

SPECIFICATION

Electronic apparatus with audible annunciator and alarm lamp

5 The present invention relates to a portable electronic apparatus, and more particularly to a portable electronic apparatus having an audible annunciator, such as a loudspeaker, and an alarm lamp.

10 A portable electronic apparatus, such as a pager receiver, having a function to alarm or to notify its bearer is equipped with an audible annunciator, such as a loudspeaker, for alerting. In the case of a pager receiver, the sound of its loudspeaker informs its bearer of his being paged. However, in those cases where a plurality of receivers are used at the same time or where a receiver has to be used in the environment of high-level noise, it may be difficult to distinguish the sounding receiver from others. Also, the pagee may fail to notice the sound. As a solution to these problems, some paging receivers are equipped with an alarm lamp provided in addition to a loudspeaker, which is turned on simultaneously with the activation of the annunciator. An example of such a pager receiver include those disclosed in U.S. Patent No. 3,783,384 and Re. 28,222.

Whereas a light emitting diode (LED) is usually employed as the alarm lamp, the activation of this LED requires about 1.5 volts. However, because a radio pager receiver or the like is ordinarily powered by a single dry battery of 1.2 to 1.7 volts to reduce its size, the dropping of the battery's voltage may disable the LED. To avoid this trouble, the inductance of the driving coil in the loudspeaker is used, the counter-electromotive forces generated at both ends of the inductance element being utilized to turn on and off the LED.

On the other hand, if the receiver has to be used in a quiet environment, it will be desired to alert the bearer of the receiver merely by turning on the lamp without giving any sound. Because, unlike in the above cited instance, the loudspeaker inductance elements cannot be used to add this function, another inductance element will have to be provided exclusively for the lamp and switched on and off as required. However, the additional inductance element is not advisable for a portable electronic apparatus which is desired to be small and light.

One object of the present invention, therefore, is to provide a portable electronic apparatus which is able to alert its bearer with its lamp alone and yet is small and light.

According to the invention, there is provided a portable electronic apparatus comprising oscillator means for generating an oscillation signal; audible annunciator means having an inductance element for generating an audible annunciating signal in response to a first actuation signal of a first frequency; light emitting means turned on and off by counter-electromotive forces developed in the inductance element in response to one of the first actuation signal and a second actuation signal of a second frequency; frequency divider means coupled to the audible annunciator means and the light emitting means for frequency-dividing the oscillation signal to provide the first and second actuation signals and for selectively generating one of these actuation signals in response to a control signal; gate means connected to the frequency divider means, the audible annunciator means and the light emitting means, for supplying the audible annunciator means and the light emitting means with one of the first and second actuation signals in response to an alert signal; and external switching means for supplying the first control signal to the frequency divider means.

Other objects, features and advantages of the present invention will be made more apparent from the detailed description hereunder taken in conjunction with the accompanying drawings, wherein:
Figure 1 is a block diagram of a pager receiver suitable for the application of a calling-alarming circuit according to the present invention;
Figures 2 and 3 show schematic diagrams of conventional calling-alarming circuits;
Figure 4 shows a frequency characteristic of an audible signal;
Figure 5 is the frequency characteristic diagram of an audible annunciator for use in a pager receiver;
Figure 6 is a block diagram of an embodiment of the calling-alarming circuit according to the present invention;
Figures 7A through 7C show time charts for explaining the circuit of *Figure 6*;
Figure 8 is a block diagram of an embodiment of the variable frequency-divider circuit of *Figure 6*; and
Figure 9 is a partial block diagram of a modification of the circuit illustrated in *Figure 8*.

Referring to *Figure 1*, a paging signal of a radio frequency caught by an antenna 1 is demodulated by a radio receiver circuit 2 into a baseband signal. Then, it is supplied to a decoder circuit 3, which checks the demodulated baseband calling signal as to whether or not it is identical with the identification number of the receiver and, if it is, gives an alert signal A as its output. In response to the alert signal A, an annunciator 4 notifies the bearer of the receiver of his being paged by sounding a loudspeaker and/or lighting an alarm lamp. For details of the circuitry up to the point where the alert signal A is provided and its functioning, reference is made to the U.S. Patent No. 4,127,846 or the U.S. Patent No. 4,194,153, both granted to the applicant of the present application.

