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CIRCUIT ARRANGEMENT FOR ELECTRICAL MUSICAL INSTRUMENTS

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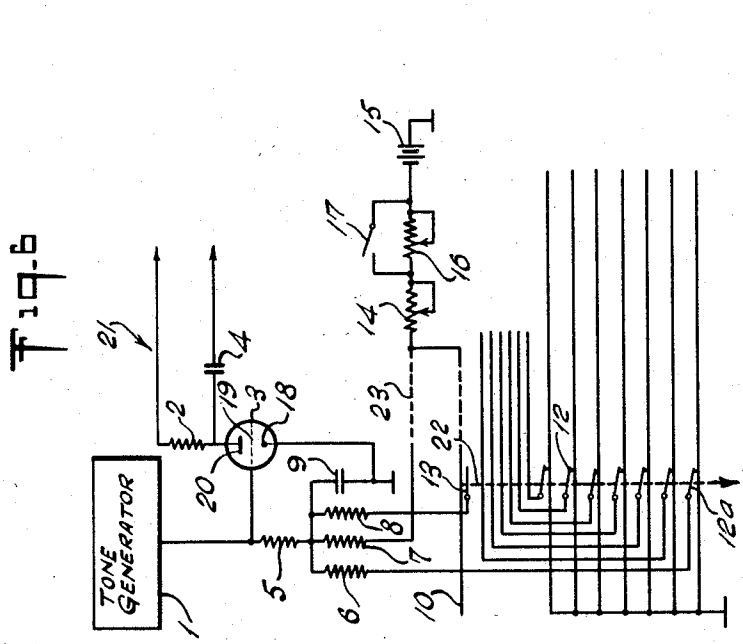


Fig. 6

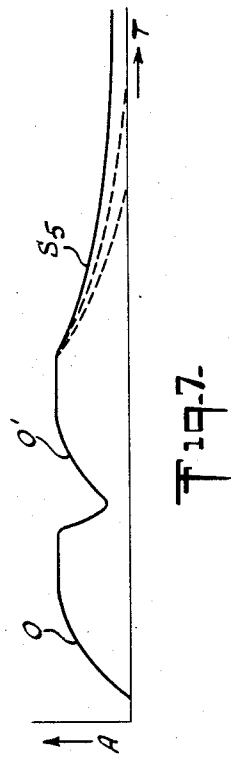


Fig. 7

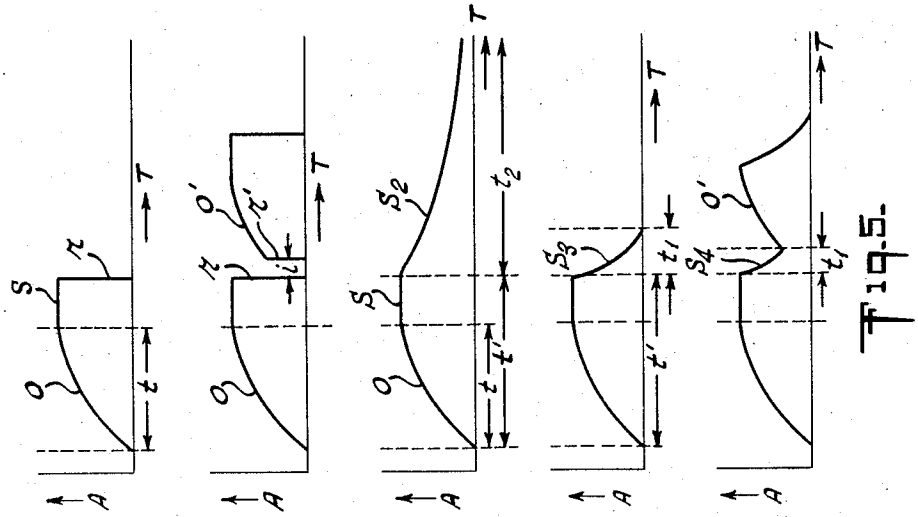


Fig. 5

Fig. 1

Fig. 2

Fig. 3

Fig. 4

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CIRCUIT ARRANGEMENT FOR ELECTRICAL MUSICAL INSTRUMENTS

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4 Claims. (Cl. 250—27)

The present invention relates to electric musical instruments, and more particularly to circuit arrangements for electric musical instruments intended to imitate the sounds of ordinary instruments, for example, the sound of an organ.

