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ELECTRICAL SIGNALING SYSTEM

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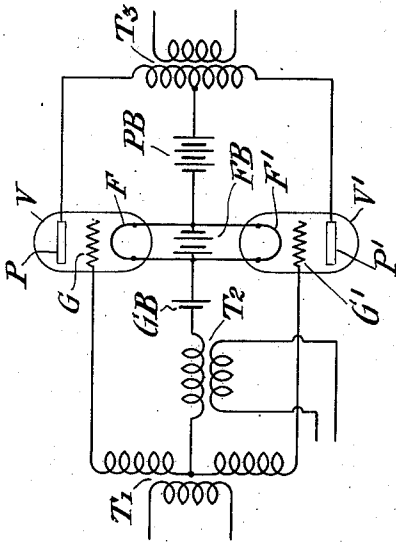


Fig. 1.

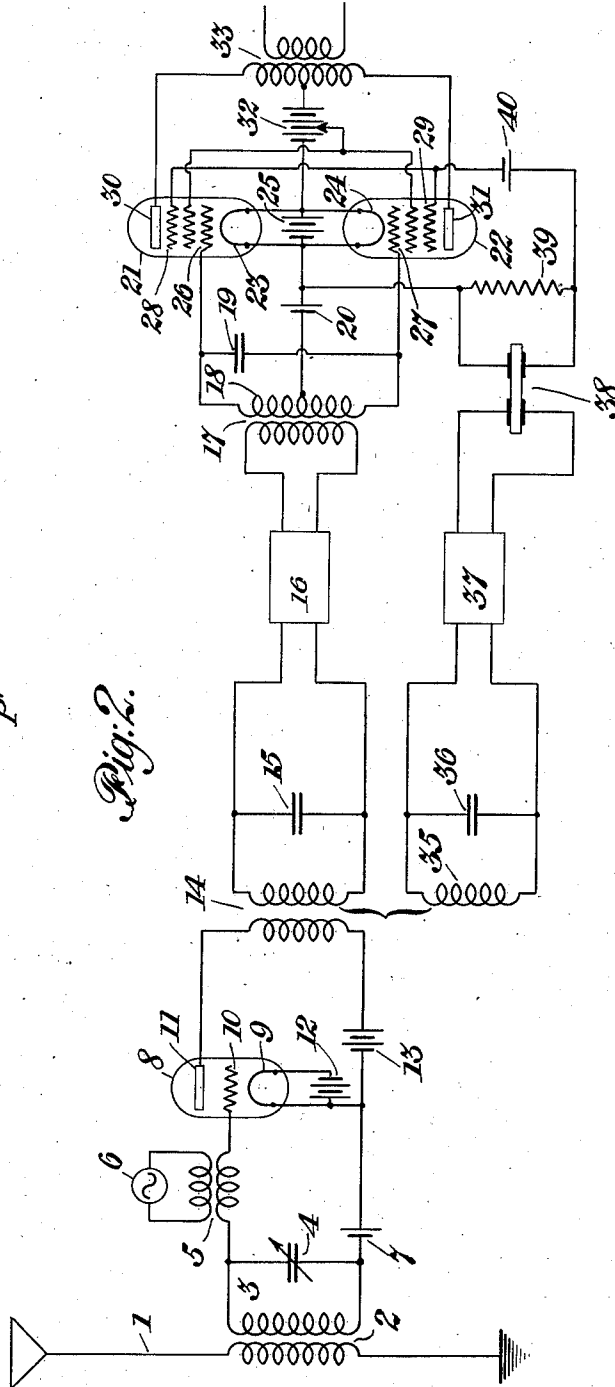


Fig. 2.

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ELECTRICAL SIGNALING SYSTEM

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3 Claims. (Cl. 250—20)

My present invention relates broadly to electrical signaling, and particularly to improved procedure for receiving and utilizing the effects in so-called "carrier" or modulated signal bearing currents or oscillations generally utilized in the practices of radio telephony, carrier current telephony and equivalent or like forms of electrical communication.

In the practice of radio telephony, for example, a definite suitably high frequency for the fundamental operating or so-called carrier current is usually chosen or assigned for each channel or service, and alternating current of this definite frequency is continuously generated during active operation by the alternating current generating apparatus located at the transmitting terminal of the system. Separate alternating currents of the sound producing frequencies of telephony are generated and impressed upon the continuously generated carrier currents, creating by so-called beating or interference action with the carrier current a series or band of oscillations of frequencies above and below the carrier current frequency in accordance with the differences between the carrier current frequency and the various frequencies of the impressed sound representing currents.

