Oct. 2, 1962 H. O. SCHWARTZ ETAL 3,056,327

ELECTRONIC TREMULANT

Filed June 9, 1960

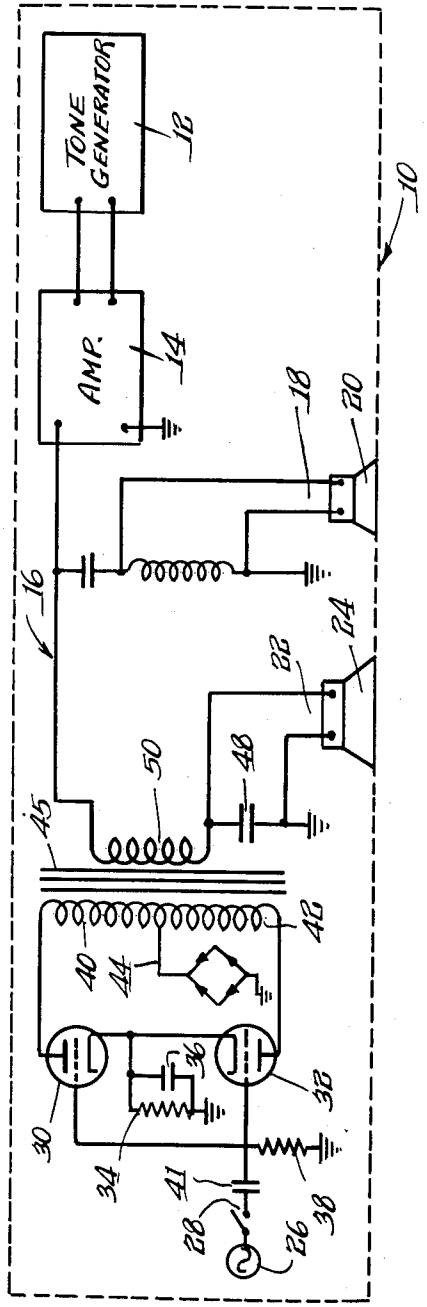


Fig. 1.

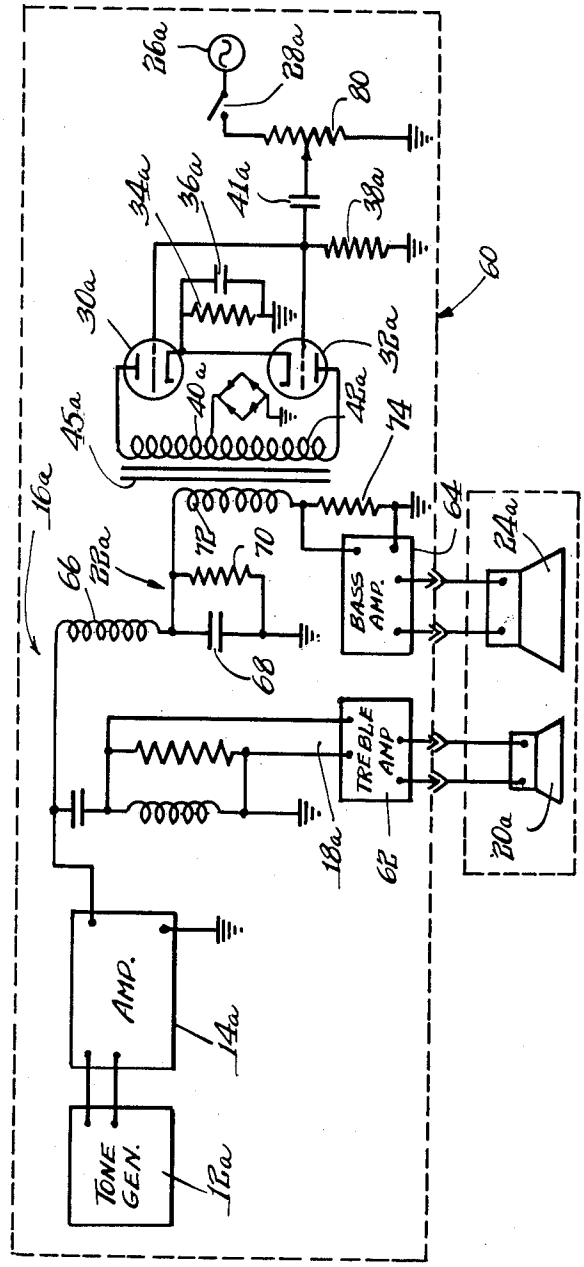


Fig. 2.

