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(58) Field of search
G4N
H3R
Selected US specifications from IPC sub-class G08B

(54) Theft alarm system

(57) The alarm system is primarily for protecting valuables during transit, e.g. valuables carried in a briefcase, and comprises a transmitter and a receiver with the receiver including an alarm device and being attached to or associated with the valuables. The system is arranged to generate an alarm signal when the receiver is taken from the vicinity of the transmitter to an extent such that a predetermined signal transmitted by the transmitter fails to be detected at the receiver or when a substitute signal is received. The transmitter is operable such that the transmitted signal comprises a carrier signal modulated by a modulation signal which is determined or identified by the carrier signal. In the receiver (Figs. 2, 3 and 4, not shown) a reconstituted carrier is generated in a predetermined manner using the received modulation as a reference. If the receiver picks up a different transmitted signal which is incorrectly modulated, even if the relationship between the modulation frequency and the carrier frequency differs from the correct relationship by only a small amount, this is detected and the alarm activated. To increase security and save battery power the transmitter can be arranged such that the modulation signal is transmitted as a plurality of short bursts. A phase shift keying technique or a frequency shift keying technique (Figs. 5 and 6, not shown) may be used.

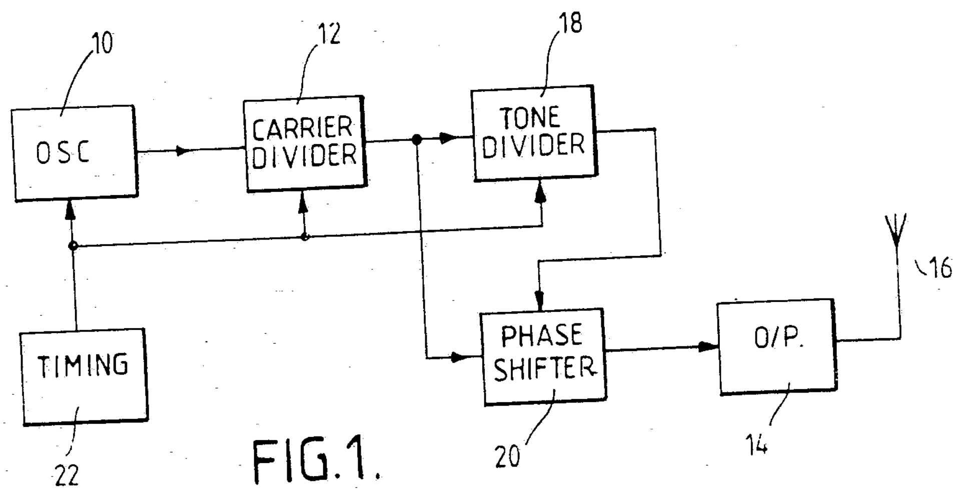

FIG.1.

The drawing(s) originally filed was (were) informal and the print here reproduced is taken from a later filed formal copy.

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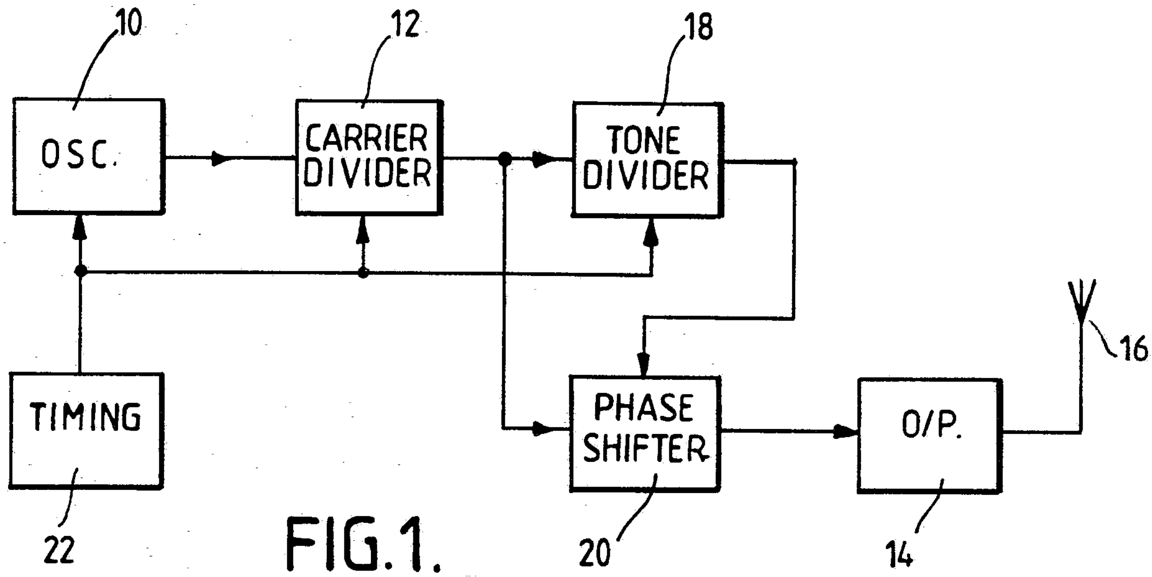

FIG.1.

