Aug. 14, 1923. 1,464,519

H. J. VENNES

SIGNALING SYSTEM

Filed July 16, 1918 2 Sheets-Sheet 1

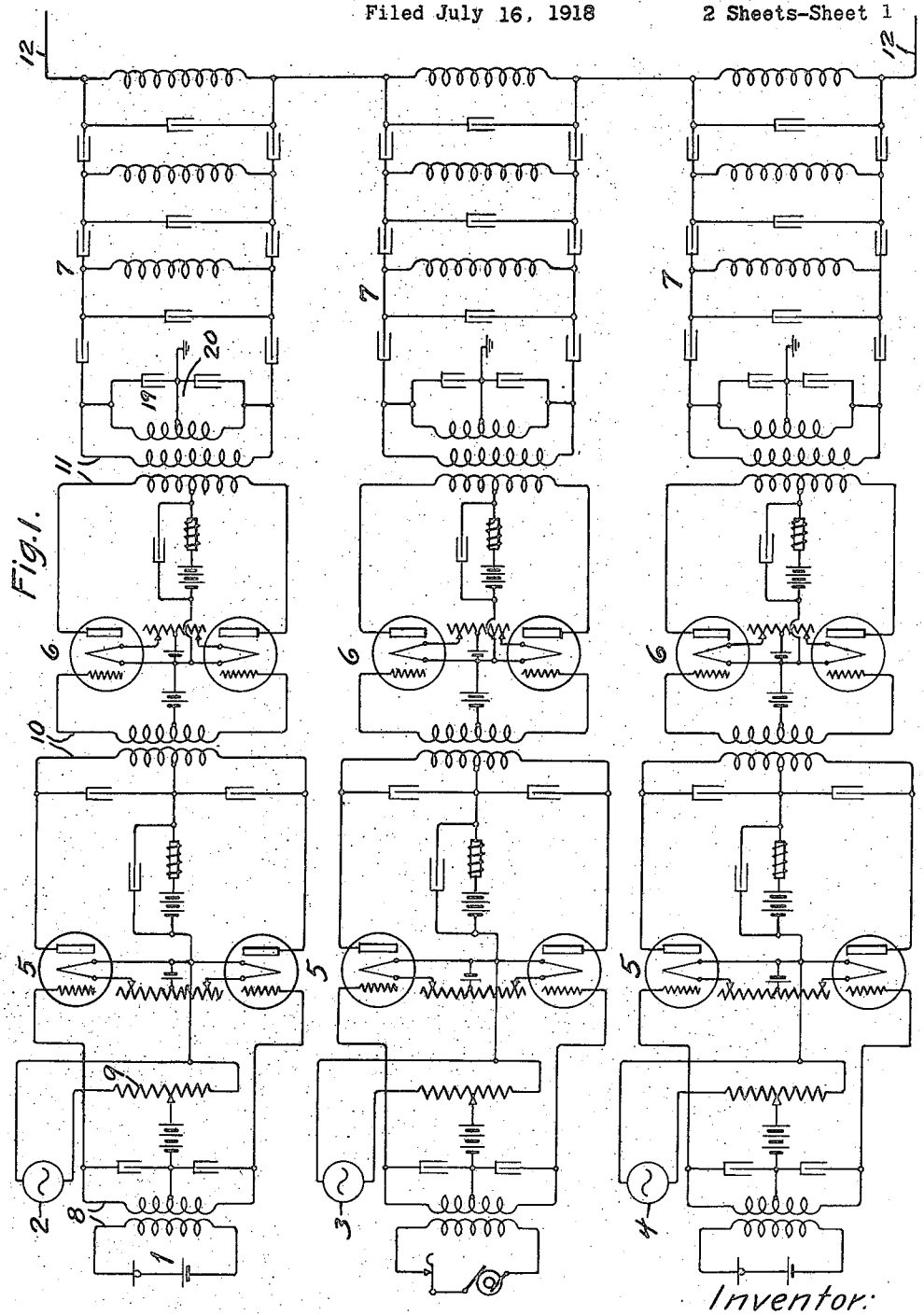

Fig. 1.