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United States Patent Office 3,056,327 Patented Oct. 2, 1962

3,056,327

ELECTRONIC TREMULANT

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Filed June 9, 1960, Ser. No. 34,919
10 Claims. (Cl. 84—1.25)

The present invention relates to electronic musical instruments in which electronic tone signals are amplified and transformed into audible sounds, and is concerned more particularly with the achievement of tremulant effects in the audio output of such instruments.

One object of the invention is to provide, in an electronic musical instrument, such for example as an electric organ, new and improved means for generating sound with tremulant effects from electronic tone signals.

Another object is to provide, in an electronic musical instrument, new and improved electronic tremolo means which operate electronically to introduce tremulant effects into the generation of sound from electronic tone signals.

Another object is to provide new and improved sound generating means having a wholly electronic mode of operation, which generates sound with pleasing tremulant effects from separately supplied electronic tone signals and cyclic electronic signals.

A further object is to provide, in an electronic musical instrument, new and improved tremolo means which respond to simple electronic cycle signals efficiently to introduce a highly effective tremulant character to electronic tone signals, which then generate sound with tremulant effects.

Another object is to provide new and improved electronic sound generating means in which pleasing tremolo effects are achieved by the reflection of the variable resistance of a vacuum tube into an electronic sound channel of the sound generating means.

A further object is to provide in an electronic musical instrument, new and improved tremolo means which is more compact, less expensive, and more stable and dependable in operation than prior tremolo devices used for the same purpose.

Other objects and advantages will become apparent from the following description of the exemplary embodiments of the invention illustrated in the drawings, in which:

FIGURE 1 is a diagrammatic illustration of an electric organ incorporating one embodiment of the invention; and

FIG. 2 is a diagrammatic illustration of an electric organ incorporating another embodiment of the invention.

Referring to the drawings in greater detail, the electronic organ **10** illustrated in FIG. 1 and forming the first illustrated embodiment of the invention, comprises a tone generator **12** which produces electronic tone signals which are amplified in an amplifier **14**.

The output of the amplifier **14** is connected to a crossover network **16** which separates the high or treble frequency in the amplifier output from the low or bass frequency in the amplifier output. The high frequency output channel **18** of the crossover network **16** is connected to drive a treble speaker **20**, and the low frequency output channel **22** of the crossover network **16** is connected to drive a bass speaker **24**.

Tremulant effects are generated in the low frequency output channel **22** connected to the bass speaker **24**. Such tremulant effects, which are produced in a manner to be described, are achieved by a cyclic variation in the output volume of the low frequency channel. Thus, the output volume is varied at a tremulant frequency which should be of the order of 6.5 cycles per second.

To control the tremulant frequency, a suitable electronic cycling device **26** is provided for supplying to a tremolo control switch **28** an output voltage which is varied cyclically at a rate of 6.5 cycles per second. A device capable of supplying a voltage which is varied cyclically at this rate can be readily provided by those skilled in the art, and hence need not be described here in order to convey an understanding of the present invention.

Upon closure of the tremolo control switch **28**, the cyclic signal voltage supplied through the switch **28** is used to produce a corresponding cyclic variation in the plate resistance of two vacuum tubes **30**, **32**. The variable plate resistance of the tubes **30**, **32** is reflected into the low frequency output channel **22** of the crossover network **16**, to effect a corresponding cyclic variation in the volumetric output level of this channel.

As shown, the cathodes of both tubes **30**, **32** are connected to ground through a resistor **34** and a capacitor **36** in parallel. The control grids of both tubes are connected to ground through a resistor **38** and coupled through a capacitor **41** with the output side of the vibrato control switch **28**, whereby the alternating voltage supplied through the switch **28** is applied to the grids of both tubes.

The plates of the respective tubes **30**, **32** are connected to two vibrato control coils **40**, **42**, wound on a magnetic core **45**. A D.C. voltage is supplied from a conductor **44** to the ends of the coils **40**, **42** opposite from the tubes **30**, **32**. The windings of the coils **40**, **42** in the directions of current flow through the respective coils are such that the coils are in magnetically bucking relation to each other.

