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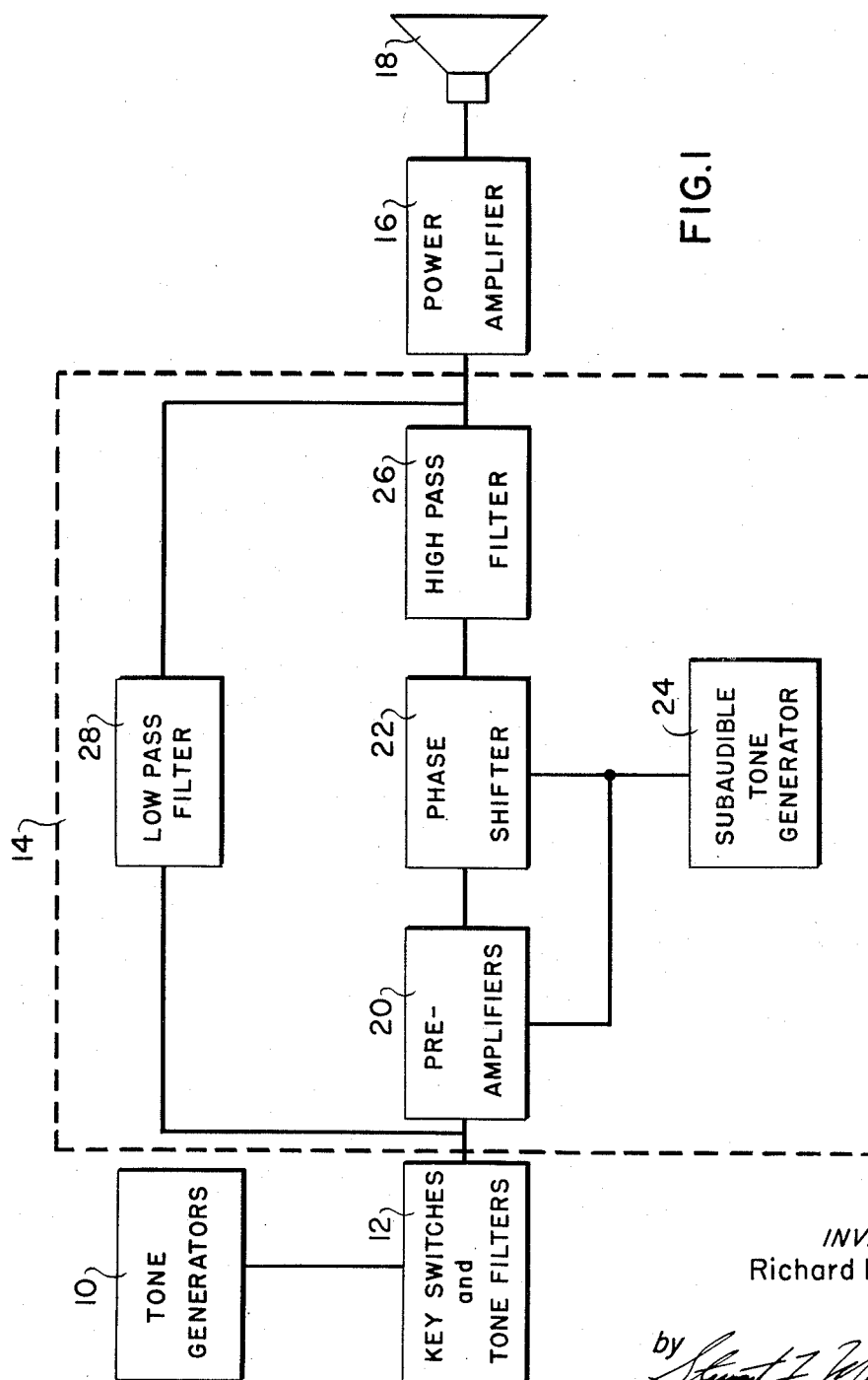
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ELECTRICAL MUSICAL INSTRUMENTS

