

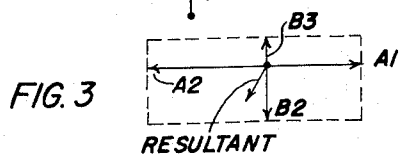
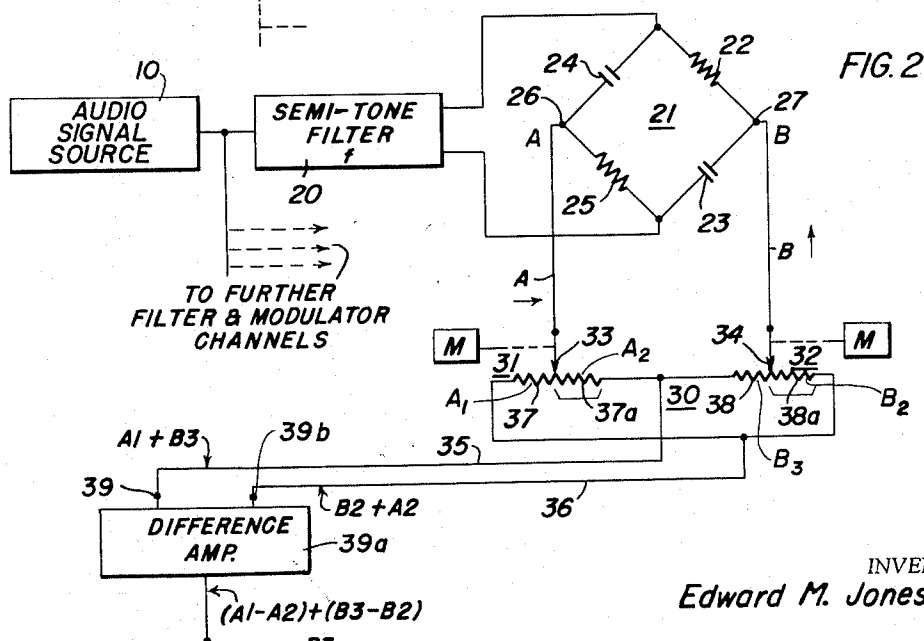
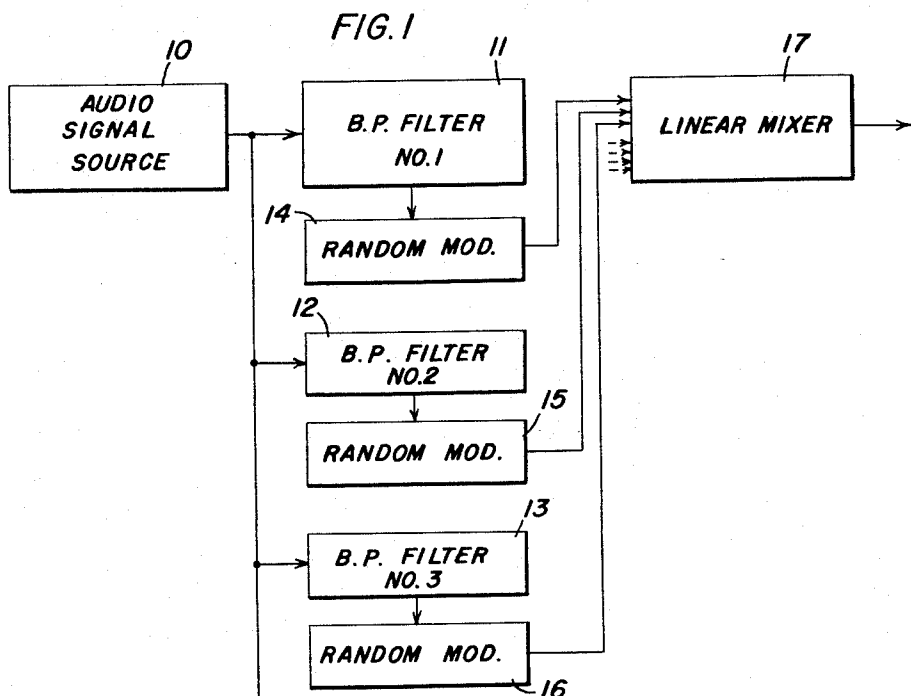
Oct. 17, 1961

