H. S. OSBORNE.

MULTIPLEX SIGNALING SYSTEM.

APPLICATION FILED JULY 28, 1919.

1,429,248.

Patented Sept. 19, 1922.

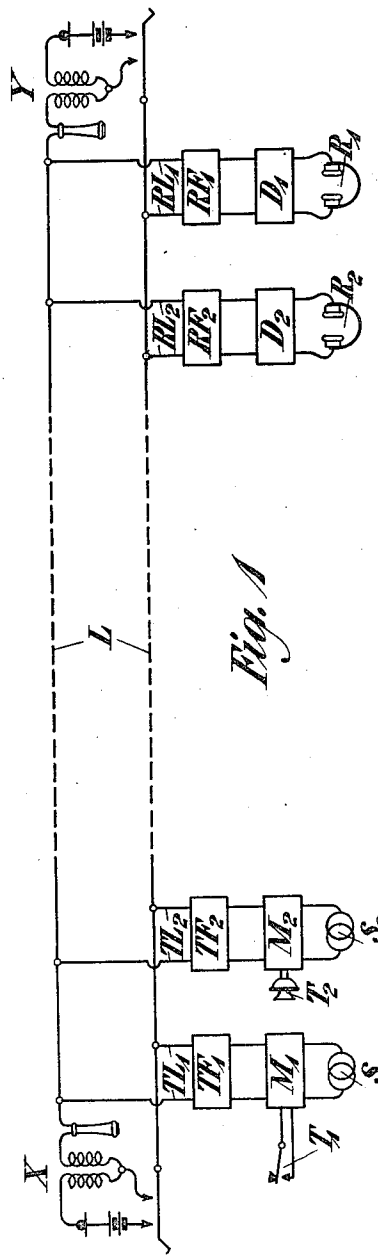

Fig. 1

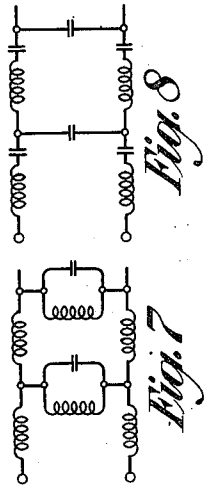

Fig. 8

Fig. 7

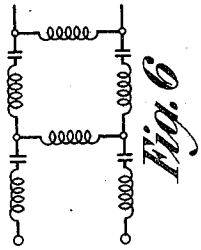

Fig. 6

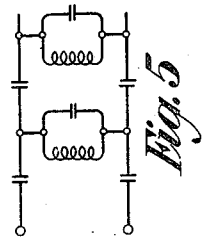

Fig. 5

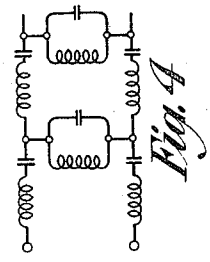

Fig. 4

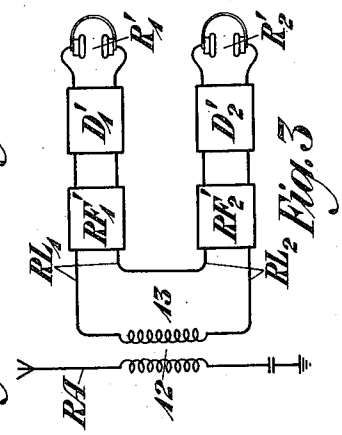

Fig. 3

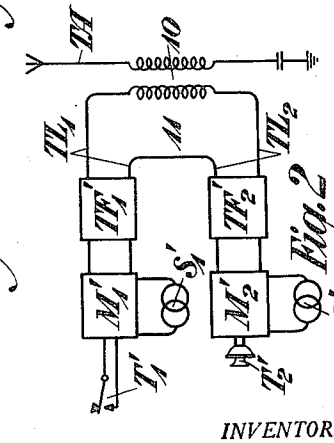

Fig. 2

INVENTOR.

H. S. Osborne

BY

ATTORNEY

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UNITED STATES PATENT OFFICE.

HAROLD S. OSBORNE, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

MULTIPLEX SIGNALING SYSTEM.

Application filed July 23, 1919. Serial No. 313,817.

To all whom it may concern:

Be it known that I, HAROLD S. OSBORNE, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Multiplex Signaling Systems, of which the following is a specification.

This invention relates to signaling systems and more particularly to signaling systems in which carrier currents are used for the transmission of signals.