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2 Sheets-Sheet 1



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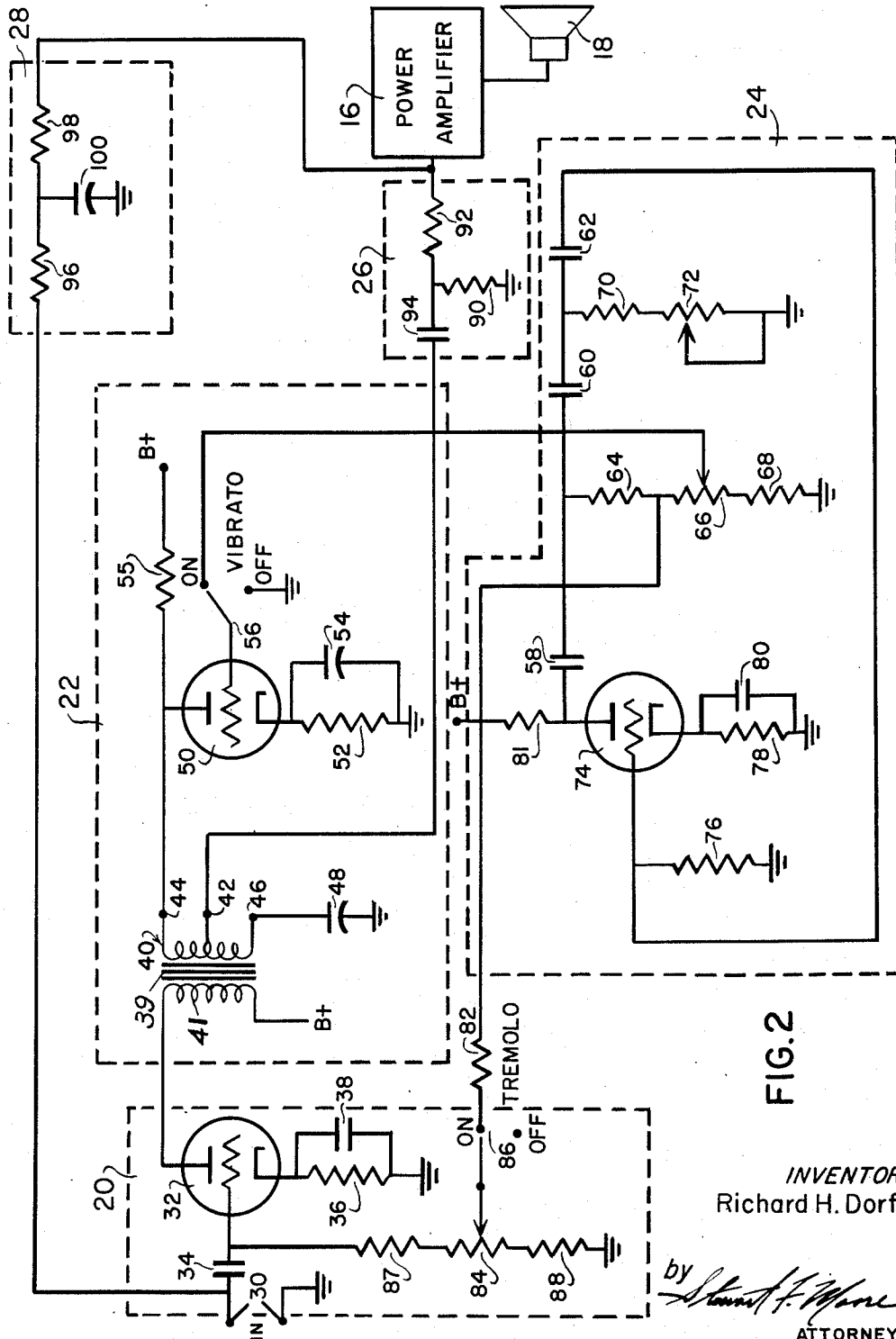
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ELECTRICAL MUSICAL INSTRUMENTS

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2 Sheets-Sheet 2



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ELECTRICAL MUSICAL INSTRUMENTS

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This invention relates to musical instruments and more particularly to a combined vibrato-tremolo system for use in an electronic musical instrument.

