Oct. 8, 1940. K. FRITZ 2,216,940

MODULATION

Filed April 1, 1937

Fig. 1

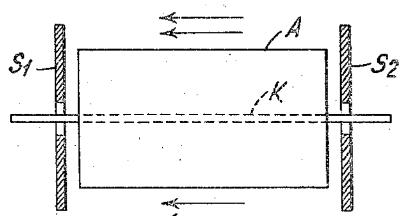


Fig. 2

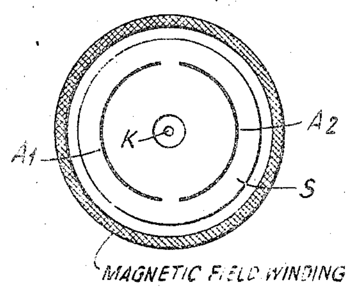


Fig. 3

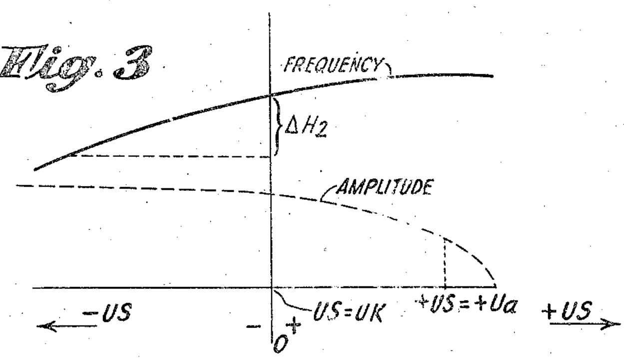


Fig. 4

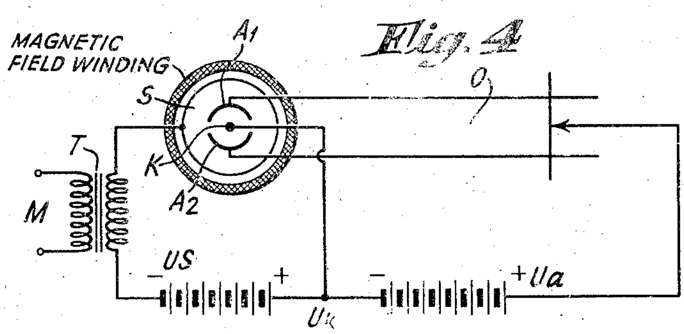
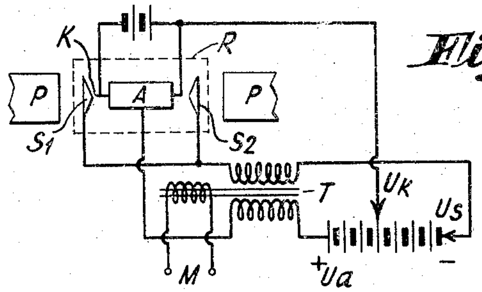


Fig. 5



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MODULATION

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5 Claims. (Cl. 179—171.5)

This invention concerns a method of and means for attaining oscillations modulated in particular in frequency in magnetron tubes and retarding field generators.

The present invention relates to a modulation method employing short wave tubes more especially magnetron tubes and retarding field tubes with so-called end-plate electrodes.

In short wave tubes having a discharge system almost closed and arranged concentrically with respect to the cathode, it is known to arrange at the ends of said system, absorption electrodes having the form of covers, and to impress thereon a positive bias potential relative to the cathode. As a result thereof an electrical field is produced having a component parallel to the axis of the system (electrical cross field). By suitably dimensioning the electrode bias potentials used in the retarding field type tubes, or the electrode bias potentials and the magnetic fields in magnetrons the greater part of the electrons can be caused to only rub against the electrodes serving for the production of oscillation, instead of impinging thereon. This part of the electrons likewise contributes to the production of oscillation, namely through influence. The electrons move along a screw line under the influence of the electrical cross field, the axis of said screw line extending approximately parallel to the axis of the system, so that the electrons reach the positively biased so-called end-plate electrodes only after describing several turns. If an alternating potential modulated with signal is superimposed on the end-plate electrodes, the produced high frequency will be influenced primarily as regards its amplitude, whereby however, automatically an additional frequency modulation occurs.