E. M. JONES
MODULATION SYSTEM

3,004,459

Filed Dec. 31, 1956

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 4

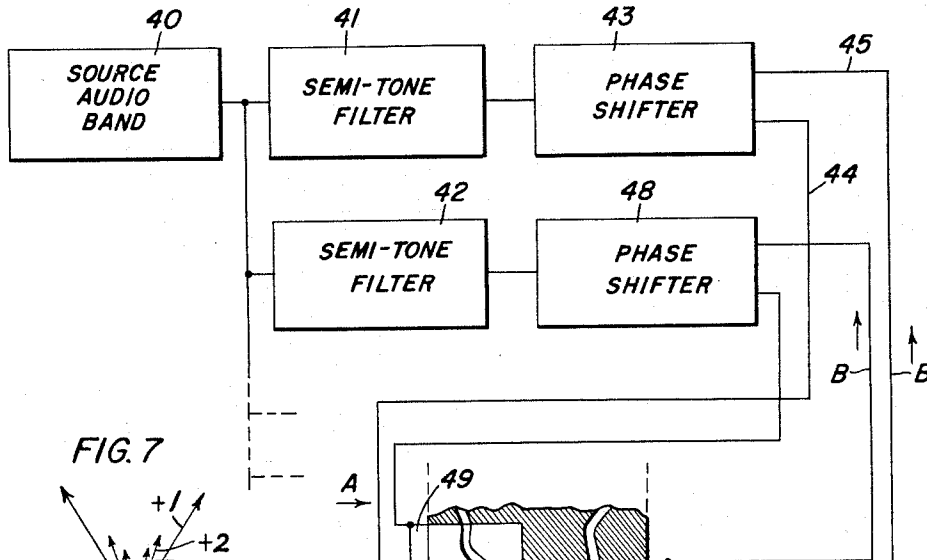


FIG. 7

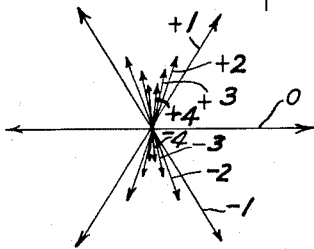


FIG. 8

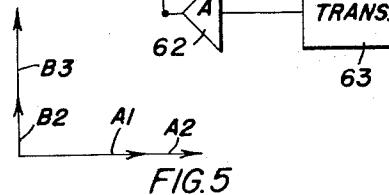
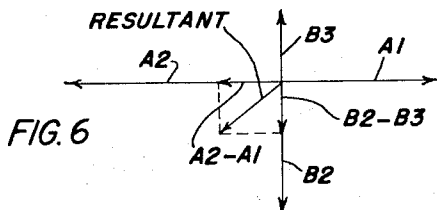
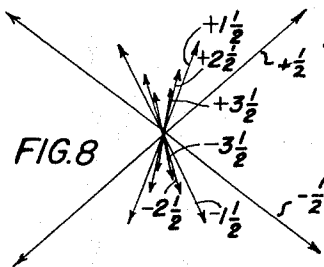


FIG. 5

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1

3,004,459

MODULATION SYSTEM

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34 Claims. (Cl. 84—1.01)

The present invention relates generally to systems for achieving chorus effect in electronic musical instruments.

Some types of electronic musical instruments display a regularity of tone production which results in musical effects distinguishable in interest from those obtainable from pipe organs. The random effects which are characteristic of pipe organs is denominated "chorus effect," and is the effect of instruments playing in unison and slightly out of tune with each other.

It is a primary object of the present invention to provide a system for generating chorus effect in electronic musical instruments.

Briefly describing the present invention, an audio signal is fed simultaneously through a plurality of filters, in parallel, the outputs of the separate filters being modulated by random functions, and then re-combined and acoustically transduced. In a practical system it may be adequate randomly to process frequencies over a portion of the audio band, say from 200–4,000 c.p.s., in response to random modulation signals, the frequencies below 200 c.p.s. remaining unprocessed, and those above 4,000 c.p.s. being in some degree simply amplitude modulated.

Frequency modulation of audio frequencies has heretofore been resorted to, to provide vibrato, the usual vibrato frequency being about 7 c.p.s., and the frequency deviation required being about 1% over the entire audio band, i.e., for each frequency in the band. In accordance with the present invention, the audio band which is to be vibrato frequency modulated may be divided into a plurality of adjacent sub-bands. Each sub-band may be subjected individually to frequency modulation, and the percentage deviation applied to the separate sub-bands may be adjusted to a desired value for each sub-band.

