June 4, 1946. A. R. RIENSTRA 2,401,372

ELECTRONIC MUSICAL INSTRUMENT

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FIG. 1

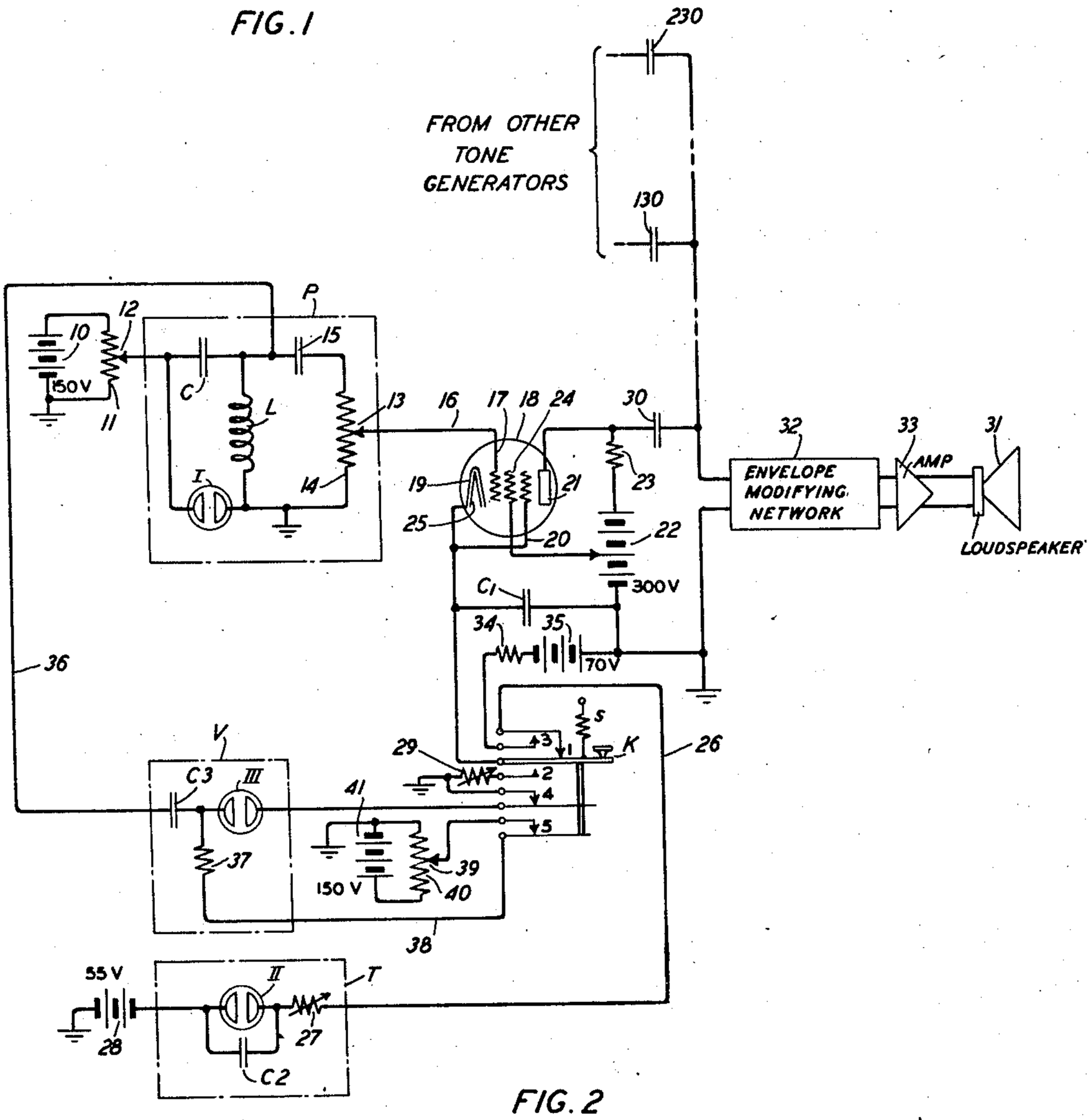
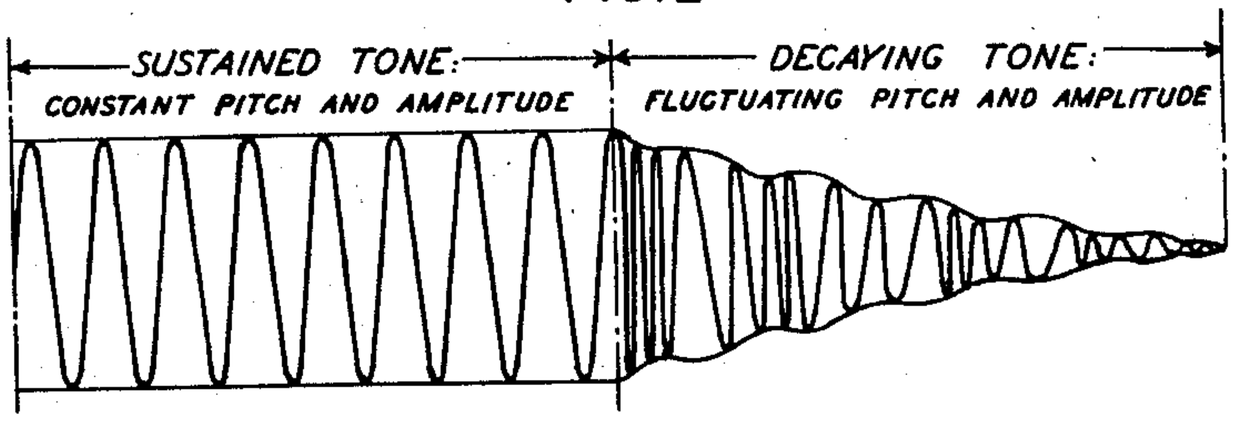


