CARRIER WAVE TRANSMISSION SYSTEM

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Fig. 1.

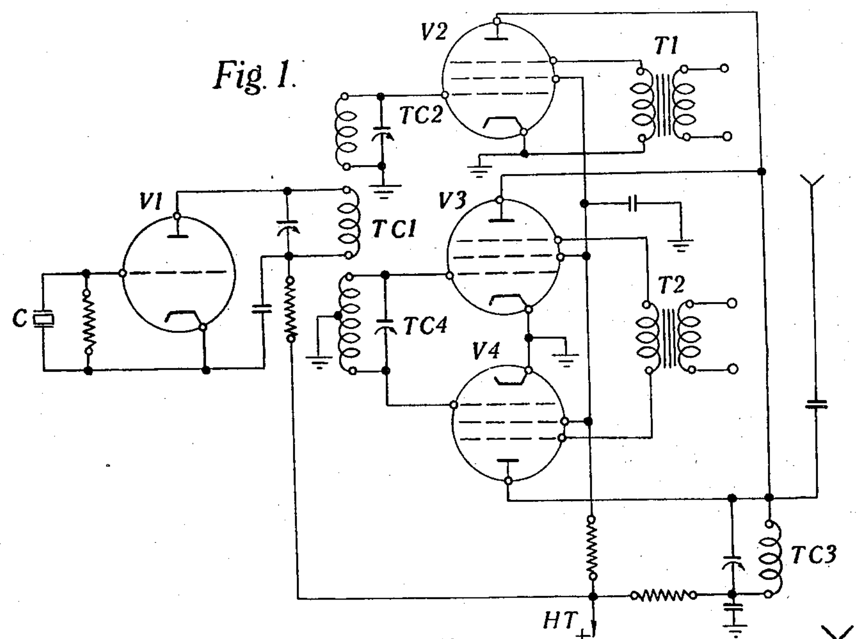
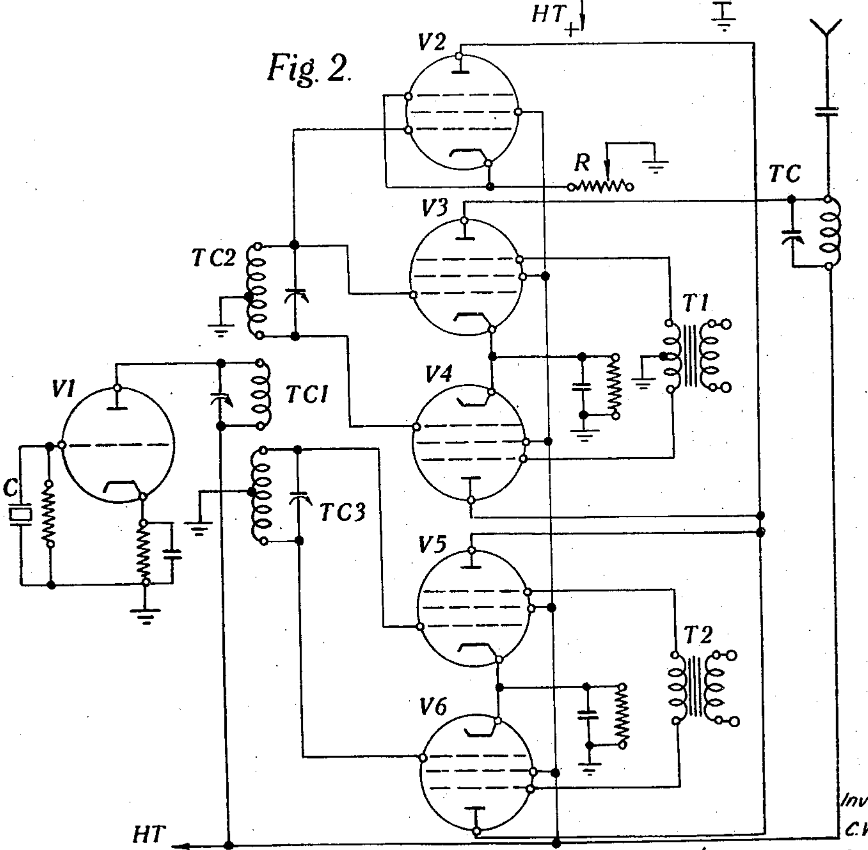


Fig. 2.



