May 11, 1937. W. R. KOCH 2,080,281

COMMUNICATION SYSTEM

Filed Sept. 19, 1935

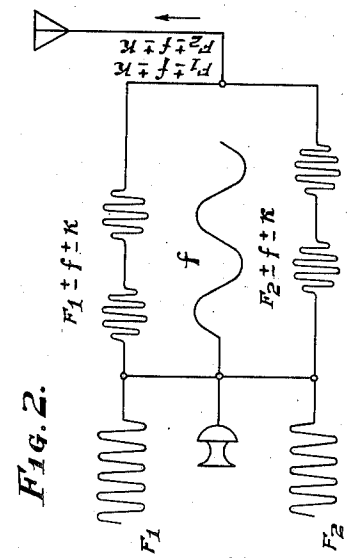


FIG. 2.

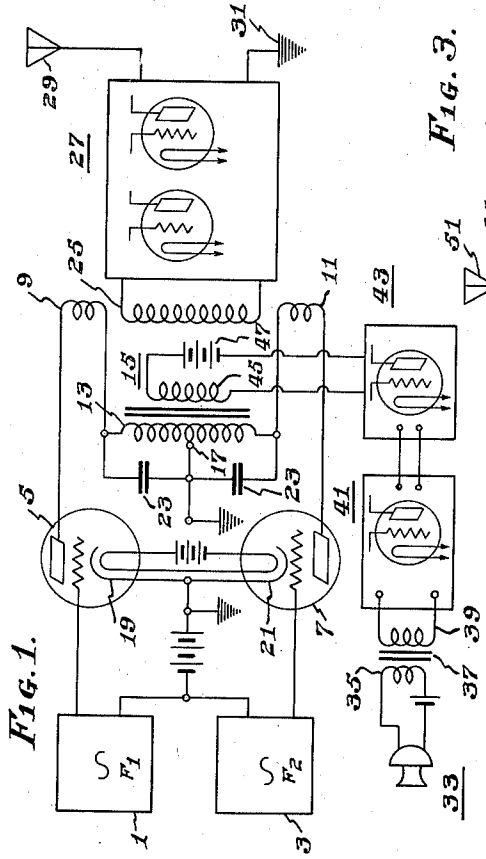


FIG. 1.

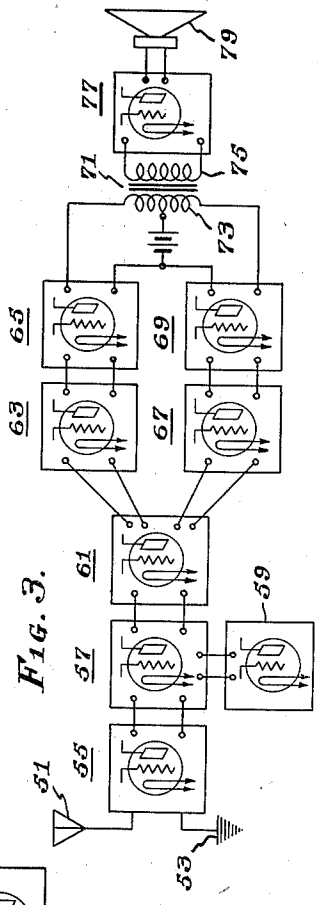


FIG. 3.

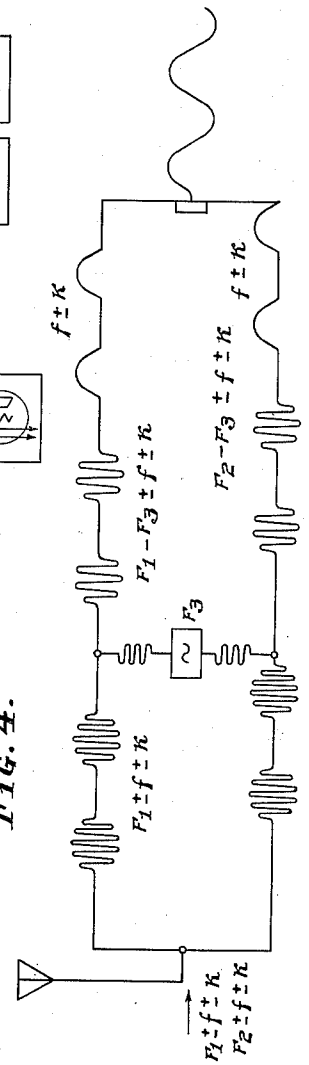


FIG. 4.

INVENTOR
Winfield R. Koch
BY R. R. Goldsborough
ATTORNEY

Patented May 11, 1937 2,080,281

UNITED STATES PATENT OFFICE

2,080,281

COMMUNICATION SYSTEM

Winfield R. Koch, Delaware Township, Camden County, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application September 19, 1935, Serial No. 41,207

4 Claims. (Cl. 250—6)

My invention relates to the transmission and reception of intelligence. Specifically, my invention is a radio system for intermittent and alternate transmission of two carrier currents and reception thereof.