Heretofore it has been proposed to secure multiplex transmission by superposing signals on high frequency carrier currents of different frequencies, all of which are impressed upon a common medium of communication so that each frequency constitutes a separate channel for transmission purposes. In order to secure selectivity, it has been proposed to utilize sharply tuned circuits to separate each frequency into its proper channel at the terminal stations. It has been found, however, that this method of securing selectivity is unsatisfactory, particularly in the case of multiplex transmission over wire lines where the carrier frequencies are not as high as in the case of wireless transmission, for the reason that the sharply tuned circuit only transmits freely a relatively narrow band of frequencies and distorts frequencies lying on either side of the critical frequency. This follows from the fact that when a carrier frequency is modulated by signaling currents such as voice currents or telegraph currents, for instance, a band of high frequencies must be transmitted, extending to either side of the normal carrier frequency to an extent equal to the range of frequencies employed for telephone transmission or telegraph transmission as the case may be. Obviously, if such a band of frequencies is impressed upon the sharply tuned circuit, the frequencies lying near the middle of the band will be freely transmitted, while those lying to either side will be considerably attenuated so that a large degree of distortion results.

This difficulty becomes more noticeable the lower the carrier frequency, as the band of frequencies corresponding to the signaling band extends over a relatively greater portion of the resonance curve when the frequency range of the signaling band becomes a substantial percentage of the carrier frequency employed. In the case of wireless signaling systems employing extremely high frequencies, while the difficulty is present, it is not so serious, but as the tendency in wireless transmission is constantly toward the utilization of lower frequencies, the distortion due to sharp tuning becomes of considerable importance.

It is proposed to overcome the difficulties above referred to by utilizing, instead of sharply tuned circuits for selective purposes, apparatus adapted to transmit with uniform amplitude a band of frequencies of any desired width, while substantially suppressing frequencies lying outside of the band. For this purpose the broad band wave filter shown and described in United States patents to George A. Campbell, Nos. 1,227,123 and 1,127,114, dated May 22, 1917, is well adapted, although any other form of wave filter having the desired characteristics may be equally satisfactory.

The invention may now be more fully understood from the following detailed description, when read in connection with the accompanying drawing in which:

Figure 1 is a simplified diagram illustrating the application of the invention to a carrier system involving wire transmission;

Figs. 2 and 3 constitute diagrams illustrating the application of the invention to the transmitting and receiving apparatus of a multiplex wireless system, and

Figs. 4 to 8, inclusive, are diagrams showing several different forms of wave filter adapted for use in connection with the invention.

Referring to Fig. 1, L designates an ordinary wire transmission line adapted for low frequency telephonic transmission and for this purpose terminating in substation sets X and Y. In order that the line L may be used for multiplex transmission, branches TL_1 and TL_2 may be bridged across the line at one station for transmission purposes, and branches RL_1 and RL_2 may be bridged across the line at a distant station for receiving purposes. Branches TL_1 and TL_2 lead to modulating apparatus M_1 and M_2 adapted to modulate high frequency oscillations supplied by sources S_1 and S_2 in accordance with signals originating in telephone or

telegraph transmitters T_1 and T_2. The modulating apparatus may be of any well known character although the well known vacuum tube modulator has been found to be the most satisfactory type. The receiving branches RL_1 and RL_2 lead to detecting apparatus D_1 and D_2 whereby the high frequency modulated oscillations are translated into low frequency signaling currents and impressed upon the receivers R_1 and R_2.

The apparatus so far described corresponds to arrangements well known in the prior art and disclosed in numerous United States and foreign patents issued to various patentees. In such systems of the prior art, however, it was proposed to use relatively high carrier frequencies. The signaling band in this system was therefor relatively narrow with respect to the carrier frequency so that tuned circuits could be used without undue distortion. When frequencies in the neighborhood of twenty-five thousand cycles or lower are used for carrier purposes, the signal band is so large relative to carrier frequency that tuned circuits distort the modulated frequencies which lie farthest away from the fundamental carrier frequency. Therefore instead of utilizing sharply tuned circuits for selective purposes, as proposed in the Squier system, in accordance with this invention broad band filters TF_1 and TF_2 are included in the transmitting branches and similar filters RF_1 and RF_2 are included in the receiving branches. These filters are preferably of the broad band type disclosed in the patents to George A. Campbell above referred to, and should be so proportioned and designed as to transmit a band of frequencies extending to either side of the carrier frequency assigned to the channel a distance equal to the range of frequencies corresponding to the signal range, or (where it is desired to suppress one side band), the band of frequencies transmitted may extend to only one side of the carrier frequency an amount equal to the signal range.