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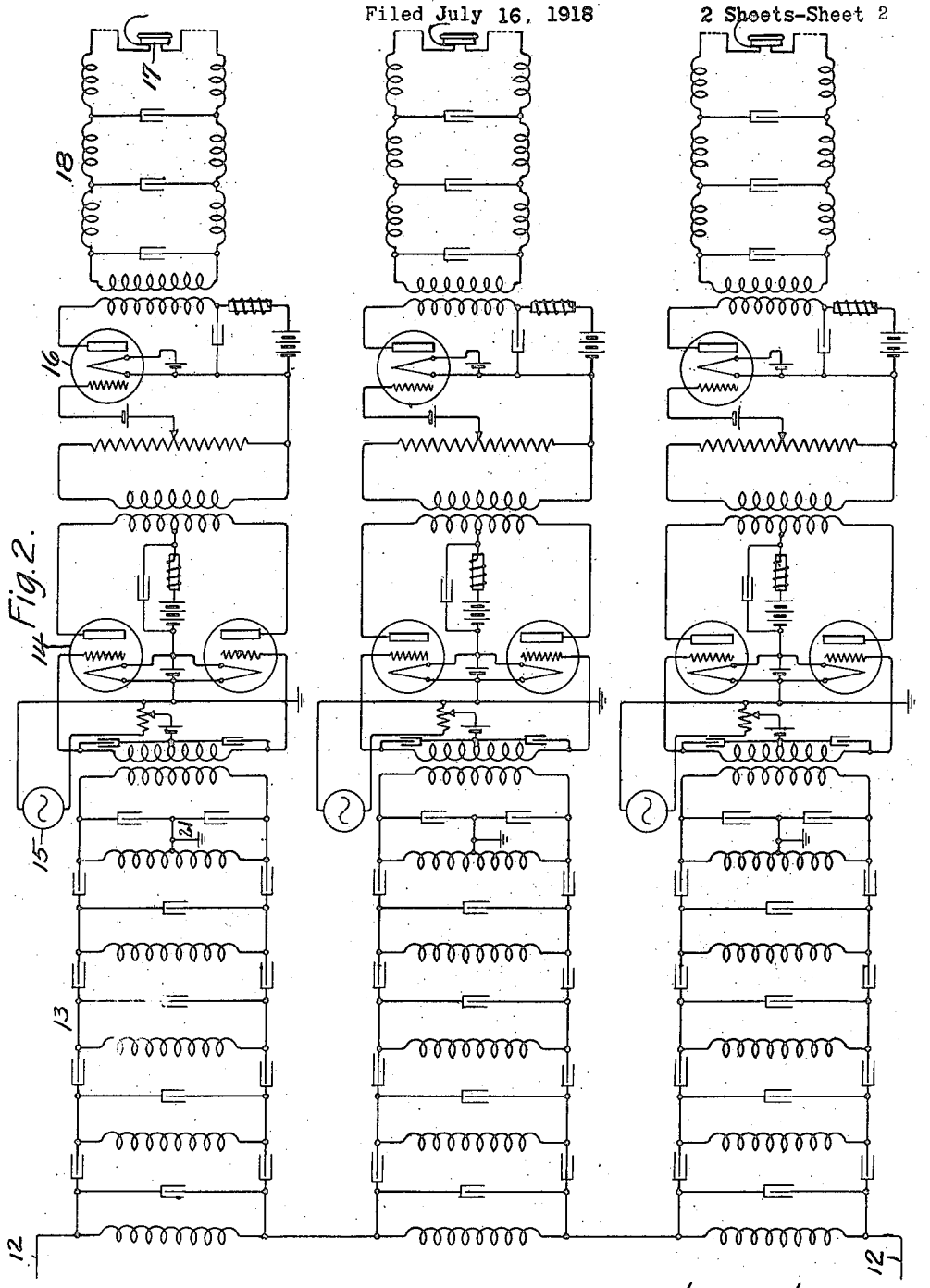

Fig. 2.

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Patented Aug. 14, 1923. 1,464,519

UNITED STATES PATENT OFFICE.

HARALD J. VENNES, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

SIGNALING SYSTEM.

Application filed July 16, 1918. Serial No. 245,134.

To all whom it may concern:

Be it known that I, HARALD J. VENNES, a citizen of the United States, residing at New York, in the county of New York, State of New York, have invented certain new and useful Improvements in Signaling Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to signaling systems and more particularly to multiplex carrier current systems in which signals are transmitted as variations or modulations of high frequency carrier currents or oscillations, and a plurality of message carrier currents of different frequencies are transmitted simultaneously over the same transmission line.

An object of this invention is to provide means for preventing cross-talk in multiplex carrier current signaling systems.

A further object of this invention is to enable the use in a multiplex signaling system of carrier currents which are exact multiples of each other.