It is an object of the present invention to improve the circuit arrangements disclosed in my copending patent application Serial No. 513,116, filed June 3, 1955, for A Circuit Arrangement for Electric Musical Instruments, now abandoned.

It is another object of the present invention to provide means for synthetically imitating the transient oscillations of a note produced by the circuit arrangement.

It is a further object of the present invention to provide means for imitating the onset of the sound corresponding to a note produced by the circuit arrangement.

It is still another object of the present invention to provide means for imitating the transients between consecutive sounds corresponding to a note produced by the circuit arrangement.

It is a still further object of the present invention to provide means for controlling the time value of the dying-out transients of a steady-state oscillation.

Other objects and advantages of the present invention will be apparent from the following detail description thereof in connection with the accompanying drawing showing, by way of example, some explanatory diagrams and a wiring diagram of a preferred embodiment of the invention. In the drawings

Figs. 1–5 are, respectively, explanatory diagrams,

Fig. 6 is a wiring diagram of part of an electric musical instrument such as an electric organ, according to the invention, and

Fig. 7 is an explanatory diagram for explaining the operation of the circuit shown in Fig. 6.

Referring now to the drawings and first to Figs. 1–5 the amplitude of a sound corresponding to a musical note is plotted against the time. The horizontal axis of a rectangular system of coordinates corresponds to the time T whereas the vertical axis of the system of coordinates corresponds to the amplitudes A of the sound. Referring in particular to Fig. 1 the onset o of a note is shown starting at the amplitude zero and increasing within the time t to a steady-state value s. When the key producing the note is released thus putting an end to the steady-state value s, the amplitude returns instantaneously without any dying-out oscillations to the zero value thereof, the return path r being a straight line vertical to the time axis T. In consequence thereof a wide frequency spectrum is generated which is accompanied by a detonating sound effect which is only obscured by the more or less extended reverberation time of the auditorium.

Referring now to Fig. 2 of the drawings it is supposed that the same note is twice sounded shortly one after the other. Thus a short time after the time value corresponding to the return path r the same note is sounded a second time, and the second amplitude thereof represented by

the curve o' starts at an amplitude value r' which is considerably different from the zero value at which the curve o starts. In consequence thereof the detonating sound effect accompanying the sounding of the second note is much smaller than it is at the first sounding of the note. The reason is that the adjusting means disclosed hereinafter in connection with Fig. 6 are in a condition at the moment when the second oscillation o' starts in which the adjusting means have not yet reduced the amplitude of the first note to zero. Although the thus generated interval i being free from sounds is partly masked by the reverberation of the first sound in the auditorium the sound effect is impaired particularly if the electric musical instrument is arranged in an auditorium having a small reverberation time.

This sudden discontinuance of the sound may be prevented by providing in the path of the electric sound voltage from the tone generator to the loudspeaker a continuous connection uninterrupted by switches or the like so that the adjusting means form the only controllable member. In this case a curve as shown in Fig. 3 is obtained provided it is the question of an isolated sounding of the note, showing that the adjusting means are enabled to reduce the amplitude o of the sound voltage gradually from the steady-state value s thereof to zero when the key is released at the time t'. The positively actuated ratio of the voltage divider more fully described in connection with Fig. 6 renders the amplitude s_2 reaching the zero value thereof only after the lapse of a time t_2 which is three to four times as long as the time t corresponding to the onset o of the sound. It will be understood that this interval t_2 is equivalent to the dying-out time of the sound. In consequence thereof the adjusting means are not enabled to carry out an appreciable adjustment of the amplitude when the same key is struck repeatedly and a kind of stationary tone amplitude is generated which is characterized by a modulation of the amplitude in the beat of the frequency of the sound so that the human ear hears a uniform vibrating sound without being in a position to differentiate the individual beats of the sound from one another.

In order to imitate synthetically and exactly the time limitation of the dying-out transient or the transitions between consecutive sounds so that they correspond to the conditions prevailing in pipe organs, the circuit arrangement according to the present invention uses adjusting means controlling the onsets and the transitions between consecutive sounds by a back-keying of the time value of the dying-out transient of the note. As shown in Fig. 4 of the drawings the dying-out transient starts at the relieving of the sounded key at the time t' and extends owing to the back keying over a predetermined time period t_1 which is chosen so that the amplitude s_3 drops to zero in the time interval t_1 according to the pattern of a pipe organ.

