Dec. 20, 1938. R. SCHIENEMANN 2,140,769

AMPLITUDE AND PHASE MODULATION

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Fig. 1

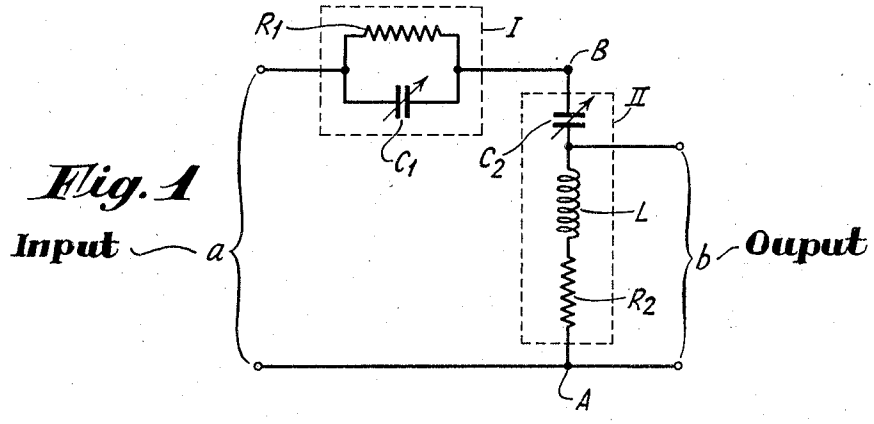


Fig. 2

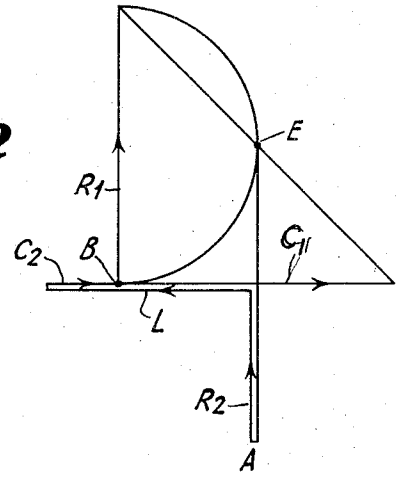
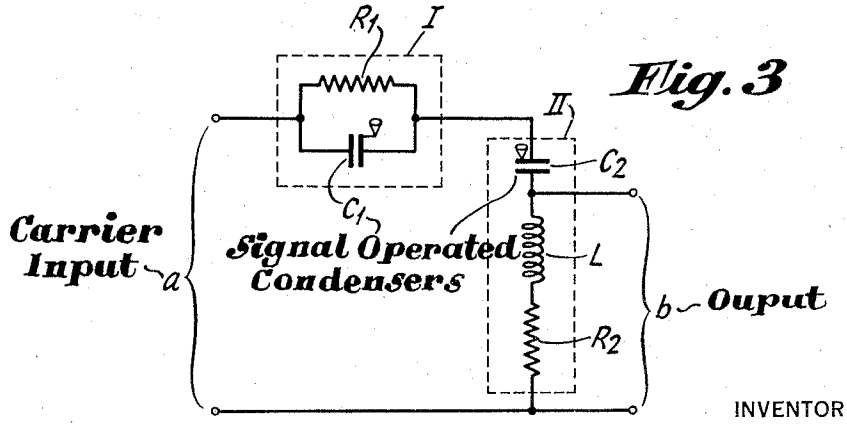


Fig. 3



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AMPLITUDE AND PHASE MODULATION

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4 Claims. (Cl. 179—171)

For various purposes, for instance for certain types of modulation arrangements, it is necessary that the amplitude and phase of a high frequency voltage can be set.

According to the invention in order to facilitate handling, the arrangement shall be such that at fixed input voltage, the amplitude and phase of the output voltage can be set almost independently of each other. This end shall be arrived at by displacing only one respective condenser of two impedance networks.

A mode of embodiment of the invention will be elucidated in the following and reference will be made to Figures 1, 2, and 3 of the drawing.

In the drawing, Figure 1 illustrates a circuit arrangement whereby amplitude or phase changes may be produced in wave energy; Figure 2 is a graph illustrating the mode of operation of the circuit of Figure 1; while Figure 3 illustrates the circuit when used to amplitude modulate and/or phase modulate wave energy by a signal or by two signals if multiplexing is desired.

In Figure 1 the apparent impedance I contains an ohmic resistor R_1 as well as in parallel thereto a variable condenser C_1. The apparent impedance II consists of an ohmic resistor R_2, a choke coil L in series therewith, as well as a condenser C_2 likewise in series. The given constant high frequency voltage is applied to the terminals *a* and the controlled voltage is derived at the terminals *b*.