One example of a circuit simultaneously giving an audible notice and lighting an alarm lamp is shown in *Figure 2*. An oscillation signal of a relatively high frequency (about 30 ~ 40 kHz) from an oscillator 11 is frequency-divided by a frequency divider 12 into an audible frequency. The divided signal is fed to an amplifier 13, to which also is supplied the alert signal A from the decoder section (*Figure 1*). Only when this alert signal is given to it, the amplifier 13 amplifies the frequency-divided signal to activate a loudspeaker 14. At the same time with the sounding of the loudspeaker 14, a counter-electromotive force generated at the inductance element 141 of the speaker 14 turns a light emitting diode (LED) 15 on and off. This circuit, which always operates the

loudspeaker 14 and the LED 15 simultaneously, is inconvenient when the bearer of the receiver wants to be notified of a call only by the lighting of the LED 15, i.e., when the call has to be silent as the bearer is in a hospital or attending a conference.

An approach to overcome this inconvenience is embodied in the circuit illustrated in Figure 3, wherein a switch 17 is closed when it is desired to activate the loudspeaker 14 and the LED 15 at the same time. Conversely, when the switch 17 is open, the LED 15 will be turned on and off by the counter-electromotive force of an inductance element 16 in response to an alert signal, but the loudspeaker 14 will not sound so that the desired effect can be achieved. However, this circuitry involves the disadvantage that it is bulky because of the inductance element 16 as stated above.

Before describing an embodiment of the present invention which is cleared of the disadvantages of the conventional circuits shown in Figures 2 and 3, it may be pertinent to explain the limits of audible frequencies and the frequency characteristic of a loudspeaker (audible annunciator) used in a pager receiver.

Figure 4 shows the lowest sound pressure level of frequencies which man can recognize as sounds. The axis of abscissas represents frequency logarithmically graduated, and that of ordinates, sound pressure level. The audible frequencies range from 15-20 Hz at the lowest to 20,000 Hz at the highest, and the lowest audible sound pressure level significantly varies with frequency.

Figure 5 charts the frequency characteristic of the audible annunciator used in a pager receiver. The axis of abscissas represents frequency logarithmically graduated, and that of ordinates, sound pressure level. Because a pager receiver is required to be small, an efficient but small audible annunciator is used therein. Since such a receiver needs sounds of no more than one frequency, there is used an audible annunciator which is caused to resonate in the vicinity of a single frequency, thereby increasing its sound pressure. This single frequency is usually selected out of the range of 2 kHz to 3 kHz taking the characteristic of Figure 4 and the power consumption of the receiver into consideration. Therefore, putting together the lowest audible sound pressure level shown in Figure 4 and the frequency characteristic of the audible annunciator charted in Figure 5 reveals that the frequencies of sounds generated by any audible annunciator, audible to the human, are limited to a very narrow range.

Figure 6 is a block diagram of a vital part of one embodiment of the present invention. An oscillator circuit 103 therein uses any one of a crystal resonator, a ceramic resonator and a multivibrator. The output of the oscillator circuit 103 is led to a variable frequency divider 108, whose dividing number can be varied with an external switch 109. The output of the variable frequency divider 108 is applied to an amplifier circuit 105, after amplification, supplied to an LED 102 and a loudspeaker 101. The amplifier circuit 105, in supplying its output signal to the loudspeaker 101 and the LED 102, is controlled by an alert signal A from outside, such as a decoder of the

pager receiver. The alert signal A actuates the amplifier circuit 105, indicating that the pager receiver has been called. A magnetic loudspeaker is usually used as the loudspeaker 101, and has a high inductance element 201. For instance, the inductances of loudspeakers used in pager receivers or the like are around 1 mH.

Suppose now that the oscillation frequency of the oscillator circuit 103 is f_1 , and the frequencies resulting from divisions by the variable frequency divider 108 are f_2 , f_3 and f_4 (where $f_2 > f_3 > f_4$). Further supposing that the numbers of division are N_2 , N_3 and N_4 , the following relationship will hold between these frequencies f_1 , f_2 , f_3 and f_4 .

$$f_1 = N_2 f_2 = N_3 f_3 = N_4 f_4$$

Figures 7A to 7C are charts schematically showing signals having frequencies f_3 and f_4 and an output signal of the variable frequency divider 108. The frequency f_3 represented by Figure 7A is an audible frequency of a few kHz, and the frequency f_4 represented by Figure 7B is a frequency of several Hz. The waveform shown in Figure 7C is an output signal of the variable frequency divider 108 combining these two frequencies, f_3 and f_4 .

When the signal represented by Figure 7C is emitted by the loudspeaker 101 of Figure 5, it will constitute intermittent beep sounds. Since the inductance element 201 of the loudspeaker 101 develops a counter-electromotive force, the LED 102 will emit light at the same time.