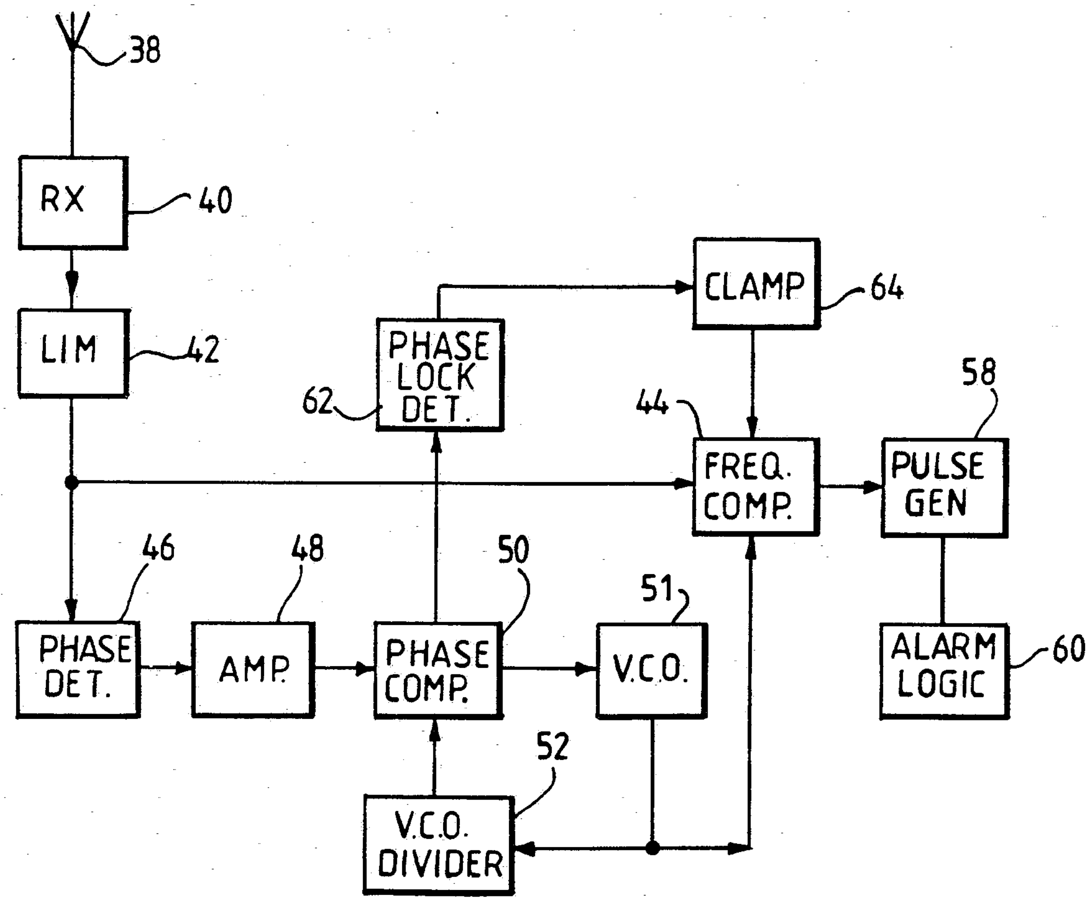

FIG.3.