The idea of the present invention is as follows: By means of the end-plate electrodes there shall be carried out practically an exclusive frequency modulation at approximately constant high frequency amplitude.

The method according to the invention, namely in attaining oscillations in maghetron and retarding field generators primarily modulated in frequency is characterized by such supply of modulation oscillations that the radii or elongations of the electron courses will in practice not be varied by the modulation oscillations.

A variation of the elongations of the electrons either necessitates a variation of the constant magnetic field or a variation of the mean acceleration potential. For this reason, acceleration potential and magnetic field shall be maintained constant. There shall be obtained only a turning of the planes of the courses of the electrons relative to a position at right angles to the cathode. This turning is accomplished through electrical cross fields which cannot exert any accelerating force upon the electrons.

The method according to the invention is preferably carried out through the use of discharge tubes having main electrodes disposed concentrically to the cathode, and further auxiliary electrodes at the ends of the discharge system. In according with the invention the modulation is applied to the end-plate electrodes, which are highly negatively biased relative to the cathode, either in equal sense, or in push-pull. Consequently, the electrons will be concentrated to a greater or lesser degree in the center of the discharge system, without change in their elongations or in the diameters of the courses they follow.

Figures 1 and 2 represent known constructions of tubes having end-plate electrodes.

Figure 3 clearly indicates the relationship of frequency and amplitude of high frequency oscillations produced in accordance with the method of the invention.

Figures 4 and 5 show examples of circuits utilizing the idea of the invention.

Figure 1 is a discharge tube with a single cylindrical anode A. The cathode K is disposed in the axis of the cylinder. At the ends of the discharge system two end-plate electrodes S_1 and S_2 are arranged preferably at right angles to the cathode.

Figure 2 shows a cross section through a similar tube having in place of the single anode cylinder A two cylinder segments A_1 and A_2 parallel to the axis.

Figure 3 shows the working characteristics of a tube according to Figures 1 or 2, whereby it is assumed that the modulation potentials are applied only to the end-plate electrodes. There is shown as abscissa the bias potential of the end-plate electrodes with respect to the cathode. In Figure 3 the direct bias of the end-plate electrodes S is plotted as the abscissa. A reference ordinate is plotted in the 0 point of the bias for the end-plate electrodes ($US=UK$). The frequency variations and the amplitude variations of the radio frequency oscillations generated are also plotted as ordinates. It will be recognized from this graphic representation that at 0 negative bias of the end-plate electrodes S and for all values of negative bias to the left of 0, the radio frequency amplitude remains constant and that only the frequency of the oscillations generated is varying. When approaching the value *US=UK*, that is to say, the value of the cathode potential from the negative range, i. e., from the left of 0, then the radio frequency amplitude begins to decrease. Therefore, only the field at the left of the reference ordinate is to be used for obtaining a sharp frequency modulation, the end-plate electrodes having a negative bias relative to the cathode in said field. It is seen that if the end-plate electrodes have a high negative bias potential, frequency modulation is possible without amplitude variation. It follows therefrom that in the modulation methods hitherto known, frequency variations and amplitude variations must be produced simultaneously when using positively biased end-plate electrodes.

Figure 4 shows a complete oscillatory circuit utilizing a split plate magnetron in a self excitation circuit. The anodes A_1 and A_2 have impressed thereon in the known manner a highly positive bias potential U_a applied across the oscillatory circuit O. The end-plates S receive a negative bias potential U_s relative to the cathode. At the same time there is impressed upon the end-plate electrodes, alternating potentials which vary in rhythm with potentials supplied from a modulation source M across a transformer T.

In a manner similar to that by which frequency modulation can be obtained, it must also here be possible to suppress an undesirable frequency modulation component with the method according to the invention. Now, methods are known as such for producing electro-magnetic oscillations which have modulated either the amplitude or only the frequency. It is also known to carry out a modulation in a circuit of an electrode other than that for the main modulation, and whereby the first modulation serves for compensating an undesirable side modulation.

Figure 5 shows a circuit in which there is obtained an amplitude modulation for instance by influencing the plate potential, and a counter-modulation by influencing the potential of the end-plate electrodes. Herein, item R designates the tube envelope and P are the poles of a magnet arrangement.

The tube which is used in a device according to Figure 5 is represented in Figure 1. The numeral M shows that at this point a microphone or a modulation amplifier is intended to be connected.