FIG. 2



INVENTOR
A. R. RIENSTRA

BY G. H. Heydt

ATTORNEY

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ELECTRONIC MUSICAL INSTRUMENT

Albert R. Rienstra, Garden City, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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5 Claims. (Cl. 84—1.26)

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This invention relates to an improvement in instruments for the production of music with particular reference to the use of electronic devices for generating musical tones. The invention provides an apparatus and a method for adding to tones so generated the effect of auditorium reverberation.

It has long been recognized that the sonorousness of the organ, for example, is in great measure due to the reverberation or repeated reflections of the subsiding organ tone in a properly designed auditorium. Not only does the reverberation prolong the decaying of the sound, but standing wave patterns are produced in the reverberant space which shift in location as the sound decays and so result for any individual listener in a fluctuation in the rate of subsidence of the sound. In addition, the air of the auditorium has its own proper frequencies of vibration determined by the auditorium size and shape and these proper frequencies make themselves apparent as a pitch fluctuation in the decaying tone.

Means are well known for generating musical tones by electronic devices. Likewise means are known to the prior art for controlling the rate of decay of such tones but it has hitherto been impossible to superimpose on this control of decay a complete simulation of the effect of a satisfactory auditorium. To do so requires, as just stated, the addition to the decaying sound of fluctuations in pitch and in amplitude, in other words, of a vibrato and a tremolo.

Accordingly, it is the general object of the present invention to improve the quality of music produced by electronic devices. A particular object of the invention is to provide means for conferring upon the decay of electronically generated tones fluctuations in pitch or in amplitude or simultaneously in both to simulate the acoustic effect of a reverberant auditorium.

Further, it is an object of the invention to provide the operator of the instrument with means enabling him to control at will the pitch and amplitude fluctuations above mentioned since it is generally desirable to have less reverberation for fast music than for slow music and also more reverberation for detached chords, especially the last one.

A feature of the invention is the use of three relaxation oscillators, one of these serving, as in the devices of the prior art, to generate the periodic electrical current which, through a loud speaker, produces a musical tone when a control key is operated. The two others act, either singly or together, when the operator by releasing

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a key initiates the decay of the sustained tone and serve to add to that tone the aforementioned fluctuations in pitch and amplitude.

Another feature of the invention is the provision of means for automatically controlling the rate of onset of the tone when the control key is operated and similarly automatically controlling the rate of decay of the tone when the control key is released.

The object stated, as well as other objects which will occur to those familiar with this art, is accomplished by the apparatus of the invention which will be understood both in structure and operation from the following description illustrated by the accompanying drawing, in which:

Fig. 1 exhibits a preferred embodiment of the invention, omitting unessential details; and

Fig. 2 symbolically represents a musical tone, at first steady and then subsiding with superimposed variations in pitch and amplitude.

In Fig. 1 potentiometer 11 is connected across battery 10 and a suitable fraction of the voltage across potentiometer 11 is selected by tap 12 thereon to supply power for the operaton of relaxaton oscillator P, generally indicated as included within the dotted outline at the upper left of the diagram. The oscillating circuit of oscillator P is composed of condenser C and inductance L in series between tap 12 and ground and shunted by tube I which may suitably be a 1-watt neon tube. Switching means, not shown, may of course be used to open or close the circuit of battery 10. When this circuit is closed, as shown, relaxation oscillations are set up in the circuit C—L—I, the fundamental frequencies of these oscillations being determined by the values chosen for C and L. These oscillations, rich in harmonics, are made available to the subsequent circuit by tap 13 of potentiometer 14 shunted across inductance L with the interposition of stopping condenser 15.

