Nov. 7, 1933. W. KUMMERER 1,933,631

COMPENSATED CIRCUIT SCHEME FOR GRID DIRECT CURRENT MODULATION

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Fig. 1

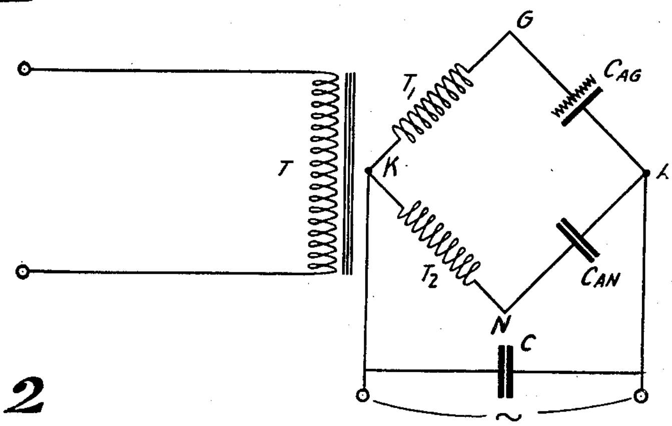

Fig. 2

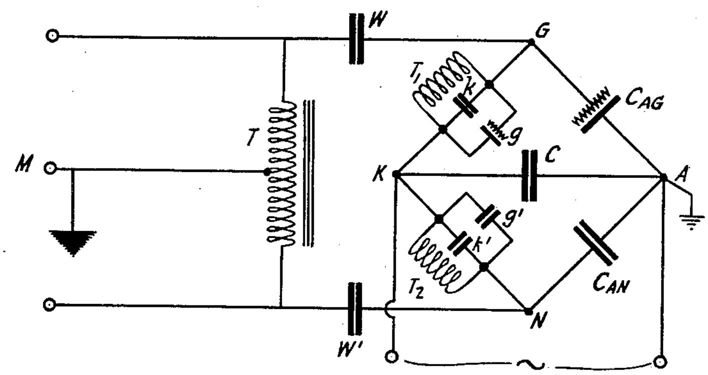

Fig. 3

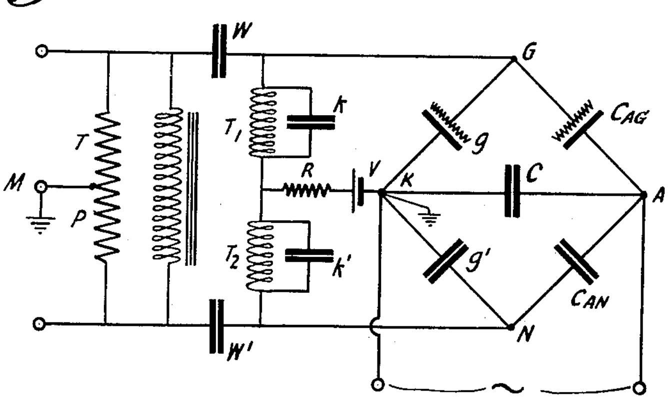

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Fig. 1a

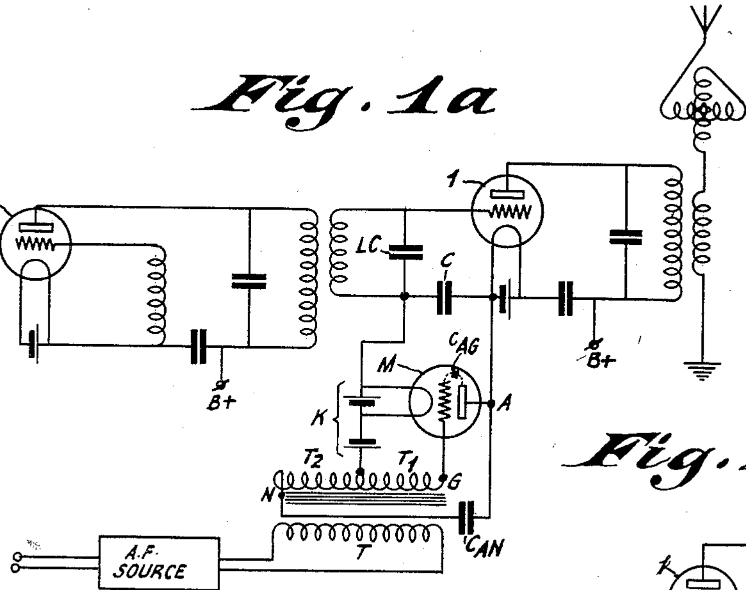


Fig. 2a

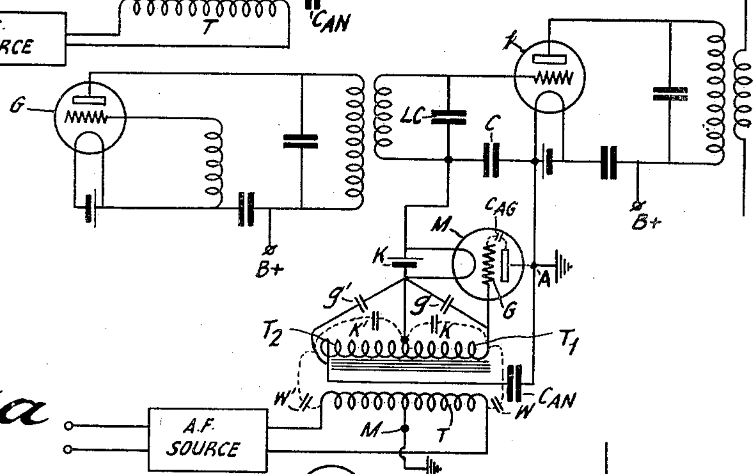
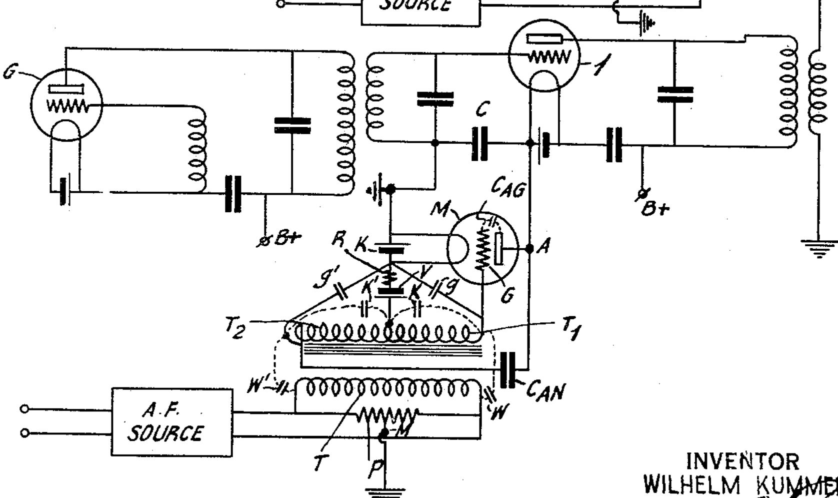


Fig. 3a



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COMPENSATED CIRCUIT SCHEME FOR GRID DIRECT CURRENT MODULATION

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5 Claims. (Cl. 179—171)

In modulation systems of the type in which the modulating currents or voltages are impressed on the terminals of a capacity in the grid circuit of the modulated stage to effect therein the grid direct current and thereby to modulate the carrier wave relay by the modulated stage, distortion of the modulated wave often occurs. Applicant finds that the distortion may bear a definite relation to the frequency of the modulated signals. Applicant also finds that the dimensions and distributed capacity and end capacity of the modulation transformer generally used between the signal source and the modulated stage which work into the grid stage of the modulated stage have considerable bearing on the resulting distortion. The distributed and end capacity of the transformer secondary winding does not depend entirely upon the static capacity between the filament and grid of the modulator tube but, rather, is governed by a considerably higher dynamic capacity caused by the appearance of the audio frequency potentials at the terminals of the condenser mentioned above in the grid alternating current circuit of the modulated stage. This audio frequency potential is, of course, on the output electrodes of the modulated stage.

Applicant has found that, by reducing this dynamic capacity effect at said condenser terminals, improved results with respect to distortion can be obtained. Applicant has also found a new and improved circuit of the bridge type by the use of which modulation of a carrier may be accomplished, and the effects of the capacity of the transformer windings are neutralized by the bridge circuit and do not reach the modulated stage.