Next will be described the characteristic operation of the present invention. When the external switch 109 is manipulated, the number of division varies from N_3 to N_2 , and the frequency changes from f_3 into f_2 , which is outside the operational frequency range of the loudspeaker 101. Or else, if the frequency f_2 is outside the range audible to the human, the output of the loudspeaker 101 will not be recognized as a sound. The output of the variable frequency divider 108, whose frequency has shifted from f_3 shown in Figure 7C to f_2 , is supplied to the inductance element 201 and to the LED 102 by way of the amplifier 105. As mentioned above, since the frequency f_2 is outside the operational frequency range of the loudspeaker 101, the loudspeaker cannot be activated or its output cannot be heard, but only the LED 102 will intermittently light.

Figure 8 is a more detailed diagram of the embodiment of the invention shown in Figure 6. An oscillation output B of the oscillator circuit 103 is led to a frequency divider circuit 111 in the variable frequency divider 108. The output of this frequency divider circuit 111 is applied to another frequency divider circuit 112 and to one of the input terminals of an AND gate 113. The output of the frequency divider circuit 112 is applied to still another frequency divider circuit 114 and to one of the input terminals of an AND gate 115.

To the other input terminal of the AND gate 115 is connected a switch 116, which is controlled by the external switch 109. To the input terminal is also connected a resistor 117 whose other end is connected to the positive electrode terminal of a battery.

The external switch 109 and the resistor 117 are also connected to the other input terminal of the AND gate 113 by way of an inverter circuit 118. The outputs of these AND gates 113 and 115 are supplied to the input terminals of an OR gate 119, respectively.

The signal divided by the frequency divider circuit 114 is led to one of the input terminals of an OR circuit 120, whose other input terminal is grounded.

The outputs of the OR gates 120 and 119 are both supplied to the input terminals of an AND gate 121. The output of the AND gate 121 is led to one of the input terminals of an AND gate 122, to whose other input terminal is supplied the alert signal A. The output of the AND gate 122 is connected to the base of a transistor 124 through a resistor 123. To the collector of the transistor 124 is connected the loudspeaker 101 and the LED 102.

The characteristic operation of the present invention in such a circuitry will be described in further detail below. Now suppose the frequency f_1 of the output signal, represented by B, of the oscillator circuit 103 to be 40 kHz. The frequency f_1 is divided at a rate of 1/2 by the frequency divider circuit 111 into the frequency $f_2 = 20$ kHz. One of the output signals of the frequency divider circuit 111 is supplied to the frequency divider circuit 112, wherein it is divided into 1/10 of the frequency f_2 to give the frequency $f_3 = 2$ kHz. This frequency f_3 is supplied to the AND gate 115. Another output signal of the frequency divider circuit 111 is supplied to the AND gate 113.

If, now, the switch 116 is open, the AND gate 115 will be opened by the resistor 117 connected to the positive terminal of the battery, and the AND gate 113, to which a negative voltage is applied by way of the inverter circuit 118, will be closed. As a result, the signal of $f_3 = 2$ kHz will be fed to the AND gate 119.

Meanwhile, an output signal from the frequency divider circuit 112 is supplied not only to the AND gate 115 but also to the frequency divider circuit 114. The signal of $f_3 = 2$ kHz supplied to the frequency divider circuit 114, which divides the input signal to it by 2000, is frequency-divided to give the frequency $f_4 = 1$ Hz, which is supplied through the OR circuit 120 to the AND gate 121. This OR gate 120 is provided either to pass the output signal of the frequency divider circuit 114 or, irrespective of the signal from the frequency divider circuit 114, to give an output signal to the AND gate 121. Thus, if the grounded terminal of the OR gate 120 is connected to the power source side, there will always be a positive voltage on the output side.

These output signals of the OR gates 119 and 120 are respectively represented by Figures 7A and 7B. The output signal of the AND gate 121 is represented by Figure 7C. If, in this state, the alert signal A is positive, the output signal of the AND gate 121 will be supplied, by way of the AND circuit 122 and the resistor 123 for limiting the current, to the transistor 124. The transistor 124 amplifies the output of the AND gate 121, and supplies it to the loudspeaker 101 and the LED 102 to sound and light them, respectively.

Next, when the switch 116 is closed, the AND gates 115 and 113 are closed and open, respectively.

Under these conditions, the OR gate 119 gives as its output a signal of $f_2 = 20$ kHz to the AND gate 121, whose output is represented by Figure 7C, with its frequency f_3 changed to the frequency f_2 outside the operational frequency range of the loudspeaker. If, in this state, the alert signal A from outside is positive, the signal of $f_2 = 20$ kHz will be fed through the AND gate 122, resistor 123 and transistor 124 to the inductance element 201 of the loudspeaker 101. The counter-electromotive force of the inductance element 201 will turn on the LED 102, but the loudspeaker 101 will not sound because f_2 is a frequency outside its operational range. Even if it does sound, if f_2 is outside the range of frequencies audible to the human ear, it will not be heard. In this manner, the present invention makes it possible to select between the mode of sound and light and that of light alone for the paging operation according to the numbers of division by the frequency divider circuits (111, 112 and 114).