Tap 13 is connected by conductor 16 to control grid 17 of vacuum tube 18, which is suitably an RCA 6U7–G. In tube 18, cathode 19 is connected to suppressor grid 20; anode 21 is supplied with voltage from 300-volt battery 22 through resistor 23 and screen grid 24 is polarized from a selected portion of battery 22. The customary current supply of heater 25 is omitted from the figure. So far the circuit is conventional.

Cathode 19 is capacitatively coupled to ground through condenser C1, preferably an electrolytic condenser of about 25 microfarad capacity. When key K is in the position shown cathode 19 is also coupled to ground by way of resistor 27

(about 80,000 ohms resistance), condenser C2 (about 6 microfarads) and 55-volt battery 28. Cathode 19 acquires under these circumstances a voltage of about 52 volts positive to grid 17 so that tube 18 is biased to cut-off. Condenser C1 acquires a corresponding charge.

When key K is depressed downward against the tension of spring S, breaking contact 1 and making contact 2, the connection of cathode 19 is transferred from conductor 26 to resistor 29 leading directly to ground. Resistor 29 is appropriately of about 200 ohms resistance so that the charge of condenser C1 is rapidly reduced. Tube 18 becomes conductive and the relaxation oscillations received by grid 17 are amplified and transmitted through stopping condenser 30 to loud-speaker 31. It may be useful but is not a necessary part of the present invention to introduce a network 32 to modify in relative amplitude the various harmonics present in the output of relaxation oscillator P and to include this network with amplifier 33 in circuit between tube 18 and loud-speaker 31.

At the same time that contact 2 is made by depressing key K contact 3 is made with the result that resistor 34 in series with 70-volt battery 35 is connected between conductor 26 and ground. Battery 35 is so poled that its voltage adds to that of battery 28 and breaks down tube II, at the same time charging condenser C2 to the 75 volts maintained by tube II across its terminals. For this purpose tube II is suitably a voltage regulator tube such as the VR75–30. The combination of tube II, condenser C2 and resistor 27 constitutes a second relaxation oscillator T. Under the conditions described, condenser C2 being of about 6-microfarad capacitance and resistor 27 in series with resistor 34, each of these resistors having about 80,000 ohms resistance, the oscillations of oscillator T have a frequency of about 3 cycles per second. This frequency may be changed by varying condenser C2 and means for giving the operator control of this variation will be obvious.

Thus when key K is depressed the conductance of tube 18 is established in about one one-hundredth second and as long as the key remains depressed a sustained tone is produced from loud-speaker 31, rich in harmonics, modified in relative amplitude by network 32 if this network is used. Registor 29 may be made variable under the control of the operator to retard or accelerate the acquisition of conductance by tube 18 thereby controlling the rate of onset of the tone produced.

By the release of key K contacts 2 and 3 are broken and contact 1 is reestablished. The conductance of tube 18 decays as condenser C1 is recharged through condenser C2 and resistor 27. With the values stated above for these elements this recharge requires about four seconds. The tone emitted by loud-speaker 31 correspondingly decays at a rate which may be controlled by varying the resistance of resistor 27. This control may also, by obvious means, be made available to the operator whereby he is given control of the subsidence as well as of onset of the musical tone produced by loud-speaker 31.

It will be clear that the operation of breaking contact 3 and restoring contact 1 permits relaxation oscillator T to add its generated oscillations to affect the rate at which condenser C1 recharges whereby the decay of conductance of tube 18 proceeds at an average rate determined chiefly by resistor 27 but fluctuating about this average in accordance with the super-added oscillations of oscillator T. The acoustic effect is that of a musical note of which the intensity decreases at first rapidly but with recurrent fluctuations as shown in Fig. 2. A tremolo decay is thus provided which simulates the sound level fluctuations accompanying the shifting pattern of subsiding standing waves in an auditorium. Obviously, without this tremolo a prolongation of the natural logarithmic decay will only inadequately reproduce auditorium effects.