It is desirable in electronic musical instruments to provide means for varying, at the will of the player, the pitch of musical tones emitted by the instrument at a low frequency or natural vibrato rate. In the past, in all-electronic instruments of the type which utilize vacuum tube oscillators for generating the musical tones, it has been the practice to vary the voltage applied to at least one of the electrodes of each of the master oscillator tone generators at a vibrato rate to produce the necessary vibrato. However, adding vibrato to the tones by such means is not generally satisfactory. An oscillator whose frequency can be varied in such a manner is inherently unstable, with the result that the instrument is subject to drifting out of tune over a period of time. Furthermore, it is advantageous to apply vibrato only to selected tone frequencies of the instrument since it is not musically pleasing to the ear that the lower or bass tone frequencies exhibit the same degree of vibrato as is found in the higher tone frequencies. When vibrato is applied directly to master oscillators of electronic musical instruments, the application of vibrato to only selected numbers of the tones is impossible, because all of the tone frequencies, including the bass tones, are merely submultiples of the fundamental tone frequencies generated by the master oscillators, and would accordingly contain any vibrato frequency component applied to the master oscillators.

Applying a natural vibrato frequency to all of the master oscillator tone generators has the additional disadvantage that the vibrato cannot be applied selectively to one or more of the manuals of an organ, as one set of tone generators supplies tones for all manuals. Thus a "chorus" effect cannot be obtained with such a system.

In some instances, it is difficult if not impossible to apply a vibrato signal directly to the tone generators, particularly when the tone generators are vibrating reeds with electrostatic pickups, or of the rotating metallic disc, electro-magnetic type. Heretofore, when electronic instruments have used such tone generators, the vibrato systems have been cumbersome and complex, and usually a combination of mechanical and electrical devices are resorted to, such as delay lines with selected tapped connections, mechanically commutated at vibrato frequency rate to supply a varying phase shift to the output of the electronic instrument.

Additionally, it is particularly desirable that the vibrato system be an electronic integrated unit which can be easily adapted to any electrical musical instrument and need not necessarily be incorporated into the instrument during manufacture thereof. Where vibrato systems are supplied as an additional packaged unit to an electronic musical instrument, the units may be cascaded at the will of the player to provide greater degrees of vibrato

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if desired, or, on the other hand, removed entirely without disrupting the internal circuitry of the instrument.

Some musicians prefer tremolo or amplitude variation of the instrument tones in addition to or an lieu of vibrato or frequency variation of the tones. It is therefore preferable that any vibrato system have means for providing tremolo alone or in conjunction with the vibrato, and that tremolo be similarly available when the vibrato system is supplied as an additive extra to an existing instrument. If a vibrato signal is applied directly to the tone generators of the instrument, it is difficult to apply such vibrato without securing tremolo at the same time since, as mentioned above, signals of vibrato frequency are usually applied to a grid of the master oscillators of the tone generating system and vary the bias thereof. Any variation in the bias not only produces frequency variation, but also amplitude variation of the outputs of the master oscillators. Conversely, attempts to apply only tremolo to other electrodes of the tone generating oscillators invariably result in some form of frequency shift of the center frequency of the oscillators.

It is therefore an object of the present invention to provide a combination vibrato and tremolo system for electronic instruments which is low in cost to manufacture and which is easily adaptable as a separate unit to all types of musical devices.

It is another object of the invention to provide a combination vibrato and tremolo system having means for selectively actuating either vibrato, tremolo, or both, at will.

It is a further object of the invention to provide a vibrato system which is instantaneous in starting and completely variable in frequency and depth over the natural vibrato range.

It is yet another object of the invention to provide a combination vibrato and tremolo system for electrical musical instruments in which the vibrato may be supplied only to selected portions of the musical tone frequencies in the instrument, or to selected manuals of an electronic organ.

It is a still further object of the invention to provide a vibrato system which may be easily cascaded with like units.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a block diagram of the present invention.

Fig. 2 is a schematic circuit diagram of the tremolo-vibrato system.

In Fig. 1 the general block schematic of the novel tremolo-vibrato system is shown as used, by way of example, in conjunction with a conventional electronic organ type of musical instrument. Such an organ generally has a plurality of tone generators 10 which may be a number of electronic oscillators, or vibrating reeds with electrostatic pickups, or any of the other well known types of tone generators. Electronic organs generally have one or more manuals of keys which are adapted to selectively apply the desired pitches generated by the tone generators to selected filters for tone coloring purposes. These key switches and filters are indicated by reference character 12 in Fig. 1.