In accordance with one modification of the present invention, amplitude modulation may be accomplished for each sub-band in response to a completely random or noise-like signal having a band-width for each sub-band which is proportional to the average frequency of the sub-band. The sub-bands may correspond to the several half-tones generated by the instrument, and the modulation signal may have no D.C. component. The consequence of this procedure is that a complex tone, in response to processing, has each harmonic spread into a band of closely spaced frequencies, the band-width for each harmonic being a constant percentage of the frequency of that harmonic. The overall effect is that of a number of tones, all having the same harmonic structure, and all played simultaneously, but in which the fundamental frequency of each tone, and each harmonic frequency, is spread over a band on either side of the original frequency in response to the modulation process. Moreover, the effect of amplitude modulation by a signal having no D.C. component is to introduce a 180° phase shift whenever the modulation signal passes through zero, and the several filters introduce various and random phase shifts into signals which pass simultaneously in parallel through overlapping filters. There is thus introduced into the system a random phase modulation, which appeals to the ear, and which renders subjectively distinguishable the upper and lower side-band products of modulation, so that the resultant wave is not

2

the classic amplitude modulated carrier in which each side-band carries identical information.

In a more complex embodiment of the present invention a series of forty-eight vibratory reeds may be employed as filters, covering the range from about 200–3000 c.p.s. (four octaves). The reed filters may be severally tuned each to one of the half tones of the musical scale, and may have a Q of 16 in each case, which implies that either the peaks or the half power points on the selectivity curves of the several filters approximate the positions of musical half-tones. The outputs of the several filters may be fed to forty-eight phase shifting networks, each adjusted to provide two outputs in phases differing 90°.

Each of the bands deriving from a single filter may be randomly amplitude modulated, and the modulation process is so carried out that two bands of signals are produced in response to each of the original bands, which are differentially varied in amplitude or varied in amplitude in opposite senses. In consequence the two bands may be such that either one is instantaneously greater in amplitude than the other. The second of the two bands derived from each filter is similarly treated, but by a different amplitude modulator. The overall result is the generation of four amplitude modulated signals, two of 0 and 180° phase, respectively, and two of 90° and 270° phase, respectively. The first two signals are randomly amplitude modulated in opposite sense, and the last two are also randomly amplitude modulated in opposite sense. The two sets of signals generated by the modulators are combined in a difference amplifier, in which oppositely phased signals are subtracted, one from the other. The output of the difference amplifier may have random 360° phase variation for the specified inputs, and a wide range of random amplitude variation, for any one input frequency. In fact, however, the output of each reed filter is not a single frequency, in general, and may comprise for example, a single fundamental frequency and harmonics of other lower frequency fundamentals. When so constituted the total signal derivable from a filter has amplitude and phase determined by the constituent input signals, which further randomizes the output of the difference amplifier.

The output of the difference amplifier may be amplified to a suitable level, and acoustically transduced, to provide output tones having strong chorus effect.

It is, accordingly, a broad object of the present invention to randomize an audio frequency band.

It is a further object of the present invention to provide a system for generating in response to each original frequency of an audio spectrum, a band of frequencies of random content approximately centered on the original frequency.

It is still another object of the present invention for processing adjacent sub-bands of an audio band differently, by a modulation process.

It is a further object of the invention to provide a system for asynchronously modulating different sub-bands of an audio band representative of music.

A further object of the present invention resides in the provision of a system for asynchronously modulating the different semitones of a musical spectrum to provide a processed musical spectrum.

Still another object of the invention is to provide a system for randomly amplitude and phase modulating a signal, the phase modulation extending to 360° and the amplitude modulation to zero.

It is a further object of the invention to provide a system for modulating the phase of a signal through 360° by amplitude modulating phase separated components of the signal.

3

The feature has been stressed that random noise may be applied as a modulating signal, the random noise having no D.C. component. In such case, and specifically in response to amplitude modulation, the phase of the modulated signal reverses each time the modulating signal passes through zero, and since this occurs at random, the processed wave has a random character, in addition to that above pointed out, because of its randomly timed phase reversals.

It is desirable that the band-width of the frequencies in the modulating signal be in all cases proportional to the center frequency, and hence to the band-width for constant Q , of the filter output being modulated. In consequence a complex tone would have each of its harmonics spread into a band of closely spaced frequency components, the spread or band-width being a constant percentage of the frequency of the harmonic. This simulates a number of tones having the same harmonic structure being played simultaneously, and having fundamental frequencies spread over a range of values on either side of the original frequency which is a constant percentage of the original frequency.

As a still further feature adjacent filters overlap, their characteristics being preferably essentially that of a single tuned circuit. It follows that a single frequency may be transmitted through plural filters, and hence differently modulated and subjected to different phase shifts and times of phase reversal in the several filters and by the several modulators. This assures that in general upper and lower side bands will not be identical, but will relatively vary in phase and amplitude in a random manner.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a block diagram of a system according to the invention;

FIGURE 2 is primarily a block diagram, including certain circuit elements, of a random phase and amplitude modulator according to the invention, illustrating in detail one modulator channel;

FIGURE 3 is a vector diagram, useful in explaining the operation of the system of FIGURE 2;

FIGURE 4 is a block diagram of a further modulator, generally according to FIGURE 2, but including a capacitive device for simultaneously varying the amplitudes of a large number of signals, and combining the resultant signals;

FIGURES 5 and 6 are phasor diagrams which assist in the explanation of the system of FIGURE 4; and

FIGURES 7 and 8 are phasor diagrams showing the effects of adding frequencies which have been amplitude modulated in separate filters and at different locations in the pass-band of each.

