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(54) BUZZER DRIVER CIRCUIT FOR ELECTRONIC APPARATUS

(71) We, CITIZEN WATCH COMPANY LIMITED, a corporation organized under the laws of Japan, of No. 9-18, 1-chome, Nishi-shinjuku, Shinjuku-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

10 This invention relates to buzzers for portable electronic apparatus e.g. an electronic time-piece.

In a conventional electronic timepiece equipped with a buzzer, it has been a common practice to have the buzzer composed of a piezo-electric vibrating element and a metallic vibrating plate secured to the vibrating element. In this structure, the vibrating element has one electrode connected to the low level or the grounded side of a power source and another electrode applied with a clock signal of a high voltage boosted by a booster coil. The vibrating element is responsive to the clock pulses and vibrates, causing the vibration of the vibrating plate by which an acoustic sound is generated. The conventional buzzer mentioned above makes use of a large number of component parts and employs the booster coil which has a large size and low efficiency.

30 According to the present invention, there is provided a buzzer driver circuit for electronic apparatus having a power supply which provides an output voltage between respective points having a high level and a low level potential, comprising: piezo-electric vibrating means having a piezo-electric element and a vibrating plate secured thereto; a first transfer switch connected to one terminal of said vibrating means to alternately connect said one terminal to said high level and said low level potentials of said power supply in response to a first clock pulse; and a second transfer switch connected to another terminal of said vibrating means to alternately connect said another terminal to said low level and said high level potentials in response to a second clock pulse; whereby said vibrating means is driven by a voltage higher than said output voltage to vibrate said vibrating plate to generate an acoustic sound.

In the accompanying drawings:—

Figure 1 is a schematic view of a preferred embodiment of a buzzer driver circuit according to the present invention;

Figure 2 is a timing chart for clock pulses applied to the driver circuit shown in Figure 1;

Figure 3 is a fragmentary cross sectional view of an electronic timepiece employing one example of a buzzer driven by the driver circuit shown in Figure 1; and

Figure 4 is a fragmentary cross sectional view of an electronic timepiece employing another example of a buzzer driven by the driver circuit shown in Figure 1.

Referring now to Figure 1, there is shown a preferred embodiment of a buzzer driver circuit according to the present invention, the buzzer driver circuit being specifically suited for an electronic calculator or electronic timepiece. A buzzer comprises a piezo-electric vibrating means 10 composed of, for example, a piezo-electric vibrating element, a pair of electrodes formed on the piezo-electric element, and a vibrating plate secured to the piezo-electric element. The buzzer 10 is driven by a driver circuit D compound of first and second transfer switches 12 and 14, each comprising an inverter. The first transfer switch 12 is connected to one terminal 10a of the vibrating means 10 to alternately connect the one terminal of the vibrating means 10 to the high level V_{DD} and the low level V_{SS} of a power supply in response to a first clock pulse ϕ . The second transfer switch 14 is connected to another terminal 10b of the vibrating means 10 to connect the other terminal of the vibrating means 10 to the low level V_{SS} and the high level V_{DD} of the power supply in response to a second clock pulse ϕ which is inverted in polarity with respect to the first clock pulse ϕ . Each of the first and second transfer switches 12 and 14 comprises a complementary pair of a P-channel metal oxide semiconductor transistors (MOSFET) and N-channel MOSFET. The P-channel MOSFET has its source terminal connected to the high level V_{DD} of the power supply, and the source terminal of the N-channel MOSFET is connected to the low level V_{SS} of the power supply. The drain terminals of the P-channel MOSFET and the N-channel MOSFET are con-

5 nected to each other and connected to the vibrating means 10. The gate terminals of the P-channel MOSFET and the N-channel MOSFET are coupled to each other and arranged to receive a clock pulse. Indicated at 16 is a variable resistor connected to the vibrating means 10 in series to adjust the flow of electric current passing through the vibrating means 10 for thereby varying the magnitude of acoustic sound.

