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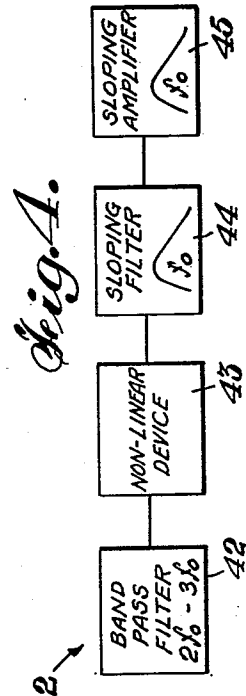
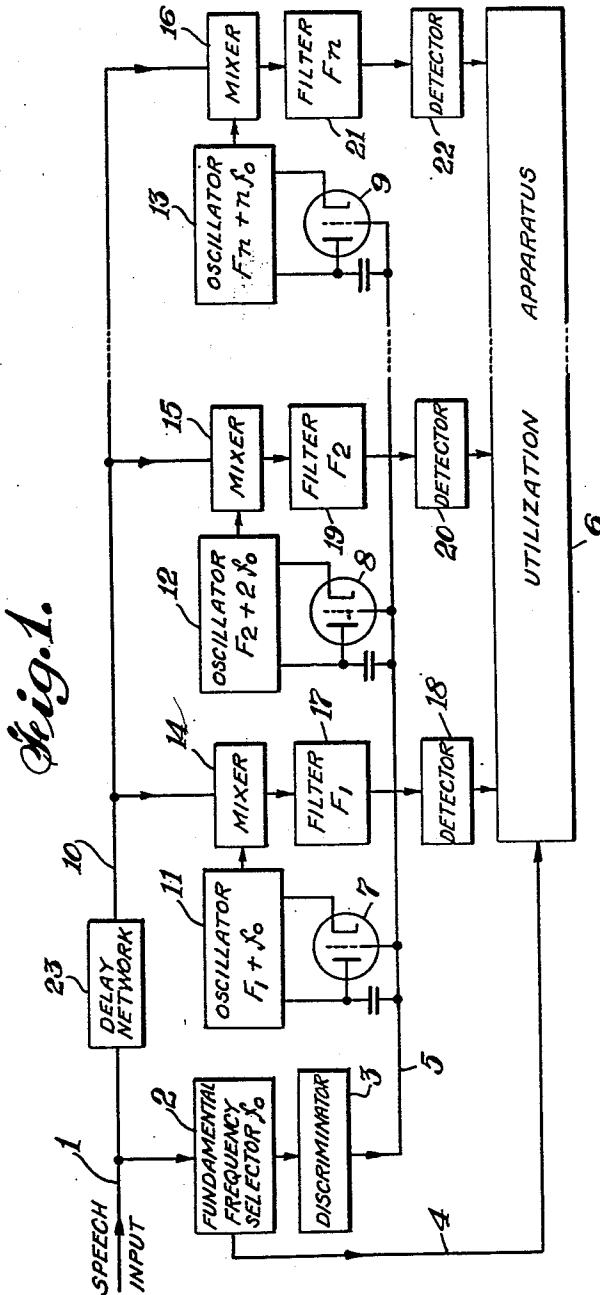
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2,553,610