In multiplex carrier current systems, it is necessary to provide a receiving device which will respond only to carrier currents of a particular frequency range. It is also necessary where oscillations, locally or otherwise produced, are combined at the receiver with incoming modulated oscillations to prevent the production of any combination frequency oscillations which might otherwise be set up and which would appear as cross-talk in a channel responsive to such combination frequencies. The accomplishment of these objects presents considerable difficulty when unmodulated carrier frequencies are present in the line and particularly where the unmodulated carrier frequencies are exact multiples of each other. Where amplifying devices are used the amplitude of such cross-talk frequency currents may be increased to such a degree that signaling is seriously interfered with.

In practice it is difficult to suppress all unmodulated carrier frequency currents and their harmonics so as to keep the transmission line entirely free from them. Unmodulated carrier currents of one frequency transmitted over the line may react with modulated oscillations of another carrier frequency to give modulated oscillations of a third frequency which will pass the filter of one of the receiving channels and appear as cross-talk in that channel.

The present invention relates to an arrangement whereby a dissipation path is provided for these cross-talk or foreign frequency currents without disturbing the selectivity of the system, thereby eliminating the interference resulting from these causes. This path is provided by grounding the electrical mid-point of one or more of the sections of each filter, but preferably the mid-point of the end section of each wave filter electrically nearest to the signal transmitting or receiving apparatus. It is to be understood, however, that the invention is not to be limited to this specific connection to ground but includes any arrangement which compensates for electrical unbalance of a filter for currents of frequencies which it is desired to exclude.

In the drawing, Fig. 1 illustrates the transmitting circuits for a multiplex carrier current telephone system; and Fig. 2 shows the coresponding receiving circuits.

Referring to Fig. 1, three individual transmitting stations are shown, each comprising a local signal circuit 1, a carrier current source 2, 3 or 4, a modulator 5, an amplifier 6, and a band filter 7. The signal circuit 1 may contain a local source of current and a microphone, a source of low frequency oscillations and a key, or any other equivalent signaling arrangement, and is preferably coupled to the input circuit of a balanced modulator 5 by a transformer 8. This modulator is preferably of a type disclosed in U. S. patent to Carson 1,343,306, issued June 15, 1920. Carrier current source 2 is connected to the input circuit of modulator 5 by a potentiometer 9. Modulated oscillations, which are set up during signaling periods in the output circuit of modulator 5, are impressed by transformer 10 upon amplifier 6, preferably of the vacuum tube type, which amplifies these oscillations and transmits them to band filter 7 through transformer 11. Filter 7 may be designed to pass currents of a band of frequencies ranging from the difference of the carrier and signaling frequencies to their sum, but is preferably arranged to pass only currents of one side frequency band as, for

example, the band ranging from carrier frequency down to the difference of the carrier and signaling frequencies.

In Fig. 2 the transmission line 12 is shown connected to three receiving stations which correspond respectively to the transmitting stations of Fig. 1. Each receiving station comprises a band filter 13 which selects currents of a band of frequencies of the range impressed upon the line by the corresponding transmitting station. Modulated carrier frequency oscillations of a particular band of frequencies are selected and are transmitted by each filter 13 to a detector 14, preferably of the balanced vacuum tube type, upon the input circuit of which oscillations of carrier frequency are impressed in any desired manner as, for example, by a local source 15. The balanced detector 14 acts like modulator 5 of Fig. 1 to suppress unmodulated oscillations of the carrier frequency in its output circuit. The incoming modulated oscillations and locally supplied unmodulated oscillations are combined by the detector to give currents of their difference, or the original signal frequency, in the output circuit of the detector. These signal currents are amplified by an amplifier 16, preferably of the vacuum tube type, and are transmitted to receiving or indicating device 17 through an ultra filter 18 designed to cut off frequencies above the signal current range.

Connected to the electrical mid-points of both branches of a section 19 of filter 7, preferably the end section electrically nearest to the transmitter, is a grounded conductor 20. Currents of the range of frequencies for which filter 7 is designed will be conducted symmetrically by the filter which will, however, present considerable impedance to currents of other or foreign frequencies. Currents of other frequencies in effect appear to be conducted between one side of the filter and ground, the filter unbalance appearing to act as a difference in capacity between the two sides of the filter and earth or other conductor. Conductor 20 establishes a low impedance path between each side of the filter and ground for currents of frequencies outside of the transmission band. The unbalanced foreign frequency current will then be practically short-circuited about a portion of the impedance path of the filter by this conductor. This does not materially change the impedance characteristics of the filter to a current of the frequency which the filter is designed to transmit. The value of the reactance between the grounded point and the sides of the filter is determined in each case for optimum operating characteristics.

