

21

SPECIFICATION

Electronic tone generator

5 This invention relates to electronic tone generators for providing melodies.

According to the present invention there is provided an electronic tone generator comprising: at least one clock pulse generating circuit; at least one

10 melody producing means arranged to produce a signal representative of a scale of notes one after the other to construct a desired melody, each melody producing means including a memory circuit for storing scale and time information and a
15 programmable counter for dividing clock pulses supplied from the said clock pulse generating circuit to produce the said signal representative of a scale of notes in dependence upon data stored in the memory circuit; a wave envelope forming circuit for
20 modulating the output of the melody producing means to produce a modulated output waveform composed of attack and release portions, the wave envelope forming circuit having a charging and discharging circuit comprising a capacitor and
25 resistor which are connected in parallel and between a first power terminal and an MOS transistor which acts as a switch, the MOS transistor also being connected to a second power terminal and having its gate electrode connected to receive the output of the
30 melody producing means; and an electro-acoustic transducer arranged to be driven by the said modulated output waveform.

The electronic tone generator may comprise at

35 least two melody producing means, a wave envelope forming circuit associated with each melody producing means, and mixing means arranged to mix and amplify the modulated output waveforms of the wave envelope forming circuits and to drive the electro-acoustic transducer.

40 The electronic tone generator may be arranged so that so that a tone generated by a first melody producing means and a tone generated by the or a second melody producing means overlap.

The first melody producing means may be

45 arranged to produce a signal representative of a scale constructing a primary melody and the or a second melody producing means is arranged to produce a signal representative of a scale shifted by a predetermined frequency from the frequency of
50 the scale constructing the primary melody, or the first melody producing means may be arranged to produce a signal representative of a scale constructing a primary melody and the or a second melody producing means is arranged to produce a
55 signal representative of the same scale as that constructing the primary melody but with a predetermined time delay.

The time constants of the modulation of the outputs of the first and second melody producing
60 means may be arranged to cause the said overlap.

Preferably signals representative of adjacent notes in a scale are produced by different melody producing means when the adjacent notes differ by a whole tone or more and are produced by the same
65 melody producing means when the difference is a

semitone or less.

The first and second melody producing means may be arranged to produce signals representative of a primary melody and a third melody producing means is arranged to produce a signal representative of a secondary melody.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

70 *Figure 1* is a block diagram of an electronic tone generator having a single scale producing circuit,

75 *Figure 2* is a block diagram of an electronic tone generator having three scale producing circuits,

Figure 3 is a score of a melody or tune produced by the electronic tone generator of *Figure 2*,

80 *Figure 4* illustrates output waveforms produced by three scale producing circuits of the electronic tone generator of *Figure 2* to produce the tune shown in *Figure 3*,

85 *Figure 5* shows practical modulated wave forms produced by the electronic tone generator of *Figure 3*;

Figure 6 is a score of another melody or tune produced by the electronic tone generator of *Figure 2*;

90 *Figure 7* illustrates modulated output wave forms produced by the three scale producing circuits of the electronic tone generator of *Figure 2* to produce the tune shown in *Figure 6*;

95 *Figure 8* is a circuit diagram of a wave envelope forming circuit of an electronic tone generator according to the present invention;

Figure 9 illustrates by means of wave forms the operation of the wave envelope forming circuit of *Figure 8*;

100 *Figure 10* is a block diagram of another embodiment of an electronic tone generator having two scale producing circuits:

Figure 11 illustrates the score of a melody or tune produced by the electronic tone generator of *Figure 10*:

105 *Figure 12* illustrates modulated output wave forms produced by two scale producing circuits of the electronic tone generator of *Figure 10* to produce the tune shown in *Figure 7*;

110 *Figure 13* illustrates in block diagram form a further embodiment of an electronic tone generator having two scale producing circuits.

Figure 14 is a score of a melody or tune produced by the electronic tone generator of *Figure 13*;

115 *Figure 15* illustrates modulated output wave forms produced by two scale producing circuits of the electronic tone generator of *Figure 13* to produce the tune of *Figure 14*;

120 *Figure 16* is the score of another melody or tune produced by the electronic tone generator of *Figure 13*; and

Figure 17 illustrates modulated output wave forms produced by the electronic tone generator of *Figure 13* to produce the tune of *Figure 16*.