These beat produced oscillations are generally termed the upper and lower side bands. The result is that the energy emissions emanating from the usual radio telephone transmitter are not wholly of the form of carrier current frequency oscillations varied in amplitude in response to the impressed sound currents, but include a series of oscillations of frequencies both higher and lower than the frequency of the carrier current, and differ in frequency from the carrier current frequency by an amount equal to the frequency of the sound producing current acting with the carrier current to form the particular side band oscillation.

It is apparent that these side band oscillations, once created, can, like any other electrical oscillation, be combined with oscillations to produce beat oscillations or currents. Obviously, if the oscillation combined with the side band oscillation is of the same frequency as the original carrier current, the resulting beat oscillations will have the sound producing frequencies of the original sound representing oscillations impressed on the original carrier oscillation. In other words, if the side band including emissions radiated by a radio telephone or like transmitter be collected or received in any manner, the original sound producing frequency oscillations can be reestablished from these side band oscillations by impressing on the received energy an oscillation of the same frequency as the original carrier current frequency. I have found that I can advantageously make use of the above outlined pro-

cedure and functioning in the reception of radio telephone and like electrical signal effects.

The extensive use made of electrical signaling compels intensive use of the principles of electrical tuning or syntony for distinguishing the operations of different communication channels one from the other. The principles involved in selectively distinguishing electrical signal operations of different channels at different frequencies, and the practices for accomplishment of the results, are so well understood and developed that legal supervision over such operations has long fixed and imposed severe selectivity requirements in such operations.

One common practice for satisfying the selectivity requirements is to receive the incoming signal bearing energy on, or pass it through, one or more highly selective (low decrement) receiving circuits. In other words, to depend upon resonant or accentuated resonant reception, the nature and characteristics of which are so well understood by the art as to require no detailed outline of them by me. For example, the neighboring stations of the officially authorized radio telephone broadcasting system now functioning in the United States are spaced not less than 10 kilocycles apart in assigned operating frequencies. This restriction makes it necessary for the radio broadcast receiver producers furnishing the public with broadcast receivers to design receivers capable of reasonable selective discrimination to avoid the objectionable effects of the signals of an unwanted station overlapping and interfering with the signals of a wanted station.

Attempt has been made to meet these severe requirements in practice by designing receiving circuits with lowest possible decrements, and cascading a number of such circuits to multiply the selectivity effects, radio receivers having three and four very low decrement tunable receiving or input circuits in cascade not being uncommon.

This accentuation of selectivity clearly operates against faithful reproduction of the incoming signal bearing energy. Obviously, the more the electrical selectivity is increased, the more the energy in the side bands is attenuated in comparison to the energy of the carrier current per se. It is readily appreciated that with a very high order of selectivity in the input receiving system, the energy of a side band 10 kilocycles (a desirable sound producing frequency) away from the carrier current accepted by the highly selective receiving system may be so small compared to the carrier current energy as to have no comparative practical value in the sound reproductive ability of the system.

Summarizing these considerations, it is seen that faithfulness of reproduction of the sounds represented in and carried by the side band oscillations suffers the more the electrical selectivity

of the receiving circuits is accentuated to increase selectivity of one transmitting station from another. Consideration of the ordinary receiving resonance curve clearly shows that the rate of attenuation throughout the usual sound side band range is far from uniform.

It is one of the principal features of my present invention that I avoid serious discrimination against the effective reception of the very important sound representing energies of the side band oscillations, this while providing for effective discrimination in the reception of the energies emanating from different transmitting stations closely spaced in their operating frequencies. In other words, I provide for maintaining high quality of reproduction without sacrificing desirable station-to-station discrimination.

The features of my invention and the uses of them are described in connection with the figures of the accompanying drawing. Fig. 1 diagrammatically illustrates an arrangement in which certain features and effects involved in my invention may be made manifest, and Fig. 2 diagrammatically illustrates the adaptation of certain features of my invention to a radio receiver.

Referring to Fig. 1, I show two three-electrode vacuum tubes V and V', conventionally energized by batteries or other suitable potential sources GB, FB and PB, these tubes being connected in parallel relation. Transformers T₁ and T₂, connected to non-indicated sources of electrical oscillations, provide means for energizing the input or grid electrodes G and G' through the parallel connected input circuits coupled in with the two input transformers T₁ and T₂. The input oscillations introduced through transformer T₁ divide so as to impress opposite polarity potentials on grids G and G' of the two tubes, while the input oscillations introduced through transformer T₂ divide so as to impress on the grids of the two tubes potentials of like polarity.