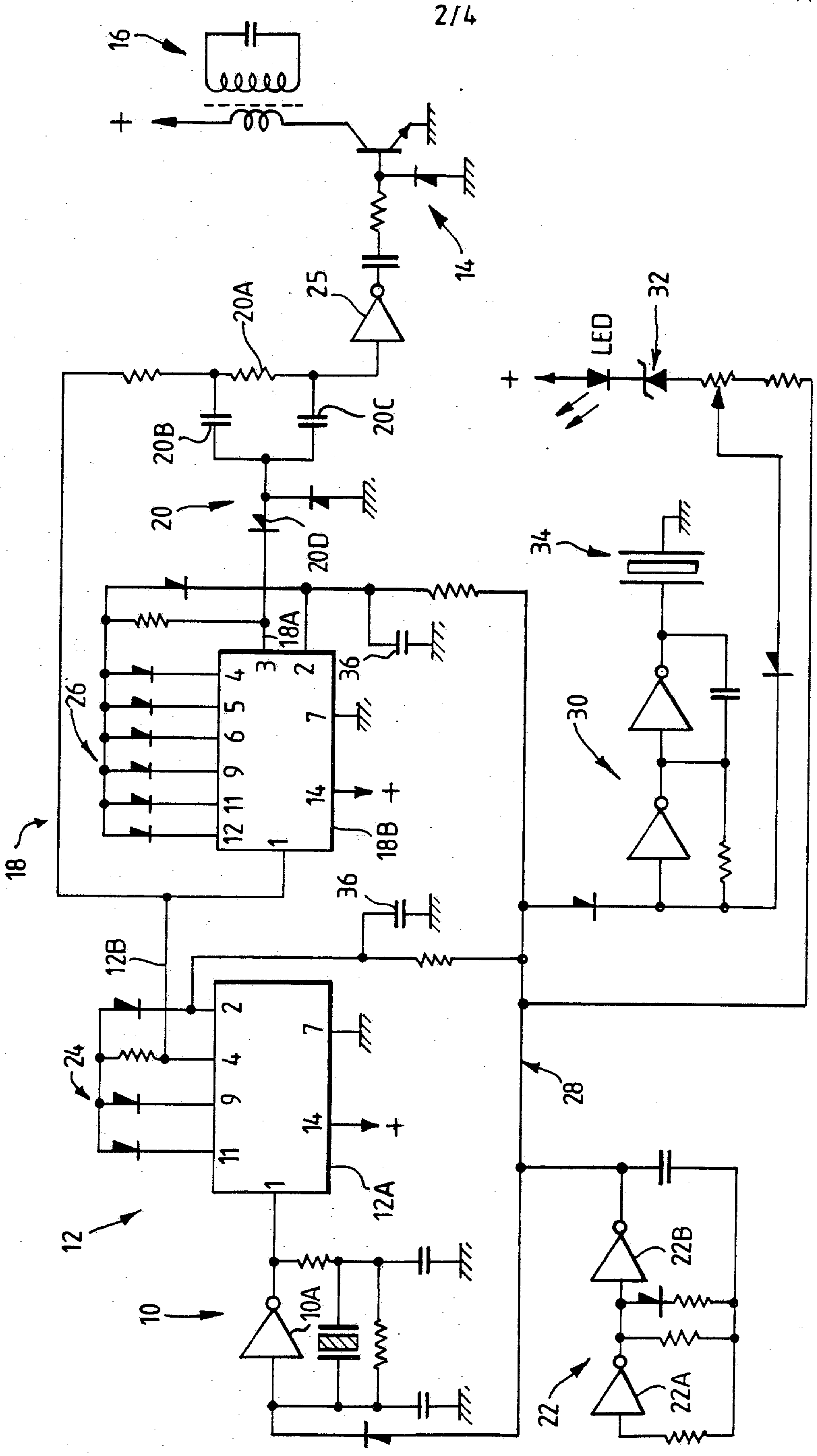
16
+
14
25
20A
20B
20C
20
20D
18A
36
LED
32
34
30
26
18
18B
12B
24
28
12
12A
10
10A
22
22A
22B

FIG.2.

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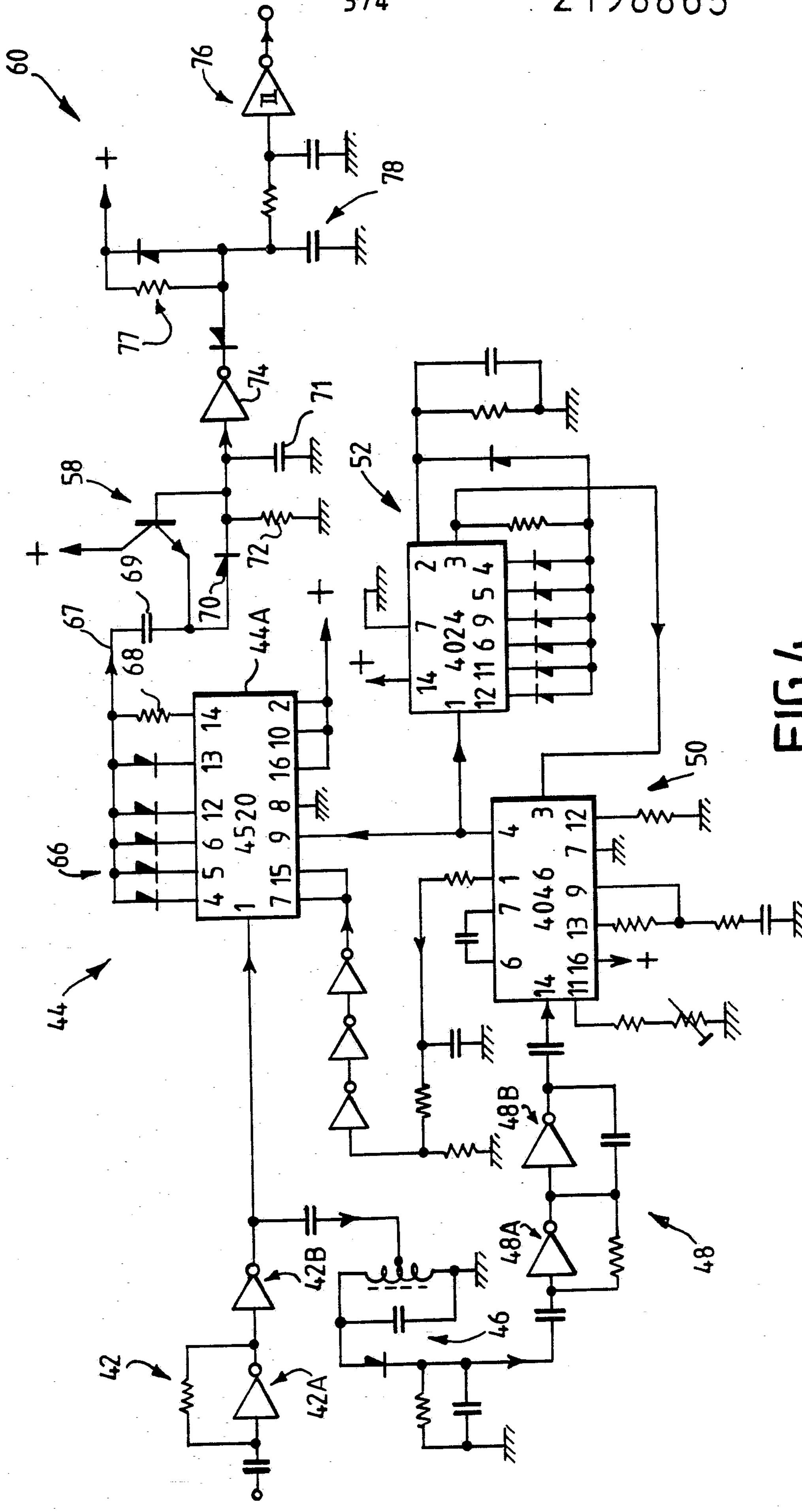