Describing various embodiments of the present invention in detail, in FIGURE 1 the reference numeral 10 denotes a source of audio signal, and may consist of an electronic musical instrument, such as an organ, in a specific application of the present invention, although I do not desire to be limited in this respect. Connected in parallel to the source 10 is an array of band pass filters 11, 12, 13, . . . which together occupy the entire audio frequency band. For example only, each filter may be centered on the fundamental frequency of a different musical half tone, although if desired the several filters may each cover a complete octave. The output of filters 11, 12, 13, . . . are applied, respectively, to modulators 14, 15, 16, . . . and the outputs of the latter are combined in a linear mixer or combining network 17. The several modulators 14, 15, 16, . . . may subject the audio signals passing therethrough to random modulation, as from a noise source having no D.C. component, or from some other source of relatively random or com-

4

plex modulatory signal, although considerable improvement in musical effect may be accomplished by employing independent single frequency sources for providing modulation signal.

Considering first the case in which the several filters 11, 12, 13, . . . are centered on the fundamental half tone frequencies, each filter may have a Q of 16, so that all frequencies in the audio band, between certain upper and lower values, may be processed. The process of modulation has the effect of generating side-bands separated from the fundamental or carrier frequency by the value of the modulating frequency. This is true whether the process of modulation is amplitude, frequency or phase, although in the case of amplitude modulation two side bands will be generated, while in the case of frequency or phase modulation more than two side bands will, in general, be generated.

Accordingly, for each fundamental frequency present in the input band, a plurality of adjacent output frequencies will be generated. Each tone is, however, composed of a fundamental frequency and several harmonic frequencies. The latter will pass through different filters than will the fundamental, and hence will be differently modulated. Moreover, the harmonic frequencies will not, in general, fall centrally of the pass-band of the filter which accepts same, and hence will suffer a phase shift and an amplitude change. The net effect is to randomize the character of the ultimate processed tone.

In a practical embodiment of the system of FIGURE 1, it would be adequate to process the band 200-4,000 c.p.s., and not to process the band 30-200 c.p.s., at all. Some amplitude modulation may be applied to the band 4,000-8,000 c.p.s.

In FIGURE 2 of the accompanying drawings is illustrated schematically a simple form of modulating system for the output of a single filter of the system of FIGURE 1. It is assumed, preliminarily and to simplify the discussion, that a single audio frequency f is to be modulated, corresponding with the fundamental frequency of a semi-tone, and available from a filter 20. The signal of frequency f is applied to a phase shift bridge 21, having two parallel arms, between which the signal is applied. One of the arms consists of a resistance 22 and a condenser 23, in series, while the other arm consists of a condenser 24 and a resistance 25 in series. The constants of the bridge circuit are so chosen that each arm effects a 45° phase shift, but in opposite sense in the separate arms, whereby two output signals A and B are available at output terminals 26, 27, respectively, which bear a 90° phase relation one to the other.

The two 90° phase shifted signals are applied to an amplitude modulation system 30, which may comprise two resistances, 31, 32, each having an associated variable tap or slider, identified by the numerals 33, 34, respectively. The resistances 31, 32 are connected in series in a closed loop, and output leads 35, 36 derive from the junction of the resistances, the separate sliders constituting input terminals for the separate input signals. More specifically, the signal A, assumed to be of 0 or reference phase, is applied to slider 33, and the signal B, assumed lagging in phase by 90° , is applied to slider 34. The sliders 33, 34 are independently actuated at random, by any convenient motor means, M, the relative positions and motions of the sliders 33, 34, being completely unsynchronized and unrelated, one to the other.

The slider 33 divides the resistance 31 into two portions 37, 37a, across each of which appears a fraction of the signal A. These fractions may be denominated A1 and A2 on the portions 37a and 37, respectively. Similarly, the slider 34 divides the resistance 32 into two portions 38 and 38a. Across portion 38 appears a fraction of signal B, denoted B3, and across portion 38a appears the remainder of signal B, denoted B2. Accordingly, on lead 35 appears $A1+B3$, and on

lead 36 appears A_2+B_2 . A_1 and A_2 are in phase with each other, but may have any relative amplitudes, while B_2 and B_3 are in phase with each other, but 90° lagging with respect to A_1 and A_2 , and likewise may have any relative amplitudes.

