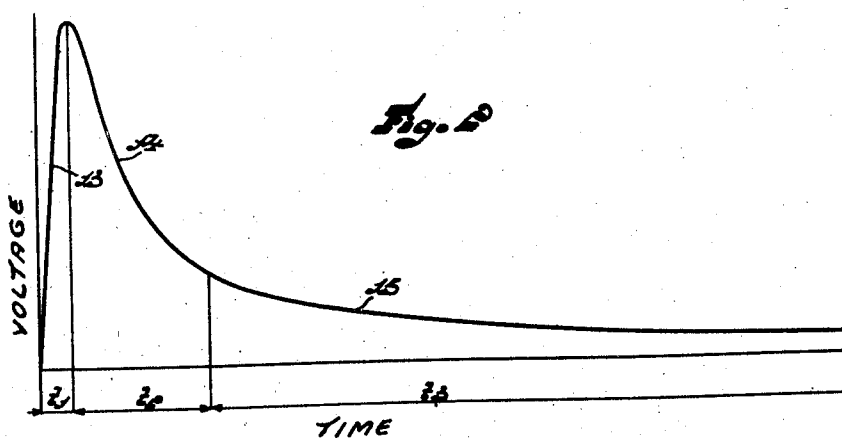
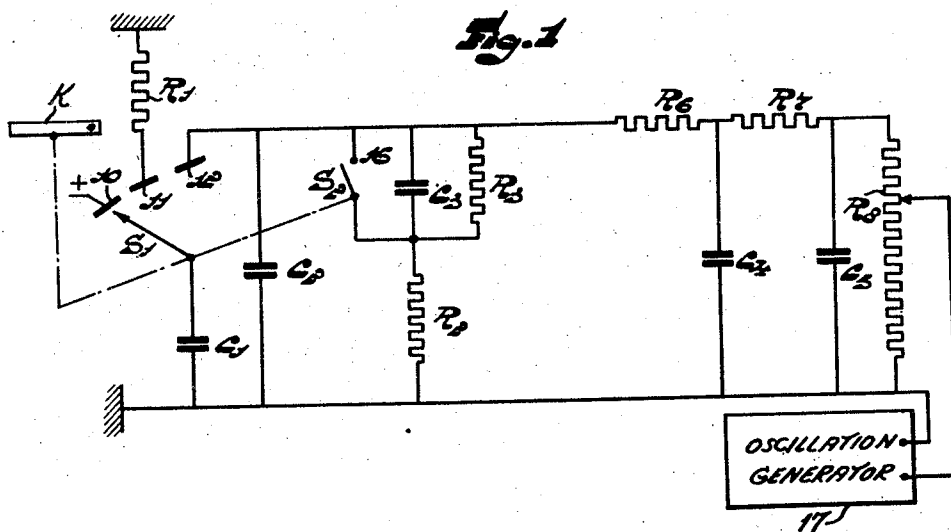


Sept. 20, 1949.

F. KERKHOF
ELECTRIC PIANO
Filed April 25, 1946

2,482,548



INVENTOR
FREDERIK KERKHOF
BY *F. F. Wendt*
ATTORNEY

UNITED STATES PATENT OFFICE

2,482,548

ELECTRIC PIANO

Frederik Kerkhof, Eindhoven, Netherlands, assignor, by mesne assignments, to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

Application April 25, 1946, Serial No. 664,745
In the Netherlands July 15, 1942

Section 1, Public Law 690, August 8, 1946
Patent expires July 15, 1962

6 Claims. (Cl. 84-1.26)

1

The present invention relates to electrical musical instruments and more particularly to an instrument playable by keys and having for each key thereof a system whose output potential controls the intensity of the note produced by striking said key.

It is already known, that the course of the decrease in intensity of the sound produced by a string which vibrates out can be approximately obtained with the aid of a decreasing electric voltage whose value decreases according to an e-function. This decrease of voltage is obtained when a condenser is discharged through one or more ohmic resistances, in which event the voltage at this condenser determines the intensity and the course of the tone.

