Feb. 24, 1931. W. T. POWELL 1,793,959

RADIO RECEIVING SYSTEM

Filed May 29, 1924

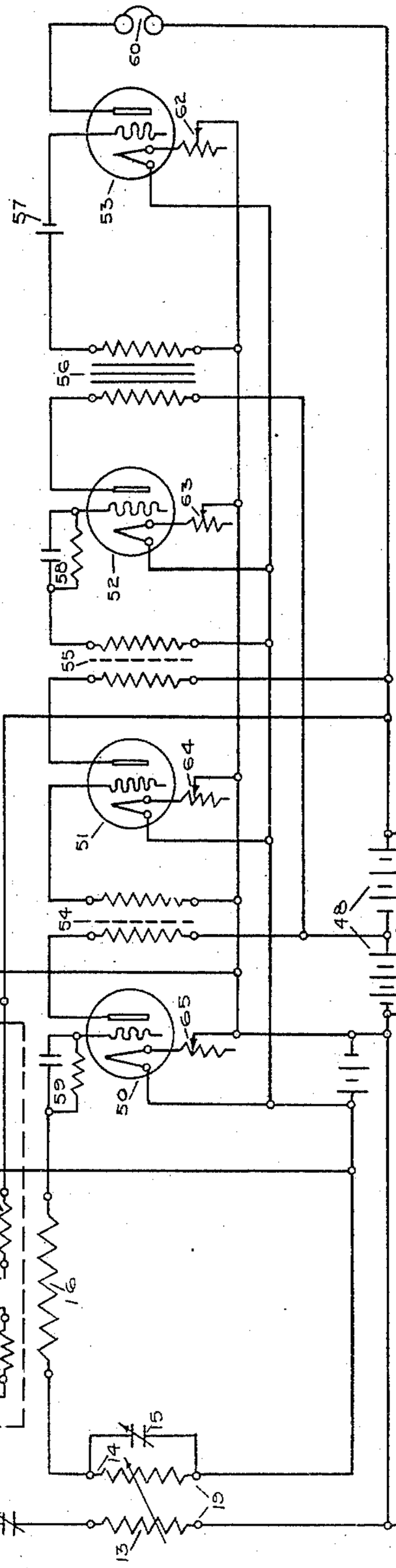

FIG.-1

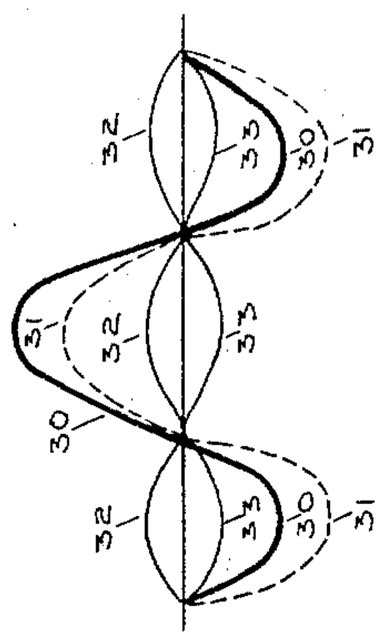

FIG.-3

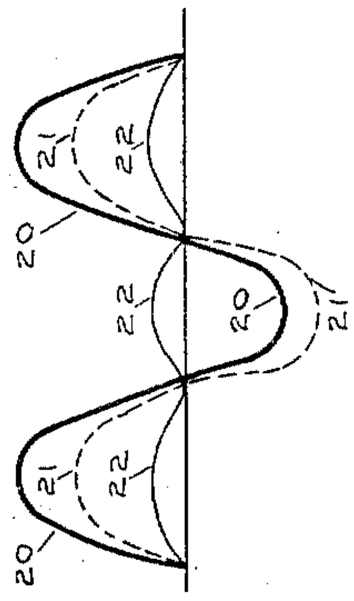

FIG.-2

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Patented Feb. 24, 1931 1,793,959

UNITED STATES PATENT OFFICE

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RADIO RECEIVING SYSTEM

Application filed May 29, 1924. Serial No. 716,786.