HARMONIC AMPLITUDE SELECTOR FOR SIGNALING SYSTEMS

Filed Jan. 21, 1950

3 Sheets-Sheet 1



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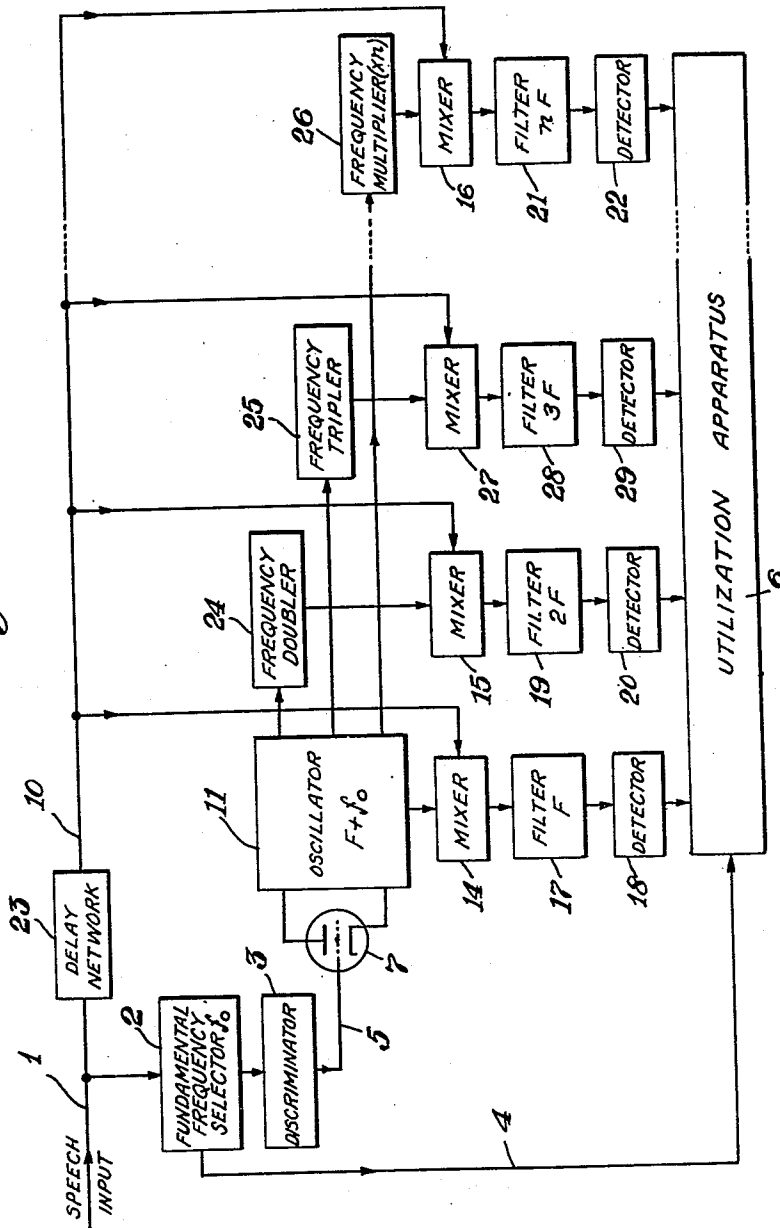
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Fig. 2.