FIG.4.

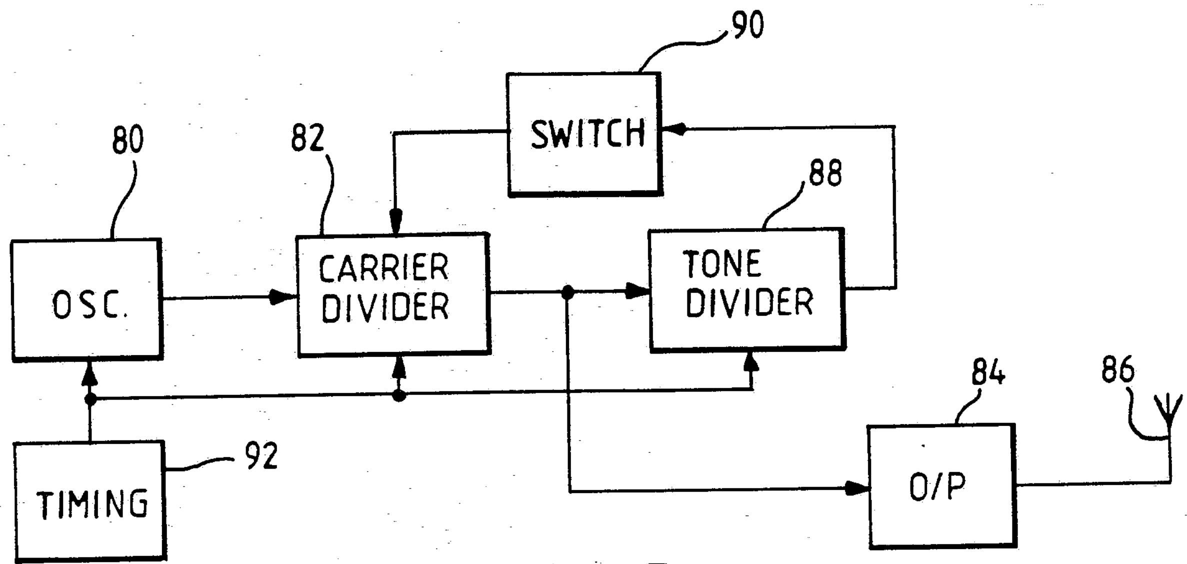
90
80
82
SWITCH
88
OSC.
CARRIER DIVIDER
TONE DIVIDER
84
86
TIMING
92
O/P

FIG.5.

