May 15, 1934. J. PLEBANSKI 1,958,954

HIGH FREQUENCY TRANSMISSION

Filed July 9, 1930 2 Sheets-Sheet 1

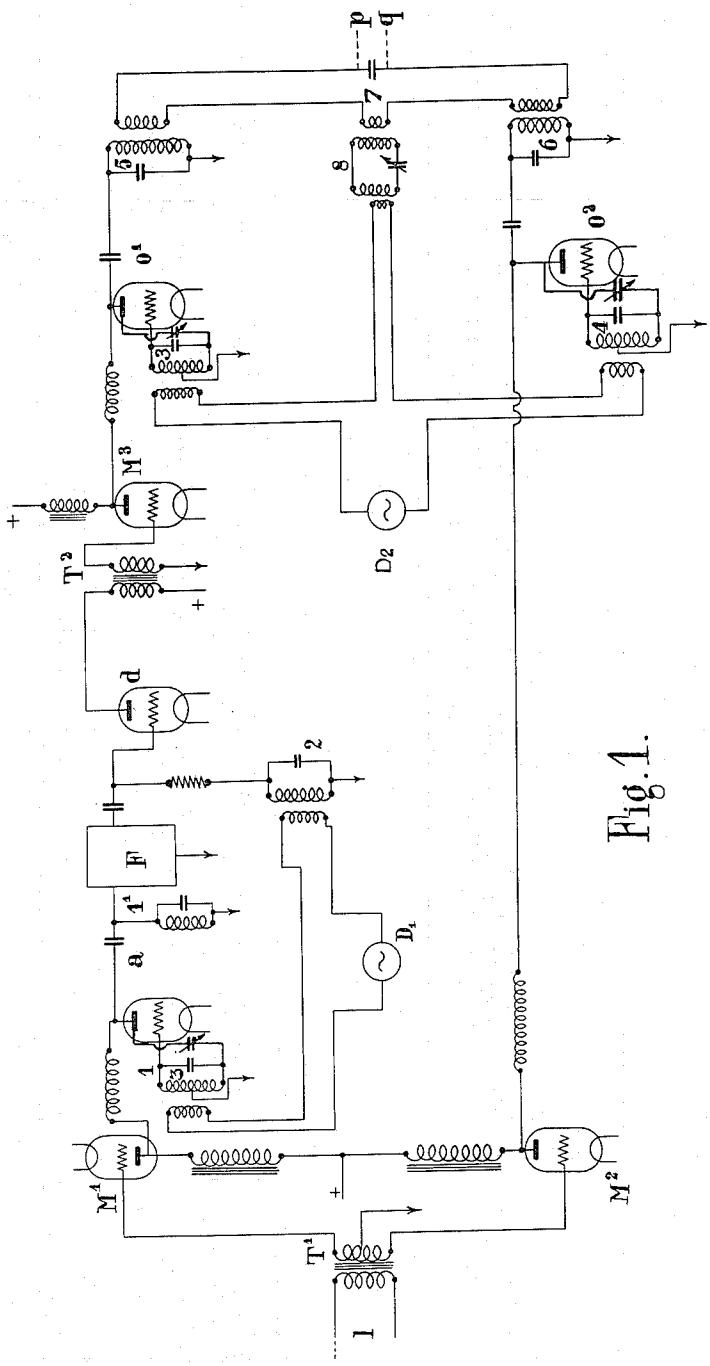


Fig. 1.

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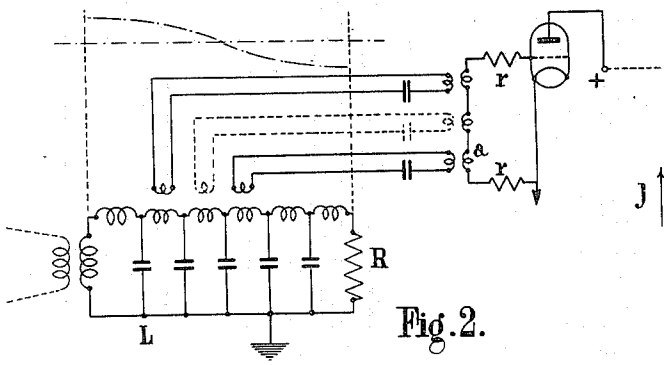


Fig.2.

