation and on the other hand that according to which the energy reflected in the guide returns towards the source and under certain conditions is detrimental to the latter.

The improvements provided by the present invention have for their object to remove such drawbacks, on one hand by substituting for amplitude modulation another form of modulation to be disclosed hereinafter with further detail and on the other hand by preventing the return towards the source of the reflected energy.

In its principle, the present invention consists in using so called quarter wave arrangements for preventing the return towards the source of the energy reflected by a modulating arrangement acting on a coefficient influencing the reflection characteristics.

Thus, the ultra-short and more particularly the guided waves are submitted to modulation inside a zone of the wave guiding means so as to modify simultaneously and in opposite directions the coefficients of transmission and reflection of the waves propagated through said guiding member, said modulation zone being com-

prised between two quarter wave arrangements incorporated into said guide. The waves propagated inside said guiding member assume preferably a rectilinear polarisation to either side of the two quarter waves defining said modulating zone inside which the polarisation is a circular or more generally an elliptic polarisation. Consequently the method proposed consists in transforming the waves fed by the transmitter into two waves polarised at right angles with reference to one another, through the agency of the quarter wave arrangements, after which both latter waves are amplitude modulated so that the peaks of one of them correspond with the minimum values of the other.

According to a particular feature of the invention, the return energy is dissipated inside an absorbing resistance.

According to a further preferred feature of the invention, the reflected energy is reintroduced into the transmission system beyond the modulator and radiated.

The energy that is finally radiated is furnished to the radiating member through two separate tracks of which one is direct and passes through the guiding zone that is controlled by the modulator while the other corresponding to mere reintroduction is followed by the energy reflected in the above mentioned zone. However, the radiating member receives energy through both tracks and radiates it in polarisation planes that are perpendicular or substantially perpendicular to one another. This provides a modulation system wherein the waves passing out of the transmitter are transformed into two waves that are polarised perpendicularly to one another and both polarised waves are amplitude modulated whereby the peaks of one wave coincide with the minimum values of the other.

The device termed quarter wave device operates quite similarly to the well known quarter wave blade used in optics when operating with crystalline media. A wave may always as well known be considered as the sum of two waves polarised in perpendicular directions and it is easy to phase-shift through 90° one of the components with reference to the other in order to obtain a so-called circular light.

According to a modification, it is possible to incorporate the modulating system inside the wave guiding member and to locate it inside the modulating zone comprised between the two quarter wave arrangements.

According to this modification there is arranged along the axis of the guiding member and inside the modulating zone an emitting cathode and perpendicularly to said axis and coaxially with reference thereto an anode-forming diaphragm.

In the vicinity of said diaphragm are arranged one or more coils fed with direct current and having for their object to form a permanent stationary magnetic field in the annular space separating the cathode from the anode.

The above arrangement forms a locked magnetron as its operating conditions are selected in a manner such that the electrons transmitted by the cathode do not practically reach the anode.

The low frequency modulating voltage is applied to the cathode and modifies its instantaneous voltage with reference to the anode whereby the paths of the electrons in the plane of the anode are more or less contracted or expanded. Consequently the distribution of the spatial loads inside the annular space between the electrodes varies at the same frequency as the modulation and the mean conductivity varies also with said distribution as well as the coefficients of transmission and reflection of the waves inside the space considered.

The connections required for heating the cathode and for energizing through the modulating voltage the anodes on one hand and the adjacent coils on the other hand, are arranged in a manner such as to disturb as little as possible the propagation of waves inside the guiding member, the modulating voltage not being taken into account from this standpoint.

The arrangements proposed will be set forth more clearly hereinafter so that the invention will be better understood by those skilled in the art to which it relates.

Referring to the drawings briefly:

Fig. 1 is a diagrammatic illustration of an embodiment of this invention;

Fig. 2 is a diagrammatic illustration of a modified form of this invention;

Fig. 3 is a view partially in section of an assembly of two quarter wave sections such as shown in Fig. 1, coupled by a magnetron;

Fig. 4 is a side view of the diaphragm forming the anode of the modulating magnetron shown in Fig. 3 and

Figs. 5 and 6 are employed for the purpose of illustrating features of operation of this invention.