10 When, in operation, the first and second clock pulses ϕ and ϕ having the waveforms shown in Figure 2 are applied to inputs of the first and second transfer switches 12 and 14, the N-channel MOSFET of the first transfer switch 12 is turned on and the P-channel MOSFET of the first transfer switch 12 is turned off at the time instant A shown in Figure 2. At the same time, the P-channel MOSFET of the second transfer switch 14 is turned on and the N-channel MOSFET of the second transfer switch 14 is turned off at the time instant A shown in Figure 2. Under these conditions, the high level V_{DD} of the power supply is connected to terminal 10b and the low level V_{SS} of the power supply is connected to terminal 10a so that electric current flows in a direction as shown by the arrows ia. At the time instant B shown in Figure 2, the P-channel MOSFET of the first transfer switch 12 is turned on and the N-channel MOSFET of the first transfer switch 12 is turned off, while the P-channel MOSFET of the second transfer switch 14 is turned off and the N-channel MOSFET of the second transfer switch 14 is turned on. Under these conditions, the electric current flow through the vibrating means 10 is a direction as shown by arrows ib in Figure 1. Accordingly, the voltage E which varies in polarity between V_{DD} and $-V_{DD}$ as shown in Figure 2 is applied across the vibrating means 10, which is consequently driven with a voltage substantially twice that of the output voltage of the power source. This makes it possible to omit a conventional booster coil.

45 Figure 3 shows a fragmentary cross sectional view of an electronic timepiece incorporating one example of the buzzer. In Figure 3, the electronic timepiece is shown as comprising a case body 20 carrying thereon an annular frame 22 by which a movement 24 is supported. A back cover 26 is screwed into the case body 20 and has a plurality of perforations 26a to admit the acoustic sound therethrough. Indicated at 28 is a metal vibrating plate held in place in a water-tight sealing manner between a plastics pressure ring 30 and a packing member 32 and which is electrically insulated from the back cover 26. Secured to the bottom surface of the vibrating plate 28 is a barium titanate piezo-electric vibrating element 34 provided on both of its surfaces with electrodes. One of the electrodes of the vibrating element 34 is connected to the vibrating plate 28. A metallic coil spring 36 is disposed between the vibrating

plate 28 and one terminal of the movement 24 to provide an electrical connection therebetween to deliver a clock pulse ϕ to the terminal 10a shown in Figure 1. Likewise, a metallic coil spring 38 is interposed between the other electrode of the vibrating element 34 and the movement 24 to deliver a clock pulse ϕ to the terminal 10b shown in Figure 1. The driver circuit D is incorporated in an integrated circuit chip of the movement 24 and applies the clock pulses ϕ and ϕ to the vibrating element 34, by which the vibrating element 34 is caused to vibrate. The vibration of the vibrating element 34 is transmitted to the vibrating plate 28, which is consequently caused to vibrate to generate an acoustic sound. This acoustic sound is transmitted through the perforations 26a of the back cover 26 to the outside. It will now be appreciated that the piezo-electric vibrating element 34 is applied with clock pulses delivered directly from the integrated circuit chip of the movement without the provision of a booster coil and its associated parts. Thus, the driver circuit of the present invention is simple in circuit arrangement and has a high operating efficiency.

Figure 4 shows a fragmentary cross sectional view of an electronic timepiece incorporating another example of the buzzer. Reference numeral 40 denotes a case body and 42 a back cover press-fitted to the case body 40. The back cover 42 has a plurality of perforations 42a through which an acoustic sound is transmitted to the outside. A piezo-electric vibrating element 47 is mounted on a vibrating plate 46 made of a metal or other suitable material. The vibrating plate 46 is provided at its outer periphery 46a as one unit with an elastic retaining member 48 serving as a sealing member which is made by insert-molding suitable material such as rubber. The retaining member 48 is compressed between the back cover 42 and the case body 40 to provide a water-tight sealing effect therebetween. Indicated at 50 is a battery. Since the vibrating plate 46 is integral with the elastic retaining member 48, the vibrating element 46 is elastically supported by the case body 40 so that the effective area in which the vibrating plate 46 vibrates is relatively large whereby the acoustic efficiency is high. The unitary construction of the retaining member 48 and the vibrating plate 46 makes it easy to assemble the plate 46 to the case body 40.