In order to indicate that at proper dimensioning of the circuit elements a separate adjustment of amplitude and phase is possible in Figure 1, there is shown the voltage diagram of the arrangement, in Figure 2. The functioning will best be understood when starting at the apparent impedance II. The ohmic resistor R_2, the choke coil L and the condenser C_2 are passed by the same current. The voltage drops appearing on the one hand at the resistor, and on the other hand, at the choke and condenser, and which are designated in the diagram by R_2, L and C_2, thus are perpendicular to each other. At the end point B of the vector C_2 a voltage vector is now to be drawn which corresponds to the voltage drop at the parallel connection R_1, C_1. This voltage vector is obtained graphically in the known manner simply by drawing the vectors R_1 and C_1 at the end point of the vector C_2, then by drawing a half circle with the diameter R_1 and by connecting the two end points of R_1 and C_1 with each other. The intersection point E of this connection line with the half circle then represents the end point of the vector which indicates the voltage drop at the parallel connection R_1 C_1. The connection line between the starting point A of R_2 and the said intersection point E then represents the input voltage at the terminals *a*. With the values, assumed in the drawing

$$\left(R_1=\frac{1}{\omega C_1} \text{ and } \omega L=\frac{1}{\omega C_2}=\frac{1}{2}R_1\right)$$

of R_1, C_1 and R_2 and C_2 as well as L the amplitude and phase of the voltage appearing at the terminals *b* can be separately adjusted to within certain limits, namely the amplitude by varying C_1 and the phase through variation of C_2. When varying the value of C_2 the vector R_1 moves in a direction perpendicular (i. e., parallel) to itself, and the vector C_1 moves in its longitudinal direction, whereby both vectors maintain their values. Also the intersection point E on the half circle drawn over R_1 moves in the horizontal without thereby varying its position on the half circle. At a constant value and direction of R_2 the input voltage AE thus changes its direction but maintains its value. This signifies likewise, that the direction of R_2 can be varied when the input voltage is fixed as regards direction and value, without the value of R_2 being varied. When varying the value of the condenser C_1 the intersection point E in Figure 2 moves along the half circle, i. e., the value of the input voltage varies while maintaining a fixed direction. But this signifies at the same time that at a constant value of the input voltage, the scale of the voltage diagram varies accordingly or which is equivalent, the value of each individual voltage vector changes accordingly. Therefore, when varying C_1 the vectors R_2 and L are subjected to a variation in value, but they are not subjected to phase variation within certain limits, since the input voltage forms a tangent at the half circle drawn over R_1.

The circuit shown in Figure 3 is similar to that shown in Figure 1. The distinction between the two figures lies in the signal operated condensers C_1 and C_2. As shown in this figure these condensers are intended to be varied by signal frequencies. This may conveniently be done by using these condensers as condenser microphones.

The variations in amplitude and phase attainable with the circuit shown, are sufficiently large in order to satisfy practical requirements, which may reside for instance in balancing the voltages supplied by the two halves of the secondary winding of a high frequency transformer which may be unequal due to unsymmetries of the winding.

I claim:

1. In a system for varying the phase or ampli-

tude or both of wave energy at signal frequency, a network including parallel resistance and capacity, a second network comprising series capacity and inductance connected in series with said first named network, means for applying wave energy to the free terminals of said networks, means for deriving wave energy from said series circuit, and means for varying the first of said capacities at signal frequency to produce amplitude modulation of said wave energy means for varying the second of said capacities at signal frequency to produce phase modulation of said wave both of said capacities being simultaneously variable to produce phase and amplitude modulation of said wave energy.

2. In a system for varying the amplitude of wave energy at signal frequency, a network including parallel resistance and capacity, a second network comprising series capacity and inductance connected in series with said first named network, means for applying wave energy to the free terminals of said networks, means for deriving wave energy from said series network and means for varying the first of said capacities at signal frequency to produce amplitude modulation of said wave energy.

3. In a system for varying the phase of wave energy at signal frequency, a network including parallel resistance and capacity, a second network comprising series capacity and inductance connected in series with said first named network, means for applying wave energy to the free terminals of said networks, means for deriving wave energy from said series network and means for varying said series capacity at signal frequency to produce phase modulation of said wave energy.

4. In a system for varying the phase or amplitude, or both, of wave energy at signal frequency, an impedance network including a variable condenser, a second impedance network also including a variable condenser and connected in series with said first named network, means for applying wave energy to the free terminals of said networks, means for deriving wave energy from said second network and means for varying the first of said condensers at signal frequency to produce amplitude modulation of said wave energy, means for varying the condenser in said second network at signal frequency to produce phase modulation of said wave, both of said condensers being simultaneously variable to produce simultaneous phase and amplitude modulation of said wave energy.

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