125 *Figure 1* shows an electronic tone generator having a single scale producing circuit 110 which includes a memory circuit 101 for storing scale information which is read out successively in response to an address signal applied to the memory
130 circuit by an address counter 102. A programmable

counter 104 divides clock pulses from a clock generating circuit 103, the division ratio of the counter 104 being varied according to the scale information stored in the memory circuit. The signal from the programmable counter is amplitude modulated by a wave envelope forming circuit 105, the amplitude modulated signal then being amplified by an amplifier circuit 106 and transmitted to an electro-acoustic transducer 107 such as a loud-speaker which produces a musical note of tone. Thus a predetermined scale, tune or melody can be produced. Time information is read out from the memory circuit 101 at the same time as the scale information already mentioned, and the division ratio of a programmable counter 108 is varied in response to the time information supplied by the memory circuit. The programmable counter 108 divides clock pulses from a clock generating circuit 109 which produces pulses having a period representative of the shortest time of notes making up a tune. The counter 108 determines the time thereby and controls the timing when each scale is read out. Thus the time of each tone or note is obtained. the clock generating circuit 109 may be dispensed with and clock pulses supplied to the counter 108 from the clock generating circuit 103. The tones or notes produced by the electronic tone generator of Figure 1 have a monotone quality and the music produced is inferior to that produced by a musical box for example.

The electronic tone generator shown in Figure 2 is provided with three scale producing circuits 201, 202, 203 each of which may be constructed in similar manner to the scale producing circuit 110 of Figure 1. Signals produced by the scale producing circuits 201, 202, 203 are amplified by mixing amplifier circuit 204 and then are fed to an electro-acoustic transducer 205. Each scale producing circuit produces scales as follows.

To produce the melody shown by the score of Figure 3, the first scale producing circuit 201 produces scales of #1, #3, #5, #7 and #9 in a primary melody, the second scale producing circuit 202 produces scales of #2, #4, #6 and #8 in the primary melody, and the third scale producing circuit produces scales of #1', #2' and #3' in a secondary melody.

Figure 4 shows the envelope of modulated waveforms produced from respective scale producing circuits, waveforms A being produced from the first scale producing circuit 201, waveforms B being produced from the second scale producing circuit 202 and waveforms C being produced from the third scale producing circuit 203. Though attack timings to produce scales are only shown by envelope waveforms in Figure 4, in practice the attack timing is a waveform having frequency of a given scale as shown in Figure 5. Though the basic wave form is shown by rectangular waves in this instance, sine wave or triangular waves also show the same effect.

Though the scales of adjacent notes are different from each other by a whole tone or more in the embodiment of Figure 2, in a score such as that

and 3 is only a semitone. In this case the scales as shown by the waveforms in Figure 7 are produced.

The construction of the electronic tone generator shown in Figure 2 is simplified and circuit elements thereof are easily integrated by using rectangular waveforms to produce the scales. As a result, it becomes easy to incorporate the electronic tone generator in a timepiece or other miniaturised apparatus. However, the invention is not limited to rectangular waveforms but may employ sinusoidal or triangular waveforms.

Figure 8 shows an embodiment of a wave envelope forming circuit of an electronic tone generator according to the present invention. One end of a resistor 801 and one end of a capacitor 802 are connected to an N-channel MOS transistor 803 which acts as a switch, and the other end of the resistor 801 and the capacitor 802 are connected to a positive power terminal 804. The transistor 803 is also connected to a negative power terminal 805. A signal wave form for attack as shown by curve A' of Figure 9 is applied to an input terminal 806 connected to a gate of the transistor 803. When the gate potential is high, the potential at a terminal 807 is changed by the On resistance of the transistor 803 as shown by curve B' of Figure 9. When the gate potential is low the transistor 803 is Off and the capacitor 802 is discharged through the resistor 801. Original waves C' of Figure 9 which are to be modulated i.e. to which envelopes are going to be applied, are fed to an input terminal 808.

Transmission gates 809, 810 are alternately turned ON or OFF according to respective potentials applied thereto. Reference number 812 indicates an inverter. The modulated signals as shown by waveforms D' of Figure 9 are obtained at an output terminal 811. If the power terminals 804, 805 are inverted or reversed the polarity of the modulation envelopes can be reversed also.