I am aware that it has been proposed to modulate a pair of carrier currents. The continuous radiation of a pair of unmodulated carrier currents is wasteful of power. My invention overcomes this waste by only radiating modulated carrier currents and by making the radiation proportional to the strength of the modulating currents, radiation of unmodulated carrier currents is prevented.

One of the objects of my invention is to alternately transmit two carrier currents of different radio frequencies.

Another object is to modulate a carrier current and only transmit the carrier during periods of modulation.

Another object is to modulate one carrier current with one phase of a modulating current and to modulate another carrier current of different frequency with the other phase of the modulating current.

A further object is to receive, demodulate the modulated double carrier currents, and rephase the resultant currents.

Additional objects will appear in the accompanying specification and claims.

Figure 1 is a schematic diagram of one embodiment of my invention applied to a radio transmitter,

Figure 2 is a representation of the essential currents flowing in the circuit of Figure 1,

Figure 3 is a schematic diagram of one form of receiving circuit suitable for reception of transmitted waves of modulated double carriers, and

Figure 4 is a representation of the operation of the essential parts of the receiver of Figure 3.

In Figure 1 a pair of constant frequency oscillators 1—3 are connected respectively to the input circuits of a pair of push-pull amplifier tubes 5—7. The output circuits of the push-pull amplifier tubes 5—7 are each connected to a pair of inductors 9—11, and to the secondary 13 of a push-pull audio frequency transformer 15. The center tap 17 of the audio frequency transformer is connected to ground. The cathodes 19—21 of the amplifier tubes are also grounded. Each half of the secondary of the audio frequency transformer is bypassed for radio frequency currents by a capacitor 23. The inductors in the push-pull plate circuit of the amplifier are coupled to the input circuit 25 of a power amplifier 27 which is coupled to antenna 29 and ground 31.

A microphone 33 is connected to the primary 35 of a transformer 37. The secondary 39 of the transformer is connected to an audio amplifier 41. The output of the audio amplifier 41 may be connected to a second amplifier 43 whose output is connected to the primary 45 of the push-pull transformer.

The operation of the circuit of Figure 1 is as follows: The two constant frequency oscillators generate currents of two substantially different frequencies. These frequencies are chosen so that they will not combine to form a new frequency within the audio frequency spectrum. The constant frequency currents are impressed on the input circuits of the amplifier tubes 5—7. These amplifier tubes 5—7 do not have any constant source of anode current and are therefore normally non-active, and pass no oscillatory currents.

When modulating currents are impressed on the first audio-amplifier 41, these currents are amplified and control the output of the second audio frequency amplifier 43, whose output circuit includes a substantial power source 47. The amplified audio currents in the plate circuit of the last mentioned amplifier may be represented as alternating currents which appear across the primary 45 of the push-pull transformer 15. On one phase a positive potential will be generated in the upper section of the push-pull secondary 13. This positive potential will energize the plate circuit of the upper amplifier tube 5 and permit the carrier F_1 and modulation currents f to combine in the plate circuit. The modulated carrier currents are amplified in the power amplifier 27 which is broadly tuned to efficiently amplify the two modulated carrier currents. On the next audio phase, the lower section of the secondary 13 of the push-pull transformer 15 will energize the plate circuit of the lower amplifier tube 7 and permit the carrier F_2 and modulation currents f to combine in the plate circuit. These modulated carrier currents are likewise amplified in the power amplifier 27 and radiated from the antenna. The antenna 29 is tuned broadly to effectively radiate both modulated carriers.

In Figure 2 the essential functions of the circuit of Figure 1 are pictorially represented. In this figure the two constant frequency carriers F_1 F_2 are modulated by opposite phases of the modulating current of frequency f. The modulated car-

rier currents are represented by $F_1 \pm f \pm k$ and $F_2 \pm f \pm k$ where

F_1=first carrier frequency

F_2=second carrier frequency

f=modulating frequency

k=other frequencies, such as the usual harmonic series.

It will be seen that the alternate phases of the modulating currents modulate first one, then the other carrier current. Radiation only occurs during the periods of modulation.

It should be understood that the two carriers will each be modulated and will each have side bands of the fundamental modulating frequency and the usual series of harmonics. No attempt has been made to show the harmonics nor represent them as a mathematical series, other than the designation $\pm k$.

The transmission band will have a frequency width slightly in excess of the usual single carrier and double side band transmission. The increased transmission band is not without advantages. For example, the distortional fading will be greatly reduced because it is extremely unlikely that each carrier would fade simultaneously. The presence of either carrier would be accompanied by a fairly high percentage of the fundamental frequencies. There will be an obvious saving of power at the transmitter because radiation only takes place during modulation and in proportion to the modulation.

