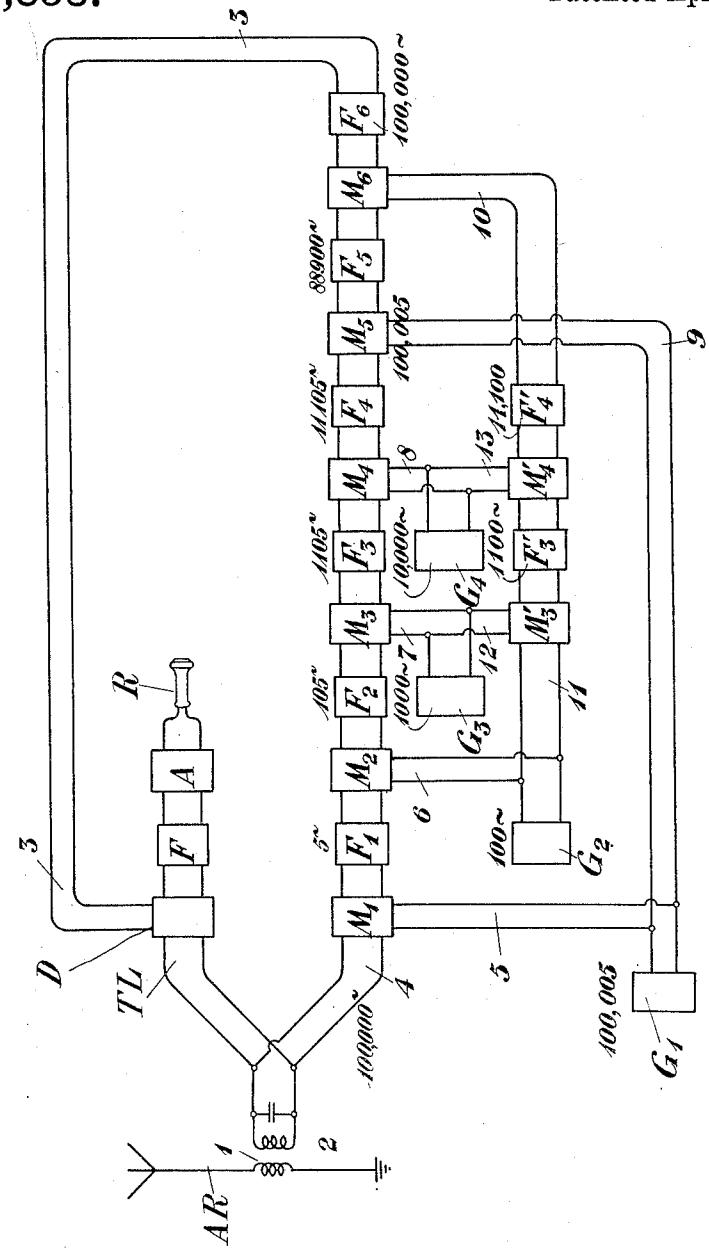
L. ESPENSCHIED.

SYNCHRONIZING SYSTEM.

APPLICATION FILED SEPT. 30, 1919.

1,412,853. Patented Apr. 18, 1922.



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SYNCHRONIZING SYSTEM.

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To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, in the county of Queens and State of New York, have invented certain Improvements in Synchronizing Systems, of which the following is a specification.

This invention relates to signaling circuits and more particularly to arrangements for maintaining synchronism between alternating currents separately generated at different stations of a signaling system.

One of the features of the invention resides in the provision of means whereby alternating currents supplied from two independent sources may be automatically maintained at the same frequency.

Another feature of the invention resides in the provision of means whereby alternating currents supplied at the receiving station of a signaling system may be maintained in synchronism with carrier currents received from a distant sending station.

These features, together with other features more fully hereinafter appearing, are realized in the arrangements set forth in the following description and illustrated in the accompanying drawing, the figure of which constitutes a circuit diagram of one embodiment of the invention.

Referring to the drawing, AR designates a receiving antenna of any ordinary construction, which is coupled through a transformer 1, with a tuned circuit 2, resonant at the desired received frequency. A receiving circuit TL is associated with the tuned circuit 2 and includes a demodulating or detecting apparatus D, a filter F, an amplifier A and a receiver R. The detector D may be of any well known type, but is preferably a vacuum tube detector operating upon the so-called homodyne principle of receiving and is therefore supplied with homodyne currents over a circuit 3, in a manner hereinafter described. These homodyne currents should be of the same frequency as the received carrier frequency upon which the signal is superposed, so that the low frequency currents corresponding to the signal will appear in the output circuit of the demodulator. The filter F may be of any well known type, but is preferably a band filter of the type disclosed in the U. S. patents to George A. Campbell, Nos. 1,227,113 and 1,227,114, issued May 22, 1917, and is designed to suppress higher frequencies, while transmitting the low frequency signaling currents. The amplifier A may be of any well known construction, but is preferably a vacuum tube amplifier.