Referring again to the crossover network **16**, it will be observed that the input terminals of the bass speaker **24** are bridged by a capacitor **48** and that one of the terminals is connected to the amplfier **14** through an inductance or high frequency choke coil **50**.

The inductance coil **50** included in the power supply to the bass speaker **24** is wound on the same magnetic core **45** on which the tremolo control coils **40**, **42** are wound.

The operational effect of this structure is to reflect into the bass channel **22** which drives the speaker **24** the cyclically varied plate resistance of the tubes **30**, **32**.

Thus, the cyclically varied grid voltage on the tubes **30**, **32** effects a corresponding variation in the current flow through the tremolo control coils **40**, **42**, which in turn effects a cyclic variation in the flux in the core **45**. The effect of this is to produce a cyclic variation in the effective inductance of the inductance coil **50**, with the result that the impedance in the circuit which drives the bass speaker **24** is varied cyclically at a frequency of 6.5 cycles per second. This cyclic variation in the impedance of the bass speaker driving circuit causes a corresponding cyclic variation in the amplitude or output volume of the sound signals from the bass speaker to produce the desired tremulant effect in the sound generated.

Since the coils **40**, **42** magnetically buck each other, changes in the current flow through these coils at the tremulant frequency of 6.5 cycles per second do not cause any corresponding induced voltage in the inductance coil **50**. Moreover, transformer coupling efficiency at this low frequency is extremely poor. Consequently, no problem arises from a voltage being induced in the coil **50** by changes in the current flow through the coils **40**, **42**.

Moreover, a very high turns ratio of the coils **40**, **42** relative to the coil **50** is used to effect an impedance match between the coils **40**, **42** and the tubes **30**, **32**, while at the same time limiting the turns of the coil **50**, so as to avoid undue attenuation of the power supply through the coil **50** to the bass speaker **24**.

The variable audio voltage applied to the coil **50** is steped up in the coils **40**, **42** and applied to the plates of the tubes **30**, **32**. Interference with the effectiveness of the tubes **30**, **32** in impressing a tremulant effect on the bass sound, by the transformed audio voltage on the tubes **30**, **32**, is effectively avoided by the push-pull relationship of the tubes to the coils **40**, **42**, and by the application of a D.C. voltage to the conductor **44** which is sufficiently high to operate the tubes **30**, **32** at high plate currents.

It will be appreciated that the tremolo means thus provided operates to produce a tremulant effect in the low frequency sound only when the tremolo control switch **28** is closed.

A modified embodiment of the invention is incorporated into an electric organ **60**, illustrated diagrammatically in FIG. 2. For simplicity in description, component elements of the organ **60** which are similar to previously described components of the organ **10** are designated with the same reference numbers, with the addition of the suffix "*a*."

Thus, as illustrated, electronic tone signals from the tone generator **12***a* are amplified in an amplifier **14***a* and supplied to a crossover network **16***a* which has a high frequency output channel **18***a* connected to a treble amplifier **62** which drives a treble speaker **20***a*.

The bass speaker **24***a* is driven by a bass amplifier **64** which connects with the low frequency output channel **22***a* of the crossover network **16***a* through means which incorporates tremulant effects into the electronic tone signals supplied to the bass amplifier.

As shown, the bass frequency channel **22***a* of the crossover network **16***a* comprises a high frequency choke coil **66** which is coupled to ground through a capacitor **68** and a resistor **70**.

The low frequency audio signal supplied at the output end of the choke coil **66** is connected through an inductance coil **72** to one side of the bass amplifier **64**, the other side of which is grounded, as shown. A resistor **74** is connected across the input terminals of the amplifier **64**. The desired tremulant effects are introduced through the coil **72** into the tone signals supplied to the input of the bass amplifier **64**.

For this purpose, the coil **72** is wound on a magnetic core **45***a* corresponding to the core **44** used in the organ **10**, previously described. Two tremulant control coils **40***a*, **42***a* wound on the core **45***a* in magnetically bucking relation to each other are cyclically energized by electronic tremulant control structure corresponding to that used to energize the control coils **40**, **42** in the organ **10** described. It will be noted with reference to FIG. 2 that a potentiometer **80** is connected in series with the coupling capacitor **41***a* to provide for adjustment of the cyclic voltage applied to the grids of the tubes **30***a*, **32***a*. This provides a convenient control of the degree of tremulant effect produced in the low frequency sound upon closure of the switch **28***a*.

