Sept. 21, 1937. G. KRAWINKEL 2,093,729

MODULATOR

Filed June 8, 1935

Fig. 1

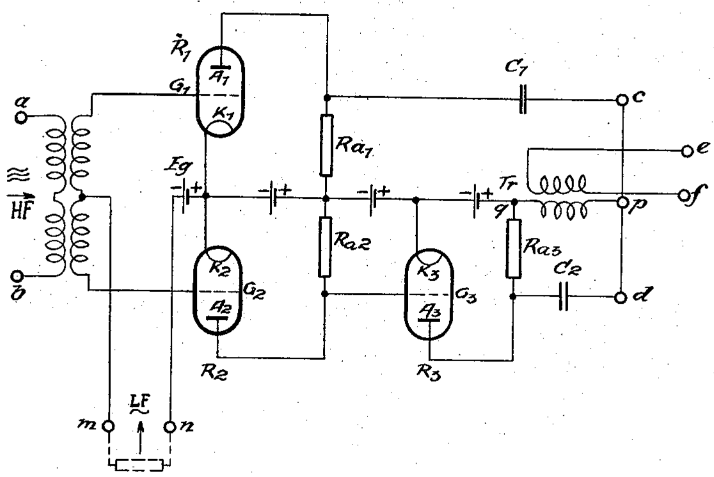
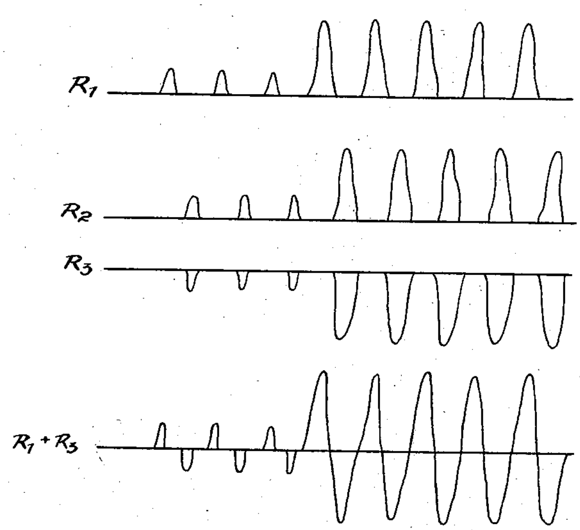


Fig. 2



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MODULATOR

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6 Claims. (Cl. 179—171)

This invention relates to wave to translating methods and apparatus, and particularly to methods and means for modulating a carrier wave by a modulating signal wave.

An object of the invention is to provide circuit arrangements, in which the modulating signals, as for example low frequency oscillations appearing in the anode output circuit of the modulation stage besides the modulated high frequency oscillations are to be suppressed and in which the use of filter circuits does not appear advisable.

For example, if the modulating low frequency and the modulated high frequency differ considerably as to number of periods, the suppression of the low frequency oscillations by means of filter chains does not involve any difficulties. On the other hand, if, for instance in television transmissions, the modulating low frequency approaches in number of periods the extreme side bands of the modulated high frequency, a considerable expenditure of filtering means would be required and phase and attenuation distortions would easily appear in the extreme side bands of the modulated high frequency.

The invention provides a modulating method according to which only modulated high frequency oscillations appear in the output circuit of the modulation arrangement, so that subsequent filtration is not necessary, even if the modulating low frequency and the extreme side bands of the modulated high frequency have almost the same number of periods. The method according to the invention is based on a suitable geometrical composition of two modulated high frequency half-waves in the outlet of the modulation arrangement.

By way of example, one form of the invention is illustrated in the accompanying drawing, in which Figure 1 shows a connection according to the invention and Fig. 2 is a diagram of the course of the oscillation.

Referring to the drawing, and first to Fig. 1, *a*, *b* are the terminals of the input circuit by means of which a high frequency carrier is connected to the tubes R1, R2 shown as triodes with the anodes A1, A2, the grids G1, G2 and the cathodes K1, K2. The terminals for the modulating low frequency tension are indicated at *m*, *n*. A source of biasing voltage E*g* lies in the grid circuit of the two tubes. In the output circuit of the tubes R1 and R2 the resistances R*a*1 and R*a*2 are provided. Furthermore, according to the invention, the tube R2 connects with an amplifier valve R3 provided with the anode A3, the grid G3 and the cathode K3 in the output circuit of which a resistance R*a*3 is disposed. The points *c*, *d* are connected with the common point *p*. Between *p* and *q* prevails the modulated high frequency tension which is passed on by the transformer T*r* with the output terminals *e*, *f*.

The carrier frequency to be modulated acts in phase opposition on the grids G1 and G2. By means of the bias E*g* the two tubes R1 and R2 are to be negatively biased to such an extent that even at the greatest possible signal frequency amplitude one half-wave of the carrier frequency oscillation controls the anode currents of the tubes R1 and R2, sufficiently large carrier frequency amplitudes being provided of course at the grids G1 and G2.

In Fig. 2 the anode currents of the tubes R1 and R2 are indicated for two different amplitudes of the modulating voltage. The anode currents consist of modulating high frequency half-waves which, in the tube R2, always stand on the voids of the half-waves in the tube R1, since the high frequency acts in phase opposition upon the grids of the two tubes. At the resistance R*a*3 of the tube R3 a voltage is generated which compared with the one at the resistance R*a*2 has a phase shift of 180°.