A grounded conductor 21 is connected to the electrical mid-point of a section of filter 13, preferably the end section electrically nearest to the detector, and serves to protect the signal channel associated therewith from the effects of cross-talk currents. Since conductor 21 offers low impedance between either side of the filter 13 and ground to currents of frequencies outside the range of transmission for the filter, and the input circuit of detector 14 offers a high impedance to currents of these frequencies, their energy is dissipated in the low impedance grounded circuit.

The wave filters 7 are connected in series in the line 12, and each is of a type offering low impedance to currents of frequencies outside the range of transmission of its associated signaling channel but offering substantially infinite impedance to currents within its transmission range. It becomes almost impossible to so place all the elements of each filter that the capacity to ground for each unit will be balanced, and that the units will be balanced collectively as well as individually. The electrostatic capacity between the windings of the transformers connecting the various channels to line may also cause considerable unbalance. In order to prevent short-circuiting of the filters, the sections nearest the transmission conductor must not be grounded. Grounding the filters in the manner described furnishes a dissipation path for cross-talk currents, and in some instances may permit considerable unbalance under normal conditions without interfering with the selectivity of the system.

The invention has been disclosed as applied to a system in which modulated high frequency carrier currents are employed for telephony and telegraphy. Obviously, however, it is in its broader aspects not limited to the use of modulated currents or even to the use of high frequency currents.

It will, of course, be understood by those skilled in the art that the particular signaling systems herein shown and described are only illustrative of means that may be employed, and that the details and arrangement of the circuits may be materially varied from what is set forth without departing from the spirit and scope of the invention.

What is claimed is:

1. A line, and a plurality of wave filters connected in series in said line, each of said wave filters comprising an end section grounded at its mid-point.

2. A multiplex signaling system comprising a line and a plurality of signal channels connected in series to said line, each of said channels including a filter having an end section grounded at its electrical mid-point.

3. In combination, a line adapted to transmit currents of a plurality of bands of frequencies, individual means connected in series in said line for selectively conducting each of said frequency bands of currents.

and means to compensate for any electrical unbalance of said conducting means with respect to the two sides of said line whereby transmission thereby of current of any foreign frequency is prevented.

4. A multiplex signaling system comprising a line and a plurality of channels connected in series relation thereto, each of said channels being designed to transmit currents of an individual range of frequencies, each of said channels having means to dissipate currents of any foreign frequency which tend to be transmitted thereby as a result of electrical unbalance of a channel with respect to the two sides of said line.

5. A signaling system comprising a line, a plurality of channels connected in series to said line, each of said channels comprising means to efficiently transfer currents of a particular band of frequencies and to exclude currents of other frequencies, means connecting both sides of each channel to ground, said connecting means offering high impedance to currents within the band of frequencies selected by the associated transfer means and offering low impedance to currents outside of said band.

6. A multiplex carrier current signaling system comprising a circuit and a plurality of wave filters connected to said circuit in series, each of said filters having an end section grounded at its mid-point.

7. In combination, a line, and means to impress a plurality of currents of different frequencies upon said line, said means including a plurality of wave filters connected in series, each of said wave filters having an end section grounded at its mid-point.

8. A line, a plurality of transmitting devices, and means connecting each transmitting device to said line, said means being connected in series, and each of said means conducting currents of a different band of frequencies and comprising a wave filter having an end section grounded at its mid-point.

9. A signaling line, a plurality of transmitting stations, each of said stations comprising a source of carrier frequency current, a source of low frequency current and a modulating device, and a wave filter connecting each of said stations to said line and adapted to transmit a band of currents of high frequency, said filters being all connected in series in said line and each having a section grounded at its electrical mid-point.

10. In combination, a line, and means to select therefrom a plurality of currents of different frequencies, said means including a plurality of wave filters connected in series and each having an end section grounded at its mid-point.

11. A line, a plurality of receiving devices, and means arranged in series and connecting each of said receiving devices to said line, each of said connecting means conducting currents of a different band of frequencies and comprising a wave filter having an end section grounded at its mid-point.

12. A signaling line, a plurality of receiving stations connected to said line, each of said receiving stations comprising a source of high frequency currents and a detector, a wave filter connecting each of said receiving stations to said line all of said filters being connected in series and means for grounding the mid-point of an end section of each filter.

In witness whereof I hereunto subscribe my name this 12th day of July, A. D., 1918.

HARALD J. VENNES.