The amplification of the output signals of the crossover network **16***a* of the organ **60** permits the usage of a crossover network having a relatively high impedance. The coil **72** and the resistance **74** in the low frequency output channel **22***a* of the crossover network **16***a* serves as a resistive voltage divider which supplies a tone signal voltage to the bass amplifier **64**.

It will be appreciated from the foregoing description that the cyclically varied plate voltage of the tubes **30***a* and **32***a* is reflected into the coil **72** to provide the desired tremulant effect. Because of the relatively high impedance of the crossover network **16***a*, which is ahead of the amplifier **64**, the turns ratio of the coils **40***a*, **42***a* relative to the coil **72** can be substantially reduced, while at the same time providing an impedance match with the tubes **30***a*, **32***a*. This effects a corresponding reduction in the transformed audio voltage applied to the plates of the tubes **30***a*, **32***a* with a consequent enhancement of the linearity of the response of the tubes to the changing tremulant control voltage applied to the tubes.

If desired, the output of the high frequency channel **18***a* and the output of the low frequency channel **22***a*, as modulated by the tremulant control structure, can be mixed together and amplified by a single power amplifier with another crossover network following.

It will be appreciated that the invention is not necessarily limited to the use of the particular structures illustrated, but includes the use of variants and alternatives within the spirit and scope of the invention as defined by the claims.

The invention is claimed as follows:

1. In an electronic musical instrument for producing sound with tremulant effects from electronic tone signals, the combination, comprising, a source of electronic tone signals, an amplifier connected to said source, a speaker, a speaker circuit for energizing said speaker from said amplifier, a magnetic core, an inductance coil on said core connected in series with said speaker circuit, two bucking coils on said core connected in magnetically bucking relation to each other, means including two vacuum tubes for energizing said respective bucking coils, and tremulant control means for supplying a cyclical control voltage to control grids of both said tubes simultaneously cyclically to vary the plate resistances of said tubes which resistances are reflected through said bucking coils and said core to said impedance coil to produce cyclic variations in the impedance of said impedance coil which produces a tremulant effect in the output of said speaker.

2. In an electronic musical instrument for producing sound with tremulant effects from electronic tone signals, the combination, comprising, a source of electronic tone signals, an amplifier connected to said source, a speaker, a speaker circuit for energizing said speaker from said amplifier, a magnetic core, an inductance coil on said core interconnected with said speaker circuit to control the output volume thereof, magnetizing coil means on said core, electron valve means connected to controllably energize said magnetizing coil means, and tremulant control means for supplying a cyclic control signal to said electron valve means for cyclically varying the current through said magnetizing coil means for cyclically varying the impedance of said impedance coil which introduces a tremulant effect in the output of said speaker.

3. In an electronic musical instrument, means for producing sound with tremulant effects from electronic tone signals, the combination, comprising a tone generator, an amplifier connected to said tone generator, a speaker, a speaker circuit for energizing said speaker from said amplifier, a magnetic core, an inductance coil on said core connected in output controlling relation to said speaker circuit, two bucking coils on said core connected in magnetically bucking relation to each other, means including two electron valves for energizing said respective bucking coils, and tremulant control means for supplying a cyclic control signal to said electron valves to produce a cyclical variation in the impedance of said impedance coil which produces a tremulant effect in the output of said speaker.

4. In an electronic musical instrument, means for producing sound with a tremulant effect comprising, in combination, tone generating means, an amplifier connected to said tone generating means, crossover network means connected to said amplifier to divide the output thereof into a high frequency channel and a low frequency channel, said low frequency channel including an inductance coil on a magnetic core, a treble amplifier and a bass amplifier connected to said high frequency and low frequency channels respectively, speakers connected to said treble and bass amplifiers, two tremulant control coils on said magnetic core electrically connected in magnetically bucking relation to each other, means including two vacuum tubes for supplying electric currents through said

magnetically bucking tremulant control coils, and tremulant control means for supplying a cyclic control voltage to the grids of both said tubes cyclically to vary the current through said tremulant control coils at a tremulant frequency to produce a cyclic variation in the effective impedance of said impedance coil which produces tremulant effects in the output of said bass channel.

