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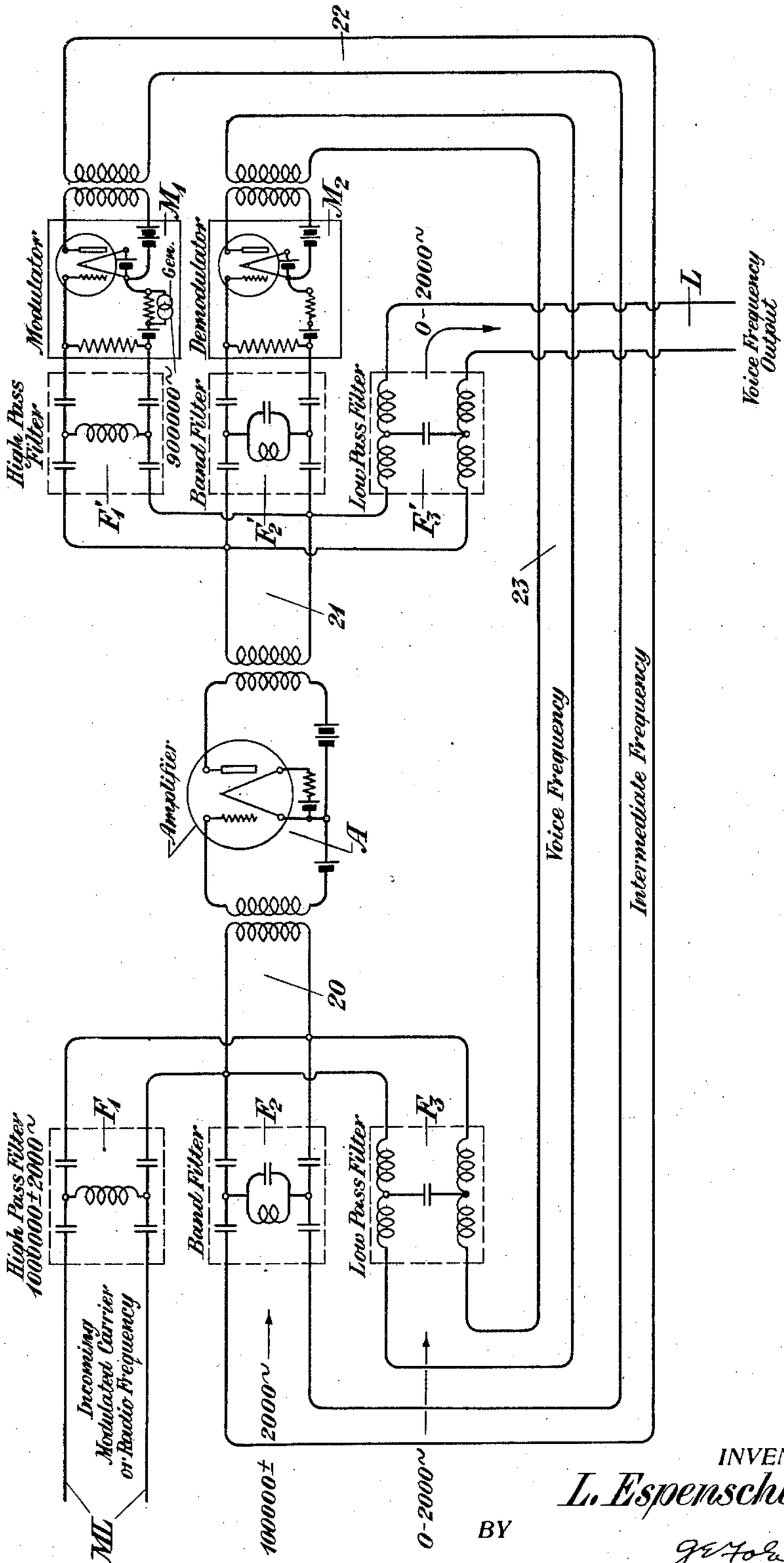

INVENTOR
L. Espenschied

BY

ATTORNEY

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LLOYD ESPENSCHIED, OF HOLLIS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

NONSINGING REAMPLIFYING CIRCUITS.

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This invention relates to signaling circuits and more particularly to arrangements for amplifying weak signaling currents.