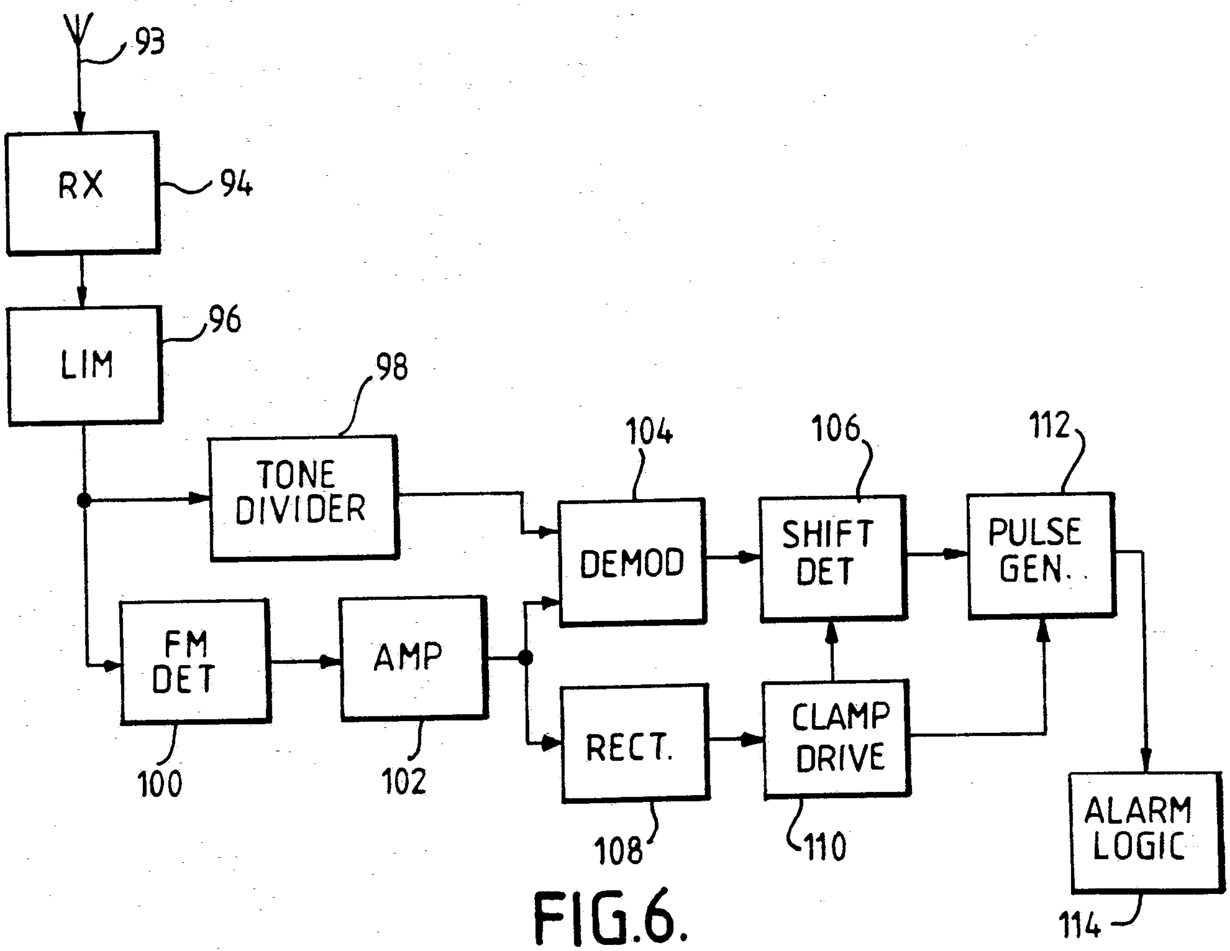
93
RX
94
LIM
96
98
TONE DIVIDER
104
106
112
DEMOD
SHIFT DET
PULSE GEN.
FM DET
AMP
RECT.
CLAMP DRIVE
100
102
108
110
ALARM LOGIC
114

FIG.6.

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ALARM SYSTEM

This invention relates to an alarm system for protecting valuables during transit, and particularly to valuables carried in, for instance, a briefcase.

A known alarm system of the above type comprises a radio transmitter worn by the person carrying the case and a radio receiver inside the case coupled to an alarm device which emits an audible or visible alarm indication when the case is removed from the vicinity of the transmitter, or which may spray the contents of the case with a dye. To provide a degree of security against attempts to substitute an alternative transmitter signal, the transmitter is arranged to transmit a coded signal, but it is feasible with current portable data processing devices to analyse the transmitted signal and generate a suitable substitute. In another known system the transmitted signal is modulated by a tone of a predetermined frequency, but such a modulated signal is also easily reproduced. It is known to modulate the signal with a sequence of tone signals of different frequencies. This, however, has the disadvantages of requiring relatively complex, power consuming and expensive circuitry, and a relatively long period of transmission to enable the receiver to detect the presence of the correct transmitted signal.

The present invention overcomes these disadvantages by modulating a carrier signal with a modulation signal which is determined or identified by the carrier. In the preferred embodiment of the invention, the transmitter is arranged to generate a modulation signal which is a tone burst of a frequency or frequencies directly related to the carrier signal, and derived from the carrier signal by means of a frequency divider. Alternatively, the modulation signal may be derived directly from an oscillator which is also used as the frequency reference for generating the carrier signal.

Thus, both the modulation signal and the carrier signal may be derived from the oscillator output using separate respective dividers. The receiver of the preferred system separates the modulation signal from the carrier signal, feeds the modulation signal to a frequency multiplier, of same ratios as the frequency divider for generating the modulation signal in the transmitter to generate a reference signal, and then compares the incoming carrier signal with the reference signal. This may be performed by a frequency comparator. If the frequency relationship between the carrier signal and the modulation signal of the received signal corresponds to that determined by the relevant divider in the transmitter, no frequency shift occurs between the carrier signal and the reference signal, causing the frequency comparator to produce a pulse. A difference in frequency, however results in the frequency comparator producing no pulse, and this condition is detected and used to trigger an alarm. By transmitting the modulation signal as a series of relatively short bursts typically less than 5 ms in duration, reproduction by analysing the transmitted signal is made relatively difficult. Security can be increased by generating a swept or switched modulation signal. In the preferred system the modulation signal is applied to the carrier signal as a phase-shift keying signal.