This invention relates to systems for receiving high frequency radio signals and more particularly to a radio receiving system in which the so-called "second harmonic heterodyne" principle is used.

As is well known a system of this type operates in general as follows: an incoming radio signal is caused to "beat" with a locally generated oscillation and the resultant wave is impressed on the input of a detector. The detected signal in the output of the detector is then amplified by means of one or more intermediate frequency amplifiers after which the signal is again detected and the resulting audio signal is then received on a telephone set either before or after passing through one or more audio frequency amplifiers. The local oscillator is operated at a fundamental frequency which is one half that required to give a resultant frequency of the proper value to operate the intermediate amplifier when the local oscillation "beats" with the incoming signal. The locally generated second harmonic is therefore of the proper frequency to "heterodyne" with the received signal for producing the proper intermediate frequency.

Inasmuch as the fundamental frequency is one half the value of the second harmonic used when receiving a particular desired signal by this method, it is quite evident that an undesired signal of the proper frequency can "beat" with the fundamental to produce the resultant intermediate frequency, and be detected at the same time as the desired signal. This is objectionable and results in considerable interference.

An object of this invention is the provision of a circuit arrangement such that the second harmonic wave of a locally generated oscillation will "beat" with an incoming signal while the first harmonic or fundamental wave of the locally generated oscillation will be prevented from combining with an incoming signal to produce an undesired signal.

It is another object of the invention to so arrange the circuits that the locally generated fundamental wave will not be impressed on the receiving antenna.

Further objects of the invention will appear in the following detailed description.

The manner in which these objects are accomplished will be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 represents a circuit diagram of one particular system in which the invention may be employed and Figs. 2 and 3 illustrate by curves how the arrangement of this invention serves to eliminate interference, due to undesired signals "beating" with the locally generated fundamental oscillations and also how radiation of the locally generated fundamental wave is prevented.

Referring to Fig. 1, reference numeral 11 indicates an antenna, which is connected to ground through a tuned circuit consisting of variable condenser 12 and primary winding 13 of coupler 19. Secondary coil 14 is bridged by variable condenser 15, these two latter elements comprising a tuned secondary circuit, which is connected to the input of the first detector tube in series with inductance coil 16. Coupled to inductance 16 are inductances 17 and 18 which are so wound and connected to the plates of the oscillators that currents in these plate circuits, which are in phase will aid in their inductive effect on coil 16, while currents which are 180 degrees different in phase or in opposition will have no effect on coil 16.

That part of the drawing within the dotted rectangle represents an oscillator unit consisting of a primary oscillator 70 which is coupled to a secondary oscillator 80, in such a manner that the former functions as a driver for the latter. The output of oscillator 70 is coupled to the input of oscillator 80 by means of condenser 71 and variable resistance 72, the contact 73 being so adjusted that, as seen from tube 80, the effective amplification of tube 70 is unity.

Tube 80 functions to repeat in its output circuit the wave appearing in the output of oscillator 70 and at the same time it produces a harmonic of its own, as hereafter described. Although the operation of tube 80 and its associated circuits resembles a combination of repeater, detector and amplifier, it will be referred to in the description and claims as an oscillator.

The tuned grid circuit type of oscillator is used in which variable capacity 41 and inductance 42 constitute a closed oscillation circuit, the natural period of which may be varied as desired. This oscillation circuit is connected to the grid 43 and filament 44 of vacuum tube 70 by means of conductors 45 and 46 respectively. Adjustably coupled to inductance 42 is inductance 47 which, in series with inductance 17, plate battery 48 and the plate-filament circuit within the tube, forms the output circuit of oscillator 70. The underlying principles of the operation of such an oscillator has been frequently described, one such description being given on page 85 of "The Thermionic Vacuum Tube" by Van Der Bijl.