A_1+B_3 are applied to one input terminal 39 of a difference amplifier 39a, and B_2+A_2 to the remaining input terminal 39b. At the output terminal appears $(A_1-A_2)+(B_3-B_2)$. Assuming A_1 to have zero phase, A_1-A_2 may have either 0° or 180° phase, depending on the relative amplitudes of A_1+A_2 . Likewise, while B_2 and B_3 have 90° lagging phase, B_2-B_3 may have either 90° leading or 90° lagging phase, depending on the relative amplitudes of B_2 and B_3 . It follows that the output of the difference amplifier may have any phase from 0° to 360° , and a range of amplitudes from zero to the vector sum of A and B , and that the variations of amplitude and phase are random.

The correct phases, and arbitrary relative amplitudes, for the quantities A_1 , A_2 , B_2 and B_3 are plotted in FIGURE 3, and a resultant signal is illustrated.

In the system of FIGURE 4 is illustrated a modification of the system of FIGURE 2, which permits considerable simplification of circuitry. The system is illustrated as applied to two semi-tone filters or channels only, for simplicity of exposition, but may obviously be extended without modification of the principles on which it is based, to any desired number of channels.

In the system of FIGURE 4 is illustrated a source of audio signals 40 such as derive from an electrical or electronic musical instrument, and consisting essentially of a plurality of semi-tones. Semi-tone frequencies are derived in separate channels by means of semi-tone filters 41, 42, . . . , for any desired substantial portion of the audio band, of, if desired, for the entire audio band of interest. For the sake of simplifying the exposition without detracting from its completeness, the system is described in detail as for two semi-tone filters, extension to any number being immediately obvious.

The output of the semi-tone filter 41 is applied to a phase shifter, 43, of conventional character per se, which provides on its output leads 44, 45 and two signals of 0° and approximately 90° phase relation, i.e., A and B , the phase relations of which are indicated in the drawings by arrows in proximity to the letter A and B .

The signals A and B are applied to separate capacitive electrodes, 46 and 47, respectively.

Similarly, phase shifted signals are derived from semi-tone filter 42 by a phase shifter 48, and applied to separate capacitive electrodes 49 and 50. The several electrodes may all be identical in shape and size, as illustrated, or they may be different if desired.

In proximity to the several electrodes 46, 47, 49, 50 is a plate 52 of insulating material, such as glass, on which has been applied a conductive coating 53, indicated by cross-hatching. The coating is divided into three tracks, each made to be of completely random width as one proceeds longitudinally of the plate, by two cuts or interruptions, 54, of the coating, both of which extend generally longitudinally of the plate 52, but at randomly varying lateral positions.

Capacitive electrodes 46 and 49 are superposed over two of the tracks, i.e. the left hand track and the center track, while electrodes 47 and 50 are superposed over the center track and the right hand track.

Voltage transferred to each track by capacitive coupling is a function of the voltage of the signal applied to an electrode superposed on that track, and of the area of the track which lies immediately under the electrode. Accordingly, as the plate 52 has movement relative to the electrodes in the direction of the arrow 55, the amplitudes of the signals applied to the several electrodes are relatively randomly modulated in amplitude. The signals present on the outer tracks are applied jointly to one input

terminal 56 of a difference amplifier 57, by means of probes 58, 59 connected to the outer tracks. The signal present on the center track is applied to the remaining input terminal 60, by means of a probe 61 connected to the center track.

Referring to FIGURE 5, if A_1 is the instantaneous amplitude of the signal transferred to the left hand track by signals A , and if A_2 is the instantaneous amplitude of the signal applied to the center track by signal A , the difference of A_1 , and A_2 , indicated in FIGURE 6, appears on the output lead of the difference amplifier. If B_2 is the instantaneous amplitude of the signal applied to the center track due to the signal B , and B_3 the instantaneous amplitude of the signal applied to the right hand track by signal B , (FIGURE 5) the difference of B_2 and B_3 (FIGURE 6) appears on the output of the difference amplifier 57.

The sum of all the vectors illustrated in FIGURE 6 may be perceived to have random phase over 360° , depending on the relative amplitudes of A_1 and A_2 , and of B_2 and B_3 , and hence of (A_2-A_1) and (B_2-B_3) . So (A_2-A_1) may have a phase of 0° or 180° , and random amplitude, and (B_2-B_3) may have a phase of 90° or 270° , depending on the relative amplitudes of B_2 and B_3 , and a random net amplitude.

The output of difference amplifier 57 may be amplified as a suitable level in an amplifier 62, and acoustically transduced, as by means of a loudspeaker 63 or the like.