The waveform D' is composed of attack and release portions as illustrated but it is possible to provide waveforms composed of attack, delay, sustenance and release portions, by complicating the circuit construction. It is desirable to determine the time constants of the wave envelope forming circuits so as to make tones produced from respective scale producing circuits overlap. Signal waveforms produced by three scale producing circuits as mentioned above are applied to the mixing amplifier circuit 204 and then are transmitted as a musical sound through the electro-acoustic transducer 205.

The electronic tone generators described above produce electronic sound which is more echoed, is acoustically comfortable and of greater tonal quality compared with the sound produced by the electronic tone generator of Figure 1 which provides only a primary melody.

All the circuit elements with the exception of the electro-acoustic transducer and perhaps a small number of resistors and capacitors of the electronic tone generator of Figure 2 can be formed of integrated circuit elements so that the electronic tone generator can be widely applied to portable electronic devices and industrial electronic devices.

shown in Figure 6 the difference between the notes 2

Particularly, a timepiece having an electronic sound producing function can be produced without increasing the number of manufacturing steps, by integrating an electronic tone generator according to the present invention on the same circuit chip as that containing, for example, the time keeping circuitry of the timepiece.

It will be appreciated that an electronic tone generator may have two, three or more scale producing circuits, the more scale producing circuits there are the more the expected improvement in tonal quality and scales of the secondary melody may be produced alternately thereby.

Even if the embodiment in accordance with this invention is applied to an optional bar of a desired tune, it never deviates from the subject of this invention.

Figure 10 illustrates another embodiment of an electronic tone generator according to the present invention. The electronic tone generator is provided with two scale producing circuits 201', 202' each of which may be constructed in similar manner to the scale producing circuit 110 of Figure 1. Signals produced by the scale producing circuits 201', 202' are amplified by a mixing amplifier circuit 204' and are fed to an electro-acoustic transducer 205'. Scales are produced by the scale producing circuit as follows. In the case of providing a melody as shown by the score of Figure 11, the first scale producing circuit 201' produces the scales corresponding to the score and the second scale producing circuit 202' produces the same scales with a predetermined delay Δt which in the illustrated embodiment represents half of the shortest time of notes constructing the tune or melody.

Figure 12 shows the modulation waveforms produced by the scale producing circuits. the waveforms A' are produced from the first scale producing circuit 201' and the waveforms B' are produced from the second scale producing circuit 202'. Though attack timing to produce the scale are only shown by envelope waveforms in Figure 12 in practice the attack timing is a waveform having frequency corresponding to a predetermined scale as shown in Figure 5. In this case, the basic waveforms are rectangular but may be sinusoidal or triangular. Sinusoidal or triangular waveforms are obtained from the envelope forming shaping circuits of the scale producing circuits from the rectangular waves produced from the programmable counters.

Considering the electronic tone generator of Figure 10 in more detail let the frequency of the scale produced by the scale producing circuit 201' be f , then the scale producing circuit 202' produces a scale having a frequency of $f \pm \Delta f$. The range Δf , which depends on scales, is desirably from 3 to 30 Hz in the case where the pitches of tones are from several hundred Hz to several thousand Hz, though it depends on the tune, $f + \Delta f$ is better to obtain a great effect. One way may be to delay the attack timing of the second scale producing circuit 202' for a predetermined small amount of time behind the attack timing of the first scale producing circuit 201'.

The electronic tone generator of Figure 10 produces beat signals so that a more acoustically

comfortable electronic tone is generated. There is no necessity for adopting this invention through a desired tune, and the adoption of this invention only to optional bars never deviates from the subject matter of this invention.

The electronic tone generator of Figure 10 has two scale producing circuits. However, more scale producing circuits may be provided, the time delay Δt being changed according to the desired tune or the time constant of the modulation of each scale producing circuit being changed according to the tune to produce acoustically pleasing sound.

In the electronic tone generator of Figure 10 if three scale producing circuits are provided, the first may produce scales of a primary melody, the second may provide scales shifted slightly by Δf from the scales of the primary melody and the third may produce scales of a secondary melody.