With the known circuit-arrangements of this kind which are utilized in electric musical instruments, more particularly in electric pianos, the voltage which determines the sound intensity varies according to a single e-function. This result is obtained by the use of a circuit arrangement with which the charge of the condenser gets an opportunity to flow away during a comparatively short or long period according to the force with which the key is touched, the residual charge being transferred to a circuit which consists of a condenser shunted by an ohmic resistance. This condenser is discharged in this case via the ohmic resistance, owing to which the voltage at the condenser decreases according to an e-function.

Although with the above-mentioned circuit arrangement an approximation of the dying away of a tone produced by a key which has been touched is obtained, it has been found that, more particularly for the comparatively low frequencies, which are consequently produced in the piano by touching comparatively long and thick strings, the tone which dies down after being electrically produced is not a faithful reproduction of the tone produced by touching a string.

According to the invention, use is made of a circuit arrangement similar to that previously described but the condenser to which, after the touch, the charge is transferred has connected in parallel to it such impedances that the voltage decreases according to the sum of at least two e-functions.

With the circuit arrangement according to the invention we obtain a long sounding-out period so that also in the region of the intermediate and low tones of the piano a satisfactory approximation of the mechanical musical instrument is obtained.

According to one particular embodiment of the

2

invention, the condenser to which the charge is transferred after the key has been touched, has connected in parallel to it the series-connection of an ohmic resistance and a capacity which previously has been completely discharged and which is shunted by an ohmic resistance.

With this circuit arrangement it is achieved that the discharged capacity functions at first as a short-circuit for the resistance by which this condenser is shunted so that the initial discharge of the condenser takes place through a smaller resistance than the further discharge when the condenser shunted by the resistance is charged and acts as an insulator.

Further features of the invention will be explained in detail with reference to the accompanying drawing wherein

Fig. 1 represents the circuit arrangement which permits to obtain the desired course of the sound intensity.

Fig. 2 shows the variation of the voltage at the condenser which determines the instantaneous sound intensity of a tone.

In Fig. 1, S₁ denotes a switch which is actuated by the hammer connected with the key K of the musical instrument, each key of the whole keyboard having such a switch S₁. This switch has three contacts, viz, 10, 11 and 12, which, when the key is depressed, successively enter into contact with the arm of the switch. In the position of rest of the key the arm of the switch stands upon the contact 10, the condenser C₁ being now connected, through the intermediary of this contact, to a source of direct-current voltage. In the position of rest of the key the condenser C₁ is consequently always charged. When one of the keys is touched, the arm of the switch S₁ concerned moves from the contact 10 along the contact 11 to the contact 12. The duration of this movement depends upon the force with which the key is depressed. During this period of time the arm passes along the contact 11 and the condenser C₁ is partly discharged through a resistance R₁. The value of the residual charge depends upon the time during which the arm touches the contact 11 and therefore upon the force with which the key is touched. When the switch arrives upon the contact 12, a condenser C₂ is connected in parallel with C₁ so that now the residual charge of the condenser C₁ is divided over the condensers C₁ and C₂. Starting from a determined direct-current voltage at the contact 10, the final charge of the condenser C₂ only depends, after the key has been depressed, upon the speed at which the arm of the switch S₁ moves and

therefore upon the force with which the key is touched. When the key is completely depressed the arm of the switch S_1 gets free from the contact 12 so that the charge remained on the condenser C_1 can no longer be transferred to the circuit present beyond the said contact; it is only the charge imparted to the condenser C_2 which is decisive for the voltage variation in this circuit. When the key is released, the arm of the switch S_1 remains out of contact with the contacts 11 and 12 and it is only when the key is completely released that it arrives again upon the contact 10. The condenser C is charged again and the key may be touched anew.

On the same shaft of the switch S_1 is mounted a switch S_2 whose movement is consequently also initiated when the key is touched. The switch S_2 is constructed, however, in such manner that the contact 16 is only closed during the downward movement of the key as long as the arm of the switch S_1 has not yet reached the contact 12. In the further movement of this switch the contact 16 is opened again. Also during the return movement of the switches S_1 and S_2 the contact 16 is not closed. When the key is being depressed, but before the tone proper is struck, the switch S_2 consequently brings about the short-circuiting of the condenser C_3 so that at the beginning of each tone the said condenser is completely discharged. If the time interval between two successive touches of the same key is sufficiently long, this condenser is completely discharged through the resistance R_3 , it is true, but in the case of touches which rapidly succeed one another, such as trills, there would exist the possibility, in the absence of the switch S_2 , of the condenser C_3 being not completely discharged at the beginning of each tone. The variation of the voltage in the circuit might therefore be different from that which is required for obtaining the natural course of the sounding-out.