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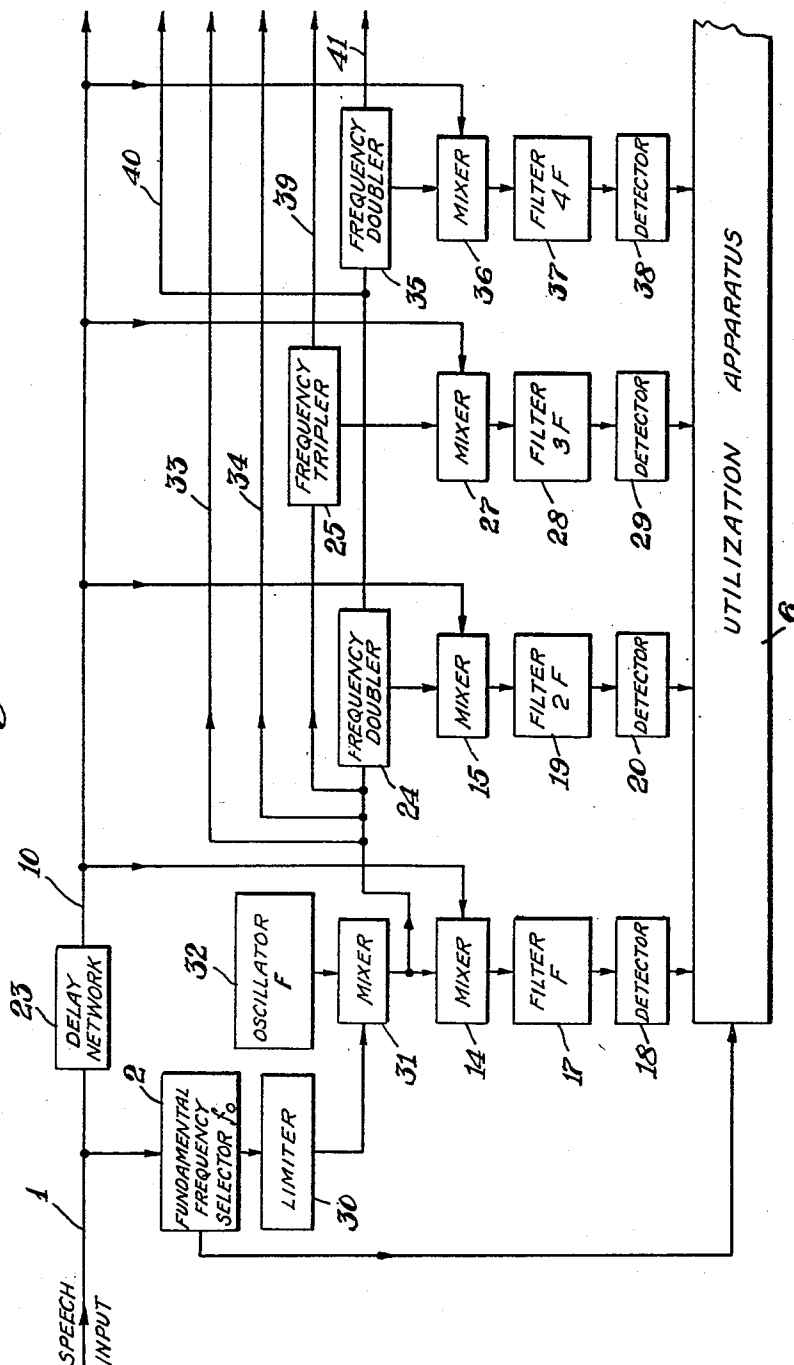
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Fig. 3.



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SIGNALING SYSTEMSHenry E. Singleton, Cambridge, Mass., assignor
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17 Claims. (Cl. 179-1.5)

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The present invention relates to a circuit arrangement for obtaining a measure of the amplitude of an electric wave subject to changes in frequency or of a plurality of such waves harmonically related to one another.

In pending application Ser. No. 50,516, filed July 24, 1948, by Jean B. Lair and Pierre R. Aigrain, there has been disclosed a communication system for the transmission of speech by way of a channel of reduced band width, as compared with the band width that would be necessary for transmitting the speech waves themselves, this being accomplished by deriving from the speech input a fundamental wave and a number of its harmonics (e. g. thirty), determining the relative amplitudes of these waves, and transmitting indications of these amplitudes and, if desired, of the varying frequency of the fundamental to a receiving station where the original speech input may be substantially synthesized therefrom. A distinction is also made between voiced and unvoiced speech components, the fundamental wave being replaced in the case of the latter with an artificially generated oscillation of predetermined frequency.

In the above system the several harmonics are selected by means of tunable filters controlled from a pitch meter designed to select the fundamental and to produce an output which is a function of the frequency thereof. These filters, as more particularly disclosed in the pending application referred to, may be a series of mechanical-optical devices including, for example, screens of varying opacity driven at controllable speeds.

Broadly speaking, the invention has for its object to provide purely electrical means for determining the amplitude of a certain wave selected among a large number of oscillations, such as a mixture of voice frequencies present in speech, the selected wave being subject to frequency changes in a determinable manner. More specifically, it is an object of this invention to provide means of this description in or for a harmonics analyzer of the general type disclosed in the above-identified application.

According to the invention, there is produced a reference wave of constant-amplitude the frequency of which consists of a fixed component (F) and a variable component (f) equal to the frequency of the selected wave, the speech or other frequency mixture being then intermodulated with the reference wave, whereupon an oscillation can be filtered out from the intermodulation products having a predetermined

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frequency (F) equal to that of the fixed component and having an amplitude proportional to that of the selected wave in the frequency mixture.

