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AMPLITUDE MODULATOR

Filed March 1, 1939

Fig. 2

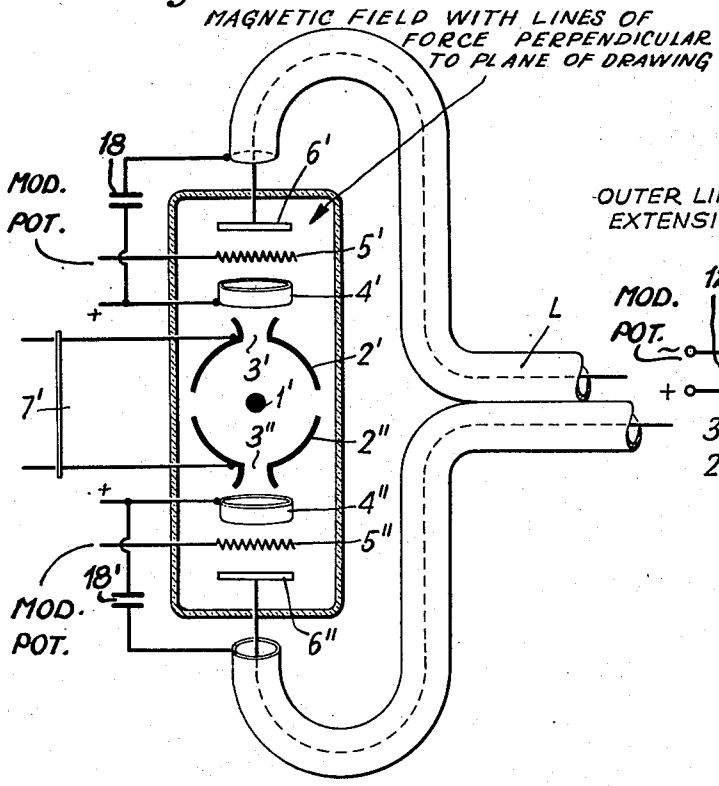


Fig. 1

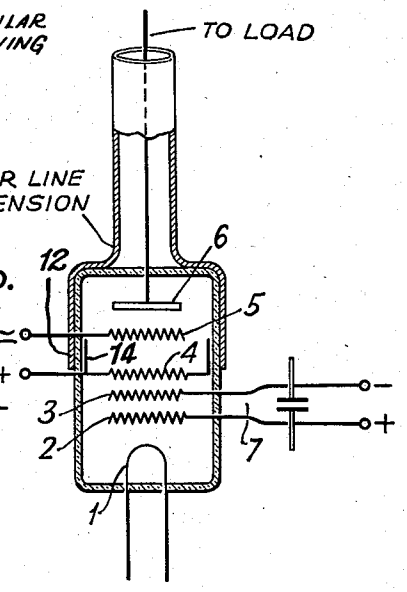
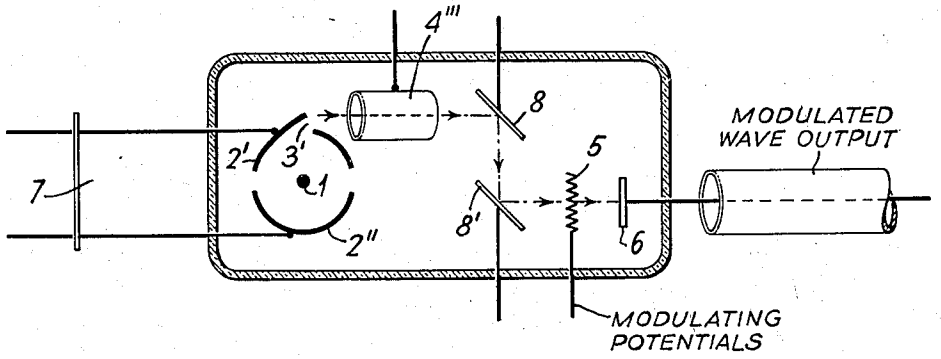


Fig. 3



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AMPLITUDE MODULATOR

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4 Claims. (Cl. 179—171.5)

It is known in the art that in the modulation of ultra-short waves in magnetron or oscillating-electron circuit organizations, the desired amplitude modulation is invariably accompanied by an undesirable and unintended frequency modulation. To the end of obviating such stray modulation, widely varying methods have been disclosed which are predicated upon compensation brought about by counter modulation or reverse modulation, an idea which necessitates complex circuit organizations. According to the present invention, pure and unadulterated amplitude modulation in an oscillator tube is made possible by completely separating, in electrical regard, the wave generation means from the modulation process so that there is no risk or chance of the latter reacting upon the means for generating the waves. According to the invention, electron coupling relationship is established between the wave generation system consisting of a magnetron or an oscillating-electron system and a distinct tube system in which the electron current issuing from the generator system is modulated and which puts out the useful or signal energy.