Since the signal synthesized and supplied by the AND gate 121 is intermittent at $f_4 = 1$ Hz as illustrated in Figure 7C, a high frequency component may be generated at the leading and trailing points of the signal of f_4 and be audible from the loudspeaker 101. To solve this problem, if the output frequency of OR gate 119 is f_2 , it will be sufficient to add a circuit for stopping the intermittent sounding by f_4 .

An example of this circuitry is illustrated in Figure 9. It is characterized by the connection of the resistor 117 to one of the input terminals of the OR circuit 120 by way of an inverter circuit 125. If the switch 116 is on so that alerting can be done only by the lighting of the LED, the output of the OR circuit 120 will be positive irrespective of the signal from the frequency divider circuit 114, and can stop the intermittent operation by the frequency of f_4 .

In addition, although the foregoing description concerned only pager receivers in detail, it has to be noted that the circuitry according to the present invention can also be applied as it is to wrist watches or the like having an indicator lamp and emitting alarm sounds, such as time signals.

As hitherto described, the present invention provides for the additional of a variable frequency divider circuit permitting variation of the number of division by external manipulation. It is accordingly made possible to supply the alerting loudspeaker and LED with signals of a suitable frequency which can be varied as required to alert the bearer by both sounding and lighting or by lighting alone. Moreover, in a pager receiver or the like, logic circuits are composed of integrated parts such as ICs or LSIs, and the sounding circuit is formed as a part of a logic circuit consisting of an IC or an LSI. Therefore, logic circuits needed to realize a variable frequency divider circuit according to the invention in an IC or an LSI are nothing more than AND gates, inverter circuits, OR gates, resistors and a terminal for connecting a switch. These components do not cause the chip size of the IC or the LSI to be enlarged, but altogether constitute a far smaller volume than an additional inductance element.



CLAIMS

1. A portable electronic apparatus comprising:
oscillator means for generating an oscillation
5 signal;
audible annunciator means having an inductance
element for generating an audible annunciating
signal in response to a first actuation signal of a first
frequency;
10 light emitting means turned on and off by counter-
electromotive forces developed in said inductance
element in response to one of said first actuation
signal and a second actuation signal having a
second frequency; said second frequency producing
15 no audible response from said audible annunciator
means;
frequency divider means coupled to said audible
annunciator means and said light emitting means for
frequency dividing said oscillation signal to provide
20 said first and second actuation signals and for
selectively generating one of these actuation signals
in response to a control signal;
gate means connected to said frequency divider
means, said audible annunciator means and said
25 light emitting means, for supplying said audible
annunciator means and said light emitting means
with one of said first and second actuation signals in
response to an alert signal; and
external switching means for supplying said first
30 control signal to said frequency divider means.
2. A portable electronic apparatus as claimed in
Claim 1, said apparatus further comprising:
radio receiver circuit means for receiving and
demodulating a calling signal of a radio frequency
35 and thereby providing a baseband calling signal;
and
decoder means connected to the output of said
radio receiver circuit means for comparing said
baseband calling signal with a predetermined num-
ber and, if they are found identical, generating said
40 alert signal to be supplied to said gate means.
3. A portable electronic apparatus as claimed in
Claim 1 or 2, wherein said frequency divider means
comprises:
45 a first frequency divider for frequency-dividing
said oscillation signal by a first ratio to provide a first
frequency-divided signal having said second fre-
quency;
a second frequency divider for frequency-dividing
50 said first frequency-divided signal by a second ratio
to provide a second frequency-divided signal having
said first frequency;
a third frequency divider for frequency-dividing
said second frequency-divided signal by a third ratio
55 to provide a modulation signal;
a first gate circuit for selectively passing one of
said first and second frequency-divided signals in
response to said control signal; and
a second gate circuit for modulating the output of
60 said first gate circuit with said modulation signal and
thereby to generate, as the output of said frequency
divider means, one of said first and second actuation
signals.
4. A portable electronic apparatus as claimed in
65 Claim 3, wherein said frequency divider means

further comprises means connected between the
output of said third frequency divider and said
second gate circuit for, in response to said control
signal, inhibiting said modulation signal from
70 reaching said second gate circuit and instead sup-
plying said second gate circuit with a continuous
modulation signal to keep said second gate circuit
always open.

5. A portable electronic apparatus substantially
75 as described herein with reference to Figures 6-9 of
the accompanying drawings.

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