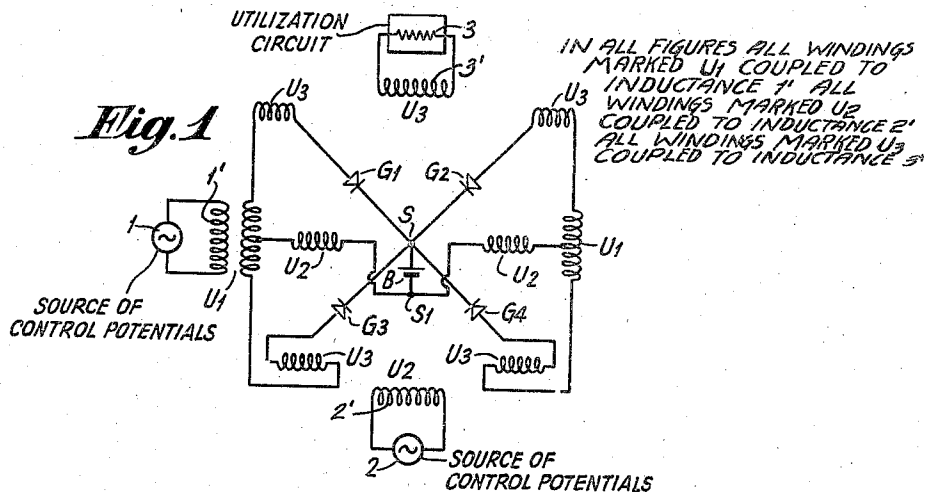
Jan. 24, 1939. W. HÄHNLE 2,144,655

ARRANGEMENT FOR MODULATION

Filed Feb. 3, 1937

Fig. 1



IN ALL FIGURES ALL WINDINGS MARKED U_1 COUPLED TO INDUCTANCE 1' ALL WINDINGS MARKED U_2 COUPLED TO INDUCTANCE 2' ALL WINDINGS MARKED U_3 COUPLED TO INDUCTANCE 3'

Fig. 2

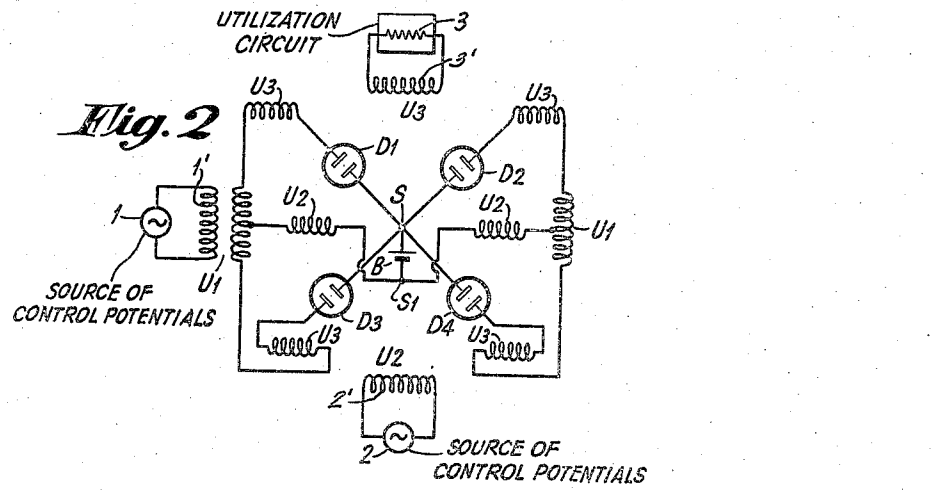


Fig. 3

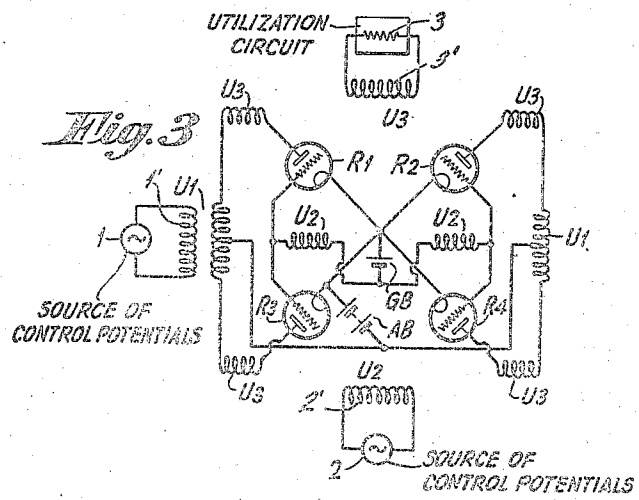
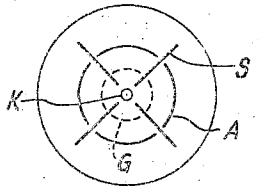


Fig. 4



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ARRANGEMENT FOR MODULATION

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4 Claims. (Cl. 179—171)

In the modern art of carrier frequency the development of simple modulating arrangements sufficing the most stringent requirements assumes a prominent place. The prior art has disclosed a number of modulation arrangements using oxide type rectifiers or tubes and it has been observed that twin push-pull modulators are particularly suitable for elimination of undesirable modulation products. Thus the prior art has for instance disclosed a double push-pull modulator using oxide rectifiers whereby the four rectifier arrangements form a closed train (ring modulator).