Various means may be employed to receive the modulated double carrier. For example two separate receivers may be employed with a common speaker and means to properly phase the audio frequency currents. I prefer to use a circuit arrangement similar to that of Figure 3. In Figure 3, an antenna **51** and a ground **53** are connected to a radio frequency amplifier **55**. The amplifier has a frequency characteristic which permits it to receive the plurality of frequencies of the pair of modulated carriers. The output of the amplifier **55** is connected to a detector or mixing tube **57**. A local oscillator **59** is coupled to the mixing tube. The output of the mixing tube may be amplified by the intermediate amplifier **61**. The output of the intermediate frequency amplifier is coupled to another intermediate frequency amplifier **63** and a second detector **65**. This combination is made resonant to the resultant frequency which is formed by combining currents of one carrier frequency F_1 and currents of the local oscillator of frequency F_3. A second intermediate frequency amplifier **67** and another second detector **69** are also connected to the first intermediate amplifier **61**. This second path comprising the intermediate frequency amplifier **67** and a second detector **69** is made resonant to the resultant frequency which is formed by combining currents of the carrier frequency F_2 and the local oscillator frequency F_3. The output transformer **71** has its primary **73** connected in push-pull relation to the output circuits of the second detectors **65**—**69**. The secondary **75** of the push-pull transformer **71** rephases and combines the modulated currents into their original pattern. These currents may be further amplified by means of an audio frequency amplifier **77** and reproduced by a suitable loudspeaker **79** or the like.

The functions of the receiving circuit, other than amplification, are represented in Figure 4. The incoming modulated carrier currents $F_1 \pm f \pm k$ and $F_2 \pm f \pm k$ are mixed with oscillatory currents F_3 from the local oscillator. The resultant currents $F_1 - F_3 \pm f \pm k$ and $F_2 - F_3 \pm f \pm k$ are detected. The resultant currents may be amplified. Each second detector rectifies alternate phases of the modulated carriers. The modulation currents are combined in proper phase relation to represent the original modulation impulses.

Receiving systems of this type are somewhat more expensive than the conventional receiver for a single carrier and the usual sidebands. Among the advantages of the double carrier system of my invention is the decreased response to static representing currents. The static may be partially balanced out by the arrangement shown in Figure 3. If the static representing currents are uniformly distributed over the frequency bands of the receiver, static currents through one branch of the intermediate frequency amplifier will oppose those through the other branch. During periods of no modulation at the transmitter, no carrier will be radiated or received. This will make the receiver quiet as there will be no carrier to heterodyne with static impulses in the receiver. Likewise when the carrier is weak, as it is during periods of low modulation, there will be correspondingly less noise.

The transmitter and receiver circuits I have illustrated are merely by way of example. Many obvious modifications within the scope of my invention will occur to those skilled in the art. I do not intend to limit my invention except as required by the prior art and the appended claims.

I claim as my invention:

1. The method of transmitting and receiving intelligence in a system including a pair of normally inactive relays which comprises generating a pair of carrier currents of different frequencies, applying said currents to said pair of inactive relays, applying signal representing alternating currents to said pair of relays means to render first one then the other active, alternately modulating said carrier currents with first one then the other phase of said signal representing currents, radiating said pair of modulated carrier currents, receiving said pair of modulated carrier currents, demodulating each of said carrier currents, and rephasing said demodulated currents.

2. The method of transmitting and receiving intelligence in a system including an inactive push pull amplifier which comprises generating a pair of carrier currents of different frequencies, applying said currents to an inactive push-pull amplifying means, applying signal representing alternating currents to said push-pull amplifying means to render first one then the other of said push-pull amplifiers active, alternately modulating said carrier currents with first one then the other phase of said signal representing currents, radiating said pair of modulated carrier currents, receiving said pair of modulated carrier currents, demodulating each of said carrier currents, and rephasing said demodulated currents.

3. In a system of the character described, a transmitter comprising means for generating a pair of carrier currents of different frequencies, an amplifier including amplifier tubes normally inactive for alternately amplifying said carrier currents, means for generating a signal representing current, and means for applying said signal representing currents in push-pull relation to the output circuit of said amplifier to render first one, then the other of said amplifier tubes active.

4. In a system of the character described, a transmitter comprising a pair of oscillators for generating carrier currents of different frequencies, a normally inactive amplifier including a pair of input circuits and a pair of output circuits in push-pull arrangement, connections from each of said oscillators to one of said input circuits, means for amplifying signal representing currents, a source of power controlled by the last mentioned amplifier, means for applying energizing currents from said source of power to the said push-pull output circuit to render active the first mentioned amplifier, and means for amplifying the modulated output currents of said push-pull amplifier.

WINFIELD R. KOCH.