July 27, 1937. E. SCHULZE-HERRINGEN 2,088,059

ARRANGEMENT FOR MODULATING THE AMPLITUDE OF ELECTRIC WAVES

Filed Aug. 23, 1935 4 Sheets-Sheet 1

Fig. 1a

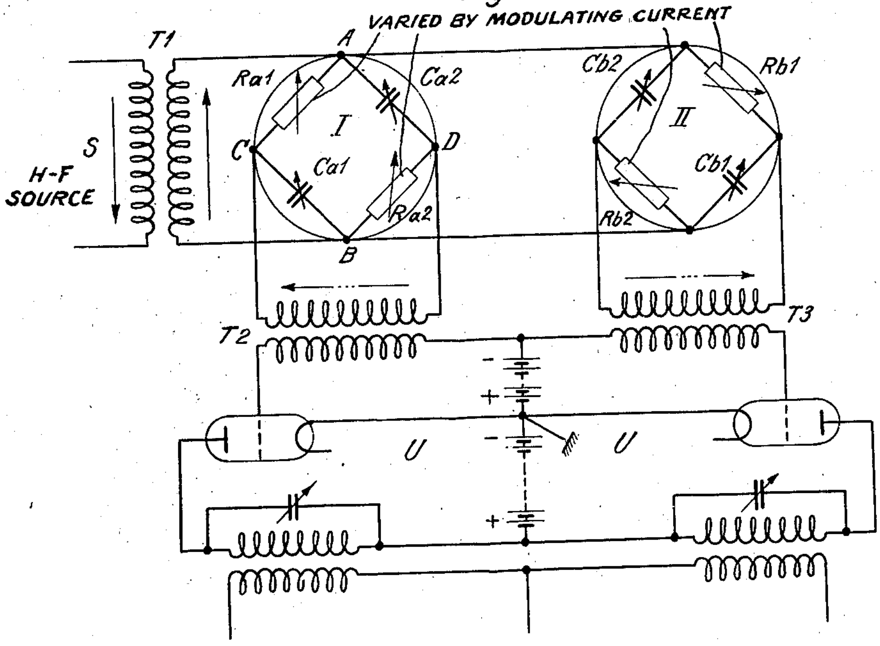
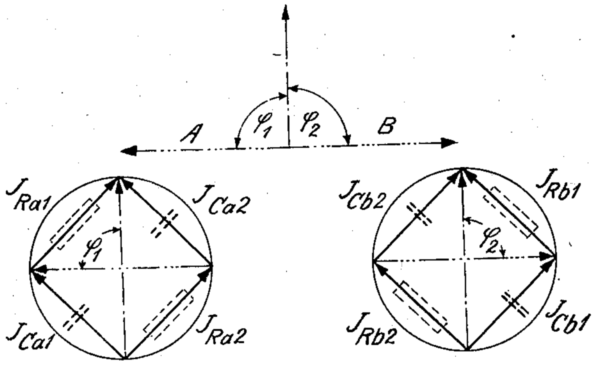