The invention will now be described by way of example with reference to the drawings in which:-

Figures 1 is a block diagram of a transmitter forming part of an alarm system in accordance with the invention;

Figure 2 is a circuit diagram of the transmitter of Figure 1;

Figure 3 is a block diagram of a receiver forming part of the same alarm system as the transmitter of Figures 1 and 2; and

Figure 4 is a circuit diagram of the receiver of Figure 3.

Referring to Figure 1, a transmitter for use in a system in accordance with the invention has a crystal oscillator 10 coupled to a carrier divider 12 for generating a carrier signal by frequency division which, after modulation is fed to an output amplifier 14 for transmission from a ferrite rod antenna 16. Modulation is applied to the carrier by a phase shift keying (PSK) technique by feeding an output signal from the carrier divider 12 to a second divider (referred to hereinafter as the tone divider) 18 and then applying the frequency divided output from the tone divider 18 to a phase shifter 20 coupled to the output of the carrier divider 12. The output from the phase shifter 20 is a phase modulated carrier signal that is fed to the output amplifier 14. A timing circuit 22 is coupled to the crystal oscillator 10 to switch on the oscillator in short bursts of 20 ms each occurring every second or two seconds so as (a) to make analysis of the transmitted signal more difficult, and (b) to save battery power. At the end of each oscillator burst, the carrier and tone dividers are reset.

Looking at the transmitter in more detail by reference to Figure 2, the crystal oscillator 10 is of conventional form and makes use of an inverting amplifier element 10A which is one of several such elements in a CMOS integrated circuit type No. CD 4069. The crystal oscillator 10 drives the carrier divider 12 constituted by a CMOS counter chip 12A type No. CD 4024 with a plurality of diodes coupled to selected outputs and to the reset input (pin 2). The connection of the diodes 24 determines the division ratio of the divider 12. Thus, with a crystal oscillator frequency of the order of 4.5 MHz, the carrier division ratio may be such as to yield an output in the range 80 to 85 Khz on line 12B.

From the output 12B of the carrier divider, the carrier is fed via the phase shifter or modulator 20 and a squaring inverter 25 to the transmitter 14. The phase shifter takes the form of the resistance 20A connected in series in the carrier signal path, and two capacitors 20B and 20C coupled via blocking diodes 20D and 20E to the output 18A of another CD 4024 counter chip 18B and associated diodes 26 together forming the tone divider 18. It follows that the frequency of the phase modulation is a predetermined integral multiple of the carrier frequency.

In both dividers 12 and 18, the arrangement of the diodes determines the division ratio by causing a pulse to be fed to the reset input when the binary outputs coupled to diodes are all at logic '1'. In figure 2, divider 18 is shown with diodes 26 arranged for the maximum division ratio of the counter chip, but it will be appreciated that the ratio can be selected from a large number of possible ratios, with the diode 26 and the chip 18B being encapsulated together in epoxy resin. A 1nF capacitor 36 on each reset input lengthens the reset pulse obtained from the diodes for reliable resetting.

The timer 22 makes use of another two inverters 22A and 22B to provide a control pulse on a line 28 coupled to the crystal oscillator 10 and the reset inputs of the dividers 12 and 18. This line 28 also serves as an input to a low battery warning circuit 30 comprising an audio frequency oscillator coupled via a zener diode 32 to a battery powered supply rail V+ and having a piezo-electric 'beeper' 34.

In summary, the transmitter of Figures 1 and 2 is a miniature battery powered portable device emitting a low-power low-frequency radio frequency signal by means of an internal ferrite rod antenna 16. The device may be worn on a person's belt or concealed in a pocket, or it may be carried by a vehicle. The transmitted signal is picked up by a nearby receiver which is typically mounted inside a case containing valuables or any other article which is supposed not to leave the vicinity of the transmitter. The receiver will now be described with reference to Figures 3 and 4.

Referring to Figure 3, the front end stage 40 of the receiver is conventional in that it is coupled to an omnidirectional antenna assembly 38 comprising three antennas arranged with their central sensitivity axes located perpendicular to each other, the antennas each feeding a respective amplifier which is operated in turn with the others to provide a combined output. The front end stage 40 feeds a limiter amplifier 42, the output of which drives, on the one hand, one input of a frequency comparator 44 and, on the other hand, a simple PM (phase modulation) detector 46.

After amplification and squaring in amplifier 48, the modulation signal extracted from the received signal is applied to a phase locked loop frequency multiplier comprising a phase comparator 50, a voltage controlled oscillator (VCO) 51 and a VCO divider 52, the divider 52 being indentical to the tone divider 18 of the transmitter. The output of the VCO 51 feeds the other input of the frequency comparator 44, and providing the received signal is present with sufficient amplitude and the carrier signal is of the same frequency as that obtained from the VCO 51, the output of the frequency comparator 44 is a train of pulses within each transmitted burst. The frequency is comparator 44 is controlled by a phase lock detector 62 and a clamp 64 such that it only operates during the transmitted bursts. If the receiver is taken away from the transmitter (by robbery of the case or other article it is contained in, for example), and the receiver picks up a different transmitted signal which is incorrectly modulated, only intermittent pulses are obtained from the frequency comparator 44. Even if the modulation frequency differs from the correct frequency by only a small amount, a detectable drop in output, due to longer gaps between the pulses, will be present at the output of the frequency comparator 44.