The modulation potentials impressed upon plate A and on the end-plate electrodes S_1 and S_2 through the transformer T (Figure 5) have to be in phase opposition if an undesirable frequency modulation is to be suppressed.

It appears to be in place to emphasize a fact revealing the principal difference between the working with positively biased end-plate electrodes and that with negatively biased end-plate electrodes.

Positively biased end-plate electrodes are best suited in magnetrons having a single part anode. A certain improvement in the efficiency can also be brought about in magnetrons with double split anode, namely, when oscillations of the first order are produced. In case of oscillations of the first order, an electron requires for a course of the loop change in direction until original direction is resumed—approximately one oscillation cycle. An electron moving with the proper phase, and which performs a pendulum movement between the anode and the cathode, always approaches the anode for instance, when the alternating potential superposed on the direct plate potential has a negative sign. The electrons therefore, rotate in circular courses between cathode and anode such that they always pass towards the incidentally negative electrode thereby delivering their energy in stages. By means of a positively biased end-plate electrode the electrons receive a lateral acceleration and they pass towards the end-plate electrodes, while delivering their energy.

In multi-split, and especially four-split anodes, the electrons rotate in their courses and gradually approach the anode. A withdrawal through positively biased end-plate electrodes would not improve the efficiency since the electrons would be withdrawn prematurely from the excitation process.

The case is different in negatively biased end-plate electrodes. These can be utilized in singular as well as multi-split anodes since the electrical fields which they produce concentrate the electron paths to a greater or lesser degree only to the center of the discharge path. The efficiency of the high frequency power will thus practically not be influenced at least not in the ranges used.

I claim:

1. In a modulation system a generator of the magnetron tube type comprising a tube having an anode and a cathode, means for applying a positive potential to said anode relative to said cathode, means for producing a magnetic field of constant strength at right angles to the path which the electrons would follow between said cathode and anode in the absence of said field, means connecting said anode and cathode in oscillation generating circuits, said tube also having end-plate electrodes, means for maintaining said end-plate electrodes negative a substantial amount relative to said cathode, means for varying the potential of said anode in accordance with modulating potentials to amplitude modulate the oscillations generated, and means for varying the negative potential of said end electrodes in accordance with modulating potentials to produce corresponding variations in the frequency of the oscillations generated.

2. In a system for producing oscillatory energy and modulating the same at signal frequency, a tube device having a substantially linear cathode, an anode concentrically disposed with respect to the cathode, and an end-plate located at each end of said aforesaid electrodes with means for producing a magnetic field of substantially constant strength in which said electrodes are disposed, means connecting said anode and cathode in an oscillation producing circuit, means for maintaining said end-plates at high negative potential relative to said cathode, and means for applying modulating potentials to said end-plates comprising a direct connection between said end-plates, and a transformer having a secondary winding connected between said end-plates and said cathode, and a primary winding excited by modulating potentials, the values of said modulating potentials and high negative potential being such that said tube operates substantially within the negative portion of its end-plate-output characteristic, whereby the oscillations produced are varied in frequency in accordance with said applied modulating potentials.

3. In a system for producing oscillatory energy and modulating the same in amplitude at signal frequency and for substantially suppressing or preventing frequency modulation thereof, a tube device having a substantially linear cathode, an

anode concentrically disposed with respect to the cathode and an end-plate located at each end of said aforesaid electrodes with means for producing a magnetic field of constant strength in which said electrodes are disposed, means for maintaining said end-plates at relatively high negative potential relative to said cathode, means for applying modulating potentials to said anode to produce corresponding variations in the amplitude of the oscillations generated, and means for applying modulating potentials to said end-plates, to produce corresponding variations in the frequency of the oscillations generated to compensate frequency variations inherently produced therein by applying said modulating potentials to said anode.

4. A system as recited in claim 3 wherein said means for applying modulating potentials to said end-plates includes a direct connection between said end-plates and a reactance on which said modulating potentials are impressed connecting said end-plates to said cathode whereby said end-plates are modulated in phase.

5. A system as recited in claim 3 wherein said means for applying modulating potentials to said anode and to said end-plates comprises a transformer having a primary winding excited by modulating potentials, a first secondary winding having one terminal connected to both of said end-plates and the other terminal connected to said cathode and a second secondary winding connected between said anode and cathode.

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