In accordance with the present invention it is proposed to treat the energy to be amplified by passing it again and again through an amplifier successively at different frequencies so that the energy is amplified a plurality of times by a single amplifier. Between each transmission through the amplifier the energy is shifted in frequency in some well known manner, as for example, by modulating it with a carrier frequency. The method is peculiarly adapted to signaling systems such as radio receiving circuits or other forms of carrier circuits in which the signaling energy is received at a high frequency and is translated to an ordinary signaling frequency. Where the receiving frequency is quite high it is often desirable to translate it to the low frequency signal by a succession of steps of demodulation and in accordance with the present invention the stepped-down frequency may be passed through the same amplifier each time it is stepped-down. While the invention, as stated, is peculiarly adapted to receiving apparatus of a radio or other carrier system it may be applied to the sending station of such a system with some economy, especially where the ordinary signaling frequency is stepped-up to a radio frequency by a plurality of steps of modulation.

One of the principal advantages of the method of the present invention resides in the possibility of working the amplifier up to its full capacity. An amplifier may be capable of amplifying the input energy impressed upon it a given number of times independently of the amount of input energy impressed upon it. If, however, the amplifier is used only to amplify a very weak current and is actually capable of amplifying an equal number of times a much larger current, it is at once apparent that a method by which the full working capacity of the amplifier may be utilized will be advantageous. Heretofore. it has been proposed to amplify very weak signaling energy by passing it through a number of successions of amplifying devices until the output energy is great enough for the practical purposes of receiving or transmitting, as the case may be. In such a system only the last amplifier of the series, if any, will be operating at its full capacity. In accordance with the present invention, the entire process of several stages of amplification may be accomplished with a single amplifier. The only instance in which it has been proposed to use the same amplifier for successive amplifications has been where a radio signal is passed through an amplifier at the receiving station, then detected, and the detected signal passed through the same amplifier. This method is limited, however, to two steps of amplification through the same amplifier because the signal is translated from the radio frequency to the detected frequency in a single step. Where the received energy is initially very small it will be obvious that such a method will not utilize the full working capacity of the amplifier and will not give a sufficiently strong signal, so that it will be necessary to pass the low frequency signal thus amplified through successive amplifiers until the desired energy amplification is attained.

The limit of the efficiency of the proposed method of amplification is, of course, the power carrying capacity of the amplifying tube circuit. Roughly, it may be stated that the sum of the energy of all the successive frequencies combined must not exceed the carrying capacity of the tube. Of course, if the tube is overloaded the currents of the several frequencies passing through it will be modulated together and interfering distorted components will be set up.

The inventior may now be more fully understood by reference to the following detailed description when read in connection with the accompanying drawing, the figure of which illustrates a preferred embodiment of the invention.

Referring to the drawing, ML designates a receiving circuit over which modulated carrier or radio frequencies, for example, may be received. In the case assumed, a filter F_1 is provided in said circuit, said filter being designed to transmit a carrier frequency of 1,000,000 cycles plus or minus a band of 2,000 cycles representing the voice signaling wave in accordance with which the carrier is modulated. This total band of 4,000 cycles is impressed upon a circuit 20 leading to an amplifier A of any well known type such as, for example, a three-element vacuum tube amplifier. The received band, after being amplified by the amplifier A, is

passed into an outgoing circuit 21, having a plurality of branches associated therewith. One of the branches includes a filter F_1' for passing the same range of frequencies as the filter F_1 and beyond the filter a modulator M_1 is provided. This modulator may be of the usual vacuum tube type and is so arranged that in addition to the amplified signaling band of 1,000,000 cycles plus or minus 2,000 cycles impressed upon its input circuit there will be a local frequency of, say, 900,000 cycles impressed upon its input circuit. As a consequence, a component will appear in its input circuit equal to the difference between the input frequencies and the local beating frequency, this component, in the case assumed, being 100,000 cycles plus or minus 2,000 cycles. This band is passed through a circuit 22 to a filter F_2 adapted to select its lower side band resulting from the modulating action of the modulator M_1 from the upper side band and other frequencies involved so that the selected band will be impressed through the circuit 20 upon the amplifier A. The amplifier A again amplifies the original received energy at a different frequency and again passes it to the circuit 21.

A second branch of the circuit 21 is provided with a filter F_2' which selects the band of frequencies represented by 100,000 cycles plus or minus 2,000 cycles and impresses said band upon a demodulator M_2, which may also be of the well known vacuum tube type. In its output circuit there will appear a detected band of frequencies resulting from the interaction of the stepped-down carrier frequency of 100,000 cycles with the impressed frequency band extending over a range of 4,000 cycles in the neighborhood of 100,000 cycles. This detected band of frequencies will comprise a band from zero to 2,000 cycles, the original signal which modulated the carrier being within this band. The detected low frequency band just referred to passes into an outgoing circuit 23, leading from the modulator M_2 through a filter F_3 to the common input circuit 20, so that the detected band is impressed upon the amplifier A and the received energy again amplified at still another frequency. The amplified energy of from zero to 2,000 cycles passes into the outgoing circuit 21 which is provided with a branch including a filter F_3' which selects from the circuit 21 the final low frequency energy and transmits it to the final receiving circuit L.