In order to supply the homodyne currents for the detector D, a source G_1 is provided, which may be any suitable form of alternating current generator, such, for instance, as the well known vacuum tube oscillator. The oscillations generated by this oscillator may in practice vary slightly in frequency from the received carrier frequency. In order that the oscillations supplied to the circuit 3 as the result of the action of the generator G_1, may be of the same frequency as the received carrier frequency, a series of modulating and filtering arrangements are provided.

This combination of devices includes modulators M_1, M_2, M_3, M_4, M_5 and M_6, arranged in a circuit 4, branched from the tuned circuit 2. These modulators may be of any well known type, but are preferably vacuum tube modulators. Filtering arrangements, such as F_1, F_2, F_3, F_4, F_5 and F_6, are included in the output circuit of the corresponding modulators, for a purpose more fully hereinafter described. These filters may also be of the type disclosed in the above mentioned patents to George A. Campbell, and are designed to transmit one of the side bands resulting from modulation, to the exclusion of the other.

The modulator M_1 is supplied with modulating current from the source G_1, over a circuit 5. The modulator M_2 is in a similar manner supplied with modulating current from a source G_2, over a circuit 6. So also, the modulator M_3 is supplied with modulating current from a source G_3, over the circuit 7, while the modulator M_4 is supplied from a source G_4, over a circuit 8. The modulator M_5 is supplied with modulating current over a circuit 9, leading from the generator G_1.

In order to supply modulating current for the modulator M_6, a circuit 10 is provided, which includes modulators M'_3 and M'_4, similar to those already described, and including filters F'_3 and F'_4 in the output circuits of the modulators, respectively. The modulator M'_3 is supplied with alternating current from the source G_2, over a circuit 11 and is also supplied from the source G_3 over the

circuit 12. The resultant side band selected by the filter F'_3 is then supplied to the modulator M'_4, which is also supplied with oscillating current from the source G_4, over a circuit 13.

Further details of the apparatus may now be understood from a description of the operation, and in order to facilitate the description, a concrete set of frequencies will be assumed, although it will be understood that these frequencies are referred to merely for purposes of illustration. If the modulated carrier current received by the antenna AR has a frequency of 100,000 cycles, together with the side band resulting from modulation, it is necessary for the most efficient detection, that the detector D should be supplied with a homodyne frequency of 100,000 cycles. Normally this frequency would be supplied by the local generator G_1. This generator, however, may supply a carrier frequency slightly different from that desired. For instance, the frequency supplied by the generator G_1 may be 100,005 cycles. This frequency is supplied to the modulator M_1 over the circuit 5, while the carrier frequency of 100,000, together with the side band frequencies, are supplied to the modulator M_1 over the circuit 4. As a result of the modulating action of the modulator M_1, frequencies corresponding to the sums and differences of the frequencies supplied to the input of the modulator, will appear in the output circuit of the modulator, consequently a frequency of 5 cycles, corresponding to the difference between 100,000 and 100,005 will appear in the output circuit of the modulator M_1. The filter F_1, which is preferably a low pass filter, may be accurately designed to select this frequency and exclude the higher frequencies.

If we assume the frequency supplied by the generator G_2 to the modulator M_2 to be 100 cycles, this frequency will be modulated by the five cycle frequency transmitted to the modulator M_2 from the filter F_1, so that by combining the frequencies, the output circuit of the modulator will be supplied with frequencies of 95 and 105 cycles, respectively. The latter frequency may be selected by the filter F_1, which is preferably a high pass filter, so as to exclude the lower frequency. This frequency is supplied to the modulator M_3, together with a frequency from the generator G_3, which latter may be, for instance, 1000 cycles. As a result of the action of the modulator M_3, a frequency of 1105 cycles will now appear among others in the output circuit of the modulator M_3. This frequency may be selected by the high pass filter F_3 and supplied to the modulator M_4. The modulator M_4 is supplied with a frequency of 10,000 cycles from the generator G_4, so that as a result of its modulating action a frequency of 11,105 cycles will appear in its output circuit as the upper side frequency. This frequency may be selected from the lower side frequency and the 10,000 cycle frequency, by means of the filter F_4, so that a frequency of 11,105 is now supplied to the modulator M_5. At the same time a frequency of 100,005 is supplied to the modulator M_5 from the generator G_1, over the circuit 9. Among the frequencies resulting from the modulation of these two frequencies by the modulator M_5, the filter F_5 may select the frequency corresponding to the lower side frequency, which will be 88,900 cycles. This frequency is now supplied to the modulator M_6.

