

"DRIVING CIRCUIT FOR AN ELECTRONIC
TONE GENERATOR"

The present invention relates to a driving circuit for an electronic tone generator.

With the recent progress in the use of electronic techniques in small electronic devices, such as electronic timepieces, it has become popular to produce electronically synthesised notes, voices, or other sounds. The sound volume control systems of such electronic devices usually function by controlling the amplification factor of an amplifier or by adjusting the voltage level of the signal supplied to the amplifier by adjusting a variable resistor. Such systems are, however, disadvantageous as they require relatively expensive or bulky components.

According to a first aspect of the present invention there is provided a driving circuit for an electronic tone generator comprising: an RC circuit; rhythm producing means for applying a low frequency rhythm signal to the RC circuit, the rhythm producing means including control means for controlling the quantity of charge stored in the RC circuit by each pulse of the rhythm signal; melody producing means for producing a high frequency melody signal; modulating means for modulating the melody signal with an output wave form of the RC circuit; and means for applying the modulated melody signal to an electro-acoustic transducer, the control means comprising means for adjusting the width of the pulses of the rhythm signal for altering the volume of audible sound produced by the electro-acoustic transducer.

The equivalent resistance of the control means may be selectively adjustable.

The control means may include two switching means the outputs of which are connected together.

5 The means for adjusting the width of the rhythm signal may include a first circuit for producing a series of pulses of narrow or wide pulse widths in dependence upon the level of a control signal, and a second circuit for producing a pulse signal each time a tone is to be generated, the output of the
10 first and second circuits being combined to produce a pulse signal whose width is dependent upon the level of the control signal.

 The control means may include an AND gate which is connected to first and second inputs and to a first output, the first
15 input also being connected to a second output, and the first and second outputs being connected to control the two switching means respectively.

 According to a further aspect of the present invention there is provided an electronic timepiece comprising a circuit
20 as recited above.

 The present invention will be illustrated, merely by way of example, with reference to the accompanying drawings, in which:-

Figure 1 shows a circuit diagram of a possible form of a control circuit for an electronic tone generator;

Figure 2 is a timing chart for explaining the operation of the circuit shown in Figure 1;

5 Figures 3 and 5 show circuit diagrams of first and second embodiments of a control circuit for an electronic tone generator according to the present invention;

Figures 4 and 6 are timing charts for explaining the operation of the first and second embodiments of the present invention
10 respectively;

Figure 7 shows a circuit for producing inputs signals for the circuit shown in Figure 3;

Figure 8 is a timing chart for explaining the operation of circuit shown in Figure 7; and

15 Figure 9 shows a circuit for producing input signals for the circuits shown in Figure 5.

Figure 1 shows a possible form of a control circuit for an electronic tone generator. The structure of this circuit is apparent from Figure 1, and its operation will be described with reference
20 to the timing chart shown in Figure 2.

A relatively low frequency rhythm signal 1 shown in Figure 2 is supplied to a gate A of a transistor T (or other switching means) of the circuit shown in Figure 1. The signal 1 causes the transistor T to become conductive so that a condenser C is charged
25 whilst the rhythm signal 1 is at a high level. The electronic

charge stored in the condenser C then gradually discharges through a resistor R whilst the rhythm signal 1 is at a low level. A reverberation waveform 2 is thus formed as the output of the RC circuit comprising the condenser C and the resistor R connected in parallel as shown in Figure 1. The shape of this waveform 2 depends upon the time constant $R \times C$ of the RC circuit.

A melody signal 3 whose frequency determines the pitch of sound to be produced is supplied to an input B of the circuit shown in Figure 1. The melody signal 3 alternately changes the conductive state of two switches S and $\bar{S}$, and the outputs of these switches are connected so that a modulated waveform 4 is formed at a point P of the circuit shown in Figure 1.

The voltage level of the modulated waveform 4 may be varied by adjusting a variable resistor VR so as to produce a modulated waveform 5 such as that shown in Figure 2. The modulated waveform 5 is supplied to an amplifier AMP and an output of the amplifier AMP is connected to drive a speaker SP (or other electro-acoustic transducer). Thus, the volume of the sound produced by the speaker SP is controlled by adjusting the voltage level of the modulated waveform 5 according to the division ratio of the variable resistor VR.

