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MODULATION SYSTEM

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Fig. 1

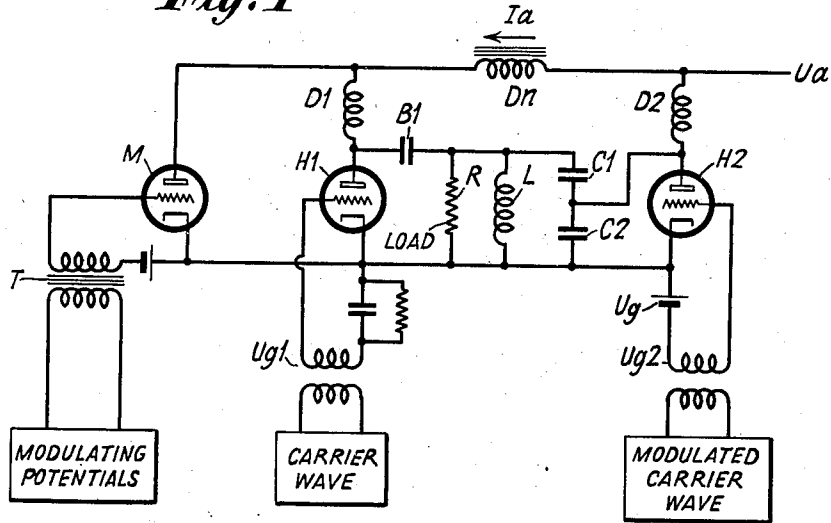
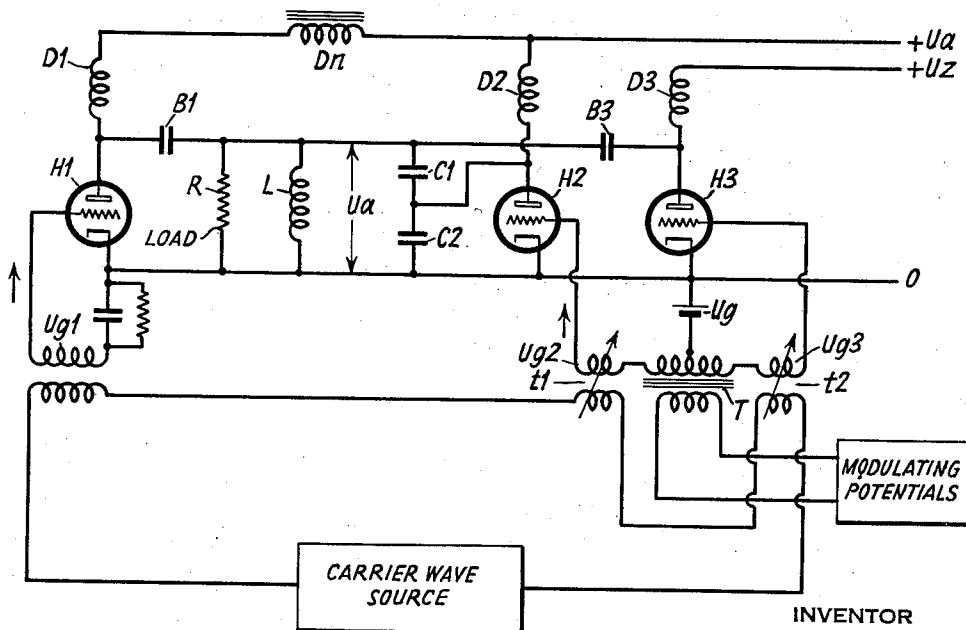


Fig. 2



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MODULATION SYSTEM

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4 Claims. (Cl. 179—171.5)

This application concerns a new and improved modulation system of an efficient type and includes means for improving the linearity of modulation. In describing my invention, reference will be made to the attached drawing wherein Figure 1 illustrates a modulation system known in the art and this figure is included in the drawing to simplify the explanation of my improved system and its relation to the prior art. Figure 2 illustrates my improved high efficiency modulation system.

Recently there has been proposed a circuit for obtaining a favorable degree of efficiency whose construction is shown in Figure 1 and whose mode of functioning will be described.