Figure 13 illustrates a further embodiment of an electronic tone generator according to the present invention. The electronic tone generator comprises a clock generating circuit 301 to produce clock pulses having a period representative of the shortest times of notes in any tune, two memory circuits 302, 302' to store scale and time information, two address counters 303, 303' to apply address signals to the memory circuits, programmable counters 305, 305' to divide the clock pulses applied from a clock generating circuit 304 in order to produce given scales on the basis of the scale information stored in the memory circuits 302, 302', programmable counters 306, 306' to divide clock pulses supplied from the clock generating circuit 301 according to the time information stored in the memory circuits 302, 302' in order to obtain the time or duration of each tone, two envelope wave forming circuits 307, 307' to apply envelopes or modulations, a mixing amplifier circuit 308 to mix and amplify the output signals from the modulation circuits, an electro-acoustic transducer 309 to transmit, as a musical sound, the composite signal supplied from the mixing amplifier circuit, and a synchronizing signal input terminal 310 to apply synchronizing signals to the two address counters 303, 303'.

The electronic tone generator of Figure 13 operates as follows. Since the division ratios of the programmable counters 303, 305' are not varied if the output addresses from the address counters 303, 303' are not changed, the programmable counters produce a graduated series of musical tones having the same amplitude. The division ratios of the next addresses in the memory circuits 302, 302' when advancing the address signals of the address counters 303, 303' by one, and thereby the tone of the next note is produced. The velocities with which the address counters 303, 303' are advanced are varied according to the duration of notes. Namely, in the case where a quaver is the shortest time in the tune, the clock generating circuit 301 is adapted to produce clock pulses having a period equal to a quaver. Thereafter, the memory circuits 302, 302' store data to vary the division ratios of the programmable counters 306, 306' so that the pulses are divided by one-half in the case of a crotchet or into quarters in the case of a minim, together with

scale and time data. Such data is then read out sequentially, the pulses are divided and applied to the address counters 303, 303' and the velocity with which the address counters are to be sequenced is varied.

The tone generator circuit of Figure 13 has two scale producing circuits. Each scale producing circuit produces scales as follows. In the case of providing a melody as shown by the score of Figure 14 the first scale producing circuit produces scales A₅, C₅, D₅ and the second scale producing circuit produces scales F₅, Bb₄ and F₅.

Figure 15 shows the effect that the scales are produced from respective scale producing circuits.

Output waveforms A'' are produced from the first scale producing circuit and output waveforms B'' are produced from the second scale producing circuit. Though attack timing to produce scales is shown only by envelope waveforms in Figure 15 in practice the attack timing is a waveform having frequency corresponding to a given scale as shown in Figure 5.

Though the scales of respective notes are different from one another by whole tones or more in the above embodiment, in the score of Figure 16 the second note is different from the third note by only a semitone. In this case, the way to produce scales as shown in Figure 18 is acoustically efficient.

CLAIMS

1. An electronic tone generator comprising: at least one clock pulse generating circuit; at least one melody producing means arranged to produce a signal representative of a scale of notes one after the other to construct a desired melody, each melody producing means including a memory circuit for storing scale and time information and a programmable counter for dividing clock pulses supplied from the said clock pulse generating circuit to produce the said signal representative of a scale of notes in dependence upon data stored in the memory circuit; a wave envelope forming circuit for modulating the output of the melody producing means to produce a modulated output waveform composed of attack and release portions, the wave envelope forming circuit having a charging and discharging circuit comprising a capacitor and resistor which are connected in parallel and between a first power terminal and an MOS transistor which acts as a switch, the MOS transistor also being connected to a second power terminal and having its gate electrode connected to receive the output of the melody producing means; and an electro-acoustic transducer arranged to be driven by the said modulated output waveform.

2. An electronic tone generator as claimed in claim 1 comprising at least two melody producing means, a wave envelope forming circuit associated with each melody producing means, and mixing means arranged to mix and amplify the modulated output waveforms of the wave envelope forming circuits and to drive the electro-acoustic transducer.

3. An electronic tone generator as claimed in claim 2 which is arranged so that a tone generated by a first melody producing means and a tone

generated by the or a second melody producing means overlap.

4. An electronic tone generator as claimed in claim 3 in which the first melody producing means is arranged to produce a signal representative of a scale constructing a primary melody and the or a second melody producing means is arranged to produce a signal representative of a scale shifted by a predetermined frequency from the frequency of the scale constructing the primary melody.

5. An electronic tone generator as claimed in claim 3 in which the first melody producing means is arranged to produce a signal representative of a scale constructing a primary melody and the or a second melody producing means is arranged to produce a signal representative of the same scale as that constructing the primary melody but with a predetermined time delay.