To carry out the above method, the invention provides a source of oscillations controlled from a pitch meter to produce a wave of the form $A \cos [2\pi(F+f)t + \xi]$ in which the amplitude A is constant, and f is a frequency equal or harmonically related to that selected by the pitch meter from a frequency mixture applied thereto and ξ is the phase angle of these frequencies, mixer means for superheterodyning the frequency mixture with said wave, and filter means for selecting from the output of the mixer means an oscillation of the form $kAa \cos [2\pi Ft + \eta]$ wherein a is the variable amplitude of the desired component of frequency f of the mixture and k is a proportionality factor and η is a phase angle.

More particularly, where the invention is applied to a harmonic analyzer as set forth above, the pitch meter may control a plurality of sources of oscillations having outputs in which the fixed component F may be the same or different for respective sources and in which the value of f ranges from a fundamental frequency f_0 through integral multiples $2f_0$, $3f_0$ thereof to nf_0 , n being, for example, of the order of thirty.

The invention will be better understood from the following description of certain embodiments, reference being had to the accompanying drawings in which:

Figs. 1, 2 and 3 are respective block diagrams of different forms of amplitude selectors according to the invention; and

Fig. 4 is a block diagram of a pitch meter or fundamental frequency selector as used in the embodiments of the preceding figures.

Referring to Fig. 1, there is shown an incoming line 1 to which a speech input or other mixture of frequencies is applied. A fundamental frequency selector 2, which together with an associated discriminator 3 constitutes what in the foregoing and in the above-identified application has been referred to as a pitch meter, this pitch meter having a first output corresponding to the selected fundamental and a second output represented by a voltage proportional to the frequency thereof. The first output is applied over a line 4 to a utilization apparatus 6 (which may be a transmitter, recorder or any suitable responsive device), the second output being applied over a line 5 to the grids of a plurality of reactance tubes 7, 8 and 9 in parallel. The

speech input is also applied to a line 10 in parallel with the pitch meter 2, 3.

Each of the reactance tubes 7, 8 and 9 forms part of the tank circuits of respective oscillators 11, 12 and 13. The output voltage of discriminator 3, varying with the selected fundamental frequency f_0 , controls the reactances of these tubes in such manner that the operating frequencies of the oscillators shown have the values $F_1 + f_0$, $F_2 + 2f_0$, and $F_n + nf_0$, it being understood that a number of intervening oscillators operating at frequencies $F_3 + 3f_0 \dots F_{(n-1)} + (n-1)f_0$, respectively, have not been illustrated.

Oscillators 11, 12 and 13 work into respective mixers 14, 15 and 16 each of which also derives an input from the line 10. These mixers may be of any non-linear type to provide intermodulation. The output of mixer 14 contains a component of frequency F_1 the amplitude of which varies proportional to that of the oscillation of frequency f_0 in the speech input; this component is separated out by a filter 17 and its amplitude detected in a detector 18. Similarly, the output of mixer 15 contains a component of frequency F_2 and of an amplitude proportional to that of the second harmonic of the aforesaid oscillation f_0 , this component being selected and detected by means of a filter 19 and a detector 20. In a like manner the mixer 16 works into a filter 21, tuned to a frequency F_n , which in turn feeds a detector 22. The outputs of all detectors, such as 18, 20 and 22, are applied to the utilization apparatus 6.

A delay network 23 may be inserted in the line 10, ahead of the first mixer 14, for the purpose of compensating for any delay introduced in the pitch meter 2, 3. Since, however, the amplitudes of the oscillation f_0 and its harmonics vary at a relatively slow rate only (not more than about 25 cycles per second), minor uncompensated delays may not be objectionable.