Returning to Fig. 1 a guiding member 1 will be supposed for sake of an easier understanding to have a horizontal axis and a rectangular cross section, the long side of the rectangle being arranged vertically and said guiding member receiving through the input 2 the waves from the transmitter. It is a well known fact that a guide thus directed transmits a wave H the electric field of which is directed horizontally.

A first quarter wave arrangement 3 transforms into circularly or elliptically polarised waves the waves H that it receives from the guide 1 to which it is connected. A second quarter wave arrangement 4 transforms again the circularly or elliptically polarised waves passing out of the device 3 into rectilinearly polarised waves that are transmitted in their turn under the form of waves H into the guiding element 5. The two quarter wave arrangements 3 and 4 are located inside a common guide 6 that by way of example and by no means in a limiting sense is assumed to have a square cross-section and to be shifted angularly through 45° with reference to the guide elements 1 and 5 of the drawing; or elese these two quarter wave arrangements form simultaneously the guiding means. But in all cases said quarter wave arrangements are separated by a space 7 wherein the branch lines 8 from the modulating means 9 enter so as to form inside the guide a transition point for the wave. Said space 7 will be termed hereinafter the modulator-controlled zone of the guide.

From the input end 6_1 of the guiding member 6, there branches off a third guiding member 10 of rectangular cross-section similar to the guide member 1, but of which the long side of the rectangular cross-section is arranged horizontally, taking into account the angular setting assumed by way of example for the other members. The guiding member 10 is thereby capable of transmitting waves of the type H the polarisation of which is rectilinear and the electric field of which is vertical.

According to a first form of execution of the invention, the guiding member 10 is closed over an energy dissipating impedance.

According to a second form of execution of the invention, said guiding member 10 opens at the same vicinity as the guiding member 5 in the input surface 11 of a horn 11 or the like suitable radiating system. Inside the guide 10 is provided a phase shifting device 13 known per se, having for its object a modification in the difference in phase between the waves H transmitted to the radiating member 12 through the guiding member 5 on one hand and the waves H transmitted through the guiding member 10 on the other hand.

The above described system operates as follows:

The waves produced by the source and passing with a rectilinear vertical polarisation into the guiding member 1 and thence with a circular polarisation into the space 7 inside the guide 6 and are submitted in said space to a reflection and a transmission of variable ratio by reason of the action of the modulating member 9.

The waves that are reflected towards the transmitter by reason of the presence of the quarter wave system 3 cannot enter the guiding member 1 but are switched into the guiding member 10 inside which they are polarised horizontally; these reflected waves cannot therefore return towards the transmitter which is thus protected against their interfering action. The guiding member 10 may be terminated with an energy dissipating impedance 41 consisting of a wedge made of wood or other suitable material, as shown in Fig. 2, so that the energy of the reflected waves is simply absorbed thereby.

If, on the contrary, as illustrated in Fig. 1 of the drawing, the guiding member 10 leads to the radiating member 12, the energy of the waves reflected at 7 is added to the energy of the waves transmitted through the quarter wave device 4 and the guiding member 5 and is then propagated through space.

In this latter case and by reason of the presence of the phase shifting device 13, in the guiding member 10, the waves H passing out of the guide 5 and assuming a vertical rectilinear polarisation are phase shifted with reference to the waves H passing out of the guide 10 and assuming a horizontal rectilinear polarisation, by a corresponding angle, and are consequently adapted to reconstitute inside the member 12 or in space waves having a circular or elliptic polarisation.

Lastly the radiating member 12 is fed on one hand through the guide 1 followed by the guide

6, followed in its turn by the guide 5 with the waves transmitted through the zone 7 controlled by the modulator 9, said system forming a circuit for direct transmission, and on the other hand by means of the guiding member 10 shunted off the above system and forming a circuit for reinjecting the waves reflected in the above mentioned zone 7.

In the improved system according to the invention, the action of the modulating member consists in reducing the coefficient of transmission in order to increase the coefficient of reflection of the waves and vice-versa; but it is a known fact that the sum of these two coefficients is constantly equal to unity. Now the energy of the reflected waves is radiated to the same extent and in the same manner as the energy of the transmitted waves and also in the same direction and through the same means. The energy of the resultant waves propagated in space is thereby constant and in all cases independent of modulation.