The circuit arrangement represented in Fig. 1 is composed as follows: In parallel with the condenser C_2 is connected the series-connection of a resistance R_2 and a condenser C_3 shunted by a resistance R_3 . Before each tone sets in the condenser C_3 is always completely discharged by the above-described switch S_2 . Furthermore, this condenser C_2 has connected in parallel with it two further series-connections of a resistance and a condenser, viz. R_6 , C_4 and R_7 , C_5 respectively. In parallel with the whole thereof is furthermore connected a large resistance R_8 which comprises several taps and from which may be taken voltages of different values which may be supplied to the tone generators.

This circuit-arrangement operates as follows: The charge imparted to the condenser C_2 by the above-described switch S_1 begins to flow away from the condenser through the various elements connected in parallel with this condenser. The condenser C_3 is completely discharged and consequently acts at first as a short-circuit for the resistance R_3 . During the first discharge period the variation of the voltage at the condenser C_2 is consequently only determined by the discharge current whose intensity is determined by the resistance R_2 . The condenser C_3 is charged by this discharge current and at the end of this charging period the condenser C_3 acts as an insulator. The discharge current of the condenser C_1 is consequently determined further on by the resistances R_2 and R_3 connected in series. Now the discharge consequently takes place less rapidly than during the first discharge period in

which only R_2 was decisive for the intensity of the discharge current.

Fig. 2 shows the variation of the voltage across the resistance R_3 ; this curve of voltage was obtained with a circuit arrangement according to Fig. 1. During the period of time t_1 in which the condenser C_2 is charged the voltage increases rapidly according to curve 13 and attains a maximum value. Immediately afterwards there follows a rapid discharge which, as has been described hereinbefore, is practically only determined by the resistance R_2 . Now the voltage 14 decrease during the period of time t_2 according to an e -function. At the end of the period t_2 the condenser C_3 is charged so that now the discharge takes place less rapidly according to curve 15 during a period of time t_3 . This voltage also varies according to an e -function with a small exponent since the intensity of the discharge current is less than during the period t_2 . Theoretically the period t_3 would have an infinite length, the curve 15 asymptotically approaching the abscissa. The voltage decrease practically to a value below the threshold of the amplifiers and the reproducing device which are utilized so that after some time the tone has sounded out.

Jointly the condensers C_4 and C_5 the resistances R_6 and R_7 form a so-called click filter. The voltage impulses which may be produced in the circuit at the contact 12 due to the arm of the lever S_1 being switched on and off cannot penetrate, owing to the presence of the filter, as far as to the resistance R_8 . These voltage impulses are consequently not made audible in the sound reproduction.

The varying voltage developed across resistance R_8 is applied to control the intensity of the tone produced by operating the key K of the instrument. This may be accomplished in a well known manner by means of a conventional vacuum tube oscillation generator 17, the voltage developed across resistance R_8 being impressed as a variable bias to govern the intensity of the generated oscillations. One known arrangement of this type is disclosed in the patent to L. Hammond, 2,126,464, issued August 9, 1938.

What I claim is:

1. In an electrical musical instrument playable by keys and having for each key thereof a system whose varying output potential controls the intensity of the note produced by striking said key, said system comprising a capacitance, means to charge said capacitance to a potential level proportional to the velocity of the downstroke of said key, and an impedance connected in parallel with said capacitance for discharging said capacitance, said impedance having first and second values successively in the course of discharge, said first value effecting a decrease in the potential of said capacitance according to an e function having a given exponent, said second value effecting a decrease in potential according to an e function having a relatively small exponent.

2. In an electrical musical instrument playable by keys and having for each key thereof a system whose varying output potential controls the intensity of the note produced by striking said key, said circuit comprising a first capacitance, means to charge said first capacitance to a potential level proportional to the velocity of the downstroke of said key, and an impedance connected in parallel with said first capacitance, said impedance being constituted by a resistance element and a second capacitance shunted across only a portion of said element.