The output oscillations, resulting from the input oscillations, circulate in both branches of the paralleled output circuits shown connected to anodes P and P' of the two tubes, passing in opposite directions through the upper and lower halves of the primary winding of output transformer T₃.

With the arrangement shown in Fig. 1, I find that the introduction of the usual modulated or side band bearing signal currents of radio telephony and the like, either separately through either transformer T₁ or transformer T₂, results in little or no manifestation of the presence of sound or audio frequency current components in the output from output transformer T₃. In other words, ordinary detection of the modulation extraction action is minor in effect irrespective of the choice of path of introduction of the incoming signal energy.

I find, however, that if introduction of signal bearing currents through either path is accompanied by introduction through the other path of oscillations of fixed frequency the same as the carrier current frequency from which the introduced signal bearing currents were generated, and of a phase other than 90° with respect to the original carrier current phase (preferably the same phase or 180° out of phase), that the sound or other signal representing components of the incoming signal currents become prominently manifested in the output side of transformer T₃.

For example, if usual radio telephone signal currents extracted from space are introduced into the system of Fig. 1 through transformer T₁ they

will not be well heard in a listening device connected with the output of transformer T₃ unless acted upon by oscillations of the same frequency as that of the generated current out of which the incoming signal bearing currents were developed, and differing in phase by something other than 90°, this accessory current being introduced through transformer T₂.

It is immaterial whether this accessory current is originated in a separate source, such as a local generator, or is extracted from the carrier current component of the incoming signal current being operated upon by the accessory current. It is essential only that the phase of the accessory current differ from the phase of the carrier current of the incoming signal currents by something different from 90°. If the accessory current is extracted from the received incoming signal current, it is desirable that the extraction be highly selective so that the accessory current is substantially pure; that is reasonably devoid of side band and other adulterating energy effects.

It is apparent that if a low order of selectivity (broad tuning) is utilized in extracting the signal current energy from space and transferring it from one portion of the system to another prior to combination with the accessory current, the high frequency side band energy is much more effectively preserved along with the low frequency side band energy than is possible with the high order of selectivity of reception now in general use in connection with radio telephone and like practices.

For example, the selectivity of reception usual to present practice, comparatively considered, enormously eliminates the energy in a 500 cycle sound representing side band as compared to a 100 cycle sound representing side band, both of which are of substantial importance to the range necessary to faithful sound reproduction.

The procedure outlined by me permits of broad, non-selective reception of the incoming signal oscillations, thereby more effectively including the high frequency side band components in comparison with existing reception practice, and distinguishing or bringing out the signal frequency components by selective beating or heterodyning the strongly maintained side band oscillations with an oscillation of frequency essential to re-converting the side band energy to its original sound representing character.

In Fig. 2, I show an arrangement for making most effective use of the procedure I have above generally outlined in connection with usual radio telephone reception, such as broadcast reception. A space energy collector or antenna 1 is coupled through a transformer 2 to a tunable circuit 3 including a tuning condenser 4, the terminals of which condenser are connected to grid electrode 10 and filament 9 of a three-electrode vacuum tube 8 having its electrodes energized by potential sources 7, 12 and 13, which potential sources are conventionally indicated as batteries.

The tunable circuit 3 is preferably made no more selective than necessary to reasonably distinguish by resonance the desired signal transmissions from those of its nearest in frequency assigned neighboring station. For example, in broadcast reception stations so closely spaced geographically as to be capable of serious interference between their transmissions within their respective listening areas are spaced not less than 10,000 cycles in assigned operating frequencies in the broadcast practice in the United States, and this close spacing in frequency is confined to those

stations widely separated geographically. In other words, the arrangement and practice makes it possible not to employ an undesirable high order of selectivity in tunable receiving circuit 3 to obtain a satisfactory degree of distinction in received energies within the requirements of my procedure.

Continuing consideration of Fig. 2, the broadly received signal oscillations are combined with fixed frequency locally generated oscillations from a suitable source, such as the indicated oscillation generator 6 coupled by transformer 5 with the input system. This arrangement results in producing a beat frequency set of oscillations including the sound representing side band components in the output circuit of tube 8, transferable onward through the transformer 14. The carrier or average frequency of this beat current is represented by the difference between the frequency of the locally generated oscillations of generator 6 and the frequency of the carrier component of the picked up or incoming signal bearing oscillation. In other words, the received signal bearing oscillations are converted into some desired new frequency carrier still having the same signal bearing effects.