In the modification of Fig. 2, elements corresponding to those of Fig. 1 have been given the same reference numerals. Instead of providing a separate oscillator for each mixer, the oscillator 11 works into a plurality of frequency multipliers such as a doubler 24, a tripler 25 and a multiplier 26. The frequency doubler 24 is the functional equivalent of oscillator 12 (Fig. 1) and produces an output of frequency $F_2 + 2f_0$ wherein $F_2 = 2F$ (F being the fixed component of the output of oscillator 11). Similarly, the multiplier 26 is the functional equivalent of oscillator 13 and produces an output of frequency $nF + nf_0$. Frequency tripler 25 serves for the selection of the third harmonic of the fundamental f_0 and works into a mixer 27, the latter feeding a detector 29 by way of a filter 28 tuned to the frequency $3F$.

In the embodiment of Fig. 3, wherein elements having equivalents in Figs. 1 and 2 have again been designated by the same reference characters, the pitch meter comprising the fundamental frequency selector 2 is shown to include a limiter 30 in lieu of the discriminator 3. This limiter works into a mixer 31 which, being fed from an oscillator 32 having a fixed operating frequency F , takes the place of the oscillator 11 in that it produces a reference wave of frequency $F + f_0$. The mixer 31 feeds the frequency doubler 24, the frequency tripler 25 and a plurality of additional frequency multipliers (not shown) by way of connections indicated at 33 and 34. The frequency doubler 25 works into a second doubler 35, serving to select the fourth harmonic of the

fundamental derived from the pitch meter 2, 30. A mixer 36, a filter 37 and a detector 38 cooperate, accordingly, with the frequency doubler 35, the filter 37 being tuned to the frequency $4F$.

Frequency tripler 25 and frequency doublers 25 and 35 may feed further multipliers (not shown) in cascade therewith for the purpose of producing harmonics of such orders as are not prime members, e. g. the sixth, eighth, ninth, etc. harmonics of the output of mixer 31. This is indicated by the provision of additional output connections 39, 40 and 41.

It will be observed that in the embodiments of Figs. 2 and 3 the fixed components of the various reference waves are necessarily multiples of the basic carrier wave F , whereas in the form of the invention shown in Fig. 1 they may assume any value, for example be identical (thus $F_1 = F_2 = \dots = F_n$). The frequencies F may, for example, be of the order of one or several kilocycles per second.

Fig. 4 shows in greater detail the portion 2 of the pitch meter used in the circuit arrangements of Figs. 1, 2 and 3. It comprises a band pass filter 42 the pass band of which extends over a range which includes the second and third harmonics of the desired fundamental frequency f_0 , or any other adjacent two harmonics thereof, bearing in mind the fact that f_0 is variable within certain limits. (The reason for selecting a pass band encompassing the harmonics rather than the fundamental itself is that the latter is often suppressed in actual speech reproduction.) The output of filter 42 is applied to a non-linear device, e. g. a rectifier or detector, where the two harmonics are intermodulated to produce the desired fundamental. A sloping filter 44, followed by a sloping amplifier 45, then serves to select the fundamental among the other intermodulation products, it being understood that the peak of the characteristic of elements 44 and 45 would be substantially flat throughout the range within which the fundamental frequency f_0 is adapted to fall.

It may be noted that the first output of the pitch meter, applied to the utilization apparatus 6 via the line 4, is only representative of the selected fundamental wave as far as frequency is concerned but that a measure of its amplitude, relative to those of its respective harmonics will only be obtained at the output of the first detector 18.

In conformity with the teachings of the above-identified application, the pitch meter may also be provided with means for generating a synthetic fundamental wave of predetermined frequency (say, 50 cycles per second) if the frequency of the fundamental actually detected falls below a certain level, thus indicating an unvoiced input. Such an arrangement, however, has not been illustrated inasmuch as it forms no further part of the present invention.

While the invention has been described with reference to certain particular embodiments, it is to be understood that the same have been given merely by way of illustration and not as a limitation upon the spirit and scope of the invention as defined in the objects and in the appended claims.