It has been suggested in the prior art to couple the output circuit, say, of an antenna by way of an electron coupling means with the oscillation generator system. However, the sole purpose of this scheme has been to generate relatively large power with ultra-short waves. In fact, the scheme was unsuited for modulation work.

A control or modulation action may be brought upon the electron current either by magnetic or by electrical ways and means. The only thing that is essential is that there should be no chance for the modulator actions reacting as far back as the generator system.

The basic idea of the invention is comparable with the principle underlying a space-charge grid type of tube in which the cathode gives off a constant electron current which flows through a space-charge grid. In the present instance, the cathode is represented by the wave generator system which emits an electron pencil or beam which is modulated at ultra-high frequency. It will be remembered that the space-charge grid in the conventional tube fulfills two functions, to wit:

1. It shields the outside space, that is to say, the space in which the control grid is confined (in the present instance the modulator means) from the cathode space (here represented by the wave generator). Hence, capacitive reactions are thus precluded.

2. The excess of current resulting from the modulation of the anode current is absorbed by the space-charge grid. The stream of electrons issuing from the cathode (here represented by the wave generator system), therefore, will not be impaired by the modulation process.

Now, the invention shall be explained more fully by reference to the drawing, in which:

Fig. 1 shows an embodiment of the invention employing a retarding-field oscillator;

Fig. 2 illustrates the invention as applied to a magnetron type of generator, and

Fig. 3 represents a further modification of the invention employing secondary electron emission.

Figure 1 shows a tube comprising a cathode 1, a positively biased accelerator electrode 2 and a retarder electrode 3. It will be noted that this system operates as a retarding-field generator, the frequency of which is governed by the transit time of the electrons from the cathode to the retarder electrode as well as by the tuning of the external circuit 7. Outside this retarding-field or oscillating-electron system is disposed the positively biased grid 4. This grid corresponds to the above-mentioned space-charge grid. It is so designed that optimum coupling conditions are obtained. This grid separates the ultra-high-frequency system comprising electrodes 1, 2, 3 from the modulator system consisting of the control electrode 5 and the collector or output electrode 6. Through the retarder electrode 3 flies a fraction of the electrons oscillating between the electrodes 1 and 3. This fraction of electrons reaches the space between the grid 4 and the anode 6, and it is here modulated by means of the control grid 5. Reaction by the modulation process upon the generation of waves is therefore completely precluded. The useful or signal energy, as shown, is put out at the anode 6 and fed, for instance, to the aerial by way of a co-axial type of feeder or lead. In this connection it will be found expedient to close also the outer sheath or envelope of the line as illustrated to result in a radio-frequency circuit including 4, lest the shielding might be incomplete. In Figure 1 the outer sheath 10 is extended as shown at 12 to overlap a conductive member 14 associated with electrode 4. This circuit so completed is similar to the circuit including the outer sheath, condenser 18, and electrode 4' of Figure 2. Such electrons which, as a result of the control or modulator action of the grid 5 are unable to reach the anode 6 are absorbed by the positive grid 4.

Another exemplified embodiment of the invention comprising a magnetron type of generator

is shown in Figure 2 where 1' is the cathode of the generator, 2' and 2'' the two anode segments, and 7' the oscillation circuit between these segments. The two segments have openings 3', 3''. Through the latter a part of the ultra-high-frequency electrons reaches the outside and by way, for instance, of the positive annular grids 4' and 4'' into the modulator space. The modulation grid mounted at both ends of the magnetron system are designed by 5' and 5'' and the two anodes are designated by 6' and 6''. As can be readily understood, the entire organization operates in push-pull, with the grids 5', 5'' being modulated in phase. In order to transmit several signals the two grids 5' and 5'', or as many grids as there are modulator systems, are modulated by different messages or signals. Of course, it is also possible to provide instead only one anode segment, say, segment 2' with an opening serving for an exit of the electrons; hence, only one accelerator grid, one control grid and one anode are employed in such case. In an arrangement as shown in Figure 2, the push-pull or phase-opposed signal modulated voltages are put on co-axial energy feeder lines and fed to another point. Also in this case, as schematically shown, the outer sheath or shield is in radio frequency connection with the accelerator electrodes 4', 4''.