The invention has been illustrated by the accompanying drawings, wherein:

Figures 1 and 1*a* illustrate a system for supplying energy to a bridge arrangement;

Figures 2 and 2*a* illustrate an improvement over the arrangement shown by Figures 1 and 1*a* for increasing the sensitiveness and balance of the system; and,

Figures 3 and 3*a* illustrate a modification of the arrangement shown by Figures 2 and 2*a*.

Now referring first to Figures 1 and 1*a*, T and T_1 and T_2, respectively, represent the primary and the two secondary windings of the modulation transformer; K represents the filament of the modulation tube M, G the grid element of the tube, and A the plate element. The point where the compensating condenser C_{AN} is united with the transformer winding is denoted by N. The grid to filament capacity of the modulated stage supplied from the modulation frequency amplifier of the present invention is indicated by the capacity C, and the grid to plate capacity of the relay tube M is denoted diagrammatically in Fig. 1 by C_{AG}. In Figure 1*a* the grid to filament capacity of the modulated tube 1 is connected, as shown, in parallel with the capacity C by way of a conventional input circuit LC. The circuit LC is coupled to any source of sustained oscillations. For purposes of illustration I have shown a conventional form of oscillation generator including a tube G with coupled input and output circuits. This generator forms no part of the present invention and need not be described in detail here. The audio frequency potentials originating in the audio frequency source AF are amplified in my balanced modulation frequency amplifier including tube M and applied by way of transformer T and tube M to the terminals of capacity C in the input circuit of tube 1, that is, in the input circuit of the modulated tube, to modulate therein the high frequency oscillations amplified and relayed by tube 1. The modulated oscillations may be utilized in any manner. For example, they may be impressed from a conventional output circuit on to a conventional radiating system. It will be readily seen by reference to the bridge circuit of Fig. 1 that the audio frequency potential resulting upon modulation at the fixed grid condenser C of the modulated stage is now unable to react upon the primary of the modulation transformer since the portions T_1, T_2 of the secondary winding are in arms of the bridge circuit which are balanced with respect to the diagonal C.

In practice conditions are more complicated, since in practical embodiments the transformers involve inter-turn capacities k and k', as indicated by Figures 2 and 2*a*, as well as interwinding capacities W and W'. Between the points K and G, as in Fig. 1, there arises furthermore the internal tube grid to filament capacity indicated in Figures 2 and 2*a* as g. If for the sake of simplicity the distributed capacities are imagined to be concentrated capacities at the ends of the windings, a diagram of the type shown by Fig. 2 then results.

In order that a bridge-balance constant also may be obtained in the presence of frequency changes, first, the distributed capacities must be of like size, and, second, a capacity g' must be connected also to the winding T_2 which is connected to the compensating condenser C_{AN}. The capacity g' should be equal to the grid-filament capacity g of the modulator tube. This type of grid direct current modulator circuit scheme makes it inherently necessary to ground suitably the point A, i. e., the plate of the modulation tube as shown in Figures 2 and 2*a*. If the middle of the transformer primary winding M is likewise grounded, in other words, joined with A as indicated in Figures 2 and 2*a*, then the distributed capacity between the windings, which is further increased by the stray inductance of the two halves of primary T which are connected in opposition, would appear as connected in parallel to the grid to plate capacity. This distributed capacity, in practical cases, amounts mostly to a multiple of the capacity C_{AG} between the anode A and grid G.

The currents forced by the potential arising across the fixed grid condenser C of the modulated transmitter by way of C_{AG} and C_{AN} through the secondary winding of the transformer (and thus also the influence upon the size of the grid alternating current potential), however, are not proportional to the ensuing capacity C_{AG} and C_{AN}. It may therefore be more favorable to connect M with K by way of ground as shown in Figs. 3 and 3*a* rather than with A as shown in Figs. 2 and 2*a*, and to insure potential separation in relation to ground by the aid of a distinct low-capacity intermediate transformer, for example, the output transformer of the audio frequency power amplifier. This circuit scheme is of greater advantage especially in cases when the grid potential is divided by purely capacitive means, as has been illustrated by Figures 3 and 3*a*. The direct current potential V required for the grid bias of the modulator tubes may be fed in at the middle of the transformer, for instance, through a high-ohm resistance R; also the grounding of the middle of the primary may be effected by way of an exactly balanced resistance P or voltage-dividing condenser. The current flowing by way of C_{AG} due to the potential between A and K results in a potential at G being so much lower, the higher the resultant capacity between G and K. It is advantageous for this reason to increase this capacity by the distributed capacity inevitably arising between the windings.