The circuit described above is disadvantageous as it requires relatively expensive parts such as the variable resistor VR, and manual adjustment is required to alter the sound volume of the tone produced. The circuit is thus not readily compatible with the

requirement for automatic electronic adjustment of the sound volume. It is, for instance, difficult to arrange for the sound level of the tone produced to be changed in dependence upon the surrounding noise level, or to be changed in dependence upon the time of day as may be appropriate in an alarm circuit of an electronic timepiece.

Preferred embodiments of the present invention seek to overcome these disadvantages by controlling the quantity of electric charge stored in the condenser C of the RC circuit by each pulse of the rhythm signal 1.

A first embodiment of the present invention is shown in Figure 3. This circuit is similar in many respects to the circuit shown in Figure 1, like parts being given like reference numerals or letters. In this embodiment, the quantity of charge stored in the condenser C is controlled by altering the pulse width of the rhythm signal applied to the RC circuit. This, in turn, controls the volume of sound produced by the speaker SP. It should be noticed that the waveform produced at the point P of this circuit is directly connected to the amplifier AMP as this circuit does not have a variable resistor VR such as that shown in Figure 1. Thus, the maximum sound volume which can be produced with the circuit shown in Figure 1 can similarly be produced with the circuit shown in Figure 3 if the waveforms 1 to 4 shown in Figure 4 are employed, these waveforms being similar to those shown at 1 to 4 shown in Figure 2.

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The waveforms shown in Figure 4 at 6, 7 and 8 correspond to those shown at 1, 2 and 4, the former being used when a reduced volume of sound is to be produced. As will be seen, a low level reverberation waveform 7 which produces a smaller volume of sound is formed by reducing the pulse width of the rhythm signal as shown at 6. When the rhythm signal 6 is used, the condenser C is only partially charged by each pulse of the signal 6. The low level reverberation waveform 7 produces a low level modulated waveform 8 so that a small sound volume is generated by the speaker SP.

A further embodiment of the present invention is shown in Figure 5. In the circuit shown in Figure 5, the quantity of charge stored in the condenser C is controlled by adjusting the value of the equivalent resistance of a transistor circuit which supplies the rhythm signal to the RC circuit.

When a large volume of sound is to be produced, a rhythm signal 1, as shown in Figure 6, is simultaneously applied to gates A1 and A2 of transistors T1 and T2 (or other switching means) of the circuit shown in Figure 5. This produces a reverberation waveform as shown at 2 and a modulated waveform as shown at 4 is thus supplied to the amplifier AMP.

When a small volume of sound is to be produced, a rhythm signal 1', which has a pulse width similar to that of the rhythm signal 1, is applied to the gate A1 of the transistor T1 but not to the gate A2 of the transistor T2. Thus, only transistor

T1 is intermittently switched on. In the latter case, the value of the equivalent resistance of the transistor T1 in the conductive state is higher than that of the transistors T1 and T2 connected in parallel when both are in the conductive state, so that the
5 condenser C is only partially charged, and a low level reverberation waveform 9 is generated and small sound volume is produced by the speaker SP.

As will be appreciated, the two embodiments of the present invention described above have the advantage that they may be formed
10 as part of an integrated circuit, and do not require switches or variable resistors that have to be adjusted manually. In the described embodiments, the sound volume produced is controlled by simply altering the quantity of charge stored in the RC circuit by selectively altering the rhythm signal applied to the RC circuit.
15 The quantity of charge stored in the RC circuit can be controlled accurately and the circuitry required is relatively simple and relatively inexpensive.

Figure 7 shows a circuit for generating rhythm signals of different pulse widths such as the signals 1 and 6 shown in
20 Figure 4. Figure 8 is a time chart for explaining the operation of the circuit shown in Figure 7. The reference symbols used in Figure 8 refer to the input or output signals at similarly labelled points of the circuit shown in Figure 7. The circuit described is arranged to produce rhythm signals of two different
25 pulse widths. Other circuits may, of course, be arranged to

produce rhythm signals of three or more different pulse widths.

The operation of the circuit shown in Figure 7 will now be described. A rising pulse DT is supplied to an input terminal d of a flip-flop F2 each time a musical tone is to be produced. A rectangular waveform CL is supplied to the terminal C11 of the divider F1, the period of the waveform CL being half the pulse width of the rising pulse DT. A control signal VC which may have either a low level or a high level is applied to an inverter I_1 and one input of an AND gate G1. The signal VC may have a low level when a large sound volume is to be produced and a high level when a small sound volume is to be produced.