Fig. 1b



Inventor:
Erich Schulze-Herringen
by R. C. Hopgood
Attorney

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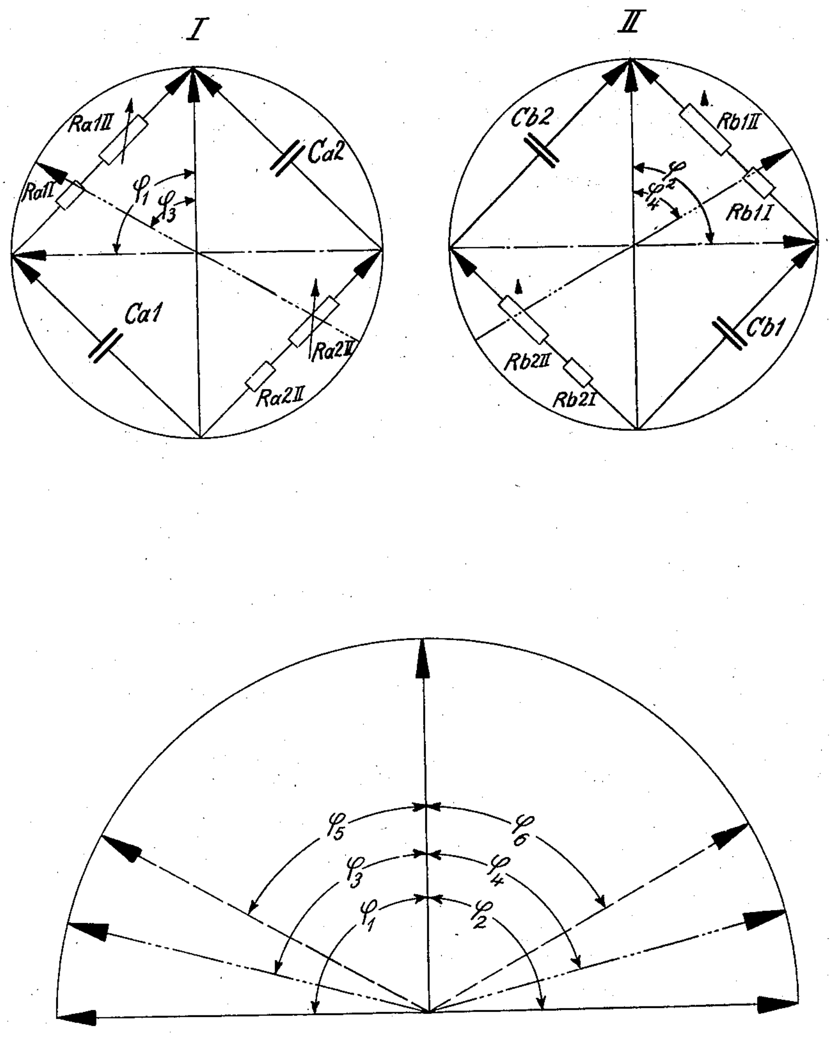
Fig.2



Inventor:
Erich Schulze-Herringen
by R. C. Hopgood
Attorney

ARRANGEMENT FOR MODULATING THE AMPLITUDE OF ELECTRIC WAVES

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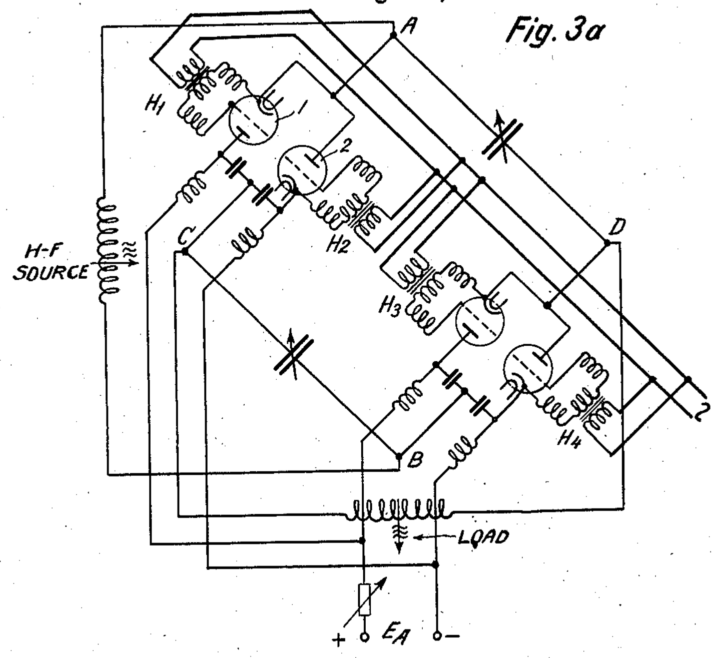