It will be obvious that additional steps of amplification, by means of the single amplifier shown, may be obtained by increasing the number of frequency translating steps to which the received energy is subjected. In other words, each time an additional step of modulation is provided the output energy resulting from the modulation may be passed through the amplifier and this process may be repeated practically indefinitely. No singing can possibly take place by reason of having the output circuit of the amplifier coupled to the input circuit owing to the fact that a change in frequency occurs each time the energy is re-passed through the amplifier.

While the method as disclosed involves the provision of additional tubes used as modulators it will be apparent that where the energy received is very weak and is quite high in frequency, the additional tubes used for modulating purposes will have to be provided in any event for the purpose of stepping the frequency down from its high frequency carrier form to its ordinary signaling frequency, so that where this is necessary the method involves a clear gain in that a single amplifier may do the work of several and, in fact, may do all of the work of which a single amplifier is capable.

The input and output transformers of the amplifier A may be assumed to be any type of arrangement capable of transmitting a wide range of frequencies. Owing to the difficulty of designing transformers capable of efficient transmission over a wide range, it will be understood that the windings conventionally indicated in the drawing may represent, in actual practice, a multiple transformer arrangement of which the component units are each efficient over a particular frequency range narrower than that over which the whole transformer operates.

It will 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 appended claims.

What is claimed is:

1. An amplifying system comprising an amplifier, an incoming circuit and an outgoing circuit, a plurality of feed-back connections between said incoming and outgoing circuits, means in each of said feed-back connections for producing a change in the frequency of energy transmitted thereover which is different from that of each of the other connections, and means in each of said feed-back connections for selecting a given frequency from the outgoing circuit and impressing a different frequency upon the incoming circuit.

2. An amplifying system comprising an amplifier, an incoming circuit and an outgoing circuit, a plurality of feed-back connections between said incoming and outgoing circuits, means in each of said feed-back connections for producing a change in the frequency of energy transmitted thereover which is different from that of each of the other connections, and wave filters in each

of said feed-back connections for selecting a given frequency from the outgoing circuit and impressing a different frequency upon the incoming circuit.

3. An amplifying system comprising an amplifier, an incoming and an outgoing circuit, means to impress high frequency signals of small energy upon said incoming circuit, a feed-back connection from said outgoing circuit to said incoming circuit, means in said feed-back connection to step down the amplified energy to an intermediate frequency stage, means in said feed-back connection to impress the intermediate frequency energy upon said amplifier for further amplification, a second feed-back connection from said outgoing circuit to said incoming circuit, means in said second feed-back connection to further step down the frequency after the second stage of amplification to a third frequency, and means to impress the re-stepped-down energy upon the incoming circuit of said amplifier.

4. An amplifying system comprising an amplifier, an incoming circuit and an outgoing circuit, means to impress high frequency signals of small energy upon said incoming circuit of said amplifier, a feed-back connection from said outgoing circuit to said incoming circuit, means in said feed-back circuit to beat the amplified high frequency signal energy with energy of another frequency to produce a signal wave of lower frequency than the original signal wave, means to impress the lower signal wave upon said incoming circuit for further amplification, a second feed-back connection from the outgoing circuit to the incoming circuit, means in said second feed-back connection for stepping down said lower frequency wave after amplification to a still lower frequency stage, and means in said second feed-back connection for impressing the energy thus stepped down upon said incoming circuit for further amplification.

5. An amplifying system comprising an amplifier having an incoming circuit and an outgoing circuit, means to impress high frequency signals of small energy upon said amplifier after amplification, a feed-back connection from said outgoing circuit to said incoming circuit, means in said feed-back connection to step down the amplified energy to an intermediate frequency stage, a filter in said feed-back connection for selecting the intermediate frequency energy and impressing it upon said amplifier for further amplification, a second feed-back connection from said outgoing circuit to said incoming circuit, means in said second feed-back connection to further step down the frequency after the second stage of amplification to a third frequency, and a filter in said second feed-back connection to select said third frequency and impress it upon said amplifier for further amplification.

In testimony whereof, I have signed my name to this specification this 14th day of May 1923.

LLOYD ESPENSCHIED.