For musical purposes the auditorium itself is properly to be considered a part of the musical instrument played therein and it has been pointed out earlier in this disclosure that the air in the auditorium has its own natural vibrations which are excited by impact. The exciting impact may be relatively abrupt, as when the tone is started, or relatively slow, as when the tone is stopped. In the latter case a distinct vibrato is added to the decaying tone. The effect is well recognized and requires here no further explanation. How it is simulated by the apparatus of the present invention will now be described.

Contacts 4 and 5, initially closed when key K is in the position shown, connect relaxation oscillator V, indicated within the dotted line at lower left in the figure, across inductance L in tone generating oscillator P. Contact 4 connects ground to one terminal of tube III which is suitably also a 1-watt neon tube. The other terminal of tube III is connected through condenser C3 and conductor 36 to the end of inductance L remote from ground. The junction of tube III in condenser C3 is connected through resistor 37, conductor 38, contact 5 and tap 39 to a selected point on potentiometer 40 which shunts battery 41, the negative side of which is grounded. Varying the position of tap 39, which may also be placed under the operator's control, varies the frequency of oscillator V by varying the resistance included between ground and the junction of tube III and condenser C3.

Oscillations in the circuit of oscillator V are ineffective until contacts 4 and 5, broken when key K is depressed to initiate the tone, are restored by the release of the key. On this release oscillations produced by the breakdown of tube III are superimposed on those of oscillator P and since tube 18 is still conductive though decreasingly so, the subsiding sound emitted from loud-speaker 31 is affected with a pitch fluctuation corresponding to the oscillations of the circuit of oscillator V.

The subsiding tone is then affected with a vibrato as well as with a tremolo and the auditorium effect in respect both to standing wave patterns and to natural frequency of the enclosed air is completely simulated. It is of course possible by easily made changes in the apparatus to omit either the vibrato or the tremolo, if desired. It will be obvious that the operator may be provided with means for controlling independently the total decay time, the rate and amplitude of the tremolo and the rate and amplitude of the vibrato.

It will be understood that the detailed description is of one only of the tone generators required for a complete keyboard. Condensers 130 and 230 are shown to which other tone generators identical with the circuit described may be connected to the sound translating devices. When desired, any number of such circuits may be provided.

There has been described an apparatus and a method for the addition of pitch and amplitude

fluctuations to a decaying tone produced by the operation of an electronic tone generator, but obviously the invention is not limited to the specific forms of oscillating circuits shown in Fig. 1, and equivalents for any or all of these are within the scope of the described invention.

What is claimed is:

1. In an electrical musical instrument, in combination, means for generating a musical tone of desired amplitude and pitch, control means operable directly to effect the onset of said tone and operable reversely to effect the decay of said tone, a first circuit means associated with said control means when operated directly to control the rate of said onset, a second circuit means associated with said control means when operated reversely to control the rate of said decay, and electrical means activated by said second circuit means for superimposing variations in amplitude and in pitch on said tone during its decay.

2. In an electrical musical instrument, in combination, means for generating a musical tone of desired amplitude and pitch, control means operable directly to effect the onset of said tone and operable reversely to effect the decay of said tone, a first circuit means associated with said control means when operated directly to control the rate of said onset, a second circuit means associated with said control means when operated reversely to control the rate of said decay, and electrical means activated by said second circuit means for superimposing variations in amplitude on said tone during its decay.

3. In an electrical musical instrument, in combination, means for generating a musical tone of desired amplitude and pitch, control means operable directly to effect the onset of said tone and operable reversely to effect the decay of said

tone, a first circuit means associated with said control means when operated directly to control the rate of said onset, a second circuit means associated with said control means when operated reversely to control the rate of said decay, and electrical means activated by said second circuit means for superimposing variations in pitch on said tone during its decay.

4. In an electrical musical instrument, in combination, means including a first relaxation oscillator for generating a musical tone of desired amplitude and pitch, manual control means operable directly to effect the onset of the tone and operable reversely to effect the decay of the tone, a first electrical circuit associated with said control means when operated directly to control the rate of onset of the tone, a second electrical circuit associated with said control means when operated reversely to control the rate of decay of the tone, and means including a second and a third relaxation oscillator activated by said second circuit for superimposing on the tone as it decays variations in pitch and in amplitude.

5. In an electrical musical instrument provided with means for generating a musical tone having desired amplitude and pitch and decaying after a finite interval, means for simulating auditorium reverberation during the decay of the tone including, in combination, control means operable directly to effect the onset of the tone and operable reversely to effect the decay thereof, electrical circuit means associated with said control means when operated reversely to control the rate of decay of the tone, and electrical means including at least one relaxation oscillator activated by said circuit means for superimposing acoustic variations in the tone during its decay.

ALBERT R. RIENSTRA.