Condenser 71 and resistance 72 are connected in series across the plate-filament circuit of oscillator 70 and contact 73, which is variably connected to resistance 72, is connected to grid 49, thus connecting the grid-filament circuit of oscillator 80 across a portion of the output circuit of oscillator 70. This arrangement functions as a double oscillator, the frequencies of the two being equal and the amplitudes in the output circuits of both tubes being substantially the same. Inductance coils 17 and 18 in the output circuits of oscillators 70 and 80 are coupled to inductance coil 16, and as above pointed out, are so wound and connected that currents flowing through coils 17 and 18 which are 180 degrees different in phase have substantially no effect on coil 16.

Vacuum tube 50 is the first detector and the detected "beat" or intermediate frequency wave appearing in the output circuit of this tube is coupled by transformer 54 to intermediate amplifier 51. One or more such amplifiers may be used and the output of the last amplifier is coupled to the second detector 52 by means of transformer 55. The output circuit of detector 52 is coupled to audio amplifier 53 by means of transformer 56. A "C" battery 57 is shown connected in the grid circuit of amplifier 53 and is for the purpose of maintaining the grid of this tube sufficiently negative for operation on the most desirable point of its characteristic curve.

58 and 59 indicate the usual grid condensers and grid leaks for detectors 52 and 50. It will be understood that additional audio amplifiers may be used for amplifying the audio signal to the proper amount for reception by the indicator 60 which may be a telephone or loud speaker. Condenser 61 acts as a radio frequency "by pass" around battery 48 while 62, 63, 64, 65 and 66 are the usual filament rheostats.

It will be assumed for the purpose of explanation that an incoming signal of a single frequency is impressed across the tuned secondary circuits 14, 15 and that this frequency is 833 kilo-cycles. It will be further assumed that the intermediate frequency amplifier is arranged to operate at 50 kilo-cycles, therefore, in order to produce this intermediate frequency when the incoming signal is "heterodyned" with the locally generated oscillation, the frequency of the local oscillation must be 783 or 883 kilo-cycles. For the second harmonic to be either of these frequencies the oscillator must be so adjusted that it will oscillate at approximately 392 or 442 kilo-cycles. Assume in this instance that a value of 392 kilo-cycles is used and that an undesired incoming signal of 342 or 442 kilo-cycles is being impressed on the antenna, it will be seen that unless some means is provided to keep the fundamental from combining with this undesired signal, they will interact to produce the intermediate or 50 kilo-cycle oscillation and the undesired signal will be received at the same time as the desired signal.

The manner in which the locally generated fundamental frequency oscillation is kept out of the incoming or grid-filament circuit of the first detector, while the second harmonic oscillation is impressed on the incoming circuit will be readily understood by referring to Figs. 2 and 3.

On account of the curvature of the characteristic, the current wave in the plate circuit of oscillator 70 is not a pure sinusoid, but is distorted as shown by curve 20 of Fig. 2. This curve may be resolved into its two components, namely, the fundamental frequency curve 21 and the second harmonic curve 22. That the second harmonic wave 22, should be in the phase shown will be apparent by noting that it must be as shown in order that the algebraic sum of the fundamental 21 and the second harmonic 22 will at all points equal the resultant wave 20.

A certain amount of the current in the output of tube 70 is tapped off and impressed upon the grid of tube 80 and since the potential impressed on grid 49 is of such value that the current wave in the output of tube 80 is of the same amplitude as that in the output of tube 70, this current wave will be as shown by curve 30 of Fig. 3. This wave will also be distorted because of the curvature of the characteristic of tube 80. Since oscillator 80 is driven by oscillator 70, the frequency of wave 30 will be the same as wave 20, but it will be 180 degrees out of phase with wave 20, due to the fact that an increase of current in the output of tube 70 produces a decrease of current in the output of tube 80.