The present invention concerns an improvement in twin push-pull modulators and suffices a number of demands that the prior art has so far been unable to realize. Thus for instance, among others, the possibility is given by the suitable choice of rectifier characteristics to remove undesirable side bands, that up to the present did not lend themselves to shielding measures and which are produced by modulation of higher order, for instance, $fh+2fn$, $fh+3fn$ etc., where fh is the carrier frequency, fn the signal frequency.

In accordance with the invention a modulation arrangement is developed using a twin-push-pull arrangement of the non-linear resistances in the manner that they are disposed in form of a star. In other words, all poles of the same sign of the non-linear resistances are one-sidedly connected in one point.

In describing my modulation means more in detail reference will be made to the attached drawing wherein Figures 1 to 3 inclusive each shows a twin push pull modulation system arranged in accordance with my invention. In Figures 1 and 2 two electrode rectifiers of different type are used, while in Figure 3 electron discharge rectifiers of the control grid type are used. Figure 4 shows schematically a tube structure wherein the several electrode systems of an arrangement as shown in Figure 3 are included in a single closure member. Figure 1 shows a star-like arrangement of four oxide rectifier elements G_1—G_4. All these oxide rectifiers are connected with their side of equal sign to common point S, the star point. The frequencies to be modulated are taken from generators 1 and 2 and brought to the modulating arrangement through transformers U_1 and U_2 while the modulation products are tapped at resistance 3 representing any utilization circuit. To simplify the drawing the winding of the various transformers have been disassociated. However, the several windings of each transformer are designated by a common symbol.

In this embodiment the leads for the potentials are selected symmetrically resulting in a decoupling with respect to the other frequency at a given moment. The two lead windings of transformer U_1 are provided with center taps connected to star point S and in whose line train are connected, symmetrically to star point S, the transformer windings of U_2. The combination of both branches is effected at point S_1 which may coincide with the star point or, as in Figure 1, offers the possibility to interconnect a biasing potential current source, for instance battery B. This symmetrical arrangement further has the advantage that energy source 1 and 2 may be exchanged, insuring the optional choice to feed the carrier frequency to 1 and the signal frequency to 2 or vice versa. The modulated frequency is delivered at the four transformer windings of U_3.

The introduction of biasing potential source B in the circuit arrangement according to invention offers further advantages which shall be discussed in more detail in what follows: It is known in the prior art that by impressing a biasing potential in the case of non-linear resistances the working point may be moved in its location. Several advantages may be obtained in this manner with respect to the modulation, but in the circuit arrangements known in the prior art the impression of a biasing potential encountered practical difficulties since the use of a single joint battery was excluded. What actually would have to be done is to provide each branch of the twin push-pull arrangement with a special biasing potential source which besides would be impressed with different alternating current potential. The present invention eliminates this difficulty.

Moreover, the use of oxide type rectifiers in these arrangements has proved quite troublesome in that the influence of the capacity is very great in carrier currents of higher frequency, thus limiting greatly the use of these modulation arrangements for higher frequencies. The use of a biasing potential battery insures the reduction of the detrimental influence of the capacity of the rectifiers. In addition, the biasing potential may further be used for regulating the wave resistance of the modulator which may for instance be of great importance in carrier current systems over cables. The biasing potential battery may further be used to particular advantage for starting and stopping operations.

The invention is not restricted to the use of oxide rectifiers as non-linear resistances but all arrangements with curved characteristics may be employed. Thus, use may be made for instance of selenium rectifiers, glow tubes, or valves, and the choice of either diodes or grid-controlled tubes is immaterial.

Figure 2 shows the same circuit arrangement as Figure 1, using four diode paths D_1—D_4 in place of the rectifiers. Also in this case a biasing potential battery is arranged in connection with the star point. Figure 3 illustrates an embodiment of a circuit arrangement with grid-controlled tube. Tubes R_1—R_4 are interconnected in a manner similar to the arrangement shown in Figure 1 with rectifiers with the difference that the windings of transformer U_2, coupled with generator 2, are connected to the grids of the tubes while the mid-points of the transformer windings of U_1 are in direct connection and are impressed with anode battery potential AB with respect to cathode potential. A grid biasing potential battery GB is likewise provided.

These examples plainly show the considerable simplifications resulting from the circuit arrangement according to invention since only one grid and one anode potential source is required for all the tubes. It may prove suitable in many cases to equip modulators with grid-controlled tubes for the use of higher power is insured thereby. With higher powers however, the demands for an exactly symmetrical structure are no longer so stringent. The allowable asymmetry of the elements is given by the required proportion carrier quiescent current to modulated current (useful current). With given asymmetry, this ratio depends on the ratio carrier current to useful current. The useful current is proportional to the fed curent to be modulated. Consequently, the radio of fed current to carrier current is decisive. This ratio may increase with suitable characteristic of tubes and suitable form of curve. But even in other respects the tube modulators may result in special advantages.