The divider F1 divides the rectangular waveform CL and produces an output signal q_1 of half the frequency of wave CL. The output q_1 is applied to one input of a second AND gate G2, the other input of this gate being connected to the output of the inverter I_1 . The output of AND gates G1 and G2 are connected to the inputs of an OR gate G3. Thus, the output of OR gate G3 is either a low or high frequency clock signal as shown at C12 in Figure 8 in dependence upon whether the signal VC has a low or high level.

The signal C12 is applied to the C12 input of delay flip-flop F2 and the input d of the flip-flop F2 is delayed by a half-period of the signal C12 to produce an output q_2 . The output q_2 is connected to one input of an AND gate G4 via an inverter I_2 , the other input of the AND gate G4 being connected to receive the pulse DT. The output of the AND gate G4 produces a signal A' which may be

used as the signal A in the circuit shown in Figure 3.

Thus, when the level of the signal VC is changed from a low level to a high level between the production of a first musical tone and a second musical tone, the period of the input clock signal C₂ to the flip-flop F2 is divided by two, and the delay time of signal g_2 with respect to the signal DT is also divided by two so that the pulse width of the signal A' is wide for the first tone and narrow for the second tone. Thus, if the signal A' is supplied to a gate of a transistor T such as that shown in Figure 3, the first tone produced is of large volume whilst the second tone produced is of small volume.

Figure 9 shows a circuit diagram of a circuit for simultaneously providing the gates A1 and A2 shown in Figure 5 with rhythm signals or providing only gate A1 with a rhythm signal. The circuit consists of an AND gate G5 connected to the two inputs VC' and A" and to an output A₂'. The input A" is also connected directly to an output A₁'.

The operation of this circuit will now be described. If a rhythm signal is applied to the input A", the rhythm signal is delivered to both the outputs A₁' and A₂' when the input VC' receives a high level signal. However, if input VC' receives a low level signal, only output A₁' is supplied with the rhythm signal.

As will be appreciated, the embodiments of the present invention described above provide electronic devices for accurately controlling the sound volume produced by an electro-acoustic

transducer which can be operated without the need for mechanical adjustment of components such as variable resistors or switches. The omission of such components also makes the manufacture of the devices less expensive.

5 Embodiments of the present invention may be used to control the sound volume of tones produced in a variety of applications. Control circuits may, for instance, be provided for controlling the volume of individual notes of a tune in dependence upon data stored in a memory, for controlling the volume produced by a loudspeaker
10 in dependence upon the surrounding noise level as indicated by a noise meter, or for reducing the sound volume produced at particular times of the day, such as the night. The latter application is, of course, particularly suitable in connection with the control of an alarm tone produced by an electronic timepiece.



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CLAIMS

1. A driving circuit for an electronic tone generator comprising:
an RC circuit; rhythm producing means for applying a low
frequency rhythm signal to the RC circuit, the rhythm producing
means including control means for selectively controlling the
quantity of charge stored in the RC circuit by each pulse of the
rhythm signal; melody producing means for producing a high
frequency melody signal; modulating means for modulating the
melody signal with an output wave form of the RC circuit; and
means for applying the modulated melody signal to an electro-
acoustic transducer, the control means comprising means for
adjusting the width of the pulses of the rhythm signal, for
altering the volume of audible sound produced by the electro-
acoustic transducer.
2. A circuit as claimed in claim 1 in which the equivalent
resistance of the control means is selectively adjustable.
3. A circuit as claimed in claim 2 in which the control means
includes two switching means the outputs of which are connected
together.
4. A circuit as claimed in claim 1 in which the means for
adjusting the width of the pulses of the rhythm signal includes a
first circuit for producing a series of pulses of narrow or wide
pulse widths in dependence upon the level of a control signal,



and a second circuit for producing a pulse signal each time a tone is to be generated, the output of the first and second circuits being combined to produce a pulse signal whose width is dependent upon the level of the control signal.

- 5 5. A circuit as claimed in claim 3 in which the control means includes an AND gate which is connected to first and second inputs and to a first output, the first input also being connected to a second output, and the first and second outputs being connected to control the two switching means respectively.
- 10 6. An electronic timepiece comprising a circuit as claimed in any preceding claim.
7. A driving circuit for an electronic tone generator substantially as hereinbefore described with reference to and as shown in Figures 3 to 9 of the accompanying drawings.