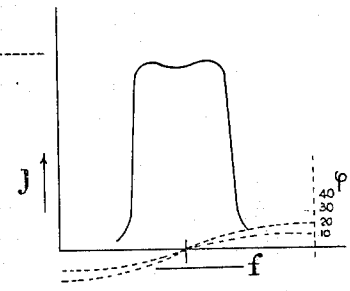


Fig.3.

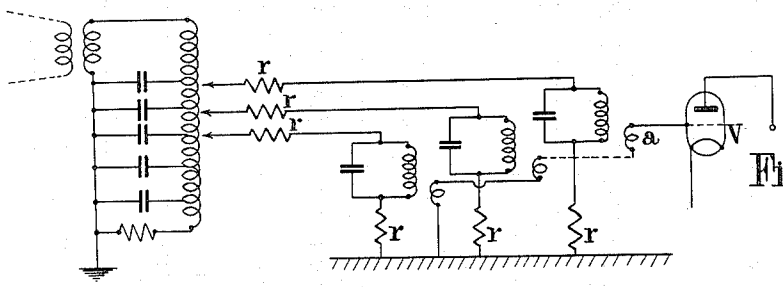


Fig.4.

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UNITED STATES PATENT OFFICE

1,958,954

HIGH FREQUENCY TRANSMISSION

Jozef Plebanski, Warsaw, Poland

Application July 9, 1930, Serial No. 466,841
In Poland July 10, 1929

2 Claims. (Cl. 179—171)

It is known that in telephony or telegraphy over wires or without wires with high-frequency currents the modulation effects an alteration in the amplitude of carrier wave, which is equivalent to originating three waves according to the figure, in the case of modulation with one audio frequency.

$$e = A \sin \omega t + B \sin \omega t . \sin pt$$

$$= A \sin \omega t + \frac{B}{2} \cos (\omega - p)t - \frac{B}{2} \cos (\omega + p)t$$

As the speech or other sounds are composed of a number of different audio frequencies, it follows that a modulated wave is composed of a non-modulated carrier of frequency

$$\frac{\omega}{2\pi},$$

a right side band of frequencies ranging from

$$\frac{\omega}{2\pi} + 30$$

to

$$\frac{\omega}{2\pi} + 10000$$

cycles per second, and a left side band of frequencies ranging from

$$\frac{\omega}{2\pi} - 30$$

to

$$\frac{\omega}{2\pi} - 10000$$

cycles per second.

As is known, only one side band, for instance the left side band, is necessary for reception. In such a system the entire frequency band radiated will be not 20000 cycles but only half of that, that is, 10000 cycles. By using one side band with the carrier it is possible, in a frequency range from 200 to 2000 metres, to utilize far more broadcasting stations than under existing circumstances utilizing both side bands.

Systems of one side band modulation with carrier elimination are known and utilized in practical work. They have however various disadvantages which are obviated in this invention.

The invention is diagrammatically illustrated by way of example in the accompanying drawings, in which

Figure 1 is a circuit diagram of a transmitting station,

Figure 2 a circuit diagram of a filter circuit or artificial line,

Figure 3 shows a valve frequency characteristic,

Fig. 4 is a circuit diagram showing a tuned circuit coupled to an artificial line.

The basic idea of the arrangement described is the utilizing of an intermediate independent drive system D_1 acting through or without an amplifier on two circuits 1 and 2 detuned in relation to one another, so that the currents induced in valves a and d are phase-shifted relatively to one another. Instead of circuits a and d any arrangement producing relative phase-shifting can be used.

Now if we modulate the oscillations in the valve a by audio frequencies from a line l through a transformer T_1 and a modulating valve M_1, then in the circuit 1' we shall have an ordinary modulated wave. If the modulated wave is now passed through a filter F, which cuts out one modulated side band and adds through a circuit 2 some phase of the carrier wave from the drive D_1, after demodulation by the valve d we shall obtain in the transformer T_2 the same audio frequencies as in T_1, but phase-shifted, because

$$i_d = a_2 \left[A \sin (\omega t + \phi) + \frac{B}{2} \cos (\omega - p)t \right]^2$$

$$= a_2 \cdot \frac{AB}{2} \sin (pt + \phi) + \cdots$$

This arrangement for the phase-shifting of audio frequencies is exactly described in my Patent No. 1,858,936. The phase shift can always be so adjusted as to be equal to 90°.