The output of the frequency comparator 44 is applied to a pulse generator 58 comprising a low pass filter and a level detector, and any significant loss of output from the pulse generator 58 causes alarm logic circuitry 60 to generate an audible or visual alarm or to spray a dye over the contents of the case.

The alarm logic is activated when there is a drop in output from the frequency comparator 44. This drop in output can be caused by the modulation frequency of the received signal differing from the correct frequency or by no signal being received.

Parts of the receiver are shown in more detail in Figure 4. The limiter 42 driven by the front end stage (not shown in Figure 4) is constituted by a pair of CMOS buffer amplifier elements 42A and 42B contained in an integrated circuit type No. CD 4069. Provided the received signal is of sufficient strength, the carrier available at the output of the limiter is sufficient to clock the frequency comparator 44 comprising a CD 4520 CMOS dual counter chip 44A and a set of diodes 66 coupling the register outputs of the counters to an output line 67.

The FM detector 46 is a simple off-tune resonant LC circuit and diode arrangement acting as a phase-to-voltage converter. This drives the squaring amplifier containing two buffer amplifier elements 48A, 48B from the CD 4069 integrated circuit.

The output from the amplifier 48 is fed to a phase comparator 50 (CD 4046) which is part of a phase lock loop also containing a VCO 51 and a VCO divider 52 (CD 4024). Since the VCO divider 52 (CD 4024) has the same division ratio as the tone divider 18 (CD 4024) used in the transmitter to generate the modulation signal from the carrier signal, it follows that, when the modulation frequency of the received signal has the required relationship with the carrier frequency and the VCO 51 is locked, the output frequency from the VCO 51 must be the same as that of the carrier signal. The VCO 51 output and the received carrier signal are separately fed to the frequency comparator 44 which detects any variation between the two signals. When the correct signal is received, the reconstituted carrier from the output of the VCO 51 has the same frequency and is in phase with the received carrier when fed to their respectivecounter inputs, (pins 9 and 1), of the freqency comparator 44 (CD 4520). Under these conditions the respective signal counters stay in step and reach their reset points simultaneously thereby causing a pulse to be generated on the frequency comparator output line 67. A resistor 68 connected to receive the most significant output if one of the counters acts as a pull-up resistor. As this is a continuous process a pulse is generated, for example, every sixteenth carrier signal cycle thereby producing a train of pulses on output line 67. An incorrect received signal having a different modulation and carrier frequency relationship results in the VCO output and the received carrier being out of phase or having different frequencies. This results in the counters being out of step, with one counter continually overtaking the other, such that they would only occasionally reach reset time simultaneously causing pulses to be generated only intermittently with long gaps between each pulse. If no signal is received then only spasmodic pulses would occur due to noise.

The output on line 67 is fed to the pulse generator 58. Each pulse is differentiated by a low value capacitor 69 before charging, via diode 70, a capacitor 71. The pulse generator thus acts as a frequency-to-voltage converter and provided that the pulses are frequent enough the capacitor 71 holds the voltage level of the diode 70 output between pulses, and, wereit not for the slow leakage through resistor 72, would generate an increasing linear staircase wave form on the diode output. The circuit values are selected such that the diode 70 output level is just beginning to drop when the next pulse arrives to recharge the capacitor 71, resulting in a substantially level output from the pulse generator to the alarm logic circuitry 60 through the inverter 74, which also acts as a buffer between the pulse generator 58 and the alarm logic circuitry 60. The alarm logic circuitry 60 is shown in simplified form in Figure 4. In essence, this comprises a Schmitt trigger element 76 coupled to the junction of the series combination of a resistor 77 and electrolytic capacitor 78 between the positive supply rail and earth. When the FM detector 46 receives a signal of sufficient amplitude, and the carrier frequency of that received signal matches the output frequency of the phase lock loop, the negative pulses produced by the pulse generator output 74 serve periodically to discharge the capacitor 78, thereby keeping the input voltage to Schmitt trigger element 76 low. In the event of the received signal disappearing or the modulation frequency being incorrect, the output of the pulse generator remains positive for the large gaps between pulses and the capacitor 78 charges progressively over a period of a number of seconds until the trigger element 76 changes state to activate the alarm through further circuitry (not shown). This delay also serves prevent operation of the alarm between transmitted bursts.

An alternative embodiment is shown in Figures 5 an Referring to Figure 5, a transmitter for use in an alternative system in accordance with the invention has a crystal oscillator 80 coupled to a carrier divider 82 for generating a carrier signal by frequency division which is fed to an output amplifier 84 for transmission from a ferrite rod antenna 86 as before. However, modulation is applied to the carrier by a frequency shift keying (FSK) technique by feeding an output signal from the carrier divider 82 to a second divider (referred to hereinafter as the tone divider) 88 and then using the frequency divided output to drive a switching device 90. This switching device 90 alters the division ratio of the carrier divider 82 thereby shifting the carrier frequency. A timing circuit 92 is coupled to the crystal oscillator 80 to switch on the oscillator in short bursts as described previously, and at the end of each oscillator burst, the carrier and tone dividers are reset.