Instead of providing distinct openings in the outer electrodes of the oscillation system, it would, of course, also be feasible to utilize the slits or splits between the various segments. As known, what emerges through the latter is an electron current which is ultra-radio frequency modulated, and this is useful for the purposes of the invention. Moreover, it may be advantageous to mount the modulation system, particularly the magnetron system, in tangential direction to the cathode rather than in radial direction. Such an arrangement is illustrated in Fig. 3 where 1 is the cathode, 2' and 2'' the anode segments, and 7' the ultra-short wave oscillation circuit. One of the anode segments indicated at 2' has a tangentially directed opening 3' through which the electrons reach the outer space. The rest of the arrangement of Fig. 3 shall be described more fully further below.

In order that the wave generation process may be affected as little as feasible, the opening giving exit to the electrons should, of course, be made as small as feasible. As a result, naturally, also the electron current reaching the modulation system will be very small, and this means low efficiency or signal output. However, basically speaking, this drawback is quite immaterial inasmuch as only a small power is delivered from the frequency-governing system properly so-called for which it is merely the question of frequency stability that plays an essential part (as is true, for instance, also of crystal-stabilized radio frequency transmitters of standard design). However, according to another object of the invention, it is also possible to amplify this small current put out by the generator system inside the tube so that before or after the modulation process a substantial increase in power is securable.

An organization of this kind is illustrated in Figure 3 in which the electrons leaving the oscillation system 1, 2' traverse first hollow cylindrical electrode 4'''. This electrode, if desired, may produce an electron-optic focusing effect together with its action as a space-charge grid. The electrons then enter a system operating according to the principle of secondary electron (emission) multiplication comprising the electrodes 8, 8'. What particular kind of secondary electron multiplication is used is immaterial. From the multiplier, the electron pencil reaches the modulation system. The latter comprises the control grid 5 and the anode 6. Instead of providing the electron-multiplying means between the oscillatory system and the modulation system, such multiplying could also be interposed between the modulator system and the useful or signal circuit. Also, both schemes could be practiced simultaneously.

The invention is not restricted to the exemplified embodiments here shown. Indeed, it may be applied to ultra-high-frequency oscillator tube system no matter of what kind or construction. Moreover, it could utilize any desired accessory electron-optic electron systems. The invention is further not restricted to modulation work, in fact, it could with equal success be used for regulator purposes, etc. The chief advantage inherent in the invention is its freedom from reaction between signal or output circuit and the generator. Indeed, the mere separation of the useful (signal) circuit and the generator circuit by means of electron coupling, even without modulation, would basically form the object of the invention.

What is claimed is:

1. In an ultra-high frequency signalling system, an evacuated container enclosing an electron emission element, a plurality of oscillation generating electrodes comprising spaced surfaces points on which are at substantially equal distances from said emission element, a space between said surfaces permitting electrons emitted by said element to travel beyond said surfaces and additional electrodes including an anode and a control electrode located in the path of the electrons which pass through said last mentioned space, means connecting a pair of said oscillation generating electrodes in an oscillation generating circuit in which circuit the frequency of the oscillations generated is controlled primarily by the electron transit time between said oscillation generating electrodes, an output circuit connected with said anode electrode, said output circuit being coupled to said oscillation generating circuit substantially only by the electrons which pass beyond the generating electrodes and through said last named space, and means for modulating the potential on said control electrode to thereby modulate the electrons supplied to said output circuit from said electrodes in said oscillation generating circuit.

2. A system as recited in claim 1 wherein a ring-like electrode is located in said container between said oscillation generating electrodes and said output electrode included in said output circuit.

3. In an ultra-high frequency signalling system, an evacuated container enclosing an electron emission element, a plurality of electrodes having surfaces points on which are substantially equally spaced from said emission element, said plurality of electrodes partially enclosing said emission element, and a plurality of corresponding electrodes on opposite sides of said emission element spaced different distances from said emission element, means connecting a pair of said electrodes partially surrounding said emission element in an oscillation generating circuit in which circuit the frequency of the oscillations generated is controlled primarily by the

electron transit time between said electrodes surrounding said emission element, an output circuit connecting a pair of said electrodes on opposite sides of said emission element in push-pull relation, said output circuit and electrodes connected thereby being coupled to said generating circuits substantially only by the electrons which pass beyond the generating electrodes, and means for applying modulating potentials to an electrode on each side of said emission element disposed between said generating electrodes and said electrodes connected by said output circuit.

4. A signalling system as recited in claim 3 wherein said container includes a ring-like electrode disposed between said generating electrodes and each of said electrodes connected by said output circuit.

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