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CARRIER WAVE TRANSMISSION SYSTEM

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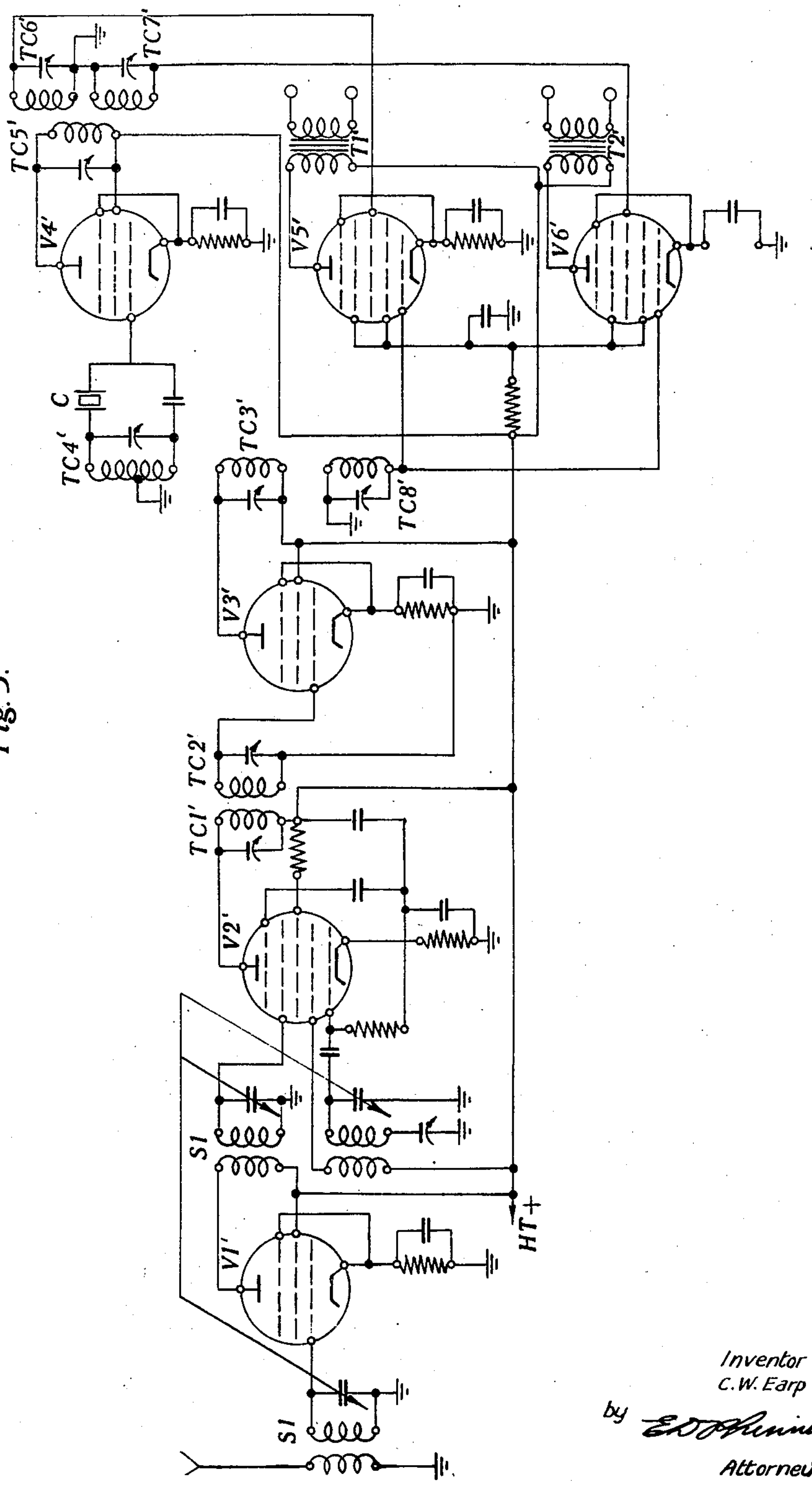

Fig. 3.

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CARRIER WAVE TRANSMISSION SYSTEM

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3 Claims. (Cl. 250—9)

This invention relates to carrier wave transmission systems.

According to the invention two carrier waves of the same frequency but of phase differing by about 90° are modulated by different signal waves to provide two communication channels. Two pairs of sidebands are transmitted, one pair being derived by modulation of a carrier frequency and the other pair being derived by modulation of the same carrier frequency dephased by 90° the signals being obtained at the receiver from either or both pairs of sidebands by demodulation with a suitably-phased wave of carrier frequency.

The system of the invention permits two completely separate communication channels to be transmitted on a single carrier frequency with no greater bandwidth than for a normal double-sideband transmission.

Theoretically, there should be no cross-talk (interchannel modulation) between the two channels, but in practice, slight cross-talk will arise, due to imperfections in the transmitter, receiver or radio path. It is therefore proposed according to a further feature of the invention to utilise the system above outlined in special cases where the two channels to be transmitted are very similar.

The most important application is in the binaural transmission of radio telephony. The system may also be used for stereoscopic television, or two-colour television. In all the above cases, the presence of slight cross-talk between the two channels would be immaterial.