Referring to Figure 6, the front end stage 94 of the receiver is conventional in that it is coupled to an omnidirectional antenna assembly 93 as described previously in the first embodiment. The front end stage 94 feed aslimiter amplifier 96, also as before. However the limiter amplifier 96 output now drives, on the one hand, a frequency divider 98 which is identical to the tone divider 88 of the transmitter and, on the other hand, a simple FM (frequency modulation) detector 100.

After amplification and squaring in amplifier 102 the modulation signal extracted from the received signal is applied to a synchronous demodulator 104 together with the output of the divider 98. Providing the received signal is present with sufficient amplitude and the modulation signal extracted by the FM detector is of the same frequency as that obtained by dividing the received carrier, the output of the demodulator 104 is (within each transmitted burst) a substantially fixed d.c. level. If the receiver is taken away from the transmitter (By robbery of the case or other article it is contained in, for example), and the receiver picks up a different transmitted signal which is incorrectly modulated, a cyclic output is obtained from the demodulator. Even if the modulation frequency differs from the correct frequency by only a small amount, a detectable shifting of phase will be present at the demodulator output.

The output of the demodulator 104 is applied to a phase shift detector 106 which is controlled, as before by a rectifier 108 and clamping circuit 110 so as to operate only during the received tone bursts. Any significant output from the phase shift detector 106 results in the generation of a pulse signal by pulse generator 42, which, in turn, operates alarm logic circuitry 114 to generate an audible or visual alarm or to spray a dye over the contents of the case.

The alarm logic is such that the alarm is also activated when the absence of an output from the FM detector for a predetermined period, a signal being applied directly to the pulse generator 58 from the clamping circuit 56.

CLAIMS

1. An alarm system comprising a transmitter and a receiver, the system being arranged to generate an alarm signal when the receiver is taken from the vicinity of the transmitter to an extent such that a predetermined signal transmitted by the transmitter fails to be detected at the receiver with a sufficient strength, wherein the transmitter is operable such that the transmitted signal comprises a carrier signal modulated by a modulation signal which is determined or identified by the carrier signal.

2. An alarm system according to claim 1, wherein the receiver has means for generating a reference carrier signal using the received modulation signal as a reference, and means for comparing the carrier signal with the reference carrier signal.

3. An alarm system according to claim 1, wherein the receiver has means for generating a reference tone signal using the received carrier signal as a reference, a demodulator for separating the modulation signal from the received carrier signal, and means for comparing the separated modulation signal with the reference tone signal.

4. An alarm system according to claim 1 claim 2 or claim 3, wherein the transmitter includes a reference signal source which is used for controlling periodic variations of both the carrier signal and the modulation signal.

5. An alarm system according to claim 4, wherein the reference signal source is a reference frequency source operable as a frequency reference in the generation of the carrier signal and the modulation signal.

6. An alarm system according to claim 5, wherein the transmitter has a first frequency divider for generating the modulation signal from the carrier signal using a predetermined frequency division ratio or ratios, and wherein the receiver has a second frequency divider operable to divide the frequency of the generated reference carrier signal by the same ratio or ratios to yield a reference modulation signal.

7. An alarm system according to claim 5, wherein the transmitter has a first frequency divider for generating the modulation signal from the carrier signal using a predetermined frequency division ratio or ratios, and wherein the receiver has a second frequency divider operable to divide the frequency of the received carrier signal by the same ratio or ratios to yield the reference tone signal.

8. An alarm system according to claim 5, wherein the transmitter is arranged such that the modulated carrier signal is a phase shift keyed (PSK) signal.

9. An alarm system according to claim [illegible] or claim 5, wherein the transmitter is arranged such that the modulation signal and the carrier signal have at least one fixed frequency ratio therebetween.

10. An alarm system according to claim 4 or claim 5, wherein the transmitter is arranged such that the modulation signal is swept in frequency.

11. An alarm system according to any preceding claim, wherein the transmitter is arranged to transmit the modulation signal as a plurality of tone bursts.

12. An alarm system according to claim 2, wherein the comparison means includes a frequency comparator.

13. An alarm system according to any preceding claim, wherein the receiver includes a delay circuit operable to delay generation of the alarm signal until the received signal of sufficient strength fails to be detected for a predetermined time interval.

14. An alarm system according to any preceding claim, wherein the transmitter is a radio transmitter arranged to be worn by a person or carried by a vehicle, and wherein the receiver is a radio receiver arranged to be housed on or in an article carried by the person or vehicle, the receiver including an alarm device and being operable such that the alarm device is activated should the article be taken from the vicinity of the said person or vehicle.

15. An alarm system constructed and arranged substantially as herein described and shown in he drawings.

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