As observed previously, the present invention insures the reduction of the undesired side-bands $fh+2fn$, $fh+3fn$, etc. This may be accomplished in various manners, thus by reduced modulation so that the resistance of rectifier is a linear function of the current. Another alternative however, consists in modulating strongly with a carrier frequency of rectangular form for which the tube modulators are especially suitable. When tubes are used their internal resistance may easily be varied between limits as low as 5,000 ohms, on the one hand, and practically infinity, say 50,000,000 ohms, on the other hand, so that the ratio of these resistances may readily be made as high as say 10,000 for example. If the terminal resistance is chosen in usual manner equal to the geometric average, the small variations of blocking and transmission resistance, due to other currents, are of no importance. Hence, the side-bands $fh+2fn$ and so forth are greatly reduced.

The use of grid-controlled tubes is not restricted to high-vacuum tubes. It is possible to employ in their place grid-controlled gas or vapor discharge paths. The latter are particularly adapted for use with low frequencies since its transmission resistance is smaller than that of vacuum tubes. Use for instance may be made of under-heated tungsten tubes in order to obtain a nearly rectangular carrier current, the tubes being modulated from the lower bend through to the saturation current. By this means a good approximation to rectangular form may be obtained since a limit is set merely by the self-capacities of the elements.

Since, as described above, only one joint grid and anode battery is used for the four tubes, a constructive simplification may be accomplished in accordance with further invention and all tube systems may be disposed in a joint vessel. But since all cathodes are connected to the star point it is further feasible to construct a multiple system with joint cathode. An embodiment of a tube of this type is shown in Figure 4. Around cathode K are arranged concentrically the four grids G and four anodes A in the form of a circular arc. It appears necessary, for electric separation of the individual systems, to insert shields and thus four shields S are inserted between the individual partial systems as shown in this embodiment, representing for instance space charge grids. But the structural development of tubes of this type is not restricted to the arrangement indicated in the figure.

It may finally be remarked that the star modulation arrangement according to invention may be equipped with more than one rectifier element per branch and may be imparted for special purposes the form of a double bridge. The arrangement may be directly used in reverse sense as demodulator.

I claim:

1. In a modulation system, a plurality of pairs of rectifiers each having like electrodes including a cathode, a connection between the cathodes of all of said rectifiers, a source of wave energy, symmetrical means for impressing wave energy from said source in phase opposition between corresponding electrodes in each pair of said pairs of rectifiers, a second source of wave energy, symmetrical circuit means for impressing wave energy from said second source in phase to corresponding electrodes in each pair of said pairs of rectifiers, a source of direct current potential connected at one terminal to said cathodes and at the other terminal to said last named circuit means for impressing operating potentials between each of said cathodes and said last named corresponding electrodes, and a load circuit coupled to corresponding electrodes in each of said rectifiers.

2. In a modulation system, a plurality of pairs of electron discharge devices each having an anode, a cathode, and a control grid, means tying the cathodes of said discharge devices together, a source of wave energy of a first frequency, a source of wave energy of a second frequency, symmetrical circuits for impressing energy from said source of energy of said first frequency in phase opposition between the anode electrodes in each pair of said pairs of said electron discharge devices, a source of direct current potential connecting a point of symmetry on said last named means to the cathodes of said tubes, symmetrical means for impressing wave energy from said source of wave energy of said second frequency in phase on the control grid electrodes in each pair of said pairs of electron discharge devices, a source of potential connecting a point of symmetry on said last named means to the cathodes of said tubes, and a load circuit symmetrically coupled to the anodes of each pair of said pairs of tubes.

3. A system as recited in claim 1 wherein a second source of potential has its positive terminal connected to a point of symmetry on said

first named symmetrical means and its negative terminal connected to the cathodes of said tubes.

4. In a modulation system, a plurality of pairs of diode rectifiers each having an anode and a cathode, means connecting the cathodes of said diode rectifiers together, a source of wave energy of a first frequency, a source of wave energy of second frequency, symmetrical transformer means connecting said source of wave energy of said first frequency in phase opposition between the anodes of each pair of said diode rectifiers, said connections each including a secondary winding of a transformer having a primary winding coupled to said source of wave energy of said second frequency, a load circuit comprising a transformer having primary windings included in each of said last named couplings, and a secondary winding connected with a load, transformer means for impressing wave energy from said source of wave energy of said first frequency on the anodes of said rectifier, said transformer means comprising secondary windings connected between points of symmetry on said first named secondary windings and coupled to a primary winding connected with said source of wave energy of said first frequency, and a source of potential connecting the cathodes of said tubes to a point of symmetry on said last named circuit.

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