Fig. 3a

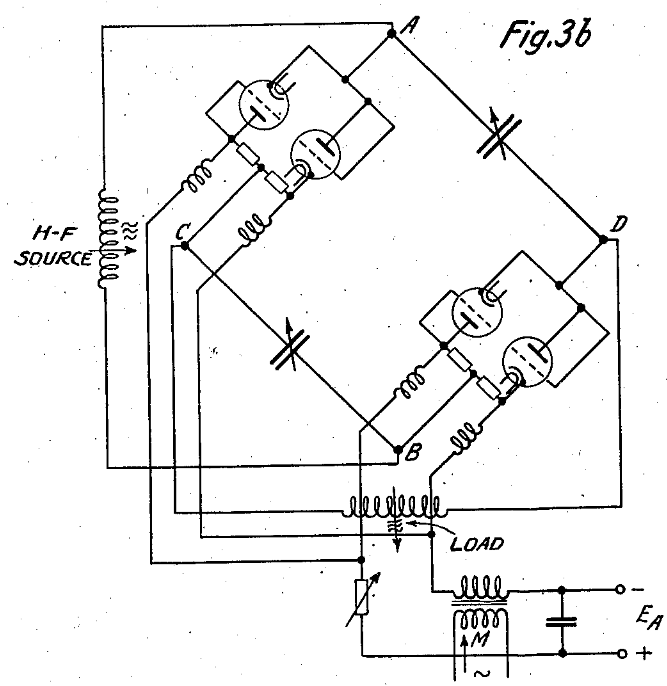

Fig. 3b

Inventor:
Erich Schulze-Herringen
by R. C. Hopgood
Attorney

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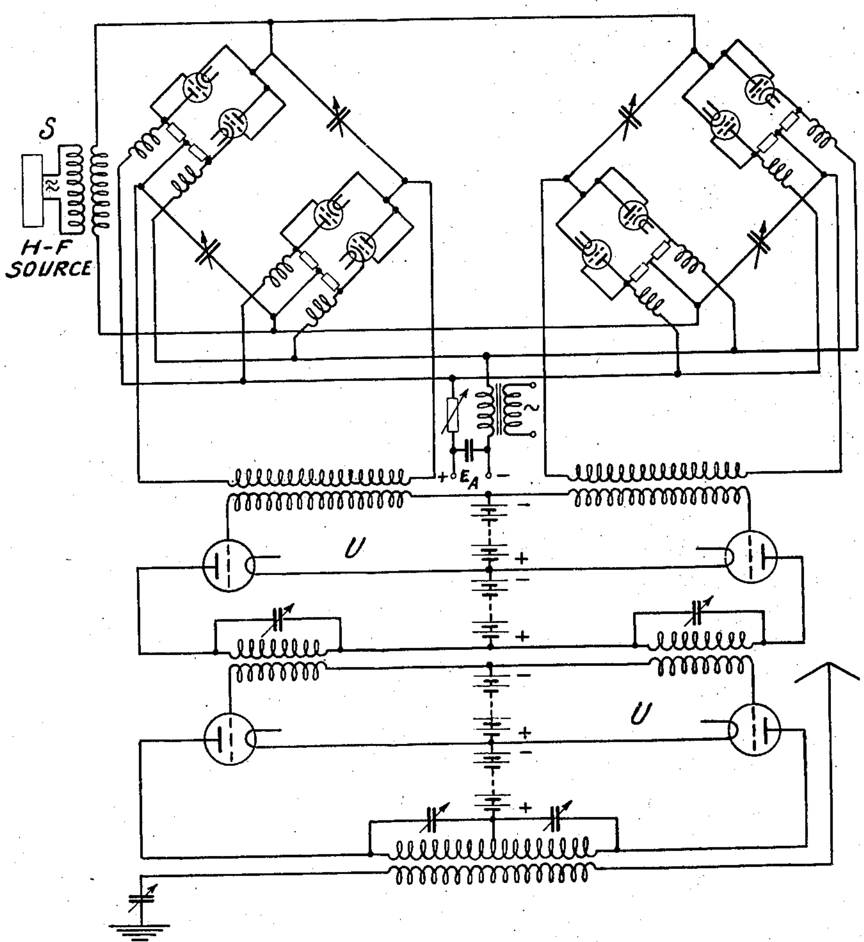
Fig. 4



Inventor:
Erich Schulze-Herringen
by R. C. Hopgood
Attorney.

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UNITED STATES PATENT OFFICE

2,088,059

ARRANGEMENT FOR MODULATING THE AMPLITUDE OF ELECTRIC WAVES

Erich Schulze-Herringen, Berlin-Tempelhof, Germany, assignor to C. Lorenz Aktiengesellschaft, Berlin-Tempelhof, Germany

Application August 23, 1935, Serial No. 37,446
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7 Claims. (Cl. 179—171)

In order to modulate the amplitude of high frequency oscillations the carrier proper may in a well-known manner be composed of two vectors whose quantity and phase vary in dependency upon the modulation frequencies.

For effecting such a modulation the carrier frequency is in accordance with the invention led to the one diagonals of two bridges which are formed of ohmic resistances and capacitive resistances, i. e. so-called capacitances, and to whose other diagonals circuits are connected that act on a push-pull arrangement, the ohmic resistances of the bridges being varied in the rhythm of the modulation.