In brief, the modulation method forming the object of the present invention consists in transforming the waves produced by the transmitter into two waves polarised at right angles with reference to one another and in modulating them both as to amplitude whereby the maximum amplitude of one wave may coincide with the minimum amplitude of the other.

Turning now to the modification illustrated in Fig. 3, 21 and 21′ designate respectively the wave guides, which are illustrated as of square cross-section, said shape being the preferred shape without this forming a limitation of the invention. This figure shows with further detail a cross-section of the modulating zone of Fig. 1, the emitting cathode is shown at 24, the axial connecting wires are shown at 25 and 25′ while 26—26′, 27—27′ designate the radial connecting wires for connecting the cathode 24 to the secondary of the transformer 42. The primary of this transformer is connected to a source of cathode heating current supply. The anode forming diaphragm 28 of the magnetron is attached to the inside of the metal housing 32 and extends into the evacuated chamber 31. The cathode 24 of the magnetron is positioned in the hole of the anode forming diaphragm 28 inside of the evacuated chamber 31. The conductive casing 32 forms a housing and electrostatic shield around the magnetron field coil 29 and also functions to connect the anode 28 with the walls of the wave guides 21 and 21′.

The heating of the cathode 24 is ensured either by means of direct current or by alternating current. In the first case, it may be of advantage to form the heating circuit for instance by means of leads 26, 25, 25′ and 26′, the heating filament passing through the cathode 24. The modulating voltage is applied to the cathode by means of the leads 27, 25, 25′, 27′.

In the second case, it may be of advantage to form the heating circuit for instance, by means of leads 25, 26 and 27, the heating filament forming a loop inside the cathode in order to do away with the magnetic field produced by the heating current and to apply the modulation voltage for instance by means of leads 26′, 25′ and 27′.

The radial connecting leads and the leads forming therewith conjugated semi-reflecting systems may or may not be connected electrically in any suitable manner such as through direct connection or through a condenser, which means are electrically protected inside the guiding member by any suitable means, such as may in particular form coaxial lines; these leads have in any case a sufficiently small cross-section so as not to produce any substantial reflecting effect inside the guide or at any rate such reflection effects should not be capable of disturbing the propagation of the waves.

It is also possible to reduce to one the leads forming the heating circuit of the cathode 24 and to apply thereto a modulation voltage so that they constitute a single axial lead extending throughout the zone where the waves assume the transversal electric type with a circular or more generally an elliptic polarisation in which case the outer connections formed by means of leads that are perpendicular to the electric field end in a zone where the waves are polarised rectilinearly.

The thickness and the opening of the diaphragm 28 forming the anode are selected in a manner such that the variations in the modulating voltage may provide a linear modification between zero and 1 of the transmission coefficient of the above described system, forming a sort of impedance inside the guiding member 21—21′. To this purpose, the opening may for instance be circular and of a suitable diameter or else cross-shaped as illustrated in Fig. 4.

For the same purpose, the field coil 29 is made as flat as possible so as to make the impedance formed by the modulating system as a whole inside the guide as little reflecting as possible. However, the cross-section of coils 29 and 29′, taking into acccunt their distance is selected in a manner such that the structure of the magnetic field in the annular space between the cathode 24 and the anode 28 may have any predetermined desired shape such for instance as that of a substantially uniform field.

Figs. 5 and 6 illustrate the paths of the electrons in the annular space separating the cathode 24 from the anode diaphragm 28.

Fig. 5 corresponds to the case where by reason of the modulation voltage applied to the cathode 24, the drop in the instantaneous voltage and the radial instantaneous electric field between the electrodes 24 and 28 are at a minimum. In this case, the paths of the electrons such as t_1, t_2, t_3 etc., assuming a spiral shape are more contracted round the cathode 24 and remain at any rate inside a circumference having as a radius r that forms the upper limit of their radial extension.