In the present embodiment, the vibrato system generally indicated as 14 is connected between the outputs of tone filters 12 and the input of the usual power amplifier 16 which in turn energizes a loudspeaker system 18. It should be understood, however, that the tremolo-vibrato system of the present invention is shown only by way of example as being connected to an electronic organ,

and particularly interposed between the outputs of the tone filters and the input of the amplifying system. The thermolo-vibrato system may be connected to any portion of an electronic organ arrangement where there is a source of audio voltage. Furthermore, the vibrato system generally indicated as 14 may be attached to any electronic musical instrument, and is not limited in applications to electronic organs. For example, the source of tones to which it is desired to add a pleasing vibrato may be electronic instruments, such as an electric guitar, electric piano, or a tape recorder.

The vibrato system includes an input amplifier 20 to which is connected a phase shifter 22 and a subaudible tone generator 24. Tone generator 24 is preferably an electronic oscillator having an output frequency adjustable over the entire natural vibrato frequency rate, that is, between 2 and 12 cycles per second. Subaudible tone generator 24 is also connected to phase shifter 22. Thus, tone signals from amplifier 20 are shifted in phase at a natural vibrato frequency rate by means of phase shifter 22, at a rate determined by subaudible tone generator 24.

In most musical instruments where a vibrato is used, it is also generally desirable to provide a source of tremulant or variation in the amplitude of the tone signals at a natural vibrato frequency rate. In accordance therewith, the output of the subaudible tone generator 24 is also connected to the input of amplifier 20 in such a manner that the tones received thereby are modulated at a natural vibrato rate.

Connected to the output of phase shifter 22 is a high pass filter 26 which may have any desired low frequency cut-off. Filter 26 is desirable as most musicians do not wish to have vibrato on tones of the lower pitches. Furthermore, high pass filter 26 insures that no signal components having a fundamental vibrato frequency, such as may be passed directly to the speaker system 18 from tone generator 24 to create an objectionable rumble in the output, are passed to power amplifier 16. Low pass filter 23 is connected between the input of preamplifier 20 and power amplifier 16 in order to allow tones of lower pitches to be amplified by the main amplifier 16 without any vibrato application thereto.

The combined vibrato-tremolo system is shown in schematic detail in Fig. 2. The vibrato preamplifier 20 has a pair of input terminals 30 which may be connected to any source of electronic musical tone as mentioned heretofore. The input grid of a suitable electronic valve 32 is connected to one of terminals 30 through a coupling capacitor 34. Valve 32 has a cathode biasing resistor 36 and associated by-pass capacitor 38. The anode circuit of valve 32 is connected to the input or primary winding 41 of transformer 39. The output winding 40 of transformer 39 has center tap connected to a terminal 42 and ends connected to terminals 44 and 46 respectively. A capacitor 48 is connected between terminal 46 and ground. The anode circuit of valve 50 is connected to terminal 44 while the cathode circuit of valve 50 comprises a bias resistor 52 with an associated by-pass capacitor 54 connected between the cathode of valve 50 and ground. A suitable positive voltage is applied to the anode of valve 50 through a plate load resistor 55.

A signal from generator 24 having a natural vibrato frequency is applied to the input grid of valve 50 through a switch 56 which is adapted to shunt the grid to ground when no vibrato is desired.

Transformer 39, capacitor 48, valve 50 and associated circuitry comprise a means for providing wide phase excursions in the tone signal appearing between terminal 42 and ground as compared with the signal applied to the input winding 41 of transformer 39. Since phase shift is synonymous with frequency shift, then as the phase of the instant tone signal is shifted at a natural vibrato rate by means of vibrato signals from generator 24, the output from phase shifter 22 as seen between ter-

minal 42 and ground is shifted in frequency at the same vibrato rate.

The principles of operation of the phase shifter may be more easily understood if valve 50 is considered as a variable resistor connected between terminal 44 and ground. As capacitor 48 is connected between terminal 46 and ground, it comprises, when taken in connection with valve 50, a resistance-capacitance circuit connected in series between the end terminals 44, 46 of transformer 39, with the midpoint between the resistor-capacitor series combination at ground potential. Due to the conventional electrical action of a center tapped transformer, the signal voltage appearing between terminal 42 and 44 is 180° out of phase with respect to the signal voltage appearing between terminal 42 and 46. Furthermore, as the transformer output winding 40 is center tapped, these two out of phase voltages are equal in magnitude.