5. In an electronic musical instrument, means for producing sound with a tremulant effect comprising, in combination, a source of electronic tone signals, an amplifier connected to said source, network means connected to said amplifier to divide the output thereof into a high frequency channel and a low frequency channel, a speaker connected to said high frequency channel, said low frequency channel including an inductance coil on a magnetic core, a bass amplifier connected to said low frequency channel, a speaker connected to said bass amplifier, tremulant control coil means on said magnetic core, electron valve means for supplying electrical current through said control coil means, and tremulant control means for supplying a cyclic control signal to said electron valve means to vary the current through said control coil means at a tremulant frequency to produce a cyclic variation in the impedance of said impedance coil which produces tremulant effects in the output of said bass channel.

6. In sound producing means the combination of an electrical sound signal circuit having an input side and an output side, a signal control coil, a magnetic core associated with said coil to coact therewith to determine the effective inductance thereof, said control coil being connected in said circuit so that a signal passing through said circuit from the input side to the output side thereof must pass through the coil so that the signal in passing through the coil is subject to modification in accordance with the effective inductance of said coil, flux inducing coil means associated with said core, an energizing circuit for said flux inducing coil means, said energizing circuit including electronic valve means for controlling the current through said flux inducing coil means, and an oscillator connected to control said electronic valve means to effect cyclic increases and decreases in the rate of current flow through said flux inducing coil means at a desired tremolo frequency.

7. Means for incorporating tremolo characteristics in electronic sound signals so that tremolo characteristics are manifest in sound produced from the sound signals, comprising, in combination, an electronic signal circuit having an input side for electronic sound signals and an output side for electronic sound signals, a control coil, magnetic core means associated with said coil to coact therewith to effect determination of the inductance of the coil, said control coil being connected in said signal circuit between said input and output sides thereof so that electronic sound signals passing through said circuit must pass through said coil so that the signal in passing through the coil is subject to modification in accordance with the effective inductance of the coil, a magnetic flux inducing coil on said core, and means for energizing said flux inducing coil at a rate which is cyclically varied at a desired tremolo frequency to effect corresponding variations in the effective inductance of said control coil.

8. Electrical means for producing electronic sound signals with tremolo effects from electronic sound signals lacking tremolo effects, the combination of a source of electronic sound signals lacking tremolo effects, a signal circuit having an input side connected with said source and having an output side adapted to supply signals for controlling a speaker, a control coil, a magnetic core associated with said coil to coact therewith to determine the effective inductance thereof, said coil being interconnected in said circuit so that the signals passing through said circuit from said input side to said output side thereof pass through said coil whereby the signals in passing through the coil are subject to modification in accordance with the effective inductance of the coil, two magnetic flux inducing coils associated with said core in magnetically bucking relation to each other, two energizing tubes connected to said respective flux inducing coils to energize the latter, and tremulant control means connected in controlling relation to both of said tubes to vary the output of the latter cyclically to effect cyclic variations of the current through said flux inducing coils at a desired tremolo frequency.

9. In electrical means for producing electronic sound signals incorporating cyclic effects from electronic sound signals lacking the cyclic effects, the combination of a signal circuit having an input side for receiving unmodified sound signals and an output side for supplying modified sound signals, a control coil, a magnetic core coacting with said coil to determine the effective inductance thereof, said coil being interconnected in said circuit so that the signals passing through said circuit from said input side to said output side thereof pass through said coil whereby the signals in passing through the coil are subject to modification in accordance with the effective inductance of the coil, two magnetic flux inducing coils associated with said core in magnetically bucking relation to each other, and frequency control means connected to energize both of said flux inducing coils at a rate which is cyclically varied at the frequency of cyclic effects desired in the sound signals.

10. In electrical means for producing electronic sound signals incorporating cyclic effects from electronic sound signals lacking the cyclic effects, the combination of electronic signal circuit means having an input side for electronic sound signals and an output side for electronic sound signals, a control coil, a magnetic core associated with said coil to coact therewith to effect determination of the inductance of the coil, said control coil being connected in said signal circuit between said input and output sides thereof so that electronic sound signals passing through said circuit must pass through said coil so that the signals in passing through the coil are subject to modification in accordance with the effective inductance of the coil, magnetic flux inducing coil means on said core, and cyclic control means for energizing said flux inducing coil means at a rate which is cyclically varied at the frequency of the cyclic effects desired in the sound signals.

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