The invention is described hereafter by way of example, reference being had to the accompanying drawings in which—

Fig. 1*a* represents a circuit arrangement showing the principle of the invention, Fig. 1*b* is a diagram relating to the operation of this arrangement, Fig. 2 shows three diagrams which likewise refer to the operation thereof, Fig. 3*a* diagrammatically represents a modification of the arrangement illustrated in Fig. 1*a*, Fig. 3*b* is a diagrammatic representation of a modification of the arrangement shown in Fig. 3*a*, Fig. 4 diagrammatically illustrates a transmitter embodying features of the invention.

The carrier frequency arriving from the control transmitter S is led to a high frequency transformer T1, after having eventually been amplified sufficiently. In the secondary circuit of T1 two bridge arrangements I, II are included over the diagonals A, B. Each of these bridges comprises two ohmic resistances Ra1, Ra2 or Rb1, Rb2 and two condensers Ca1, Ca2 or Cb1, Cb2. Connected to those diagonals, C,D of these bridges not fed from T1 are high frequency transformers T2, T3 which serve to feed a push-pull arrangement U. By dimensioning the resistances and capacities properly the arriving high frequency vector is turned by 90°, as will be seen from Fig. 1*b*. This is the case if

$$Ra1=\frac{1}{\omega Ca1}=Ra2=\frac{1}{\omega Ca2}=Rb1=\frac{1}{\omega Cb1}=Rb2=\frac{1}{\omega Cb2}$$

The bridges I and II commonly connected to the transformer T1 on the secondary side are of such resistance and capacity values that the derived tensions at one bridge are shifted by +90° and at the other bridge by −90° over the primary tension. In the push-pull connection there results a tension shifted by 180° the resultant of which is zero as shown in the present case. Fig. 1*b* is showing corresponding diagrams for the bridges. The arrow A represents the secondary voltage at the bridge I, the arrow B the secondary voltage at bridge II, whereas the arrow directed vertically towards the top represents the voltage applied thereto. The angles $\varphi 1$ and $\varphi 2$ result from the current diagrams shown for both bridges. The resistances and condensers shown in Fig. 1*a* are marked by dotted lines and the designations for the current vectors correspond with the designations applied to the resistances and condensers in Fig. 1*a*.

The modulation is effected by changing the resistances Ra1, Ra2, Rb1, Rb2 from the fixed value $Ra1I=Ra2I=Rb1I=Rb2I$ to a higher value.

When using an infinite resistance the phase angle would become zero, which does not happen in practice. Fig. 2 is showing the current diagrams for both bridges in which the individual resistances and condensers are drawn in for a better characterization, bearing the same designations as those shown in Fig. 1*a*. The resistances Ra1, . . . are represented relatively by two resistances, namely, by a stationary resistance RaII and a variable resistance Ra1II according to the above statements. By changing these variable resistances also the position of the vector determining the angle φ may be changed. In the diagram further shown in Fig. 2 it is denoted how the phase angle becomes smaller when the resistance is increasing. The angles $\varphi 1$, $\varphi 3$, $\varphi 5$ result from an increase of the resistances Ra1 and Ra2. The angles $\varphi 2$, $\varphi 4$ and $\varphi 6$ correspond with the enlargement of the resistances Rb1 and Rb2. From the position of two vectors belonging together, for instance of those formed by angles $\varphi 3$ and $\varphi 4$, there results the size of the resultant vector combined of them. The vector shown in the middle as to its size corresponds approximately with the single vectors corresponding to $\varphi 5$ and $\varphi 6$. When using $\varphi 3=\varphi 4$ and $\varphi 5=6<90°$ respectively the resultant is no longer zero but determines the value of the carrier frequency required for amplitude modulation.

The resistance variation in the rhythm of the modulation amplitudes is according to a further feature of the invention effected by means of electronic tubes. The principal arrangement of the bridges is shown in Figs. 3*a*, 3*b*, whilst Fig. 4 represents a complete transmitter inclusive of the bridge arrangements.

According to Fig. 3*a* the ohmic resistances of the bridge are replaced by the inner resistances of the valves. In order to change the inner resistance of the valves in case of modulation, the modulation frequency is led to the centres of the valves over the low frequency transformers H1 . . . H4. The high frequency is kept away from the transformers by means of connecting thereto high frequency chokes.