The tone signal voltage output is developed between the midpoint 42 of two 180° out of phase voltages and the junction point between two complex impedances, namely capacitor 48 and variable resistance valve 50, which have the two out of phase voltages impressed thereacross. Therefore, it will be seen that the resultant output signal is always equal in magnitude to one-half the voltage developed between terminals 44 and 46, but varying in phase with respect to the input voltage of transformer 39, depending upon the magnitude of the "RC" impedances with respect to one another. Accordingly, if R, the plate resistance of valve 50, is varied while the value of C48 is held constant, the phase of the output signal voltage developed between terminal 42 and ground will vary accordingly, and will approach 180°. The action of the circuit can be better understood with the aid of the theory of extremes. If the plate resistance value of valve 50 is reduced to zero, the output terminals become terminals 42, 44 of transformer 39, and the output signal has the amplitude and phase of that half of the transformer. If the capacitor is at zero reactance, the output signal has the phase and amplitude of the signal appearing across terminals 42, 46 of transformer 39. It follows that at intermediate values of resistance and reactance the phase of the output is somewhere between these two 180° extremes, but the amplitude of the output signal is always constant, namely one half of the signal voltage developed between terminals 44, 46 of transformer 39.

It has been found that a value of .001 microfarad for capacitor 48 provides a suitable degree of phase shift when used with most conventional valves.

Plate resistor 55 serves to isolate end 44 of transformer winding 40 from ground so as to allow valve 50 to be the principal resistance therebetween. It has been found in actual practice that phase shifts as high as 175° may be obtained.

Vibrato frequency generator 24 may be any conventional type, low frequency oscillator which is adapted to oscillate between 2 and 12 cycles per second. For purposes of illustration, a phase shift oscillator is shown which employs resistance-capacitance combinations to supply the necessary phase shift to cause valve 74 to oscillate. The phase shift components comprise capacitors 58, 60 and 62 and resistors 64, 66, 68, 70, 72 and 76. Resistor 66 is a variable or potentiometer type which adjusts the "depth" of the vibrato. It is connected to one pole of switch 56 and provides a terminal from which the output voltage of the oscillator 24 is taken and applied through switch 56 to the input grid electrode of valve 50. Switch 56 has a pole connected to ground. By manipulating the switch, the vibrato signal may be removed from the output of the instrument.

Resistor 72 is also adjustable, and provides a means for varying the frequency rate of the oscillator so that the vibrato rate may be adjusted. It is preferable that the rate be set between 4 and 6 cycles per second as this range is the most pleasing vibrato rate to the human ear.

Yet the oscillator should be capable of adjustment over the whole natural vibrato frequency range.

The phase shift network is connected to a valve 74 which is caused to oscillate in a well known manner. Valve 74 has a grid to ground return resistor 76 and a cathode to ground resistor 78 with an associated by-pass capacitor 80. A plate load resistor 81 is connected to a source of positive voltage and the anode of valve 74.

In some instances, it is desirable to provide tremolo as well as vibrato, that is, a variation in amplitude of the instrument output tones as well as a variation in frequency. Accordingly, vibrato frequency generator 24 may also serve as a source of tremolo signal. This feature is provided by injecting a portion of the output voltage of oscillator 24 into the input circuit of pre-amplifier 20, thereby modulating the signal amplified by pre-amplifier 20 in accordance with the frequency of the subaudible tone oscillator 24. Connections between vibrato oscillator 24 and the input circuit of preamplifier 20 are provided by means of isolating resistor 82, potentiometer 84 and resistors 87 and 88. Potentiometer 84 and resistors 87 and 88 provide a control grid to ground return path for valve 32. The "depth" of the tremolo may be adjusted by varying the amount of signal voltage fed from oscillator 24 to the control grid of valve 32 by means of potentiometer 84. If desired, potentiometers 66 and 84 may be of the ganged type, so that the depth of the vibrato and tremolo may be varied simultaneously. The rate or frequency of the tremolo is a function of the frequency of oscillator 24 and is accordingly the same as the vibrato frequency. Therefore, manipulation of rate control 72 varies both the vibrato and tremolo rate simultaneously. A switch 86 is connected in series between the input contact of potentiometer 84 and resistor 82 to remove the tremolo signal from preamplifier 20 when the tremolo feature is not desired.