As set forth in said Campbell patents, there are five general types of filters which will conform to these requirements. These five forms are illustrated in Figs. 4 to 8, inclusive. As shown, each filter comprises a series of sections, each section including both series and shunt impedance elements. While but two sections of each form of filter are illustrated, it will be understood that as many sections may be provided as are desired. The form of filter shown in Fig. 4 includes series inductance and capacity in series with the line, and parallel inductance and capacity in shunt with the line. Fig. 5 differs from Fig. 4 in that the inductance element in series with the line is omitted. Fig. 6 differs from Fig. 4 in that the capacity in the shunt combination is omitted. Fig. 7 differs from Fig. 4 in that the capacity in series with the line is omitted while Fig. 8 differs from Fig. 4 in that the inductance of the shunt combination is omitted.

It will be apparent from Fig. 1 that if filters TF_1 and RF_1 are arranged to transmit the same band of frequencies and if filters TF_2 and RF_2 are arranged to transmit a similar band somewhat remote from the band transmitted by filters TF_1 and RF_1, transmission may take place between transmitter T_1 and receiver R_1 without interfering with receiver R_2. In a similar manner, transmission may take place between transmitter T_2 and receiver R_2 without affecting receiver R_1.

In the case illustrated, it is assumed that the bands of frequencies employed in carrier transmission are relatively high with respect to ordinary telephonic frequencies so as not to produce any appreciable effect upon the receivers of the low frequency telephone sets X and Y.

The general idea disclosed in Fig. 1 may be applied to wireless transmission as illustrated in Figs. 2 and 3. Referring to Fig. 2, TA designates a transmitting antenna which is coupled through a transformer 10 to a local circuit 11, having branches TL_1' and TL_2', each of which includes broad band filters and modulating apparatus similar to that described in connection with Fig. 1. In this case the branches are illustrated as being connected in series instead of in parallel as in the case of Fig. 1, but it will be understood that the series and parallel arrangements are equivalent.

The corresponding receiving arrangement is shown in Fig. 3 in which a receiving antenna RA is coupled through a transformer 12 to a circuit 13 having serially included therein branches RL_1' and RL_2' leading through filters RF_1' and RF_2' respectively, to the detecting and receiving apparatus similar to that described in Fig. 1. The filters shown in Figs. 2 and 3 are in all respects similar to those in Fig. 1, thereby enabling transmission to take place between transmitter T_1' and receiver R_1' and transmitter T_2' and receiver R_2' without interference.

While the invention has been illustrated as embodied in a telephone transmission system it is equally applicable to multiplex carrier current telegraph transmission and in the latter connection its importance increases the lower the frequency of the carrier current employed. It will be seen that by means of the arrangements above described, selective transmission without distortion is possible and it will be understood that the invention may be embodied in many or other organizations widely dif-

ferent from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a signaling system, means to transmit a plurality of carrier frequencies, means to impress low frequency signal variations upon each of said carrier frequencies, said signal variations having a frequency range constituting a substantial percentage of the carrier frequency upon which they are impressed, receiving apparatus for each carrier frequency and selective means associated with each receiving apparatus to prevent transmission of undesired frequencies to each receiving apparatus, said selective means being so proportioned and arranged as to transmit with equal freedom a band of frequencies in the neighborhood of said carrier frequency and having a width substantially equal to the range of frequencies employed in connection with said low frequency signals.

2. In a signaling system, means to transmit a plurality of carrier frequencies, means to impress low frequency signal variations upon each of said carrier frequencies, said signal variations having a frequency range constituting a substantial percentage of the carrier frequency upon which they are impressed, receiving apparatus for each carrier frequency and selective means associated with each receiving apparatus to prevent transmission of undesired frequencies to each receiving apparatus, said selective means comprising a broad band filter adapted to transmit with equal freedom a band of frequencies in the neighborhood of said carrier frequency and having a width substantially equal to the range of frequencies employed in connection with said low frequency signals, and adapted to substantially suppress frequencies lying without said band.

3. In a signaling system, a transmitting station, a receiving station, means at said transmitting station to modulate each of a plurality of carrier frequencies in accordance with low frequency signal variations, each of said signal variations having a frequency range constituting a substantial percentage of the corresponding carrier frequency, selective means at the transmitting station for each of said carrier frequencies to determine the frequencies to be transmitted from each modulating means to the receiving station, said selective means being so proportioned and arranged as to transmit with equal freedom a band of frequencies in the neighborhood of said carrier frequency and having a width substantially equal to the range of frequencies employed in connection with said low frequency signals.