The high-frequency tube H1 operates in class C amplification connection and supplies the load R with the carrier power. A second high-frequency tube H2 is connected in parallel to the oscillatory circuit L C1 C2 of the first tube but the second tube remains blocked in the negative modulation phase on account of the grid biasing potential—Ug—so that it may be disregarded on the negative half of the modulation cycle. The tube H1 has the direct potential Ua applied thereto and is supplied with the plate current Ia flowing through the audio-frequency choke Dn. Items D1 and D2 are high-frequency chokes which as regards the low frequency represent almost a zero resistance but as regards high-frequency they are very high resistances. The tube H1 has placed in parallel thereto a modulator tube M which is fed at the grid side across an audio-frequency transformer T. As long as the tube H2 remains blocked the circuit is the same as that of a pure parallel tube modulation circuit (Heising constant current modulation). The modulator M operates in class B amplification; hence, with very little continuous current. In the downward part of the modulation cycle of the modulated wave the grid of tube M is made more positive with a resulting increase in plate current and decreased potential on the plate of tube H1 thereby reducing the power which the tubes H1 supplies for the load R. In the upward part of the modulation cycle of the modulated wave the modulation tube M remains blocked since it operates in class B amplification. But now in the grid circuit of the tube H2 the grid potential supplied by an amplifier of modulated high-frequency oscillations is increased so that the tube H2 likewise supplies power for the load R. Since the alternating grid potentials Ug1 and Ug2 and thus also the plate currents of the tubes H1 and H2 have the

same phase, the plate current of the tube H1 would decrease unless it is kept practically constant by the audio-frequency choke Dn. The choke Dn produces a potential increase in the positive modulation half so that the current fed into the tube H1 is maintained practically constant. On account of the voltage division C1 C2 the tube H2 has applied thereto in the blocked state practically half the alternating plate potential. At 100% modulation both high-frequency tubes supply at the peak value together four times the carrier power, namely, at the brief double direct potential (direct potential+choke potential) the tube H1 supplies the same current as at carrier potential, while the tube H2 at pure direct potential supplies twice the current as the tube H1 at carrier. The difference between the mode of functioning of this circuit in the positive modulation phase and the modulation system described by Doherty in the September 1936 I. R. E. at page 1163 resides in that in the present case the two high-frequency tubes are connected directly to the load circuit without an intermediate coupling network and owing to the audio-frequency choke used here the carrier tube H1 undergoes a potential increase on the positive half of the modulation cycle, while in the case of the Doherty system of modulation described in the publication, the current of the carrier tube will be increased at constant potential on account of impedance inverting action of the high-frequency network. In the arrangement shown in Figure 1, the amount of energy saved is the same as in the circuit of the publication. A drawback of the arrangement shown in Figure 1 solely resides in that the bend of the characteristic of the high-frequency tube H2 functioning in C-operation existing at low current values is to be brought into conformity, at low degrees of modulation, with the bend of the audio-frequency tube M functioning in B-circuit such that these bends approximately compensate each other.

In accordance with the present invention, a much straighter characteristic can be obtained if in a system operating in principle like Figure 1 the circuit proposed in my United States application Serial #206,578, filed May 7, 1938, is utilized. The new circuit is shown in Figure 2. In place of the modulator tube M of Figure 1, there is provided a high-frequency tube H3 operated by modulating potentials in phase opposition in regard to H2, thus consuming power on a portion of the modulation cycle. Since the tube H3 absorbs current in the positive half period of the

alternating plate potential, it need have a direct plate potential U_2 only in the case of a very extensive control, said direct potential is to have approximately the value necessary for tube saturation potential. The circuit operates as follows:

The carrier power is again supplied to the load R at a favorable degree of efficiency by the tube H1 connected for class C-operation. The tubes H2 and H3 are so biased as not to yield any appreciable output in the absence of modulation. In the positive modulation half, the tube H2 operates while H3 remains cut off. In the negative half of the modulation cycle the tube H2 remains cut off while the tube H3 becomes operative and decreases the power output of the system. Now, if the tube H1 would, without the use of intermediate chokes D_n , have the direct potential immediately applied thereto, the current would increase because the load resistance $R+H3$ of tube H1 is lower. The choke D_n , however, prevents this increase in current in that it produces a counterpotential attaining the value of the direct potential at the largest modulation peak which appears. The number of tubes required for this circuit is not greater than that of Figure 1. The tube H1 is to have at the operation with the direct potential U_a , a power rating which is equal to the carrier power. At the same direct potential, the tube H2 should supply twice the carrier power and, therefore, it is to have twice the emission of tube H1. The value of the tube H3 depends on the value of the applied alternating potential. If the tube has the total alternating potential U_a applied thereto, it is to have the same power rating as the tube H1. Since through corresponding over-coupling the tube H3 may have much higher alternating potentials applied thereto because it has hardly any direct potential, it can be chosen correspondingly smaller. When assuming that H2 and H3 have high amplification factors and H3 has the total alternating plate potential impressed thereon when setting the carrier, such as indicated in Figure 2, the alternating grid potential U_{g3} needs only be half as high as U_{g2} such as can be accomplished through corresponding adjustment of the couplings of the high-frequency transformers $t1$ and $t2$. The advantages of this circuit over those shown in Figure 1 are seen, aside from the more favorable modulation characteristic, in a simpler and clearer mode of operation as well as in the possibility of obtaining a somewhat better degree of efficiency than in the case of the circuit shown in Figure 1.

Instead of giving both tubes H2 and H3 high-frequency load and audio-frequency load at the grid side, the tube H3 and the modulation transformer may be omitted while only the side band oscillations are applied to the tube H2 across the transformer $t1$ in which case the tube would operate as class B-amplifier in the positive modulation half period and as load in the negative modulation half period.

What I claim is:

1. In a modulation system, a high-frequency amplifier tube having input electrodes and output electrodes, a load circuit coupled to said output electrodes, a source of wave energy of carrier wave frequency coupled to said input electrodes to impress wave energy on said input electrodes, a pair of tubes each having input and

output electrodes, means coupling the output electrodes of said tubes to said load circuit, means coupling the input electrodes of said pair of tubes to said source of wave energy for impressing wave energy from said source on the said input electrodes of said pair of tubes, the phase of the wave energy on the input electrodes of one of said pair of tubes being substantially the same as the phase of the wave energy on the input electrodes of said first tube, means for modulating the impedances of said pair of tubes in phase opposition whereby one of said tubes supplies power to said load on positive halves of the modulation cycle and the other of said tubes draws power from said load on the negative halves of the modulation cycle and means for supplying said first tube, substantially constant output direct current.

2. In a modulation system, a source of wave energy of carrier wave frequency, a source of direct current, a load impedance, a class C amplifier tube coupling said wave energy source to said load impedance, means connecting said source of direct current to said tube to supply substantially constant direct current thereto, a second tube having output electrodes coupled to said load impedance and having input electrodes coupled to said wave energy source, a connection between the output electrodes of said second tube and said direct current source, a third tube having output electrodes coupled in parallel to said load and input electrodes coupled to said wave energy source, and means for controlling the impedances of said second and third tube in phase opposition at signal frequency.

3. In a modulation system, a source of wave energy, a load circuit, a class C amplifier coupled between said wave energy source and said load circuit, a source of substantially constant direct current for said class C amplifier, a second amplifier coupled to said load circuit, means for supplying wave energy from said source to said second amplifier of a phase substantially the same as the phase of the wave energy supplied to said class C amplifier, a third amplifier coupled to said load circuit, means for supplying wave energy from said source to said third amplifier of a phase which substantially opposes the phase of the wave energy supplied to said second amplifier, and means for controlling the outputs of said second and third amplifiers at modulation frequency.

4. In a wave modulation system, a source of wave energy voltage to be modulated, a source of modulating potentials, a load circuit, three electron discharge tube systems each having input and output electrodes, means coupling said source of wave energy to the input electrodes of all of said tube systems to excite the same co-linearly by wave energy voltages to be modulated, means including a source of substantially constant direct current for operating one of said tube systems class C, means coupling said source of modulating potentials to the input electrodes of the other two of said tube systems to excite the same in phase opposition or push-pull relation by modulating potentials, and means coupling the output electrodes of all of said tube systems to said load circuit to impress the output voltages of all of said tube systems on said load.

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