Several important advantages result from the use of the system as will become apparent hereafter, the transmitter required by the invention need not be unduly complicated and one balanced modulator only need be added to an existing circuit; further, the new type of receiver could be produced cheaply while existing receivers would continue to give the same results as formerly, when used in the new system. No extra bandwidth is required and with the new system once established, steps could be taken to suppress the carrier wave.

The theoretical considerations underlying the present invention will be understood from the following explanation referring to the transmission of two signal waves corresponding to binaural sound waves resulting from speech.

Let the speech wave No. 1 be $f_1(t)$, and the speech wave No. 2 be $f_2(t)$.

Using a carrier frequency of

$$\frac{w}{2\pi}$$

which has the form (E sin wt), the speech waveform $f_1(t)$ produces (in a balanced modulator) sidebands which will be represented by $E \sin wtf_1(t)$. Similarly, if a carrier of the same frequency

$$\frac{w}{2\pi}$$

but dephased by 90° so that it has the form (E cos wt) be combined with channel No. 2, in a balanced modulator, the output is: $E \cos wtf_2(t)$. The total transmission then is: $E \sin wtf_1(t) + E \cos wtf_2(t)$ to which a "pilot" carrier-wave may be added, if desired. Upon demodulation with a carrier K sin wt (at the receiver), the output is:

$$K \sin wt(E \sin wtf_1(t) + E \cos wtf_2(t)$$
$$= KEf_1(t) \sin^2 wt + KEf_2(t) \sin wt \cos wt$$
$$= \frac{KE}{2} f_1(t)(1 - \cos 2wt) + \frac{KE}{2} f_2(t) \sin 2wt$$
$$= \frac{KE}{2} f_1(t) + \text{modulated radio-frequency terms.}$$

i. e., this output gives the speech wave No. 1. Similarly, demodulation with a carrier K cos wt, results in an output of

$$\frac{KE}{2} f_2(t)$$

which is the speech wave No. 2.

A system embodying the invention is illustrated in the accompanying drawings of which Figs. 1 and 2 are circuit diagrams of alternative radio transmitting arrangements and Fig. 3 is a circuit diagram of a radio receiver.

Referring to Fig. 1, C is a quartz crystal controlling the frequency of the valve oscillator V1, the output of which is tuned by the tuned circuit TC1. Coupled to this is a tuned circuit TC2 which supplies carrier waves to the modulator V2. Speech currents are applied to a transformer T1 which being coupled to the suppressor grid of modulator valve V2 causes modulation of the carrier-wave. The output appears in a tuned circuit TC3 and may be transferred to an aerial. So far this is a normal radio transmitter which may be used to transmit channel No. 1.

The tuned circuit TC4 also is coupled to TC1 from which it derives carrier frequency. TC4 is symmetrically connected to the balanced modulator composed of valves V3 and V4. Modulation is applied through transformer T2 and the output obtained is a pair of sidebands corresponding to the modulation (channel No. 2). The anode circuits of all three valves V2, V3 and V4 are connected in parallel, and the total signal fed to the aerial is composed of first the carrier wave from V2, secondly, the sidebands of channel No. 1 from V2 and thirdly, the sidebands of channel No. 2 from V3 and V4.

Now, in order that the two channels shall not be inextricably mixed the following tuning adjustment is necessary. The condenser of tuned circuit TC2 is adjusted to raise the natural frequency of TC2 above the condition of resonance until the phase of the carrier voltage applied to V2 has been rotated by about 45°. The condenser of tuned circuit TC4 is adjusted to lower the natural frequency of TC4 below the condition of resonance until the phase of the carrier voltage applied to V3 has been rotated by about 45°.

Accurate relative adjustment of the two condensers will provide a condition in which the carrier phase on the grid of valve V2 is exactly 90° displaced from that of the grid of valve V3. The carrier phase on the grid of valve V4 differs from that on grid of valve V3 by 180°.

Referring further to Fig. 1, if the carrier input to V2 is represented by E sin wt, the input to V3 is: $E \sin (wt+90°) = E \cos wt$, the input to V4 is: $-E \cos wt$.

If the input T1 is: $f_1(t)$ and the input T2 is: $f^2(t)$ the output from V2 is: $E \sin wt(1+f_1(t))$ and the output from V3 and V4 is: $E \cos wtf_2(t)$.

The total output for transmission is thus: $E \sin wt + E \sin wtf_1(t) + E \cos wtf_2(t)$.

Referring now to Fig. 2, which shows another transmitter, provision is made for an adjustable carrier level. Two balanced modulators (composed of valves V3, V4 and V5, V6) are used for the two channels, and the tuning of oscillatory circuits TC2 and TC3 is adjusted so that the carrier phase difference at the grids of V3 and V5 is 90°. Carrier is also applied to V2 which is unmodulated. By means of resistance R the bias of valve V2 can be controlled, and hence the amount of carrier passed through V2 to the aerial circuit. (When the bias of V2 is large the carrier wave would be completely suppressed.) Comparison of this circuit with Fig. 1 and the description of Fig. 1 will make the further features of the circuit clear.