A simplification of the system of FIGURE 4 is possible, which, moreover, presents advantages in that the randomness of the processed audio band is increased. It will be appreciated that perhaps 48 individual channels (4 octaves) may be processed in a system according to the present invention. The reduction of components required per channel is therefore of prime importance. In accordance with a further modification of the present invention phase shift circuits are dispensed with, and use made of the fact that a resonant circuit employed as a filter has points on its selectivity characteristic for which phase shifts of $+$ and -45° occur. In the case of a series resonant circuit, these points are the half-power points of the selectivity curves.

If, in the system of FIGURE 1, the filters have each a Q of about 14, any given semi-tone fundamental frequency will pass through a plurality of the filters, and in different phase and amplitude in the several filters. If now the amplitudes of the signals, or the frequencies of the signals, or the phases of the signals, or any combination of these is differently modulated in the separate filters, and then combined, the amplitude and phase of resultant or combined signal will vary in a random fashion. In FIGURE 7 is shown the relations, in respect to amplitude and phase for a tone the fundamental of which occurs centrally of a filter, and in FIGURE 8 the relations for the case in which the pertinent frequency is located on the half power points of adjacent filters, e.g. where phase shift is $+45^\circ$ for one filter and -45° for the adjacent filter.

In FIGURE 7 the horizontal phasors represent phase and amplitude of a signal which occurs centrally of the band-pass of a band-pass filter. The phasors indicated as $+1$ and -1 represent the phases and amplitudes of the responses of the next higher and next lower filters, respectively, to the signal. The responses of further displaced filters are then represented by phasors carrying numerals which identify the filter number, above and below the filter for which response occurs centrally. It will be observed that, in departing from the filter for which response occurs centrally, the phases continuously increase, positively and negatively, while the amplitudes continuously decrease, precise values being dependent on the Q factors for the filters, and on their frequency separations.

In FIGURE 8 the frequency under investigation occurs at the half power points of two adjacent filters.

For this condition the phasor marked $+\frac{1}{2}$ refers to the nearest filter which is tuned higher than the signal frequency and shows a phase lead of 45° , whereas the phasor $-\frac{1}{2}$ refers to the nearest filter which is tuned lower than the signal frequency. The phasors $\pm\frac{1}{2}$, $\pm\frac{2}{2}$ and $\pm\frac{3}{2}$ refer to the filters which are tuned respectively at frequencies increasing in their displacement from the signal frequency.

If the phasors are amplitude modulated randomly by a signal having no D.C. component, for each filter the resulting phasor will be either in the same direction having amplitudes anywhere from zero to the value shown or in the opposite direction over the same range of amplitudes, as indicated by the unmarked phasors in FIGURES 7 and 8. This 180° reversal in phase can be performed in the same manner as discussed in connection with FIGURES 2 and 4 by using a difference amplifier. It can be seen from the symmetrical distribution of these phasors that when these phasors are combined, there is equal likelihood that the resultant at any instant will have any phase between 0 and 360° . Thus the system of FIGURE 1 will operate to give random phase modulation, as well as amplitude modulation, even though the modulation blocks 14 represent pure amplitude modulators. Consequently, the phase-shifter circuit of FIGURE 2 is not actually necessary to accomplish the desired results. The output of the semitone filter 20 can be connected directly to the arm 33 of the potentiometer 31, the potentiometer 32 being completely unnecessary.

Similarly, in FIGURE 4, a phase-shifter 43 is unnecessary, and the output of the semi-tone filter 41 can be fed directly to probe 47, the probe 46 being unnecessary.

It will further be appreciated that while I have shown in FIGURE 4, a single track and multiple sets of electrodes, that a separate track may be employed for each pair of electrodes, as 49, 50 or 46, 47. The tracks may conveniently be placed on a rotating disc so that each track will be endless. In the latter case, the tracks which modulate the higher frequency tones are selected to be of greater radius, so that their tangential velocities will be greater than for lower frequency tones.

It will further be appreciated that where I have employed the term harmonics that partials are intended to be included where appropriate. So in piano music partials, rather than true harmonics, are generated.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the general arrangement and of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. In an audio system, a source of a relatively wide band of audio frequency signals representing music, a plurality of relatively narrow band pass filters connected in parallel to said source and together having a pass band at least equal to said relatively wide band, each of said band pass filters centered at a different position within said band, whereby said band pass filters provide a plurality of sub-bands of said relatively wide band of audio frequency signals, a plurality of frequency modifying devices, means for applying each of said sub-bands to a different one of said frequency modifying devices comprising devices for coupling said band-pass filters one for one with said frequency modifying devices whereby said frequency modifying devices provide processed sub-bands, and means coupled to said frequency modifying devices for combining said processed sub-bands to provide a processed audio frequency band representing said music.