3. In an electrical musical instrument playable by keys and having for each key thereof a system whose varying output potential controls the intensity of the note produced by striking said key, said key being displaced during the downstroke thereof from a rest position to a depressed position and during the release stroke from the depressed position to the rest position, said system comprising a source of constant potential, first and second capacitances, a first discharge impedance, switching means operatively coupled to the key and arranged to connect said first capacitance in the rest position of said key across said source to be charged thereby, and successively in the course of the downstroke across said first impedance for a period depending on the velocity of said downstroke and then in parallel with said second capacitance, said first capacitance being disconnected by said switching means both in the depressed position and in the course of the release stroke, and a second impedance connected in parallel with said second capacitance, said second impedance being constituted by a resistance element and a third capacitance shunted across only a portion of said element.

4. In an electrical musical instrument playable by keys and having for each key thereof a system whose varying output potential controls the intensity of the note yielded in a tone generator by striking said key, said key being displaced during the downstroke thereof from a rest position to a depressed position and during the release stroke from the depressed position to the rest position, said system comprising a source of constant potential, first and second capacitances, a first discharge impedance, switching means operatively coupled to the key and arranged to connect said first capacitance in the rest position of said key across said source to be charged thereby, and successively in the course of the downstroke across said first impedance for a period depending on the velocity of said downstroke and then in parallel with said second capacitance, said first capacitance being disconnected by said switching means both in the depressed position and in the course of the release stroke, a second discharge impedance connected in parallel with said second capacitance, said impedance being constituted by a resistance element and a third capacitance shunted across only a portion of said element, and means for applying the varying potential developed across said second impedance to the tone generator to control the amplitude thereof in accordance with said varying potential.

5. In an electrical musical instrument playable by keys and having for each key thereof a system whose varying output potential control the intensity of the note produced by striking said key, said key being displaced during the downstroke thereof from a rest position to a depressed position and during the release stroke from the depressed position to the rest position, said system comprising a source of constant potential, first and second capacitances, a first discharge impedance, switching means operatively coupled to the key and arranged to connect said first capacitance in the rest position of said key across said source to be charged thereby, and successively in the course of the downstroke across said

first impedance for a period depending on the velocity of the downstroke and then in parallel with said second capacitance, said first capacitance being disconnected by said switching means both in the depressed position and in the course of the release stroke, a second discharge impedance connected in parallel with said second capacitance, said second impedance being constituted by a resistance element and a third capacitance shunted across only a portion of said element, and a shorting switch operatively coupled to said key and connected across said third capacitance, said switch being closed at the rest position of the key and in the course of the downstroke preceding the connection by said switching means of said first capacitance in parallel with said second capacitance, said switch being open for the remainder of said downstroke and at the depressed position and in the course of the release stroke.

6. In an electrical musical instrument playable by keys and having for each key thereof a system whose varying output potential control the intensity of the note produced by striking said key, said key being displaced during the downstroke thereof from a rest position to a depressed position and during the release stroke from the depressed position to the rest position, said system comprising a source of constant potential, first and second capacitances, a first discharge impedance, switching means operatively coupled to the key and arranged to connect said first capacitance in the rest position of said key across said source to be charged thereby, and successively in the course of the downstroke across said first impedance for a period depending on the velocity of the downstroke and then in parallel with said second capacitance, said first capacitance being disconnected by said switching means both in the depressed position and in the course of the release stroke, a second discharge impedance connected across said second capacitance, said second impedance being constituted by a resistance element and a third capacitance shunted across only a portion of said element, a shorting switch operatively coupled to said key and connected across said third capacitance, said switch being closed at the rest position of the key and in the course of the downstroke preceding the connection by said switching means of said first capacitance in parallel with said second capacitance, said switch being open for the remainder of said downstroke and at the depressed position and in the course of the release stroke, an output potentiometer, and a click filter network arranged to couple said second impedance to said output potentiometer.

FREDERIK KERKHOF.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,126,464	Hammond	Aug. 9, 1938
2,126,682	Hammond	Aug. 9, 1938
2,214,764	Hammond	Sept. 17, 1940
2,302,457	Midgley et al.	Nov. 17, 1942