While the present invention has been shown and described with reference to particular embodiments by way of example, it should be noted that various other changes or modifications may be made without departing from the scope of the present invention.

WHAT WE CLAIM IS:—

1. A buzzer driver circuit for electronic apparatus having a power supply which provides an output voltage between respective points having a high level and a low level potential, comprising piezo-electric vibrating

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nected to each other and connected to the
vibrating means 10. The gate terminals of the
P-channel MOSFET and the N-channel MOSFET
are coupled to each other and arranged to
5 receive a clock pulse. Indicated at 16 is a
variable resistor connected to the vibrating
means 10 in series to adjust the flow of electric
current passing through the vibrating means 10
for thereby varying the magnitude of acoustic
10 sound.
When, in operation, the first and second
clock pulses ϕ and ϕ having the waveforms
shown in Figure 2 are applied to inputs of the
first and second transfer switches 12 and 14,
15 the N-channel MOSFET of the first transfer
switch 12 is turned on and the P-channel
MOSFET of the first transfer switch 12 is
turned off at the time instant A shown in
Figure 2. At the same time, the P-channel
20 MOSFET of the second transfer switch 14 is
turned on and the N-channel MOSFET of the
second transfer switch 14 is turned off at the
time instant A shown in Figure 2. Under these
conditions, the high level V_{DD} of the power
25 supply is connected to terminal 10b and the
low level V_{SS} of the power supply is connected
to terminal 10a so that electric current flows in
a direction as shown by the arrows ia. At the
time instant B shown in Figure 2, the P-channel
30 MOSFET of the first transfer switch 12 is
turned on and the N-channel MOSFET of the
first transfer switch 12 is turned off, while the
P-channel MOSFET of the second transfer
switch 14 is turned off and the N-channel
35 MOSFET of the second transfer switch 14 is
turned on. Under these conditions, the electric
current flow through the vibrating means 10 is
a direction as shown by arrows ib in Figure 1.
Accordingly, the voltage E which varies in
40 polarity between V_{DD} and $-V_{DD}$ as shown in
Figure 2 is applied across the vibrating means
10, which is consequently driven with a voltage
substantially twice that of the output voltage of
the power source. This makes it possible to
45 omit a conventional booster coil.
Figure 3 shows a fragmentary cross sectional
view of an electronic timepiece incorporating
one example of the buzzer. In Figure 3, the
electronic timepiece is shown as comprising a
50 case body 20 carrying thereon an annular frame
22 by which a movement 24 is supported. A
back cover 26 is screwed into the case body 20
and has a plurality of perforations 26a to admit
the acoustic sound therethrough. Indicated at
55 28 is a metal vibrating plate held in place in a
water-tight sealing manner between a plastics
pressure ring 30 and a packing member 32 and
which is electrically insulated from the back
cover 26. Secured to the bottom surface of the
60 vibrating plate 28 is a barium titanate piezo-
electric vibrating element 34 provided on both
of its surfaces with electrodes. One of the
electrodes of the vibrating element 34 is con-
nected to the vibrating plate 28. A metallic
65 coil spring 36 is disposed between the vibrating