In order to compensate the rectification effect of the tubes, each resistance consists of two tubes which are grid-controlled and whose anodes and cathodes are connected in the manner shown, the anode of each tube being in connection with the cathode of the other tube, viz. connected to the same point. When using only one valve in a bridge branch, the resistance of the valves would change in the rhythm of the applied high frequency whereby the phase of the high frequency itself would be changed continuously. By the fact that a cathode and an anode of the valves are connected with each other they are parallel for the high frequency and their resistance is constant with respect to the high frequency. For the voice frequency however the valves are connected in series. On modulation the working point of each valve is shifted in the rhythm of modulation. The low frequent modulation is supplied over auxiliary low frequency transformers H1, H2, H3, H4. The primaries of H1, H2, H3, H4 are connected in parallel and in such a manner that on the one hand all the grids and on the other hand all the cathodes are connected to the same side. Instead of the grid-controlled tubes diodes may be arranged which are given the required anode biases.

The arrangement according to Fig. 3*b* differs from the example shown in Fig. 3*a* in this that in the case of Fig. 3*b* diodes are employed and that the low frequency is supplied at the anodes. According to Fig. 3*a* the control of the inner resistance of the valve has been effected by the grid through the use of transformers. But also the inner resistance of the valves may be changed by varying the anode direct voltage in the rhythm of modulation. Such a connection is shown in Fig. 3*b*. The anode direct voltage E_A is varied over the low frequency transformer M in the rhythm of modulation. By special chokes connected to the valves the high frequency is retained and is prevented from flowing off over the direct current source as well as the two bridge branches are prevented from influencing each other. The variable resistance disposed in the + line is adapted to serve for the adjustment of the exact working point. In these two figures the inductance connected across diagonals C—D, which may be the primary of a transformer, is for supplying energy to a load circuit. The circuit elements are evident from the drawings.

The arrangement may be adjusted for a predetermined at rest value of the carrier with the aid of the at rest current of the tubes of the bridge arms, this being effected by varying the continuous anode voltage, but may be adjusted also by means of the capacities disposed in the bridge arms.

Should the amplitude of the phase-controlled vector not remain constant or a change corresponding to predetermined laws be desired, then a variation of the amplitudes may be attained by varying one of the resistances of the bridge arms not to the same extent as the other or in the limiting case by keeping it constant.

Figs. 1*b* and 2 are showing arrangements in which the resistances are equally varied in the two bridge branches. If for instance one resistance is left constant whereas the other one is varied, there are not only changed the phases of the derived voltage over the applied voltage, but there occurs also an amplitude variation.

In the transmitter arrangement shown in Fig. 4 the carrier frequency of the control transmitter S is led to bridge arrangement of the kind represented in Fig. 3*b*. To these a push-pull arrangement U is connected.

What is claimed is:

1. In an arrangement for modulating the amplitudes of electric waves, the combination of a high frequency source with two bridge arrangements, each comprising oppositely disposed ohmic resistances and oppositely disposed capacitances, means connecting said high frequency source to a diagonal of each of these bridges, a plurality of electronic tubes connected in push-pull relation, means interconnecting the input of the push-pull tube arrangement with the other diagonals of said bridges; and means for varying said ohmic resistances in the rhythm of the modulation amplitudes.

2. An arrangement according to claim 1, wherein the said ohmic resistances are constituted by electronic tubes controlled by said modulation.

3. An arrangement according to claim 1 wherein each of said ohmic resistances comprises two electronic tubes and means for connecting the anode of each tube with the cathode of the other tube.

4. An arrangement according to claim 1 wherein each of said ohmic resistances comprises two electronic tubes, means for connecting the anode of each tube with the cathode of the other tube and common voltage sources for feeding said tubes.

5. An arrangement according to claim 1 wherein means is provided for varying said ohmic resistances dissimilarly in order to produce amplitude variations following a predetermined law.

6. An arrangement in accordance with claim 1 wherein means is provided to regulate the continuous anode voltage in order to adjust the rest value of the carrier.

7. An arrangement in accordance with claim 1 wherein said capacitances are variable so that by regulation thereof the at rest value of the carrier may be adjusted.

ERICH SCHULZE-HERRINGEN.