Fig. 5 of the drawings shows the effect of the back keying according to the invention on a repeated striking of the same key. By comparing the diagram shown in Fig. 5 with that shown in Fig. 2 it will be realized that the time interval i shown in Fig. 2 between the return paths are of the first sounding of the note and the start r' of the second sounding is eliminated by the dying-out transient s_4 of the first sound, the second oscillation o' starting before the dying-out transient s_4 has reached zero amplitude. In this way the detonating sound effects are avoided at the breaking off or discontinuance and the onset of a sound.

Referring now to Fig. 6 of the drawings a wiring diagram of a preferred embodiment of the invention is shown. It should be understood that for the sake of simplicity only one single tone generator corresponding to the first harmonic C_1 of the fundamental such as C is shown together with adjusting means and that the funda-

mental and other harmonics of the fundamental are to be provided with analogous adjusting means as described in my copending patent application Serial No. 513,116 mentioned hereinabove, particularly Fig. 5 and that the fundamental need not be the note C but might be replaced by any other fundamental, if desired.

A tone generator 1 indicated by the key producing the sound corresponding in frequency to the note C_1 is connected to an adjusting stage 3 shown as an evacuated tube having a cathode 18, a grid 19, and an anode 20. The anode 20 is connected to a circuit generally denoted by 21 and including an anode resistor 2 and an anode condenser 4 connected thereto. The anode condenser 4 enables a sound voltage to be taken off from the anode circuit 21 which is free from direct components. A grid leak resistor 5 is connected with one terminal thereof to the grid 19 of the tube 3 and connected with the other terminal thereof with one terminal of each of the resistors 6, 7, 8, and the condenser 9. The other terminal of the condenser 9 is connected with the cathode 18 of the tube 3, the connection being grounded. A bus bar 10 is provided for the back keying according to the present invention and cooperates with a switching contact 13 connected to the other terminal of the resistor 8. A group of grounded bus bars 11 cooperates with a group of contacts 12 assigned to the key (not shown) of the sound C and including a contact 12'. To this key also the switching contact 13 is connected by an actuating member 22.

The operation of this device is as follows:

The resistor 8 is connected in parallel to the resistor 7 during the back-keying because the bus bar 10 is connected to a connection 23 connecting the other terminal of the resistor 7 with the adjustable resistor 14 more fully to be described hereinafter so that the switching contact 13 establishes a parallel connection of the resistors 7 and 8 between the grid leak resistor 5 and the connection 23 connected to one terminal of the adjustable resistor 14. The switching contact 13 is closed while the contacts 12, 12*a* are opened thus interrupting the connection with the bus bars 11. When the contacts 12 are in open position and the switching contact 13 is in closed position the adjusting stage formed by the tube 3 is blocked because the maximum negative bias voltage is connected with the grid 19 of the tube 3 so that no sound voltage appears on the condenser 4.

When the key C is depressed the contacts 12, 12*a* are shifted into the position shown in Fig. 6 and thus establish the connection with the grounded bus bars 11 whereas the switching contact 13 is opened. In consequence thereof the resistor 6 connected to the lowermost contact 12' of the contacts 12 is connected to ground so that the relatively high negative grid potential at the grid leak resistor 5 is reduced in the voltage divider ratio of the resistors 6 and 7 to a value corresponding to the normal operating point of the tube 3. The condenser 9 having also the potential of the grid 19 as long as the adjusting means are not actuated prevents the grid bias from being reduced too suddenly. If the resistor 6 is connected to ground by actuating the key C the condenser 9 discharges over the resistor 6 in a period of time which corresponds to the R–C ratio of the two members 6 and 9; therefore the grid bias is reduced in a certain period of time which interrupts the adjusting stage 3 slowly in a predetermined time so that the sound voltage across the anode resistor 2 or the anode condenser 4 increases in the same period of time.

When the key 1 is released the resistors 7 and 8 which are connected in parallel and the condenser 9 define a time constant defining in turn the duration of the dying-out transient. Since the voltage divider ratio of the resistors 6 and 7 cannot be changed for the reasons set forth hereinabove, the charging of the condenser 9 at the release of the key 1 would take too long a time as shown in Fig. 3. In order to overcome this drawback according to the present invention the resistor 8 is connected in parallel to the resistor 7 when the key is released. The thus resulting smaller resistance value forms with the condenser 9 an aggregate having a much smaller time constant so that the dying-out transient follows the course shown in Fig. 4 if the note is sounded only once. However, at the repeated sounding of the note as shown in Fig. 5 the transitions of the sounds follow each other without a break according to a curve which is laregly adapted to the conditions realized in a pipe organ.