These new frequency oscillations are passed on through split transformer 17, after amplification in an indicated intervening amplifier unit 16, if desired, to a parallel connected pair of electron tubes 21 and 22 similarly as described in connection with the arrangement of Fig. 1. The output electrodes 30 and 31 of these parallel connected tubes, like Fig. 1, are connected to the opposite terminals of the split primary of output transformer 33.

In order to make effective the sound representing side band effects in the new frequency oscillations passed along to the paralleled tube system above outlined, some of the new frequency oscillation energy is utilized as the accessory oscillation that must be impressed on the signal current to bring out the effects in the manner described in connection with Fig. 1. Coil 35 is shown coupled to the secondary winding of transformer 14, and with the aid of tuning condenser 36 this absorbing circuit may be highly selective of the carrier or average frequency component of the new frequency oscillations.

This selectively absorbed accessory oscillation may, if desired, be amplified by passing through an indicated amplifier 37, this in order to duplicate any amplification that may be imparted to the new signal oscillations by amplifier 16 previously referred to. The accessory oscillation is shown subjected to a highly selective as to frequency electrical filter 38 such, for example, as the quartz crystal now commonly used to forcibly determine oscillating periods of electrical systems, or other electromechanical resonance arrangements such as is possible with magnetostriction effects.

The resulting sharply defined accessory oscillation is now impressed on the new signal oscillations by applying the potentials developed by the accessory oscillation in resistance 39 in shunt to filter 38 to the auxiliary grid electrodes 28 and 29 in tubes 21 and 22, which arrangement is a preferred form of combining or bringing together the desired effect producing oscillations over that shown in the simple three-electrode tube of Fig. 1. While the functioning in both arrangements is equivalent in results, the auxiliary grid arrangement of Fig. 2 is the more efficient and lessens

difficulties in selection of impedance and the like in satisfying design requirements.

The potential sources 20, 25, 32 and 40, conventionally indicated as batteries, provide for the usual operative energizing of the various electrodes of tubes 21 and 22.

The arrangement provides for satisfactory phase relation between the new signal oscillations and the accessory influencing oscillation. While the transfer of energy from the secondary winding of transformer 14 to coil 35 involves a phase displacement of approximately 90°, the undesired phase relation, the quartz crystal filter unit also introduces a phase displacement of approximately 90°, so that the over all result in the travel of the accessory current effects to the auxiliary grid electrodes of the tubes is considerably removed from the unwanted 90° displacement.

Reduction of the procedure to the fixed, one frequency basis provided for in the arrangement of Fig. 2 is of decided benefit and advantage to practice. Other than the simple adjustment needed to select out of the antenna the energy of the desired transmitting station, the system is of fixed, permanent nature throughout, and yet capable of reception at all the frequencies of the broadcast range.

Having fully described my invention I claim:

1. In combination, a receiver of a modulated carrier having a sufficiently broad tuning characteristic to amplify substantially uniformly the audio-frequency side bands of said carrier, means for selecting the carrier frequency from the modulated carrier including a circuit selective to the carrier frequency only, a circuit resonant at carrier frequency and adapted to suppress all side-band frequencies, the latter circuit being connected to said selector circuit, and a combining circuit including two translating devices and circuit connections therefor for impressing the amplified modulated carrier upon said devices in opposite sense and impressing the carrier from said resonant circuit upon the devices in the same sense.

2. In combination, a receiver of a modulated carrier having a sufficiently broad tuning characteristic to provide substantially uniform amplification of the audio-frequency side bands of said carrier, a tuned circuit loosely coupled to said receiver, said circuit being selective to the carrier frequency only, an electro-mechanical filter connected to said tuned circuit, said filter being resonant to the carrier frequency only, and a combining circuit including two translating devices and circuit connections therefor for impressing the output of said filter upon said devices in the same sense and impressing the amplified modulated carrier upon said devices in opposite sense.

3. In combination, a receiver of a modulated carrier having a sufficiently broad tuning characteristic to provide substantially uniform amplification of the audio-frequency side bands of said carrier, a tuned circuit loosely coupled to said receiver, said circuit being selective to the carrier frequency only, an amplifying circuit resonant at the same frequency and connected to said tuned circuit, the over-all amplification of said broad and selective circuits being of the same order of magnitude, and a combining circuit adapted to demodulate the broadly tuned modulated carrier by means of the output of said resonant amplifying circuit.

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