2. A modulation system, comprising a source of signal to be modulated, means for deriving from said source of signal to be modulated two further signals having ap-

proximately 90° phase relation, means for deriving from each of said two further signals two differently amplitude modulated signals, and means for differentially combining each of said two differently amplitude modulated signals.

3. A modulation system comprising a source of signal, means for deriving from said signal two first differently amplitude modulated signals of one phase, means for deriving from said signal two second differently amplitude modulated signals of phase substantially different from said one phase, means for differentially combining said first signals, means for differentially combining said second signals, and means for combining both differentially combined signals.

4. A modulation system comprising a source of signal, means operatively associated with said source for deriving from said signal a further signal of random amplitude and of randomly alternatively 0° and 180° phase, means operatively associated with said source for deriving from said signal another signal of random amplitude and of randomly alternatively approximately 90° and 270° phase and means connected to both means for deriving for combining said further signal and said another signal to provide a resultant signal having random amplitude and phase values at random over 360° .

5. A system for achieving chorus effect in electronic musical instruments, comprising an electronic source of a band of audio frequencies representing music, means connected to said electronic source of a band of audio frequencies for differently musically modifying the total content of different sub-bands of said band of audio frequencies while maintaining the musical character of the said contents, means connected to the means for modifying for separating the different musically modified sub-bands into separate channels, and means connected to the separate channels for acoustically transducing the electrical content of said separate channels, wherein said means for musically modifying is arranged and adapted to introduce new frequencies on a steady state basis.

6. A system for achieving chorus effect in electronic musical instruments, comprising an electronic source of a band of audio frequencies representing music, consisting of a plurality of distinct and different frequency sub-bands, means connected to said electronic source for differently musically modifying the frequency content of each separate one of said sub-bands, the extent of the modification for each sub-band being a direct function of the average frequency of said sub-band, and means connected to said means for modifying for acoustically transducing into a common area the modified frequency content of said sub-bands.

7. The combination according to claim 6 wherein the means for modifying frequency content includes a frequency modulator for modifying the frequencies of signals in the sub-bands.

8. The combination according to claim 6 wherein said means for differently modifying is a separate means for each of said sub-bands.

9. The combination according to claim 8 wherein separate ones of said means for modifying is arranged to modify the entire frequency content of one of said sub-bands substantially identically.

10. In combination, a source of electrical signals, occupying a primary band of audio frequencies and representing music, means connected to said source for separating said primary band of frequencies into a plurality of overlapping frequency sub-bands, said sub-bands together including all the frequencies of said primary band of frequencies, said means for separating including filters, those of said filters having adjacent pass-bands having pass characteristics with radially overlapping skirts, whereby given frequencies pass through plural filters and suffer different phase shifts, and means connected to said filters for modifying the frequencies of the signals in different ones of said filters to different

extents as a function of the positions of the pass bands of the filters with respect to the primary band of frequencies.

11. The combination according to claim 10 wherein the pass characteristics of each of said filters is substantially that of a single tuned circuit.

12. The combination according to claim 10 wherein said means for modifying is a means for randomly modifying frequency.

13. The combination according to claim 10 wherein said means for modifying frequency is a frequency modulator which modulates frequency positively and negatively with respect to a mean value as a function of time.

14. A system for processing a band of audio frequencies consisting essentially of a plurality of musical semi-tones, each of said semi-tones including at least a fundamental frequency component and partial components thereof, comprising means for differently musically modifying the frequencies of a plurality of said components, and means operatively associated with said means for modifying for acoustically reproducing said processed musical components wherein said means for differently musically modifying is arranged and adapted to introduce new frequencies on a steady state basis.

15. A system for processing a band of audio frequencies comprising a plurality of musical semi-tones, each of said semi-tones including at least a fundamental frequency component, comprising filters for separating into separate channels certain of said fundamental frequencies, means operatively associated with said filters for separately musically modifying in relatively different fashions the frequencies contained in each of said channels so as to provide processed musical semi-tones, and means connected to said means for separately modifying for combining the modified outputs of said channels to provide a processed band of audio frequencies representing music, wherein said means for differently musically modifying is arranged and adapted to introduce new frequencies on a steady state basis.