As further shown in Fig. 6 a variable resistor 14 is connected between the voltage source 15 providing the grid bias and the charging resistors 7 of all the adjusting devices, not only of the device shown in Fig. 6 but also of devices (not shown) belonging to different keys and being designed in the same manner. By an adjustment of this adjustable resistor 14 the values of all charging resistors 7 are uniformly increased so that the time period t_1 of the transitions shown in Figs. 4 and 5 may be adapted to the acoustical conditions of the auditorium. This adjustment is made within narrow limits.

Additionally to the adjustable resistor 14 an additional adjustable resistor 16 is connected in series thereto and between the same and the battery 15. This adjustable resistor 16 allows a considerable lengthening of the dying-out transients at the moment when all sound generators such as 1 are switched off so that a considerable reverberation period is obtained. In order not to disturb the transitions by the additional variable resistor 16 a switch 17 is arranged in parallel thereto, the switch 17 being closed by hand or automatically as long as at least one of the keys such as 1 is depressed and in consequence thereof one of the tone generators is switched in.

Referring now to Fig. 7 the same shows a first wave *o* corresponding to the onset and a second wave *o'* shaped as shown in Fig. 5. This second wave *o'* has a prolonged decreasing amplitude s_5 which may be adapted to the conditions by closing and opening the switch 17 shown in Fig. 6.

It should be understood that the present invention is applicable in case of an additive sound formation from discreet sinusoidal frequencies as well as in the case of a subtractive sound formation, that is a reduction from spectra being rich in overtones.

I have described hereinabove my invention in connection with a preferred embodiment of a circuit arrangement for electric musical instruments. However, I wish it to be understood that many changes, modifications, and substitutions of equivalents will be apparent to any person skilled in the art and which may be made in the embodiment described hereinabove without departing in any way from my invention which is defined by the appended claims.

I claim:

1. In an electrical musical instrument having a plurality of keys; a tone attack and decay control arrangement for each key, comprising an electronic vacuum tube provided with a cathode and a grid, grid bias means including a resistor connected to said grid, and a source of voltage connected between said resistor and said cathode capacitance means connected in parallel with said grid bias means and defining with the latter an R–C circuit controlling in accordance with its time constant the rate of increase and decrease of bias voltage applied to said grid, additional resistance means arranged for connection in parallel with said resistor, and switch means operable by a respective key, said switch means being open upon depression of said respective key for disconnecting said additional resistance means from said resistor, and being closed upon release of said respective key for connecting said additional resistance means to and in parallel with said resistor, whereby the tone decay duration is reduced, a second resistor, and second switching means operable by said respective key for connecting the second resistor in parallel with said capacitance means upon depression of said respective key and for discon-

necting one terminal of said second resistor from said capacitance means upon release of said respective key.

2. In an instrument according to claim 1, said grid bias means comprising variable resistance means connected in series with the first mentioned resistor of each bias arrangement, whereby the control voltages applied to all of said control arrangements may be adjusted simultaneously and uniformly.

3. In an instrument according to claim 2; said grid bias means comprising an additional variable resistance means connected in series with said first-named variable resistance means, and additional switch means connected across said additional variable resistance means and maintained in closed position, shorting out said additional resistance means, during depression of any of said keys, said additional switch means being opened upon concurrent release of all of said keys.

4. In an electric musical instrument having tone generator means and a plurality of keys each associated with some of said tone generator means; a control arrangement for each key, comprising an electronic vacuum tube provided with a plate, a grid connected to a respective one of said tone generator means, and a grounded cathode, an output circuit connected to said plate and including capacitance means and resistance means connected in parallel with one another, a first fixed resistor connected to the junction between said respective tone generator means and said grid, a second fixed resistor connected to

said first fixed resistor, first switch means operable by the respective key upon actuation and deactuation thereof for connecting said second fixed resistor to and for disconnecting the same from ground, respectively, third and fourth fixed resistors arranged in parallel and connected to the junction between said first and second fixed resistors, a first variable resistor connected to said third fixed resistor, second switch means operable jointly with said first switch means by said respective key upon actuation and deactuation thereof for disconnecting said fourth fixed resistor from and for connecting the same to the junction between said third fixed resistor and said first variable resistor, respectively, a second variable resistor connected to said first variable resistor, a source of D.-C. bias voltage connected with its negative terminal to said second variable resistor and with its positive terminal to ground, manually operable third switch means connected across said second variable resistor, and a capacitor connected between said cathode and said junction between said fixed resistors.

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