As mentioned heretofore, it is desirable to prevent signal components having the fundamental frequency of the vibrato oscillator from appearing in the output of amplifier 16 where an objectionable "rumble" would be heard, and it is further desirable that the lower frequency tones be vibrato free. A high pass filter 26 provides both of these functions. Since it is preferable to have a gentle roll-off characteristic rather than a sharp knee in the characteristic curve of the filter, a simple RC filter may be used. Such a filter is shown by way of illustration as comprising resistances 90, 92 and a suitably chosen capacitor 94. To allow the low tone frequencies to appear in the output of amplifier 16 without having any vibrato frequency components superimposed thereupon, a low pass filter 28 is provided. Such a filter may also be of the simple RC type, consisting of suitably chosen resistors 96, 98 and a capacitor 100.

In electronic musical instruments, the general tone output should have a constant amplitude for all tone frequencies. This feature is easily provided by the present invention because the output from the phase shifter is always constant in amplitude due to its unique design.

By applying conventional filter design techniques, the roll-off characteristic of the filters 26, 28 may be suitably shaped to intersect at a point of magnitude substantially equal to that of the respective pass bands of each filter, and the filters may also be designed to have substantially identical transmission efficiencies. As a result, to the listener there is no apparent decrease of amplitude in either the high or the low frequency tone signals, but only a gentle decrease in vibrato as the tone frequencies become lower.

Since the signal fed to transformer 39 is amplified by valve 32, it has a greater magnitude than the signal fed to low pass filter 28. However, gain equalization between these tone signals may be provided in any conventional way. For example, a resistor attenuating network may be inserted in series in the line between terminal 42 and high pass filter 26, or the turns ratio of the transformer

may be adjusted to compensate for the voltage amplification provided by valve 32. The latter means is preferable as it has been found that the phase shifter functions better if winding 40 presents a comparatively low impedance to the phase shifting components.

Each tremolo-vibrato system 14 is a completely integrated unit, and may be cascaded with like units to provide a very great degree of vibrato, tremolo, or both. Furthermore, the systems need not be connected to the output stage of an electronic organ but may be connected to preceding stages, for example, to the output connections of one or more manuals in a multi-manual organ. For example, in a two manual organ, the invention may be connected to the swell manual only to provide tremolo-vibrato for the solo stops of the "swell." In this manner the "great" manual and pedal clavier would be free of vibrato or tremolo as is often preferred.

On the other hand, a separate tremolo-vibrato system 14 may be connected to each of the manuals so that a "chorus" effect will be obtained when both manuals are played together.

While the present invention has been disclosed by means of specific illustrative embodiments thereof, it would be obvious to those skilled in the art that various changes and modifications in the means of operation described or in the apparatus, may be made without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. In an electrical musical instrument, means for producing audio frequency tone signals, an amplifier for amplifying said signals, said amplifier having input and output circuits, means connected to said output circuit for shifting the phase of signals amplified by said amplifier, means connected to the input circuit of said amplifier for modulating said audio signals, a subaudible frequency source in connection with said phase shifting means and said modulating means operative to modulate and simultaneously shift the phase of said audio signals at a sub-audible rate, whereby said signals exhibit both tremolo and vibrato simultaneously, a high pass filter connected to said output circuit to filter out the subaudible frequencies introduced in said signals by said source of sub-audible frequency, and a low pass filter connected between the input of said amplifier and output of said high pass filter to by-pass low frequency tone signals around said amplifier circuits.

2. The apparatus defined in claim 1, wherein said low pass filter and said high pass filter have substantially equal roll-off frequencies and transmission efficiencies.

3. In an electrical musical instrument, the combination including two sources of audio tone signals having a substantially 180 degrees out of phase relationship, means including a plurality of impedances serially connected across said signal sources for combining said sources of signals, means for varying at least one of said impedances at a selected vibrato rate independently of said other impedance, and output paths connected to said sources and said serially connected impedances for providing a third audio signal having a constant amplitude and varying in frequency at said vibrato rate with respect to said first and second audio signals.