What is claimed is:

1. A circuit arrangement for obtaining a measure of the amplitude of a selected electric wave subject to changes in frequency, said wave forming part of a mixture of several oscillations, comprising a pitch meter adapted to derive from said

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mixture an output representative of the frequency of said selected wave, a variable source of oscillations, circuit means for applying said output to said source in such manner as to operate said source to produce a reference oscillation having a fixed component and a variable component harmonically related to the frequency of said selected wave, mixer means for superheterodyning said mixture with said reference oscillation, and filter means for selecting from the output of said mixer means a resultant oscillation of a frequency equal to said fixed component, said resultant oscillation having an amplitude proportional to that of said selected wave.

2. A circuit arrangement according to claim 1 wherein said source comprises an oscillator having a tank circuit and said circuit means comprises a reactance tube forming part of said tank circuit.

3. A circuit arrangement according to claim 1 wherein the output of said pitch meter is a wave of constant amplitude and of a frequency equal to that of said selected wave, said source comprising an oscillator having an operating frequency equal to said fixed component and mixer means for modulating said operating frequency with said output of the pitch meter.

4. A circuit arrangement for measuring the relative amplitudes of a plurality of harmonically related oscillations forming part of a frequency mixture, said oscillations being subject to changes in frequency, comprising a pitch meter adapted to select the fundamental frequency of said harmonically related oscillations from said mixture and to produce an output representative of said fundamental frequency, a plurality of variable sources of oscillations, circuit means for applying said output to said sources in such manner as to operate said sources to produce respective reference waves of the form $A \cos [2\pi(F+f)t + \phi]$ wherein A is an amplitude fixed for each source, F is a frequency component fixed for each source and f is a frequency corresponding to a different harmonic of said fundamental frequency for each of said sources, a plurality of mixer means for superheterodyning said respective reference waves with said frequency mixture, and a plurality of filter means for selecting from the output of each of said mixer means a resultant oscillation of the form $kAa \cos [2\pi f t + \eta]$ wherein k is a proportionality factor and a is the amplitude of a respective one of said harmonically related oscillations.

5. A circuit arrangement according to claim 4, comprising a plurality of detector means respectively connected to said mixer means for producing an output proportional to said amplitude a .

6. A circuit arrangement according to claim 5, comprising utilization means connected to all of said detector means to receive the said output

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thereof and further circuit means for applying a wave of said fundamental frequency from said pitch meter to said utilization means.

7. A circuit arrangement according to claim 4 wherein each of said sources comprises a separate oscillator.

8. A circuit arrangement according to claim 7 wherein each of said oscillators is provided with a tank circuit including a reactance tube, said circuit means including discriminator means adapted to derive from the fundamental frequency selected by said pitch meter a voltage proportional to said fundamental frequency and to apply said voltage to all of said reactance tubes.

9. A circuit arrangement according to claim 4 wherein said sources include oscillator means controlled from said pitch meter and frequency multiplier means controlled from said oscillator means.

10. A circuit arrangement according to claim 9 wherein said oscillator means is provided with a tank circuit including a reactance tube, said circuit means including discriminator means adapted to derive from the fundamental frequency selected by said pitch meter a voltage proportional to said fundamental frequency and to apply said voltage to said reactance tube.

11. A circuit arrangement according to claim 4 wherein said sources include an oscillator of fixed operating frequency and mixer means connected to said pitch meter for modulating said operating frequency with the fundamental frequency selected by the pitch meter.

12. A circuit arrangement according to claim 11 wherein said sources further include a plurality of frequency multipliers connected to be controlled from said mixer means for producing harmonics of the output of said mixer.

13. A circuit arrangement according to claim 12 wherein at least some of said multipliers are connected in cascade.

14. A circuit arrangement according to claim 4 wherein said sources include a first source controlled from said pitch meter and a plurality of frequency multipliers connected to be controlled from said first source for producing harmonics of the output of said first source.

15. A circuit arrangement according to claim 14 wherein at least some of said multipliers are connected in cascade.

16. A circuit arrangement according to claim 4 wherein said fixed component F is the same for all of said sources.

17. A circuit arrangement according to claim 4 wherein the fixed components F of all of said sources, respectively, are harmonically inter-related.

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No references cited.