It is obvious that for telephonic transmission it is important to have the relative phase shift of all frequencies equal to 90°. Therefore the filter F must have such a characteristic that all frequencies of the one side band passed will have the same or about the same phase. Otherwise, after detection in the transformer T_2, the audio frequencies will not all be phase shifted at 90° to original frequencies in T_1. In my opinion the most suitable arrangement for this purpose will be the filters described in my British specification No. 211,151.

By now modulating, through modulating valves M_3 and M_2, the valves O_1 and O_2 fed from the driver D_2, but with a relative phase shift of 90° owing to the circuits 3 and 4 or other arrangements in the circuit 7, for instance by increasing the capacitative reactance of one of these grid circuits and increasing the inductive reactance of the other, and thereby de-tuning the valve O_1 to a shorter wave and the valve O_2 to a longer wave,

the difference or sum of current of the circuits 5 and 6, is obtained. In circuit 5,

$$e_5 = A \sin \omega t + B \sin pt \sin \omega t$$

$$= A \sin \omega t + \frac{B}{2} \cos (\omega - p)t - \frac{B}{2} \cos (\omega + p)t$$

Circuit 6,

$$e_6 = A \cos \omega t + B \cos pt \cos \omega t$$

$$= A \cos \omega t + \frac{B}{2} \cos (\omega - p)t + \frac{B}{2} \cos (\omega + p)t$$

In the circuit 7 we will get:

$$e_7 = A.\sqrt{2} \sin (\omega t + 45°) + B \cos (\omega - p)t$$

or

$$A.\sqrt{2} \sin (\omega t - 45°) - B \cos (\omega + p)t$$

In this case the modulation could be possible not deep by reason of the elimination of one side band, therefore we can diminish the carrier wave by the addition of a suitable phase of the carrier from D_2 through the arrangement 8, which may be made either with an amplifier (valve), as in the scheme O_1, or without.

Finally, by adjusting a reverse phase through the arrangement 8 we can eliminate the carrier.

The one side band modulated output obtained at the points p and q may be amplified and utilized in any manner.

As pointed out above, the most important feature in the arrangement described is a filter circuit which will allow some frequency band to pass with substantially the same phase displacement.

For this purpose the most suitable arrangement should be the filter shown in Fig. 2, which should be substituted for the circuit 1′ and F in Figure 1.

It is known that in an artificial line L (Fig. 2) the resistance R can always be so chosen that no reflected wave can be present in the system. In this case different phases can be obtained in different parts of the line.

By coupling a number of tuned circuits to such an artificial line as shown in Fig. 4 at different points in this line a frequency characteristic like that shown in Fig. 3 can be obtained in the valve V with small phase differences.

The above circuits can be so tuned that for some frequency band the phases will be the same.

In Figs. 2 and 4 are shown circuits not coupled to one another. The letter r signifies resistances which can be varied for the adjustment of suitable electro-motive forces in the different circuits. The above-mentioned circuits may act on an aperiodic circuit connected to the grid of a valve.

What I claim is:—

1. A high-frequency radio transmitter for the transmission of one side band, comprising a source of audio-frequency oscillations, a first modulator of the unbalanced type adapted to modulate a first carrier wave by means of audio-frequency oscillations from the said source, a filter adapted to pass one side band of the wave modulated by the first modulator, means for adding a phase-shifted carrier wave to the filtered wave, means for so demodulating the resulting wave that after demodulation modulating frequencies appear, but phase-shifted, two second modulators, in which two phases of a second carrier, differing in phase from one another by ninety degrees, are modulated by modulating frequencies also differing in phase from one another by ninety degrees, one of the said second modulators receiving its modulating frequency directly from the same source as the first modulator, and the other second modulator receiving a phase-shifted modulating frequency from the demodulating means, and a differential output circuit for utilizing the waves modulated by the two second modulators.

2. A high-frequency radio transmitter as claimed in claim 1, further comprising means for adding some phase and amplitude of the second carrier to the final product in the differential output circuit.

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