4. In an electrical musical instrument, the combination including two sources of audio tone signals having a substantially 180 degrees out of phase relationship, means including a plurality of impedances serially connected across said signal sources for combining said sources of signals, means for varying at least one of said impedances at a selected vibrato rate independently of said other impedances, and output paths connected to said sources and said serially connected impedances for providing a third audio signal having a constant amplitude and varying in frequency at said vibrato rate with respect to said first and second audio signals, one of said output paths including a filter for filtering out the subaudible

frequencies introduced into the audio output signals by said impedance varying means.

5. In an electrical musical instrument including an electrical device having an output for distributing electrical signals whose frequencies correspond to that of sounds to be produced, means for dividing said signals into components of equal magnitude and opposite phase relationship, means including a plurality of impedances serially connected across said dividing means for combining said signal components of equal magnitude in opposite phase relationship, means for varying at a selected vibrato rate at least one of said impedances independently of said other impedances, and output paths connected to said dividing means and said serially connected impedances for providing an audio signal having a constant amplitude and varying in frequency at said vibrato rate with respect to the output signal from said electrical device.

6. In an electrical musical instrument including an electrical device having electrical output signals whose frequencies correspond to that of sounds to be produced, means for dividing said signals into components of equal magnitude and opposite phase relationship, said dividing means having output terminals, a serially connected reactive element and a variable impedance element connected in shunt across said output terminals, means for varying said variable impedance element at a selected vibrato rate independently of said reactive element, a first output path from said dividing means, a second output path from the junction point of said serially connected reactive element and said impedance element whereby said paths provide output signals therebetween varying in frequency at said vibrato rate, with respect to the output signals of said electrical device.

7. A musical instrument including an electrical device having electrical output signals whose frequencies correspond to that of sounds to be produced, means for dividing said signals into components of equal magnitude and opposite phase relationship, said means including a connection effective to establish for said components a point of common phase reference, means including a plurality of impedances for combining said signals, means for varying the magnitude of at least one of said impedances at a selected vibrato rate independently of said other impedance, and output paths connected to said point of common phase reference and said combining means respectively for providing output signals therebetween varying in frequency at said vibrato rate, with respect to the output signals of said electrical device.

8. In an electrical musical instrument including an electrical device having an output for distributing elec-

trical signals whose frequencies correspond to that of sounds to be produced, means for dividing said signals into components of equal magnitude and opposite phase relationship, means including a plurality of impedances for combining said signals, means for varying at least one of said impedances at a selected vibrato rate, output paths from said dividing and said combining means respectively for providing output signals varying in frequency at said vibrato rate, one of said output paths including a high pass filter for filtering out the subaudible frequencies introduced into the output signals by said impedance varying means, and a low pass filter connected between the output of said device and the output of said high pass filter to by-pass low frequency signals around said dividing and combining means.

9. In an electrical musical instrument, including means for producing audio frequency tone signals, an amplifier for amplifying said tone signals, said amplifier having an output circuit, a transformer connected to said output circuit, said transformer having a center-tapped secondary winding, an electronic valve having at least an anode circuit and a signal input electrode, a capacitor connected to a terminal of said secondary winding, the anode circuit of said valve being connected in series between a second terminal of said secondary winding and said capacitor, a generator of subaudible frequency oscillations connected to said input electrode and operative to shift the phase of said audio signals at a subaudible rate whereby said signals exhibit a vibrato frequency shift at said subaudible rate, output terminals for said frequency shifted signals connected to said center tap and said series connection between said capacitor and said anode circuit, and a filter connected to said output terminals for filtering out the subaudible frequencies introduced into the output signals by said generator of subaudible frequency oscillations.

10. Electrical musical apparatus according to claim 9 wherein said amplifier has an input circuit, and said generator of subaudible frequency oscillations has a switchable connection to said input circuit, whereby said signals are selectively amplitude modulated to provide tremolo concurrently with said vibrato frequency shift.

References Cited in the file of this patent

UNITED STATES PATENTS

2,382,413	Hanert	Aug. 14, 1945
2,401,372	Rienstra	June 4, 1946
2,466,306	Daniel	Apr. 5, 1949
2,485,538	Rowe	Oct. 18, 1949
2,565,033	Leonard	Aug. 21, 1951
2,574,577	Martin et al.	Nov. 13, 1951