Designating by ρ the radius of the actual opening of the diaphragm 28, the operation, by reason of the modulation, is the same as if the effective opening therein were reduced to an annular opening the surface of which remains constantly between the two values $\pi(\rho^2—r^2)$ and $\pi(\rho^2—R^2)$.

In brief, it may be stated that the modulation has for its object to modify automatically the opening of the diaphragm located inside the wave guide, in a manner similar to that of the modification by hand or automatically of the opening of the iris diaphragm of a lense for optical purposes.

The variations at the frequency of modulation of the coefficient of transmission of the diaphragm are a direct consequence of the variations of its efficient opening.

What I claim is:

1. A modulating system for modulating ultra-short waves comprising a wave guide, two quarter wave sections connected in series in said wave guide, a magnetron between said quarter wave sections for modulating said waves, means for transmitting the modulated waves, a wave guide

connected between said last mentioned means and the input to said magnetron for feeding the reflected waves therefrom to said transmitting means and phase shifting means in said last mentioned wave guide.

2. A modulating system for modulating ultra-short waves comprising a wave guide, two quarter wave sections connected in series in said wave guide, a magnetron in said wave guide between said quarter wave arrangements for modulating said waves, means for transmitting the modulated waves and a dissipating impedance adapted to absorb the reflected wave energy returned by said magnetron.

3. A modulating system for modulating ultra-short waves comprising a wave guide, a first quarter wave section and a second quarter wave section connected in series in said wave guide, a magnetron in said wave guide between said quarter wave sections for modulating said waves, and means for reinjection into said wave guide at a point beyond said second quarter wave section, the energy reflected by said magnetron.

4. A modulating system for modulating ultra-short waves comprising a wave guide, means for rectilinearly polarizing the waves fed to said wave guide, a first quarter wave section and a second quarter wave section connected in series in said wave guide, a magnetron in said wave guide between said quarter wave sections for modulating said waves, means for reinjecting into said wave guide at a point beyond said second quarter wave section, the wave energy reflected by the said magnetron, and means for transmitting said modulated waves.

5. A method for modulating guided ultra-short waves, the steps consisting in transforming the waves into two component waves polarized at right angles with reference to one another, passing said waves through a first quarter wave section, and amplitude modulating said waves so that the maximum values of one of said polarized waves occur simultaneously with the minimum values of the other of said polarized waves.

6. A modulating system for ultra-short waves comprising a wave guide, means for rectilinearly polarizing the waves entering said wave guide, two quarter wave sections connected in series in said wave guide, means in said wave guide between said quarter wave sections for modulating said waves, means for reinjecting into said wave guide at a point beyond the second quarter wave section, the wave energy reflected by said modulating means, means for polarizing the last mentioned wave energy in a plane perpendicular to the waves passing out of said second quarter wave section, a radiating member adapted to receive waves passing out of said second quarter wave section and the reflected waves passing out of said reinjecting means and phase shifting means in said reinjecting means for producing a difference in phase through a predetermined angle between the waves transmitted to said radiating member directly and the reflected waves passing through said reinjecting means.

7. A modulating system for modulating ultra-short waves comprising a wave guide, two quarter wave sections connected in series in said wave guide, means for modulating the waves in said wave guide between said quarter wave sections, said means including a magnetron system located inside said wave guide and constituted by a cathode arranged axially of said wave guide, an anode consisting of a diaphragm coaxial with and surrounding said cathode, a coil surrounding said anode and said cathode and means for energizing said cathode and feeding it with a modulation current for modifying the transmission coefficient for the ultra-short waves through said magnetron at the frequency of modulation.

8. A modulating system for guided ultra-short waves comprising a wave guide, two quarter wave sections connected in series in said wave guide and means in said wave guide between said quarter wave sections for modulating said waves, said means including a magnetron system located and constituted by a cathode arranged axially of said wave guide, an anode consisting of a diaphragm coaxial with and surrounding said cathode, a coil surrounding said anode and cathode and means for energizing the cathode and feeding it with a modulation current for modifying the transmission coefficient through the magnetron at the frequency of modulation and means adapted to prevent said last mentioned means from affecting the propogation of the waves through said wave guide.

GEORGES ROBERT PIERRE MARIÉ.

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