6. An electronic tone generator as claimed in any of claims 3 to 5 in which the time constants of the modulation of the outputs of the first and second melody producing means are arranged to cause the said overlap.

7. An electronic tone generator as claimed in any of claims 2 to 6 in which signals representative of adjacent notes in a scale are produced by different melody producing means when the adjacent notes differ by a whole tone or more and are produced by the same melody producing means when the difference is a semitone or less.

8. An electronic tone generator as claimed in any of claims 2 to 7 in which the first and second melody producing means are arranged to produce signals representative of a primary melody and a third melody producing means is arranged to produce a signal representative of a secondary melody.

9. An electronic tone generator substantially as herein described with reference to and as shown in the accompanying drawings.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon, Surrey, 1982.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

scale and time data. Such data is then read out sequentially, the pulses are divided and applied to the address counters 303, 303' and the velocity with which the address counters are to be sequenced is varied.

The tone generator circuit of Figure 13 has two scale producing circuits. Each scale producing circuit produces scales as follows. In the case of providing a melody as shown by the score of Figure 14 the first scale producing circuit produces scales A₅, C₅, D₅ and the second scale producing circuit produces scales F₅, Bb₄ and F₅.

Figure 15 shows the effect that the scales are produced from respective scale producing circuits. Output waveforms A'' are produced from the first scale producing circuit and output waveforms B'' are produced from the second scale producing circuit. Though attack timing to produce scales is shown only by envelope waveforms in Figure 15 in practice the attack timing is a waveform having frequency corresponding to a given scale as shown in Figure 5.

Though the scales of respective notes are different from one another by whole tones or more in the above embodiment, in the score of Figure 16 the second note is different from the third note by only a semitone. In this case, the way to produce scales as shown in Figure 18 is acoustically efficient.

CLAIMS

1. An electronic tone generator comprising; at least one clock pulse generating circuit; at least one melody producing means arranged to produce a signal representative of a scale of notes one after the other to construct a desired melody, each melody producing means including a memory circuit for storing scale and time information and a programmable counter for dividing clock pulses supplied from the said clock pulse generating circuit to produce the said signal representative of a scale of notes in dependence upon data stored in the memory circuit; a wave envelope forming circuit for modulating the output of the melody producing means to produce a modulated output waveform composed of attack and release portions, the wave envelope forming circuit having a charging and discharging circuit comprising a capacitor and resistor which are connected in parallel and between a first power terminal and an MOS transistor which acts as a switch, the MOS transistor also being connected to a second power terminal and having its gate electrode connected to receive the output of the melody producing means; and an electro-acoustic transducer arranged to be driven by the said modulated output waveform.

2. An electronic tone generator as claimed in claim 1 comprising at least two melody producing means, a wave envelope forming circuit associated with each melody producing means, and mixing means arranged to mix and amplify the modulated output waveforms of the wave envelope forming circuits and to drive the electro-acoustic transducer.

3. An electronic tone generator as claimed in claim 2 which is arranged so that a tone generated by a first melody producing means and a tone

generated by the or a second melody producing means overlap.

4. An electronic tone generator as claimed in claim 3 in which the first melody producing means is arranged to produce a signal representative of a scale constructing a primary melody and the or a second melody producing means is arranged to produce a signal representative of a scale shifted by a predetermined frequency from the frequency of the scale constructing the primary melody.

5. An electronic tone generator as claimed in claim 3 in which the first melody producing means is arranged to produce a signal representative of a scale constructing a primary melody and the or a second melody producing means is arranged to produce a signal representative of the same scale as that constructing the primary melody but with a predetermined time delay.

6. An electronic tone generator as claimed in any of claims 3 to 5 in which the time constants of the modulation of the outputs of the first and second melody producing means are arranged to cause the said overlap.

7. An electronic tone generator as claimed in any of claims 2 to 6 in which signals representative of adjacent notes in a scale are produced by different melody producing means when the adjacent notes differ by a whole tone or more and are produced by the same melody producing means when the difference is a semitone or less.

8. An electronic tone generator as claimed in any of claims 2 to 7 in which the first and second melody producing means are arranged to produce signals representative of a primary melody and a third melody producing means is arranged to produce a signal representative of a secondary melody.

9. An electronic tone generator substantially as herein described with reference to and as shown in the accompanying drawings.