The carrier input to V2, V3 is $e \sin wt$.
The carrier input to V4 is $-e \sin wt$.
The carrier input to V5 is $e \cos wt$.
The carrier input to V6 is $-e \cos wt$.

If the inputs to transformers T1, T2 are respectively $f_1(t)$ and $f_2(t)$ the total output is:

$$-RE \sin wt$$
$$+E \sin wtf_1(t)$$
$$+E \cos wtf_2(t)$$

the three terms representing respectively the outputs from V2, from V3, V4 and from V5, V6.

Fig. 3 shows one form of suitable receiver. Up to V3' the circuit is perfectly orthodox: V1' is a radio frequency amplifier, V2' is a frequency changer and V3' is an intermediate frequency amplifier, the tuned circuits TC1' and TC2' being tuned to the intermediate frequency.

A tuned circuit TC3' tunes the anode circuit of valve V3' and to this circuit are coupled two more tuned circuits, TC4' and TC8'. TC4' forms part of a "crystal gate" filter well-known in the art, in which, owing to the sharp fluctuations in impedance of crystal C' within a few cycles of its resonance frequency, the modulation is more or less completely removed from the carrier wave passed on to valve V4'.

The anode circuit of V4' is tuned by TC5' and to this circuit are coupled further circuits TC6' and TC7', which are connected to the modulating grids of demodulating valves V5' and V6', respectively. The condenser of TC6' is advanced beyond resonance, and that of TC7' reduced from resonance, until the carrier voltages across TC6' and TC7' differ by 90°.

Tuned circuit TC8' is coupled to TC3' and feeds the signal grids of both valves V5' and V6'. The tuning of TC8' and TC5' is so arranged that the carrier wave applied to the signal grids of V5' and V6' is exactly in phase with the carrier applied to the modulating grid of V5'. Detection of signals does not take place on the signal grids except by electron stream modulation applied to the third or modulating grids.

The audio frequency outputs from V5' and V6' through T1' and T2' correspond to the two different channels.

The signal passed to V1' is: $kE \sin wt + E(\sin wtf_1(t) + \cos wtf_2(t))$.

Assume that the frequency is changed in V2' to

$$\frac{a}{2\pi}$$

the signal passed to V3' is then:

$$kE \sin at + E(\sin atf_1(t) + \cos atf_2(t)).$$

This also represents the signal passed to the signal grids of V5' and V6'.

The carrier only is passed through V4', and after phasing in TC6' and TC7', the carrier applied to the third grid of V5' is: K sin at and that applied to the third grid of V6' is: K cos at. Then the output from T1' is:

$$(kE \sin at + E \sin atf_1(t) + E \cos atf_2(t))K \sin at$$
$$= kKE \sin^2 at + KE \sin^2 atf_1(t) + KE \sin at \cos atf_2(t)$$
$$= \frac{kKE}{2}(1-\cos 2at) + \frac{KEf_1}{2}(t)\ (1-\cos 2at) + \frac{KEf_2}{2}(t) \sin 2at$$

The only L. F. term of this is the speech wave or channel No. 1 represented by

$$\frac{KE}{2}f_1(t)$$

Similarly the output from T2' is proportional to $F_2(t)$ which is channel No. 2.

It is evident that both transmitter and receiver could take other forms. In particular, in the receiver, the separation of carrier for demodulation could be carried out in other ways, for example, the demodulating carrier could be supplied by an oscillator which is synchronised to the signal carrier: such a refinement would provide a demodulating carrier more completely free from modulation.

A most useful refinement to the receiver shown on Fig. 3, would be the addition of an automatic frequency control, so that there would be no tendency for the relative tuning of transmitter and receiver to drift. Such control could conveniently be achieved by using a crystal or other sharply selective filter in the manner described in British patent specification No. 457,485.

What is claimed is:

1. A transmitting system for transmitting two separate related signals on carrier waves of the same radio frequency, comprising a source of radio frequency energy, two modulators at least one of said modulators being a balanced modulator, means for applying carrier frequency from said source in phase quadrature to said modulators, means for applying said related signals to respective ones of said modulators to produce independent signal modulations, means for ap-

plying said modulations to a non-directional transmitting means, and means for applying carrier to said transmitting means in phase with one only of said modulations.

2. A transmitting system according to claim 1, wherein one of said modulators is of fthe unbalanced type, said last named means being said unbalanced modulator.

3. A transmitting system according to claim 1, wherein both said modulators are of the balanced type, said last named means comprising a coupling for independently applying said carrier to said transmitting means.

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