Curve 30 may be resolved into its fundamental curve 31 and second harmonic curve 32. That curve 32 is in the phase shown, is for the same reason as pointed out above for tube 70. It should be noted that curves 22 and 32 are produced by 70 and 80 respectively. Since current wave 22 appears in the output of tube 70, a certain amount of it will be

impressed on the input of tube 80 and will be reproduced in the output of this tube, but will be 180 degrees out of phase with curve 22 as shown by curve 33. The reason curve 33 is 180 degrees out of phase with curve 22 is also due to the fact that an increase of current in the output of tube 70 produces a decrease of current in the output of tube 80.

Since fundamental curves 21 and 31 are 180 degrees out of phase and as these curves represent currents flowing through coils 17 and 18 respectively, it will be seen, by noting the current directions through these coils, as shown by the arrows, that the fundamentals will neutralize each other and will not induce currents in coil 16. It will also be noted that the second harmonic waves represented by curves 22 and 33 are also 180 degrees out of phase and will neutralize each other with the result that they will not induce currents in coil 16. Curve 32, however, which represents a second harmonic wave, is not cancelled and it will be effective to induce a second harmonic current into coil 16, which will "beat" with the incoming signal impressed on this coil by tuned circuits 14, 15 and the resultant wave will then be impressed on the grid-filament circuit of the detector, detected and amplified in the well known manner.

Since the fundamental frequency of the oscillator is not fed into coil 16, it will be apparent that this frequency, which is of considerable amplitude, will not be radiated from the antenna. It therefore, follows that this invention provides a means for substantially eliminating the fundamental frequencies developed by the amplification of alternating current waves by devices having a curved characteristic.

This invention, however, is not limited to the case where the two stages are exactly similar. Even where the tubes have widely different characteristics the fundamentals may be considerably reduced by the adjustment of potentiometer 72, so that the fundamentals in the output of tube 70 will be substantially neutralized by the fundamentals in the output of tube 80.

It is to be understood that the circuit arrangement above described may be variously modified without departing in any way from the spirit of this invention, as defined in the appended claims.

What I claim is:

1. The combination in a signal receiving system of an incoming circuit upon which signals are impressed, a local oscillation circuit for impressing first and second harmonic current waves upon said incoming circuit, and means for neutralizing said first harmonic current waves.

2. The combination in a signal receiving system of an incoming circuit upon which signals are impressed, an oscillation circuit for impressing fundamental and harmonic current waves upon said incoming circuit, and means for neutralizing said fundamental current waves.

3. The combination in a signal receiving system of an incoming circuit upon which a signal wave is impressed, an oscillation circuit coupled to said incoming circuit, means for producing in said oscillation circuit a current wave of two components, one of which is a harmonic component, and means for neutralizing one of said components.

4. The combination in a signal receiving system of an incoming circuit upon which a signal wave is impressed, an oscillation circuit upon which a local wave consisting of two components is impressed, one of said components being a harmonic component, a detector for receiving a resultant wave and means for combining said signal wave with one component only of said local wave to produce said resultant wave.

5. The combination in a signal receiving system of an incoming circuit for receiving a high frequency signaling current, an oscillator for producing a plurality of high frequency local currents, and means including a detector network for combining said high frequency signaling current with one of said high frequency local currents to the exclusion of the other of said high frequency local currents.

6. A stage in the method of receiving an alternating current signal wave, which comprises the step of impressing said wave upon a device having an input voltage-output current curved characteristic, whereby a fundamental and harmonic waves of said alternating current wave are produced, impressing said fundamental and said harmonic waves upon a second device having an input voltage-output current curved characteristic whereby the phase of the fundamental and certain of the harmonic waves are changed, and combining said waves to substantially eliminate said fundamental and certain of said harmonic waves.

7. The method of detecting an alternating current signal wave which comprises the steps of producing a fundamental and a harmonic frequency, developing from said fundamental frequency a phase displaced fundamental frequency, combining said fundamental frequencies whereby they are neutralized, and changing the frequency of the remaining harmonic frequency by combining it with said signal wave.

In witness whereof, I hereunto subscribe my name this 27th day of May, A. D. 1924.

WINFRED T. POWELL.