The modulator stage of the several figures including the windings T_1 and T_2 is, as shown, arranged in a bridge circuit so that the capacitive effect of said windings is neutralized and can not be transferred in either direction between the output electrodes and the input electrodes of the modulator stage M. The bridge, however, is not neutralized with respect to the signal currents or potentials applied from the winding T to the windings T_1 and T_2. This is due to the fact that the winding T_1 in the one arm of the bridge is connected between the grid and cathode of the amplifying repeater M so that the bridge is not balanced with respect to these potentials which appear amplified between the anode and cathode of the tube M and are consequently impressed across the terminals of the capacity C.

In the above embodiments, circuit schemes have been shown in which voltage division between G, K and N is effected by purely inductive means, as in Figures 1 and 1*a*, or purely capacitively, as in Figures 3 and 3*a*, and the combination of both as shown in Figures 2 and 2*a*, though always at the ratio of 1:1. Fundamentally speaking, this division could also be at any other ratio as long as the bridge connection is balanced. What is of importance is that the secondary winding of the transformer should be carefully symmetric in reference to the primary end.

Having now described my invention, what I claim and desire to secure by Letters Patent is the following:

1. A balanced modulation frequency amplifier and a balanced modulation frequency transformer for supplying energizing currents thereto and means for preventing the modulation signal potentials in the output circuit of said amplifier from affecting said modulation transformer including, a thermionic tube, a symmetrical secondary winding having two portions, the terminal of one of which is connected to the grid electrode of said tube, a connection between the midpoint of said winding and the cathode of said tube, a connection between the free terminal of the other of said portions and the anode of said tube, a neutralizing capacity in said connection, means for connecting a load circuit across the anode cathode impedance of said tube, all of said connections being arranged in a balanced bridge circuit such that the effective capacity of the component circuit over the entire audio frequency band is zero.

2. Signalling means comprising, a thermionic relay adapted to repeat high frequency oscillations, a source of signal potentials, and means for modulating said oscillations at signal frequency including means for preventing the energy resulting when said oscillations are so modulated from reacting on the source of signal potentials comprising, a modulation frequency transformer having its primary winding connected to said signal source and its secondary winding forming adjacent arms of a balanced bridge circuit, a diagonal of which is connected with electrodes in said thermionic relay.

3. Signalling means comprising, a thermionic relay having input electrodes adapted to be energized by high frequency oscillations and output electrodes connected with a work circuit, means for modulating oscillations repeated in said relay comprising, a source of signal voltages, a bridge circuit having one diagonal connected with the impedance between two of the electrodes in said thermionic relay tube, said bridge circuit comprising four balanced arms, some of said arms being composed in part of the impedance between electrodes in a thermionic amplifying tube, and means for impressing signal voltages from said source onto the other diagonal of said bridge circuit, whereby the signal voltages impressed on said relay tube are amplified and when impressed from said bridge circuit onto the impedance in said relay tube can not react on said source of signal voltages.

4. Signalling means comprising, a thermionic relay having input electrodes adapted to be energized at high frequency and output electrodes connected with a work circuit, a source of signal potentials, a thermionic tube having its anode to cathode impedance connected with the input impedance of said relay tube, said impedance being in the diagonal of a bridge circuit, a modulation frequency transformer having its primary winding connected to said modulation potential source and its secondary winding forming two adjacent arms of said bridge circuit, the midpoint of said secondary winding being connected to the cathode of said last named tube, one terminal of said secondary winding being connected by way of a compensating capacity to the anode of said last named tube and the other terminal of said secondary winding being connected to the control electrode of said last named tube, whereby energy resulting in the output circuit of said last named tube is prevented from reacting on said source of high frequency oscillations.

5. An arrangement as claimed in claim 4 in which the electrical center of the primary winding of said modulation transformer is connected to ground, and an electrode in said modulation amplifier is connected to ground.

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