plate 28 and one terminal of the movement 24
to provide an electrical connection there-
between to deliver a clock pulse ϕ to the
terminal 10a shown in Figure 1. Likewise, a
metallic coil spring 38 is interposed between
70 the other electrode of the vibrating element 34
and the movement 24 to deliver a clock pulse
 ϕ to the terminal 10b shown in Figure 1. The
driver circuit D is incorporated in an integrated
circuit chip of the movement 24 and applies the
75 clock pulses ϕ and ϕ to the vibrating element
34, by which the vibrating element 34 is
caused to vibrate. The vibration of the vibrating
element 34 is transmitted to the vibrating plate
28, which is consequently caused to vibrate to
80 generate an acoustic sound. This acoustic sound
is transmitted through the perforations 26a of
the back cover 26 to the outside. It will now be
appreciated that the piezo-electric vibrating
element 34 is applied with clock pulses delivered
85 directly from the integrated circuit chip of the
movement without the provision of a booster
coil and its associated parts. Thus, the driver
circuit of the present invention is simple in
circuit arrangement and has a high operating
90 efficiency.
Figure 4 shows a fragmentary cross sectional
view of an electronic timepiece incorporating
another example of the buzzer. Reference
numeral 40 denotes a case body and 42 a back
95 cover press-fitted to the case body 40. The
back cover 42 has a plurality of perforations
42a through which an acoustic sound is trans-
mitted to the outside. A piezo-electric vibrating
element 47 is mounted on a vibrating plate 46
100 made of a metal or other suitable material. The
vibrating plate 46 is provided at its outer peri-
phery 46a as one unit with an elastic retaining
member 48 serving as a sealing member which is
made by insert-molding suitable material such
105 as rubber. The retaining member 48 is com-
pressed between the back cover 42 and the case
body 40 to provide a water-tight sealing effect
therebetween. Indicated at 50 is a battery.
Since the vibrating plate 46 is integral with the
elastic retaining member 48, the vibrating
110 element 46 is elastically supported by the case
body 40 so that the effective area in which the
vibrating plate 46 vibrates is relatively large
whereby the acoustic efficiency is high. The
unitary construction of the retaining member
48 and the vibrating plate 46 makes it easy to
115 assemble the plate 46 to the case body 40.
While the present invention has been shown
and described with reference to particular
embodiments by way of example, it should be
noted that various other changes or modi-
fications may be made without departing from
the scope of the present invention.
120 WHAT WE CLAIM IS:-
1. A buzzer driver circuit for electronic
apparatus having a power supply which pro-
vides an output voltage between respective
points having a high level and a low level
125 potential, comprising piezo-electric vibrating



- means having a piezo-electric element and a vibrating plate secured thereto; a first transfer switch connected to one terminal of said vibrating means to alternately connect said one terminal to said high level and said low level potentials of said power supply in response to a first clock pulse; and a second transfer switch connected to another terminal of said vibrating means to alternately connect said another terminal to said low level and said high level potentials in response to a second clock pulse, whereby said vibrating means is driven by a voltage higher than said output voltage to vibrate said vibrating plate to generate an acoustic sound.
2. A buzzer driver circuit according to Claim 1, further comprising resistor means connected to one of said terminals of said vibrating means.
3. A buzzer driver circuit according to Claim 2, in which said resistor means comprises a variable resistor.
4. A buzzer driver circuit according to any of Claims 1 to 3, in which said second clock pulse is reversed in polarity with respect to said first clock pulse.
5. A buzzer driver circuit according to any of Claims 1 to 3, in which each of said first and second transfer switches comprises an inverter.
6. A buzzer driver circuit according to Claim 5, in which each said inverter comprises a complementary pair of a P-channel MOSFET and an N-channel MOSFET.
7. A buzzer driver circuit for portable electronic apparatus substantially as hereinbefore described with reference to the accompanying drawings.
8. An electronic timepiece comprising a buzzer driver circuit according to any of Claims 1 to 7, a case body, a back cover secured to the case body, a frame supported by said case body, a movement carried by said frame, an insulating pressure ring disposed in said back cover, a sealing member compressed between said frame and said back cover to hold said vibrating plate, first spring means disposed between said vibrating plate and said movement to provide a first electrical connection therebetween, and a second spring means disposed between said vibrating element and said movement to provide a second electrical connection therebetween.
9. An electronic timepiece comprising a buzzer driver circuit according to any of Claims 1 to 7, a case body, a back cover secured to the case body, and an elastic retaining member provided on the outer periphery of said vibrating plate and compressed between said case body and said back cover to elastically support said vibrating plate.
10. An electronic timepiece according to Claim 9, in which said elastic retaining member is formed by insert-molding a rubber member onto the vibrating plate.

MARKS & CLERK