Returning now to the modulator M'_3, frequencies of 100 cycles and 1,000 cycles are supplied to said modulator over circuits 11 and 12, respectively. The sum of these frequencies, which, of course, results from the modulating action of the modulator M'_3, may be selected to the exclusion of the lower side band, by means of the filter F'_3. This sum corresponds to a frequency of 1100 cycles, which is supplied to the modulator M'_4, together with a frequency of 10,000 cycles from the generator G_4. The modulating action of this modulator produces sum and difference frequencies, as before, of which the former, corresponding to a frequency of 11,100 cycles, may be selected by the filter F'_4 and transmitted over the circuit 10 to the modulator M_6.

The modulator M_6 is consequently supplied with currents having frequencies of 88,900 and 11,100, which, when combined in the modulator, produce a frequency of 100,000 cycles, as well as lower frequencies. The frequency of 100,000 cycles may be selected by the filter F_6 and supplied over the circuit 3 to the demodulator D. It will be noted that this frequency of 100,000 cycles has exactly the same frequency as the received carrier frequency, even though the generator G_1 varies from said carrier frequency, and this will hold true however the frequency of the generator G_1 may vary, at least within limits. The detector D, upon being supplied with the beating frequency of 100,000 cycles, detects the low frequency signaling currents in a well known manner and these currents are passed through the filter F, amplified by the amplifier A and then operate the receiving instrument R.

The frequencies above referred to are, of course, merely illustrative and may be varied as conditions may require. It will also be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. The method of synchronizing two fre-

quencies which consists in combining the two frequencies so as to produce a frequency corresponding to their difference, stepping up the difference in the frequency spectrum a predetermined amount, combining the stepped up frequency with one of the frequencies to be synchronized and producing from the resultant frequency a frequency corresponding to the other frequency to be synchronized.

2. The method of synchronizing two frequencies which consists in combining the two frequencies so as to produce a frequency corresponding to their difference, stepping up the difference frequency in the frequency spectrum by a predetermined amount, combining the stepped up frequency with one of the frequencies to be synchronized and combining the resultant frequency with another frequency equal to the amount by which the difference frequency was stepped up.

3. The method of synchronizing two frequencies which consists in combining the two frequencies so as to produce a frequency corresponding to their difference, subjecting the difference frequency to a beating action with at least one other locally supplied frequency, thereby producing a frequency determined by the difference frequency but higher in the frequency spectrum, combining the resultant frequency with one of the frequencies to be synchronized and then beating the combined frequencies with another frequency to produce a frequency corresponding to the other frequency to be synchronized.

4. The method of synchronizing two frequencies which consists in combining the two frequencies so as to produce a frequency corresponding to their difference, subjecting the differency frequency to successive beating operations to produce a frequency determined by said difference frequency but higher in the frequency spectrum, combining the resultant frequency with one of the frequencies to be synchronized and then combining the resultant frequency with a frequency differing from the frequency derived from the difference frequency by an amount equal to the difference frequency.

5. In a synchronizing system, a modulator, means to supply to said modulator two frequencies which are to be synchronized, means to select the difference frequency from said modulator, apparatus to step up said difference frequency in the frequency spectrum by a predetermined amount, a second modulator, means to impress said stepped up frequency and one of the frequencies to be synchronized upon said second modulator, and means to derive from the resultant frequency a frequency corresponding to the other frequency to be synchronized.

6. In a synchronizing system, a modulator, means to supply to said modulator two frequencies which are to be synchronized, means to select the difference frequency from said modulator, means to step up said difference frequency by a predetermined amount through a succession of beating operations, a second modulator, means to impress said stepped up frequency and one of the frequencies to be synchronized upon said second modulator, means to select the resultant difference frequency from the modulator, means to produce a frequency differing from said stepped up frequency by an amount equal to the original difference frequency, a third modulator and means to apply the frequency thus produced and the frequency selected from the second modulator to said third modulator, thereby producing a frequency corresponding to the other frequency to be synchronized.

In testimony whereof I have signed my name to this specification this 29th day of September 1919.

LLOYD ESPENSCHIED.