16. A system for processing a band of audio frequencies, comprising a source of a plurality of musical semi-tones, each of said semi-tones comprising a fundamental frequency and a plurality of harmonic frequencies, a plurality of band pass filters operatively associated with said source and having different center frequencies and connected in parallel to said source of a plurality of musical semi-tones, each of said band-pass filters arranged and adapted to have a pass frequency band equal to at least a semi-tone, means coupled to said filters for differently musically modifying the frequencies of the signal outputs of at least some of said filters, and means operatively associated with said means for modifying for combining the musical signals provided by said means for differently modulating, wherein said means for differently musically modifying is arranged and adapted to introduce new frequencies on a steady state basis.

17. The combination according to claim 16 wherein said means for modifying includes a modifying signal generating device for generating a signal having a characteristic approximately proportional to the frequency of the modified signal for modifying each signal output of each of said filters to an extent approximately proportional to the frequency of the signal output.

18. The combination according to claim 16 wherein said means for modifying includes means for randomly modulating phase over 360°.

19. The combination according to claim 16 wherein said means for modifying includes means for amplitude modulating and phase shifting concurrently.

20. The combination according to claim 16 wherein said means for modifying is a means for frequency modulating.

21. The combination according to claim 16 wherein said means for modifying is a means for modifying the frequencies of the signal outputs of all of said filters.

22. A modulation system for a source of a signal spectrum representative of music, each tone of which includes a fundamental frequency and multiple harmonics, comprising modulators coupled in parallel to said source for differently musically modifying the frequencies of said fundamental frequencies and of each of said multiple harmonics.

23. A modulation system for a musical spectrum, comprising a source of a band of frequencies representative of a musical spectrum, and comprising for each semi-tone a fundamental frequency and a plurality of partials, filter means coupled to said source of a band of frequencies for separating a fundamental frequency deriving from one semi-tone and partials deriving from other semi-tones into a common channel, and means for musically frequency modulating the frequency content of said common channel.

24. A modulation system for a musical spectrum, comprising a source of a band of frequencies representative of music, said band of frequencies comprising the frequency of at least one musical semi-tone and multiple partials of said frequency of at least one musical semi-tone, separate filters operatively associated with said source for separating into different channels said frequency of at least one musical semi-tone and at least one of said partials, and means operatively associated with said separate filters for modulating the separate frequencies passed by said filters differently while maintaining the musical character of the last named frequencies.

25. A modulation system for a musical tone, said musical tone comprising plural frequencies, comprising means for musically modulating the frequency of one of said plural frequencies, means for musically modulating the frequency of another of said plural frequencies asynchronously with respect to said one of said plural frequencies.

26. A modulating system for a musical tone, said musical tone comprising plural frequencies covering a band of frequencies, comprising plural filter means together co-extensive with said band of frequencies, means operatively associated with said filters for differently musically modifying the signals passed by each of said filters, said filters having pass band characteristics that overlap sufficiently that at least some of said frequencies will pass through at least two filters with appreciable amplitude but in different phase relationship, and means operatively associated with said filters for combining the outputs of all the filters, wherein said means for musically modifying is arranged and adapted to introduce new frequencies on a steady state basis.

27. A modulation system for a band of frequencies representative of music, said band of frequencies divisible into substantially adjacent sub-bands comprising means for separating said sub-bands into separate channels, and means operatively associated with said means for separating for individually musically modifying the frequency content of each of said channels, wherein said means for musically modifying is arranged and adapted to introduce new frequencies on a steady state basis.

28. The combination according to claim 27 wherein is further provided means operatively associated with said means for musically modifying for combining the modified frequency content of said channels in a single path.

29. The combination according to claim 27 wherein is further provided means operatively associated with said means for musically modifying for acoustically radiating signals corresponding in frequency content with the modulated frequency content of said separate channels into a common space.

30. In an audio system, a source of audio musical frequencies covering the gamut of a musical scale, a band pass filter connected to said source, a musically frequency modifying modulator connected to said filter, a second different band pass filter connected to said source, a second musically frequency modifying modulator connected

11

to said second filter and an output system connected to said two modulators, wherein said modulators are arranged and adapted to introduce new frequencies on a steady state basis.

31. The combination according to claim 30 wherein said band pass filters have adjacent pass bands. 5

32. The combination according to claim 30 wherein said band pass filters have approximately octaval widths.

33. The combination according to claim 30 wherein said band pass filters have approximately semi-tone widths. 10

34. In an audio tone processing system, an electronic organ providing audio musical frequencies covering the gamut of a musical scale, a plurality of tone processing channels each including a band pass filter, said filters having at least approximately adjacent pass bands and being connected to said electronic organ for passing said audio musical frequencies, a separate musically frequency modifying modulator connected to each of said filters, and an output system coupled to said channels for passing the tones processed in said channels, wherein said modulator connected to each of said filters is arranged and adapted to introduce new frequencies on a steady state basis. 15 20

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