4. In a signaling system, a transmitting station, a receiving station, means at said transmitting station to modulate each of a plurality of carrier frequencies in accordance with low frequency signal variations, each of said signal variations having a frequency range constituting a substantial percentage of the corresponding carrier frequency, selective means at the transmitting station for each of said carrier frequencies to determine the frequencies to be transmitted from each modulating means to the receiving station, said selective means comprising a broad band filter adapted to transmit with equal freedom a band of frequencies in the neighborhood of said carrier frequency and having a width substantially equal to the range of frequencies employed in connection with said low frequency signals, and adapted to substantially suppress frequencies lying without said band.

5. In a signaling system, a transmitting station, a receiving station, a plurality of transmitting channels at said transmitting station each adapted to transmit a carrier current having a frequency individual to that channel, means associated with said channels to impress low frequency signal variations upon said carrier currents, the signal variations of each channel having a frequency range constituting a substantial percentage of the carrier frequency assigned to the channel, a plurality of receiving channels at the receiving station corresponding to the channels at the transmitting station, receiving apparatus for each receiving channel, and selective means associated with each of said receiving channels, said selective means being so arranged and proportioned as to transmit with equal freedom a band of frequencies in the neighborhood of the carrier frequency assigned to each channel and having a width substantially equal to the range of frequencies employed in connection with the low frequency signals transmitted to the corresponding channel.

6. In a signaling system, a transmitting station, a receiving station, a plurality of transmitting channels at said transmitting station each adapted to transmit carrier currents having a frequency individual to that channel, means associated with said channels to impress low frequency signal variations upon said carrier currents, the signal variations of each channel having a frequency range constituting a substantial percentage of the carrier frequency assigned to the channel, a plurality of receiving channels at the receiving station corresponding to the channels at the transmitting station, receiving apparatus for each receiving channel, and selective means associated with each of said receiving channels, said selective means each comprising a broad band filter adapted to transmit with

equal freedom a band of frequencies in the neighborhood of the carrier frequency assigned to each channel and having a width substantially equal to the range of frequencies employed in connection with the low frequency signals transmitted to the corresponding channel, and adapted to substantially suppress frequencies lying without said band.

7. In a signaling system, a transmitting station, a receiving station, a plurality of transmitting channels at said transmitting station each adapted to transmit carrier currents having a frequency individual to that channel, means associated with each of said channels to modulate said carrier currents in accordance with low frequency signal variations, the signal variations of each channel having a frequency range constituting a substantial percentage of the carrier frequency assigned to the channel, a plurality of receiving channels at the receiving station corresponding to the transmitting channels at the transmitting station, receiving apparatus for each receiving channel, and selective means for each transmitting channel to determine the frequency to be transmitted from the modulating means associated with said channel to the receiving station, said selective means being so arranged and proportioned as to transmit with equal freedom a band of frequencies in the neighborhood of the carrier frequency assigned to each channel and having a width substantially equal to the range of frequencies employed in connection with the low frequency signals transmitted to the corresponding channel.

8. In a signaling system, a transmitting station, a receiving station, a plurality of transmitting channels at said transmitting station each adapted to transmit carrier currents having a frequency individual to that channel, means associated with each of said channels to modulate said carrier currents in accordance with low frequency signal variations, the signal variations of each channel having a frequency range constituting a substantial percentage of the carrier frequency assigned to the channel, a plurality of receiving channels at the receiving station corresponding to the transmitting channels at the transmitting station, receiving apparatus for each receiving channel, and selective means for each transmitting channel to determine the frequency to be transmitted from the modulating means associated with said channel to the receiving station, said selective means each comprising a broad band filter adapted to transmit with equal freedom a band of frequencies in the neighborhood of the carrier frequency assigned to each channel and having a width substantially equal to the range of frequencies employed in connection with the low frequency signals transmitted to the corresponding channel, and adapted to substantially suppress frequencies lying without said band.

9. In a high frequency signaling system, the combination of a plurality of communicating transmitter and receiver circuits, each of said transmitter circuits comprising a source of carrier oscillations of a frequency different from that supplied by the remainder of said transmitter circuits; each of said transmitter circuits also comprising a source of signal oscillations, means for modulating said carrier oscillations in accordance with said signal oscillations, and a band filter adapted to selectively transmit modulated oscillations from its respective transmitter circuit to the exclusion of different frequency oscillations from other of said transmitter circuits.

In testimony whereof, I have signed my name to this specification this 25th day of July 1919.

HAROLD S. OSBORNE.