As the voltages at resistance R*a*1, R*a*2 and R*a*3 are proportional to the respective anode currents, Fig. 2 shows also the course of the voltage in time at the resistance R*a*1, R*a*2 and R*a*3. It will be seen now that the composition of the modulated half-waves of the first and third lines of Fig. 2, i. e., the voltages at the resistances R*a*1 and R*a*3 will produce a clear modulated high frequency oscillation, as indicated in line 4 of Fig. 2. This combination may possibly contain modulated oscillations of higher order of the modulated high frequency, which, however, practically produce no distortion but it is free from the modulating low frequency oscillations which are still contained in the individual voltages at the resistances R*a*1 and R*a*3, provided the amplification of the reversing tube R3, Fig. 1, is adjusted so that equal high frequency half-waves are produced at the resistances R*a*1 and R*a*3. The composition of the two half-waves in the connection according to Fig. 1 is effected by connecting the points *c* and *d* to the joint point *p*. Between the points *p* and *q*, Fig. 1, there prevails the modulated high frequency tension shown in line 4 of Fig. 2, which may be passed on for instance by the transformer T*r* in Fig. 1.

According to the method described, the following problem can for instance be solved:

A carrier frequency of 1200 to 1300 k. c. is to be modulated by a low frequency band of 0 to 500 k. c. in such a way that the lower side band of 700 to 1200 k. c. can be put to further use and that the low frequency band of 0 to 500 k. c. is not to be present in the output circuit without resorting to frequency filters. The modulating low frequency as well as the modulated high frequency should have an R. M. S. voltage of 0 to 15. The known push-pull connections can be used only with relatively large tubes and must therefore be readjusted for operating reason.

Furthermore, the invention makes it unnecessary to provide for equality of the characteristics of the modulating tubes R1 and R2, Fig. 1, provided the straight portion of the characteristic is considerably longer than the curved part in the lower bend of the characteristic, which applies to a large number of known tube types. At the grids of the modulating tube exists such a great high frequency tension that marked high frequency half-waves are produced in the anode circuits, which may differ in size, as the tubes R1 and R2 may differ in steepness, but which are equal in shape, as the high frequency tension at the grids extends far into the rectilinear portion of the characteristic. The reversing tube R3, operating in the rectilinear portion of its characteristic and amplifying to a larger or smaller degree compensates accurately the difference in size, if any, between the two high frequency half-waves, so that at the point P of the connection according to Fig. 1 two high frequency half-waves meet and jointly produce a clear modulated high frequency which acts upon the transformer Tr as an example of an outlet. Distortion or asymmetry of the two high frequency half-waves can take place only if the lower bends of the two modulating tubes R1 and R2 do not completely harmonize. Such a distortion will become noticeable in case of small modulation amplitudes. The greater the modulating tension, i. e. the farther the modulating tubes are controlled in their rectilinear part of the characteristic, the lesser will become the percentage of distortions, i. e., the arrangement according to the invention unlike normal modulation, involves in case of greater modulation amplitudes a decreasing penetration percentage of the low frequency. This is a fundamental advantage, especially in view of the fact that the maximum distortion can be kept very small initially by paying some attention to the uniformity of the lower bends in selecting tubes. The second advantage afforded by the invention compared with normal modulation is that the entire rectilinear portion of the characteristic of the modulating tubes can be utilized, whereby the modulating voltage and the size of the tubes are brought into a reasonable relation.

The method is equally well suited for modulation about an average value of the high frequency oscillation and for telegraph-like modulation, wherein the high frequency is controlled only in one direction from a steady value.

I claim:—

1. The method of eliminating the signal components in the output of a modulator which comprises modulating a carrier wave with a signal wave, producing two modulated half-wave trains therefrom, dephasing one of said half-wave trains, combining the dephased half-wave train with the other half-wave train, and utilizing the modulated carrier product.

2. The method which comprises modulating a carrier wave with a signal wave, producing two modulated half-wave trains, dephasing one of said half-wave trains, bringing both half-wave trains up to the same amplitude, and combining the dephased half-wave train with the other half-wave train.

3. A modulator system comprising a modulating device, a circuit fed from said device, means for introducing a wave to be modulated and a modulating signal into said device, means for producing two modulated half-wave trains, means for combining the two half-wave trains and means including a phase shifting circuit operative on one of said half-wave trains for deriving from said circuit a resulting modulated wave free of the modulating signal.

4. A triode modulation system, comprising two grids and two anodes, an input circuit connected to said grids, an output circuit connected to said anodes, means for applying a carrier wave counterphasally to said grids, means for applying a modulating signal current to said grids cophasally, means for producing two modulated half-wave trains in said anode circuit, means for reversing the phase of one of said trains, and means for combining the other of said half-wave trains with said reversed-phase train for deriving therefrom a modulated carrier free of the modulating current.

5. In a modulator system, a carrier frequency source, a modulating frequency source, a pair of modulator tubes having grid circuits and anode circuits, means for impressing said carrier frequency upon said grid circuits in respective phase opposition, means for impressing said modulating frequency upon said grid circuits in co-phase relation, means including a negative bias on said grid circuits for producing a train of modulated half-waves in the anode circuit of each tube, means including a vacuum tube disposed in one of said anode circuits for producing a phase reversal of the half-wave train therein, means for restoring said reversed phase train to exact amplitude equality with the half-wave train in the other of said anode circuits, and means for combining said wave trains in a common output circuit.

6. In a modulator system, a carrier frequency source, a modulating frequency source, a pair of modulator tubes having grid circuits and anode circuits, means for impressing said carrier frequency upon said grid circuits in respective phase opposition, means for impressing said modulating frequency upon said grid circuits in cophase relation, means including a negative bias on said grid circuits for producing a train of modulated half-waves in the anode circuit of each tube, means including a vacuum tube connected to one of said anode circuits for producing a phase difference of 180° between said wave trains, and means combining said wave trains in a common output circuit.

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